Specially drawn for this work by Warwick Reynolds, R.S.W.

WATER VOLES AT HOME.

The water rat or water vole, *Arvicola amphibius*, is widespread throughout England and Scotland, making burrows in the banks of streams, and living an amphibious life. It feeds on roots and on water-plants, and often explores far inland. Although it swims well it is not web-footed, which indicates that it was not very long ago terrestrial. It is much less prolific than the field vole.

THE NEW NATURAL HISTORY

BY

PROFESSOR
J. ARTHUR THOMSON

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XL

THE WAYS OF BRITISH MAMMALS

IN a previous chapter we considered the diverse ways in which British mammals hold their own, we must now take a wider view of their Natural History in general, selecting, as before, a number of representative types, for, though the list is not a long one, we cannot discuss them all.

Bats.

Towards a dozen kinds of bats may be regarded as genuinely British, notably the Greater Horseshoe, the Lesser Horseshoe, the Pipistrelle—smallest of all, the Barbastrelle, the Noctule—largest of all, the Serotine, the Whiskered Bat, Natterer's Bat, Dawbenton's Bat, and the Long-Eared Bat. They are the only mammals that have the power of true flight, and they are, in many other ways, bundles of peculiarities.

The wing is formed by a double fold of skin, which usually begins at the shoulder, extends along the upper margin of the arm to the base of the projecting thumb, thence between the long palm-bones and fingers, and down the sides of the body to the hind-legs, and even to the tail, if there is one. There are strong breast muscles for flight, and they are fixed to a slight keel on the breastbone; the thumb is always clawed, but the other digits are unclawed, except the second one in most of the fruit-eating bats. All our British bats are insect-eaters, and the back teeth have sharp crunching prominences or cusps. The hind-limbs are relatively weak, and are used when the creatures hang themselves up to sleep; the knee is turned backwards like an elbow; the five toes are clawed. There is usually a skin basket (or inter-femoral membrane) between the hind-legs, with the tail in the middle. The skin is exquisitely sensitive, so that bats do not knock against things in the dark. The temperature of the body is high. There is usually a single young one at a time, and the mother carries it about on her aerial journeys.

The Story of the Red Deer.

Our handsomest British mammal is certainly the Red Deer. It stands forty-two to fifty-two inches high at the shoulders; it may be over six feet long; it may weigh thirty stone—yet it can run fifty miles at a stretch, and the word "steep" is not in its dictionary. It is a very graceful animal, holding its head high, and very

Photo: Frances Pitt.

THREE NOCTULES, OR GREAT BATS (*Nyctalus noctula*).

The noctule is widely distributed in Britain, a gregarious frequenter of trees, of a yellowish colour, with long, soft fur. It feeds mainly on cockchafers and other large beetles, hunting them in mid air. The spread of wing, from tip to tip, may be fifteen inches.

THE LONG-EARED BAT

The long-eared bat (*Plecotus auritus*) has ears almost as long as its body, with a long inner flap or tragus. It has long silky brown fur but the ears are mostly bare. It feeds in great part among the branches of the trees, where it hunts for small insects.

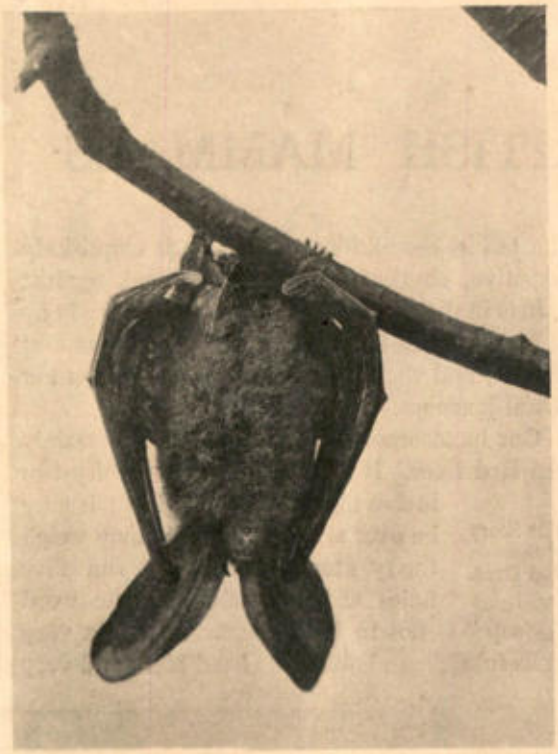

Photo: John J. Ward, F.E.S.

The bat, alighting on a branch, grips firmly with its toes;

Photo: John J. Ward, F.E.S.

it tucks its huge ears away, one at a time.

Photo: John J. Ward, F.E.S.

hiding them under its neatly folded leathery wings, which it wraps

Photo: John J. Ward, F.E.S.

round its body, leaving only the inner flap of the ear projecting.

Photo: H. M. Bell.

RED DEER STAG, MIDSUMMER, "IN THE VELVET.'

The red deer (*Cervus elaphus*) is dark reddish-brown in summer, greyish-brown in winter, with a large whitish patch above and including the tail. The rounded antlers usually show a brow-, bez-, and trez-tine, and above these a somewhat cup-shaped group of sur-royals. As the antler grows, it carries with it the hot, sensitive skin or velvet, rich in blood-vessels.

light on its feet. It can clear a seven-feet fence and twenty feet of a chasm, and there are a good many places called "Hartsleap" throughout the country. The deer is also a good swimmer and a brave fighter. The coat is reddish-brown, short and glossy, in summer; greyish brown, long and rough, in winter; and, after the manner of deer, the young are spotted till the spring after their birth. The dappling is perhaps suited for concealment in the broken light of the copse. When a young animal shows a feature that afterwards disappears, it is in many cases to be regarded as an old-fashioned feature that the ancestors of the animal exhibited. Perhaps the Red Deer's ancestors had spots.

For a great part of the year the stags and the hinds live apart. The stags frequent the higher levels, and we sometimes see them on a ridge, silhouetted against the sky. The annual growth of antlers comes to an end about the beginning of August, and the hot skin or velvet, which was for a time rich in blood-vessels, is rubbed off against branches or in the peat-bog. About the end of September is "the day of the roaring," when the stag sends forth his challenge and invitation. There are savage combats between rivals, and the conqueror wins several wives. The calving is in May or June, and the young one (there are rarely twins) is hidden among the bracken and heather, or at the side of a wood.

Antlers, confined to the males except in the reindeer, are solid outgrowths of the forehead or frontal bone. They fall off and are replaced each year, like the leaves of a tree. In the first year, when the calf is eight to ten months old and still with the hinds, a mere knob grows out. This is a permanent structure. In the second year there is, in addition, an unbranched stem. Next year the new antler bears a brow-point or tine, growing forward and upward from near the base of the main stem or beam. Next year a bay-point is added, and these first two "defend the brow of the stag." Next year, some way up the new beam, there is added a tray-tine, obviously

Photo: C. Reid, Wishaw, N.B.

RED DEER STAG (*Cervus elaphus*).

The branches of antlers are called tines, their tips are called points. A twelve-point stag, as in the photograph, is known as a Royal; the record is twenty-two, eleven on each antler. The antlers fall off in early spring, and the new growths are completed before the breeding season, in September. Long before that the velvet has shrivelled and been peeled off.

French for third. So on it goes, beginning afresh each year and adding point after point until the climax is reached, after which the annual regrowth gradually wanes. A "full antler" shows brow, bay, tray, and three points on the top, six altogether, but there may be a dozen or even a score of points on a really splendid head.

The hot, almost inflamed, skin or velvet is very sensitive, and this saves the stag from knocking his antlers against branches, which would lead to abnormal growth. Very remarkable is the automatic arrangement, set agoing as soon as growth begins, which cuts off the supply of blood to the velvet and the antler-bone, and secures the shedding in March. It is usual to regard the antlers as weapons, but it must be remembered that hornless stags or "hummels" fight very effectively with teeth and hoofs; perhaps antlers are merely exuberant outcrops of masculine vigour. Foxes and eagles occasionally kill the calves but the adult Red Deer has practically no enemies, and if the antlers were weapons against enemies it would be difficult to explain their absence from the hinds. Moreover, the forefeet and the teeth are much used in the stags' fighting. The cast antlers are not often seen, partly because the stag, who is rather sorry for himself at the time, gets rid of them in solitary places where there is dense growth of vegetation; and partly because he gnaws at them after they are cast. The marks of the teeth are sometimes quite plain.

We associate the Red Deer with mountains and moorland, and quite rightly. But it was originally, strictly speaking, a forest animal, and its survival in more or less bare places like Exmoor and the Scottish Highlands testifies to its vigorous constitution. It is fond of the leaves of trees, such as lime, beech, birch, alder, and hazel; but often, of course, it has to be content with grass and heather-tops. As distance means little to it, we are not surprised that it should roam about at dusk and dawn, seeking pleasant things in field and orchard, even going down to the distant shore to lick the salt off the rocks. Red Deer show a great liking for acorns and apples, cabbages and carrots, potatoes and turnips, young corn and ripe corn, and, unless kept within bounds by means of high fences, they often do much damage. In his well-known "Red Deer," Richard Jefferies noted that whereas the hinds eat turnips down as sheep would, the stags are extraordinarily wasteful. "The stag as he walks across the turnip field bites a turnip, draws it from the ground, and throws it over his shoulders, the jerk detaching

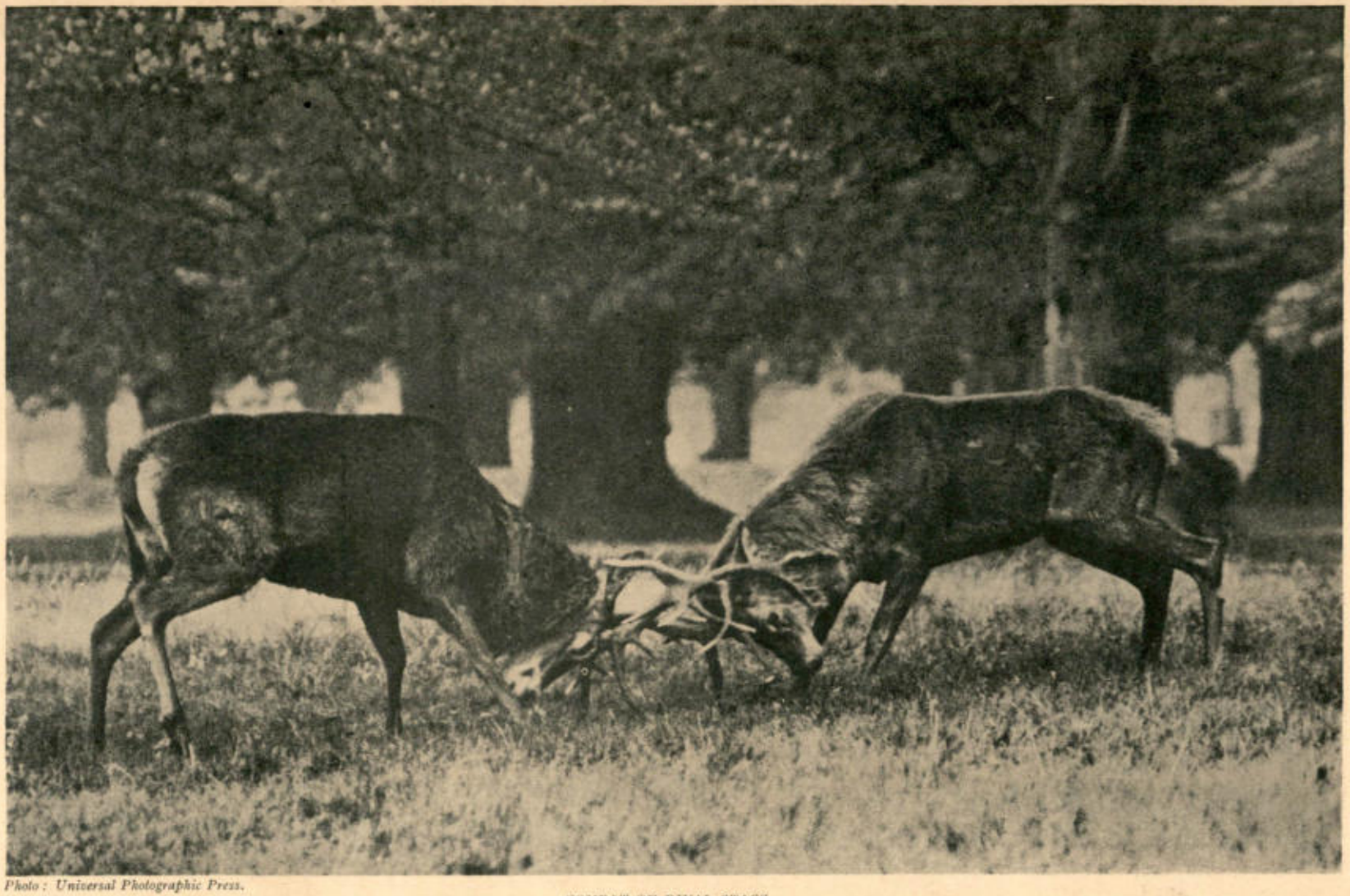

Photo: Universal Photographic Press.

COMBAT OF RIVAL STAGS.

Rival stags at the "rutting season," each desirous to add to the number of females who follow them, charge furiously at one another with their antlers, and they may also use their teeth and fore-hoofs. The red deer stag stands about four feet high at the withers; the fallow deer buck (*Cervus dama*), with flattened sur-royals, stands about three feet high; the male roe deer (*Capreolus capræa*), with simple three-tined antlers, stands about a couple of feet.

Photo: Frances Pitt.

COMMON FOX (*Canis vulpes* or *Vulpes vulpes*).

The fox is now the only living representative of the dog tribe of Carnivores in Britain; but within comparatively recent times there was also the wolf. Most of the fur is golden red; the chest is white; there is black at the tips of the ears, muzzle, and paws.

they will even force the restless youngsters down among the bracken. The stags post sentinels; they can scent a man a mile off; their hearing and eyesight are extraordinarily acute.

Compared with the remains found in peat-bogs, the Red Deer of to-day seem to be dwindling in stature and in thickness of bones and antlers, and this may be connected with the persistent reduction of the forests. It is to be hoped that the dwindling will not go too far, and that the Red Deer will continue in vigour on those moorlands which can hardly be put to better use than preserving such noble animals. For, as Jefferies says, "there is no more beautiful creature than a stag in his pride of antler, his coat of ruddy gold, his grace of form and motion. He seems the natural owner of the ferny coombes, the oak woods, the broad slopes of heather." Long life to the Red Deer.

the fragment he holds between his teeth, which is the only portion he touches. He takes but one bite at each turnip, casting the remainder aside in this way, and his course can be traced from one side of the field to the other by the turnips pulled and thrown away after his snatch. In this disdainful manner he damages far more than he actually eats." The Red Deer's hard times come when the land is covered with snow.

The Red Deer is the only wild survivor of the larger mammalian fauna which used to find a home in Britain, and we cannot but regard him as an admirable aristocrat. To strength he adds subtlety—destroying the scent by crossing and re-crossing the stream, or seeking a rock where he may stand at bay without risk of being surprised from behind. The hinds utter an alarm call, "Bruach," bidding the calves lie quiet;

The Fox.

Reynard the Fox is one of the few large-sized survivors of the old Forest Fauna in Britain. Another good reason for giving it prominence is that since the last wolf was killed in Britain (about 1743), the fox has been the only native representative of the dog tribe of the Carnivores. A very fine representative it is, with its handsome variable coat, usually reddish-brown above and white below; with its tapering muzzle which suggests inquisitiveness; with its large black-backed triangular ears that indicate alertness; and with its bushy tail which may be half the length of the almost yard-long body. We may have strong convictions as to the relations between the fox and poultry, but there is no denying that the fox is one of the handsomest of wild animals. The dog-fox is rather larger and handsomer than his mate.

The fox (*Canis vulpes*) is a solitary, for the sexes live separately, except at the pairing time, and the hunting is always on the "each for himself" plan. Sometimes a natural hole or a badger's burrow is used as a retreat; usually the fox digs an "earth" for itself. Most of the hunting goes on in the gloaming, or under cover of darkness, or in the early morning; and thus the fox is not such a familiar animal as one would expect from its numbers. It often lurks unsuspected in tangled woods that people pass every day. Long distances may be covered in a night and great daring and ingenuity may be shown in getting at coveted booty. It is said that a speed of twenty miles an hour may be reached when the fox is hotly pursued, and there are many stories of foxes baffling the hounds by finding some unexpected refuge—even below the surface of a stream. There is no doubt as to the alertness of its senses and the nimbleness of its wits. It is not for nothing that the fox is second cousin to the dog.

Habits.

The length of the fox's bill of fare is also noteworthy, for it is always easier for a creature to survive when it can make many different kinds of meals. A fox will eat rabbits and rats, chickens and ducks, pheasants and partridges, lambs and leverets, field voles and water voles, grouse from the moor, frogs from the marsh, and crabs from the seashore. Cases are known of foxes condescending to eat insects, but this is little more than a curiosity, like a man eating locusts. The fox's teeth are very like those of a dog, and the same in number. Very conspicuous are the sharp canines that give the killing grip, and one of the back teeth on each jaw above and below has a particularly sharp cutting blade, well-suited for snapping slender pieces of skeleton, or severing tendons, or getting the last shreds of flesh off a big bone.

Like many other Carnivores, the fox has a scent-gland beneath its tail, from which there comes a slightly greasy secretion with an odour disagreeable not only to man, but to some wild mammals as well. It probably helps the fox to recognise the vicinity or the track of its kindred, but there is evidence that the animal may occasionally behave like the skunk and use the repulsive substance to induce its enemies to pass by on the other side.

Another remarkable habit is that of "feigning

Photo: C. Reid, Wisbaw, N.B.

COMMON FOX ON THE PROWL.

The fox is the embodiment of caution when it is stalking, for it avoids putting its feet on dead branches or crackling herbage, and when it moves a fore-foot it brings the corresponding hind-foot forward into the same place.

death," when the fox lies unmoving and awry after it has been struck, but uses its first opportunity to make a sudden bolt for freedom. In lower animals this assumption of immobility usually means a sort of fit or catalepsy ; in the fox, however, it may be in part a deliberate ruse. Its bolt is sometimes preceded by a shrewd snap at its captor.

Foxes breed in winter, and the males sometimes fight savagely for a desired mate. A quaint detail is the sudden flicking of the brush in a rival's eyes. The mother carries her young for about two months before birth, and the cubs—three to as many as seven of them—are born at the end of March or the beginning of April. From the time of birth to soon after the opening of the eyes they have a uniform sooty colour; this changes into tawny above and smoke-grey below ; much later they begin to look like their parents. The cubs are suckled for a month, and then they are fed for a while on rats and voles and other tender things. The vixen is indefatigable and intrepid in finding food for her family. She has been seen hurrying home with half a dozen field voles in her mouth. Like many other carnivore mothers, she teaches her offspring, who remain with her till September, playful and delightful creatures. Both the schooling and the playing greatly increase their chances of success in their subsequent struggle for existence, but eventually the vixen cuts the apron-strings, and the young ones are driven off to fend for themselves. They go off on separate paths, Ishmaelites from the start, and seek for unoccupied territory. They are not full-grown till eighteen months old. The playfulness we have just mentioned is sometimes turned to direct use. For a fox, like a stoat, will sometimes gambol in an extraordinary manner (chasing its own tail, for instance) in the presence of rabbits, who stand by like interested and amazed spectators until the clown suddenly makes a snap at a throat and the comedy ends in a tragedy !

Family Affairs.

There is no evading the charge that foxes kill lambs, especially on hill-farms. The remains have been found at the den, and the circumstantial evidence is convincing. Moreover, like some other carnivores, the fox sometimes " runs amok " and kills more lambs than he can possibly use. We take this to mean that when the killing instinct gets agoing, *and the stimulus persists*, there is no stopping the urge. And we should remember what an extraordinary experience it must be for a wild Carnivore to come on a field with a hundred young lambs ! There is nothing like that to be seen in the whole of Wild Nature—not even among wild sheep.

Indictment of the Fox.

The fox has been called " the nightly robber of the fold," but perhaps the " fold " oftenest visited is the poultry-yard. From a detached Natural History point of view the depredations of Reynard

Photo : Frances Pitt.

FOX CUB, THREE MONTHS OLD.

Three to seven cubs are born in early spring, usually at the end of March or the beginning of April. They are blue-black in colour when very young, and afterwards show variable tints of brown. The vixen looks after them with love and courage.

Photo: Miss Onslow.

FOX CUB.

The attractive fox cubs, blue-eyed in their early days, show considerable variability in their colouring. Playful as they are, they cannot be domesticated, and though individuals taken very young may submit to being stroked, they remain radically wild, and it is better so.

FOX CUBS AT HOME.

Like many of the young Carnivores, the fox cubs are delightfully playful, and the vixen watches them with a proud eye, sometimes in their midst, sometimes from a little distance. The play often takes the form of an anticipation of the hunting for booty.

the Fox on chickens, ducklings, goslings, and the like are often of great interest, they show such cleverness. But the poultry-keeper cannot be expected to take this point of view! The loss is often serious, and though one suspects that the vanishing fox is sometimes a convenient scapegoat, there is no getting past the remains of victims found at the den.

The third charge is that the fox levies a heavy toll on birds that nest on the ground, such as pheasants, partridges, and grouse. This also must be admitted, and it is readily intelligible that in places where "game" birds are important, e.g., on high moorland, the number of foxes must be strictly controlled. There are curious circles in these inter-relations of living creatures: the more foxes the fewer pheasants, one may say; but it is just as true that the more pheasants (or pheasant-preservers) the fewer foxes there will be.

The fourth charge involves greater difficulty. It is that in fox-hunting counties foxes are preserved to an extent that is prejudicial to agricultural interests, and that the hunt itself does considerable damage to cultivated land. In most cases, however, compensation is made to farmers for damage that can be traced to either of these causes. The question of fox-hunting in itself is outside science, but the probability is that if fox-hunting stopped there would soon be no foxes.

Just as turkeys have persisted because man has thrown over them the shield of domestication—for the Wild Turkey seemed, till recently, a doomed bird—so foxes survive in a highly cultivated country because they are hunted!

The list of British mammals is a short one, and it would be a loss to the general interest of the country if the fox disappeared.

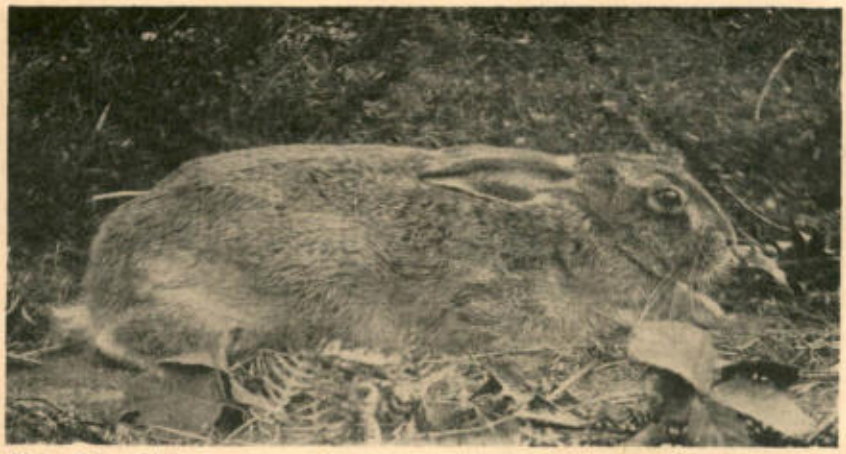

Photo: Frances Pitt.

BROWN HARE (*Lepus europæus*), AT REST.

The colouring of the hare varies considerably and changes a little as it is shed; but it is almost always well suited to conceal the animal when it lies at rest by day, squatting very low among the herbage.

What is to be said for the Fox?

It cannot, indeed, be ranked, like its second cousin the wolf, as a fierce animal dangerous to the lieges, but there is no doubt that it does a considerable amount of harm—little, however, compared with that done by rats. The question arises whether there is much to be said for the fox except that it is an interesting and handsome animal, and that it affords good sport. The answer is that the fox helps to preserve a wholesome Balance of Nature—for it keeps a check on the multiplication of rabbits, rats, mice, and voles. We have already referred to the number of field voles that the untiring vixen catches for her cubs. That alone should cover a multitude of depredations. At the same time we must conclude that the multiplication of foxes must be kept under control.

It is possible that the difference between the smaller "terrier foxes" of the lowlands and the larger "greyhound foxes" of mountainous regions is due to the sterner struggle for existence in the uplands and northern parts. The survivors will tend to be finer specimens than those seen in areas where foxes are "preserved" and hunted! But it may be that there are also racial differences; and it must be remembered that large numbers of foxes have been introduced into England from the Continent.

We cannot leave the fox without recalling that it has been a native of Britain since Upper Pliocene times, and that it has survived in spite of heavy odds, the most serious of all being the destruction of the great forests where it originally found shelter. It has survived because of its swiftness, its alertness, its burrowing and noc-

Photo: C. Reid, Wishaw, N.B.

ON THE ALERT.

When the hare is out feeding, or when it is questioning whether it should take to its heels, it sits upright with its black-tipped ears erect, as the photograph shows. From its lair or "form" it often takes a magnificent leap, certainly far over a couple of yards.

Photo: C. Reid, Wishaw, N.B.

THE COMMON HARE.

The hare likes open rolling country and a resting position from which its long-sighted eyes can get a good view. It makes a "form" by stamping and moulding the herbage. Characteristically, it runs best up hill, and it can do wonders in jumping when hard beset. It has been known to cross a river and even to swim for a short distance out to sea—a very remarkable occurrence.

turnal habits, the maternal care, and the education of the young. But part of its success is the reward of sheer cleverness. The fox kills its own scent, plays 'possum and escapes at the last moment, makes a trap go off without being caught, and drifts down a river like an old potato-sack until it is safe to land. We cannot wonder that Bacon advised statesmen to study the fox! As an aid in this study we would strongly recommend John Masefield's "Reynard the Fox"—for that reaches an understanding which science can only approach.

A March Hare.

One of the sure signs that the Spring has really come is the behaviour of the March hare as it rushes across the field. It is almost beside itself with the desire to mate—the pairing urge. Its mood at this season is high-strung and hot-blooded, quite different from its usual temper throughout the year.

The Common Hare might be called a gentle Ishmaelite. Everyone's hand is against it, but it is against no one unless it be greatly roused. Fox and otter, stoat and lurcher, and various birds of prey are but a few of its many enemies, and the list used to be longer when polecats and wild cats were common in Britain. We cannot say, however, that it lives in the bondage of fear, for it is singularly fitted to elude its enemies, and it knows it, too. It seeks resting-places from which it gets a good look-out over the surrounding country; it has long-sighted eyes, quick ears, and keen smell; it utters a danger call by grinding its front teeth; its heart is such that it can put on full speed the moment that danger is signalled, it rejoices in an uphill race; it criss-crosses its tracks so that even the fox is baffled; it disappears like an arrow when it is startled, and even when it is resting among the ferns and herbage, or on a ploughed field, it is almost invisible save as to its wide, staring eyes. Much as it dislikes wetting its coat, which is slow to dry, it will swim a broad river to baulk pursuit or to reach greatly appreciated dainties, like musk and camomile. Epicure as it is, fond of the tender corn and the sweet trefoil, of wild thyme and the seashore pea, it has a long bill of fare, reaching from lichens on the rocks to the twigs of furze-bushes, from dandelions to brambleberries. And it always makes for success when

an animal can find sustenance in a great many different kinds of food.

It has been said that the Common Hare has the maximum of enemies, and yet it is so well endowed with capacities of sense and muscle and with instinctive ruses that it can outwit them all. Let us take three more illustrations of fitness. How simple and effective is its habit of taking a great leap from or into its "form" or nest, so that the scent-track is interrupted. A hare has been known to make a clean jump of three or four yards from its resting-place, and it often breaks its scent in the field. How interesting is Mr. Tregarthen's note in his fine "Story of the Hare," that the doe leaves little scent whilst her young ones are helpless, that is about the month of April. How striking is the fact that she will sometimes divide her litter, when it reaches to five or six, so that there are two or three nests, each with one or two leverets —a quaint case of not putting all the eggs into one basket. When a particular nest becomes dangerous, when a hungry vixen, for instance, gets wind of it, the doe hare will transport the leverets to a safer place, carrying one at a time in her mouth as a cat does her kitten. This, of course, is done at dead of night, and it is indeed at dusk and dawn that hares are generally most active. They positively dislike the glare of day.

Elusive is the word for a hare, but at the breeding season in March the instinct of self-preservation wanes before sex-passion. The cautious hare becomes reckless of danger, showing itself in the open at all hours of the day. The bucks race about at a high speed searching for the coy does and chasing them in circles when they find them. Rivals fight savagely, kicking with their hind-legs and boxing with their paws—a common trick is for one to jump over the other, kicking back as he clears, and this is sometimes fatal to the under hare. When exhausted with racing and fighting, the rival bucks sit and stare at one another by the half-hour. Then one will suddenly get up and dash over the lea, not with the usual easy loping canter, but at a tearing gallop. We smile to one another, and say, "March hare."

Of course there is plenty of racing and playing and fighting in other months, but it is mostly done on the quiet, whereas in March (and sometimes in August) the madness of love is recklessly obtrusive. A wearied hare with bedraggled fur is a melancholy sight, but, in spite of what most of the poets say, the spirit of the creature

Photo: Frances Pitt.

A BROWN HARE LEVERET.

A young hare or leveret is one of the most attractive of living creatures, with large liquid eyes and soft, ruddy-brown fur. Five is a common number in a litter, but there may be more or fewer. The young ones can see at birth, and are covered with hair. They need little in the way of instruction, and are easily tamed.

Photo : Albert Henry Willford.

YOUNG WILD RABBITS, THREE WEEKS OLD.

Although young rabbits are born blind, naked, and helpless, they grow quickly and are soon able to fend for themselves. When they emerge from the burrow, where the mother shuts them up in their early days, they show quickness to learn and notable self-confidence.

is quite otherwise, being gay and buoyant. The leverets sometimes play merrily in the light of the moon, and there is no melancholy in the way a hare jumps on an impertinent weasel. We should notice, by the way, that the buck hare is rather a roving lover, very far from domesticated. He may consort with one doe for a little while, but he soon seeks another.

The quick beating of the heart, the rapid breathing movements, and the tremulousness of the long ears, have suggested the epithet "fearful," but one may doubt whether there is much fear in the hare's composition. It is extraordinarily alert ; it understands the wisdom of lying low ; it takes no needless risks except in March. On the whole, the hare presents a brave front to persecution, and it utters its poignant cry only when there is no possibility of escape.

The contrasts between hares and rabbits are many, and there is no love lost between the two species. It is plain that the hare has been specialised for a much more adventurous life, and in connection with the giving-up of the burrowing habit (of which, however, there are interesting reminiscences) the leverets are born furry and open-eyed—impatient to leave the nest—very different from the naked young of rabbits.

In many countries the hare has become the type of alertness and astuteness, and the first of these qualities is certainly characteristic. Although it does not sleep with its eyes open, it is rarely to be caught napping ; it seems always in training, and we have never seen any fat in the usual place below the skin.

The Rabbit.

The rabbit suffers from having such a distinguished relative as the hare, but it has its own points. It must have a good constitution to be able to stand importation to climates so different as those of Scotland and Australia. And it thrives in Ireland, though not in cold countries like Scandinavia. There is little doubt that for many centuries after the Ice Age there were no rabbits in Britain. They seem to have come over with the Conqueror, for their headquarters in post-glacial times were Mediterranean and Iberian.

To some extent the rabbit succeeds because it multiplies so rapidly. It works with a large margin. This is not a high virtue, for low-grade fishes can spawn by the million ; but it stands for something. It means a certain kind of vigour, even if it be exemplified in the millions of mites that frequent the great cavern of the over-dry Stilton cheese. Now a rabbit may have four to eight litters in a year ; the period of life before birth is just under a month ; there are three to eight young ones in each litter ; and the young rabbits are ready to multiply in half a year. This is almost like "spawning," and since the rabbit's infantile mortality is not very high, the great fertility means a rapid increase of population.

No one can call the rabbit a clever animal, and whoever "Brer Rabbit" was, he was not our *Lepus cuniculus*. In many countries he was certainly the astute and resourceful hare ; in North America he was probably a Cottontail (Sylvilagus). Yet the rabbit has its gifts—keen scent, a considerable degree of alertness, wit enough to sound a danger-signal by thumping

with the hind-legs, and a pleasant playfulness of an evening. It is not courageous in the presence of its enemies, such as fox and stoat, buzzard and owl, but a furious mother will occasionally fight for her offspring. A rabbit may even bite a dog! There is something very ineffective in the fear-paralysis which sometimes besets a rabbit when it looks round and sees the stoat on its heels: it stops running and starts screaming. There is a pleasanter suggestion in the way the seniors flick up their white tails when danger threatens in the dusk, thus giving the youngsters a lead in finding the burrow as quickly as possible.

There are records of pairs of rabbits which remain together for a year at least, but this is not the way with the majority. Their morals are of the loosest. Rodier's plan of dealing with the Australian rabbit pest was to kill as many does as possible, but no bucks. The local result was that the bucks killed the helpless young, and the disproportion between males and females became so great that the females perished. But in the immense areas of Australia the only hope of permanent relief from a gratuitous tangle in the web of life (rabbits were introduced about 1860) seems to be the increase of the agricultural population.

To the rabbit's credit we must also place its domesticability. Not only does it breed well in artificial conditions, but it has proved itself a fountain of change. It has given origin to a multitude of varieties—the popular "Belgian Hare" (sometimes accepted by the credulous as a cross between hare and rabbit), the small Dutch and the Flemish giants, the beautiful Angoras, often like mops of silky white hair, the quaint Lop-Ears with the ear-trumpets spread out on the ground on each side of the head, the Himalayans and Patagonians and Siberians and Black-and-Tans! Numerous "factors" or hereditary items go to make up the beautifully coloured coat of the wild rabbit; when one of these drops out of the inheritance there is a colour-variety, when two drop out there is another colour-variety, and so forth, with the result that we have blacks and whites, yellows and "blues," and other colour-varieties, not to speak of tortoise-shells. When these varieties inter-breed there is in the offspring a reappear-

Photo: C. Reid, Wishaw, N.B.

WILD RABBIT AND YOUNG.

The young rabbits are born in a grassy, fur-lined nursery in the recesses of the burrow. The mother blocks up the entrance with earth when she is away feeding. After the young ones are weaned and looking after themselves, they obey the danger signal made by stamping on the ground with the hind-feet.

ance of the wild-rabbit type, not through any mysterious "reversion," but simply because there is a *re-combination* of the peculiarities which have arisen by sifting apart the various components of the original wild complex. When the components re-combine the coat of the wild rabbit re-appears.

We get a useful picture of what a different species means in Natural History when we contrast the rabbit and the hare. The rabbit has shorter feet and it runs in a different way; it has shorter ears and there is little hint of the hare's black tip; it is gregarious and normally a burrower, while the hare is solitary and rests in an open "form"; its young are born naked and remain blind for eleven days, whereas those of the hare are born furry and open-eyed; its danger signal is thumping with the hind-legs, whereas the hare grinds its front teeth against one another; the rabbit is much more prolific than the hare, with a much wider range of appetite, with a different voice, a different colouration, and a different temperament. Its flesh has an entirely different taste. It is not surprising to find that hare and rabbit are incompatibles. They are not known to be capable of inter-breeding and the fastidious hare leaves the pasture which the rabbit has fouled. The hare is altogether more of a gentleman!

Photo: Edward Step, F.L.S.

ENTRANCE TO BADGER'S "SETT."

The badger's burrow or "earth" is usually in a wood or an old quarry, or on a bushy hillside. While there is a single entrance, shown in the photograph, there is often a series of twisted passages, added to in the course of years, the whole being called the "set" or "sett," and if the situation is a suitable one, it may be used for several generations of badgers. The burrow is often made comfortable with bracken.

Many are the points at which the circle of the rabbit's life cuts into man's. Rabbits destroy crops and young trees; but they afford pleasant food and fur. Rabbits turn fertile land into a desert; but they make the most effective golfing turf in the world. They assist in the education of the medical student and in the training of the shot. And Bunny has done much for the human child.

The Badger.

Among the native British hillside animals we can still include the badger—a creature of long pedigree, that lingers in our midst in spite of heavy odds. In some parts of the country, such as the New Forest and Devon, it still has a firm foothold; but, on the whole, it is surviving and no more. That it was once much commoner is proved by the number of place-names such as Brockhurst, for Brock means badger. The question arises how this big animal holds its own at all in a country where agriculture spreads and woodland shrinks, and where the desire to kill anything strange and interesting seems almost ineradicable. How does the badger survive? In the first place it has become noc-

Specially drawn for this work by Warwick Reynolds, R.S.W.

THE BADGER.

The long coarse upper hairs are somewhat subtly coloured—reddish, white, and merging in a "badger colour." The soles of the feet are covered with hair.

turnal—a creature of the shadows, with a strong instinct for self-effacement. Even after dusk it will work its way down a dry ditch or along the side of a hedgerow rather than cross the open. The variegated grey colour of its fur favours invisibility, and the striking white bands on its head are much less conspicuous at night than during the day.

Moreover, the badger has strong virtues of its own. It is a very muscular animal, with a first-class heart and circulation, and a good wind. The lower jaw works in a socket so deep that dislocation is almost impossible, and the grip is unsurpassed in tenacity. Its thick coat helps the badger to withstand the cold of winter, and it also stores a good deal of fat. Furthermore, it is endowed with keen senses, shrewd intelligence and a capacity for taking things easily. It is more alert than it looks, it is at once cautious and cunning, it is dogged without being obstinate, and it does not fuss or worry. It is a creature with a great deal of character and strong idiosyncrasies.

Again, like the otter, the badger has an extraordinary catholicity of appetite, which is always an advantage in the struggle for existence. If one kind of food fails, it can fall back on something else—roots and fruits, worms and grubs, frogs and snakes, eggs and young rabbits, the larvæ in the wasps' bike, and the honey in the humble-bee's nest, and much more besides. Another factor in survival is to be found in the burrowing habit, for it is always advantageous for a terrestrial animal to get off the surface of the earth, whether up a tree or underground. The "earth" or "set" on the copse-covered hillside or in the recesses of a wood has tortuous passages which often go far in; there may be several entrances, and one burrow may communicate with another.

Photo: M. H. Crawford.

THE BADGER (*Meles meles*).

The badger is rather over two feet in length, with seven and a half inches of tail besides. Its prevalent colour is grey, washed with black, but the face is white, with a black band on each side passing from the eye to the ear; and this colouring makes it inconspicuous at night.

Photo: Frances Pitt.

BADGER AT STREAMSIDE.

The badger likes to slake its thirst at a spring or rivulet, and its sett is sometimes excavated not far from a stream; but it cannot be said that this creature, cleanly as it is, is fond of the water. It is very emphatically a dry ground mammal, and as characteristically nocturnal.

Careful observers seem to be unanimous in commending the badger's sanitary regulations. It wipes its feet before going indoors, and it does not foul its set. There is a big spring-cleaning before the in-lying time, and another after that anxious period is over. Some naturalists have had the good fortune to see the badger carrying to the warren a huge bundle of bracken and dry grass, wherewith to replace the bedding that has been rejected. The badger is neither foul nor surly.

Sometimes the safety is increased by the seclusion of the home, away on the top of the heather-covered hill, where a cairn may afford shelter, and where no enemies intrude. The badger shares such solitudes with the Mountain Hare and the Ptarmigan; the only disadvantage is that the seclusion implies a somewhat ascetic menu and many a long mile of heavy walking in search of food. A badger may go six miles of a night.

We are inclined to attach great survival value to the education which the mother badger gives to her silvery-grey cubs. There are usually just two or three of them, born in spring, after an ante-natal life of perhaps twenty-two weeks (but this is a subject regarding which there is extraordinary discrepancy). When they have got their sight, some nine or ten days after birth, and had the usual gastric education on milk, they are taken outside the warren and well-groomed. But then comes schooling, and the mother is a stern disciplinarian. She punishes the inattentive and foolhardy cubs, and gradually instructs them in the long alphabet of woodcraft.

A badger is a thick-set, round-backed, rather bear-like carnivore, somewhat over two feet in length, with an additional seven inches to the tail. It has a long muzzle, well-suited for its restlessly inquisitive poking into holes and corners; the small, round ears are not in the way among the brushwood; the bluish-black eyes leave nothing to be desired in brightness. The heavy body does not seem to be lifted much off the ground, the snout is often held low, the soles

of the feet are entirely on the ground in true plantigrade fashion. Nevertheless the movements are easy and stealthy, and the creature does not know what it is to be tired. There is a peculiar odoriferous gland under the tail, which may possibly enable badgers to keep up their acquaintanceships. Badgers growl when angry and chuckle when cheerful, and the husband and wife have a good deal to say to one another in a somewhat stoat-like chatter. Those who have the privilege of knowing badgers intimately, speak of their playfulness and of the dislike the male has to find the female sleeping when he is busy, and conversely! It is quite certain that badgers do not hibernate, though they may doze through days of compulsory fasting. Their severest trials must be when the ground is covered with snow, and their activity then is evident enough from their characteristic spoors.

An elusive creature with a strong individuality readily becomes the centre of myths, and one of the strangest concerning the badger is that the limbs on one side of the body are shorter than those on the other—this being an adaptation to movement *along* the hill-slopes. A wonderful adaptation, indeed, forcing the creature, however, to be very uncomfortable when it turns homewards again! But perhaps "the uneven badger" always makes a circuit! The badger does not need the lies of men, but it could do with a little more admiration. For this old-fashioned creature of the shadows is a precious legacy from distant days and should be held in due respect. Perhaps we are growing a little more appreciative, for we do not go in for the badger baiting our forefathers enjoyed.

The Polecat.

This attractive member of our dwindling mammalian fauna is one of the bear-badger-otter-stoat tribe of Carnivores, and has nothing to do with any cat, large or small, wild or tame. It is Arctoid, not Feline. It is easily known by its size, for the male is about two feet long, including seven to nine inches of tail; and the female is almost one-third less. The long, dark, coarse outer hairs, which probably help to throw off the rain, hide the yellowish under fur. What the word polecat means seems very uncertain, but the alias foumart is probably an abbreviation of foul marten. Another name is fitchet.

The polecat is widely distributed in North Europe, and our cave deposits show that it was an ancient (early Pliocene) British mammal. It was doubtless exterminated during the Ice Ages, and found its way back again from the Continent before the insulation of Great Britain. Now it is approaching extermination again, for it is very rare south of the Caledonian Canal. The reasons for this disappearance of an interesting relic are to be found in the extension of arable land, in the severity with which the polecat is persecuted by gamekeepers and poultrykeepers, and also in a certain recklessness which leads the animal to use the same run over and over again—a mistake the otter rarely makes. It would not have survived so long had it not been in great part nocturnal in its hunting, and had

Photo: W. S. Berridge, F.Z.S.

POLECAT (*Putorius putorius*).

This is fast becoming a very rare mammal in Britain, mainly because of man's persecution. A full-grown male may be seventeen inches long from the tip of the snout to the root of the tail which occupies about six to seven inches more. The corresponding figures for a female would be eleven to twelve inches and five inches.

Photo: Frances Pitt.

POLECAT SCRATCHING IN LOOSE SOIL.

The polecat's head is massive, the limbs are short but strong, the fur is soft and loose, the general colour is brown, lighter below. A fearless, bloodthirsty carnivore, the polecat keeps to the ground, wanders from place to place, is in the main nocturnal, and is death to birds and rabbits.

it not been able to utilise a great variety of food. During the day it usually rests in a thicket or in a borrowed burrow, in a little cave or in the recesses of a wood-stack, or about a ruined cottage. Under cover of darkness it moves quietly about with great ability and defiant courage.

What flesh will it not eat? It is able to take eels from the river or pond, for it is a good swimmer; it condescends to frogs from the marsh; it is clever enough to kill snakes, and it is said to be immune to the adder's poison. It sucks the eggs of birds that nest on the ground, and it follows rabbits into their burrows. To its credit must be put its destruction of rats and mice; against it are its depredations in the poultry-yard. It bites a biggish animal behind the ear or in the throat, and it is said to relish the gush of blood from the jugular vein. A smaller victim is bitten through the skull, and the brain is said to be a tit-bit. In the majority of cases the booty is carried to the lair and enjoyed at leisure and in safety; but the creature sometimes satisfies its hunger on the spot. And what makes the polecat's depredations so serious is a sort of Berserker fury which leads it to kill and kill beyond all possibilities of utilisation. We suppose that an instinctive killing impulse is actuated which cannot stop as long as there is any victim left to be slain. Such an opportunity as a hen-house offers is obviously not one that has many counterparts in Wild Nature, and the polecat makes the most of it. No one can be surprised at the persecution which has made the polecat a rarity, yet the animal has its usefulness as a check on the prolific multiplication of rats, mice, voles, and rabbits, and as an eliminator which tends to weed out the weaker individuals first, and thus improve the vigour of a stock like that of grouse.

In addition to this useful pruning and sifting, which is part of the process of natural selection, the polecat is a creature that demands our admiration for its litheness, its indefatigability, and its courage. Like the stoat, it is almost without a trace of fear in its composition. It is nervous, but not timid, and it will attack a full-grown hare, a turkey, a goose, or, in desperation, man himself. It is very strong in neck and limb, and the skull (of the male in particular) is a little masterpiece. The polecat has great tenacity of life, and it seems a pity that a creature with so many virtues should dwindle before man's artificialities.

The male is called the "Hob" and the female the "Jill," and their pairing time is towards the

end of winter. Four to six young ones are born in May or June, blind and helpless and with buff-white fur. There is usually a " but and a ben " in the retreat, the one for storage and the other a living-room. The offspring are carefully nurtured, and they begin to be educated out of doors when about six weeks old. In another month the mother's apron-strings are cut, and the youngsters are left to fend for themselves, which they are thoroughly capable of doing. It may be mentioned that the " Jill " puts on an entirely new suit of fur after her maternity, and the " Hob " changes his in a more leisurely way a little later in the year. He is then known as the " Black Ferret." As to the fetid smell to which the name " foul-marten " refers, it is, in part at least, a protective quality, and it is not much in evidence unless the animals are irritated or in extreme danger. The malodorous fluid comes from two special glands at the end of the food-canal, and it is almost as repulsive as the similar secretion of the skunk.

It is generally believed that the ferret is a domesticated variety of the polecat (*Mustela putorius*), but this is not quite so certain as is usually stated. One great authority, Mr. G. S. Miller, maintains that the ferret is more nearly related to *Mustela eversmanni*, a species found in Western and Northern Asia. Most ferrets are albinos, that is to say, the hereditary " factors " for colouring or pigmentation have dropped out of the inheritance. Thus, the fur is cream-coloured and the eyes are pink, the red blood shining through an unpigmented iris. But there are also dark-coloured ferrets which are very like polecats, though there are some notable differences in the skull and in the fur. The ferret is also a hardier and less " nervous " animal. Miss Frances Pitt writes :—

" In such intangible peculiarities as temperament and disposition the ferret is very different from the polecat, as is shown by the ease with which it is tamed even after being neglected while young. An adult-caught polecat is quite untamable, and even half-bred ones require constant handling from their earliest youth to make them docile. It takes a very serious fright to make a placid easy-going ferret emit the vile defensive odour, but the hybrids never hesitate to make use of it. In disease-resistance, too, the ferret differs from the polecat, being less susceptible than the wild animal to some of the diseases met with in captivity " ("Journal of Genetics," September, 1921). On the whole, Miss Pitt's facts seem against the view that the ferret is a domesticated variety of the British polecat. The ferret crosses readily with the polecat, and the hybrids are fertile among themselves and

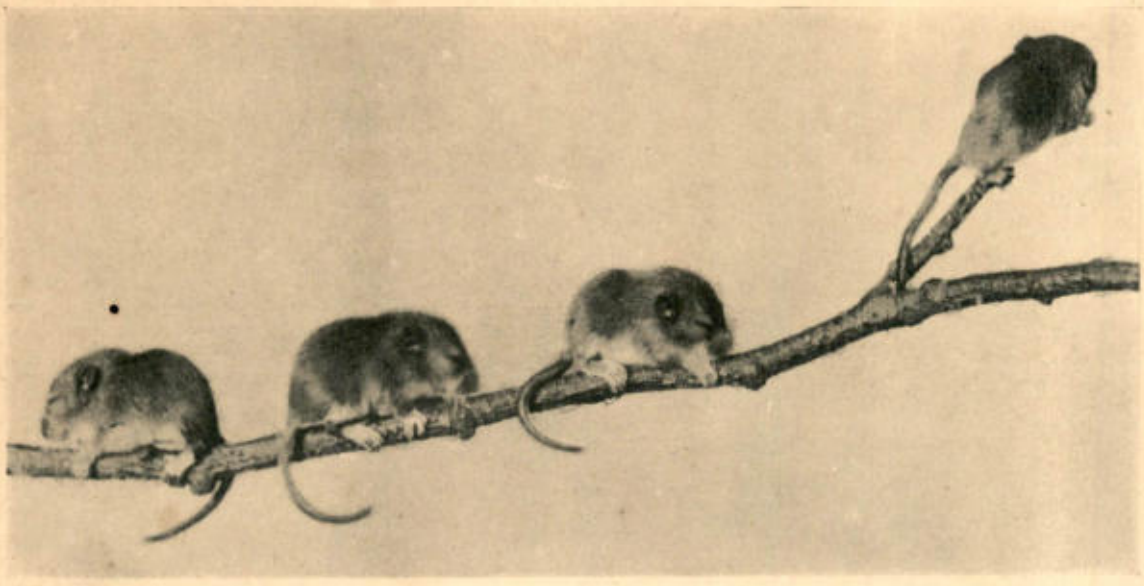

Photo : Frances Pitt.

BABY DORMICE.

The young of the dormouse have some down on their body when they are born, and they very soon get a furry coat. There are usually about four in a litter, born in August or September. As the photograph suggests, the tail can be twisted a little round a branch.

with either parent. The first crosses show complete, or almost complete, dominance of the polecat type as regards outward appearance, but in skull characters the ferret is dominant.

One is all too apt to think of evolution as something that occurred in the past only, instead of realising that it is going on now. A good example may be found in the "red" polecats which have been cropping up recently in Cardiganshire. The "red" variety occurs among ferrets as well as among polecats, and is probably due to the dropping out of one of the hereditary "factors" determining the normal colouring. When red varieties are crossed with white ferrets, all the offspring of the first generation are red, or, to put it in Mendelian language, redness is *dominant* to whiteness. But if red varieties are crossed with black-brown varieties, all the offspring of the first generation are black-brown. In other words, red is *recessive* to black-brown. In both ferrets and polecats the redness is associated with large size, and in the ferret at least it is usually accompanied by a quick temper and a general increase of vitality. Here we have plainly to deal with a new departure, at present manifesting itself in Wales, and quite likely to gain a firm foothold. Evolution is going on.

Crosses between ferret and wild polecat are said to be very effective for work in a rabbit warren; and this is especially true of the immature young females, which are very agile. Dark varieties that escape and become feral are apt to be confused with pure-bred wild polecats. We cannot pass from ferrets without recalling Sir John Millais' story of the big man for whom the doctor had prescribed leeches. "These little worm things!" his wife exclaimed, "I put a ferret on him."

The Dormouse.

As a type of the true hibernators or winter-sleepers we take the dormouse (*Muscardinus avellanarius*), an attractive member of the order of Rodents or gnawers. It is in October that the dormouse usually passes into the state of winter-sleep, and it remains hibernating till April. It is very fat when it betakes itself to a well-lined nest in a mossy bank or in a tree-stump; it is lean when it reawakens. In its comfortable nest the "sleeping mouse" lies for half the year, with its tail wrapped round its head and back, and with its paws on its cheeks. In very mild weather it may rouse itself and eat a little (there is often a store of food in the nest); but normally the hibernation is continuous. Sudden coercive awakening may be fatal. To the soundness of the slumbers the name of dormouse (dormir, to sleep) plainly refers; and Shakespeare speaks of awakening "your dormouse valour." Many of its other names are pleasant, like "dory-mouse" and "sleepy mouse." So is "chestle-crumb," but we do not know what it means.

The dormouse occupies a position somewhere between squirrels and mice. Some of its features are: the compact body about three and a half inches long in head and trunk, the thick-haired slightly prehensile tail with a length of over two inches, the thick soft yellowish hair, the prominent eyes, the blunt snout, the rudimentary thumb, and short first toe, the small but very strong claws well suited for climbing. It is widespread in England, but does not occur in Scotland or Ireland. It belongs to an old-fashioned stock, confined to the Old World, and established before Japan was separated from China, or Africa from Europe.

A timid, gentle creature, "the squirrel of the thickets," very clever in making its way in the dense undergrowth. It sleeps for the greater part of the day in a dormitory of grass, moss, and leaves, not usually far off the ground. In the dusk or at night it hunts for nuts and berries, acorns and grain, and occasionally small animals. When eating it usually sits on its haunches, and holds the food to its mouth; but it can also enjoy its food hanging head downwards by its toes. There is safety in its tangled habitat, in its quick movements, and in its avoidance of the light of day. It seems to be a very silent creature, making scarce a sound save a slight hiss when frightened. One of its few near relatives, the garden-dormouse (Eliomys) of the Continent has been known to avoid capture by surrendering its tail in lizard-like fashion. This is a very remarkable occurrence in a mammal, and its efficacy is increased by the capacity for replacing what has been lost. A tail for a life is a useful jettison. But this is not known in the Common Dormouse (*Muscardinus avellanarius*), whose second name refers to a supposed fondness for filberts or hazel-nuts. In this country it is just

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Photo: Frances Pitt.

DORMOUSE AMONG HAZEL TWIGS.

The dormouse has very large jet-black eyes, yellowish-buff upper fur, whitish under fur, a somewhat bushy tail, and pink feet. Its name, from the French dormeuse, has nothing to do with "mouse." The daintily eating creature is fond of nuts and the fruits of the wild rose, varying this vegetarian diet with insects.

Photo: E. J. Bedford.

NEST OF DORMOUSE.

There are three kinds of nest made by the dormouse. First there is the ordinary shelter nest or sleeping nest, shown here, often called the drey. Second the cradle or nursery nest, larger than the other, made towards the end of summer. Third there is the hibernating nest.

as fond of the tart fruit of the rowan-tree or mountain-ash.

The dormouse seems to be monogamous, and though there may be a number of summer dormitories near one another, the inmates keep themselves to themselves. When the time comes the female makes a nest separate from the dormitory and rather larger (about six inches in diameter), and there, after a short ante-natal life of three weeks or so, the young ones are born. Four is a common number and there may be two or more families in the season. The young ones are born naked, with closed eyes and ears, and they certainly need a nest. The young dormice have to be nurtured in the nest for about three weeks before they are able to fend for themselves. An interesting point is that the members of a family born late in the year are likely to perish. There is not time for proper nurture before the mother sinks into hibernation and it seems to be a condition of successful hibernation in dormice that a considerable quantity of fat is accumulated before the animals begin to lie low. It should be mentioned that the winter dormitory is often underground and that the dormouse "sleeps" alone. Dormice may live for three or four years in pleasant captivity—one of the conditions being that the atmosphere of their home is not allowed to become too dry even in winter. It may also be useful to mention that dormice like plenty of water to drink. They are not very "brainy" animals, but they are very attractive, and they have no smell.

The question rises, how do these timid, gentle, inoffensive creatures hold their own in Wild Nature? As we have indicated, the answer must be found in their elusive ways—living in thickets and active at night, in their alertness of sense and adroitness of movement, in their long bill of fare, in their careful mothering of numerous families, and in the capacity for "winter-sleep." As a matter of fact, dormice have few enemies; and even the owl may be a friend in disguise, for it will be most likely to catch those that are dull or careless. A race of animals is always the better of some sifting, and the same applies to mankind. "Behold the life of ease, it *drifts*," as George Meredith said.

If we consider house mice apart from the damage they do, we must admit their attractiveness. They are neatly built, pleasant in colour, smart in their movements, alert in most of their senses, and as clever as they need to be. If we consider them economically we must use the word *pest*. For they devour enormous quantities of food, they spoil more by their droppings, they destroy useful things like clothes and books, they gnaw their way through partitions and floors, they have an unpleasant odour, and, if they get the upper hand, they may cause a veritable plague.

Mice.

The common mouse, or house mouse (*Mus musculus*) is now almost cosmopolitan, but it probably came to Europe from the East not earlier than Neolithic times, when man began making a better class of stone implements. It

Photo: Ellison Hawks.

DORMOUSE HIBERNATING.

The dormouse is almost as good an example of true hibernation as the hedgehog. When the cold weather sets in there is a search for a sheltered hole, perhaps in an old tree, and a comfortable grass nest is made, in the midst of which the creature "sleeps" through the winter.

has been with us so long that it has established local races or new species in St. Kilda and the Faeröes. It is very variable in its colouring and plastic in its habits, for the country mouse and the town mouse are the same species! Perhaps there is nothing they will not eat or chew, from cheese to lead pencils, from the stores of the beehive to the sea-weed on the shore. Even tobacco is not refused. An individual mouse is not unpleasant, especially when it sings in the evening; two or three may be smiled at; but when they become numerous they are intolerable. It is not merely that they devour materials and make nests of important papers, there is danger in their contamination of food, and they are vehicles of serious parasites like those associated with plague and the trichina-worm. There is no moderation in their productivity. They may be parents before they are a year old; they carry their young before birth for only three weeks; they may have half a dozen litters in the year; and there are usually five or six in a litter. A little one soon becomes a thousand! The desirable checks are, of course, to keep foodstuffs well covered, to be careful with crumbs, to give hospitality to a good "mouser," and to use traps before a pest becomes a plague. It is sometimes forgotten that if we greatly reduce the number of rats, which is most desirable, we are bound to increase the number of mice; therefore measures must be taken which are checks *to both*.

The field mouse or wood mouse (*Apodemus sylvaticus*) is the most abundant and most widely distributed of European mammals, and occurs in all sorts of places from sea-level to far up the mountains. It differs from a house mouse in its much longer hind-legs, larger hind-feet and ears, and larger, more bulging eyes. It is a hardy, alert, versatile animal, with a good many accomplishments—"a fine jumper, a good climber, a capable digger, and a fair swimmer." As its prominent eyes suggest, it is in the main nocturnal. It bounds about in an unpredictable sort of way, and Messrs. Barrett-Hamilton and Hinton note that "at all times, even when it walks, its long hind feet give it a characteristic 'action' in moving about, which is probably its most peculiar feature." One has been known to leap down fifteen feet and proceed unhurt, which says a good deal for its elasticity of limb.

Mainly a vegetarian, it has a very wide range of appetite—grain, fruits, roots, leaves, and even flowers. Many people are sadly aware of its fondness for crocus corms and hyacinth bulbs. In many cases it has been known to eat insects, and the burglary of a beehive has been occasionally reported. It is very rarely that field mice enter a house, though they may draw to the farmyard in the winter. As Virgil noted, the *exiguus mus* makes stores, which usually consist of grain, and it falls back on these reserves when the weather is very severe. There is no true hibernation.

Rodents, as everyone knows, are extraordinarily prolific, but it is probable that the field mouse beats them all. Females will breed at five months old, and one has been known to have five

Photo: Ellison Hawks.

DORMOUSE (*Muscardinus avellanarius*).

This attractive rodent, with a suggestion of the squirrel, is not uncommon in the central and southern parts of England. It becomes rarer northwards, and does not often cross the border into Scotland. It is a frequenter of thickets and makes a shelter nest, or drey, well off the ground.

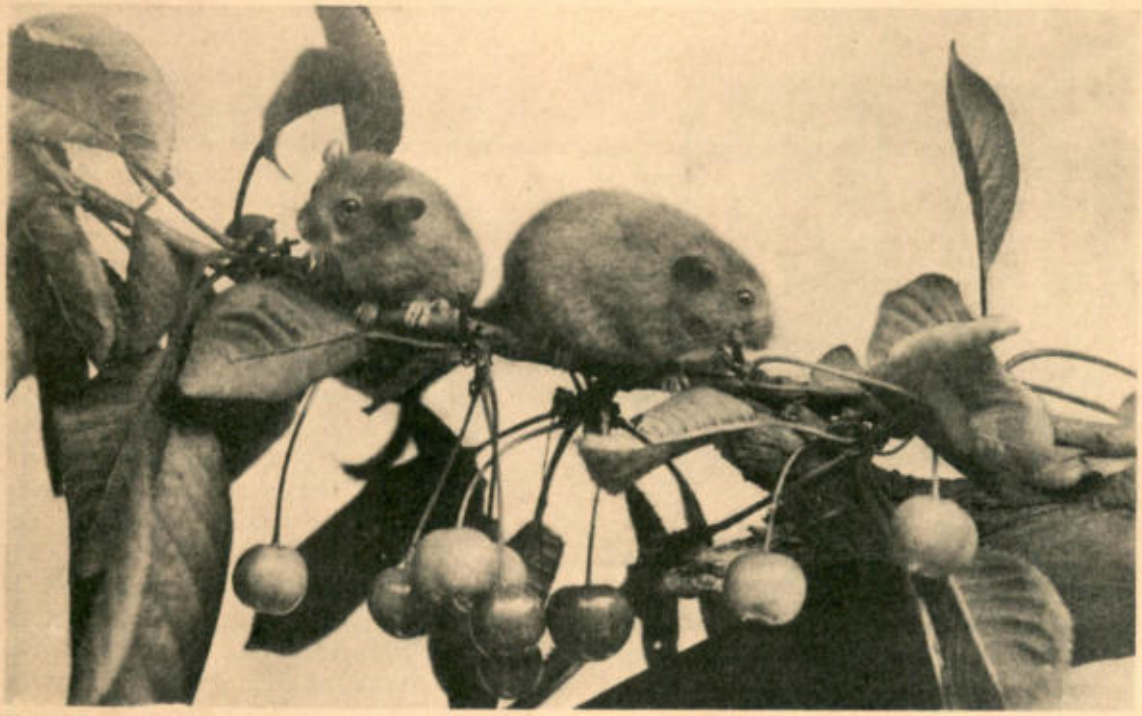


Photo: Ellison Hawks.

FIELD VOLES ON CHERRY TREE.

The field vole will eat almost anything vegetable, but it has a preference for green food, such as clover, and has specialised tastes for carrots and yellow crocus and other rather out-of-the-way things. It likes to have an abundant supply of water.

families between the beginning of March and the month of July. Four or five is the commonest number in a litter. Gilbert White and others have called attention to the way in which the young ones cling to their mother's teats or even to her hair, so that she can carry them for a short distance if the nest or burrow has been suddenly disturbed. The mother field mouse is certainly a very thoroughgoing mammal, and the story goes that when several families live together, as they sometimes do, she does not mind whether the children she nurses are her own or not. But these maternal virtues are not much appreciated by the farmer, and it is some satisfaction to know that field mice have many enemies—all the beasts and birds of prey. If creatures like weasels and owls were left alone, the balance of Nature as regards field mice would be steady enough. The field vole belongs not only to a different genus (Microtus), but to a different sub-family (Microtinæ); we have been discussing *Mus musculus* (the house mouse) and *Apodemus sylvaticus* (the field or wood mouse) in the sub-family Murinæ. There are four other kinds of field mouse in Britain, the Hebridean, the St. Kilda, the Fair Isle, and De Winton's yellow-necked field mouse. Those from the islands are interesting as examples of the origin of new species in isolation.

But we have another and delightful mouse, the harvest mouse or *Micromys minutus*, which has found its particular niche of opportunity among the corn and the tall grasses. It is a pigmy, coming next to the pigmy shrew, which is the smallest of British mammals, about two and a half inches in body length and two inches more for the tail. Its weight (about a fifth of an ounce) is just a sixth of that of the field mouse. As Gilbert White put it in his graphic way, "Two of them in a scale weighed down just one copper halfpenny." It can poise itself on an ear of wheat! It is interesting to notice how this pretty rodent is particularly suited for its habitat among the corn. It is the only British mammal with a prehensile tail, and it can actually hang free for a second or so. The hands and feet are relatively large, and they bear pads which greatly help the acrobat in its climbing. Unlike the field mouse, it is most active during the day. Both for its own comfort and for the rearing of its frequent

Photo: Frances Pitt.

HOUSE MOUSE (*Mus musculus*).

Wherever man has gone this mouse has gone, fond of getting into his dwellings, but very well contented with the plenty to be found in stackyards and barns. It seems to be a genuine native of Britain, thus differing from the alien rats.

families it makes a ball-like nest of plaited grass leaves, fastening the structure to growing corn or to ranker vegetation. As many as a hundred leaves may be used in the construction. There are often special winter nests, sometimes underground and sometimes among the reeds; but if the harvest mouse can get inside a stack, that serves its purpose well. There is no true hibernation, but in many cases there is some storing of grain for the winter. The every-day food consists of seeds and insects, and is very varied. When eating a grain of wheat the harvest mouse sits up like a squirrel, holds the grain horizontally between its two hands, and revolves it rapidly till it has bitten off the outer envelope and got at the real thing. A dainty creature! We can well believe that it makes an interesting pet, and it has this further recommendation that, like the field mouse, it is without the characteristic odour of the alien Mus, which does not belong to Britain at all.

Photo: Frances Pitt.

LONG-TAILED FIELD MOUSE (*Mus sylvaticus* or *Apodemus sylvaticus*).

This common mouse, badly called wood mouse, is slightly larger than the house mouse, with a longer tail, and with longer hind-feet, which are white in colour. It roams in summer and seeks the farmsteadings in winter. One knows that it is not a vole by the prominent ears and the narrowed muzzle.

The Field Vole.

The little field vole (*Microtus agrestis*) is representative of those animals that are hostile to man by interfering with his agricultural operations. Small animals are much more likely to be detrimental than large ones, partly because they usually multiply much more rapidly, and partly because it is easier for them to escape capture. The Field Vole is a case in point. The length of the head and body of a mature male is only about four inches (the female a third of an inch less), and the tail does not exceed an inch and a half. So we have to deal with a very small animal, as compared with a rat, for instance. But against the small size we have to weigh the multitudinous numbers, for there are three or four litters in the year, with an average number of five young ones each time. Thus they tend to become very abundant and then the grass begins to suffer. Since that is their favourite food, there is much to be said for the commonest of the popular names for the little creatures, namely "grass mice."

Many authorities distinguish the Highland

Photo: C. Reid, Wishaw, N.B.

LONG-TAILED VOLE OR BANK VOLE (*Evotomys* or *Microtus glareolus*).

The woolly fur hides much of the ear-trumpets, but less than in the field vole or water vole. The body is about three and three-quarters to four inches long, the tail about half as much; the legs are very short; the colour of the fur, often somewhat ruddy, varies considerably. The bank vole is common in hedgerows and on banks dense with herbage.

Photo : Frances Pitt.

TWO FIELD VOLES AT ENTRANCE TO NEST.

Voles are great burrowers and they store in their tunnels. They can be distinguished at once from mice by the broad head, the blunt muzzle, the inconspicuous ear-trumpets, smaller eyes, and the shorter, hairy tail. The details of the teeth are different.

Field Vole or Grass Mouse (*Microtus agrestis*) from the Common Field Vole or Grass Mouse (*Microtus hirtus*) which is the common species in England and the Scottish Lowlands. The former represents the older stock, but the two kinds are very nearly related and may be considered together. Once the splitting up of kinds or species begins, it is difficult to know where to stop.

Field Voles are usually either russet-brown or greyish-brown above and greyish-white below, but there is considerable variability in the colouring. In many cases it is well suited to hide the animals against the background of the soil, serving as a " cloak of invisibility." When we look at a Field Vole we notice at once the blunt muzzle, the broad head, the inconspicuous ears almost buried in the fur (so different from the upstanding ears of a mouse !), the short hairy tail. When we look more closely we notice the moderately hairy soles of the feet, the six or seven naked pads, a sharp nail on the minute thumb, the two strong chisel-edged front teeth (incisors), the three cheek-teeth (molars) which continue growing throughout life as they get worn away on the surface. It is worth looking for a skull that the ants have cleaned, for then we can more readily examine the structure of the teeth with a lens, and observe, for instance, the neat little zigzag triangles of enamel on the crown of the molars.

Field Voles are gregarious and companionable, but they show no co-operation or social life in the strict sense. They frequent pastures, arable land, bents, moors, plantations, hedgerows, and similar places from Cornwall to Caithness, and in Europe generally. But they do not occur in Ireland. The food they like best is what they find in the succulent bases of grass stems, but they have a wide range of appetite for shoots and roots, fallen corn and leaves, even bark when the worst comes to the worst. The chisel-edged incisors are well suited for slicing and gnawing, and the back teeth for making pulp.

Field Voles work by night as well as by day, and all the year round. If the frost is very severe they may fall " asleep " for several days, but they should never be called hibernators. Some

times they lay up stores for hard times, but this does not seem to be common or necessary in Britain. At all times the appetite of these Rodents is enormous and they require a good deal of water. They make runs on or just under the surface, and these often intersect in a complicated way, so that a plan reminds one of the streets of a town. One and the same run may be above ground at one place and under ground at another. The runs seem to be common property. At other times the Field Voles make deeper burrows to get at roots or to form a nursery in cold weather, but they are not in any special way suited for burrowing, as moles are, or for climbing, like harvest-mice. They run smartly, without bounding, and they do not bite when they are caught. They are good swimmers. They probably sleep a good deal between meals, but they sleep lightly. They are careful in keeping their fur in good order—as careful as cats; and they have also cleanly ways of disposing of their ordure. Their voice, used when they are excited or hungry, is "half a grumble, half a squeak."

As to family affairs, it seems that the Field Mice live together in pairs, but there is some indication that there are many more males than females. We do not know enough to tell whether they are monogamous in actual fact. The breeding begins in April and may continue till winter, three or four litters being common. The offspring are often between three and six, but there may be litters of ten when food is very abundant and the weather very genial. The female has eight teats. The life before birth is believed to last for about twenty-four days, and a mother suckling her offspring is often at the same time with young. All this points to the possibility of rapid multiplication, but it should be noted that the Field Vole is not nearly so prolific as the mouse or the rat. Mr. Barrett-Hamilton notes in his fine "History of British Mammals," that in captivity the male may be safely left with his family, though he will devour

Photo: Edward Step, F.L.S.

NEST AND YOUNG OF FIELD VOLE.

The common field vole or short-tailed field mouse (*Microtus agrestis*) makes a nest of loose dry grass on the ground, and gives birth to four or five young ones, with the possibility of three or four litters in the year. Thus it multiplies prodigiously and becomes a pest.

Photo: W. S. Berridge, F.Z.S.

FIELD VOLE (*Microtus agrestis*).

The common short-tailed field vole or field mouse ranges all over England and Scotland, but does not occur in Ireland. It does a great deal of damage by eating all sorts of crops, and it stores in its burrow for the winter. So it is fed at the farmers' expense all the year round.

strange litters. This points in the direction of genuine monogamy.

From ancient times "vole plagues" have been known, and one may recall the defeat of Sennacherib's army owing to the innumerable voles that came by night and gnawed away all the quivers, arrows, and bowstrings. The last British "plague" on a big scale was in 1891–93, when large areas in the South of Scotland were turned into desert. Mild weather brings about an abundance of grassy food, and the voles have large litters. Beasts and birds of prey have their innings, and they also multiply more than usual; but they cannot stay the tide of rodent life. Gradually the grass gets scarcer and the Field Voles take to unusual ways of feeding, such as barking the trees and gnawing at their roots. Sooner or later, however, famine sets in among the voles; fertility drops; some disease occasionally gets a grip; the numbers sink to a minimum; the vegetation begins to show face again—the plague is over. But much damage to agriculture is often done before the balance is restored.

It is usual to refer "mouse years" to two causes—unusually mild and moist weather, on the one hand, and a destruction of natural enemies on the other. There is no doubt that both these causes will tend to favour the increase of voles, but it is quite possible that there is some obscure factor producing a natural cycle. Plagues have occurred in places where there was no game-preserving reduction of the beasts and birds of prey; and the facts do not seem to warrant more than a cautious statement to the effect that great reduction in the number of natural checks will tend to a great increase in the number of voles. Among the natural checks we may mention weasels, stoats, foxes, owls, kestrels, crows, and rooks.

It cannot be said that man has been very successful in combating vole plagues. Vigorous use has been made of poisons, infection with a microbe, burning out, hunting with dogs, flooding, trapping, and making numerous pitfalls much broader at the bottom than at the mouth, so that the voles cannot climb up the overhanging walls. One of the safest poisons to use is a mixture of red squill powder and oatmeal.

It is probable that "vole-plagues" on a small scale are not infrequent, and it is common sense to try to nip these in the bud, so to speak. A serious vole-plague is so costly that its beginnings should be carefully watched. Besides

Photo: W. S. Berridge, F.Z.S.

COMMON BANK VOLE (*Evotomys glareolus*).

This relative of the field vole has a tinge of chestnut in its upper fur, and it is therefore often called the red field mouse. A deeper difference is that the cheek teeth develop roots in the full-grown animal, which is never the case with the field vole.

Photo: Frances Pitt.

SKOMER BANK VOLE (*Evotomys skomerensis*).

This little creature, slightly larger than the bank vole, is peculiar to the Island of Skomer, till recently uninhabited, off the Pembrokeshire coast. It differs from the bank vole in minute features of the skull and the teeth. It is very docile and makes a good pet—till it dies.

the judicious encouragement of the natural enemies already mentioned, there is the counteractive of destroying rough grasses about hedges and field-margins and waste places *in the vicinity of pasture*. This tends to rob the Field Voles of part of their shelter and to expose them to hungry eyes. In a deep sense it may be said that the better the agriculture, the fewer voles there will be.

On three counts at least there is a strong case against Field Voles. First, they destroy the pasture by eating the bases of the grass stems. They sometimes do similar damage in corn-fields, and they are fond of clover leaves and the like. Secondly, their networks of tunnels underneath the surface of the ground may seriously disturb seed beds and young roots. Thus they do much damage in disturbing as well as in devouring. Their tough summer nests, made of dried grass, are sometimes troublesome to the reaping machines. Thirdly, they often "ring" young trees, cutting off the bark just above the ground. They may also nibble through the roots. A common preventive is to surround the base of the tree with a cylinder of wire netting of narrow mesh, pressing the lower edge of the cylinder well into the ground. A poison wash of strychnia sulphate mixed with starch and glycerine may also be brushed on to the base of the tree.

The circle of the Field Vole's life cuts many other circles, such as those of grasses, weasels, kestrels, and man. Charles Darwin was probably referring to Field Voles in his story of the "field mice" which destroy the combs and nests of humble-bees, and thus lessen the useful work of these insects in pollinating the red clover. Field Mice also destroy a destructive sawfly that attacks the larch.

Much less important from the agricultural point of view is the Bank Vole (*Evotomys glareolus*), a rather smaller animal than the Field Vole, ruddier above and whiter below, with slightly longer ears and tail. Its cheek teeth are rooted in the adult, which never happens in the Field Vole. It likes sheltered dry places and often finds its way into gardens, where it attacks bulbs and newly sown beans and peas. It also does much harm in plantations. As it works chiefly at night it is seldom seen. It does not seem to multiply so quickly as the Field Vole, and that is something to be thankful for.

The Water Vole.

Everyone delights to call the water vole the water rat, for this never fails to annoy the zoologist. We confess that it always seems to us a little pedantic to try to alter a name that is almost universal. The only important point is that the

Photo: Frances Pitt.

ORKNEY VOLE (*Microtus orcadensis*).

It seems that the Orkneys have two species of vole all to themselves—the Orkney vole (*Microtus orcadensis*) and the Sanday Island vole (*Microtus sandayensis*). This shows that new departures arising on islands have a strong tendency to become by in-breeding firmly established new species.

water rat is *not* a rat. At a glance one sees several differences: the body is more robust, the head is more rounded, the muzzle is blunt, the ears scarcely show above the fur, the eyes are much smaller, and the tail is hairy and much shorter. When the glance becomes a scrutiny, deeper differences appear, and one is bound to admit that the "Water Rat," *Arvicola amphibius*, is not a rat! For a rat has a much narrower head and snout, much larger ears and eyes, and a longer tail nearly naked, besides, of course, more technical peculiarities.

Yet it is well, we must admit, to emphasise the fact that the water rat is a vole, for this gives us the key to the whole situation. The creature is a large-sized vole that has circumvented the severity of the terrestrial struggle for existence by becoming in great measure aquatic. It is large and palatable, so it has taken refuge in the water! No doubt this partial change of habitat has meant new enemies, such as the heron and the pike, and new dangers, such as floods and frost, but it has worked well on the whole, and the genus of water vole is represented from the Scottish Highlands to the Altai Mountains, from the South of France to the shores of the Arctic Ocean. But our British species, *Arvicola amphibius*, is confined to this country, not including Ireland. There is a brown variety, commoner in the south, and a glossy black variety, commoner in the north. It often wanders at night in search of succulent food, and as things look big in the dusk, it is sometimes called the "earth-hound." It is credited with visiting graveyards by night, but this is just a picturesque touch, with no justification save that the water vole is a rover. It has been seen in Scotland 2,000 feet up among the hills. It is by no means a nocturnal creature in the strict sense.

One cannot say that the water vole is in any special way adapted to aquatic life, except that the ear-valves are well developed, the coat is thick and not easily wetted, the feet are slightly fringed though not webbed, and the long tail may help in steering. The creature swims and dives admirably, but it shows itself an evolutionary newcomer in habitually, though not invariably, using hind-feet as well as fore-feet in swimming, as non-aquatic mammals do when tumbled into the water, and in showing much of its head and back above the surface. On the other hand, the young ones are able to swim very early, even before they can see. The important point is this, that while keeping one foot, as it were, on land, the water vole has secured relative safety by discovering the resources of ponds and sluggish streams.

But more important than any of the slight adaptations in structure is the nature of the burrow that is excavated in the bank. For

while it is sometimes rough and ready, it almost always has one entrance at or under the water level and another on the land side. Sometimes the burrow has several under-water entrances and several branches with chambers. In one of these the young ones are sometimes nurtured, but well-hidden surface nests, made of reeds and grasses and away from the burrow, seem to be commoner.

There are three to eight young ones in a litter, and there may be two litters in a year. The young ones are born with their eyes shut, but not very helpless. In many cases the mother has been seen transporting them by water from a threatened nest. She grips the young one in her mouth and presses it under her throat, swimming and diving without embarrassment. Thus we see that maternal care is one of the factors in securing survival.

Another advantage, shared by many other animals, is the long bill of fare. This always counts for much, for it is of survival-value to be able to thrive on many different kinds of food. This is certainly true of the water vole. Predominantly vegetarian, it must be ranked as potentially omnivorous. All is grist that comes to its mill—roots and shoots, leaves and bark, turnips and potatoes, water-lilies and horse-tails, nuts and haws, earth-worms and dead trout, mussels and crayfishes, and stranger things still. Yet after we admit that water voles cannot be acquitted from the charge of damaging osiers or of breaking down the banks of streams, we cannot say that they do much harm to man's crops or property, or to his trout-fishing. There does not seem to be good evidence of any storing habit in British water voles, and it need hardly be said that they do not hibernate. A creature that can burrow for roots and swim about under the ice is not likely to be much inconvenienced by a British winter. We cannot leave its feeding habits without recalling the pleasant picture one sometimes sees of the water vole enjoying its meal just outside the doorway of its burrow or on a half-floating platform of rushes and waterweed. It usually sits upright like a squirrel and nibbles neatly at the piece of root or shoot which it holds in its paws.

Rather against the water vole's success in life, one would think, is its short-sightedness, but there is little evidence that this is a serious handicap in the ordinary conditions of its life. Against the poor sight may be balanced the advantage afforded by the possession of paired glands, about two-thirds of an inch in length, situated half-way between the shoulder-blade and the root of the tail. As in shrews, there is a somewhat oily odoriferous secretion, and there is strong probability that this serves as a deterrent to even hungry enemies. In any case the water vole's ways do not suggest a timid or worried creature. The youngsters are playful and the adults can be tamed. They are not so clever as rats, but they are certainly not stupid. We have watched them off and on for long over half a century, but we never heard them make a single observation. We would rather infer our deafness, however, than their dumbness. It is difficult to feel at all sure about their temperament. Some naturalists call them sedate

Photo: W. S. Berridge, F.Z.S.

WATER VOLE (*Microtus amphibius* or *Neomys fodiens*).

The colour varies, sometimes greyish-brown, sometimes quite black. The length of the head and body is about eight and a quarter inches, and that of the tail four and a half inches. There is little indication of the short, rounded ear-trumpets; the head is broad and rounded; the neck is short; the eyes are black; the front teeth are brownish-yellow.

Photo: Frances Pitt.

THE WATER VOLE EATING.

The food consists exclusively of vegetable substances, such as roots and underground stems, and even grass and willow-bark. Sometimes the water vole goes far from the water and robs the farmers' potato-pits. When it is eating it often sits on its haunches and holds the food to its mouth like a squirrel.

and melancholy, but is there any reason to believe in melancholy *wild* animals? Water voles are usually regarded as gentle creatures unless their sense of property is outraged. For they have a keen sense of riparian rights. Mr. H. W. Shepheard-Walwyn, in his very interesting "Spirit of the Wild," takes the water vole as the expression of the spirit of contentment, and perhaps this is as near the truth as we can get just now. We would only add that they appear to be monogamous.

There can be no better example of elusive, self-effacing little people than the shrews.

Shrews.

Popular prejudice against them dies hard, in spite of their elegance, nimbleness, alertness, and general winsomeness. They have been penalised by their name, by a widespread human ignorance that mixes them up with mice or field voles, and by ugly superstitions which make them scapegoats for ailments that afflict cattle and other domestic animals. Gilbert White refers to the horrible custom of making a "shrew-tree" by boring a hole with an auger in the stem, usually of an ash, putting in a living shrew, and closing the opening with a firm peg. To cure the cattle it was enough to stroke or strike the affected part with a switch cut from the shrew-tree. We suppose that this particular superstition is dead, but the prejudice against shrews lingers. The farmer no longer says, "I beshrew thee," but he still kills the shrew—certainly one of his best friends, for it destroys a great many slugs and grubs of injurious insects.

On a hedgerow bank or a dry meadow we often see a sudden movement among the herbage and dry leaves, and a little reddish-brown person darts into the open, hurries along a run, and disappears into a hole. We confess that we have never seen for ourselves the common shrew except in these momentary and very tantalising glimpses, but others have watched the playful gambols, the fierce combats of the males, and the mother interlacing grass leaves to make a roof for the nest, which is hidden away among the withered leaves.

The ways of shrews are very pretty. So are the animals themselves, with their daintily small bodies, the pleasantly coloured velvety fur, and the tapering snout (shrews have the same number of teeth as we have, namely, thirty-two). Eyesight is not their strong point, but they have very keen hearing and a delicate sense of touch. They appear to be highly strung animals, and it is alleged that they often die during a thunderstorm.

The Common Shrew is represented all over the northern regions of the Old World and the New, except in islands like the Shetlands, Skye, Iona, and Ireland. It seems to be a delicate creature; it does not store or hibernate; its bite is trivial; it has many enemies, such as owls and kestrels, stoats, weasels, and moles. How does the shrew hold its own? On each of its flanks is a gland, marked by a double row of coarse hairs, which secretes a substance with a pungent odour; and this may save the shrew from some of its

more fastidious enemies. But as the repulsive secretion seems to save the shrew from being eaten, rather than from being killed, there is not much consolation here! Then there is the puzzling habit of "feigning death," becoming suddenly inert when captured, which may occasionally make escape possible. We think also of the safety secured by the keen senses of hearing and touch—the shrew is the embodiment of alertness—and by the very nimble, unpredictably jerky movements.

Once more, there is the shrew's capacity for prolific multiplication, for there are from five to seven in a litter, and it is possible that it may breed more than once in the year. But when we add up all these factors in securing the shrew's survival, they do not seem sufficient; and the largest part of the answer is simply, we think, to be found in the minuteness of the shrews. They are indeed a little people, and extraordinarily elusive.

Photo: M. H. Crawford.

THE COMMON SHREW (*Sorex vulgaris* or *araneus*).

An elegant little creature of a reddish mouse colour above and greyish beneath, with a length of two and three-quarter inches to its head and body, and an inch and a half to the four-sided tail. The ear-trumpet hardly projects; the snout is long and slender.

The difficulty of the shrew's life is increased by its imperious appetite. Like the mole, it has very rapid digestion and a chronic hunger. It seems to require meals every few hours, and this must be associated with the fact that while it is mainly crepuscular and nocturnal in its hunting, it also works by day. As Millais says, the Common Shrew leads the "strenuous life"; except for short intervals of sleep, it is constantly foraging, eating, or fighting, and whatever it does it does in earnest. As in the mole, another strenuous Insectivore, the hunger-urge is extraordinarily strong in the shrew, and this has probably a good deal to do with the undoubted quarrelsomeness. A hungry shrew is an angry shrew. They are playful none the less, and the mother shrew is a good mother.

One of the puzzles in the natural history of shrews is the high death-rate in autumn. Many dead bodies are found lying by the roadside and in the meadow. Various explanations have been offered. According to some naturalists, the beasts and birds of prey levy a particularly heavy toll in the autumn, and leave the victims uneaten. According to others, there is keen intra-specific competition when the territory becomes crowded and food scarce; and this suggestion is corroborated by direct observation of fighting and of wounds, and indirectly by the fact that shrews often combine on a trekking

expedition when there is famine in the land. Perhaps, however, the main factor is simply that shrews are very short-lived creatures, perhaps hardly more than annuals. The seniors die off before hard times set in.

What we have said in regard to the Common Shrew applies also to its first cousin, the Pigmy Shrew, the smallest British mammal. It has a total length of only three inches from the front of the snout to the tip of the tail, and its weight is less than one-fifth of an ounce. Its skeleton is like a miniature and its thirty-two teeth are so small that they can hardly be seen without a lens. As in other Insectivores, the crowns of the back teeth are covered with "cusps"—mountain-top-like prominences well adapted for crunching small insects. The Pigmy Shrew seems to be even more widely distributed than the Common Shrew, and the more the merrier!

Deserving to be better known is the Water Shrew, which may have a body five inches long, as contrasted with the Common Shrew's three. We have already spoken of this creature, *Crossopus fodiens*, which is widely distributed from Aberdeenshire to the Altai Mountains, and is to be regarded as a shrew that has found in aquatic life a refuge from severe persecution on land. It is a beautiful animal, velvety black above and white below. It swims prettily on the surface, half in, half out, with scarcely a ripple. Its efficiency is increased by stiff hairs on the digits, and on each side of the tail, which serves as a rudder. The food consists of insect larvæ, small crustaceans, fresh-water snails and the like, and the animal is a clever diver, often seeking its prey by turning over small stones and other objects lying on the bed of the stream. The grass-lined nest is at the end of a burrow in the back, and the young ones are deliciously playful.

Photo: M. H. Crawford.

THE PIGMY SHREW (*Sorex minutus*).

This is probably the second smallest mammal in the world; and the only one smaller is another shrew. The length of the head and body is about two inches, that of the tail about an inch and a half. The teeth, like ours in number, cannot be seen without a lens!

XLI

LIFE-HISTORIES

A LIFE has often been compared to a great arched bridge over a river, with a good many possibilities of tumbling in, especially near the beginning of the crossing.

First there is an ascending part of the bridge—the early life. This includes the development of the embryo out of the egg, and then the hatching which means getting out of the shell or envelope. What comes out may be a miniature of the parent, as in the case of a chick. In such cases we say that what is hatched out is a young creature. But it often happens that what emerges is not at all like the parent—it is a larva. Thus a caterpillar comes out of a butterfly's egg and a tadpole out of a frog's egg. The larval stage is suited for conditions of life quite different from those in which the parents live. Thus the larvæ of shore starfishes swim in the open waters and the larvæ of dragonflies live in ponds. The larva is sometimes very old-fashioned when compared with the full-grown animal, thus a tadpole is in some ways like the ancestral fish. But what is in most cases more noticeable is that the larva is well adapted to particular haunts and ways of life quite different from those of the adult. Thus caterpillars are suited for creeping about on plants and eating large quantities of leaf. They accumulate stores which sometimes serve them for the whole of their life. The larval period is usually a hungry time and a growing time; there are great risks, and there is much mortality. After a time—which may be days or years—a great change or metamorphosis sets in and quickly or gradually the animal becomes a miniature of the adult.

Whether there is a larval period or not, there must be a time of development and growth. Two processes are always going on in the young creature—there is increasing complexity and division of labour (differentiation), and there is increasing control and harmony (integration).

In some of the higher animals, as in cats and dogs, otters and foxes, there is a very interesting playing period. There may be sham fights and sham hunts, races and follow-my-leader, gambols and "daring-do." What is the meaning of animal games? To some extent the playing is a

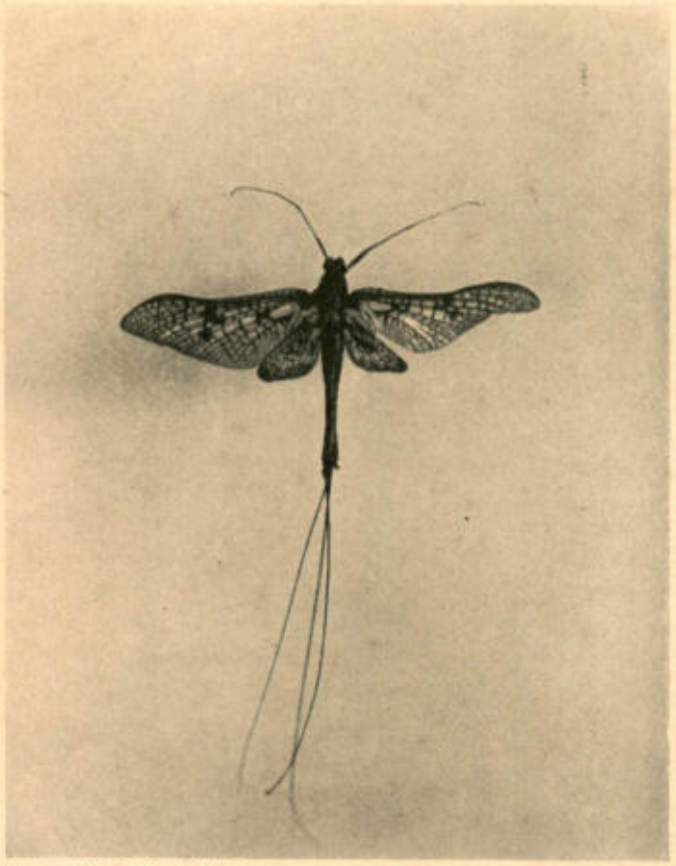


Photo: John J. Ward, F.E.S.

COMMON MAYFLY (highly magnified).

Mayflies form an order of insects distantly related to dragonflies, and like them in having aquatic larvæ. They have delicate wings, somewhat gauze-like, the hind pair always smaller than the fore pair; there are two or three long tail filaments.

Photo: Harold Bastin.

COMMON MAYFLY WAITING TO CAST OFF ITS LAST "SKIN."

Mayflies are peculiar in having a final moult after they get their wings. They have a preliminary flight and then settle down on a branch, where they get rid of their cuticle, a non-living husk outside the living skin. This unique moult makes a considerable difference in the form and colour of the short-lived adult insect.

safety-valve for overflowing energy and spirits; to some extent it allows the young creatures to express and test their originalities—if they have any—before life has become too serious; but most of all it is a sort of apprenticeship to the business of life. Play is the young form of work. The playing time allows opportunity for the education of aptitudes that are essential in after-life, and for replacing or changing inborn or instinctive promptings by the results of experience and experiment. For animal as well as for man, there is in play an opportunity for learning and testing, roving and adventuring.

If the young animal gets safely up the ascending part of the steep bridge, it has often to pass through a critical period of growing-up or adolescence, when it puts away childish things and puts on full-grown characters. This may come quickly or slowly in different types—quickly in rats and mice, slowly in stags and elephants.

Often there is a courting-time, such as we have illustrated by the Bower-birds, and then there is the mating and the beginning of a family. This time of mature strength and fullest life might be compared to a level stretch in the middle of the bridge.

Sooner or later, however, the creature begins to relax a little, to weaken and to grow old. There is a gradual slope downwards which ends in death. Among wild animals there is nothing of the decrepitude and senility that we often see in mankind. For when the animal becomes slightly weakened it is pushed off the stage by some buffet from the outer world, or it is devoured by one of its alert enemies. Of ourselves we may perhaps say: "And so, from hour to hour, we ripe and ripe, and then, from hour to hour, we rot and rot and thereby hangs a tale," but this does not apply in Wild Nature. It may be seen in the old age of a pet dog or the like, too long sheltered, but not in natural conditions. Not only is it the case that most wild animals come to a violent end, but they have not the physiological bad debts that man accumulates. They may be old, but they are never senile.

The ascending and descending curve that we have spoken of for animals will be seen, of course, in plants as well. There is the delicate development of the embryo and seed, the sprouting and the growth of the seedling, the ascent to the full vigour of leafing and branching, the reproductive period with its flowering and fruiting, after which comes the withering and

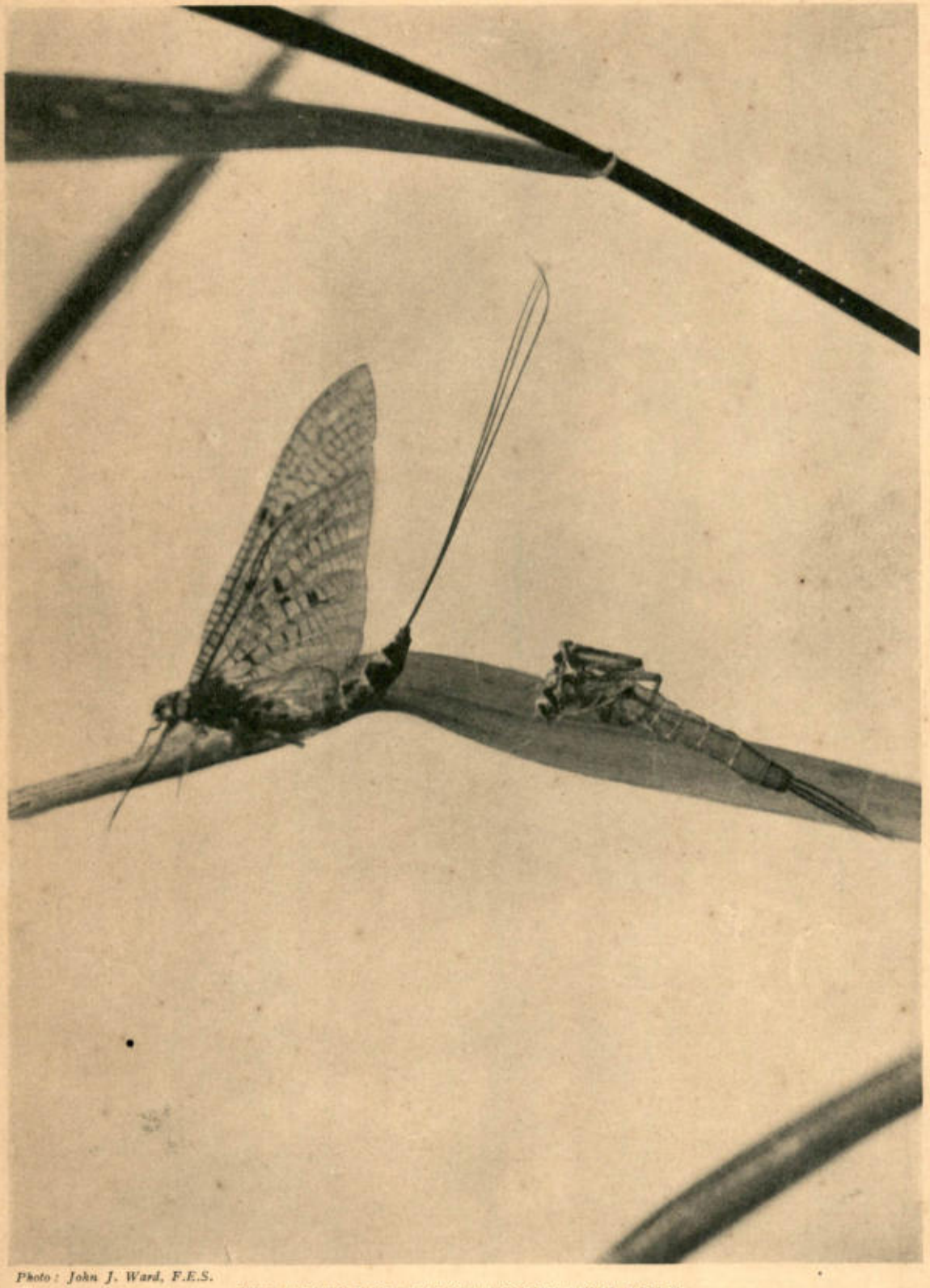


Photo: John J. Ward, F.E.S.

THE MAYFLY JUST EMERGED FROM ITS FINAL MOULT.

The fully formed Mayfly, which has a very short aerial life, is a graceful creature, with delicate wings and long tail-whisks. It has very short feelers or antennæ, but the front pair of legs is held forwards in front of the head. The winged adult is sometimes exhausted in a day.

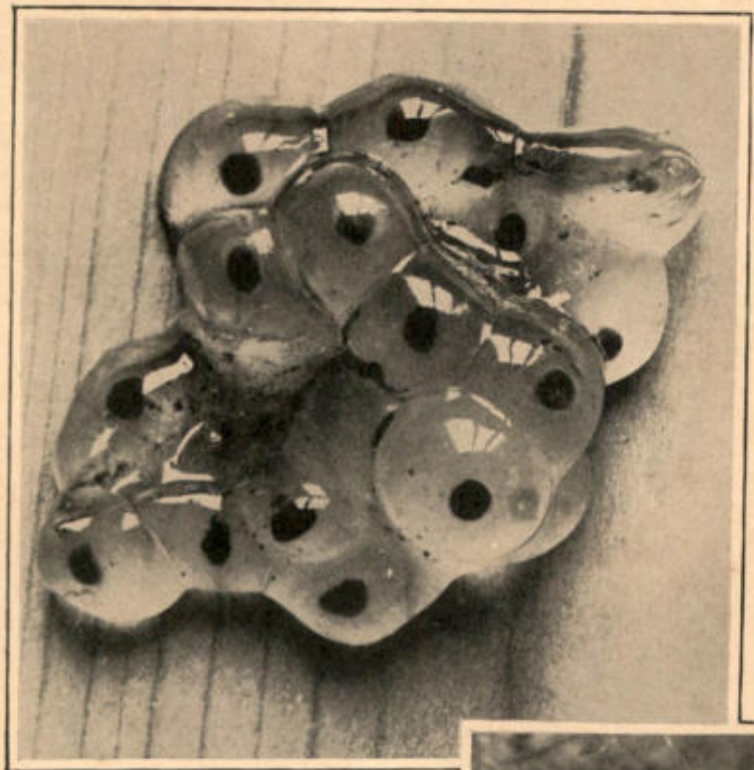


Photo: M. H. Crawford.

No. 1—EGGS OF THE COMMON FROG (*Rana temporaria*).

A frog produces 1,000 to 2,000 eggs, each about a tenth of an inch in diameter, but surrounded by an envelope of jelly. This swells in the water and raises the eggs from the bottom of the pool, to which they at first sink, and buoys them on the surface.

fading to the rest of winter, or, in the case of annuals, to a death which cannot be evaded.

Before we pass to particular life-histories, we must refer to a very useful general idea, that one life-history differs from another by the elongation of one part and the compression of another. There is lengthening here, say, of the time of play, and there is telescoping there, say, of the larval period. Thus Mayflies often have two or three years of sub-aquatic larval life and only two or three days of adult aerial life. In one case the whole of the adult life is telescoped down to one hour.

The lampreys are larvæ ("niners") for four or five years, and after they put on the adult characters they have a vigorous life for a considerable time, but they die abruptly after spawning. The same seems to be true of the Common Eel. The strange Peripatus—a connecting link in some respects between worms and insects—may carry its young ones before birth for a whole year, which is longer than a mare carries her unborn foal. In the case of Peripatus, which is a very old-fashioned animal and very defenceless, it is all-important that the young ones should be born able to fend for themselves. Similarly among wild horses, the foal must be able to stumble along beside its mother soon after birth, and

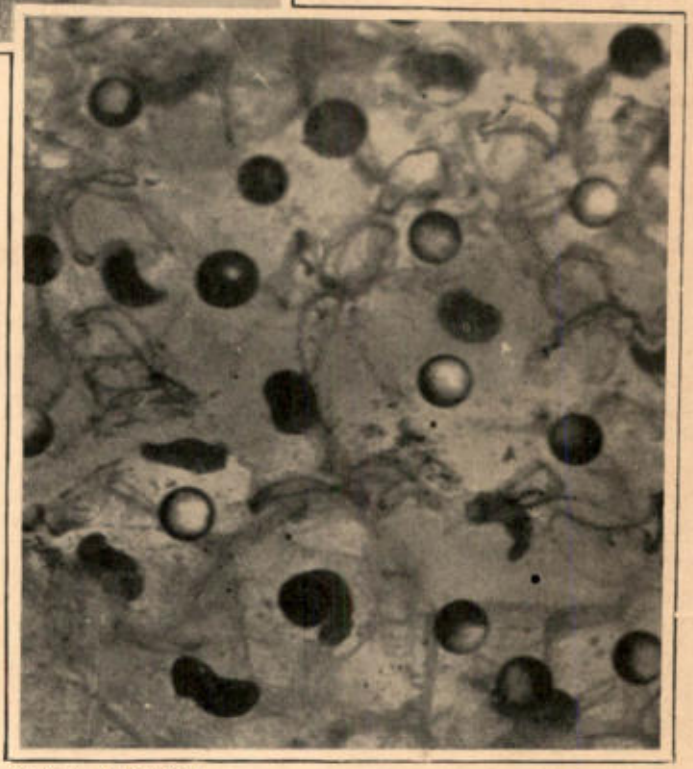


Photo: M. H. Crawford.

No. 2.—FROG SPAWN HATCHING OUT.

The tadpoles are leaving the spheres of jelly in which they pass through their early development. The jelly buoys them up, serves as a buffer when the water is ruffled and has the further advantage of being unpalatable. In the interstices between the spheres of jelly there are usually microscopic green plants, which give off oxygen, and minute animals, useful in loosening the jelly.

Photo: M H. Crawford.

No. 3.—PHOTOGRAPH TAKEN TWENTY-FOUR HOURS AFTER No. 2.

The newly hatched tadpoles are still developing, thus the mouth has not yet opened, and the eyes, growing out from the brain, have not yet reached the skin. By means of a cement gland the young tadpoles adhere to water-weed.

this throws light on the fact that the ante-natal life lasts for eleven months. In the opossum, on the other hand, this before-birth period is sometimes telescoped down to a fortnight, and this must be linked to the fact that the mother carries her baby after birth in a skin-pocket or fastened to her tail. In bats, the highly specialised mammals of the air, the before-birth period is again very short; and this is to be connected with the fact that the young one hangs on to its mother for a long time by toes and thumbs and mouth, and has many a giddy journey through the air before it is able to use its own wings. In birds the juvenile period is often very short—mound-birds can actually fly on the day of their hatching. The reason for the shortening of the youthful time in birds is partly that, after they leave the relative safety of the nest and are venturing about on the ground or on the branches, they are exposed to great risks from their watchful enemies. The sooner they can use their wings the better, unless indeed they have some peculiar fitness, such as invisibility, that makes them safe. In mammals in the main the tendency is to lengthen out the youthful period when it can be done with safety. This has the two great advantages of allowing for play and providing opportunities for the education of the young by their

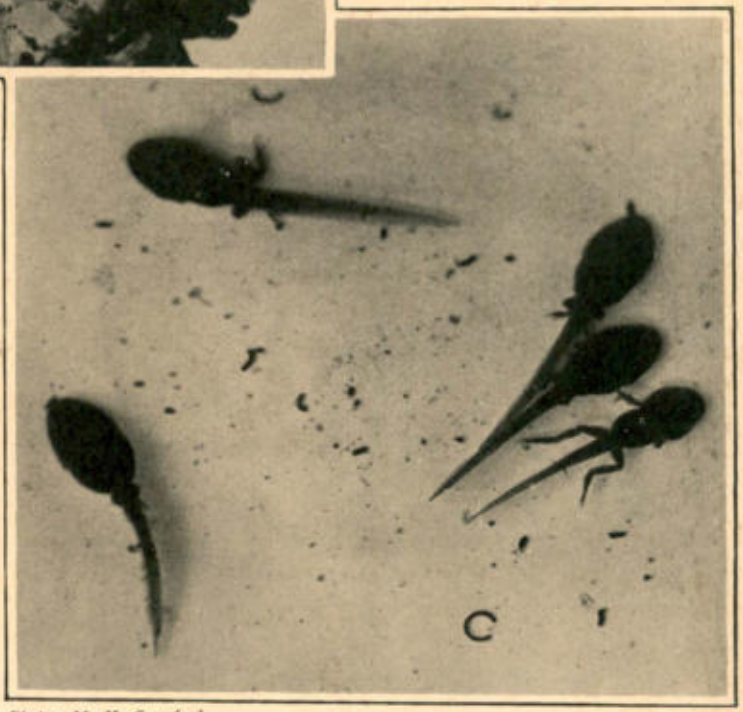


Photo: M. H. Crawford.

No. 4.—OLDER TADPOLES.

When about two months old the tadpoles begin to show the emergence of limbs, and the photograph shows various stages, some with one pair and others with two. The muscular tail serves as a very effective swimming organ. About this age the tadpoles are still breathing by gills, which are hidden under the gill-covers; but they are also learning to use their lungs, and are taking gulps of air at the surface. Thus they are like the old-fashioned double-breathing mud-fishes. The final stages of development are shown overleaf.

Photo: M. H. Crawford.

No. 5.—THE YOUNG FROG.

At this stage, about three months after hatching, the miniature frog must get out of the water, for it has become a lung-breather and all trace of the gills has disappeared. In an aquarium they will drown unless allowed to come ashore.

parents. But what we wish to carry on is the general idea that the different stretches on the life-curve or trajectory of a living creature, whether plant or animal, have become adjusted in different cases to particular conditions of life. Thus there may be short youth or long youth, short adolescence or long adolescence, and so with maturity and with ageing.

Water-babies

Perhaps we may use the word "water-babies"—the title of Charles Kingsley's evergreen book—to include all the young animals that are born in the water, whether they sojourn there all their life, like fishes, or change into some other haunt, as gnats and tadpoles do.

There is much to be said for the Open Sea, or for the open waters of a lake, as a cradle for young animals, always provided that they are born in sufficient numbers to allow for the appetites of their enemies. In the shallow water of the seashore area there is apt to be a rough-and-tumble kind of life: the tides dislodge stones, the breakers batter delicate animals to bits, there is a risk of being left high and dry, or of being smothered in sand, there is keen competition, even for standing room. In the Open Sea there

Photo: M. H. Crawford.

No. 6.—A FULL-GROWN FROG (*Rana temporaria*).

A frog sitting at rest shows a hump on its back, where the hip-girdle joins the backbone. There is evidently no neck region nor tail region; the arm is weak compared with the leg; behind the eye is seen the circular drum of the ear, flush with the surface.

is abundant room, there is nothing to knock against, there is an endless supply of simple plants and simple animals on which animals of higher degree can feed, and storms can often be avoided by sinking for a while into deeper waters. It is not surprising then that the Open Sea should be a nursery for many different kinds of water-babies.

Water-babies of the Open Sea.

What a delight it would be to call the roll of all the water-babies that are cradled in the waves! There are transparent balls of cells that one cannot see with the naked eye that drive themselves along by means of living lashes or cilia—who would suspect that these are the young stages of sponges that will soon anchor themselves on stones and seaweeds. Charming swimming-bells, with the mouth hanging down like the clapper, move gently by contracting their delicate domes; these are medusoids, most of which have been budded off from plant-like zoophytes that live in shallow waters near shore. Hydroids bud off medusoids; medusoids produce eggs and sperms; and from the fertilised eggs there develop free larvæ that settle down to grow into hydroids again—a strange see-saw that is called *alternation of generations*. Not to be confused with medusoids are the young Open-Sea stages of jellyfishes or medusæ, and many of these have a strange life-history too. For the larva that develops from the fertilised egg of a jellyfish, settles down on a rock or seaweed and buds off a "pile-of-saucers" series of little discs, which topple off, one after the other, and become young jellyfishes.

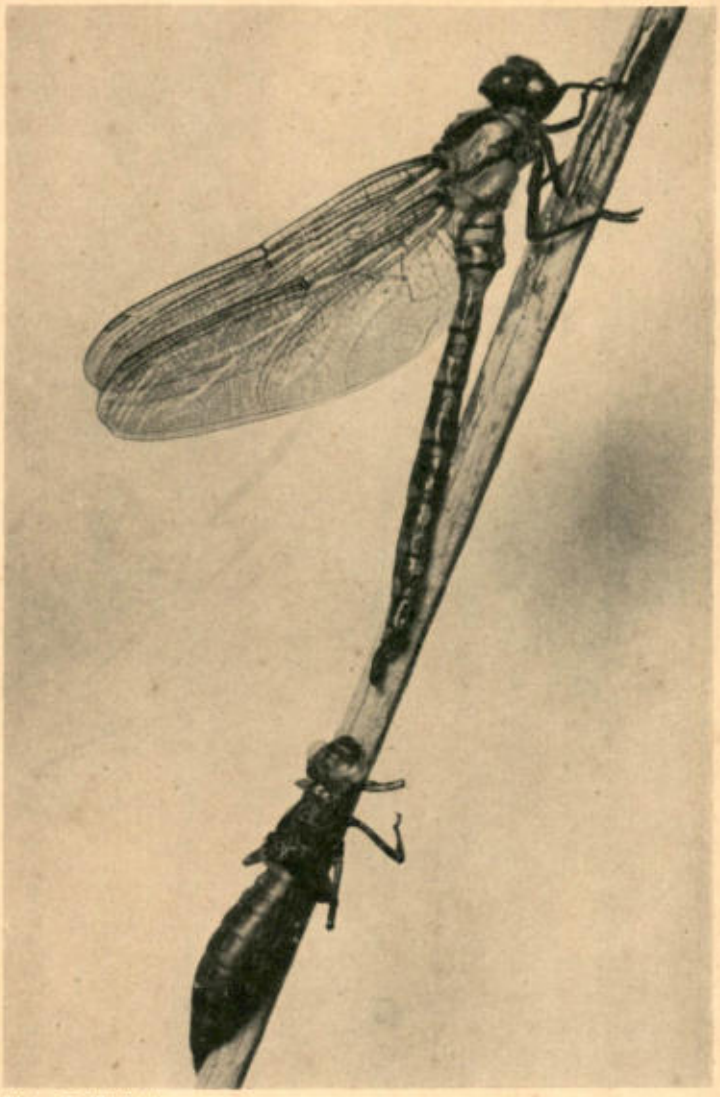


Photo: F. W. Bond.

DRAGON-FLY JUST EMERGED FROM THE NYMPH AND DRYING ITS WINGS.

The larval dragon-fly is aquatic and very unlike the adult; it moults several times, and the future wings begin to show about the third or fourth moult. There is no pupa stage, but the larva or nymph becomes like the adult and creeps out of the water to undergo the last change. During the aquatic phase the mouth-parts form an extraordinary food-gripping 'mask.'

Very characteristic of the Open Sea are the free-swimming larvæ of sea-urchins, starfishes, brittle stars, and sea-cucumbers. Quaint shapes many of them have, some like painter's easels with many legs, swimming gently upside down, others like microscopic water-babies propelled by rings of cilia. The most peculiar feature is that instead of being gradually modified into the fully formed creature, they seem as it were to change their style of architecture altogether. Part of the delicate larval body is absorbed or got rid of, and inside the remainder the adult form begins to arise on a new foundation. This is sometimes called circuitous development; part of its meaning is just that the delicate

Photo: Harold Bastin.

1.—CATERPILLAR OF THE WHITE ADMIRAL BUTTERFLY (*Limenitis sibylla*).

The full-grown caterpillar of this butterfly is dark green with yellow dots, and has reddish, bristly spines with pinkish tips. A caterpillar is a larval stage interpolated, as it were, in the life-history so that food-reserves are accumulated for the subsequent aerial life. Behind the head there are usually thirteen rings or segments, with three pairs of jointed legs and five pairs of unjointed pro-legs or claspers.

larvæ, specially adapted for Open-Sea life, secure dispersal and also secure relative safety. In the same way there are free-swimming pelagic stages of worms that will afterwards settle down to grovelling in the mud on the sea-floor; there are active free-swimming larvæ that give little hint of the fact that they are soon to subside into the slow-going oysters and mussels, whelks and limpets. The numbers of these Open-Sea or pelagic larvæ are almost past counting; they form a great part of the slowly swimming or drifting "plankton"; they afford delicate food for many creatures of higher degree, such as young fishes.

Many small crustaceans or water-fleas, as well as the larger relatives of shrimps and prawns, spend their whole life in the open waters—*permanently pelagic*; but it is interesting to notice that the ranks of the water-babies include the young stages of the barnacles that hang from floating timber and of the acorn-shells that make the sea-shore rocks rough with their little castles of lime. Out of the egg of the acorn-shell comes a free-swimming "nauplius" larva, with three pairs of locomotor appendages, an unpaired eye, and a delicate dorsal shield. It feeds and grows and moults; it gains a firmer shield, a longer spined tail, and stronger limbs. It changes into a somewhat water-flea-like form—the Cyprid larva—which has two lateral eyes, six pairs of swimming appendages, a bivalve shell, and other new features. This swims very actively, but, as it does not feed, it soon gets tired, and fastens itself head downwards to a rock or shell by means of its first pair of feelers and a little drop of cement. It loses its bivalve shell and makes another of a different pattern. It undergoes a metamorphosis, fasting all the time, and gradually becomes a miniature of the adult acorn-shell with its beautifully waving curl-like appendages. Huxley compared it to a shrimp fixed head downwards and back downwards to

Photo: Harold Bastin.

2.—THE CATERPILLAR HANGING FROM ITS SILK PAD.

In the autumn, while still very small and brownish, this caterpillar makes a winter retreat by bending the edges of a sallow leaf together with silk, and becomes a very beautifully ornamented chrysalis. Before sinking into the quiescent pupa stage, the caterpillar, hanging head downwards, gets rid of its old cuticle in a very wonderful way. The silk of a caterpillar, used sometimes for making a complete bag or cocoon, and sometimes for suspension, is secreted in a pair of silk-glands behind the mouth, and exudes by a little tubular papilla on the labium, which forms the third pair of mouth-parts.

Photo: Harold Bastin.

3.—THE CHRYSALIS, WITH THE OLD CATERPILLAR CUTICLE STILL ADHERING.

The chrysalis of this butterfly has a peculiar shape and very fine colouring. It is brownish with a purplish or olive tinge, with patches of green and gold. Inside the chrysalis there is completed the great change or metamorphosis which transforms the crawling caterpillar into the winged aerial butterfly or moth. It is a marvellous process, in the course of which the larval tissues are broken down and the adult body is built up on a new plan.

a rock, kicking its food into its mouth with its legs. The "moults" of acorn-shells with the six pairs of curl-like limbs are very common offshore; but they are only cast-off clothes, not real animals.

Another inconspicuous but very romantic water-baby is the tadpole stage of a sea-squirt or ascidian. The adult creatures are strange nondescripts that stumble at the threshold of Vertebrate life. They are usually like double-mouthed leather water-bottles and live attached to rocks on the floor of the sea, or to stones and seaweed in the shallower waters. No anatomist however clever could tell that these sea-squirts were relatives of backboned animals, but life-history reveals their real nature. Out of the egg comes a free-swimming larva, somewhat tadpole-like, but much smaller and almost quite transparent. It is not merely on the outside that they suggest frog's tadpoles, there is a deep internal resemblance. For these tadpole-ascidians have (1) a brain and a spinal cord, (2) a short supporting rod (notochord) that stiffens their locomotor tail, (3) an eye growing out from the brain, (4) a simple ventral heart, and (5) several gill-clefts opening from the beginning of the food-canal to the outer world. We have enumerated these five features, for these are fundamental characteristics of backboned animals. There is no doubt that the larval sea-squirt is a Vertebrate; and it should be mentioned that there are a few members of this class of animals (Ascidians or Tunicates) that retain some or all of these characters throughout life. But these are rare exceptions. What happens in more than ninety-nine per cent. of cases is a very rapid degeneration of the water-baby. It becomes exhausted and fastens itself by its head-end; its spinal cord disappears; its brain dwindles; its eye vanishes; the supporting rod is absorbed; the gill-clefts are wholly altered; and the body becomes strangely deformed, twisted posteriorly through 180°, so that the end of the food-canal is near the

Photo: Harold Bastin.

4.—THE BUTTERFLY EMERGING FROM THE CHRYSALIS WITH ITS WINGS STILL MOIST AND CRUMPLED.

There is a very striking contrast between the hungry and active caterpillar and the quiescent chrysalis, with its internal transformation, but there is a contrast equally great between the butterfly and both its antecedent stages. Except that the wings are spread, as seen in the photographs overleaf, there is no further growth after emergence from the chrysalis.

Photo: Harold Bastin.

5.—WHITE ADMIRAL BUTTERFLY JUST EMERGED FROM CHRYSALIS.

mouth. This is an outline of the strange story of a common kind of water-baby that begins rather well, but ends rather ill. What is radically wrong with its constitution, it is hard to say; but it certainly does not fulfil the promise of its youth!

The Life-history of the Fiddler-Crab.

A good example of an intricate life-history is the crab's. Whether we take the shore-crab's (*Carcinus mænas*), or the edible crab's (*Cancer pagurus*), or any other matters little, for the general features are the same. We select the Fiddler-crab (Gelasimus), which is a common shore animal on Atlantic coasts and in the Indian Ocean. The male is a quaint little creature, for one of his great claws is often bigger than the whole of the rest of the body, which is just about an inch across the shell.

In the case of a dog the legs carry the body; in the fiddler-crab the body carries the great claw. Moreover, one's sense of proportion is puzzled by the fact that it is only one of the two claws (usually the right) that is so much exaggerated. When the fiddler burrows into the sand along with his mate he sometimes uses the great claw as a door—a door that can pinch. When he goes on the warpath he brandishes his great claw in the face of rival males.

Photo: Harold Bastin.

6.—READY FOR FLIGHT.

5.—Its wings are spread and become firmer; they are dark in colour, with white markings, and with fine ornamentation on the under side.

6.—The wings are now dry and the butterfly alters its position prior to taking its first flight.

Specially drawn for this work by Roland Green, F.Z.S.

THE FIDDLER-CRAB.

The fiddler-crab (Gelasimus) occurs on tropical shores in both hemispheres. One of the great claws of the male, usually the right, is much exaggerated. It seems to be used as a decoration to excite the interest of the female, as a weapon in combats with rival males, and as a door to the burrow when the female is safely inside. It is often bright red in colour.

It is like a heavy club. In the Indian Ocean fiddler, according to Dr. Alcock, the great claw is used for exciting the interest of the female. It is bright red in colour—in the American kinds usually white with a few colour-markings—and it is waved about excitedly. So the exaggerated claw may have three uses—as a door, as a club, and as a flag!

The adventurous life of the North American fiddler-crab has been recently studied by Mr. O. W. Hyman, Fellow in Biology of Princeton University, and we wish to refer to some of the interesting facts he has brought to light. There are in North America three different species of fiddler, and the commonest occurs in droves of thousands on the sandy beaches, the colouration of the shell harmonising protectively with the wet sand. Another is fond of a muddy shore and of exploring among the sedges in the adjacent marsh-land. The third one frequents brackish water, and may be found in ditches two or three miles from the sea. It should be noticed here that some relatives of the fiddlers have become land-crabs, living in inland places except at the breeding season, when they march in great troops to the shore, returning when the spawning is over. The young ones follow them later on, when they have safely passed through the troubles of their riskful juvenile life. There is another relative which climbs up the mangrove bushes and gnaws the leaves, just as the robber-crab climbs the coco-palms to get the nuts.

The fiddler-crab gets its name because the male carries the great claw in front of the body somewhat in the position of a fiddle, which its shape also suggests. In spite of this burden the animals run very quickly with the four pairs of walking-legs, which all crabs possess. But when they are in danger they burrow, and may dig down for a foot or more. Or they may slip down a burrow already made. These burrows are temporary shafts, for the tide fills them up and the walls fall in. But a fiddler-crab cannot be buried alive in wet sand, enough oxygen being always available in the saturating water. They are not given to going into the sea itself, for they cannot swim. But they wander about the shore in search of food and are fond of walking along the sand-ripples left by the receding tide.

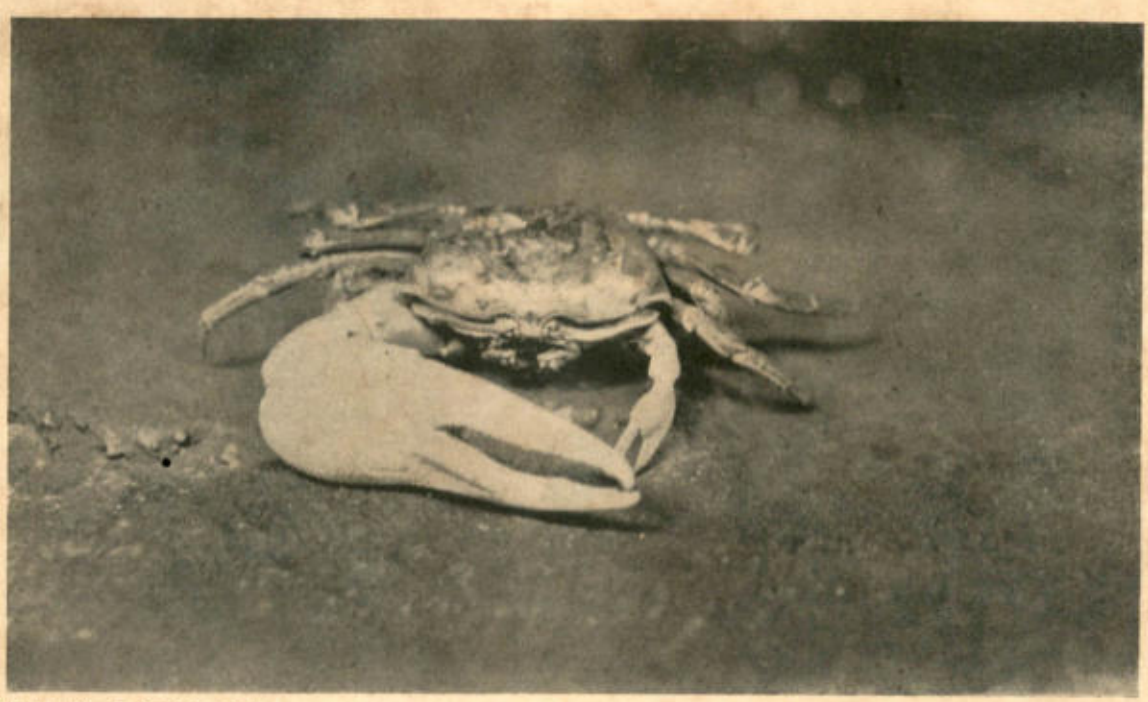


Photo: W. S. Berridge, F.Z.S.

MALE FIDDLER-CRAB, SLIGHTLY ENLARGED (Gelasimus).

This is a large species of fiddler-crab which frequents the lagoons and swamps on many tropical coasts. It is only the male that has the enormously exaggerated great claw, which may be actually larger than the rest of the body—a quaint disproportion!

They scoop the sand into their mouths for the sake of the minute organisms which it contains. Their enemies are shore fishes and big crabs, but they hold their own in millions. The battle is not always to the strong. The fiddlers succeed because they are small, alert, protectively coloured, quick to efface themselves in their burrow, and able to feed well at a low level, namely, on very minute plants and animals in the sand. But this is not the whole story, for they succeed because they are many.

In early spring the female fiddler liberates the eggs into a basket formed by her broad tail, and there they are glued to the four pairs of tail-appendages and fertilised by the male. They look like numerous "bunches of tiny purple grapes," for the yolk is purple and not yellow. As the embryos develop inside the egg-shells, they use up the purple yolk, which is their legacy, and the colour changes to dirty grey. The mother moves awkwardly when she is carrying all these bunches of eggs, but she is careful to aerate them by standing in the water and jerking her tail up and down. During this period the females spend most of the day in the safety of the burrow. "After dusk, however, they go down to the water's edge with the others when the tide is ebbing." And it is always at dusk that the family is set free. The mother is fanning with her tail as she has done many times before, but this time the minute larvæ are ready to emerge, and at each forward flick of the tail a small spray of young larvæ is shot forward into the water. The mother may go on fanning for twenty minutes before she gets all her children away from her "apron strings."

The newly hatched fiddler is much smaller than a pin's head. Its full length is about a millimetre, which is about one twenty-fifth of an inch. In fact, they are just visible to the unaided eye. They are called zoëæ, which means "life," and they swim actively in the water, flexing and straightening their minute body, bending it double in fact. They have two fixed sessile eyes, not on mobile stalks as in the adult, and they always swim in the direction of most light. This brings them to the surface even when it is dusk, and although the surface has all the dangers of a crowded population, there is more food there, and more freshness, too, than on the shore or in deeper water. The mother's behaviour in fanning with her tail is what we call *instinctive*, that is to say it requires no learning; the larva's behaviour in making towards more light is rather different, the little creature is obeying a useful constitutional obligation just like that which, in unnatural conditions, brings the misguided moth into the candle-flame. This sort of activity is called "tropistic" by those who make a special study of animal behaviour.

In the surface waters the tiny larvæ capture microscopic organisms much smaller than themselves. They feed and grow, and for four or five days they are swept in and out with the tide. But a crisis is not far off; they become too big for their clothes, and they must moult. That is to say, they must cast off the non-living inelastic husk or cuticle of chitin which covers them in every part. The husk splits across the back, and the larva wriggles out through the slit, first the anterior part and then the tail. But the muscles have to be pulled out from within the slender limbs, and the zoëa has seven

Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

VELVET FIDDLER-CRAB (*Portunus puber*).

This swimming-crab is common on many British coasts, especially in the south-west. The last pair of walking-legs is modified into a pair of paddles, and it is to their movements that the word "fiddler" refers. There is no near relationship to the big-clawed fiddler, Gelasimus.

Photos: F. Martin Duncan, F.R.M.S., F.Z.S.

THE FEMALE VELVET FIDDLER-CRAB (*Portunus puber*).

In the upper photograph is seen the female Velvet Fiddler-crab with the tail opened out, showing the great mass of eggs. The lower photograph shows the slender limbs on the out-folded tail, which are used for carrying the eggs. In the living animal the tail is always tightly folded forwards and upwards. It is much broader in the female than in the male. The name "velvet" refers to the dense covering of fine bristles all over the body.

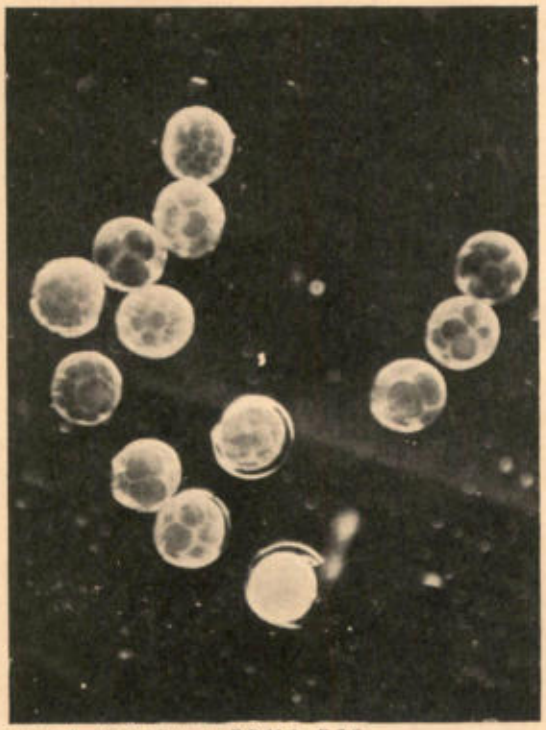


Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

LIFE-HISTORY OF THE VELVET FIDDLER-CRAB.

1.—Segmenting eggs, highly magnified, showing the cells.

pairs. It is a fatiguing process, and the larva sinks to the bottom. Out of the old husk comes a second zoëa, a little different from the first, and the first thing it does is to rise to the surface again. The same thing happens over and over again, till a fifth zoëa is formed. But it is not lively like its predecessor; it moves sluggishly and awkwardly near the bottom of the sea; it ceases to be able to move at all of itself, and is simply rolled along by the tide. Its structure undergoes great changes, and out of the husk of the fifth zoëa there emerges, about a month after hatching, a very different creature, called big-eyes or megalops.

This reminds one of a butterfly coming out of a chrysalis, the change is so abrupt. "Instead of being a motionless, sluggish creature at the bottom, the megalops is a powerfully swimming corsair of the ocean's surface." What is it like? About an eighth of an inch long, with an anterior body like a compromise between a crab's and a lobster's, with a tail sticking out behind, but tucked under the body when the creature is at rest. It swims by means of the swimmerets on its tail, and so quickly that few surface animals can catch it.

Balancing organs have now developed at the base of the first pair of feelers, and these make accurate swimming practicable. The pincers are well-formed and are effective, both as weapons and as food-catching organs. As Mr. Hyman says: "The food of the megalops consists of any animal small enough for it to cope with successfully. Other smaller crustaceans come within this category, and many a luckless zoëa of its own race falls a prey to the fierce cannibalism of the megalops. The prey is caught and crushed in the pincers and passed back into the grasp of the mouth parts. These prepare it for swallowing. The prey is not bitten into pieces, but rather is mashed until it can be crammed whole into the mouth opening." These details may perhaps sound somewhat unreal to those who are unacquainted with megalopses, but they give a glimpse of the nicety and subtlety of the intimate life of humble creatures. And there is nothing here that is not in a general way true of the ordinary shore-crab of the British coasts or of the edible crab from deeper

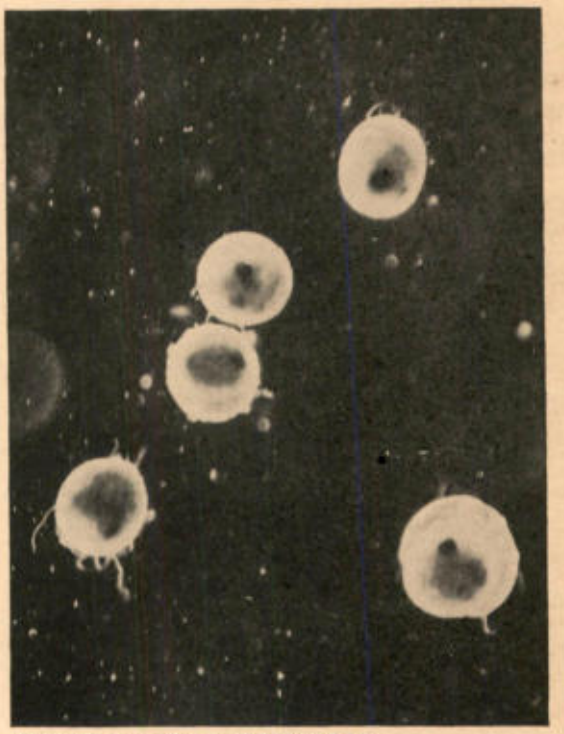


Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

2.—Eggs hatching. The baby crabs, with large eyes, can be seen through the delicate egg-shell.

Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

3.—Young zoëa stages, highly magnified. Very noticeable is the long spine on the back. The little pin-head creatures swim by the limbs quite in front of the tail.

water. There, too, we have the larva called zoëa or "life" and the larva called megalops or "big-eyes," both very unlike what they are going to become.

Let us return to the fiddler. The megalops swims for nearly a month, but towards the end of that time the swimmerets on its tail begin to shrivel and the creature seeks shelter in crevices on the floor of the shallow water near shore. There is a critical moult and a little crab emerges which climbs up the slope to between tide-marks. It has little strength and does not venture far out of shelter. But it feeds, grows, and moults —always that logical sequence—and after the third moult, when it is about one-sixth of an inch across its shell, it is recognisable as a young fiddler, and for the first time the males are distinguishable from the females. The eyes are raised on long stalks like periscopes, and the young fiddlers begin to burrow after the fashion of their kind. They feed and grow, and moult many times. If cold weather sets in before they are old enough or strong enough to make a burrow they die of exposure, for all the North American fiddlers have to spend the winter in retirement. What a long and treacherous Mirza bridge the fiddlers have to cross! Little wonder that Nature works with a big margin!

Story of the Young Ant-Lion.

There are dangers in the water, but there are even greater dangers to which young animals are exposed on the surface of the earth. We have already seen that these dangers are evaded in many different ways. But if our picture is to be true it must include the fact that there are animals that live dangerously and come out of it very well. Some of them are unpalatable, others have a repulsive smell, some are inconspicuous, others are well provided with armour or with weapons, and so on. But there are a few that defy danger like "dare-devils," and succeed by having some quite unusual peculiarity of structure or habit. We wish to illustrate this with the story of the young ant-lion.

The ant-lion is a common insect that verges on the incredible. It is not a native of Britain,

Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

4.—The megalops stage, transitional between the zoëa and the young crab. The eyes are now stalked and the swimming tail sticks out in a line with the rest of the body.

Photo : F. W. Bond.

ONE OF THE ANT-LIONS OR MYRMELEONS (MUCH ENLARGED).

The winged ant-lions are not very familiar insects, partly because they are in great part nocturnal in their habits, and partly because they do not occur in large numbers. There are no British representatives, but species of Myrmeleon occur in Central and Northern Europe.

but several kinds or species are abundant in various parts of Europe. It is common around Paris, for instance, where Réaumur studied their extraordinary habits in the early years of the eighteenth century. The full-grown insect, which is somewhat like a delicate dragonfly, is not well known, for it comes out at night ; it is the larva that has been the subject of many studies, the last and best being by Professor Doflein, of Freiburg.

Ant-lions, by which we mean the larvæ, frequent dry, well-sunned waste-places, with loose soil, in the vicinity of a wood or copse where there are lots of ants. When full grown they are about half an inch long, with a somewhat shield-shaped, arched posterior body, bearing a mobile head with formidable sharp-pointed jaws, a little like pruning hooks. The general colour is pale yellow often obscured by adhering particles of sand, but the numerous bristles on various parts of the body are dark brown or black, there is a broad reddish band across the back, and there are pigment spots every here and there.

When the ant-lion emerges from the egg it is a tiny miniature of what it afterwards becomes. But it is to the manner born as regards ants. A little creature, only a twelfth of an inch long, yet it proceeds to make a funnel-shaped pit in the ground, ensconces itself at the foot with only the jaws showing, and waits for an ant bigger than itself to tumble into the trap ! In suitable places, such as a sandpit, there may be scores of funnels of different sizes, up to four inches in diameter ; and when a funnel works well the ant-lion keeps to it for months. The requirements are that the soil is not damp or over-hard, that the place is sunny yet sheltered from the wind, and that there are many ants and other small insects in the vicinity.

But numerous experiments make it clear that we must not think of the ant-lions *choosing* a suitable locality in our sense of the word choosing. They move about in spiral courses, hind-end always in front, towards warmth, towards light, away from dampness, and sooner or later they find a satisfactory spot. Like some other animals, they are always automatically adjusting their bodies (as if they had a gyroscope inside) so that they are equally stimulated to right and to left. In darkness and in uniform diffuse daylight they tend to remain quite still, but when there is inequality of stimulation they simply have to move on. Of course, it is sometimes necessary to make a sort of compromise, for inequalities of light and inequalities of

warmth may pull in different directions, in experimental conditions at least. Professor Doflein notes the interesting fact that during many years devoted to studying ant-lions in his laboratory and study he never lost one, for even if one escaped he could always predict where it would be found. The ant-lion's consistency in moving backwards is remarkable; the creature would always do itself credit before royalty. On no occasion will it make an exception and move head-foremost. The meaning of its always moving backwards is probably to be found in the fact that it is a great burrower, and it always burrows tail foremost.

Having found a suitable place, the larva moves backwards in a circle, ploughing into the earth with its posterior body, which ends in a cone. Particles of earth from the inner side of the circle are shunted on to the top of the burrower's head, and are sent flying outwards with an explosive jerk. There is a most admirable anterior joint that makes this easy, and the arrangement of the bristles on the body, almost all directed forwards, also helps in the performance. The legs assist a little in the burrowing, but most of the work is done by the hind end of the body.

The ant-lion continues ploughing round in circles and hurling out the earth until the funnel is deep enough. It then buries itself at the foot with only the jaws protruding, and it always keeps its face away from the light. If an ant tumbles into the pitfall, the jaws lose no time in clinching, and perhaps there is some poisonous juice. Along the under side of each jaw or mandible there is a groove within which another of the mouth parts plays backwards and forwards, helping to draw in the juice of the impaled ant. The groove leads into the mouth-cavity, for the mouth aperture is practically suppressed. The beginning of the food canal is very muscular, and functions as a suction-pump; and when the victim has been sucked dry its body is tossed out of the trap. One of the many

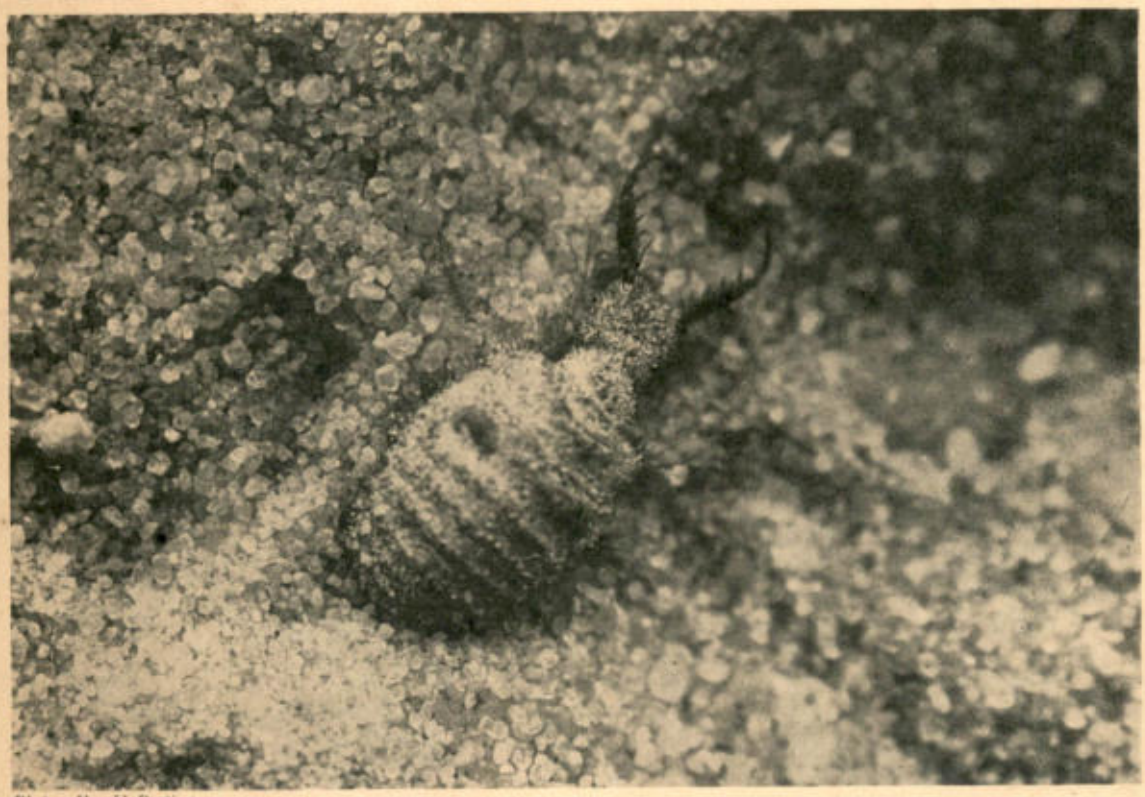


Photo: Harold Bastin.

LARVAL ANT-LION IN A SANDY SPOT, ABOUT TO BEGIN MAKING ITS PIT.

The photograph shows the formidable gripping mandibles or jaws and the roughened broad body, which is used as a sort of plough. Behind the jaws is the strong head, by means of which the excavated sand is thrown to a distance with a sudden jerk.

Photo: F. W. Bond.

ANT-LION'S PIT IN SAND.

The pit is a little like a miniature of the crater of a volcano, but with a gentler slope. It is a wide conical tunnel, in the centre of which the larva lies, with its body quite buried, but with the formidable jaws outspread.

peculiarities connected with the feeding habits of the larval ant-lion is that the stomach ends blindly. Any undigested material must come out at the mouth!

The tossing movement that is seen in making the pitfall and in throwing out the sucked victim occurs also in a third connection. When an ant has slipped a little way down the slope and tries to recover its foothold the ant-lion does an extraordinary thing. It bombards the ant with sand, and the almost inevitable result is that the struggling insect is borne to the foot of the funnel and then seized as usual. This bombardment seems at first sight almost devilishly deliberate, but Professor Doflein's interpretation is different and almost certainly correct. When the bombardment is carefully watched it is seen to be towards all sides of the funnel. There is no aiming at the struggling ant; it is merely a repetition of the usual tossing action that has its trigger pulled when moving grains of sand touch the exquisitely sensitive bristles on the burrower's body. The fact of the matter seems to be that the ant-lion is an insect of low intelligence, but well endowed with a repertory of ready-made tricks. It has a poor brain, but it has several very perfect inborn capacities, which work well from the very first. These actions correspond to the capacities we illustrate when we swallow, or cough, or sneeze, or draw back our finger from a hot surface. They are technically called "reflex actions." To throw off sand from the top of its head is to the ant-lion "as easy as winking"; it needs no learning. The creature is a little automaton that does a few things extraordinarily well. But although the ant-lion does not nowadays need to use its mind to catch the ants, it does not follow that the mind was not used during the long ages when the inborn dexterities were being established. There had to be testing

Photo: Harold Bastin.

A FLY (ENLARGED) CAPTURED BY A LARVAL ANT-LION.

The ant-lion is buried beneath its victim, which it is holding in its jaws and sucking dry. Without relaxing its grip the larva works one of its mouth parts backwards and forwards in the groove of each jaw. It thus draws in the food, but it is helped by the suctorial pharynx.

of little improvements generation after generation. A great rule in the advance of life has been: "Prove all things and hold fast that which is good."

What kind of life-history has this wonderful creature? The eggs are laid in the earth; minute larvæ creep out in early summer and begin to catch ants; they feed and grow and moult, the rate of growth varying with the abundance of food. If the summer is cold and wet the larvæ may still be larvæ when winter comes, and may pass the winter in this state. In a fine summer, however, the larva soon becomes full-sized and undergoes its great change or metamorphosis within a cocoon made of sand-grains fastened with very fine silk. A silk worm's silk comes out at a spinneret beside the mouth, but the ant-lion's issues from the posterior end of the food-canal, which is not used at this stage for any other purpose. In some cases the winter is passed within the cocoon, but when the conditions are favourable the great change is accomplished in three or four weeks, and there emerges the shy, nocturnal winged adult which the old naturalists called a "land-dragonfly." But our reason for making much of the early chapters in the life-history is because the ant-lion is a good example of a young dry-land animal that holds its own by having almost incredibly peculiar habits!

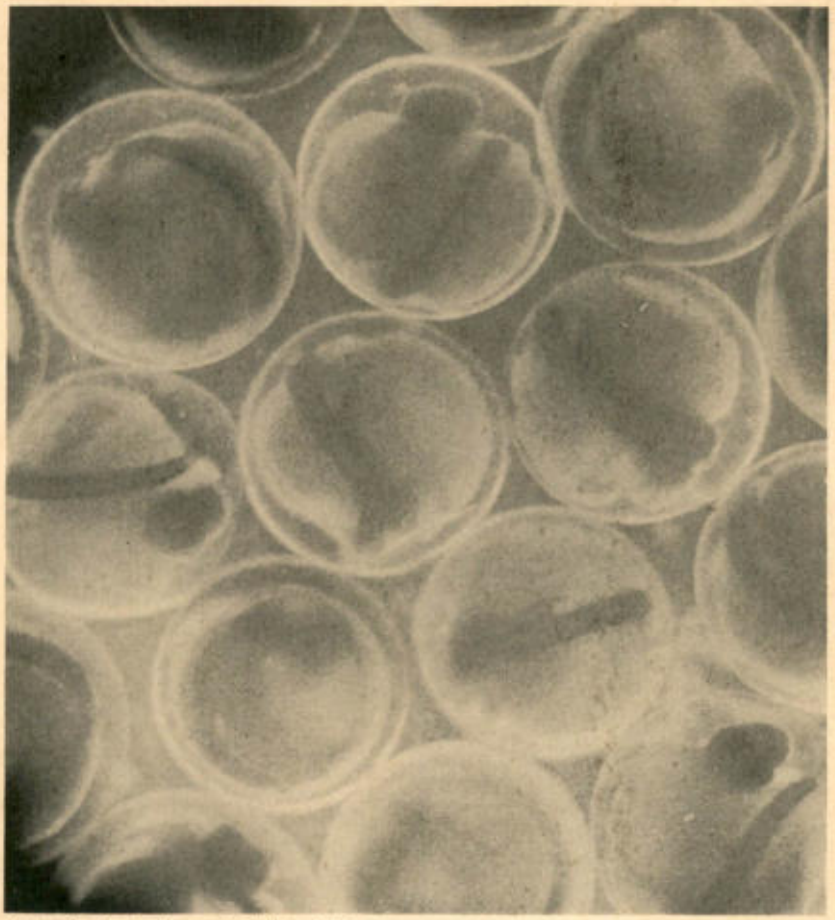


Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

DEVELOPING EGGS OF THE PLAICE.

A large plaice may liberate half a million eggs, each a minute sphere, about a twelfth of an inch in diameter. They float near the surface. The developing embryos in various stages can be seen through the egg-membrane.

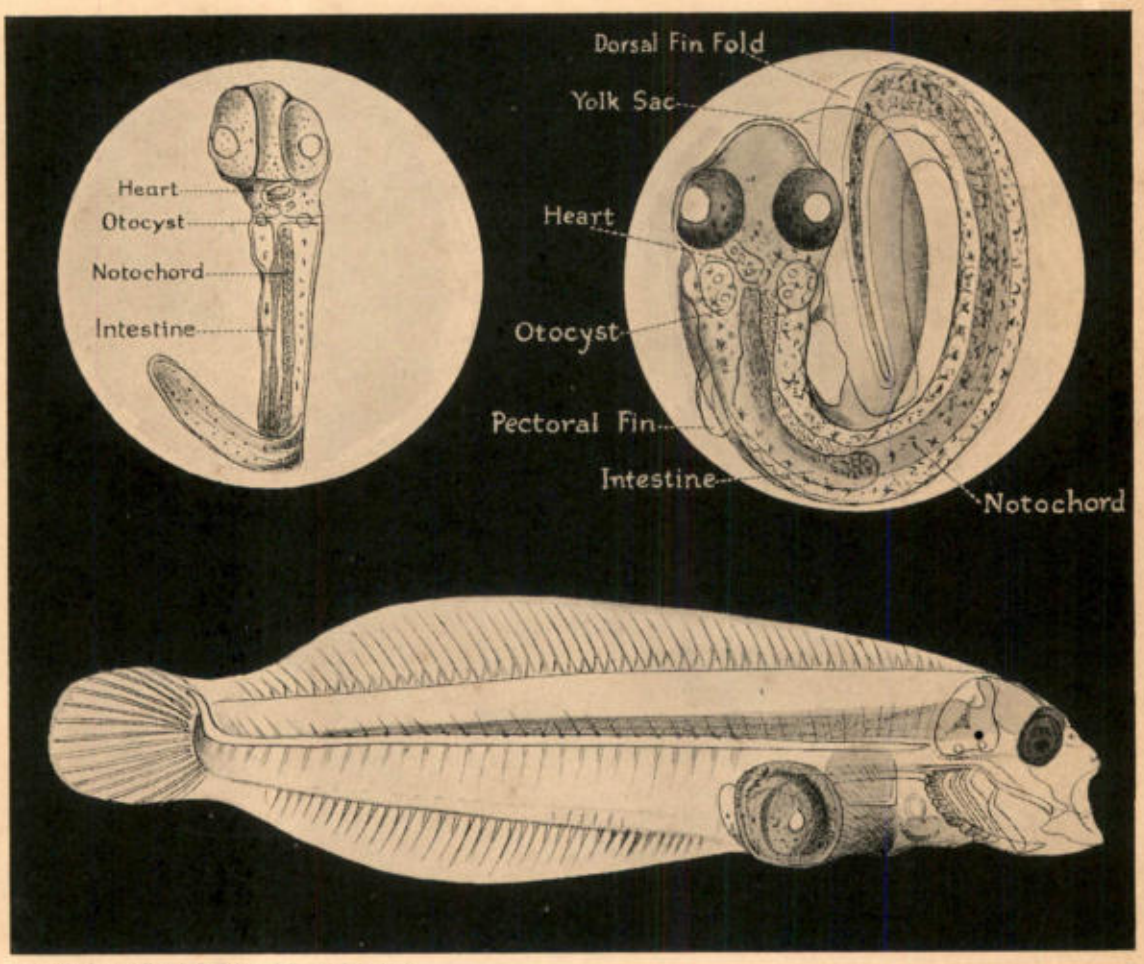
In a previous chapter we discussed the salmon's life-history, now let us take the plaice, a fish that keeps to the sea. On the British list of practically important food-fishes—a list much shorter than in waters farther south, such as the Mediterranean—the plaice occupies a prominent position. It is not nearly so abundant as the haddock or the herring, and it is not cured; but it is a general favourite, and it is very nutritious. It is a near relative of dab and flounder, but it grows larger and plumper, and is far more important commercially. It commonly weighs two or three pounds, but often more. In favourable circumstances, where it is not greatly harried and where food is abundant, it grows on and on, and becomes a giant. For it must be remembered that few fishes show the definite limit of growth familiar in most animals. A lucky haddock may grow to be as large as an average cod, say three feet long.

Story of the Plaice.

The adult plaice is fond of lying on a sandy bottom in shallowish water, and its up-turned

side, usually olive-brown with orange spots, changes in colour in harmony with that of the immediate surroundings. Like its relatives, the other bony flat-fishes, the plaice can put on a cloak of invisibility, the change depending on the contraction and expansion of the irregularly shaped pigment-cells of the skin. But the plaice does not need this protection when it is resting, for its body is mostly covered with a thin layer of sand, and only the watchful eyes protrude. The plaice keeps a sharp look-out for molluscs, crustaceans, and worms; it is a very clean feeder, and that is probably one reason why it is so palatable. Like most of its relatives, excepting brill, megrim, and turbot, the plaice rests and swims on its *left* side; and everyone knows that the down-turned surface is silvery and without any pigment. The silveriness is due to the reflection of light from minute spangles of a waste-product called guanin, which accumulates in certain skin-cells called iridocytes. The originally left eye travels round till it lies beside the other on the right-hand side. Otherwise it would get scratched; moreover, it comes to lie where it is of most use. But the travelling round is very remarkable.

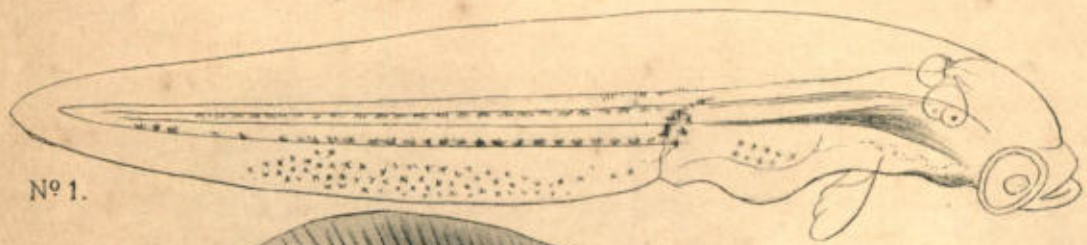
Plaice spawn in the early months of the year, when the temperature of the water is at its lowest. The eggs are shed and fertilised in the upper layers of the water, but they tend to sink as development goes on. They are about one-twelfth of an inch in diameter, so that about a



After Professors Frank J. Cole and James Johnstone.

DEVELOPMENT OF THE PLAICE.

The left upper figure shows an embryo on the ninth day after fertilisation; the minute spots are yellow pigment-cells. The natural size is under a twelfth of an inch. The right upper figure shows the embryo now ready to hatch out, seventeen days after fertilisation; black pigment-cells have now appeared. The lower figure shows a young plaice, about three-fifths of an inch long, just beginning to feed, having used up all the yolk.



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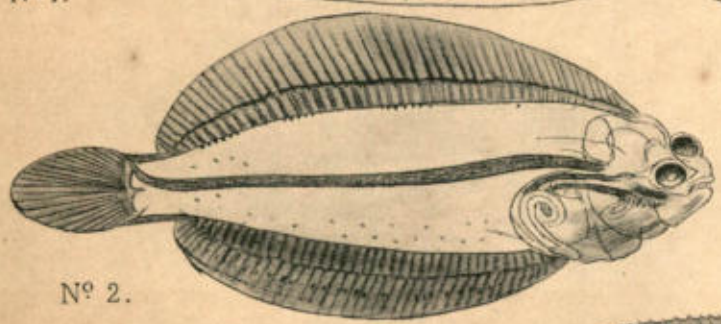

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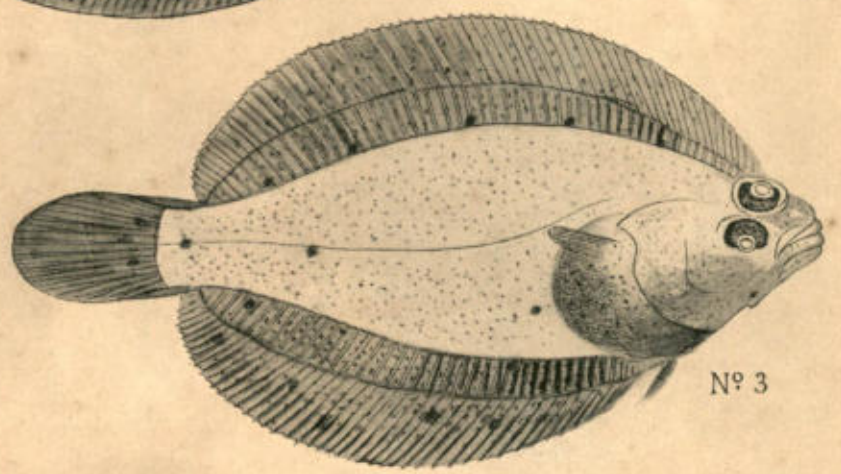

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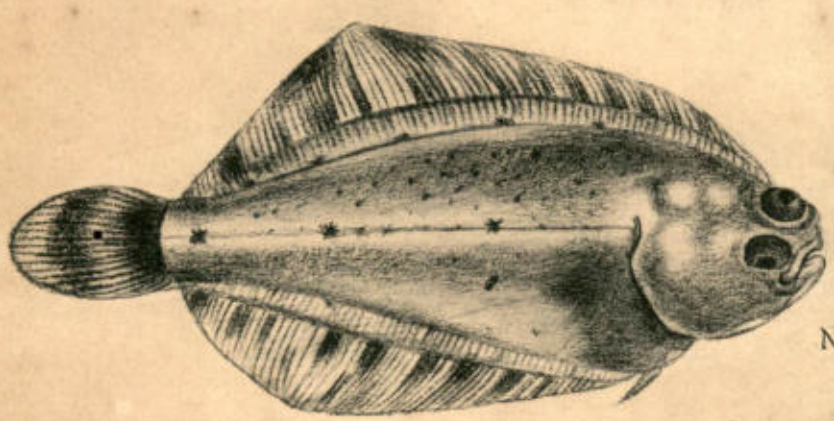


Nº 4.

After McIntosh and Masterman.

LIFE-HISTORY OF THE PLAICE (*Pleuronectes platessa*).

No. 1 is a well-advanced larval plaice, with the symmetry of an ordinary "round fish." No. 2 shows the great change in progress; the body is becoming flattened from side to side; the left eye has come round to the right up-turned side. It is not yet half an inch long. No. 3. The young plaice has now reached the floor of the sea; it rests and swims on its left side, and is about an inch long. No. 4. A young plaice on the sea bottom; the colour-cells are developed on the right up-turned side; they have disappeared from the left down-turned side, which is silvery. The two eyes lie side by side on the up-turned side.

fifth of a million might be contained in a fluid quart. The spawning is in a way very discriminate, for it is practically restricted to the area between the shallow-water zone and the 30-fathom contour-line. According to recent investigations, the suitability of a sea-area for spawning depends, not on the depth, nor on the salinity, nor on the proximity to the land, if we consider these conditions by themselves, but rather on the temperature of the water and on the formation of eddies. These great eddies are no doubt connected with the configuration of the coast and the lie of the sea-floor. They are well known in all the great spawning grounds, namely, the "Flemish Bight," the "East of Dogger" area, the "Flamborough Off" area, and the Moray Firth. We must put the well-known Scottish area last, for, while it is the most important plaice-nursery for Scottish waters, its contribution to the total North Sea plaice population is small in comparison with that from the southern spawning grounds.

Inside the egg-membrane the development of the larva goes on for about twenty days, and during this period the floating eggs are to some extent dispersed by currents. Thus some of those liberated in the Moray Firth seem to be carried eastwards and southwards, and probably go to stock inshore waters on the East of Scotland, south of Rattray Head.

First there is the spawning, secondly the development within the egg, and, thirdly, there is the hatching. There emerge the larvæ—about two-sevenths of an inch in length—which exhibit occasional jerky movements, but for the most part drift passively. Each is encumbered with a legacy of yolk, on which it depends for food, for a few days entirely, and for a few more days partially. When the larva is about four days old it opens its mouth and begins to steer its course. It feeds on floating microscopic plants called diatoms and on other larvæ; and it passes through a very critical week, on till the twelfth day or so, when the yolk is entirely used up and the "post-larva" becomes a "fry." It is important to notice that this "fry" is shaped just like a young "round fish," such as a haddock. It swims vertically, with its dorsal middle line up to the sky. Entirely dependent on its own resources, it runs great risks, and the more energetic it is in seeking for food, the more likely it is to attract the attention of hungry enemies. There is great mortality.

Egg, embryo, larva, post-larva, fry—these are the five chapters of the first month in the life-history of the plaice. But the sixth chapter is the strangest of all. It is the time of the great change or "metamorphosis," the transformation from a miniature "round fish" to a miniature "flat fish." The left eye moves to the right side; the skull becomes strangely unsymmetrical; the body is flattened from side to side—just the opposite of the skate's flattening, which is from above downwards. The young plaice, about three-fifths of an inch in length, sinks to the bottom, and henceforth rests and swims on its left side, which must be the heavier. We have already noticed that the pigment-cells become restricted to the up-turned side, which is more under the influence of light. Experiments have proved that light is needed if the pigment is to develop; and when light was thrown up for four months from a mirror on the floor of an aquarium, where young flounders were sinking downwards and changing their shape, ten out of thirteen developed yellow and dark spots on the down-turned side, which is normally without pigment.

If the metamorphosis is safely accomplished the young plaice probably gets a firmer foothold in the struggle for existence, if we can speak of a fish having a foothold. It is more of a free agent than in preceding phases; it has passed from the surface to the floor; and it has a readily available refuge in the sand, where it devours small crustaceans and the like. But it seems to be a restless creature—obedient to the almost universal urge after greater satisfaction. It feels its way from the spawning areas to the inshore nurseries, even between tide-marks. It grows to a length of about three and a half inches by the end of its first summer. The tendency of the growing plaice is to seek deeper water in the winter, and as it grows older it lives farther from the shore as long as it can find plenty of young cockles and mussels, which form its staple food. On an average the males are mature at the end of their fourth summer and the females a year later; but their size at maturity varies with their opportunities for food and with the depth of the water. It must be kept in mind that the full-grown plaice is a good

deal of a rover, passing from region to region, always in search of the better.

It is computed that a very large female plaice may contain half a million eggs, and an ordinary six-year-old fish over a quarter of that number. This illustrates Nature's way of working with a large margin. But the chances of death are enormous! Many eggs probably die unfertilised, and many are devoured at the very start. Some are drifted into unsuitable places. There is great mortality during early development, especially perhaps at the critical time when the larva is beginning to fend for itself. The great change from the "round fish" to the "flat fish" type is another crisis. Then there are fluctuations in the supply of the molluscs and crustaceans on which the plaice depends for sustenance. There is no doubt that there must be keen competition among the plaice themselves when an area becomes overcrowded, and the multiplication of fishes outruns that of the backboneless animals on which they feed. Moreover the plaice is too palatable a fish not to have many hungry enemies all through its life. Finally, more than any other fish, perhaps, the plaice shows in its fluctuations of abundance and of size the influence of man. Before the war, experience pointed to the conclusion that the fishermen—the trawlermen in particular—were taking too many plaice out of the North Sea. Good-sized plaice were becoming less and less abundant in the catches. But when fishing was resumed after the war, "the catch per day's absence" increased in a very striking way. As against 2·1 cwt. in 1913, it was 4·5 cwt. in 1919; and there was a considerable increase in the numbers of large and medium-sized plaice, far outweighing an actual decrease in the numbers of small fishes. In what precise way the stoppage of the fishing during the war brought about this result is a question not to be answered lightly, but the general fact that the fishery was greatly improved by the "rest" is clear. But the improvement did not last, and the very important practical problem is how to keep up the supply of this very valuable and palatable food-fish. There are two main suggestions. One is that millions of young plaice should be transplanted from abundantly peopled coastal grounds to suitable feeding areas like the Dogger Bank. The other is that certain areas, where young plaice abound and grow rapidly, should be closed to certain kinds of fishing for the whole or for part of the year. Man always tends to be shortsightedly greedy, killing the goose that lays the golden eggs.

Photo: Ellison Hawks.

A FEMALE GNAT (*Culex pipiens*).

This irritating little insect has a body about a fifth of an inch in length, but its legs are longer. The male has bushy antennæ, and he usually keeps to the nectar of flowers, refraining from drawing blood. There are two notes, the shrill buzzing being confined to the female.

Another common animal with a remarkable life-history is the gnat. There are about a score of different kinds of gnats or mosquitoes in Britain, including the Dapple Wing, which

carries and disseminates the malaria germ in such countries as Italy. It used to do the same in some parts of Scotland, as the hospital records show, for "ague" is just another word for malaria. If numerous malaria patients should come to Britain, as a number did after the war, the Dapple Wing mosquito (*Anopheles maculipennis*) might resume its rôle as a distributor of the disease in this country.

The Common Gnat.

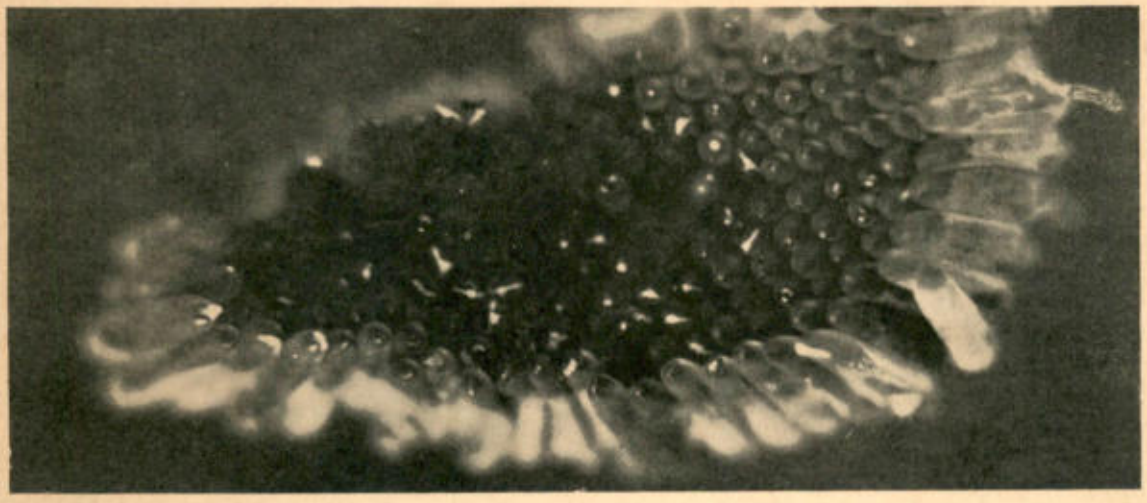
But we wish to tell the story of the commonest British gnat (*Culex pipiens*), often called the Grey Gnat or the House Gnat. It is a delicately built, long-legged, clear-winged insect, about one-fifth of an inch in length of body. In typical specimens the second ring behind the head is reddish above, and there is a good deal of yellow on the hinder parts. These two colour characters may serve to distinguish the Common Gnat from its many relatives; moreover it is the only European species that is given to flying about houses.

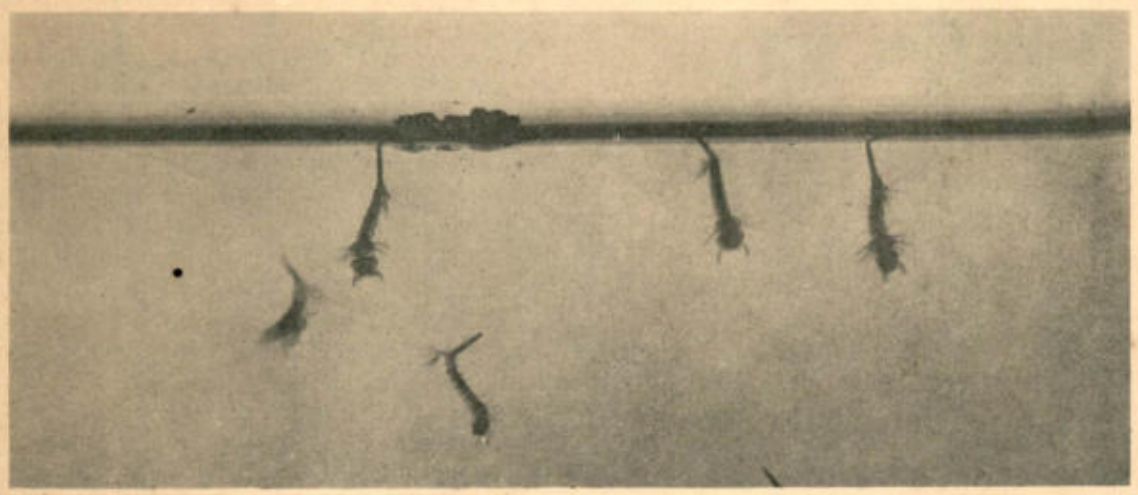
The buzz of the gnat is twofold. The deeper note is due to the rapidity of the wing-strokes, of which there are many hundreds in a minute. But there is a shriller note, apparently confined to the females, which is due to the vibration of tense membranes at the openings of some of the anterior breathing-tubes. It was shown long ago that if the same note is produced artificially, by means of a tuning-fork, in the vicinity of a tethered male he exhibits a sympathetic quivering of his bushy feelers. By automatically adjusting his body so that the two feelers are equally stimulated the free-flying male is likely to find the clamant mate; if he gets off the line in his flight a fresh adjustment occurs. But in some cases at least, the females spontaneously join the swarms of buzzing males.

The usual food of gnats is the sweet juice of flowers and fruits, and the males keep to the old ways. Only the females bite, and those of the House Gnat are very keen to gorge themselves with the blood of man and mammals, or even of birds. It may be an acquired taste, but it has got a strong hold now; and in the Common Gnat it seems clear that the draught of blood is a useful stimulant before egg-laying. On the other hand, it has been proved experimentally that the blood-sucking is not indispensable. The cause of the irritation produced after the insertion of the sharp needles and the subsequent suction is rather subtle. It was investigated twenty years ago by Professor Schaudinn, who showed that a partner-fungus lives in three little sacs which are connected with the gnat's gullet. They seem to assist in the fermentation of the sugary food, and relatively large quantities of carbonic acid gas are generated. Some of this gas will be introduced into the wound the gnat makes when she bites; it will cause irritation of the muscle, and it will also tend to prevent blood-clotting. Moreover, there is an injection of a minute quantity of the ferment which the fungus makes, and this will increase the blood pressure and also the irritation. It is probable that some of the fungoid cells will also pass over into man's blood, and it has been shown that the symptoms of a bite can be mimicked by rubbing a scratched piece of skin with a gnat's gullet. We see, then, why a gnat's bite is worse than a pin-prick!

There is considerable variety in the life-history of different kinds of gnats; we confine our attention to that of the commonest species, a fine account of which was given by Réaumur in the early eighteenth century. In ordinary cases the female gnats seek out sheltered winter quarters, such as cellars, about the end of September, and they persist in a lethargic state through the cold months. The males all die after the last autumn mating. The females are in good condition in late autumn, with a notable amount of reserve fat in their bodies. It is rather difficult to account for this fatty store, unless it be the residue of what was accumulated by the aquatic larvæ. This is one of the questions which "Alice Through the Looking Glass" omitted to ask during her long conversation with "a very large gnat, about the size of a chicken." The fatty reserve gradually dwindles throughout the winter, but the re-awakening gnat is vigorous enough. It is usually in May that she liberates about 200 eggs, somewhat like small-bore shot, and glues them into an unsinkable and uncapsizable raft, which floats on the surface of a stagnant pool or a rain-water barrel. In two or three days the larva emerges, breaking off a lid on the broad lower end of the shot-like or cigar-like egg-shell.

The larva, popularly called a "wriggler," is a legless creature, fond of hanging head-down-





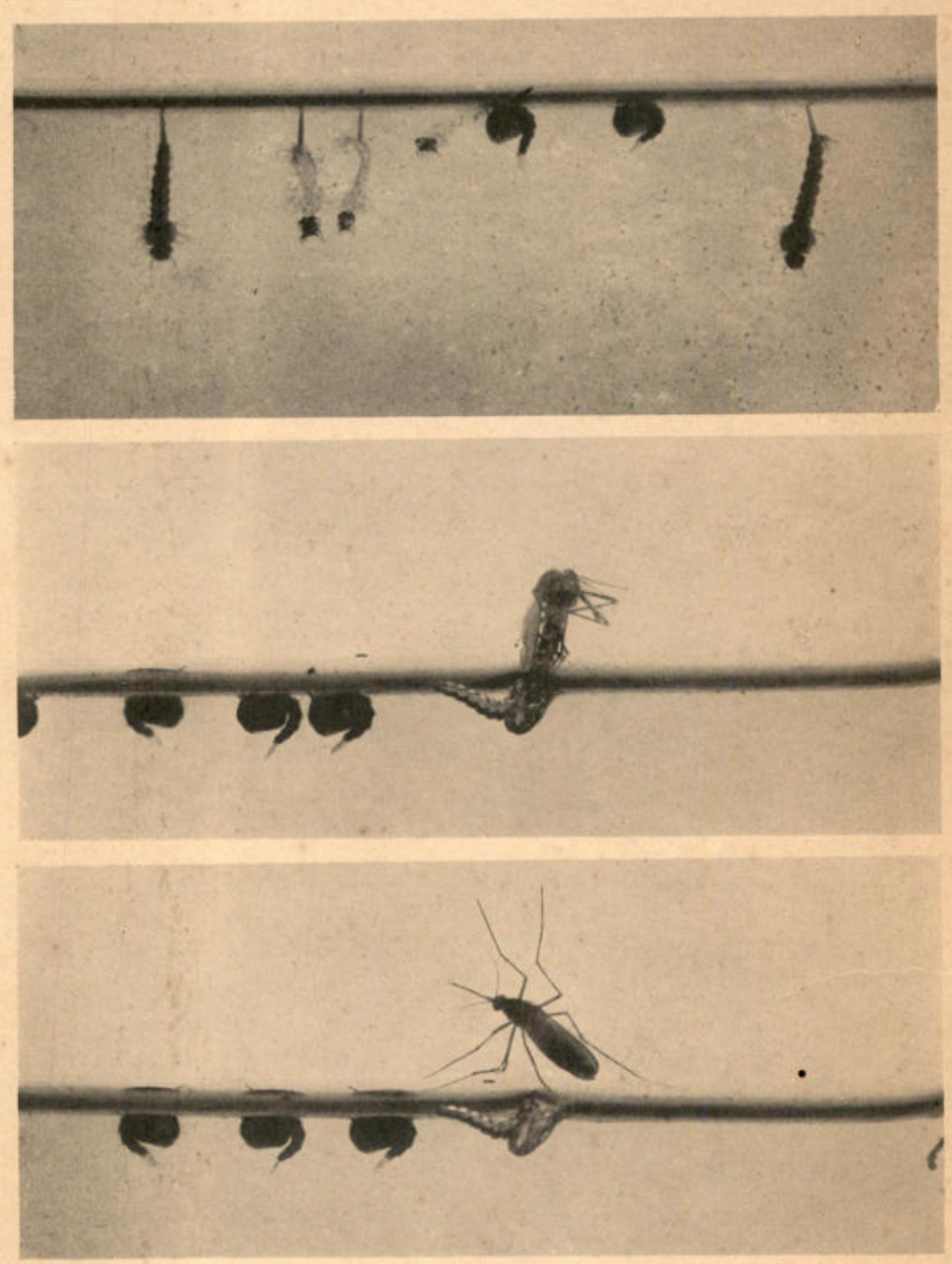
Photos: John J. Ward, F.E.S.

A SERIES OF PICTURES SHOWING THE DEVELOPMENT OF THE COMMON GNAT (*Culex pipiens*).

Top: The egg-raft floating in the water, consisting of two hundred or so eggs glued together.

Centre: Four egg-rafts from which one thousand larvæ have emerged. They are hanging to the surface-film by the respiratory tube on the tail.

Bottom: Gnat larvæ four days old; each shows the respiratory tube and a tuft of bristles that help in swimming. From the surface-film they hang head downwards. The story is continued in the pictures overleaf.



Photos: John J. Ward, F.E.S.

Top: Larvæ ten days old; two of them have changed into "big-headed" pupæ, with respiratory tubes anteriorly.

Centre: When about fourteen days old the gnat emerges from the pupa case at the surface of the pool. To the left are three pupæ.

Bottom: This is a critical moment when the winged insect presses down the pupa-case from which it has emerged. It would be fatal if the wings were wetted.

wards from the surface film. The suspension is effected by an air tube on the eighth ring of the posterior body or abdomen. This pierces the surface film and opens by spreading out five valves or flaps, like the rays of a conventional star. When these valves close together the larva slips from the surface film and sinks in the water, it may be to the bottom. But soon it jerks itself up again, helped in its vigorous strokes by ten tufts of stiffish bristles on the tip of the tail. There are also four terminal platelets, two much larger than the others, which contain air tubes and seem to be more important for capturing oxygen than for locomotion. There are plenty of these wrigglers in pools in early summer, and they are interesting creatures to watch with a good lens or a very low power microscope. One of the most important facts in the world is that if they are to live they must be able to hang on to the surface film. When a little paraffin or petrol is poured on a stagnant pool the larval gnats or mosquitoes can no longer hold on, and they drown. This obviously checks malaria.

The larvæ of the common gnat feed at the surface on minute organisms and organic particles which they waft into their mouth by means of bristly mouth parts. Unlike some other species, they are able to thrive in very foul water. They feed easily and well, they grow quickly, they moult their cuticles; and in two or three weeks, after the fourth moult, they turn into big-headed pupæ. These are very different from the larvæ; thus there are two breathing tubes opening far forward, and no food is taken. They are more active than ordinary pupæ, for if we touch one it jerks itself quickly downwards into the water, helped by two terminal tail-flaps. It rises again passively and buoyantly. Within the pupa-husk the winged gnat is built up, and there is a critical moment when the cuticle splits up the back and the fully formed insect seeks to emerge without getting its wings wet.

The mating takes place in the air, and most people have admired the swarms of dancing and noisy males. The females seem to be attracted by the throng—perhaps by the sound. In the case of the Common Gnat there may be two or three generations in the course of the summer, and in each generation there may be three or four broods. There are some quaint people who are always asking: "What is the use of this or that?" As regards gnats, the answer is easy; *they form an important part of the food of many kinds of birds.* Who will not find the gnat's complete justification in its triumphant re-embodiment? One may almost say that gnats turn into birds!

We now take a life-history that has nothing to do with the water—that of the crane-fly or daddy-long-legs. Sometimes, especially at the end of summer, there are so many rising on the links that the golfers complain of them flying up in their

Daddy-Long-Legs.

Photo: John J. Ward, F.E.S.

LEATHER-JACKET OR LARVA OF DADDY-LONG-LEGS IN THE SOIL.

This destructive larva eats the roots of grasses and cereals and does much harm. It may be an inch long, and is coloured like the ground. The head is telescoped into the front end of the somewhat maggot-like body and bears two strong jaws.

faces and spoiling their play. Perhaps it is a little disconcerting to have such a sprawling insect in one's face; its legs cover so large an area that one does not know where it is and where it isn't. It has more "leg" in proportion to "body" than almost any other kind of animal, except the quaint spiderish "harvestmen" that stalk about among the stubble in the autumn evening.

It is a bit of a surprise, if one thinks about

things, to see a winged insect wriggling out of the ground, but closer scrutiny shows that the crane-fly is emerging from a gaping *pupa-case* which is standing vertically just below the surface of the soft earth. What we see is near the end of a long story, to which we shall turn in a moment.

But it is interesting to linger over the picture of the crane-flies creeping out of their pupa-cases on the links, for the picture includes crowds of Black-headed Gulls which are searching over the golf-course for these dainty morsels. It is pretty to see them quickening their pattering to a very rapid run when they detect an insect showing face. The more crane-flies the birds destroy, the better for the turf next year, for the hungry larvæ or "leather-jackets" do a great deal of harm to the roots of the grasses. Not only do they injure links and pasture, but they destroy the roots of cereals and some other crops. They are so destructive that in some parts of Britain the farmers call them "*the* grub" as if there were not many other kinds.

Photo: Harold Bastin.

LARVA AND PUPA SKIN OF DADDY-LONG-LEGS
(*Tipula oleracea*).

The fleshy larva (to the left) lies quiet through the winter and turns into a pupa (to the right) the following spring. The pupa has rough projecting spines and works itself vertically in the soil, resting at the surface. On the head are two respiratory horns.

It is interesting to watch among the Black-headed Gulls the beginning of a sense of property. For if one gull has hit upon a profitable area, e.g., a teeing-ground, rich in emerging crane-flies, will it let another gull join in? On the contrary, if an intruder alights, he is at once driven off with bad words, and he always goes.

Everyone knows the full-grown flying Daddy-Long-Legs, with the almost inch-long body, the big wings and the very lank limbs, which seem in fact too long for usefulness. There are two common kinds—*Tipula oleracea* of earlier summer, with a greyish body and an expanse of wing about two inches across, and *Tipula paludosa*, that comes out from July to September, with a reddish-brown body and shorter wings. No one can readily confuse either of them with gnats, which have not such ridiculously long legs, though in truth they are long enough. Like gnats, the daddy-long-legs are two-winged flies, and it is interesting to look carefully at them to see behind the wings a pair of quivering rodlets with pinhead-like ends. These "poisers," as they are called, are restricted to two-winged flies (Diptera) and the males of scale-insects; they are the equivalents of hind-wings, and discharge some obscure sensory function. As "poisers" are true correspondents of hind wings, one would expect among the thousands of different kinds of two-winged flies to find some types with transitional forms between wings and poisers. No such case is known.

If we follow the lanky creatures that wriggle out of the ground and escape the hungry eyes of the gulls and other birds, we see that they scramble on to the grass and take to flight. The females meet the slightly smaller males, and pairing takes place. Thereafter the males die, and so do the females after they have deposited their eggs. When about to lay, the female usually seeks out a damp spot in the ground, or she may deposit the eggs among coarse grasses and rubbish.

When she is laying, she holds her body bolt upright, with the hindmost and longest legs on the ground and the other two pairs in the air; and she has an egg-laying organ or ovipositor at the tip of her tail that helps in the process of literally popping the eggs into a hole or crevice.

Photo: Harold Bastin.

MALE DADDY-LONG-LEGS OR CRANE-FLY (*Tipula oleracea*).

The features of the adult crane-fly are the slender body, the very long legs, and the narrow, finely-veined wings, and the unusually prominent "poisers" or "halteres" which represent the posterior pair of wings. They are seen projecting in the photograph.

The eggs are little black ellipses, and one female may lay about three hundred.

It does not seem easy to explain the crane-fly's long legs; they are readily broken off on slight provocation; the insect is very apt to leave them behind; and when they are lost they do not seem to be missed. The only light we have on the subject is that the long legs appear to be serviceable in struggling among the jungles and thickets of meadow and hedge-row, and in the process of egg-laying.

Out of the egg in about a fortnight there is hatched a larva—a sort of subterranean maggot. In contrast to the adult insect it has no legs, but it moves about in the soil by contracting and expanding its muscular body. Its black head is retractile and inconspicuous until the strong biting jaws are protruded. With them it plays havoc with all sorts of roots. The blunt hind end is marked by six tubercles. On the last ring of the cylindrical body there are two breathing openings, by which air from the interstices in the soil passes into the respiratory tubes, which penetrate into every hole and corner of the internal parts. In most animals the blood goes to the air (e.g., on gills or in the interior of lungs); but in insects the air goes to the blood.

The larval crane-fly writhing in the soil is a great contrast to the larval gnat or mosquito wriggling in the pond; but the essential features in the two life-histories are much the same. The larva feeds, grows, and moults—again the necessary sequence; and at last it is a full-grown "leather-jacket" about an inch long. It is an unattractive creature, with a tough skin (as its popular name suggests), and very difficult to kill, as the farmer well knows. A summer leather-jacket may become an autumn crane-

Photo: Harold Bastin.

FEMALE OF DADDY-LONG-LEGS OR CRANE-FLY.

The end of the body is slender in the female, ending in two pointed structures, which are used in pushing the eggs into the moist soil. In the male, as the photograph shows, the end of the body is thick and blunt.

fly; but an autumn leather-jacket will remain as such in the ground until the following spring. If there be frost, it wriggles beyond the reach of its chilly fingers.

When the time for the great change or metamorphosis draws near, the leather-jacket takes up a vertical position just at the surface of the ground, and becomes a pupa or chrysalis which has spines on each ring of its body and two horns on its head. Inside the pupa-case the miracle occurs; the development begins afresh; the old house is broken down and a new one is constructed on a different architectural plan—that of the winged insect. The pupa wriggles upwards out of the chrysalis case, helped by its spines, and then, half out of the earth, there is a splitting of the cuticle and a liberation of the winged Daddy-Long-Legs.

If no creature's hand were against Daddy-Long-Legs it would fare badly with the farmer. He may clear away the rank grasses which the crane-flies love; he may clean the hedgerows which give them shelter; he may harrow and roll; he may drain the moist places where the female insect finds opportunity to pop its eggs into the soil; he may use gas-lime and "tipulin"; but he has still to confess that Daddy-Long-Legs is too much for him. Luckily, however, there are natural enemies which tend to keep the balance even. For the larvæ are picked out by rooks, starlings, lapwings, and gulls, or crunched up by moles. The winged crane-flies are caught by rooks, black-headed gulls, and swallows, and the wasps that people grumble at so much must get credit for playing a useful part.

Horse-Hair Worms.

As an example of unfamiliar life-histories let us take that of the "horse-hair worms" that we sometimes find in little pools in the overflow water of a roadside stream. Old-fashioned natural history books give recipes for the production of these horse-hair worms. The simplest of these is to put some black hairs from a horse's tail into a sheltered pool in a stream, making a little rampart of stones so that they cannot be floated away. After many days they will be found writhing and wriggling about—living horse-hair worms. These worms are in some ways quite well known; they are distant relatives of the common threadworms or round-worms (Nematodes); they are cylindrical, often six inches long, like thick horse-hairs, varying in colour from greyish to black. Many of them bear the name of Gordius, and a considerable number may be found together, tied up in a knot difficult to unloose—a Gordian knot.

One Saturday, fifty years ago, four schoolboys put some black horse-hairs in a pool in a tiny stream. Not that they had read the old recipe; it was just a country tradition, like many others almost swept away now. Some weeks afterwards, when the boys remembered their experiment in the midst of many urgent affairs, they went back to the pool and found wriggling black worms as living as living could be. There was no one to explain the mystery. Another day they found an interesting pool in a streamlet that ran right across a by-road (the place was called Hermiston)—interesting because it was so crowded with black horse-hair worms that one of the boys lifted a handful of over two dozen—we feel them wriggling still—and that was not nearly all. Surely it must have been a big horse—a Pegasus, perhaps—that dropped so many hairs from its tail!

Modern research has cleared up a great part of the mystery of the horse-hair worms. The long living threads *creep out of insects*, especially out of crickets and grasshoppers and beetles, that come to the pools for an evening bath or for some other reason. The horse-hair worms have been living for months inside the insect's body. They absorb fluid food from their host's blood, and they absorb it, apparently, by their whole surface, for they have either no mouth at all or only a pin-prick opening insufficient to allow much in the way of nutritive juice to enter. The gullet is usually blocked.

These unpaying boarders that live in grasshoppers, beetles and other insects, are not at first in any hurry. They feed, they grow, and they moult—a logical as well as a biological sequence. As they grow they have to cast off the non-living enveloping cuticle, for which they have become too big. A growing animal often becomes too big for its clothes. But when they have reached that mysterious colon: Full Size, they become ill at ease. They dispose themselves inside their host with their head-end close to the surface, just as if they knew that this was the best attitude for creeping out quickly when the insect enters water to bathe,

LIFE-HISTORY OF COMMON TOAD

The common toad (*Bufo vulgaris*) spawns in March or April, liberating two thousand or more eggs in two strings of jelly wound among water-plants. These eggs are fertilised just as they are set free. After about a fortnight's development minute tadpoles emerge, and these pass through a succession of stages as in the frog. Small fully-formed toads are ready in about three months, and these migrate from the water to the fields. There is great mortality, but in about five years a certain percentage reach maturity.

1. Eggs of the Common Toad, a double row embedded in each of two gelatinous strings, often ten feet in length.

2. Toad tadpoles rising to the surface of the pool. They are hatched out from the eggs in about a fortnight.

Photos: M. H. Crawford.

3. A young toad that has passed through its long-drawn-out development (taking about three months) and become a miniature of the adult.

4. Fully grown Common Toad, showing the rough skin, and the large poison-gland, immediately behind the finely coloured eye.

or comes to the water-edge to drink, or lingers to cool itself among the damp grass near the pool.

When the insect-host is in moist surroundings, which may mean water, the horse-hair worms force their way out. They wriggle to a pool, or, if they are in the water already, they proceed at once to swim about urgently. The males, which are marked by a slightly forked tail, seek for the females till they find them. After the pairing, the females twist about among the roots of half-submerged grasses and among other vegetation more thoroughly aquatic, and lay their eggs in white strings, often intertwined with the plants. A short time afterwards, the parents of both sexes begin to be sluggish; they wilt away and die. For it often happens that starting a new generation means a full stop to the one before. Reproduction is often the beginning of death. It is very interesting to try to trace, in the great diversity of present-day animals, the various expedients that have been arrived at, age after age, to stave off the death that is apt to be the penalty of multiplying. This is a *trend of evolution* which is in progress still. The big lusty lamprey dies after spawning, but the migratory bird may journey half round the world after the fatigues of its breeding season.

In the case of the horse-hair worms, the eggs in the twisted strings develop into transparent, thread-like larvæ, and these cut themselves free by means of an anterior proboscis armed with sharp stilets. For a short time these microscopic threads swim actively in the water, but their inborn impulse is to bore into something animal. Long ago, perhaps, they may have lived, as many thread-worms live, in rotting material, and only gradually came to improve upon this by boring into a living creature. For in such simple ways many forms of parasitism may have begun, and we should remember that to a horse-hair worm an insect is not an insect, but simply an inviting corner which suggests energetic boring. That this is not a perfect or finished world is revealed in the little detail, that the larval horse-hair worms sometimes bore into a host which disagrees with them more than they disagree with it, and then they die. But if they bore into an appropriate host, such as a grasshopper or a cricket, they develop into full-grown worms, which return to the water by and by. Sometimes there are complications, for the larva may enter the aquatic young of an alder-fly, or of a mayfly, or of a harlequin fly, which may be devoured by a predaceous beetle or some other hungry creature. In this second host the larval horse-hair worm continues its development.

There are said to be over a hundred different kinds of horse-hair worms, and there is no doubt some variety in the life-history. But in a general way the story is now clear. The living horse-hairs which the schoolboys found in the stream were Gordian worms. They came out of the body of an insect, in which they had spent their youth as parasites, usually troubling their host very little. After producing eggs and fertilising these, the adult horse-hair worms die; but the eggs develop into larvæ, which enter insects and grow up there. And so the story goes on. It is much more wonderful than if the horse-hair worms were the outcome of soaking horse-hairs in water. For that would be magic.

By the Light of the Moon.

To understand life-histories one must try to connect the different chapters with changes in the outside world. Thus it is plain that winter is naturally a resting time and summer an energetic time; and so on. The internal tides of life are connected with external changes. This kind of inquiry is still very young, and we cannot give more than a few illustrations.

Mr. H. Munro Fox, Fellow of Gonville and Caius College, Cambridge, has recently made an interesting inquiry into the connection between the phases of the moon and the reproduction of sea-urchins. He quotes passages from ancient authors, from Aristotle to St. Augustine, which show a widespread belief in the influence of the moon on the life-curve of "shell-fish" and other marine animals. The typical story is: "Luna alit ostrea et implet echinos." In the second volume of the "Philosophical Transactions" of the Royal Society, published in 1667, travellers to the East Indies are asked to inquire "whether those shell-fishes that are in these parts plump and in season at the full moon, and lean and out of season at the new, are found to have contrary constitutions in the East Indies."

The belief that the size and seasonableness of certain marine animals vary with the phases of

the moon is held to-day in the fish-markets around the Mediterranean and in the Red Sea. Mr. Munro Fox writes: "At Suez sea-urchins and crabs are said to be 'full' at full moon and 'empty' at new moon, and at Alexandria the same thing is said of mussels and of sea-urchins, the Tarentines believe that oysters are fattest at full moon, while at Nice, Naples, Alexandria, and in Greece, urchins are said to be fullest at full moon." In the case of crabs the reference is to the size of the muscles, which become much smaller when the animals are going to moult their shell; in the case of sea-urchins the reference is to the reproductive

Photo: John J. Ward, F.E.S.

GIANT PUFF-BALL (*Lycoperdum giganteum*), GROWN IN ONE NIGHT.

The puff-ball portion is only the fructification, and the supplies of soil-water come from hundreds of thousands of underground threads.

Photo: John J. Ward F.E.S.

GIANT PUFF-BALL, TEN DAYS OLD, FORTY-FOUR INCHES IN CIRCUMFERENCE AND ELEVEN INCHES IN HEIGHT.

The rapidity of growth is very remarkable. An American specimen of *Lycoperdum bovista* was fifteen and a half feet in circumference.

organs or gonads which form the only edible part.

The question which Mr. Munro Fox tackled was whether the ancient and widespread supposition has a basis of fact. His answer is somewhat surprising. He found that the supposition is untrue for mussels and sea-urchins in the Mediterranean, and untrue for mussels and crabs in the Red Sea, but true for the sea-urchin found at Suez—which is quite different from the common Mediterranean species. In the large Suez sea-urchin, often called Diadema," the gonads undergo a cycle of growth and development corresponding with each lunation throughout the breeding season. Just before full moon the ovaries and testes are at their greatest bulk, filled with eggs or with spermatozoa respectively, which are spawned into the sea at the time of full moon. The shrunken gonads then gradually fill again with ripening sexual products to be shed at the next full moon." This is a remarkable conclusion, not only as a

Photo: John J. Ward, F.E.S.

GIANT PUFF-BALL COMPARED WITH A TWO-POUND LOAF.

The outer coat flakes away and an opening of the inner coat near the top allows of the escape of thousands of spores. A knock or a gust brings them out like puffs of smoke.

Photos: Harold Bastin.

GROWTH OF ANTLERS ON THE WAPITI (*Cervus canadensis*).

The three photographs, taken on March 20th, April 17th, and May 14th, show the prodigious growth of these hard bony structures. The supplies for the growth are brought by blood-vessels in the substance of the antlers, and there are also numerous blood-vessels in the soft sensitive skin or velvet that covers them.

statement of a puzzling scientific fact, but also because it indicates that the old story which was current in Mediterranean countries is untrue of that region, yet based on fact at Suez. It is suggested that in ancient Egypt the belief began at Suez, that it spread to Greece, and that it was accepted without verification for the Mediterranean shores in general.

Here then is a well-established biological fact, a certain Red Sea Echinoid shows a periodic reproductive cycle corresponding to the lunar month. But what is the meaning of the periodicity? Why is it that the eggs and sperms are spawned about the time of each full moon until the breeding season closes in September? Why is it that a fresh crop begins to be formed during the declining phases of the moon? There may be some external influence which acts on the germ-cells throughout their growth and multiplication, and comes to a climax when the moon is full. Or, more probably, there is some influence at the time of the full moon which has a trigger-like action on the reproductive organs which have become full of germ-cells. But all this is rather in the air unless we can specify what the external influence is. Perhaps it is tidal, and there are some marine animals that are known to spawn at spring tides. Yet this is not a very easy theory. One difficulty is that the Suez sea-urchin has a single reproductive cycle in each lunation, which includes two spring-tide and two neap-tide periods. Perhaps, as Mr. Munro Fox points out, this is not a fatal objection to the tidal influence theory, "for during the summer months at Suez the new-moon spring tides have a greater range than the full-moon springs, so that the maximum tidal range is attained once only during each lunar month."

If the external influence is not tidal it may perhaps be the *light* of the moon. Now it has been noticed in some rivers that there is a maximum frequency of minute Algæ and minute crustaceans (water-fleas) at full moon. As the crustaceans feed on the Algæ, the problem narrows itself to the occurrence of the Algæ; and it may be that the moonlight is an appreciable factor in photosynthesis. That this is the case has been alleged for a common green organism called Euglena, where Knauthe found a photosynthetic effect of moonlight with a ratio to that of sunlight of 2:9. But when Munro

Fox tried this experiment for the Canadian pondweed, he found that the amount of photo-synthesis was, if any, very small—less than 0·013 that of sunlight. So this remains inconclusive at present.

It has been proved, however, that moonlight is not without its influence on plants, for instance, in hastening the germination of seeds and in causing leaves to open their stomata at night. There are some plants that turn to the moon, as the sunflower to the sun, and there are some seaweeds that produce a crop of sex-cells once or twice in each lunar month—again suggestive of tidal influence.

Story of Palolo Worms.

The best-known cases of lunar periodicity in reproduction are those of various marine worms that are called "Palolo." In the Palolo (*Leodice viridis*) of Pacific coral reefs, the reproductive crisis occurs at the last quarter of the moon in October and even more markedly at the same time in November. The head-end of the worm is kept fixed in the crevices of the coral, while the posterior body, laden with germ-cells, is broken off and set adrift. These headless sections of worms burst in the water, liberating the germ-cells. For a short time the sea is green with "worms," like thick vermicelli soup, and the eye cannot penetrate below two or three inches. The natives collect the delicacies and have a great feast, and even the land-crabs arrange a visit to the worm-strewn beach. The fertilised egg-cells develop into free-swimming larvæ. Many perish, of course, but there is a large margin of safety. The head-ends in the coral are also able to regrow what they have set adrift. There is an evasion of the death-penalty, which is often incident on giving origin to new lives.

The Atlantic Palolo worm (*Leodice fucata*) of Samoa and the Fiji Islands, behaves in much the same way, but its date is different. The swarming usually occurs within three days of the last quarter of the moon between June 29th and July 28th. According to Dr. A. G. Mayer's description, the mature worm backs out of its burrow, two fathoms down in the coral, and liberates its posterior segments—salmon-red or dull pink in the male, greenish-grey or drab in the female. These swim to the surface and wriggle about there, hind-end foremost. "When the sun is about to rise, and the first faint rays

Photos: Harold Bastin.

The three photographs, for June 12th, September 4th, and October, continue the story of the antlers of the Wapiti, which is often badly called the American Elk. The September photograph shows the dead velvet dropping off in shreds. In October the antlers are bare. Eventually the gorgeous growth is shed, and next season the process begins again.

Photo: John J. Ward, F.E.S.

SYCAMORE BUD, APRIL 30TH.

A bud is a young shoot with young leaves, the whole enclosed in protective bud-scales, in this case varnished.

of light fall over the ocean, the worms begin to contract violently"—so violently that they burst. Light is not the sole, but a contributory cause of the muscular spasms. It may be noted that when the third quarter of the June-July moon falls late in July, the Atlantic Palolo has an earlier swarm at the first quarter. The distantly related Japanese "Palolo" swarms at the time of both the new and the full moon in October and November, and there are other cases of bi-lunar, apparently tidal, periodicity.

Dr. Mayer made two very interesting experiments. Thirty days before swarming was due he put some pieces of rock with eleven worms in them in a scow-shaped live-car, which was floated, half-full of water, on the sea. In this artificial "tideless" sea only four of the eleven worms swarmed. This proved that the Palolo worms *can* swarm without the immediate influence of the tides, but it is quite possible that those that swarmed in the box had previously acquired a tidal rhythmicity—an engraining or enregistering well illustrated by another worm, Convoluta. Perhaps, as Dr. Mayer suggests, the other Palolos in the box would also have swarmed if the circulation of water had been more perfect. In his second experiment Dr. Mayer provided the scows with light-tight wooden covers. The moonlight was thus excluded, and out of twenty-two worms none swarmed. This suggests that the moonlight is a necessary liberating stimulus. Unfortunately, if one may so say, subsequent experiments by Dr. Treadwell yielded an opposite result! More trials must be made and with larger numbers. It might be useful to try to keep individuals apart, for Mr. Munro Fox calls attention to an interesting fact, that when sea-urchins are ripe, a spawning male stimulates adjacent ripe individuals of both sexes so that they also spawn. A spawning female also stimulates ripe males to spawn. This simultaneous spawning makes the fertilisation of the liberated ova more certain. Similar facts have been noted for one of the Nereid worms; so they may apply to the Palolos.

What has been established by Mr. Munro Fox

Photo: John J. Ward, F.E.S.

THE SYCAMORE'S OPENING BUDS, MAY 4TH.

As the sap from the stem reaches the buds, which were made in the abundance of the previous summer, growth begins afresh.

Photo: John J. Ward, F.E.S.

YOUNG LEAVES OF THE SYCAMORE, MAY 6TH.

As the growth of the leaves recommences under the influence of water and sunshine, the bud-scales are burst and fall to the ground.

is that the large Diadem sea-urchin of Suez spawns punctually month after month, from spring to autumn, at the full moon. It is probable that the influence is of the nature of a trigger-pulling stimulus, for five individuals (of another species) examined had ripe eggs in abundance nine days after spawning, and it may be inferred that the germ-cells are ready long before the full moon. The extrusion of the germ-cells is due to the contraction of muscle-fibres in the walls of the reproductive organs, and it is probable that the outside stimulus acts on these through the nervous system, which is of a low order in sea-urchins. What the outside stimulus is, remains uncertain. Does it operate through the tides, or is it due to the light of the moon, or to both, or to neither?

We have given this case in some detail, though it is not very conclusive, because it points the way to a new kind of study—an inquiry into the rôle of outside changes in punctuating the internal changes of living creatures. Perhaps it should not be called "new" since there are old-standing beliefs connecting such changes as those of moon and tide with vital rhythms in man and beast; but what is new is *the precise study* of the real or supposed influences.

Growing and Ageing

Behind all the life-histories with their fascinating variety, there looms the large fact of Growth—a fundamental characteristic of living creatures. Everyone has heard the saying of Linnæus: "Stones grow; plants grow and live; animals grow and live and feel." But it requires some modern correction. For we know that plants have several senses, and even a tree, as Sir Jagadar Bose has proved, may answer back to a passing cloud. And as to the growth of "stones," it may be doubted whether the increase in the size of a crystal is more than remotely comparable to the growth of a sapling or of a young bird. When a small piece of crystal is placed in a somewhat concentrated solution of the same substance, or of another substance with an identical mode of crystal formation, it increases in size in an

Photo: John J. Ward, F.E.S.

EXPANDING LEAVES OF THE SYCAMORE ON MAY 15TH.

What was laid down in 1925 is unfolded in 1926; the young leaves of the bud become the unfolded leaves of the growing shoot, and the tree is covered with green.

orderly and beautiful way. The molecules in the solution are attracted to the surfaces of the little piece of crystal, and, uniting into little groups or " crystal units " are added on to the already existing edifice. But the living creature absorbs its food, transforms it, and uses it to increase its body from within. This is very different from crystal-accretion or the enlargement of a rolled snowball. Moreover, the living creature, whether plant or animal, obtains its growth-material from food substances which are in varying degrees different from what they become. Thus the green plant utilises air, water, and salts; and the foal grows at the expense of the grass.

The power of growth must be taken at present as a fundamental characteristic of organisms, for it cannot as yet be redescribed in chemical and physical terms. The word is a convenient label for a variety of processes which lead to an increase in the amount of living matter, and while there are chemical and physical factors involved in these processes, we are bound in the present state of science to admit that growth depends on the secret tactics of life. Its results are extraordinary achievements, which would be called astounding if they were not so familiar. From a microscopic egg-cell there develops an embryo-plant which grows into a Californian " Big Tree "—perhaps three hundred feet in height and over two thousand years old. The egg-cell of a frog is under a tenth of an inch in diameter; " the mass of the human adult is fifteen billion times that of the human ovum." In the strict sense growth means an increase in the amount of the organism's living matter or protoplasm, but it is often associated, as in a cucumber, with the accumulation of water; or, as in the case of bone, with the accumulation of non-living scaffolding outside the living cells. Growth is usually effected by a multiplication of cells, but in some cases, especially in plants, there is first an increase in the mass of living matter, and secondarily a partitioning of portions of this into distinct cells—a partitioning that makes it easier for the intricate bustle of life to continue without disorder. When a nerve-fibre grows on and on, feeling its way, as it were, into the distant parts of the growing body, there is growth without cell-division; and the same is sometimes seen, even in an adult, when a muscle-cell grows greatly in length and breadth.

As Herbert Spencer pointed out long ago, the growth of a regularly shaped cell involves a disproportion in the increase of volume and surface. In spherical cells the volume increases as the cube of the radius, but the surface increases only as the square. Thus increase of volume tends to outrun increase of surface. But as it is through the surface that very important kinds of " give and take " are effected, notably the absorption of food and the getting rid of poisonous waste, a disproportion between volume and surface is hazardous. Internal changes are set up which lead to the profitable solution—cell-division. The volume is halved and the surface is increased.

Another reason why cells do not usually grow large is probably to be found in the partnership between the nucleus of the cell and the surrounding protoplasm. There has to be a certain proportion between the amount of nuclear material (chromatin and the like) and the amount of protoplasm to be controlled. When the cell becomes too large for the sway of its nucleus, division is the easiest way of avoiding disaster.

The indispensable condition of growth is that income be greater than expenditure. A variable amount of the food-income is used to meet the everyday expenses of living; the surplus is available for growth, which must be understood as including, besides increase in size, that imperceptible growth which brings about the replacement of worn-out cells by fresh ones. Green plants are great growers when compared with animals—the giant bamboo may grow a foot in a day—and that is mainly because they feed easily at a low chemical level. With the help of part of their complex green pigment (chlorophyll) the leaves are able to use a fraction of the abundant sunlight that bathes them, and build up or synthesise sugars, starch, and more complex substances. On this " photosynthesis " the growth of all animals directly or indirectly depends.

Food, as we have said, is an indispensable condition of growth, but there are some apparent exceptions of great interest. In his lucid and stimulating book called " Growth " (London, 1924), Mr. G. R. de Beer recalls the quaint behaviour of an excised median portion of a simple Planarian worm. The excised fragment has no food-canal and is incapable of taking in

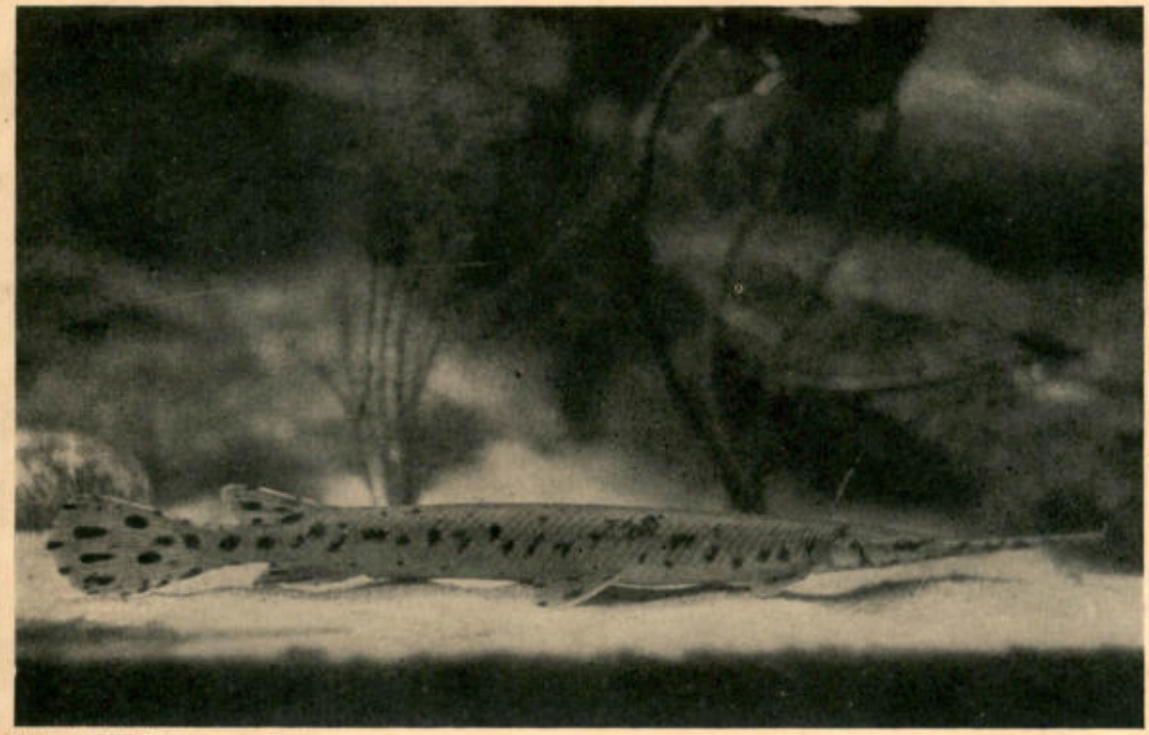


Photo: F. W. Bond.

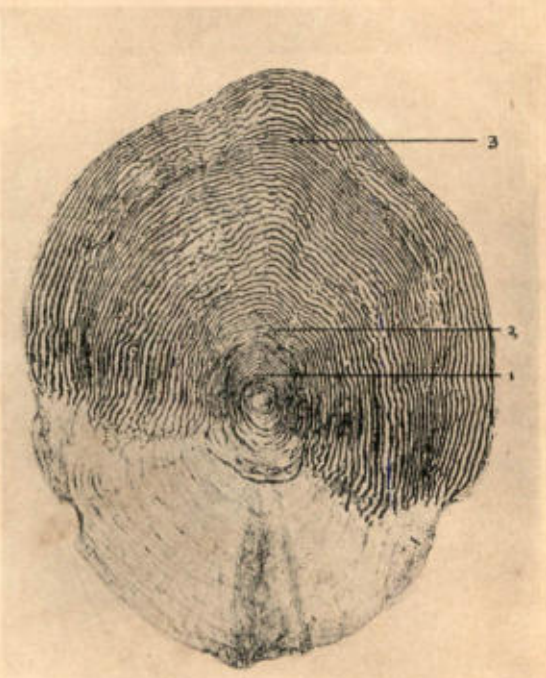
NORTH AMERICAN BONY PIKE OR FRESHWATER GARFISH (Lepidosteus).

The common long-nosed garpike (*Lepidosteus osseus*), of North American rivers and lakes may reach a length of five feet. It has beautiful four-sided scales, covered with a silvery enamel-like material called ganoin. It preys upon smaller fishes.

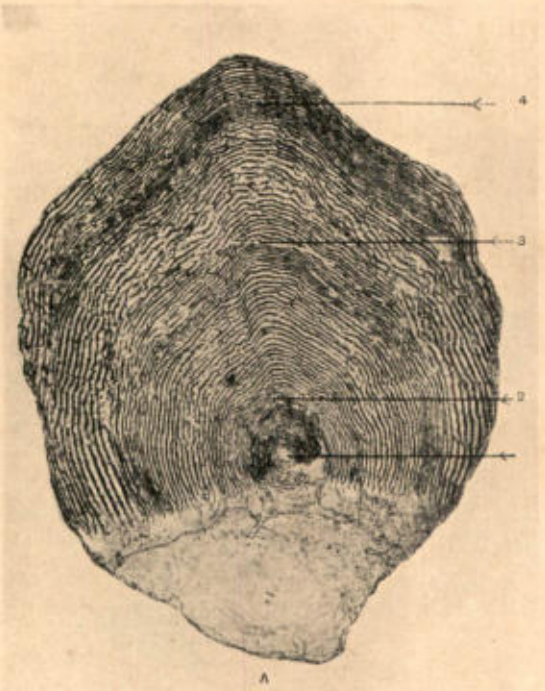
and assimilating any new material. Yet it grows a head and a posterior end, fashioning its substance afresh into the form of a complete worm. It does not increase in size, and to get building material it has to become much narrower. But it makes a perfect miniature worm! Perhaps this is rearrangement and restoration rather than growth, but it is difficult to draw the line. The case we have mentioned leads us to note that growth is often expressed in the replacement of a lost part, such as the arm of a starfish. Moreover, when growth becomes discontinuous, it leads to asexual reproduction such as the separation of buds. One of the most extraordinary instances of replacement-growth is that seen annually when the stag gets a fresh set of antlers, which may weigh seventy pounds!

When we think of the fact that the great majority of animals have a definite limit of growth, an optimum size, which is normally attained by the adult and rarely exceeded, we realise that there must be some method of growth-regulation. On the other hand, some fishes and reptiles continue growing as long as they live, just like many trees. A haddock may grow to the size of a cod. This shows that a definite size is not peremptorily insisted on in every case. Or when we think of unhealthy giants and dwarfs (to be sharply distinguished from quite vigorous giants and dwarfs), and of the rarity of their occurrence, the idea of regulation is again suggested. So also when we observe the occurrence, and yet rare occurrence, of abnormal growths among animals, we see that growth is essentially *a regulated increase* in the amount of living matter. By what means is the regulation effected? The modern answer to this question is twofold. The regulation is partly due to certain "chemical messengers" or hormones which are produced in the ductless glands and distributed through the body by the blood. Thus the secretions of the thyroid gland and the pituitary body have been definitely proved to have among their functions that of growth-control. The other part of the answer is that certain parts of the body, where vital activity (or metabolism) is very intense, such as the head end of a Planarian worm or the growing point

Scale of a smolt from the Wye, showing two years' river growth, from the centre to 1, and from 1 to 2, and beyond that a few growth-rings of the third year.



Scale from a grilse, showing two years in the river from the centre to 1, and from 1 to 2; beyond that the summer growth in the sea, 2—3, ending in a winter band; beyond that the beginning of another summer zone in the sea.



Scale of a small summer-salmon, a fourteen-pound male, showing two years' river growth, centre to 2 and two and a half years of sea-growth, from 2 outwards

Scale of a Norwegian salmon, a thirty-four pound female, showing two spawning-marks towards the periphery. (All the figures by kind permission from Mr. J. A. Hutton's "Life-History of the Salmon," 1924.)

of a plant stem, have a sway or dominance over the growth of adjacent parts. But the nature of the dominance remains a secret.

Fish-Scales.

In connection with growing it will be useful to discuss fish-scales, for they furnish fine illustrations of the recording of the rhythms of growth in a sort of living diary. The markings of the scales register the growth.

Mammals are known by their hairs, for practical purposes innumerable and not quite absent even in the case of whales; birds are known by their feathers; reptiles by their *epidermic* scales of horn; amphibians by their nakedness; and fishes by scales, which are in most cases entirely due to the under-skin or *dermis*, and are never composed of horn. In most cases the tissue-paper-like epidermis of the fish extends right over all the scales, but it is so delicate that it comes off on our finger and thumb when we grasp the animal either living or dead. When the scales are very strong and spine-like, they may pierce the epidermis and stand out nakedly.

A thoroughly scientific grouping of fish-scales is an intricate matter, but we can go a long way on simple lines. On the upper surface of a thorny skate (a thornback) there are numerous very sharp denticles, sometimes called "skin-teeth" or placoid scales. They are tipped with enamel, based in bone, and cored with dentine or ivory—with some central soft pulp into which blood-vessels pass. It may be noted that these three hard tissues occur in the order of their hardness—the enamel at the tip, the ivory lower down, the bone at the base. It seems that the enamel tip is formed by the epidermis, and the rest of the scale by the dermis. On the long tail of the sting-ray one of these scales has become a barbed spine which makes a very formidable head for a javelin. In dog-fishes and sharks the whole of the skin is densely covered by minute denticles with the same structure as the skate's skin-teeth. The sharp tips all point backwards so that the skin does not seem very rough when it is stroked towards the tail, but it feels like the coarsest sandpaper when one draws one's finger the other way. In a dried state it is used for polishing furniture and the like, and goes by the name of shagreen.

If we suppose a large scale from a skate to be reduced to its basal plate of bone, we get the kind of scale that is seen, for instance, on a sturgeon. This large and handsome "royal fish" is armoured with five longitudinal rows of stout bony plates. If such plates were to be varnished over with substance called ganöin, which is akin to ivory, the result would be what is seen so well in the Bony Pike of North America. This fish, which is no relation of the Common Pike, is covered with neatly fitting parallelograms, rhomboidal platelets of bone varnished over with ganöin, very suggestive of silvery scale-armour. It is very interesting to find that the scales of the young Bony Pike carry ivory spines which afterwards disappear. Returning to the skate's scale, we can picture it being reduced to a thin plate of ivory or sometimes of bone, and this is the kind of scale that is characteristic of the ordinary food-fishes.

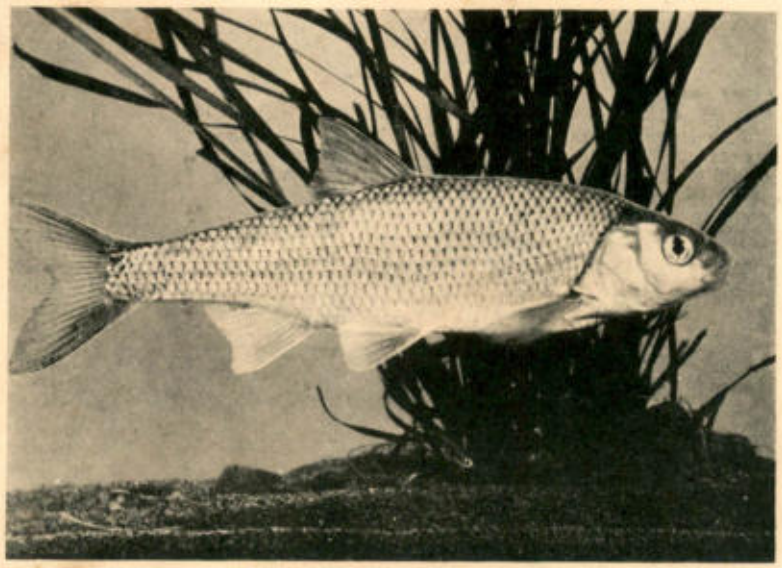


Photo: Stanley C. Johnson, M.A.

THE DACE (*Leuciscus leuciscus*).

A graceful and lively fish of clear streams in England and North Europe, of a silvery white colour, sometimes about a foot long. Its name refers to its darting movements. The scales consist of translucent vitro-dentin.

Photo: John J. Ward, F.E.S.

SCALES ON THE SKIN OF A DOG-FISH.

Each minute scale has a sharp tip of enamel, a base of bone, and a core of ivory with a little pulp in the centre. The sharp points are all directed towards the tail, so that the skin feels soft when stroked in that direction, but like sandpaper in the opposite direction.

Round the curing stations the scales of the herring are blown about by the wind; they are so delicate that they are transparent. In many cases, however, they are more substantial, and those of the tarpon are as large as oyster-shells. These scales of herring and tarpon, cod and halibut, trout and salmon, and a thousand more are called "soft" scales, for they are usually delicate and flexible, but most of them consist of a hard tissue, approaching ivory, which is technically called vitro-dentin. In some cases, as in the brilliant Bleak, this material, along with the silvery waste product guanin, which lies in crystalline form below the scales, is used as the basis of artificial or Roman pearls, which are pleasantly beautiful and would certainly be regarded as very valuable if they were made by molluscs and not by man.

Photo: John J. Ward, F.E.S.

SCALE FROM AN EEL, SHOWING ZONES OF GROWTH.

The small scales of an eel are embedded in the slimy skin and occur in little groups. As the feeding is practically confined to summer, the zones on the scale represent summer growths; the narrow interspaces correspond to the winter. Scales do not appear in the eel until the fish is between three and four years old.

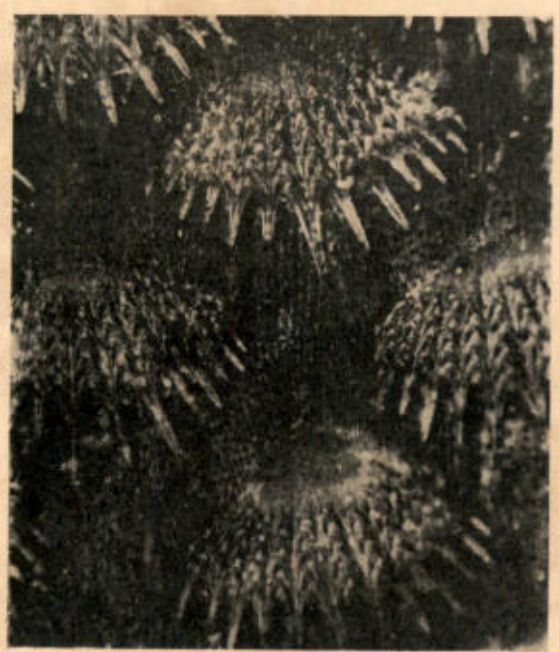


Photo: John J. Ward, F.E.S.

SCALES OF SOLE.

The posterior part of a scale projects beyond the part overlapped by the scale in front. If the margin is smooth and unbroken, as in a salmon, the scale is called cycloid; if it is toothed, as in the sole, the scale is called ctenoid, which means like a comb.

In ordinary Bony Fishes or Teleosts the scales are constant in number after larval life is over. Any one of them may be added to by marginal contributions from the dermis, but, accidents apart, the total number remains the same. If scales are lost they are not replaced, and the spot from which they have been rubbed off may

Specially drawn for this work by Warwick Reynolds, R.S.W.

GIANT PYTHON.

The pythons are large strangling snakes without any venom. There are about twenty different kinds, mostly found in the Tropics of the Old World and Australia. Some specimens of *Python reticulatus* are known to have attained a length of about thirty feet. Most of them feed on small mammals and birds.

form a sore. It is an interesting fact that some fishes, such as the American Whitefishes, are considerably put about by such a simple operation as the removal of a few scales with a pair of forceps. The wrench is sometimes fatal. It must be remembered that the scales have to be pulled out of pockets of the under-skin or dermis in which they are partially embedded. The hind part of every scale overlaps the anterior part of the one behind it, and the free hinder part is covered by the transparent epidermis only.

The appearance of a typical "soft" scale has been aptly compared to that of a finger-print. It has a central whorl called the focus, which represents the original scale of the young fish. Outside that there are numerous concentric lines —the ripple-marks of growth. Crossing these there are radiating ridges, four being a common number. But, unlike finger-prints, the scales show an alternation of light and dark bands or zones, and two of these go to a year. The light band is formed in the warmth and abundance of summer, and consists of a number of strong, complete, widely spaced circles. The darker band marks the interruption of growth during the cold and scarcity of winter, and consists of broken lines, close together and often entangled. Between this winter band and the summer band there may be a number of incomplete circles, marking a transition period of decreasing growth at the end of summer. The details vary in different scales, but the main fact is the alternation of light and dark bands or zones, corresponding to rapid growth and to retardation or cessation respectively. The annual increase in the dimensions of the scale—especially as regards the diameter—maintains throughout life a constant ratio to the annual increase in the length of the body of the fish.

That a light and a dark band taken together correspond to a year in the life of the fish has been satisfactorily proved in the case of salmon and some other fishes, but the most satisfactory demonstration that has been forthcoming is due to Mr. Van Oosten's recent study of the Whitefishes in the New York Aquarium. These representatives of the genus Coregonus, to which our Vendace and Grayling belong, were hatched in the aquarium in 1913, so that their age is certain. The number of double bands in the scales corresponds exactly with the winters of the fish's life, not counting that of the year of hatching. Just as we can tell the age of a felled tree by counting the rings, which are defined by the contrast between spring wood and late summer wood, so we can tell the age of the Whitefish by counting the double bands, which are defined by the sharp contrast between rapid growth and its stoppage. It must be carefully noted, however, that while Whitefish and Salmon are clear cases, there are others, like the herring, where "reading the scales" is very puzzling. The science of "lepidology," as it has been called, Lepis being Greek for scale, is sometimes like the reading of hieroglyphics.

An interesting corroboration of scale-reading is sometimes obtained by making a section of the stone-like otolith that lies in the cavity of the fish's ear, for it also shows lines of growth which can be distinguished for several years. The same is true of the beautiful lines of bone-growth that are often readable on the ends of the double-eggcup vertebræ. In the salmon the scales are not only reliable as a basis for estimating age, they show much more. They indicate, for instance, how long the fish remained in fresh water before it went down to the sea, and how old it was when it first spawned. In other words, the fish keeps a sort of diary in its scales, and it is often possible to distinguish good years from bad. The experiments on the American Whitefishes go to show that when spawning is being prepared for, growth stops; and that in adult fishes it is the change in external temperature that counts for most in bringing about the winter retardation or cessation of growth. As a Scottish authority, Dr. T. Wemyss Fulton, has said: "Temperature is active in modifying the rate of growth by acting directly on the metabolism of the fish and also by affecting the rapidity of digestion. In very cold water the fishes give up feeding altogether, because the ferments upon which digestion depends do not act, or act very slowly, at low temperatures, and in fishes, as in other animals, appetite waits on digestion."

There is great variety among fish-scales. In "Trunk-fishes" the scales unite to form a rigid box; in "Globe-fishes" they are formidable spines all over the body; in some cases they are so minute and delicate that the skin has a

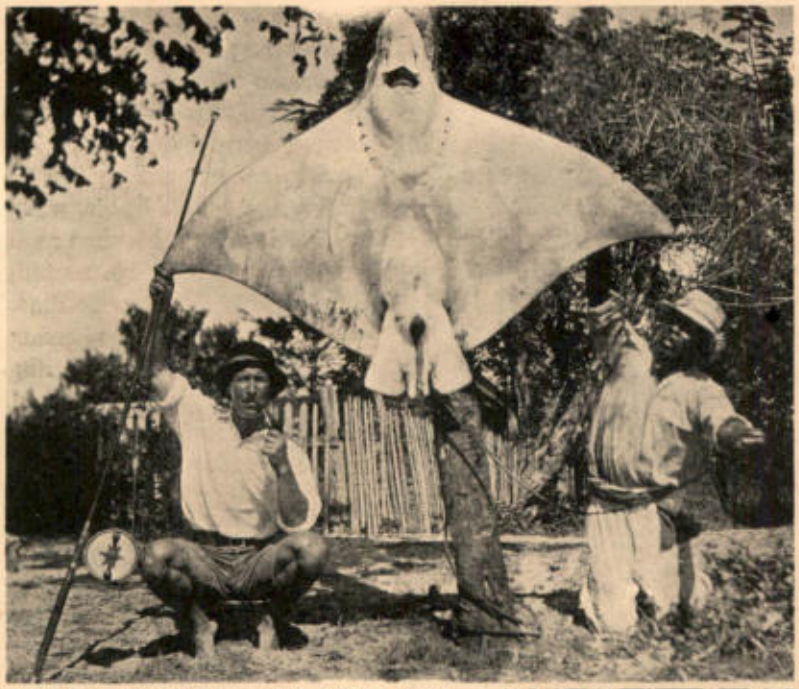


Photo: F. A. Mitchell Hedges, F.L.S., F.R.G.S., F.Z.S.

FRONT VIEW OF A GIGANTIC WHIP-RAY.

This remarkable fish, a relative of the skate, was caught by Mr. F. A. Mitchell Hedges on a rod and line. It was seven feet and a half across the "wings" or pectoral fins, which form the swimming organs. The nostrils are seen in front of the mouth, and the five pairs of gill-slits behind. The weight of this monster was 410 pounds.

velvety appearance; or they may be strangely complicated, as when they bear movable spines working in sockets. In the Common Eel scales are abundant, but they are not developed till the third year, and even then they remain buried in the skin. In the Torpedo and the Electric Eel scales are quite absent, which is somehow connected with the fact that these fishes are able to give an electric shock.

From growth we naturally pass to giants, meaning not so much occasional freaks like Goliath or a yard-long haddock, but those animals that have managed to be huge and yet well-balanced. The giants of to-day are the whales. Thus a Hump-back is credited with a length of sixty feet, a Right Whale with seventy, a Cachalot with eighty, and a Blue Whale with eighty-five—all of them prodigious. An elephant may stand twelve feet high at the shoulders, and weigh several tons. A giraffe can raise its mouth to pull the leaves from a branch of an acacia tree more than eighteen feet above the ground; and its food-canal has a length of ninety yards—as long as a creditable mashie shot.

Giant Animals.

The spread of the wings in an albatross may be eleven feet four inches from tip to tip, but it is obvious that a flying bird cannot be gigantic. An ostrich stands a little over eight feet high and weighs 250 pounds. The extinct

Photo: F. A. Mitchell Hedges, F.L.S., F.R.G.S., F.Z.S.

DORSAL VIEW OF THE SAME WHIP-RAY.

The whip-tail, which is a formidable weapon in these fishes, was in this case nine feet and a half in length! All over the back there are strange white spots, well brought out in the fine photograph.

Æpyornis of Madagascar stood about sixteen feet high, and, if it was built like an ostrich, it must have weighed about 1,500 pounds. Among living reptiles the largest are pythons, which may reach a length of ten yards. A "mugger" crocodile may be twelve feet long and still growing at that; a gavial from the Ganges may exceed twenty. The circumference of the carapace of a giant tortoise in Mauritius measured eight feet six inches and its weight was about 350 pounds. But what are these dimensions compared with those of some of the extinct giant reptiles, such as Diplodocus forty feet long, Brontosaurus sixty, and Atlantosaurus over one hundred, with a thigh bone as high as a very tall man?

Modern amphibians are small, tending indeed to be pigmies. Even the Giant Salamander of Japan, which has been known to reach a length of five feet three inches, is small compared with the extinct Labyrinthodont amphibians of the Trias, one of which had a skull nearly a yard long. It is hard to think of an amphibian as big as a donkey!

Since aquatic animals are supported by the water, a large size is practicable. Thus, like the mammalian whales, the Basking Shark, among fishes, may be forty feet long, and weigh twenty tons. The still larger Rhinodon is credited with a weight of a hundred. The oar-fish or "king of the herrings" is sometimes over twenty feet long, but it is lightly built. The very substantial sturgeon may reach a length of eighteen feet and a weight of over two tons. A sword-fish of fifteen feet will weigh a ton, and the tarpon, which gives such good sport off the coast of Florida, reaches a length of six feet and a weight of one hundred and ten pounds. A single scale is over two inches in diameter! Another large and heavy fish is the tunny, peculiar in its high temperature. It may be ten feet long and weigh well over half a ton.

Photo: F. A. Mitchell Hedges, F.L.S., F.R.G.S., F.Z.S.

GIANT GREEN OR EDIBLE TURTLE (*Chelone mydas*).

This huge turtle was caught in a net by Mr. F. A. Mitchell Hedges, who photographed it and set it free. A length of four feet has been recorded. These edible turtles feed on seaweed along the coasts of the Atlantic, Indian, and Pacific Oceans.

There are not many giants among backboneless animals, but there are some. From time to time Squids have been reported with a body fifteen feet long, not counting the arms; and this would imply a weight something like that of an elephant. The arms of another giant

Photo: Harold Bastin.

AFRICAN GOLIATH BEETLE COMPARED WITH SEVEN-SPOT LADYBIRD.

These giant beetles may attain a length of four inches, as in *Goliathus druryi* from the Gold Coast. In the male there are peculiar horn-like processes on the head, and on the front of the thorax. It is not known that they are of any use.

cuttlefish, Architeuthis by name, have been described as thirty or even forty feet long, to which must be added ten feet more for the body. And if it be said that these dimensions of Architeuthis were measured in American waters, how can one get past the case of one captured off the coast of Ireland with arms thirty feet long and eyes about fifteen inches in diameter—a very creditable sea-serpent for St. Patrick's Island. Speaking of large molluscs, we may recall the Giant Clam (Tridacna) of Eastern seas, whose shells are sometimes used as holy water fonts. There are two enormous valves in the British Museum which weigh 154 and 156 pounds respectively; and still heavier shells are known. The flesh of a big Tridacna, which Captain Cook found to be very palatable, weighs about twenty pounds, much of this going to form an enormous muscle which closes the massive valves. A man's hand or foot caught in their grip is not easily saved.

It would not be fair to include in our review the huge blocks of madrepore coral which are seen on most reefs, for these are animal-colonies with thousands of individual polyps; but we must mention two genuine back-boneless giants. One of them is the Giant Crab (Kæmpfferia), of Japanese waters, believed to be the largest living crustacean, sometimes spanning from one outstretched claw to the other as much as eleven feet, about the same as the wing-span of a big albatross. This is true for the male crab only; the female is built on a much smaller scale. Here it may be noted that some of the huge lobsters brought to the fattening ponds at Roscoff, in Brittany, are about twenty inches in length, without including the long feelers. They may weigh as many pounds as they measure in inches. We saw some betasselled with seaweed, that were a yard long, counting the outstretched antennæ.

The other giant backboneless animal we wished to recall is an Arctic jelly-fish, a near relative of the blue and the amber-coloured Cyanea that is common round our coasts. In cold waters the life-processes are much slower than usual; the vital expenditure is greatly reduced, so there is more surplus for growth. Thus in Polar and in abyssal regions there are often forms that are gigantic for their race, and the Arctic Cyanea has been known to have a disc-diameter of seven and a half feet, with

tentacles trailing behind it in the sea for 120 feet. This must be by far the longest backboneless animal, and, like the big cuttlefishes, it would make a reasonable foundation for a sea-serpent story. When we think of whales, pythons, gavials, sharks, cuttlefishes, and Medusæ, we realise that there are a good many giants still living.

In many different groups of animals there has been an emergence of giants; but in most cases they have been short-lived, as geologists call short. Thus the giant ammonites, amphibians, and reptiles had their respective Golden Ages, and ceased to be. The Moa, which stood about twelve feet high, lasted till four or five hundred years ago, but it followed the still larger Æpyornis into extinction. The mammoth had a long survival, but it disappeared from the stage as surely as the great Megatherium, a ground-sloth as big as an elephant, or the huge Diprotodon, a giant-kangaroo the size of a rhinoceros. Why is it that the giants are doomed?

Large size is apt to mean conspicuous exposure to enemies, sluggishness of movement, and huge nutritive demands. All these imply an increase in the chances of death, a decrease in the chances of racial survival. There may be counteractive adaptations, such as taking to the water, or seeking out the deep sea, or becoming nocturnal; but these only stave off the evil day. It is also probable that increase in size and weight beyond certain limits, which differ widely from type to type, involves physiological difficulties, mainly dependent on the simple fact that the increase of the volume of living matter to be kept alive tends to outrun the increase of the alimentary, respiratory, and excretory surfaces, by which the keeping alive is effected. There are, for

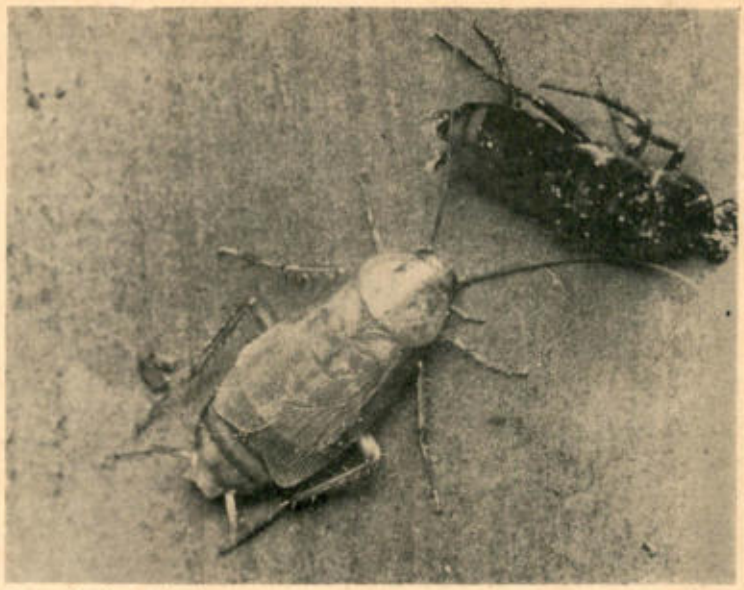


Photo: M. H. Crawford.

NEWLY MOULTED COCKROACH (*Blatta orientalis*).

This cockroach takes about five years to become full grown, and undergoes five moults. The newly moulted creature is white; only at the last moult is there a clear appearance of wings, and in this species they remain rudimentary in the female. The fully formed insect draws itself out through a crack along the middle line of the back in the thorax. In the case photographed, it proceeded to eat up its cast clothes.

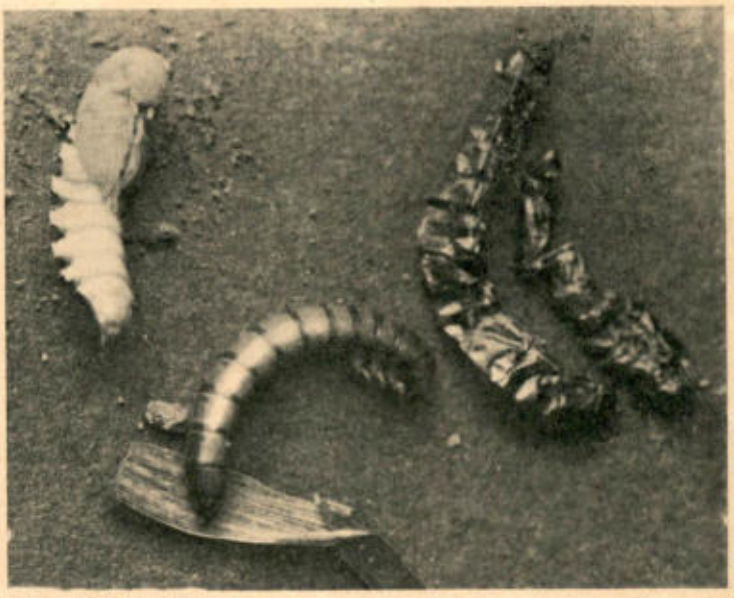


Photo: M. H. Crawford.

GRUBS OF MEALWORM BEETLE MOULTING.

Mealworms are the larvæ of a deep brown-red, almost black, beetle (*Tenebrio molitor*), about half an inch in length. The grubs are almost twice as long, narrow and yellowish. They feed on meal and flour, and moult several times before they sink into the mummy-like pupa stage, which bears curious projections on its sides posteriorly.

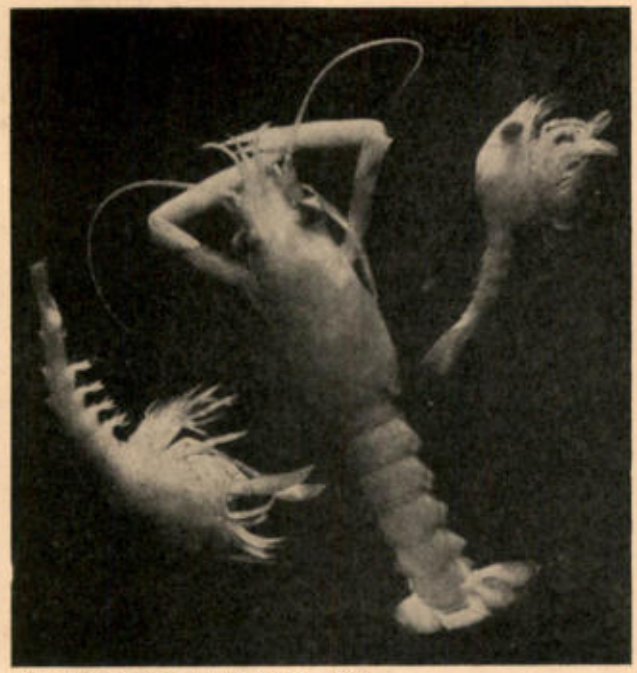


Photo: F. Martin Duncan, F.R.M.S., F.Z.S.

LARVAL STAGES OF THE LOBSTER.

First, second, and third stages in the life-history of the lobster. The eggs develop under the tail of the mother, attached to the swimmerets, for ten to eleven months. The newly hatched larva is about one-third of an inch long, and is called a Mysis. It has no appendages on its tail, and swims near the surface. After five or six months it sinks to the bottom and becomes a miniature lobster.

instance, good physiological reasons why insects, with their peculiar mode of respiration, by branching air-tubes, cannot become large except at a great risk. An accumulation of energies has been an important factor in organic evolution, but it may readily be carried too far. Giants illustrate a momentum that is apt to be fatal. To some extent, again, they probably represent a failure in the usual growth-regulation, whether effected by pituitary and other hormones, or in some even subtler way. The giants have constitutionally forgotten the motto: *Ne nimium*—which means that you may have too much of a good thing, even such a good thing as capital.

The Casting of the Shell.

Among jointed-footed animals, like insects, spiders, crustaceans, the life-history is, so to speak, punctuated by the frequent occurrence of a remarkable process called "moulting." Everyone knows how mammals cast their hair, especially at certain seasons, and how birds moult their feathers, and there is the less familiar "sloughing" of snakes. As these changes of dress differ not a little from the shedding of the old husk that is seen in Arthropods or jointed-footed animals, there is some need for a special name, and the word used in reference to Arthropods is "ecdysis." The use of a special technical word is to avoid calling different things by the same name, which always leads to confusion of thought and blurred pictures. We need not use the word "ecdysis" if we clearly understand that what a crab or a caterpillar or a growing spider throws off when it "moults" is a husk or cuticle that never had any life in it, whereas hairs and feathers and sloughs were for a time built up of genuinely living cells. A true cuticle is a pro-

Photo: F. W. Bond.

MOULT OR CAST CUTICLE OF A LOBSTER.

In the moulting process the whole of the shell is cast off and the animal draws itself out through a split at the junction of the tail and the anterior body (or cephalothorax), where the photograph shows a break. The front of the body, with the associated limbs is drawn out first, and then the tail part (or abdomen). A lobster ten inches long has moulted twenty-five times.

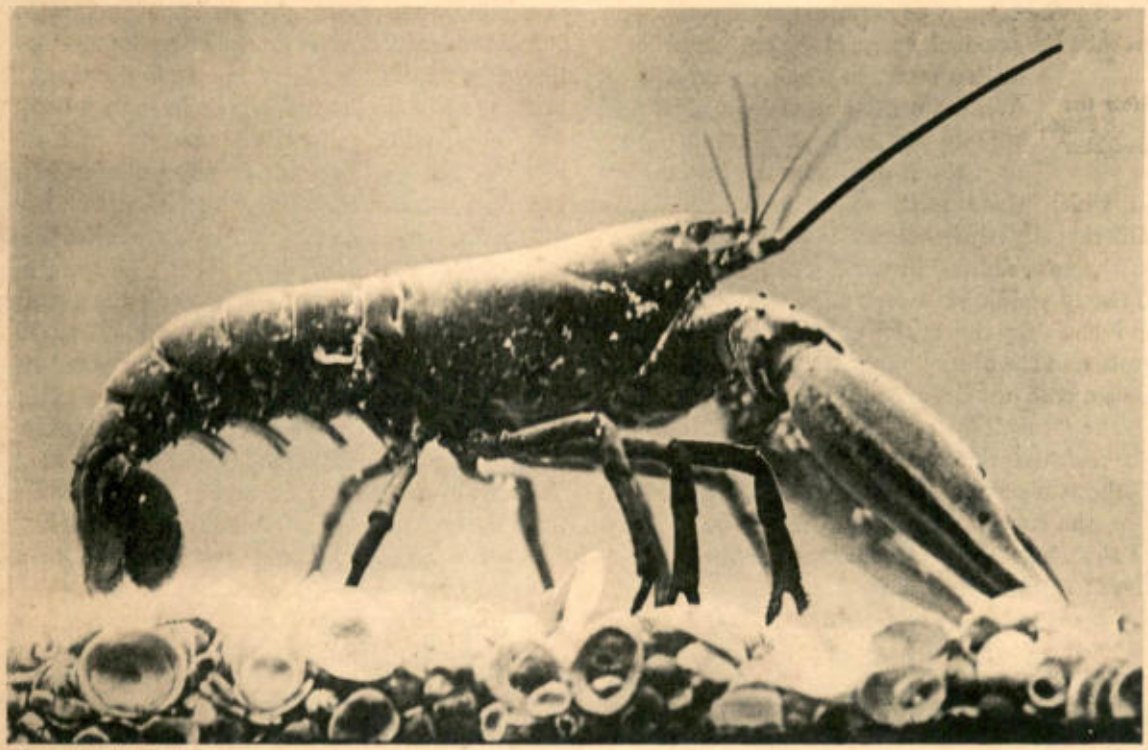


Photo: Neville Kingston.

COMMON LOBSTER (*Homarus vulgaris*).

On the front of the head are the small feelers or antennules, each with two branches, and the long feelers or antennæ, longer than in the photograph. Behind the little feelers are the large stalked eyes. Behind the great claws are four pairs of walking-legs. The tail bears small swimmerets and a terminal pair of large paddles, which are jerked forwards in swimming. Thus the lobster swims tail-foremost.

tective outer layer, without cells and without life, which is made and also remade by the underlying living skin. It has to be thrown off because it cannot grow.

The first animals to show clear casting of the cuticle are the threadworms or Nematodes, whose skin is covered with a firm, glistening, non-living membrane which does not allow the animal to grow larger after it becomes firm. But much better illustrations are found among the jointed-footed animals, where the cuticle is much thicker and firmer than in the threadworms. In centipedes, insects, spiders, and scorpions, the cuticle is made of a very resistant material called chitin ; in crustaceans this chitin is usually strengthened with carbonate of lime, as in crabs and lobsters which are very strongly armoured. As regards insects, except in Mayflies, there is no moulting after the wings are formed, for there is no more growing after that. In other words, insects do their growing and moulting when they are young, and that usually means in their *larval* stages, when they are, for instance, caterpillars, grubs, or maggots. A caterpillar often moults five times, but a butterfly or moth is free from all trouble of this kind. In insects like locusts, grasshoppers, and crickets (Order, Orthoptera), there is no worm-like larval stage, but what comes out of the egg is, on the whole, like the full-grown creature, except that there are no wings. There is rapid growth and a succession of moults ; but in the final full-sized stage the wings appear (unless it be a wingless Orthopteron), and after that there is no more moulting. The important big fact is that moulting or ecdysis is necessary because the cuticle cannot grow in a living way and has very little power of expansion in a non-living way. If the animal grows there must be moulting, and there is a spurt of growth after each moult, before the new cuticle has hardened. Compared with crabs and lobsters and other Crustaceans, there is an improvement among insects for they get done with all their moulting in their juvenile stages. The moulting is part of their " growing pains."

To understand this moulting more clearly, let us take the particular case of the crab, and begin with a common seashore experience. When we lift seaweed, or shift and replace stones in a shore-pool, we sometimes disclose a miniature cave in which there seem to be two shore-crabs differing slightly in colour. If we lift the brighter of the two, dressed in vivid grass-green, we feel its body yielding between our finger and thumb. It is as flabby as wet cloth. It is a newly moulted crab, and the other " crab " is the cast-off shard. It is a case of substance and shadow !

How the Crab Sheds its Shell.

The " moult " of a crab is a perfect image of the crab that has moulted. Every detail is there —the two pairs of short feelers, the husk of the eye, the covering of every limb, and the shard of the whole body. It is easy to distinguish the moult from a dead crab that has been cleaned up in the sea, for the carapace or shield-portion of the moult divides in your hand into an upper and a lower half, along a twisted line going right round the body. This is the splitting or moulting line, and its meaning is plain. It is the line of breakage which allows the crab to get its body out. When the animal has managed to clear not only the broad shield-like carapace portion, but also the tail which was tucked up underneath, the husk falls together again and lies like a ghost of the former tenant. It is a pleasure to pick up the ghost and open it along the clean-cut moulting line, for then one sees that the crab has left behind it the covering of all the numerous gills. One can also see the tendons of many of the muscles. The moulting is very thoroughgoing.

We must understand that the shell or external skeleton of a crab or a lobster is very different from that of an armoured backboned animal like a tortoise. The scales of a tortoise are built up of living horn-making cells which add to the size of the scale as life goes on. But the shell of a crab, as we have already seen, is non-living. It

Photo : F. W. Bond.

MUSK OX SHEDDING ITS COAT.

This Arctic cud-chewer (*Ovibos moschatus*), related to both cattle and sheep, used to live in northern Europe and Asia, as well as in North America, but is now confined to the New World, north of Hudson Bay. Its long dark hair, which sometimes reaches the ground, is shed in a somewhat untidy fashion.

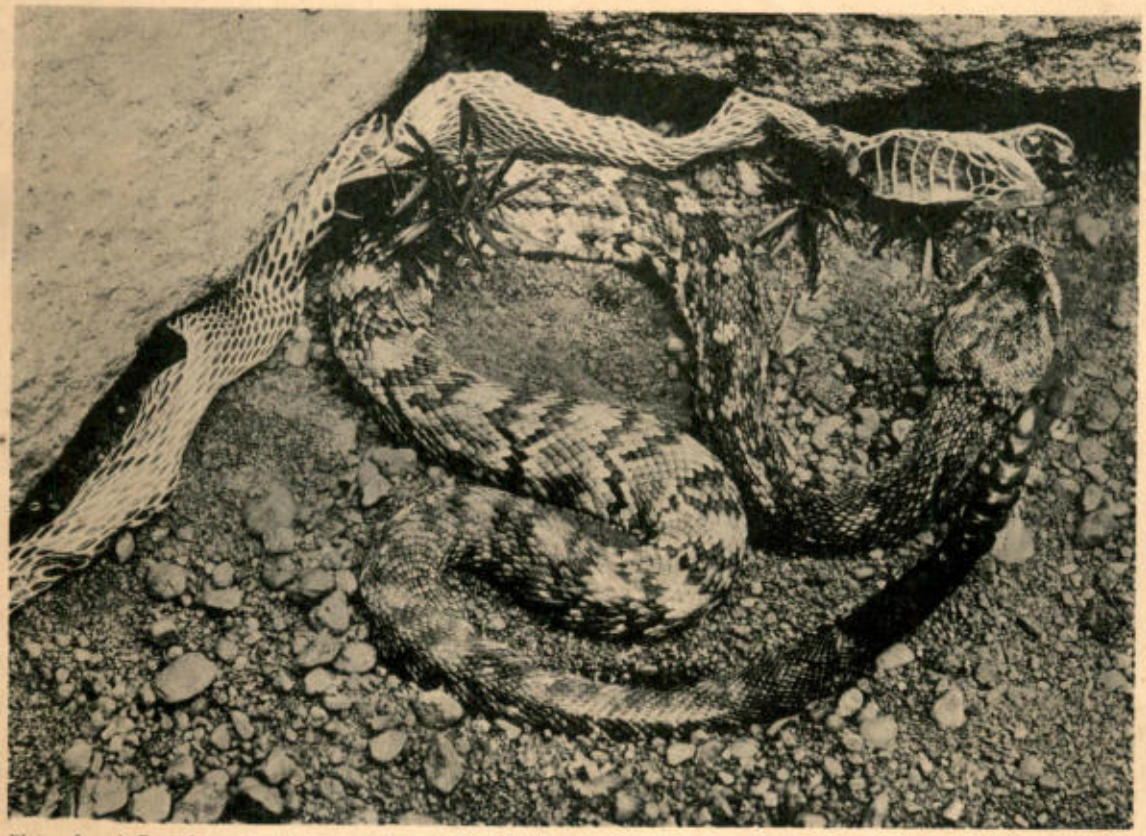


Photo: James's Press Agency.

RATTLESNAKE (Crotalus) AND ITS SLOUGH.

The "slough" of a snake is the outermost layer of the epidermis that covers the scales and shows their imprint. It is peeled off in a piece, being turned inside out; and in the rattlesnake an addition to the rattle is made at every moult. But some of the "bells" of the rattle, shown in the photograph, are dropped off from time to time.

is a cuticle, made and remade by the underlying living skin. It is made of the resistant organic substance called chitin, and also of carbonate of lime, which makes the husk still more substantial. Such, then, is the armour in crab and lobster and all their relatives, very strong but not too heavy, very durable and quite callous except where delicate sensitive bristles project. First-class armour, with well-protected flexible membranes at strategic points, such as the joints of the limbs. But the tax to be paid on this armour is moulting. The animal inside the husk is a growing creature, but the non-living husk cannot grow. The creature comes to be like a young knight condemned to wear the suit of chain-armour which was given to him when he first mounted a horse. The growing crab or lobster is always getting into physiological difficulties; it is always becoming too big for its clothes. Hence the necessity of moulting; hence also the spurt of growth that takes place immediately after the casting of the old cuticle, before the new one has had time to harden.

In the case of the fresh-water crayfish, which is found in some of the rivers of England, there are seven moultings in the first year of the animal's life, five in the second, three in the third, and then a further reduction till moulting stops altogether. The meaning of the series—7, 5, 3, 2, 1 is very clear, for the rate of growth is greater in early life. It gradually wanes so that the need for moulting occurs at longer intervals. It finally stops, for growing has stopped. We see crabs and lobsters with clusters of barnacles and other encrusting animals on their shells, proving that there has been no moult for a long time. These big crabs and lobsters have either reached their limit of growth, or they have stopped growing for several years. Moulting is the tax that jointed-footed or

Arthropod animals have to pay for their armour, but when they stop growing the tax is remitted. Taxation because of armaments is not confined to crabs and lobsters!

As we have said, the moulting of the cuticle is very thoroughgoing. The muscles of the limbs have to be drawn out of their encasements, and the tendons, which are non-living strips of chitin, have to be left behind. The covering of the eye has to come off and the lining of the ear has to be surrendered. The elaborate grinding mill or gizzard, which one finds inside the crab or lobster, arises as an intucking of the outer skin, and it follows that its cuticle-lining, with hard crunching teeth and sifting bristles, has also to be relinquished. As a matter of fact, the lining of the gizzard breaks down and is ejected from the mouth! The internal chewing apparatus, for such it is, has to be made afresh after each moult. All this scrapping and beginning again means an expenditure of vital energy; and it is fatiguing.

Moreover, there is considerable risk of breakage, especially during the extraordinary process of drawing the strong muscles of the limbs through the narrow joints. The difference in architectural idea between the backboned animal and the Arthropod is very striking, for in the former the muscles are outside the skeleton, whereas in the latter they are inside. The skeleton of a backboned animal is a living growing skeleton; that of a crab or lobster, beetle or scorpion, is non-living and non-growing. Yet if any animals have "growing pains," the moulters must surely have them.

Another aspect of the case is the helpless state of the animal just after moulting. It is soft like wet cloth, and at the mercy of its enemies. Naturally enough it retires from public life at this time and makes the moulting as private an affair as possible. It is safe to say that few people in Britain have ever seen a lobster moult. And apart from these risks, what a state the creature is in! It has lost the covering of the eye, the lining of the ear, and the tendons of its muscles. It has dismantled its gizzard and given away its jaws. To stand on its own legs is out of the question; so it lies low and says nothing.

Photo: Neville Kingston.

SOUTH AFRICAN GROUND HORNBILL, MOULTING.

The hornbills of Africa, India, and Australia are marked by an enlargement on the top of the strong bill. Moulting makes a sorry spectacle of many birds for a short time, as this photograph well shows. The tail, for instance, should have ten strong feathers. Most of the hornbills feed on fruits and insects, but the one photographed is evidently disposing of a young rat.

Everyone who has eaten a lobster knows that the largest single piece of flesh lies in the second last joint of the great claws or forceps. This is the closing muscle of the formidable forceps and it is of great strength. Similar muscles on a smaller scale occur inside the other limbs—a lobster has nineteen pairs altogether—and the question arises how such relatively big pieces of flesh or muscle can be drawn through the narrow tortuous joints. It is easy for us to draw our finger out of a glove, but suppose the cavity of the glove-finger was interrupted by numerous hard partitions, leaving only narrow gaps! The answer to the conundrum is of great interest. Muscles are composed of elongated living cells, and there is a great

deal of water in them. Living matter often contains 90 per cent. of water. What happens before moulting is a great loss of water on the part of the muscles, so that they shrink to a quarter or less of their normal bulk. It is this reduction of size that enables them to slip readily through the narrow passages inside the legs. The old naturalists supposed that the muscles liquefied so that they might pass through the joints; but if they had opened a limb just before a moult they would have seen that what occurs is just the opposite of liquefaction. How much better it is to look than to guess. As Fabre used to say: Look first, and theorise afterwards.

Returning for a moment to the crab and its ghost in the shore-pool, we must ask what happens to them. The ghost or moult is soon washed away and broken against the rocks. We find its minute fragments in the sand. The flabby crab, unable to move or eat, grows at the expense of animal starch and other stores which were accumulated in its body before the moulting began. But the growth must be rapid, for the skin soon begins to secrete a new armour of chitin and of lime. A supply of lime was also laid up in reserve before the moulting crisis, and it is deposited in little patches in the new soft husk. Gradually these patches spread and join together; the chitinous matrix becomes firm; the crab is once more equipped with first-class armour, and so the story begins again. Moulting is a disadvantage attendant on a great advantage.

Along with the "moulting" of crabs and other jointed-footed animals, let us take the shedding of parts in general. We are not well off for words to designate the processes by which animals shed various parts of their body, as trees shed their leaves. The moult of a bird is very different from the moult of a lobster, and the casting of a stag's antlers is very different from the shedding of the slough in a snake, yet most of the surrenders we are thinking of have something in common; they are periodic, they have to do with constitutional or with seasonal changes and they are usually followed by the renewal of

Photo: F. W. Bond.

THE KING PENGUIN MOULTING.

This penguin (*Aptenodytes patagonica*) usually stands very erect, with the tip of the bill directed upwards. In the moulting there is a detachment of big patches of the plumage, not merely of individual feathers. The photograph brings out very clearly the flipper-like swimming wings and the rather clumsy feet.

The Shedding of Parts.

Photo: W. S. Berridge, F.Z.S.

MALE OF NORTH AMERICAN WHITE PELICAN, WITH THE DISC ON ITS BILL.

In the male of this species (*Pelecanus erythrocephalus*) there is a triangular horny excrescence on the middle of the bill. It develops at the breeding season.

what had begun to be outworn. It may be of interest to think over a representative series.

The hairs of mammals are structures with a limited length of life, and as they get old they fall off. There is a loosening of the connection between the bulbous root of the hair and the little papilla (with blood-capillaries in it) at the foot of the moat or follicle in which the hair is fastened. Thus the hair is readily shed. A new hair may be formed by multiplication and horn-making (cornification) on the part of the epidermic cells on the top of the old papilla, or a new papilla may be developed. In many cases the falling out of the hairs is so gradual, like the fall of the leaves from evergreen trees, that it is hardly noticeable. In other cases it is very marked and seasonal, as when the heavier winter coat is partially replaced by a shorter and lighter summer one; and in a few mammals, like the stoat, there is a change in colour. When there is a special moulting season the sensitive hairs or vibrissæ, such as those so conspicuous on a cat's cheeks, are not shed along with the others, but at a different time.

Photo: F. W. Bond.

MALE OF NORTH AMERICAN WHITE PELICAN, WITHOUT THE RIDGE.

After lasting for about two months, the excrescence drops off, leaving no trace. The cast discs can be gathered by the bushel at the nesting-ground.

The moulting of feathers in birds is closely comparable to the shedding of the hair in mammals, for what falls off is a specialised horny growth of the outer skin or epidermis, fed as long as it is growing by a papilla of the under-skin or dermis. But it is generally held that a new feather-germ is formed at the base of the moat before the feather is moulted, and that the old papilla dies. The moulting is periodic and is sometimes so condensed, as in ducks, that some time must elapse before the bird can fly again. All birds moult once a year, usually before their autumn flight, if they are migrants; some moult twice, like the Garden Warbler; the ptarmigan moults thrice; and some authorities regard the multiple moulting as primitive. Among the peculiarities of penguins is the moulting of the feathers in big patches, reminding one of the way in which the tangled fleece of the brown "murrid" sheep in Shetland can sometimes be pulled off in a big coherent sheet.

Mammals are marked by hair, birds by feathers, and reptiles by scales—all of them epidermic outgrowths of a horny nature.

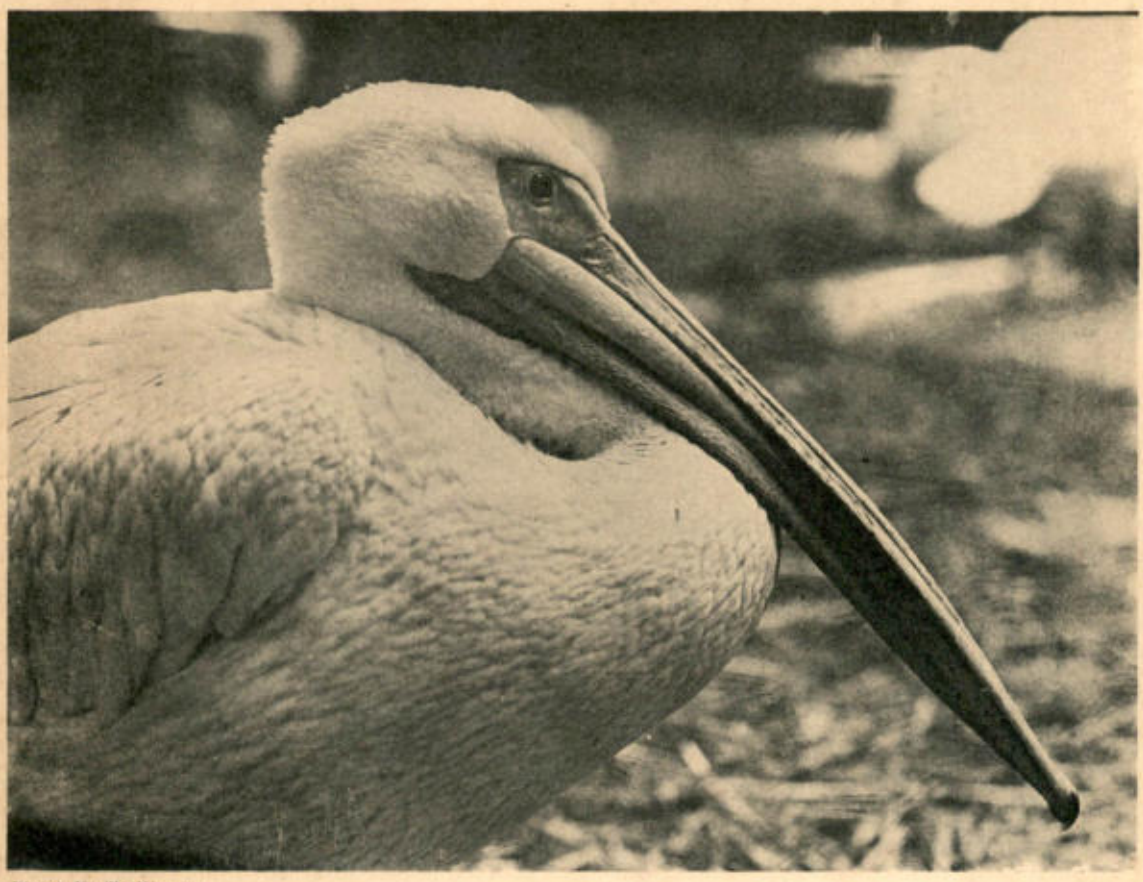


Photo: Neville Kingston.

WHITE PELICAN.

The long flat bill is hooked at the tip, and below it there is an enormous throat pouch which can be greatly distended with fish. Pelicans waddle rather awkwardly on land, but they are at home in the water, swimming and diving well. They have a powerful flight and can "sail" at a great altitude.

But no transitional forms are known between hairs, feathers, and scales; and the moulting in reptiles is very different from what typically occurs in birds and mammals. When a snake casts its "slough," what precisely does it cast? Certainly not its skin, certainly not its scales; what it casts is the dead outermost layer (the stratum corneum) of the epidermis which extends over the scales. The snake begins to moult at the lips and it gets its head clear first; it peels off the slough from in front backwards, turning it inside out, so that the tail is the last part to get rid of the old covering. The creature often helps the disrobing by rubbing itself gently against the herbage, but the peculiar feature is that the slough remains quite coherent, and we may find one among the heather like a ghost of the adder itself. When we look at it we see that it bears the imprint of each scale, including the watch-glass-like transparent covering of the front of the eye. It may be mentioned that the upper and lower eyelids are vestigial in snakes, only seen in the embryo, and that their place is taken by an immobile window-pane, which is probably the third eyelid or nictitating membrane. What we see on the slough is the outermost layer of the epidermis, which extends over the transparent lid of the staring eye.

In other reptiles there is a similar casting of the dead outermost layer of the epidermis, but it usually comes off piecemeal and inconspicuously. In chamæleons the casting is condensed into a few hours, and the quaint creature is seen for a short time as if its body were wrapped up in semi-transparent tissue paper. It rubs this off against the twigs, from the head tailwards, and the last parts to be clear are the soles of the split hands and feet. In backboned animals the skin consists of the outer epidermis and the inner dermis, the latter with blood-vessels in it.

The epidermis consists of two strata, each composed of many layers of cells. There is the outer horny stratum, the stratum corneum, and there is the deeper Malpighian stratum, which is always adding to what lies outside it. In a blister on our hand we see the horny stratum lifted off from the Malpighian stratum, and what happens in moulting is much the same. What is lifted off is the worn and dead horny layer, and the lifting off is in some cases helped by microscopic processes which grow up from the under layer of the epidermis. These are badly called "casting hairs." Their remains may be seen on the outside of the new horny layer, or as fine markings on the scales, or as the numerous bristles on the plaited toes of the gecko-lizards that are able to run up smooth walls or along the roof of a room. The occurrence of these "casting hairs" is interesting in another way, for there is a somewhat similar "hair" formation in the moulting crayfish or crab. From the surface of the living epidermis there is a growth of minute bristles which help in heaving off the old shell. But there the resemblance ends, since the cuticle thrown off in crustaceans and other jointed-footed (Arthropod) animals is a structure that never had any life in it. It is a true cuticle—a non-cellular, non-living, outer covering, made and remade by the underlying living skin.

We see then that while mammals moult hairs and birds moult feathers, reptiles do not moult their scales. What is surrendered is only the outermost epidermis that covers the whole body, outside the scales. The same stratum is worn away from the exposed parts of our own skin, such as the lips; and we may see it very clearly in the toad, for the animal peels it off with its fingers and toes and tucks it into its mouth. There is rarely any sign of moulting in healthy fishes, and the scales of fishes are in most cases made exclusively from the under-skin or dermis. If lost, they are not replaced.

Let us now retrace our steps to mammals, where there are some remarkable cases of shedding that cannot be included along with the ordinary casting of the hair. Most noteworthy is the process, so carefully studied by Sir William MacEwen, by which the stag loses his antlers. At an early stage in the development of the antlers a preparation begins to be made for their removal. It is an intricate matter, an eating away of the strong bone, extraordinarily like a disease-process that has become normal. It is preceded by the stripping off of the hot skin or velvet, and that leads one to think of what happens in the North American Pronghorn, where there is an annual shedding of the "semi-corneous" horn that covers the persistent bony core. It is said that a shedding of the horny covering occasionally occurs in a few species of antelope.

A curious case of shedding was recently described by Dr. Ernest Warren. It concerned a Zulu youth who had on each hand a little horny spur, inserted in a well-defined socket in the skin, and about two-fifths of an inch in height. Their symmetrical occurrence was interesting, and also the fact that after nine to fifteen months' growth the base of the spur would become inflamed, the whole would drop off, and a new one would begin to grow!

Among birds also there are peculiar forms of moulting. Most striking perhaps is the autumnal shedding of nine horny bill-plates in the puffin, a change that greatly alters the physiognomy of the bird. A similar process occurs in several related genera. In the white pelican of North America there is a dropping off of a curious horny triangle which grows on the ridge of the bill at the breeding season. Everyone knows that the little "egg-tooth" or "shell-opener," borne on the tip of the bill in many developing birds, drops off soon after hatching; but it is a less familiar fact that the grouse moults its claws at the end of summer. We have kept off those surrenders of parts that are summed up under the title of autotomy or adaptive self-mutilation, as illustrated by the starfish breaking off an arm, for these are plainly far away from moulting. But there are some other cases that should be included in a complete survey, such as the lamprey's periodic loss of its horny teeth and the dropping off of the viper's fangs.

Length of Life in Plants.

We think of plants as characteristically transient or ephemeral. All flesh is as grass. The grass withereth and the flower thereof falleth away. The wind passeth over it and it is gone; and the place thereof shall know it no more. On the other hand, we know that some of the "Big Trees" of California have attained

a longevity of over two thousand years, and Dragon Trees may be older still. The poet speaks of the lily of a day and of the oak standing for three hundred years. What are the broad facts of the case in regard to length of life among plants?

Beginning with very simple plants, we must allow them a monotonous immortality. That is to say, many of them are exempt from natural death. A Bacterium divides into two, and in an hour or two these repeat the process. If the environment is suitable this may go on for years, and we cannot speak of dying. There is nothing to bury. If the environment is unsuitable, the microbes lie low, and we do not know the limits of their latent life. Everyone has noticed moulds that flourish for a few days on a nourishing substratum, like a saucer of paste. They then disappear and their place is taken by another kind. This is probably because they alter the substratum in a fatal way, either by exhausting food-stuffs which are essential, or by producing poisonous substances. It is known, however, that the fungus that follows the bacteria in Salmon Disease may live for at least six years; and it must be remembered in regard to very transient fungoid growths that shoot up in a night and shrivel in the sun of their first day, that they are but the above-ground fructifications of a subterranean threadwork (or mycelium) which may persist for many years, as in mushroom-growing.

Some of our common weeds, as the patient gardener knows, show several generations in a year. They are short-lived, but they are always with us. Chickweed and groundsel, for instance, pass rapidly through leafing, flowering and fruiting, and die as their seeds are scattered. Their whole life may be completed in two or three months. More normal in North Temperate

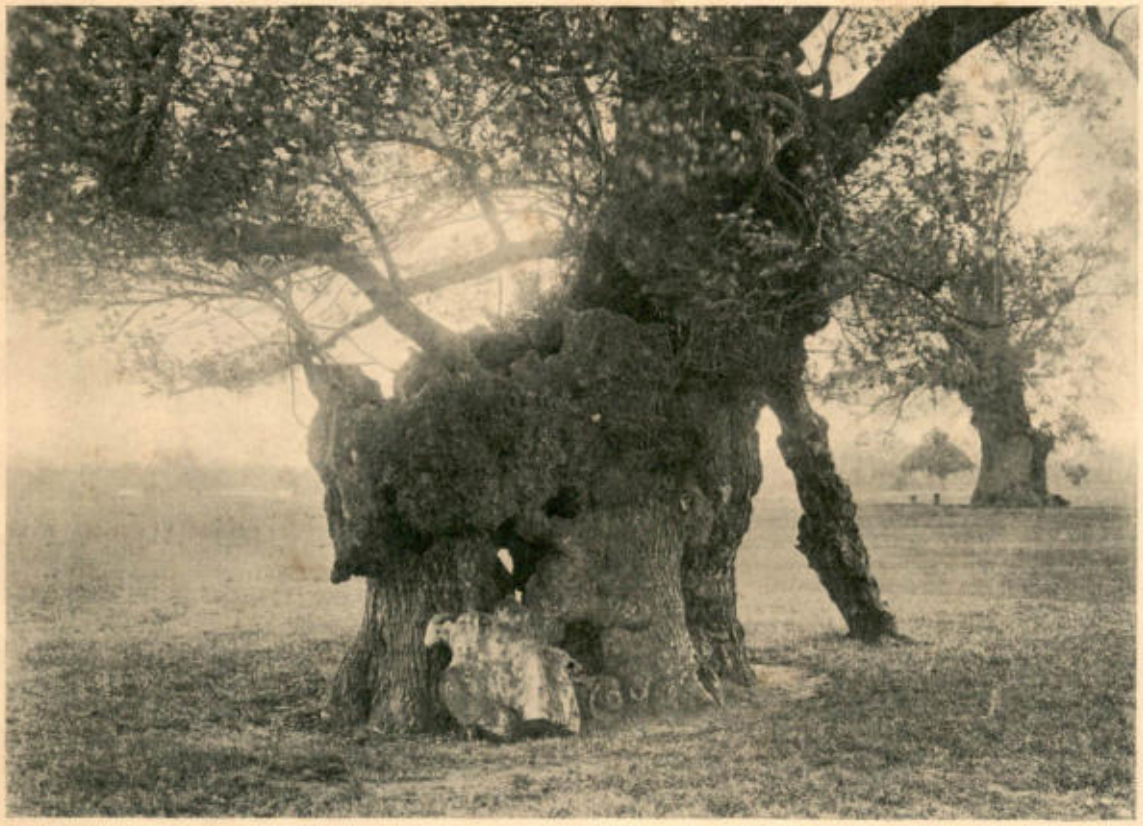


Photo: James's Press Agency.

AN ANCIENT OAK TREE AT HAMPTON COURT.

The gnarled and knotted appearance of this ancient but still flourishing oak testifies to its immense age. The spreading branches have a tendency to assume a tortuous form, owing to the central shoots becoming abortive. Thus there is caused the zigzag and picturesque development so noticeable in the above photograph.

Photo: A. W. Dennis.

THE DRAGON TREE (Dracæna).

This tree, famous for its size and its longevity, belongs to the order of Lilies (Liliaceæ), and is distributed in the Tropics of the Old World. The Teneriffe tree (*Dracæna draco*), blown down in 1868, was forty-five feet in girth; the resin that exudes from this species is called dragon's-blood.

regions are the common "annuals," whose life-curve corresponds with the march of the seasons. They sprout and grow in spring, flower in summer, fruit and die in autumn, and the possible members of the new generation pass the winter in a state of latent life as well-protected seeds. But many of these "annuals" might be more appropriately called "once-seeding" (or "monocarpic"), for there may be several generations in the year if the external conditions are favourable. Similarly a typical biennial, like a foxglove, which accumulates stores in its first year, when it is purely vegetative, and flowers, seeds, and dies in its second year, is still monocarpic. It is obviously nearer to an annual than to a perennial plant which accumulates reserves and is able to flower and seed many times, being in short "polycarpic." But it is a matter of degree, varying with circumstances; thus the perennial common daisy, which we call *Bellis perennis*, is an annual at Petrograd.

The oldest living creatures in the world, after we get away from the immortal unicellulars, are certain trees. Most satisfactorily known are the Sequoias of California, more familiar in this country under the name of Wellingtonia. They belong to a geologically ancient race, and they exhibit extraordinary tenacity of life, not only in the great age to which they may attain, but in their capacity for repairing wounds—even the scars of fire. "There is something in the sap of the Big Tree," an enthusiast declares, "that is an elixir of life, something deposited in its wood that resists in an unexampled way the dreadful tooth of time." Some of them have attained a height about double that of the railway track across the Forth Bridge, and familiar advertisements have informed us all that a carriage and pair—or is it a coach and four?—can be driven through the base of the trunk. If the view of most botanists be accepted that the rings of wood afford a reliable index of the years of life, some of these Sequoias must be prodigiously old. One of the largest showed 2,425 rings, and must have begun its existence 525 years before the Christian era. "We have, deep in their annual rings, records which extend far beyond the beginnings of Anglo-Saxon people, beyond even the earliest struggles for liberty and democracy among the Greeks—records of forest conflagrations, of the vicissitudes of seasons, of periods of drought and periods of abundant and favouring rains." In thinking of the longevity of ordinary Dicotyledonous trees it should be kept in mind that the great bulk of the organism is dead. The interior of the trunk is sapless and lifeless, and it is difficult to find its analogue among animals, where the supporting skeleton usually remains alive, unless it be in the hard central axis of horny material that supports the arborescent growth of sea-fans and black corals.

Specially drawn for this work by F. Mansell.

THE GOLDEN EAGLE.

The Golden Eagle is a fine instance of longevity, and captives have been recorded as centenarians. Of sixty years or more there is little doubt. They have found refuge on the mountains and moorland, where, in Scotland, they feed mainly on grouse. With extraordinary dexterity a Golden Eagle can descend on an unsuspecting, or it may be weakly, bird, seize it in its talons, and reascend in its magnificent curve without more than an instant's pause.

These sometimes attain large size and great age. Professor Molisch compares an old tree to a partially ruined castle in which a relatively small number of rooms are still habitable and furnished.

The longevity of the Dragon-trees (Dracæna) is probably even greater than that of the Sequoias, but it cannot be precisely estimated, since they are monocotyledons and do not form the usual rings of growth. There was a famous giant at Orotava, in Teneriffe, which was going strong and receiving worship when the Canaries were first explored by Europeans in the fifteenth century. Towards the end of the eighteenth century it was described by Humboldt as having a girth of about fifty feet and a height of seventy-five. It was, unfortunately, destroyed by a great storm in 1868, but comparison with other Dragon-trees led to its being credited with an age of 6,000 years. A similar longevity is claimed for a famous water-cypress in Mexico, which has a girth of over a hundred feet at a height of about a yard above the ground. Many conifers give evidence of three or four hundred years; some cedars and cypresses probably approach the two thousand years of the Sequoias. A fortunate beech is said to have survived for nine hundred years and an oak for a thousand, always on the assumption that the ring-counting method is reliable. It is interesting to notice that a plant may attain great age without great size. Thus a blaeberry bush may be twenty-five years old and the common ling may get into the forties.

It is interesting to ask how plants can be assisted to attain a great age. Longevity will be favoured by an avoidance of extremes, by warding off enemies—whether insects or moulds—by periods of rest, and by preventing flowering and fruiting, pollination and seed-production. The Mexican Agave, the so-called century aloe, which is not an aloe, and does not usually, if ever, live for a hundred years, is interesting in this connection. It has a huge basal cluster of large, fleshy, sharp-edged leaves, and from the midst of these there arises a lofty flower-stalk—it may be twenty to thirty feet high—with thousands of blossoms. After flowering and seeding the individual Agave dies, though there may be lateral buds at the base. In Mexico the flowering normally occurs from the eighth to the tenth year, but in Europe, whether under shelter or in the open, the flowering may be suppressed for

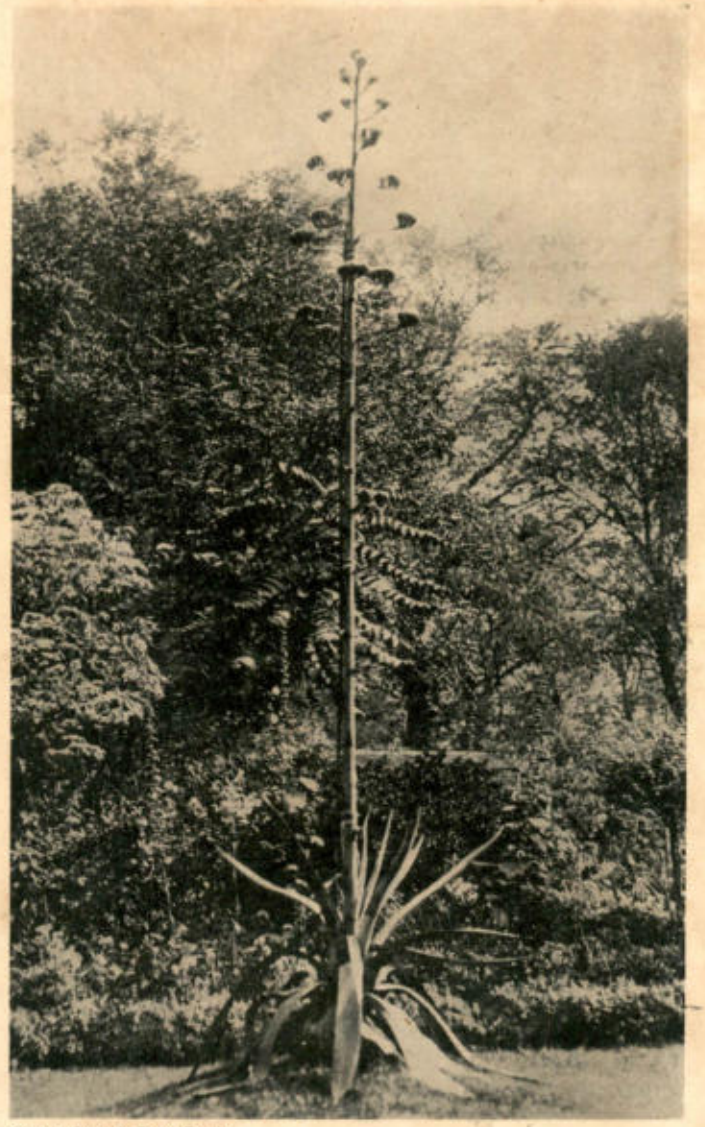


Photo: James's Press Service.

THE AMERICAN ALOE OR AGAVE (*Agave americana*).

This "Century Plant" belongs to the daffodil order (Amaryllids), and for many years it is represented by a great rosette of thick fleshy leaves, around a short stem. But in the course of time, five to sixty or even fourscore years, it sends up a lofty flower-stalk, as the photograph shows, perhaps twenty feet high, bearing numerous flowers. When the fruit is ripe, the plant dies.

Photo: Harold Bastin.

WATER-CYPRESS OR SWAMP CYPRESS (*Taxodium mexicanum*) IN SUMMER.

The American Cypresses used to flourish along with the Sequoias in the present Arctic Regions, but with changes of climate they had to travel south, the Sequoias towards the Californian coast, the Cypresses to the east. They are now restricted to swamps and watercourses, or to places which are submerged for part of the year. They show considerable plasticity of form and habit, and the record of their longevity is 6,000 years

twenty to sixty years—an enormous increase in the duration of life. Another interesting point is that the Mexicans habitually cut out the big flower-bud and secure a copious flow of sweet juice, which they ferment into pulque, the national beverage of those parts.

As we have seen, there is no reason to doubt that more than one kind of tree may attain to a longevity of over two thousand years. This is to be thought of in connection with the persistence of embryonic tissue or cambium which makes it possible for the tree to continue growing in its peripheral parts, while its interior has become little more than a passive supporting skeleton. But another aspect of the tree's longevity is the periodic surrender of the hard-worked leaves and their replacement by fresh growths. This means an evasion of the wear-and-tear tax that most animals have to pay, especially as regards their most active organs. There are various humble creatures, such as some of the moss-animals (Bryozoa) which periodically scrap their organs and begin afresh, but in higher animals there is no possibility of anything so drastic. A higher animal cannot get rid of an over-worked heart or liver and begin afresh. But that is what trees do when they get rid of their leaves and make new ones. This continual rejuvenescence may ward off senescence for six thousand years, and it is the more effective when the tree is not an evergreen, but has alternating periods of winter rest and summer activity. But every living creature with a complex structure is subject to limitations, and the centenarian trees are no exception. Thus, to take a simple illustration, there are limits to the height that the tree can profitably attain, for as it grows higher the transport of nutritive-materials, both up and down, becomes more and more difficult. At a variable height the top of the tree begins to grow old.

Photo: H. J. Shepstone.

CALIFORNIAN BIG TREE, SEQUOIA OR WELLINGTONIA.

The mammoth tree of California (*Sequoia gigantea*), may attain to a height of 320 feet and an age of at least 1,500 years. Another species (*Sequoia sempervirens*), the redwood much valued for its timber, may grow to an even greater height. The man's figure should be noticed.

Photo: Underwood Press Service.

SECTION OF STEM OF CALIFORNIAN "BIG TREE," SHOWING THE RINGS.

The photograph shows part of the cross-section of a Big Tree in the Natural History Museum in London, with labels indicating historical events that occurred when the tree was of such and such a girth. The section includes the centre and periphery of the colossal stem.

How long do Animals Live?

It is difficult to get hold of reliable facts in regard to the comparative longevity of animals. Even when the creature is in captivity all its days, who can tell whether its duration of life is greater or less than it would be in the natural conditions of freedom? In some cases the sheltered conditions under man's shield may prolong life; in other cases the inevitable artificiality may operate in the opposite direction. It must be kept in mind that in Wild Nature the onset of ageing is in most cases followed very quickly by violent death. The least putting aside of armour or laying down of weapons or slowing of reactions, and the creature is hustled out of the arena or is devoured by the ever-watchful enemy. Thus most wild animals of higher degree die a violent death, and none ever shows senility. That is reserved for man and his pets, as the Nemesis of a life of ease or of physiological arrears of an unnatural type. Thus the fact that a parrot may become an octogenarian in captivity does not imply that it will ever attain to that age in the forest. It is highly improbable. Nevertheless the records of longevity in captive animals give us limits, and it is interesting to know that an elephant may live for two hundred years, a golden eagle for fifty, a toad for forty, a crayfish for twenty, a blackbird for eighteen, and so on.

Photo: F. W. Bond.

BROWN CAPUCHIN EATING RICE.

The 'Capuchins" are broad-nosed American monkeys, of the genus Cebus, one species of which often accompanies organ-grinders. The tail is usually long, hairy, and very prehensile. Though fond of vegetable food, they are not restricted to it, and some will eat caterpillars and the like with eagerness. A species of capuchin is reported to have lived in captivity for forty-one years.

To Professor E. Korschelt we owe a critical survey of records of animal longevity, and we shall select a few examples. Anthropoid apes have been known to live at least ten years in captivity, and more than one orang has been credited with half a century. Monkeys often survive fifteen years of captivity, and a capuchin is reported as reaching forty. A domesticated horse may attain to the same age, and Przewalsky's wild horse to over eighteen. A quagga in the London Zoo, one of the last of its now extinct race, reached the age of twenty-nine. Domesticated cattle may occasionally touch or exceed a score of years, and an aged sheep of fifteen has been recorded. A dromedary may live as long as a horse, and a pig about half as long. The greatest age well documented for a domestic dog is thirty-four years, but our faithful friend is very old at a third of that. A cat often lives for ten years, and there seems no doubt that the age of twenty is occasionally reached. Metschnikoff had a cat of twenty-three, which he had probably fed on the sour milk, which he regarded as a specific for longevity; but a Tom-cat of thirty-eight borders on the incredible. It must surely have

Photo: F. W. Bond.

ORANG-UTAN WHICH LIVED TWENTY-FIVE YEARS IN THE ZOOLOGICAL GARDENS.

The orang (*Simia satyrus*) is a native of Borneo and Sumatra, of markedly arboreal habits. Temporary nests are made in the trees, and these are used as nocturnal shelters by the mother orang and the family. The males live for the most part alone, except at the breeding season. In old males the face is broadened out, as the photograph shows, by a callous expansion of naked skin, a sign of senescence.

been renewed from time to time, like the lamb in Barnum's "happy family" cage. But we were forgetting that a cat has nine lives. A beaver has been credited with fifty years, but fifteen is certain. A hare is old at eight years, a rabbit at five, a rat at three.

In spite of the intensity of their life, many birds reach a great age. Eagles, vultures, ravens, swans, and parrots may be centenarians. There are records of eighty years for geese, seventy for storks, sixty for owls, fifty for pigeons, forty for gulls, thirty for magpies, twenty for canaries, ten for poultry, and so on.

As for reptiles, with their slow growth and slow ways, some of the figures are prodigious! Thus Lord Rothschild had a giant tortoise from the Chagos Archipelago that was over three hundred years old, and others are known that were quite lively at two hundred. A crocodile of forty is quite certain, and sacred ones have lived to be as old as Methuselah. The serpent is also slow to die, but which of us can tell how long the common adder usually lives. There is a good record of thirty-three years for a slow-worm.

Among amphibians the first place is always given to the toad, which may live as long as a horse (forty years), but newts have been known to reach fifteen years and tree-frogs ten. Pike and carp are believed to be centenarian fishes, and in many fish stories the age rises still higher. Scale-reading often affords a precise method of estimating the age of a fish, but unluckily there is not always agreement among the readers. It is most satisfactory when the concentric layers in the ear-stones or otoliths and the lines on the gill-cover bones confirm the growth-rings on the scales. There are records of plaice reaching an age of thirty-seven. Eels may attain to ten, perhaps even twenty years without spawning and without showing any trace of ageing. Some authorities credit the herring with the same longevity, which the fishermen do their best to prevent them attaining. What a contrast to the life-span of a little fish called *Aphya pellucida*, which is actually an annual.

When we pass to backboneless animals we find bewildering variety. The giant clams, called Tridacnas, whose massive shells are used as holy

Photo: A. H. Hall.

THE BATELEUR EAGLE (*Heliotarsus ecaudatus*).

This African eagle has wings longer than the tail and a very prominent crest of plumes. The colour is for the most part black with maroon patches on the shoulders, back, and tail; the face is coral-red, fading in captivity to orange-yellow. The bird is said to attain a great age.

water fonts, are believed to reach an age of sixty to a hundred years ; and the same is said of some of the river-mussels that occasionally contain pearls. The common oyster is old at ten. A periwinkle has been kept in an aquarium for twenty years, and many of the fresh-water snails reach an age of four or five. Some small squids are only annuals, but what a duration of life is represented by a fossil giant Ammonite with a spirally coiled, many-chambered shell as big as a cart-wheel !

Most insects are short-lived, but when we think of such dramatic instances as Mayflies, whose aerial life may be over in an evening (in one case in a single hour !), we must remember that the larval life is often prolonged for three or four years. Ants have been known to live for ten to fifteen years, but a summer worker-bee may fatigue itself to death in a couple of months. A beetle may attain the venerable age of seven years, and some of the larvæ that bore in wood may prolong their tedious life for forty-five. Very striking is the case of the North American Cicada, where the larva lives for seventeen years and the adult insect for only a few weeks. Spiders are very often annuals, but there are rare cases of their reaching an age of four to seven years, and the big Bird-catcher is credited with fifteen. Among crustaceans one of the longest lives is that of the fresh-water crayfish, which may attain to over a score of years.

A medicinal leech of twenty has been known, and an earthworm of ten. A starfish may attain to five years, and a sea-cucumber to twice as many. The famous Edinburgh sea-anemone died at the age of sixty-seven. The fresh-water sponge is often an annual, but some of the marine kinds live for many years. Among the single-celled animals there seems to be often an entire evasion of natural death.

So far the facts, but how are they to be understood ? By combining two sets of considerations,

Photo : Underwood Press Service.

BLACK SWAN ON THE THAMES.

The black swan (*Chenopis atrata*), a native of Southern Australia and Tasmania, is occasionally domesticated in England. It is a very handsome bird of blackish-brown plumage, with some white feathers on the wing, as the photograph shows. The feet are black ; the bill is pink. Some of the feathers are prettily curled They are strong vigorous birds, living to a great age.

which are complementary, not antithetic. On the one hand, there are physiological considerations: what length of life will a particular kind of constitution readily allow? There are long-lived constitutions, which are marked by abundant income, a big capacity for accumulating capital, a steady way of living, a not too exciting manufacture of hormones (chemical messengers from the ductless glands), a good stock of resting habits, and a not too costly mode of reproduction. Very different are the short-lived constitutions which are marked by little or no storage, an excitable temperament, a habit of living dangerously, and modes of reproduction that severely tax the resources of the body.

But along with these and similar physiological considerations, we must keep in mind that length of life in any kind of animal is subject to intrinsic variability, and that it is therefore possible to have it adjusted, in the course of Nature's sifting (Natural Selection), so that it meets the chances of death by sufficiently large families and yet restricts the multiplication to the effective, vigorous years. Thus animals that did not live long enough to replace themselves would come to an end, while others that lived too long and continued to multiply when on the down-grade would also automatically pass off the stage.

Toads in Stones.

Speaking of length of life in animals makes one think of the many stories of toads immured in stones. To take a good example, we heard of a farmer who found a live frog, of medium size, occupying a small pocket-like hole "in a hard, and to it impenetrable, substance four feet beneath the surface of the ground." The frog was unearthed in "a layer of coarse sandstone mixed with bits of rock—like a sort of conglomerate—of sufficient hardness to be broken only with difficulty by a pickaxe." This is one

Photo: S. Crook.

SWAN ON A PARTLY FROZEN LAKE.

There are three swans on the British list. Two of these are winter visitors, the Whooper swan and the smaller Bewick's swan. The third is the Mute swan (*Cygnus olor*), which is half-domesticated, though thoroughly wild on the Continent. It may be distinguished from the others by the black knob or "berry" at the base of the orange bill; this is larger in the male. It is very long-lived, and may be a centenarian.

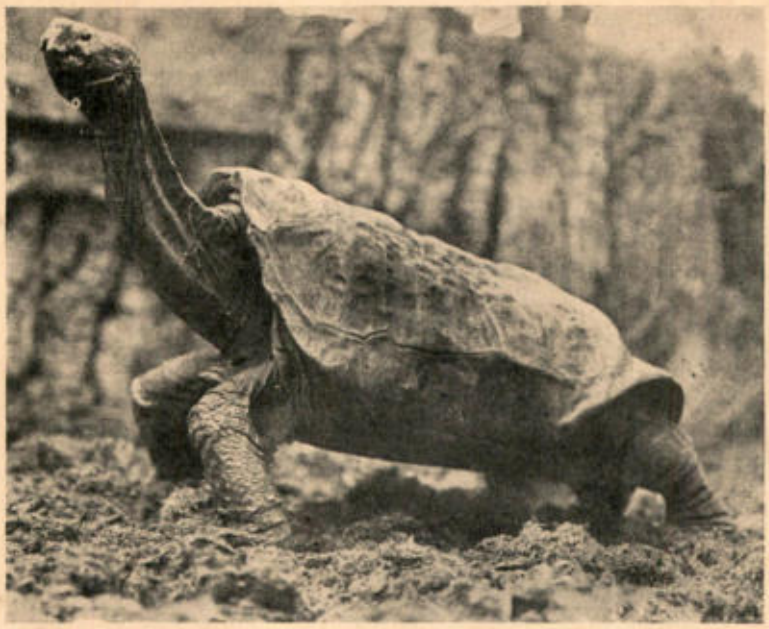


Photo: F. W. Bond.

ABINGDON ISLAND TORTOISE (*Testudo abingdoni*).

All the Giant Tortoises, like this species from one of the Galapagos Islands, attain or attained to great age. There is good evidence of their reaching 150, 200, and even 300 years. There is a British Museum specimen of the Abingdon Island giant that weighed 200 lbs. when alive.

of the best "frog stories" we have heard, and we cannot but believe it. That is to say, there is no reason to doubt the trustworthiness of the interesting narrative, which was well worth recording and is unusually circumstantial. But it does not follow that the circumstances were observed with sufficient precision. We have heard the same type of story in connection with a quarry the rocks of which dated from a geological period antecedent to the historical emergence of either frogs or toads!

When the young frogs at the end of their first year migrate from the fields to winter quarters, which are sometimes, but not always, in the vicinity of the water-pools where they began their life, they are obeying an instinct to get away from the growing cold. They seek for secluded corners where they may perchance be beyond the reach of the frost's fingers, and where they can lie inert without being discovered by hungry eyes like the otter's. They snuggle into holes in a mossy bank, they creep into an obsolete drain-pipe, they find a tortuous passage among loose stones and earth, and they sometimes ensconce themselves in the mud by the side of the pond. We do not think that our Grass Frog is much given to burying itself in mud that is under water, either stagnant or flowing. But the habits probably differ in different parts of the country.

Our point is that frogs and toads are not brainy animals, and that when young and old are obeying their autumnal instinct to hide themselves, they may creep into passages and tunnels, crannies and crevices, where they may be loosely buried alive, or they may tumble down little shafts from which it is difficult to return. When a workman is using a pickaxe or the like, and not thinking of "toads in stones," it is easy to overlook the opening which led into a pocket-like hole within which the amphibian has been spending the winter in lethargy.

It is a strange state into which these cold-blooded creatures sink; it is quite different from the true hibernation of hedgehog and bat, marmot and dormouse, and a few other mammals. There the frog lies, with all its vital functions at a minimum, mouth shut, eyes shut, nostrils shut, breathing through the skin, and with the heart beating very slowly and feebly. The temperature sinks with that of the surroundings, whether in the mud or in a hole in a mossy bank, and if it sinks so low that the blood begins to freeze the frog never reawakens. In many cases, however, the frogs and toads become vigorous again in spring, none the worse for their long fast, all the better for their long rest. Toads in particular have often to migrate for a considerable distance from their winter quarters to the water in which they pair and spawn; and the same is often true of our British frog *Rana temporaria*, though its Continental cousin, the edible frog (*Rana esculenta*) habitually spends its winter in the mud of the pond.

There is no difficulty in believing that a frog or a toad may lie low in a hole for the winter months, and that the path by which it entered

Photo: M. H. Crawford.

THE COMMON TOAD (*Bufo vulgaris*) looking for a suitable place in which to lie up for the winter.

Photo: M. H. Crawford.

Snuggling in backwards, and throwing out in front the leaves and rubbish, he is quickly hidden in a comfortable and well-ventilated hole. The term hibernating should be retained for certain warm-blooded mammals, like hedgehog and dormouse. The winter-state of the cold-blooded toad is very different, and might be called suspended animation or lethargy.

may become loosely blocked. If a modicum of air gets in the creature may remain alive, just as it habitually does in its normal winter quarters. It may remain alive in a hole from which there is no escape, and no one is certain how long a frog or a toad can live without food. Frank Buckland made some rather ghastly experiments, but we must remember that he was exasperated by newspaper accounts of live toads discovered inside blocks of stone. He put a dozen toads into separate holes excavated in a block of porous limestone, covered them up tightly with a glass plate, and buried the block three feet down in the ground. After a year and two months most of the toads were still alive, with their eyes open, and they did not succumb to starvation till they had been in prison for eighteen months altogether. A second dozen were placed in holes bored in a block of dense sandstone, but when these were looked at after a year and two weeks they were found to be dead and decomposed. There is no need to repeat these ugly experiments. Toads and frogs buried alive in closed holes to which air cannot find access must soon die for lack of oxygen, without which the fire of life cannot keep burning. Even if some air gets in they must eventually die of starvation. Dr. Gadow notes, however, that toads which tumble into deep and dry wells may manage to keep alive for years on the spiders, woodlice, earwigs, and the like, which have also tumbled in.

For many years the Natural History journal called the "Zoologist" published good instances of "toads in stones," and these were discussed by Philip Henry Gosse in his " Romance of Natural History " (second series, 1867). Gosse was a sound naturalist, whose work on sea-anemones and on rotifers was of high value, and it is rather interesting to find him declaring, with full knowledge of Buckland's experiments, that the " facts upon record prove the possibility of toads surviving a prolonged incarceration." The kind of data that the "Zoologist" published may be illustrated by two or three instances. In blasting for a railway cutting in Yorkshire, at a depth of four feet, the workmen came across a rock containing many hard nodules, crystallised in the interior. " After blasting, the labourers were much surprised to find among the fragments several of these nodules, each one containing a frog, as many as seven having been counted after one shot." It never rains but it pours for some people.

Some labourers were pulling down an old wall, and they found a toad completely immured in stone and mortar. " There was no doubt that he had been there for many years, for there was no hole or chink by which he could have entered or left the place of his long sojourn." To make sure that he was a real live toad one of the workmen hit him with his pickaxe. Some miners in Fife were taking out the freestone pavement of the seam coal, forty-five fathoms below the surface, when they came upon a cavity in which a frog was lying. The frog jumped about for some time, but it died on its way to the surface. " It was very attenuated, which cannot be wondered at, considering its domicile for so many ages, its original existence being, of course, considered contemporaneous with the formation of the freestone rock in which it was contained." To clinch the matter the frog was exhibited for some days by Messrs. Sanderson and Sons, George Street, Edinburgh.

Gosse seems to have been a good deal impressed by these narratives, and for our part we admit that we cannot satisfactorily explain them any more than we can explain the instance of the farmer's frog with which we started. Yet we do not believe for a moment that toads can long survive incarceration in a stone, where they are isolated from air and food. Our scepticism is partly based on the physiological difficulties of the situation, for the phenomenon of prolonged latent life without food or air is restricted to relatively simple animals, to juvenile stages, and to quiescent phases such as seeds illustrate. But our other reason for scepticism is simply our awareness of the great difficulty of making precise observations and the equally great difficulty of telling the truth. People get angry when one says that one does not believe what they say. 'Do you doubt my word?' they hotly ask; but that is missing the point. What one doubts is not " their word " but their discipline in scientific methods of observation and statement. We have been liars ourselves.

Speaking of toads in stones leads us to think of the stone in the toad, but, unfortunately, we do not believe this story either. It is an amulet

and an antitoxin in one; it lies in the toad's head; it answers to the name of Crampadine. If you doubt whether you have got a right one, "holde it before a tode so that he may see it, and if it be a ryghte and true stone the tode will leape towards it, and make as though he would snatch it; he envieth so much that none should have that stone."

Photo: G. Hearn.

LARGEST AND SMALLEST EGGS OF BRITISH BIRDS—MUTE SWAN AND GOLDCREST.

The greenish-white egg of the mute swan (*Cygnus olor*) has an average size of 4·3 by 2·9 inches. The eggs of the goldcrest (*Regulus regulus*) are buffish-white with minute reddish spots, and average about half an inch by two-fifths. What makes an egg large or small is the amount of yolk and white, not the amount of living matter.

Eggs.

It may seem strange to end our illustrations of life-history with eggs. Surely these should have come at the beginning, for almost every living creature starts as a fertilised egg-cell. The reason is that this is a book of Natural History, not of Biology, so we must give prominence to big open-air facts.

When we think of eggs the first picture that rises in our mind is that of the familiar hen's egg. Its familiarity has bred contempt, which is increased by its edibility. Yet it is as full of wonder as it is full of meat. The shell is beautifully finished, a protective cradle for the young bird. It is firm enough to resist the pressure of the brooding mother, yet it was quite pliable not long before it was laid. It is solid and yet it is porous enough to let fresh air go in and used air come out. For it is through the shell that the developing chick gets the indispensable air for the three weeks that precede hatching. Inside the egg-shell there is a double delicate membrane, which is white and papery in the boiled egg. The two tissue-paper-like sheets separate from one another at the broad end of the egg, and form an air-chamber which increases in size as development goes on. When the twenty-first day arrives, the chick thrusts its bill into the air-chamber and gets its first draught of air. Invigorated by this, it breaks its prison-doors by pressure from within, and steps out into the world.

Where does this very wide-awake chick come from? As was asked by William Harvey, the discoverer of the circulation of the blood (1628): "What is the efficient cause of the chicken?" He had to confess, to use his own quaint words, that "neither the schools of physicians nor Aristotle's discerning brain have disclosed the manner how the cock and his seed doth mint and coine the chicken out of the egg." That is the everyday wonder!

In the middle of the white of egg there floats the "yolk"; and what we call the "yolk" is the egg-cell greatly dilated by the accumulation of nutritive materials (both fat and protein). On the top of the sphere of yolk there lies a minute drop of clear living matter with a nucleus, and it is out of this that the whole of the chick is developed. In some way that we cannot picture, the whole inheritance of the bird lies condensed in that tiny drop—much of it, certainly, in the living matter of the kernel or nucleus, and part of it, probably, in the surrounding living matter of the egg-cell. Corresponding to the characters of the plumage, skeleton, skin, brain, eyes, and other parts of the adult bird, there are hereditary items or initiatives in the egg-cell and its nucleus. It is usual to call them the hereditary "factors," and development means that they find visible and tangible expression. The latent becomes

patent, the potential becomes actual, the invisible becomes visible; but we do not understand the process.

The nucleus of the egg-cell is a little world in itself. Thus it contains a definite number of transparent rodlets called "chromosomes," each kind of animal having a particular number of them. Thus the number for man is probably (it is difficult to be sure in counting these infinitesimally minute things) forty-eight. There is nothing in the number itself; the important point is that all the cells of the body usually show the same number, whatever that number may be, except the ripe egg-cell and the ripe sperm-cell, which have half the normal number. When these two elements unite in fertilisation, the normal number is restored. Two halves make a whole.

Returning to the inheritance, which is somehow packed away in the microscopic sperm-cell and the usually microscopic egg-cell, we must notice the extraordinary step that has been taken by investigators of certain animal types. They are able to say that the factors for particular characters, e.g., colour of eye and length of wing, lie in a longitudinal row in the rodlets or chromosomes of the nucleus. More than that, they can sometimes say, though it is difficult to explain how, that the hereditary factor for a particular character lies in a particular area of a particular chromosome! Each factor is an initiative which will develop into a particular character, or will share in the development of a character, provided always that there be appropriate nurture. For these mysterious hereditary "factors" are like buds on a tree; if they receive generous nurture they will unfold fully; if they are starved they will form stunted shoots, or remain dormant altogether. A character is always the product of hereditary "nature" and appropriate "nurture."

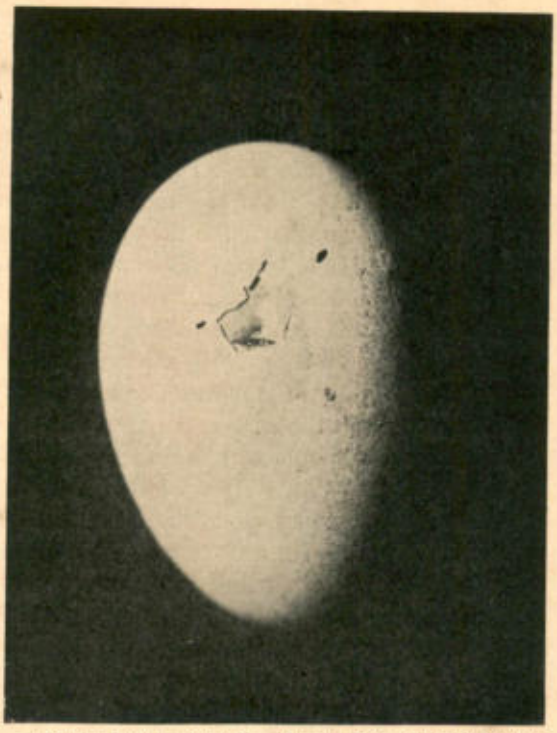
Photo: E. Staniland Pugh.

HEN AND YOUNG CHICKS IN THE GRASS.

Unlike most of the young birds in perched nests which are helpless for many days, the young of birds that nest on the ground are precocious and able to run about and feed soon after hatching. In the familiar case of chicks there are very few inborn instinctive capacities, but there is an extraordinary power of rapid learning from the mother and from experience.

If a bird's egg is to develop at all, it must first be fertilised. This takes place in the oviduct of the female bird before there is any enclosure of the egg-cell in the white of egg and the shell. This process of fertilisation is another mystery. The paternal inheritance, carried by the sperm-cell, and the maternal inheritance, carried by the egg-cell, enter into intimate and orderly union; for in all ordinary circumstances a new individual life starts with a dual stock of initiatives. Whether both sets will find expression in the

1. Fresh-laid egg carefully opened, showing circular germ-disc which develops into the chicken. The germ-disc is always nearest the brooding hen, however the egg is turned.



2. Coming through the shell. After 21 days, the chick becomes restless within the egg and chips the shell by knocking on it with the "egg-tooth" on its bill. The photograph shows the first crack.

Photos: Harold Bastin.

3. Five hours after No. 2. The shell has been broken nearly all round, allowing the chick to struggle out. As it frees itself, it gets rid of the embryonic membranes (amnion and allantois).

4. Chick two hours after hatching, able to run about and snap at insects. The "egg-tooth," which helped in shell-opening, soon falls off,—a good example of a structure used only once.

development of a particular feature—say, the colour of the plumage—or whether the young bird will take after one side of the house as regards that feature, is a detailed question in inheritance the answering of which has come much nearer of recent years. We know, for instance, that if two Blue Andalusian fowls are paired together, the offspring will be, on an average, three blacks, three whites, and six blues to the dozen. But if the parents are Black Andalusians and White Andalusians, the offspring will be all Blues. We are beginning to understand a little of the minting and coining of the chicken out of the egg.

Another thing should be kept in mind. When we look at the minute drop of living matter lying on the top of the yolk, and then look at the chick breaking its way out of the shell, it seems almost incredible that the former should give rise to the latter. It seems too magical to be true. But it is just the same sort of difficulty that we have when we compare an infant of a day with a young man come of age. The one process takes twenty-one days, the other twenty-one years; and the impression of magic disappears in both cases when we study the gradualness of the development. The drop of living matter, one cell to start with, divides into a disc of many cells. Along the middle line, even on the first day, the nervous system begins to be laid down, and day after day one system is added to another. The cells, which seemed all homogeneous at first, become heterogeneous; for some are nervous and others muscular, some are skeletal and others glandular. Division of labour becomes more and more marked, and yet at the same time the developing embryo is gradually bound into a harmonious unity.

During the first few days of the chick's development it is somewhat difficult to distinguish it from the embryo of a reptile such as a turtle. This means that the individual chick in its development is recapitulating the evolution of its race, for there is no doubt that birds sprang from some ancient stock of extinct reptiles. *The bird climbs up its own genealogical tree.* Surely no one can see the tiny gill-clefts on the side of the embryo's neck without an imaginative thrill, for these carry the pedigree much farther back to an *aquatic* ancestry. Of these transient gill-clefts only one comes to anything, namely, the first, which is transformed into the Eustachian tube connecting the ear-passage with the back of the mouth. But the gill-clefts illustrate the hand of the past upon the living present. About the sixth day the developing chick leaves the broad highway which it shares with the reptiles, and diverges on a path of its own—the bird-path.

We have left no space for any discussion of the eggs of other birds, with their varied shapes and sizes, colours and patterns. It is interesting to find that the waste-pigments of the blood and the bile are used to paint the egg-shells, and that the painting is *sometimes* profitable to the young bird by making the egg almost invisible. It is interesting to notice that the top-like shape of the guillemot's single egg is well suited for the narrow ledge of the sea-cliff on which it is laid. For if it be jostled by the wind or by a knock from its parent's foot, it simply *rotates* on its short axis and does not *roll* into the sea. Wherever we tap Animate Nature it seems to flow with purpose.

XLII

THE WAYS OF REPTILES

BIRDS and Mammals are warm-blooded, that is to say, they can regulate the temperature of the body so that it remains the same, day and night, summer and winter. But Reptiles, Amphibians, and Fishes are cold-blooded, that is to say, they tend towards the temperature of their surroundings. Thus they are more in the grip of their surroundings than birds and mammals are, and have not so much freedom of behaviour. Moreover, in proportion to their size, their brains are smaller, and the part which is the seat of intelligence is not nearly so well developed as in birds and mammals. So one must not expect them to have such interesting ways as the higher backboned animals.

The Senses of Reptiles.

There is nothing very remarkable about the senses of reptiles. Touch counts for much in snakes where it has its seat in the quivering forked tongue, which is shot out and flicked in very rapidly and very frequently. The snake tests everything with its restless tongue. Vision is often acute in reptiles and it is interesting to watch the precision with which a chamæleon measures the distance—sometimes seven inches—from which it can strike an insect with its long protrusible tongue, swollen like a club at its tip

Photo: W. S. Berridge, F.Z.S.

TROPICAL AMERICAN TUBERCULATED IGUANA (*Iguana tuberculatus*).

A common lizard of Tropical America, a favourite article of food. There is a long compressed tail and a remarkable crest of lance-like, yet leathery, scales, extending from the neck along the back. There is a pouch below the throat. The Iguana is vegetarian in the main and fond of climbing trees—even up to the tops—as its long slender toes suggest. It is four to five feet long, an irregular mixture of green, black, and yellow.

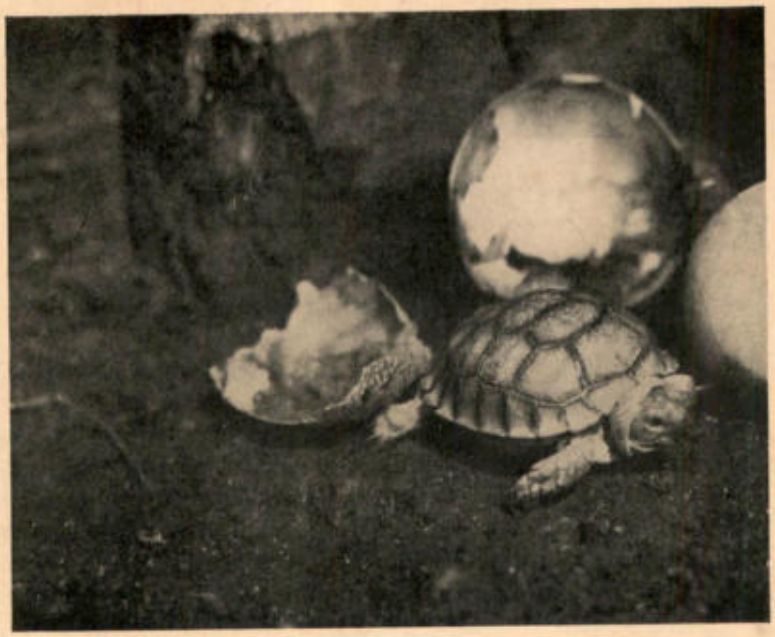


Photo: F. W. Bond.

GROOVED TORTOISE (*Testudo calcarata*), JUST EMERGED FROM EGGS.

This Abyssinian tortoise has a rather flattened shell, which may be twenty inches long, and has a uniform horn colour. The eggs are hard-shelled and white, and more or less spherical in form. As the photograph shows, the newly hatched young one is fully formed.

and very sticky. The two eyes stand out prominently on the chamæleon's head, and are moved independently. First one is focussed and then the other, and when both are adjusted, out comes the tongue and in goes the fly. This is the only thing that the chamæleon does quickly. It is a leisurely lizard that has taken to living among the branches.

The Crocodile's Nest.

Many reptiles have an acute sense of hearing, as is well illustrated by the Madagascar crocodile. The mother deposits her eggs, which closely resemble those of a goose, deep in the warm sand, twenty to thirty in one nest. Sometimes they are two feet below the surface, and it would be awkward indeed if they hatched there. But when, after twelve weeks, the young one is ready to come out of the shell it makes a hiccough-like sound, which the mother, who often sleeps on the top, understands as a signal. She digs away the earth so that the young crocodiles are not buried alive. A naturalist once surrounded the nest with a fence, which the mother partly destroyed. A stronger one was made, but the mother dug a ditch below it, and although she did not get in herself, she managed to get her children out and took them to the water. The same naturalist put some crocodiles' eggs in a box in his room, and covered them with two feet of sand. When he walked past or tapped on the box the young crocodiles uttered their piping sound. Perhaps they hear their mother's movements, though they cannot know what they mean. We may mention here that the young crocodile has an "egg-tooth" on the tip of its upper jaw which is used like a borer in breaking through the shell.

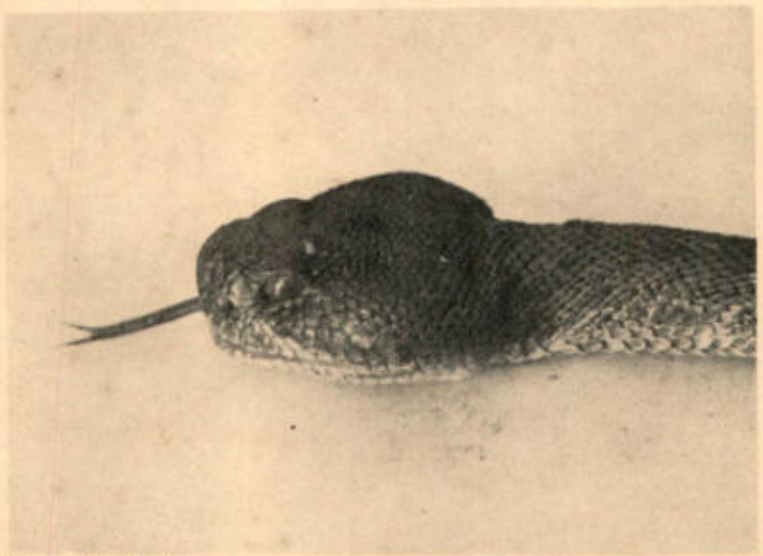


Photo: F. W. Bond.

HEAD AND TONGUE OF RATTLESNAKE (*Crotalus ruber*).

There are about a score of different kinds of rattlesnake (Crotalus), mostly restricted to the United States. The rattle has received many interpretations, but its meaning is uncertain. It may drive away unprofitable animals, like peccaries; it may attract inquisitive victims; it may be a sex-call at the breeding season. The maximum number of "bells" on a rattle at one time is a dozen.

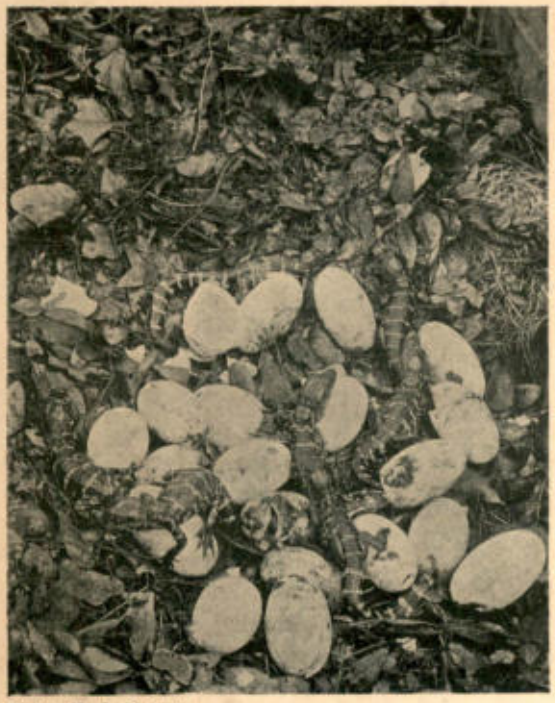


Photo: H. J. Shepstone.

ALLIGATOR'S NEST.

The "nest" of the alligator is a mound of water-soaked twigs and moss, and may contain about forty eggs, each from 2 to 4 inches in diameter, which are deposited in layers among the rotting plants. The heat produced by the fermentation helps the development.

Photo: F. W. Bond.

YOUNG ALLIGATOR EMERGING FROM THE EGG.

Before it is hatched, the developing alligator breathes through the porous egg-shell. It breaks its way out, very much as a chick does, and it is soon ready for the usual business of life, being fully equipped from the first.

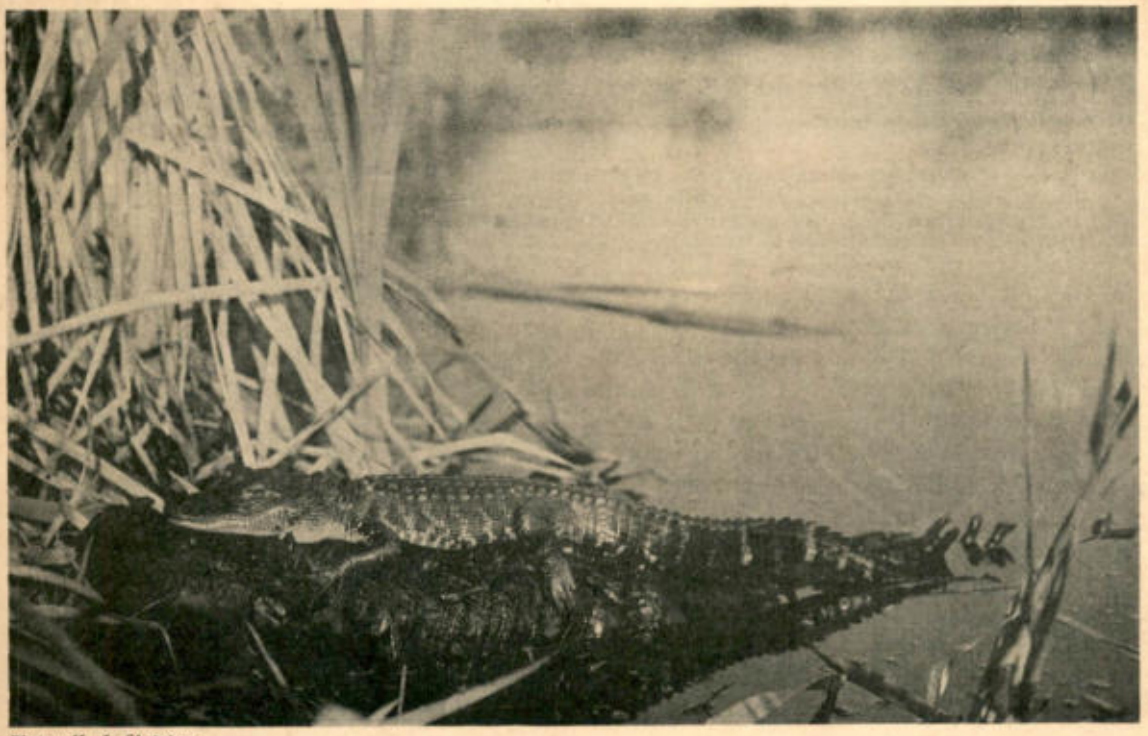


Photo: H. J. Shepstone.

AMERICAN ALLIGATOR AT HOME (*Alligator mississippiensis*).

This alligator is common in the rivers, lakes and estuaries of the South-Eastern United States. It rarely exceeds ten feet in length, but longer forms used to occur. It utters a "rattling bellow" that can be heard for a mile.

Photo: Neville Kingston.

EGYPTIAN COBRA IN THE ACT OF STRIKING.

This species of cobra (*Naja haje*) shares with the horned viper the reputation of having been concerned in the death of Cleopatra. It is a vicious snake, spreading its hood like the Indian cobra; but it has not the spectacle-marks on the neck.

It falls off when the creature is two weeks old. Another peculiar thing is that the newly hatched crocodile is so big for the size of the egg. This is rather a puzzle. The egg is a little over three inches long, but out of it comes a baby-crocodile of eleven inches. Of course it is bent upon itself inside the egg, but even then!

The young crocodile utters its sound *instinctively*, that is to say, as we have seen, it is part of its inborn equipment to give this signal. It does not require practice or learning; and it does not need to understand what it is doing. There is a great deal of instinctive behaviour among reptiles, and we shall take as an example the American "soft-shell" tortoise, whose technical name is Aspidonectes. It is a powerful swimmer and hunts among the freshwater weeds for crayfish and insect larvæ. But it is quite at home on land, and covers the ground so quickly that it can hardly be overtaken by a man running. It is fond of basking on a floating log, and always lies facing the water, so that no time is lost if danger threatens. At the onset of winter it rocks itself to and fro in the soft mud, sinking deeper and deeper until it is below the frost-line. There it lies low for months.

The "Soft-shell" Tortoise.

The female is very careful in choosing a suitable place for egg-laying. She scrapes a hole in the ground, lays a number of eggs, covers them with moist earth, lays some more in an upper tier, and then tramps firmly over them. If she is disturbed during the egg-laying, she tries to cover them up before she goes. Now all that this turtle does in its ordinary life is done in the same way by them all. This is routine instinctive behaviour.

But another note is struck when a reptile *learns* something, no matter how simple. This is illustrated by some interesting experiments which Professor Yerkes made with the small-speckled turtle. It is one of this creature's instincts to snuggle into a dark secluded corner. Like many of its relatives it is, so to speak, wound up to seek out such places. What Professor Yerkes did was ingenious. On the road leading to the turtle's dark nest of damp grass, he put a maze which the turtle had to traverse if it meant to reach home. The maze consisted of a box about a yard long divided by partitions into four compartments with suitable doorways between. The turtle, making for home, entered the maze

The Turtle's Lesson.

and was much puzzled. It wandered about in a futile sort of way for thirty-five minutes, and at last, more by chance than good guidance, it managed to get through. Two hours later the experiment was repeated, and on the second trial the turtle reached its nest in fifteen minutes. There was much less wandering in the maze.

Experiments were made every two hours. On the third trial the turtle only required five minutes, on the fourth three-and-a-half. From the fourth trial onwards the path ceased to be irregular. The tenth trial was made in three minutes five seconds, with only two mistakes in turning. The twentieth trial took only forty-five seconds, the thirtieth forty seconds, the fiftieth thirty-five seconds. Both in the thirtieth and fiftieth trials the course followed was quite direct; the turtle had learned its lesson.

We need not credit the turtle with much intelligence in all this, but it is plain that it profited by experience. Perhaps it learned to get quickly through the simple maze somewhat in the same way as we learn to play certain games of skill, such as golf. It gradually got rid of futile movements.

A newly hatched crocodile will snap at your finger, but this is not intelligence. It is the kind of action called *reflex*, such as we illustrate when we shut our eye on the approach of a stone. A newly hatched turtle will make for the water in the darkness, and if you turn its head the wrong way it rights itself. But this is not intelligence. It is an engrained obligation, something like the moth's attraction to the candle flame. From amid the pathless sea, the fish-eating turtle finds its way, year after year, to the same sandy island. We do not understand this "homing," but it is not due to intelligence.

There is some memory in the "homing," and there are records of snakes remembering people after an absence of six weeks. In his "Natural History of Selborne," Gilbert White tells of a tortoise that "whenever the good old lady came in sight, who had waited on it for more than thirty years, it always hobbled with awkward alacrity towards its benefactress, while to strangers it was altogether inattentive."

There is a large American lizard called the

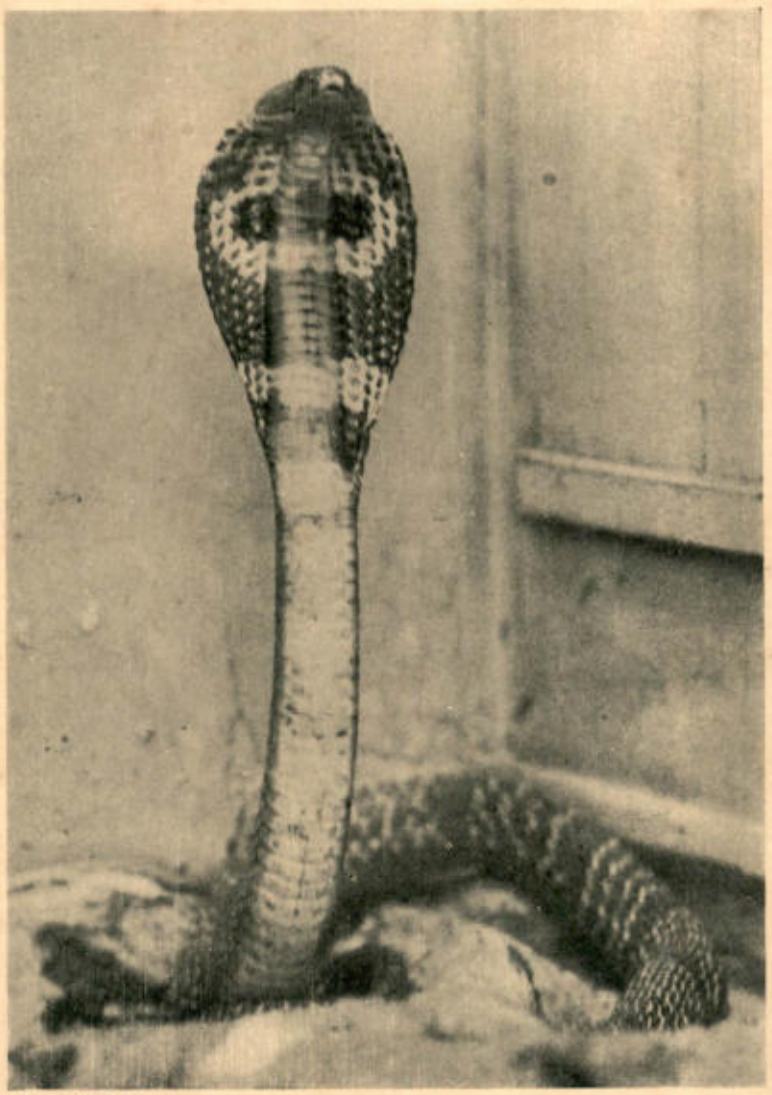


Photo: F. W. Bond.

INDIAN COBRA (*Naja tripudians*), SHOWING UNDERSIDE OF HOOD.

There is a whitish spectacle-mark on the dorsal surface of the expanded hood, and a large black and white spot on the corresponding position on the under surface. A cobra five feet long is considered large. It occurs from Transcaspia to China and Malay.

Photo: James's Press Agency.

NORTH AMERICAN HOG-NOSED SNAKE (Heterodon).

The hog-nosed snakes owe their name to the sharply upturned shovel-like snout. They use this in burrowing in dry sandy places. The anterior ribs can be spread out in a manner suggestive of a cobra's hood. Another peculiarity is the habit the hog-nosed snake has of passing into a limp motionless state as if it were feigning death. Several species are common in North America.

Iguana, usually a gentle creature, which has been known to defend its mate with fury and with what would be called courage in man. So there may be more feeling slumbering in the reptile than one is inclined to think; and the same may be true in regard to their intelligence. Let us consider this question with particular reference to snakes.

The Wisdom of the Serpent.

There is a widespread belief in the wisdom of the serpent or snake, but it does not seem to have a very strong foundation in fact. No doubt these strange limbless reptiles are very effective in movement, food-capture, attack and escape, but their wisdom is far to seek. What they do is the outcome of engrained hereditary capacities which work well—not so much instincts as simple answers-back to everyday questions. They do not give much evidence of inventiveness or plasticity; their intelligence seems to be of a low order. We must remember, however, that when an animal's inborn equipment is sufficient to enable it to cope with nine out of ten difficulties in everyday life, it is not likely to give evidence of much understanding. It is rare for an animal to show more intelligence than it needs.

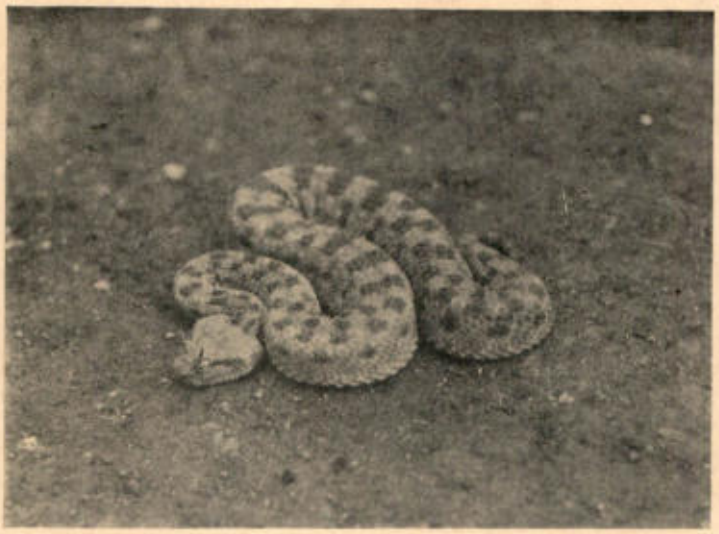


Photo: W. S. Berridge, F.Z.S.

CERASTES OR HORNED VIPER (*Cerastes cornutus*).

Above each eye there is a large horny spike made out of a scale, and these protrude when the creature buries itself in the sand during the heat of the day. The eyes and nostrils are also exposed. The horned viper attains a length of two and a half feet, and is yellowish-brown above, white below. It occurs from Algiers to Arabia.

But even when the mind of the snake finds some expression, it is not what one would call brilliant. This may be illustrated by one of the most flattering records, a story told by Layard of a cobra in Ceylon. This snake had thrust its head through a narrow aperture and swallowed a toad. This was effective enough, but the narrowness of the opening prevented the snake withdrawing its head when it was expanded with the booty. So it had to disgorge the toad, which naturally tried to get away. "This was too much for snake philosophy to bear, and the toad was again seized; and again, after violent efforts to escape, was the snake compelled to part with it. This time, however, a lesson had been learnt, and the toad was

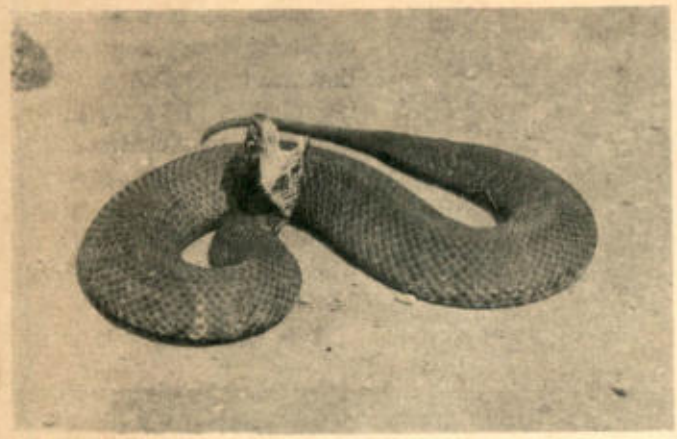


Photo: W. S. Berridge, F.Z.S.

WATER MOCASSIN SNAKE (*Ancistrodon piscivorus*).

A semi-aquatic snake, with a stout heavy body and abruptly tapering tail. A common size is about four feet long; a common colour is dull olive with blackish blotches. It is a very omnivorous and very deadly inhabitant of North American lagoons.

seized by one leg, withdrawn, and then swallowed in triumph." Perhaps the word "triumph" is a little like "reading the man into the beast," but it will be generally admitted that mind was stirring in that cobra. It would have been satisfactory if the experiment had been made of repeating the situation, for it would have been interesting to discover whether the cobra would seize the second toad by one leg at the very start. For if it did so, there would be convincing proof of *intelligent learning*. There may have been a good deal of luck in reaching the first solution.

As to senses, we have already referred to the restless tongue which is whipped out and in as a touch-organ. The eyes are well-developed, though lacking one of the usual muscles—the retractor. The risk of injury when the animal is creeping among obstacles is lessened by the fusion of the lower eyelid to the upper. The result is a complete transparent blind over the front of the eye. The immobility of the lids gives the snake its unlimited capacity for staring. The Scriptures speak of "the deaf adder that stoppeth her ear," and although they have no ear-hole that they could stop, the description conveys a good idea of their listlessness to most sounds. They have no drum to the ear, and it is safe to say that hearing does not count for much in their life.

Why are snakes believed to be so wise? We must find the basis for this generosity in the dread and respect with which they are regarded by simple people. And the dread and respect must be due to the mysterious movements of the animals, their elusive ways, and their frequent deadliness. From very early days, at any rate, snakes have been symbols of the dæmonic powers of the earth, and it is one of the ways of primitive man to credit a

Photo: Neville Kingston.

HAMADRYAD OR SNAKE-EATING COBRA (*Naja bungarus*).

This is one of the largest poisonous snakes, reaching a length of twelve feet. It ranges from India to South China and the Philippines, and is one of the terrors of the jungle. Its food seems to consist entirely of other snakes—its only recommendation.

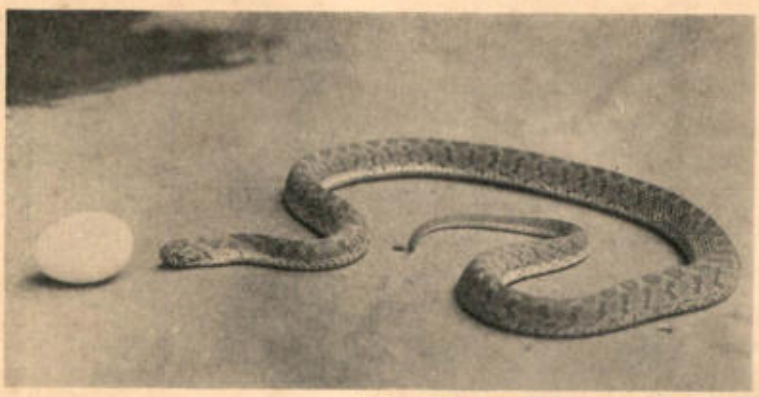


Photo: W. S. Berridge, F.Z.S.

EGG-EATING SNAKE (*Dasypeltis scabra*).

This snake is the only species of its genus, & well-known for its egg-eating propensities. There are only a few teeth, but some of the vertebræ in the neck region have sharp processes which pierce the roof of the gullet and serve to break the egg shells, so that none of the precious contents is lost.

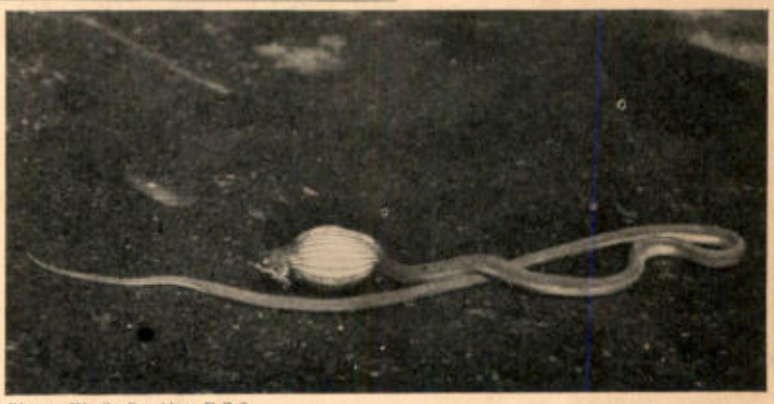


Photo: W. S. Berridge, F.Z.S.

DASYPELTIS JUST AFTER IT HAS SWALLOWED A PIGEON'S EGG.

Dasypeltis inhabits Tropical and South Africa; it rarely exceeds two feet and a half in length, but an individual of this size can deal effectively with a hen's egg. As the photograph shows, the swallowed egg distends the region of the gullet in an almost incredible fashion.

Snakes have been given credit for doing many things that are impossible or vastly improbable. In spite of the assurances of eyewitnesses, it is impossible that a snake should put its tail in its mouth and make a hoop or wheel of its body. It can't be done.

It is said that one snake may begin to swallow another which is at the same time engaged in swallowing it; and it has been recorded that two snakes may meet in the middle of a victim that they are both swallowing. But one must not swallow all the snake-stories one hears. Over and over again the story crops up that a mother-snake has been seen to swallow her young ones temporarily, so as to save them from great danger. But no criticised account of this has been given. Sometimes the observer has killed the snake and opened it and found young ones inside, and, unaware that some snakes bring forth their young as little snakes (viviparously) and not eggs inside (oviparously), has leapt to the conclusion that the mother had saved its offspring by swallowing them for the time being. Yet when one remembers

symbolic animal with the virtues or abilities of the Power which it symbolises. So it comes about that the serpent gets credit for greater subtlety than any other beast of the field, and what seems to us a somewhat commonplace mind has been invested with extraordinary wisdom — a generous exaggeration.

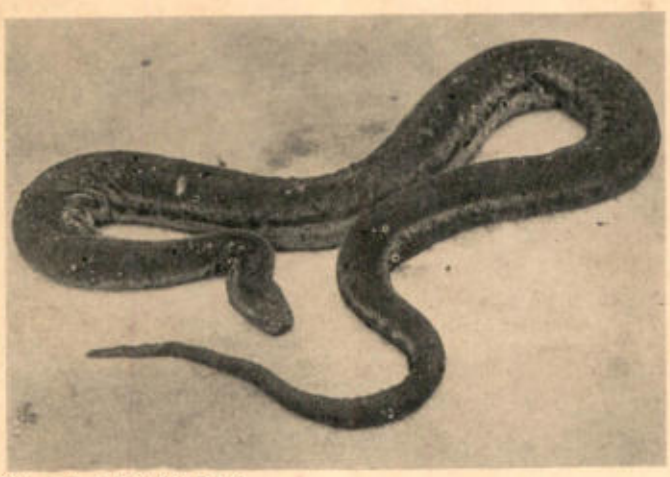


Photo: W. S. Berridge, F.Z.S.

ELEPHANT-TRUNK SNAKE OR JAVAN WALL-SNAKE (*Achrochordus javanicus*).

This is a very peculiar olive-brown snake, with no specialised ventral shields, an absence which may be associated with the aquatic habits. The scales are small and the flat head is covered with granules. It attains a length of four feet and feeds on fishes.

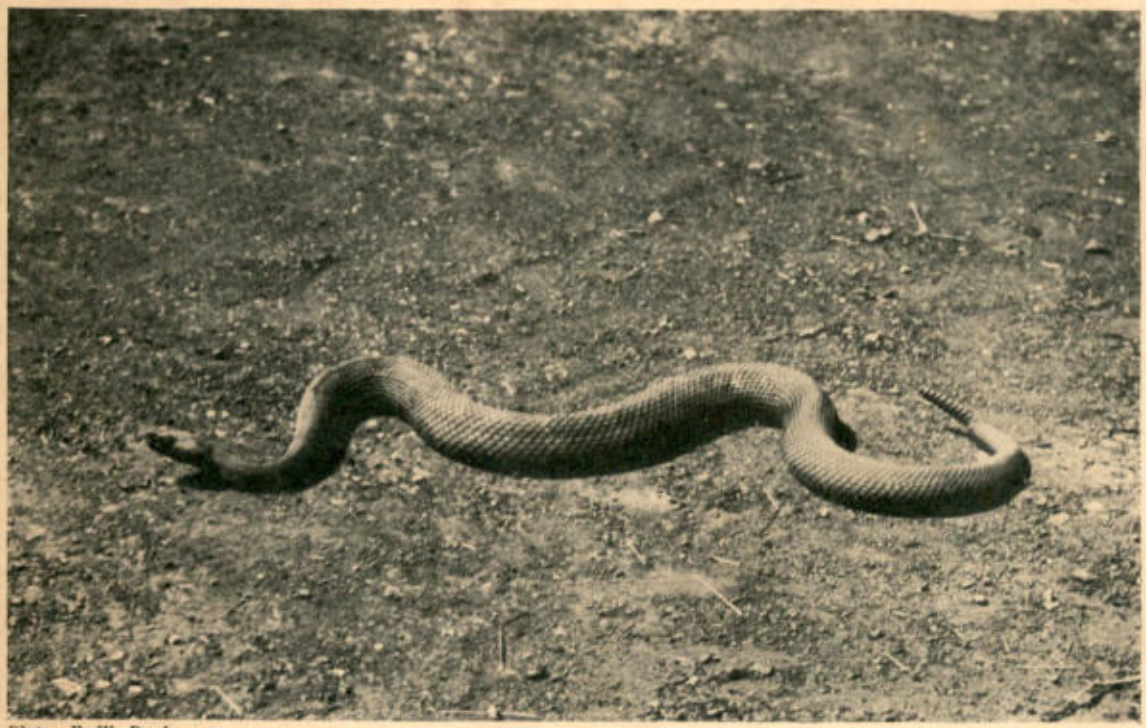


Photo: F. W. Bond.

RATTLESNAKE (*Crotalus horridus*).

Rattlesnakes (Crotalus) are represented by ten or so species from Canada to Northern Argentina. The largest attains a length of eight feet, but most are nearer half that. They feed on small mammals and the like, and the shrill sound of the rattle helps to drive off unprofitably large creatures. This, at least, is one of the many interpretations, and it is obviously wasteful for a rattlesnake to strike at a peccary.

Photo: F. W. Bond.

SHIELDED ERYX OR BURROWING BOA (*Eryx thebaicus*).

This is one of the strangling python-like snakes (Boidæ), mostly Asiatic, fond of burrowing in sandy places, feeding on lizards and mice. Although flabby in appearance, they are very agile in their movements and pugnacious to one another.

that among fishes and frogs there are cases known where the male parent at the breeding season always shelters the eggs and the young ones inside his mouth, one is not inclined to call this snake story impossible or incredible. What one may say is that it is vastly improbable.

There is also reason to be very doubtful in regard to the widespread belief that snakes are susceptible to the soothing influence of music, and that the Hindu snake-charmers take advantage of this in dealing with the cobras they carry about in baskets. The poor cobra has had its poison-fangs wrenched out, and in many cases at least its movements in the snake-charmer's hands are made under compulsion.

It was a better trick that the magicians played long ago before Pharaoh, when they turned snakes into sticks and back again. This trick illustrates the strange state called "animal hypnosis" into which it is possible to send many animals, from crayfishes to hens. It is a peculiar fatigued state of the nervous and muscular systems, not yet fully understood. The snake is held firmly by the tail and just behind the head. Orders pass out from the brain and spinal cord commanding the muscles to contract. But the snake is held firmly and no proper contraction is allowed. The orders keep coming, but the muscles cannot obey them, and a peculiar state —a sort of contradiction in terms—sets in. The animal becomes stiff and motionless; it lies quietly without being held. The state is quite different from the hypnotised condition in man, but there is something in common. In any case the snake "becomes a stick" and remains a stick for a long time. By and by, the blood begins to circulate freely, the fatigue effects pass off, the wheels begin to go round again, and the stick becomes a snake. But there is no wisdom here.

Perhaps the same should be said in regard to those snakes that "feign death" when they are suddenly and hopelessly cornered. It is probable that their state of "lying low" is closely akin to animal hypnosis. It is a condition into which the animal passes, reflexly not reflectively, when it gets a sudden shock or is quite baffled. It is in all likelihood at a much lower level than the "playing 'possum" exhibited by a genuinely clever animal like a fox, where real feigning is not out of the question. We must admit, however, that there are experienced naturalists who take a more generous view of the snake's behaviour. Thus, in speaking of the common Hog-nosed Snake of the New England States, which will hang inertly like a piece of rope if you carry it, head downwards, by its tail, Dr. Hornaday says: "Of course it hopes to escape by its clever ruse, and, no doubt, it often does so from the hands of inexperienced persons." There is no doubt that the peculiar answer-back may save the snake's life, but there is no proof that it is a clever ruse, and we may doubt

Photo: F. W. Bond.

TENTACLED SNAKE (*Herpeton entaculatum*).

This is one of the poisonous river and estuarine snakes, frequenting the harbours of Cochin China and Siam. It is a fish-eater, with two tentacle-like prominences on the snout. The tail is rounded, not flattened as in the true sea-snakes. The young ones are shown wriggling round the mother.

Photo: Underwood Press Service.

INDIAN BULL SNAKE AND EGGS.

Some of the snakes of the python and boa family (Boidæ) incubate their eggs. As the above photograph shows, the mother snake coils her body around the laid eggs, and this may increase the temperature as well as secure safety

Photo: F. W. Bond.

FALSE MOCASSIN SNAKE AND YOUNG (*Tropidonotus fasciatus*).

This snake, belonging to the same genus as the British grass snake (*Tropidonotus natrix*) lays soft eggs, which hatch outside of the body, liberating perfectly formed miniatures of the adult. The young ones seem to be able to catch small animals almost immediately after they are hatched out, thus illustrating instinct.

whether the Hog-nosed Snake or any other snake ever hopes for the best or dreads the worst.

Dr. Hornaday is Director of the New York Zoological Park, and has a large experience of snakes and of many other animals. It is fair, therefore, to notice that he does not share our view of the snake's very limited intelligence. In his "Minds and Manners of Wild Animals" (1922) he speaks of "the keen intelligence and ratiocination" of snakes. He bases this belief on "the success of all species in meeting new conditions and maintaining their existence in face of enormous difficulties." But efficiency, which no one doubts as a quality of snakes, is not the same as intelligence, and alertness is not "ratiocination," which really means a chain of reasoning.

Telling of his experience, Dr. Hornaday says again: "I have emerged with a fixed belief that

Photo: W. S. Berridge, F.Z.S.

INDIAN RAT SNAKE (*Zamenis mucosus*).

This is the common, ill-tempered rat snake of India, extending from Transcaspia to Java. It is brownish above, often with black cross-bands posteriorly; the under parts are yellowish. There is a strong dorsal ridge; and a length of seven feet may be attained.

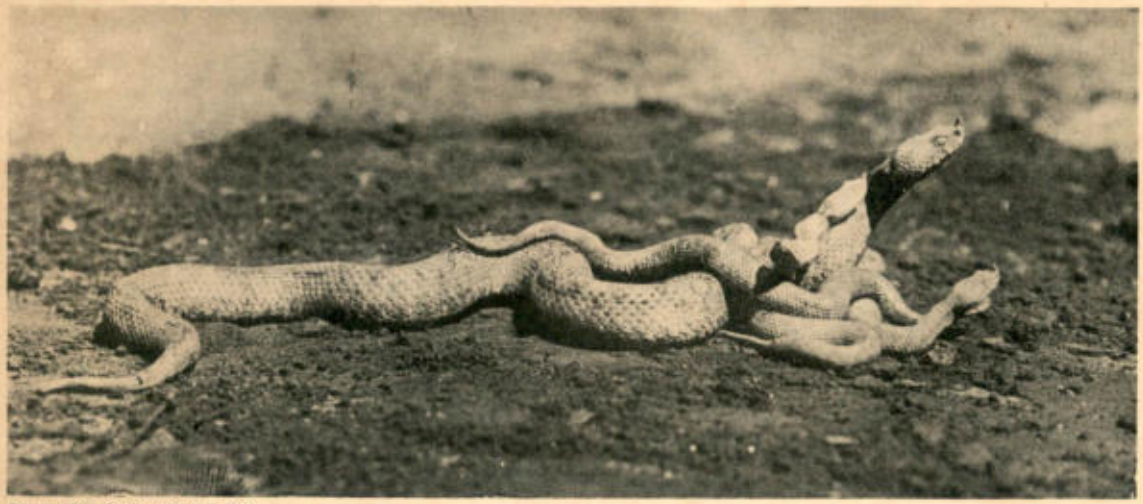


Photo: W. S. Berridge, F.Z.S.

EUROPEAN NOSE-HORNED VIPER (*Vipera ammodytes*).

In this viper of South-Eastern Europe the snout is turned up at the tip and prolonged into a soft scaly projection. This recalls the horny spike above each eye of the "Horned Viper" (*Cerastes cornutus*) of North-Eastern Africa.

of all Vertebrate creatures, snakes are the least understood, and also the most thoroughly misunderstood. The world at large debits serpents with being far more quarrelsome and aggressive than they really are, and it credits them with knowing far less than they do know." He attaches great importance to the case of a Reticulated Python, twenty-two feet long, which had been, on its long journey from Singapore, "unable to shed its old skin on schedule time," and had to be *peeled* to save its life. At first it writhed and resisted, but the five keepers "worked quietly and spoke soothingly," and all went well. "For a long hour or more, and even when the men pulled the dead scales from the eyes and lips, the creature made no resistance or protest. I have seen many people fight their doctors for less. That wild, newly caught jungle snake quickly had recognised the situation, and acted its part with a degree of sense and appreciation that was astounding. I do not know of any *adult wild* mammal that would have shown that kind and degree of wisdom under similar circumstances."

Of course, a good deal depends on what is meant by the word "wisdom," but it is open to doubt whether the python was as intelligently acquiescent as Dr. Hornaday believed. There was a good deal in its condition to lead it to non-resistance. Our general view is that snakes have a good many engrained or inborn ready-made ways (reaction-capacities), which are sufficient for the ordinary problems of life, and that when something quite unexpected happens they manage to wriggle out of it with credit. If they were less efficient, they might, perhaps, be more intelligent.

There is another power that snakes are often said to have—the power of fascinating birds. We have watched what happens—a painful sight, even though full of scientific interest, and it seemed to be a clear case of fear-paralysis, such as many animals show. It looked anything but charming or fascinating. The birds seemed to be dazed with fear; they moved stiffly and stupidly twice or thrice; and then stood rigid. We have seen a pony so "fascinated" by a motor-car that we had to share in lifting it, like a frozen animal, off the road. So, even in regard to the so-called "bird-charming," what impressed us was the efficiency of the snake, not its wisdom.

XLIII
THE WAYS OF AMPHIBIANS

SOME animals, such as pigs, are much cleverer than they look, but many other animals look much cleverer than they are. Frogs and toads belong to the second group. When we watch a toad climbing up a bank by the roadside, we get a suggestion of a shrewd old man. When we watch a frog focussing a fly we get an impression of intense concentration. The creature looks as if it were "intending its mind thereunto," to use Sir Isaac Newton's famous phrase. But there is good reason to suspect that the suggestion and the impression are both too generous. Perhaps we are misled by the relatively large head, forgetting the almost ludicrously small brain inside. There is something in the eye, especially the toad's, that inclines us to be generous. Miss Frances Pitt, in her delightful "Wild Creatures of Garden and Hedgerow," speaks well of the toad's "gleaming jewel-like eyes. They are a pale metallic brown with reddish lights like flickering fires in their depths."

§ 1

Frogs and toads can learn to distinguish between different people, but we do not know how. They can find their way "home" from a distance of two hundred to three hundred yards. But the most satisfactory observations are those made by Professor Asa Schaeffer on various kinds of American frogs. He found that frogs learned after a few trials to avoid disagreeable objects, such as hairy caterpillars, and that the lesson was remembered for at least ten days. Another frog learned in two trials not to have anything to do with earthworms that had been dipped in some drug. The lesson was perfectly remembered for a short time, and somewhat imperfectly for five days. When a frog got a mild electric shock on seizing an earthworm it declined earthworm for a whole week, but it did not decline mealworm. We see then that *frogs can learn*, and it is plain that a few observations made with great care are of much more value than a multitude of anecdotes that will not bear scrutiny.

Experiments on Learning in Frogs.

Some of the details of Professor Schaeffer's experiments are of unusual interest. When the frog seized the hairy caterpillar, it at once rejected it violently from its mouth. It had this experience to stamp in the fact that the caterpillar was very undesirable. On the other hand, the chemically treated caterpillar was actually eaten; there was no muscular rejection; but there must have been indigestion, for the frog remembered. The lesson "No more earthworm for me" lasted for some time, but for a much shorter time than in the case of the hairy caterpillars.

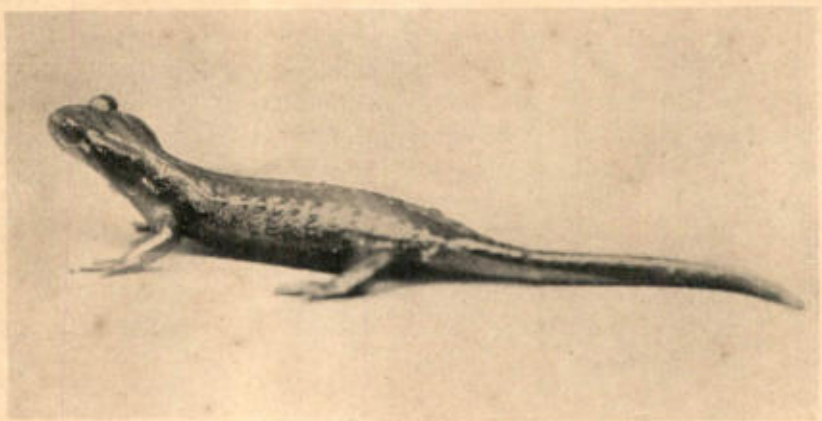


Photo: W. S. Berridge, F.Z.S.

THE ALPINE OR BLACK SALAMANDER (*Salamandra atra*).

This Alpine salamander, five to seven inches long, uniformly black in colour, lives at altitudes of 2,000 to 9,000 feet on the Alps from Savoy to Carinthia. It frequents the vicinity of waterfalls, where there is some spray; but the two young ones are not born till the gill-breathing stage is past. In other words, in adaptation to the conditions of life, the whole of the usual larval period is telescoped.

Photo: W. S. Berridge, F.Z.S.

JAPANESE GIANT SALAMANDER (*Cryptobranchus japonicus*).

This Japanese salamander, a near relative of the North American "Hellbender" (*Cryptobranchus alleghaniensis*), attains a length of five feet. It lives in shaded, cool brooks, and feeds on fishes, other amphibians, insects, and worms. It has very small eyes.

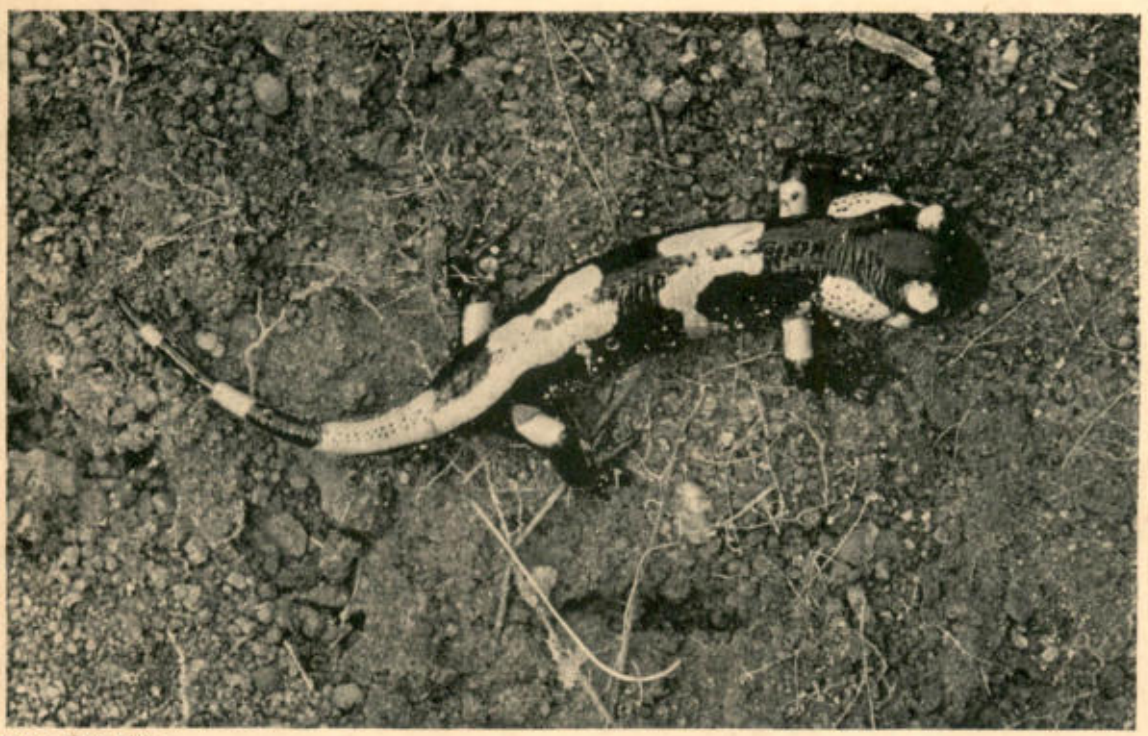


Photo: Hugh Main.

YELLOW-SPOTTED SALAMANDER (*Salamandra maculosa*).

The spotted or fire salamander has a striking livery of yellow and black in very varied proportions. It is widely distributed in Central, Southern, and Western Europe, but does not occur in Britain. Its skin is very glandular and the milky secretion is poisonous.

Now it is very important for frogs and other Amphibians in their everyday life to learn rapidly to avoid disagreeable foods. It saves time and energy and pain. What we may safely say is this, that a frog begins by testing many things, but *learns* after some experiences to avoid those that are undesirable. This is quite different from obeying an inborn feeding instinct that never makes mistakes. It is not difficult to understand why the frog that is fairly quick to learn about food, is very slow to learn how to get out of a maze, or even how to circumvent a transparent thread—by hopping over it. For these are difficulties which it does not need to face in its ordinary daily life.

Let us linger a little in Professor Schaeffer's laboratory. By a simple device it was arranged that when a frog made a rapid mouthful of a cockroach it got a mild electric shock. This stopped the eating of cockroaches, but it also stopped all eating for some days. The surprise put the frog off its food altogether. There was not much *learning* here.

But when the frog got a mild electric shock on eating an earthworm, there was a prolonged abstinence from earthworms, but mealworms (which are beetle-grubs) were eaten. There was the beginning of learning here.

In the case of the hairy caterpillars that we referred to, there was a rapid linking together of the sight of the caterpillar and "not having any"; and the lesson lasted. Here there was the beginning of the habit of not eating hairy caterpillars!

But there was another experiment that takes us a little further, and gives us, we think, a glimpse of the frog's mind at work. A hairy caterpillar was dropped in front of an experienced frog and began to crawl away. But a frog likes things that move, it will not eat dead things, so it hopped after the hairy caterpillar and closely examined it as it crawled. The frog was interested, but it refrained from further action. The movement of the caterpillar had pulled the trigger of the frog's interest, leading it to hop; but closer inspection awakened an old prejudice—perhaps a memory of a previous disagreeable experience. But when the frog carefully scrutinised the hairy caterpillar which it had followed was it not "making up its mind"? In any case it said to itself "No."

But the story does not end here. The hairy caterpillar, in which the frog had lost interest, tumbled into a dish of water and wriggled energetically on the surface. This novel wriggling once more arrested the frog's attention, and a re-investigation took place. But ten seconds sufficed to assure the frog that it was the same old hairy caterpillar; and it finally turned away. We do not say that there was much of a mind here, as men count mind, but surely there was a glimmering.

§ 2

Frog and Toad contrasted.

It is interesting to contrast the ways of the toad with those of the frog. The toad is leisurely and dignified; the frog is quick and nervous. The toad crawls, the frog hops. This may be due to a deep down difference in constitution or temperament, but we wonder whether it may not have something to do with the fact that the toad's life is much safer than the frog's, because of its much more abundant poison. The toad cannot spit poison, but its skin manufactures an irritant and unpalatable poison called "phrynin," and although there is something approaching this in the frog it is small in amount. There are very few animals that will take a toad in their mouth, and the leisureliness of the toad may have something to do with this. Perhaps the toad has a sense of security.

§ 3

Experimental Enterprise among Amphibians.

We have been considering experiments on Amphibians, but what of these animals as experimenters on their own account? Let us think of their history and of the acquisitions they made. The race of Amphibians, represented nowadays by frogs and toads, newts and salamanders, and by the strange earthworm-like Cæcilians, emerged towards the end of the Old Red Sandstone Age, and we think that there must have been considerable adventurousness and inventiveness in the original Amphibian temperament; they made so many new steps of great importance. They were experimental.

Derived from a fish-stock, such as is indicated to-day by the Mudfishes or "double-breathers"

Specially drawn for this work by Roland Green, F.Z.S.

CRESTED NEWTS, MALE AND FEMALE (*Molge cristata* or *Triton cristatus*).

There are three British Newts, the Crested, the Smooth, and the Palmated, in order of size. They are aquatic at the breeding season, more or less terrestrial at other times. The courting male develops a strong serrated dorsal crest and a deep membranous fin along the tail.

(Dipnoi), which have turned their swim-bladder into a lung and are able to breathe dry air for half the year, the Amphibians made the great step of leaving the water and getting on to dry land. Some backboneless animals had already taken this dangerous, but promiseful step; but Amphibians were the first backboned animals to live on land. And it must be remembered that only a few of them, like some of the tree-toads and the Black Salamander (*Salamandra atra*), that lives above the snow line on the Alps, have quite emancipated themselves from the water. In all ordinary Amphibians the youthful stages, such as the familiar tadpoles of frogs and toads, must be cradled in the water. They die if the pools dry up.

From Water to Land.

Photo: Ellison Hawks.

COMMON SMOOTH NEWT (*Triton vulgaris*).

This common newt is about three inches long, olive-green to brown above, yellow and orange below. At the breeding season the male has a wavy crest, but it is not serrated as in the crested newt. There is also a blue stripe on the tail.

It is a general rule in the animal kingdom that if a race has changed from one habitat to another, the members tend to go back to the old kind of haunt when they are about to start a new generation. Thus the fish-eating turtles, like the Loggerhead, come from the open sea to lay their eggs on the sandy beach; and the robber-crabs come from their inland haunts to lay their eggs in the shore waters. For Amphibians this rule of life holds particularly true. We see the toads at the breeding season walking a considerable distance to a suitable pond. The juvenile stages are for some time very fish-like—in their mode of respiration by gills, in their two-chambered heart, in their non-mobile tongue, in their lateral line of sensory cells, and so on. There is a great deal of the fish still lurking in the tadpole. During the first three months of its life, the frog has to climb up its own genealogical tree, but eventually it achieves individually what the Amphibians achieved as a race—the transition from water to dry land.

One is not forgetting, of course, that some Amphibians, like newts and axolotls, are much less terrestrial than others; but all normal forms develop lungs and are able to breathe dry air. If the shores of the North American lake are uninviting, the axolotls may remain all their life in the water and retain their gills—just as children with an imperfect constitution sometimes remain for years like infants. But if the shores are attractive, the axolotls get on to the land, lose their gills, and change their shape not a little. The axolotls become Amblystomes (see figure), for a long time regarded as different animals. To put it in another way, the axolotls are permanently larval forms, which do not quite attain to the adult characters of the Amblystome, though they are able to breed. But the large fact is that among backboned animals, the adventurous colonisation of the dry land is to the credit of the ancestors of our Amphibians. No doubt there may have been long periods of drought during which

Photo : F. W. Bond

TRANSFORMED AXOLOTL (*Amblystoma tigrinum*).

This is the commonest species of axolotl, ranging from New York to California. The male is about six inches long, the female three inches more. If it remains always in the water it keeps its three pairs of much branched gills ; but if it leaves the water it changes its shape and loses its gills, becoming an Amblystoma. Even in the gilled or axolotl stage the animal may become mature and have young ones.

water-basins dried up, giving their tenants the alternative—to explore or die ; no doubt there may have been overcrowding in the pools ; but something, we think, should be allowed for the deep tendency that there is in living creatures to test all things and hold fast that which is good.

§ 4

Fingers and Toes.

Another great step taken by pioneer Amphibians was the acquisition of fingers and toes. In fishes, which came before Amphibians, there were two pairs of limbs, but they were not more than fins. That is to say, they were without digits. The gaining of digits by Amphibians meant much : it meant some power of grasping—a support or a mate ; some power of tucking food into the mouth ; and some power of feeling things in three dimensions. We get a glimpse of the days of small things when we look at the weak limbs of most newts, hardly able to lift the body, slowly levering the creatures along the mud or paddling gently in the water. The important swimming organ in these animals is the tail, just as in fishes ; or, more accurately, it is the muscular posterior region of the body, which displaces masses of water to either side alternately. In a few cases, it is interesting to notice, the amphibian hand is used for digging.

§ 5

A Mobile Tongue.

In most cases the hard parts of animals are the only parts that are preserved in fossil form, so that we cannot say much about the tongue in the ancient extinct Amphibians. But we know that Amphibians sooner or later gained a movable tongue, and they are the first animals to be able to shoot out the tongue. Many a fish has a tongue, but it is a *non-muscular* mass (connective tissue covered by mucous membrane), and it cannot be moved as such. It cannot move except along with the whole floor of the mouth. But the frog moves its tongue to good purpose, shooting it out on the unsuspecting insect, and taking very good aim.

The frog's tongue is very different from ours. It is fixed to the very front of the lower jaw, and is loose behind and broadly bilobed. When it is shot out, downside up, it can reach to a considerable distance, and its moist surface helps to secure the insects. Now it is very interesting to find that the young tadpole cannot move its tongue. It has muscle-fibres in it, but they have to develop for a while before they are strong enough to move the tongue as a whole. Here again it seems as if the frog was slowly climbing up its own genealogical tree.

§ 6

The first Vertebrate Voice.

We cannot tell what vocal powers were possessed by the pioneer Amphibians, which had their Golden Age in the Carboniferous times, when most of the coal-measures were laid down. But we know that the Amphibians were the first vertebrate animals to have a voice. As in ourselves, the sounds made by the male frogs when they are serenading their mates, are due to the rapid passage of out-breathed air over the vocal chords stretched taut in the larynx. The first significance of the voice was as a call from male to female, and so it remains in Amphibians. One cannot think too often of the natural history of the voice, how it broadened out from being a sex-call to be a maternal call, a filial cry, a kin-signal, a warning of danger, a way of conveying tidings and expressing emotion, and, at last, a medium of reasonable discourse. The carrying power of the Amphibian voice has been estimated at three-quarters of a mile for an American bull-frog. It is often increased in the males by the development of a pair of resonating sacs (badly called "croaking" sacs), which sometimes protrude like soap-bubbles from the mouth. They are delicate paired expansions of a special muscle of the throat region, and are inflated when the frog is croaking. They are well seen in the males of the Common Edible Frog (*Rana esculenta*) of the Continent. In many cases they are present without protruding. In the common tree-frog the two unite to form a median pocket which can be inflated so as to equal in size the whole of the rest of the body—a very extraordinary state of affairs.

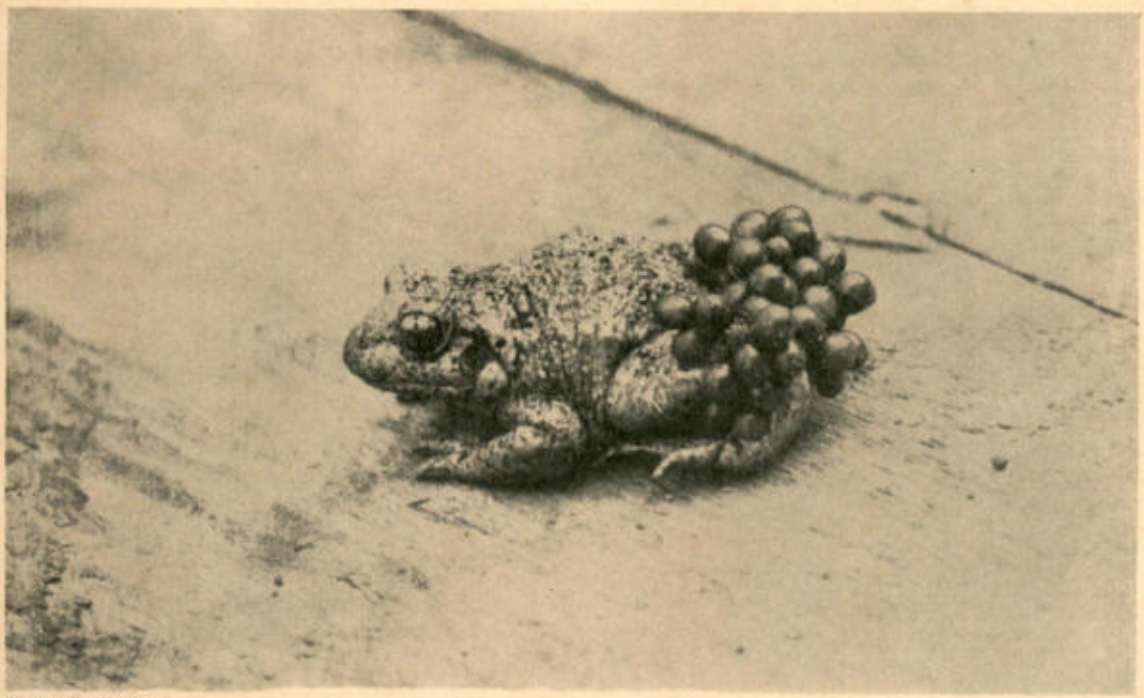


Photo: F. W. Bond.

MIDWIFE TOAD, MALE CARRYING EGGS (*Alytes obstetricans*).

This quaint toad is not uncommon in Spain, France, and Germany, and occurs from sea-level to sub-Alpine heights. As the eggs are liberated from the female they are entangled on the hind-legs of the male, who retires with them into his hole. After about three weeks he seeks the water, where the larvæ burst out from the gelatinous envelopes of the eggs.

Photo: F. W. Bond.

AMERICAN BULL-FROG (*Rana catesbiana*).

The body of this huge frog is often five inches long, and there are records of giants two inches more. Its home extends over the whole of the United States east of the Rockies. Its deep bass voice, saying "broom," is said to be audible from a distance of half a mile. It is a very voracious frog, able to tackle young water-birds. The photograph shows very clearly the drum of the ear behind the prominent eye.

We have ventured to speak of Amphibians as having an *experimental constitution*, and we get a glimpse of this in the case of Darwin's frog (*Rhinoderma darwini*), a small South American species in which the resonating sacs are used by the male for sheltering the eggs and larvæ. There are five to fifteen eggs; and as many as thirteen young ones have been found in the two resonating sacs. These become so large that they spread over the whole ventral surface of the father-frog. Eventually the young frogs clamber out of their father's mouth. This is certainly one of the strangest of cradles!

But the resonating sacs may have another use, which is also quaint. In two kinds called Paludicola (which means marsh-dweller) and Breviceps (which means short-head), the resonating sacs can be inflated very suddenly, and this is believed to have a "terrifying" effect on enemies. The armourless and weaponless Amphibians need all the help they can give themselves. The ancient Amphibian giants, called Labyrinthodonts because their teeth had an intricate labyrinth-like internal pattern, had armour, and there are minute scales embedded in the skin of the burrowing Cæcilians, which are the most old-fashioned of present-day Amphibians. But apart from the Cæcilians and two or three exceptional cases, the modern Amphibians are marked by their *nakedness*. Thus we can understand the value of a poisonous unpalatable skin, or of an arboreal habit, or of being green in green surroundings, or even of such a quaint peculiarity as blowing two balloons out of the mouth.

§ 7

Experiments with the Young.

The usual Amphibian method of dealing with the eggs is seen in ordinary frogs and toads. The eggs are liberated in the water and float, helped by the swelling up of the transparent white-of-egg or albumen. In the case of the frog the "spawn" consists of buoyant masses of gelatinous spheres, each with a dark centre, about a tenth of an inch in diameter, which is the egg itself. In the toad there are two long glairy strings, which are twined among the water-weeds.

In the blind, limbless, burrowing Cæcilians, which look superficially like earthworms, the eggs are laid in damp earth, and the gills, which would not be of use underground, are shunted back into the embryo stage, before the egg-envelope has been burst. This shows how the past lives on in the present, for the gills persist though they might well be dispensed with. The case of the Cingalese Cæcilian called Ichthyophis is very interesting, for the adult has become a thoroughly terrestrial animal—burrowing like an earthworm. It could not deposit its eggs in water; the fact is that it drowns if it is put into a pool. The mother lays a few eggs in damp earth, often near water, and she coils her body round about them, secreting slime from her skin which keeps them moist, and also, perhaps, nourishes them. When the larvæ are hatched out, they make for the nearest stream and sojourn there for a while—an interesting instance of a temporary return to the ancestral haunt of the Amphibian race.

If the Cæcilian blindworm coiled round its little bunch of eggs points the way to the brooding python, there are other Amphibians that anticipate the Marsupials in having a pouch for the eggs and young. Thus in the female Nototrema (which means back-pocket), a dorsal fold of skin forms a capacious backward-opening brood-sac in which the eggs develop. The larvæ may have long respiratory threads continued out from the gills, and in the tadpole of *Nototrema oviparum* there is a pair of beautiful long-stalked balloon-like bladders projecting from the breathing aperture. Each balloon has two blood-vessels, one coming to it with impure blood, and the other going from it with pure blood. This is one of the most extraordinary breathing arrangements in the animal kingdom, and it has to do with the fact that the young ones remain for a considerable time huddled together in the pocket. In this case the tadpoles change into little frogs within their mother's pocket; but in other Nototremas the tadpoles escape into the water.

On a different line but not less interesting is the case of one of the tree-toads called Phyllomedusa where the eggs are laid in a nest made

Photo: W. S. Berridge, F.Z.S.

SOUTH AFRICAN BURROWING TOAD (*Breviceps gibbosus*).

Small, very globular burrowing toads, with the head and limbs only slightly projecting. They have a horny spade-like outgrowth on the ankle, and by means of this they dig into the nests of the white ants, and also into the ground. They bury themselves in the dry season and emerge again in great numbers when the rains return. In shape they have been compared to an over-stuffed round bag.

of leaves on a branch overhanging a pool. At the appropriate time the bottom of the nest gives way, launching the larvæ into the water. Nothing could be better.

The Surinam Toad.

Very extraordinary is the experiment that has been made by the Surinam Toad (*Pipa americana*) found in Guiana and Brazil. At the breeding season the skin of the back of the female toad becomes honeycombed with small pits with a rich blood supply. As the female lays the eggs (forty to one hundred in number) she manages to get them on to her back, helped by the attentions of the male who fertilises them. They sink into the skin-cradles, which are then closed with a firm coverlet. Development proceeds, and by and by the mother's back is covered with a crowd of little toads, which burst off the coverlet, squirm half-out, and look round! There is a tadpole stage with external gills and with a long tail which probably helps in respiration; but the young ones do not leave their mother's back until they are fully-formed miniature toads. They do not go near the water at all, so the Surinam Toad is an Amphibian that is ceasing to be amphibious.

Very different is the story of the Nurse Toad (*Alytes obstetricans*) which is not uncommon in some parts of Europe. The male takes possession of the eggs just as they are laid by his mate, and after they have been fertilised he manages to entangle them round the lower part of his hind-legs, for the eggs are bound together by elastic threads. He sometimes goes the length of having two bunches of eggs to look after. All this happens on dry land and the father-nurse remains there, except that on very dry evenings he sometimes has a bath, which will be all the better for the eggs. After about three weeks, however, he plunges into a pool, and the young ones, now at the stage of limbless tadpoles, bite their way out of the jelly of the packet and are free. When he has got rid of all his family the nurse-frog returns to dry land. It is interesting that there should be among Amphibians so many instances of paternal rather than maternal care. It is a line of experiment that has not been much followed among higher animals, though one must not forget that many male birds share in the patient task of brooding.

Why should there be among Amphibians such a variety of devices for securing the safe development of the young? Part of the answer is that Amphibians are betwixt-and-between animals—one foot on land and one in water, so to speak. They were the first backboned animals to try with persistence the hazardous passage from water to dry land, and they were also, as we have mentioned, singularly destitute of armour and weapons. The problem of safely disposing of the eggs could not always be met by laying them in the water, as the Common Frog does. Other devices had to be tried, especially when the parents became more and more terrestrial. So one of them makes a leaf nest overhanging the pool and another digs a burrow in a moist bank; a mother may carry the eggs and young in a pocket on her back; a father may shelter them in an enlarged resonating sac. How are we to think of these experiments?

We cannot suppose that individual Amphibians sat down and pondered over the problem they had to face, for Amphibians have very poorly developed brains, and it is probable that Nature's way of working was more indirect. Changes or variations in behaviour are frequently arising, just like variations in structure; they well up from the fountain of changefulness that there is in the germ-cells when the individual life begins. These new departures or variations are tested by the individual in the course of its life, and those that are most successful become part of the hereditary ways of the race. To change the metaphor, a living creature often finds itself with a new "hand" of hereditary cards; it is for the individual to play this "hand" with all the mental ability it possesses, testing everything and holding fast that which is good. *What is certain* is that Amphibians show a great variety of ways of solving the problem of giving the next generation a good send-off in life.

Many Different Habitats.

We have spoken of the peopling of land and sea, and with regard to this subject we may get a useful hint from the study of Amphibians. The big fact which we have already emphasised is that, among backboned animals, the Amphibians were the first to persist in the great adventure of colonising the dry land. It opened up the possibility of a life on a higher turn of the ascending spiral, but it meant *living dangerously*.

Thus we understand better why Amphibians should show a great variety of ways and a great variety of habitats. They were feeling their way. The Common Frog represents a sort of average; it is aquatic-and-terrestrial, literally *amphibious*, but there are many departures from the average. Thus there are *arboreal* Amphibians like the attractive tree-toads, *burrowing* Amphibians like the blindworms which have discovered the possibilities of the underworld, a *secondary return to the water* on the part of some other blindworms, and a *swooping habit* exhibited by the Java tree-frog called Rhacophorus, where an exaggeration of a web between the fingers and another between the toes forms an effective parachute, enabling the creature to descend obliquely from a considerable height. These and other departures from the average show that Amphibians are inventive. If necessity is the mother of invention, as is often remarked, perhaps the biologist was right who said that curiosity was the father! Or if not curiosity, then a certain experimental adventurousness.

XLIV

THE WAYS OF FISHES

MOST anglers are agreed that trout become wary, and there are show-ponds where the fishes crowd to the bank when the dinner-bell is rung. That means that fishes can link together certain sights or perhaps sounds with certain impulses. But we know very little about intelligence in fishes.

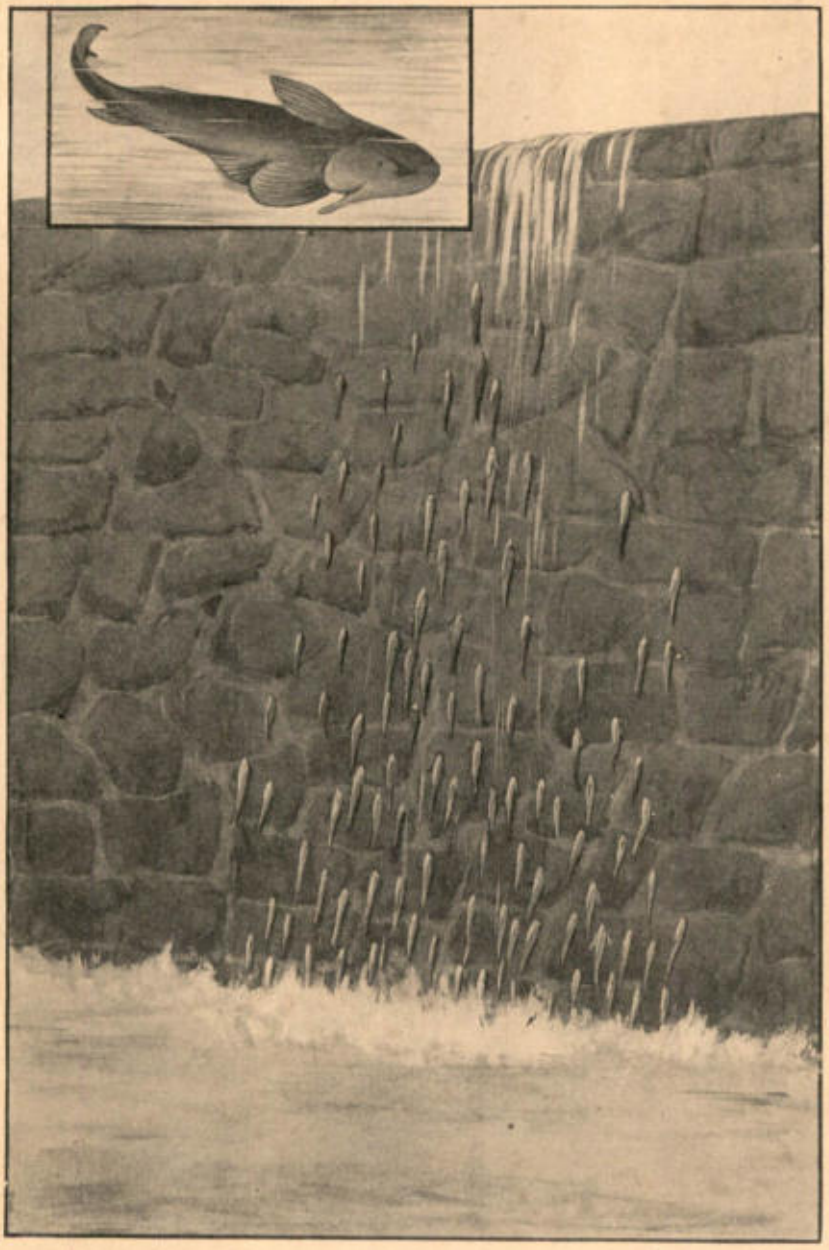
§ 1

Senses of Fishes.

A dogfish becomes aware of a piece of flesh which is hidden from sight, and there is no doubt that some other fishes have a strong sense of smell. A carp may be seen trying a morsel of food and then rejecting it with apparent disgust. There is abundant evidence of the sense of taste in fishes, and it may have its seat away from the mouth-cavity altogether, on various parts of the body such as the fins. There is an American catfish that can taste its food with its tail! In various parts of the skin there is another sense—a chemical sense—that makes the fish aware of changes in the composition of the water.

Touch is not a strong point with fishes, but it is sometimes developed about the head and lips, or on feeler-like processes, one of which is well seen on a cod's chin, called barbels. If you look at almost any bony fish, you see a "lateral line" running along each side. It consists of a row of sensitive cells embedded in slime and sunk in an open groove, or in a canal roofed in by scales and communicating with the exterior by means of small pores. Experiments show that this lateral line is the seat of a sort of mechanical sense that makes the fish aware of a pressure in the water working in a definite direction. Thus when a fish is coming near a rock the recoil of the water that is displaced by the fish's movements is felt by the lateral line and the creature turns aside. Or again, it is by the lateral line that a fish becomes aware of a tributary entering a river. This sense must be of much use at night and in muddy water. It is probably concerned in the persistence with which some fishes, like migrating salmon or young eels, go straight up stream. For it makes the fish aware of the direction and strength of the currents in the river; and fishes have an engrained obligation (or "tropism") to adjust their body (it comes about automatically) so that the pressure is equal on the two sides. It may be noted that in gristly fishes like skate and dogfish the place of the lateral line is taken by numerous branching jelly-tubes which lie in the skin and open by minute pores.

Oscillations and vibrations in the water are detected by some fishes, both by the ear and by the lateral line. In some cases the sense of hearing has been proved, but in other cases the fishes pay no heed to even loud noises. This



CATFISH CLIMBING THE WALL OF A DAM.

A number of the freshwater tropical fishes, known as "Catfishes" or Silurids, have great power of climbing waterfalls and even a wall with a drip of water. Some ascend torrential mountain streams in an almost incredible way. They are helped by two spines projecting ventrally near the gill-cover.

does not necessarily mean that they are deaf; it may simply mean that they are not interested. But the fact is that we do not know very much about the sense of hearing in fishes. Perhaps it may seem strange to ask whether fishes can hear, when the fact is that they have all got well-developed ears. But the ear has another use besides hearing; it is a balancing organ, especially in that part known as the "semi-circular canals." Before the ear was a hearing ear, it was a balancing ear.

As to sight in fishes, there is sometimes, as in trout, a quick detection of differences in light and shade; and the bony flat-fishes show great sensitiveness to the colour of the background on which they rest. For in a short time they are able to adjust their own colour and pattern to suit their surroundings. The colour of an object, like bait, is not perceptible, at a short distance below the surface, and yet some fishes are most attracted to artificial bait of a particular colour. But few of those who have experimented with fishes have been careful to draw the distinction between different colours and different degrees of brightness. Professor Hess, who attended to this distinction, was led to the conclusion that fishes see different colours simply as different shades of grey. In other words, they are in this respect like men who are totally colour-blind. But we must be careful not to make general statements until more cases have been studied. All that we can say is that colour-blindness occurs in some fishes.

In judging of the ways of animals we must always think over the ordinary conditions of their life and the actions that are suited to these.

A reliable fisherman tells us of a pike whose eye had been accidentally wrenched out with a hook, which nevertheless a few minutes afterwards swallowed that eye! We are tempted to call this action very stupid, but that would be a wrong conclusion. For what the fish did was merely to snap *reflexly* at a glittering object. It did what was probably a profitable thing to do in ninety-nine cases out of a hundred in the ordinary conditions of its life. Of course the one-eyed pike did not know that it was snapping at its own missing eye!

Photo: John J. Ward, F.E.S.

THREE-SPINED STICKLEBACK (*Gasterosteus aculeatus*).

This little fish, never more than four inches long, is found in the rivers and on the coasts of the Northern Hemisphere. There are no true scales, but the sides of the compressed body are armoured with bony plates, which show considerable variability in number and size.

§ 2

Memory in Fishes.

A zoologist called Oxner has made some interesting experiments with the sea-perch (Serranus). In his aquarium he placed a red vessel and a green vessel, hanging them by silk threads of the same colours. Then he put some food in the red vessel. On the third day, after nosing about for a quarter of an hour, the fish entered the red vessel and ate the food. Next day it did the same after five minutes; on the fifth day after half a minute. From the sixth to the tenth day it rushed in at once. So it had formed a linkage or association between the red colour and the food. It was not any odour that attracted the fish, for on the eleventh day it entered a fresh red vessel that had no food in it, and waited there for three minutes. On each of the following six days it rushed into the empty red vessel, and when Oxner dropped in some food a little was eaten. But the sea-perch was not much appetised, and on the eighteenth, nineteenth and twentieth days it did not eat what was offered to it in the vessel. But the interesting point was that it could not resist rushing in! The colour pulled the trigger without fail. It was not the *red* colour in particular that was attractive, for the same results were reached in another set of experiments where other colours were used. What happened was a linking together of a signal (the colour) and a pleasant experience (eating the food); and it seems very likely that in the every-day life of fishes this sort of linkage is very common. A certain sight pulls the trigger of a reminiscence and action follows—sometimes

Photo: W. S. Berridge, F.Z.S.

TEN-SPINED STICKLEBACK (*Pygosteus pungitius*).

The dorsal spines vary from seven to twelve. The nest is not built on the bottom of the pool, as in the Three-spined species, but is attached to water-weeds. Except in the Far North and in the Baltic region this species is usually confined to fresh water.

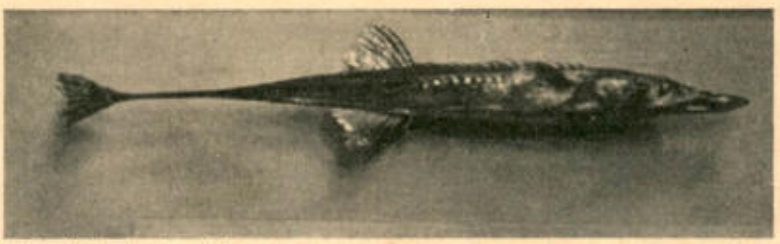


Photo: W. S. Berridge, F.Z.S.

SEA OR FIFTEEN-SPINED STICKLEBACK (*Spinachia spinachia*).

This stickleback differs from the other British species in being exclusively marine. The male makes the nest in sheltered shore-pools, binding seaweeds and zoophytes together with glutinous threads. Like his relatives, he is pugnacious and devotedly paternal, and apparently short-lived.

swimming towards the object if it be food, sometimes swimming away if it be an enemy. In the course of time it may not be necessary to have the reminiscence.

§ 3

The Mind of a Minnow.

Very pretty experiments have been made by Miss Gertrude White on American mud-minnows and sticklebacks. Two cloth packets, one with meat, the other stuffed with cotton, were hung at opposite ends of the aquarium. The sticklebacks were immediately interested in the meat-bag, darting upon it furiously and pulling it about. From the cotton-bag they turned away at a distance of about two inches. The mud-minnows were not interested in the bags, but they watched moving objects very intently.

Fragments of liver were held to the little fishes from the end of forceps and kept from touching the water. The fishes could see the food but could not smell it. To get it they had to leap out of the water, and they learned to do this neatly. Then Miss White slipped a disc of coloured cardboard over the lower end of the forceps, so that what the fishes saw was a morsel of food in the centre of a coloured circle. The fishes soon established a mental linkage between coloured disc and food so that they could not resist jumping up to a coloured disc even when there was no food there. Better than that, the mud-minnows learned to associate a blue disc with real bait, and a red disc with paper-bait. They learned to ignore a kind of larva that they could make nothing of, and to link together the approach of a visitor and the prospect of a meal. It has been proved up to the hilt that fishes form simple associations of this sort and hold to them firmly.

Photo: W. S. Berridge, F.Z.S.

THE MUD-SKIPPER OR WALKING FISH (Periophthalmus).

These quaint fishes are common on estuarine mud-flats in tropical Africa, Asia, and North-West Australia. They jump about, hunting small shore-animals, using the muscular scaly base of their pectoral fins. The eyes stand out prominently on the top of the head and are very movable.

§ 4

Do Fishes Think?

Salmon come back from the sea to spawn in the rivers of their birth; elvers show an admirable perseverance in overcoming obstacles on their up-stream journey; the male sticklebacks make nests of seaweed or parts of fresh-water plants; the male sea-horse carries the young ones in his pocket; the male lump-sucker guards and aërates the eggs in the corner of a rock pool. There is no difficulty in multiplying instances of this kind of behaviour; but it all seems to illustrate obedience to inborn promptings to go through a certain routine. It is very effective behaviour, but there is no proof of intelligent learning.

Here, however, is an instance of a kind of behaviour which shows something more. In the aquarium of the Monaco Museum, M. Oxner made some experiments with a fish technically called *Coris julis*, which seems to have no common name. He tried it with a hook well disguised, and he caught it as often as he pleased. That proved that the disguise was very perfect and that the fish was very hungry; and it suggested that the fish was of a somewhat unsuspicious nature. Then M. Oxner placed a piece of red paper on the gut-line a couple of inches above the well-hidden hook, and offered it to an inexperienced and quite unprejudiced Coris. For the first week the fish remained indifferent; but on the eighth, ninth, tenth and eleventh days

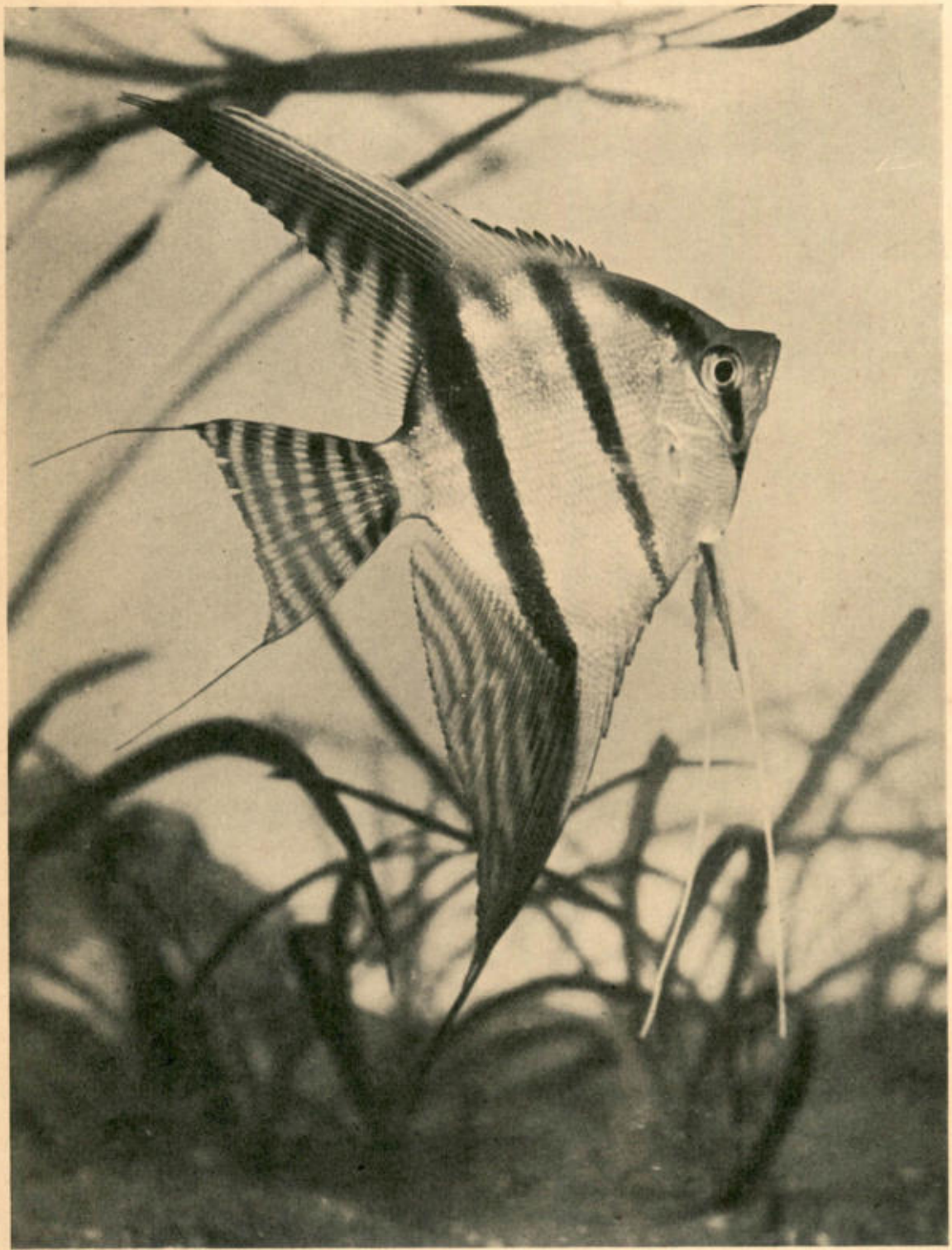


Photo: G. H. and W. T. Pitt.

ANGEL FISH OR PTEROPHYLLUM.

A remarkable freshwater fish of Central and South America in the family of Cichlidæ, famous for its beauty and for its parental care. Besides the fan-like tail with two streamers there are extraordinary wing-like extensions of the dorsal and ventral unpaired fins, to which the name angel fish refers. The same name is applied to a brilliant blue and yellow coral fish of the Bermudas (*Holacanthus ciliaris*).

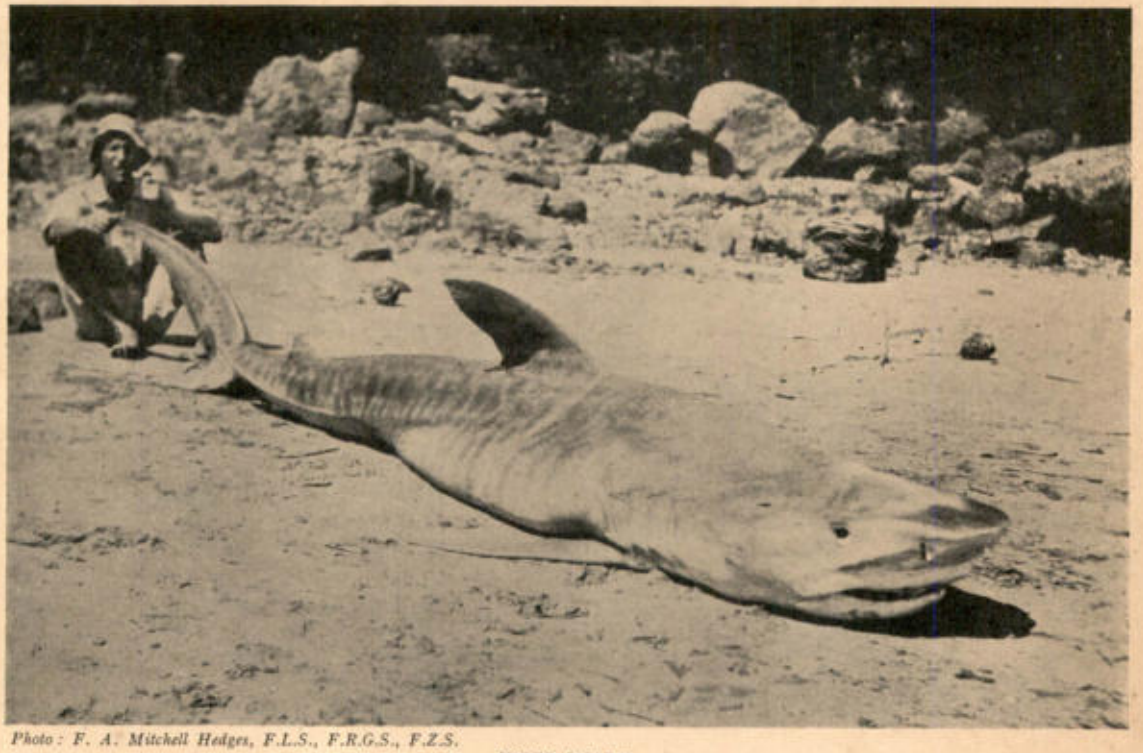


Photo: F. A. Mitchell Hedges, F.L.S., F.R.G.S., F.Z.S.

TIGER SHARK.

This huge Tiger Shark was twenty feet nine inches long, eleven feet seven inches in girth, and weighed 1,760 pounds. Its stomach contained a large part of a bullock (probably thrown from a cattle boat), and remains of four pelicans, two sea-hawks, and two cormorants. It was caught near Panama in the Pacific.

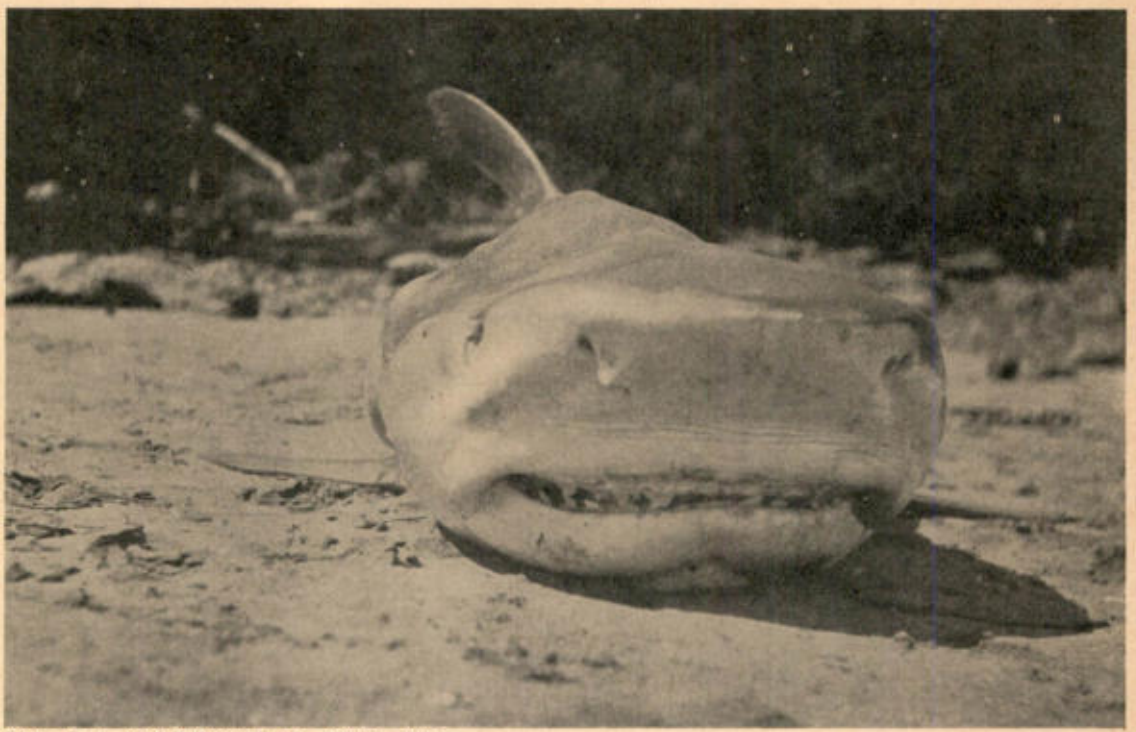


Photo: F. A. Mitchell Hedges, F.L.S., F.R.G.S., F.Z.S.

FRONT VIEW OF TIGER SHARK.

When the jaws of this big fish were cut out it was found that they easily encircled two men standing back to back, passing over their heads. They had a circumference of seven feet four inches. The photograph gives a glimpse of the formidable curved teeth, and shows the large nostrils above the mouth.

it took the bait. On the twelfth day, however, it refused the bait until the red paper was removed. On the thirteenth, fourteenth and fifteenth days it refused the bait with the red paper on, though it examined it carefully. On the sixteenth day and on the following six days it began by snapping at the red paper, and then, turning to the hook, bit off the bait in small scraps, without any hurry, and with a thousand precautions. *It had learned its lesson.*

Let us think over what happened. A linkage was established in the mind of the fish between red paper and hook. The inborn or instinctive prompting was, of course, to swallow the bait, but the red paper served as a warning. It was a danger signal which the fish obeyed. Gradually, however, the fish profited by experience, it learned a new trick, it discovered how to nibble at the bait without gulping at it and thus getting the hook into its mouth. So it disregarded the danger signal and got its tit-bit. This was coming near an intelligent understanding of the situation.

We see then that fishes have many interesting habits to their credit, but they do not show more than the dawning of intelligence. By far the best brains are to be found among the gristly forms like skate and shark; in bony fishes the fore-brain, which is the seat of intellectual processes in higher animals, is very poorly developed.

§ 5

Pioneering Fishes.

As fishes had established themselves, both in fresh waters and in the sea, during the ages called Silurian—that is to say, a great many millions of years ago—they have had time to make a great many experiments, or to test the many new promptings that arose ever and again from within.

Photo: F. A. Mitchell Hedges, F.L.S., F.R.G.S., F.Z.S.

HAMMER-HEAD SHARK (Sphyrna).

Hammer-heads are marked by the prolongation of the head into two great lateral lobes, which bear the eyes at their outer ends. In this specimen, caught near Taboga in the Pacific, the hammer-head was four feet six inches from tip to tip, the total length of the animal being seventeen feet six inches. Hammer-heads are voracious viviparous sharks; *Sphyrna zygæna* occasionally visits British coasts.

Strange Habitats.

Animals are always insurgent, always looking out for a new kingdom to conquer. If they cannot get a new kingdom, they will be content with a new corner. The great abysses of the ocean may serve to illustrate a new kingdom, which fishes have possessed. It appears as a very inhospitable haunt with its eternal night and eternal winter, its enormous pressure and its plantlessness. Yet many fishes are at home there, having probably

Photo: F. A. Mitchell Hedges, F.L.S., F.R.G.S., F.Z.S.

SAW-FISH (or Pristis).

In the true Saw-Fishes (Pristis) the front of the skull is prolonged into a long flattened gristly saw or rostrum, which bears strong tooth-like scales implanted in sockets along each side. The saw can tear off a great piece of flesh from another big fish or from a whale. The photograph shows a Pacific giant stranded on the beach; it was twenty-nine feet long, nineteen feet in girth, and weighed 4,500 pounds.

followed the down-drift of food from the shore area or from the open sea. We shall inquire later on into the peculiarities of these Deep Sea fishes, for some of them are blind and others have large goggle eyes, many have an extraordinary width of gape suited for making sure of a meal when an opportunity offers, and many are luminescent.

What a contrast between the abysmal habitat and that of some fishes which climb up mountain torrents. There are some fishes that frequent the mountain torrents of India and may be seen clambering up from stone to stone. They are almost leaf-like in shape, and this enables them the better to resist the down-rush of the current. There is a great reduction of scales on the under surface of the body, and this makes it easier for them to adhere to the smooth surface of rocks. We know how tightly two sheets of wet glass will cling to one another. The paired fins may also help as holdfasts, and some kinds of mountain-torrent fishes have special adhesive organs. The eyes are much smaller than usual and are pushed towards the upper surface. In short there are various adaptations which enable these climbing fishes to succeed in their strenuous mode of life.

In estuaries and fresh waters of India there lives the so-called Climbing Perch (*Anabas scandens*), whose native name means "the fish that climbs palmyra trees." Its climbing powers have been exaggerated, it is true, but they are remarkable. Mr. Wilson, of the Madras Fisheries, once trained a few of them to ascend a nearly vertical sheet of cloth dipped into the water of the aquarium in which they lived. They learned to swarm up, using their movable gill-covers and spines. It is well-known that these Climbing Perches sometimes make considerable excursions on land.

There is a curious complication of the breathing arrangements in the Climbing Perch. It has the usual fish-gills, on which the blood is spread out, but one of the gill-arches has a complicated bony labyrinth with many blood-vessels on its wall. Air is gulped in at the mouth; it passes into the labyrinth; it loses part of its oxygen to the blood-vessels and absorbs carbon-dioxide; and then passes out by the gill-chamber.

The late Dr. Nelson Annandale, of the Indian Museum in Calcutta, described another climbing fish, which ascends the posts supporting wooden houses built over the water by the shores of lakes. This little fish moves slowly up the post, browsing on encrusting plants and animals. It seems to use its tail in climbing, after a fashion which recalls the woodpecker's way of pressing its stiff tail-feathers against the roughnesses of the tree-stem. When the little fish wishes to rest on its ascent, it takes firm hold with its lips.

Widely distributed on tropical shores is the mud-skipper (Periophthalmus) which jumps about when the tide is out and hunts small animals. It is famous for its protruding eyes which stand out on the top of its head and look all round. In its life out of water it seems to breathe in part through the blood-vessels richly spread out on its tail. This mud-skipper is sometimes to be seen fairly high up on the kneed above-ground roots of the mangrove trees, and one might speak of it as a fish that climbs trees! The fore-limbs or pectoral fins are muscular enough to be used as little legs. A fish out of water indeed, but a conqueror of the shore!

These are strange haunts and strange ways for fishes, and many more might be noticed. But the point is simply to illustrate the pioneering of some fishes. We have not to do with curiosities, but with the tendency of animals to seek out *vacant niches of opportunity*, new corners in which they can escape for a time from the keen severity of the struggle for existence.

Strange Ways of Feeding.

Along many different lines fishes have tried to solve the "bread-and-butter" problem. There are a few that have vegetarian diet. Thus the long food-canal of the Mediterranean Bogue or Box seems never to contain anything but fragments of seaweed and sea-grass. The Rudd of British streams might also be called a vegetarian, though not absolutely consistent. The fact is that most fishes that eat water-plants and seaweeds like a good deal of fleshy relish in addition. And there is an inclined plane leading to fishes like carp, which will eat anything and everything. At the lowest level are those offshore fishes that depend mainly on what may be called sea-dust—the organic crumbs that are washed out from the seaweed zone.

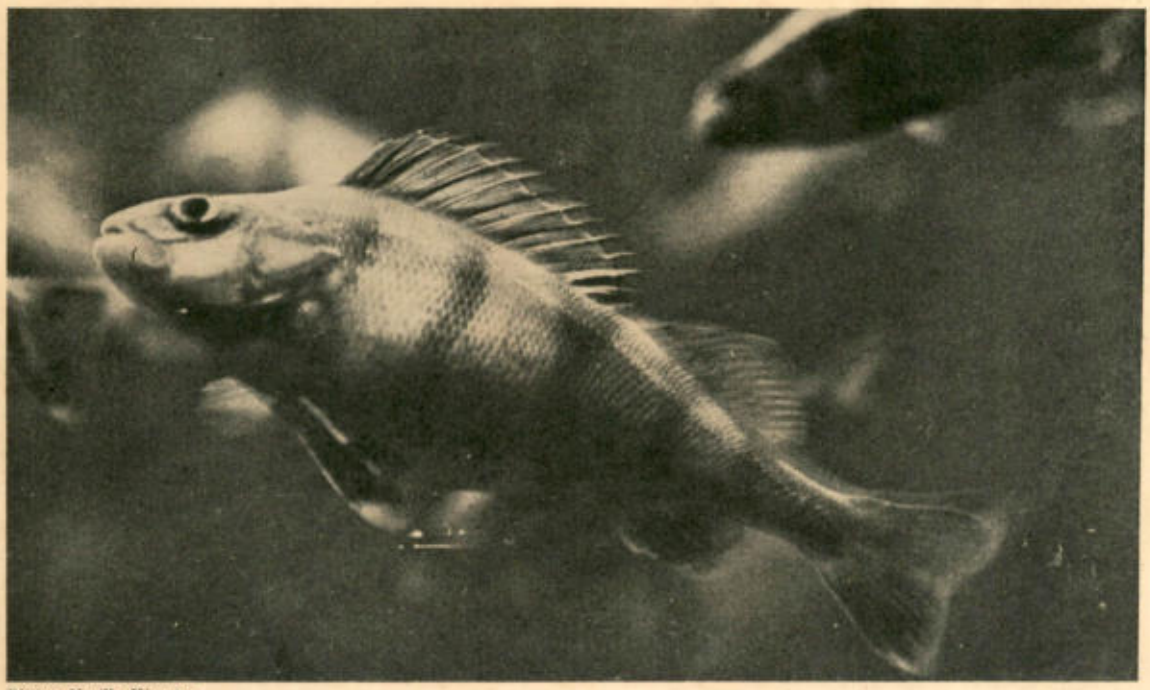


Photo: Neville Kingston.

THE COMMON PERCH (*Perca fluviatilis*).

The well-known Perch, common all over Europe and represented in North America by a closely allied species, is a pugnacious fish, feeding on smaller fishes, such as minnows, and on worms. Very characteristic are the humped back, spiny dorsal fin, and dark bars conspicuous against a background varying from greenish-olive above to golden-yellow below. A common weight is half a pound, but a five-pound fish has been recorded.

The carnivorous fishes are legion—the shark devouring other fishes, the dogfishes fond of octopus, the skate preying on crabs and oysters, the pike thinning the trout, and so on through a long list. But rather different from these predatory forms, which feed at a high level, are those that depend on relatively minute creatures which are sifted out of the mud or caught among water-weed. Thus many freshwater fishes depend to a large extent on the aquatic larvæ of insects like Mayflies, and the stomach of a trout is often found stuffed with scores of small freshwater snails and nothing else. Highest of all, in a way, are those dainty feeders, like herring and mackerel, sardine and sprat, which depend on the minute and sometimes microscopic plants and animals (the plankton) of the Open Sea. These plankton-eaters are usually very palatable, as one would expect from the delicacy of their diet.

So far the common solutions of the problem of food-getting among fishes, but against this background, to illustrate plastic "ways," let us notice a few strange methods. Thus it is recorded of more than one kind of "Javelin Fish" (Toxotes) in Indian streams, that they get part of their sustenance by squirting jets of water from their mouth on passing insects. What a contrast to the behaviour of the Sword-fish (*Xiphias gladius*), which has a long, pointed, sword-like prolongation of the upper jaw with which it sometimes transfixes a Tunny or even a porpoise. It has been known to send its sword accidentally through the two-inch plank of a vessel. There is less certainty as to the Sawfish (*Pristis antiquorum*), which has its snout prolonged into a broad saw, often over a yard in length, with a row of strong, sharp, socketed teeth, projecting at right angles on each side. It is believed by some naturalists that the Sawfish cuts off great pieces of flesh from its booty; but others maintain that the chief use

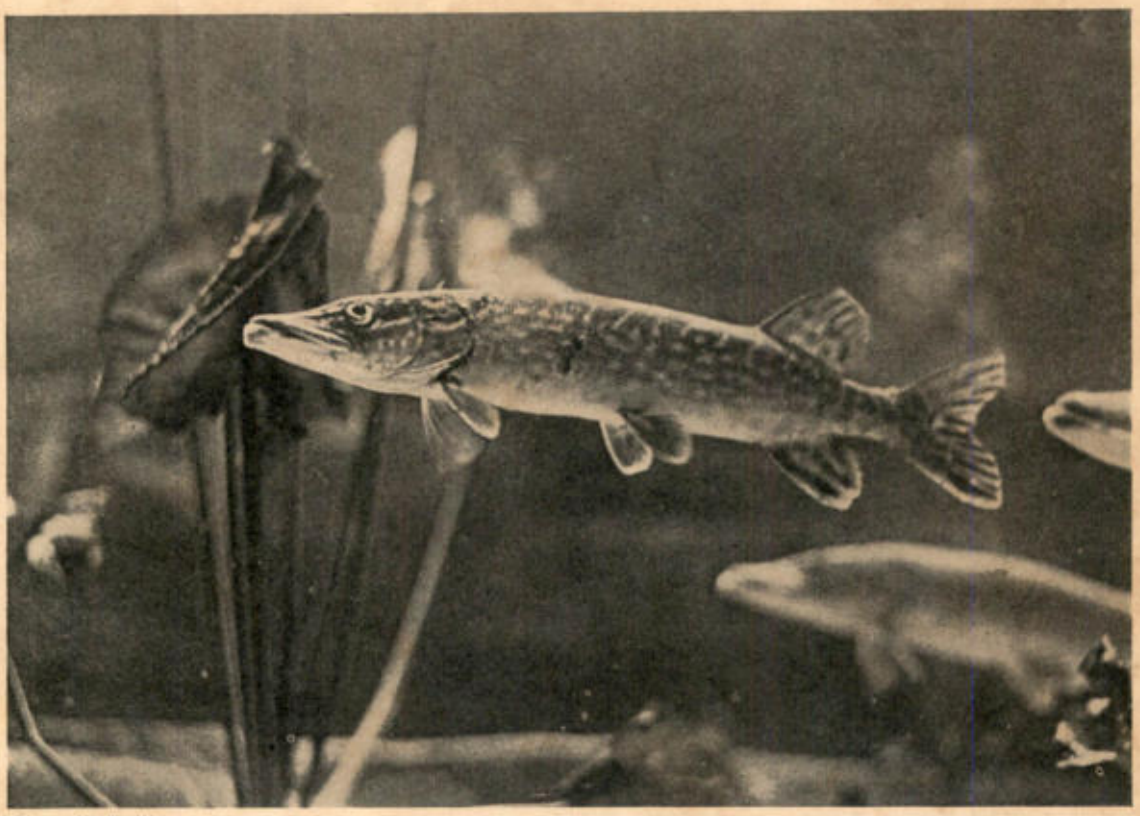
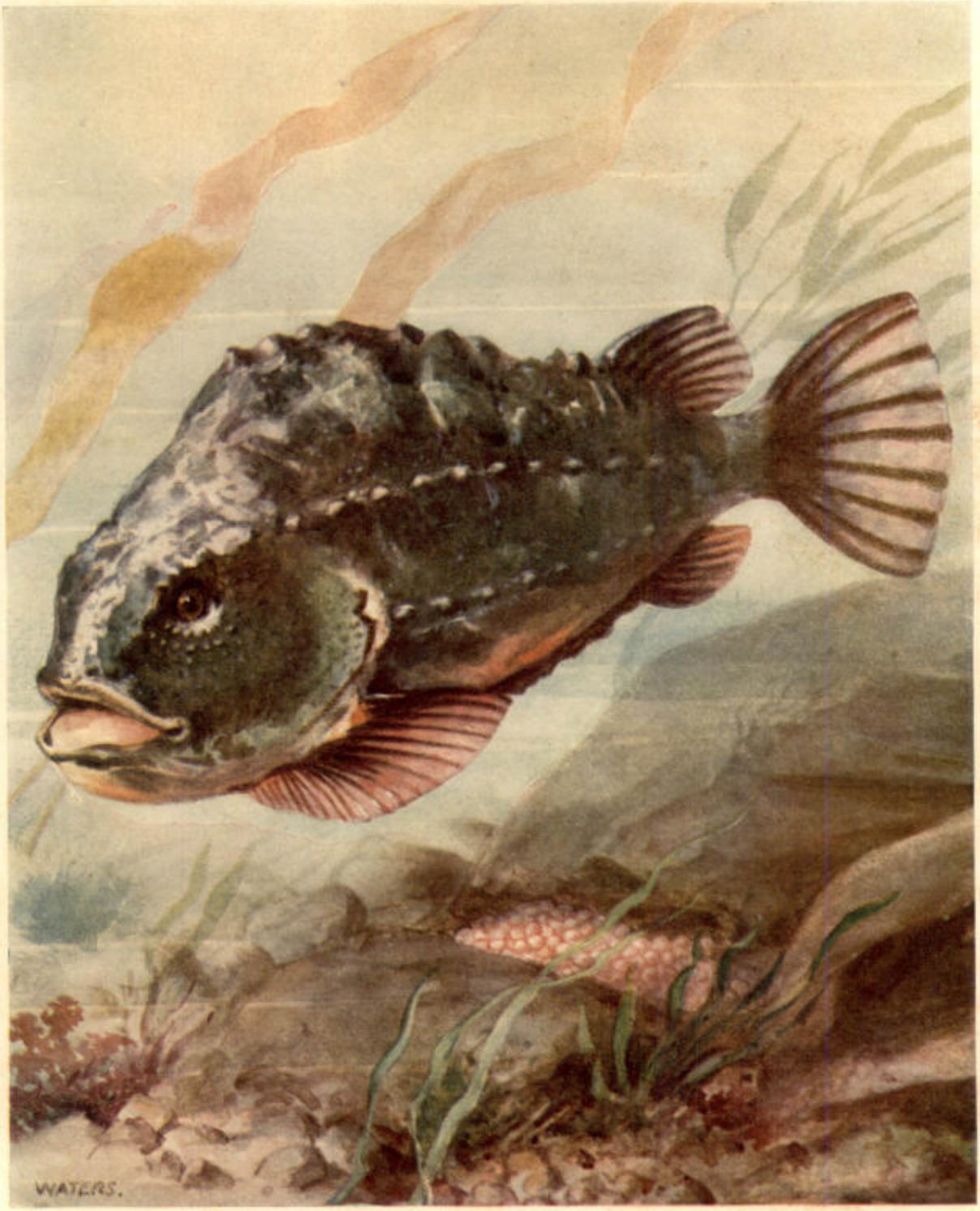


Photo: Neville Kingston.

THE COMMON PIKE (*Esox lucius*).

This Old World fish, now represented by one species, attains a great size, sometimes over forty pounds, and a great age, perhaps a year for every pound. It lives a solitary life in lakes and rivers, and is famous for its voracity, devouring not only other fishes, but water-voles and ducks. Sometimes it will eat its own weight in a day without suffering from indigestion.



Specially drawn for this work by J. Waters.

THE LUMPSUCKER (*Cyclopterus lumpus*).

Lumpsuckers are quaint fishes frequenting the shallow waters around the coasts of the North Atlantic. Between the pectoral fins there is a fusion and modification of the pelvic fins to form a strong ventral sucker, by means of which the fish can fix itself. The male mounts guard over the pinkish eggs, which the female deposits in a depression among the rocks. There are rows of strong tubercles on the skin, but a great part of the internal skeleton is grisly. The Scottish name of the quaint creature is "cock-paidle."

of the saw is to rout up the mud at the bottom of the sea, so as to expose the molluscs and crustaceans on which the fish feeds. This requires further investigation.

How different again is the habit of some of the electric fishes, such as the Torpedo and the Electric Eel, which use their powerful battery, not merely in offence and defence, but in paralysing or killing their prey, which often consists of other fishes. But we shall return to this in connection with Animal Weapons. As a last example of plasticity take the Sucker-Fish or Remora (Echeneis), which has an elaborate sucker on the head and anterior dorsal region, by which it fastens itself to sharks, other large fishes, turtles, cetaceans, and even ships. The little Remora does its living bearer no harm, for it is no parasite; it hangs on for the sake of transport and because it may share in what its bearer secures. Semon observed in the Torres Straits that when edible material was thrown out of his boat, a number of Remoras darted out from beneath, seized some of the food, and then fixed themselves again. It is difficult to think of the origin and evolution of this extraordinary habit and others like it without allowing fishes at least a trace of the experimental mood. The association between the Remora and its bearer must have been sustained for a long time, for the attaching sucker is an elaborate contrivance. The association must also be very constant in the individual, for the lower surface of the Remora is darker than the upper one which is next the bearer. This is, of course, quite contrary to rule. One must not forget the human touch, that on the East African coast and elsewhere the native fishermen tie a line to the Remora's tail and let it loose in the sea to find a turtle. When the Remora has fastened itself to the reptile, true to its inborn aptitude (or "reaction-tendency"), then the fishermen pull in the line very carefully and secure the booty. Then the Remora is sent a-fishing again.

§ 6

Parental Experiments among Fishes.

Few fishes have any use for parental care. They have such large families that there is a big margin for casualties. It is often said that a cod may have two million eggs, and a conger-eel ten million; and though these numbers are perhaps too large, there is no doubt that fishes spawn profusely. Parental care, in most fishes, is neither necessary nor possible. There are exceptions, however, where the number of eggs is small, and where parental care occurs. The two factors work together. If a reduction in the number of eggs has come about, then the race will be continued only by those individuals who change in the direction of taking good care of them. On the other hand, if there is successful parental care, then changes in the direction of reducing the size of the family will be practicable. This is not a vicious

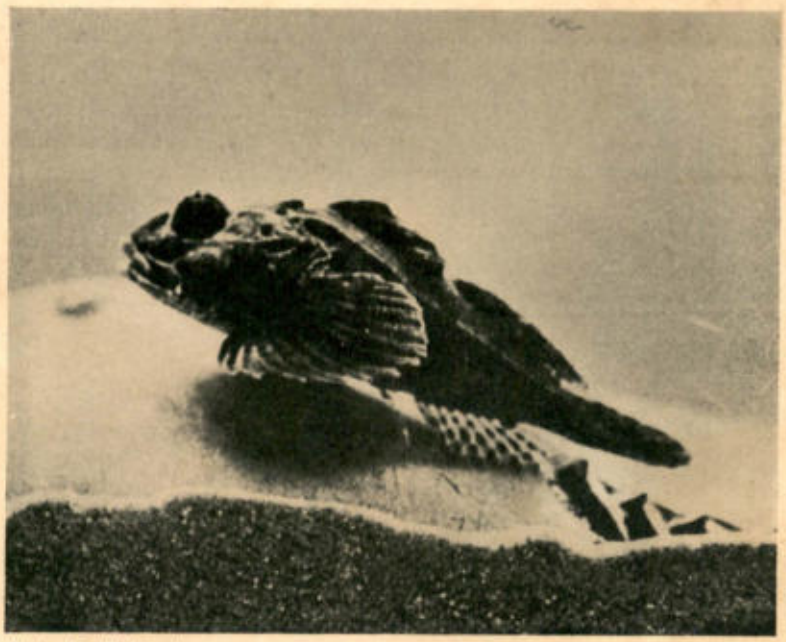


Photo: Neville Kingston.

BULLHEAD RESTING.

The name Bullhead is applied in Britain to various species of Cottus, such as *Cottus bubalis* and *Cottus scorpio*, both of them common shore-fishes. The eggs are laid on a stone, and the male keeps beside them for five or six weeks, driving off intruders. The American bullhead, Ameiurus, is an entirely different type, one of the catfishes.

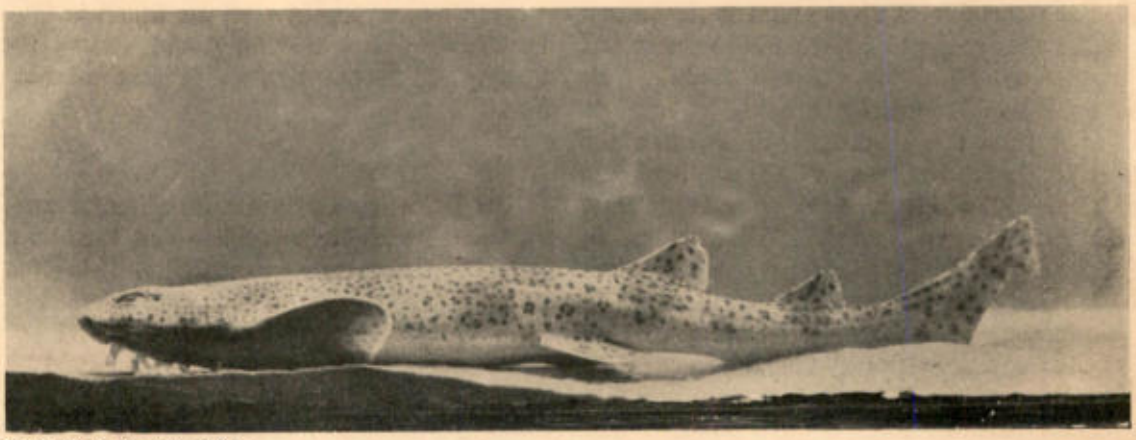


Photo: W. S. Berridge, F.Z.S.

THE NURSEHOUND, ONE OF THE DOGFISHES (*Scyliorhinus stellaris*).

This larger Spotted Dogfish, not uncommon around British coasts, may attain a length of about four feet. It is a voracious, coarse fish, and troublesome to the line fishermen, for it often takes the bait and is of little value if hooked.

circle, it is a "virtuous circle," and the story of evolution has many another example.

Photo: W. S. Berridge, F.Z.S.

EGG PURSES OF DOGFISH.

The eggs, enclosed in pale yellow horny shells, or "purses," are laid late in the year, and the long thread-like tendrils, one from each corner, serve to moor them to zoophytes or seaweed, so that they are less likely to be smothered or injured. The young dogfish escapes at one end.

In skates and rays, in many dogfishes and sharks, there are comparatively few eggs, and these are large in size. Each is enclosed in a shell of horn—the "mermaid's purse" of skate and dogfish—which often becomes attached to seaweed or rock, so that the young embryo is not smothered in the mud. Still more certain of securing safety is the method seen in the Torpedo and in many dogfishes—the young ones are kept within the mother until they are able to fend for themselves. In a few cases there is a further improvement, for a close connection is established before birth between the offspring and the mother—a far-off anticipation of what occurs in ordinary mammals. This is seen, for instance, in most species of the dogfish called Mustelus, and it is very interesting to note that the state of affairs was quite clearly understood and described by Aristotle more than two thousand years ago.

As the seashore is a changeful and strenuous place to live in, we are not surprised to find parental care illustrated by some of the fishes that have

Photo: W. S. Berridge, F.Z.S.

HEAD OF DOGFISH.

As in other gristly or cartilaginous fishes (Selachians), the mouth is ventral, not terminal. The jaws bear small but strong teeth, suited for eating crabs and lobsters. In front of the mouth are seen the two nostrils; the eyes are deeply insunk; on each side of the neck there are five gill-slits for the passing out of the water that enters by a spiracle—a dorsal gill-cleft behind the eye.

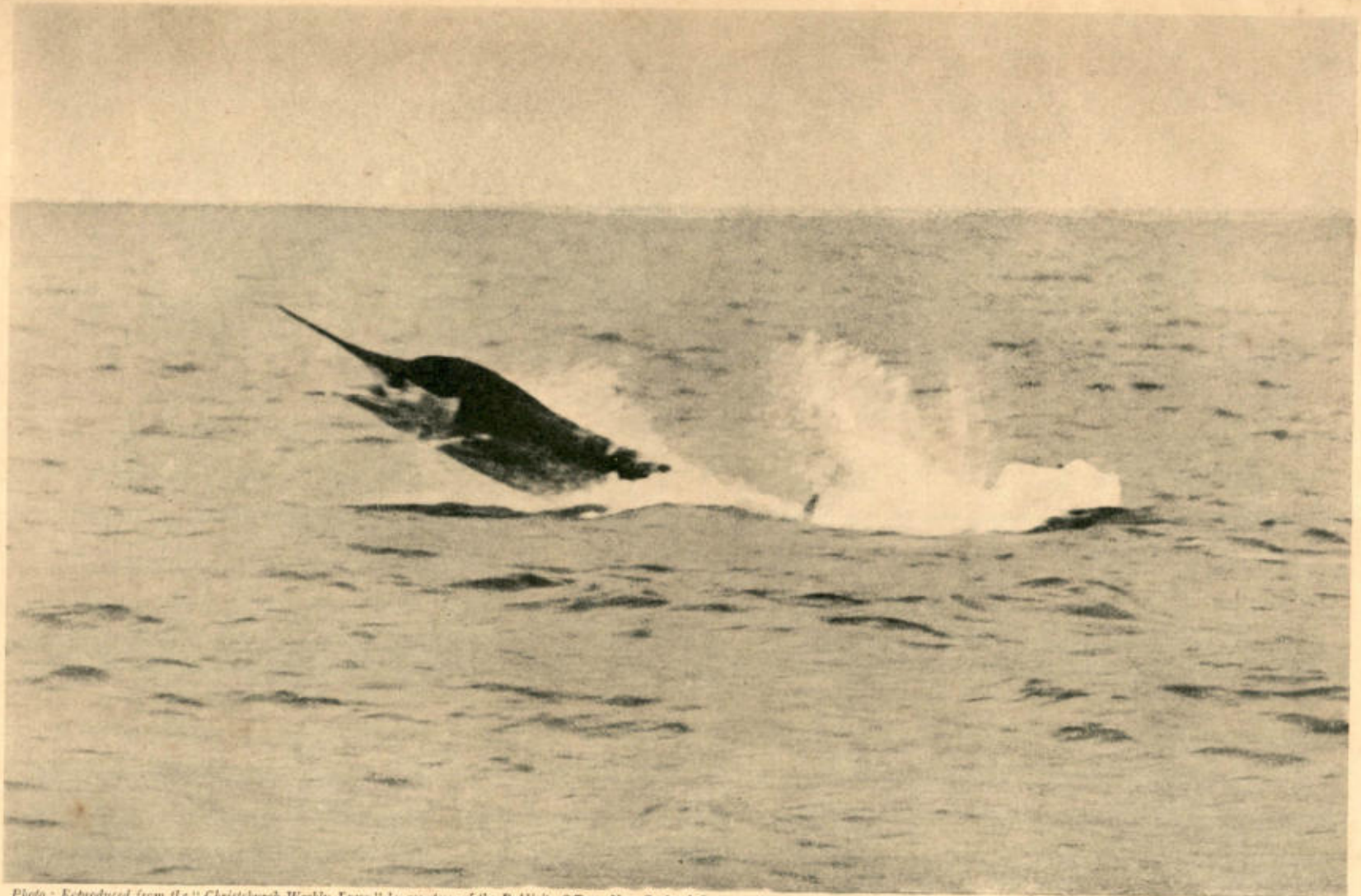


Photo : Reproduced from the "Christchurch Weekly Press," by courtesy of the Publicity Officer, New Zealand Government.

THE SWORDFISH (*Xiphias gladius*).

The largest of the bony fish, the Swordfish attains a length of fifteen feet, with a sword three feet long and three inches in diameter at the base. The young have both the upper and lower jaws elongated, a high dorsal fin right along the back, and four series of spiny plates along each side of the body, but the adult has only the upper jaw prolonged, the dorsal fin is divided into two and the bony plates have disappeared. The Swordfish is common in the warm seas of the Mediterranean and the West Atlantic, but occasionally wanders into British waters.

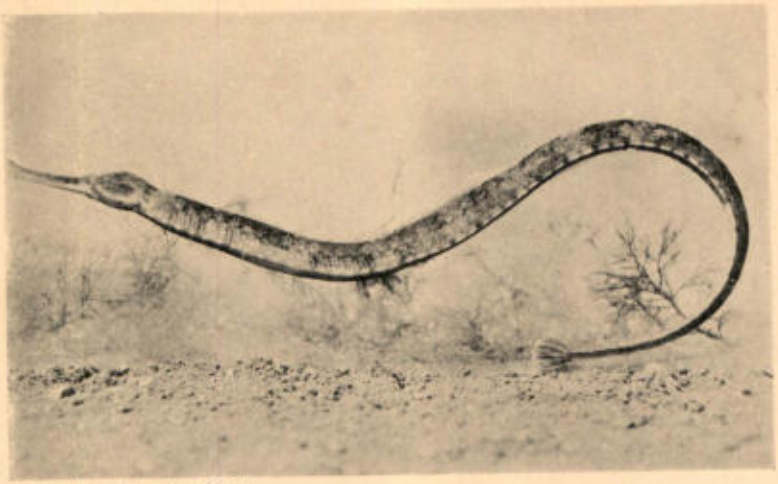


Photo: W. S. Berridge, F.Z.S.

GREAT PIPE-FISH (*Syngnathus acus*).

This interesting fish usually lives near shore, both in Europe and America, among the seaweed-covered rocks, where it hunts for small shrimps and the like. By the closure of two long folds on the anterior ventral surface of the male a shallow pocket is formed, in which the eggs are received and retained throughout their development. Pipe-fishes live a leisurely life, swimming slowly and holding their stiff body in a half-vertical position. They may attain a length of over a foot.

their home there. The butterfish, or gunnel (*Centronotus gunnellus*), which is very common in shore-pools and very well adapted for slipping through narrow chinks, is in the habit of rolling its eggs into a little ball, and then twisting its body round them. It often secures additional safety by getting into a hole which a piddock or a sea-urchin has bored in the rock, or even between the valves of an empty oyster-shell. It seems to be still uncertain whether this beginning of brooding is on the part of the male only or of both parents. In any case we have to do here with parental care without complications.

Shore Fishes.

Another step has been taken by the Lumpsucker or Cock-Paidle (*Cyclopterus lumpus*), a quaint stocky fish with its hind limbs (pelvic fins) transformed into an adhesive sucker, situated far forward. The brightly coloured pinkish or yellowish eggs are laid in a large mass in a niche among the low-tide rocks. The male pushes the mass of spawn firmly into the crevice, and makes deep conical depressions on the surface, which allow the water to get well in towards the centre of the clump. He then mounts guard, driving away hostile intruders, removing crawling creatures like starfishes, crabs, and whelks, and aërating the eggs by driving in currents of water by energetic contractions of his gill-cover. During this strenuous exercise, the male holds on to the rock by his sucker. He sometimes vibrates his body so excitedly that a sound is produced! He has been known to draw blood by biting at the hand of a too inquisitive observer. His devotion, if one may use the word without implying too much, lasts till the young ones hatch out.

§ 7

The Toadfish (*Batrachus tau*) of North

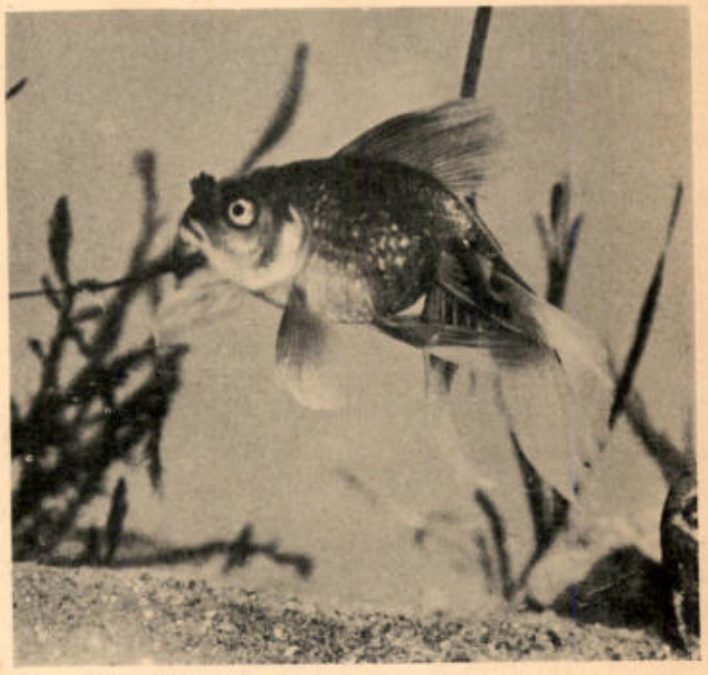


Photo: G. H. and W. S. Pitt.

THE VEIL-FISH OR RYAKIN, A JAPANESE FANCY GOLDFISH.

In the fancy breed called the Veil-fish, derived from the wild Carassius, the body is short and stout, and the tail-fin is greatly elongated and so flexible that it has been compared to a lady's veil. The Chinese breed their goldfishes in very insanitary conditions, and freaks are of common occurrence.

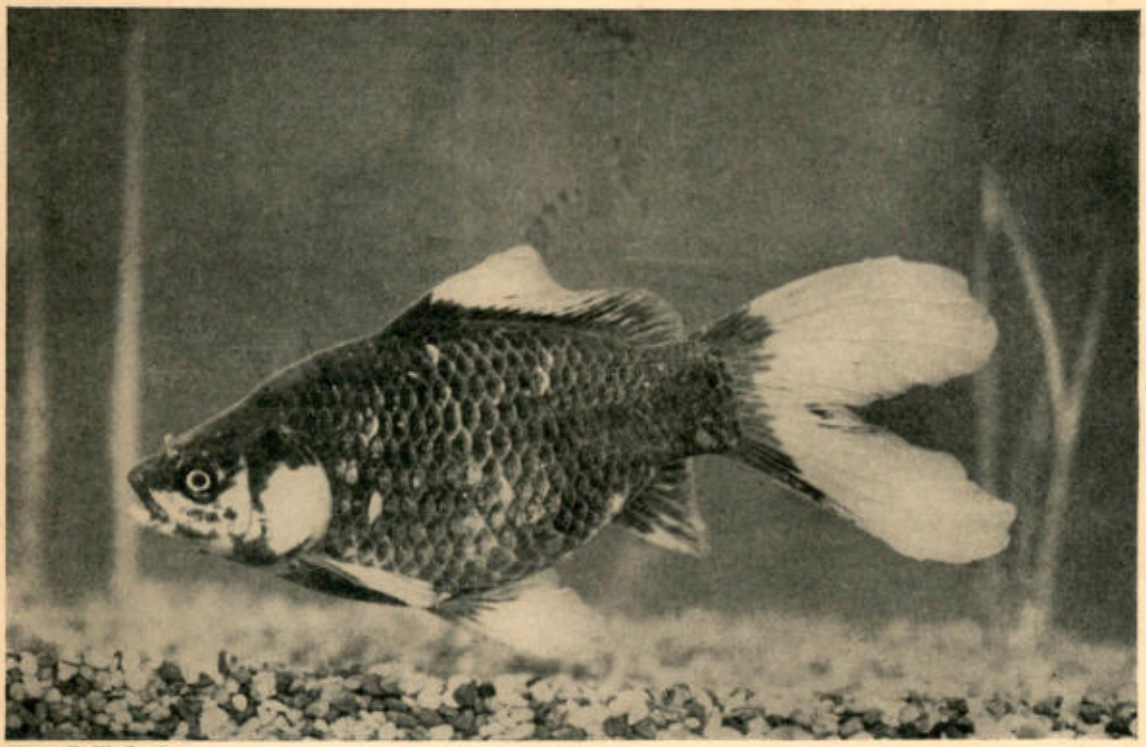


Photo: F. W. Bond.

COMET GOLDFISH (*Carassius auratus*).

The wild ancestor of the Goldfish is a kind of carp (*Carassius auratus*), found in the rivers of China. From this origin all the strange domesticated races, such as the "Comet," with an exaggerated tail, have been derived. They breed true for a time, but gradually revert to the more normal and healthier ancestral forms. In the conditions of Wild Nature they would soon be eliminated.

American coasts leads us a step further. Several females fix their eggs in a hole in the rock, or within an empty shell, or even inside a tin, and the male mounts guard. He expels intruders and he remains at his post even at very low tide. When the young ones are hatched he is careful to keep them within bounds until they are ready, and he seems to be happy in sheltering them beneath his pectoral fins. It is plain that we do not get an adequate impression of fish nature unless we consider cases like this.

Nests of Fishes.

The Bow-fin (*Amia calva*) of the Great Lakes of North America makes a nest among the reeds and rushes by biting off the stems over a circular area. The eggs are laid on the floor of this clearing, and the male mounts guard. He is sometimes quiet for hours; but, at intervals, he effects artificial aëration of the eggs by making very energetic respiratory movements with his gill-cover. After the young are hatched, they are led about and defended by the male fish. Dr. Bashford Dean writes: "He appears to be constantly watchful, and when alarmed exhibits the greatest solicitude for his charges. Sometimes he backs quietly into some reed-screened pool, hiding below in the shadow of floating weeds, his presence only betrayed by the black mass of larvæ about him; at other times he will slip cautiously away, drawing the swarm after him as rapidly as possible." When discretion is impossible he has recourse to valour, and will face a formidable enemy. The youngsters usually remain under the paternal care for several weeks, but in some cases the period of tutelage lasts much longer.

The Gourami is a large freshwater fish of the Malay Archipelago, which has been introduced into many parts of the world, such as Madras. It grows nearly two feet long, and its flesh is very palatable. At the breeding season it makes a nearly spherical nest of water-grass and the like, and usually fastens it to plants growing at the margin of the pond. At this time the fish assumes a jet-black colour and flashing red eyes, and becomes very pugnacious in defence of the nest. The Gourami is one of those fishes that can use dry air gulped in at the surface, and a very

interesting fact is that every now and then the mother brings down a mouthful of air and discharges it upon the eggs, thus securing their thorough aëration. Here we have a fish puffing air on its eggs! Surely that is *experimental*.

Let us take another instance from India. It concerns a fish called Etroplus, common in weedy ponds, ditches, and rivers near Madras. About 200 eggs are laid in a shallow cup-like nest scooped out in the bottom débris and lined with green silky fibres. The two parents mount guard at the nest, and every now and then they carefully scrutinise the eggs. But Mr. Sundara Raj tells us of a sight he saw which looks like something unique. After the eggs were hatched, he saw the mother-fish dig at the root of a water-plant, get a mouthful of dark sediment, and discharge this into the nest. Unless there is some misunderstanding, this looks like the mother feeding the young fry! However this may be, when the young fishes leave the nest they move about for a while in company with their parents, by whom they are courageously protected until able to look after themselves.

§ 8

Quaint Devices.

There are strange elongated fishes called Pipe-fishes or Needle-fishes, which show interesting gradations in their parental care. Thus, in one of the North Sea Needle-fishes, the eggs are attached externally to the male, while in others (Syngnathus) there is a special cavity formed by two longitudinal folds on the male's ventral surface. When the males and females come together, the female puts some eggs into the front of this space, where they are fertilised. The male afterwards packs them in and asks for more. In some cases there is an exudation from the blood-vessels in the two folds, and this serves as nourishment for the young ones. In an Indian Ocean Pipe-fish (a kind of Solenostoma) it is the female that takes charge, and the pocket is formed by the hind limbs or pelvic fins.

But the climax is reached by the whimsical sea-horse (Hippocampus), common in the Mediterranean, a little fish with a head like a horse's, a prehensile tail like a monkey's, and a beautiful fan-like dorsal fin that vibrates with great rapidity. The male gets the eggs just as

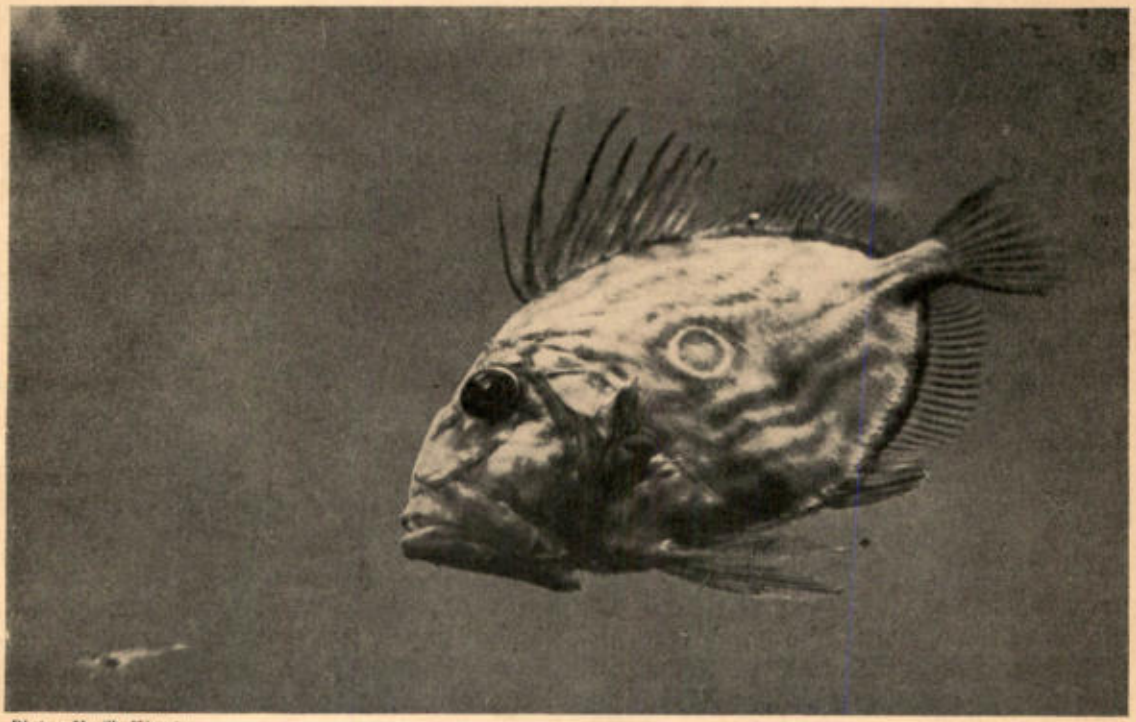


Photo: Neville Kingston.

JOHN DORY CHASING A SHRIMP.

This very palatable fish, technically called *Zeus faber*, is much compressed from side to side and swims vertically. Seen "head on" it is very inconspicuous when swimming, but on side view it bulks large. It is one of the fishes that produce a sound from the swim-bladder.

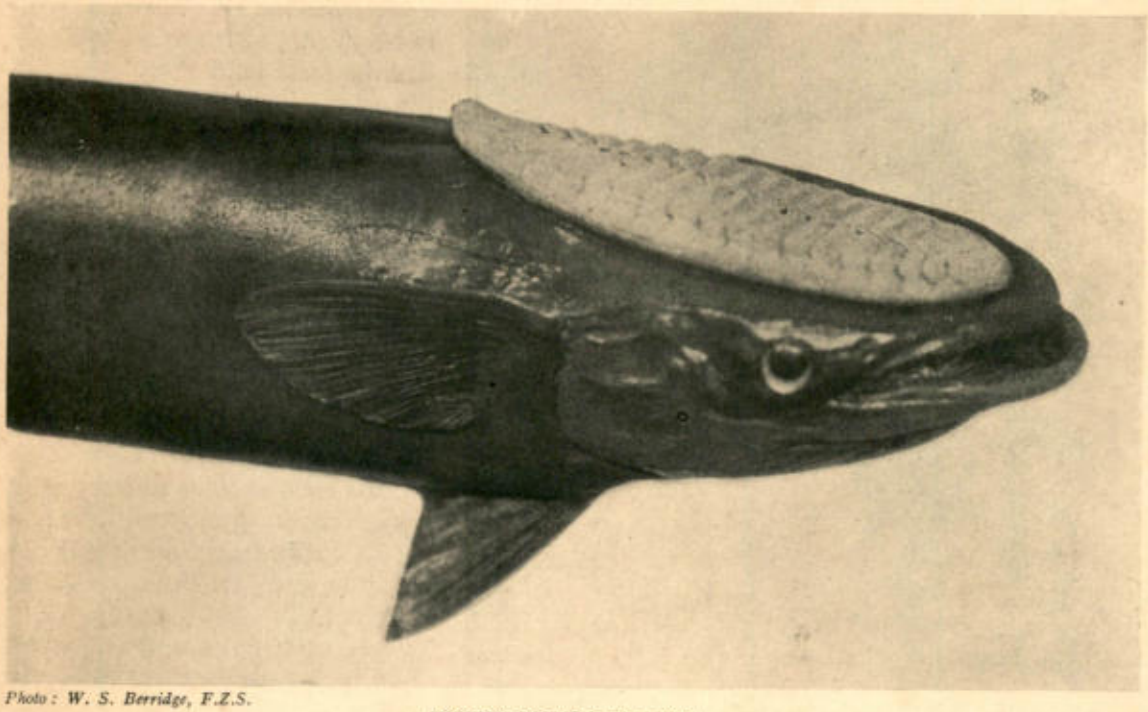


Photo: W. S. Berridge, F.Z.S.

SUCKER-FISH (*Echeneis remora*).

The sucking fish (Echeneis and Remora) are common in warm seas, and occasionally reach the south coast of England. They feed on other fishes, such as dogfishes, and attachment is the first step. Sometimes, however, they attach themselves for transport only.

they are liberated by the female and stows them away in a capacious brood-pouch on the ventral surface. This pouch is formed by the closing up of two folds just as in the Pipe-fishes, and its opening is at the front end. The male receives only a few eggs from the female, but he soon gets more from other females. When his pocket is full it is closed. In the interior there is a spongy tissue rich in blood-vessels and in this the eggs are separately embedded. There is an exudation from the blood which affords food to the young fry. When they are ready the pocket opens up along the line where the two folds joined, and thus the family is liberated. According to Professor Doflein, who is generally punctiliously accurate, the young Sea-Horses may return to the paternal folds if danger threatens, but this is vigorously denied by others.

In this remarkable case and in some others approaching it, the number of eggs is small, and, as we noted to start with, this throws light on the need for parental care.

In the case of Kurtus, mentioned elsewhere in this work, the male fish carries the eggs on the top of his head, but there are even stranger devices. In some kinds of fish belonging to the

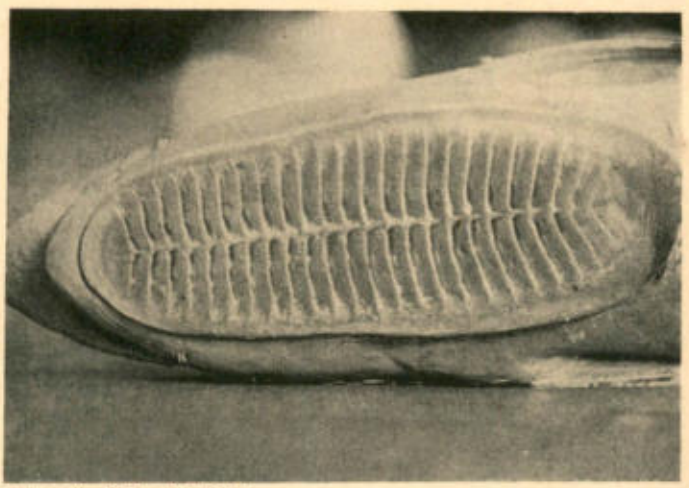


Photo: W. S. Berridge, F.Z.S.

SUCKING APPARATUS ON HEAD OF THE REMORA.

This remarkable adhesive organ, by means of which the Remora fastens itself, seems to be developed by a transformation of the first dorsal fin. It consists, as the photograph very clearly shows, of a number of transverse plates, which are pressed against the skin of the victim, and secure adhesion.

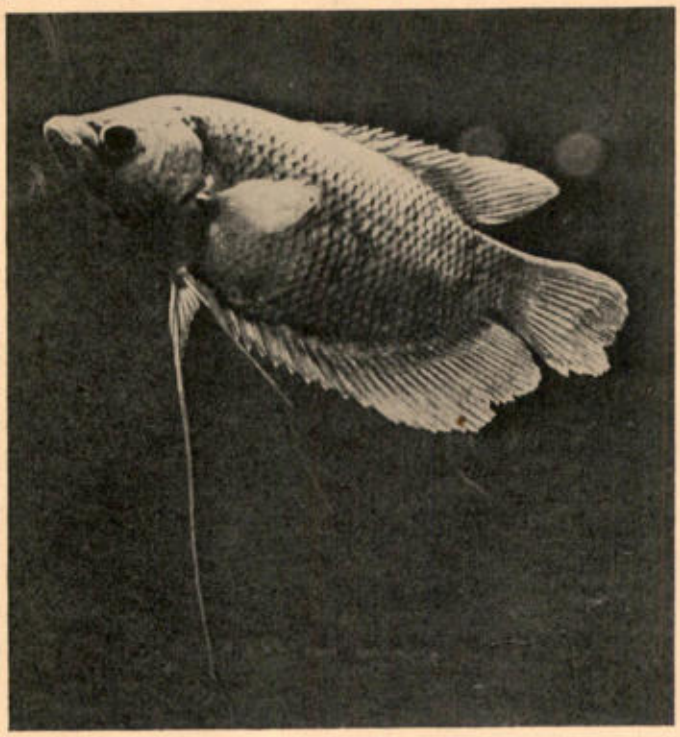


Photo: Neville Kingston.

INDIAN GOURAMI (*Osphramenus olfax*).

This Malayan freshwater fish, acclimatised in India, the Guianas and Mauritius, is famous for the bubble-nest that the male constructs and guards. It is made of air-bubbles entangled in a mucous secretion from the mouth. The fish itself may grow to be two feet long, and is very palatable.

genus Arius the male carries the eggs in his mouth, which seems to imply that he fasts until they hatch and the young ones escape. In some cases it is the female that surrenders her mouth to maternal care. In the South American Aspredo the fertilised eggs become attached in little stalked cups to the under surface of the mother, reminding one quaintly of the Surinam Toad which bears her progeny on her back.

Professor Doflein cites the peculiar case of Brazilian fishes belonging to the genus Geophagus, where both parents seem *at times* to carry their young ones in their mouth. This is partly to save them from danger and partly to transport them to suitable places. Even when the young fishes have grown to be of considerable size they may seek safety within the parental mouth!

The question rises why parental care in fishes, which is exhibited only by a very small minority, should be usually paternal and only rarely

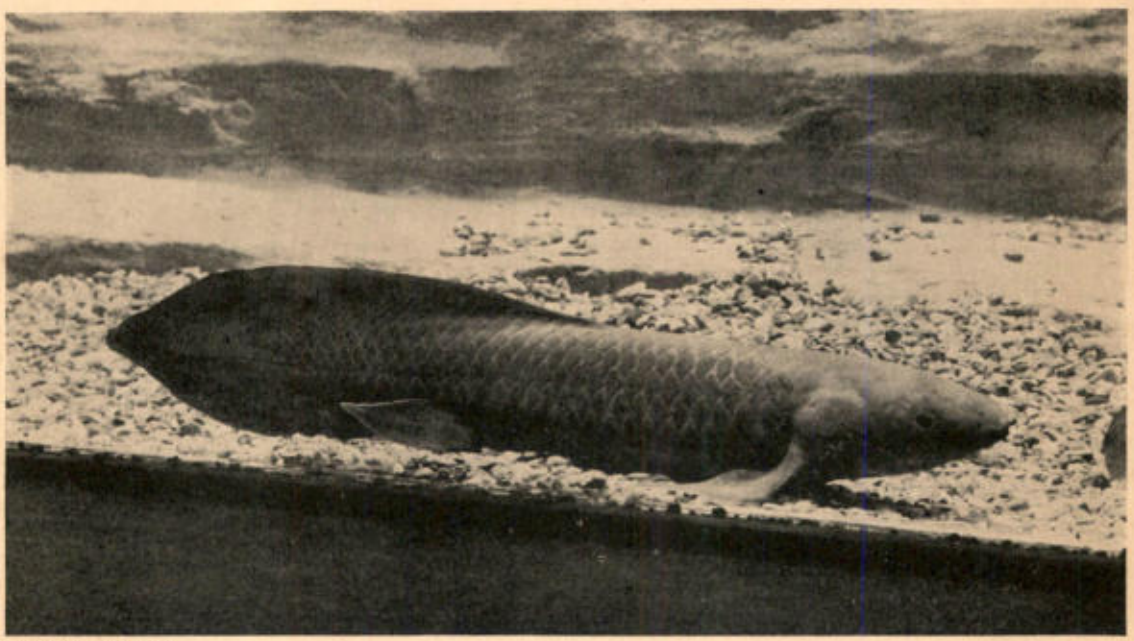


Photo: "The Times."

AUSTRALIAN LUNG-FISH (*Neoceratodus forsteri*).

This remarkable type, a Dipnoan, breathing by a lung as well as by gills, is now represented by a single species in the Burnett and Mary rivers in Queensland. It is a sluggish animal, feeding on crustaceans, worms, and molluscs, to obtain which it crops the water-plants. Although its swim-bladder has become a lung, life out of water is impossible. A length of about five feet may be reached.

maternal. It is difficult to answer this question, but in some cases the female is much exhausted after spawning and may even die. The male is the more vigorous of the two.

But if parental care is exhibited only by a very small minority of fishes, why should we give it so much prominence in this book? Our answer is that it gives us a glimpse of possibilities in the nature of fishes that we should hardly have expected from a study of their everyday life.

XLV

THE MAMMALS OF THE ARCTIC OCEAN

THE land surrounding the Arctic Ocean supports only a few kinds of mammals, and these, with two exceptions, are but small in size. Yet the Polar basin itself is the home of a many very large mammals, some of them the largest animals now in existence. What is the reason for this difference? It lies in the fact that the sea is very rich in microscopic organisms, both plant and animal, and on these minute forms of life all the others ultimately depend. The dependence may not be direct, but it is none the less real, however many be the links in the nutritive chain.

Thus—to take a long chain—the Polar Bear feeds mainly on seals but the seals feed on fishes; the fishes depend on the exceedingly abundant crustaceans, and these again find their food supply in the millions of microscopic plants and animals that people the surface of the ocean. The first link in the nutritive chains of the sea must always be found in the microscopic plants like diatoms, for all green plants, whatever be their size, have the power to live on inorganic material—air, water, and salts. With the exception of a few minute animals that have gained possession of the characteristic green pigment of plants, chlorophyll, no animals can feed as plants do, and thus the inexhaustible supply of nourishment to be found in the inorganic world has first to be made available by the plants.

Photo: F. W. Bond.

HEAD OF POLAR BEAR.

This brings out well the slenderness of the polar bear's head as compared with that of ordinary bears; and when the various other peculiarities, such as the long neck and the hairy soles, are added up, there is much to be said for putting the polar bear in a genus (Thalarctos or Thalassarctos) by itself.

In some places there are abundant seaweeds, and these afford pasturage for many animals such as sea-urchins; while the débris or plant-dust sinks downwards and outwards to enrich the mud on the floor of the sea. Another point of importance is that the icebergs, breaking off from the sea-end of the glaciers, often carry much rock-waste, which adds to the depth of the mud. In the summer there are similar contributions of great magnitude from the turbid glacier rivers. What forms fertile alluvium on an inland plain—at the foot of the Alps, let us say—becomes in Arctic regions the soil of the sea.

The question rises why there should be such prodigal abundance of minute organisms in the surface waters of northern regions, for they are far more plentiful there than at the Equator. The late Sir John Murray used to say that no one with a boat and a tow-net need starve in northern waters, for in a short time it is easy to catch a substantial meal of small crustaceans. These little creatures, distantly related to shrimps, are highly nutritious, for their bodies contain a considerable proportion of oil, which is very useful as part of man's diet in cold surroundings. In addition to small crustaceans the cold waters contain abundant free-swimming molluscs, notably the "sea-butterflies" that form a great part of the food of whales. There are many other minute swimmers and drifters of great practical importance to man, because they have made the northern fisheries so successful, but the important fact is the inconceivable, though not incalculable, numbers of minute green plants that form the "floating sea-meadows." With these plants we must include microscopic green animals like the Peridinids which are able to feed at the same low level as plants do.

A further question arises. Why should the number of individuals of a given species, of diatom or peridinid, be greater in the colder than in the warmer waters? The probable answer is that the low temperature slows down the vital processes so that the tenure of life is longer, and thus there are more generations living at the same time than in warmer waters, where the rate of vital change or metabolism is greater, and the length of life shorter. In any case the fact is that, while there are more kinds of peridinids, for instance, in the southern waters, the number of individuals is far greater in the north.

The Polar Bear.

The Polar Bear is a magnificent instance of life's conquest of the cold. It dares the worst, for it seldom comes beyond the southern limits of the ice-pack. Most of its summer is spent on the circumpolar ice, or swimming tirelessly in the open spaces; in the dark winter there has to be a continual exploration of islands and continental coasts in search of food. It is only at this hungry time that the Polar Bear is distinctly aggressive towards man.

Not only is the Polar Bear the largest of its tribe—attaining to nine feet in length—but it is the most thoroughly carnivorous. It must require a large quantity of animal food, and yet its home is the frozen polar sea.

The explanation as indicated is the abundance of seals. Animate nature implies cycles of incarnations. The Polar Bear seems to find the seals rather by scent than by sight, and it is very clever at taking them unawares. In one case a bear swam across a patch of open water to a seal basking on the ice, and, raising itself half out, crushed the seal's skull with one stroke of its paw.

Even more striking is the feat, well vouched for, of lifting a seal clean out of the water with one stroke. The bear was seen lying on its belly at the edge of a floe waiting patiently for a seal to come to the surface to breathe. "No sooner had the seal's head appeared than one fell stroke of the heavy paw of the bear landed its prey, stunned, on to the floe." In this case there was not only a feat of strength; there was good judgment, enduring patience, and great rapidity of action at the critical moment. The Polar Bear is an expert stalker.

The Polar Bear can swim for many miles without apparent fatigue; its thick coat and its fat must help to conserve the precious animal heat; the quite unusual hairiness of the soles of its feet may perhaps make the footing on the ice more secure. The whole animal spells success.

Scottish whalers used to call the Polar Bear the "Brownie," in reference to the creamy-yellow colour of the fur, which is often very like the "yellow ice" that occurs in patches all over the floe. The yellowness is due to an admixture of microscopic diatoms among the ice. The late Dr. W. S. Bruce, who had great experience in Polar exploration, points out that while the

Photo: Neville Kingston.

POLAR BEAR (*Thalarctos maritimus*).

This circumpolar bear lives for the most part on the pack-ice, often hundreds of miles from land. It is marked by its permanent whiteness, its long neck, its slender, pointed head, and the fur on the soles of its feet—probably useful in gripping the ice. In summer it swims a good deal in open places among the ice, hunting young seals and the like; in winter it often prowls about ashore.

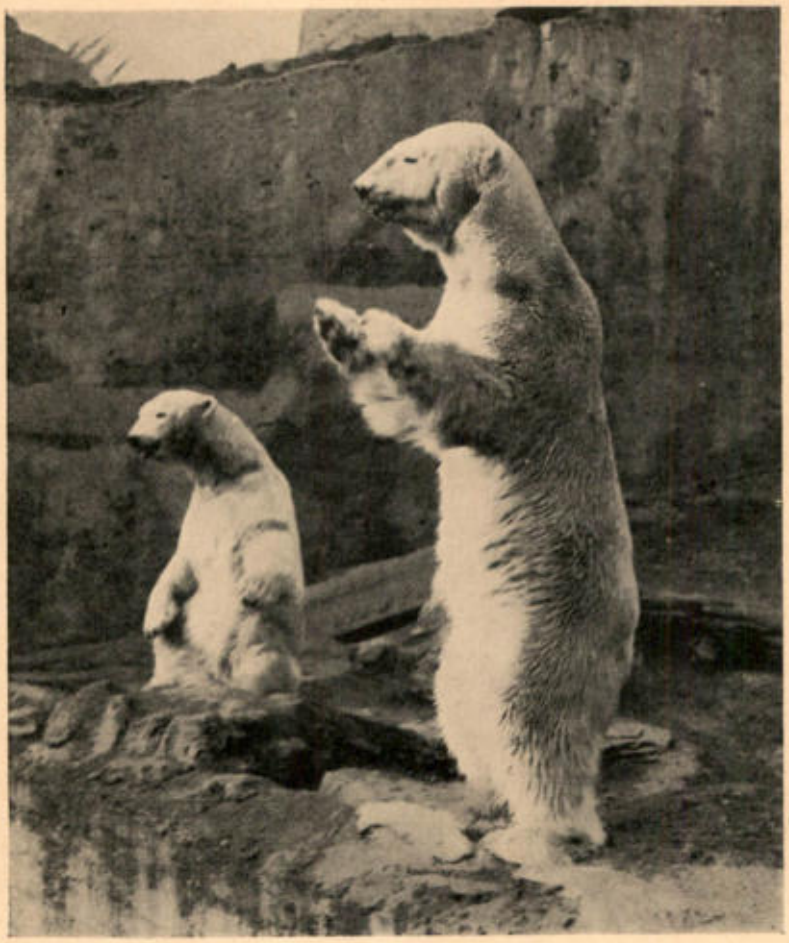


Photo: F. W. Bond.

SAM AND BARBARA, TWO POLAR BEARS, ON THE MAPPIN TERRACE AT THE LONDON ZOOLOGICAL GARDENS.

The colour of a polar bear's coat is very nearly white in winter, but is often brownish-yellow in summer, not unlike the "yellow ice," which is discoloured with an abundance of microscopic diatoms.

bear's yellowness makes it almost conspicuous in its natural surroundings of white ice, it provides a cloak of invisibility among the yellow patches. He tells of a Polar Bear that approached within a hundred yards of a congregation of twenty-five sailors who were having a service on deck, and was unseen by all but the mate, who was reading the lessons. The bear was in full view, yet almost invisible, it was so like the yellow ice!

As the Polar Bear has practically no enemies except man, we cannot suppose that its yellow colour has a utilitarian significance in saving it from molestation. Nor can we place much confidence in the theory that the colour has its *raison d'être* in the help it gives the bear to keep itself hidden whilst stalking. For the yellowish colour is rather conspicuous against the white ice, as the word "Brownie" suggests. The utilitarian interpretation, if it is wanted, must be sought elsewhere, namely, in the fact that, for a warm-blooded animal in very cold surroundings the physiologically best dress is white fur, for it loses least of the precious animal heat. Next to snow-white comes creamy yellow. The Polar Bear is whitest when young, and it is whiter at the end of winter and in early spring than at other times of the year.

A curious fact is the appearance of a white band on the dorsal part of the neck of a newly born brown bear, like a similar, but persistent collar on the under part of the neck in the Asiatic Sun-bears and Collared Bears. Since characters that are present in youth and afterwards disappear are usually regarded as indicative of ancestry, one cannot but ask whether the newly born Brown Bear's white neck-band may not be a hint that the ancestral bears were light in colour.

The error of calling the Polar Bear a winter sleeper dies hard. There is no true hibernation in the Polar regions; it is prohibited by the intense cold, both above ground and under ground during the long months of darkness. All that happens in the bear's case is that it may make a sort of cave of snow and ice in very severe weather, or at the time when the female is about to give birth. This takes place in winter, and there is of course much need for temporary shelter both for the mother and the one or two naked cubs. But they do not stay long in their den among the snow-hummocks, naturally

enough, since food has to be found, and that means tramping about.

The Polar Bear is a devoted mother and she will defend her young ones with complete disregard for her own safety. The two or three bears sometimes seen together mean a mother and one or two cubs; and the apron-strings are cut when the time of apprenticeship is over. Except at the pairing-time the males and females live apart—stern individualists.

Let us then salute the Ice-Bear, for that is its truest name—a supreme Polar explorer, a conqueror of the cold, strong as a lion, callous as a yak, a better stalker than any cat, more patient than any dog, severely individualist and yet motherly; inexterminable, let us hope, in its Polar fastness. Vivat Ursus maritimus!

The Walrus.

Next to the Polar Bear as characteristic of the Arctic Seas must be ranked the walrus (*Trichechus rosmarus*), that quaintest of circumpolar mammals. The walrus belongs to the same family as the seals, but it is larger than any of these. It is usual to distinguish two forms, a Greenland and a Pacific, but the differences between them are mainly a matter of size and weight.

"Of all living monsters that ever move upon land," writes Dr. Hornaday, of the New York Zoological Park, "the Pacific Walrus is one of the most wonderful. A full-grown male is a living mountain of heaving flesh, wrinkled, furrowed and seamed, ugly as a satyr, and as strange in habits as in appearance."

Not a very attractive animal from this description! The walrus has its good points, nevertheless, even in appearance. The head, with its heavy moustaches, is relatively small, and the shoulders are very broad and massive, so that when a herd of walruses is seen from in front in their favourite position, almost erect in the water, they are described as looking nothing less than majestic. They have sometimes been credited with being the originals of the mermaid legend, but that distinction is now generally accorded to the sea-cow.

A full-grown male walrus is about twelve feet in length, and weighs between 2,000 and 3,000 pounds. The skin is very thick, rough, and

Photo: W. S. Berridge, F.Z.S.

POLAR BEARS PLAYING.

In a den among the sea ice the mother polar bear gives birth in winter to one or two naked cubs, which she guards with devoted courage. They are playful creatures, and more than a little of this playfulness may be continued for many years, by the mothers at least.

Photo Underwood Press Service.

YOUNG POLAR BEARS ON THE PACK-ICE.

Polar bears are as much at home in the water as on land, and can swim for many miles without being tired. Except when they are young and at the breeding-season, they live a solitary life. It is worth remembering that in the Glacial Ages they came as far south as Hamburg.

warty. The young walrus has a covering of short brown hairs, but as it grows the hairs tend to fall out, and an adult may be nearly if not quite naked. The muzzle is mobile, and bears long, very thick bristles, which, from their arrangement about the mouth are believed to act as a sieve.

The upper jaw bears two long canine teeth or tusks, those of the female being slightly longer though not stouter than in the male. The tusks go on growing throughout life, and may reach a length of three feet. They have several uses and are of very great importance to the life of their possessor. They are formidable weapons, for the walrus can strike downwards, sideways, and even upwards quickly and effectively. Even the Polar Bear, which is the only animal strong enough to attack him, has to be very wary, for if the walrus succeeds in pinning him down he will hold him under water until he is drowned. The tusks are also used, it is said, in clambering up the slippery side of the ice-pack.

But their chief use is in food-getting. The walrus feeds mainly on the clams and other molluscs that abound in the mud of the shallow waters, and these mud-animals he digs up with the points of his tusks. He can remain under water for a long time—even up to an hour, it is said, though that must be very unusual—and the great weight of his bones, which are heavy relatively to his enormous bulk, helps him to keep his balance on the floor of the sea. It used to be thought that molluscs, with crabs and smaller crustaceans, formed his sole food, but investigation of the contents of the stomach has shown that many fishes, and even an occasional seal may be consumed. Thus, it is probable that the Walrus, like the Polar Bear, takes whatever animal food it can get at the moment.

The feet are webbed. The fore-foot bears small nails, and underneath it has a rough pad which helps the walrus to keep its footing on slippery ice. The fore-legs are free from the elbow, but the hind-legs are connected nearly to the foot by a fold of skin which also encloses the tail. Obviously, then, the movements of the walrus on land must be difficult and clumsy. Yet he does not flop along like his seal-cousins, for he has the

advantage over them in being able to turn his hind-feet forward, so that he can walk after a fashion. But the sea is his real home and he rarely goes far from the water's edge.

It is not because of any peculiarity of its own constitution that the walrus is confined to the Arctic seas ; it has simply been driven farther and farther north by constant persecution. As late as the fifteenth century their wanderings extended to the north of Scotland, and much later than that they were common in Iceland. Now it is comparatively seldom seen even on the northern coasts of Spitzbergen, where, we read, in 1852 a hunting expedition destroyed so many hundreds in a few hours that the ships were quite unable to carry more than half of them away, and the bodies of the rest were left to rot slowly on the beach. Nowadays the Atlantic walrus remains all the year round among the ice to the north of Greenland, while the Pacific form occurs all along the coasts of Alaska and moves freely about among the islands of the Behring sea. In these remote regions they are fortunately still abundant. An American observer reports having cruised for hours along the edge of the ice-pack on the shores of Alaska, all the time passing " an unbroken line of walruses, which must have numbered tens of thousands."

When resting on land, they always lie very close together, and this habit must help to keep them warm ! But the preservation of the animal heat depends also on the thick layer of fat they put on in summer when they are active, and their oily food is abundant. Like other warm-blooded animals they can call on their muscles to produce more heat when it is wanted. In autumn they become lethargic and often lie in heaps for days at a time without going to look for food. They do not set sentinels as do most gregarious animals, but they have a method of watching all their own ! One walrus wakes up suddenly, looks all round suspiciously for a minute or two, then gives his next neighbour a push, and composes himself to sleep again. The neighbour does the same, and prods the walrus on the other side, and so on all down the line. Since the line may include hundreds of individuals they can obviously never all be asleep at the same time.

Photo : New York Zoological Society.

IMMATURE WALRUS.

Walruses are gregarious but not polygamous the mothers show great devotion in nurturing and defending their young. The food consists chiefly of clams and other molluscs, which are collected on the sea-floor. Movement on land is slow and awkward, but the swimming powers are well developed. An old male may weigh 2,000 to 3,000 pounds, and the value of the blubber, the skin, and the ivory tusks has led to a serious reduction of the numbers. Indeed there is great risk that the walrus will suffer extermination. The characteristic tusks are shown on next page.

For the two or three months of the breeding season the walruses remain on land, or as close to it as their feeding-grounds will allow. They are not polygamous like the seals, but live in pairs. Only one young one is born at a time, at any rate in the Pacific form. Indeed, it is difficult to see how a walrus mother could ever look after more than one such huge baby, for she keeps it with her and even suckles it till its second year. The reason for this very prolonged nursing seems to be that the tusks are slower in developing than the body, and till they have grown the youngster has no means of digging up its own food. The mother walrus is very devoted to her offspring, and, timid at other times, she becomes fierce if danger threatens it. She dives into the water holding her young one between the forelegs, but in the water she carries it on her back. Dr. Bruce reports having seen a herd of over a hundred mothers swimming near the ship, each with her baby on her back. Young walruses have sometimes been taken captive, and have shown themselves sociable and playful, but they always die soon, and adults can never be kept alive in captivity.

The walrus is of the highest importance to the coastal tribes of Eskimos. Seal meat and fat may be more palatable, and sealskins make softer garments, but walrus "veal" is not to be despised, and even the beef can be made to serve when other things fail. The thick skin makes admirable harness for the sledge dogs; the blubber is used for lighting and cooking; and the ivory of the tusks, though neither so hard nor so white as elephant ivory, is used for drinking vessels. The bones and sinews, too, are put to many uses.

The Eskimo kill the walrus easily enough on land, and hunt it in their light skin-covered canoes at sea. That is a hazardous enterprise, for though walruses are not naturally combative they throng about the boats from curiosity, and the killing of some incites the others to rage, and they will attack a canoe and overturn it with a single blow. Against the Eskimos with their canoes and harpoons the walrus could hold its own, and the number needed for food would make little impression on the vast total. But unfortunately the blubber, hide, and ivory are of value to many besides Eskimos, and it was the ruthless and wasteful killing by the earlier traders that brought this interesting animal so near the verge of extinction, except in the least accessible parts of the Arctic seas.

There are many seals in the Arctic Ocean and they have gone even further than the walrus in the way of becoming aquatic, for their hind-legs are turned backwards and connected with the short tail to form a powerful propeller. Seals are thus at a great disadvantage when on land, and their awkwardness of movement is apt to be their undoing. Their way of life has already been discussed.

Other Marine Mammals of the Far North.

As there are many seals, so there are many whales of different kinds. Absolutely confined to the Arctic Ocean, but dwindling rapidly in numbers, is the huge Greenland whale, from fifty to seventy feet in length, which feeds delicately on the teeming multitudes of pelagic crustaceans and molluscs, caught and strained off on the frayed edges of the baleen-plates, and left stranded on the tongue. Very striking is the white whale or beluga, with a cream-coloured skin, a cetacean about ten

Photo: W. S. Berridge, F.Z.S.

HEAD OF ADULT WALRUS.

The tusks of the walrus are exaggerated canine teeth of the upper jaw, which may be thirty inches in length. They are perhaps of use in digging up molluscs from the sea bottom, but they probably illustrate what may be called "momentum in evolution."

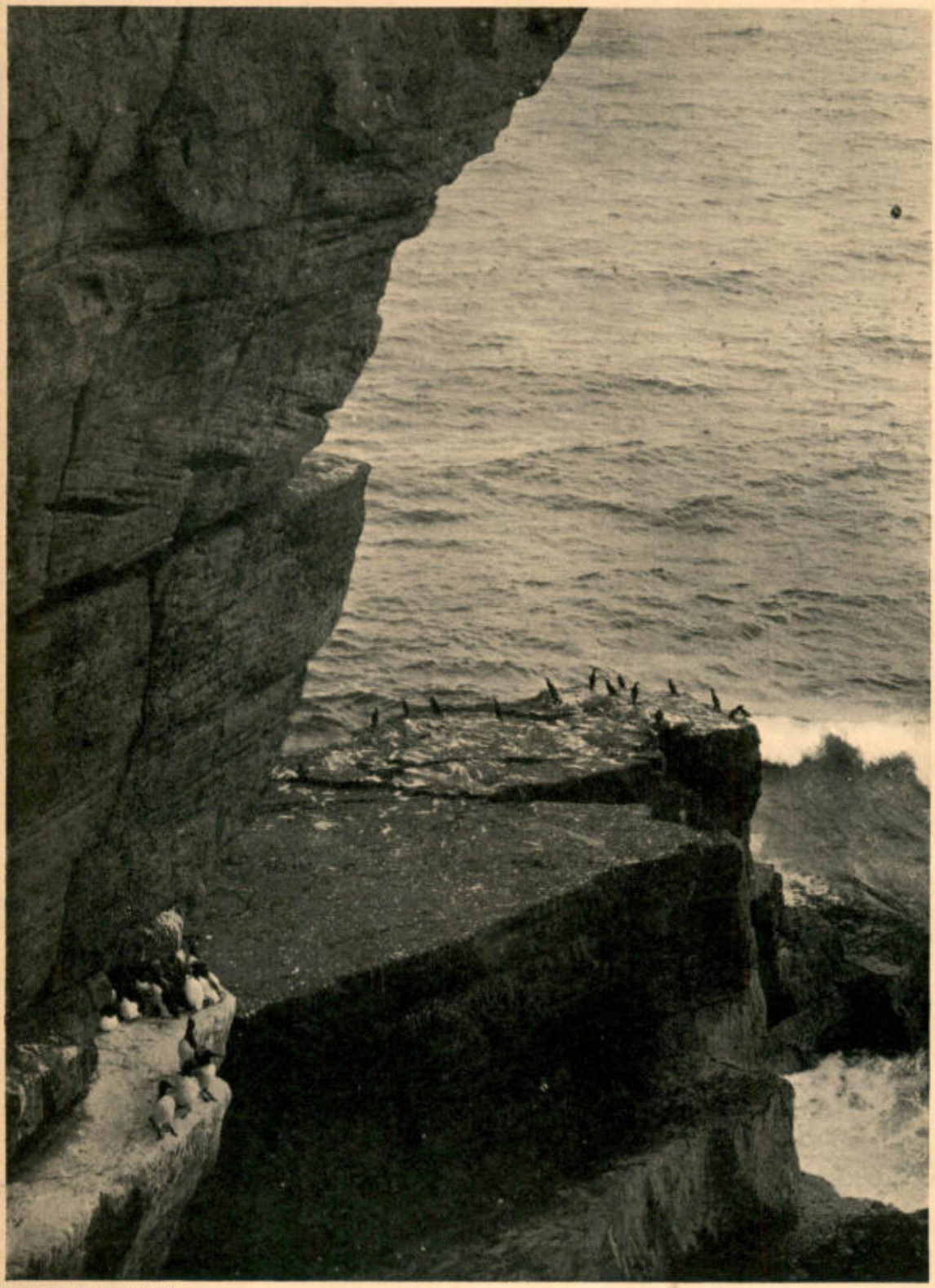


Photo: Norrie, Fraserburgh.

GUILLEMOTS AND SHAGS ON HANDA ISLAND.

Handa is a small island off the west coast of Sutherland, with many shelves on the stratified rocks, and thus a very suitable breeding-place for guillemots and razorbills, which are present in tens of thousands. There are also puffins, shags, cormorants, and kittiwakes in large numbers at the breeding season. The photograph shows many birds as black spots on the water.

Photo: W. S. Berridge, F.Z.S.

RAZORBILL (*Alca torda*).

A summer visitor to European and North American coasts, where it "nests" on the cliffs, laying a single top-shaped egg on a narrow ledge. During the rest of the year it is a bird of the open sea, except in stormy weather. The bill is deep and laterally compressed, with transverse grooves; the breast is brilliantly white; the upper parts are black. When the bird is sitting, the whole of the instep (tarso-metatarsus) is on the rock. The bill is flatter than the photograph shows.

Photo: F. W. Bond.

GUILLEMOT (*Uria troille*) IN WINTER PLUMAGE.

The Common Guillemot is a bird of the North Atlantic and North Pacific, like the Razorbill in its habits. It is a browner, less compact bird, with a longer neck, and a long sharp-pointed bill. It swims and dives well, using its wings under water; it flies swiftly, skimming near the surface; like other auks, it is for the most part a fish-eater.

feet long that skirts the Arctic shores, and ascends the rivers in pursuit of salmon and other fishes. A very interesting point is that the young belugas are blackish, and only become white as they grow up.

Related to the white whale is the sailor's "unicorn," the narwhal, which is also circumpolar. It is famous because of the reduction of the teeth to one—the long, spirally twisted tusk of the male, in rare cases double. It is rudimentary in the female; it may be seven or eight feet long in the male! But the use of it seems very uncertain.

One more mammal of the Arctic seas we must mention—the Sea Otter (*Enhydris lutris*). It is the only member of the otter tribe that is really marine, though our common otter, to which it is distantly related, often frequents estuaries and river mouths. The sea-otter is now rarely seen, although in the glorious days—for the sea-beasts!—before commercial enterprise and firearms had penetrated to the Far North, it appears to have been very abundant. Its movements on land are clumsy, but it is a powerful swimmer; and herds have been seen as far as fifteen miles from land. They are very fond of floating on their backs with the hind-legs and large webbed feet stretched out, and they resume this position at once after fishing. We are told that a sea-otter will amuse itself lying thus by throwing a ball of tangle from one "hand" to the other, and a mother otter, holding her baby between her fore-arms, "would play with it for hours at a time."

They rest frequently on large floating masses of tangle, and even the breeding may take place on beds of drifting seaweed instead of on land.

* * * * *

Arctic Birds.

We are here concerned with the great sea-beasts, but it is hardly possible to form anything like a true picture of the life of the Arctic Ocean without taking account of the innumerable birds that return

Photo: Norrie, Fraserburgh.

EIDER DUCK ON NEST, FARNE ISLANDS.

The Eider (*Somateria mollissima*) is a large heavy duck, at home on the North European seaboard, with a near relative in North America. The handsome drake has a good deal of white on his upper parts, and black beneath; the duck is brown, mottled with black. They feed on molluscs, crabs, starfishes and the like. The foundation of the nest is made of grass or seaweed, and above that is the delicious quilt of down. The duck is a very close sitter, and may be sometimes stroked as she crouches.

year after year to its cliffs and islets to breed. A few birds are resident all the year round even on the ice-bound shores, and for many months these must pick up a scanty living as best they can. Gulls and fulmars are not very fastidious anywhere!

The great northward inrush of birds begins in May, when the ice is beginning to melt. The eider-ducks come only after all the ice that joins up the little islets has gone, for only then are they safe from the depredations of the Arctic Fox. They form close colonies round these islets, and there bring up their large broods, finding abundant and easily obtained food in the layers of water just beneath the surface. For the shore-birds and waders a rich table is spread at every ebb-tide, when the mud-flats with their wealth of soft-bodied animals are uncovered. Above the water-line no food is to be found, for the rocks are polished smooth by the friction of the ice.

But the characteristic feature of the Arctic shores is the abundance of cliff-nesting birds—the swimmers and divers that depend, not on the shore, but on the sea itself. Not every cliff or rocky islet is deemed suitable. It must be

Photo: W. S. Berridge, F.Z.S.

LITTLE AUK (*Alle alle*).

The Little Auk or Rotche is a compactly built bird, about eight inches long, with a short conical bill. It breeds on Arctic islands, but is a common winter-visitor to Britain, and goes as far south as the Canaries. It flies fast and far, and uses its wings under water, steering with its webbed feet. It feeds chiefly on small crustaceans. The crouching attitude shown in the photograph is interesting, but the bird usually sits half-erect.

inaccessible to beasts of prey, be sheltered from the bitterest winds, and as fully exposed as possible to the rays of the sun. Every cliff or rock that fulfils these requirements is quickly colonised by a dense crowd of birds, chiefly razorbills, guillemots and little auks, with puffins wherever there are hollows that admit of burrowing. Brooding and fishing go on all day and throughout a great part of the clear night, for birds can do with very little sleep.

With this intensive feeding the young birds grow very rapidly. There are many casualties, and the robber gulls levy a heavy toll, but by mid-August the young birds are ready to fly with their parents to less severe lands, there to spend the winter resting and feeding quietly, and so preparing for the northward flight, and the brief spell of love and labour which is the climax of their year.

XLVI

THE TUNDRA

BEHIND the precipitous and ice-bound shores of the land-masses which almost surround the Polar basin, there lie vast tracts of inhospitable country, known as Tundra in the Old World, and as " Barren Grounds " in the New. This desolate land stretches back to the limits of the Arctic Circle, and in some places far beyond it, till it merges gradually into the great belt of coniferous forest. For many months of the year it is a wilderness of snow—not everywhere very deep, however, for the air is dry, and the Tundra has rocky heights as well as marshy flats. The light, powdery snow is readily blown off the hills by the wind till only a thin covering is left. But at the sheltered base of the hills and in every hollow the snow drifts accumulate to a depth of several feet.

These inequalities in the distribution of the snow have a great influence on plant and animal life. The stony heights bear little except a covering of lichens, especially of the kind known as reindeer moss, and all through the winter the Alpine Hare, the musk-ox and the reindeer must literally scrape a living. Under the deeper snow many berry-bearing bushes, like cranberries and cloud-berries, Liliputian forests of dwarf willow, and clumps of dwarf birch and dwarf alder are completely covered from the deadly cold, and the little lemmings tunnel their way among them and nibble at their roots. The larvæ of insects and the eggs of many lower forms of life, as well as the seeds of hardy plants, lie dormant in the frozen soil.

With the coming of summer—for there are no between-seasons in the tundra—there is a sudden change. The snow melts and the surface of the ground thaws, but only to a depth of two or three feet. Great stretches of morass are formed, and these are covered with bog-moss, and with crimson-flowered saxifrages in masses so thick and extensive that they suggest a Scottish moor when the heather is in bloom. The sand-dunes and the stony slopes which dry quickly become covered with Arctic poppies and many other flowering plants, which sprout, bloom, and set their seeds within a few weeks. The mean temperature is not high, but a part of the day is hot and the sun shines uninterruptedly for weeks. The continuous light is the chief factor in stimulating plant-life to " feverish " growth.

In the tundra the most characteristic plant is the dwarf birch. Only under very favourable circumstances does it reach a yard in height, but it predominates over the greater part of the tundra so insurgently that the other bushes and plants seem only to have filled up the few gaps between the birches. " It spreads over all tracts where it can take root, from the shore of the sea or river to the tops of the mountains, forming a more or less thick covering so equal in height

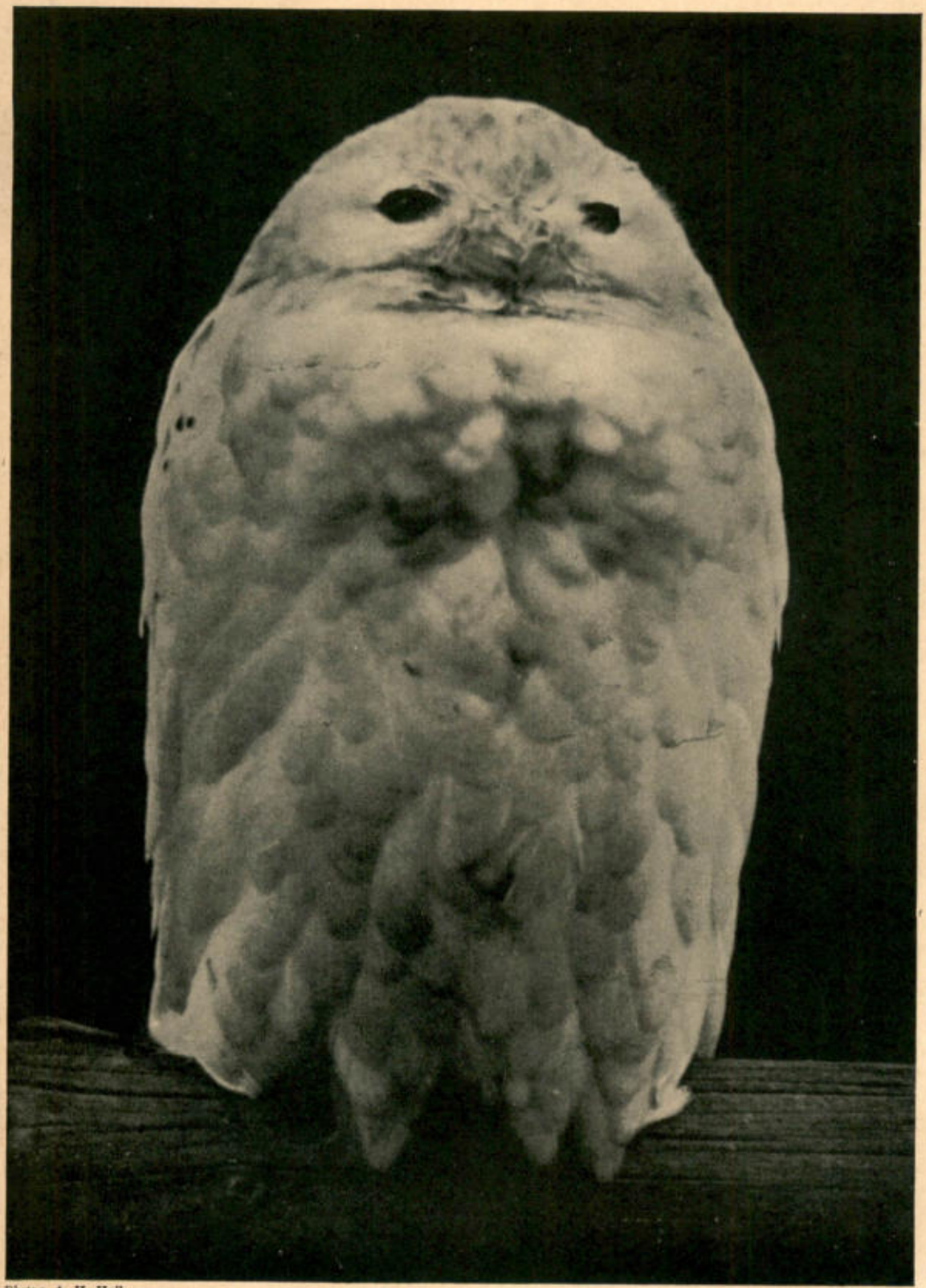


Photo: A. H. Hall

THE SNOWY OWL (*Nyctea nyctea*).
A characteristic bird of the Far North, with beautiful soft white plumage.

that great stretches look as if they had been shorn along the top; it recedes only where the ground is so soaked with water that it forms swamp or morass; it is stunted only where the heights are covered with infertile quartz or stiff clay, which hardens readily in the sun; but it strives for mastery with the bog-moss on all the low grounds and with the reindeer moss on every height."

When the plants re-assert themselves there is also an awakening of many animal-eggs and animal resting stages that have been buried in the mud all winter. A notable instance is the mosquito, a very characteristic feature of the tundra. The naturalist-traveller, Brehm, tells us that "as soon as the sun, once more ascending, has thawed the snow, the ice and the upper crust of the earth, the life of the mosquito, latent in winter but not extinguished, begins to stir again. . . . The larvæ escape from the eggs, and in a few days they become pupæ; the pupæ become winged insects; and generation follows generation in quick succession. The heyday of this terrible pest lasts from before the beginning of the summer solstice until the middle of August.

"During the whole of this time they are present on the heights as in the low grounds, on the mountains or hills as in the valleys, among the dwarf birches and sallows as on the banks of rivers and lakes. Every grass-stalk, every moss-blade, every twig, every branch, every little leaf sends forth hundreds and thousands of them all day long. The mosquitoes of tropical countries swarm only at night; the mosquitoes of the tundra fly for ten weeks, for six of these absolutely without interruption. They form swarms which look like thick black smoke; they surround, as with a fog, every creature which ventures into their domain; they fill the air in such numbers that one hardly dares to breathe; they baffle every attempt to drive

Photo: F. W. Bond.

MUSK OX (*Ovibos moschatus*).

This interesting ruminant, now restricted to Arctic America, suggests a small buffalo. It has short, thick legs, broad, sharp-pointed horns, and long shaggy hair. It is a gregarious creature, with a keen sense of smell, able to climb steep slopes, with few natural enemies except wolves. A herd brought to bay will form a circle around the calves.

Photo: New York Zoological Society.

ARCTIC FOX (*Canis lagopus*).

This beautiful fox, pure white in winter, "bluish" in summer, is widespread in the Arctic regions. Iceland is now its southern limit, but its remains have been found in Britain and in Germany. It feeds largely on birds and on what is cast up on the shore.

them off; they transform the strongest man into an irresolute weakling, his anger into fear, his curses into groans."

But though Brehm speaks thus feelingly of the numbers of mosquitoes, and their unpleasantness in relation to man, he quite realises that they play a very important part in the general scheme of things. They form a great part of the food not only of the fishes in the lakes and rivers, but also of the flocks of little birds that come north to the tundra to breed. Fishes and birds in their turn are preyed upon by the birds of prey—the snowy owl, the buzzards, the Great Black-backed Gulls, the skuas, and many others.

During summer there is a rich and varied bird-life in the tundra, but only a very small number of forms brave the rigours of the winter. Most characteristic of these is the ptarmigan, which in summer feeds abundantly and brings up its young on the young shoots, buds and leaves of growing plants, but in winter changing its variegated dress to white, must burrow in the hillsides to find the berries and leaves of low-growing cranberries, bearberries, and cloudberries, which are preserved as in cold storage under their mantle of snow, and are still on the bushes when they are uncovered in spring. Failing its favourite food, the ptarmigan contents itself with reindeer moss and other lichens.

The Snowy Owl, too, remains, though not quite so steadfastly as the ptarmigan, for during

Photo: H. J. Shepstone.

CARIBOU OR REINDEER IN ALASKA.

Two nearly related species of reindeer occur in Alaska, the Woodland Caribou (*Rangifer caribou*) and the Barren Ground Caribou (*Rangifer arcticus*). The somewhat irregular antlers are borne by both sexes, a unique feature that separates reindeer from other deer.

times of special stress some of them move southward, and in most years stragglers reach the Orkney and Shetland Islands. But on the whole the Snowy Owl is a truly Arctic bird, nesting in a hollow on the bare ground, usually high enough up to be free from damp. It feeds its young ones on its own food, chiefly lemmings, for these abundant little rodents are to the birds and beasts of prey what the insects are to the fishes and song-birds. But ptarmigan and Arctic hare are also frequent victims, and Audubon gives a lively picture of the Snowy Owl's method of lying in wait for and "spearing" fish.

The Arctic owl, *Nyctea nyctea* by name, is a startlingly handsome bird, about two feet in length, the female larger than the male. Some varieties are almost wholly white, while others are abundantly and very beautifully barred with brown. The whiteness may make the big bird inconspicuous against the background of snow, and thus enable it to catch more lemmings and the like; but there is probably more significance in the fact that a white dress conserves more of the precious animal heat than does any other colour. In Arctic regions this must be very important. The feathering of the sole of the foot as well as of the instep and the upper surface of the toes is a straw that shows how the evolutionary wind has blown. We see the same feathering of the sole in the ptarmigan and the polar bear.

The bird is extraordinarily handsome, and even when it is not spotlessly white, the dark bars accentuate its snowiness. There is a suggestion of a powdery snow-drift in the delicious softness of the feathers. Like other owls it flies almost noiselessly, its feathers are so soft. It passes like a ghost. According to the experts it does not cry "*o-ooo*" as it flies, but keeps very silent, only occasionally shouting "*krau-au*" or some other word when excited in the chase. The eyes of the bird are golden yellow, gleaming with fierceness. It must be a bad moment for the ptarmigan when this white death with scorching eyes appears out of the blizzard, but perhaps twenty seconds will suffice for the encounter. The only criticism of

the Snowy Owl's beauty that we have heard is that the head is so perfectly round that it looks "funny." But we cannot think of a Snowy Owl looking funny as long as its eyes are open. All that we can admit is that the bird would be even finer if the feather-tufts, called "ears," were just a little less inconspicuous. In any case it is a ghostly wonder, this owl of the snows.

Mr. Alfred M. Bailey, of the Colorado Museum, has recently described a Snowy Owl's nest which he studied in Alaska. It was on a ridge that rose from the tundra—"a mere depression in the moss, scantily lined with willow leaves." It contained three addled eggs and four little owls, "ungainly and homely, their eyes tightly closed against the northern light." Huddled together with their faces hidden, they looked like so many pieces of cotton. The parents were very anxious, and the snow-white male darted again and again within a few feet of the intruders, "his wings whistling and his talons outstretched."

Mr. Bailey's photograph indicates nestlings with white down, and so does his reference to pieces of cotton; but the authoritative description is that the first down plumage is sooty brown or sooty grey, while the second down plumage is barred white. Perhaps there is variability among the nestlings, just as among the adult birds. The male mounts guard while the female broods, and it devolves on him to provide food, not only for his mate, but for the young birds as well. They seem to be fed on the same materials as the adults enjoy, but it is probably prepared for them by the mother. The rule seems to be that the male collects the food and hands it over to the female, who apportions it among the family. As there may be ten nestlings, all very hungry, we cannot wonder that the father gets very thin. But the point is that the Snowy Owl wins through. It is not a common bird, but it holds its own against fearful odds. We like to think of it as an emblem of Life's victory over Winter.

Of the beasts of prey, the Arctic Wolf, which follows the reindeer and the musk-ox very far north, and the Arctic Fox are the most noteworthy. The Arctic Fox is about two-thirds of

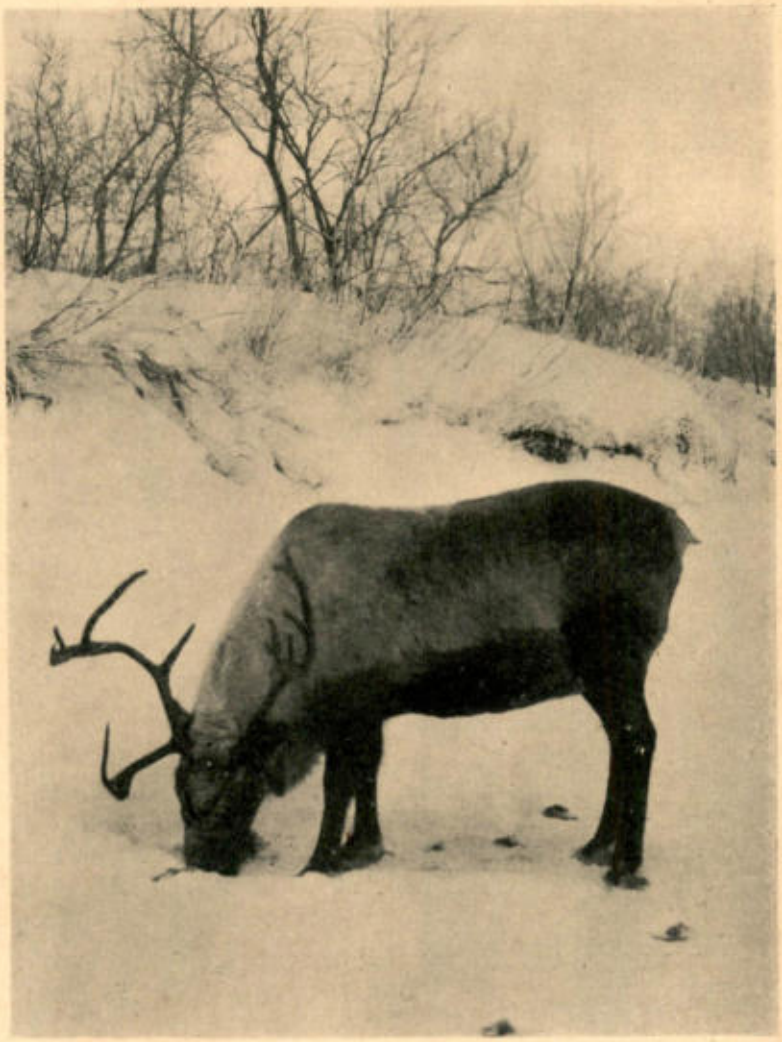


Photo: H. J. Shepstone.

ALASKAN REINDEER OR CARIBOU (*Rangifer arcticus*) SEARCHING FOR FOOD AMONGST THE SNOW.

A strongly built, thick-legged Reindeer, of many shades of colour, occurring both in the wild state and under domestication. The light-coloured Peary Caribou, one of the various races, extends to beyond eighty-three degrees of North Latitude, and must spend three to five months of the year in continuous darkness, feeding sparsely on lichens and the dwarf Arctic vegetation. But all the Barren Ground Caribous lay up in summer and autumn a great dorsal slab of fat, which serves as a winter store.

the size of the common red fox, and it is normally clothed in long and loose white fur of great beauty. "Blue" Arctic Foxes are colour varieties. Most explorers speak of this fox with some enthusiasm, for not only is it very handsome, but its inquisitiveness often relieves a grim situation. The creature cannot resist coming to see what man is doing, and it is venturesome to the verge of recklessness. The late Dr. W. S. Bruce gave a vivid description of the ways of Arctic Foxes: "The Scottish explorers (in Prince Charles Foreland) in 1906 and 1907 had these animals coming within a few feet of them, eating the fat out of the frying pan of the canteen, stealing the sugar, bacon, and other foodstuffs, feeding even out of the hands of the explorers, and sleeping within a few yards of the tent, preferably on the tops of the covered caches of provisions." Dr. Bruce relates also that once when he was cooking he emptied a fruit tin and threw the tin on the ground in front of him. A fox immediately darted between his legs and carried off the tin to lick at a little distance. As it requires flesh food the Arctic Fox must often be hard put to it to get a living. Often it gets a lemming, occasionally a hare, and more rarely still there is a prolonged feast on a whale's carcass stranded on the shore. Mainly, however, it depends on birds which it captures among the snow, e.g., ptarmigan, or at the lake-side, or at the foot of the sea-cliff, or on the Arctic islands, for it reaches these by crossing the ice, or even, like the Polar Bear, by letting itself be carried on a drifting floe. Every tundra mammal has its particular secret, and the secret of the Arctic Fox is its resourcefulness. It lives by its wits.

The Arctic Fox.

Apart from carnivores, there are only four mammals entirely resident in the tundra and dependent on it for food. These are the Lemmings, whose habits have been described in another chapter, the Arctic hare, the musk-ox, and the reindeer.

The Arctic hares (*Lepus arcticus* and their relatives) are found even in North Greenland. They are snowy-white in winter, all but the black tip of the ear, and the fur is long and thick. They usually change in summer to iron-grey, or greyish-brown, but those that live farthest north are white all the year round. The winter whiteness, seen also in the Banded Lemming, may have a protective value, hiding the animal from the hungry eyes of fox or falcon; but its deeper significance for a warm-blooded animal in very cold surroundings is that a white dress is physiologically the best, for it loses least of the precious animal heat.

The Musk-ox (*Ovibos moschatus*) is represented by fossil remains in North Europe and Asia, but the living animal is now restricted to the Barren Grounds of Canada. A slightly different form is found in Greenland. It is a unique kind of ruminant, presenting some of the characteristics of the sheep, but more of those of the ox. Its figure is squat, for it stands only about four and a half feet in height and is six and a half feet in length. Its outer coat is of very long coarse hair, which hangs down over the short legs and almost touches the snow. This outer coat is in the main amber-coloured with a lighter "saddle-mark." Underneath the outer coat there is a dense covering of fine woolly hair, which may be shed in warm weather. The horns, much flattened at the base, cover the whole front of the head, curve downwards, and then recurve at the tips.

"How this animal finds food of any kind during the dark and terrible Arctic winter is one of the secrets of Nature. After making all possible allowance for the grass, willow, and saxifrage obtainable by pawing through the snow or on the ridge-crests that are swept bare by the blizzards, it is still impossible to explain how the herds of musk-ox find sufficient food in winter not only to sustain life but actually to be well fed."

Leaving man out of account, we may say that the musk-ox has no natural enemies except the wolf, and this it baulks by its gregariousness—herd against pack. When they are threatened, the musk-oxen retreat to a height and form a line or circle of defence, with their sharp horns against the enemy. If there are calves they are kept between the line and the crags, or in the centre of the circle. A herd may consist of a male and a dozen or more females, or there may be several males, each with a large following. Herds have been seen to form up in line on the approach of sportsmen's dogs, but the formation is not an effective one against firearms! Fortunately, the haunts of the musk-ox are not easily reached, and the interesting creatures

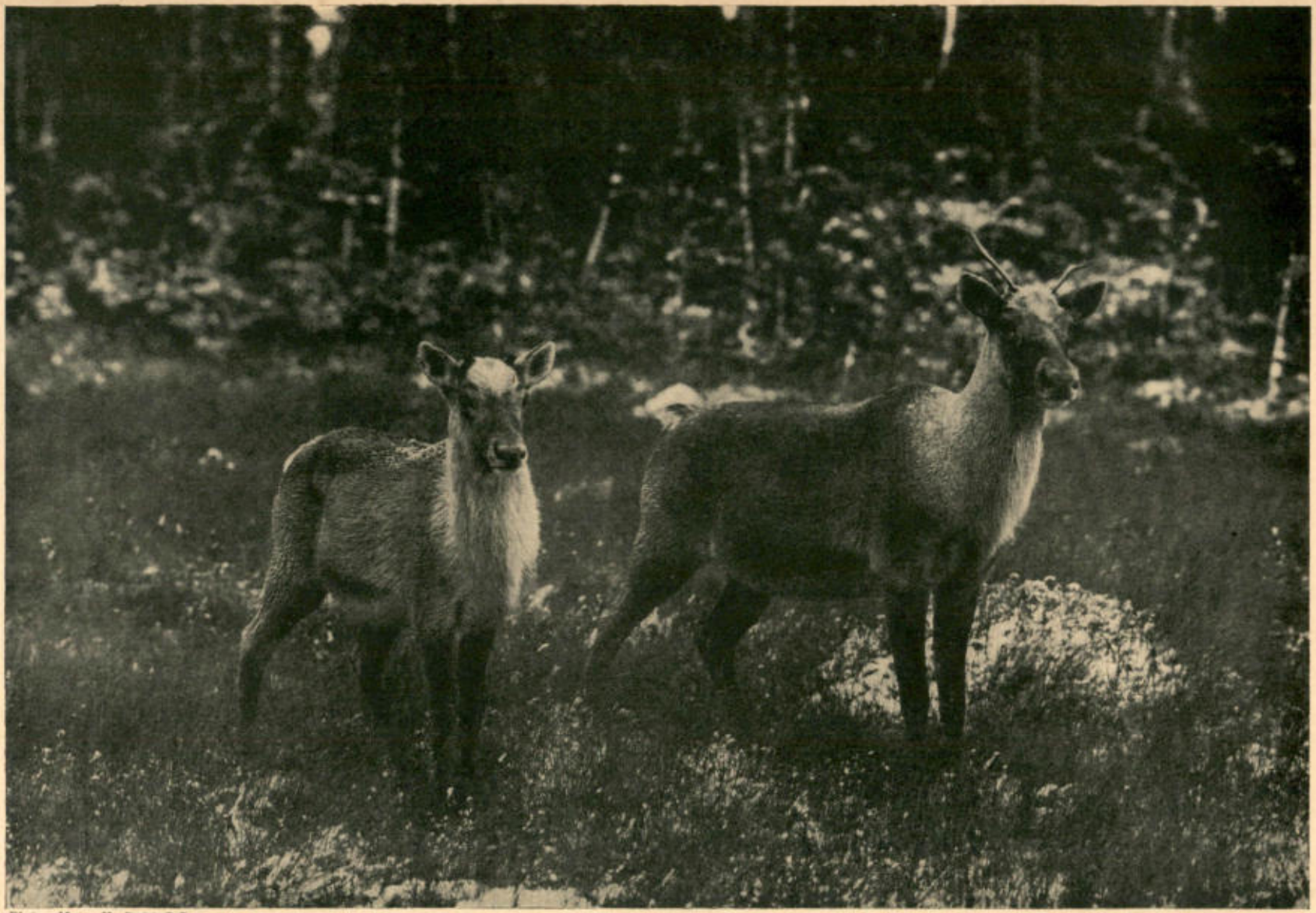


Photo: Major H. Radclyff Dugmore.

CARIBOU DOE AND FAWN.

This beautiful photograph shows the female's young antlers—a peculiarity confined to reindeer. The antlers photographed are still very young, but they never grow to be as thick and long as in the stags. They fall off as usual every year, and begin afresh next season. Almost always there is but a single calf or fawn, which Major Dugmore has been very successful in "taking."

Photo: Major H. Radclyff Dugmore.

CARIBOU STAG (*Rangifer caribou*).

This excellent photograph shows a Caribou stag, probably about three years old, coming through the snow-covered bushes. It shows an animal much less graceful than an ordinary deer, but very strong; not so swift, but of great endurance. The stags keep to themselves for most of the year; the ordinary herds consist of females and calves; but there may be large herds, including stags, in winter.

are fairly well protected by "Jack Frost and mosquitoes."

The Reindeer.

One must admit that the reindeer is not up to the average of its tribe in elegance. Its legs are rather short and thick, the hoofs are very broad, the head is held low. It is an artistic unity none the less, and Brehm speaks enthusiastically of the great herds seen on the snowy heights of the tundra against the blue sky.

But what is more impressive is the reindeer's fitness to the Far North. The shovel-like feet, with the hoofs spreading out under pressure, are crackling noise which is produced by the ankle-joints as the animal runs. The same is true of the moose.

The greatest peculiarity in the reindeer is that the antlers are present in both sexes, whereas in all other cases they are restricted to the males. In the reindeer the antlers are smaller in the female in the great majority of cases, and it is possible that we have to do with an exaggeration of a primitive state of affairs in which small antlers were originally common to both sexes, like the horns in cattle. But the solid antlers, covered with hot skin, and falling off after the

Photo: Major H. Radclyff Dugmore.

NEWFOUNDLAND CARIBOU FAWN SWIMMING.

Especially at the height of summer these reindeer of the Far North—both young and old—are fond of bathing in the lakes and then basking in the sun. This is one of their ways of getting away from tormenting clouds of mosquitoes and other flies.

well suited for running on snow-covered or boggy ground; and they are useful for digging as well. The long dense hair and the thick skin are protective against the terrible cold of the Polar winter. From "the wolf at the door" it is saved by its ability to thrive on scraps of vegetation of all sorts; from the real wolf it is more or less saved by its acute senses and its enduring speed. Though its gait is rather shuffling or like sliding, the pace is sometimes tremendous. One of the curious features is the

breeding season, are very different from the permanent horns of cattle and antelopes, where the core of bone is covered by a longer sheath of horn. So it does not help us very much to notice that in some antelopes the horns occur on both sexes, while in other genera they are confined to the males.

Another possibility is that reindeer illustrate evolution going on, that the originally masculine antlers are being transferred to the females as well. This is what seems to have happened with

Photo : Major H. Radclyff Dugmore.

NEWFOUNDLAND CARIBOU, TAKEN AT RANGE OF TWENTY YARDS.

The tame reindeer of so much importance to northern peoples are half domesticated descendants of the wild caribou, and it is interesting to remember that the caribou or reindeer meant much to the primitive hunters who inhabited so many of the European caves. In the summer and autumn the caribou often come out of the forest to bathe in the shallows of a lake, as the photograph suggests.

Photo : Major H. Radclyff Dugmore.

HERD OF WOODLAND CARIBOU (*Rangifer caribou*).

This interesting photograph shows the stag trying to regain command of his herd of females, who are threatening to desert him. The Woodland species is much less gregarious than the species that frequents the Barren Grounds further north, but large herds sometimes congregate in winter. Unluckily the total numbers of this fine creature have been greatly reduced in recent years.

giraffes, for in the extinct Miocene giraffe, Samotherium, there were small horns in the males only, while in the modern giraffe they are present in both sexes. These questions are very puzzling.

Since the reindeer's antlers occur on the females, one would expect to find that they have some everyday use ; but there seems to be no agreement among naturalists on this point. At the breeding season in September the mature stags try conclusions with their rivals, and then the antlers have their use. The conqueror reduces the number of his rival's harem, and a veteran polygynist has often a large and difficult handful, for the hinds have minds as well as antlers of their own.

According to Nordenskiold, the Spitzbergen reindeer feed in the summer in the ice-free and grassy valleys ; in late autumn, when they are very fat, they move to the sea-coast to eat the seaweed that is thrown up on the beach ; in winter they retire to the lichen-clad mountain heights, where they thrive exceedingly well. With their hoofs they scrape away the snow to get at the " reindeer moss," a kind of lichen that grows on the rocks. In his book, " A Cigarette-Maker's Romance," Mr. F. Marion Crawford gives a vivid picture of the stampede of the half-tamed reindeer from the Laplanders' inland village to the sea ; the trot becomes a gallop, and the gallop a breakneck race, in which the weaker are thrown and trampled. They seem to get wilder and wilder as they get nearer the smell of the salt shore.

In Siberia there appears to be a winter migration from the exposed heights to the forests, and the woodland Caribou (a variety of reindeer), of Newfoundland and Labrador, often comes further south in the winter. Its near relative, the Peary Caribou, flourishes to beyond eighty-three degrees of north latitude, and endures three to five months of continuous night. Its persistence must largely depend on its extraordinary power of storing up fat in days of plenty. In late summer it accumulates a layer of tallow (" back fat "), which may be four inches to six inches thick at the rump. If the Eskimo and Indian hunters do not secure it for their winter feasts, it stands the caribou in good stead. It is gradually absorbed through the grim winter, and it is quite gone by spring.

Speaking of migrations, we should have noticed that the herds of reindeer are often prompted to move before the attacks of excessively troublesome bot-flies, that lay their eggs in the nostrils or in the skin, often with fatal results. Reindeer are also liable to dreadful epidemics of splenic fever.

When man came to Scotland after the last Ice Age, say 10,000 years ago, he must have been familiar with the reindeer. We know from its bones that it used to browse in the meadows from the Solway to the Pentland Firth, and we know that man hunted it with stone-tipped javelin and arrow. For a long time the reindeer held its own, outliving Neolithic man ; but with the shrinkage of the forests and the use of metal weapons its numbers slowly suffered diminution. The last reference to it as a living animal in Scotland is in the twelfth century.

The reindeer meant much to the early hunters, and it has entered into manifold relations with the peoples of the north. We suppose there is no part of the creature that is not used, for the contents of the stomach are boiled as a vegetable and the still warm marrow is eaten raw. The flesh is food ; the bones and antlers are fashioned into tools ; the tendons become string ; the hide is a garment and a shroud ; even the hoofs are used. Reindeer may be used for the sledge or as beasts of burden ; and they may be milked. Their domestication is rarely more than skin-deep, but that varies with the kind. Thus the reindeer of the Ostiaks are docile and willing, while those of the Lapps are mulish and impatient of man's yoke. Mankind certainly owes much to the reindeer.

XLVII

THE NORTHERN FOREST

AT the edge of the tundra there is a belt of forest consisting mainly of coniferous trees, interspersed in the north with birches. There is no sharp line of demarcation; here and there patches of tundra stretch into the forest zone; here and there groups of straggling trees encroach on the tundra, stately larches grow in the gorges cut by the rivers, and the birches spread everywhere, becoming more and more stunted as they are more exposed. As the forest stretches southwards, mountain-ash, bird-cherry, and alder soon mingle with the pines and birches, other deciduous or leaf-shedding trees appear, and the forest loses its coniferous character except on the high mountains, and finally merges into the Steppes.

The coniferous region shows nothing of the density of the tropical forests. The trees are farther apart, the undergrowth is not so rank, there are no great creepers or lianes and thus, though there are many obstacles, such as fallen trees, in the way of free passage, there are no really impenetrable thickets. Therefore the animals are much less well-marked as forest animals than those of the tropics. There are indeed many of them that live almost wholly on the trees, but they are not confined to them, and they show no very special adaptations to arboreal life. The great majority of the inhabitants of the northern forest are equally well suited for life elsewhere, and have chosen this haunt for its shelter, for the relative abundance of food, and above all for the stability of the supply.

There is never the extreme luxuriance of plant-growth that makes the steppe a paradise for herbivorous animals in spring and early summer, but neither is there the extreme scarcity which there inevitably follows on the heels of the fat season.

The capercailzie, blackcock, willow grouse and other game-birds, which abound in certain localities of the coniferous forests, feed comfortably in spring on young shoots and fresh buds; as summer advances they make daily excursions, often of several miles, to one of the great clearings made by the forest fires, and there they fare sumptuously on the fruits of the many low-growing, berry-bearing bushes which flourish between the blackened tree-stumps. These berries last far into autumn, and there are still the juniper berries and the edible seeds of the cembra pine to fall back upon.

When snow comes the hardy birds burrow down to the ground at dusk, and remain in these shelters often till high noon the next day. Then they break their way out by beating their wings, and feed, if all else has failed, on the needles of the pines, for some of the branches and twigs have always been blown free of snow. These hardy birds are not without enemies, of course, for the smaller carnivores hunt them ceaselessly, and the larger ones do not disdain them. But there are very few snakes and very few egg-eating mammals, and the birds can baffle the sportsman by their habit of constantly changing their feeding-grounds. Thus, on the whole, the forest offers them very favourable conditions of existence.

The coniferous forest offers shelter and suitable food to many of the larger herbivores, especially those of the deer tribe, which are typically forest animals. Reindeer and Caribou have each their woodland variety which grows slightly larger than that which frequents the open tundra. The Maral stag, the Red deer and the Roe-deer occur in the forests of the Old World, Wapiti and Virginian deer in those of the New. But perhaps the most interesting is the largest of all deer, the Elk (*Alcis machlis*) of Europe and Asia, represented in Canada by the similar but rather larger moose (*A. americanus*).

The elk is an uncouth-looking animal with its long legs, short neck, overhanging, prehensile upper lip, and great shovel-shaped antlers. It is intolerant of disturbance, and indeed it appears to become bewildered when it is surrounded, so it has disappeared before the advance of

Specially drawn for this work by Warwick Reynolds, R.S.W.

THE BROWN BEAR (*Ursus arctos*), CLIMBING AFTER HONEY.

During the summer the Brown Bear feeds well and lays up stores within its body. These are gradually exhausted during the hard times of winter, especially when there is a great deal of snow. So the bear that is very plump and good-humoured in autumn is thin and cross in spring. There is often some winter sleeping, but probably no hibernation in the strictest sense. The bear has many tastes, but the strongest of all is for honey, and Mr. Warwick Reynolds has here shown it climbing a tree to get at the hive which the peasants have hung up to be safe.

Photo : W. S. Berridge, F.Z.S.

WILLOW GROUSE (*Lagopus albus*) IN SUMMER DRESS.

This grouse, first cousin of the ptarmigan (*Lagopus mutus*), is widely distributed in Northern Europe, Asia, and America. Many, if not most, of the ptarmigan seen in English poulterers' shops are willow grouse imported from the Continent. The summer dress of the willow grouse is rather like that of the red grouse, but the wing-quills are white.

cultivation. But it is still carefully preserved in Scandinavia, and in Russia and Siberia it is well able to hold its own. "A forest animal in the full sense of the word, as much at home in swamp or bog as in thicket or wood, overcoming with equal ease all obstacles of forest and morass, assured by the nature of its diet from the scarcity of winter, it escapes more readily than any other beast of the chase from pursuit either by man or by other dangerous enemies. The latter include wolves, lynxes, bears and gluttons; but it may be doubted whether all these beasts of prey together very seriously affect the elk. For it is as strong as it is courageous, it has in its sharp hoofs even more formidable weapons than its antlers, and it knows right well how to use both. It may fall victim to a bear who surprises and overcomes it, but it undoubtedly hurls a single wolf to the ground, and may even be victorious over a pack of these eternally hungry creatures."

The elk is unable to graze on the ground; its short neck and long legs only allow it to reach the lower branches of trees, the tops of bushes, and long grasses. But in summer it spends a great part of its time, especially at night, sunk deep in the mud of the marshes, and there it feeds royally on succulent water-plants, plunging its head into the water to uproot them, and then blowing mud and moisture from its nostrils with a snorting noise that can be heard at a long distance. When the marshes begin to freeze, the elk retreats to higher ground, and must then content himself with a drier diet. The moose of Canada is said to stamp out a "moose-yard" and feed on the bushes all round it, thus securing himself a firm foothold if he is attacked by wolves.

Wherever there are many herbivores there are sure to be many carnivores, too. And all through the "Taiga" of Europe and Asia, and the forests of Canada the wolf is abundant. How abundant it is difficult to say, for "they are found everywhere and yet nowhere; to-day they fall upon

Photo : W. S. Berridge, F.Z.S.

WILLOW GROUSE IN WINTER PLUMAGE.

Like the ptarmigan, the willow grouse turns white in winter, but the lateral feathers of the tail are black. The bird's name refers to its fondness for willow-scrub on the uplands. The food consists chiefly of the shoots and fruits of mountain plants, such as bilberries.

the herds of a village, and to-morrow they ravage the sheepfolds somewhere else ; they leave certain districts suddenly and establish themselves in them again just as unexpectedly ; here they defy their persecutors and there precautions against them are almost superfluous." In the "Taiga" the wolf does not usually hunt in packs, but a single animal can do a great deal of damage among cattle and sheep.

The Lynx.

The Wild Cat, which is still comparatively common in some parts of Europe, and not yet extinct in the North of Scotland, does not seem to occur in Siberia, where the only representative of the Cat tribe, save for rare incursions of the tiger from the south, is the lynx. This beautiful creature is the largest of the "wild cats," and may be as much as four feet in length. The legs are unusually long for a cat, and it stands quite two feet high at the shoulder. The long pointed ears with a tuft of hair at the tip, and the other tufts of hair on the cheeks mark it off from others of its tribe. It is clever and wary, and is seldom taken in traps, though it often destroys them. It is content with small game—birds, squirrels, hares, and even mice—and as these are usually abundant in the depths of the forest it has little need to seek the open. "How much the lynx is feared by the game-birds may be seen from the fact that every wooing capercailzie or blackcock is immediately dumb when a lynx lets himself be heard."

In times of scarcity, or when his usual victims have changed their feeding-ground, the lynx comes nearer the fringes of the forest, and then becomes very destructive to larger animals. "Like all Cats, he has not a particularly fine sense of smell, and his pace is not sufficiently rapid to allow him to pursue his prey. His patience, and the skill with which he creeps noiselessly, brings him close up to his victim. More patient than the fox, he is less cunning ; less hardy than the wolf, he leaps better and can resist famine longer. He is not so strong as the bear, but he keeps a better look-out, and has sharper sight. His strength resides chiefly in

Photo : H. J. Shepstone.

WAPITI OR AMERICAN ELK (*Cervus canadensis*).

The name elk, which belongs to the European moose, has been transferred to the Wapiti, which is closely related to the European stag. In America and Canada it used to have a very wide range, but it has been pressed on to the mountains, except where sheltered in reserves like the Yellowstone National Park.

Photo: Major H. Radclyff Dugmore.

YOUNG BULL MOOSE (*Alces americanus*).

This fine photograph shows the growing antlers on the young male, before they have reached their final palmated form. The young bulls seem to be fond of the water in the summer time, and often wade up to the neck in a lake in search of succulent water plants. The photograph shows very clearly the heavy, strangely moulded snout.

his teeth, jaws, and neck. He is not voracious, but he loves warm blood. . . ." So bloodthirsty is the lynx's nature that a single individual has been known to destroy forty sheep within a few weeks. "The Canadian lynx has been seen to jump on the back of a sheep, and bring it to the ground by repeatedly biting at its eyes."

The Brown Bear.

The Brown Bear is a very "individual" animal with a place by himself. He cannot be ranked either with the herbivores or with the carnivores, since he eats both animal and plant food at all times. Except at the pairing season, he lives a solitary life, and wanders through the forest, to which, however, he is by no means confined, molesting no one if he is not attacked, and only exceptionally killing larger animals for food. Yet the popular conception of him as a good-natured beast not without a sense of humour is far from correct. According to Brehm his good-nature is indifference, and his reputation for humour is due to the drollness of his rolling gait. But this leisurely-looking amble gets him quickly over the ground, and he can break into a gallop that is extraordinarily fast. His long hind legs make it easy for him to go up steep hillsides, but he has to come down warily lest he should overbalance himself. His strong sharp claws are of great help in climbing trees, and he swims well. He is very suspicious and watchful, but he has nothing of the cunning of the fox or the wolf; he prefers to avoid direct contact with man or any other powerful enemy, but if that

Photo: Major H. Radclyff Dugmore.

COW MOOSE (*Alces americanus*).

A beautiful Canadian scene, for which we are indebted to Major Dugmore's skill and patience. The cow moose, being a true deer, has, of course, no antlers, the reindeer being the only case where they occur in both sexes. At the breeding season the cow calls to the bulls, who come quickly through the forest. The photograph brings out very well the characteristically long legs of the moose.

is not possible he stands his ground, and trusts to his prodigious strength.

His normal way of life throughout the summer is comparatively harmless. He wanders about his own particular beat in the forest, appearing each day at the same point at nearly the same time. His day's round can be read from the tracks and traces he leaves behind him, and it has been described by various sportsmen who have followed them. Here he pulls an ants' nest to pieces and consumes with equal eagerness the fat white grubs and the ants themselves; there a handful of scattered feathers shows that he has made a successful leap upon a covey of game-birds. Reaching a river-bank, he fishes for a while but, food being plentiful, he eats only the head of his victim and leaves the body lying on the bank. Had it been spring-time he would have followed the migrating fishes up stream for days, but now he wanders back into the forest, bending down the tops of the young mountain-ashes to pull some of their ripe fruits, and picking grubs from under the bark of decaying trees as he goes. Presently he comes to a clearing where he is wont to feast on the abundant cranberries, whortleberries, and bilberries. But the clearing is not far from a human settlement, and it is already occupied by women and children picking the berries. The bear does not retreat, he simply stands still and growls. The pickers do not wait—he knew they would not—and he has no further interest in them. In their haste some of them have upset their baskets or left them behind, and he has his feast without any trouble. He is satisfied for the time and retires into the forest again to dose the warmer hours away. Towards evening he wakes up hungry again, and at once climbs a high tree to look round. There are no men or dogs visible, and the golden grain is

Photo : Major H. Radclyff Dugmore.

BULL MOOSE (*Alces americanus*).

The American moose is a large edition of the European elk (*Alces machlis*). It inhabits the northern forests and varies considerably in different regions. A full-grown bull-moose stands higher than a horse, weighs over half a ton, and carries antlers with a spread of six feet.

tempting. He makes for the harvest-field, enters it, squats down on his haunches, and pulls down the laden ears all about him. One spot stripped, he pulls himself along, still squatting, clearing and breaking down the grain as he goes.

Then the smell of honey attracts him and he looks about for the hives. The peasants have tried to keep them safe from him and yet let the bees benefit by the flowers at the forest fringe by fastening the hives to a high branch, and stripping the trunk of the tree smooth. But the bear is not easily baulked ; his claws are sharp and his love of honey amounts to a passion. He succeeds in climbing the tree and knocking off a hive, carries it away. It is not easy, for the angry bees swarm all about him and sting him repeatedly in his few vulnerable parts. He puts down the hive and rubs off his tormentors with his paws ; but they return at once ; he rushes to the nearest swamp to rub his burning nose in the cool mud. But he comes back, and in the end he gets his honey.

As winter draws near the bear gets very fat, especially, it is said, if he has taken a journey far enough southwards to add acorns to his dietary. When snow comes he seeks out a hole, a cave, or a hollow tree, lines it comfortably and becomes more or less sleepy according to the amount of fat he has been able to put on. But the bear is no hibernator. The female keeps quiet and is often sleepy just before the birth of her cubs, but after she has suckled them for a little she becomes very hungry and must go forth to forage.

The winter huntsmen often attack the bear in his resting quarters, but it is a dangerous sport, for a disturbed bear becomes mad with rage, and is afraid of nothing. It is at this time that he is most dreaded, for there is little plant food, and he will attack any large animal he can get near. Sometimes, too, the taste for fresh

meat becomes too strong, and the lust for killing grows. When that happens he "becomes a beast of prey in the fullest sense of the word," for he will not only attack elk and other deer, he will kill the horses in the fields and break into the cattle sheds to get at the cows. We are told that a bear has been known to lift a newly-killed cow in its forepaws, and to walk upright with it through a brook, and to hoist an elk out of a ditch and drag it half a mile through the swamp.

The European Bison.

For a picturesque and also for a pathetic reason we wish to include among our examples of forest animals the European Bison or Wisent, first cousin of the American Bison. The picturesque reason is that the animal is one of the most impressive of living mammals, standing nearly six feet high at the shoulders, a powerful and fierce creature. The pathetic reason is that this grandiose animal is on the verge of extinction. The Great War left only a few small herds in what might be called a wild state, and most if not all of these have perished in the aftermath.

The European Bison, technically called *Bison bonasus*, has received many names, such as wisent and zambra, and, unfortunately, aurochs, a title that belongs to the Primitive Ox, *Bos taurus primigenius*, which disappeared for ever in the early years of the seventeenth century, perhaps about 1627.

The European Bison, like its American relative, is very massive in its forequarters, highest at its shaggy shoulders, with the line of the back falling from that apex. The head is short, blunt, and depressed ; the horns are of medium length, but very strong. The horns and hoofs are black. One gets an impression of great shagginess, for there is a thick covering of long, soft hair, brownish, reddish, and dark grey in colour. There is an almost black brush on the tail, and a beard of the same colour below the chin, which is said, curiously enough, to be most pronounced in the cows and young bulls. There is a change of hair after the first fall of snow, so that the bisons get their warmest suit in the winter. This is shed very rapidly when the spring thaw begins. The bull's pelage is ruddier in summer than in winter ; the cows change from ruddy-brown to dark grey. The skin has a musky smell, which also affects the flesh.

The bison was once widespread throughout Europe, including Britain ; it probably extended into Asia Minor, perhaps even to Turkestan, and, according to Lydekker, there are bones in Canada and Alaska that belong to the European, not to the American, species. With the cutting down of forests, the spread of agriculture, and the growth of civilisation, the range of the splendid animal was in the course of centuries more and more restricted, until at the beginning of the nineteenth century it was represented only in the forest of Bialowieza, in Lithuania, and in some of the wooded parts of the

Photo : F. W. Bond.

AMERICAN BAY LYNX OR BOBCAT (*Lynx ruffus*).

The ears of the widespread American bobcat are less tufted than is usual in lynxes. It is an inoffensive creature as far as man is personally concerned, but it is an unsurpassed hunter of small mammals and birds, and it levies toll on poultry, perhaps even on lambs. It is for the most part nocturnal in its activities. Though a clever climber, it hunts chiefly on the ground.

Circassian mountains. The bisons of Bialowieza were said to number about 300 in the early years of the nineteenth century, and more than twice as many in 1914, but while the Napoleonic war left a sturdy remnant, the Great War left none, or, some would say, seven, which have since perished. Some small herds were left in the virgin forests of Circassia, but it seems that they also are now gone.

The bison is pre-eminently a forest animal, though it may leave its retreats in search of pasture. It dislikes the heat and the glare, but in upland forests it often enjoys the fresh coolness of open spaces near streams where there is a thick growth of butterbur. Bisons like to roll in the sand, and there used to be short slopes called "totchki" on the Circassian mountains where they slid down on their backs for two or three yards. They can ascend to 5,000 feet or so, but they do not go beyond the end of the trees. They seek lower levels in winter when the snow is very deep and the frost keen.

Photo: F. W. Bond.

NORTHERN LYNX.

Lynxes are long-legged, short-bodied, short-tailed cats, well-marked by their tufted ears. They frequent the northern parts of the Old World and the New, and there is very little difference between the European and Asiatic species (*Lynx lynx*) and the Canada Lynx (*Lynx canadensis*). The smaller American bobcat (*Lynx rufus*) is another of these handsome cats. They feed chiefly on birds and small mammals, and do not attack man.

Bisons go about in small herds of cows and young males, usually six or seven in number, occasionally over a score. The old bulls live alone in the forest, except at the breeding season, when they take command of the herd. There are many stories of the bad behaviour of these "solitaries"—how one will eat up the peasant's hayrick and another his potato pit, how one will lie down for the day across a road and refuse to budge even for the Forest Commissioners, and how another becomes like a "mad bull," requiring little in the way of "red rag."

A bison can smell a man from a distance of 200 yards, and is also quick of sight. There are so many little noises in the forest that the sense of hearing does not seem to count for much, unless it is much more acute than the bison's.

Photo : H. M. Bell, F.Z.S.

BROWN BEAR (*Ursus arctos*).

This familiar animal, frequenting the north of Europe and Asia, attains a length of about six feet and is prodigiously strong. It lives a solitary life, feeding largely on fruits and roots, but asserting itself as a carnivore when opportunity offers. Its fondness for honey is well known. It is not aggressive to man unless it has been severely provoked, or when the cubs are threatened. It may kill its enemy in a terrible bone-breaking hug. It is not very distantly related to the American Grizzly, but the relationship of the various kinds of bears are very difficult.

The voice must be a terror ; it has been compared to thunder, to a discharge of firearms, to the grunting of a pig. If these comparisons are all appropriate, the bison must have a considerable range of vocal expression ! It seems to say Too-oo-oor very loud. In exceptional cases there is a melancholy moo, as when a cow-bison has been robbed of her calf, and is sometimes as dangerous as the savage bull.

The staple food is grass, notably sweet vernal, the fragrance of which is said to be discernible in the flesh and in the thick milk. There seems to be fondness for plants that have a good deal of flavour, such as the bitter buttercup, the marsh marigold, the meadow geranium, and the balsam. In winter the bisons have to depend on harder plants, such as thistles and brambles and ling, and they often tear the bark off the trees.

The pairing is usually at the beginning of September, and the rival bulls fight furiously. A young aspirant of three years old is often killed by an older bull. On one occasion the two combatants were so preoccupied that the firing of several shots did not interrupt their encounter, and we read that a third bull arrived on the scene, tore up a sapling four inches in diameter, twisted it up in his horns, and charged the others with the tree on his head ! " Quand la poussière se dissipa il n'y avait d'animaux."

The cow bison has a calf when she is five or six years old, and she gives birth in May or June.

But two years must elapse before she bears again, and the probable explanation is that she suckles her calf for the great part of a year, as in the American bison, and does not rejoin the herd until the safety of her offspring is for the time being secure. But there is great discrepancy in the accounts that are given of the relations between cow and calf, especially as regards the courage or timidity of the mother and the precocity or feebleness of the offspring. It may be that there is considerable variability. The length of life is probably thirty to forty years for the cow bison and fifty for the bull. But unless something is done speedily all these sentences will have to be changed to the past tense.

For many years the poacher was the bison's worst enemy in the North, in spite of punishment by death (as a formal sentence) under the Polish Government, and deportation to Siberia (afterwards changed to a huge fine) under the Russian *régime*. But now, as we have said, there are no more northern bisons to be poached. Collectors of heads have for long been ruthless in Circassia, and the Bolshevists seem to have finished off the small post-war herds by using mitrailleuses. Apart from man, the only serious enemies of the bison have been wolves and warble-flies. No doubt there have been occasional outbreaks of microbic disease and occasional bad infections with liver-fluke, but it is not through any casualty of this sort that the bison has been brought to the verge of extinction. For that is due to man alone.

The question rises whether man, thoroughly ashamed of himself, might not make a fresh start with bisons. The Duke of Bedford has a small herd at Woburn Abbey; the Zoological Garden at Budapest had seven in 1922; the Zoo in Berlin had five in the same year; and Sztolcman knows altogether of twenty-eight still living in similar conditions. It is possible that there is a total remnant of seventy, and the hope is entertained

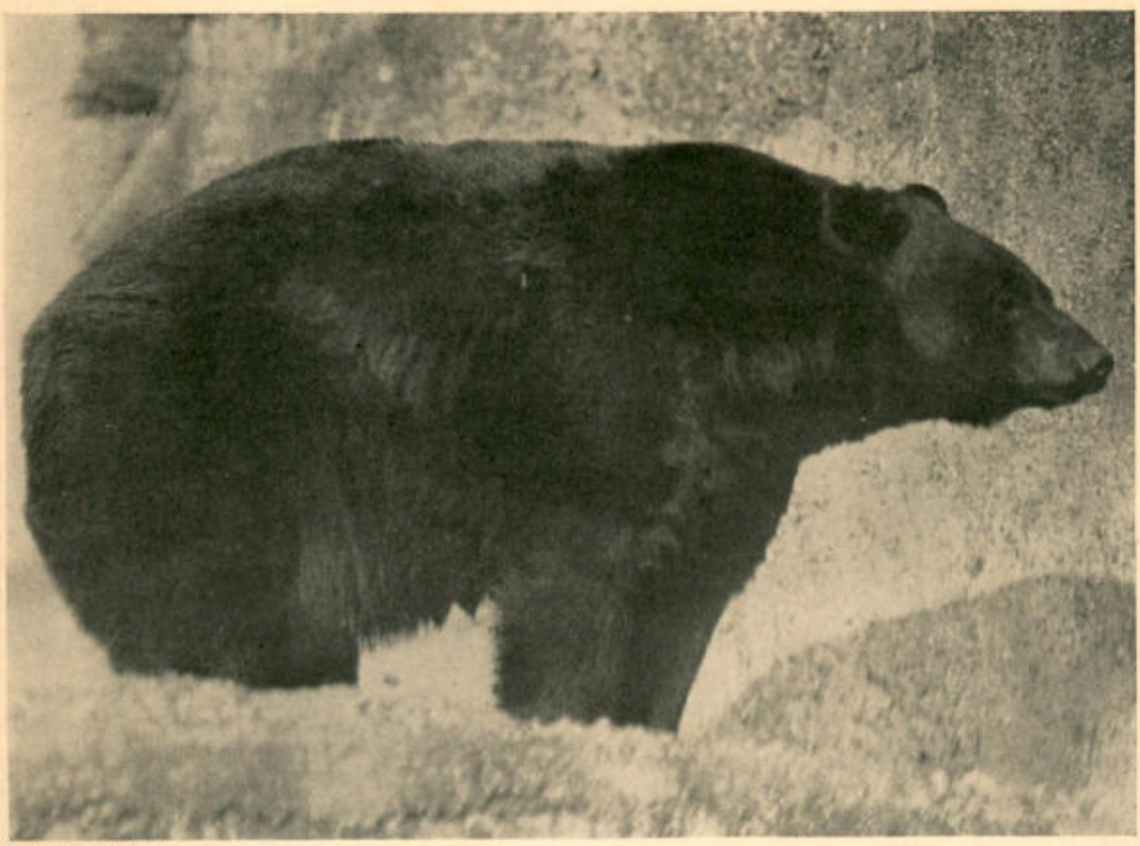


Photo: F. W. Bond.

BLACK BEAR (*Ursus americanus*).

Handsome, powerful, shy beasts, not aggressive to man, largely nocturnal, eating almost anything. They have poor eyesight, but alert hearing and a delicate sense of smell. Like the grizzlies, they are said to sleep for months in winter; and it is at that season that the young ones are born, only eight to nine inches long, almost naked, and with eyes remaining closed for more than a month.

Photo: W. S. Berridge, F.Z.S.

BEHRING-SEA BROWN BEAR (*Ursus arctos beringianus*).

There seems to have been a comparatively recent multiplication of bear species, for although the cave-bear of the times of Palæolithic man has disappeared, its place has been taken by the brown bear (*Ursus arctos*) and its numerous varieties. The palms and soles are naked, unlike those of the polar bear; the ear trumpets are conspicuous; the snout is strong; the brain is richly convoluted.

that it may be possible to re-stock suitable places with this splendid type. It is to the lasting credit of Dr. William T. Hornaday, of the New York Zoological Gardens, that he has saved the American Bison from immediate danger of extinction. Through the efforts of his Bison Protection Society the numbers were raised from about 1,000 in 1889 to over 8,000 in 1923, and by similar skill and enthusiasm the European Bison might still be re-instated. Its reduction to between thirty and seventy individuals leaves little margin, but the endeavour is certainly not hopeless. The European Bison is an antique type with splendid qualities, doing little harm and with usefulness in every inch of its body. Must it follow the Aurochs to extinction? This would be a disgrace to civilisation. Let us hope that it may be avoided.

The Rambles of the Mammoth.

Early in the nineteenth century the bones of the mammoth, thawed out of Siberian bogs, were described by the great Cuvier as those of a big northern elephant. Before that they had been badly misunderstood, for some held them to be the remains of a race of giant men, and others regarded them as huge burrowing animals that died at once if they were by any chance unearthed. The puzzle was increased when the finds included not only the bones, but pieces of shaggy skin and chunks of frozen flesh at which the hungry dogs began to gnaw. In 1806 the intrepid explorer, Adams, secured an almost complete frozen mammoth on the banks of the Lena River. Though it must have been in cold storage for thousands of years, the flesh was being eagerly devoured by wolves and polar bears that came from great distances to the strange feast. Some bold native had sawn off the ivory tusks, but most of the bones were available, and Cuvier did not require any genius to know that he had to deal with a species of elephant. A number of mummy mammoths have since been found, and we actually know a good deal about the tongue and trunk, the stomach and blood of this giant mammal long since extinct.

As compared with a modern elephant, the mammoth had a very bulky head, a shorter but more massive body, a shaggy hide, and in the male huge recurved tusks, often bent round to fully three-quarters of a circle. The largest mammoth tusk in the Petrograd Zoological Museum has a length of thirteen feet seven and three-quarter inches. A formidable weapon indeed, but probably to be regarded as an expression of intense virility which was carried to an extreme, like the enormous antlers of the so-called Irish Elk. One of the mammoth carvings made by Aurignacian man on the walls of caves shows two finger-like processes at the tip of the trunk, and we may be almost sure that this was the case. But the trunk of the mammoth was not nearly so large or strong as that of either the African or the Indian elephant, and its chief use was doubtless

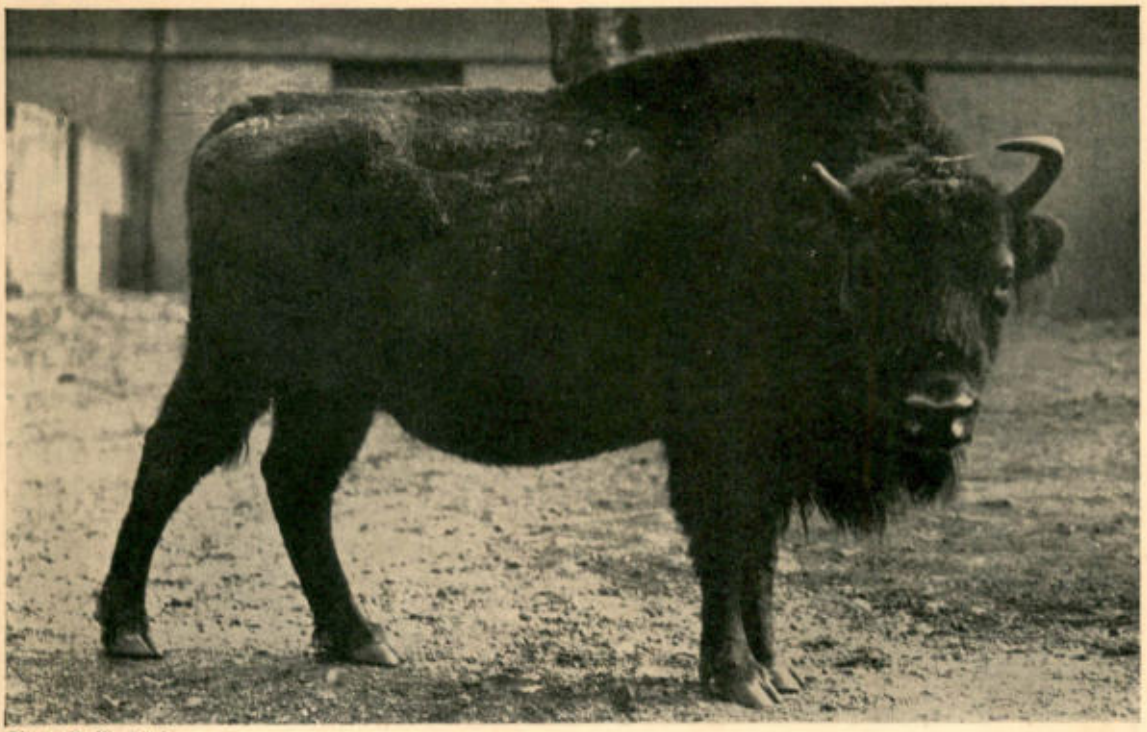


Photo: F. W. Bond.

EUROPEAN BISON OR AUROCHS (*Bos bonasus* or *Bison europæus*).

This magnificently strong animal, now verging on extinction, is a near relative of the North American Bison (*Bison americanus*), and shows the same shaggy mane and shoulder hump. A good specimen may stand six feet high at the shoulders. It is also known as the Wisent and the Aurochs, but the last name belongs to Wild Cattle (*Bos taurus*).

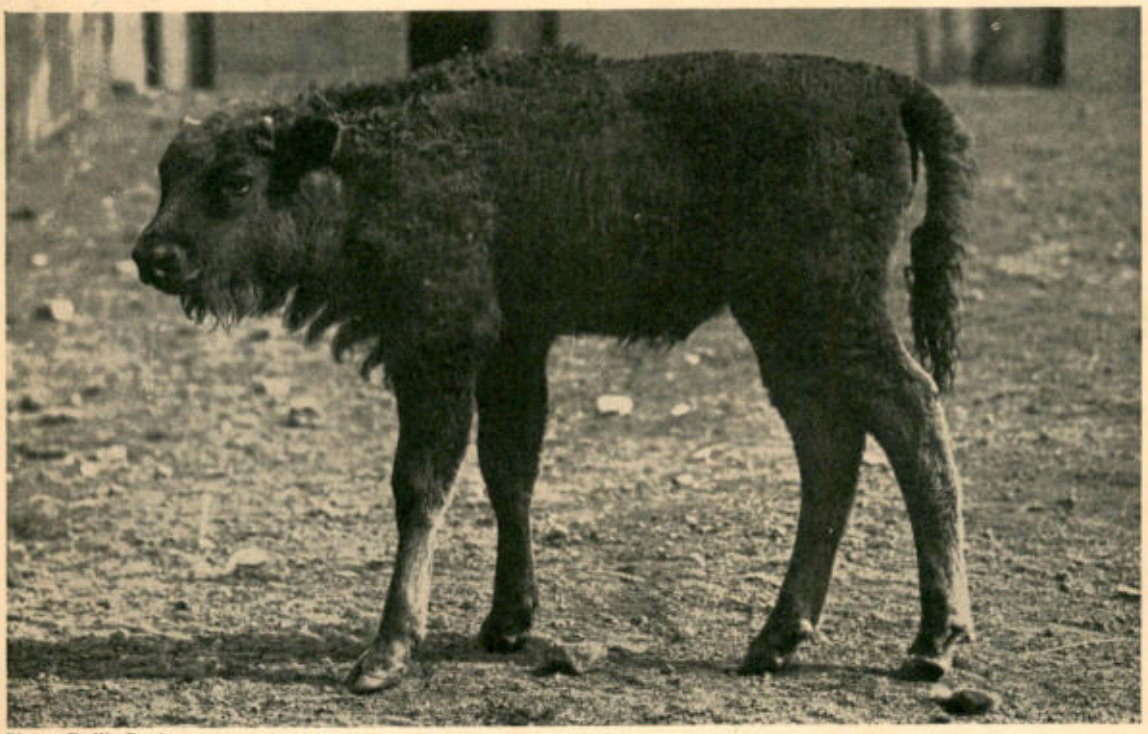


Photo: F. W. Bond.

EUROPEAN BISON CALF (*Bos bonasus* or *Bison europæus*).

The photograph shows a male calf, about ten days old. It must be noticed with great regret that the wild herds are at present (1926) almost exterminated, though a number of individuals are still surviving under protection. In old days the bison ranged over the greater part of Europe, just as the American Bison did on the prairies. Its practical disappearance in a wild state followed the Great War.

Photo: H. Morrey Salmon.

PAIR OF BUZZARDS AT NEST (*Buteo buteo*).

Buzzards nest both on cliffs and on trees, and their bulky construction is built of branches and twigs, heather-roots and grass, often with an added decoration of green foliage. There are usually two or three whitish eggs, marked with red, brown or violet, and the male shares in brooding. The nestlings have white down, and are solicitously fed, occasionally defended, by their parents.

that of gathering grass and sappy herbage in the Arctic meadows.

In a very interesting recent study of the mammoth, Mr. Herbert Lang, of the American Museum of Natural History, argues from the surface of the huge molar teeth that the mammoth fed on "rather tough, but very nourishing, boreal meadow plants." He contrasts this diet with that of modern elephants that swallow bulky succulent masses of tropical vegetation. Thus a more compact diet would allow the mammoth to dispense with immense alimentary organs, in this way keeping the body, behind the head, rather shorter. As to mammoth's food we are not left to conjecture, for there has been an actual identification of parts of plants found between the teeth and in the stomach of Siberian mammoths. They represent plants that are found in the same country to-day —five kinds of grasses, such as foxtail, two kinds of sedges, wild poppies, the seeds of a buttercup, the pods of a vetch, and wild thyme for flavouring. It is quaint to think of the mammoth looking for a "bank where the wild thyme grows"!

In his study, already mentioned, Mr. Lang makes out a good case for regarding the mammoth as given to rambling. Many of the herbivores move about in search of pasture, and it is probable that the mammoths wandered hither and thither through most of the northern countries of Europe, Asia and America. They have left their bones in many parts of Great Britain; they are found as far south as Spain and Italy, California and Carolina! A trapped mammoth must have been a winter godsend to Palæolithic man. A human appreciation even in those early days reached far beyond the cupboard: witness a child's necklace of mammoth ivory beads found at Predmost in Moravia.

Mr. Lang discusses the old puzzle of the large number of mammoth bones sometimes found together. Thus no fewer than eight hundred individuals have been found at Predmost, and there are other crowded graveyards. The occurrence of innumerable stray skeletons is readily intelligible, but why should there be a great many together? One can only conjecture that the members of a large herd trekking in search of pasturage became ensnared in boggy ground from which they could not extricate themselves, or were smothered in a snow-storm, or were surrounded in a river-flood, as horses sometimes are, and were drowned. "Or did furious gales and blizzards cover them alive with icicles that quickly grew to encasing blocks of ice?" In some cases "the cramped position, broken bones, large amount of clotted blood in the body cavity, as observed in the Beresovka mammoth, point, as Salensky shows, towards instantaneous death by accident. The victim did not even have time to throw out or swallow the quantities of fodder between its molars and in process of mastication."

In any case the herds of mammoths dwindled, though the trade in their ivory continues. They were highly specialised, slow-breeding masterpieces, adapted to boreal conditions and unable to change. It is not necessary to suppose that something went wrong with their hormones, though that may have been. Like many other giants, they had their day and ceased to be.

XLVIII

ANTARCTIC ANIMALS

WHEN we turn from the Arctic regions to the Antarctic we find very different conditions. Instead of a Polar basin surrounded by land there is a great continent at the South Pole. This vast land mass is perpetually covered with ice and snow. No higher plants grow there, but only a few mosses and lichens, among which lurk sparse and stunted representatives of insects and other invertebrates. When there are few

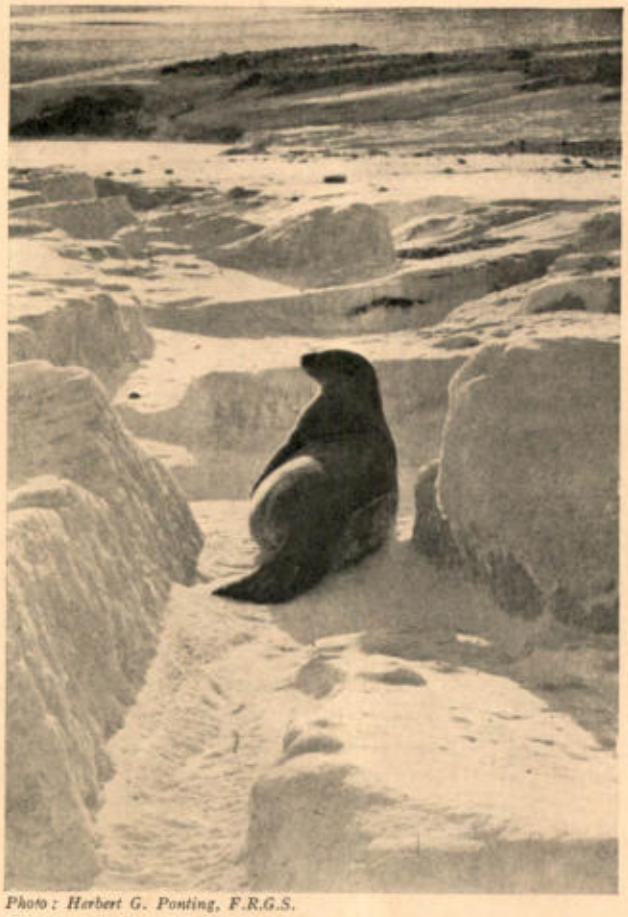


Photo: Herbert G. Ponting, F.R.G.S.

WEDDELL SEAL (*Leptonychotes weddelli*).

This powerful southern seal is found on or near all Antarctic shores. It feeds on true fishes, cuttlefish, and other molluscs then comes ashore and sleeps heavily while digesting. A favourite position is turned almost on its back.

insects there are necessarily few land birds; when there are no grasses or flowering plants there cannot be herbivores, and without these there can be no carnivores. Thus "in an area of five and a half million square miles, or a continent the size of Europe and Australia together there is not a single mammal."

The reason for the contrast between the animal and plant life of the north and the south lies in the climate. The mean temperature for the year is much the same for similar latitudes, but the distribution is more uniform in the south. The winters are not quite so cold, and the summers are not quite so warm, the temperature rarely reaching what is necessary for plant growth. Add to this that bitter winds blow frequently, and that the sun seldom penetrates the cloud of mist, and it is not difficult to understand why the Antarctic continent should be perpetually ice-bound and barren.

But it is far otherwise with the sea. As in the north, the surface of the ocean is rich in minute animal and plant organisms, which form the first link in the nutritive chain on which all higher animals depend. One intermediate link is of great importance. This is a crustacean called Euphausia, which early explorers spoke of as "red shrimps" or "small red lobsters." It occurs in immense numbers quite near the surface of the Polar seas, and at a greater depth in warmer latitudes. It has a complicated life-history and goes through various changes before it reaches full growth, when it is shrimp-like in form and three or four inches long. At one stage or another it forms the main food-supply of many fishes—our own "Loch Fyne" herring are said to owe their plumpness to the abundance of a nearly related species—of many birds, especially the penguins, and it enters into the dietary, directly as well as indirectly, of many seals and whales.

Photo: Herbert G. Ponting, F.R.G.S.

WEDDELL SEAL COMING UP TO BREATHE.

The Weddell Seal feeds to a considerable extent on what it can secure off the bottom in comparatively shallow water near shore, and it has to come up at frequent intervals to get a long breath among the ice. The short neck is very characteristic.

Photo: Reproduced from Capt. Frank Hurley's "Argonauts of the South," by permission of the publishers, Messrs. G. P. Putnam's Sons.

ADELIE PENGUIN AND HER CHICK.

The mother-bird is here shown ready to defend her chick. Fluffy down is still adhering to the upper part of the young bird, while the lower half has assumed adult plumage. The excellent photograph shows very clearly the flipper-like wings and the massive toes.

Whales occur in "immense schools" in the Antarctic seas. "The Scottish Expedition of 1892-3 passed through thousands of finner whales. On December 16th, 1892, many came quite close to the ship, and as far as the eye could reach in all directions one could see their curved backs and hear their resounding blasts." They are much hunted, but as they go well in among the pack-ice there is some hope that they may not soon be exterminated.

Seals, too, are abundant, especially the species known as Weddell Seal, which frequents all Antarctic shores. The great Sea-elephant is sometimes seen among the ice, but it has a wide range and is not strictly a polar animal. Another very characteristic seal is the agile sea-leopard, which is able to prey on the penguins, catching them as they swim, and dragging them down under water.

The Antarctic Continent proper has no resident land birds, and only one, the sheath-bill, is known to reach it as a migrant. But wherever the cliffs and shores are free from ice and snow they are peopled in summer by incredible hordes of sea-birds. Skuas, the great Antarctic robbers that prey on the eggs and young of other birds, gulls, terns, and at least one kind of cormorant are known to occur, but by far the most numerous are the Petrels and the Penguins.

The petrels make their nests for the most part high up on precipitous cliffs. There are many kinds of them. The dainty little Snowy Petrel, which is about the size of a swallow, is at home all round the Pole, and the early explorers regarded its presence as a sure sign that they were coming near the pack-ice. The Giant Petrel, known to sailors as the "Nelly" or "Stinker," is like most of the order, a strictly oceanic bird, feeding, resting, even sleeping in the open sea and only visiting land for the few weeks of the breeding seasons. It is a bird of powerful flight,

Photo: Reproduced from Capt. Frank Hurley's "Argonauts of the South," by permission of the publishers, Messrs. G. P. Putnam's Sons.

ADELIE PENGUINS AT THE MOULTING TIME.

The moulting season makes grotesque caricatures of penguins, for the plumage comes off in big patches and not as single feathers in the usual fashion. Captain Hurley's vivid photograph shows three strayed dishevelled birds, meeting an old acquaintance after a blizzard.

and will follow the whaling vessels for long distances to gorge itself on the blubber and refuse. The beautiful big "Cape Pigeon" (*Daption capensis*), also a petrel, nests high up on the cliffs of the Antarctic Continent and of many of the islands. The naturalists of the Scottish Expedition estimated that there were about fifty thousand nesting on the cliffs of the South Orkney Islands alone. Their food consists mainly of small crustaceans, and they, too, quickly gather about a vessel when a whale is killed, the attraction in this case being the small animals known as "whale-food" which are cast up in masses by the dying monster. The Cape Pigeon, like other members of its family, has, Dr. Bruce tells us, "the habit of ejecting from its tubular nostrils a red, oily, foul-smelling fluid composed of the half-digested remains of Euphausia." The birds can squirt this fluid to a distance of several feet with considerable precision, and the explorers were apt to get their clothes drenched with it when they climbed in search of the large white eggs, which they were the first to bring home from the Antarctic regions.

Most characteristic of all the birds of the Antarctic are the Penguins, and they are like nothing else anywhere in the world! It is true that their short wings, their close, oily black and white plumage, and their upright position when sitting give them a certain resemblance to the guillemots, razorbills and other auks of the North, but this resemblance is purely superficial and does not extend to details of structure.

The penguins do not fly at all. Their short flipper-like wings are movable only at the shoulder joint and are covered entirely with small, somewhat scale-like feathers. The flippers used in swimming and diving have a rotatory motion somewhat suggestive of paddles.

After the painting by Philip Richmax.

PTARMIGAN IN WINTER (*Lagopus mutus*).

Ptarmigan are first cousins of the Red Grouse and the Willow Grouse, adapted to live at high altitudes on the mountains, strong of heart and strong in flight, able to thrive on very frugal fare. The picture shows that while the general winter-colouring is snowy-white, there are some dark markings.

On land the penguins are awkward, for their legs are enclosed in skin down almost to the rather clumsy foot, and their bodies are top-heavy so that they toddle along like fat babies "one hundred and thirty steps to the minute, six inches to the step, two-thirds of a mile an hour." Every now and again they flop forward on their breasts and toboggan along for a little, using their wings as they do in the water, and their legs as propellors. "No living thing I ever saw expresses so graphically a state of *hurry* as a penguin when trying to escape. Its neck is stretched out, flippers whirring like the sails of a windmill, and body wagging from side to side as its short legs make stumbling and frantic efforts to get over the ground. There is such an expression of anxiety written all over the bird, it picks itself up from every fall, and stumbles again with such an air of having an armful of bundles, that it escapes quite as often by the laughter of the pursuer as by its own really considerable speed."

Photo: W. S. Berridge, F.Z.S.

STORM PETREL (*Procellaria pelagicus*).

Colonies of the Storm Petrel, or "Mother Carey's chicken," as it is often called, are found in the Shetland and Orkney Islands, and islands off the southern coasts of Wales and north and western coasts of Ireland; it also breeds abundantly in the Scilly Islands. The eggs are not laid until the middle of June, and the period of incubation is extraordinarily long. The young take more than ten weeks to become fully fledged. The petrel family is well represented in the Antarctic.

But in the water they are incomparably agile. They swim by means of their wings alone, using their legs, except at the very surface, only as a rudder. With their lungs filled with air they dive down, it may be ten feet, after a fish which they catch and swallow under water. They rise to the surface again, turn on one side and "in sheer playfulness and excess of joy beat the water with the uppermost wing, wriggle about, then turn over and splash with the other."

The largest of the penguins is the Emperor (*Aptenodytes forsteri*) which weighs about eighty pounds and stands, when erect, from three and a half to four feet in height. It is less numerous and widespread than many of the smaller species, but large breeding colonies may be seen year after year

Photo: Reproduced from Capt. Frank Hurley's "Argonauts of the South," by permission of the publishers, Messrs. G. P. Putnam's Sons.

SILVER-GREY PETREL, OR SOUTHERN FULMAR, ON NEST.

The Fulmar which Captain Hurley has so admirably photographed is one of the slightly differentiated species of *Fulmarus glacialis*, found in the Behring Sea, the North Pacific, and the Antarctic. It is essentially an oceanic bird, only haunting the land at the breeding season. Although very like our common gull in appearance and flight, it is true petrel and belongs to the family Procellariidæ.

in certain localities. The Emperor penguin differs from all others in that it arrives at its breeding places in mid-winter and lays its egg on the bare ice. It is then transferred to a pocket formed by a loose flap of skin that hangs over a bare patch on the lowest part of the body, and thus covered it lies upon the feet of the parent bird. The chicks are protected in the same way, but notwithstanding this remarkable adaption the mortality due to weather conditions is very heavy.

The " jackass " penguins, so called from their habit of braying, make a burrow in which to lay their eggs. In inaccessible places the burrow may be just deep enough to cover the bird, or may even be only a depression under a tussock of grass or an overhanging ledge, but where, as in the Falkland Islands, the birds are liable to be molested they may tunnel as far as ten feet under ground. How they dig does not seem to have been observed, but it is probable that both bill and feet are used. The jackass penguins begin to bray as soon as the young are hatched, and continue to do so incessantly from sunset to sunrise until they leave for their winter quarters.

A fine account of the breeding habits of the penguins has been given by Dr. Murray Levick, of the "Terra Nova" Expedition. It applies to the Black-throated or Adélie penguin (*Pygosceles adelia*), which is one of the smaller species, and is also more restricted to the actual ice region than some of the others. Dr. Levick's observations were made at Cape Adare, where the birds began to arrive about the middle of October, at first in twos and threes, but soon in ever-increasing hordes, until by the end of the month the rookery contained about three-quarters of a million birds. When they have landed safely the hens at once betake themselves to the old nests or scoop out new hollows and sit down to wait. For awhile the cocks are languid after the fatigue of the voyage, but by-and-by they begin to look about for a mate. Approaching the chosen one they " lay an imaginary stone at her feet." She,

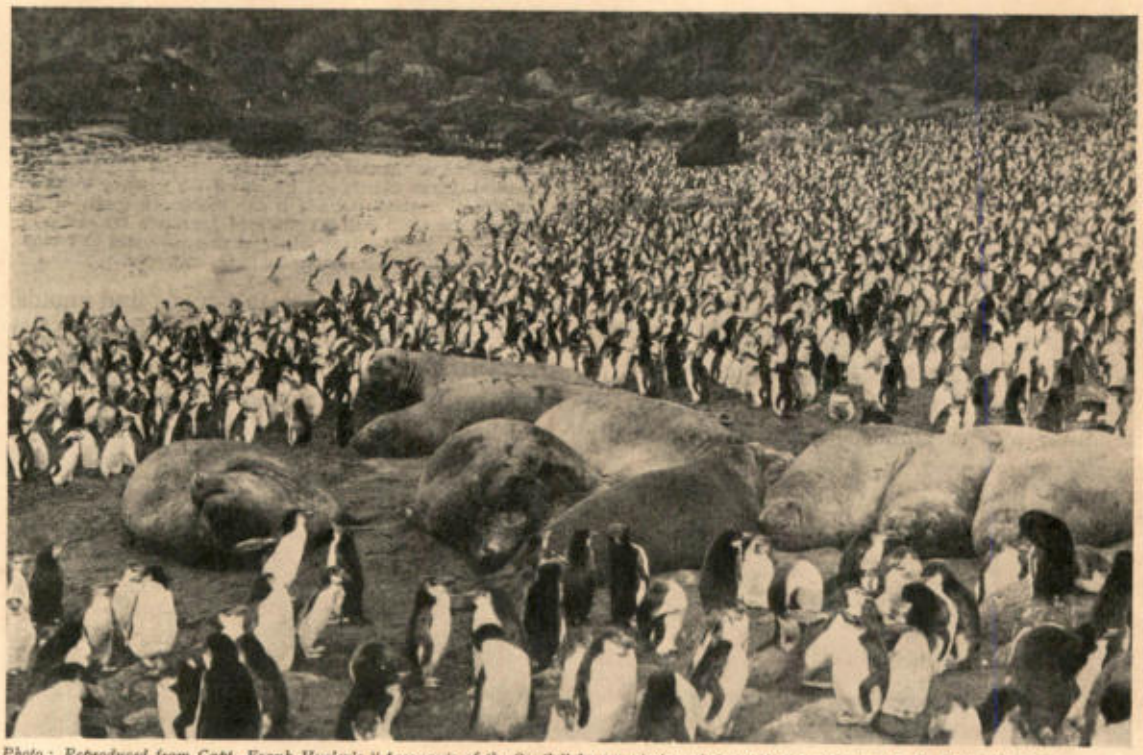


Photo: Reproduced from Capt. Frank Hurley's "Argonauts of the South," by permission of the publishers, Messrs. G. P. Putnam's Sons.

SEA-ELEPHANTS AND ROYAL PENGUINS AT SOUTH END ROOKERY, MACQUARIE ISLAND.

Captain Hurley, in describing the remarkable sight shown in the photograph, alludes to the unerring instinct which enables the parent birds, when returning from sea with food for their young, to find their families among such large numbers of their kind. The rookery may be some sixteen acres in area, and may contain nearly a million penguins.

Photo: Reproduced from "The Great White South," by Herbert G. Ponting, F.R.G.S.

McCORMICK'S ANTARCTIC SKUA-GULL STEALING PENGUINS' EGGS.

The Skuas (Stercorarius) have particularly strong wings, and are furnished with powerful hooked bills and sharp claws to their toes; but they would be no match for the penguins were the latter able to fly. The Skuas are content to hover overhead until the penguin rises to air her eggs, when they swoop down and seize an egg with startling rapidity.

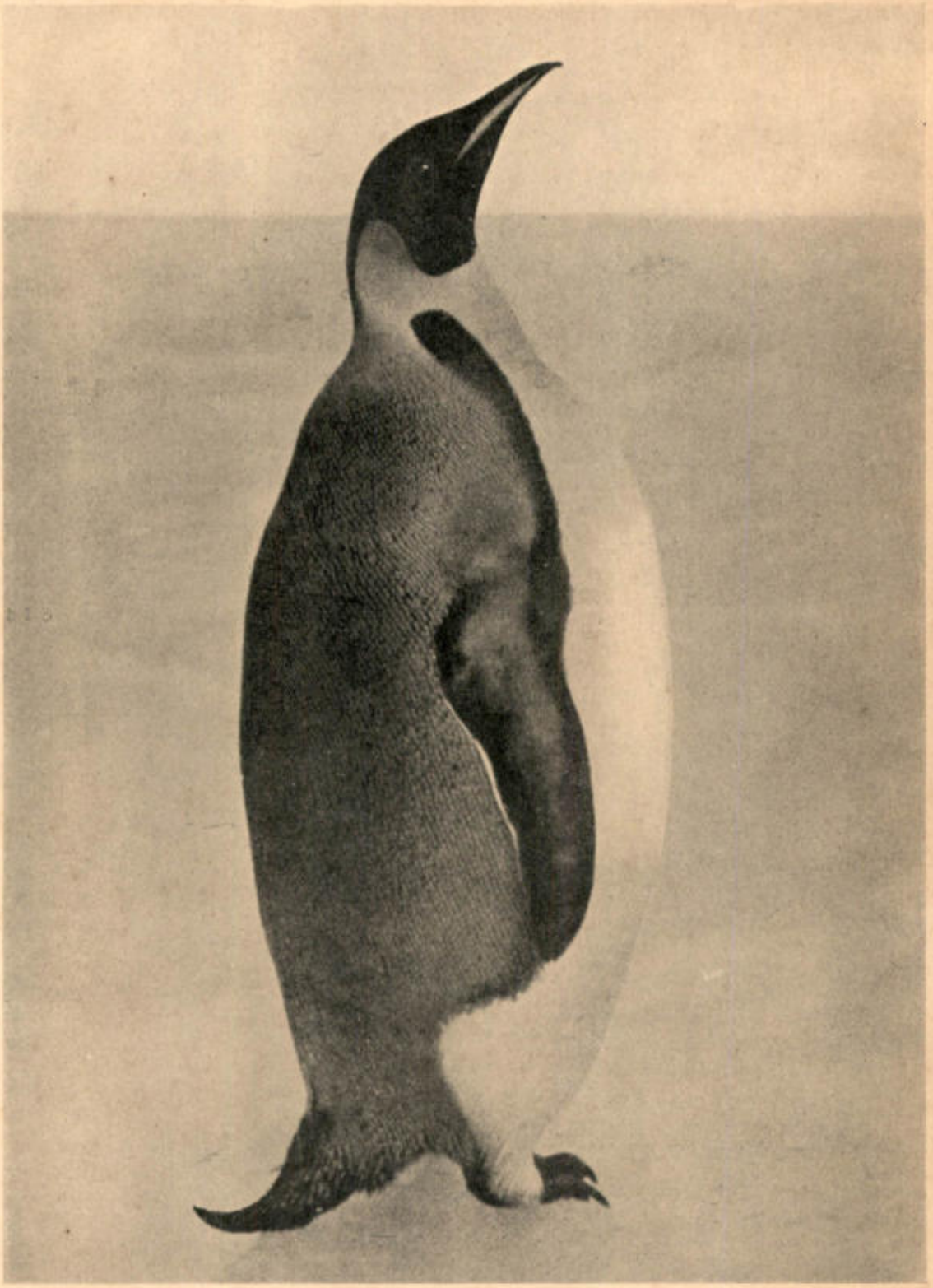


Photo: Reproduced from "The Great White South," by Herbert G. Ponting, F.R.G.S.

EMPEROR PENGUIN (*Aptenodytes forsteri*).

The Emperor Penguin is the largest of the family, and is distinguished from the King Penguin by the yellow streaks on the head being confined to a small patch behind the eye. They breed in the coldest latitudes in the coldest months of the year, and are very careful parents.

probably still tired, takes very little notice of her suitor until a rival one appears. A fight takes place, the combatants pressing their breasts close against each other and raining blows with their flippers, while the female looks on with mild interest. The combats do not seem to be very serious, for though the observer occasionally saw blood drawn, he never saw a cock killed in fight. The victorious bird has to spend a few days guarding his nest and driving off intruders, but by the end of the month all were mated and the birds settled down to their domestic affairs. Both birds remained at the nest, of course without food, until the eggs were laid, but then one of them went off to sea and remained away for several days, when it returned to relieve the other. After the young have emerged the parents take turn about of sitting on the nest and going to sea to fetch food. As the Adélie penguin nests, not on a flat shore but on a stony slope from 500 to 700 feet up, the transport is no easy task. Going down is easy enough; they simply toboggan with outspread "wings," the thick layer of fat under the skin enabling them to bounce unhurt from stone to stone. But coming up again is a different matter! "During the whole of the time when they are rearing their young brood, these mountaineers must make several journeys during the twenty-four hours, to carry their enormous bellyfuls of Euphausia all the way from the sea to the young on their nests—a weary climb for their little legs and bulky bodies, each upward journey taking them some two hours of strenuous climbing." Sometimes, indeed, if they have tried to carry too big a load, the journey proves too much for them. They get sick before they reach the top, and the fruits of their labour are lost.

When the laden parent reaches the nest it opens its mouth wide, and the young one thrusts its head in and helps itself.

The mother penguins sit very steadily on the nests, but the cocks are easily distracted and drawn off to a fight. They often do a good deal of damage in this way in the crowded rookery and the sitting hens scream their expostulations from all sides. The skuas, too, take toll of the chicks, and great havoc is sometimes wrought by a landslide or a sudden snowstorm. Yet on the whole the penguins seem to live a happy and successful life.

As the young birds grow up, the parents stay away longer and longer at the sea to play. For play they unmistakably do, tobogganing, diving, leaping out of the water, crowding on to an ice-floe, and letting themselves be carried to the end of the rookery, then tumbling off and swimming back for another ride on a fresh floe. All this time the young ones are left in groups or

Photo: F. W. Bond.

YOUNG ELEPHANT SEALS (*Macrorhinus leonina*).

The Sea-Elephant, or Elephant-Seal, is the largest of all the carnivores, the males sometimes attaining a length of twenty feet. They are said to come ashore on the coasts of the Antarctic South Shetlands in the early part of the year, but return to the sea before the end of April.

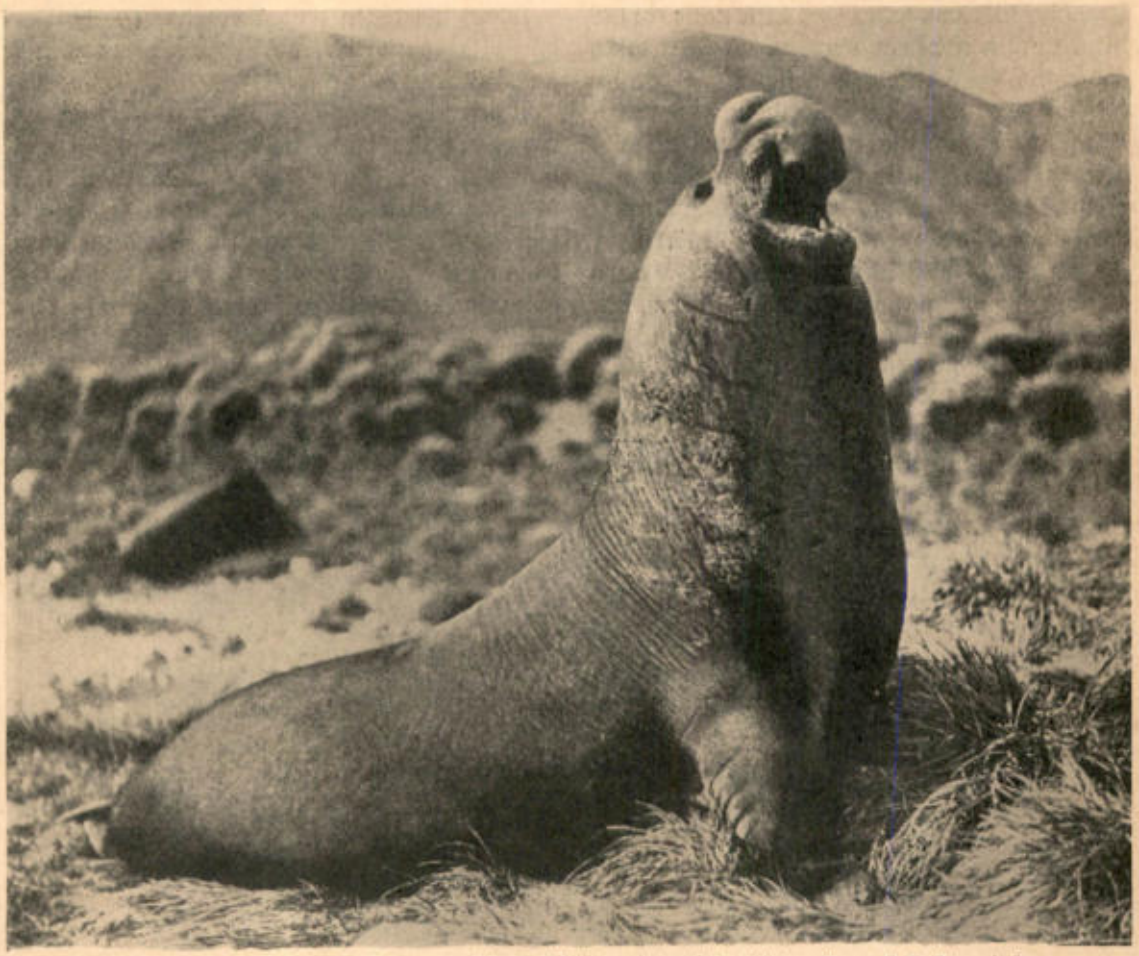


Photo: Reproduced from Capt. Frank Hurley's "Argonauts of the South," by permission of the publishers, Messrs. G. P. Putnam's Sons.

AN ENRAGED BULL SEA-ELEPHANT IN FIGHTING ATTITUDE.

Sea-Elephants are very sluggish when on shore, and can only crawl along very slowly. They are easily approached, but will offer a determined resistance even to man. At the mating season two bulls will fight long and furiously for the possession of a cow. The male's swollen muzzle is very characteristic.

" crêches " under the charge of staid and reliable birds who fend off the skuas, and tend the chicks. The parent birds visit their offspring from time to time, each carrying food and each keeping strictly to its own crêche. As the time for leaving the breeding grounds approaches, the birds may be seen *drilling* in thousands on the ice—executing ordered movements for hours at a time. This is a preliminary to the autumnal journey northwards to the unknown winter quarters, and in a short time all the penguins have disappeared again into the mist and blizzard whence they emerged in spring.

There is a peculiar fascination in the life of penguins—their winglessness, their gregariousness, their parental care, their games, their exploits in swimming, diving, climbing and tobogganing, their southward migration to breed on the Antarctic Continent, their winter quarters in the Open Sea. But the biggest fact is simply that they have found very difficult haunts both for summer and winter, and have achieved highly successful adaptation. Although they have lost the power of flight, a loss that is apt to be fatal to birds, as in the case of the Great Auk, they hold their own very effectively, and would show no diminution in numbers if man did not harass them so ruthlessly. This is part of the perennial charm of Natural History to see animals living dangerously, yet triumphing in their adventures.

XLIX
ANIMALS OF THE MOUNTAINS AND PLAINS

THERE are two great kinds of mountains—the original and the carved-out. Original mountains are due to the piling up of volcanic and other material on the earth's surface or to the crumpling of the crust. Fuji-Yama in Japan, Cotopaxi in Ecuador, Popocatepetl in Mexico, and the Peak of Teneriffe are well-known examples of volcanic mountains. But carved-out or relict mountains are the remaining portions of more or less elevated tracts that have been carved out unequally by frost and rain and other weathering agencies. Relict mountains are "monuments of erosion"; they have been carved out of plateaux or great rock masses. This is very largely the case with the mountains of the Lake District in England and of the Highlands in Scotland. But a mountain is a mountain to its animal tenants, however it may have arisen. At the same time it must be noted that different kinds of rocks imply different kinds of vegetation, and this affects the animal population very intimately.

Every typical mountain shows three zones. Lowest there is the tree-covered zone, passing gradually into the forests and woods of the low country. Second there are the treeless steppe

Photo: F. W. Bond.

GRECIAN IBEX (*Capra aegagrus*).

One of the wild goats of Southern Europe and Asia Minor, the Ibex was once common in the mountain ranges of Germany, Switzerland, and the Tirol. It is a handsome creature, measuring some four and a half feet in length, and standing forty inches high at the shoulder. The summer coat is of short, ashy-grey fur, but in winter long, yellowish-brown hairs conceal the thick fur beneath.

tracts with varied herbage and often with good pasture on shelves and plateaux. One sees in Switzerland how the industrious peasants shift their cattle in summer to narrow shelves high up the mountains, where there is much better grazing than one would expect. Uppermost there are the relatively barren heights with "Alpine" plants of a hardy sort, and, finally, with nothing but lichens on the exposed rocks. Higher still there may be snow. When we take a survey of the tenants of the mountains we might well arrange them according to these three zones. Thus, there are bears in the forest; there are goats on the steppe tracts; and there are marmots on the sparsely clad uppermost stretches. But we wish to suggest another grouping of the mountain animals, with special reference to the mammals and birds. (*See* Thomson's "Science Old and New," 1924, p. 11.) We may recognise three groups: The *relicts*, the *insurgent colonists* and the *refugees*.

Zones on the Mountains.

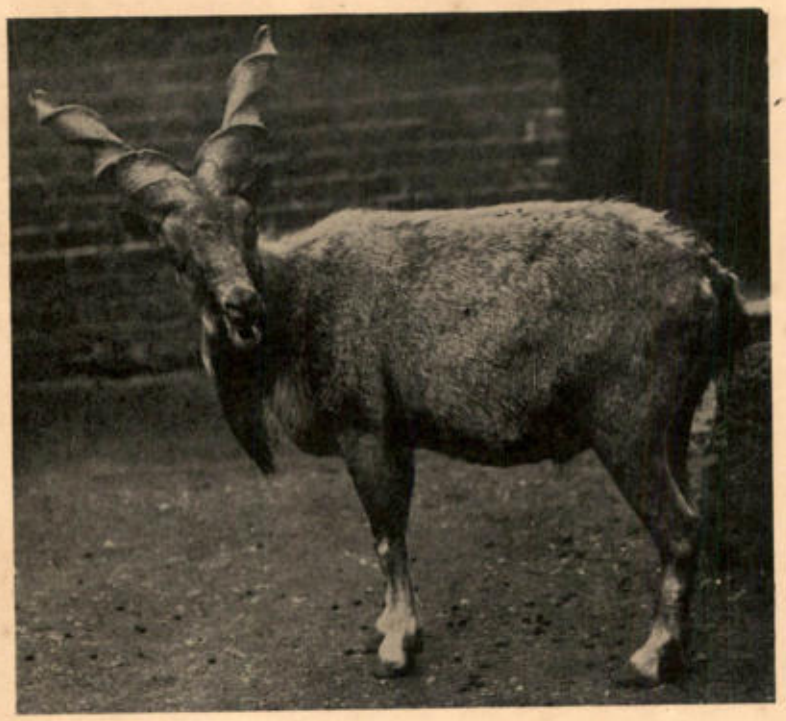


Photo: F. W. Bond.

MARKHOR (*Capra megaceros*).

The horns of this remarkable animal are curved to form a corkscrew spiral, and good specimens may be three feet in length. The Markhor is the largest of all the species of goats, standing forty inches high at the shoulder. Its colour varies from a light brown in the summer months to a grey in winter. It is found on the slopes of the Himalayas.

During the time of the Ice Ages there was an extension of Northern or Arctic animals far southwards, e.g., into Central Europe. We know this from their bones preserved in the floors of caves and the like. When the climate changed for the better and the glaciers retreated, some of the Northern animals died away; others, like the reindeer, were able to trek northwards; but there were others that ascended the mountains. These may be represented by the little snow-vole, which very rarely descends below 4,000 feet; by the whistling marmot of the Alps, which used to be a tenant of low-lying steppe-land; by the mountain or variable hare, which turns snow-like in winter; and by the ptarmigan, which shows the same seasonal change to winter whiteness. These and some others have found on the mountain-heights the same sort of conditions as their ancestors found in the far north, or on the low ground at the foot of the glaciers when these crept far southwards.

Relict Mountain Animals.

The second contingent of mountain animals includes adventurous colonists from the low grounds that discovered the possibility of making a living at considerable heights. Sturdy animals are always on the look-out for new opportunities. It is partly, no doubt, because they tend to become too numerous, thus making it more difficult to get a living; but there is probably in many cases something of the adventurous spirit. Hunger is a sharp spur, but many a higher animal has curiosity and an exploring turn of mind.

Insurgent Colonists of the Mountains.

Among the insurgent colonists we include the chamois, which was probably, to begin with, an antelope of the Asiatic steppes. Along with the chamois must be ranked the goral of Indian altitudes, the Rocky Mountain Goat, the grunting Yak of Tibet, the unlucky ibex of the Alps, the

Photo: Harold Bastin.

CHAMOIS (*Rupicapra rupicapra*).

The Chamois, originally a steppe-animal, has found refuge among the mountains of Europe and Asia Minor, and is the European representative of the goat-like antelopes. They generally collect in herds of fifteen to twenty, and feed on lichens and moss during the cooler parts of the day. In summer they are chestnut in colour, but in winter the coat becomes almost black.

Photo: F. W. Bond.

GORAL (*Nemorhædus goral*).

Like the chamois, the Goral prefers to feed in the morning and evening, resting in the shade during the heat of the day. It is a native of the Himalayas, and has many of the characteristics of the antelope. It is a very small animal, standing little more than two feet high.

Photo: F. W. Bond.

PUMA OR MOUNTAIN "LION" (*Felis concolor*).

Of all large cats the Puma is the best climber. It is dull brown in colour, and is thin-bodied, flat-sided, and very tall for its weight, which seldom exceeds 225 pounds. It is the best known of the big cats in the mountain ranges of the United States, British Columbia, and Florida, and next to the jaguar, is the largest of the American cats.

fine markhor of the Himalayas. And when the wild sheep and wild goats found pasturage by exploring to high shelves, they found safety, too. It was only for a time, however, for they were, of course, followed by insurgent carnivores; and so we understand the snow leopard and the mountain puma. In the same way we interpret the Golden Eagle as a colonist of the heights, following the grouse and the mountain hare.

The Refugees.

The third set of mountain animals includes "hard-pressed creatures which have sought for a way of escape from the too intense competition of the crowded low grounds. We cannot draw hard and fast lines, but they differ from the colonists inasmuch as they seek an asylum rather than a conquest. They suffer from some handicap. This is well illustrated by the coneys or hyraxes of Africa, Palestine and Syria. They are small mammals, a "feeble folk"; they are not very quick nor very clever—wary rather than wise; they have little in the way of weapons or armour; they do not burrow. Some have saved themselves by becoming arboreal; the others by ascending the mountains even to 10,000 feet. They have thick coats "to keep out the cold"; their feet are well-suited for scrambling among the rocks. Similarly the desman of the Pyrenees, a small Insectivore that used to occur in Britain, is a refugee on the heights. It has added to its safety by becoming aquatic, and it is also a burrower. It is a little creature, about five inches long in body and the same for the tail—a bundle of curiosities. Thus it has a very mobile snout, like

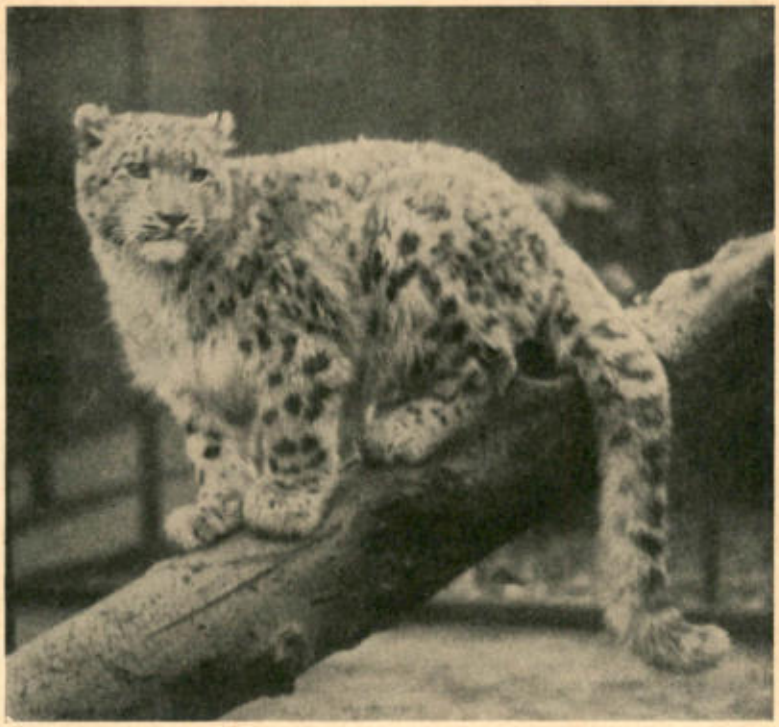


Photo: F. W. Bond.

SNOW LEOPARD (*Felis uncia*).

The fur of this beautiful cat is white in colour, tinged with grey, and the characteristic spots are less well defined than in the common leopard. It is found in the mountainous districts of Central Asia and, like the puma, is a dreaded enemy of the wild sheep, goats, and marmots which inhabit the mountains. It has followed its prey as they ascended the heights.

Photo: F. W. Bond.

YOUNG PUMA.

In the Puma kitten the spots are well defined, thus illustrating the general law that the young stages of an animal's life-history come nearest to the ancestral type. It is delightful and playful in its youth, but it gradually becomes fierce.

Photo: By permission of the Natural History Museum, South Kensington.

THE RUSSIAN DESMAN (*Myogale moschata*).

A photograph of a stuffed specimen of this remarkable animal, which used to be represented in Britain. Among its characteristics may be noted the long proboscis-like snout, the long tail which is partly used in swimming, and the burrowing claws. It is one of the Insectivora.

the beginning of an elephant's trunk. Now if we understand the hyrax and the desman, we also understand the Alpine shrew, the Tibetan mole-shrew, the Himalayan swimming shrew, and others like them; all are refugees. Here also we should include such a bird as the water-ouzel or dipper, which is particularly fond of mountain streams.

In particular cases we have shown how animals have become suited to the exposure, cold, scarcity, steepness, and other difficult conditions of the mountains, but it will be useful to accentuate mountain-adaptations. There is protection against the cold in having a thickset coat, such as we see in a chamois, or dense plumage such as that of a ptarmigan. Turning white in winter, as in Mountain Hare and ptarmigan, lessens the loss of the precious animal heat, and may also hide the creature from its enemies. The ptarmigan has a stronger heart than its cousin the Willow Grouse that does not ascend high, and a strong heart is useful for mountain-climbers. In exposed places it is important to have a danger-signal, and we can hear this in the whistling marmot. It is often very valuable to have specially firm foothold among the rocks, and this is very well illustrated by the chamois and the hyrax. Another important adaptation is the ability to thrive on varied food, as bears do, and at times on Spartan diet, as the Mountain Hare does when it eats the lichens off the rocks. (*See* Thomson's "Mountains and Moorland," 1921.)

Fitnesses for the Mountains.

About a century ago there was discovered in Western North America a veritable living fossil, the Mountain Beaver (Aplodontia), which is regarded by some authorities as the only surviving representative of the group from which all living Rodents (gnawing mammals like beavers, squirrels, porcupines, voles, rats, mice, rabbits, and hares) have been evolved. In any case, there is no doubt that the Mountain Beaver is an antiquity—a survivor from very distant ages. It is restricted to the Pacific coast of North America between British Columbia to the north and California to the south—a short-tailed, blunt-snouted, "chunky" creature, rather over a foot in length, grey to black in colour, with small eyes and ears, and at the base of the ear-trumpet a white spot.

The American Mountain Beaver.

The Mountain Beavers are elusive nocturnal burrowers, not very well known. They require firm deep soil with abundant vegetation, preferring the banks of streams or damp hillside slopes where the water seeps down. In California they always choose a site covered with ferns, thimbleberry and other low-growing plants which hide the openings of the extensive but shallow underground tunnels. There are cross ways joining one tunnel to another, so that a network is formed; and here and there comes a globular nest, lined with the leaves of fern and cow-parsnip. Beside a nest there is sometimes a low square room, with floor and sides showing signs of constant use. There are also pockets with stored roots, stems, and leaves, and these cupboards are sealed up with pellets of earth.

The habits of the American Mountain Beaver have been carefully studied by Mr. Charles L. Camp, of the University of California, to whose description we are much indebted for information about this retiring animal. It is a vegetarian with a varied bill of fare. It likes the root-stocks or rhizomes of ferns, the fleshy roots and succulent shoots of many plants, the stems of sapling trees, and many kinds of grasses. It seeks its food at night and rests throughout the day. It is slow in its movements, cumbersome in its gait, and timid by temperament, so we can understand its gathering by night a lot of food which it afterwards consumes at leisure in the security of the burrow. Observers have often noticed an interesting "haymaking," parts of plants being neatly cut into lengths and laid out to dry. But this dried material seems to be used as a lining for the nest, and not as food.

There is no doubt, however, that pieces of sappy stem are laid by for hard times. The Mountain Beaver eats in a somewhat squirrel-like fashion, using its fore-paws or one of them to hold the food to the mouth. There is something rather striking in the fact that this primitive creature, an antediluvian, a sort of "living fossil," should have such good table manners. An interesting little detail is that it uses the short first finger as we use our thumb. Unlike a squirrel it sits back on its short tail when it is munching its food.

The Mountain Beavers sometimes ascend to heights of 6,000 to 8,000 feet, but they do not seem to hibernate like their distant cousins the marmots of the Alps. They have been seen hurrying rather awkwardly on the snow—they cannot hurry much; and they actually climb on

Photo: By courtesy of the New York Zoological Society.

MOUNTAIN BEAVER (Aplodontia).

The little known Mountain Beaver is a nocturnal burrower, but is also able to climb bushes of some four feet in height. It prefers wet, marshy ground, although it is able to burrow and live comfortably on high and dry country. Until recently believed to be restricted to the north-west regions of America, it has been found as far south as California. It is a very good example of a mountain-refugee.

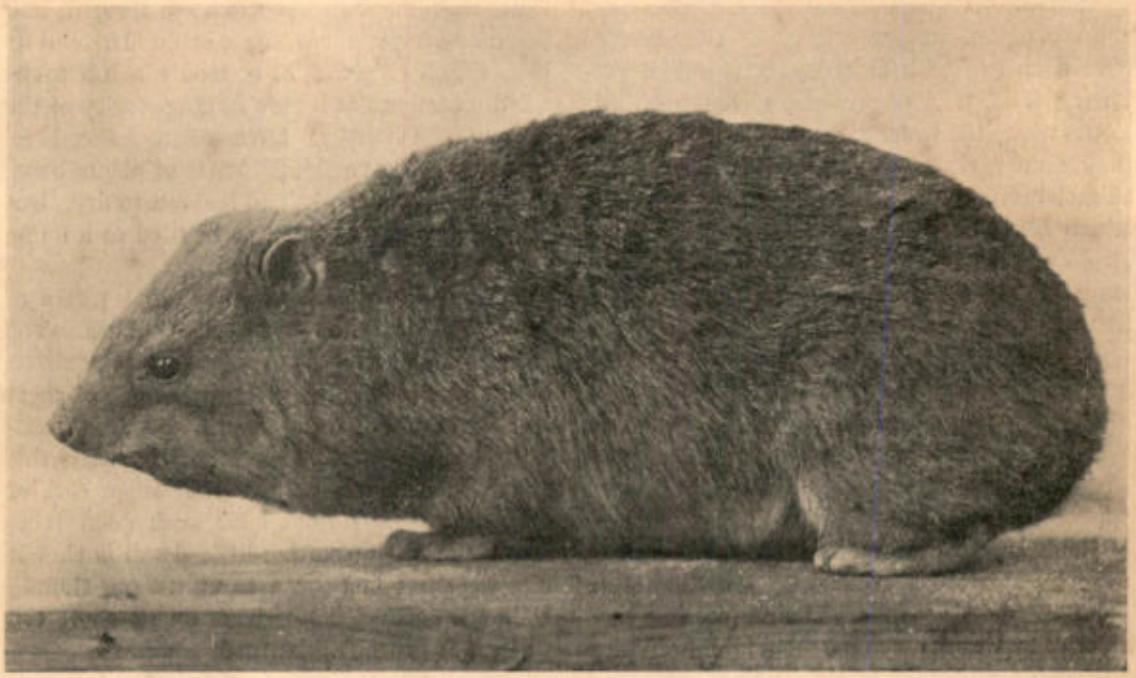


Photo: F. W. Bond.

CAPE HYRAX (*Procavia capensis*).

There are some twenty species of these strange, rodent-like animals found in Africa, Arabia, and Syria. They have three toes on the hind-feet, and four functional toes on the fore-feet. The second toe of the hind-foot is clawed, but all the other toes are protected only by short, broad nails. The Cape Hyrax is confined to Cape Colony and Natal, and differs from the other species in having a black, instead of a light-coloured, patch on the back.

Photo: F. W. Bond.

DORSAL HYRAX (*Dendrohyrax dorsalis*).

The Dorsal, or Liberian, Hyrax is a large species, with a long, shaggy coat of black hairs tipped with white. It is an excellent climber, and feeds on the leaves and young shoots of trees. It is well adapted for arboreal life, and it adds to its safety by being for the most part nocturnal.

low bushes to get at sappy shoots. When a mammal can find food all the year round and can fall back on stores in the very worst times, it is not likely to be a hibernator. Mountain Beavers are very cleanly creatures, and the burrows are always well-drained. The refuse is probably buried.

How do these old-fashioned creatures hold their own? Sight and hearing seem to be dull, but the Mountain Beaver is exquisitely sensitive to *touch*, as befits a burrower. "The slightest touch upon a hair will be responded to instantly by quick jerking movements." The sense of smell seems to be keen, and these shy but social creatures probably recognise one another by scent, for there are strongly developed odour-making glands. A curious feature—especially in a gregarious mammal—is the apparent absence of a voice, but an alarm note is produced by rasping the lower front teeth (incisors) across the tips of the upper ones. The same sort of dental sound is made by some other Rodents, such as the North American pocket-gophers and marmots, and we may hear it from the Common Hare.

Almost nothing is known about family affairs, but there are probably two litters in the year, with four to six young ones in each. We have already mentioned the safe and comfortable nest.

It is important to understand the *meaning* of this strange life. Here we have a slow-going mammal which a child can catch, a rather dull creature, too clumsy in its movements to fight effectively when attacked, an animal of a timid temperament and a far from hardy constitution! What better could such a creature do than take refuge on the mountains and in their underworld? As a burrower it is at home, able to move head foremost or tail foremost, with small eyes and ears and a short tail, none of them the least in the way. Its touchiness helps it in its nocturnal foraging, and there is a note of perfection in the white sticky tears, for they may lessen the risk of the eyes being scratched in the burrowing. So the Mountain Beaver still holds its own, in spite of skunks and wild cats, eagles and horned owls.

Snow Animals.

One of the most welcome winter visitors to Scotland is the Snow Bunting, a relative of the Reed Bunting and the Yellow-Hammer. Flocks of them come across the sea from Norway and farther north, appearing suddenly out of the mist, twittering as they fly. They often get the pretty name of "Snow-flakes," though there is a good deal of black as well as white in their winter plumage. They are like melting snowflakes in a way, for they are soon lost sight of in the air, or when they settle down to hunt for small animals on the shore, or for seeds on the ploughed field. They are cheerful birds, paying our shores the compliment of joyously declaring them a good home in winter; they have a pleasant, linnet-like flight-note. "Sea-Linties" they are sometimes called. A few stay for the summer, nesting in remote places like the slopes of Ben Wyvis; but most of them return in early spring to upland regions in Scandinavia and Siberia. Not to be

Photo: W. S. Berridge, F.Z.S.

SNOW BUNTING (*Plectrophanes nivalis*).

The Snow-Bunting is a characteristic winter visitor to the British Isles, but occasionally breeds in the North of Scotland. The plumage at the mating season is very handsome, black above and white below in the males; the hen bird has the black back somewhat dulled by grey or blackish-brown, and the white underside much less pure in tone. It flies in little flocks, uttering a pleasant note.

Photo: W. S. Berridge, F.Z.S.

COCK PTARMIGAN (*Lagopus mutus*).

The photograph shows an intermediate stage between the white plumage of winter and the greyish-brownish plumage of spring and of summer. As there are three moults in the year, the whole story of the changes in colouration is rather intricate, but the big fact is that the bird is always well hidden.

confused with the Snow Bunting is the Snow Finch, which comes to Britain as a casual wanderer from the Pyrenees or the Alps. It is a handsome bird of the mountains, with a good many snow-white feathers on the wings and tail.

Amidst the winter snow on the Cairngorms and other mountains of the Scottish Highlands there are "packs" of Ptarmigan, which break up in the spring. The birds are almost entirely white in winter, and this makes them nearly invisible against a background of snow. They are the more difficult to detect since they often burrow in the snow, a habit occasionally seen in their first cousins, the Red Grouse. They are searching below the surface for lichens and heather-tips and other Spartan fare. The ptarmigan is remarkable in having three moults in the year; and each suit harmonises well with the environment at the time. Interesting also is the ptarmigan's unusually strong heart, which is well adapted for a strenuous life at high altitudes. A distant relative, the Canadian Ruffed Grouse, is famous for the long tunnels it makes beneath the snow, and for a winter growth of thin plates on each side of the toes—an adaptation that doubles the surface and enables the bird to walk on the soft snow without sinking far. This is like an anticipation of man's snow-shoes, which distribute the weight over a large surface.

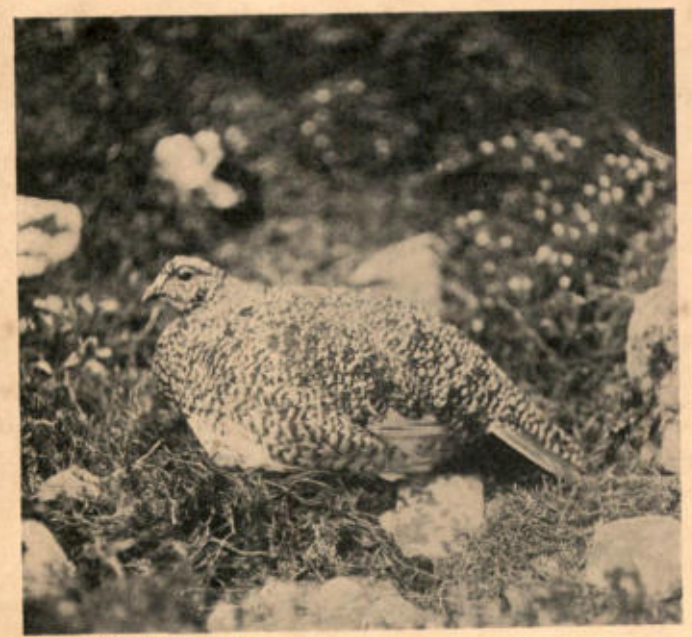


Photo: W. S. Berridge, F.Z.S.

HEN PTARMIGAN.

Both cocks and hens put on the almost white plumage in the winter, but the beautifully marked greyish and brownish plumage of the other seasons is also well adapted to make the birds inconspicuous against the background of their mountain environment, e.g., among lichen-covered rocks.

On a Scottish high moor, mostly snow-covered, one may sometimes have the luck to see at the same time two white animals—the Mountain Hare and the Ermine. The first is snow-white, all but the black tips of its ears; the second is snow-white, all but the black tip of its tail. It is not altogether a fortuitous coincidence that the two white mammals are sometimes seen at the same time, for the ermine often meditates an attack on the hare. But this raises again a problem, already hinted at. The winter whiteness of the mountain hare certainly gives it inconspicuousness against the snow, so this will conceal it from the hungry eyes of its enemies. But the ermine, which is the chestnut-brown stoat in summer, is also concealed in the same

way, which will make it easier for it to get near the hare! There is nothing contradictory in this, but it leads us to look for some other usefulness in the snowy whiteness; and there is no doubt that for warm-blooded animals in cold surroundings the best dress is white fur, or white feathers. The reason is that a white dress conserves more than any other colour the precious "animal heat" of the body, the warmth that is necessary to make the wheels of life run smoothly.

On a different evolution-tack altogether are the tiny dark-coloured "glacier-fleas," sometimes seen in millions on the surface of the snow. Some of them are only an eighth of an inch in length, and when an animal is built on such minute proportions there are physical reasons which keep it from losing too much heat. So the blood does not freeze in these pigmies.

Another pigmy, but a mighty giant compared with the "glacier-flea," is the Snow Mouse, or Snow Vole, common on the High Alps. It is about five inches long, with two more to the tail, rusty-grey or whitish-grey in colour. It lives from the snow-line to the summit of the mountains, and it is often seen scampering over the snow. Perhaps there is no mammal that lives so

Photo: M. H. Crawford.

PTARMIGAN IN WINTER PLUMAGE.

This shows the predominant whiteness of the Ptarmigan's winter plumage, especially when the bird is crouching and not flying. The change to whiteness follows the autumnal moult, and is due to the development of a fresh set of feathers without pigment.

They look like black dust, they are so small; but they are moving and even jumping. They are trekking across the snow in search of food and more comfortable quarters. They are not fleas, of course, but primitive wingless insects called Spring-tails, and many different kinds are common about the snow-line on the Alps. Most of them are covered with very minute bristles which may help to keep them warm; most of them are very dark in colour, and it is said that for cold-blooded creatures in very cold surroundings the best dress is black. But they are protected against the cold in another way—by their extreme minuteness.

Glacier-Fleas.

hard a life. It does not migrate in winter; it does not turn white; it does not hibernate; and yet it holds its own. It burrows beneath the snow to get at the roots of "Alpines," and it makes in summer a little store of chopped grass and the like, to fall back on when the worst comes to the worst. The snow mouse is interesting as a relic of a northern fauna that came down to mid-Europe during the Great Ice Ages. Some of its companions, like the reindeer and the Arctic fox, migrated northwards again when great ice-sheets melted, but the little snow mouse went up the mountains. It has to live a very strenuous life, but it has this reward, that it has

almost no enemies in the heights which it frequents.

When we shut our eyes and say "snow animals," we see many pictures. We see the Reindeer scraping with their hoofs to lay bare the lichens, the Arctic Fox in its pure white dress coming down from the snow-fields to feed on a dead seal thrown up on the shore, the Lemmings making long winding tunnels in the snow and working their way from root to root, the large and extraordinarily beautiful Snowy Owl of circumpolar regions, an occasional visitor to Britain, very conspicuous when it is away from its normal white environment, and another visitor from the north, the Greenland Falcon, elusive like a wraith among the snow, the terror of most other snow animals.

Photo: M. H. Crawford.

RED-FOOTED FALCON (*Falco vespertinus*).

One of the many Falcons, typical birds of prey. Among the characteristic features may be noted:—The strong hooked bill, well-suited for plucking, skinning, and tearing; the strong and sharp claws which grip and kill; the keen sense of sight; and the cross-barring of some of the feathers, as seen in the tail in the photograph.

White Animals.

When there is a "white Christmas" with snow everywhere, it is interesting to notice from a distance that the white waterfall on the side of the hill is whiter than its frame of snow, as may be seen where the Whitewater in Arran tumbles down from Goatfell. The snow and the waterfall owe their whiteness to the same cause—the total reflection of the light from the surfaces of the air-bubbles entangled among the transparent particles of fluid or frozen water; but the waterfall is whiter than the snow when seen from a distance.

Similarly in the case of fleecy clouds, all the different wave-lengths of the light are being reflected from the surfaces of the water particles or ice crystals suspended in the air. The white hair of the ermine, as contrasted with the chestnut of the summer stoat, is due partly to the absence of the brownish pigment, but partly to the presence of numerous gas-bubbles inside the hair. The same holds for the white feathers of the ptarmigan or of the snowy owl; there is reflection from a multitude of gas-bubbles. Treatment with some saturating clear fluid, or removal of the gas-bubbles under an air pump, leaves the hair or feather almost transparent. It may be noted, however, that a hair, one of our own for instance, which looks practically white, may be seen under the microscope to contain some pigment. The lingering presence of the pigment is robbed of its effect by the number of gas-containing vacuoles, and the hair appears to be white.

In white flowers, such as snowdrops, the colour is again due to the uniform reflection of all the rays of light from the numerous air-containing vacuoles in the intercellular spaces. If we press a piece of the white

Photo : F. W. Bond.

GREENLAND FALCON (*Hierofalco candicans*).

A native of North Greenland and other countries within the Arctic Circle, the Greenland Falcon occasionally visits the British Isles. It is larger than most of its relatives, and is to be distinguished by the prevailing white of the plumage at every age. When young the dark markings are in the form of stripes, but after the first moult they change into, and remain in, the form of bars. It is an extraordinarily handsome bird.

perianth of a Narcissus very hard between our finger and thumb we see it become transparent, for we have driven out the air or gas in the intercellular spaces. The brilliant white seen in the bark of a birch tree, probably helping as a non-conducting layer, is also due to entangled gas. The fact is that in the majority of cases whiteness is due to the inclusion of numberless bubbles of air or some other gas in a transparent medium or amid transparent particles. The whipped white of egg becomes whiter as the air becomes more and more entangled with it. The individual particles of powdered glass are transparent, but a heap of them has a white colour ; and we see the same in the salt cellar.

In the minority of cases the whiteness is due to uniform reflection from solid particles, as in

the case of white paints, such as white lead. The common water-colour Chinese white (oxide of zinc), is another familiar example. The whiteness of the chalk cliffs of Dover is largely due to solid white particles, the minute shells of Foraminifera which accumulated on the floor of an ancient sea. We suppose that flour is white because of uniform reflection from the minute solid particles, but this kind of whiteness is uncommon among living organisms. In short, organic whiteness is usually structural and rarely pigmentary.

Special reference must be made to white butterflies, investigated long ago by the well-known bio-chemist of Cambridge, Sir Frederick Gowland Hopkins. In cases like the garden white the whiteness is due to uric acid deposited inside the minute scales covering the wing; and as uric acid is a common nitrogenous waste-product, we have here a good illustration of "beauty for ashes." It must be noted, however, that a few Lepidoptera have a pigmentary whiteness which is not due to uric acid, as in the case of the marbled white; and that others are white for structural, not pigmentary reasons. Another waste-product that often produces a more or less white appearance is guanin, which is used in the manufacture of Roman pearls. It occurs in the form of crystals in the scales of fishes, in deeper layers of the skin, and in hidden parts like the swim-bladder and the lining of the body-cavity. It is not a pigment, but it enhances the æsthetic value of true pigments in the skin of many fishes, and it is responsible for the characteristic silveriness so familiar in the fishmonger's window. On the down-turned side, usually the left, the pigment-cells disappear, but spangles of guanin are very abundant and produce the brilliant silveriness of plaice, soles, dabs, flounders, witches, and halibuts. In passing, it may be noted that brill, megrim, and turbot swim on their right side, which happens in these cases to be the heavier. Guanin, which is sometimes amorphous, is of occasional occurrence in amphibians and reptiles, but it is most characteristic of fishes, and, since it is a nitrogenous waste-product, it affords another instance of organisms utilising as a decoration the ashes of their living fires.

As to the utility of whiteness among living creatures, we require to be cautious in our statements. The fruit of the mistletoe is white because of the bubbly nature of the glutinous pulp, and the primary significance of the whiteness may be in connection with the formation

Photo: Ellison Hawks.

ERMINE (*Putorius erminеus*).

In an earlier chapter we have illustrated the Stoat in its chestnut-brown summer dress. The winter coat is without pigment, all white save for the tip of the tail, when the creature is called the Ermine. The white hairs are mainly new growths in late autumn; but single hairs sometimes blanch. While this change in colour serves to conceal the Ermine amongst the snow, it is also useful in conserving the "animal heat" of the body.

of this all-important seed-attaching glue. But this is not inconsistent with there being value in the white colour as an advertisement appealing to the eyes of the mistletoe-thrush or missel-thrush. Guanin is deposited in the skin of fishes, and its primary significance is that it is a nitrogenous waste-product which is better away from the more intimate parts of the body. But this is not inconsistent with there being value in the guanin spangles in increasing the attractiveness of the male Gemmeous Dragonet when it goes a-courting. In gristly fishes like sharks there is likewise abundant guanin in the skin, but it has very little in the way of lustre.

The primary reason for white fur and white feathers in Arctic regions and in winter may be that the low temperature is associated with some slight peculiarity in the chemical routine of the body, which suppresses the precipitation of superficial pigment and increases the formation of gas-vacuoles. But this is not inconsistent with there being a value in the white dress, in certain cases at least. For we know that white is the colour that loses least of the precious animal heat of the body, and we know that it sometimes gives its wearer a garment of invisibility against the snow. So we must try to distinguish throughout between (1) a primary physiological significance, in which the whiteness as whiteness need not count ; and (2) a secondary significance in which the whiteness contributes to the well-being of the body, both in itself and in its relations with its environment. Where this secondary significance in the struggle for existence is not obvious there is no need to worry ; it merely means that the quality has not yet been seized upon in the course of Nature's sifting.

Everyone is familiar with white rats, mice, and rabbits. They have pink eyes, due to the blood shining through the unpigmented iris. This whiteness is called *total albinism*. The usual production of skin-pigment has been suppressed. Occasionally one sees a " white " sparrow or even a blackbird in which many of the feathers are white. This is *partial albinism*, where, through some constitutional defect, probably of germinal origin, there was not enough pigment to go round the plumage. The manœuvres that go on in the maturation of the germ-cells are so intricate that there are opportunities for items in the inheritance dropping out. Thus it may happen that some or all of the factors determining pigmentation may be lost in the shuffling of the hereditary cards, and then there appears an albino, like a ferret. If in certain conditions it happened to be of life-saving advantage to be white, a few albinos might start a new species. But we do not mean that all the white animals in Wild Nature began as albino variants ! For then they would have red eyes !

This well-nigh sacred bird is peculiar to Britain, but it has been introduced elsewhere.

Photo : W. S. Berridge, F.Z.S.

WHITE MICE.

White Mice are usually albino varieties of the common House Mouse. They arise as freaks or sports, technically " mutations." That is to say, the hereditary " factor " for pigment-forming has been lost in the early history of the germ-cells. Albino mice, with pink eyes, breed true, but white mice occur that are not albinos.

Photo: C. Reid, Wishaw, N.B.

RED GROUSE (*Lagopus scoticus*) ON NEST.

An exclusively British Game-bird, the Red Grouse is found on the moors of England, Scotland, and Ireland. It is able to thrive and flourish on the young shoots of heather and mountain berries; it nests on the ground. The plumage varies from red and black to white-spotted in the males, and from red and black to white and buff-spotted in the females. Like the ptarmigan, the red grouse has a growth of feathers on the legs and feet.

Like the St. Kilda Wren, it is all our own, and we cherish it—especially in the month of August, when we shoot it in legions. The Red Grouse is an interesting bird in many ways. It illustrates the origin of a species under conditions of insulation. It thrives in very diverse places, where there is heather and ling, from the shore of the sea to moors of high altitude. It is able to flourish on Spartan fare, the young shoots of heather and crowberry, the mountain berries and the fruits of sedges and rushes, but it seems to enjoy a change to corn when there are harvest fields accessible. The difficult days for the grouse are when the snow is deep and continuous, and then it descends to the more sheltered valleys, or joins with its fellows in a long trek to more comfortable quarters. Its strong rounded wings give it a power of rapid flight, but this is not usually long sustained. There is considerable variability in the colouring of the plumage. Thus the experts distinguish red, black, and white-spotted males, and red, black, white-spotted and buff-spotted females; and, besides these different types there are noteworthy seasonal changes in the course of the year.

The Red Grouse.

Unlike its relatives the blackcock and the capercailzie, but like its cousin the ptarmigan, which goes higher up the mountains and puts on a white dress in winter, the Red Grouse is monogamous. In the spring we see the cock mount on a little elevation on the moor, and we hear his somewhat noisy challenge—"*Kok, kok, kok, go back, go back.*" The hen crouches near by, and seems to be interested in what follows. Another male comes near, and then there is a fight. The rivals jump into the air and lunge downwards with their beaks, trying to get a blow in on the head. The female seems to encourage her mate in combat.

The blood-red eggs, reminiscent of the plumage, are laid in a ground-nest and the hen does all the brooding. The young birds are very precocious, and both parents lead them about in search of flies and small caterpillars. At this time the cock defends his family against

intruders, and shows great courage. We have known him fly up on a low tree and give an evil-intentioned crow a buffet on the face. After youth is past, the grouse has few external enemies except the Golden Eagle, who probably serves a useful purpose in weeding out the relatively weaker and less wary. This will keep up the vigour of the race.

It is not known that grouse suffer from any constitutional disease, but they have many parasites, and in overcrowded ill-fed birds some of these, especially certain minute threadworms called Strongyles, may get the upper hand and cause death. In Sir Arthur Shipley's investigation of grouse-diseases, it was found that the bird carries about a "fauna" of about twenty-five parasites. "On the outside of its skin, amongst the bases of the feathers, numerous insects browse, whilst beneath the skin in the spaces of the body, such as that of the alimentary canal, and in the cells and tissues, such as the lining membrane of the intestine, and in the blood, worms and unicellular animals swarm."

Along with its vegetable food the grouse swallows some small insect or the like (it is unknown) which contains the juvenile stage of a tapeworm, and this may be the beginning of a very serious intruder. Or the grouse, in picking a berry from the ground, may be infected with the strongyle, just as children may be infected with maw-worm by eating imperfectly cleaned vegetables or fruit that has been lying on the moist soil. The strongyle or threadworm of the grouse is so very thin and fine that it is difficult to see a living specimen, it is so transparent. It is an intruder even more serious than the tapeworm. It finds its way to the paired blind-tubes in the food-canal, which correspond to man's vermiform appendix, and there it multiplies. The trouble is that in February, March, and April the food on the moor is scarce, only a small proportion of the heather tips being fit to eat. Therefore, all the birds on a moor tend to congregate on the small areas where there is sufficient food. The soil becomes heavily infected with strongyles from the droppings, and repeated infection is inevitable. The grouse get more and more threadworms, and the soil is infected more and more thoroughly. If spring did not come with its fresh heather-shoots hardly a bird would survive!

Among young grouse there is heavy mortality during the first few weeks of their life, corresponding to the remediable infantile mortality in our cities from microbic diseases like diphtheria and scarlet fever. In the case of the grouse the infection comes from microscopic spores (Coccidia) picked up from the ground; serious

Photo: Albert Henry Willford.

NEST AND EGGS OF RED GROUSE

The eggs of the Red Grouse have a mottled blood-red colour, and are laid in a rough hollow in the grass; the hen, which does all the brooding, is inconspicuous amongst the heather and other thick vegetation of the moor. The number of eggs is usually from five to seven.

Photo: T. M. Blackman.

YOUNG OF THE RED GROUSE.

The young of the Red Grouse are very precocious, and well able to follow their parents afield, in search of grubs and caterpillars, very early in life. There is a heavy mortality among the chicks, but this seems to be due more to man's overdone protection of these game-birds, which makes them weaker and more susceptible to parasites, than to the ravages of their natural enemy, the Golden Eagle, whose sifting makes for vigour.

inflammation of the food-canal results, often ending in death. But the trouble is that before they die the young grouse are able to infect the soil with millions of spores.

But let us turn from this dismal subject. What is of principal importance is this: that there is no constitutional disease in Wild Nature, and that diseases due to parasites and microbes are usually, if not always, due to man's interference. So it seems to us. Over-preserving, e.g., by shooting Golden Eagles, means that the grouse standard of health is lowered because the weakly or unfit (in some form or other) are not sifted out. Most healthy animals have parasites, and so has the grouse. But a live-and-let-live policy is established between host and parasite, and the presence of the parasites seems to do little harm unless there has been some weakening of the constitution by bad feeding or lack of Nature's sifting (Natural Selection), or because of some exaggerated multiple-infection, as often happens in crowded areas.

There are big areas in Britain where, under the present state of the soil, there cannot be anything but unprofitable heather-covered moors. These are the haunts of the grouse. The shooting of the grouse is an exhilarating luxury for those who can afford this sort of thing. If "big bags" and artificial "drives" could be abolished as inconsistent with true sport, then grouse-shooting might be regarded as a lawful luxury. As far as the Red Grouse itself is concerned, things are all right, for the bird holds its own in spite of, and partly because of, the August thinning. But let every owner of a grouse-moor protect the Golden Eagle!

It is outside strict science, but one cannot help associating distinctive birds with distinctive

human types. The storm-petrel is the sea-gipsy and the tern is Columbus. The golden eagle is a robber-baron and the sparrow is plebeian. It seems to us that the peewit is the joyous cavalier. Many people speak of its plaintive cry or even of the bird's wailing, but, whatever the sound conveys, the peewit is cheerful and defiant, sociable and sometimes jocose.

The Peewit.

In most parts of Scotland it is represented all the year round, but it is a " partial migrant " ; that is to say, some of those that were with us in summer may cross to Ireland in winter, while their place is taken by others from farther north. Some, of course, may leave our shores altogether and winter in Africa. In the wintry season in the North we have ample opportunity to admire this bird of many names—lapwing, green plover, peewit, teuchit. It is very common on the fields, very conspicuous when it flies, very much the reverse when it runs, but always graceful.

The lapwing is one of the most persecuted of birds, for its eggs are luxuries and the bird itself is often netted for the table. Yet it holds its own from Ireland to Japan, from the Arctic circle to India. Our first question must be how the bird survives with heavy odds against it. One reason for success is a certain plasticity, which enables the peewit to flourish in very diverse haunts—on the moor and on the shore of the estuary, in the farmer's fields and on marshy flats. Another reason is the considerable length of its bill of fare, for it eats a great variety of insects, such as wire-worms and leather-jackets, besides earth-worms, slugs, and small snails. Parenthetically we may recall the well-known fact that the peewit is one of the farmer's best friends. But there must be other qualities securing survival besides the variety of haunt and diet. There is the bird's great wariness, for it is difficult to take a peewit by surprise. There are the precautions for securing the safety of the eggs, and there is the young bird's useful instinct of lying low when danger threatens. To these

Photo : T. M. Blackman.

LAPWING ALIGHTING AT NEST.

The Peewit, or Lapwing, is common in the fields of Great Britain, but also has a very widespread distribution. The colour varies considerably in the course of the year. The mobile crest of six or eight feathers is common to both sexes, but it is longer in the male, and the wing is broader and more rounded.

we must return. But there is also the gregariousness which makes it easy to drive off an intruder or an enemy. Finally, the bird is clever and courageous and cheerful. It is self-confident without being cocksure; and when we watch their gaiety in stormy weather we know that behind all their success there is a vigorous constitution.

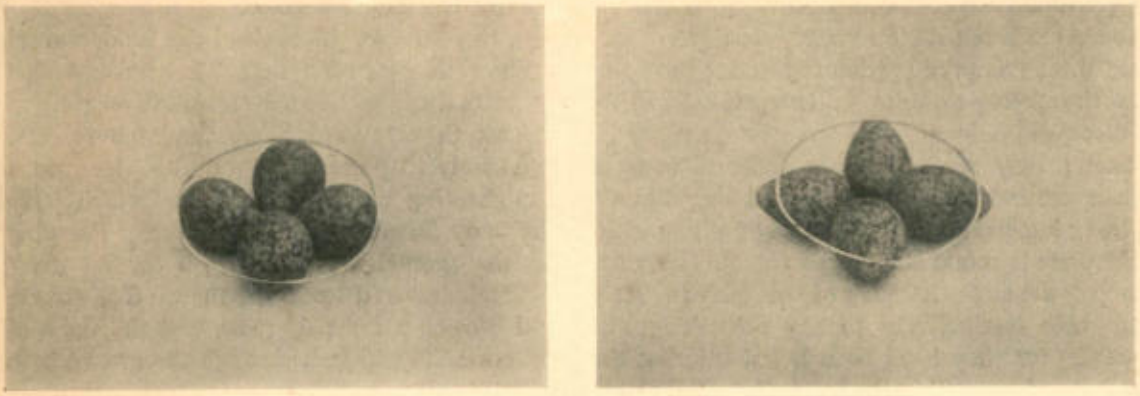
The colours of the lapwing beggar description. It is best to look at the bird, and in spring especially, for there is a little toning down in winter. One sees green and purple, grey and copper, black and white, and the tail-coverts are bay or fawn. All is set off by the metallic sheen, which is due to the physical structure of the feathers, and it is this that transfigures an ordinary dark pigment and gives it a green, purple, or bluish colour. The adult males and females have the same colouring, and both have got the mobile crest of six or eight feathers. It is a little longer in the male, and he has a broader and more rounded wing. The word lapwing refers to the slow flapping of the powerful wings, which sometimes suggests jerky rowing. But although the beats are slow the flight is powerful, as is usual in birds whose wings are of the broad, rounded type. Especially in migrating and in courting, the lapwing may fly at a great speed, and it is able at the breeding season to produce a vibratory or whirring sound which is due to the wings only. Many of us have heard the whirr at very close quarters, when the lapwing, resentful of our intrusion, flies boldly past our face.

The courtship of lapwings has several aspects. First, there is the jealous guarding of the open place that has been chosen for nesting. As in many other birds, there is a recognition of "territory" or preserves. If another male intrudes there is a fight—an aerial combat—between the rivals. Second, there are the courtship flights, in which the birds fly far and wide, calling insistently, whirring with their wings, and tumbling extraordinarily in the air. To watch and listen is one of the delights of the spring. Third, there is an elaborate showing-off on the male's part. He circles in the air round his desired mate, who is for a fortnight or so very indifferent. He tries to excite her interest, and displays the bright buff tail-coverts.

Photo: John Armitage.

LAPWING ON NEST.

The male and the female Lapwings share in sitting on the eggs, which take twenty-six days to incubate. If disturbed, the female runs quietly along the ground, and is soon lost to sight; while the male, rising into the air, endeavours by a series of swoops to frighten away the enemy. It sometimes seems as if he tried to divert attention from the nest, but it is difficult to prove this.



Photos: G. Hearn.

LAPWING'S CLUTCH RIGHTLY AND WRONGLY ARRANGED.

The illustrations serve to show how the Lapwing arranges her eggs to economise space. In the photograph on the left the eggs are set in the way in which the bird always arranges them, the points to the centre, and a wire ring is laid over them. In the right-hand picture the same ring is in use, while the eggs point outwards. The saving in space can easily be seen, and the "top-like" shape may be interpreted as adaptive.

Fourth, there is a remarkable making of "scrapes" in the ground. These are made at first by the male, who scratches a little depression with great vigour, and uses it as a stage for his display. When the female's interest is roused she also may make a scrape, and her scrape may be the future nest. The male is passionate, the female is coy, and it may be that the scrapes made so energetically by the male serve to convey to the female some subtle suggestion of a nest. For the nest is little more than a scrape in the ground with a few grass stems added. There are often two or three "scrapes" in the vicinity of the nest, and these seem to have been misinterpreted as "false nests," intended to distract the attention of enemies. It is almost certain that they have to do with courting, not with what follows.

Almost invariably there are four eggs, laid in April, with the more pointed ends towards the centre of the nest, thus economising space. The eggs are famous, like those of the black-headed gull and the guillemot, for their extraordinary variability of colouring. It is easy to get fifty different types, but the great majority are comparatively inconspicuous against the back-

Photo: Albert Henry Willford.

NEST AND EGGS OF THE LAPWING.

The nest of the Lapwing is little more than a slight hollow in the ground, with a few grass stems added. The eggs, invariably four in number, vary very considerably in colour, but are darkly mottled on a brownish-olive background so that they blend harmoniously with the colour of the soil.

ground of the soil. Both parents brood and the young are hatched after twenty-six days. There are three points of particular interest in regard to the young peewits. They are extremely precocious, able to leave the nest in 24 to 48 hours; they are often very inconspicuous in their natural surroundings; and they have a strong instinct to lie low and say nothing when the parents sound the danger signal. They are among the most charming of young birds. They are able instinctively to say something like peewit, for they have been heard uttering the call-note from within the egg! But the parents play up to their offspring. When intrusion is inevitable the female slips off the eggs and runs quietly along the ground to some distance, crouching as she runs, while the male overhead makes a great to-do and swoops down on the enemy. When the young are hatched and out of the nest, the two parents unite their efforts in trying to distract attention, and they will even stand up to a crow or a gull that comes too near. There seems to be insufficient evidence for what is often stated, that the parent peewits will feign lameness in order to divert attention from their offspring. It may be true, however, for the birds are clever. There is general acceptance of the story that they stamp on the earth, and thus induce earthworms to come to the surface. One can believe a good deal of a bird that does that.

But let us end where we began. The peewit's cry sounds plaintive and prayerful to many ears, but if that be the correct musical interpretation from man's "point of view," it is not what the bird means. The peewit is a gay bird, a jovial gallant, a sociable fellow, a keen lover, a proud parent. One doubts if he knows what it is to be either dull or afraid. And his mate is like himself.

A prehistoric prejudice, established in the time of the "Cave-men," if not much earlier, keeps us from doing justice to snakes in general, and to the adder in particular. The practical justification of the prejudice is obvious in a country much beset with snakes, but even that should not keep us from giving the adder or viper the tribute of admiration that is its due. The shape is pleasing, with the head broader than what we may call the neck, and with the body tapering to a short tail. There is an interesting individuality in the adder's colouring and markings, e.g., the cross on the back of the head, and we agree with Petruchio that "his painted skin contents the eye." No one can fail to appreciate, at least, the celerity of the creature's movements; and surely they are very beautiful—the sudden straightening of the sinuous line which jerks the body forwards, and the ordinary "rowing on the ground with every rib for an oar." "Startle it," said Ruskin, "the winding stream will become a twisted arrow, and the wave of poisoned life will lash through the grass like a cast lance."

The Common Adder.

The tips of a pair of ribs are attached to each of the large ventral scales which run across the under-surface of the snake. Certain muscles raise the scales so that their hind edges grip the ground, and then a certain number of ribs are moved so that the scales are brought into place again—the result being that the long body is pushed forward. It seems more like a multitudinous punting than rowing.

What a bundle of fitnesses is an adder! The shape is suited for creeping in the tangled herbage and between loose stones. All these ribs have changed a limbless creature into a millipede—and how quickly it disappears as we approach! Deep ball-and-socket joints and double articular processes give the numerous vertebræ great freedom of side-to-side movement without risk of dislocation. Everything inside the animal is adapted to the lengthening of the body, thus a broad organ like the liver has become long and narrow; and the kidneys are not opposite one another but in a line. There is not room for two well-developed lungs, so the left one is very small. The rush of air from the rapidly compressed right lung, when the snake is startled, accounts for the hiss.

On the other hand, no one could call the adder a neat eater. It kills mice and voles, slow-worms and small fledglings, newts and young frogs. Its hunting is at night. While one jaw grips the booty, the other is moved forwards and fastened: then the other side is loosened and advanced. So the adder gets outside of its victim, which often appears an almost impossible mouthful. In some cases the snake has to help its swallowing by pushing the protruding hindquarters of its prey against a stone. When the victim has got past the mouth into the gullet, the downward

Photo: C. Reid, Wishaw, N.B.

YOUNG LAPWING JUST HATCHED.

The young of the Lapwing, like that of the grouse, is extremely precocious, and after one or two days is able to leave the nest. The photograph illustrates this well, for the young chick is seen leaving the immediate vicinity of the nest before the remaining eggs are hatched.

passage seems to be helped by spasmodic movements of the ribs. One might think that the animal would choke during the laborious swallowing when the mouth is certainly as full as it can hold. But the front end of the windpipe is shunted forward, right out of the mouth, so that air can pass down to the lung. Not that an adder is easily choked anyhow.

The poison gland appears to be a transformed salivary gland, and the fang is a tooth folded upon itself so that a canal is formed down which the venom is ejected. This is Nature's

way of transforming the old into the new. By a neat automatic arrangement the opening of the lower jaw, in preparation for striking, erects the fang on the upper jaw (maxilla), and leads also to the compression of the poison-gland. If the fang is wrenched out by a bad stroke, or reaches the end of its life-tether and falls off, there is another behind it ready to take its place, and behind that another on a smaller scale. There is indeed an indefinite succession of reserve fangs—providential from the snake's point of view. There must be an interesting anatomical snap means relatively little, but there are some people to whom even a fleabite is dangerous.

Everyone knows about "the deaf adder that stoppeth her ear," for acquaintance with bad Natural History is widespread. But the adder is by no means deaf, and it has got no earhole which it could stop! There is no drum either, but the anatomical connections between the jaw and the well-developed inner ear are such that the adder must have a trombone accompaniment to all its meals. Like every snake, the adder stares at you, for the eyes are not

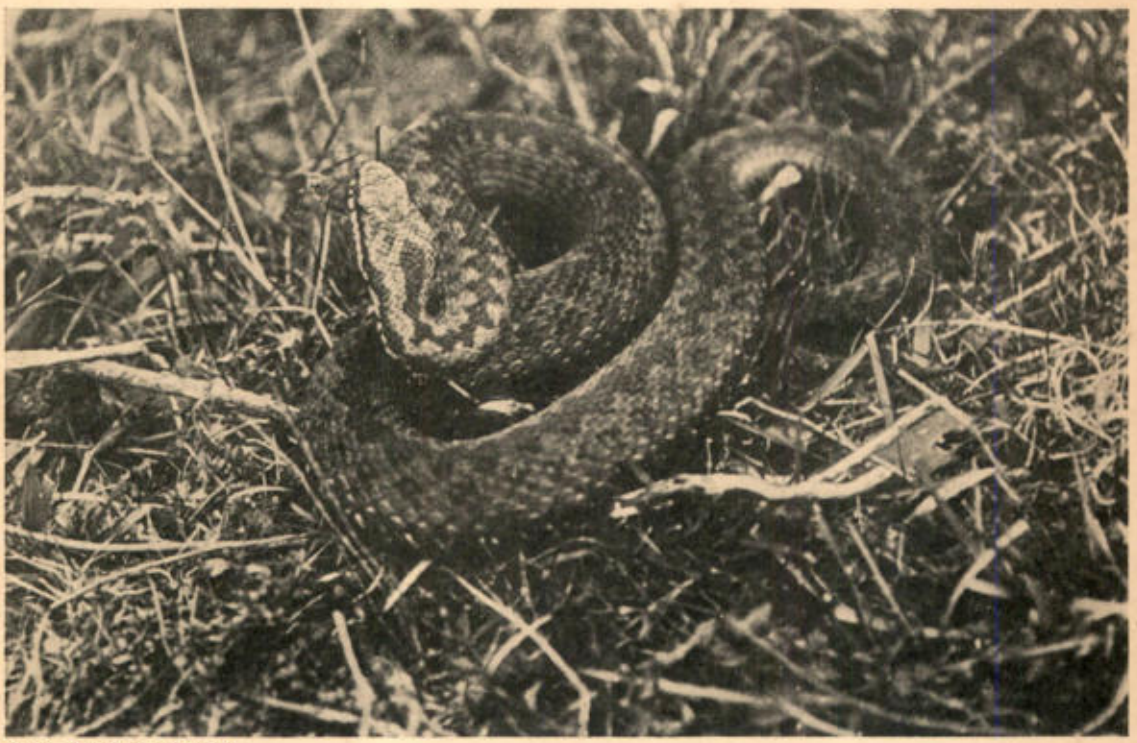


Photo: James's Press Agency.

COMMON ADDER ABOUT TO STRIKE.

The Adder hunts at night, preying upon mice and voles, young birds, and frogs. It can lash through the grass by rapid straightening and jerking movements, and it can move less quickly by rowing on the ground with its ribs. The ground colour is greenish-olive or brown usually, but varies considerably. The cross on the head is a distinctive marking, and so is the zig-zag along the back.

moment when the front end of the poison-duct is reconnected with the base of a fresh fang.

The bile of the adder is an antidote to its own venom, a fact which may be useful to anyone badly bitten who has presence of mind enough to kill the adder and extract and swallow the gall-bladder. We say "badly bitten," for there seems to be a waxing and waning of the poisonousness. When the adder is in good fettle and has not bitten for a while, there will be abundant poison available. To most adults the adder's movable, and the lids, which are mere vestiges in the embryo, come to nothing in adult life. What the eye looks through seems to be a fixed third eyelid, covered with a transparent horny scale like a miniature watch-glass, beautifully seen on the cast slough. We do not say that an adder sheds tears over a lost frog, but if it does then they must pass out by the nose.

As another example of moorland animals we take the limbless lizard called the slow-worm (*Anguis fragilis*), one of the most interesting

animals in Britain. It frequents dry grassy places where there is shade among the herbage or the heather, and an abundance of slugs. Often mistaken for a snake, and killed accordingly, it is, apart from its shape and limblessness, as unlike a snake as a reptile could be. Its scales are roundish and overlapping, very much the same over the whole surface of the body, and they have thin, bony plates below them—thus very different from a snake's scales. There is this resemblance, however, that the dead outermost layer of the epidermis covering the polished scales is moulted in a piece, like a snake's slough, being turned inside out from the head backwards, except that the tail is sometimes pulled forwards out of the dead husk, "like a sword out of its scabbard," as has been quaintly said.

The Slow-Worm.

The slow-worm has a long tail, whereas a snake has a short one; a slow-worm has always dwindling vestiges of the breast-girdle, which a snake never shows; the skull, the jaws, the ribs, and the soft parts are very different in the two types. It does not say much for popular Natural History that the slow-worm should also be called the blind-worm, for it has quite distinct eyes with movable eyelids, and one of the old zoologists describes them as "sparkling with pleasure" at the sight of a slug. There is more excuse for missing the ear-holes, for they are minute and well-hidden by scales. The tactile tongue is notched; not bifid like a snake's.

In the month of April or May, according to the climate and weather, the slow-worms awaken from their winter lethargy and emerge from their retreats. They pair and begin to hunt for food, which consists mostly of small slugs, earthworms, and caterpillars. They do not pounce or dart; but with slow movements they take what they can get. Though very shy and timid, they work by day, especially in shady places among the tall heather on the moor or in the herbage about the hedgerow. In August or September the mother lays eight to twelve soft-shelled eggs, which open just as they are laid, liberating beautiful young ones like silvery worms, about an inch and a half long. To begin with, they feed on very delicate spiders and insects. In six weeks they have doubled their initial size, and in five or six years they are full-grown, usually about ten inches in length, nearly half of this being tail. There is an unusually large slow-worm in the British Museum seventeen inches in length. When the cold comes and food is scarce, there is a retreat to the recesses of a mossy bank or to some cosy chamber among withered leaves, or into soft, dry soil. As many as twenty may lie up together in their winter quarters, as if to keep one another warm, but probably because good places are used year after year.

To kill a slow-worm is rather contemptible; first, because it is a very interesting product of evolution; second, because it is a gentle, tamable creature with a distinct individuality; third, because its backward bent teeth, though sharp, are not strong enough to draw blood, and the animal is innocence itself; and, fourth, because from man's point of view it is useful in destroying slugs and small caterpillars. But nothing will persuade the average man that the slow-worm is not a snake, or that it is non-venomous. Even the learned will ask: Why is it called "Anguis fragilis" if it is not a snake? and will perhaps quote a tag from Virgil, *Latet anguis in herba.*

This limbless lizard, widely distributed in Europe and Asia, is interesting in many ways. It has the snake's shape, the two very distinct types being similarly adapted to similar conditions of life, such as gliding through narrow passages. To this kind of superficial resemblance between unrelated animals the term "convergence" is applied. The slow-worm stiffens when captured and readily surrenders its tail, as most lizards do, thereby often saving its life. This reflex or automatic self-mutilation is called "autotomy," and it is referred to in the specific name "fragilis," which Linnæus gave the slow-worm. It must be a very ancient reaction, for there is a pre-established weak plane where breakage is especially likely to occur. If the surrender is successful, the lost part is re-grown at leisure, and though the new tail is rather a makeshift, the regeneration is a fine instance of the healing power of Nature.

Rising from the upper surface of the brain there is, as in many backboned animals, a parietal or pineal organ; and in the slow-worm, as still more markedly in that "living fossil" called the New Zealand Lizard (Sphenodon), it shows distinct traces of eye-structure. It may be a residue of an old-fashioned median upward-

Photo: Ellison Hawks.

THE SLOW-WORM (*Anguis fragilis*).

Though often mistaken for one, the Slow-worm has few of the characteristics of the snake. It is a limbless lizard with a long tail, and is covered with round, overlapping scales, underlaid by thin, bony plates. The diet of the Slow-worm consists of small slugs, earthworms, and caterpillars, for which it searches in dry, grassy places. The Slow-worm is a very shy animal, but it is not nocturnal.

looking eye; in the slow-worm it seems to be still a sense-organ of some sort—perhaps susceptible to changes of temperature, for the creature is quick to get away from very sunny places, especially when it is young.

Lastly, the slow-worm is a fine example of what has been called the "cryptozoic" mode of life; it can easily efface itself; it is not rare, yet it is seldom seen; it survives because of its elusiveness, and that is an art in itself.

L
STEPPES AND THEIR FAUNA

IN contrast to the animal life of the mountains and uplands we propose to take that of the plains and low grounds, beginning with the steppes. It is not easy to draw a hard and fast line between steppe and desert, since similar conditions as to drainage and rainfall obtain in both, in different degree, and in many places one merges almost imperceptibly into the other. The word steppe in its wider sense is generally applied to large inland tracts of grass-bearing lands in temperate latitudes, where the rainfall is insufficient for the growth of trees, and great extremes of heat and cold prevail. But the name is usually restricted to the great plain south of the forest zone, which includes the whole of Central Asia, and extends into South-Eastern Europe, although vast tracts with similar characters exist elsewhere. Most closely comparable with the steppes of Asia are those regions south of the coniferous belt in North America which are known as prairies, for the two areas show a certain general similarity in the character of their plant and animal life.

The steppe region is by no means uniform. At some places it is broken by river beds which form deep gorges, in which poplars and willows grow, and reed thickets abound, and where the grass does not dry up in summer. It is these valleys, like oases in the sandy desert, that make life possible to the Kirghiz and other wandering tribes, for there they can cut hay and store it for the winter, they can find relative shelter for their winter camp, and, above all, they can be certain of an unfailing supply of water.

There are lakes, too, some of them surrounded with a fringe of bushes, and these, in spring and early summer, are the haunts of a rich and varied bird life. Other lakes, lacking an outlet, have become brackish, and only the hard dry plants of the salt-steppe surround them. Few birds pay these salt lakes more than a brief visit, except the sheldrake and the pretty avocet which, for some reason, seem to favour these very inhospitable shores.

Notwithstanding the deeply cut gorges and numerous lakes the general character of both steppe and prairie, if seen from a height, is of undulating plain rolling away to the horizon. The Asiatic steppe is richest in herbage near the tree-line, and at the foot of the surrounding mountains, and becomes poorer and poorer towards the south and east, until desert conditions get the upper hand. In winter these wide plains are covered with snow, and not a green thing is to be seen. Nearly all steppe plants are bulbous, dying down in winter, for all that lifted their heads above the snow would be cut off by the deadly north and east winds. But when the snow melts slowly in the spring sunshine and soaks down to the roots of the plants there is a great awakening. "From the apparently sterile earth herbaceous and bulbous growths shoot up; buds are unpacked, flowers unfold, and the steppe arrays itself in indescribable splendour. Boundless tracts are resplendent with tulips, yellow, dark red, white, white and red. . . . Immediately after the tulips come the lilies, and new, even more charming, colours appear wherever these lovely children of the steppes find the fit conditions for growth, on the hill-sides and in the deep valleys, along the banks of all the streams and in the marshes. More gregarious and richer in species than the tulips, they appear in much more impressive multitudes. . . . Here and there blue lilies and yellow are gracefully intermingled, the two complementary colours producing a most impressive effect—a vision for rapture!" Grasses of various kinds, dwarf almond, honeysuckle, and the shrubby spiræas make low thickets dense enough to give cover to many of the smaller animals, for the animal life awakens or returns with the plants.

There are snails with shells thick enough to enable them to tolerate the intense cold of winter and, by preventing evaporation, the terrible drought of summer. Above all there are insects and insect larvæ which have lain dormant in the soil, mosquitoes, flies, wasps, beetles,

Photo: F. W. Bond.

RUDDY SHELDRAKE (*Casarca casarca*).

An inhabitant of Central Asia, this Sheldrake has been known to stray to the British Isles. It often haunts the inland waters of India in the winter months. It is a uniform bay in colour, except for the quill feathers of the wings and tail, which are black. In the male there is also a black ring round the neck.

swarms of grasshoppers, and hordes of destructive locusts.

But the insects do not long have it their own way, for the birds return early, sometimes even before winter has quite gone. The beautiful rose-starling eagerly searches the ground for the grasshoppers, the Lesser Kestrel and the Red-footed Falcon pounce on them and tear them to pieces in the air. Larks of half a dozen different species soar and sing over the dry plains all day long, and they and their young ones have to be fed. Innumerable lizards run about on the alert for every moving insect. The Harriers follow the larks, and demoiselle cranes stalk about feasting on the lizards. Yet the supply of these never fails. For Nature is impartial to all her children, and the lizards are swift, their colour is well suited for concealment, they can burrow rapidly and, like most of the steppe animals, they are very prolific. Conspicuous among the larger birds are the imperial eagle, the great bustard, and the ruffed bustard. Many of them, finding little shelter except the grasses and low-growing plants, have changed their habits and nest upon the ground.

Photo: F. W. Bond.

ARABIAN BUSTARD (*Eupodotis arabs*).

A large long-legged bird, typical of the steppe-country, famous for its powers of rapid running. But it is, of course, one of the Flying Birds.

Birds of all kinds, from little songsters to the great white heron, the cormorant, and the pelican frequent the river-banks and the reed-thickets, not indeed in such hordes as congregate on the shores of North African lakes, "where the feathered tribes of three-quarters of the globe have their winter rendezvous," yet in considerable numbers. But they are only temporary residents, and show no particular adaptation to steppe life.

Among the mammals of the steppe region, as we should expect, herbivores are greatly in the majority. Predominant among them are the Ungulates or hoofed animals, and the rodents, or gnawing animals, and both these show special fitnesses for the prevailing conditions. The Ungulates are typical animals of the plains. None of them occur in the steppes with the extraordinary abundance, for instance, of the springbok on the South African Karroo, or of the buffalo in its heyday on the prairies of North America. For the sprinkbok, when driven by thirst, migrates in armies which are said to cover many square miles of open country. The buffaloes, before the railway crossed their haunts, and ruthless persecution began, wandered in millions from one feeding ground to another, keeping always to the same route and tramping out trails that might be several feet in depth. "When a great herd was stampeded the thunder of its countless hoofs shook the earth, and in its flight it rushed like a huge black torrent over the landscape."

Though the steppe has nothing to compare in

Photo: F. W. Bond.

DEMOISELLE CRANE (*Anthropoides virgo*).

Breeding in Southern Europe and eastwards to the north of China, these Cranes winter in North Africa and North-West India. Their diet consists largely of small reptiles, such as lizards. They are as intelligent as they are handsome, and are noteworthy for their sociality.

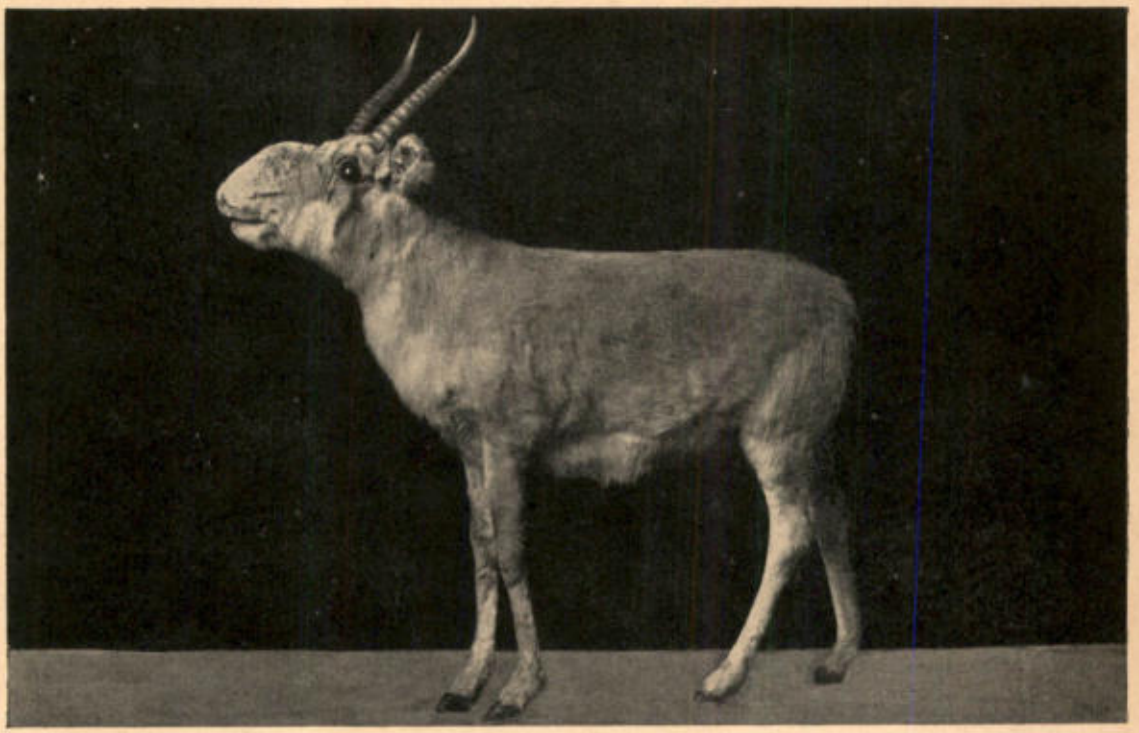


Photo: By permission of the Natural History Museum, South Kensington.

THE SAIGA ANTELOPE.

These Antelopes are found in the steppe country of South-Eastern Europe and Western Asia. In summer they frequent the open country in small herds; but the winter cold drives them south, when they collect in large herds and are more easily approached. The males have a large swollen nose, convex and inflated, which gives them a very strange appearance. For short distances the Siaga is very fleet.

richness of individuals with these other plains it has interesting ungulates that are all its own. The odd-looking Saiga antelope roams in thousands over the plains. It is about the size of a fallow deer, with short legs, a yellowish coat that turns much paler in winter, and lyrate horns in the male. Its most peculiar feature is a greatly elongated and swollen nose with very wide nostrils set far apart. Though it resembles other antelopes and gazelles in its general characters and habits, it has an "ovine expression" and its fleece, too, is sheep-like. In common with all the large animals of the steppes, where concealment is scarce and famine or drought comes suddenly, it has great swiftness. But it lacks staying power and the Kirghiz horsemen can often run it down.

The Bactrian or two-humped camel with shaggy hair, hard feet, and short legs, is very characteristic of the steppes. It is a highly valued domestic animal among the nomad tribes, but it is a disputed point whether the wild herds that undoubtedly exist are really wild, or only feral like the well-known herd in Spain. It is suggested that so many human settlements and even cities have been destroyed by hurricanes or sand-storms that the "wild" herds may really be descendants of camels that belonged to the inhabitants of these. However that may be, they are well adapted to steppe life, for unlike the Arabian camel, they walk easily on hilly or rocky ground; they can endure great cold, they are satisfied with the salt herbage, if nothing better can be got; they drink freely of brackish water; and the two humps enable them to store up fat for times of scarcity.

Wild Horses and Asses.

Among the most interesting, and certainly the most attractive, of the ungulates of the Asiatic steppes are the wild horses and asses. There are at least three kinds, the tarpan or wild horse, Przevalsky's horse, which shows most affinity to the domesticated form, and the kiang or wild ass which chiefly frequents the high plateaux of Tibet. All three have similar habits. During summer they wander about in small troops of ten or fifteen mares with their young ones, each troop led by a single powerful stallion. All

other males are driven out of the herd as they approach maturity, and they wander about singly till they have come to their full strength. Then a solitary stallion will stand for hours at a time on a hillock, on the look-out for a troop. When one appears he rushes to meet it, challenging its leader, who is never slow to defend his rights. The battle between the two stallions is fierce and may be long, but the rest of the herd look passively on. If the intruder is victor they immediately follow him and he rules them as despotically as did their vanquished leader. Strength and alertness are as necessary to the wild horses as swiftness, for there is no cover for animals so large, yet the shrubby thickets may conceal the slinking wolf. But a stallion strong enough to gain and keep a troop of mares is a match for any wolf, and even for more than one. It is only the laggards and the weaklings that are apt to fall a prey, and even these not very often in normal circumstances, for the acute senses of the horses gives them early warning of the enemy's nearness.

Human enemies are more difficult to evade, and hunting wild horses has long been a favourite sport with the nomads. The wild horse has been described as a proud, fascinating creature, full of dignity, strength and high spirits, shy, but almost coquettish in its bearing. When pursued they stare curiously for a while, then take to flight. A troop retreats in orderly line, stops, faces round, turns again, and resumes its swift flight with beautiful precision at the leader's command. They hardly need to use their utmost speed, and may often be seen holding themselves in for the sake of the foals, and they are only

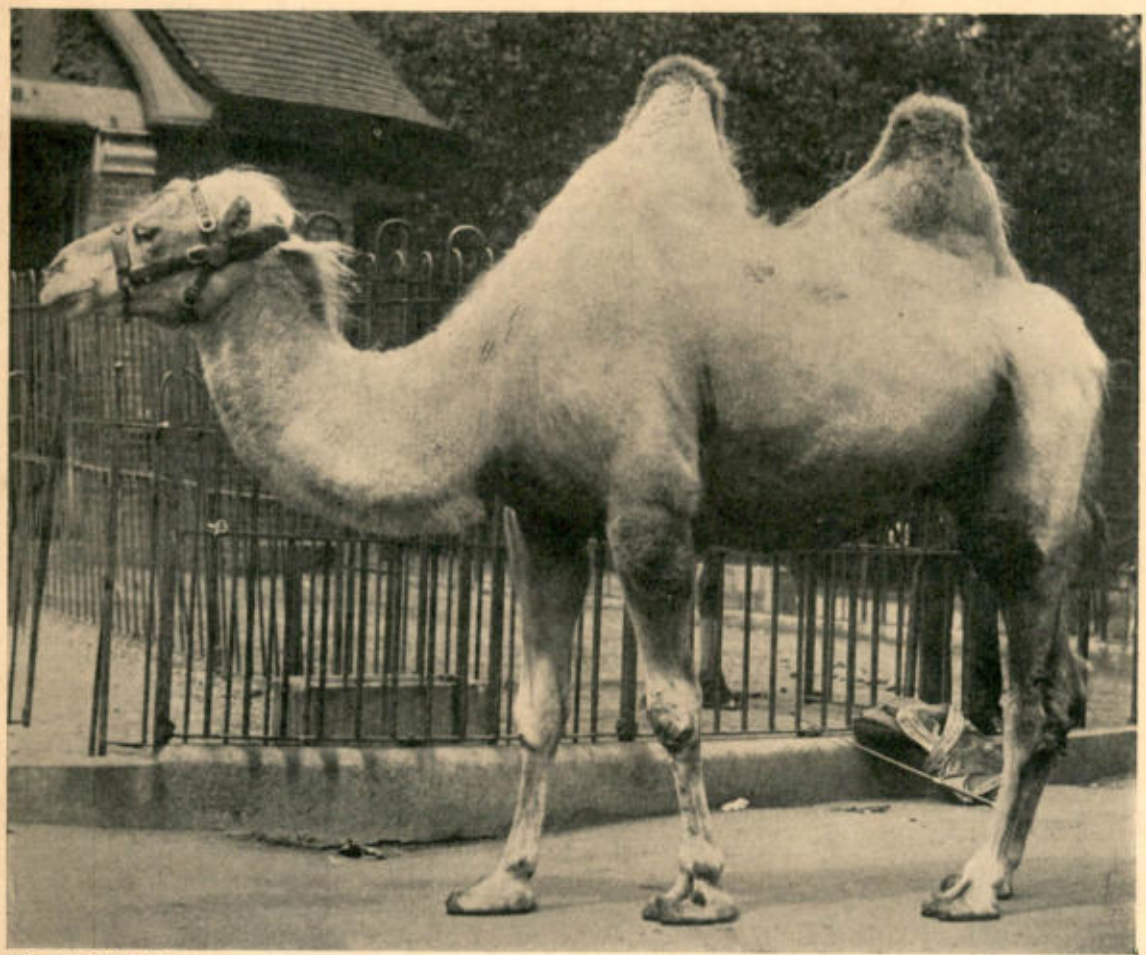


Photo: F. W. Bond.

BACTRIAN CAMEL, (*Camelus bactrianus*).

Widely distributed in Central Asia, the Bactrian Camel is able to thrive on the salt and bitter plants of sparsely vegetated regions. It is to be distinguished from the Arabian Camel by its long, shaggy hair and shorter limbs, and by the two fatty humps on the back; but it must not be confused with the Dromedary. The humps stand erect when the animal is well fed; they begin to fall to one side during starvation diet.

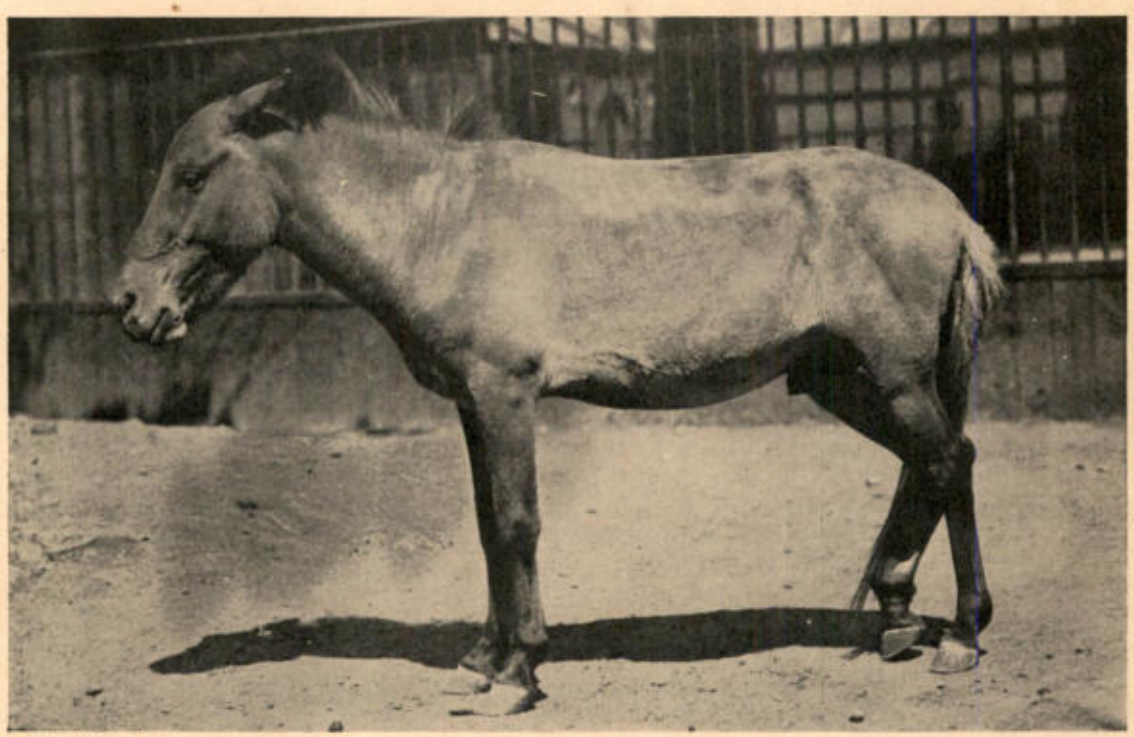


Photo: F. W. Bond.

PRZEVALSKY'S HORSE (*Equus przevalskii*).

Przevalsky's, or the Mongolian Wild Horse, is dun in colour, with a black mane and tail, and black on the front of the legs. It in some ways resembles the ass, having an erect mane, no forelock, and the upper part of the tail short-haired; but it is generally believed to be on the ancestral line of our domestic horse. In any case, it is nearer to the horse than to the ass.

run down when they are surrounded with horsemen in a wide circle.

"The time of blossoming is short and the time of withering and dying is long in the steppes." Springtime, with its rainfall and its melting snow, is the only season of real plenty. The hot dry summer comes all too soon, and everything is withered up. Autumn brings some improvement, for a little; there are seeds and fruits and withering grasses, and the wild horses are easily contented. But when frost comes and the pools and lakes are coated with ice, they are hard put to it for water. Troop joins troop till a great army is formed, and they wander, not towards the warmer south, but northwards to regions of deeper snow, where they may satisfy their thirst, and find sufficient food by scraping away the snow with their hoofs. Winter at the best is a time of scarcity and hardship, and the whole herd becomes thin and starved looking. They can endure great cold, but should a slight thaw set in, followed by frost, they are unable to break the surface-cake of ice over the snow and many perish miserably. This is the wolf's opportunity. But the plucky little creatures are very elastic; those that survive soon recover their high spirits, and, at the first hint of brighter days, they gallop joyously back to their summer pastures, where they break up into little troops as before.

Rodents of the Steppes.

The rodents of the steppes are more numerous than even the ungulates, though they are much less conspicuous. They owe their success to certain characters which they all have in common. They are small in size, they are burrowers, and so have a way of escape from many enemies, and shelter from all but the most severe storms; many of them have learnt the trick of laying up stores; they need little water; many of them sleep through the winter, and a few combine storing and sleeping. All of them are extremely prolific. Many different rodents inhabit different localities of the steppe region, and most of the Asiatic species are represented by nearly related forms on the prairies of North America. One of the most conspicuous is the steppe-marmot or bobac, a smaller animal than its cousin the Alpine marmot, which keeps to higher ground. The bobac is about fifteen inches

long, with close-growing fur, short tail, and very short ears—all these suited to its burrowing habits. The tunnels made by the bobac may go down three yards or more into the ground. They have numerous blind side-alleys and end in a roomy chamber, warmly lined with blades of grass. The animals retire to their burrows in early autumn but remain active within them and feed on their stores till late December when they fall asleep. Up till that time if they are disturbed they simply dig rapidly down, and this they do also if the frost penetrates to their dwellings, as it does when the snowfall has been light. In March they clear away the earth from their entrance tunnels and emerge, plump and fit—choice morsels for many hungry prowlers! In summer they make much shallower dwellings close together, and live in sociable colonies while the business of family life goes on.

This sociability is even more marked in the American "prairie-dog," so-called from its continual shrill bark, which is said to resemble the sound made by a toy dog when the bellows is squeezed. The prairie dogs are extraordinarily abundant over vast areas—in Texas one continuous colony extends for two hundred and fifty miles. "The vivacity and hearty enjoyment of life by the occupants of a prairie dog 'town' is most entertaining to an observer. With the first peep of the sun above the horizon they are out on the mounds at the entrance to their burrows, first sitting erect on their hind feet and looking sharp round for any prowling enemy. If all is well they begin to run about from one hole to another, as though to pass the compliments of the day, and scatter through the adjacent grassy feeding ground. At any suspicious occurrence the first to observe it runs to his entrance mound, if the danger is not pressing, but otherwise to the nearest mound, where he sits up to his full height, 'barking' and vibrating his tail, ready if necessary to disappear

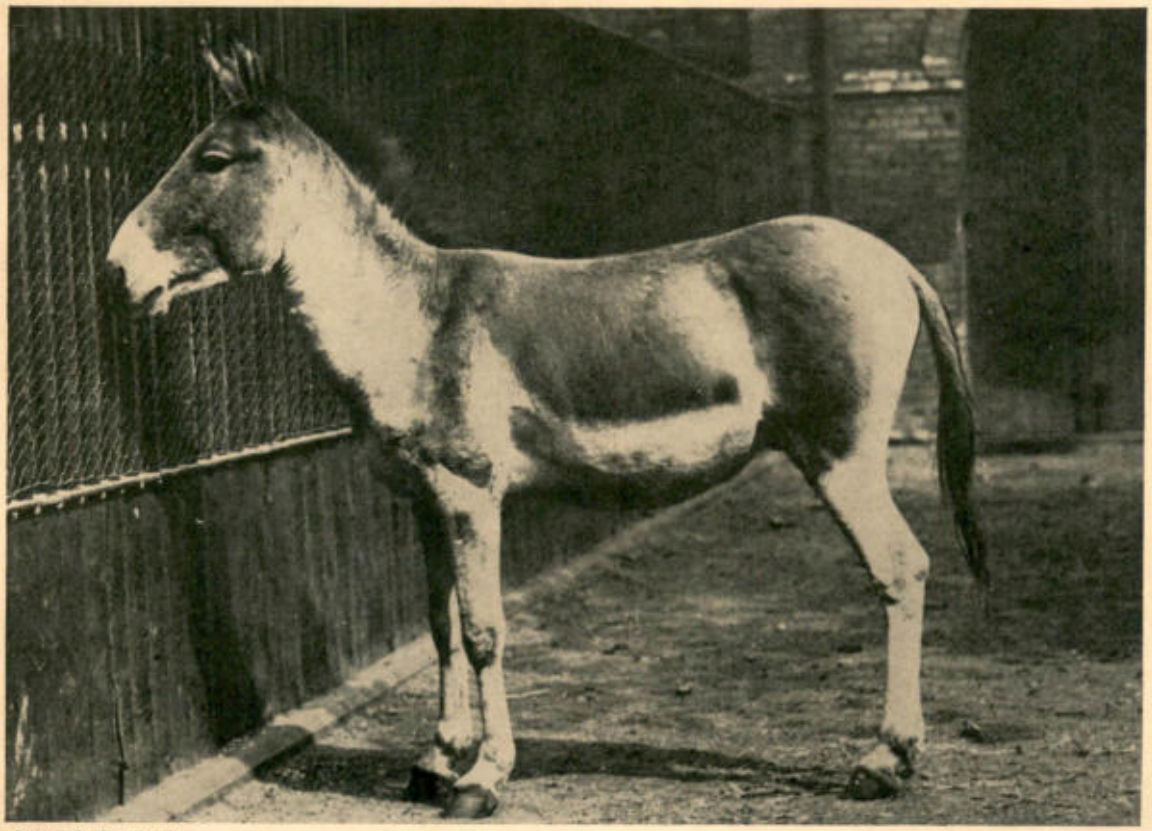


Photo: F. W. Bond.

KIANG (*Equus kiang*).

The largest of the wild asses, yet showing considerable resemblance to the horse, the Kiang is a dark reddish-brown in colour, with a narrow dorsal stripe and a thick, shaggy, winter coat. It inhabits the highlands of Mongolia and Tibet, gathering usually in small herds, and feeding on grasses and rather coarse woody herbage. It is typical of the high Tibetan plateaux and a very attractive creature.

instantly. At the same time the 'town' is alive with scurrying figures of the inhabitants rushing for their homes, and the air is filled with a chorus of their little barking cries. When all have been frightened to cover, barking continues in the burrows, but an hour or more may pass before a 'dog' will reappear."

The little sousliks, related to the ground squirrels, also form colonies of burrows on the

Photo: F. W. Bond.

EUROPEAN SOUSLIK (*Citellus citillus*).

The Sousliks are small rodents, for the most part Asiatic, but also found in some parts of Central Europe. They are related to the squirrels, and have cheek-pouches, short limbs and tails, and are somewhat more broadly built than the true squirrels. Gregarious, they form colonies of burrows, and subsist upon coarse herbage, bulbs, seeds and insects.

Asiatic plains, while the picas or tailless hares abound on the higher stony ground. These last provide for the winter less securely than the deeper burrowers by building a hay-stack outside their holes in any sheltered cranny. Failing natural shelter they are said to thatch the stacks with wild rhubarb or other broad leaves.

In the jerboa the shortening of the fore-legs is carried to an extreme, and the hind-legs are very long. So great is the difference between fore- and hind-legs that the animal looks like a little kangaroo, especially as, unlike the other rodents, it has a long tail. Feeding on the ground is not very practicable, so the jerboa digs up its favourite bulbs with its fore-feet, sits up, and carries them to its mouth. Running, too, is impossible, and its progress is by a succession of unpredictable jerking leaps which, however, get it over the ground so rapidly that a horseman can hardly overtake it. The related jumping-mouse of the prairies, if pursued, can cover ten feet at a leap, and a mother animal will take flight thus with her young ones hanging on to her teats. Some of them drop off, of course, but they lie where they fall, and when the danger is past the mother goes back on her tracks and retrieves them.

The abundant rodents of the steppes form the basal food supply of the carnivorous birds and beasts, as the lemmings do in the tundra. There are many beasts of prey—wolf, stoat, weasel and others—but none of them, except perhaps the Manul or Asiatic wild-cat, is specially distinctive of the steppe region. In a general way it may be said that the cycles of life are relatively simple in the steppes. The abundance of grassy vegetation makes many Ungulates and Rodents possible; and on these the Carnivores levy toll. The links in the nutritive chain are not so numerous as in most haunts of life, but we must now correct this false simplicity.

Snapshots in the Steppes

In a country like Britain, and in many a large area in North America, the steppes are represented by great stretches of grassland, from the "bents" on the seashore to the inland links

Specially drawn for this work by Warwick Reynolds, R.S.W.

THE JERBOA.

The most charming of the Steppe rodents, a long-legged jumping biped, digging up roots and bulbs and holding the food to its mouth with its hands. Very characteristic is the greatly elongated tail, which carries a terminal brush of hair. The drawing shows the long sensitive whisker hairs or vibrissæ.

and prairies. It is not possible to draw any hard and fast line, e.g., between steppe and meadow, but the haunt of life that we are here trying to picture is characterised by an abundance of grasses, sedges, and other narrow-leaved plants; by the absence or scarceness of trees; and by the relative shortness of the period of leafage and flowering. It is particularly true of the steppe-land that the grass withereth and the flower thereof fadeth. But a short time of vigorous leafing and flowering implies, as we have seen, that there is—must be—much making of hay when the sun shines. In other words, when the conditions of life are propitious there is a storage of nutritive capital in the underground parts of the plant, whether these be roots or tubers, runners or bulbs. Another feature of the steppe vegetation is that the leaves of the grasses or grass-like plants rise more or less vertically, parallel to one another, so that there is no shading of one leaf by another. This is fundamental: it means that the only survivable plants in the steppe-land are grassy plants, or it may be plants whose leaves are much cut-up, so that they expose a large surface in proportion to their size, like a country of small area but with a large coastline. The significance of this for the plant is that the surface is the area for absorbing the gaseous food and utilising some of the energy of the sun's rays. The more surface, the better.

Amongst the multitudinous grasses there are legions of insects, especially of the grasshopper order (Orthoptera) and of the bug order (Rhynchota), so that the plant is always being reincarnated into an insect. But many of the steppe-birds, like the larks, are greedy insect-eaters, and so the incarnations continue, from Avatar to Avatar. Many people who are always asking "What is the use of this or that?" do not realise the commonplace of Natural History, that bugs become birds!

In a South African steppe we once watched in vain by the ill-smelling haunt of a Cape ant-eater (Orycteropus), an antediluvian mammal, which might be called a "living fossil."

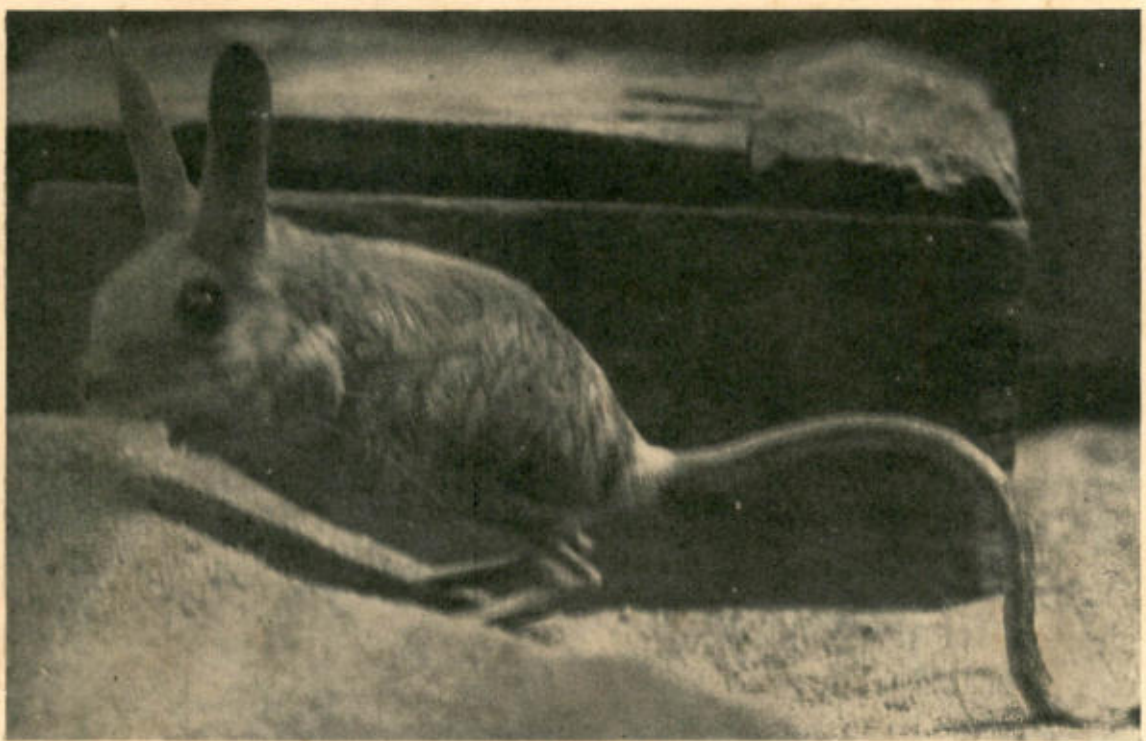


Photo: F. W. Bond.

FOUR-TOED JERBOA (*Siarturus tetradactylus*).

This species of Jerboa is strictly nocturnal, and hibernates for a considerable period during the cold season. It is a burrower, and the young, which usually number five or six, are placed deep under the earth at the end of a burrow. It inhabits the steppes of Central Asia, Persia, and South-Eastern Europe—an agile, alert, swiftly-leaping, incalculable, highly successful biped.

Photo: F. W. Bond.

MANUL, OR PALLAS'S WILD CAT (*Felis manul*).

A thoroughgoing cat, in all respects typical, which has established itself as the cat of the Asiatic steppes. The photograph shows very clearly the tactile whisker-hairs or vibrissæ, which are well innervated at their base. Also well seen are the beautiful velvet gloves which hide the claws of steel.

The Aard-vark comes out from its den in the cover of darkness and burgles the solid ant-hills of the termites. The powerful claws break down the earthen walls; the long worm-like tongue flies out and in from the aard-vark's mouth; the termites disappear like greased lightning. The insects become part and parcel of the mammal.

When we get on to the magic carpet and shift the scene to the grasslands round Bologna, we see the courtship of the Italian Fireflies or Luciolas. Sparks in the air respond to sparks in the grass; and the active males, in answer to the beautiful light-signals and love-signals, settle down around the sedentary females, till a sex-choice is made.

The quagga has unfortunately gone for ever, but a typical creature of the steppe-land remains in the zebra, represented by several African species. We have spoken of it in another connection, but it must be included here in the steppe-picture—an elusive rover, swift and alert, disappearing like a mirage, conspicuous close at hand but obliterated at a short distance, in spite of, or rather because of, its startling stripes.

Amongst the grasses of the steppes there are many spiders, that feed on the legions of insects—another incarnation. Some of these steppe-spiders are of great interest, especially those whose females make trap-door nests for the protection of the young. What a dramatic and yet apparently commonplace snapshot is a slope of steppe, where close inspection shows what is hidden at first glance, a dozen circles on the ground, the outlines of the silken-hinged lids of the shafts that are sunk by the mother trapdoor-spiders.

The steppe-stage is crowded with insects and spiders, in some places with scorpions as well, and also with creatures of higher degree, such as lizards and snakes. In most of these steppe-animals there is a capacity for lying low in unfriendly seasons, especially underground, or for trekking to other regions, as in the case of antelopes and wild horses. When a season of plenty is naturally followed by great increase of

Photo: F. W. Bond.

AARD-VARK OR CAPE ANT-BEAR (*Orycteropus capensis*).

A quaint antediluvian African Ant-Eater, belonging to a race of long pedigree. It is one of the primitive mammals which are bundled together in the rather heterogeneous order of Edentata. It comes out at night to break into the earthen edifices of the White Ants, on which it feeds greedily.

numbers, and this, in turn, by a local scarcity of food, there is need for a raid. The most familiar instance of this is the mass-movement of locusts—a hunger-spurred stampede—which should not be called a migration. Under the urge of hunger, they trek, first on foot, and then on wing, from one part of the steppe-land to another, or beyond the steppe-bounds altogether. This is another of the features of the steppe-fauna, that many of its tenants tend to like the Wapiti: they have been driven from the plains to the heights.

We call the roll of the steppe-fauna, and the bipedal jerboas come jumping, with a multitude of lesser rodents sharing in the "Adsum." And if we say African steppe, we summon a lion, in some ways "King of Beasts." There are Asiatic steppe-birds, like the Sand-grouse, in their feathery stockings, and there are the stately Secretary-birds, that make short work of snakes

Photo: Major H. Radclyff Dugmore.

GROUP OF ZEBRA.

This beautiful photograph shows a number of Grant's Zebras digging for water in the sandy bed of the Olgerei River, British East Africa.

become nomads, just like man himself. In the course of evolution many great changes have probably been due to a trekking of steppe animals when the steppes became arid and no longer grassy. Thus, to take a familiar instance, the chamois is an Oriental steppe-antelope that has been driven into refuge on the mountains, and the same is true, during more recent times, of some of the North American mammals, on the Karoo. There are inconspicuous serpents and lizards among the steppe reptiles.

We see on the steppes a centipede and a scorpion pursuing the same spider, who defeats them both by disappearing down the beautifully plastered shaft, which must be called her masterpiece. A leisurely Ground-chamæleon, remaining true to the old terrestrial tradition of Lizard, finds its bread and butter among the insects on

Photo: Major H. Radclyff Dugmore.

GRANT'S ZEBRA IN BRITISH EAST AFRICA.

This beautiful picture is the outcome of a telephotograph taken at a distance of about forty yards. The Zebra is not more than mildly interested. While the remarkable striping makes the Zebra very conspicuous in a photograph, the living animal often fades into its natural surroundings.

Photo: G. Hearn.

SKYLARK (*Alauda arvensis*) FORAGING.

The food of the full-grown Skylark consists chiefly of insects and seeds; but its feeding habits are very adaptable, and nothing comes amiss to it, young green corn being especially sought after. For about three weeks the young chicks have to be fed in the nest, and the parents collect and bring to them insects and small earthworms.

the bushes of the South African steppes. The Prairie-dog, as we have seen, is a conqueror of the steppe-land, along the line of sociality ; and it is a type of many others. This mode of life may find expression in herd-instinct, as in the old bisons—or it may sink into less differentiated communalism, as in our familiar rabbits. Thus, in steppes, as in other haunts of life, we see (*a*) individualistic effort, seeking out some new niche of opportunity, as in the Manul or Steppe Cat ; (*b*) a definite communal integration, where the social ægis shelters many individual delinquencies, as in steppe-marmots ; and (*c*) some special adaptation to steppe-life as in the nomadic Wild Horses, or the jumping Jerboas.

Grasslands and Meadows

The Skylark.

We take this familiar joyous creature as a type of the birds of the grasslands. It is characteristic of many British links and moors, which, even when not particularly beautiful in themselves, are transfigured in springtime by the abundance of gorse blossom and enlivened by the almost continuous songs of skylarks. The songsters begin as soon as the sun warms the air a little, and they continue till dusk. In summer they stop singing only for two or three hours in the middle of the night. And not only is the lark singing late and early, by night as well as by day, it sings all through the year. We often hear it in January.

What is most impressive in the skylark's song is its vigorous impetuosity and yet its apparent ease. We hear, as Shelley suggested, the outpourings of a full heart, "a flood of rapture," "a rain of melody." The lark has not nearly so much to say as a blackbird or a thrush, but it says it over and over again untiring. There are, indeed, variations in his theme, but the compass is small. We agree with John Burroughs : "Its type is the grass, where the bird makes its home, abounding, multitudinous, the notes nearly all alike and all in the same key, showering down as thick and fast as drops in a summer shower." The motif is simple, but there is no doubt as to the skylark's ecstasy—with a note of vehemence too. That is what Wordsworth was referring to when he wrote : "There is madness about thee" ; the song is passionate within narrow limits. An interesting point is the imitative incorporation of snatches of song from other birds, as if to relieve the monotony. For we cannot agree with those—great authorities too—who speak of the *variety* of the lark's song.

Photo : Albert Henry Willford.

NEST AND EGGS OF SKYLARK.

Unlike most of the other members of the order of Perching Birds or Passeres, the Skylark makes a nest on the ground, and a very slight nest it is. There are three to five eggs of an inconspicuous brownish and greyish colour ; and two broods are reared in a season.

We have considerable sympathy with the American in John Burroughs' story, who, with Shelley's poem in his hand, went hunting about in English fields in search of a skylark and reported that he could not discover even one. We do not mean, of course, that poems should be used as aids in "telling the birds from the flowers," but it does not seem outrageous to inquire whether all Shelley's melodious phrases about the bird are apposite.

Photo: Albert Henry Willford.

SKYLARK ABOUT TO ASCEND.

In most birds the launching into the air requires considerable effort, and a pigeon, for instance, gets woefully tired if it has to rise frequently from the ground in a short time. We often see cormorants taking a run along the rock to get sufficient momentum for sailing off into the air. In the lark there is a preliminary crouch and then a sudden straightening of the legs and an upward leap, accompanied by very rapid wing-strokes.

There is more of the real lark, we think, in Meredith's poem:

"He rises and begins to round,
He drops the silver chain of sound
Of many links without a break,
In chirrup, whistle, slur and shake,
All intervolved and spreading wide
Like water-dimples down a tide
Where ripple ripple overcurls
And eddy into eddy whirls;
A press of hurried notes that run
So fleet they scarce are more than one."

The song is characteristically rendered in mid-air, and the bird sometimes soars so high, perhaps a thousand feet up, that it is lost to view. As Shelley says:

"Like a star of heaven
In the broad daylight
Thou art unseen, but
yet I hear thy shrill
delight."

Perhaps Shakespeare is finest of all in his simplicity:

"Hark, hark, the lark at
heaven's gate sings."

It is a very wooden thing to correct the poets on matters of scientific fact, but John Lyly's lines:

"Now at heaven's gate
she claps her wings,
The morn not waking
till she sings,"

suggest the remark that the singing is usually a prerogative of the females. We know that there are cases of female larks singing, but that is quite exceptional. The skylark's song is the audible aspect of "love," and is wrapped up with courtship, but it is possible that the basis is broadening, and that the song is coming to be an expression of vigour, good spirits, and general *joie de vivre*. In some cases the rival males sing as they fight, and we have heard them singing in the rain, and on the ground, and on a whin-bush. They are certainly "blithesome and cumberless."

After the painting by Philip Rickman.

SKYLARKS

This charming drawing shows the female Skylark sitting on her nest on the open hillside, while in the distance her mate rises in the cloud-dappled sky of a spring dawn, singing as he soars.

Half of the courtship is song; the other half consists of a sort of play. The male shows off the outermost feathers of the tail, which are almost entirely white; he hovers with quivering wings a few feet above his desired mate; there are many aerial evolutions which do both parties great credit. There is some evidence that a male lark selects an area or "territory" which he holds as his preserve. It may be noted that the sexes are practically identical, and that both are crested. The buffish-brown colour is well suited for concealment against the ground, yet on the links we frequent the sparrow-hawks get many a lark in spite of their inconspicuousness.

The "blithe spirit," "like an unbodied joy," has a very wholesome appetite; and its success in life depends partly on the fact that it can thrive on vegetable as well as on animal food. It eats insects, including some that are injurious, spiders and small worms; but it also utilizes many kinds of seeds, the tender leaves of small plants, and the delicate shoots of grass and corn. It levies a slight tax on seedling turnips and young corn, but this is far outweighed by its destruction of many weeds and injurious insects. It is a crime to kill a lark. The bird's hard times are when snow covers the ground, and if the storm lasts they must trek through the air, say to Ireland, or perish.

In April the lark makes a simple nest in a depression on the ground. It is made of grass stems, finer to the interior, and there is sometimes a little hair. The male collects the materials; the female fashions them into the nest. It is she also who does most of the brooding on the three to five greyish or brownish eggs. After a fortnight the young larks are hatched out—blind and sparsely clothed with down; they require much attention for several weeks, and are fed on insects and small earthworms, both parents sharing in this labour of love. There are usually two broods in the season, and there may be more. The nest is often well hidden among the grass, but we have noticed on the golf links that it is often built in what man would call a very stupid place, right in the fairway or just at the edge of a little path through "the rough." It is said that the female generally avoids

Photo: John Armitage.

YOUNG SKYLARK.

The eggs of the Skylark are incubated for about a fortnight, and the young ones are hatched out in a very helpless state, quite blind and with only a few wisps of downy feathers. In about three weeks the first plumage is completed, and the young lark leaves the nest and begins to make attempts at flight. It learns very quickly, and is soon able to fend for itself.

alighting on or flying off the nest ; in her comings and goings she runs for a short distance along a twisting path in the grass.

Mr. Pycraft, the distinguished ornithologist of the British Museum, has called attention to the bright yellow colour of the interior of the mouth of the young lark—a feature that is common among the Passerine birds or Perchers. But in the lark there are two black spots at the root of the tongue, and there is a triangular one at the tip. He suggests that these, like analogous markings in some other young birds, may be of advantage in enabling the parents to put food into the nestling's mouth without any fumbling or loss of time. The meals occur every quarter of an hour or so, and it is obvious that the less fuss there is about the nest the safer the nestlings will be from birds and beasts of prey. The young birds leave the nest before they can fly.

The lark is a quick runner on the ground ; but the meaning of the great elongation of the claw or " spur " of the backward-turned big toe is uncertain. It is actually longer then the rest of the toe, and one would think that it cannot be of great advantage among the grass. The ordinary flight over the ground is strong and swift, seen at its best in the winter. When we come suddenly upon a lark we see the deep crouching of the body which precedes the rapid leap into the air. But it is the soaring that is so particularly admirable. The wings beat up and with great rapidity, the usually backward component of the stroke being suppressed. The bird begins to sing when a few feet off the ground, and continues as it rises.

" The blue deep thou wingest,
And singing still dost soar, and soaring
ever singest."

The ascent continues till the bird is a speck in the sky or quite invisible ; but the singing goes on. After drifting about a little, it may be, the bird suddenly begins the descent—a series of drops with outspread wings, often interrupted by brief hovering ; but the singing goes on. When he is a few feet off the ground the songster

Photo : G. Hearn.

SKYLARK BRINGING FOOD TO YOUNG.

When the parent Skylark comes to the nest with food in its bill, the young ones open their mouths widely. This gaping, well shown in the photograph, is a reflex action, just as the subsequent swallowing is ; and the hereditary engraining of the reaction saves much time and trouble.

Photo : G. Hearn.

SKYLARK FEEDING THE YOUNG.

A continuation of the previous photograph shows the parent bird inserting its bill into the gaping mouth of its offspring and thus making sure that the food is gripped. There is no fumbling ; all is precision ; and yet the process takes place very rapidly. The quicker the better, since the business of feeding directs the eyes of enemies to the nest.

stops singing, and drops to earth, or darts off hoizontally till he is lost in the herbage.

There are many birds that decrease in numbers as agriculture spreads, but it is otherwise with the lark. It is a lover of open places ; it often nests in the growing corn, where it is particularly safe from molestation. We have spoken of its varied menu and its inconspicuousness of colouring—both making for success in life. Then, a pair of larks may have several broods in the season, so that, as Professor Newton calculated, " their produce on the average may be set down as at least quadrupling the original stock." Of course there is stern sifting by man and severe weather, by stoats and weasels, cats and rats, hawks and crows, but larks work with a large margin, and they are more than holding their own. Long may this continue ! In a general way the lark may be called a resident bird in Britain, but it is more accurately termed a " partial migrant." There is a great deal of coming and going, and the migration phenomena exhibited by larks are of unusual intricacy. One of the striking facts is the autumnal arrival of enormous flocks from the Continent, the stream sometimes continuing for several days. But we have perhaps said enough to indicate the general Natural History of a universal favourite.

Desert Animals

One of the well-defined haunts of life is the desert—an arid tract such as is suggested by the names—Gobi, Sahara, Kalihari, and Arizona. Vast areas these deserts are, covering, according to some authorities, about a fifth of the earth's dry terrestrial surface, but their population of plants and animals is so relatively meagre that we cannot regard them as constituting more than a minor haunt of life. Our first wonder is that they are peopled at all, for the conditions of life that they offer are very inhospitable ; but Animate Nature abhors a vacuum. In other words, the struggle for existence is so keen that every corner of earth and water is explored. There are two or three animals in the intensely briny waters of the Great Salt Lake, and the great abysses of the ocean are well peopled ! We wish to use Dr. P. A. Buxton's very interesting study, " Animal

Life in Deserts" (London, 1923), in answering the question: How are desert animals fitted to meet the peculiar conditions of their environment?

The largest of deserts is that which extends, almost continuously, from the Atlantic coast of North Africa to North-West India and the heart of China; and second to that comes the desert interior of Australia. What does such a desert imply? A desert means (1) great drought or aridity, but this is not inconsistent with a considerable rainfall in the course of the year; it means (2) the occurrence of great extremes of temperature—for it may be very cold as well as very hot; and it means (3) a marked contrast between the low relative humidity of midday and the high relative humidity of the night; it means (4) the rise of violent winds laden with sand and dust; it means (5) excessive evaporation and unusual exposure to sunlight. But Dr. Buxton is right in emphasising the fact that what makes the desert so unfriendly to life is the occurrence of terrible extremes. The maxima and minima tell.

When we shut our eyes and say "Desert," we see great stretches of sand dunes, with here and there a clump of palms, a camel, and a vulture. But everyone knows that many deserts are not sandy. The surface may be covered with gravel or with sun-baked clay, as well as with sand, and there may be stretches of bare rock. It is safe to say, however, that a desert is an area with bad drainage, where most of the water is wasted, and that a desert is characteristically destitute of decaying vegetable matter or humus, except in the oases.

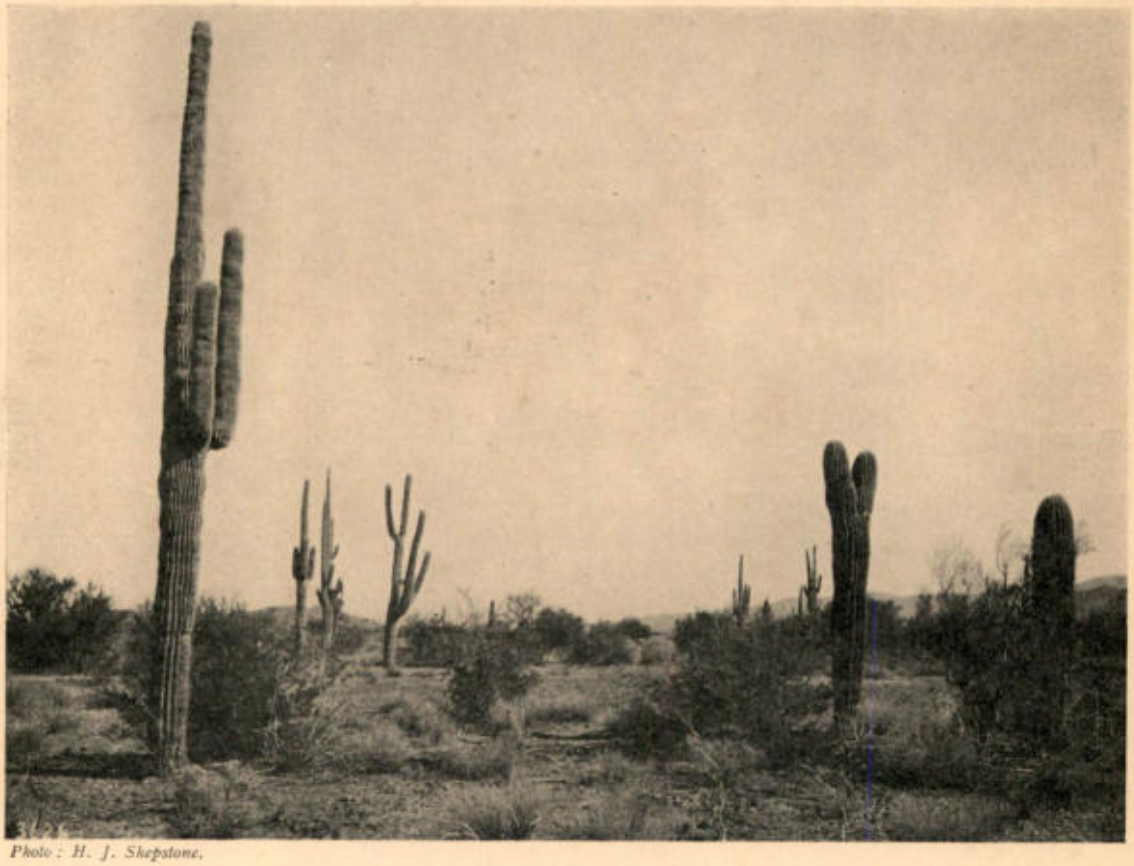


Photo: H. J. Shepstone.

THE GIANT CACTUS.

The Cactuses (Cactaceæ) are, with one exception, New World desert plants, with their headquarters in Tropical America. Their place elsewhere, especially in South Africa, is often taken by Cactus-like Spurges (Euphorbias), which are not nearly related. In most Cactuses, in adaptation to desert life, the leaves are suppressed and the green stem tends to be cylindrical; there is a thick cuticle that lessens the loss of water vapour; the green rind does the work of leaves, such as sugar making; the interior of the stem serves for water storing. There are many spines or prickles, as in the Prickly Pear which has been introduced into many countries. The Giant Cactus, often called the Candelabra Cactus, is common in the great deserts of Colorado and New Mexico.

The plants of the desert are in many different ways adapted to the difficult conditions of life. Some have great powers of storing water, which is greedily absorbed when the rains come; and they are helped to secure this by having a vast system of shallow roots. A single cactus, sixteen feet high, may contain thirty gallons of water. Some reduce their foliage to a minimum and accomplish their photosynthesis or manufacture of food by the green surface of their rotund stems. This dispensing with leaves lessens the loss of water by transpiration. Others have very thick cuticles which are often wax-varnished, waterproofs that keep the water in, not out. Others lie low for a great part of the year. There are other adaptations among desert plants, but it is with the desert animals that we are chiefly concerned.

Photo: E. J. Manly.

WEST AFRICAN JERBOA.

The long and powerful hind-legs, and the short, insignificant fore-legs, led to this family of desert animals being called Dipodidæ, or "two-footed." The Jerboas have an immense range, being found in sandy deserts and grassy plains in Asia, Africa and Europe. They are burrowing animals, feeding by night, and, like the kangaroos, able to cover an extraordinary distance in a single leap.

Just as many desert plants have their periods of activity and passivity, so is it with some of the desert animals. Thus Mr. Buxton made careful observations which showed that many different kinds of insects, which are often linked more or less closely to plants, have two periods of vigour—one in the relatively clement spring and the other in the relatively temperate autumn. At between times they lie low, in many cases very well hidden. *This is their only chance.* To illustrate the sensitive way in which the productivity as well as the vigour of animals may respond to the environment, he cites, from Professor Baldwin Spencer, the interesting case of a small mouse-like marsupial, Sminthopsis, of the Central Australian desert. In good years and in seasons of plenty this little creature has ten young ones in its skin-pocket or marsupium, but in bad years and in prolonged drought it has only four or five. Similarly, a desert bird may have two broods in a wet year and only one brood in a dry year. The population often adjusts itself automatically to the means of subsistence.

Perhaps the most attractive of desert animals are the jerboas, long-legged, long-tailed, three-toed, sand-coloured rodents that have become thorough-going bipeds. We studied one once at a dinner-party in Africa, and it remains in our memory as the most agile animal we have ever seen. It was a joy to see the way in which it cleared glasses and flower-vases and cruet-stands without upsetting anything but the gravity of the diners. We cannot imagine any bird or beast of prey catching a jerboa, for it seems always to be changing its mind as to where it is going; its hops are prodigious, and it disappears like a dry leaf before the wind. Now, it is very interesting that the jerboa-like type occurs in three other families of rodents, such as the gerbils, and also in two families of marsupials. It must have been evolved at least five different times, probably in indirect response to desert conditions.

A dominant difficulty in the desert is to get something to drink. Living is a very watery business, for protoplasm or living matter usually contains at least 70 per cent. of water. Where is this to come from when there is not a drop to drink? Some gazelles and antelopes are total abstainers, outdoing the Rechabites, for they do not even take water. As a matter of fact, their virtue is a necessity, for there is no liquid refreshment of any kind available. This raises a genuine scientific difficulty. How can they do without water, which is essential to life?

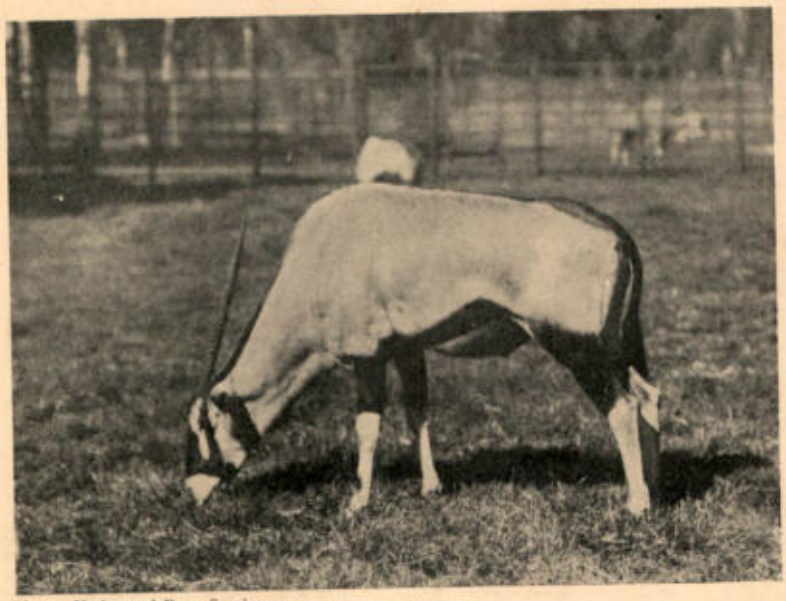


Photo: Underwood Press Service.

ORYX OR GEMSBOK (*Oryx capensis*).

The Gemsbok got its name because it suggested the chamois or gemse. It used to be common in Cape Colony, but it has retreated into the Kalahari Desert and Damaraland. It is yellowish above, whitish below, with black markings on head, legs, and flanks. The almost straight horns, slightly longer in the female, may be a yard in length. Ancient figures of the horns, one eclipsing the other, as in the photograph, may have helped to bolster up the unicorn myth. The Gemsbok is very swift, and it can give a good account of itself against enemies or rivals.

Particular solutions of the drought problem are well known. Thus the camel, setting out on a journey over the desert, takes an enormous drink, and fills up a set of "water-cells" in its so-called stomach and subsists on that supply till it reaches the first oasis. It is probable, however, that the fluid in the camel's "water-cells" is sometimes derived from the sap of the vegetable food.

Another solution is that desert animals may sip the dew, and instances of this are known. On the whole, however, the desert is not a place where one looks for ilka blade o' grass bearing its ain drap o' dew.

In most cases the answer to the question: "Where do desert animals get their water?" must be that they get it from their food. Whether the food is vegetable or animal tissue it contains a considerable percentage of water; and it is possible that in some cases the modicum may be added to in the course of the chemical processes associated with digestion. One must remember that many desert plants are succulent, that a single cactus tree may store hundreds of gallons of water, that many of the rodents feed on roots and bulbs which are very sappy, and that birds think nothing of flying a long way to an oasis. Mr. Buxton cites Meade-Waldo's very interesting observations on the sand-grouse. The adults fly to the watering-place, but what are the young birds to do? It has been observed that the male puts his breast plumage into disorder by rubbing it on the ground, that he then gets into the shallow pool and saturates his feathers, and that the young birds dry them in their mouths. "The young pass the feathers through their bills, and keep changing places until the supply becomes exhausted. Until they can fly they take water in no other way."

Next to drought, the greatest difficulty that desert animals have to face is connected with the extreme heat of the day and the frequently intense cold by night. For our present purpose the injuriousness of light-glare need not be separated from the danger involved in extremely high temperature. Birds and mammals have their special advantage in being "warm-blooded," that is they can automatically adjust their internal production of heat (from the muscles mainly) to their external loss. This adjustment is obviously life-saving. Moreover, we can understand why it is profitable for birds that have wintered in the tropics to fly northwards to breed, since the temperature-regulating

Photo: H. M. Bell.

MALE PERSIAN GAZELLE (Gazella).

Gazelles are small antelopes of Africa and Asia, well known for their gracefulness. The usual colour is sandy, with white below; often with streaks on the face and flanks. The eyes are very fine. The ringed horns are usually present in both sexes.

Photo: Martin Johnson.

THOMSON'S GAZELLE.

Commonest of all the antelopes in British East Africa, Thomson's Gazelle is abundant in the Kenya country. In colour it is a light fawn, running into white below, and the dark lateral band is very noticeable. Both the male and female have horns, as is usual in the antelope tribe.

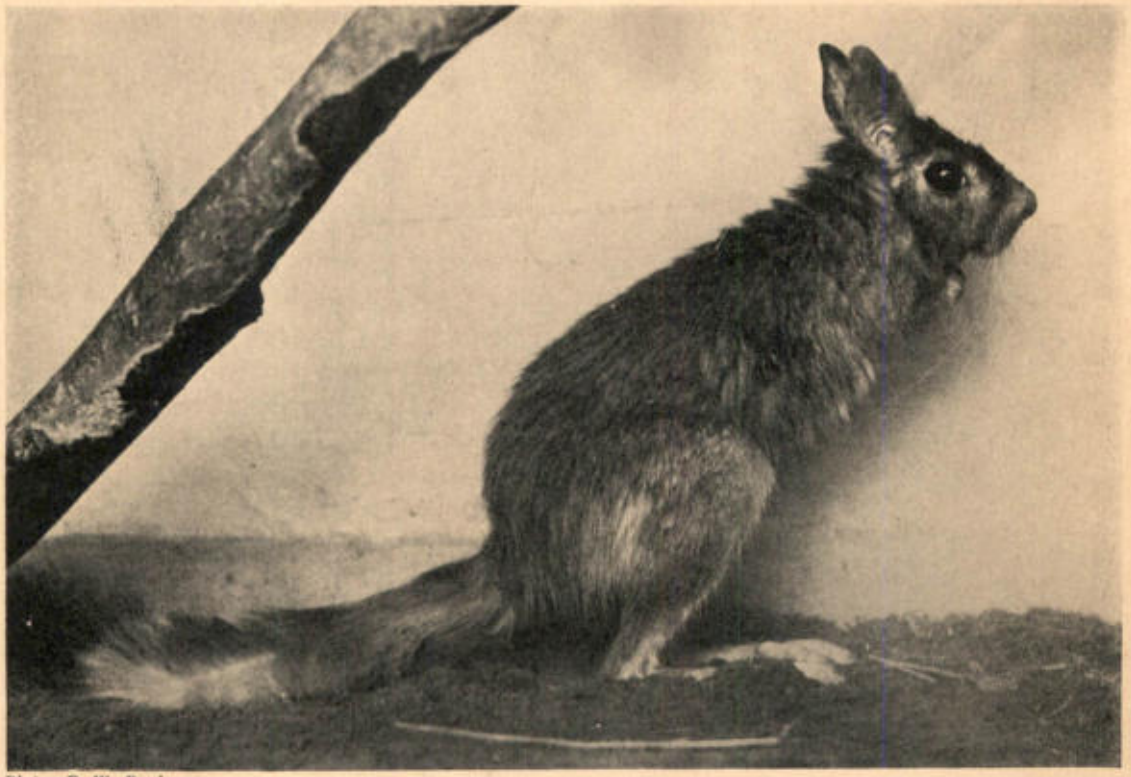


Photo : F. W. Bond.

CAPE JUMPING HARE (*Pedetes caffer*).

The Spring Haas, as the Dutch call this animal, is not a Hare, but nearer the Jerboa family. It is found over a wide area of country, from the Cape to as far north as Angola. The hind-legs suggest those of a Kangaroo, and the animal—well named Springer—is able to cover as much as thirty feet at a single leap. It is a burrowing rodent and feeds at night on many kinds of plants ; it sometimes trespasses in gardens. The flesh is palatable. The photograph brings out the large eyes and ears, and the long tail, which may be over seventeen inches long—as long as the body.

arrangements are imperfectly established in the nestlings, which would therefore be apt to die miserably in great heat.

There are other adaptions to be thought of—the closing of the nostrils to keep out the blown dust ; the broadening out of the feet, on the snowshoe principle, in various types from lizards to camels ; the burrowing habit by which some animals, such as snakes, avoid the extreme glare and heat of midday or the extreme cold at night ; the cultivation of the crepuscular habit ; the disappearance of wings in many insects of storm-swept regions. Sometimes the adaptation is structural, such as the evolution of a hard snout or rostrum in various burrowing snakes. Sometimes the adaptation affects habit, as in the case of several desert birds, like larks, which invariably place their nest on the windward side of a small bush, because sand settles in the relative calm of the lee. In some cases they then proceed to fortify the outer side of the nest with a mass of pebbles, thus forming a wind-screen. Here, as everywhere, we see life triumphing over matter.

We have spoken of the fitnesses of desert animals, and now we wish to consider their colour by itself. The rather curious word " isabelline " is widely used to denote the reddish-buff or sandy-grey colour which is characteristic of the animals that live in deserts and of those in happier countries that spend much of their time on naked ground. Whether the desert be covered with sand, gravel or sun-baked clay, or show great stretches of bare rock, the negative feature is the absence of continuous vegetation stretching over the ground ; and the general fact is that the animals are inconspicuous, just like a hare or a partridge on a ploughed field. It is not that the sandy colouring is simple, for in the majority of cases the appearance of uniform " self-colour " is attained by complex means, by intricate mottling and graining. Anyone who peers into the fur of the wild rabbit will see what a subtle mixture it

Sandy-coloured Animals.

is—equally inconspicuous on a considerable variety of backgrounds, and very different from a piece of brown paper. Whatever may be the origin and value of sandy colouration, it is certainly inconspicuous; and this is enhanced when the under surface of the animal is pale compared with the upper parts.

In all the deserts of the world, the same sandy or buff dress is the rule. It is worn by big mammals like gazelles and small animals like jerboas; it is worn by desert-larks, sand-grouse and partridges; it is characteristic of snakes and lizards. Moreover, among the backboneless animals the same is true—sandy grasshoppers, sandy flies, sandy beetles, sandy spiders, sandy centipedes. The sameness of dress at so many different levels must have a meaning.

It is always interesting to look out for exceptions to a general proposition, and one is rarely disappointed. Some desert insects seem to shimmer in silver or in gold—an effect due to numerous fine bristles of a pale colour. But in many cases these dainty creatures are not in the habit of settling on the ground and are very inconspicuous as they flit about or hover in the air. Another exception is the occurrence of some black animals, such as beetles of the mealworm family. It is probable that these are recent colonists from outside, and it is noteworthy that many of them are nocturnal. On the other hand, there is no blinking the fact that some big black beetles are conspicuous animals on some parts of the great Palæarctic Desert, which stretches from the Atlantic Coast of North Africa to Mongolia. The "scarab" beetle is black and certainly not inconspicuous. Blackness also occurs in some other desert insects—for instance, among flies and grasshoppers. Moreover, ravens are common in the desert; there are many black and white wheatears and chats; the spiny-tailed lizard is sometimes very black; and there is a conspicuous black and grey weasel on the South American pampas which sometimes fade into desert. If one is committed to the theory that sandy colouration is a matter of life and death for most desert animals, one is bound to search for special reasons why a small minority can afford to be black; and

Photo: F. W. Bond.

ARABIAN DESERT FOX (*Vulpes zerda*).

The Desert Fox or Fennec is found on both sides of the Red Sea. Compared with other foxes, it is a small creature, being not more than a foot in length with a tail of about six inches. Its immensely long ears testify to its keen powers of hearing. Small as it is, the Desert Fox has all the pluck of its British cousin. It feeds largely on insects, such as beetles and grasshoppers. It differs from other foxes in its liking for sweet food, such as dates. It is also fond of eggs. No doubt it is the Fennec that figures in the old fable of the "Fox and the Grapes."

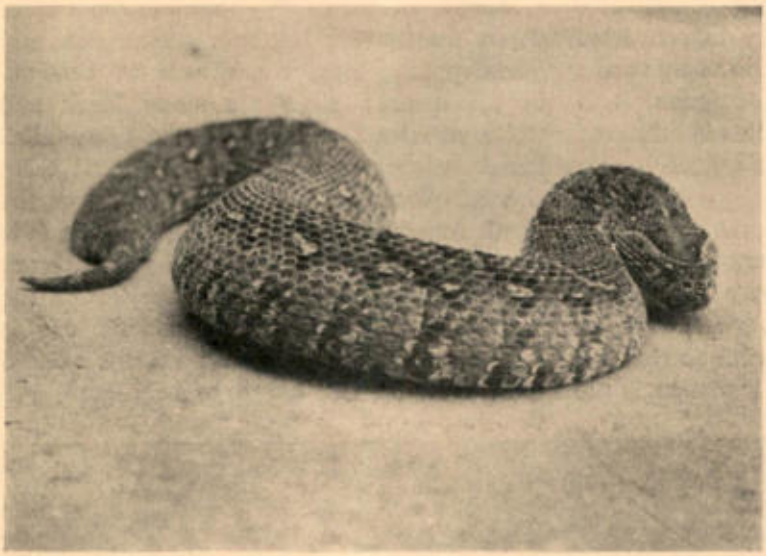


Photo: W. S. Berridge, F.Z.S.

THE PUFF ADDER (*Bitis arietans*).

To be found almost all over the African continent, and in Southern Arabia, this repulsive snake may attain a length of five feet. Its name is derived from the habit, when angry or alarmed, of drawing in its breath and causing its body to swell, when it allows the air to escape, producing a loud warning noise to its enemies. Lying hidden in the sand, only its head exposed, the Puff-Adder is a danger to even the largest of mammals, which quickly succumb to its deadly poisonous bite.

these special reasons are apt to be a little far-fetched!

In his admirable study, "Animal Life in Deserts," Mr. P. A. Buxton tells us of a patch of ground in Baghdad where one could always be certain of finding at least a score of Egyptian Nightjars: "Though the ground was absolutely bare, and though I visited the place repeatedly, I never succeeded in detecting a Nightjar before it flew, and this in spite of the comparatively large size of the bird. We must admit it as a fact that the prevalent colour of desert animals does render them most difficult to see so long as they remain motionless."

But while the sandy colouring makes the creature inconspicuous, it is a different proposition to say that the sandiness is therefore of "survival value" as a protection. Each case of apparent life-saving protection must be judged on its own merits and tested in some experimental way. And even if it be *proved* that sandy colouration does sometimes save the animal's life by giving it a cloak of invisibility, there is much force in Mr. Buxton's argument that this cannot be said to work as an *all-round* interpretation. For some of the sandy animals do not require to be protected against any enemy; some of them are conspicuous whenever they begin to move; some of them are nocturnal and others are burrowers. What one would like to get at is some deeper, more general, physiological reason why sandy colouration should be so characteristic of the desert; or, to put it in another way, why brilliant colouration is conspicuous by its absence. With a physiological basis to start with, we should then feel more confidence in discovering

Photo: Stanley S. Johnson, M.A.

THE COMMON SKINK (*Scincus officinalis*).

A small lizard, seldom exceeding a length of five inches, the Common Skink is found in the desert regions of North Africa. Though very well adapted for sand-burrowing, unlike the mole it does not find its food below the surface; but basks in the sun, on the hot, dry sand, pouncing with lightning-like rapidity on flies and other insects. It burrows in the sand immediately danger threatens.

Photo: F. W. Bond.

RAVEN (*Corvus corax*).

The largest and cleverest of the crows, becoming rare in Great Britain, but still common in desert regions. It kills small mammals like rats and rabbits, but is fondest of carrion. The bulky stick nest is oftenest built on a cliff, and is comfortably lined inside. The voice is a deep croak; there is an interesting somersaulting or rolling in the air, especially at courting time.

the advantages of sandy colouring in certain cases.

We cannot think of the desert without thinking of the camel, which is certainly one of its most characteristic tenants. One of its conquerors we may say, for the fitnesses of the camel to desert life are many. Long limbs and freely moving thighs make for speed—150 miles a day for four days on end, and ten miles an hour when the camel pleases. The hoofs are reduced to nail-like structures, and the two digits (numbers three and four), which lie very flat on the ground, are supported by cushion-like pads, suited for shuffling over the desert. Moreover, the lower end of the cannon-bones (the fusions of the two palm bones in the fore-limb and of the two instep bones in the hind-limb) diverges into two knobs which have lost the usual keels that restrict sideways movements of the digits. Thus it is that the two toes yield and spread out in a splay-footed fashion, thereby tending to keep the heavy animal from sinking deeply into the sand.

The Camel.

The camel has two humps, the dromedary has one, consisting of gelatinous fat, and this means a reserve for a desert journey. In evil days the quaint excrescence sinks down flaccidly on one side, the camel being most dejected when it shows least hump! Also noteworthy are the water-reservoirs in the wall of the paunch, about 800 little flasks with a closing muscle round the mouth of each. They are filled automatically when the camel slakes its thirst or when there is fluid sap in the paunch. "In time of water scarcity," Professor Lull writes, "the stored liquid is allowed to trickle out into the stomach and is thence available for the impoverished blood." Here it may be mentioned that while camels chew the cud they resemble the

old-fashioned chevrotains or deerlets in having only three chambers in their " stomach " instead of the usual four. The ordinary third chamber, the " manyplies " of sheep and cattle, is only hinted at. Perhaps it is beginning, or is it disappearing ? The cheek-teeth are well suited for grinding the rough herbage, which forms a large part of the camel's diet.

The head is carried high, and thus the eyes are removed from the ground-reflected heat ; the lashes are long and keep out dust ; the ears are stopped with hair, and the nostrils can be closed against the driven sand ; the camel is long-sighted, and it scents water from afar. In short, there are many ways in which the camel has answered back adaptively to desert conditions. And besides details like the tough skin and the callosities on the knees and chest, there is the general virtue of endurance. Thus we read of a hundred well-loaded camels journeying for thirteen consecutive days with absolutely no fresh water. Professor J. W. Gregory cites a case from Australia, where some of the naturalised camels were marched 537 miles in thirty-four days without watering. One must not, of course, make a miracle of such instances, for camels get fluid by picking up plants as they journey.

The consequence of the camel's fitness, and likewise of its usefulness both living and dead, was that man made it his slave. Those that were too rebellious or cantankerous were eliminated ; all work and no play made the camel a dulled beast of burden. No doubt some of them occasionally mutiny and run away, like the " wild " herd in Spain. No doubt they protest continually, grumbling and growling, biting and kicking. Perhaps, as Mr. Henty says, they have cultivated ill temper until it has become a form of enjoyment. It almost seems as if they had formed a sort of Camel Union, one article in the constitution being that no transport camel's pace shall ever exceed two and three-quarter miles an hour ; and another that if man will ride on them he shall know how " the ship of the desert " can roll. It does not appear to be true that the last straw breaks the camel's back, for if the burden is too heavy the camel will not even attempt to rise. But the sad admission must be made that man has engendered in the camel an obstinate " dourness." Man gives it no affection, and this is reciprocated. No artist would call a camel ugly, but it gazes at the world with a bored contempt, with a " sculptured sneer." On the other hand, as it ruminates, it sometimes seems as if it were preoccupied with some precious thought, such as that Camelidæ are the only mammals with elliptical red blood corpuscles. Camels are aristocrats in chains.

Uncertainties still obscure the story of the domestication of the camel and the dromedary. We do not know the where or the when. The two kinds will inter-breed, the mule having the single hump of the dromedary and the brown, shaggy coat of the Bactrian camel ; but a separate origin from two wild species is practically certain. The camel probably arose more to the North, between the desert of Gobi and the plateau of Iran. The dromedary's headquarters were probably in Arabia and North Africa. Both have had a long servitude, but, perhaps, for the beasts, that is better than extinction. There are certainly no wild dromedaries nowadays and it is very doubtful if there are any wild camels. There are the famous herds of Lob-nor and Turkestan, but it is very likely that these should be called " feral," which means escaping from domestication into wildness.

The race of camels began in North America millions of years ago, in the Upper Eocene Age. It began with a little creature called Protylopus. It was no larger than a jack-rabbit and had four digits, but Nature waved her wand and said : I shall make a big thing out of you. So, as millions of years dragged their length along, there arose in the Oligocene another pioneer camel, Poëbrotherium, which attained to the stature of a sheep and had almost quite lost the second and fifth digits on each limb. In the Miocene came the two-toed Procamelus, rather bigger than the modern llama, which is the camel's second cousin. The Pliocene saw the advent of Pliauchenia, and in the Pleistocene there were herds of camels which trekked across the Behring Strait bridge to Europe, leaving North America with no living representatives, but with a glorious graveyard of camel-like progenitors. And yet some people in America have the effrontery to say that they do not believe in evolution !

Characteristic of deserts in warm countries, or well-sunned waste places, as in the South of

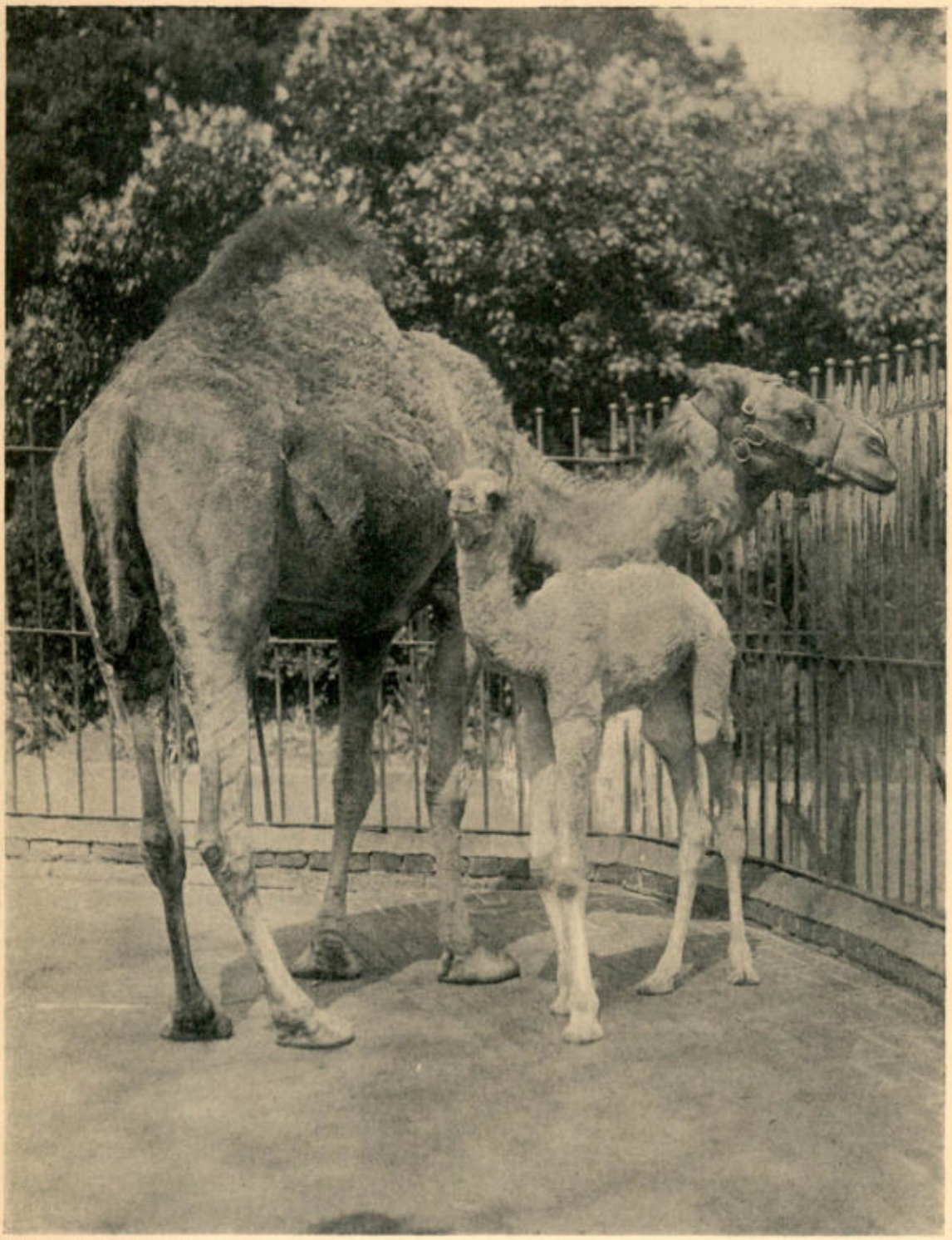


Photo: W. S. Berridge, F.Z.S.

DROMEDARY AND YOUNG.

The Dromedary or one-humped camel (*Camelus dromedarius*) is Arabian and African, but has been imported into other countries. It stands about seven or eight feet high at the shoulder, while the Bactrian Camel is distinctly larger. But there is considerable diversity of size and colour. Pure white Dromedaries are greatly valued.

France, is the tribe of scorpions. They are very unlike most other animals. If one's acquaintance with mammals were limited to such typical representatives as dog, horse, and rabbit, one might have some difficulty in recognising that bats and porpoises are also mammals. If one had been brought up among ostriches and knew them as birds par excellence, one might be a little puzzled in applying the same name to a storm petrel or a humming bird. But whoever has once looked for a vivid moment at any kind of scorpion would recognise instantaneously every other kind. There are many different genera, but scorpions could not be confused for a moment with spiders or with lobsters or with insects. The differences between one kind of scorpion and another are within a narrow radius.

Scorpions.

What are the distinctive features? The head and the thorax have coalesced, and are covered dorsally by a hard "cephalothorax" shield bearing several pairs of simple short-sighted eyes. The posterior body or abdomen consists of seven broad rings and five narrow ones, behind which there is a sharp-pointed sting. Like other spiderish animals or Arachnids, the scorpion has no feelers, though it is one of the most sensitive of creatures to everything that can be touched. In front of the mouth is a small pair of pincers (chelicerae) for holding the food close or for tearing it to pieces. Second, there is a pair of large clawed appendages (pedipalps) for seizing the food, for fighting with, and for "joining hands" when two mates indulge in their remarkable "promenade à deux," as Fabre called it. Then come four pairs of walking legs; and on the front of the under-surface of the abdomen there is a pair of curious combs (pectines) that are very tactile, and feel what the scorpion crawls over. Behind these combs can be seen four pairs of oblique slits leading into the purse-like lung-books which are suited for breathing dry air.

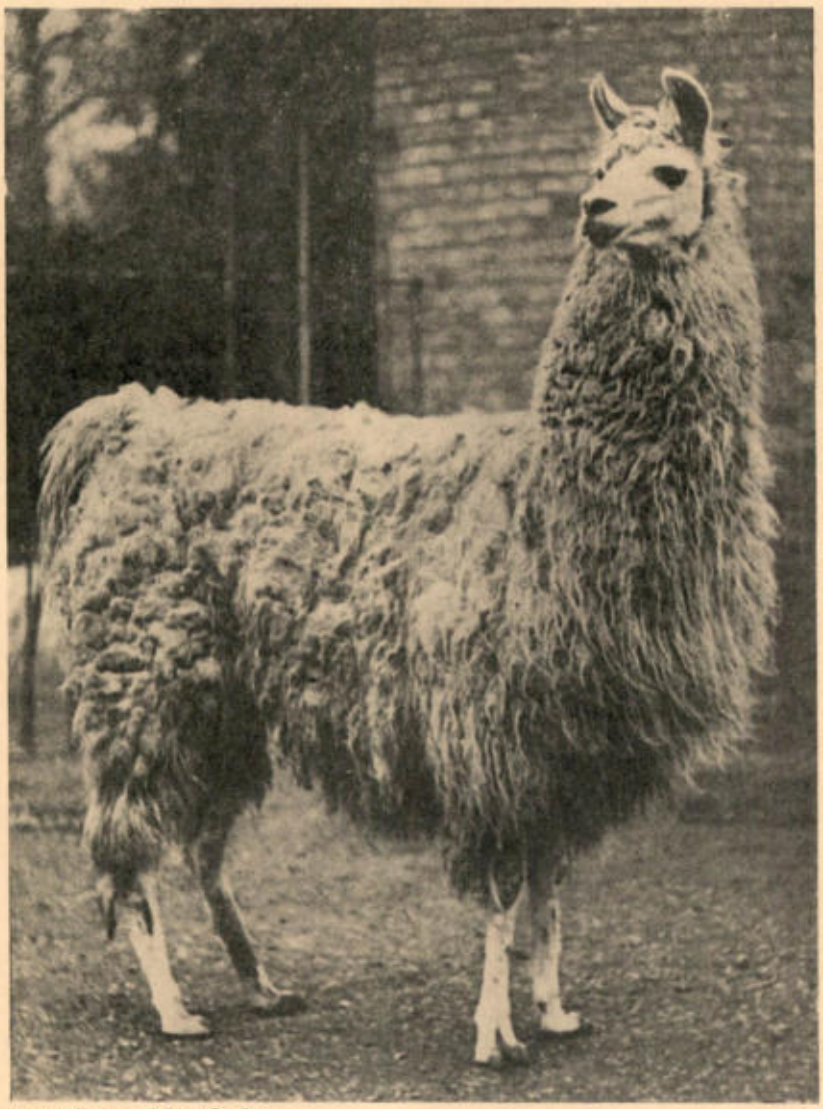


Photo: Underwood Press Service.

THE ALPACA.

Both the Llama and the Alpaca are domesticated forms of the wild Guanaco, a member of the camel tribe, which shares with the Bactrian Camel its ability to thrive on salt water. It is found in the barren mountainous districts of Bolivia and Peru.

Photo : Martin Johnson.

WATERING CAMELS IN THE GAZOOT DESERT.

Mr. and Mrs. Martin Johnson spent two years in British East Africa photographing wild animals in their natural state, with excellent results. One of their greatest difficulties was to secure adequate water supplies, and the photograph shows the camels of the caravan slaking their thirst at a hole which has been dug over the dry bed of a stream. After satiating its thirst the camel is able to go without water for many days. They get some moisture by picking up plants on their journey, and the fluid drained off from their food is stored in peculiar chambers (" water-cells ") on the wall of the paunch.

The whole body is strongly armoured with a non-living cuticle or armour of chitin, and on strategic places there are numerous touch-bristles.

Scorpions are children of the desert and able to do without water. That is to say, they obtain the necessary fluid from the insects and spiders on which they feed. They move quickly, with the tail usually upraised, rarely trailing ; they catch their booty with their pedipalps, and if there is a struggle the sting injects poison. They seem to care more for the juices than for the solid parts of their victims. Like many spiders, they can survive for months without eating anything. In natural surroundings, however, they prefer cannibalism to fasting, and Fabre notes grimly that if two scorpions are found under the same stone the one is always engaged in eating the other. Sir Ray Lankester cites an experience recorded by the old naturalist Maupertuis. He had 200 scorpions in a cage in the South of France, and had to leave them to themselves while he obeyed a summons to Paris. On his return he found one plump scorpion in the box, surrounded by the disjecta membra of the others. " The survivor was in the position of Gilbert's ancient mariner, who said that he was ' the cook and the mate, and the captain's boy and the crew of the Nancy brig.' "

Scorpions hunt in the twilight and darkness, trusting to their tactility. They lie in hiding during the day under stones or in holes. But, like many animals that avoid the light of day, they are " attracted " at night to the abnormal glare of a camp fire. This is one of the " moth and the candle " phenomena.

The venom of the scorpion is manufactured in a double gland inside the tip (or telson) of the tail, and it is injected into the victim through two minute holes at the sharp down-curved point, which is thrust upwards and forwards in the actual stroke. The poison has a very rapid

Photo: Martin Johnson.

THE ELAND (*Orias canna*).

The largest and most ox-like of all the antelopes, the Eland, often weighs as much as one thousand pounds, and may stand from five to six feet high at the shoulder. Its horns, larger in the cow than the bull, may attain a length of thirty inches. The gentle and unsuspecting disposition and the palatableness of the flesh, have led to a great reduction of the Eland's numbers on the plains.

Photo: Martin Johnson.

FEMALE GERENUK.

This peculiar animal, somewhat suggestive of a giraffe in the length of its neck and strange gait, is found in bushy country in Somaliland. It stands about three feet high at the shoulders and the horns, which are confined to the male, are about thirteen to sixteen inches in length. The Gerenuk is said to be able to live without water as such, getting sufficient moisture from the grass and herbage.

paralysing action, and it may produce serious symptoms in man, though the name Androctonus (" man-killer ") of one of the worst kinds is not to be taken too literally. The old story about scorpions committing suicide, when surrounded by a ring of fire is not good Natural History. In the first place, it is not certain that they could thus wound themselves, unless they managed to insert the sharp tip of the sting between two joints in their armour. In the second place, even if they could wound themselves, the poison would not be injurious ; for they have in their blood, owing to the normal absorption of small quantities of the poison from the glands, an anti-body or counter-active which neutralises the effect of an experimental injection, and would do the same in the case of an attempt at suicide. In the third place, they do *not* sting themselves ; the suicide does not happen ! Even when they fight savagely with one another they use the pedipalps and do not sting. It should be recalled, however, that experiments made by Sir Ray Lankester showed that scorpions surrounded by a ring of fire rush about for a little and then " faint." That is to say, they pass, as many endangered animals do, into a fit-like or cataleptic state of rigidity, from which they recover if the crisis is safely passed.

Photo : F. W. Bond.

IMPERIAL SCORPION (*Pandinus imperator*).

Scorpions, which are distant relatives of spiders, are widely represented in dry, warm places. They are nocturnal animals, feeding mostly on insects, which they pick to pieces and hold close to the mouth. The largest Scorpion is about eight inches long, the smallest under an inch. The young ones are fully formed at birth, and often clamber on the back of their mother. The sting at the end of the tail is used if the insect-victim offers strong resistance.

The two sexes of scorpions are almost quite the same, except that the male has larger combs. Fabre has given a picturesque account of the mating. The two scorpions stand face to face and raise their tails upright over their bodies till the two stings touch. The male clasps the female's pedipalps with his, and bids her come along. He walks backwards ; she has to follow. Often the way is long and the promenade lasts for an hour or more. At length, without letting go his hold, the male burrows backwards under a flat stone and the two of them disappear into the retreat. The male's usage seems to be somewhat rough, and he often pays for it with his life. For after the consummation, as Fabre observed, the female often devours her mate. Her tender mercies are cruel.

Scorpions pass through their slow development within the mother, and they are fully formed when they are born. Thus scorpions are usually described as viviparous. It should be noted, however, that Fabre's account of the matter is that what pass from the mother are fully formed miniature scorpions that are still wrapped up in their egg-envelopes. With fastidious care the mother scorpion tears off the egg-membrane and thus liberates the delicate miniature. In the Languedoc scorpions the new-born offspring are about three-eighths of an inch long, the adults having a length of over three inches, but the new-born little creatures are quite perfect in structure. They climb up the appendages and settle down on their mother's back, apparently gripping the bristles with their claws. There may be two dozen of them entangled on the mother ; she is " clad in her children " and greatly resents any interference. For the first week they do not feed at all, yet they grow larger, doubtless through internal utilisation of reserve food and through rearrangements of molecules.

This growth necessitates a first moulting, during which the cuticle comes off in shreds. The young ones are now able to move about on the mother, and it is reported that they share her meals. They go on growing and moulting, but the later moults differ from the first one in being very neat. A single crack or fissure occurs in the region of the cephalothorax, and it is through this that the body is carefully extricated, leaving a ghost-like husk behind. A mother scorpion may carry two dozen young ones on its back—one of the many quaint experiments in parental care; and a rather pretty point is that after the young ones have ceased to be carried about they sometimes betake themselves to the old retreat when danger threatens.

It must be noted, however, that scorpions are animals of some individuality, each species "itself and no other," so that the accuracy of Fabre's account of the Languedoc scorpions is not impugned if the life-history of other species turns out to be different in detail. Here is one of the many opportunities for fresh observations. But as regards this "New Natural History," we are simply interested in showing that scorpions are characteristic examples of the fauna of the desert, and are well adapted to holding their own in that inhospitable environment.

LI

THE TROPICAL FORESTS

THE vast forests of the tropics form a girdle round the globe, and in many ways they are alike, whether they be in Africa, in America, or in the East. In some regions, where there is a definite dry season, the trees shed their leaves and there is a resting-time, as in our own winter, till the rains return and the new leaves appear. But in hilly areas near the equator, where there is almost daily rain, there are great stretches of evergreen forest. Here the climate is one long moist summer. It is always hot and always damp—ideal conditions for the growth of plants.

The trees of the rain-forest grow to an immense height, and form a dense canopy under which the air is always heavy with moisture, indeed it is almost stagnant, for no storms penetrate the thickest parts of such a forest, so that there is little movement in the air. The light is dim, and there is a weird stillness below the canopy. The forest seems to be "built in flats." On the ground there are shade-loving shrubs; above them woody climbers struggle ever higher towards the hidden sun, many of them beginning their race for light and air not from the ground, but from nooks and crannies in the trees. Among the rope-like stems of the climbers are layers of ferns and perched plants, or even parasites, fastened on the branches of the trees; moss and lichens shroud the stems and branches, and even the leaves are veiled with minute algæ like those that make our gate-posts green in muggy weather. Seen from below, the canopy looks green and brown, but in reality it is the home of many vivid orchids, that, hoisted on the shoulders of the giant trees, can flaunt their glowing blossoms in the sun.

Sometimes the plants that grow on other plants, and live at their expense, become so strong that the overburdened tree beneath gives up the struggle and dies. That is what happens in the case of the parasitic fig-tree. A tiny plant sprouts from a seed lying in the fork of a tree, and begins to send down long roots to the ground. These long suckers form a network round the trunk of the supporting tree. They reach the ground, and after a time become strong and woody. The smothered tree dies at last, and rots away, leaving a trellis-work fig-tree in its place. The strands of the trellis fuse together gradually, till the fig-tree comes to have a huge solid trunk, one of the forest giants.

The Parasitic Fig-tree.

Where the loaded branches of the trees make so dense a canopy that the sky cannot be seen at all the underwood becomes more scanty. There

Photo: T. Alexander Barns. RAPHIA PALMS (*Raphia vinifera*).

This beautiful Palm, sometimes called the "wine palm," is a native of Central Africa, and grows best on the open shores of lakes and rivers. Its stems yield an abundant sap, which is collected by the natives and fermented into a sort of wine. The fine group here shown was photographed in Southern Congoland.

are thirty-foot striplings in thin ranks, allowing one to see for a considerable distance along the dim glades of the forest, while under them the ground-growth is very low, or even in some places absent altogether. In the darkest spots the forest-floor is covered merely with a carpet of pale fungi, and a scattering of dead leaves from the giants overhead. But where the canopy is incomplete, and sunlight penetrates, the underwood becomes so thick and leafy that one can see only a few feet ahead, and may stumble on some sleeping animal unawares.

There is no grass in the true rain-forest, owing to the lack of sunshine, but where a stream flows or there is a clearing where a tree has fallen, there is a richer plant-life, with coarse grasses like those of the bushland at the fringes of the forests. To these places the animals of the forest are sure to come. In the dense places there are not many ground mammals; those there are must be heavy enough to force their way through the thickets, like the elephant, whose story is told in another chapter, or short-legged like the pigs, and thus able to pass under the bushes.

Although all the tropical forests have much in common, as regards their climate and the way in which the plants grow, each forest region has its own special types of animals. The forests of Africa, of Borneo, and of South America are separated from one another by great oceans, and each of them contains animals not found in the others. One of the most interesting regions is the Ituri forest, of Central Africa, which, as Dr. Cuthbert Christy, the explorer, says, "contains the last remaining and rapidly disappearing representatives of Africa's one-time virgin forest inhabitants, both animal and man."

Photo: T. Alexander Barns.

GIANT FERNS GROWING ON THE SLOPES OF THE RUWENZORI MOUNTAINS.

The native standing below the ferns will give an idea of their height. They illustrate the luxuriance of the tropical vegetation even on the heights.

Here are the big fig-trees; and the tall trees whose red wood is sold as mahogany on the West Coast; and many another huge-buttressed giant. Beneath their interlocked tops deep silence reigns, and the light is as dim as in a great cathedral. But, after a time, sounds of the life of the forest will reach the listener's ear.

"The oppressive silence," writes Dr. Christy, "is now and then broken by the weird Punch-and-Judy like laughs of the noisy-winged Hornbill high overhead, the whirr of the Turaco or Plantain-eater, the hollow rattle of the Colobus monkey, or the echoing hoots and yells of the Chimpanzee. The tap of the Woodpecker may be recognised, or far away the loud, clear-ringing cry of the chocolate-and-white breasted Fishing Eagle, which often enough gives the hunter his bearings as nothing else can do, for the bird never leaves the vicinity of water."

The animals of the forest are always on the look-out for water; not only to drink, but to bathe in. And if the earth at the watering-place

Photo: T. Alexander Barns.

CRYPTOGAM FROM THE ITURI FOREST, EASTERN CONGO.

One of the flowerless class of plants, this Cryptogam is a light fawn in colour, with a "puff-ball" centre. It was found by Mr. T. Alexander Barns, growing on the decaying vegetable matter or humus of the primeval forest.

is saltish, so much the better. Salt seems to be very necessary to the animals, as a tonic, perhaps, or a restorative; and wherever there is a "salt-lick," a mud-hole or a stream-bank with salt in it, the neighbouring thickets are broken by innumerable paths all leading to the same spot. The explorer may not be able to surprise the animals that tread these paths on their way to lick the refreshing salt mud, but he will find their tracks. There will be footprints of monkeys and of leopards and hoof-marks of various shapes and sizes. The soft mud will show the marks of pigs' tushes, and of buffalo horns, and deep grooves where the elephant pressed its tusks against the bank.

Watering-places.

Commoner than "salt-licks," however, are the wallow-holes. A wallow-hole may be just a little muddy pool in the forest, but the animals will find it, and come and lie there for coolness, and to soothe their skins, which are often greatly irritated by the ticks and flies that flourish in the steamy heat of the rain-forest. Bigger watering places—"edo" is the name given to them in Central Africa—are found in open spaces in the forest where a stream makes a clearing. Water-plants and coarse grasses grow along its banks, and buffaloes come for the grass, while pigs come to wallow at the muddy brink, and antelopes to quench their thirst and lick the cool mud. The elephants come through the forest, using their mighty strength to uproot trees and clear a path, and make the "edo" their meeting-place.

The Okapi.

The tropical forest of Central Africa is the home of a rare and little-known animal, the okapi (*Okapia johnstoni*). Rumours had been heard of a strange, shy creature that roamed through the forest; some said it was an antelope, others said it had stripes like

Photo: T. Alexander Barns.

BANANA FLOWER AND FRUIT (*Musa sapientum*).

The Banana is one of the most important food-plants in the world, and many different forms are cultivated in tropical and semi-tropical countries. The fruit is really a long fleshy berry, with practically no seeds in the cultivated forms, which are propagated by cuttings from the underground stem. Above the fruits the photograph shows a number of tubular flowers that do not form fruits.

a zebra, but it was not until the year 1900 that Sir Harry H. Johnston made the okapi known to Science. Even now no one has succeeded in bringing a living one to this country, although one survived for a short time in the Antwerp Zoological Gardens. Perhaps the only people, besides a few daring explorers, who know the okapi really well are the strange Pygmy natives of the Ituri forest. These sharp-eyed, agile little men are expert trackers, but even they find it easiest to catch the wary okapi by trapping it in a pit dug in the ground.

The okapi is related to the giraffe, but the line of its back is not markedly giraffe-like, for the shoulder is very little higher than the croup. Its neck is not very long, but its head is giraffe-like, with large, thin shell-like ears. Its colour, like that of many forest animals, is a deep chocolate or purplish-red, but broken up by white stripes on the hind-quarters and by white on the face and legs. The " horns," which occur in the full-grown male okapi, are similar in shape and development to those of its relative, the giraffe. Some years after the animal reaches maturity the horns, which are then two or three inches long, become firmly fixed to the skull, but they do not remain entirely skin-covered, as the giraffe's do, for they become bare at the tips, showing the bone below. They never have any horny covering such as is seen in the buffalo, they consist entirely of bone. The female okapi, which is hornless, is larger than the male, which is unusual among hoofed animals. The height of a big female from the hoof to the highest point of the shoulder may be as much as five feet, while the length from the tip of the nose to the end of the shortish tail is over seven feet.

The footprints of the okapi are not unlike those of a donkey, but quite unlike the hoof-marks of a buffalo or a forest hog, for the two halves of the cloven hoof separate so little that the division is scarcely seen even on soft ground. It is by the footprints that much of the animal's story is known. By them the tracker can tell when it wandered alone and when it met with its mate. For weeks at a time a pair of okapis will roam about a certain area of forest, perhaps extending several miles, each one going its own way for the most part, but, as the tale of the footprints shows, keeping in touch with one another and meeting every now and then. When there is a calf the parents meet more frequently, or even wander about together, with their youngster beside them.

The okapi does not like swampy ground, it avoids mud and soft earth, preferring whenever possible to tread on leaves. Nor does it like the dense, leafy jungle, for it is not so powerful as the red buffalo, which can force a passage. It chooses rather the well-drained ridges or the high ground near some stream. It roams far during the evenings and the early mornings, but during the day it keeps to the gloomy, silent aisles of the forest where the big trees are biggest, and the canopy so thick that the underwood is thin and upright. When it is feeding it seeks a spot under a big tree, where sounds carry well, avoiding thickets where it might be taken by surprise by its enemies. With an unbroken canopy overhead sounds carry far, and rustling leaves or snapping twigs give warning if anything is coming near. But in the silent depths where " this spectre of the forest " loves to roam there is little to disturb it. The cry of a hornbill or the shout of a chimpanzee will not alarm it, though sometimes it may take fright as an elephant crashes past or a giant forest-hog comes grunting through the gloom.

When the okapi bolts it carries its neck straight in front, or even lowered, just as a running giraffe does, but when it stands listening the neck-line is higher. Its hearing is very acute, and it has a keen sense of smell ; its broken colouring helps to conceal it among the shifting lights and shades of the forest, so it is a very difficult creature to track. When it is surprised it gives a sudden snort or " blow," like the giraffe's, the only sound it ever utters, as it turns and runs for safety. It feeds chiefly in the late afternoon and early morning, on the leaves of young saplings among the underwood. It never eats grass, for, as we have seen, no grass grows in its favourite haunts. Its long, muscular tongue is very well suited for hooking down the leaves. The okapi's kinship to the giraffe must be most clearly seen when it is feeding, stretching up to its full height, with neck extended, and curling its long tongue round the leaves of the trees.

Although dark brown striped with white sounds a somewhat striking colour-scheme, in reality it has great advantages to the animal

Photo : Major H. Radclyff Dugmore.

COKE'S HARTE-BEEST (Bubalis).

The Harte-beests, of which Africa possesses several species, are among the more ox-like antelopes. They are large, rather heavy animals, with little of the grace of the smaller antelopes. They have heavy shoulders, with a distinct hump, and the body falls away behind. The doubly curved horns are about a foot long, crescent-shaped. Unlike most antelopes, which prefer the plains, the Harte-beest may often be found on the rocky hillsides. This very excellent photograph of the animals at a water-hole at night was taken by flashlight.

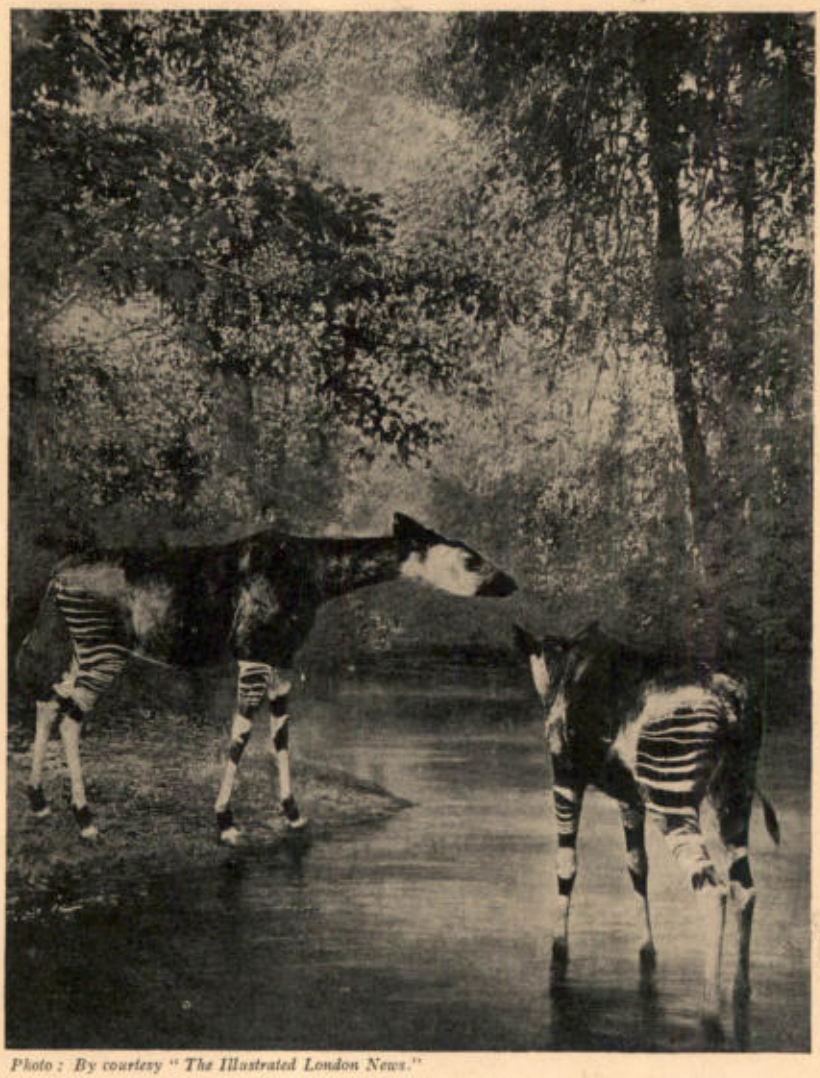


Photo: By courtesy "The Illustrated London News."

OKAPI (*Okapia johnstoni*).

The strange Okapi, discovered by Sir Harry Johnston in the Belgian Congo district, is a unique creature, a distant relative of the giraffe. It has a rich brown colour with longitudinal stripes on the fore and hind limbs. Its head and skull are giraffe-like. It lives in pairs in the deep recesses of the forest.

in concealing it from its enemies, and the bongo, another animal of the African forest, has the same kind of colouring as the okapi. The bongo (*Boocercus eurycerus*) is a handsome animal of the antelope tribe, and its dark chestnut coat striped with white is a good example of protective colouration. The white lines break up the outlines of the body, so that it merges with the background in the bongo's natural haunts in the forest, making it quite inconspicuous, especially when the sun is shining and the forest is full of contrasting lights and shadows. In just the same way the bold stripes of the tiger make it almost invisible in its particular haunts. Desert animals must have plain, dun-coloured coats for concealment, but in forest and jungle broken lines and colour contrasts make for security.

The Bongo.

The bongo's home is in the forest, but it roams far afield to bamboo jungles and swampy ground. Unlike the okapi it is fond of soft ground, and spends a good deal of time wallowing in the swamps. Although it is a wary animal, it has one habit that often leads to its undoing, it returns again and again to a favourite wallow-hole, and, moreover, uses the same paths each time, which may lead to its being trapped by the Pygmy natives. It is a powerful beast, with massive horns which it has a trick of rubbing against trees till they are highly polished. When the okapi is making its way through the forest it tends to go over obstacles whenever possible, but the bongo has a positive aversion to jumping. It will scramble or crawl round or under anything, but it will seldom take a clean leap over a bush or a fallen tree. This habit it shares with the little red buffalo of the forest. Perhaps the uneven ground and the numerous tangles of creepers make jumping inadvisable in the dense parts of the forest.

Two very interesting examples of the contrast between forest and bush types are the buffaloes and the elephants. In both cases the forest animal is very much smaller than its relative of the more open country. The forest elephant

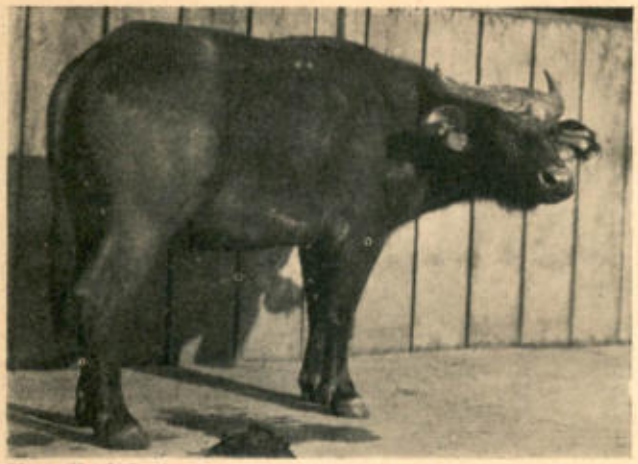


Photo: Harold Bastin.

DWARF AFRICAN BUFFALO (*Bubalus pumilis*).

This small Buffalo stands about forty-two inches at the shoulders. It is yellowish, with black on the head and legs. The horns are slightly compressed at their base, and are directed upwards, not covering the skull as much as those of some other species. It is not such a dangerous animal to hunt as the Caffer Buffalo, shown beneath.

faces of the buffaloes on the plains; their ears are fringed, and usually have a lock of white hair on them; their coats are thick and shaggy, and brown or red until they become black in old age; spreading horns are a disadvantage to an animal that spends its life among trees, so the horns of the forest buffalo are small, and curve out and up and back, without the downward sweep that is so characteristic of the big black buffalo of the open country.

The little red buffalo is as wary as the okapi. Dr. Christy believes that it is "the one animal clever enough to recognise the tread of man by hearing alone." It is very active and can run through the forest at a great rate on its short and sturdy legs, ducking its head under the creepers and scrambling through the shrubs. It is a very difficult animal to find, for it spends a large part of the day lying resting in the heart of some tangled thicket, or undergrowth, where it retires after its morning meal, and waits till the evening before it comes out warily and sets off to visit some favourite "edo."

Pygmy Elephants and Buffaloes.

which is found only in the rain-forests of the equatorial belt of Africa, is a remarkably hairy animal, with long bristles about its ears and trunk; and its skin is quite unlike the horny, hard greyish skin of the bush elephant. Owing to the perpetual moisture in the rain-forest, the smaller elephant has a skin that is "creased and furrowed, black and supple, almost rubber-like."

In the buffalo we see again the red-brown colouring so common among forest animals. The much more numerous and widely-spread buffaloes of the bush and plains are very big, massive beasts with black coats and huge, sweeping horns. The little red group is confined to the forests. In the Niger region they are much larger than the lightly built, almost diminutive buffaloes that live near the okapi and the bongo in the Ituri forest—pygmy buffaloes that are hunted by pygmy men in this ancient forest, where Old World types survive. They have small muzzles and narrow faces, with straight or even concave profiles, unlike the heavy "Roman"

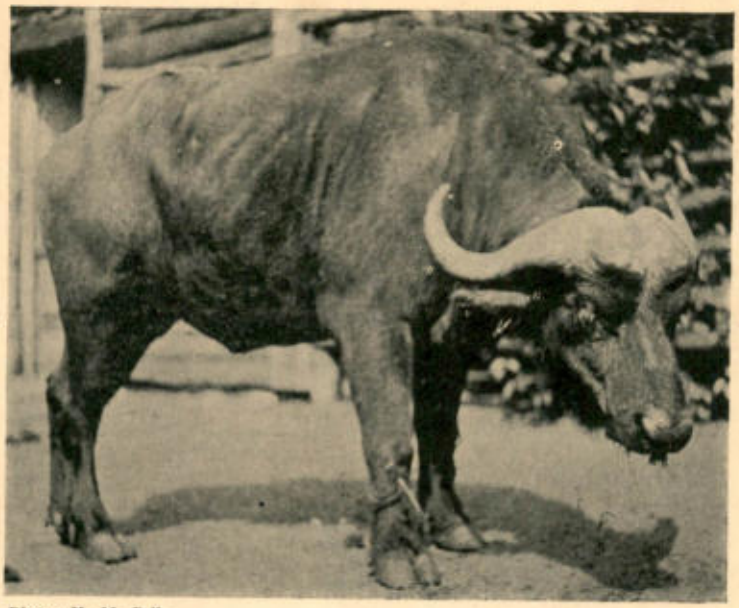


Photo: H. M. Bell.

EAST AFRICAN BUFFALO (*Bubalus caffer*), FEMALE.

This strong black Buffalo was once widespread in Africa, but is gradually being restricted in range, owing to excessive hunting. The bases of the horns broaden and become ringed, covering and protecting a considerable part of the skull. It is a clever animal, showing fierceness when aroused. It stands nearly five feet at the shoulders.

Photo: Underwood Press Service.

WART-HOG (*Phacochærus æthiopicus*).

This massive, comparatively naked, African pig is marked by the huge tusks in both jaws, which are used in rooting up food. They are the canine teeth, but those of the upper jaw are turned upwards, not downwards, as usual. This is seen in still further exaggeration in the almost hairless Babirusa of the Celebes. The Wart-Hog has two large wart-like protuberances on the front of the skull; these are well shown in the photograph. When very angry it carries its short tail erect in a quaint sort of way.

Forest "Giants."

The Ituri forest is the home of pygmies, both animal and human, but it is also the haunt of giants. These include the giant rat; the huge forest-hog, with its long, black, bristly coat, and massive head with an enormous snout-disc and swelling "warts" beneath its eyes; and the giant scaly ant-eater, that climbs the trees with its curving claws fitting round the trunk, and its strong tail pressed grippingly to the bark, till it reaches a termite's nest, and picks out the luscious "white ants" with its worm-like tongue. And here, too, is that curious creature the aardvark, the big "ant-bear," another eater of termites. It is a great unwieldy animal, heavy and fat with a thick powerful tail, and it prowls about the forest in the night. It is an expert digger—"it can almost dive into the ground"—and it tunnels into the ant-heaps and pushes its long, flat tongue among the swarming insects, drawing it in again when its sticky surface is covered with dozens of the coveted ants. Its burrow is not a pleasant place, and its heavy musky odour attracts hundreds of flies to its entrance. And after the flies come other creatures of the night, the innumerable bats that flitter through the forest shades.

LII
ANIMALS OF THE TREES

PLANTS grow luxuriantly in the steamy heat of the tropical forests and there is a wealth of fruit. Insects, too, are exceedingly abundant, so there is no lack of food for the many kinds of birds that throng the trees.

Many of the birds have strong bills for cracking hard fruits, but few have such a mighty weapon as the beak of the noisy-winged hornbill, that flies high over the trees uttering its strange cackling cry, which has been described as between the tooting of a motor-horn and the braying of a jackass. In its long, sharp, powerful bill the bird can seize and break up all sorts of food, from roots and fruits to a small tortoise, and it can also scoop out a hole in a tree to make a nesting-place. The story of the imprisonment of the hornbill is a very curious one. When the hen-bird has laid her eggs in the nesting-hole and is ready to sit and keep them warm till the young birds hatch out, she begins to plaster up the entrance with mud till only a small opening remains. Good observers say that she does much, if not most of, the walling-up herself, using materials (clay and resin) previously collected, and the meaning of her procedure is probably to protect herself and her brood from the attacks of malicious monkeys or climbing snakes. Other observers insist that the male bird builds up the prison-door from the outside. Probably both sets of observers are right. In any case the cock-bird is in close attendance.

The Hornbill's Story.

Photo: F. W. Bond.

THE HORNBILL.

Hornbills, forming the family Bucerotidæ, occur chiefly in Africa and India, living for the most part on trees near rivers. They are famous for the helmet above the exaggerated bill, the heavy lumbering flight (though the bones are more "pneumatic" than usual), their hoarse cries, the shutting up of the brooding female in a hole in a tree, and the paternal care of the male bird. They feed chiefly on fruits and insects.

The mother-bird is not left to starve in her prison, for her mate feeds her through the little opening that has been left in the mud wall. He comes to the tree and gives a signalling knock so that the hen-bird raises her beak to the hole to receive a juicy fruit or perhaps a frog or a mouse. In some cases the food is done up in a thin skin moulted from the male bird's gizzard, and the packet has a quaint resemblance to a sausage. The cock-bird is so devoted, and works so hard to keep his mate supplied, that by the time the young birds have hatched out and the mother is ready to leave the hole, he is sometimes almost worn to a skeleton. Occasionally he dies of exhaustion!

Another fruit-eating bird with a curious beak is the brilliantly coloured Toucan of Tropical America. The huge orange bill is flattened from side to side, and is shaped like the claw of a lobster. Although it is very large it is not heavy enough to hamper the Toucan's flight, and it is a very useful instrument when it comes to picking fruit. The rather heavy-bodied bird is able to sit securely on a comfortable branch and gather fruits from even the slenderest twigs all around it with the tip of its enormous bill.

Photo: W. S. Berridge, F.Z.S.

WOOLLY OPOSSUM AND YOUNG.

Most of the Opossums (Didelphys) have no pouch, though they are certainly to be ranked as Marsupials, which means "pouch-bearing." They are for the most part arboreal animals, and insectivorous, though with a margin for larger tit-bits, such as birds' eggs. When the young ones leave hold of the teats, whether there is a pouch or not they hang on to the mother's body, as the photograph shows. Azara's Opossum, about the size of a cat, may have eleven young ones on its back, each the size of a rat.

But the birds form only one group of the fruit-eaters of the forest. The trees of the African forest, where the hornbill has its home and the crimson-winged plantain-eater seeks its food, are swarming with monkeys of every size and colour. Every morning, when the night hawks have given up hunting the bats, and the day-sleepers are looking for comfortable resting-places, the forest echoes with the sounds of the monkey-chorus, rattling cries and weird yells and hoots. And then the monkeys set to work to gather fruits and leaves for breakfast.

The Chimpanzee.

The chimpanzee is an animal of the trees, though it spends a good deal of time on the ground. The scaly ant-eater, as we have mentioned, will climb trees in search of food, but its home is on the ground; whereas the chimpanzee lives and sleeps among branches, though it will come down to grub for roots and tubers, or if it thinks fit to leave one tree for another. At night the chimpanzee makes a platform of

fresh, leafy branches some fifteen or twenty feet up, and sleeps there till daybreak, when it adds its shouts to the monkey-chorus. Although it often indulges in hooting, it can be very quiet in the trees, feeding silently and dropping nothing on the ground to give a sign of its presence. It does not seem to have a large vocabulary. Dr. Cuthbert Christy writes: "During the day the chimpanzee spends most of his time in some big tree, taking life seriously, picking young shoots or fruit, fondling friends and grimacing, or doing aimless trapeze work. Occasionally he dozes on some fallen log. At the first sign of danger the wary old male forsakes his family, and coming down from the tree-top with a few acrobatic swings and a drop, he makes off along the ground. He uses his great arms to help himself along, to push off from trees in his haste, or for swinging creepers and branches out of the way, rather than for running with." That the chimpanzee does not need its arms for walking is clearly shown by its tracks, for often only footprints appear, with here and there a knuckle mark, as the animal wanders through the forest, picking leaves as it goes.

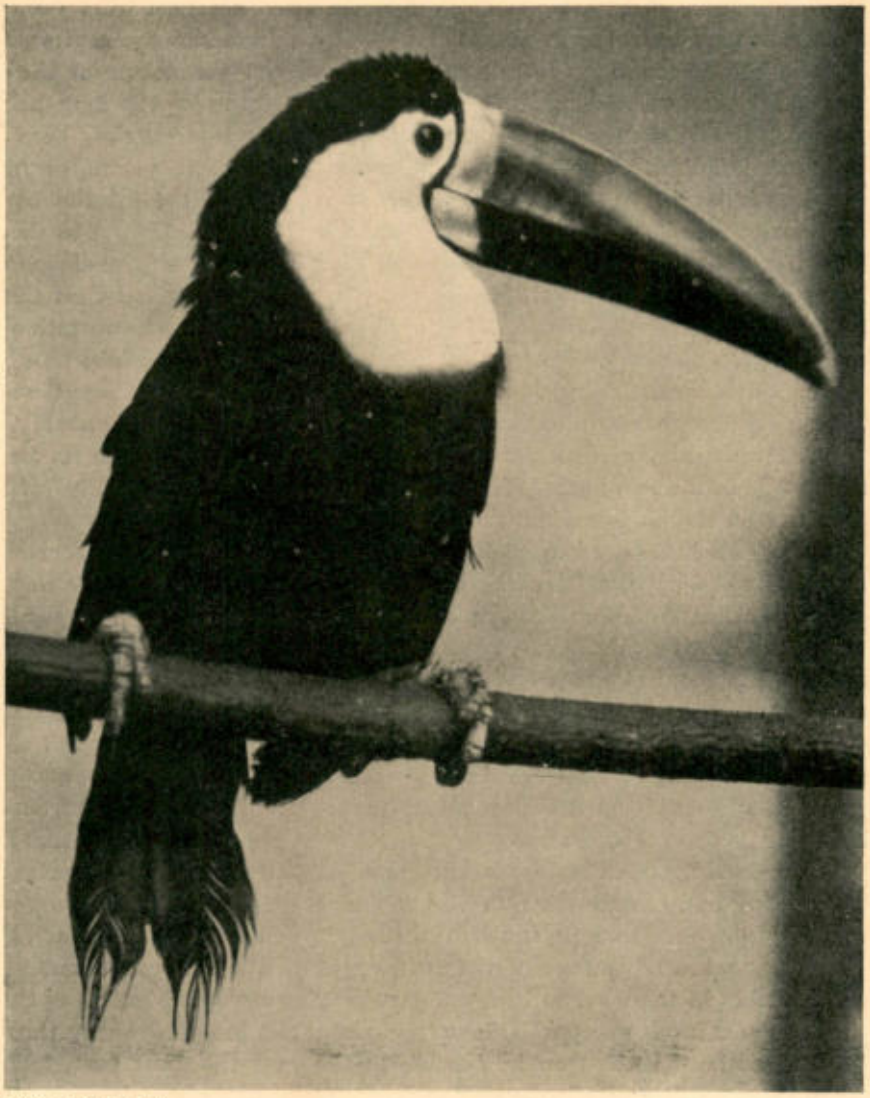


Photo: F. W. Bond.

CUVIER'S TOUCAN (*Rhamphastus cuvieri*).

The quaint Toucans range from Mexico to Guiana and Bolivia, and may be thought of as the South American counterparts of the African and Indian hornbills, which have the same exaggeration of the bill, but are not nearly related. In the hornbills the bill usually carries a big casque or helmet, which the Toucans do not show. The huge bill is lightly built, and is used in chewing fruits and the like.

While the chimpanzee and the scaly ant-eater of Africa are animals which spend part of their time on the ground and part of it in the trees, in the tropical forests of America there are hairy ant-eaters, some of which—little two-toed ant-eaters—live entirely among the branches. These small ant-eaters have a marked resemblance to another arboreal animal, the sloth; and this is due to the fact that both of them live the same kind of life. They show, indeed, a greater resemblance to their distant relatives, the sloths, than to any of the ground-dwelling ant-eaters. But while the tree ant-eater has a long tail, like a monkey's, for twining round the branches, the sloth has

The Sloth.

only a stump of a tail, which is of no use either as a balancing organ or as an extra hand.

The sloth is found in the dense forests of equatorial America, ranging north into southern Mexico. It is the most purely arboreal of all mammals; indeed, it is practically helpless if it ever leaves the trees. Its life is an upside-down one, for it hangs back downwards from the branches. It has a curiously round head, with its eyes set very wide apart, and it can twist its head far round on its mobile neck to look down over its shoulder. It hangs by its strong, curved claws from the branches. These hook-like claws cannot be separated from one another; in the three-toed sloth there are three on each foot, while in the two-toed sloth of Brazil there are three on the hind feet but only two on the "hands." Its limbs are long, and the two pairs are of unequal length, which adds to the animal's difficulties if it comes to the ground. It can make no headway at all on a smooth surface, but if the ground is rough and uneven it can crawl slowly along, but with great difficulty. Its long legs and peculiar feet are only suited for life among the branches. On the ground it works its way along on its elbows, dragging its hind feet along on their sides.

In the trees the sloth is slow and inactive. It never leaps, and has no adaptation to enable it to pass from one tree to another, though it sometimes takes advantage of the swaying of the branches in the wind to bridge a gap. For the most part it can manage to move from place to place without much trouble, because in the dense forests where it lives the trees are so covered and bound together by ropes of creepers that the sloth's hooks will always find some support to grasp. In addition to its long arms and hooked claws, the sloth has many other fitnesses, in regard to its bones and its internal structure, that make it perfectly adapted for its peculiar mode of life.

The sloth is almost defenceless. It seldom uses its peg-like teeth or claws as weapons, but unless a dog or other assailant is very alert, the sloth may wind its long arms round its neck and strangle it. Its chief foes are the prowling jaguars and the big snakes that climb trees, but against these it has one useful defence, its inconspicuousness. Its hair is very long and shaggy. Perhaps the thickness of the woolly coat that covers even its face is in itself a protection against its worst enemies, the snakes; but the colour of the hair is also important. Naturally the long hairs are grey, but in the damp forest they become covered with minute one-celled plants, or Algæ, which lodge in the roughnesses of the coarse hairs, and flourish there till they give the sloth a complete green coat. The Algæ die when a sloth is brought into captivity, and then the grey colouring is seen, but the damp warmth of the forest favours their growth, and here among the green creepers of the tangles, where the sloth naturally lives, the green coat is probably of advantage in hiding the animal from its foes. The presence of the Algæ is probably what one might call an accidental asset.

"They well deserve their name of sloth, for they are not only slow to move, but slow to think, and slow to die." The sloth is apathetic and unintelligent, and if the branch to which it hangs is broken by a shot, it will fall, clutching at other branches, and finally come to rest within easy reach of the hunter, and yet show no concern whatever. But it has a wonderful power of recovery from injury, and great resistance to poisons, so that in spite of its helplessness it can survive a great many trials.

The sloth may sleep where it hangs, or it may curl itself up in a ball, tucking its head between its arms. Like many defenceless animals, it reserves its activities till after nightfall. It goes its inoffensive way through the darkness, silent for the most part, but occasionally uttering a curious long-drawn moan. It feeds as it moves, hanging downwards from the branches. Its teeth are simple pegs without enamel, suitable for crushing the leaves and fruits that form the staple food. The sloth depends mainly on leaves, choosing young shoots and juicy buds, and gathering them with its mouth. It never uses its clawed "hand" in food-getting. The Mexican two-toed sloth drinks no water, but it sucks the milky sap of its favourite food-tree.

There is only one young one at a time, which is suckled at the mother's breast. It has to be carried about wherever the mother sloth goes. The usual way is for the young one to cling to the shaggy fur of the mother's back, but a sloth that was watched in captivity always carried her baby on her "lap."

Another arboreal animal which is confined to the American forests is the opossum. It belongs to the same group as the little tree-kangaroo, which, like the big ground kangaroos, has a pocket of skin for carrying its young one. The opossum is very different from the round-headed, stumpy-tailed sloth; it is a somewhat rat-like, active little animal, with a very long tail, which it can hook round the branches. Its feet, too, are well suited for grasping, for the great toes are opposable to the others so that a branch can be firmly held between the big toe and the rest of the foot. As the little mouse-opossum scrambles about on the trees in search of the insects that are its chief food, it carries its babies on its back. They are quite safe, because the mother keeps her long tail curved forward above them, and they "strap-hang" to this support by twisting the ends of their little tails around hers.

The Opossum.

W. H. Hudson, the naturalist, wrote of a larger kind of opossum: "I have seen an old female opossum with eleven young, large as old rats—the mother being less than a cat in size—all clinging to various parts of her body; yet able to climb swiftly and with the greatest agility in the higher branches of a tree. . . . The opossum never quitted its hold on the tree, and it also supplemented its hand-like feet, furnished with crooked claws, with its teeth and long prehensile tail." Opossums frequently come down from the trees, and when they are on the ground they are known to make use of the "roads" trodden smooth by processions of ants making their way through the forest.

Many different kinds of animals have found that taking to the trees is the solution of the problem of finding a livelihood. It gives new opportunities of feeding and of nesting, and new possibilities of movement. It is interesting to find the same kind of adaptations to life in the trees in animals of widely separated groups. In the opossum which is a mammal, and in the chamæleon which is a reptile, there are marked points of similarity. Thus both have long tails, admirably suited for coiling round the branches, and both have feet more or less cleft in two parts for gripping purposes.

We have seen how necessary it is to the sloth that the trees among which it lives should be so close together that it can swing from one to another by means of its long arms, but in many forest regions there are gaps between the trees. This means that the animals must take to the ground if they wish to travel, or else use some other method of bridging the chasm. So we find that in several quite different groups of animals there are attempts at flight.

Birds may often be seen "planing" down from a great height, without a single beat of the wings for a long time; this kind of movement is the same as that of the "parachutists" of the trees. It is a sort of prelude to true flight. The

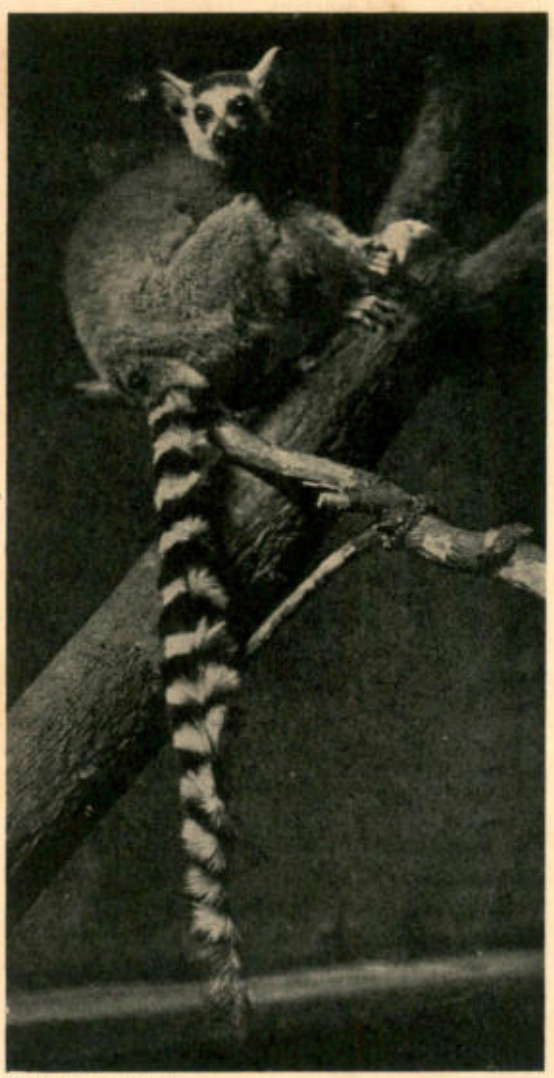


Photo: Harold Bastin.

RING-TAILED LEMUR (*Lemur catta*).

This gentle creature lives gregariously in Madagascar forests, often among rocks and bushes rather than on trees. It is active and graceful in its movements, and utters a plaintive cry like a domestic cat. Its general colour is delicate grey, but the tail has alternate rings of black and white as the photograph well shows.

"flying squirrels," for example, have fur-covered skin stretched from limb to limb, making an effective "plane." There are all sizes of planing squirrels, down to one that is only three inches long, but a typical one is the brown flying-squirrel, an animal not unlike our own squirrel, except for the additional parachute. It has a long, bushy tail, which helps it to keep its balance, and the skin extends from wrist to foot along the sides of the body. When the limbs are spread out this flap of skin is stretched to make a plane. The squirrel cannot move its "wings," but by movements of its body and tail, it seems able to steer at least a little. As the animal has only a parachute, and no true wings, it cannot fly upwards, but it launches itself boldly from the top of a high tree, and planes across a gap to another tree, where it lands at a lower level.

The "Parachutists."

The movements of the American flying squirrel have been thus described: "At times one would be seen darting from the topmost branches of a tall oak, and with wide extended membranes and outspread tail gliding diagonally through the air, till it reached the foot of a tree about fifty yards off, when, at the moment we expected to see it strike the earth, it suddenly turned upwards and alighted in the body of the tree. It would then run to the top, and once more precipitate itself from the upper branches and sail back again to the tree it had just left. Crowds of these little creatures joined in these sportive gambols; there could not have been less than two hundred."

Other observations, for instance, of the flying lemur (Galeopithecus), whose parachute extends even to the tip of its tail, show that the planing animals can cross a gap many yards wide, and also that, though they cannot fly to a higher level than their starting-point, they can guide their course and even make a slight upward movement while they are in the air. The same type of parachute is seen in mammals of very different groups—insect-eaters and gnawers—and also among the pouched mammals. Of one of the small animals of the pouched mammal group it is said that they climb to the tops of very high trees

Photo: F. W. Bond.

INDIAN FRUIT BAT (*Pteropus medius*).

The large bats of the genus Pteropus, numbering over forty different kinds, range from Madagascar, through the Seychelles to India, Ceylon, and Burma, and on through the Malay Archipelago to Australia. They are often called "Fox-Bats" or "Flying Foxes" in allusion to the long pointed muzzle and the thick-furred neck. But there is no tail, and they are fruit-eaters, so the less said about "fox" the better.

Specially drawn for this work by E. Mansell.

THE LEOPARD OR PANTHER (*Felis pardus*).

The Leopard, like the lion, is African and Asiatic. Its name, leo-pard, refers to the old erroneous belief that it was a cross or hybrid between the lion and the pard or tiger. There is considerable colour-variation, but the characteristic feature is the presence of rosettes of black spots surrounding a central field of a tawny colour; a dappling which, by imitating the jungle lights and shadows, is of value to the animal for the purpose of concealment.

with the greatest agility, " then they spread out a fold of skin, which connects their limbs and tail and serves as a parachute, and noiselessly, in gentle flight, float downwards towards the foot of a distant tree. Thus I sometimes saw them float through distances of fifty yards, never failing their goal, and even managing to change their direction in the midst of their downward sweep and to settle on another tree than that they had first chosen."

The Fruit-Bat.

Side by side with the parachuting mammals of the forest are the bats, the only mammals which have fully solved the problem of flight. On the ground the bats are helpless, but many of them, the fruit-bat for instance, can scramble about quite quickly on the trees. The fruit-bat has very sharp claws on its toes, which it uses in climbing to grip the bark of the trees. With the sharp claw of its thumb it spears the fruit that is its food. This thumb-claw is all that remains of its hand as a hand, for the rest is taken up in the making of a wing. In the parachutists the plane is a mere extension of the skin of the sides of the body, but in the bat the wing, which can be freely moved and folded, is supported by bones. The fingers are enormously long, and so are the bones of the arm, and on them the thin skin-wing is spread out. The skin stretches along the upper margin of the arm and across the palm of the hand, leaving only the thumb-claw free, and down to the hind-legs. The wing is extraordinarily delicate and sensitive, so that the bat is aware of any object near it. It can fly at a great speed through even a dense forest without once touching a twig with its fluttering wings.

The Flying Lizard.

Perhaps the neatest parachute of all, that coming nearest to a true wing, is that of a lizard, the " flying dragon " (*Draco volans*) of the East. This brightly coloured little lizard has fan-like " wings of skin" supported on five or six mobile ribs prolonged from the sides of the body. When the " dragon " is resting, the wings are folded against its sides. It does not flap them when it flies, for it is only a planing animal, but it has a pretty habit of opening and closing them as it rests among flowers as gaily coloured as itself. It looks more like a butterfly than a dragon ; a fascinating creature. Another lizard (Ptychozoon) has fringes of skin all round its body, head, trunk, tail and limbs, which act as a parachute, and are even more important as a means of clinging to the branches.

Tree Frogs.

In some of the tree-frogs, too, there are large discs on the toes which may help them to plane when they leap, but they are probably rather " hold-fast " organs than parachutes. One of the problems that tree-loving animals have to solve is how to take care of the young ones, and some tree-frogs carry theirs on their back, or even in their mouth. Dr. Christy describes a tree-frog's nest on the upper surface of a large leaf in the forest near a swamp: " The nest consists of a lump of white surface-dried froth or ' spittle,' about the size of one's fist, and discoloured on the outside. Broken open, it is seen to contain a number of small tadpoles moving about vigorously in the wet frothy interior. In this mass the eggs are hatched, and when the tadpoles are old enough to look after themselves they drop into the water beneath or live amongst the leaves and moist verdure of the swamp."

The animals of the trees are for the most part small and lightly built. The largest are some of the big snakes that ascend the trees, and distribute their weight over a strong branch. But the common tree-snakes are not large. Many of them are bright green in colour, so that they are not easily seen, and they often twist their tails several times round a branch, imitating the " hold-fast " tails of chamæleons and opossums and monkeys. Snakes have no need to fly, for they can glide with amazing rapidity up tree and down tree and along the ground, but even so it is said that a tree-snake will sometimes launch itself out of a tree and reach the ground diving as easily and safely through the trees as it would through the waters of the swamps !

To sum up : What are the general characteristics of tree-loving animals ? It matters not whether they have become arboreal refugees because they were in difficulties on the ground, or arboreal explorers attracted to woods and forests as a new area for exploitation. The adaptations will be the same in both sets of cases.

One very obvious condition of arboreal life is moderate size. Perhaps the pythons and boas are the heaviest animals that go up trees, though the oran-utan is no light weight ; but a snake has the advantage of being able to distribute its

Photo: New York Zoological Society.

A TREE-FROG CLIMBING, WITH ADHESIVE DISCS AT THE TIPS OF ITS DIGITS.

The Tree-frogs or Hylidæ, nearer to toads than to frogs, are very widely distributed in warm countries, except in Africa; but their head-quarters are in South America in the steamy forests. Climbing is helped in most cases by terminal discs or muscular pads on the tips of the fingers and toes, the adhesion being due to the molecular attraction of the two closely appressed bodies—the pad and the surface on which the creature climbs. The close apposition is assisted by a slight skin secretion, but this is not sticky. There is neither suction nor gluing-on.

ponderosity over a large area of branch. The huge Anaconda is interesting in its combination of arboreal, aquatic, and terrestrial life. It makes the best of three worlds! But when we shut our eyes and see arboreal animals—tree-frogs that blow themselves up to the magnitude of golf-balls, changefully coloured chamæleons whose body (not including the tail) is no longer than the tongue, tree-creepers and wood-peckers, opossums and squirrels, tree-shrews and the tarsier-spectre, lemurs and marmosets, why, the general impression is: moderate size and moderate weight.

Another characteristic of arboreal animals is some hold-fast. Thus some of the tree-frogs have large adhesive discs at the ends of their digits. The chamæleon has not only its monkeyish prehensile tail, but a splitting of the fingers and toes into two groupings so that they grip the branch between them. The deliciously delicate Tree-creeper has long curved claws that enable it to run up trees like a mouse; and many tree-loving birds have some toe adaptation that makes holding on easy. Some of the arboreal snakes twist their sinuous short-tailed body several times round a branch, and various tree-lizards, like the Agamas of the Old World and the Iguanas of the New, have greatly elongated tails which lie closely opposed to the branch though they do not attain to the prehensile powers of the chamæleon. In many mammals there are prehensile tails anticipating those so characteristic of monkeys. The prehensile power implies not merely great mobility and strength in the terminal part of the tail, but also great tactility, usually localised in a naked streak on the under side.

Another very frequent feature of tree-animals is some measure of squatness in the body or an abandonment of the usual quadrupedal position. The monkeys with their long limbs are the most notable exceptions, but these unsurpassable gymnasts can do anything they like. With their tail as a fifth limb, with feet turned into hands, and with their extraordinary "swinging" power monkeys have nearly attained to what engineers

call "universal freedom of movement." It is obviously of great advantage when an arboreal animal can pass readily from one tree to another. The monkey swings itself across the chasm; the squirrel takes its daring leap, helped a little by its bushy tail; and skin-expansions that act as parachutes are borne by many unrelated arboreal animals.

There are other conditions that tree-loving animals must fulfil, and towards which they are more or less adapted. They must be able to find and capture food—we think of the woodpecker tapping the maple tree for syrupy sap, or the chamæleon shooting out its tongue on a distant insect. They must not be too conspicuous—we think of the tree-creeper pressed close to the bark, or the tree-sloth with its lichen-like shaggy hair. They must be able to secure the safety of the eggs and of the young—we think of tree-frogs that carry their eggs in their mouths, and Azara's opossum with her young ones on her back, their tails twisted round hers. So we reach the conclusion that an arboreal animal is often far from being "up a tree"!

The Spectral Tarsier.

One of the most interesting of all tree mammals is the little Spectral Tarsier of the forests of Borneo, Java, and the Philippines. It is interesting in its structure and behaviour, still more in its relationships and its promise. It is a unique creature, *Tarsius spectrum*, the only species of its genus, and the only living representative of its family—a family which perhaps gave origin to the lowest true monkeys. Some call it a lemur or half-monkey, but it differs widely from all the members of this order. It seems more monkeyish than half-monkeyish.

You can hold a spectre on the palm of your hand and its baby at the same time. The body is about six inches long, the tail two or three inches longer. There is a thick, woolly fur, brownish-grey above, lighter below. An extraordinary elongation of two of the ankle-bones, reminding one of the frog's foot, makes the hind leg disproportionately long, and this is well suited for jumping from branch to branch, or from one bamboo stem to another. In its dainty

Photo: Hugh Main.

TREE-FROGS, ILLUSTRATING PROTECTIVE COLOURATION.

It will not be obvious at first glance how many little Tree-frogs there are in this photograph. Tree-frogs in general can arrange their colour within a considerable range; and thus they may be extraordinarily inconspicuous. Some tint of green is, of course, commonest. Some of the Tree-frogs are little more than an inch in length. All are vociferous.

body the Tarsier recalls the bipedal Jerboa, which also stands high on its hind-legs (anatomically different, however), and has a very long rudder-tail ending in a tuft. Another strange feature is the development of circular cushions at the ends of the fingers and toes, helping the Tarsier to grip the branches. They are curiously like the adhesive discs on the digits of tree-toads, thus illustrating convergence, or the occurrence of similar adaptations in unrelated types.

The most striking feature, however, is the bigness of the eyes, which are relatively huge circular discs, directed forwards, gleaming yellow at night. The head, very mobile on its short thick neck, has been compared to a two-lensed lantern, movable in all directions on a ball-and-socket joint. The reduction of the snout, natural enough in an arboreal animal, beginning to have a free hand, has brought the eyes to the front of the face. But the experts tell us that while Tarsius has binocular vision, it is not yet capable of appreciating stereoscopic effects. It is not yet able, Professor Elliot Smith says, to appreciate the texture or the details of the things seen. " For this purpose it is necessary to be able to move the two eyes in any direction in the closest co-ordination the one with the other." Tarsius has not got this length, but it seems to feel the need of it. For it has the power of moving its head upon the vertebral column through an extraordinarily wide range. With its body pressed against a branch, it can turn its head almost to the extent of 180 degrees and look backward. " This means that Tarsius feels the need of moving its two eyes in co-operation the one with the other, but as it lacks the necessary range and precision of conjugate movements, it moves its head much as a cat does, and so roughly achieves its purpose of bringing the two eyes at the same distance from the object." The Spectral Tarsier must be hailed as a pioneer in precise vision ; and for the animal itself this is of great importance, for it is a crepuscular and nocturnal animal, catching its prey with its head as it jumps, and needing all the precision its eyes can give it in the dim light.

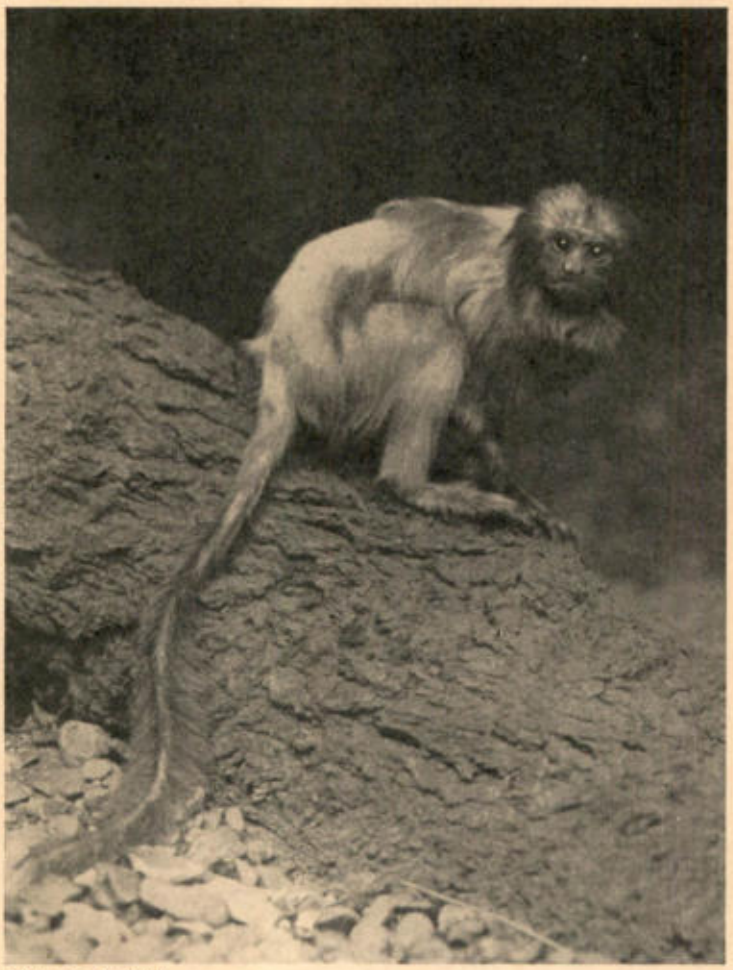


Photo : F. W. Bond.

LION MARMOSET (*Leontocebus rosalia*).

The Marmosets or Hapalidæ form the lowest family of monkeys, and are confined to the New World. They are attractive animals, not larger than squirrels, living in small companies on trees, active and agile in their ways, adding insects to their ordinary diet of fruit. The tail is not prehensile, and the thumb cannot be opposed to the fingers, which bear claws, not nails. This shows that they are far below the level of ordinary monkeys.

The spectres sleep during the day in holes in the trees, and are naturally rather cross when wakened up. At night they hunt for small animals, such as insects and lizards, and their moving about is singularly noiseless. They have not much to say to one another, but utter now and again a sharp shrill call. They live in pairs, monogamously, and with few exceptions there is but one baby at a time. It is able to hold on to its mother's legs,

Photo: W. S. Berridge, F.Z.S.

SPECTRAL TARSIER (*Tarsius spectrum*).

This quaint creature, rather smaller than a squirrel, is found in the forests of many of the islands of the Indo-Malayan Archipelago, such as Borneo and Sumatra. It sleeps by day and hunts at night for insects and small lizards; it is able to take big jumps from place to place; its nocturnal habit is suggested by its big ears and eyes. Except the second and third toes, which are clawed, the digits end in flat nails. The name Tarsius refers to the much elongated tarsal or ankle region. It brings forth only one young one at a time.

but Dr. Hose has seen one being carried in the mouth like a kitten. Almost from the first, the spectral pickaninny is able to climb, but it likes to be carried, and the mother is not unwilling.

The Tarsier seems fascinating to our eyes, but the natives regard it with horror. Is this because of its quaintness of build, or its huge goggle eyes, or the uncanny silence of its movements? Professor Elliot Smith suggests that the people of Java and Borneo have "a sort of instinctive horror at the sight of the ghost-like representative of their remote Primate ancestor!" But this is perhaps too subtle; for although technical zoological science strongly supports the view that Tarsius connects Lemurs and Monkeys, and is more or less in the direct ancestry of the latter, this is not the sort of thing "natives" bother about.

One of the most impressive diagrams ever published is that in which Professor Elliot Smith, in his recent "Evolution of Man" (1924), makes a comparison of the brains of Jumping Shrew, Tree Shrew, Tarsier, and Marmoset—the last being the most primitive of living monkeys. The Jumping Shrew is a terrestrial animal with comparatively poor brains. Its life

is dominated by the sense of smell, and the smell-perceiving region of the brain is relatively enormous, while the centres for sight, hearing, taste, touch, and the control of precise movements are diminutive. But when its cousin the Tree Shrew became arboreal a profound transformation was effected. We speak of being "up a tree," yet no step has meant more in evolution. It implied a gradual setting free or emancipation of the hand, a reduction of the snout, a bringing forward of the eyes, an enlargement of the brain-case, and an increasing complication in the roof of the brain, with its centres for vision, hearing, touch, and skilled movements.

It may be objected that there are arboreal marsupials which cannot be called clever; the answer is that their brain is built on lines somewhat different from that of ordinary mammals which possess an adaptable and unifying region, the "neopallium." It may be objected, again, that there are many intelligent mammals that are not arboreal. The answer to this is that there are possibilities in a monkey's brain that surpass the achievements of dog, horse, and elephant. The special interest of the Spectral Tarsier is that its brain shows a great extension of the visual territory and a marked reduction of the olfactory territory of the fore-brain. This becomes still more striking in the Marmoset, where besides an enlargement of the centres for sight, touch, hearing, and motor control, there is a strengthened development of an area (called prefrontal) which has to do with securing manipulative skill, stereoscopic vision, and mental as well as ocular focussing. Along precisely similar lines the Tree Shrew rises above the Jumping Shrew, the Tarsier above the Tree Shrew, the Marmoset above the Tarsier, the ape above the Marmoset, and man above the ape. Professor Elliot Smith's conclusion is that the cultivation of vision has played an important part in the evolution of man's intellect. Does this not mean that success is to the visualisers, that clear seeing leads to clear thinking? In any case, we find food for thought in that little squirrelish, shrewish, monkeyish, goggle-eyed Spectral Tarsier—a pioneer in seeing things clearly.

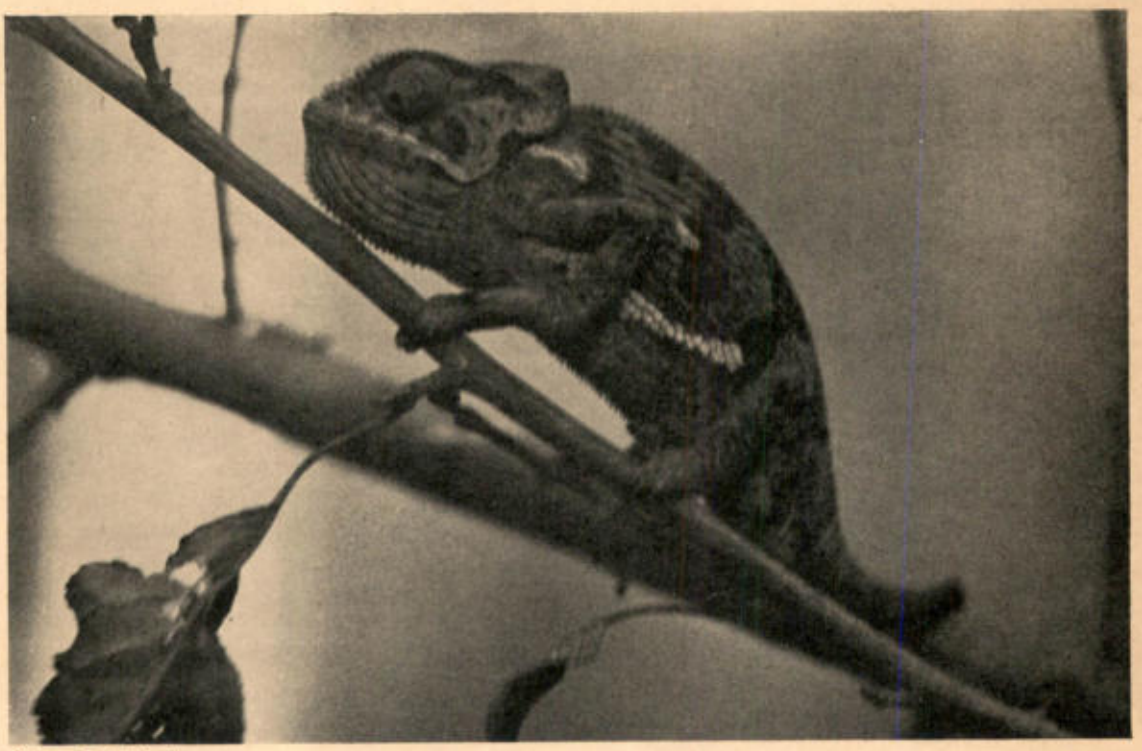


Photo: F. W. Bond.

FLAP-NECKED CHAMÆLEON (*Chamæleon dilepis*).

Chamæleons seem to be somewhat ill-tempered animals. They blow themselves up even when politely approached, or they gape widely, showing the inside of their mouth, or they grunt in an irritable way, or they bite shrewdly. They quarrel a good deal among themselves, the breeding males in particular. They also object to any encroachment on their particular sleeping place on a branch.

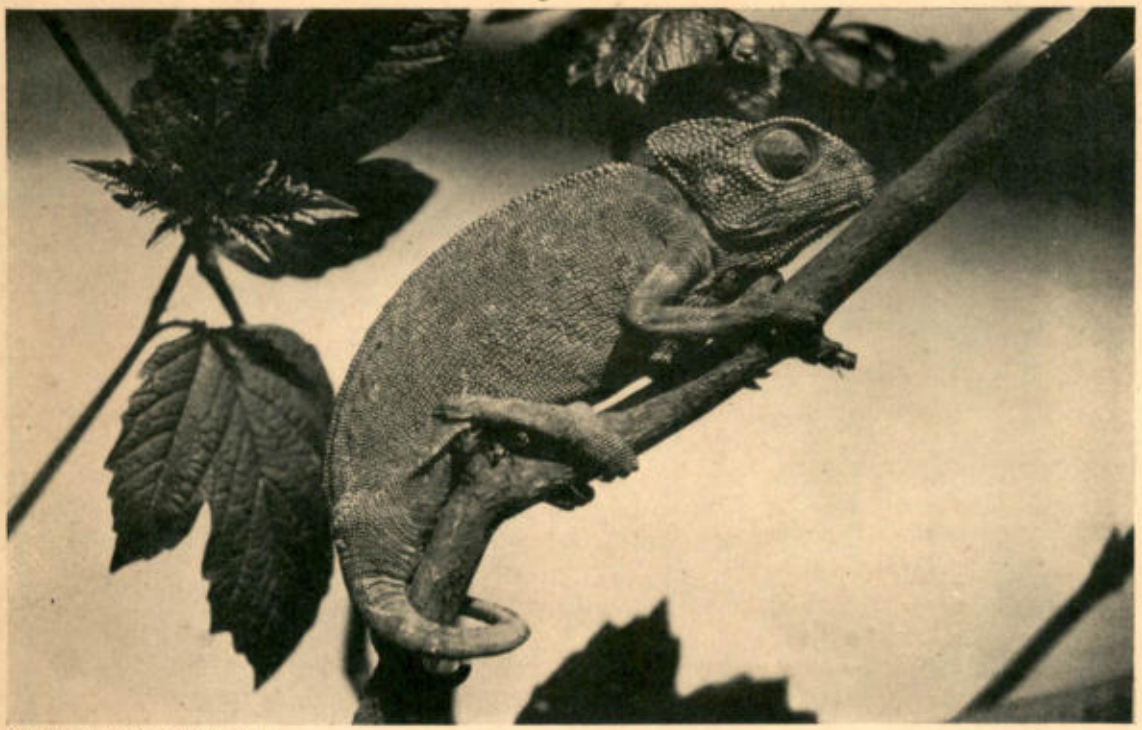


Photo : Stanley C. Johnson, M.A.

COMMON CHAMÆLEON (*Chamæleo vulgaris*).

The outer skin or epidermis is colourless, but the under skin or dermis contains many cells with pigment (chromatophores), many with little crystalline spangles of a waste-product called guanin, and others with yellow oil-drops. The change of colour is mainly due to the contraction or expansion of the pigment-containing cells. The change also is partly under nervous control, but it may come about in response to outside changes of light and temperature.

The word chamæleon means "ground-lion," but most chamæleons are very markedly animals of the trees. They are genuine lizards, but their origin from the average lizard type is very remarkable. It must have been one of the most remarkable of the many transformations that have occurred in the course of the advance of life throughout the ages. It seems that the descendants of some sort of tree-shrew became bats, and that the descendants of some sort of pipe-fish became sea-horses; these were very striking transformations, yet neither seems to us so astounding as the evolution of a lizard into a chamæleon.

The Ways of Chamæleon.

Every animal is a bundle of fitnesses or adaptations, but the chamæleon is a bag of tricks. We have watched them in South Africa, standing so still on the branch that we thought they had fallen asleep, and then all of a sudden, shooting out a clubbed, sticky tongue as long as the body, not counting the tail. They have an eerie way of moving so slowly that one cannot see when they shift. There is a quaint independent focussing of the eyes, which protrude in a strange way; and the focussing is so deliberate that one can hardly believe that the chamæleon will not lose the chance of the resting fly. First it focuses the right eye, and then it focuses the left eye; and when both are adjusted out comes the tongue. It takes a long time to get the sights right, but after that the discharge of the tongue is almost explosive. Perhaps "catapult-like" would describe it better. In any case it is usually a bolt from the blue for the fly.

We have said that the word chamæleon means "ground-lion," and it is a very quaint name. Not only does it tax the imagination to find a resemblance between a chamæleon and a lion, but most of the species live not on the ground but on the branches. Why should the curious creature be called "lion"? Can it be because they strike terror in some eyes—a dog's, for instance? When they are attacked they occasionally make themselves *smaller*, but at other times they inflate their body and seem to threaten with their gaping mouth. Sometimes they hiss and sway angrily from side to side. Is

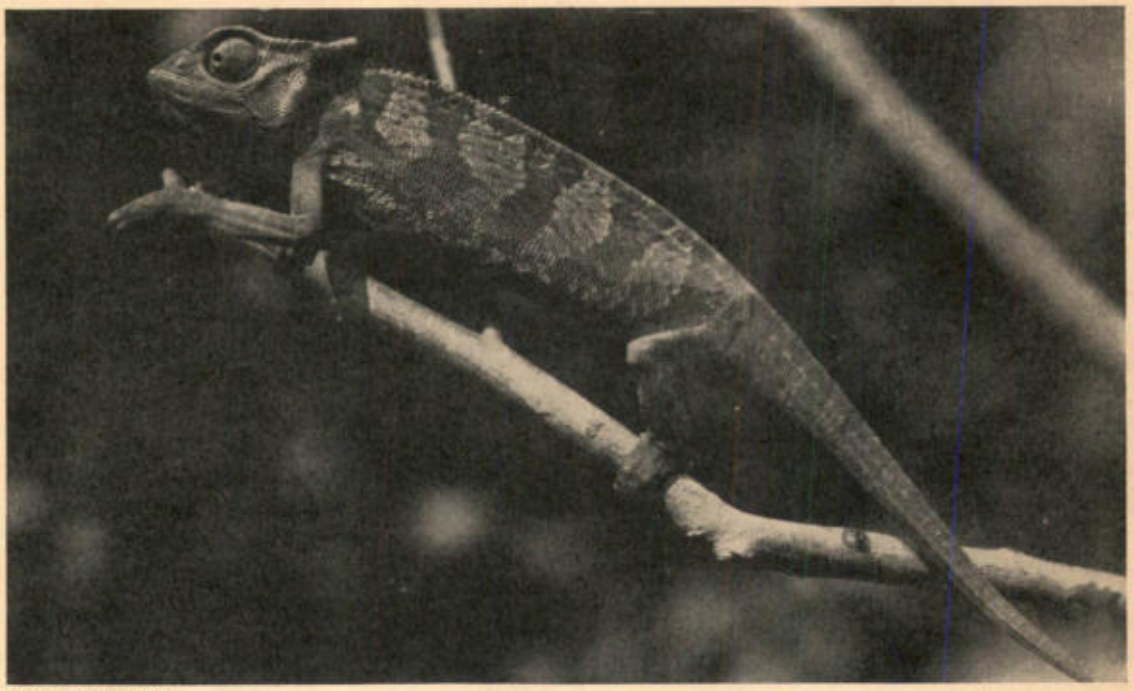


Photo : F. W. Bond.

SENEGAL CHAMÆLEON (*Chamæleon senegalensis*).

Chamæleons are bundles of fitnesses. Thus the hands and the feet are split so that they grip the branches very effectively ; the tail, very unusual in bending, dorso-ventrally is as prehensile as a monkey's ; the colour-change is often protective ; the tongue is a wonderful insect-catching instrument.

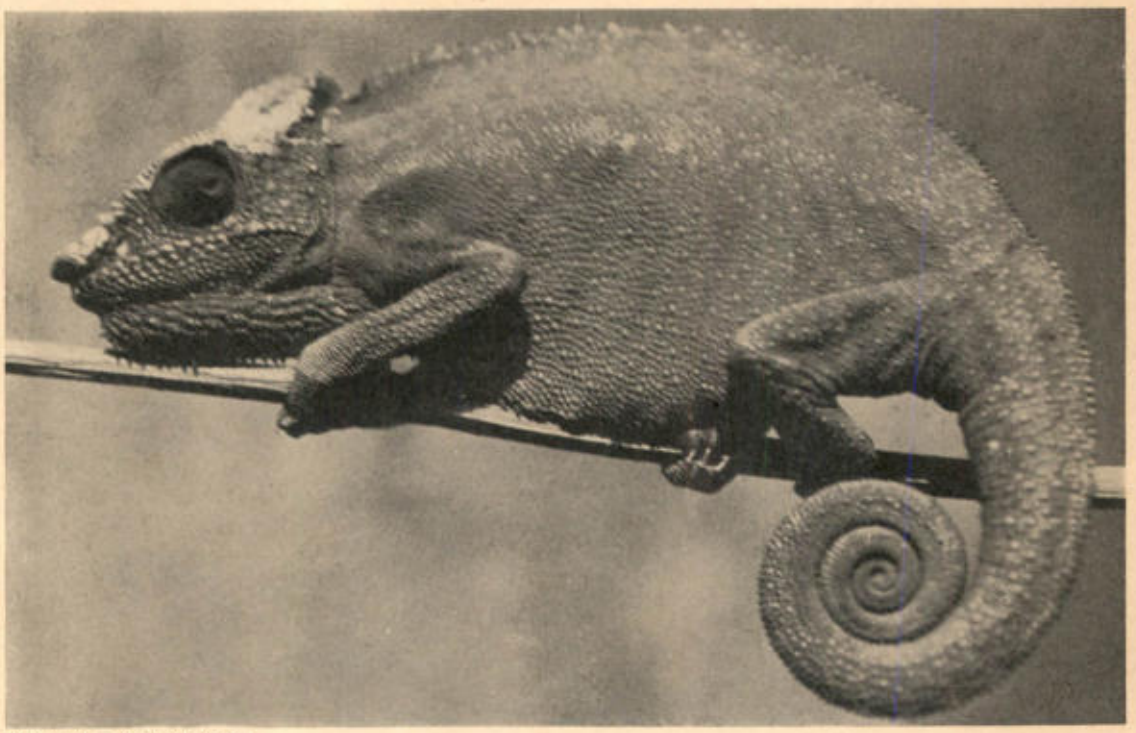


Photo : W. S. Berridge, F.Z.S.

WARTZ CHAMÆLEON (*Chamæleon villosus*).

The skin of the Chamæleon is not covered with the usual scales that are characteristic of lizards, but with small granules. The photograph shows the compression of the head and body from side to side, the union of the eyelids so that only a small central opening is left, and the coiling of the tail in an almost unique way.

there in this exaggeration of size, due to the expansion of lungs and air-sacs, some hint of the cat's similar bluffing of the dog? And is not the king of cats the lion, hence chamæleon? But it is dangerous for ordinary people to discuss etymologies, so we do not press our suggestion that the inflated indignant chamæleon is, through the analogy of the transformed cat, a "ground-lion."

We are on safer ground when we ask how the chamæleon is suited for life among the branches! Its prehensile tail is like a far-off hint of the monkey's, and the hands and feet are split so that they embrace the support. It is interesting to notice that the hand is divided into three fingers to the inside and two to the outside, whereas the foot is split with two to the inside and three to the outside! The Common Chamæleon may show half-a-dozen colours in the twenty-four hours. At night it is usually cream-coloured with yellow patches; during the day it is habitually grey-green, with numerous dark specks and some pale-brown patches; when excited it shows maroon-brown patches and golden-yellow spots; or, if it is very angry, the yellow spots become blackish-green. But this by no means exhausts the colour-repertory.

The colour-change is partly an expression of the creature's moods and partly an answer back to outside change; sometimes it increases conspicuousness, as if in warning; but sometimes it serves as a self-effacing cloak of invisibility. Just as the animal sometimes makes itself larger and sometimes smaller or slimmer, so in the colour-changes there seem to be two kinds of tactics—bluffing on the one hand and self-effacement on the other. The change of colour is brought about by the contraction or expansion of branched pigment-cells which lie in the under-skin or dermis, but the effect is complicated by the presence of numerous cells with yellow oil-drops and with guanin crystals or other strongly refractive particles. Speaking of the chamæleon's skin makes one think of the often repeated moulting, when the outermost layer of the outer skin (epidermis) dies away and rises up in blisters like pieces of tissue paper. The chamæleon gets rid of these in flakes by rubbing its body gently against stones and twigs.

The chamæleon is a bundle of unique peculiarities. When an ordinary lizard loses its tail at the hands of an enemy, it usually grows a new one, sometimes a bit of a makeshift. But the chamæleon's tail is not brittle, and it cannot be re-grown if removed. These two associated peculiarities may be understood when we think of the prehensile function of the chamæleon's tail, for if it is to support the animal it must be tough, and if it is coiled round the branch it is not exposed to danger.

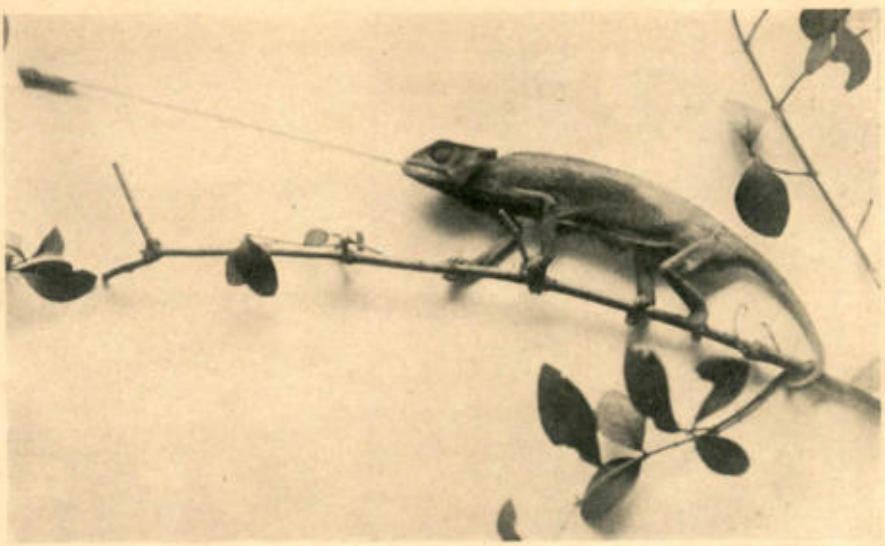


Photo: W. S. Berridge, F.Z.S.

LOBED CHAMÆLEON (*Chamæleon parvilobus*).

A big Chamæleon can strike a fly with its tongue at a distance of seven or eight inches, and catching is easiest when the object is at the proper distance, namely, the full length of the tongue. Before protrusion there is an inrush of blood into the tongue, which shoots out as if a spring were released. It is sticky at the end, and often with two flaps or lobes, which facilitate capture. The whole marvellous performance takes about a second when the insect is at the proper distance.

Instead of scales on the skin there are granules; the eyelids are united so as to leave a pin-hole aperture; the tongue is kept like a spring in a tube, and its forceful propulsion is helped by an inrush of blood; the large lungs are continued

into long narrow air-sacs—these are some other peculiarities of chamæleons.

Most of the chamæleons lay eggs in the ground, and the white miniatures are hatched out after a prolonged development. The mother usually broods. In a few cases, like the dwarf chamæleon of South Africa, the young ones are hatched inside the mother, illustrating a step that many different animals have taken in the course of evolution, the step towards viviparous birth.

Very little is known of the intimate life of chamæleons, partly because they are elusive creatures and partly because they do not readily survive removal from their native haunts. It is not that they die quickly ; they go on hunger-strike for months ; but the end is almost always the same. They are almost rigidly insect-eaters, but they have capricious appetites. They require plenty of water. They sleep on the branches, securely fastened on. They circumvent extremes of temperature by taking refuge in the ground, but very little is known of this " lying low." We must think of them as transformed terrestrial lizards, for the most part remarkably well suited for arboreal life, which return to the old haunts when the season is too severe, or when they are about to start a new generation.

Extraordinary Spiders

Many woods and forests are rich in insects, and that usually means an abundance of spiders. We wish to return to these interesting creatures. So much admiration is lavished on ants, bees, and wasps that there is apt to be a scarcity when we come to spiders. Yet they often exhibit an originality and daring that cannot be surpassed among insects. We must contrast spiders and insects, for we might as well call a reptile a bird as call a spider an insect. They belong to different classes, and have very little in common Perhaps, when naturalists come to know spiders better, it will be found that, though well provided with a repertory of instincts, they have a more active intelligence than insects usually display. We are using the word intelligence to mean an ability to put two and two together and to profit by experience by perceiving in some measure the relations of things.

Photo : W. S. Berridge, F.Z.S.

DWARF CHAMÆLEONS OF SOUTH AFRICA (*Chamæles pumilus*).

This little creature has a total length of five or six inches. The middle line of the back is very markedly serrated, as the photograph shows. The general colour is green, with a brick-red patch on the sides and bright red spots in many places. It does not turn pale at night, but becomes dull and dark when angry. It is hardy, as Chamæleons go, being accustomed to cold nights. It is viviparous.

As our first illustration we take the large Australian spider called the Magnificent (*Dicrostichus magnificus*), whose habits have been well described by Mr. Heber A. Longman. The adult female, with whom we are concerned, is about half an inch long and equally broad. But what colouring! "The abdomen is cream-coloured above, with darker vermiculations and a mosaic of fourteen salmon-pink spots on the front edge; the two prominent tubercles are yellowish. The dainty little turret on the cephalothorax has an alabaster base, and the wine-coloured turret itself supports two pairs of eyes." It is not for nought that this spider is called the Magnificent.

She makes remarkable cocoons, three to four inches long, with a maximum diameter of about an inch. They are hung from twigs, and look like pendant white fruits. The spider may spin about five of these silken bags in a season, and each contains about six hundred eggs. But they are not simple bags. There is an inner cocoon, beautifully pear-shaped, with a texture like fine rice-paper; the outer envelope is much larger and stronger; and between the two there is a loose packing of delicate silk. The whole structure is finished in one night, sometimes in moonlight, but equally well in the dark. It is a typical instance of instinctive behaviour, involving a multitude of movements, but without deviation from routine, even when that would be useful. During the day the spider rests in a retreat among the leaves. When the spiderlings are hatched they work their way out of the cocoons without any assistance; they climb to the top or on to adjacent leaves; they spin fine ballooning threads which are caught by the breeze and away they go. Mr. Longman thinks that the majority of the little aeronauts are captured by sparrows before they get far from their cradle.

But more extraordinary than the cocoon-making is the method used in capturing moths. During the cocoon-making season at least there is no sticky web or other snare entanglement, but there is an extraordinary device. The spider makes a filament, usually about one and a half inches in length, which is suspended downwards, and bears at its end a globule of very viscid matter a little larger than the head of an ordinary pin, occasionally with several smaller globules above. Now we must let Mr. Longman tell his story. "The filament was held out by one of the front legs, the miniature apparatus bearing a quaint resemblance to a fisherman's rod and line. On the approach of a moth the spider whirls the filament and globule with surprising speed, and this is undoubtedly the way in which it secures its prey. The spectacle of the moth fluttering up to the spider, sometimes two or even three times before it was caught, is one of the most interesting little processes which the writer has ever witnessed in natural history. The supposed desire of the moth for the star is a poet's fancy, but the attraction of the moth to the Magnificent Spider, although mysterious, can be seen by any patient watcher." The globule is so gluey that leaves can be hung on it by a mere touch; and the moth, once in contact, is as helpless as a fly in ointment. The captured moth is drawn up to the Magnificent, apparently killed by an injection, neatly bound in a little bundle (probably to keep the legs and wings out of the way), placed in front of the spider's mouth, and then sucked dry. For spiders always feed on juices, not on solids.

How are we to estimate such behaviour? That angler casting for aerial fish, and with a bait that is also a hook! Is the Magnificent's device nowadays an inborn aptitude, the outcome of ages of Nature's picking and choosing among new departures in methods of snaring? Is it comparable to her cocoon making? Or can it be genuinely intelligent, both in origin and in persistence? This would not be inconsistent with the spider's serving an apprenticeship in angling, which might include taking imitative advantage of the dexterities of other spiders. We should gladly hear more of these matters, for the truth is we have not facts enough. What we personally feel quite sure about is that the Magnificent Spider-Angler, whirling her deadly line, is not a mindless automatic machine.

Let us now shift the scene to South Africa (Pietermaritzburg), where a relative of the Magnificent Spider has been recently found and studied by Dr. Conrad Akerman. It is called Clavomela, and the adult female is about three-fifths of an inch long and of striking appearance. Large cocoons, up to five in number, are set in a row on grass stems bound together. They look very like fruits. Within a very tough silken

envelope there is loose floss-silk surrounding the eggs. During the day the spider sits huddled beside her works of art, to which she herself has a strong resemblance; but she becomes alert at dusk and begins angling for insects. She spins a thread with, at its end, a pinhead-like viscid globule, holds it out on her third or shortest leg, and whirls it rapidly with a rotary motion in a horizontal plane. She keeps this up for about fifteen minutes without a pause, then draws up the thread and swallows the viscid droplet. After resting for a few minutes she repeats the performance, spinning another line with a terminal globule and rotating it again for about fifteen minutes. The renewal of the globules, which suggests changing the bait, is probably connected with the fact that the globule gradually loses its stickiness on continued exposure to air. The droplet is always rotated in a clear place and is thus kept off stationary objects; but the capture of the booty has not been observed as yet.

It will be seen that the idea in the behaviour of the Natal spider is the same as in the case of the Brisbane spider, though the details are different; and the question rises whether the remarkable habit has been independently evolved in the two countries, or whether the two spiders are descended from common ancestors which exhibited the device in somewhat simpler expressions.

From inside big bunches of bananas imported to this country we have twice or thrice procured living spiders of formidable size, representatives of the predatory types which sometimes kill and suck small birds. But there are even stranger feeding habits. Thus an Argentine zoologist has described a spider that drove a tadpole into a funnel-shaped net which dipped into shallow water; and there is a South African species that has been known to kill and devour not only tadpoles but small toads and tree-frogs.

From time to time there have been reports of spiders that captured small fishes, but they have been lacking in detail. Now we have a careful description by the Rev. Nendick Abraham, who watched both the fishing and the meal in the case of a Natal spider, a species of Thalassius. The name suggests the sea, but the fishing is in fresh water. The spider spread itself out on the surface of the aquarium, but kept hold of a projecting stone by means of its hindmost legs. When a small fish came swimming underneath the spider made a rapid plunge and caught its booty without letting go of the stone. The spider drew the fish ashore and began without delay to eat it, or, perhaps one should say to drink it. For there is probably a rapid digestive solution outside of the mouth. In any case, the fish disappeared. There is another spider that . . . . but perhaps we have said more than enough already.

LIII

JUNGLES AND SWAMPS

REPTILES are very abundant in all the tropical forests. They like the warm, damp atmosphere, and food is always plentiful. Snakes large and small haunt the trees and the undergrowth. One of the very poisonous kinds (*Bitis arietans*)—the puff-adder—has the habit of lying under a plant covered with prickly burrs, and of pouncing on birds that come in search of seeds. The birds are apt to get entangled among the burrs, and before they can free their feathers from the prickles the snake has raised its deadly head from its hiding-place among the leaves, and struck with its venomous fangs.

The Crocodile.

In Western Africa, wherever the forest is broken by the course of a river, or the rain-forest gives place to jungle and swamp, the great aquatic reptiles, the crocodiles, are found. The crocodile is stiff and awkward on land, finding it difficult to turn round quickly, so it takes to the water when it is alarmed, and it does its hunting from the water, too. But it likes to lie on a warm sand-bank at the edge of the river, basking in the sun for hours

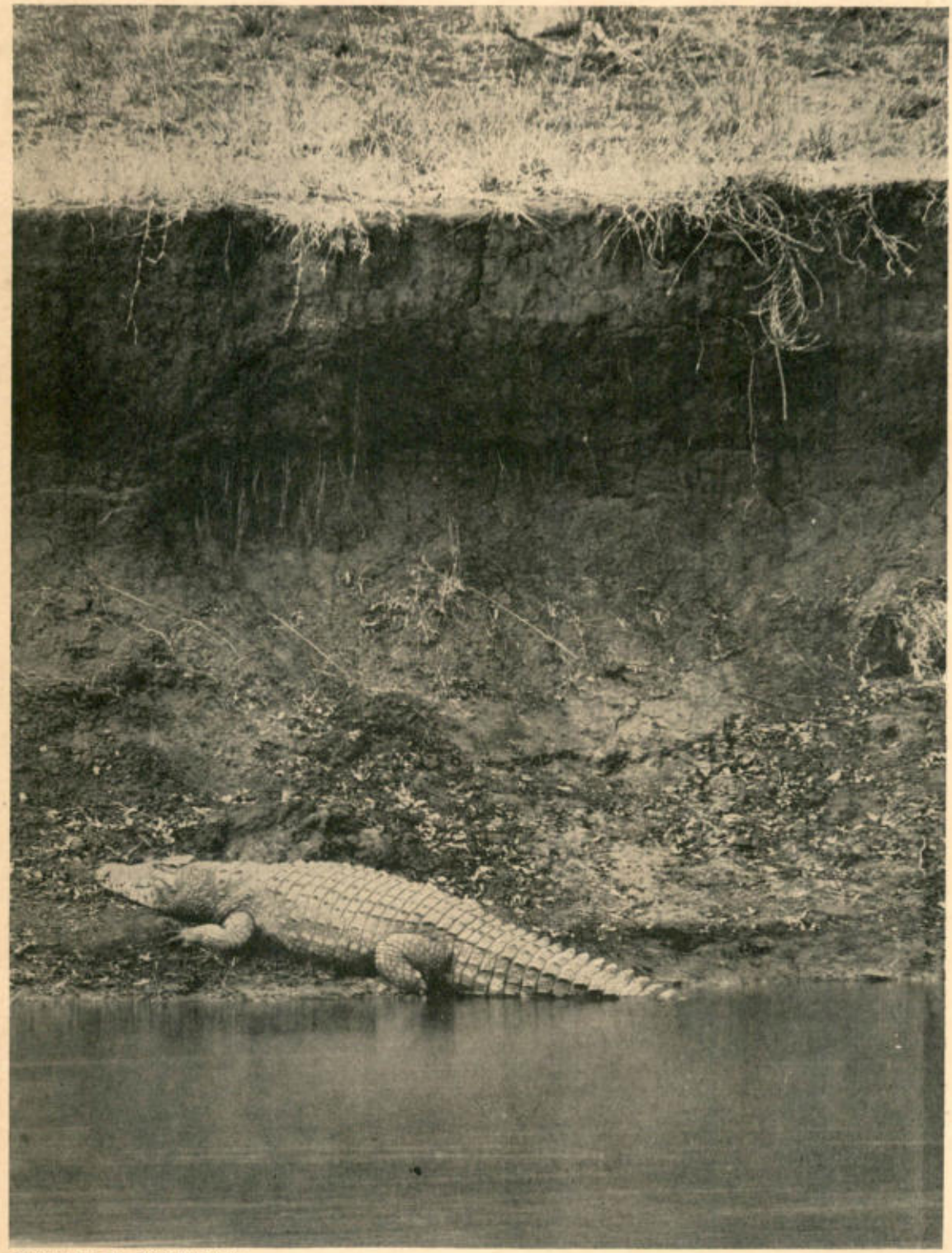


Photo: Major H. Radclyff Dugmore.

LARGE CROCODILE ON TANA RIVER, KENYA.

Crocodiles have a wide distribution, three kinds in Africa, three kinds in Tropical America and the West Indies, and about four kinds in Malayan, Indian, and North Australian countries. A common species of West African rivers is *Crocodilus cataphractus*. The Nile crocodile may attain a length of nearly fifteen feet.

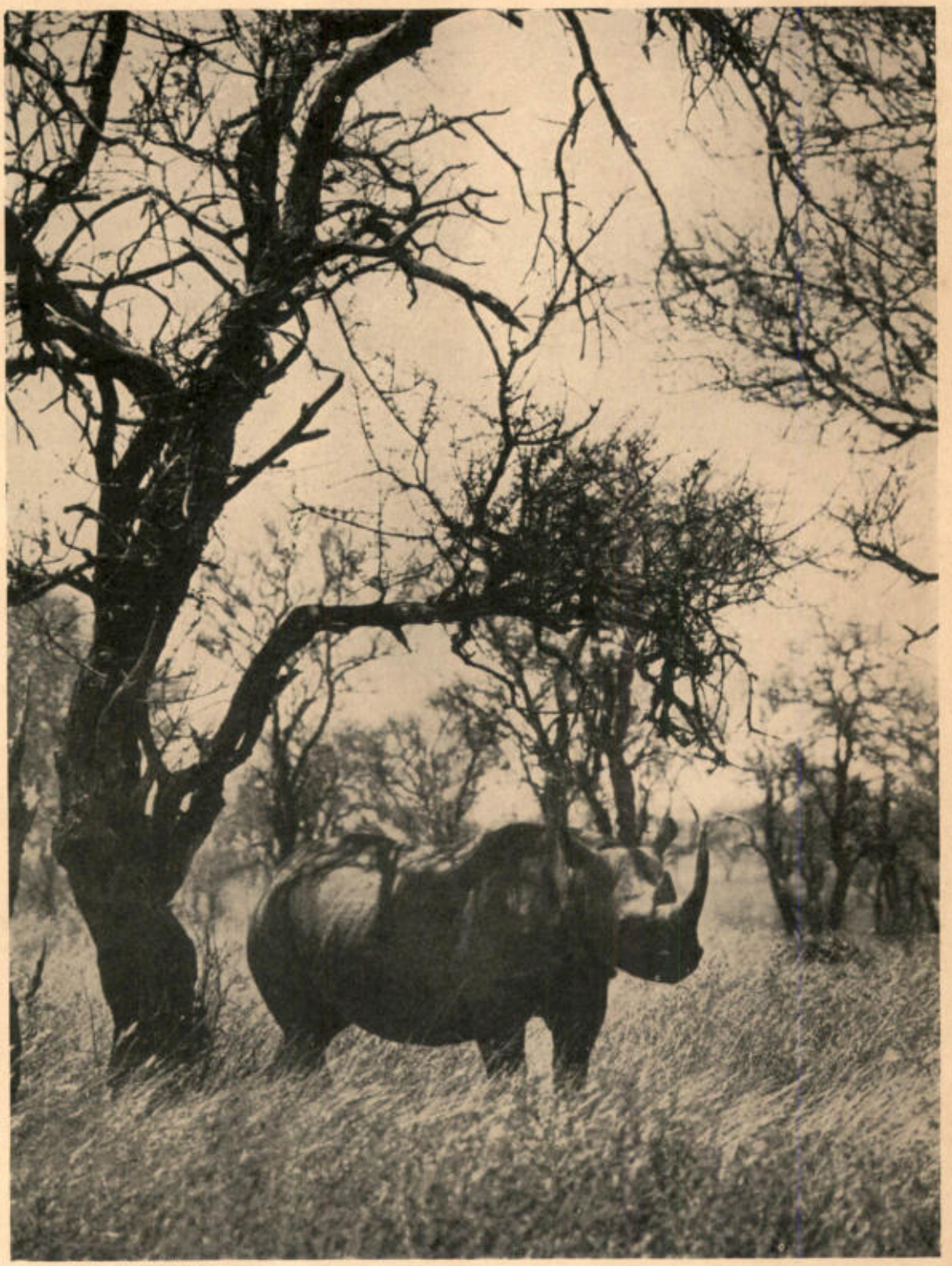


Photo: Major H. Radclyff Dugmore.

BLACK RHINOCEROS (*Rhinoceros bicornis major*).

Though smaller than the so-called white Rhinoceros, the black species is a formidable beast, being about eleven feet in length and five in height. It has two horns, of which the front one may be two feet high. Although called black, it has a flesh-coloured skin. This Rhinoceros is gregarious, five or six being often found together. The photograph represents a female, one of a herd of five.

during the hottest part of the day. Dozens of them will sometimes lie quite close together along a stretch of sand, attended by a crowd of plover-like birds, which hop about the monsters fearlessly, picking leeches from their armoured backs.

The crocodile crawls down the bank on its short legs and disappears under the water. For a long time it lies there motionless, with only the tip of its snout showing, but it is not dozing now, it is watching for its prey. A little antelope slips out from the edge of the jungle and stands at the brink in its curious " whipped dog " attitude. It does not see the nostril-bearing snout of the crocodile, which might be just a stone or a lump of mud, so it stoops to drink. Noiselessly the crocodile swims nearer, then with a sudden rush and a lashing of its mighty tail it is upon the antelope, and has caught it fast in its powerful jaws. The crocodile usually drowns its prey, and it is able to hold the animal under water without drowning itself, because it can close its nostrils both externally and at the posterior opening far back in the mouth. The entrance to the windpipe is shunted forwards against the posterior nostrils, and if the anterior nostrils are then opened and raised above the surface, breathing can go on undisturbed by the water in the mouth. Cattle, sheep, and all kinds of wild animals and birds and fish become the crocodile's victims, and even human beings are sometimes attacked when they come to the river to draw water.

The crocodile comes on land for another reason besides basking in the sun, for it makes its nest in a hole in the sand. The mother scoops out a fairly deep hole and there lays her large white-shelled eggs which are like those of a goose. She covers them over with the warm sand, and spends a good deal of time on guard, using the spot as her basking-place. In about three months' time the young ones break through the shells, chipping them open with a special " egg-tooth " and make curious little sounds, which have been compared to a hiccough, till the mother comes and helps them to struggle out of the sand. She is more affectionate than most reptile mothers, and she proudly leads her family to the water.

It is interesting to note how often the big animals of the swamps have their attendant birds. The crocodile-birds are useful to it in ridding it of troublesome parasites, while the bird profits by a constant supply of food. The red buffalo, which is a splendid swimmer, is often accompanied by a flock of buff-backed egrets and other birds, which follow it through the swamps in order to catch the insects disturbed by the buffalo's hoofs. Sometimes these bird companions are useful to the buffalo in drawing attention to some approaching danger. It is quite certain that the rhinoceros depends a good deal on its " sentries," the little tick-birds that fly about with it and settle on its back to seek the ticks on its hide. If the birds fly up suddenly the rhino at once becomes alarmed, while their return and placid settling down to feed again have a soothing effect on the big beast.

The Rhinoceros.

The rhinoceros has rather an evil reputation. It is said to be ill-tempered and malicious. It is undoubtedly inquisitive, and it has very indifferent sight ; moreover, it is naturally an animal of the night, and spends most of the day in sleep, so that when it is wakened suddenly by a blundering traveller, it is apt to charge. The forest rhino, which has long, tapering horns, is probably more ill-natured than the rhino of the plains whose chief desire is to be left alone, though it will make a savage attack if it is disturbed. Originally an animal of the plains, the shorter horned rhinoceros has been forced further and further into the bush, and then into the forests by the advance of the settlers in the open country. Its food on the plains, namely, small thorn bushes and, perhaps, grass, is replaced by leaves and twigs in the jungle.

There is only one young one at a time, and it runs beside its mother till it is quite big. A mother rhinoceros has been seen accompanied by two young ones, a very small one and a big one that was obviously an older brother, but usually the mother drives away a well-grown youngster and lets it shift for itself before its successor arrives. During the day the rhinoceros sleeps, usually alone, lying under a solitary tree on the plain or in the shelter of a thorn-bush or in the heart of a thicket in the jungle. In rocky places it often chooses a high ledge, for, in spite of its unwieldy body and short, thick legs, it can climb like a goat. It will lie stretched out on its side, like a huge pig, for hours without moving, while the tick-birds search its tough hide for food. Its sleeping-place in the forest is usually well away from water, on high ground.

About four o'clock in the afternoon, when the heat is less intense, the rhinoceros bestirs itself and starts its daily journey to its favourite watering-place. It feeds as it goes, wandering in a leisurely way from bush to bush, but it manages to reach the "edo" early in the evening. If it is late it will stop feeding and break into a trot, for, in spite of its stumpy legs, it can cover the ground at a good pace, and arrive at the water at the usual time. Rhino-trails, about twenty inches wide, and worn smooth by constant traffic, lead to the water-holes.

Photo: Major H. Radclyff Dugmore.

BULI, RHINOCEROS COMING TOWARDS THE CAMERA.

The Rhinoceroses form a family of odd-toed Hoofed Mammals, related to horses and to tapirs. They are heavily built, thick-skinned, with little hair, with three nearly equal toes on both fore- and hind-limbs. The front of the head bears a peculiar horn, or two horns, one behind the other. Each rises from a rough patch of bone (on the nasals), and consists of agglutinated hair-like structures. Rhinoceroses occur in Asia and Africa.

Where they go through dense thickets, they are tunnels, just the height of the animal's body. They are not safe tracks for an explorer to use, any more than a rhino-trail is a good camping-spot, for these animals are very faithful to old paths, and use the same ones for a very long time.

Numbers of rhinos meet at the watering-place, and when they have quenched their thirst they begin to play, "romping like a lot of overgrown pigs." Their squealing and grunting resound through the dark forest. When they are tired of playing, they return to the water to wallow, or seek a convenient tree against which to scratch their wrinkled hides. Apart from the daily excursion to the water-hole, the rhinoceros wanders little for the greater part of the year, but seasonal wanderings take place when the driest months come. The rhinoceros finds its favourite water-holes dried up, so it sets out in search of deeper pools. It has a keen "water-sense," and is known actually to dig for water, using its fore-feet and throwing up the sand between its hind-legs, like a dog. Other animals make use of these holes, and may deepen them a little, but very few sink wells for themselves.

The Hippopotamus.

Another very large animal, which has been driven even further into the depths of the forest than the rhinoceros, is the hippopotamus, now only plentiful on the rivers in the interior of Africa. The hippopotamus is "behemoth" of the Old Testament, "the chief of the ways of God."

"Lo! now his strength is in his loins
And his force in the sinews of his belly.
He bendeth his tail like a cedar;
The muscles of his thighs are knit together;
His bones are pipes of brass;
His limbs are like bars of iron."

A full-grown hippopotamus weighs about four tons, and may be as much as fourteen feet long—a veritable giant. Its huge rounded body is supported on short, thick legs. Its massive head, with its broad muzzle and enormous teeth, is so heavy that the animal is sometimes seen resting it on the ground, as though even its thick neck could scarcely bear the strain of its weight. The body is almost hairless, and its hide much smoother than that of the rhinoceros.

Photo: Captain Hurley.

THE SUPERB BIRD OF PARADISE (*Paradisea minor*).

The female is a plain brownish bird, but the male is gorgeous beyond belief. The orange-yellow blaze of the tail feathers, for instance, is like a fountain of gold. The emerald of the throat is dazzling like a jewel. When the male bird displays himself before his desired mate, like the peacock before the peahen, the whole plumage is vivified in an extraordinary way that beggars description.

The hippopotamus feeds on grass and water-plants, its stomach can hold five to six bushels! The German naturalist, Brehm, describes the hippopotamus feeding in this way: "The hideous head disappears into the depths, and grubs about for a few minutes among the plants, till the water is darkened with mud. Then Behemoth reappears with a great thick bundle—for him a mere mouthful—lays it on the surface of the water, and consumes it at his leisure. The stalks and tendrils hang far out of his mouth on either side; a greenish plant-juice mixed with saliva flows continually over his swollen lips; half-chewed balls of grass are thrown out and swallowed again; the expressionless eyes stare fixedly, and the great teeth exhibit themselves in all their monstrosity."

The hippopotamus is enormously strong, a mere push from its snout is enough to overturn a boat, and it can drag cattle under water quite easily. It does great damage in cultivated districts, where it raids the rice-fields and destroys with its feet far more than it eats. But on the whole it is afraid of the settlers, against whose guns it has no defence, so in inhabited districts it is active only at night. During the day it remains under water. Its nostrils are placed high on its snout, and it keeps them above the surface, but usually well hidden among the water-weeds, so that there is nothing to betray its presence. It makes no sound during the day, except by its breathing, but at night it bellows and grunts and snarls.

In out of the way regions, where there is little chance of its being disturbed, the hippopotamus is not nearly so nocturnal in its habits. It comes boldly out of the water in the daytime, and basks in the sun. Sometimes the calf—there is usually

Photo: Major H. Radclyff Dugmore.

HIPPOPOTAMUS AND CROCODILE, TANA RIVER.

The Hippopotamus is a distant relative of the pigs. It is confined to Africa, but its range used to include Madagascar. It can swim, and it can also walk along the floor of the stream. The skin sometimes shows a blood-red sweat, and "Behemoth"—the hippopotamus—is spoken of in the Book of Job as having a "ruddy" hide. A length of fourteen feet is sometimes attained. The excellence of the photograph is shown by the presence of numerous plover-like birds on Behemoth's back, picking off leeches and the like—an interesting partnership.

only one at a time—is left under cover to sleep during the day, but often the mother swims with the young one on her back. She herself can remain under water for fully ten minutes, but she comes up oftener when she has a calf, as it must breathe more frequently. If danger threatens, the mother is very brave in defence of her young one.

Mr. Blayney Percival describes how a "mud-bank" on an African river turned out to be the backs of fully a hundred hippos. They were not in the least alarmed, and two or three of them came swimming towards the observer to see what he was doing. He also tells of the "most charming and comical scene of animal life" he ever witnessed, a gathering of hippos at a favourite resting-place. "They came singly, in twos and threes, old and young, and they laid them down in a mass, literally in heaps, for it seemed the recognised thing that they should use each other as cushions. They lay there in the sun like dead things—at least the old ones did. The calves were less reposeful, walking round and over and among their seniors, and small blame to their restlessness. If a little fellow did lie down, a big one always came and sat on him; it was manifestly hippo tradition to use the children as pillows. Down the big one would go atop of the unfortunate toto, and then a pardonable tempest of squeals from the half-crushed sufferer till he succeeded in wriggling clear of the ponderous mass, which took not the slightest notice of his screams and struggles. Having escaped, the little one would shuffle about a bit, then, finding himself comfy, go to sleep." The crowd of hippos on the bank took not the smallest notice when two huge ones in the river had a disagreement. A terrific fight followed, with much grunting and biting, and churning of the water, but the slumberers never moved, and presently the battle ended as suddenly as it had begun.

Photo: Reproduced from "Jungle Peace," by William Beebe, by courtesy of Messrs. Henry Holt & Co.

NESTLING HOATZIN CLIMBING WITH THUMB AND FOREFINGER.

The Hoatzin (Opisthocomus) is a survival of an ancient stock of birds. Anatomically regarded, it might be called a "living fossil." One of the antique features, reminiscent of arboreal reptiles, is the gripping of the branch with the bird's thumb and forefinger.

Birds of Jungle and Swamp.

In the early morning, in forest and jungle, the birds begin to stir, screeching guinea-fowls, green love-birds, quails, and weaver-birds, and many another. Parrots, some of them ashy-grey with long red tails, get to work among the seeds and fruits. Their claws are well-suited for climbing about the branches, and their strong beaks for dealing with hard fruits. Sometimes they rise in a chattering band and fly high over the trees. As the heat becomes more intense the jewel-like sun-birds begin to fly from flower to flower, in search of insects and honey, but the drowsy parrots rest in the shade. The day wanes and the parrots fly to a pool, fringed with feathery golden mimosa, to splash joyously in the water in the coolness of the evening.

The Story of the Hoatzin.

Gleaming sun-birds of Africa; humming-birds like living gems darting through the forests of South America; and beautiful birds of paradise in the jungles of New Guinea; the brilliant birds of the tropics would make a very long list; but, to the naturalist, there is no bird of the jungle and swamp more interesting than the

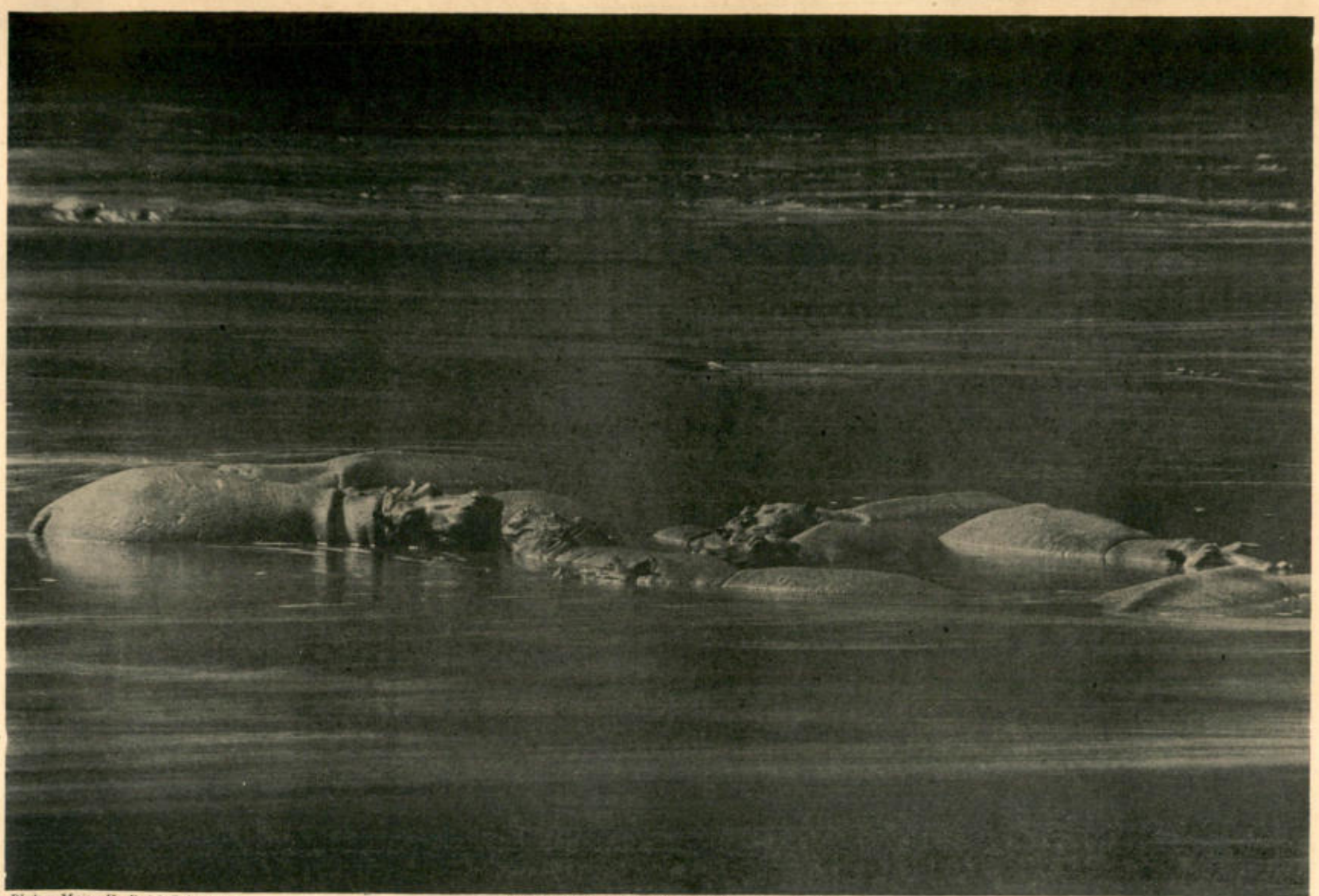


Photo: Major H. Radclyff Dugmore.

HIPPOPOTAMUSES ASLEEP IN THE TANA RIVER.

Hippopotamuses are sociable animals, and a herd of them will lie basking on the surface of a river or lake. "They lie close together like pigs," says Gordon Cumming, writing of the hippopotamuses of the Limpopo River, "and as they sprawl in the mire have not the least objection to their neighbours pillowing their heads on their backs and sides. A full-grown hippopotamus may weigh as much as four tons. There is a dwarf species in Liberia. This excellent photograph shows partner-birds perched on the monster's hide.

Photo : Harold Bastin.

KING BIRD OF PARADISE (*Ancinnurus regius*).

This is a small bird, about seven inches long, not counting the tail-wires, but it shows extraordinary brilliance. The main colour is glossy crimson, with a metallic green band dividing the throat from the white beneath. On each side there is a raisable fan of ashy plumes tipped with enamel. The median tail-wires end in a coiled green disc. The bill, half covered with feathers, is orange-coloured ; the feet are cobalt blue. What wealth of decorative colouration ! Often, however, it is born to blush in the jungle.

hoatzin. This curious bird, which is found in British Guiana, is a living link between reptiles and birds. In many of its ways it is much more like a reptile than like any other flying bird. "For it," as Mr. William Beebe says, "the dial of the ages has moved more slowly than for the rest of organic life . . . and in their classic reptilian affinities—voice, actions, arms, fingers, habits—they bring close the dim epochs of past time, and renew for our inspection the youth of bird-life on the earth."

Hoatzins always build their nests over the water, in trees at the edge of a lotus-covered swamp or along the banks of a river. The nests are scarcely more than platforms of dry sticks, only slightly hollowed out, and often not very securely put together. They are usually from six to fifteen feet above the water, sometimes less and occasionally very much more, even fifty feet up a tall tree. The birds are extraordinarily tame, and will not leave the nest till the branch on which it is built is actually shaken by the intruder. A bird sitting on the same branch as one which is shot will calmly go on preening its feathers, without so much as a glance at its companion's falling body. But when at last the parent-birds do realise that their nest is being tampered with, they begin to croak in their strange, hoarse voices. The female's voice is deeper than the male's, with a more gurgling sound, but the usual note of both is something like a frog's croak. "At last," writes Mr. Beebe in his delightful book, "Jungle Peace," "the never-to-be-forgotten hoarse gutturals of hoatzins came to our ears, and dimly through the rain we saw one small branchful of four birds, bunched up with drenched plumage. Two others were posed as rain-worshippers—rufous wings widespread, heads stretched out, welcoming the sheets of water which poured over them. Their wild crests, though sodden and glued together, were still erect, dripping and swaying."

The home of the hoatzins is in the thorn trees or "pimplers," which grow right down to the mud that is washed by the brackish tide of the river estuary. The trees are covered with big thorns, their flowers are delicate, Wistaria-like,

pale mauve blossoms, and their leaves, which form the food of the hoatzins, are soft and green. Among these trees the birds spend their time, building their nests in the forks of the branches, and sitting close on the eggs. When the heat is intense the mother-bird sits on the rim of the nest so that her body casts a shadow on the nestlings. Year after year they remain in the same place, owing their safety to their strong, musky odour, which keeps possible enemies at a distance.

Mr. Beebe describes how a week-old hoatzin chick, whose life had till then held "nothing but siestas and munchings of pimpler leaves," behaved when its scared mother forsook the nest and it was left alone to face the intruders. As its head, with beady black eyes and thick, blunt beak, and its long, thin neck appeared over the edge of the nest it looked extraordinarily like some extinct reptile of past ages. Its body was covered with scanty, sooty black down; on its head the slightly longer down already suggested a crest, but its flight-feathers were only half an inch long, so it had no chance to escape by flying. But the young hoatzin has a free thumb and forefinger, which it can use in climbing till its wings are strong enough for flight; so the chick did not wait to be picked up by the man who was climbing painfully up the thorn tree and making the nest sway perilously. It took a few uncertain steps to the edge of the nest that it had never left before and raised its mittened hands. The brave little hoatzin began to climb, using its feet and its thumbs and forefingers, and craning its neck like a tiny turtle. With many a twist and turn it reached the end of a branch. It was almost within the climber's grasp. Then it played its trump card, and did what no other modern land bird would do. "The young hoatzin stood erect for an instant, and then both wings of the little bird were stretched straight back, not folded, bird-wise, but dangling loosely and reaching well beyond the body. For a considerable fraction of time he leaned forward. Then without effort, without apparent leap or jump he dived straight downward, as beautifully as a seal, direct as a plummet and very swiftly. There was a scarcely noticeable splash, and as I gazed with real awe, I watched the widening ripples which undulated over the muddy water—the only trace of the whereabouts of the young bird."

Photo: Harold Bastin.

SIX-WIRED BIRD OF PARADISE (*Parotia sexpennis*).

The general black colour has a sheen of bronze and purple; there is a golden throat-patch suggesting scales; the breast shows metallic green and blue; a white patch crosses the front of the head; the top of the head is green, blue and purple; three wires, from each of two side tufts on the head, end in black discs. Each side of the body bears erectile patches of black feathers. All this gorgeously decorative plumage is confined to the male and is displayed in the shades of the thick jungle.

After some minutes the bedraggled little bird reappeared, but when they rowed towards it, the chick dived again, and came up in the middle of a tangle of weeds, well out of reach. The glistening black nestling then began to climb back to the nest fifteen feet above water, and never faltered till it tumbled into the nest, when it uttered a pitiful squeak. The mother bird had been urging it on for the last few minutes with hoarse cries, and now she was ready to comfort it and stuff its little crop full of soft " pimpler " leaves.

Mr. Beebe sums up the story of the baby hoatzins in this way : " They crept on all fours, they climbed with fingers and toes, they dived headlong, and swam as skilfully as any Hesperornis of old. This was, and I think always will be, to me, the most wonderful sight in the world. To see a tiny living bird duplicate within a few minutes the processes which, evolved slowly through uncounted years, have at last culminated in the world of birds as we find it to-day—this is impressive beyond words."

LIV

LIFE OF THE CRATER-LAND AND CONGO FORESTS

ONE of the strangest and yet most densely peopled haunts of life is the " Great Crater-Land " in Eastern Tropical Africa in Tanganyika Territory. It includes Ngorongoro, the largest crater in the world, 12 miles in diameter, 35 miles in circumference, 2,000 feet deep, and said to contain 75,000 head of big game, which never stray outside its protecting walls. It has been recently described by Mr. T. Alexander Barns in his fascinating book, " Across the Great Craterland to the Congo " (Benn, 1923), a sequel to " The Wonderland of the Eastern Congo." We are indebted to Mr. Barns for some characteristic photographs of the tropical flora.

The word crater is often applied to any bowl-shaped hollow connected with a volcano, but

" Craters and Craters."

Professor J. W. Gregory distinguishes five different kinds. There is the *upbuilt* crater, such as is seen at Vesuvius, " a pit left by the piling up of lava or volcanic ashes in a ring-shaped hill around the mouth of a volcano." Second, there is the *explosion* crater, as at Krakatoa, made by the blowing away of the top of a volcanic mountain. Third, there is the *subsidence* crater, a pit formed by a sinking of the ground, as in the great caldrons of the Grand Canary. Fourth, there is the *erosion* crater, a pit excavated on a volcanic mountain by streams of water, aided by rain and wind or by the sea. Fifthly, there is the *impact* crater, a hole punched by the fall of a colossal meteorite. According to Professor Gregory, the craters of the Engotiek Highlands, which Mr. Barns explored, are subsidence craters, or caldrons, and while we cannot but think of big built-up craters like Etna, which is about a mile wide, we must keep in mind that Ngorongoro is immensely bigger. It is eleven to twelve miles in diameter, is surrounded by steep walls from 1,700 to 2,000 feet high, and includes a lake four miles long. It is rich in luxuriant vegetation and gorgeous tropical flowers ; it is crowded with wild animals—often strangely tame ; and it may well be called " the most remarkable zoological garden in the world." It is a vast *natural sanctuary*, and it would make a very suitable reservation area, where animals would settle their own affairs, unmolested by man.

Many of the caldrons in this volcanic Tanganyika Territory are quite small, but Ngorongoro

The Great Crater.

itself must be magnificent. After an arduous journey the travellers came suddenly on the " edge of the world," and looked down on the giant caldron. On all sides it is encircled by precipitous cliffs ; where the lava once seethed there is luxuriant vegetation—forests, meadows, and grassland ; where the volcano once spluttered and exploded there

Photo: Major H. Radclyff Dugmore.

HERD OF GRANT'S GAZELLE NEAR THE OLGEREI RIVER IN AFRICA.

This is one of the characteristic Gazelles of the Crater-land. In the open country it is by no means easy to get within close range of these alert creatures. The photographer's stalking necessitated crawling on the ground and dragging the camera. The animals were entirely unsuspicious, and a very excellent picture was secured.

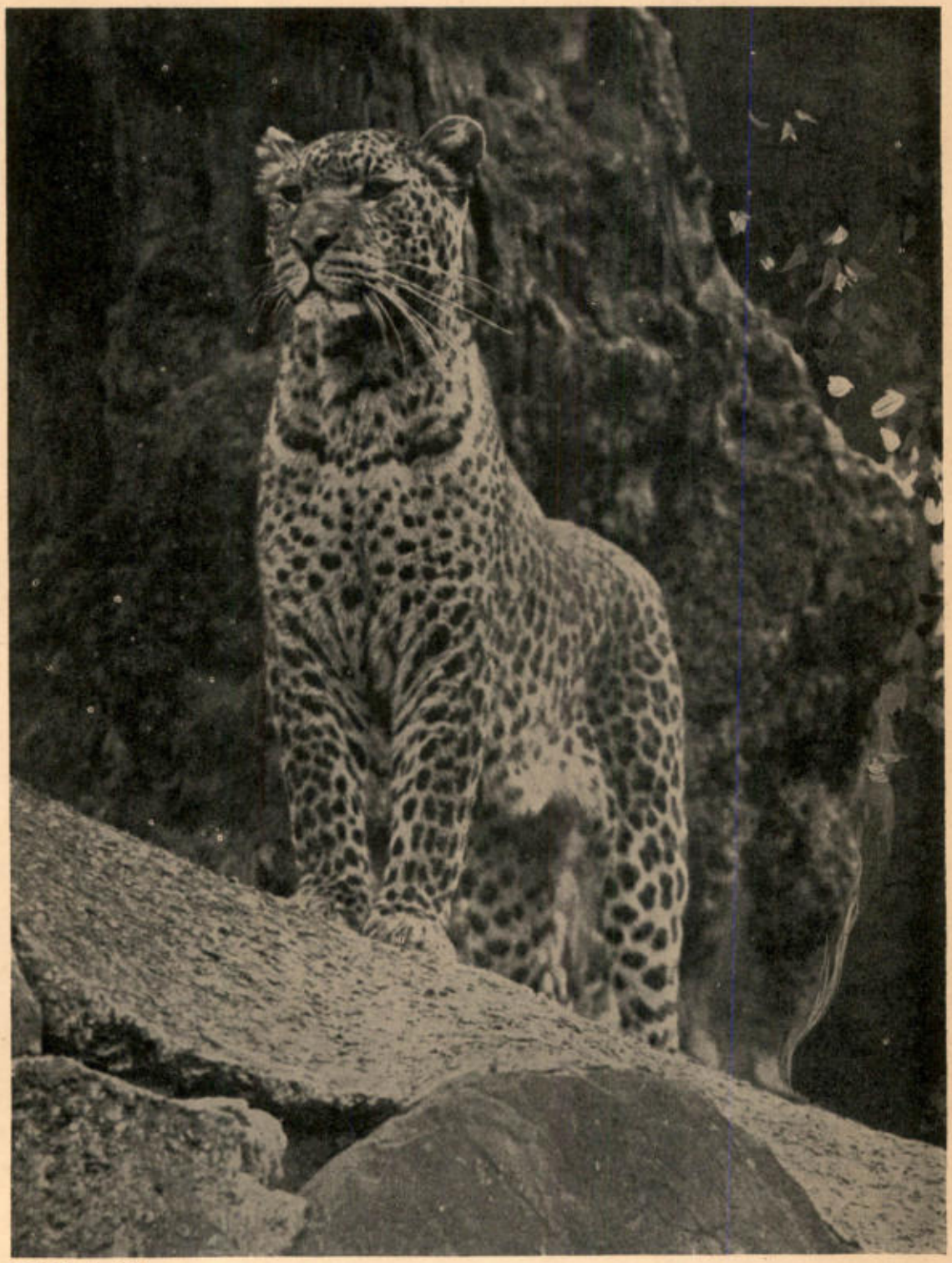


Photo: F. W. Bond.

LEOPARD (*Felis pardus*).

This beautiful carnivore, African and Asiatic in distribution, shows two kinds of spots, both seen in the photograph. A rosette of black spots may surround a tawny centre, or the spot may be solid black. At high altitudes the colour tends to be darker all over. The Leopard is a clever climber, a fierce hunter who makes few mistakes.

lies a great lake, blue and gleaming amidst its marshes and mud-flats; where the heavy volcanic smoke was once swept hither and thither by great gusts, there are crowds, even *crushes*, of big game.

"By reason of its vastness, its novel surroundings and scenery, its brooding mystery and teeming life, Ngorongoro far surpasses, in my opinion, such sights as Kilimanjaro or the Mountains of the Moon, or even the great Kivu Volcanoes. Of such a place one might well say, 'See it and die,' for surely no place was ever half so beautiful."

Photo: F. Radcliffe Holmes.

BABOONS ON THE MARCH.

Baboons, of the genus Cynocephalus, are monkeys much higher than the New World monkeys, yet much lower than the Anthropoid Apes. They are gregarious in habit, and illustrate very markedly the instinct of the herd.

Wallowing in the pools of the marsh there were hippopotamuses (hippos, for short); roaming about more restlessly were rhinoceroses (rhinos, for short). Thousands of zebras were half-hidden, half-advertised by their stripes, and the great family of antelopes was represented by wildebeeste, hartebeeste, Thomson's gazelle, Grant's gazelle, the rather ox-like eland, and many others. Somewhat by itself, yet among antelopes, is the Brindled Gnu, suggesting a pony in its hairy face, rump, and tail, but bearing the horns of an ox. Preying upon the herbivores were the beasts of prey—lions, cheetahs, hyænas, and jackals. Baboons were to be seen in troops of a hundred or more; and on the distant heights there were family parties of gorillas. Some ostriches had found their way into the crater, besides guinea-fowl, giant bustards, wintering cranes and storks, quail among the grass, and ducks by the marsh-pools.

Crowded Life.

The sides of the lake were too bitter to be popular. It was not only the variety, but the density of the animal population that impressed the explorers. Two hours they took to cross the amphitheatre, and they were walking through mixed herds of wildebeeste, hartebeeste, gazelle, and zebra all the time. "Wherever one looked over the far crater-plain there were animals, and, looking at them along an absolutely flat surface, they might well be described as a sea of backs with an undercurrent of legs, as they moved hither and thither about us." Having

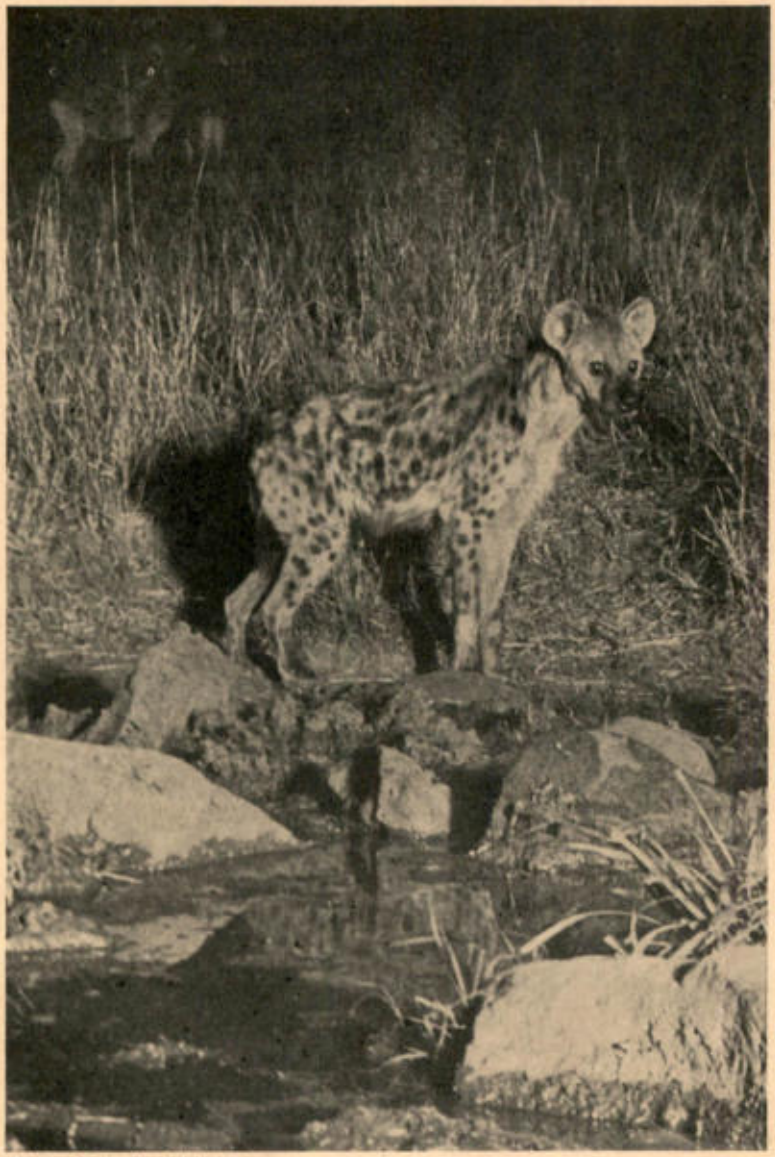


Photo: Major H. Radclyff Dugmore.

AFRICAN SPOTTED HYÆNA (*Crocuta maculata*).

Hyænas are related to mongooses, genets and suricates, and are widely represented in Asia and Africa. They have a short tail and non-retractile claws. There is neither a thumb nor a big-toe. They are for the most part carrion-eaters. They have no scent-glands, but their sense of smell is acute.

but little experience of man, the wild animals were very tame; and a big rhino lay down to sleep in the open within 250 yards of the camp.

The Flora.

There is no difficulty in understanding how the beasts of prey are fed—there are antelopes galore; but what of the herbivores—shut up in a crater with a "ring-fence" of cliffs? The answer is that the greater part of the amphitheatre (5,800 feet above sea-level!) is covered with a close mat of succulent white and red clover, sometimes knee-deep for acres and acres. There are fragrant mints and thymes, too, which the rhinos enjoy; thick-set "lad's love" bushes, arborescent brooms, and trees heavily hung with moss and fern, besides great "herbaceous borders" of delphiniums, lupins, mallows, petunias, campions, scabions, camomiles and marguerites. The great majority have fragrant leaves.

Lions of the Crater.

Mr. Barns was able to see a good deal of the lions of Ngorongoro, for freedom from molestation had made them bold. Instead of being nocturnal, they were often seen abroad in the daytime. They were large and fat, with fine manes, inclined to a "live and let live" policy as regards man, yet charging fiercely when roused by danger. In adjacent areas some lions become addicted to man-eating, and then the pursuit of wild animals returns to its original and most justifiable form of direct competition, for that was man's first relation with the larger beasts of the field. They were his direct rivals in the struggle for existence.

The giant crater contained hyænas by the hundred, "low-caste carnivores" that no one is very enthusiastic about. They seem to be related to the civets, genets, mongooses, and suricates (South African "meerkats"), and they are mainly carrion-feeders, though some are fond of white ants. They hang about when a lion is devouring its kill, and often get the leavings of the feast. They are African and Asiatic in range, and have more than their share

of fables associated with them. Their human-like howls are supposed by the credulous to be deliberate attempts to lure unwarily tender-hearted travellers to their doom; and the eye contains a stone which will confer on a man the gift of prophecy if it is carefully held beneath his tongue. They are said to change their sex every year, and some travellers tell us that hyænas are male and female at once. The fact is that the male and the female are almost indistinguishable externally. Even Mr. Barns does not get quite free from this supposition, for he vouches for the accuracy of the statement that the young are suckled by the males as well as by the females. But with this we are unable to agree. Though on rare occasions a male mammal may produce some milk, as in the case of hares, no mammal ever makes a habit of so doing. But we are none the less grateful to Mr. Barns for his vivid word-pictures of scenes, and for scores of snapshots like the following: "Ross, who after he left me, went for a shooting trip in Kenya, assures me that one night, while sitting over a dead zebra waiting for a lion, so many hyænas came around the bait that they resembled a large flock of sheep." There seem, indeed, to be too many hyænas in Kenya Colony.

In the Congo Forest.

Outside the crowded crater, in the more varied Congo forests, there is an even greater variety of animal life. Some of the mammals are very remarkable. Thus there is the aquatic chevrotain or deerlet (*Dorcatherium aquaticum*), a representative of a unique family (Tragulidæ), ranked among the cud-chewers or Ruminants, but in many ways different from all the rest. There are no horns in either sex; the canine teeth are very long, especially in the upper jaw of the males; the stomach is simpler than in ordinary cud-chewing mammals, and has three chambers instead of the usual four; the feet have usually four toes.

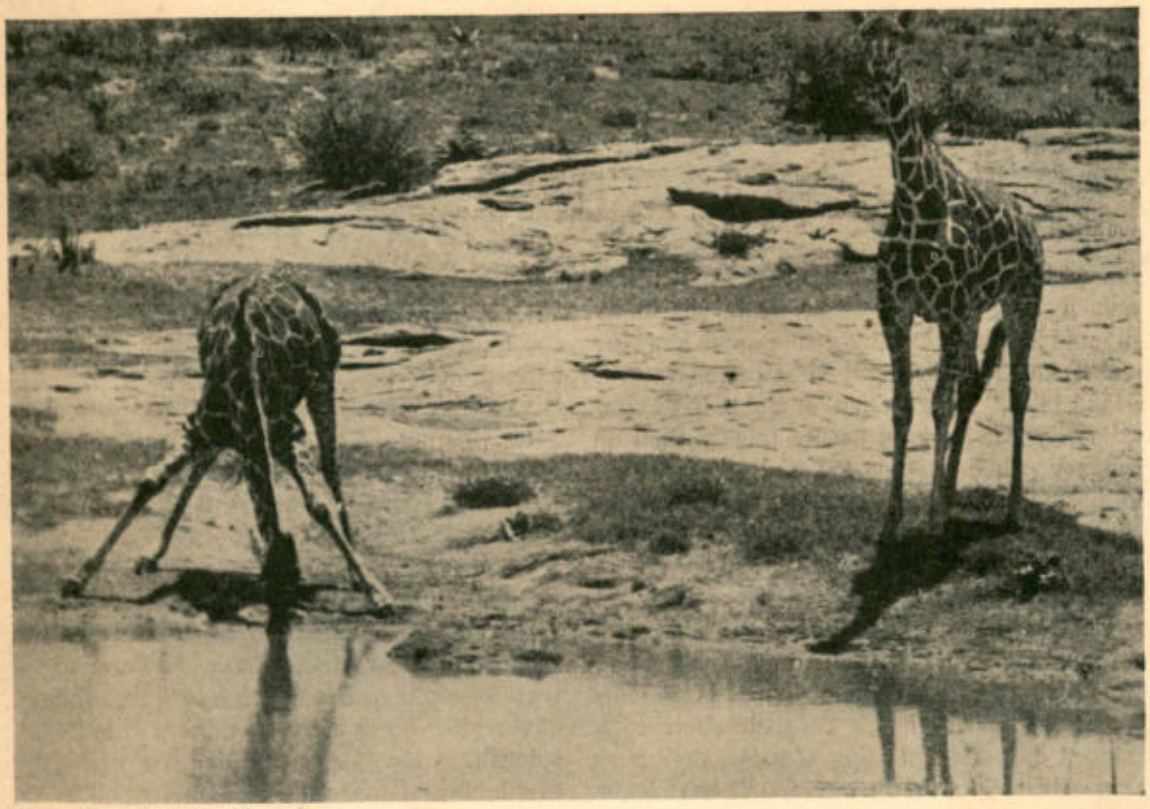


Photo: Major H. Radclyff Dugmore.

RETICULATED GIRAFFE.

The Giraffe is an African Ruminant occupying a position by itself, approached only by the Okapi. Its long neck has the same number of vertebræ as in all but four other mammals, namely, seven. Its length is such that, as the photograph shows, the legs have to spread apart if the mouth is to reach the water. Its use has been interpreted as an adaption to reaching the leaves on high branches and as helping the Giraffe to keep an outlook for lions. The markings on the skin make the big creature very inconspicuous among the mimosa trees.

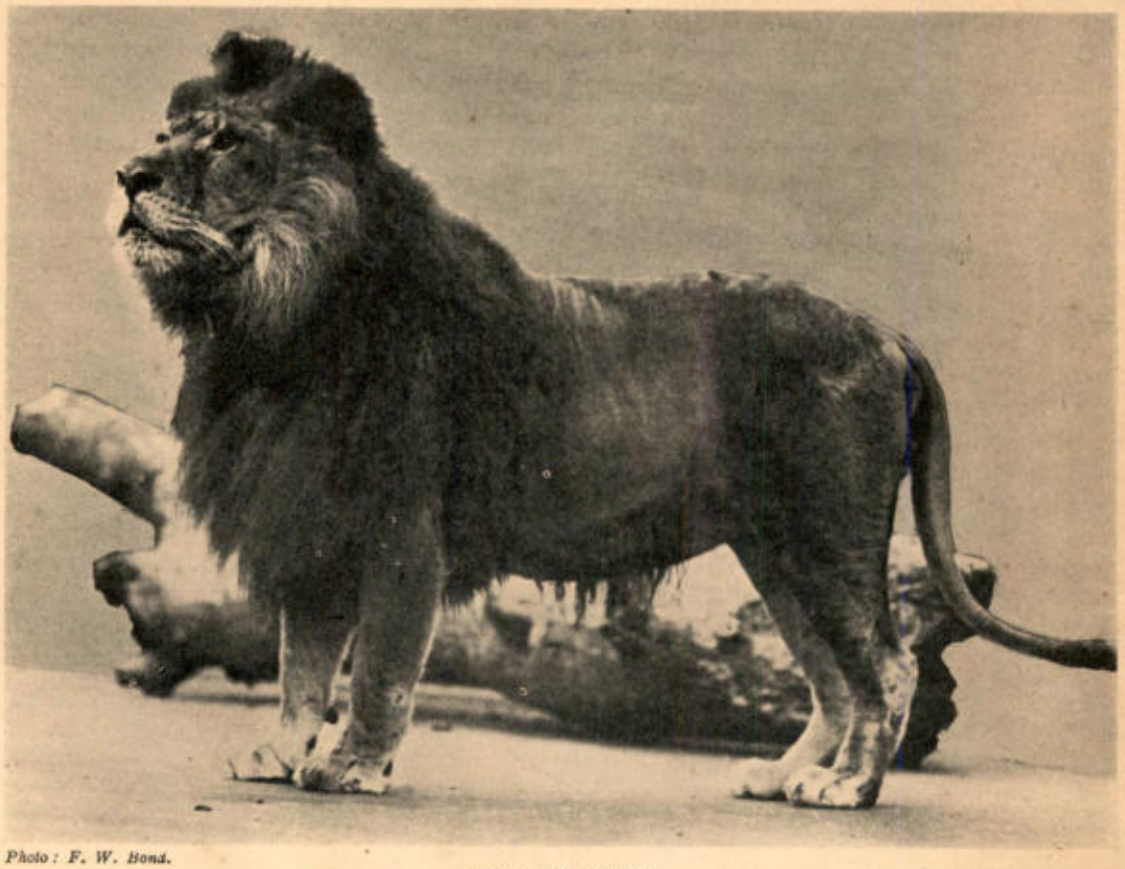


Photo: F. W. Bond.

THE LION (*Felis leo*).

The most impressive of the "cats," occurring in Africa, India, and some parts of Asia, ranging into Europe within historic times. Unlike most "cats," it cannot climb. It hunts chiefly by night, and it does not roar until it has supped well. There is a curious little claw at the end of its tail.

The African Water Deerlet has "small round ears, a long pig-like snout, stiff chocolate-coloured hair with creamy-yellow spots and bars over it, and short legs bare of hair almost to the second joint." The Indian Tragulus has extraordinarily slender legs, hardly thicker than an ordinary pencil. These graceful creatures are neither antelopes nor deer, but simply chevrotains or deerlets, quite by themselves.

Another oddity is the tree-coney or Hyrax (*Procavia dorsalis*), which makes the forest resound with its nocturnal cries. While some of the coneys live chiefly among the rocks, shy and wary little folk, this particular kind is at home in the tropical forests. In their short ears, reduced tail, and squatting attitude, they have a resemblance to gnawing mammals or rodents, but this is quite superficial. In fact, they seem to form a little order by themselves, with very distant relationships to Rhinoceroses! It is interesting to note that some extinct ancestors of the coneys were as large as tapirs, whereas the modern refugees among the rocks and in the forest are not larger than hares. They are shrewd little creatures, a "feeble folk" but "exceeding wise," quick to retreat into their holes whether on cliff or tree. In spite of the Old Testament description, they do not chew the cud; but they look as if they did, they move their jaws so much.

Another very remarkable forest animal is the Brush-tail Porcupine (*Atherura africana*), a relative of the Common Porcupine which occurs in Europe. The African form has fewer of the very long spines, but it has a brush at the end of the tail. There is such a mix-up of hairs and spines that Mr. Barns, who had the prickly job of skinning a Brush-tail Porcupine, said it looked as if someone had been playing a joke trying to produce a new animal. The strong spines or quills are transformed hairs, and like hairs they fall out and are grown afresh. But porcupines

can hardly be said to throw off their spines deliberately, although we have had letters from eye-witnesses who have seen them discharging them like javelins. We believe that the mistake is partly due to the falling out just mentioned, and partly to the fact that in some cases (like the North American Erethizon) the loosely attached spines are readily jerked off in convulsive muscular movements. An inexperienced observer may also be deceived by the way in which the animals spread out their big quills, and in so doing produce a rattling noise, perhaps a warning or a challenge. It is said that provoked porcupines sometimes hurtle up backwards against an assailant, thus presenting the sharp tips of their spines. Porcupines belong to the order of gnawing mammals or rodents, and like the coneys some are mainly arboreal while other kinds keep to the ground.

These are only a few representatives of the forest-folk. For there are tree ant-eaters or pangolins, almost invulnerable within their covering of overlapping scales, gorgeous leopards with all their spots, grotesque wart-hogs and Red River Hogs by the streams, the nocturnal half-monkeys or lemur, moving about like ghosts, fierce baboons in troups, besides chimpanzees as clever as they make them.

Mountain Gorillas.

But we wish to go back to the Great Crater Land, to study for a little the great gorillas that are at home there. There are two or three different kinds of gorilla—the West African lowland species (*Gorilla gorilla* and *Gorilla matschiei*) of the North Congo Forest, the Cameroons, and the Gaboon, and the highland Eastern Congo species (*Gorilla beringei*) from north-west Tanganyika and the volcanoes of Kivu. The last species has also been recently studied by Mr. Barns, who has had unique opportunities of observing the greatest of the apes at home.

The Highland gorilla ascends the mountains to a height of 10,000 feet, and that is associated with the fact that the bamboo, which forms its staple food, grows at high elevations in these parts of Tropical Africa. With the mountainous haunts we may also associate the thick coat of

Photo: A. H. Hall.

LIONESS.

The lion breeds healthfully in captivity, and by using plenty of natural food it has been found possible to avoid "rickets" and other ailments. The cubs show the playfulness of many of the more intelligent carnivores, and are very attractive in their ways. Their play sometimes illustrates, like that of kittens, an instinctive anticipation of what would be in natural conditions their natural everyday occupation in adult life.

Photo: T. Alexander Barns.

RUWENZORI VEGETATION.

Alpine plants at a height of 12,500 feet above sea level, on the Ruwenzori Mountain, Congo-Uganda border. Senecios, lobelias, and everlasting flowers (*Alchemilla cinerea*) covering the foreground.

Photo: T. Alexander Barns.

FLORAL LUXURIANCE OF THE GREAT CRATER.

Large white Anemones (*Clematopsis stuhlmanni*), with flowers four inches in diameter, from the highlands of the Great Crater, Tanganyika.

dark hair which covers the body except the bare chest; and on the crown of the head there is a magnificent shock that suggests a busby.

The gorilla's proportions are on a big scale. One that Mr. Barns shot was six feet two inches from the sole of the foot to the crest of thickened skin on the top of the head. In another individual the span of the arms was ninety inches, and the weight over thirty-two stone. Even with ju-jitsu an athlete has no chance with a full-grown gorilla. It can break a thick branch in its great hands, or a lion's forearm, or a leopard's neck. It "could doubtless tear even a Hackensmidt or a Sandow limb from limb in a few minutes." If a man has been unfortunate enough to enrage a gorilla he must either shoot or start a gramophone. Not that the music soothes the savage breast, it is for some occult reason unendurable.

We were brought up to believe that apes remained apes because they persisted in remaining up trees, whereas the ancestors of man came down to terra firma; but Mr. Barns is emphatic in calling the gorilla non-arboreal. Neither its hands nor its feet are suited for climbing trees, but the huge creature has a curious way of walking quickly over a bamboo forest, using the stems like stationary stilts. An onlooker from a high vantage point, may see the black heads bobbing up and down and the huge arms rising and sinking as if the monsters were swimming in a green sea! On the ground the gorilla seldom walks erect, except when it is holding on to branches overhead, or when it is attacked by man, who is probably its only serious enemy. In point of fact the gorilla shuffles along on all fours, with the fingers doubled under so that their backs are in contact with the ground.

The Highland gorilla never makes a "nest" in trees, but sleeps on or near the ground. There is practically no danger, and the only thing to be avoided is being drenched by one of the frequent rainstorms. Thus the gorilla may sleep in a hollow tree or under dense overhanging branches, or in a hole lined with ferns and twigs, or on a platform of half-broken bamboos. On such a bamboo platform the gorilla often enjoys a sun-bath, reaching around now and again to pluck a tender leaf.

The Highland species seems to be less omnivorous than the western forms, for it is not keen on fruits and it does not dig for roots. Honey it may take, when it can, but mainly it feeds on the tender parts of bamboos and on juicy herbage, such as docks, sorrels, and hemlock.

According to Mr. Barns, gorillas go about in small family parties, consisting of the father, several fully grown females, and four or five children. But we should like more numerous and critical observations on this important

Photo: T. Alexander Barns,

LUXURIANCE OF THE CRATER FLORA.

One of the Larkspurs (*Delphinium candidum*) growing among thistles on the plateau of the Giant Craters in Northern Tanganyika Territory.

question. "Old man" gorillas, who have lost their family status, are sometimes found living alone, "having been beaten and thrown out by a younger and stronger rival." They are not to be regarded as crusty old bachelors; they are superannuated fathers.

Can we obtain a closer view of the gorilla? It has a magnificent chest development (sixty inches), a massive jaw, and most formidable teeth, a roar like a buffalo's but with considerable scream. Usually, however, gorillas are quite silent, which shows that they are not naturally quarrelsome. When they are interested and curious they utter a loud whine like a great dog, and follow this by beating on the bare breast with their fist. This produces a resonant "clopp, clopp, clopp," which may be a danger-signal or a kin-signal. "Also, I think to 'hearten' themselves, for I have heard it when there was no possibility of the animals being alarmed."

Photo: T. Alexander Barns.

HEAD OF GORILLA.

The Mountain Gorilla (*Gorilla beringei*) from the highlands of Tanganyika. It is marked by a hard thickening of the skin on the top of its head, a great shock of hair, and some other peculiarities. It feeds mainly on the tender parts of bamboos, and does not seem disposed to live dangerously. Its great strength keeps off almost all enemies save man.

A full-grown male gorilla, over six feet in height, a study in black and grey, sometimes with a hint of red-hairedness, must be a very impressive sight, and though Mr. Barns assures us that a London crossing is more dangerous, we should prefer the "death-trap."

The gorilla would be accorded a higher rank of handsomeness if his arms were not too long for his legs, for this offends the human sense of proportion. The young ones look, too, like "pot-bellied teddy-bears" to be awarded more than a leaf or two off the palm of beauty. But no gorilla would be condemned as ugly by an unprejudiced jury.

Gorillas are not quick of sight, hearing, or smell; they trust to their herculean strength; they are as clever as they need to be, and experiments show that they have great potentialities of intelligence which can be awakened by appropriate liberating stimuli. It is an erroneous idea that an animal's inheritance, or a man's, may not include unused intellectual reserves. "Free from molestation, famine, or disease," gorillas probably live to a much greater age than man.

The gorilla's reputation for ferocity is probably for the most part a misunderstanding, and is certainly not borne out by the results of Miss Cunningham's tuition of the two-year-old "John Daniel," who was gentle as well as clever. When a captive gorilla is brought up in uncongenial and inappropriate surroundings, it naturally becomes morose. According to Mr. Barns the wild gorilla is "a great bluffer, certainly not looking for trouble." On a recent Scandinavian expedition no fewer than fourteen gorillas were shot, far more, one would think, than were necessary for scientific purposes; but Mr. Barns strikes a humaner note: "When hunting these great apes no one with a spark of feeling can free himself from the thought that killing them is akin to murder. They are so very human and interesting, the young ones so unsuspicious of danger, the older ones so full of curiosity, that hunting them can hardly be called sport." One is glad to hear even talk of a Congo sanctuary for gorillas, for although we cannot number them among our ancestors, they are included under our trusteeship, and there are no creatures more deserving of all the humane protection that man can offer. Long live the gorilla!

Specially drawn for this work by Warwick Reynolds.

GORILLAS, IN A BAMBOO FOREST, FEEDING ON THE YOUNG SHOOTS.

The largest of the Apes, represented by three African species. A creature of prodigious strength, a strict vegetarian, not given to climbing trees, often bending the backs of its fingers on the ground in walking. It does not seem to be an aggressive animal, but it certainly shows temper as well as intellect.

LV

NATURAL HISTORY OF SPRING

IT is in the nature of living things to be rhythmic. That is to say, there are deep reasons why a period of great activity must be followed by a period of relative rest. If there is much expenditure of energy, there will soon be need for more income. If there is waste, it must be followed by repair. Thus there is alternation of up-building and down-breaking changes in the living material, and these have come to be adjusted to the great external periodicities, such as day and night, the ebb and flow of tides, and the march of the seasons. What we wish to illustrate here is the punctuation of rhythmic life by seasonal periodicities.

It must also be noted that living always means action and reaction between the living creature and its surroundings. The organism acts on its environment; but at another time the environment acts on the organism; function is the give and take between them. Living thus includes the two aspects O→ *f*→ *e*, when the organism is an active agent, and E→ *f*→ *o*, when the environment acts on the organism. And since the environment varies from season to season, it is necessary to think of the changes that go on in the thrust and parry throughout the year.

Thirdly, it must be noted that the course of an organism's life—what might be called its trajectory—must always show an ascending curve of developing and growing till mature strength is reached, and a descending curve of weakening and ageing till death comes. In the case of an annual—whether plant or animal—this ascending and descending curve must in a general way correspond with the sequence of the seasons, for spring is the time of youth, summer of maturity, and autumn of dying away. And if the plant or animal lives for many years, then there are detailed undulations on its life-curve, which are to be connected with the periodicities of the seasons. Everyone sees this in the growth-rings on a tree-stem; it is just as clear in the growth-rings of a salmon's scale.

The Fresh Life of Spring.

In the sunshine of early spring many living creatures get a new lease of life, and many new lives begin. The trees make a fresh start; the seeds sprout; the frogs spawn; the ewes bring forth their lambs.

One of the first signs of the re-awakening of life is *the opening of the buds*. They were made in the vigour of last year and have been lying quiet throughout the winter, well wrapped up in bud-scales which are waterproof and often resinous. An ordinary bud is a young shoot with the beginnings of leaves tightly packed together, often in a spiral. We get a good idea of what a bud is like if we look at a cabbage halved vertically. For a cabbage is a giant bud that finds it very difficult to get away from being a bud. Brussels sprouts are also big buds. Halving a typical bud, like one from a horse-chestnut tree, shows us a young shoot in the core and the beginnings of leaves crowded round about. The shoot will push out and the leaves will expand in their appropriate places. What brings this about is growth, and the conditions are the spring sunshine and the spring rain. The buds cannot open unless they begin to grow, and the growing means a multiplication of cells, and this cannot come to pass without sap. In some measure the sap is water that has been stored in the stem, but it is also the soil-water which the roots have absorbed and passed on. These thousands of buds a hundred feet above the ground on the tall tree are opened by the ascent of sap and by the sunshine breaking the prison-doors.

But besides leaf-buds there are flower-buds, and some of these were also made the year before. It is interesting to notice the blackthorn or sloe by the wayside, for it is covered with white blossom before any of the leaf-buds have opened. There is a common garden shrub called Daphne, with purplish blossoms that burst forth very

Photo: G. C. S. Ingram.

WOOD-ANEMONES (*Anemone nemorosa*).

No appearance is more characteristic of spring than the abundant blossoming of the wood-anemone beneath the trees. The white flowers, with sometimes a purplish flush, hang gracefully on narrow stalks, and as they nod in the breeze they are true to their name of "wind-flowers." In early spring they are the outcome of the reserves that have been stored during the previous season in the underground stems, which run far.

Photo: Reginald A. Malby.

POT OF BEAN SEEDLINGS.

The two seed-leaves or cotyledons of the French Bean are what we ordinarily call the two halves of the seed. In the sprouting shown here they have been lifted high off the soil. Above them on the shoot there are the first two ordinary foliage leaves.

early in the year before there are leaves. But these cases are unusual; the rule is: First the leaf and then the flower; and it must be understood that a growing shoot may form flower-buds in the axils of its leaves—flower-buds which will unfold later in the season.

An interesting feature in the early flowers is the frequency of white and yellow colours. The reds and purples usually come later. It is easy to find exceptions, but the prevailing colour in spring is yellow. Think of the celandine (the swallow's flower), the winter aconite, the coltsfoot (before the leaves), the primroses and cowslips, the golden saxifrage, the kingcups or marsh marigolds in the ditch, the dandelions, the daffodils, the wild wallflower, the laburnum's "dropping wells of fire." No doubt there are wood-hyacinths, wood-periwinkles, and sweet-violets—all early and all blue; but the more primitive yellows predominate.

Many spring flowers are white, such as the sloe already mentioned, snowdrops, wood-anemones, wood-sorrel, white dead-nettle (though the red one is earlier still), the greater part of the crimson-tipped daisy, and the white narcissus. Now whiteness means that there is no pigment or colouring matter at all; it means that the light is being entirely reflected from a multitude of bubbles in or between the living cells of the petals. A snowdrop is white for the same reason that snow is white, and perhaps it may be said that there are many white flowers in spring because the warmth of the sunshine is not yet enough to rouse them to the more intense life which usually results in the production of colouring matter.

Travellers tell us of the sudden splendour of spring in the Asiatic Steppes after the snow has gone. Acres of tulips, yellow, white, and red; acres of lilies, in blue and in gold. We can see this on a small scale nearer home in the stretches of wood-anemones, wood-hyacinths, and buttercups. The natural question rises, where do the resources come from, so early in the year, that allow this floral splendour? There may be only a few leaves as yet unfolded; in any case they have not had time enough or sun enough to manufacture much food for the exuberantly blossoming plant. The answer is, first, that the buds of these early flowering plants were made the previous year; and, second, that great quantities of stored food are laid up in underground parts—in the corms and bulbs, the root-stocks and tubers. What happens in spring is a lavish spending of the savings of the year before. It is useful to sacrifice a properly ripened hyacinth bulb, cutting it vertically to see how plump with nutriment the bud-scales are, and how they enclose a series of flower-buds all in miniature, ready to be awakened and unfolded. With the nourishment stored away in bulbs we are familiar when we eat a boiled onion; we verify the same in eating potatoes, artichokes, salsify,

and many other pleasant "vegetables." Though they are not *bulbs*, they illustrate the same underground storage of the past year's income.

Sprouting Seeds.

A third sign of spring in the plant world is the sprouting of seeds. They were made last summer and scattered last autumn, and they were tended for a while by the parent plant before they were set adrift. A seed consists of a very young or embryo plant, with a legacy of food-material around it or within it; and the whole is wrapped up in a firm envelope, very familiar to us when we remove it with knife and fork from "broad beans" that have been boiled with husk on. "Shelling" peas or beans means breaking away the wall of the pod (the fruit, the carpel, the lower part of the pistil, or, worst name of all, the ovary). But after that is done in the case of "broad beans," there is the removal of the rather tough envelope of the seed, which bears, as everyone remembers, an elongated scar at one end, marking the place where the seed was fastened to the wall of the seed-box. In eating "French beans" we eat everything—pod and all.

When we take a ripe seed from the pod of the "broad bean" or the pea, we notice a whitish embryo at one side, with the beginning of a stem (the plumule) and the beginning of a root (the radicle), and on each side there is a plump seed-leaf (or cotyledon), full of reserve food for the young plant, to keep it going until it is able to fend for itself. In the pea the store is in the young plant itself, namely, in the two cotyledons. But in many other cases, such as a grain of wheat, the legacy of food is round about the embryo. There are two facts that one must be clear about: first, that the seed is not like a new-laid egg, but rather like one that has been brooded on and has made considerable progress in development; and, second, that its store of nourishment came from its close connection with the parent plant. It is interesting that in the highest plants, just as in the highest animals (the

Photo: Harold Bastin.

SYCAMORE SEEDLING.

The lowest figure to the left shows the fallen fruit of the Sycamore, with its crumpled parachute, which has served to carry it beyond the shade of the parent tree. The young root or radicle is entering the ground. The second figure suggests the beginning of the growth of the young stem or plumule, and the raising of the seed, with its two seed-leaves or cotyledons off the ground. The third figure shows the unfolding of the two cotyledons, which become long and narrow green blades. The last figure shows the first pair of ordinary foliage leaves, borne on the young stem above the cotyledons. There are also several rootlets on the young root.

mammals), there should be a long sheltering of the offspring within the parent before it is set free to begin an independent life of its own.

Many of the seeds that sprout or germinate in spring are already six to nine months old. They have been lying quiet since they were scattered last autumn. For although there are some seeds, like those of poplar trees, that sprout whenever they are sown, this is not the way with the majority. They require a resting time, and in certain cases this may last for more than a year, which shows that the delay is not altogether due to the fact that winter in northern countries is not a suitable time for sprouting. There has to be preparation within the seed, and one feature of the preparation is the activity of ferments which make the condensed food-material of the seed more available for the young plant. In a word, there is *digestion* going on before the sprouting begins. Another feature is the gradual decay of the seed-coats which are often hard and firm. The doors must be opened to let the young plant out. But there cannot be any decaying or rotting without Bacteria, and this brings us to the fact that the microscopic microbes which often cause death are here at work assisting in the liberation of fresh life.

A remarkable fact has been discovered in regard to some seeds, that, if they are to develop, they must have partners to help them. Thus, the seeds of clovers, peas, beans, lupins and other Leguminous plants require to be infected with partner-Bacteria from the soil, which eventually enable the plant to utilise (in some mysterious way) the free nitrogen of the air. It has been shown that most, if not all, Orchids must have a fungus (mycorhiza) in partnership with their roots ; but it has also been discovered that the seeds require the same fungus if they are to germinate. Orchid-growers, who were previously baffled in their attempts to get the seeds to sprout away from their native haunts, have got over the difficulty by supplying the partner-fungus. And it must be a particular kind.

If there is to be sprouting in ordinary seeds there must be an insoaking of water and a rise of temperature in the soil. Then growth begins and the young plant pushes out its plumule and its radicle. This is one of the great events of spring—the germination of seeds.

The young root is so constituted that it must grow in the direction of gravity, and if the seed is upside down the growth of the root will still be towards the earth. It is pushed into the crevices of the soil by its own growth, sometimes becoming a long tap-root like a carrot, sometimes stopping short and giving off numerous rootlets, as in grasses.

The young stem is so constituted that it must grow upwards ; it has to do the opposite of what the root does. As it grows out of the seed-coats, its tip is often held back by the two seed-leaves or cotyledons which have not yet left the seed ; and this leads to a curious loop or bend that we often see on sprouting seeds. But as the bent young stem grows longer and stronger it becomes able to lift the cotyledons out of the ground. There are gradations between the state of affairs in a pea or bean, where the cotyledons remain beneath the ground, and what we see in sycamore, beech, ash, cress, mustard, and hundreds more, where the cotyledons are carried up by the young shoot and spread out in the light. Their chief use in such cases is to be ready-made first leaves. When the seed-leaves are large and laden with stored food, as in the pea, the germination is usually rapid, and this may be contrasted with the slow development of the very small seeds of Orchids. Moreover, the pea is an example of the Dicotyledons with two seed-leaves, and the orchid of the Monocotyledons with one. It is interesting to collect half a dozen different sprouting seeds to see how they differ, especially in their cotyledons. In the sycamore there are two narrow strap-like cotyledons ; in the beech they are fan-like ; in the lime they are broad and five-lobed. They are kidney-shaped in the mustard, three-lobed in the cress. A great many kinds are described in Lord Avebury's big book on seedlings, and it is shown for numerous plants that the shape of the cotyledons is influenced by the shape of the seed. The round seed of the sycamore is suited for the rolling up of two long narrow straps, but the three-sided shape of the beech-nut is better filled by the two beautifully folded fans.

Very interesting are the movements of seedlings. As the young stem grows upwards, it bends and bows to the different points of the compass, its tip describing a tiny circle or ellipse. It sways as it grows. The reason is that it is not growing equally all round, and the reason for

this is that the lighting is not usually the same on all sides, and changes from hour to hour. Light slows the rate of growth, and if seedlings are growing in a box that is lighted from one end only, they will soon be all bent towards the light. But we must also take note of the changing temperature, which likewise influences the growing plant and helps to cause movements. Whereas light slows growth, warmth hastens it; and as the sunshine affects the plant unequally and changes in the course of the day, it is also a factor in the movements, which are so inconspicuous in most plants that we are apt to forget them altogether.

General Features in the Natural History of Spring.

We shall give a few vivid illustrations of the Natural History of Spring, but what are its general features? It is a time of re-awakening what has been at rest, of re-invigorating what has been flagging. It is a time of giving birth to new lives, a time of youth and renascence. Thus it is a time not only for a fresh start with the old, but for a new departure altogether. Spring is a season of variations and promise.

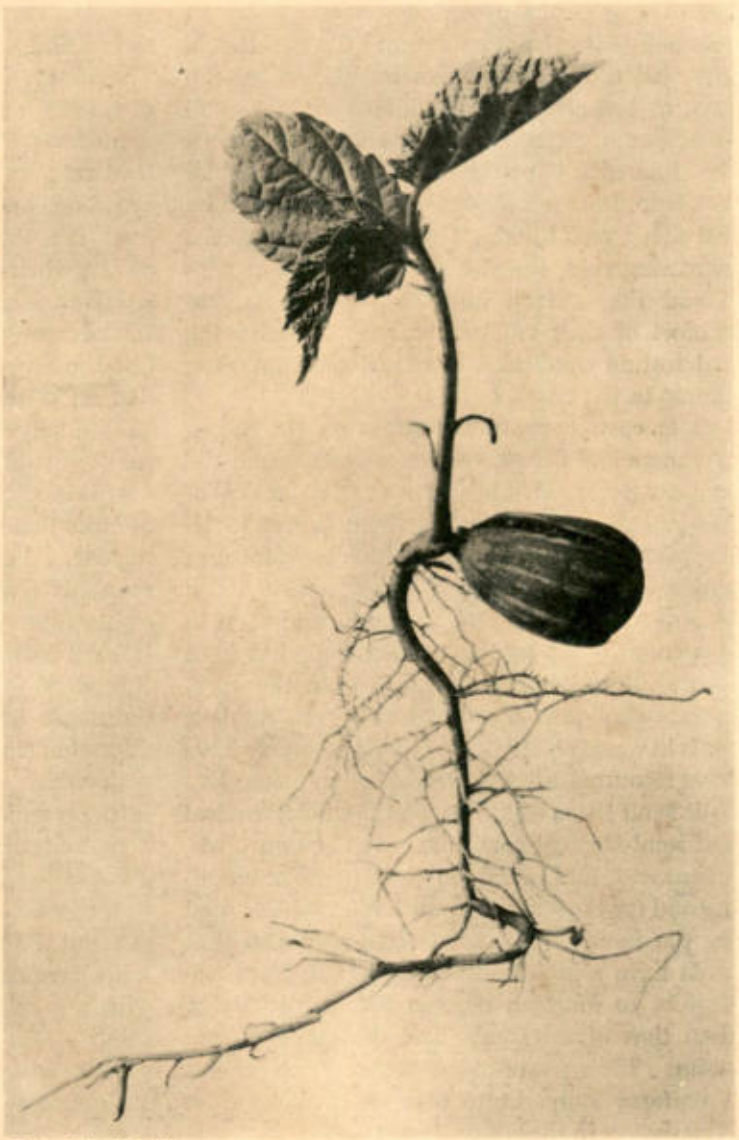


Photo: Harold Bastin.

FILBERT SEEDLING.

The nut, rich in reserves of food, has sprouted in the ground. Making its way downwards and giving off rootlets is the main root. The young shoot is rising into the air and developing green foliage leaves.

Return of Migrant Birds.

Seed-time and harvest, summer and winter, these and many other great periodicities are familiar; but not less regular, though relatively recent in origin, is the ebb and flow of the tide of migratory birds. We do not propose to discuss the well-known facts—that the majority of our British birds are summer visitors, like swallow and swift, warblers and wheatear, cuckoo and nightingale; that they evade the winter by migrating at the end of summer or in autumn to the south and south-east; that our winter visitors, like the Snow Bunting and the Fieldfare, return in spring to their breeding places in the north; that many of our birds, such as lapwings, are "partial migrants," moving, when winter comes, from an exposed to a sheltered part of the country; and that we have not very many strictly resident birds, like the welcome robins and the too obtrusive sparrows.

The problem we wish to think over is the old-standing one—Why do the migrants come back? They have been wintering and recuperating in a more or less luxurious environment, perhaps on

the steamy banks of an African river, where insects fly into the open mouth ; the question is why they should leave this luxuriance for the more or less strenuous conditions of the North Temperate regions. It is easy enough to discern the immediate reasons for their autumnal departure from our shores—the scarcity of fruits and seeds and insects, the short daylight, the increasing cold, the stormy weather. But why should they return from the abundance and comfort of their winter quarters to the taxing and testing conditions of life in their breeding haunts in the north ?

It is customary to lay stress on the inconveniences and dangers of warm countries in the summer time. Most birds require a great deal of water, and in warm zones there is apt to be drought. Most birds suffer at high temperatures and in the glare of the sun. This is particularly true of young birds and nestlings, and even in this country the mother golden eagle has been seen shading her two nestlings from the over-intense sunlight. No doubt there are resident birds in warm countries, for living creatures have great resources in the way of adapting themselves to difficult situations ; but, on the whole, tropical and semi-tropical conditions are hard on birds, and are not well suited for the patience of brooding and for the strenuous work of providing food for the family. We must remember also that birds have a high body temperature, from two degrees to fourteen degrees Fahrenheit higher than that of mammals, and that they do not sweat. Their warm-bloodedness, which secures a uniform temperature of body and blood, is very perfect in the adults, but it is only gradually established in the nestlings, which are, therefore, endangered by extremes. In this country the prolonged absence of the brooding bird from the nest means that the young ones will become colder and colder—the heat-regulating arrangements not being perfected—and when they pass below a certain limit they will die of cold. The converse will be apt to occur in very warm countries, with the result that the exposed nestlings will die of heat. Birds have a constitutional tendency to high temperature—to what we might call fever-temperature—and in the most exacting part of their year they are safer out of the hot zones. Therefore, the migrants come back.

It is customary in the second place to lay stress on the attractions that northern countries offer as breeding haunts, and this also is sound sense. There is an abundant supply of fruits and seeds, of insects and small animals ; there is an unstinted supply of water in most places ; there is a moderate temperature, well suited for patient brooding, and also for energetic foraging ; and there is a variety of nesting possibilities, much greater than in hot countries. No doubt there are risks, such as a late spring frost at night, but the advantages of the north are great. There is also the long daylight, which makes it possible to live on a multitude of items of food that are individually very minute and require many hours for their capture.

It is interesting to notice the length of the list of birds that breed very far north—in the Arctic regions. For Europe and Asia Mr. Dresser counted eighty-nine species of land birds and eighty-four species of wading and aquatic birds. In his " Siberia in Europe," Mr. Seebohm writes : " Birds go to the Arctic regions to breed, not by thousands but by millions. The cause of this migration is to be found in the lavish prodigality with which nature has provided food. Seed-eating or fruit-eating birds find an immediate and abundant supply of cranberries, crowberries, and other ground fruit, which have remained frozen throughout the winter, and are accessible the moment the snow has melted, while insect-eating birds have only to open their mouths to fill them with mosquitoes." We are not accustomed to think of the Siberian tundra as a paradise, especially as we do not enjoy the birds' protection against mosquitoes, which often cover land and water with a living mist. But a birds' paradise it is for two or three months of the year between the lifting of the snow-blanket and its in-tucking once more. Alfred Russel Wallace had a vivid picture of what this Arctic paradise means for many birds. He speaks of the buntings, tits, grosbeaks, pipits, warblers, wagtails, and a host of others which press into the tundra in spring. " What a delight to them all must be this rush northward into a land of perpetual daylight, swarming with the most nutritious food, fruits and berries for the parents, and inexhaustible clouds of mosquitoes and the equal myriads of their larvæ in every little pond or water-hole, as well as quantities of larger worms and larvæ." Again we see why the migrants come back.

Drawn by E. Mansell.

BLUE-TITS (*Parus cæruleus*).

One of the most familiar of British birds and very widely distributed. The Blue-Tit is beautiful in form, in colouring and in movements. It destroys injurious insects and should be protected. The nest of the Blue-Tit is made in a hole in a tree or wall, and lined with moss, wool, fur and small feathers. The brooding bird resents intruders with a hissing sound.

It is useful to consider the present-day reasons why so many migrant birds should fly south at the end of summer and return to the north in spring. But there is a danger of emphasising them unduly. We must remember that the present-day reasons are operating on constitutions that have in the course of ages become wound up to a seasonal rhythm. There is an old-established inborn urge, to which external conditions are simply the trigger-pullers, or what are called the liberating stimuli. It is not the discomfort of approaching winter that compels our summer visitors to fly south after the breeding season, for many of them leave before there is any physical need, just as some hibernating mammals go to sleep before there is much cold. Nor is it a shrewd prevision of the coming storms and hard times that moves them, for they have never known a winter in their year.

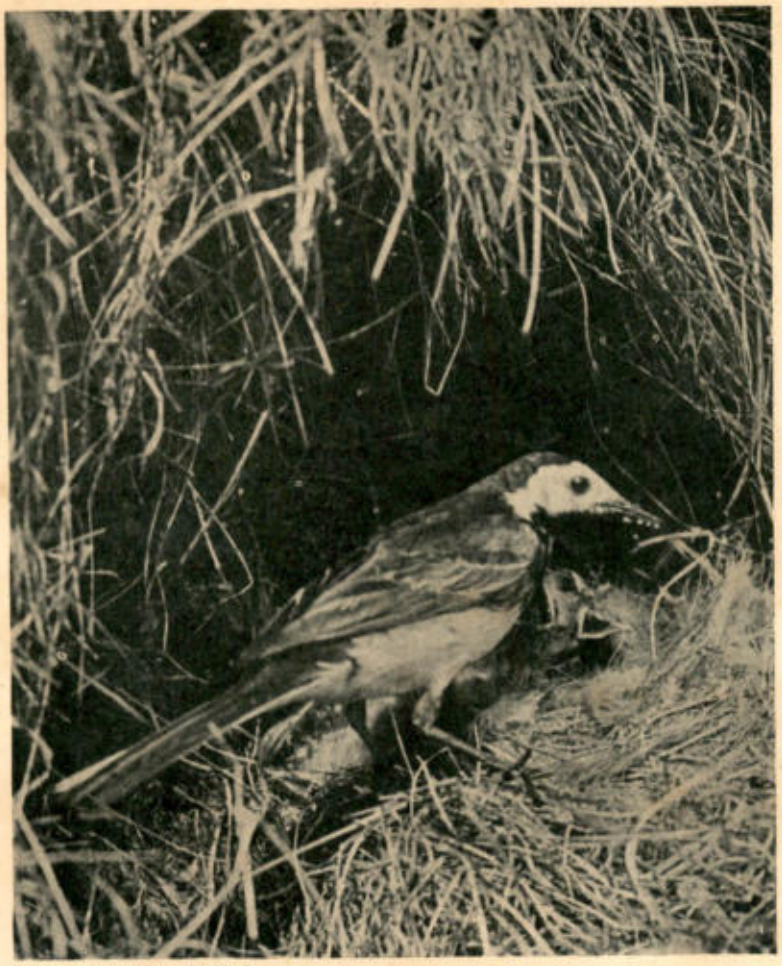


Photo: Albert Henry Willford.

MALE WAGTAIL FEEDING YOUNG AT NEST.

The Pied Wagtail or Water Wagtail, *Motacilla lugubris*, is an early immigrant on British shores, arriving even in February; but some individuals stay all the winter. It is fond of streams, where it captures the larvæ of water-insects, such as gnats. But the Grey Wagtail, *Motacilla boarula*, which has a good deal of yellow beneath, is even more of a water-bird. The up and down movement of the wagtail's long tail is registered in its name. In most cases the nest is in a nook in the bank of the stream or among the exposed roots of trees.

Similarly, in regard to the return journey in spring, it is unlikely that it is much affected by any apprehension of the dangers of sojourning and nesting in the tropical summer, nor by any individual memory of the delights of the Siberian tundra. The onset of the breeding urge probably counts for much more, but in this connection it must be noted that many of the younger migrants are still immature, and do not breed on the occasion of their first return to their northern birthplace. We have to deal in all probability with a rhythm enregistered in the bird's constitution, punctuated so as to keep time with the external periodicities of the season.

In old days most of our birds were probably more or less resident over large areas in north temperate zones. As winters grew colder there was an advantage in shrinking southwards in autumn and returning to the old haunts in spring. There was also the need for scattering from overcrowded and deplenished homesteads. A premium was put on variations in the direction of restless adventuring, and the migratory routine which we admire to-day is the outcome of regularised roving, criticised and sifted by ages of natural selection, but now enregistered in the recesses of the nervous and psychical constitution, and awakened appropriately by external and internal periodicities.

Certainly the cuckoo is an enigmatic bird—a bundle of incongruities. It is almost unique in

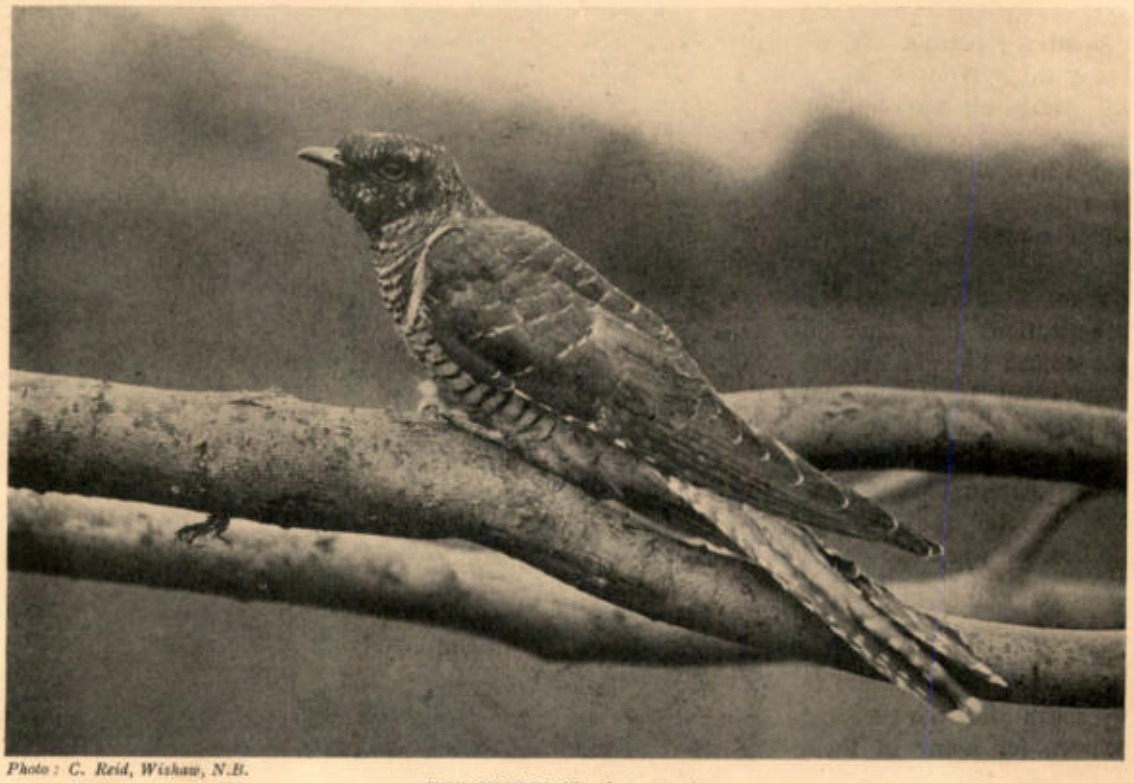


Photo : C. Reid, Wishaw, N.B.

THE CUCKOO (*Cuculus canorus*).

This well-known summer visitor to Britain, more often heard than seen, has many peculiarities besides its habit of shirking the duties of nest-making, brooding, and the nurture of the young. The adults often return to the South (Africa) and the East a month or more in advance of their young ones, whose foster-parents are not always migratory. There are more males than female adults, and the female bird courts several males at once. The shouting "cuckoo" note is the male's, but it is not certain that the female does not say something like it as well. She certainly has some voice.

not making any nest, for, although some of the unrelated American cow-birds also shirk this, there are others of them that fall into the traditional and respectable line. It is a strange fact that one kind of cow-bird that shirks brooding altogether actually utilises the nest of one of its cousins, which is true to the nesting and brooding instinct. As for mound-birds, which lay their eggs in hot-beds of fermenting vegetation and the like, it would not be fair to regard them as evading parental responsibilities. Their young ones, effectively pre-arranged for, are able to wriggle out of the mound, and to run, if not to fly, on the day on which they are hatched.

The Vagaries of the Cuckoo.

The cuckoo is unique among our British birds also, inasmuch as the adults leave our shore before the young birds are ready, preceding them by six weeks or more. In all other cases, the youngsters are the first to go. This peculiarity is no doubt wrapped up with the fact that the adult cuckoos feed very largely on hairy caterpillars, and have to migrate when the supplies give out. But their offspring are fed by the duped foster-parents.

The cuckoo has other peculiarities, which could, no doubt, be unified, if we were better biologists. The female lays her eggs at unusually long intervals ; the egg is small for the size of the bird, the female is polyandrous, that is, it has many husbands, the males being in a great majority. There is also some deep constitutional peculiarity in the young cuckoo, for during its early youth it is extraordinarily sensitive to touch—it is thrown into convulsive fits when one of the rightful tenants of the nest in which it is hatched touches the small of its back. It writhes and jerks—an inborn "dog in the manger"—and instinctively ejects its neighbour from the nest. The young cuckoo is big for the nest in the great majority of cases, and its treatment of its neighbours is just an instinctive attempt to make room. We know some children who cannot bear to be touched, and the young

cuckoo hatched in its foster-parents' nest is one of these "touchy" creatures. After the first eleven days, they say, the exaggerated touchiness wanes.

Until recently, the general view of ornithologists has been that the mother-cuckoo lays her egg on the ground, takes it in her mouth, and flies down the hedgerow or over the meadow until she espies a suitable nest, say, of a hedge-sparrow or of a meadow pipit, into which she places her egg, and thinks no more about it. Many good observers have, we believe, seen the cuckoo laying on the ground, taking the egg in her mouth, and depositing it in the foster-parents' nest—which is probably selected with great care before the actual deposition of the egg takes place.

Miss Hilda Terras, in her delightful "Story of a Cuckoo's Egg" (1920), writes: "I saw a bird suddenly sail quickly down from the roof above me, and fly on to the hedge about two feet from the nest. It was the cuckoo. . . . There it sat, nervously turning its head this way and that, and looking about it in the same stealthy, cunning way that it had done on the occasion of its previous visit. I could almost swear it was saying to itself anxiously, 'Are they looking? No, thank goodness, I've done them at *last*!' And then, without any hesitation, it hopped straight into the hedge and disappeared from view. For about a minute it was there; then it came out and flew away. Burning with curiosity, I hurried into the garden, and, eagerly parting the branches of the hedge, looked into the nest, and lo and behold, there, lying in Henrietta's (the hedge-sparrow's) dear cup-shaped, softly-lined home, I saw the cuckoo's egg! One of my sisters had again watched with me, and once more we were amazed at the positive uncanny sagacity of the bird. The whole thing seemed so extraordinarily intelligent, and so *mean*!" We have quoted the account because we believe it to be true and typical. The mother cuckoo lays its egg on the ground, takes it completely into its large mouth, flies to a previously selected nest, and pops it in.

Photo: S. Crook.

MEADOW PIPIT FEEDING YOUNG CUCKOO.

An extraordinary spectacle, the foster-child demanding and receiving food from its foster-parent, now much the smaller bird. As long as the young cuckoo is within the meadow-pipit's nest the power of association must keep the parental instinct active, but it is less easy to understand the continuance of the arrangement after the young cuckoo has "flown." In some cases at least the young bird utters a peculiar call, "like a little silver bell," which seems to summon the devoted foster-parent.

But this does not in the least prove that there is anything wrong in the account which Mr. Edgar Chance has also given of this strange business—an account substantiated by a beautiful and continuous film of the mother-cuckoo's behaviour. Mr. Chance found that the cuckoo *laid* its egg in the meadow-pipit's nest, and that it removed and devoured the foster-parents' eggs. There is likely to be variability in these relatively modern subtleties of instinctive behaviour, especially in a case like the cuckoo's, where a want of time-keeping between the normal chapters has set in, and we do not doubt that Mr. Chance observed an egg-laying. He is not the first to make this suggestion, and Raspail speaks of the mother-cuckoo removing and destroying an egg from the foster-parents' nest. But we should not like to generalise from Mr. Chance's fine observations, and that for several reasons. A number of good observers have seen the mother-cuckoo take her egg in her bill. She sometimes stays at the foster-parents' nest for a very short time—far too short for egg-laying. We have, in the famous "Fenton Collection" of eggs in the Aberdeen University Museum, a cuckoo's egg from such nests as a swallow's, a reed-warbler's, and a tree-creeper's, in which she could not lay it. In Pomerania, we think, one of the commonest hosts is the wren, and we cannot picture a cuckoo laying its egg in a wren's nest. Therefore, and for other reasons, we believe Jenner's old account of the business is in the main correct, for the majority of cases.

As an instance of the "summer visitors," that come to Britain in spring, we take the wheatear.

The Wheatear.

It returns from the South in March and continues coming—wave after wave—until the middle of May. But the last waves seem mostly to consist of a large variety, the Greenland Wheatear, which is only a bird of passage in Britain, and does not nest till it reaches the Faëröes, Iceland, and Greenland. Our wheatear is a welcome herald of the spring, one of the first of the migrants to come back to the old home.

It is a satisfactory bird because everyone can recognise it at a glance by the dazzling white rump to which it owes its name. This is very conspicuous when the bird flies, and it is shown by both sexes. As the wheatear is harried by hawks, some naturalists have suggested that the white flag may serve to distract the hostile aim from more vulnerable parts. But the white splash must also be a dangerous advertisement, and we should think that safety was mainly secured by the bird's cleverness in hiding itself in a bush or in a burrow, and also by a certain unexpectedness in the restless flight. At frequent intervals it turns and twists in the air in a very adroit fashion, partly to catch insects, no doubt, but partly perhaps because jerky movements are disconcerting to enemies. But we need not wrinkle our brows trying to find far-fetched uses for such features as the wheatear's white rump. The probability is that its beauty is its only meaning.

Another satisfactory fact about the wheatear is that it always tells you it is there. For as it nods to you from a stone, flirts its tail and flies restlessly hither and thither and back once more, it says *chack, chack*, over and over again in a very emphatic and cheerful way. Its note is like the stonechat's, but a little different, and the two birds often frequent the same rough and open places, with outcropping stones and plenty of gorse. So the wheatear is sometimes called stonechat, which is a pity, for the two birds are very different in appearance. As a matter of fact, however, the wheatear and the stonechat are second cousins, and members of the same thrush family. Both have the "chack" danger-signal, like that made when two stones are clapped sharply together, but the wheatear has a much finer song, in which he often mingles notes and phrases borrowed from other birds. He has good taste of his own, but he cannot refrain from plagiarism. Perhaps the end justifies the means, for all is fair in love.

It is very difficult to understand why the wheatear should be regarded in many parts of the country as a bird of ill-omen, especially if it says "chack, chack," when seated on a stone, which is just what it usually does. Can it be merely that the bird frequents lonely and wild places, where the open spaces get on the nerves of the timid? They hear in the "chack, chack," the sound of the mason carving their name on a tombstone! What a conceited idea! The facts are all against the superstition, for the wheatear is a buoyantly cheerful bird. It says, "chack, chack," but it is unafraid: the cock-birds court with gaiety, and fight with zest; they often sing

Photo: Jos. A. Speed.

WHEATEAR (*Oenanthe œnanthe*).

Wheatear means white rump, and this is a conspicuous feature as the bird flies along in front of us. The rump-feathers and the tail-covers are a brilliant white. It is the first real summer visitor to reach Britain, and is always welcomed. Its "chack-chack" call as it flits restlessly about is very familiar in wild open places.

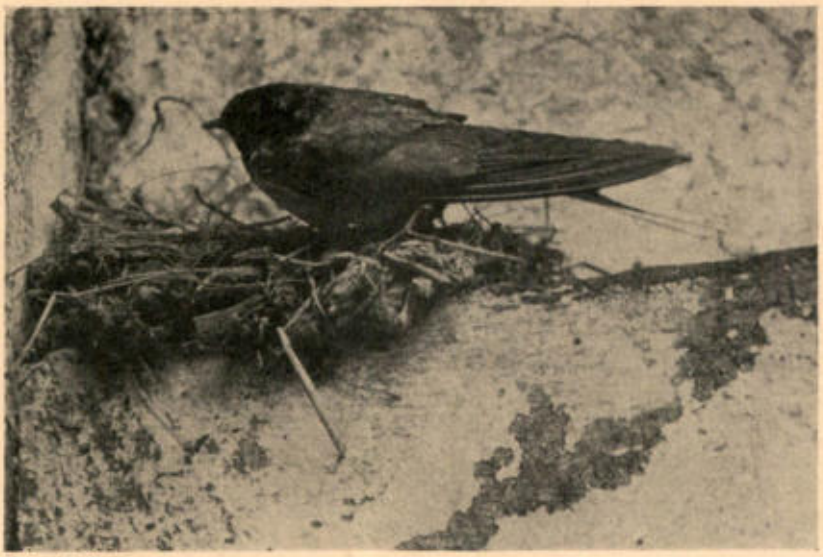


Photo: G. Hearn.

SWALLOW AT NEST (*Hirundo rustica*).

The true Swallow has continuous blue-black, chestnut and blue breast bands, and long tail-streamers. The likewise blue House-Martin is conspicuous by the white rump and under parts. It has a shorter tail. The Sand-Martin is a distinctly smaller bird, brown above, mostly white below.

not only as they fly, but as they fight, which surely proves their high spirits.

The way in which wheatears accompany one across a moor, flitting from boulder to boulder, always keeping a little way ahead, shows alertness, but no timidity. Professor Newton wrote: "The cock with his bluish-grey back and light buff breast, set off with black ear-coverts, wings and part of the tail, is rendered still more conspicuous by his white rump as he takes short flights in front of those who disturb him, while his sprightly actions and gay song harmonise so well with his delicately tinted plumage as to render him a welcome object to all who delight in an open country." That strikes the right note; the wheatear is constitutionally, that is to say at heart, a very cheerful bird.

The male wheatear sings to his desired mate and shows off before her, both on the ground and in the air. There is unusual "abandon." As Miss E. L. Turner says: "He seems positively drunk with the joy of life." There are excited combats among rival males, but they do not seem to do one another much hurt.

The nest is often made in a rabbit's burrow or in any similar hole. It is a loose cup of grass and roots, quilted with rabbit's fur, sheep's wool, or any similar material. There are about six pale-blue eggs, which usually hatch out in May. The cock-bird helps in nest-making, and a little in brooding. Both parents, themselves insectivorous (including small snails among insects!), collect spiders, caterpillars, moths, and the like for the nestlings, who keep well in hiding. The food is often pounded into pulp before it is given to the young ones.

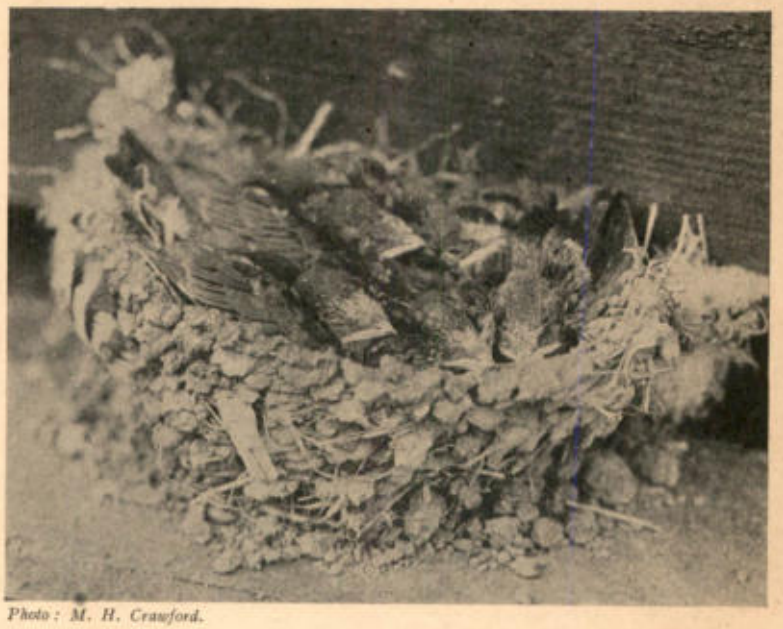


Photo: M. H. Crawford.

SWALLOW NESTLINGS, EIGHT DAYS OLD.

There are four to six young Swallows in a brood, and there may be two or even three broods in a year. They are fed with packets of insects, which are mostly caught in flight. Before and during incubation the male feeds the female. It is usually said that the young ones require to be taught to fly, but Mr. T. A. Coward states that he has often seen a nestling fly well after blundering for a second or two, the very first time it tried.

The autumn migration to the South begins in August, when the birds steal off by night in small companies, seeking "warmer lands and coasts that keep the sun." Gilbert White wrote in 1773 that many wheatears were to be seen all the winter through in many parts of the south of England, and some good observers have in recent years reported their occasional presence in mid-winter. This matters little, for we could not find a better example of a "summer visitor." About this season, many years ago, we watched the wheatears arriving on the coast of Cornwall, aweary with their journey across the sea, and we remembered Tennyson's fine lines:

"Faint as a climate-changing bird that flies
All night across the darkness, and at dawn
Falls on the threshold of her native land
And can no more."

We have in our gallery an unforgettable, though ugly, picture of a crone we saw one spring in the market-place in Pisa, plucking small birds like wheatears with incredible, almost hawk-like rapidity, jerking the plumage to one side and the bodies to the other. She looked like a symbol of grim human necessity, ruthless to Nature.

Photo: T. Dobson, F.E.S.

SWALLOW'S NEST, WITH HAND-MIRROR INSERTED TO SHOW INTERIOR.

The original site for a Swallow's nest was probably a cave or under a shelf of rock. Nests are still found in such places. But the habit has been formed of nesting in or on some human building, such as a shed in a farm-steading. The nest is a fine instance of constructive skill, for a firm saucer or a half-saucer is gradually built up of minute beakfuls of mud. There is a lining of feathers and grass, and the same foundation may be used by the same bird in two successive years.

Happily man is getting beyond, even if he were allowed, the unthinking, unimaginative, wholesale trapping of wheatears, which in Gilbert White's day "begin to be taken in great numbers at the time of the wheat harvest; are sent for sale in vast quantities to Brighthelmstone and Tunbridge; and appear at the tables of all the gentry that entertain with any degree of elegance."

As everyone knows, there are three swallows, summer visitors to Great Britain, and the order of their coming is usually sand-martin, swallow, and house-martin. It takes the three of them to make a summer. The sand-martin is smallest, quickest, jerkiest of our three swallows, known at a glance by being brown above and white below. It hawks for insects over the ponds and lochs and nests in the burrow which it has excavated, sometimes for a yard, in the face of a sand pit or river bank. Its short beak does not look like a digging instrument; it is helped by the toes which scratch out the loosened earth. There are not very many birds that burrow! Sand-martins are cheerful, sociable creatures, fond of clinging in quivering flocks to the face of the pit or cutting,

Swallows making Summer.

fond also of aerial evolutions, especially after they have left their nests—no longer very wholesome—and are congregated among the reeds and osiers talking eagerly about the long journey they are soon going to take.

The house-martin is familiarly marked by the splash of brilliant white on the rump, the rest of the upper surface being steel-blue, and by having the under parts white. Mr. Kirkman says very prettily that when the bird flies away over the unruffled surface of a lake or river, " there are two white spots to be seen, one speeding through the air, and beneath it another, the reflection of the bird's under parts speeding through the water—twin stars that vanish imperceptibly." Very characteristic also are the house-martin's white gaiters.

Photo : Albert Henry Willford.

NEST AND EGGS OF SAND-MARTIN (*Riparia riparia*).

The nest is a slight and formless bed of feathers and straws at the end of the burrow, which may be from a few inches to three feet in length. Both parents take part in the tunnel-making, using their feeble bill as pick-axe and the toes for scratching out the loosened material. The seamy side of the nest is that it tenants a large number of insects.

There can be no doubt that the house-martin's original nesting site was the face of a cliff under a protecting ledge ; and many of them still build in such places. Thus we understand why the nest, unlike the swallow's open half-saucer, should be a half-cup, closed save for the small door near the top. The half-inch walls of hardened mud are built very gradually, interlaced a little with straw and hair and perhaps mixed with some saliva. There is a lining of feathers and bits of grass. In the quite unrelated cave-inhabiting sea-swifts (Collocalia) of the Far East, the edible nests which the Chinese dissolve into costly soup, are made of the mucin secreted by the bird's large salivary glands and are naturally very digestible. They look like half-saucers of frosted sugar, but when a couple of nests, made in succession, have been collected for exportation to China, the bird has to fall back on seaweed, for the supply of salivary juice becomes exhausted. As we have said, the sea-swifts have nothing to do with swallows, but the latter have also abundant saliva and it would be interesting to know if they use it in nest-building. The primary use of the glutinous secretion in all these cases is probably to help in the entanglement and compacting of insects within the mouth. The parent house-martins feed their nestlings —two of them at a time—every few minutes. They thrust their beak into the young one's mouth and deliver a mass of confused feeding. Perhaps they account for at least a thousand insects apiece in the course of a long summer's day.

The swallow is such a beautiful bird that one could wish it a finer name. There is probably no reference to its gape but " hirondelle " seems more fitting than " swallow." The adult male is steel-blue above, save that the forehead is chestnut-red and the outspread dark green tail feathers show long oval white spots. The throat is chestnut again, and then comes a band of blue ; the rest is light buff except the chestnut of the under tail-coverts. The female is nearly as handsome but not quite. But the fine colouration is almost lost sight of in the beauty of the movements—such a complete mastery of the art of flight that we cannot wonder at Athene once taking the swallow's form. A characteristic feature is the length of the wing, especially of the primary feathers, " every one of which," Ruskin wrote, " may be briefly described as the strongest scymitar that can be made of quill substance ; flexible within limits and elastic at its edges—carried by an elastic central shaft—twisted like

Photo : S. Crook.

NESTING SITE OF SAND-MARTINS.

The tunnels are excavated in sand or a mixture of sand and gravel. Considering the size of the bird and the instruments used, the excavations are often very striking. But the beginning is hinted at in some nests that are only a few inches below the surface. The food consists mainly of small insects, especially of those, such as gnats, whose larval stages live in the water.

Photo : Albert Henry Willford.

SAND-MARTINS AT NESTS.

The nesting is characteristically social, for there may be a hundred nests in a suitable place. As good sites are not very common, the Sand-Martins come back to the same place year after year. At intervals the busy life of the colony suddenly ceases and the birds rise high in the air, returning after a short time, spent in aerial evolutions. The meaning of this is uncertain.

Photo: Underwood Press Service.

NEST OF HOUSE-MARTIN (*Delichon urbica*).

As with the swallow, the original nesting-place of its cousin, the House-Martin, was in caves or on cliffs, and many may still be found nesting there. But the bird's favourite place is under the eaves, and the carefully built nest is attached behind, below, and often above. Only a narrow entrance is left, so that an intrusive sparrow cannot get in after the structure is completed. Both males and females build, and they seem to put fun as well as art into their architecture.

a windmill sail—striking with the flat, and recovering with the edge." The tail is more delicately forked than in the martins, but we must think of the long wings as responsible for almost all the aerial steering.

Ruskin speaks of the swallow's mouth as "a net for the catching of gnats," but that suggests a bird flying with its mouth open, which is not true even of a goatsucker. The swallow, like its relatives, snaps at flying insects, and the glutinous saliva in the mouth keeps previous captures from escaping. Gilbert White noticed that swallows were able to drink from the surface of the water without pausing in their flight, but they are not restricted to this method.

Ruskin's knowledge of birds was not so great as his love for them, but he sometimes hit the nail on the head. It was graphic, for instance, to point out some of the swallow's paradoxes. "Of all land birds, the one that has least to do with the earth; of all the least disposed and the least able to stop to pick anything up; what will it build with? Gossamer, we should say—thistledown—anything it can catch floating like flies. But it builds with stiff clay." It revels in space and freedom. "You would fancy its notion of the place for a nest would be the openest field it could find; that anything like confinement would be an agony to it; that it would almost expire of horror at the sight of a black hole. But its favourite hole is down a chimney."

The swallow is not narrow-minded in its choice of a nesting site; but it likes a roof over its head. One may perhaps say that it prefers insides, just as a house-martin prefers the outsides of

buildings. But both were at the nesting business long before there were any human dwellings and the biological explanation is simply that house-martins were originally cliff-nesters, and swallows originally cave-nesters. Preferably with something in the way of a supporting bracket, and always beneath some sort of roof or ledge that will keep the rain off, swallows build their substantial half-saucers of coherent mud. There is ease and apparent pleasure in their constructive genius.

Some British-born swallows fly south as far as Natal and Cape Colony—a long distance for a small bird. We have seen them in autumn resting for a while on a liner steaming northwards from Cape Town, and then starting again upon their southward journey. It has been proved up to the hilt that they sometimes return to their northern birthplace, even to the same building, and to the old nest. It should be noted, however, that when swallows return early they usually spend some days near water and away from buildings. This leaves time for exploring the neighbourhood and may facilitate the rediscovery of the old chimney! There are usually two broods of swallows, about five in each; and this seems to be necessary to compensate for the mortality during the migratory journey and for the assaults of sparrows and other enemies. When we think of the vitality of the swallow and its *joie de vivre*, the outcome of ages of stern sifting, we see part of the meaning of Goethe's saying that death is one of Nature's devices for securing abundant life.

LVI

NATURAL HISTORY OF SUMMER

SUMMER is the time of maximum output and income of energy, when the fires of life not only burn brightest, but are built up for another season. The buds of spring are replaced by leafy boughs, and many of these bear flowers. There is intense activity in the leafage of the forest and in the hives of bees; every living thing is working up to its limit, unless indeed the temperature rises too high. Then the leaf may droop and the animal may have a long siesta. Spring is often a playing time; summer is characteristically the working season.

General Features.

But it is also the finest floral season, and this means preparing for the generation to come. So is it also with animals; everywhere we see "love" as well as hunger. Summer is the time for studying family affairs among animals.

If we wish to find a kind of animal to be a type and emblem of summer, can we do better than choose butterflies? They are among the most delicate of living creatures and strike the three notes of beauty—in their form, in their colours, and in their movements. They express the idea of summer not least in this, that the winged adults are mostly preoccupied with "love" and very little with "hunger." This is another form of the contrast between foliage and flowers; and there are some butterflies which never eat at all. The explanation is, of course, that the big appetite of the caterpillar makes the gay life of the butterfly possible. As Shakespeare says: "Your butterfly was a grub"; and this particular contrast is but a particularly vivid instance of a see-saw that can be discerned throughout the world of life, the see-saw between "hunger" and "love," between nutrition and reproduction. It is in a way the see-saw between caring for self and caring for others.

Summer Butterflies.

The familiar grouping of Lepidoptera into moths and butterflies seems to be more convenient than scientific, but most butterflies have a knob at the tip of the feeler, which is rarely the case in moths; and in the great majority of moths there is a special bristle arrangement for hooking the front of the hind-wing under the posterior margin of the fore-wing, a contrivance not found in butterflies, though here also there is a combined action of the two wings on the

Photo: John J. Ward, F.E.S.

CHALK HILL BLUE BUTTERFLIES.

Blue Butterflies (Lycæna), such as the Common Blue (*Lycæna icarus*), or the Chalk Hill Blue (*Lycæna corydon*), or the Adonis Blue (*Lycæna bellargus*), are famous for the diverse colouring of the sexes; for while the males are brilliant blue, the females are brownish.

same side. There is not much in the familiar distinction that most butterflies are active by day and most moths by night.

Very characteristic also is the fact that the mandibles or jaws which mean so much in most insects—and so much in the caterpillar!—are usually indistinguishable in the butterfly, though some dwindling vestiges are sometimes discernible. But a portion of the maxillæ, that is to say, the second pair of mouth-parts, is greatly developed to form the spirally coiled proboscis. This is a beautiful structure, with all the marks of efficiency; yet in many butterflies it seems to be of very little use. The probability is that in ancient days, before the task of accumulating nutritive reserves was laid so completely on the shoulders of the caterpillars, the adult butterflies had themselves to do a good deal of nectar-sipping to keep body and soul together. This may account for the elaboration of the proboscis in those present-day butterflies that are often hardly nutritive at all. Even among those that dally with flowers the amount of nectar ingested is often trivial. Hunger is over, love is ascendant. We are not denying that the proboscis is sometimes part of a really important suction pump; our point is simply that for many butterflies feeding is quite unimportant. They make love and become parental on the strength of having once been caterpillars. In short, they live on their past.

This is far too cold a way to speak of butterflies, for they are unsurpassed in their combination of beautiful colours, beautiful forms, and beautiful movements. One cannot but believe that they give us a joyous glimpse of something as much in the heart of life as the see-saw of colloidal metabolism. Is there not a glimpse of the butterfly's sub-personality in man's unusually happy way of naming many of his butterflies: there is a charm in such titles as the Purple Emperor, the Red Admiral, the Painted Lady, the Peacock's Eye, the Green Fritillary, the Lady of the Woods, the Swallow Tail, and the Aerial Blue.

The total number of British butterflies is probably sixty-six, and ten of these are only visitors, like the Camberwell Beauty, which cannot find a permanent footing, perhaps because of adverse climatic conditions, perhaps because of the absence of suitable food-plants.

The colouration of many animals, take lobsters for instance, is due to pigments; but in other cases, like the inside of the mother-of-pearl oyster, there is no colouring matter at all, all the

rainbow hues being the result of physical structure, as pounding a piece of shell at once shows. For it becomes white chalk! But the finest colour effects, such as those of butterflies and humming-birds, are due to a combination of pigments with fine surface architecture. The beauty of the pigments is enhanced, one might almost say transfigured, by the fine lines and layers on the surface. Thus the scales on a butterfly's wing are covered with microscopically fine lines which give rise to the iridescence. There are many blue butterflies, but there is no blue pigment. The combination of pigment-colouring and structure-colouring is often so beautiful in butterflies that one thinks of them sometimes as flying flowers.

Just as the male mosquito can find the female from some distance when she produces her shrill note, so some male moths can find their mate from a mile off by help of the characteristic fragrance which they emit. Among the butterflies that are fragrant, however, it is usually the male that gives off the scent, and observations have proved that this is attractive to the desired mate. The fragrance is produced by skin-glands; it often oozes out by fine pores or accumulates in a little pocket. Much more than this has in some cases been described—namely, the presence of minute reversible brushes with delicate hairs which allow the scent to diffuse into the air. The brush may be at the end of the tail and the scent-glands on the wings so that the butterfly has first to sweep his wings; and an extraordinary detail is that in certain cases there are "dust-filaments" in the brush-bag which readily break up into fine perfumed dust which is scattered in the air. As Dr. Eltringham says in his delightful "Butterfly Lore" (Oxford, 1923): "The apparatus is really an animated powder-puff." This expert advises those interested to catch a male of the "Green Veined White," a common spring butterfly, in order to verify the distinctiveness of

Photo: John J. Ward, F.E.S.

SWALLOW-TAIL BUTTERFLY (*Papilio machaon*).

A supremely beautiful British butterfly, with yellow wings ornamented with black, blue, and red. The sexes are similar in colouring, but the female is the larger. The eggs are laid on the leaves of the milk-parsley; and on this and on allied plants the greenish caterpillars, otherwise banded and spotted, have vigorous nutritive life. This beautiful butterfly has a wide distribution from Continental woods and meadows to Japan.

the fragrance. In this species it is like lemon-verbena. It should be noted here that butterflies of both sexes have often repellent odours, which are probably in most cases protective against enemies.

Butterflies are exquisitely sensitive creatures, quivering to many different kinds of environmental stimuli, but it seems that the use of the sensory receivers is rather to pull the trigger of certain actions than to give the butterfly information about the outside world. Only in the higher animals do the senses come to be very important as the gateways of the mind.

Photo: John J. Ward, F.E.S.

PAINTED LADY BUTTERFLY ASCENDING THE STEM IN READINESS FOR FLIGHT.

The Painted Lady (*Pyrameis cardui*), predominantly tawny orange but exquisitely marked, is a relatively rare North African immigrant to Britain. It often flies late in the day, when other butterflies have gone to rest.

The sense of smell, which we have noticed in connection with butterfly courtship, is probably located in the knobbed antennæ, which have also to do with effective flight; the sense of taste is often near the mouth, but in the Red Admiral, which has a very sweet tooth, it is mainly in the feet; the sense of touch is at strategic points in many regions of the body. Some moths produce sounds, but this is very rare in butterflies; and even when there is a sound—a sort of instrumental clicking—it is difficult to prove that it is heard.

When we speak of smell and the like in butterflies, we must not suppose that their senses are much the same as ours of the same name. This is very obvious in the case of vision, for the butterfly's eye is utterly unlike that of man. It is fixed and lidless; it consists of thousands (five thousand in the Tortoise Shell) of eye-elements, each complete in itself, with cornea, lens, and retina; it is extremely shortsighted, having a range of only a yard or so. The image formed in the recesses of the eye is an erect image, not inverted as in our case. Besides image-forming, there is, in some degree, a discrimination of colours. But butterflies do not see the world as we do!

The eggs of many butterflies are remarkable in their decorativeness. Butterflies have been flitting about for perhaps three million years, is it surprising that they should now be perfect works of art? And the egg is the living creature in the one-cell phase of its being. But this is only one of the many butterfly puzzles. What living hand of the past is upon the mother butterfly that she lays her eggs, often singly, on the one and only kind of plant that the caterpillar can use as food? And how are we to think out the way in which development begins afresh in the quiescent chrysalis stage, on a new architectural plan so that what fell asleep a caterpillar awakens a butterfly? This is a big puzzle indeed.

One of the most familiar sights in early summer, in June let us say, is the "cuckoo-spit." In the fields and by the wayside and in the garden, on many different kinds of plants there are curious splashes of white froth. There seems to have been an old idea that when the mother-cuckoo goes about in spring looking for the nest of a meadow-pipit or of some other bird

Frog Hoppers.

Photo: John J. Ward, F.E.S.

LARGE WHITE BUTTERFLIES (*Pieris brassicæ*).

This commonest of British butterflies has typically black tips to the fore-wings. The male has a black spot on the front margin of the hind-wings. The female has, in addition, two roundish black spots on the fore-wings.

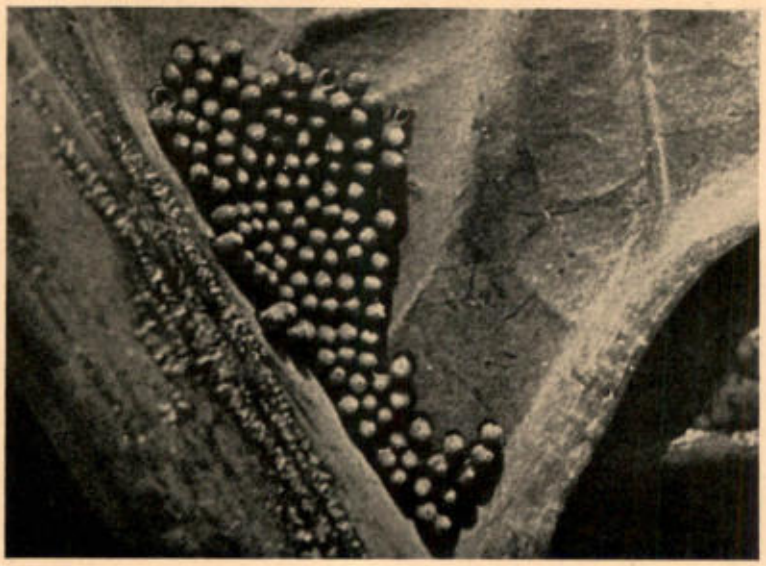


Photo: By courtesy of the British Instructional Film Co., Ltd.

1. EGGS OF LARGE WHITE BUTTERFLY ON CABBAGE LEAF.

The minute yellowish eggs are laid in batches of six to a hundred on the leaf of the cabbage or some similar plant.

in which to place her own egg, she spits and spits every here and there! But no one who cares to look can any longer believe that "cuckoo-spit" has anything to do with the cuckoo. In an earlier chapter, "The Quest for Food," we have already given a short description of how the froth is made, but this interesting insect is worthy of our further attention.

Let us try to understand something of the natural history of "cuckoo-spit," keeping especially to the particular insect, *Aphrophora spumasia*—one of the commonest kinds. Where does the insect come from? How does it make the foam? What is the meaning of the foam? What becomes of the creature later on in the year? It is only fair play to have the answers to these questions before us before we call the cuckoo-spit repulsive. We must remember the lesson St. Peter learned on the house-top, which warned him not to be too quick in calling any living thing "common" or "unclean."

The life-story for the year is something like this. In the autumn the mother frog-hopper, an active insect approaching half an inch in length, lays her eggs in deep crevices in the bark of willow-bushes or the like, and soon afterwards dies. The eggs hatch in the spring, and there emerge little green larvæ with the body flat below and pointed behind, with a head bent down upon the breast, with a sharp, piercing beak well suited for penetrating the skin of young leaves, and with the usual three pairs of legs well suited for taking a firm grip of the plants. If one puts the creature on a clean leaf and watches it through a good pocket lens, one sees it probe with its beak, which consists of sharp needles inside a green tube-like case. By means of the beak the young larva sucks

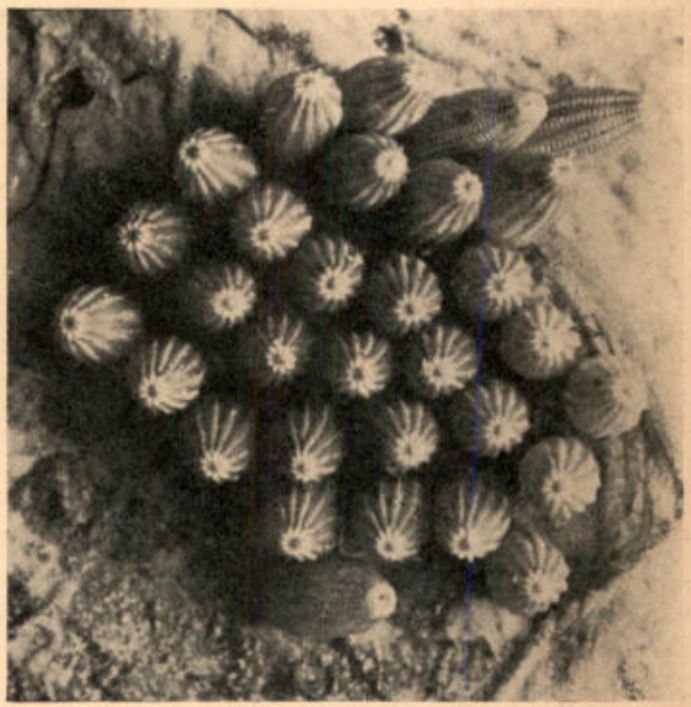


Photo: M. H. Crawford.

2. THE EGGS MAGNIFIED FIFTEEN DIAMETERS.

The eggs are deposited on end, often three or four a minute, and they are beautifully sculptured. After a few days they hatch out the small caterpillars seen on the following page.

up the sugary sap of the leaves, just like its relatives the green-flies or Aphides. And just as "honey-dew," as it is called, passes out of the green-flies in large quantities and smears the leaves, or even falls like drops of rain to the ground, so the surplus sap passes through the food-canal of the frog-hoppers and forms the familiar foam-like "spit." The food is very abundant and the insect grows and moults, and grows and moults again. Finally, it passes into a resting or pupa stage; its wings grow, and other changes of structure are brought about; it leaves the froth and moults for the last time; then it becomes a full-grown winged insect, and there is no more foam to be seen on the herbage. Everyone must have noticed that what is so abundant in the early part of summer disappears altogether later on. All the frog-hoppers have grown up. Yet as late as the first week of August we have seen plenty of "cuckoo-spit" in some of the valleys of the Cairngorms.

They say that it was Isidore, Bishop of Seville, who started the name "cuckoo-spit" about 636 A.D., and to him it was very wonderful that from within a fleck of froth there should arise a singing insect, namely, the singing cicada. Now he was wrong in thinking that the little frog-hopper became a cicada, though they are certainly cousins; he was wrong in supposing the cuckoo had anything to do with it; and he was most of all wrong in supposing that the froth made the insect, for we know that it is the insect that makes the froth. We know nowadays, thanks to many keen eyes, much more about frog-hoppers than the old Bishop, yet for all that the "cuckoo-spit" is not less wonderful to us than it was to him. Is it not a remarkable device, living under water and yet in the open air, conspicuous and yet concealed, in the sunshine and yet cool!

As an example of what we may call the *by-play* of the animal body, we may take the luminescence of the glow-worm, which we see on summer evenings. The glow-worm is a small beetle, first cousin of the fire-flies and the American "lightning-bugs." The female is wingless, but it is she who produces most light. She is about three-fifths of an inch long, while the winged male does not attain to half an inch. It is in the warm summer evenings that the females shine in their "dells of dew," sometimes climbing on to stems and displaying their lights in different directions, probably to catch the eyes of the males who fly about. We know a mossy bank where the road skirts a damp wood, and on a summer night we have seen scores of "fixed stars" or females among the herbage.

Glow-worms.

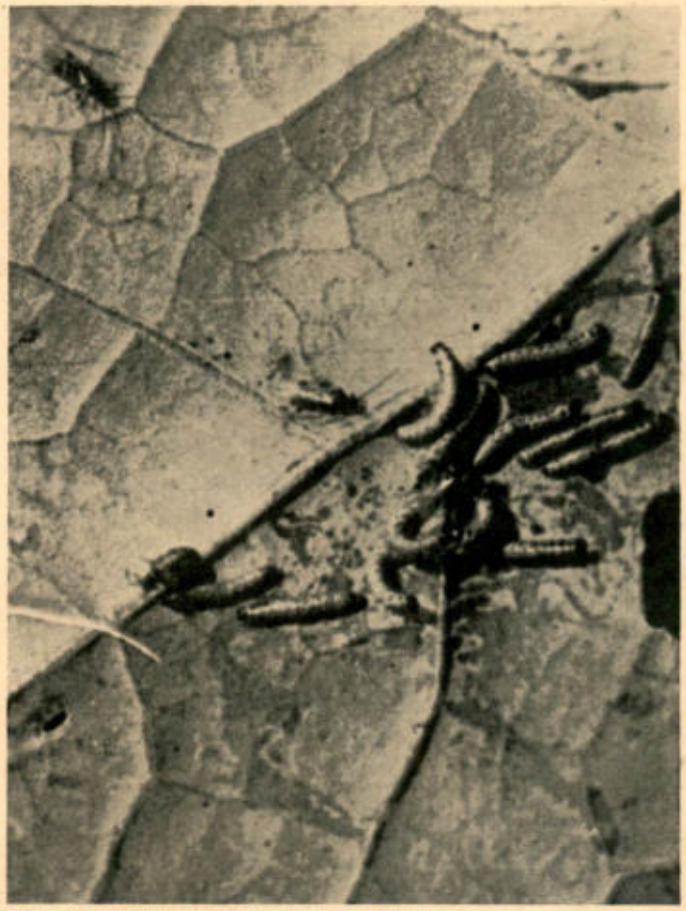


Photo: By courtesy of the British Instructional Film Co., Ltd.

3. YOUNG CATERPILLARS OF THE LARGE WHITE BUTTERFLY.
Hatched out from the eggs in about a week after laying; they become greenish, with blue or grey above. The story of their development is continued overleaf.

The "wandering stars" or males are not so

Photo: By courtesy of the British Instructional Film Co., Ltd.

4. CATERPILLAR FULLY DEVELOPED.

The full-grown caterpillars are usually to be seen about mid-summer, often crowded on the cabbage leaf, and producing an unpleasant smell.

noticeable. Both are hidden during the day. Like many full-grown insects they live for love, and do not seem to care for food. But it is very different with the young glow-worms, for they have a big appetite and are keen to attack small snails, which they deal with in a way of their own. They seem to inject a paralysing poison with their bite, and they make the snail's flesh so soft before they swallow it that their meal is practically fluid. Since the larval glow-worms feed chiefly on small snails, and since these frequent moist and shady places, we understand the habitat of the full-grown insects.

The seat of light-production in the female glow-worm is in two strata of cells at the hind end of the body. The cells are not unlike those of the "fatty body," a common reserve-tissue in insects, and they are traversed by fine branches of the air-tubes (or tracheæ) that take air to every hole and corner of the insect's body. In most animals the blood goes to the air (in the lungs, for instance), but in insects the air goes to the blood. There is no doubt that oxidation has to do with the production of the "glow," and it is recorded that the light becomes more intense when the insect is put into a vessel with an extra percentage of oxygen. It is highly improbable, however, that the light-production is the outcome of mere oxidation. There is strong evidence in support of the theory of Professor Raphael Dubois, corroborated by Professor Newton Harvey, that a fermenting substance in the blood, called luciferase, acts on a light-producing substance, called luciferin, in the cells of the luminous patches. That the fermentation of luciferin by luciferase is accompanied by a rapid oxidation is highly probable.

There is a rival theory, that the luminescence is due to internal nests of luminous bacteria, like those we see on dead fishes. This is probably the correct explanation in some luminous animals, but experts say that it should be ruled out of court in the case of glow-worms and fire-flies. It need hardly be said that "living lights" have

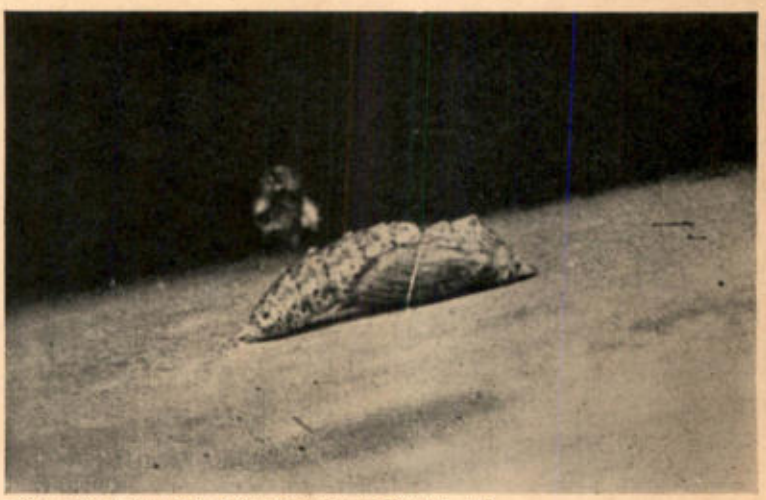


Photo: By courtesy of the British Instructional Film Co., Ltd.

5. CHRYSALIS OF LARGE WHITE BUTTERFLY.

The chrysalis or pupa is greyish, more or less spotted with black and streaked with yellow. It is often fixed horizontally to wall-copings, fence-bars, window-sills, and the like.

Photo: By courtesy of the British Instructional Film Co., Ltd.

6. LARGE WHITE BUTTERFLY EMERGING FROM THE CHRYSALIS.
Inside the pupa-case there is one of the most remarkable processes in the world. A change, which began in the later caterpillar life, brings about a radical reconstruction. The larval body is scrapped (histolysis), and by reconstruction (histogensis) a new body—the butterfly's body—is built up.

nothing to do with phosphorus; so the word phosphorescence should be dropped in this connection. Of great interest is the fact that the light-production of the fire-fly and the glow-worm is in a sense the most perfect light-production in the world, for the light is "cold light," without any heat-rays. None of the chemical energy (electron jerks, no doubt) is lost in the form of heat. We wonder, then, if "glow" is the right word for the glow-worm's light.

The glow-worm spends the winter in the larval state, hiding itself in deep recesses. It becomes active in spring and hunts for snails. As in its relatives, the form of the body strongly suggests that of the wood-louse, which is, of course, a crustacean that has wandered from its ancestral home in water and become terrestrial. The light of the larva is faint, and as it is turned towards the soil it is not readily noticed. After a period of great activity and keen appetite the larva becomes a pupa, which is also slightly luminous. The pupa is not so thoroughly quiescent as most pupæ are, for it can push itself along the ground. Metamorphosis is taking place, but in the life-history of the female the change is not conspicuous, for the full-grown female retains the appearance of the larva—an unusual state of affairs.

The winged males pair with the wingless females, and the fertilised golden-yellow eggs are laid in early summer among the moss or moist grass. They soon develop into larvæ which hunt for snails and accumulate sufficient internal stores to keep them alive through the winter. We suppose that the full-grown insects die after they have secured the continuance of the race. The fact that the eggs, larvæ, and pupæ are faintly luminous, and that only the females of our *Lampyris noctiluca* can glow to much effect, seems to indicate that the luminescence is a sort of chemico-physical by-play of the ordinary routine of the life, and that

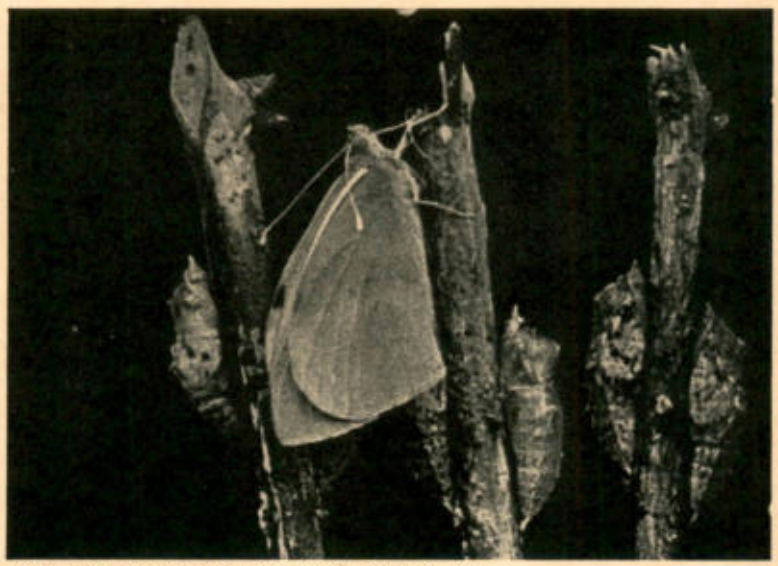


Photo: By courtesy of the British Instructional Film Co., Ltd.

7. THE LARGE WHITE BUTTERFLY DRYING ITS WINGS.
From within the fixed pupa-case or chrysalis there emerges such a different creature—the "imago" or winged butterfly. What a metamorphosis!

Photo: John J. Ward, F.E.S.

THE FEMALE GLOW-WORM (*Lampyris noctiluca*).

The female of this luminescent beetle, for such the Glow-worm is, has no wings or wing-covers, but there is a diffuse illumination from the under-surface of the three last segments of the abdomen. In the light-producing organ there is a rich supply of air-tubes.

it is of no use in the early stages at least. In the perfect female, however, it is probably an important love-signal and it must be noted that in many relatives of our glow-worm the males are the more brilliant and have very fine eyes. All the dancing fire-flies that one sees in Italy, for instance, seem to be males; the rare females sit among the herbage. Flashes of light pass to and fro till each female has attracted a little levee of suitors. Finally there is some sort of "choice," and mating occurs.

Some observers have seen full-grown glow-worms eating minute pieces of green plants and also rotten fragments. In some cases they have been observed enjoying particles of sugar. But the general opinion is probably correct, that the adults take almost no food. It is very different with the larvæ, which devour small snails. Professor Bugnion agrees with Fabre that a poisonous secretion is injected from the jaws into the snail, and that this serves to "chloroform" them. According to Miss Kathleen Haddon a dark fluid is injected through a canal in the glow-worm's mandibles, but she does not admit that there is a preliminary anæsthetising. There is still much to be discovered in regard to glow-worms, but natural history has made progress since the days when they were said to be "generated of dew."

Along with butterflies, as types of summer, we take Humming-Birds, for they are especially, though not exclusively, flower-visitors, and they are themselves like flying flowers. No doubt some are mountain-birds and may ascend the Andes, for instance, to near the level of perpetual snow, but most of them are linked to flowers and therefore to summer.

Humming-Birds.

It is difficult to avoid extravagance in writing about humming-birds. The colours are so brilliantly beautiful that Audubon called the humming-bird a "glittering fragment of the rainbow," and Buffon wrote that "the emerald, the ruby, and the topaz glitter in its garb." The movements are so graceful and aerial, as it hovers with humming wings, or flits from flower to flower like a butterfly. Not only "living gems," as Gould, their monographer, called them, but "dancing gems." Then there is the large number of different kinds—at least five hundred species—a fact that spells success. And the number of individuals is also, in many cases, enormous, just as if they were insects! Another attraction is in their dainty feeding, for, as one of the earliest observers wrote in 1671 of the Ruby-throated: "'Tis an exceeding little bird, and only seen in summer, and mostly in gardens, flying from flower to flower, sucking honey out of the flowers as a bee doth; as it flieth, not lighting on the flower, but hovering over it, sucking with long bill a sweet substance." As a matter of fact, humming-birds feed on insects as well as on honey, and in some cases they are mainly insectivorous. But they always feed daintily.

There is a fascination, too, in their minuteness, for the total length of the smallest is two and a quarter inches, its body being less than the bulk of the head of the largest, the Giant Hummer of the Andes, which equals a good-sized swift. As one looks at a dwarf humming-bird, one cannot help wondering if it really contains the counterparts of all the organs in our body. The Vervian

Humming-Bird of Jamaica is about two and a half inches in total length; its nest is three-quarters of an inch in diameter; the eggs are 0·28 of an inch in length, and 0·20 of an inch in width. Here is a case of *maxime miranda in minimis!*

Humming-birds are confined to the New World, where they extend from Patagonia to sixty-one degrees North Latitude in Alaska. They are most successful in mountainous countries, and their centre of distribution is among the Northern Andes. There is a peculiar group of Hermit Hummers, which are characteristic of Brazil. Of these, Dr. Robert Ridgway writes in his masterly memoir on humming-birds: "They are all very plainly coloured birds, with little metallic colouring, sometimes none, and instead of living in the sunshine and feeding among the flowers, they inhabit the gloomy forests and subsist wholly on insects gleaned from the branches and leaves of trees."

In Temperate countries, humming-birds are migratory. Thus, the Ruby-throated has its summer home in eastern North America, while in winter it goes as far south as the Isthmus of Panama. It, and some others, may have a migratory range of over two thousand miles. Dr. Ridgway notes that: "It is only in the warm valleys of California and in Southern Florida that any species of humming-bird regularly passes the winter within the borders of the United States." He also calls attention to their remarkable *vertical* range: thus, he saw one in the doorway of a ranch in Ruby Valley, Nevada, at an altitude of 6,000–7,000 feet, and another of the same kind on the same day, nearly 6,000 feet higher on the summit of the East Humboldt Mountains.

An ordinary bird in everyday flight rows on the air with its wings, but a humming-bird has, as it were, revived the insect's method of flight—by extremely rapid vibration of the wings. This is associated with the unique structure of the wing, for the upper-arm and fore-arm bones are relatively very short, the primary pinions (ten in number) are relatively very long, and supported on long hand-bones, whereas the secondary pinions (six in number) are much abbreviated. But these secondaries, borne by the fore-arm, count for most in the flight of ordinary birds. Thus the humming-bird has come to be a very rapid *flutterer*. It flits from flower to flower, it hovers with its body almost vertical while it thrusts its tongue into a blossom; it buzzes like a bee among the flowers near the ground; it suddenly shoots up in the air and over a tree-top. But there is no vigorous striking of the air, as in ordinary birds; what is seen is an extremely rapid vibration. In proportion to the humming-bird's size the muscles of flight are magnificently developed, and the keel of the breastbone to which they are attached is, size for size, stronger than an eagle's.

The rate of a humming-bird's flight is probably less than it seems; what is remarkable is the number of wing-strokes per minute. Dr. Lucas estimates the number at about 500, whereas the gannet, or solan goose, a bird with slow strokes, but not of slow flight, has about 150 per minute. Five hundred strokes of the wings in one minute must imply a prodigious expenditure of energy,

Photo: John J. Ward, F.E.S.

WINGED MALE GLOW-WORM (*Lampyris noctiluca*).

The male Glow-worm has large wings and wing-covers. There is luminescence from two spots at the end of the abdomen, but there is not the diffuse glow seen in the female. There is also faint luminescence in the eggs, larvæ, and pupæ. The larvæ are voracious snail eaters. They pupate in April or May, and the full-grown beetles emerge in about a fortnight.

Photo: National Association of Audubon Societies.

MALE RUFOUS HUMMING-BIRD.

Most of the Humming-birds are species of the large genus Trochilus, and there is a close general resemblance amongst them all.

and it is not surprising to find that the humming-bird has a very strong heart. It is not for nothing that humming-birds are related to swifts! Their flight lacks momentum, and they may be caught by a cobweb! They cannot run on the ground; they keep to trees and to the air.

The bill of the humming-bird is usually slender and elongated. In one case it is four and a half inches long, exceeding the length of the whole bird. In most species it is almost straight, but in some it is bent downwards, and in the Avocet humming-bird it is bent upwards—these strange twists being apparently suited for dealing with flowers with curved corollas. The lower jaw fits into a groove in the upper jaw, so that the closed bill is like a tube. Corresponding to the typical bill is the extremely long tongue, which can be whipped out and in with great rapidity. It is tubular at its base, but divides, at about half its length, into two free tips. Each of these is a sort of half-tube or gutter, and also bears an up-curled membranous fringe somewhat frayed towards the end. The whole apparatus seems to be suited both for nectar-sipping and entangling small insects that frequent the flowers. In certain cases the hummers are of real use to the flowers they visit, for some carry the fertilising golden dust or pollen from blossom to blossom, and there are others that destroy unwelcome floral visitors.

Humming-birds are very successful in the struggle for existence, and this is shown in certain features of their behaviour. They are very inquisitive, and they often fly close to the observer's face as if to take a good look at him. They show a "charming confidence in the human species," and may be readily taught to come for honey. The males are very pugnacious—big souls in little bodies—and they not only fight with their kin at the breeding season, they drive off much larger birds that intrude into the vicinity of the nest. There is a good deal of twittering conversation among humming-birds—expressing fondness, good-humour, anger, and alarm, but "it is doubtful if any approach more nearly to a song than a sort of warbling twitter, which the males of many species produce during the pairing season." The "humming" is, of course, due to the rapid vibrations of the wings. Of their intelligence little is known except that in connection with nest-making, but there it seems certain. For they sometimes depart from what may be called the instinctive routine; thus, they have been known to use a stone or a

piece of clay to weigh one side of a hanging nest that threatened to turn turtle.

Whatever may be the mental aspect of nest-building—a mingling of instinct and intelligence, we think—the humming-birds' nests certainly show exquisite architecture. Many are about the size of an egg-cup, some not much bigger than the end of a driving-glove thumb. They are carefully felted structures in which fairies would love to slumber, for the materials are so delicate, the cottony down of plants interlaced with gossamer, and compacted outside with pieces of lichen and leaf. Most are like cups, some are like turbans; most are saddled on twigs, some are hung on the ends of long-pointed leaves—more or less out of reach of monkeys; and some that resemble hammocks are swung on to the face of cliffs by means of spiders' webs!

The nests are so well disguised that they are rarely detected except by accident or when the bird is seen flying off. There are always two eggs, nearly dead white, and somewhat oblong. They look like little peas, but it must be noted that they are large for the size of the bird. They require twelve to eighteen days' incubation, and there are usually two broods in the season.

We see, then, that these pigmy birds — some hardly bigger than humble-bees— have found a large niche for themselves in the crowded world; they have few enemies; they find their food easily; their nests are not readily detected. For these and other reasons they are probably relieved from very severe sifting in the struggle for existence, and this relative freedom has allowed them to blossom out exuberantly like the flowers they visit.

Envoi, or General Outlook.

When all is said, and we have only given glimpses, what is summer but the heyday of vital activity? The green leaves, on which all creation depends, are at their busiest in their synthetic laboratories, where carbon-compounds are built up from simple components. There is not only income, there is an accumulation of capital for future use. The flowers also are at their busiest, making and equipping the new generation, and in their unconscious joyance laying themselves out to secure insect visitors, whether by flags of colour, feasts of honey, or fragrant incense. The flower-visiting insects are naturally at their busiest, for what secures continuance of generation to the flowers means meat and drink to the bees and butterflies and other pollinators.

Many young animals are still playing in the summer, but many have passed from apprenticeship to journey-work. They are securing foothold, they are founding homesteads, they are subconsciously saving for their youngsters, yet unborn. All unbeknownst, they are storing for days to come, when food will be scarce. Though they take no deliberate thought for the morrow or the winter, they behave as if they had prevision, for such is the ministry and mystery of instinct. Summer is a time when many an animal makes hay while the sun shines, as the hive-bees accumulate their honey, which, if man would allow it, is their store for the hard times of winter.

Photo: Exclusive News Agency.

RUFOUS HUMMING-BIRD AT A FLOWER.

Humming-birds are noteworthy as flower pollinators, for in many cases they carry the pollen from blossom to blossom, and thus effect pollination.

Photo: Ullstein.

HUMMING-BIRD FEEDING YOUNG.

There is an indescribable daintiness in the way the Humming-birds poise beside their thimble-like nests and feed their young.

Summer is the time of maximum industry, and this means, for many an animal, some new departure. Necessity is not the only spur to adventure; there is some stimulus also in capital and in summer leisure. Animals have occasional holidays! In summer the beavers dig more canal and strengthen their dam; the ants add to their ant-hill; the termites increase the height of their termitary.

Another aspect of the Natural History of Summer is that it affords for many an animal an opportunity for strengthening the links of family affection. The young ones, in many cases, stay about their birthplace in the summer; they profit by the parental pattern and parental tutelage; there is also free play of affection, before the evil days come when the individual in each breast is tyrannous to sunder kin from kin. Perhaps there would have been no animal sociality if there had been no summers.

Another aspect of the deeper Natural History of Summer is that it allows of the establishment of permanent products which last on from generation to generation. We are thinking of the ant-hill, the termitary, the beaver-village, the Viscacha colony, and so on, where there is some registration outside of the organism, some dim adumbration of what is supremely characteristic of man—*a social heritage*. Even the beginning of this external registration—conspicuous in the bee-hive, which is more than half artificial—means a great step in evolution.

Finally, to some creatures, migrant birds, for instance, and many insects, the summer season means a time set apart for courtship and mating, having a family and enjoying domestic life. Summer is a season of work, but also of play; it is a time for accumulating capital, but also a time of adventure. It is the height of the animal's wave, often breaking into sunlit spray, but sometimes ending against the cliff-face of death. Above all, we may say, summer is for most animals and some plants the season of reinvigoration, of gathering strength for fresh endeavour. So it should be for man also, for in his life the rhythm of the seasons' fiat should have its sway.

Photo: E. R. Gamage.

NEST AND EGGS OF HUMMING BIRD.

A Humming-bird's nest is often about the size of a thimble, and in its daintily lined cup there lie the tiny eggs. Usually these are two in number, but in some species there is only one. This indicates that the hummers are relatively secure in the struggle for existence.

After the painting by Philip Rickman.

THE COMMON PHEASANT (*Phasianus colchicus*).

The Pheasant's technical name indicates that it comes from the Black Sea region and is not a native British bird. Probably it was brought to Britain from Asia by the Romans, but it is now thoroughly acclimatised in England, Wales, and some parts of Scotland. The original species has been crossed with several others, and no pure race is left. With its brilliant plumage and fine flight, no bird is a greater ornament to the woods in autumn and winter; none affords a more difficult target to the sportsman.

LVII

NATURAL HISTORY OF AUTUMN

THERE is great charm in fine autumn days—the nip in the air, the cloud effects, the flush of the withering leaves, the ripening fruits, the whirling seeds, the farewells of the migrant birds as they set out for the south. It is a quiet time compared with spring and summer—the singing birds have gone or are quiet, the instrumentally musical insects have ceased. But colour makes up for silence; the great splashes in wood and moorland are even finer than the summer meadows.

There are many sights and events of great scientific interest—the gossamer showers that follow the aerial journeys of little spiders, the arrival of northern birds, the salmon leaping the falls, the earthworms planting seeds, the fall of the leaf, the dying away of wasps and humble-bees, the storing industry of the squirrels, and so on through a long and delightful list.

There are four sets of facts that seem to us to stand out in the Natural History of autumn. (1) Individuals are dying away, but the race lives on; and there are all sorts of ways of securing this. The plants die, the seeds live on; the butterflies die but many of the chrysalids are safe. (2) There is along various lines a sacrifice of parts and even individuals, while the whole or a remnant survives. Thus the leaves fall, but the tree stands; the workers and drones among the humble-bees all die, but the young queens survive the winter. (3) Very characteristic are the preparations for hard times—preparations sometimes automatic (like fattening), sometimes instinctive (as in hive-bees), sometimes intelligent (as, perhaps, in beavers). All sorts of storing, of which we have already spoken; all sorts of blankets—in buds and seeds, in cocoons and furred animals. (4) Then there are autumnal circumventions of difficulties, familiar in the birds that evade the winter by migration, and in the true winter-sleepers like the hedgehog.

In some ways autumn seems a sad season—a time of retreat, entrenchment, lethargy, farewell, and death. But this has to be corrected by looking at the other side—it is a time of endurance and persistence, of preparation and circumvention, a time of victory.

Earthworms.

No doubt, the work of earthworms continues all the year round except when the soil is hard with frost or covered with snow, but it is most in evidence in autumn. This is in part connected with the autumnal abundance of withered leaves which the earthworms drag down into their burrows. We see more worm-castings in autumn than at any other time of year. On one of the putting-greens on the golf course, the men had poured some solution or other—"salts," they said—and the earthworms had come up in hundreds to die. We may safely say hundreds because the men were brushing them on to a wooden spade, and they had filled a large pail with—the most useful animals in the world.

That was, of course, what Darwin proved, that earthworms are the most useful animals in the world, having in the course of ages made the greater part of the fertile soil of the globe. In a previous chapter, "The Work of Earthworms," we have told of his patient and exact observations, showing the truly astonishing work performed for mankind by these lowly organised creatures.

The earthworms are continually dragging leaves into their burrows, partly to eat them when they rot, and partly to make the underground retreats more comfortable. Thus in the course of time they have made most of the vegetable mould of the world.

Then there is no doubt that they often plant trees by burying the seed, and this is almost always well. They bring bacteria to the surface, which may mean exposing virulent ones to the sunlight that kills them, or to the wind that scatters them abroad. It may be said that Pasteur was continuing the Darwinian tradition when he suggested that earthworms bring to the

surface the deadly microbes of the deeply buried sheep or bullock that died of anthrax or splenic fever. But this was not confirmed by the subsequent investigations of Koch, and it may be that the reappearance of the disease in fields where "anthrax-carcases" have been buried is due to the contamination of the surface soil while the infected animals were still alive. It remains true, however, that earthworms bring microbes to the surface, whether for good or ill. They make bacteria circulate, as well as the soil. Of their uses to moles, birds, and anglers nothing need be said, except that these are only representatives of the many circles of life that the earthworm's circle intersects.

For every animal there is a particular point of view that is especially illuminating, and the earthworm, as it seems to us, should be considered as an early discoverer of the underworld that has ceased to be quite so comfortable as it once was. Various arguments, such as the presence of gills on Alma, Dero, and some other earthworms, lead to the conclusion that earthworms are derivatives of an aquatic race. When the pools dried up, some pioneers took to burrowing in the soil—a poorer soil then than now. They discovered a new world. They entered upon a Golden Age of peace and plenty. But this was too good to last, and other creatures followed on the earthworms' track—venomous centipedes, predatory beetles, carnivorous slugs like Testacella, and after long ages moles. Our point is that with the increase of competition a refuge-habitat ceased to afford anything like the original degree of safety. The underworld ceased to be secluded. The earthworms are nowadays much persecuted animals. We can understand, therefore, why they have many accessory peculiarities that have evolved in indirect response to stress. They have no ears, but they are exquisitely sensitive to vibrations; they are able to detect the light footsteps of the thrush. They have no eyes, but they are sensitive to the dawn, and hurry back to their holes. Those that we see during the day are usually parasitised or half-drowned; and the early bird gets not the early worm, but the belated one—who stayed out too long, who would not go home till morning, so to speak.

There is safety likewise in their acquisitiveness; thus we once got ninety-one leaflets from a single burrow, certainly suggestive of some margin for the frosty day. And another string to the earthworm's bow is the "regenerative capacity," for, in propitious circumstances, they can regrow a new tail to replace that which the mole, the bird, or even the centipede has bitten off. Our list does not exhaust the resources of earthworms, but it is long enough to show how they hold their own although they are neither clever nor prolific, and although their underground retreats have been invaded by many enemies.

We are too apt to speak of "the earthworm" as if they were all alike. The fact is that there are many different kinds even in Britain. In the ages at their disposal they have spread over the world, splitting up into many races just as in the case of mankind, but with divergences relatively much greater. They have attained to an almost cosmopolitan representation, except in very wet places like peat-bogs, very dry places like the Sahara, and tracts where they are within the reach of the spray of the sea. For their constitution cannot stand salt. They are relatively scarce in areas that have not recovered from severe glaciation, as in some parts of Canada. On the whole, however, earthworms are everywhere—they are the universal soil-makers and the most useful of all animals.

The Partridge.

To our autumn picture we wish to add this familiar bird, for though it is with us all the year, who can help associating it with the harvest-fields? Unlike the pheasant, it is a native of Britain, but its range extends as far as the Ural Mountains and Siberia. It must, therefore, be called a very successful bird, and we wish to ask why.

One reason is to be found in its cryptic colouration. How inconspicuous it is on a ploughed field or even among the stubble. Its plumage is as protective as it is beautiful. The main colour is slate-grey, but this is shaded with black hair-lines and barred with chestnut and buff. There is a good deal of chestnut about the head and throat, and there is a chocolate crescent on the breast. It is worth while peering into the colouring to see how subtle it is, and then one discovers that there is no small degree of individuality. This suggests that the partridge must have a firm foothold in the struggle for existence, for when a creature is still insecure, variations from the profitable form of colouring

A BEECHWOOD IN AUTUMN.

It is only when the leaves have fallen and the tracery of bare branches stands clear against the pale sky that the exquisite shapes of deciduous trees can be properly appreciated. Our photograph shows a beechwood upon a still November day, the ground beneath carpeted deep with dead leaves. There are very few flowering-plants that will grow under beech trees, but even the bareness has its beauty.

Photo: W. S. Berridge, F.Z.S.

HEN PARTRIDGE (*Perdix perdix*).

Unlike the pheasant, the common or grey Partridge is a true native of Britain, and is found in every part of the British Isles except the Outer Hebrides. The partridge is essentially a bird of the cultivated lands, and hence has greatly increased in numbers during the last century.

are nipped in the bud. But our point is that the partridge has its share of the cloak of invisibility, and yet it is one of the most beautiful of British birds. For practical purposes the two sexes are the same in plumage.

The partridge among the stubble is deceptively like a clod, and the protectiveness is increased by the habit of lying low. The birds crouch or squat till we are almost on them. Then comes the explosion—a startled cry and the whirr of the rapid wing-strokes. There is safety in the rapidity of the flight though it cannot be kept up for long. The strong development of the breast muscles which work the wings, is familiar to all who have the good fortune to enjoy cold partridge; and the roundness of the short wings is characteristic of birds that put on a very rapid spurt. As the birds rise we may notice the outspreading of the tail, which has always eighteen main-feathers, the outermost of a chestnut colour. And as the birds get tired we may see them "resting on their oars"—and what is flight but rowing in the air?—for they glide along with their wings outspread and slightly drooping.

Like many other successful creatures, the partridge has a long bill of fare; and it is obviously a great advantage to be able to utilise a large variety of food-materials. We may mention the tender shoots of grass and corn, the tips of the young clover, the ends of the heather twigs, the fruits of the blaeberry, many kinds of seeds, occasional plump spiders, and numerous insects, not forgetting injurious caterpillars. The young partridges or "cheepers" have to be fed on insects, and they continue to be fond of them after they begin to fend for themselves. It may be said that the Common Partridge thrives where agriculture flourishes, and they do good as well as harm, though not very much of either.

From February till winter comes again, the partridges are in pairs, or, later on, in family parties. But in winter there is often a combination of families into large coveys, and this gregariousness must afford some protection against enemies. Union is strength. They are said to sleep in circles with their heads turned windwards, and this will make a surprise attack more difficult.

When the coveys break about the end of February the mating season begins, and this means some liveliness. The males challenge one another, calling loudly and jerking up their tails. They have excited tussles, fighting with feet, wings, and beak. But there is much cry and little wool; the assaults do not involve any bodily injury. The hens run round the combatants as if they enjoyed the fray, and we are not sure that they do not fight also. Perhaps

they have something to say to the minxes who were making eyes at their husbands. For the fighting goes on after the partridges have paired. Perhaps it is safe to say that the honeymoon period is prolonged, for the serious business of egg-laying does not begin till April or May, or even later. Once the birds have settled down to matrimony, they are faithful to one another. In other words, they are monogamous, which is more than can be said of many game-birds.

The nest, hidden among the herbage, is hollow lined with grass and leaves. It is often in a hedgerow or near the margin of a wood. There may be ten to twenty eggs, usually olive-brown or grey-olive, often far from conspicuous in their natural surroundings, often hidden by the leaves of the nest if the mother-bird has left them for a minute. But she is well known to sit very close, and she has the somewhat puzzling power of suppressing her natural scent during incubation. Even an experienced dog will pass close to a brooding partridge ; so long as he does not see her, she is safe. The suppression of the scent requires further investigation. It may be that the oil-gland at the root of the tail, which produces an odoriferous ointment in many birds, passes into a condition of temporary inactivity during the brooding, perhaps because of some subtle chemical messenger or hormone. It may be that the mother bird is fasting. But facts are needed rather than theories.

The brooding lasts for twenty-two to twenty-four days, and though the cock does not share, he is not far off. He stands on guard, and if the worst comes to the worst he can sound the danger-signal and fight. Good observers have noticed that when the day of hatching arrives, the cock bird comes as close as possible to his mate and assists her by drying the young ones as they are hatched out. Both parents are very brave in defence of their fascinating offspring. They will attack hawks, crows, stoats, dogs, and even man himself. They are clever in covering the retreat of their brood, and have been seen

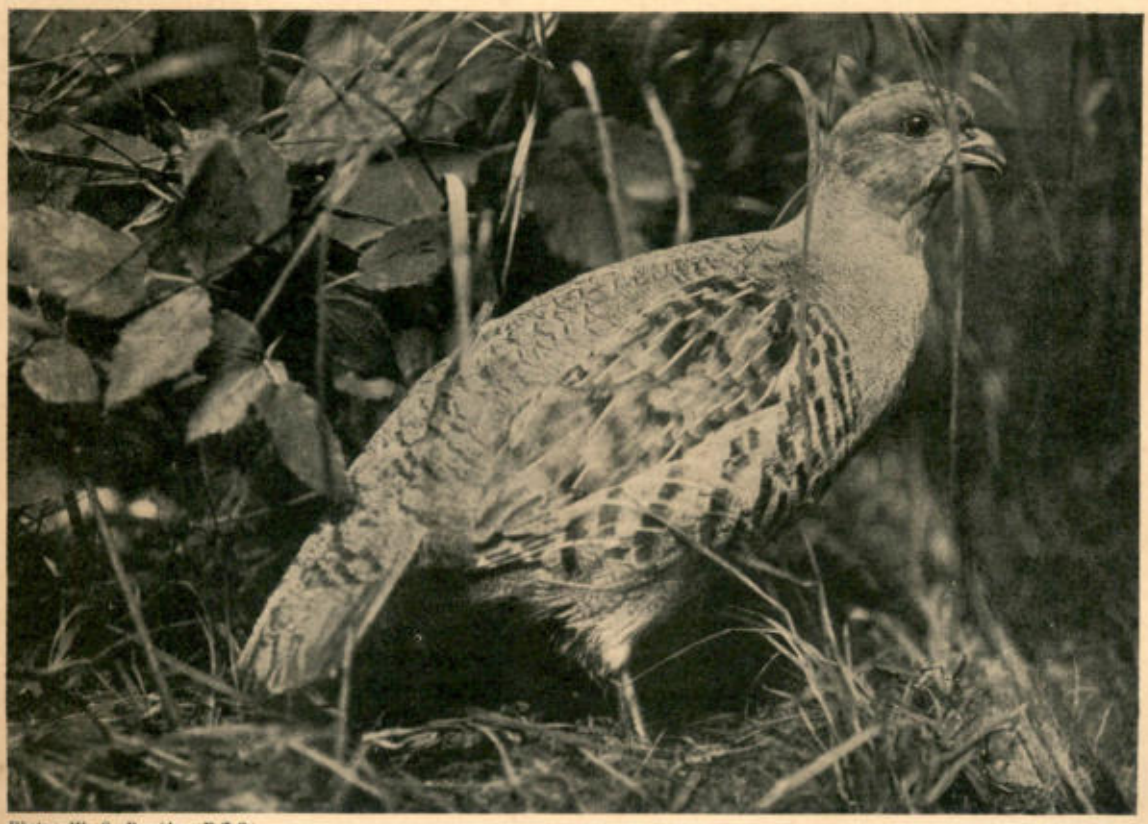


Photo : W. S. Berridge, F.Z.S.

COCK PARTRIDGE (*Perdix perdix*).

The cock Partridge is usually distinguishable from the hen by the chestnut-coloured horse shoe mark on the breast. In length a cock partridge measures about twelve and a half inches, and is distinctly larger than the female. While the pheasant is polygamous the partridge keeps to one mate. He is a good father, showing great bravery in repelling the assaults of enemies that attack his young brood.

Photo: Albert Henry Willford.

NEST AND EGGS OF THE PARTRIDGE.

The nest of the Partridge is made upon the ground, usually among brushwood or long grass. As the photograph shows, it is roughly constructed, yet serves its purpose well. Twelve eggs is a usual number, but as many as twenty have been counted in one nest. Like little chickens, the buffish-brown black-spotted young partridges or "cheepers" are able to run as soon as hatched.

"feigning injury to distract attention." At an earlier stage they have been known to remove the eggs to another nest, carrying them, we suppose, one by one, in their beak. What usually happens is that the parents utter a characteristic note, which the buffish-brown young ones instinctively obey. They scatter and become invisible. When we think of the number of the eggs, the close brooding, the parental courage, the filial obedience, we understand once more why the partridge is a success.

In countries with a cold winter it is impossible for ordinary insects to continue active. Their food supply has been exhausted and a rhythm has been set up in their bodies which enforces rest until the return of warmth and flowers. But it is not always in the same chapter of their life-history that insects pass the winter. The queen humble-bee lies as an adult in the sheltered recess of a mossy bank, and a great many beetles spend the winter in the same state, sinking into a state of torpor. The dormitory is often inside a hollow stem, or underneath bark, or in a rotten trunk, or in a crevice on the sheltered side of a wall. In mild winters we sometimes see Small Tortoiseshell butterflies fluttering about, which shows that they are able to pass the winter as full-grown winged insects, though that is not what they usually do.

Cocoons and Chrysalids.

On the other hand, to turn to the other end of the life-history, some insects pass the winter as eggs. This is only possible if the egg has an exceedingly slow development or is able to stop developing for months and begin afresh in spring. The mother Lackey Moth gums her eggs in bracelets round the twigs of the hawthorn, and covers them with a gum that hardens into a protective crust. They remain unaffected by the storms of winter and in a state of suspended animation.

Somewhat commoner is the case of insects that pass the winter in the larval state, and this must be the method when the larvæ live as larvæ for several years. The caterpillars of the Goat Moth which tunnel in poplars and other trees make a winter sleeping-sack of chewed wood and a little silk. Those of the Ghost Moth —famous for the way in which the female

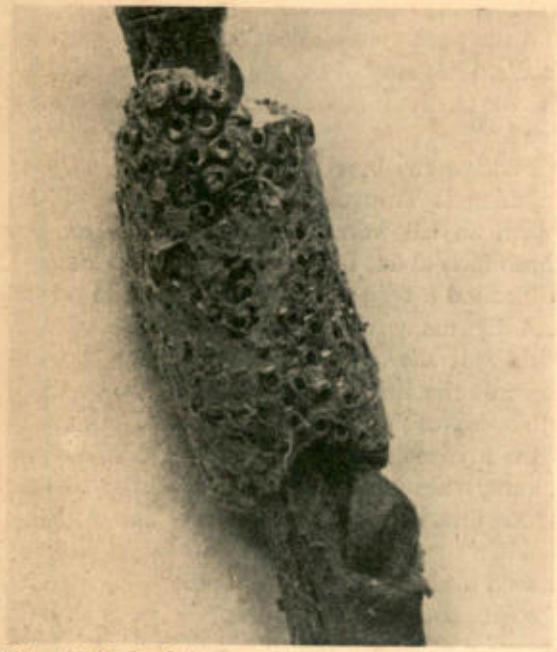


Photo: M. H. Crawford.

BAND OF EGGS OF THE LACKEY MOTH ON AN APPLE TWIG.

One of the pests of English orchards is the Lackey Moth (*Malacosoma neustria*). The female, brownish in colour and measuring an inch and a half across the wings, lays her eggs closely glued together in a broad ring around a twig. Frequently half a dozen twigs close together bear these bands of eggs.

seeks out the male—lie under stones in a silk-lined bed.

But the majority of insects pass the winter as quiescent pupæ or chrysalids, the encasement of which is called the cocoon. The larvæ seek out a sheltered and concealed place and fall into quiescence, during which, however, great changes occur. Of these chrysalids there is considerable variety, as one would expect, but most of the peculiarities have to do with protection. In many cases, among moths, for instance, the larva makes an earthen cell in the ground and pupates there. In many beetles the pupa lies without much personal covering in a chamber bored in a tree, and the chamber may be varnished inside with gum or wall-papered with silk. When there is a well-adapted chamber the need for an elaborate pupa-case is obviously less. The making of a silken cocoon is most familiar among moths like the silk-moths, but there are at least six orders of insects (e.g., Hymenoptera) in which the larvæ may spin a silken envelope for their pupation. Butterflies have given up cocoon-making, except that there are slight traces of it in the family of Skippers, but the pupa has a tough case which is often suspended to a twig by a silken girdle. The Milkweed caterpillar spins an attachment of silk and hangs itself to a leaf upside down ; it moults its cuticle and becomes a pupa which entangles its tail end in a complicated way in the silken attachment. This pupa is at first rather long and soft, but in an hour or so it has contracted and hardened.

In the Cecropia silk-moth, widely distributed in the United States, with a six-inch spread of wing, the cocoon is a tough, waterproof, two-layered structure, of a dull-brown colour, with two air-spaces around the pupa, so that the injurious influence of sudden changes of temperature is circumvented. In some near relatives the silken cocoon is covered with a curved leaf, which disguises it, and then, just before the larva wraps itself up finally, the leaf is bound to the twig by a silken wrapping. The masked

Photo: John J. Ward, F.E.S.

YOUNG LARVÆ EMERGING FROM THE EGGS OF THE LACKEY MOTH.

The larvæ of the Lackey Moth are shown in this photograph emerging from the eggs. The caterpillars are striped blue, red and yellow, with a white line on the back. They live together under one common web of silken threads.

Photo: John J. Ward, F.E.S.

LARVA OF THE COCKCHAFER BEETLE (*Melolontha vulgaris*), JUST BEFORE CHANGING TO THE PUPA STAGE.

The large beetle called the Cockchafer appears in May. After a few weeks the female deposits her eggs in the ground, and then dies. The eggs take about a month to hatch, but the larvæ remain below ground, and there spend the winter.

Photo: John J. Ward, F.E.S.

LARVA OF THE COCKCHAFER PUPATING IN THE GROUND.

The larvæ change to the pupa stage, but still remain below the surface, doing great damage to crops and herbage. It is not until it is four years old that the cockchafer pupa assumes the winged form, and, working its way to the surface, takes flight with a loud whirring sound.

cocoon hangs there safely throughout the winter, and the pupa goes on developing in its swaying cradle. In many of the bag-worms the pendent cocoon is often extraordinarily like a pendent dry fruit.

Perhaps the best description of the cocoon-spinning is Trouvelot's (1867) account of the American silk-worm. The caterpillar on the shrub feels about for leaves; it winds a layer of silk round a twig; it fastens a thread to a leaf, and by many times doubling this fibre and making it shorter every time it draws the leaf towards the twig; it does this for two or three other leaves; and then inside this shelter it spins a cocoon of threads of silk united by a gummy substance. The silk is distributed in zigzag lines of about one-eighth of an inch long. "When the cocoon is made the worm will have moved his head to and fro in order to distribute the silk, about 254,000 times." A gummy resin is spread over the inside of this half-day's work; and then, after a few minutes' rest, the larva continues its operations, spinning an internal cocoon of finer threads. Thus the larva is shut up in its almost airtight cradle and the great change begins. For, as everyone knows, what goes to bed as a caterpillar awakens as a butterfly. Treviranus, who shares with Lamarck the credit of making the word "biology," spoke of the grain of wheat dreaming of the wheat-plant yet to be; and we may perhaps venture to speak of the chrysalid dreaming of the butterfly. And usually its dreams come true.

But what is it that happens? Within the cocoon there is a series of remarkable changes that began in the larva. There is a change from one type of architecture to another. Many of the larval organs are scrapped and then there is reconstruction on a new architectural plan, for the contrast between caterpillar and butterfly is very striking. In the scrapping process an important rôle is often played by amœboid blood corpuscles—the phagocytes—which act as sappers and miners, attacking the old tissues, absorbing their material, shifting it about, and then surrendering it again for the reconstruction. In many cases, however, there is no evidence of this industry of phagocytes. In the case of flies the scrapping is very thoroughgoing, so that inside the pupa there is little trace of muscles, food-canal, or air-tubes; in the case of butterflies

and moths the breaking-down and the building-up proceed in a sort of piecemeal fashion. The analogues of the two methods are familiar in a town where big buildings are undergoing transformation. Sometimes the whole structure is demolished and reconstruction follows after an interval during which business has been suspended. But in other cases the transformation is accomplished gradually, from corner to corner, with business as usual all the time.

In the reconstruction that results in a winged insect, an important part is always played by buds of young cells that grow in from the outer wall of the larva. These were discovered by Professor Weismann, who called them imaginal "buds" or folds. The strange name *imaginal* refers to the fact that they go to form, for instance, the wings and legs of the *imago* or winged insect. It must be understood that these "buds" of the future wings and legs are already present in the full-grown caterpillar. What begins in the caterpillar is carried to completion in the chrysalids, and then there emerges a butterfly.

The old naturalists were greatly impressed by the great change or metamorphosis by which a caterpillar becomes a butterfly. Thus Swammerdam wrote: "This process occurs in so remarkable a fashion in butterflies, that we see therein the resurrection painted before our eyes, and exemplified so as to be examined by our hands." Our wonder is on different lines. We see in the caterpillar a feeding, growing, saving stage which has been, so to speak, inserted into the life-history, and makes the intensely active, often fasting, winged butterfly more possible. The juvenile life concerned with feeding is suited to an environment very different from that of the adult life, concerned with mating and mothering, and the change from the former to the latter is apt to be revolutionary. We call it a transformation or metamorphosis. What is perhaps most puzzling is the way in which the creature's inheritance seems to get a second impulse and starts afresh on a new plan altogether.

The Green-Fly.

On fine days in early autumn the air is often crowded with minute green-flies of various kinds. We see them rising and falling like the droplets of a feeble fountain. They do not fly far with their lightly built transparent wings; sometimes they look as if they are almost floating. Anyhow, their

Photo: John J. Ward, F.E.S.

COCOON OF THE LOBSTER MOTH (*Stauropus fagi*).

Rather a rare insect, the Lobster Moth is of a brownish-grey colour with darker markings, and has a wing-spread of two and a half inches. It feeds upon the leaves of beech and a number of other trees. The photograph shows the cocoon amongst beech leaves.

Photo: John J. Ward, F.E.S.

COCOON OF THE LOBSTER MOTH OPENED.

The cocoon has been opened to show the pupa and cast skin of the larva. The caterpillar has very long front legs and two posterior appendages. These and the way in which it stands, with both ends of the body hoisted up, have given it the name of Lobster Moth.

numbers are prodigious, and in some suburbs of the town they darken the air and cover our clothes like snowflakes in winter. Some of those we have collected lately are blackish, but they also are " green-fly " in the technical sense, with various aliases, such as plant-lice, blight, or aphides. What is their story ?

The typical life-history of green-fly is this : Eggs which are laid in crevices in autumn remain dormant throughout the winter, but hatch in the spring, giving rise to wingless females. These multiply parthenogenetically, as was discovered by the old French naturalist Bonnet ; in other words, they produce eggs which develop without requiring to be fertilised. These parthenogenetic eggs develop inside the mother into small wingless females, so we require another awkward technical term to describe the situation—the term viviparous. Throughout the summer, there is generation after generation of wingless, parthenogenetic, viviparous females which infest our rose bushes, pear trees, bean plants, hops, and so on.

As a young one is ready in a short time, often a week or so, to be itself a mother, the generations succeed one another very rapidly.

In typical cases there are no males throughout the summer months, and experiment has shown that the virgin-birth may be continued for four years in the artificial summer of a greenhouse. But although males are not usually born in the summer, there is often an interruption of the wingless generations by the appearance of winged forms which secure migration from one plant to another. The flights of winged ants that are sometimes seen are nuptial flights, in which the males and females meet ; but it is different with aphides. The cloud of winged atomies seems often to consist of females only, and although males appear in autumn and are often winged and may share in the migration, it should be carefully noted that the females that are fertilised by the males in the fall of the year, and lay the eggs hatching next spring, are always wingless, and that their mates are often in the same condition.

It is not very easy to tell the story quite clearly, because it is subject to considerable variation, but the outline we have given is often true—fertilised eggs hatching in spring, viviparous parthenogenetic wingless females in many successive generations through the summer, migrating winged females also viviparous and parthenogenetic, males (winged and wingless) which fertilise the wingless females who lay the eggs we started with. The migration is often followed by the production of males and pairing females.

Green-flies are greedy insects which, if unchecked, would soon make an end of all vegetation, as one of them—the Phylloxera—often threatens to do in European vineyards. They make an abominable mess of many of the plants we are fond of, smothering them with their progeny and honey-dew, which has already been spoken of in earlier chapters, " Linked Lives " and " The Quest for Food." Apart from their transparent wings they have no great beauty, and we like them best when

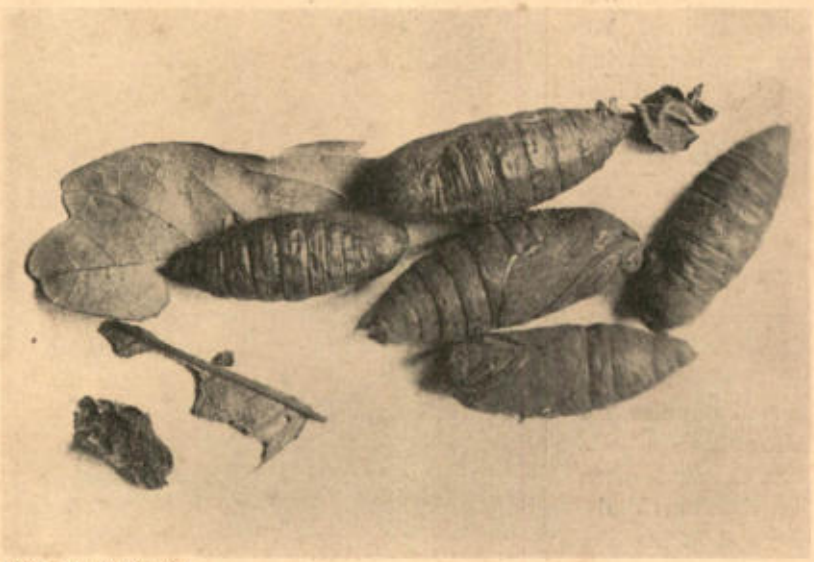
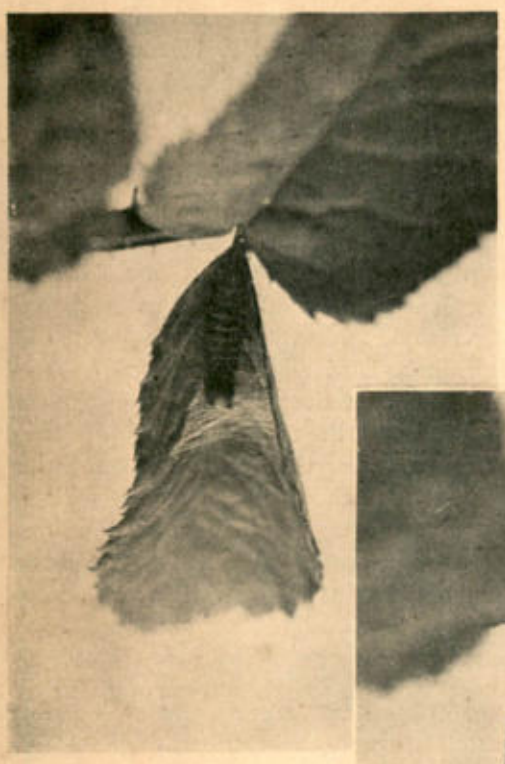
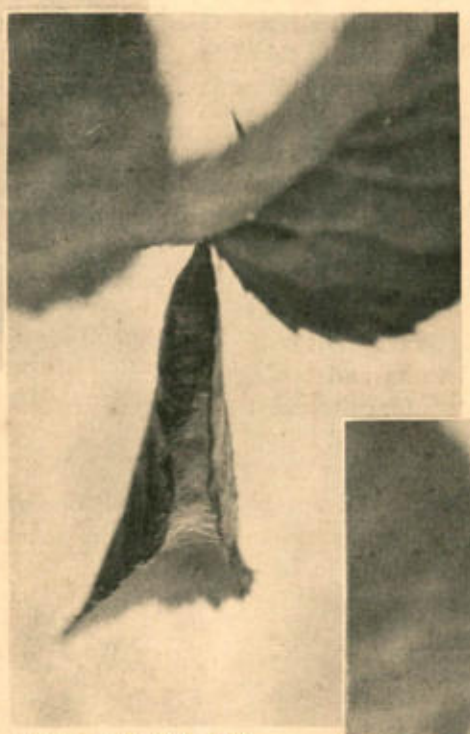


Photo : M. H. Crawford.

CHRYSALIS OF THE POPLAR HAWK MOTH (*Smerinthus populi*).

The Poplar Hawk Moth belongs to the great family of Sphingidæ, of which the largest variety found in Britain is the huge Death's Head Hawk Moth. All hawk moths have stout bodies and great powers of flight. The photograph shows the chrysalis of the moth, the well-protected phase in which the insect is able to survive the cold of winter.





Photos: John J. Ward, F.E.S.

THE ROSE LEAF MOTH.

The Rose Leaf Moth is one of the many insects which provide for themselves a special cloak or covering to protect them while in the pupa stage. The photographs show three stages in the formation of the cloak, in this case a rose leaf, the edges of which are drawn and stitched together by a finely spun web. The second picture, taken five minutes after the first, shows the rapidity with which the edges are drawn together. In the third picture the larva is seen completely enclosed in its leafy garment, protected not only from the weather, but also from most of its enemies.

they are reincarnated in other insects. They are undoubtedly our enemies, but we cannot deny that they have their points. It is an extraordinary every-day miracle, this rapid transformation of vegetable sap into green-fly, this torrent of life, this flourishing maleless multiplication, this see-saw of asexual and sexual multiplication of viviparity and oviparity, this persistence in spite of the severest sifting. A little one soon becomes a thousand, and a small band a great army.

We have given only a glimpse of the biological and human interest of these little creatures which we have just been watching as they danced in the air among the trees in the garden. Ours were not the only eyes that were on them, for we saw some sifting going on, and this led us once more to admire the balance of the System of Animate Nature. If it were not for this balance it would be so easy for green-flies to put an end to everything!

Pheasants.

We cannot refrain from including the pheasant to give warm colouring to our autumn picture. It is a feast for the eyes to watch the cocks picking corn among the stubble, in the low autumnal sunlight. Exuberant is a fit word for their gorgeous beauty of red and orange, grey and green, yellow and purple. Pheasants are aristocrats among fowls, winning our esteem by their decorative handsomeness rather than by their brains or by any force of character.

The *Common* Pheasant—if one may say "common"—is a native of Asia Minor and the shores of the Caspian Sea. It is still a wild bird there, but in many parts of the world it now flourishes under man's shield. Yet it refuses to become domesticated. It may be tamed, but it remains itself and no other. It does not produce such a copious crop of variants as the Common Fowl, and it will not surrender itself, as that plastic bird has done, to man's wishes: e.g., in the matter of laying eggs more or less all the year round. As the illustrious Charles Waterton

says: "Notwithstanding the proximity of the pheasant to the nature of the barndoor fowl, still it has that within it which baffles every attempt on our part to render its domestication complete." What the difficulty is we cannot at present define—there is *some lack of plasticity*. The same is true of many other creatures; thus we do not suppose that anyone would claim the ostrich as domesticated. How truly wild most hive-bees remain! Waterton thought that what persisted in the pheasant was an "innate timidity" which expressed itself whenever anything unexpected happened. On the other hand, cock-pheasants may become almost embarrassingly tame; they have been known to attack the squires' ladies when the fashion of the day—e.g., crinolines—pulled the trigger of their fury.

The probability is that the Romans introduced the pheasant into Britain and into other European countries. In modern times it has been established far and wide; e.g., in New Zealand and North America. What it likes is a wood with abundant undergrowth, affording not only shelter but a varied diet of fruits and seeds, shoots and roots. In the struggle for existence it is always an advantage to have a varied bill of fare. If one item fails, another may be available. Omnivorous creatures always have an advantage over the specialists in diet. The pheasant, like the common fowl, has a long menu; in fact, almost everything is grist that comes to its mill—as the gizzard may well be called. Even pebbles are of use. Pheasants eat grain, seeds, fruits, buds, leaves, roots, flowers, insects, larvæ—what not? There is no use blinking the fact that they are very fond of grain, but it is equally unfair to forget that they account for enormous numbers of wire-worms and other injurious insects. Among the strange items on their bill of fare are mice, adders, oak-spangles, hazel-nuts, acorns, polypody-fern, and bracken. Pheasants are, we must admit, rather fond of the table, and we cannot think that stuffing the crop with ferns is an indication of intelligence! But if they would form a habit of eating *bracken*, then the hill-farmer at least would give them his blessing. For the bracken is a serious enemy of upland pasture.

The pheasant's wings are not large in proportion to the size of the bird, but they are broad and rounded, and the wing-muscles, as we know on a feast-day, are strongly developed. The whirring flight is very rapid, and we have known of a pheasant crashing right through a plate-glass shop-window. This has been often recorded, and it testifies to great velocity of flight. In preserves they often become rather lazy—and why should they fly away from a congenial home?—but pheasants are among the fastest British game-birds. The experts tell us that "driven grouse with a gale of wind behind them, driven partridges late in the season, twisting as they top the fence, make hard shooting; but there is nothing more difficult than a pheasant curling at his top speed over the roof of the trees." It is interesting to notice that pheasants can swim very well, though they will not readily take to the water. As for running, they are hard to beat, and the continual scratching in the ground for seeds and small animals keeps their leg-muscles in good form.

Like most of their game-bird (or gallinaceous) relatives, pheasants are polygamous by nature. As is usual in such cases, the rival males, armed with spurs, fight with one another, the stronger driving the weaker away, and securing a larger number of mates for themselves. In so far as the weaker males are left unmated, this form of selection is obviously for the good of the race. The cock-pheasant, coming to his own, utters his crow and then claps his wings, just the opposite of chanticleer, who claps his wings and then crows. The cock-pheasant's crowing is a prelude to disporting before the hen-pheasant. He poses so as to show off his good points. On the side nearest the object of his desire the wing is partly opened and depressed, the tail is expanded, and the upper surface turned sideways. There are subtler details, too; thus, to quote from Tegetmeier's "Pheasants," "the bright vermilion skin around the eye is greatly extended and the little purple aigrettes are erected." This is like chapter one of an evolution series which finds its climax in the courtship of the Argus pheasant where the secondary feathers of the wing are greatly enlarged and adorned with beautiful eye-like spots. The male Argus runs about before the female, and then, suddenly pausing, raises the decorated feathers like an upright semi-circular fan. He hides his head behind the fan, so that the female gets an uninterrupted view of the extraordinary living allurement, which is sometimes suggestive

Photo : Oliver G. Pike.

THE PHEASANT ON HER NEST.

More sober in colouring than her gorgeous mate, the hen pheasant's plumage blends marvellously with the thick herbage in which she makes her nest. The nest itself is but a rough heap of leaves and grass, in which are laid eleven or twelve olive-brown eggs. It is said that the pheasant loses her distinctive scent during the period of incubation. She sometimes uses the nest of a partridge or some other ground bird.

Photo : Albert Henry Williford.

NEST AND EGGS OF PHEASANT.

The edge of a wood or thick plantation is the favourite nesting site of the pheasant. How clever the bird is in finding both shelter and security is proved by this photograph of a typical pheasant's nest.

of one of a skirt-dancer's devices. Two long tail-feathers are swayed about and make a rustling sound: and the gorgeous fan itself is gently waved. When the light strikes the feather-eyes from above—there may be over twenty on one vane—they stand out like ball-and-socket ornaments. It must be noted that the "eyes" are confined to the male and that they are quite hidden when the wing is closed up.

In April or May the hen-pheasant makes a simple nest, almost invariably on the ground and under some covert. It is little more than an apology for a nest—a hollow scraped in the ground. Eight or nine eggs are laid—greenish-brown to greyish-green—and the hen sits close for twenty-four days. Neither in the nest-making nor in the brooding does she get any help from the cock, for this is not the way of the polygamist. The domestic cock is often extraordinarily gallant and unselfish, calling to his favourites when he has unearthed a tit-bit, and looking aside somewhat self-consciously as if he had no experience of what an appetite meant, but we do not know that the cock-pheasant shows any domestic virtues of this sort. There are isolated cases, no doubt, of cock-pheasants leading about a brood of young ones, occasionally even brooding, but the significance of this is not great. It probably means just this, that living creatures are variable and that the cleavage between the sexes is often far from being clear-cut. Frequently, as in pigeons, there are rather feminine males and rather masculine females. Another expression of variability—the fountain of living changefulness that never runs dry—is seen when a hen-pheasant utilises the tree nest of a pigeon, or even of a squirrel, and succeeds in at least hatching her eggs in that unusual site. It must be remembered that in cold weather it is quite usual for pheasants to roost in trees. Yet another variation is well known to those who live in the country, namely, the sharing of the nest with two or three other pheasants. As many as thirty eggs have been found in one nest, implying three different mothers. This peculiar occurrence points the way to the multiple nest of some of the mound-birds, where one mass of

fermenting herbage is utilised by several mothers. And there are other instances of social or communal nesting. Or it may happen that a partridge utilises a pheasant's nest, or a pheasant a partridge's, and here, again, we get an interesting evolutionist glimpse : what is merely a curious aberration or experiment in one animal may become established and of survival value in another. For we know how the European cuckoo has made a habit of using the nest of another bird.

Pheasants have many enemies, some destroying the eggs and young, as is the case with rooks, crows, and sparrow-hawks, others attacking the full-grown birds, as do foxes and stoats. Here must be noted the interesting and somewhat obscure fact that the brooding pheasant, like the partridge, suppresses her scent. As Tegetmeier says: "Dogs, even those of the keenest powers of smell, will pass within a few feet, or even a shorter distance, of a sitting pheasant without evincing the slightest cognisance of her proximity, provided she is concealed from sight." The fact is certain and its value to a ground bird is obvious ; we do not know how the suppression of the scent is brought about.

We may make a natural bridge from autumn to winter by thinking of evergreens for a little.

Evergreens.

They are very conspicuous towards mid-winter in the country and in parks, in churches and shop-windows, but *what exactly are they* ? How do they come to brave it with their greenery when other plants are gaunt and bare, or may have shrunk beneath the ground altogether ?

Evergreens form an attractive assemblage—the mistletoe, the holly, the ivy, the yew, the pine, the laurel, the rhododendron, and the bay —and how many more ? What is their secret ?

Photo : S. Crook.

THREE YOUNG PHEASANTS.

Timidity is a characteristic of the pheasant, and even when artificially reared under domestic hens in coops, young pheasants never become tame like chickens. They come for their food in a timid nervous manner, and as they grow older soon become quite wild.

Photo: H. W. Dennis.

THE SEED BOXES OF THE PANSY.

Autumn is the time of seed dispersal, and the Pansy is one of the plants which produce their fruits in the form of dry boxes or capsules. When fully ripe the fruit splits into three valves, and each valve into two, scattering the hard seeds widely. The photograph shows three stages in the process, and from the empty valve in the lowest figure the force of the explosion can be inferred.

How are they exempt from the fall of the leaf to which other plants are liable?

The answer is that the question is wrongly put. For evergreens shed their leaves, which are very mortal organs, but they do it on the sly. Some day in summer, if we look under the holly tree, we find that there has been a little shower of worn-out leaves. And everyone knows that the floor of the pine wood is softly carpeted with the fallen twin-needles, out of which certain kinds of ants build their huge communal nests.

There are birds, e.g., in the order of ducks and geese, that moult their feathers so simultaneously that they cannot fly at all for, perhaps, a fortnight. These are like ordinary "deciduous" trees which shed all their leaves at once—in autumn. But most birds moult their feathers in more piecemeal fashion, though at definite periods of the year, and these are never unable to fly. They are more like the evergreens; but the comparison must not be pushed too far.

Our first point is that *evergreens are not so evergreen as they look.*

The probability is that the evergreen habit is primitive, being suited to countries where the seasons are not so sharply punctuated as with us. In easy-going semi-tropical conditions, a leaf drops off when it is tired; but there is no abrupt "fall." Thus what we are apt to think of as the exception is probably the old-fashioned rule. In short, the shedding of the leaves all at once in autumn is a new-fashioned adaptation to meet the difficulties of sharply punctuated seasons.

In North Temperate countries the fall of the leaf enables the plant to survive when the available water in the cold soil is greatly reduced. If the leaves remained on the branches, and gave off even a fraction of the usual amount of water-vapour, and fixed water as usual in the manufacture of sugar and other carbon-compounds, then the tree would soon be bankrupt. The expenditure of water by the leaves could not be met by the income of water from the soil.

It may be objected that there is surely plenty of water in the soil in winter. That is quite true, but the difficulty is for the roots in the cold soil to *capture* the water. There may be "physiological drought," as it is called, when there is abundant outside moisture. "Water, water, everywhere, but not a drop to drink."

Our second point, then, is that *the evergreen habit is primitive*; and that the autumnal fall of the leaf is a secondary adaptation to regions with the seasons sharply marked.

The common British Oak loses its leaves in autumn, and we say that this is a life-saving adaptation, since the roots cannot supply an income of water sufficient for the demands of the foliage.

Moreover, it is plain that the delicately built leaves, with an obvious liability to the fatal formation of ice-crystals in their tissues, imply *a great vulnerable surface*—unless they fall. There is also the point that the leaves have been

very hard-worked, photo-synthetic laboratories all through the summer, and that the furnishings have suffered from the wear and tear. It is probably better that the leaves should die—better, at any rate in North Temperate countries.

But as we follow this line of thought, we soon run up against a noteworthy set of facts. The British Oak drops its leaves in autumn, but the Holm Oak, imported from the Mediterranean region, remains evergreen. The Common Cherry sheds its leaves in autumn, but the Cherry Laurel, another species of the same genus, is evergreen.

Thus the question is this: How, of two first-cousins, does it come to be that one is deciduous and the other evergreen, yet both are thriving in the same country?

How is it that an old-fashioned plant, shedding its leaves at irregular intervals, as its ancestors did, may flourish as an "evergreen" in a North Temperate country, where its relatives alongside are deciduous? Think of British Oak and Holm Oak. To this the whole problem is now narrowed down. The answer is that the Evergreens, whether indigenous like the Scotch Fir, or imported like the Rhododendron and the Cherry Laurel, have special and secondary adaptations or fitnesses which enable them to withstand the physiological difficulties of the winter. What are these fitnesses?

Very familiar are the polished leathery leaves of laurel and bay, and many more; and this means a great reduction of the loss of water in transpiration. This is an obvious answer back to the exigencies of the winter. A conservation of warmth may also be brought about by a varnish of wax, by the secretion of ethereal oils, by putting on a woolly blanket or a covering of scales, or even by turning red as in the blaeberry.

One of the signs of autumn that everyone enjoys is the fine colouration of the withering leaves. It sometimes happens that the leaves fall off very green, ruptured by early frosts and wrenched off by the storms before they have had time to die. In most cases, however, there is a wonderful transfiguration. The withering leaves make the trees floral. We see the flowers of the forest. The birch is golden-yellow, the ash almost lemon, the beech ruddy-brown, the oak russet, the wild cherry crimson, the virginia creeper scarlet. The leaves of the bramble and the vine are like painters' palettes, a medley of colours.

Autumn Colours.

As we have seen, autumn is the curfew of the year. The fires are covered up or put out; there is retrenchment and surrender of vulnerable parts; some creatures, like the migrant birds, say good-bye; and others, like the hibernators, say good night. In the fall of the leaf we see the tax that has to be paid on the summer's industry.

We have mentioned the occasional fall of leaves while they are still heavy, but everyone knows that fallen leaves should be light, easily whirled hither and thither by the wind, and

Photo: A. W. Dennis.

GLOBES OF RIPE DANDELION FRUITS.

As each tiny bloom of the Dandelion's composite flower-head turns to fruit in early autumn, each nutlet-fruit or cypsela develops a number of feathery hairs. These act as parachutes, and the seed drifts hither and thither on the wings of the wind, sometimes dallying in a corner as if it were searching for a suitable place to anchor. Each little hard fruit contains a single seed.

Photo: John J. Ward, F.E.S.

THE PARACHUTES OF THE GOAT'S BEARD.

Another instance of plants that rely on the autumn breezes for the dispersal of their seeds is the Goat's Beard. The photograph shows how the nutlet-fruits with their feathery parachute are detached by a gust of wind, and blown about with the breeze, finally settling at some distance from the parent plant.

rustling as they sweep along the ground. For one of the big facts is that the withering leaves surrender to the parent stem all they have that is worth having. There has been a transport of manufactured goods all through the summer, and it goes on as long as there is any life left in the leaf. This is important in understanding some of the autumn tints, for they are associated with the disintegration of the leaf-green—the chlorophyll corpuscles. These green discs, which are somehow indispensable in the utilisation of the sunlight, have a complex equipment of pigments. There are two of a blue-green tint, and these are the important ones in the photo-synthesis. There are two of a yellow-green tint, whose use is obscure. In a general way, what happens in the withering, when the chlorophyll complex breaks up, is that the valuable blue-green pigments pass from the leaf into the stem, to be used over again next year. The yellow-green pigments remain, for it does not pay to remove them, and after undergoing some change they give the withering leaves their yellow and gold. Beauty for ashes, in short.

The chlorophyll-yellows account for the gold left behind in these empty houses, but what of the ruddy jewels—rubies, garnets, cornelians, which we admire in the purple of bird cherry and wild service tree, in the scarlet of barberry and wild cherry, in the violet of cornel and spindle-trees? These are all due to various states of the pigment anthocyanin, which may at times co-operate with disintegrated chlorophyll-yellows in producing complex mixtures of colours. Anthocyanin, which is the subject of a fine monograph by Dr. Muriel Wheldale, is a widespread pigment among plants, occurring in solution in the cell-sap. We see it on the under-surface of the leaves of many shade-loving plants, like cyclamen, on the red harshly smelling leaves of Herb Robert, on the spotty leaves of the meadow orchis, in the young leaves of the briar, in the copper beech and the red cabbage, in a vast variety of flowers, such as larkspur and begonias, on fruits like cherries, grapes, brambles and strawberries, on the stems of dogwood, in the roots of the beet. It often appears in leaves that persist through the winter, and in Alpine plants; we see it in pelargonium leaves that are not getting enough of water. In short, the anthocyanins, for there are many, are among the most ubiquitous of pigments.

As to the origin of anthocyanins, that is a question that would soon lead us into deep waters of chemistry. They seem to be by-products of the leaf's laboratory. As everyone knows, the green leaf makes sugar all the day, and from sugar there can be built up yellow crystalline substances called flavones, which have an almost universal distribution in plants. It is probable that these flavones, with the assistance of ferments, give rise to the anthocyanins which account for all the finer autumn tints except the yellows.

Many attempts have been made to find a use for anthocyanins, and it may be admitted that they play their part in advertising the flowers before the eyes of welcome insect visitors, and in advertising the fruits in the eyes of seed-scattering birds. But when we inquire into their use in leaves, the answers are even more conjectural. It has been suggested that anthocyanin forms a light-screen, protecting the chlorophyll from being over-sunned, that it facilitates the activity of the ferment which changes starch into sugar, and that it converts certain light rays into heat. There is something to be said for each and all of these views; thus the temperature of red leaves is higher than that of green. Nevertheless, in her monograph of 1916, Dr. Muriel Wheldale concluded the chapter on the meaning of anthocyanin with the cautious words: "For the time being we may safely say that it has not been satisfactorily determined in any one case whether its development is either an advantage or a disadvantage to the plant."

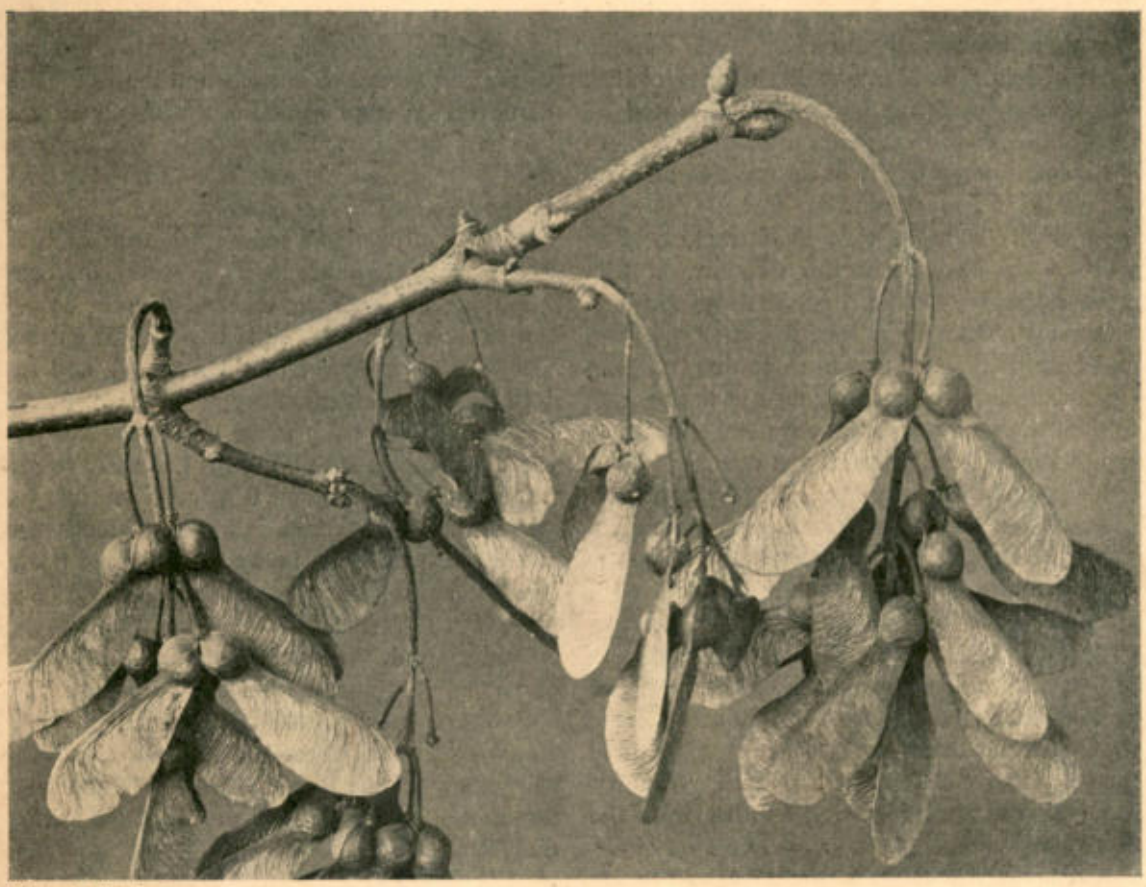


Photo: A. W. Dennis.

WINGED FRUITS OF THE SYCAMORE.

The method evolved by the Sycamore for scattering its seeds differs considerably from that in which the plumed fruits of the Goat's Beard and dandelion are dispersed, yet it is not less effective. These nut-like fruits, each with a single seed, are winged, and instead of dropping straight to the ground, they twist and turn in the air and are finally spread over a wide area.

So as we look over these glorified woods, we must be content to do without discovering a use for all the feast of colour. It is the curfew of the year, and we are looking at the ashes left by the summer fires. Is there anything that dies so beautifully as a withering leaf?

LVIII
NATURAL HISTORY OF WINTER

IT is plain that winter in the North means cold and stormy weather, a short day or, in Arctic regions, none at all, and a scarcity or concealment of food. It is interesting to inquire how this difficult season is met or circumvented by different kinds of living creatures.

No doubt, the neatest of all ways of meeting the winter is to circumvent it by migration. This is the solution that is characteristic of most of the birds in northern countries. The great majority of the British birds go south in autumn to their more genial winter quarters, and there is much "partial migration" among those that never quite leave us, but are content to shift their quarters from the more exposed to the more sheltered parts of the country. Thus it has been proved by "the ringing method" (attaching numbered and addressed aluminium rings to the "instep") that many of the Aberdeenshire lapwings spend the winter in Ireland, where the conditions of life are less strenuous. It is true that there are lapwings in Aberdeenshire in every month of the year, but some of those that are seen in mid-winter have come from farther North, taking the place of those that have shifted farther South. We must think of one wave following another from the north southwards.

Another aspect of the migration solution is the arrival of winter visitors from their summer quarters farther North, where they nest and breed. Thus to the north of Scotland there come such winter visitors as the fieldfare and the redwing, the snow-bunting and the Great Northern Diver, and several kinds of wild-duck, which find Scotland quite comfortable for their wintering.

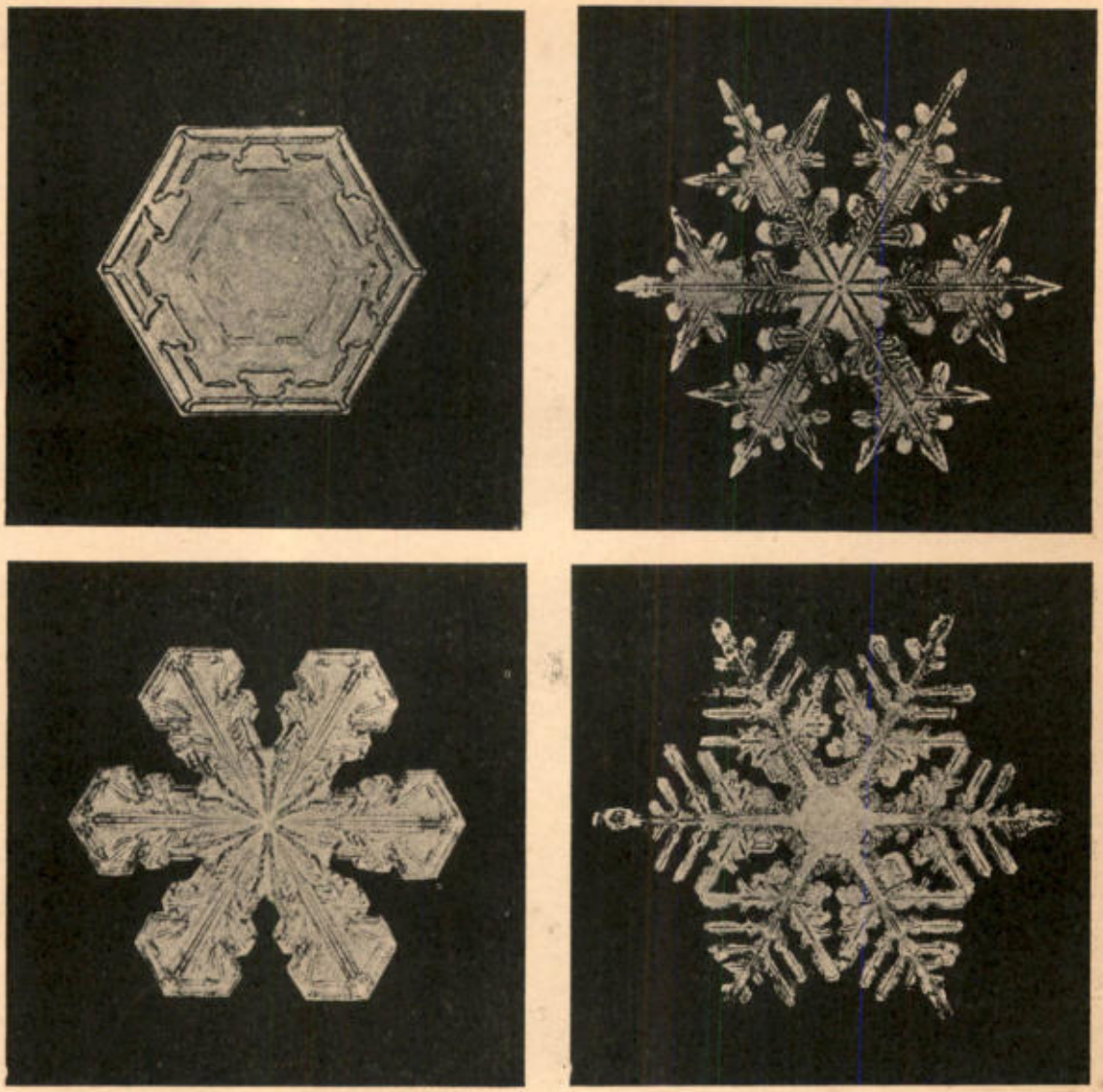
On a very different tack are those animals of strong constitution that face the winter without flinching. They tighten their belts and quicken their pace. The wolves hunt more keenly; the fox becomes more subtle; the deer become less timid. Many of them, however, have to change their ways not a little when the country is covered with snow. Thus the otter is often seen at such times exploring on the seashore, reduced to making a meal of mussels and limpets. This dauntless creature sometimes fishes under the ice-sheet of a lake, a very dangerous thing to do, for it may not be able to find its way back to the hole by which it entered. The Arctic Fox comes down from the snow-covered uplands to search along the shore for some stranded whale. The Mountain Hare may descend from the deeply buried mountain-side to the low-ground pasture where it has a chance of getting food, and the Red Deer may become so hungry that it ventures into the village. The reindeer uses its hoofs to good purpose in shovelling off the snow to get at the lichens on which it largely depends for winter fare. This, then, is a second solution of the winter-problem: many animals face up to the difficulties, but are often helped by some change in their habits.

Adders and slow-worms may be taken as examples of those cold-blooded animals that seek out secluded retreats and there lie low in a state of "suspended animation." In the middle of a cairn, or well into the heart of a stack, or sometimes in the warmth of a not too rotten dungheap, a number of adders may pass the winter in company. In a comfortable recess, deep in a dry mossy bank, there may be half a dozen slow-worms huddled together. Frogs and toads lie quietly in holes, sometimes in a dry drain-pipe, sometimes in the stump of a decayed tree, at the worst in the mud. They are in a strange state of lethargy, with no income save a little oxygen, and with almost no expenditure. There they lie—mouth shut, nostrils shut, eyes shut, their heart beating feebly, and breathing as they did when they were newly hatched, namely, through their skin. This sort of lying low of cold-blooded animals is best called cold-coma, so as to reserve the word "hibernation" for the "winter-sleep" of

Photo: Reginald A. Malby.

THE WOODS IN WINTER.

When the snow falls gently on a day without wind, or when the moisture crystallises on the twigs in the form of hoar-frost, the woods become like fairyland. The fascinating effect is partly due to the way in which all the details of the branching are brought out; but this is enhanced by the sparkle of the crystals.



Photos: W. A. Bentley. By courtesy of the Meteorological Office.

SNOW CRYSTALS. (Highly Magnified.)

The best snow crystals are seen in the snowflakes that fall in a very hard winter; they are finer in Scandinavia and North America than in England. They are typically six-pointed, often feathery, but if the gaps get filled up by the further growth the result is often a hexagonal plate.

certain mammals, such as hedgehog and dormouse. For these are warm-blooded animals, and the hibernation of a warm-blooded mammal is a very different state from the cold-coma or lethargy of a cold-blooded reptile. In the cold-blooded animal the temperature of the body goes down and down, and the body of the frog, for instance, may become literally stiff with cold. The fatal limit is when the blood or any other fluid of the body begins to freeze. From that there is no recovery. When a mammal hibernates it does not become nearly so cold as the cold-blooded reptile or amphibian, its body-temperature approximates only to that of the confined space in which it hides itself, and this is considerably above that of the open world round about. But we shall return to the hibernating solution.

Among many backboneless animals there is a kind of winter-collapse into a state of suspended animation, comparable to the cold-coma of reptiles and amphibians. Snails often creep far into the recesses of an old wall, and seal up the mouth of their shell with a lid of hardened slime

and lime. Some that we examined seemed to show a certain amount of degeneration in the tissues of their body, but the heart was still beating, though very feebly. There are other cases of animals slipping below the level of ordinary health in their winter collapse, but in most cases there does not seem to be anything wrong except that the ordinary activities of life have come to a standstill. The creature reminds us of a river that has frozen, so that we do not *see* any flow. Or it reminds us of a wound-up watch that has suffered some jar, so that it has stopped. Give it another jar and the wheels may begin again to go round. The creature looks as if it were in a deep sleep, but we do not clearly know what we are saying when we speak of the "sleep" of the lower animals; and it is probably a confusion to speak of the "sleep of plants."

When an insect-eating bird, like a Tree Creeper, spends the winter in the North, instead of migrating like most of its neighbours, it must feel very keenly the scarcity of insects. For that is one of the striking differences between winter and summer. What, then, do the insects do in winter? Those that survive the autumn pass the winter in concealment in sheltered places, and we have already seen that they can do this in any phase of their life-history. Some lie low as full-grown adults, as is the case with some of the house-flies, which come out of their hiding-places when the winter fire makes the rooms unusually warm. The young queens of the humble-bees, the only survivors of the large family that saw the light in the summer nest, spend the winter deeply hidden in a mossy bank. But it is much commoner for insects to get through the winter as well-protected pupæ, and we may mention the cocoons of the diamond-back moth as one example among thousands. But others winter as larvæ, like the grubs of cockchafers deep in the ground, or the so-called "grubs" of daddy-long-legs. There remain those that survive the winter as eggs, as in the case of the hop aphis or green-fly. In such cases the victory of winter over life is almost complete for the time being, since there are only the eggs to represent the race. But as everyone knows, it is a very temporary victory. If even a percentage of the numerous eggs survives the winter, as is usually the case, the race represented is safe enough.

It is probable that the origin of a prolonged pupa or chrysalid stage in the life-history of many insects first arose in cases where the life-history could not be completed within the year. The caterpillar or grub period was lengthened out, for it is a profitable time for growing, and also for laying up internal stores, but if this prolongation of the larval period was continued beyond the time when a change into a winged insect would be safe, the way out of the difficulty was to sink for the winter into a quiescent state. There is a suspension of activities and there is often considerable simplification of internal structure, and both these relapses tend to make

Photo: John J. Ward, F.E.S.

HOAR FROST ON ELM TREES.

Winter has no more beautiful sight to offer than a frost fog, which covers every twig with a thin coating of ice. Then when the sun breaks through, the great elms glitter as though hung with a million diamonds.

Photo: G. C. S. Ingram, M.B.O.U.

THE TREE CREEPER (*Certhia familiaris*).

The Tree Creeper is well described by its Scottish name of Bark-Speeler, or climber. It is a small, quiet, insignificant bird, which lives upon insects found in the crevices of the bark. Unlike the nuthatch, which flies from the top of one tree to another, the Creeper always begins operations near the foot of the tree. Here we see a Tree Creeper searching for a meal on a sunny winter day.

survival easier. Moreover, when an insect-larva gives up activities which are no longer practicable, it can cover itself up in a blanket of silk, or varnish itself over with water-proof, or ensconce itself in a sleeping-bag.

It is rather striking to look through a clear sheet of ice on a pond and see fishes slowly nosing about close to the bottom. They may be taken as examples of many aquatic animals that save themselves in winter by keeping near the floor of the pond or pool. They are saved by an almost unique property of water that it expands when it is about to freeze. The maximum density of water, that is to say the state when its molecules are most closely packed together, is at four degrees Centigrade; if it gets colder than that it expands and must rise towards the surface to form a sheet of ice covering the pool, or to add to that which has been already formed. This sheet of ice serves as a protective covering, lessening the risk of further cooling of the water. But if the cooling goes on, more water rises and the sheet of ice becomes thicker. This explains why the pool does not readily freeze solid, and why for eighty-five days of the year the temperature at the bottom of the pool is higher than that at or near the surface.

This remarkable property of water makes it possible for a great many fresh-water animals to pass the hard winter near the floor of the pond. Had it not been for this, it would have gone hard with the fresh-water fauna during the winters in northern countries.

There are many other ways of meeting the winter besides those that we have spoken of, and besides hibernation, which deserves a section to itself. It is a pleasure to watch a lively herd of Shetland ponies on a bitter day in mid-winter. They do not seem to be in the least bit downhearted. What great-coats they have, with the thick under-fur waterproofed by the longer, harder hair which grows through it and throws off the rain and snow. For many a mammal, winter means a thicker fur coat; or it may mean a thicker layer of fat or blubber beneath the skin, which is useful as a non-conducting quilt and also because the fatty material can be in part used as a sort of internal fuel to help in keeping up the warmth of the body. Then there is the subtlety of the white coat, elsewhere referred to, which we see in such animals as the ermine and the mountain hare; it diminishes the loss of heat from the warm body.

On another tack, already discussed, are the animals that lay up external stores for wintry weather, as is familiarly illustrated in squirrels

and beavers, hive-bees and ants. We should also recall in this connection a number of vegetarian animals that have learned to burrow beneath the snow, which is rather a help than a hindrance. The snow shelters them from the wintry blast; the myriads of air-bubbles entangled in it make it a non-conductor; and if burrowing is practicable the buried plants can be reached. Thus the lemmings make long winding tunnels under the white blanket that covers the Tundra, and pass from root to root without attracting the hungry eyes of the Arctic Fox. The snow-vole has been described in connection with the mountain fauna, and we may remember that some upland birds, like ptarmigan, red grouse, and Canadian Ruffed Grouse, get under the snow for short distances—far enough to reach the tips of the heather and such-like plants on which they feed.

We have spoken of the migration solution of the winter problem, and we have seen that a great many birds literally "know no winter in their year," as the poet said. They evade or circumvent the winter by migrating. But we have given this special section to winter visitors because they form a very attractive group and come at a time when birds are scarce.

Winter Visitors.

Early every winter we welcome bands of Snow Buntings from across the North Sea. When a blizzard is approaching from the north, and feathery snowflakes form in the air, a buoyant crowd suddenly appears over the dunes, as if fleeing before the storm.

There is a charm in their flight, for they seem to be taking a succession of bounds through the air, and a charm in their soft note, for as they fly they call to one another encouragingly. They turn this way and that way as if seeking something, which is, no doubt, the case, for when they reach a stubble-field they sink to the ground and begin a hunt for food, discovering small seeds and perhaps an occasional insect as relish. It is possible that the changefulness of the flight seen when they are not "rushing" headlong over the pathless sea, may save them from hawks, and

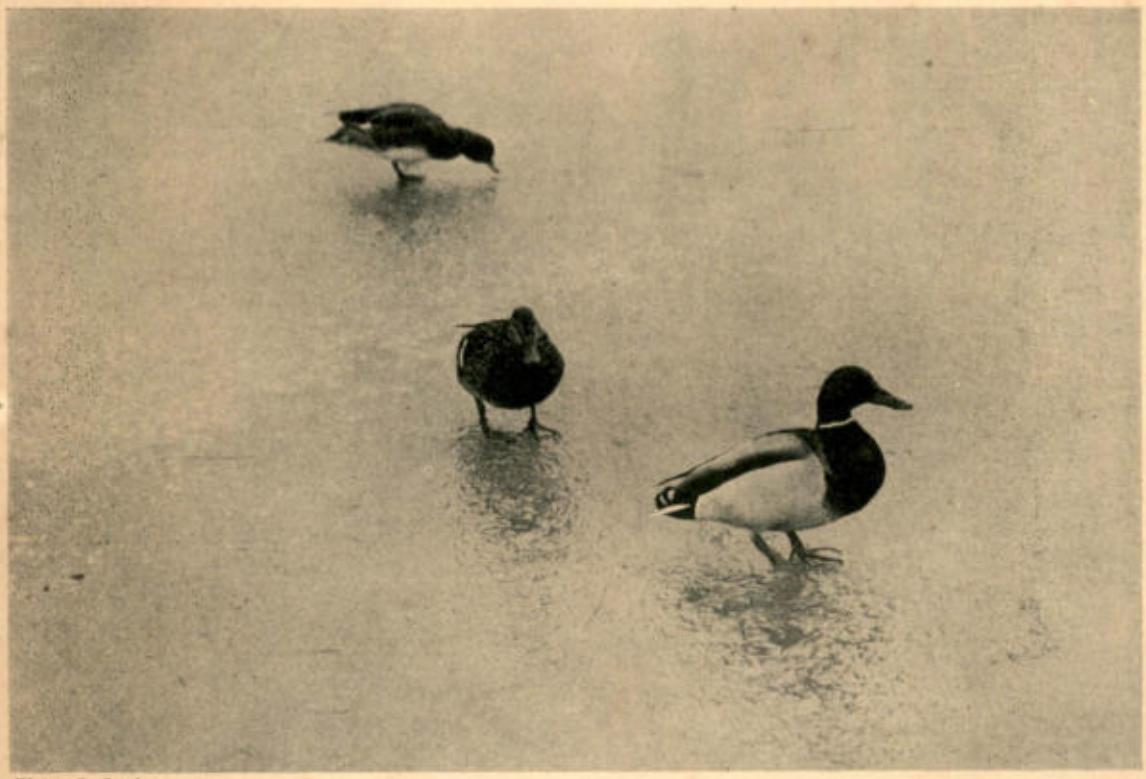


Photo: S. Crook.

WILD DUCK AND WIGEON ON FROZEN LAKE.

The common Wild Duck or Mallard (*Anas platyrhynchos*) is found in most parts of the Northern Hemisphere. The Wigeon (*Mareca penelope*) breeds in Scotland, and is common in England in winter. The photograph shows the unusual sight of two wild duck and a wigeon on a frozen lake, unusual because when there is severe frost these birds usually move off to salt-water estuaries where food can still be obtained.

that the white patches on their plumage may have a similar protective value.

At the point of a rocky promontory, jutting into rather deep water, there is, on the southern and sheltered side, a veritable naturalist's chair, where the observer becomes, as it were, part of the rock. There, one winter day, almost genial, we sat for a long time very still, and we had our reward. For to our feet, within touching distance, there came a Little Auk that had paddled round the corner as quietly as a water-shrew in a pond. A most attractive winter visitor it is, neatly dressed in black and white, hardly more than six inches in length, with webbed feet, a very short tail, and hazel eyes.

A big soul in a little body, this "Ice-Bird," which habitually braves Arctic conditions. It feeds daintily on minute crustaceans in the sea, and when the parents are collecting for their sooty young one, hidden in a hole in the Spitzbergen cliff, their cheeks are distended with reddish mush, fragments of the vast sea-soup. Lively, restless, talkative birds they are, and able to fly under water like the puffins. In very stormy weather we have found dead Little Auks twenty miles from the coast; it looks as if they sometimes got flurried and flew headlong anywhere.

It is a rather cold pleasure watching birds at the mouth of the river in December, but we are always warmed when the Great Northern Diver appears on the stage, and that is to be expected in midwinter. For many weeks he is in evidence, though not necessarily every day, for he is oftenest seen when it is rough weather out to sea. He cannot be always baulking the billows, so he comes in for a rest. And there is good fishing in the quiet estuary, whereas a prolonged storm in the open sea sends the upper zone fishes into the deeper waters, out of even the Diver's reach. This, indeed, is the greatest risk that open sea birds have to face, that their normal food may sink into inaccessible depths. After a few days of short commons the bird loses tone and becomes unable to stand up to the sea of troubles.

The Great Northern Diver.

The Great Northern Diver is an almost invincible bird and at home in stormy northern waters, but even he, to our delight, is appreciative of a rest in the waters of the estuary. Many go far inland to quiet lochs, where they must enjoy a real winter holiday. A much more familiar Diver at our river-mouth is the Red-Throated Diver—a smaller, perhaps more graceful, bird—hardly so impressive as its big cousin.

In the first place, the Great Northern Diver is a bird of long pedigree, an antiquity. It takes us back to the great extinct Hesperornis, a wingless, toothed, small-brained diving bird, about five feet in length, that hunted for fishes in the Cretaceous seas many millions of years ago. It had extraordinarily powerful hind-legs, probably of no use on land, but admirably suited for swift swimming and deep diving. The Great Northern Diver or Loon is a scion of the house of Hesperornis. It is a living reminiscence.

In the second place, the efficiency of the Great Northern Diver wins our respect. Its swimming and diving are unsurpassable, and though it cannot rise from dry land, and requires the momentum of its swimming and perhaps of a wave and very rapid wing-beats when it launches itself off the water, it is quite capable of a long flight, at a considerable altitude, and at a great pace. In the air it presents an unusual appearance, with its long thick neck stretched out in front, and its wings set far back and working very hard. It suggests one of the extinct flying dragons or Pterodactyls: in any case, it does not look modern.

The diving is such a rapid somersault that very few people can see what happens. The bird disappears head foremost, after a quick turn in the air. The powerful feet are the chief instruments in swimming and diving, but the wings may also be used a little under water. There is a remarkable upward process of bone at the knee-joint, to which muscles are attached with great effect. An additional leverage is secured that adds greatly to the strength of the stroke in swimming and diving. It is an interesting point that the same kind of knee-process is seen in grebes and in Hesperornis, with the same meaning in each case, and yet the details of the making of the instrument are on three different plans.

The strength of the Great Northern Diver may be inferred from Saxby's story of one which pulled a light thirteen-foot boat, made of Norway pine, for several minutes by means of a rope attached to one foot. And it was slightly wounded, too! But its feats on the open sea in

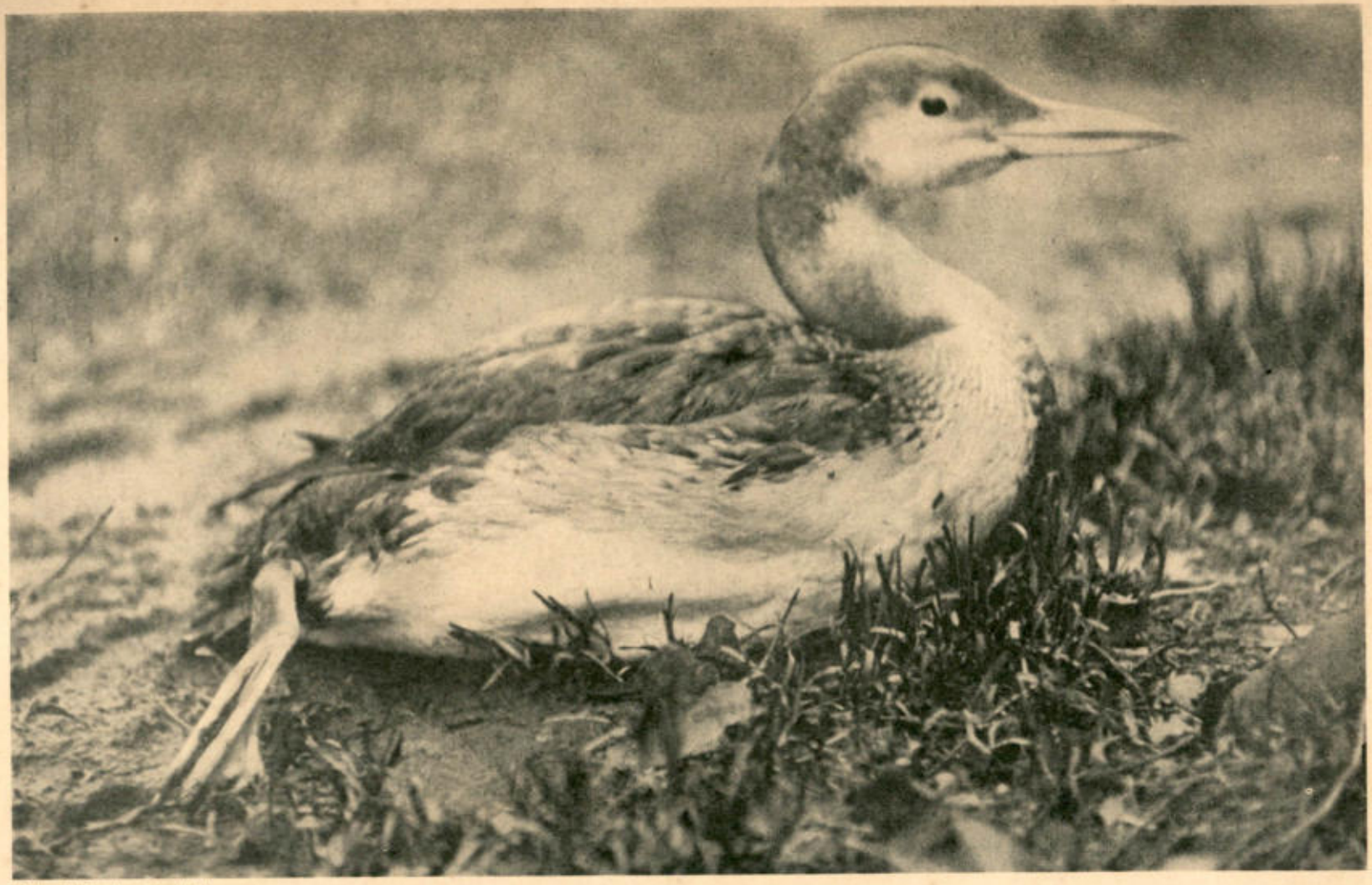


Photo: W. S. Berridge, F.Z.S.

GREAT NORTHERN DIVER (*Colymbus immer*).

This large, handsome bird is seen on British coasts in autumn and winter. In spring it flies far to the North to breed. Feeding entirely on fish, it keeps well out to sea, only coming to shore when the weather is stormy. Its plumage is marked by the fine purplish gloss of the head and neck, the two collars on the neck, longitudinally striped with white, and the numerous white spots over the upper body.

After the painting by Philip Rickman.

GOLDEN-EYES (*Glaucion clangula*).

This beautiful bird never breeds in Britain, but arrives here in October and remains through the winter. Its breeding places are in Northern Europe, and Asia; and there is a near relative in North America. The drake has a conspicuous white patch under the eye, absent in the female bird. As a quick diver the Golden-Eye is hard to beat.

stormy weather are in reality much more interesting. Somewhat puzzling is its way of slowly sinking in the water, just the opposite of the quick dive. It goes straight down like a sinking ship, till only the head is visible. We hope someone knows how the trick is done. It is sometimes followed by a genuine dive without the usual somersault. The duration of submergence is in most cases about two or three minutes, but it is a little difficult to be quite sure that the bird does not pop its head up for a few seconds.

The Great Northern Diver or Loon is one of the handsomest of sea birds. The upper surface is black, ornamented by belts of quadrangular white spots, which produce what is called the chess-board pattern; the under parts are white; the throat is black in summer, but crossed in front by two bands of white, streaked with black. In the winter the fore-throat is white. Of course, there is much more colour than this, for the black has an indescribable metallic sheen at the breeding season, and there are little details like the blue-black bill, the greenish legs and the crimson iris. There is no difference between the sexes; they are equally handsome.

The Great Northern Diver is a typical winter visitor to Britain, or it may be a bird of passage when it seeks its winter quarters, as far south as the Mediterranean. In spring they make for the North again, for they never breed in Britain, nor at any station nearer than Iceland. Their true home is in the Far North—in Greenland, in the fur countries, and on the northern coast of Asia. There is something of the melancholy of the North in their wails and growls; their more musical and victorious love-call we have not been fortunate enough to hear. The nest in the Far North is usually by a fresh-water loch and very near the water, for the birds are very awkward on land. There are two brownish eggs, which are incubated for about a month by both parents. The young ones are said to take to the water in a few hours, and their immediate skill in swimming, diving, and fish-catching illustrates what is meant by instinctive behaviour. They move on land by frog-like leaps, and much less awkwardly than their parents. This is readily intelligible, for young creatures are often nearer the ancestral type.

A bird always nests in the coldest part of its migratory range; the Great Northern Diver in Iceland and Greenland; the Little Auk in Spitzbergen and Novaya Zemlya; and the Snow Bunting in the same regions, as well as in the Faëroes, North Scandinavia and North Russia. Occasionally, indeed, the Snow Bunting nests in the screes of the Cairngorms and the like; but this is the sort of exception that proves the rule. Thus, just as our summer visitors fly south in the autumn, so the three birds we have mentioned (and others like some of the Diving Ducks) are the summer visitors of the Far North *who find our shores passable winter quarters.* A roving impulse has in the course of ages become a life-saving racial habit. The impulse to migrate and the capacity for way-finding are engrained in the constitution; the storms and scarcity of the North serve as liberating stimuli that pull the trigger; and so we have our winter visitors.

Golden-Eyes.

One of the many compensations for wrestling with the severities of winter in North Britain is the opportunity of studying Golden-Eyes. To many estuaries they come every year about the end of November and stay with us till March. If there are halcyon days, these diving-ducks disappear and explore the shallow waters up and down the coast; but when there is stormy weather they come again to the shelter of the river mouth. They always swim about in a flock, sometimes as many as thirty together, full-grown males and rather smaller females, and some youngsters in their first year. Though they are not dumb, we have never heard them say anything, and yet they give us the impression of being a very joyous company. What strikes us at once is the dazzling white of part of the plumage against the adjacent black or brown; and even from a distance one can see a large white spot at the base of the bill of the full-grown drake. The contrast of black and white accounts for the name "magpie-diver," which is often applied to this species, and the gilded iris of the drake accounts for the beautiful name Golden-Eye.

This bird is a thoroughly good example of a winter visitor, for there is no secure evidence that it ever breeds in Britain. It nests in the north of Scandinavia and Russia, and eastwards into Asia, but it leaves these northern latitudes in the autumn and betakes itself to southern estuaries and coastal waters and fresh-water lochs. In March or April it becomes restless and

Photo : Sport and General Press Agency.

DEER IN WINTER.

On the approach of winter the stags draw together and they keep by themselves through the hard months. The hinds and calves live together, away from the stags. When there is heavy snow the difficulty of getting sufficient food is often great, and both stags and hinds may be seen near the crofts and villages.

leaves us for farther north. It is thus for Britain a typical winter visitor.

The Golden-Eye belongs to the group of Diving Ducks, which includes, for instance, Pochard, Tufted Duck, and Scaup, the point being that, instead of paddling in the shallows, like mallard, teal, wigeon, and domestic duck, they prefer to dive in deepish water. Indeed, the Golden-Eye is at times almost incessantly diving, being in the course of half an hour oftener below than above water. Mr. Coward found an average of twenty-three seconds below the water, and three or four seconds on the surface between each dive. It has been estimated that four-fifths of the day may be spent below the surface, but a flock may often be seen swimming hither and thither without diving at all. We suppose this means that they have eaten enough for the time being, and have nothing to do but to amuse themselves.

Could the Golden-Eye's diving be improved on ? The plunge is extremely rapid and forceful, and the reappearance of the bird is sometimes just where it dived, sometimes at a distance.

As we watch from the bank we cannot but admire their defiance of cold and their apparently inexhaustible energy, as they emerge and disappear again, time after time, hour after hour. We know, indeed, of their perfect warm-bloodedness, that the temperature of their body never changes ; we take account of the unwetted plumage, the thick quilt of non-conducting down, and the fat below the skin ; we are willing to allow that, since they come from the Far North they possibly find our winters genial ; but, when all is said, the diving of the Golden-Eyes is a fine achievement. Our feet get cold as we stand watching them ; why are their yellow feet not cold, having neither boots nor stockings ? No doubt the Golden-Eyes have a first-class circulation, and although they come ashore occasionally, they are usually moving about restlessly on the water.

In our estuary the bird feeds mainly on small crustaceans and molluscs which it finds in the mud ; in the shallow water along the shore it searches for mussels and shrimps ; in the inland lochs it depends to a large extent on fresh-water

snails and the larvæ of insects. No doubt it sometimes eats fresh-water plants, sea-grass, and seaweed, but on the whole it feeds on small fry, which it transmutes into its tireless energy and wonderful beauty. We do not suppose it has many enemies.

As the Golden-Eye is a winter visitor, we owe our knowledge of its family affairs to those observers who have been able to follow it farther north. The drake shows off a bit, swimming round the female. He raises his bill to the zenith and utters a loud, rasping disyllabic cry. He jerks his head back again, and strikes the water violently, showing his orange feet all aflame. In North Britain, as we have confessed, we have never ourselves heard the Golden-Eye utter a cheep, but expostulatory grunting is well known.

White Hares.

As we took the antics of the March Hare as typical of Spring, so we may take the blanching of the Mountain Hare as characteristic of the life of Winter.

When Thomas Pennant made his tour in the Scottish Highlands in the autumn of 1769, he saw "white hares," as he called them, on the mountains, and wrote to Gilbert White about them. In the answer from Selborne there is the interesting sentence: "It pleases me to find that white hares are so frequent on the Scottish mountains, and especially as you inform me that it is a distinct species; for the quadrupeds of Britain are so few that every new species is a great acquisition." These white hares continue to hold their own, and in some parts of the Highlands they are actually plentiful, as the windows of the game dealers' shops plainly testify. They have been introduced here and there in England and Wales.

Compared with the Brown Hare, the Mountain Hare is smaller, more rabbit-like, with larger head, fuller eyes, shorter ears, relatively longer hind legs, and softer pelage. It is not so quick on its feet though very swift compared with most

Photo: W. S. Berridge, F.Z.S.

MOUNTAIN HARES (*Lepus timidus*).

The Mountain or Blue Hare has as one of its Latin names *Lepus variabilis*, meaning the hare that changes colour. Greyish-brown in summer, it turns snowy white in winter all but the tips of the ears, which remain dark. It occurs in Scotland and Ireland, and has been re-introduced in various parts of England, where it had become extinct. Those in Ireland and in the South of Scotland do not usually show the characteristic colour-change to the degree seen in the North.

mammals, and it is not so alert or "timid," perhaps because it is less accustomed to enemies, perhaps because it is a much less intelligent animal. Another difference is that instead of having a "form" among the grass, the Mountain Hare hides in clefts of the rocks or among stones; and on rare occasions it may even excavate a hole in the ground which some would count as a burrow. It is able to live on food much coarser than the Brown Hare will touch, unless indeed the worst comes to the worst. Thus the White Hare will eat heather-tips in the winter and nibble the lichens off the rocks. Little wonder then that the flesh is less palatable, though that varies greatly with the locality, and little wonder that its price in the shops is much less.

The Mountain Hare begins to change its dusky brown upper colour in September. Towards mid-winter it is quite white, except the black ear-tips. Like most rodents, it is always shedding hairs, and those that are replaced in the autumn are more or less unprovided with pigment. They, are therefore, white; that is to say, they reflect all the rays of light, especially when they are massed together in the fur with intervening air spaces. But this is not the whole story, for individual brown hairs in the pelage or fur may change into white ones, as Professor MacGillivray, of Aberdeen, showed long ago. How is this transformation effected? The answer is largely due to the illustrious zoologist and physiologist Metchnikoff, who showed that wandering amœboid cells from the core of the hair pass into the outer layers, engulf the microscopic granules of brownish pigment, and carry them away, passing through the base into the skin. Soon afterwards the hair becomes a dead structure, in its exposed parts at least. The same phenomenon occurs, according to Metchnikoff, in the winter-whitening of the ptarmigan's plumage and when man's hair becomes grey. He called the wandering cells chromophages, which means colour-eaters.

We remain personally of the old opinion, which we express with caution because our observations have not been extensive, that the whiteness is partly due to the presence of minute bubbles of gas, and not wholly to the absence of pigment.

We have watched a white hare hirpling over a snow-covered moor, and stopping to look at us inquisitively. When we gave chase it disappeared like a wraith. The first thought, if it is not the last one, is that this creature is well-protected against a background of snow. It has the secret of the Gyges ring; it makes itself invisible. There are good reasons, however, for not pressing this interpretation. When the White Hare is *not* on a background of snow, and that is often, its whiteness makes it very conspicuous. It must be remembered, moreover, that when there is much snow on the hills and uplands the White Hare tends to seek lower elevations and more sheltered places where its whiteness is almost like an advertisement.

The chief meaning of the whiteness must be sought, we think, in another direction. It is primarily due to the fact that in autumn the conditions of hair-development on the upper parts of the body are different from those that are operative at other seasons. This does not mean that the animal is out of condition, for the reverse is the case in autumn; moreover, the fur of the under-parts is always white. Secondly, this physiological rhythm has been fixed by ages of natural selection, not so much because the white coat is sometimes a cloak of invisibility, though that may have considerable value among animals that live in Arctic regions, but because it is the coat that loses least of the precious animal heat of the body.

The males and females live more or less apart in the winter, but very early in the year the buck scents out the spoor of the doe. He is a free lover, and rivals often fight, standing up on their hind-legs and boxing, or biting at one another with their chisel-edged front teeth.

Winter Sleepers.

Falling into sleep is among Mammals one of the recognised ways of circumventing the severity of the winter, which means short commons as well as cold. Obvious enough is the advantage of being able to evade hard times by retreating into winter quarters, reducing expenditure to nil and playing a waiting game till spring comes. But can we understand how the habit was established? Everyone knows that Birds and Mammals are alone among living creatures in being "warm-blooded," which means that they are able to preserve an almost constant body-temperature year in year out. This is in contrast to what is true of "cold-blooded" animals like Reptiles, Amphibians, and Fishes, whose body

Specially drawn for this work by Warwick Reynolds, R.S.W.

SHETLAND PONIES.

In appearance, sweetness of disposition and hardiness the "Sheltie" ranks perhaps the highest of all breeds of ponies. In the winter months they often herd together with their backs to the cold blast, and of great value is the double coat of hair, for the longer outer hair allows the rain and snow to fall off without the under coat being wetted. But in addition to this there is no doubt a first-class circulation.

temperature sinks or rises according as the outside world is cold or warm. When the approximation to the external temperature forbids the continuance of the ordinary routine of vital processes in the cold-blooded animal, it falls into a state of lethargy.

This peculiar condition of suspended animation is in several respects different from that of the Mammalian hibernators. To understand the latter we must notice that all Mammals are not equally perfect in their warm-bloodedness. Thus the Duck-mole and the Spiny Ant-Eater of Australia, so peculiar in being egg-layers, are very imperfectly warm-blooded.

That is to say, some Mammals are constitutionally unable to effect with any great precision the regulation of the heat-production and the heat-loss.

Now, it seems that the winter sleepers, like Bat and Hedgehog, Marmot and Dormouse, are in this position; they are imperfectly "warm-blooded." Therefore, when the winter approaches, they do not attempt the impossible, but sink into a state of inactivity within a confined space, to the temperature of which their body temperature tends to approximate. If they fell asleep in an exposed situation they would be frozen to death; but in a snug hole or sheltered nook the coma is more or less safe. If the sleeping berth becomes very cold the inmates pass from sleep to death. During the ordinarily successful winter sleep there is no income of food, and there is no getting rid of waste; the heart beats very slowly and feebly; respiration has practically stopped; some stored fat is usually burned away to keep up a modicum of animal heat, compensating for the inevitable loss.

It may be that the relative warmth of the sleeping berth and its close air help to keep the sleeper sleepy, and that an accumulation of waste-products in the body brings about "auto-intoxication," but we have to remember that the winter sleeping is a racial, not an individual, characteristic. In the course of ages it has been engrained in the constitution as an internal rhythm, normally but not necessarily corresponding to the external seasonal periodicity. Woodchucks may go to bed while the weather on the Adirondacks is still warm and pleasant, and unusually severe cold may waken a hibernator.

There is a good deal of truth in one of the hard sayings of an old investigator, that winter sleep is not sleep, and that it has nothing to do with winter. There is no distinction between the summer sleep of the Tenrec of Madagascar and the winter sleep of the European Hedgehog.

The winter sleepers differ considerably in the soundness of their slumbers. The sleeping hedgehog may be immersed in water for twenty minutes or subjected to noxious gases without awakening; and the Marmot is another heavy sleeper. The Dormouse, on the other hand, is a rather light sleeper; and many Bats awaken when there is a spell of fine weather in mid-winter. Artificial disturbance of deep hibernation is said to have an injurious effect on the constitution; it disturbs the rhythm of life and may be fatal. When the reawakening comes and the animal becomes active again, the body temperature is rapidly restored to the normal. Thus Dr. Pembrey found that an awakened Dormouse raised its temperature by nineteen degrees in forty-two minutes.

If it be asked why a Hedgehog hibernates, while a mole does not, part of the answer is that the Mole is a burrower who finds earthworms and grubs beneath the reach of the frost's fingers even in mid-winter. If it be asked why Bats hibernate while Birds do not, part of the answer is that the great majority of North Temperate birds evade the winter by migrating. If it be asked why Marmots hibernate, and Stoats do not, part of the answer is that the Stoat turns in winter into the White Ermine, and that the white robe makes the problem of facing the cold much easier. If it be asked why the Jerboa of the Kirghiz Steppes hibernates, while the squirrels in the forest farther north do not, the answer is in part that the Squirrels accumulate stores of food. Generalising this, we may say that the non-hibernating Mammals have very often some special adaptation or fitness that enables them to cope with the winter, or, if they have none, they have hardy resistent constitutions, as in Wolves and Foxes. But there is another half of the answer.

Mammals are descended from cold-blooded animals; some are less perfectly warm-blooded than others, having some imperfection in their heat-regulating arrangements. These have made a virtue of necessity by becoming hibernators. They cannot sustain the temperature at the level

required for a continuance of everyday life, so they relapse into a life-saving cold-bloodedness and inactivity. They pass into a state in which they can fast without feeling the worse for it; they lie low with dulled sensitiveness instead of fretting themselves to death in a hopeless struggle with the cold and scarcity.

In other words, the winter sleep is a slowly wrought-out adaptive reaction of survival value.

To all this, however, must be added the idea that the long rest of the winter sleep—a rest even from eating—gives an opportunity to processes of rejuvenescence (becoming-young-again) to stave off that senescence (ageing) which is the universal tax on having an intricate body.

The Story of Mistletoe.

In a crowded wood one often sees polypody ferns and even flowering plants like hawkweeds perched on the trees twelve feet or so from the ground. It would be interesting to know whether the spores and seeds are carried up or wafted up; but apart from this question there is no particular puzzle in the position of these plants away from any contact with the earth. In some niche or cleft in the tree a little humus has formed from rotting leaves, helped, no doubt, by small animals that are fond of vegetable crumbs. Dust in the air may contribute a little in the course of the tree's lifetime, whether it be borne in by the wind or centred in raindrops. We have sometimes found in a tree-cleft enough soil to fill a saucer, and in this there were many different kinds of small animals, especially insects and mites. Even earthworms occur in such places, and it is a little difficult to account for them. Perhaps juvenile earthworms or the cocoons of earthworms were transported in the clodlets on birds' feet, and thus marooned on the island which the cleft represents on the vast sea of the tree's surface.

We are not forgetting mistletoe in all this; we wish to suggest the idea that a tree is a biological centre or focus. When we look into the matter carefully we find that every tree is an area which many different life-circles intersect. Furthermore, these more or less fortuitous perched plants, which we see on trees in this country, point on to the habitual perched plants or epiphytes which are characteristic of the tropical forest.

True perched plants or epiphytes are those that habitually live off the ground and spend their whole life on other plants. The seeds are often very small and specially adapted for transportation among the branches and for fixation in suitable places. There are usually some special adaptations for reducing the loss of water or for absorbing rain and water-vapour. The attaching roots frequently have a sponge-like rind. The habit is well illustrated by orchids and bromeliads in the steamy tropical forest. The advantage is obviously that of getting into the light and fresh air and away from the darkness and smothering tangle of the undergrowth. But the risk is scarcity of water except in the rainy season. It will be understood that these perched plants are in no sense parasitic; they do their bearers no harm except by occupying a certain amount of surface; they are often beautifully green, and they make their own food, like all independent plants, by photo-synthesis. It is probable that some of them have evolved from casual perched plants like the polypody fern and Herb Robert that we see occasionally on our trees. Indeed, there is one of the species of polypody that has emancipated itself altogether from the ground. In other cases, however, the probable origin of the epiphytes is to be found in climbing plants which have become independent of the soil, as frequently happens in the life-history of the individual. As is so often the case in evolution stories, the success of the epiphytes is partly due to luck and partly to cunning—if we may use this last word in a wide sense to include the plant's deeply rooted endeavour or "urge" towards the light.

We have spoken of perched plants or epiphytes because the mistletoes and their relatives may be interpreted as an advance—if it be an advance—along this line of evolution. They are not only perched plants; they tap the water and dissolved salts that ascend by the young wood of the tree. Having abundant chlorophyll, they can synthesise their own food from carbon-dioxide and water—an alchemy that the botanists are trying hard to understand, and with some success. For there is extraordinary interest in the demonstration, due to Professor Baly and his collaborators, that light of very short wave-length (from a mercury vapour lamp) can effect from carbon-dioxide and water the synthesis of formaldehyde, and from that beginning pass on to sugars. But we must not wander from the mistletoe, whose

1. A missel-thrush has wiped its beak on the rough bark of an apple branch, leaving behind a mistletoe seed. This remains in a crevice of the bark all through the winter, but sprouts with the warmth of spring. The young stem presses against the branch and gives off a root which ferments its way inwards.

2. In the second spring the young mistletoe develops green leaves, a short shoot and a spreading root-system. In this picture the bark is removed to show the absorbing roots. The dotted lines represent the roots which have actually penetrated the wood of the host.

3. The mistletoe is at first a very slow growing plant, and this third picture depicts the plant after the second spring. The shoot is free and is growing straight up, but there are as yet only two leaves.

4. The mistletoe has now developed from a seedling into a fruiting plant, more than a year old. In spite of its size it does little harm to its host, for though it is a parasite it draws a larger part of its nourishment from the air.

THE STORY OF THE FROGBIT

The Frogbit (*Hydrocharis morsus-ranæ*) is a rootless water-plant, European and British. It belongs to the same Monocotyledonous family as water-soldiers, Canadian water-weed, and Vallisneria. Somewhat circular leaves float on the surface, and there the flowers open. In summer the plant develops runners or stolons; at the end of each a new plant is formed. Big oval buds on the stolons drop off in autumn, sink to the bottom, spend the winter there, and rise to the surface in spring, starting a new plant.

1. Frogbit with runners or stolons in the water, bearing winter-buds.

2. Frogbit with circular leaves floating at the surface. A bud is sinking.

3. A winter-bud has reached the bottom of the pool.

4. Winter-buds have risen to the surface and are opening.

(*Photos: John J. Ward, F.E.S.*)

beautiful green leaves save it from being more than a little bit of a thief. The only material it takes from the tree is soil-water, and that is not scarce.

The life-history is interesting. A missel-thrush is attracted by the white berries of the mistletoe, but it does not swallow the seed that lies embedded in the sticky pulp. It wipes the seed off its bill on to the branch of the tree (such as black poplar, silver fir, apple or pine), and the drying of the bird-lime mucilage automatically draws the seed close to the bark. The seed is fixed, and after a period of quiescence it proceeds to germinate when the weather begins to be genial in spring. Sometimes, no doubt, the seed is sown by having been first swallowed by the thrush, but this is the exception, not the rule.

From the sprouting seed there emerges part of a tiny stem which presses against the twig. It seems to be indifferent to gravity, but it bends away from the light, and that is all to the good. It presses against the twig, as we have said, and broadens into a little attaching disc. From this there grows a secondary root which penetrates into the bark. Sometimes there is one root going upwards and another downwards, parallel on the whole to the surface of the twig. But from the bark-root there arises a branch that works its way inwards in a radial direction and reaches the wood, where it begins to tap the crude sap. This is all that happens the first year, and the little bent stem still keeps its connection with the seed glued on the surface of the twig. It draws its organic supplies from the stores in the seed, its water and salts from the tree. Next spring it frees its tip from the exhausted seed and begins very slowly to grow into the air. The ingrowing radial root or roots must become embedded in the additions that are made to the young wood, and there is increase in length and thickness to keep pace with this. As the twig adds ring after ring of new wood the mistletoe root takes a firmer and deeper grip. But this would be in itself ineffective if the growing zone of the mistletoe root did not give off side roots which grow up and down along the branch in the region of the young wood. From these side roots there may arise shoots which break through on the surface of the branch, so that one mistletoe becomes many. The aerial growth is at first very slow, but after a few seasons it becomes cumulative and even exuberant.

The mistletoe's life-history is, as we have seen, a little intricate, but it is very successful. This is shown not only by the vigour of the plant but by the large number of species. For there are hundreds of different kinds of mistletoe, distributed all over the earth. It is very interesting to find that there is a very small minority of species, the members of which stick to the old ways—germinating in the ground. When we inquire further into this we find that they alone have hard fruits without the adherent bird-lime. It looks as if that was the critical secret of the golden bough. We are not inclined to call the mistletoe a parasite : it is a handsome adventurer.

LIX
ANIMALS ROUND THE YEAR

IN the foregoing chapters we have sketched some of the events of each season of the year —the industries of summer, the preparations that are made in autumn, the fight against the winter, and the fresh start that is made in spring. Let us now follow a few representative animals through the year, beginning with the Humble-Bee.

There is something very attractive about these humble or bumble bees. Their furry coats and pleasant colours suggest comfort ; their flight is masterly ; their industry is a sublime infatuation ; the hum of their intensely rapid wing-strokes (as distinguished from the excited buzz when the breathed-out air vibrates a taut membrane at each of the four breathing-holes beneath the wings) is pleasant to our ears ; and they show a restraint in stinging which we wish hive-bees

would imitate. But even more attractive is the dramatic interest of their year's life, of which a remarkably fine account is given in Mr. F. W. L. Sladen's "Humble-Bee" (Macmillan, 1912), one of the best of modern Natural History books. What in a few words is the life-story which has been worked out by Mr. Sladen and others?

Towards the end of summer a young queen is attracted by the flower-like fragrance of a drone and is fertilised. Immediately thereafter she seeks for a dry bed in the ground or among moss and thick herbage, preferring a northern aspect where the sun will not waken her too early in the spring. Her torpor lasts for about nine months, and her awakening—when she makes for the willow catkins and other early flowers—is sometimes not very thorough, for she may sink to rest again if the weather be chilly. Once fully awake and well-refreshed, the queen seeks for a suitable nesting-place, such as the deserted burrow of a vole, and this she makes comfortable with fragments of grass, moss, and other soft material, fashioned into a hollow ball. We have heard of one that nested in the spare-room bed-quilt. For the first few times of coming and going, the queen educates herself carefully as regards the lie of the land, so that there may be afterwards no mistake in making a bee-line for the nest.

Photo: G. H. Hewison.

THE HUMBLE-BEE.

The genus Bombus or Humble-Bee has over one hundred species, of which about twenty are found in Britain. Larger in size than the Honey Bee, the Humble Bee makes a loud droning sound as it flies. Its industry is amazing, for it works from earliest dawn until latest dusk. Our photograph shows the long tongue which enables it to suck honey from deep flowers.

In the centre of the dry material a snug cavity is made, about the size of a large marble, and in the middle of the floor of this a lump of honey-moistened pollen is deposited and topped with a circular wall of wax. In this cell—about the size of a pea—the queen then lays her first batch of (six to twelve) eggs, sealing them up with a waxen lid. She broods over them all the night and most of the day, and she reduces the number of food-collecting interruptions by making near the entrance to the nest-chamber a delicate waxen honey-pot, about the size of a black currant, in which there is a continually replenished store. All this detailed carefulness has to do with the future as well as with the present—it makes for success in rearing offspring, and on this success, as Darwin insisted, the survival of a race may in great part depend, especially when the number of offspring is not very large.

In four days the eggs hatch into whitish grubs, which devour their bed of pollen paste, and are also fed, first all together and afterwards one by one, with liquid food which the mother injects at intervals. Each feeding time means cutting a hole in the waxen lid of the cell and closing it up again. On the eleventh day after egg-laying the larvæ are full-grown, and form tough papery cocoons, clustered together so as to leave a median groove in which the queen lies outstretched, trying to keep them warm. Out of each cocoon, about three weeks after egg-laying, there emerges a fully-formed, silvery-grey bee. "Her legs are weak and unsteady," Mr. Sladen writes, "and almost the first thing she does is to totter to the honey-pot, where she slowly unfolds her proboscis and takes a sip of the life-supporting drink. Then, refreshed and strengthened, she returns to the brood and nestles under the warm body of her parent." In a couple of days she has her mother's fine colouring, and differs only in size and in being a "worker," a female that does not *usually* become a mother.

The queen proceeds to lay more eggs, which are deposited in cells attached to the sides of the cocoons of her first brood; and as her children

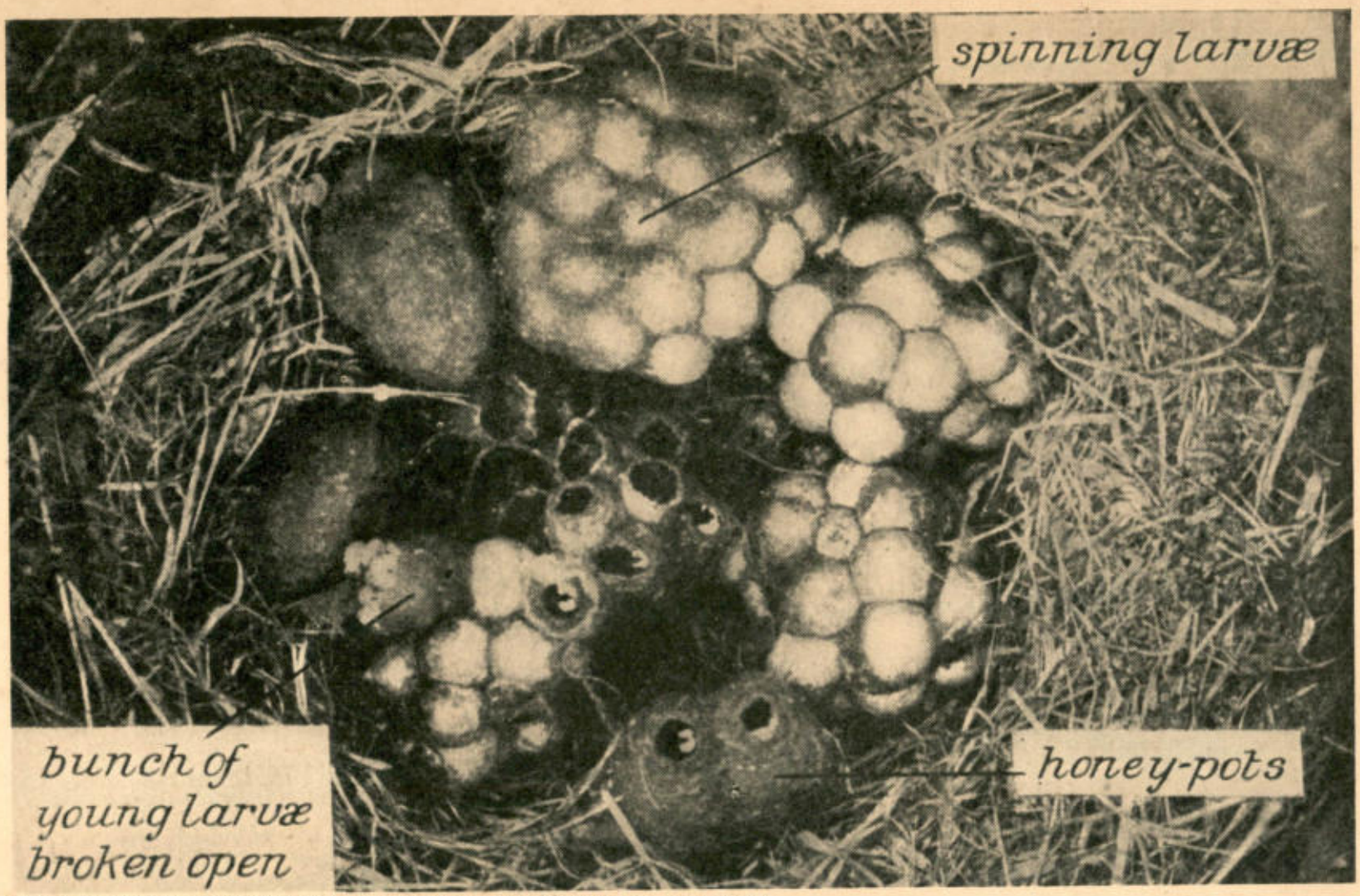


Photo: Reproduced from "The Humble-Bee," F. W. L. Sladen, by courtesy of the publishers, Messrs. Macmillan & Co.

COMB OF THE STONE HUMBLE-BEE (*Bombus lapidarius*), SHOWING TWO HONEY-POTS FULL.

The first honey-pot is made by the queen, to hold a store of honey to keep her alive at night when she is brooding or in bad weather. It holds nearly a thimbleful. When workers are developed they make other honey-pots, and two are shown here, brimful of honey. The larvæ of this species develop in compact masses covered by a soft skin of wax; within this they spin a loose web of silk, and then each spins a cocoon.

Photo: Reproduced from "The Humble-Bee," F. W. L. Sladen, by courtesy of the publishers, Messrs. Macmillan & Co.

NEST OF THE LARGE HUMBLE-BEE (*Bombus terrestris*), SHOWING THE GROOVE IN WHICH THE QUEEN SITS.

This groove is formed by the arrangement of the cocoons. A honey-pot is also shown, in front of the groove.

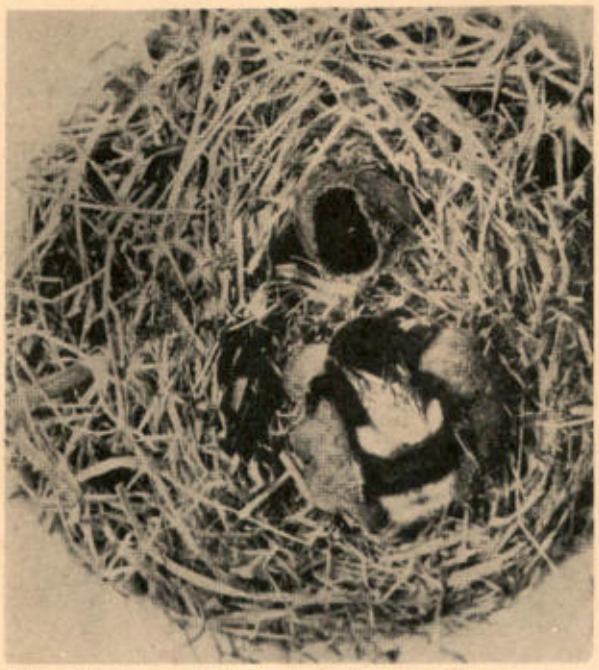


Photo: Reproduced from "The Humble-Bee," F. W. L. Sladen, by courtesy of the publishers, Messrs. Macmillan & Co.

QUEEN OF THE LARGE HUMBLE-BEE (*B. terrestris*) INCUBATING HER BROOD.

She presses her distended abdomen on the cocoons, and remains brooding for many days. She usually faces the honey-pot from which she feeds.

increase in number and are able to bring in plenty of food, she settles down entirely to indoor maternal duties. The workers fill up empty cocoons with honey and may make special honey-pots as well; pollen is also stored, by some kinds in vacated cocoons, by others in special waxen pockets. Here we have a far-off hint of the storing instinct of hive-bees. As the comb grows bigger the nest material is pushed out to make room for it, and a waxen canopy or ceiling is often made. The population of workers increases, and through their short life, lasting only about a month, they are busy the livelong day, the younger ones as nurses, the older ones as foragers. All night, too, they are more or less active, building and tidying up, feeding and brooding over the young, or ventilating the nest by continual fanning with their wings.

As the weeks go past, the queen begins to lay eggs which develop into drones or males and into queens or mothers. Unfertilised eggs develop into drones; late-laid fertilised eggs develop into queens; but it is likely that the food given to the queen-producing larva requires to be somewhat different from that given to the worker-producing larva, which also develops from a fertilised egg. Mr. Sladen observed in the nest of the Stone Humble-Bee that the workers made for a time persistent attempts to destroy the cells in which the queen has laid eggs destined to become drones or queens. But she eventually has her way. When the young drones are able to fly they leave the nest and do not return. They prowl about for three or four weeks, seeking mates, and making favourite "pausing-corners" fragrant. As the queen ages she becomes bald and tired; she ceases to lay so many eggs; and then it often happens that "laying workers" appear—the virgin mothers of drone offspring. These drones, like other drones, have obviously mothers but no fathers.

A populous nest of the Stone Humble-Bee (*Bombus lapidarius*), the Large Earth Humble-Bee (*B. terrestris*), or the Small Earth Humble-Bee (*B. lucorum*) may have

200 to 300 workers and about fifty young queens; while, perhaps, a hundred drones have taken wing. But the numbers vary greatly with the degree of prosperity. Sooner or later, however, all comes to an end; the stores are exhausted and cannot be replenished; the short-lived, over-industrious workers die off; and the queen, though she may rally for a while and renew her youth after she ceases to be so prodigiously maternal, succumbs to brain-fatigue and falls into a final sleep. Only the young queens, hidden in their winter-quarters, are left to continue the race, and if everything goes well they may live to be a year old.

There are not many animals that will say "bo" to a queen bumble-bee, but workers may be found spiked on thorns in the red-backed shrike's hedgerow larder; and the great tits share with Bottom, in the "Midsummer Night's Dream," a liking for the red-hipped bee's honey-bag. But the vulnerable spot in the humble-bee's scheme of life is the nest, well-concealed as that may be. When the queen is from home, a field-vole or a shrew may effect a burglary, and devour the early brood. An invasion of ants may put an end to everything; the caterpillars of the wax-moth can destroy a large comb and its contents in a few days; and there are many other unwelcome intruders. Of great interest is the handsome fly, *Volucella bombylans*, which is a "double" of the worker Humble-Bee, and buzzes like it, and frequents the same flowers. The females lay their eggs in Humble-Bees' nests, and Mr. Sladen notes the interesting point that even if they are stung to death as intruders "they are always able to finish laying their eggs." The larvæ live in the débris under the comb and seem to be scavengers rather than parasites. It is a strange world with all these entanglements in the web of life.

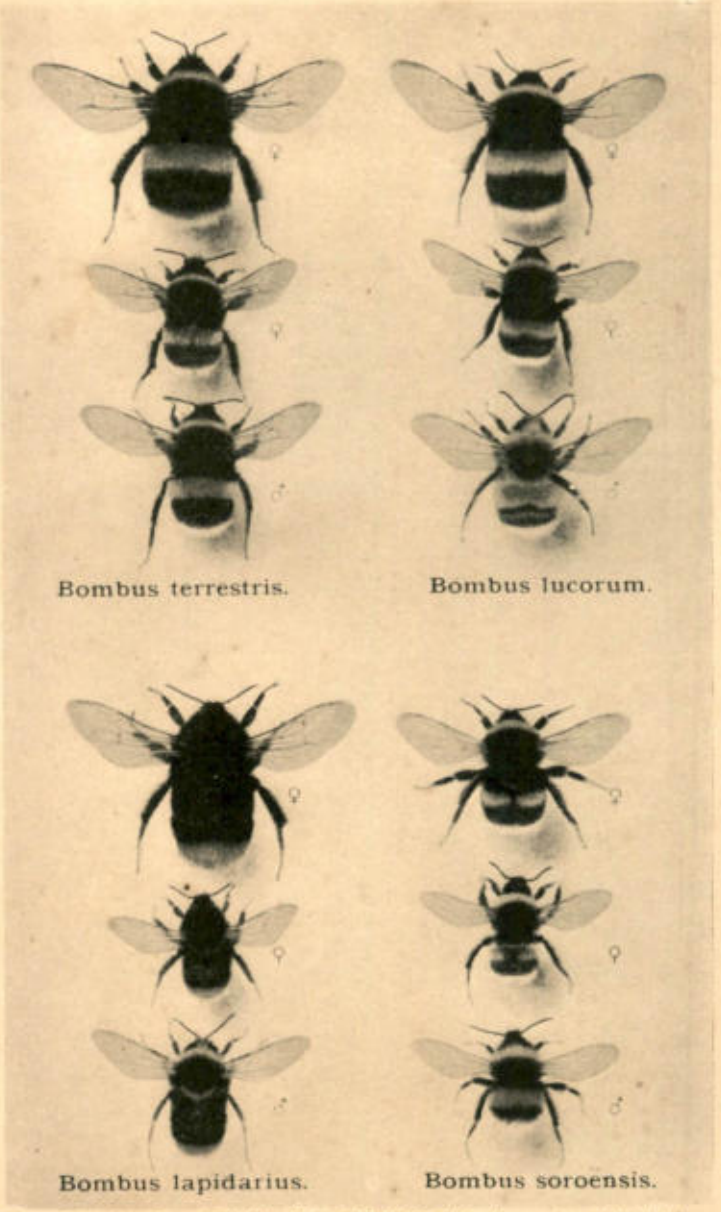


Photo: Reproduced from "The Humble-Bee," F. W. L. Sladen, by courtesy of the publishers, Messrs. Macmillan & Co.

TYPES OF HUMBLE-BEES (Natural size).

These are four species of pollen-storing British Humble-Bees. In each case the group of three individuals consists, from above downwards, of a queen, a worker, and a drone. The English names are: Large Humble-bee (*B. terrestris*), Small Earth Humble-bee (*B. lucorum*), Stone Humble-bee (*B. lapidarius*), and the Ilfracombe Humble-bee (*B. soroensis*).

But the deadliest enemy of all is one of the Bumble-Bee's own zoological household (i.e., Bombus), namely, the Usurper-Bee, whose technical name of Whisperer (Psythirus) is suggestive of its soft hum and its underhand ways. This is one of the most remarkable facts about Bumble-

Bees that some species have "Whisperer" doubles so like them that only an expert can tell the difference. One kind of "Whisperer" frequents the nests of the Stone Humble-Bee, another is associated with the Large Earth Humble-Bees. They occur as males and females, but there are no workers. The females have no pollen-collecting apparatus, their skin is thick and hard, their sting is stouter and more curved than in Bombus, they are slow and awkward in getting food for themselves, they sneak into the nests of the industrious Bumbles, they sting the queen to death, and get the workers to work for them and rear their offspring. Mr. Sladen notices that the Usurper female seems to ingratiate herself with the workers, while the rightful queen becomes strangely despondent. The unequal struggle between rightful queen and usurper seems to be evaded until the intruder is about to lay. The Humble-Bee queen cannot stand *that*, and she does not usually survive to witness it, for the issue of the combat is, according to Mr. Sladen, a foregone conclusion. The "Whisperer" wins. Other observers have reported that there is sometimes a rather ignominious compromise, as the outcome of which the Humble-Bee workers minister to the invaders. It is very interesting to find strong evidence that from the "Whisperer" has evolved as an offshoot the Bumble-Bee race in relatively recent times. It is a rather disreputable new departure; evolution is not always progress. Perhaps we should mention that the males of the "Whisperers" keep outside this strange tangle, and play about in the flowery meadows, seeking for mates.

The part of the Humble-Bee's life-history that we wish to emphasise is the contrast between the busy summer life when there may be two or three hundred bees about the nest and the tragedy of autumn when all die off or are killed except some young queens that rest through the winter and start fresh families in the early spring.

The Salmon's Year

The anatomist becomes so familiar with the body that he can see right through it with his eyes shut, and picture every organ in its proper place. So the naturalist gets to know some animals so well that the story of their year unrolls itself before him as in a film. No doubt there are in many cases gaps and jerks which represent the imperfections in the naturalist's knowledge, but for a good many animals like the frog and the eel, the gnat and the bee, the film is almost continuous. The salmon is one of these well-known animals, and the task nowadays is to pass from the well worked-out consecutive description to a study of the physiological and historical impulses behind the events. Just as palæontography —a description of the succession of animals in the

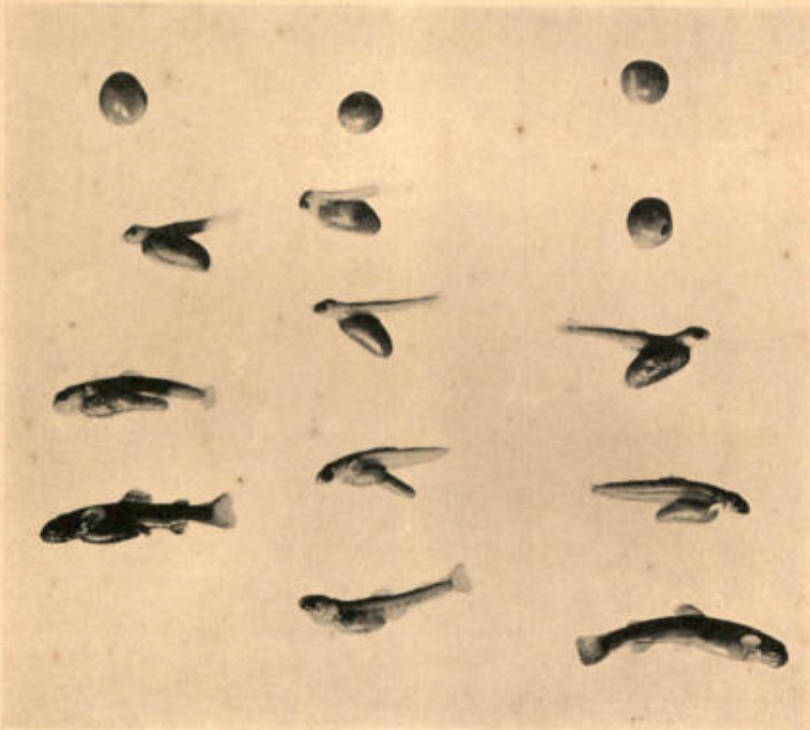


Photo: J. Arthur Hutton.

DEVELOPMENT OF THE SALMON.

The spherical egg develops into an embryo, and when the egg-membrane bursts this is hatched out as an "alevin." This is weighed down with a large yolk-sac, which furnishes food for a month or two. When the yolk-sac has been absorbed, the young fishes are about an inch long, and are called "fry." But this term is often used to include the "alevin" stage.

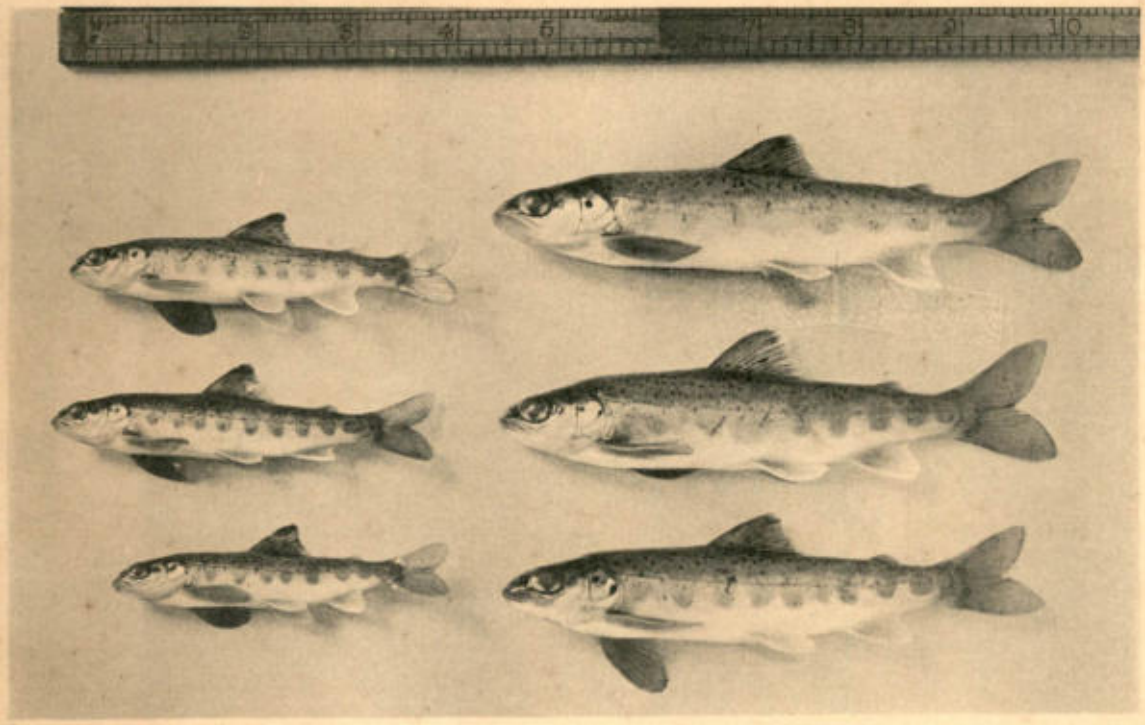


Photo: J. Arthur Hutton.

SALMON PARR FROM THE WYE.

These young fishes are from six to eighteen months old, and the parr stage continues till an age of about two and a quarter years is attained and a length of about six inches. The parr is marked by seven to eleven large bluish marks, oblong to oval in shape, along each side.

rock-record—passes slowly into a true palæontology, an account of the factors in the racial history or evolution, so in the study of life-histories must we try to pass from the 'graphy to the 'logy, if one may so say. But the sequence of events in the salmon's year is what concerns us here.

During the coldest part of the year, about midwinter, the female salmon ploughs her furrow in the gravelly bed of the stream, often seeming to choose a stretch where the stones are not too unstable. With strokes of her tail she makes the "redd," and the eggs pass from her like amber-coloured beads. With flicks of her tail she half covers them with small stones, and the male liberates upon them the fertilising milt, which is very largely washed downstream and wasted. This spawning may be observed by day, but in most cases, we believe, it takes place in the darkness. Mr. W. L. Calderwood, Inspector of Salmon Fisheries for Scotland, has called attention in a recent paper to the interesting combination of adhesiveness and resilience in the newly extruded salmon's egg. For a short time after fertilisation the egg is slightly adhesive, and is not very easily detached from stones by the current. At the same time the egg readily rebounds from stones which it strikes. "The egg may be likened to a gummed ball which will still bounce off objects, but when once at rest will slightly adhere to any of them until, as it were, the gum is washed off." In spite of this, there must be a considerable wastage, not by crushing, but by washing away; and among the eggs that are safely caught among the stones there is about fifteen per cent. of failure because of non-fertilisation. Nature works with a big margin, however, and a salmon weighing twenty pounds may liberate 17,000 eggs. Not that this is a large number compared with that produced by marine fishes like the cod and the conger-eel.

Vital processes involve chemical reactions, and these are quickened or slowed by higher or lower temperature. Thus it is readily intelligible that the salmon's egg should develop very slowly in the cold water in the winter months. With great deliberation—so unlike the hurry of the blow-fly's egg developing in the exposed flesh on a summer day—the salmon's egg realises its inheritance. Out of the apparently simple there is built up the obviously complex; brain and eyes,

heart and gills, "in continuance they are fashioned while as yet there is none of them." When about three months have passed, the eggs hatch.

Out of the eggs come alevins, encumbered by their legacy of yolk, which protrudes in a ventral sac and hinders rapid movement. The alevins move in a helpless sort of way in the chinks among the stones, and they are anything but obtrusive. The yolk-sac becomes smaller and smaller, however, and in a month, or it may be in two months, the alevins have changed into inch-long, freely moving fry, able to fend for themselves.

Photo: J. Arthur Hutton.

A trout at the top, then a parr with marks, and then three smolts. The scales have been partly removed from the two lower smolts, to show the darker parr colouring underneath the scales. A smolt is a young salmon about to go down to the sea or on its way. Its silvery sea-jacket masks the parr markings. See "The Life-History of the Salmon" (1923), by Mr. J. Arthur Hutton, to whom we are greatly indebted for the photographs.

It is now April, about five months after the liberation of the eggs, and the waters show the usual spring renascence of small animals, such as insect larvæ. These furnish food for the salmon fry, which may be seen darting about in pursuit, often coming near the surface. They may grow from an inch and a third in May to three inches in October, when the food supply gives out. The fry have to live a very quiet life throughout the winter.

In the second year the fry grow into parr, which often reach a length of five or six inches. They are like small trout, but much more graceful, and they show eight or nine more regularly arranged "finger-marks" on each side of the body. These marks are due to patches of cells containing dark pigment; they belong to the under-skin or dermis, and they are seen through the transparent scales and through the transparent epidermis which lies outside everything.

In the following spring, when the young fishes are beginning their third year—of course, there is considerable variability in the punctuation—the parr changes into a smolt. The scales have become more substantial and more silvery, and this masks the parr's "finger-prints." The smolt puts on its silvery sea-jacket, and there is a subtle change in the constitution. In some way that we do not yet understand the smolt hears the call of the sea. There is probably some internal chemical messenger or hormone at work; at any rate the fish becomes restless. Imprisoned smolts have been known to throw themselves out of the tank when the call came.

In the salt water, with its abundant nutrition and stimulus, the smolts change into grilse, but the intermediate phases are little known. The scales of a grilse show, for its sea-life, a summer zone, a winter-band, and the beginning of a second summer zone; and at that age, say three and a half years old, the grilse may enter the river in the summer months, to spawn in the fall of the year. But there are some fish that pass

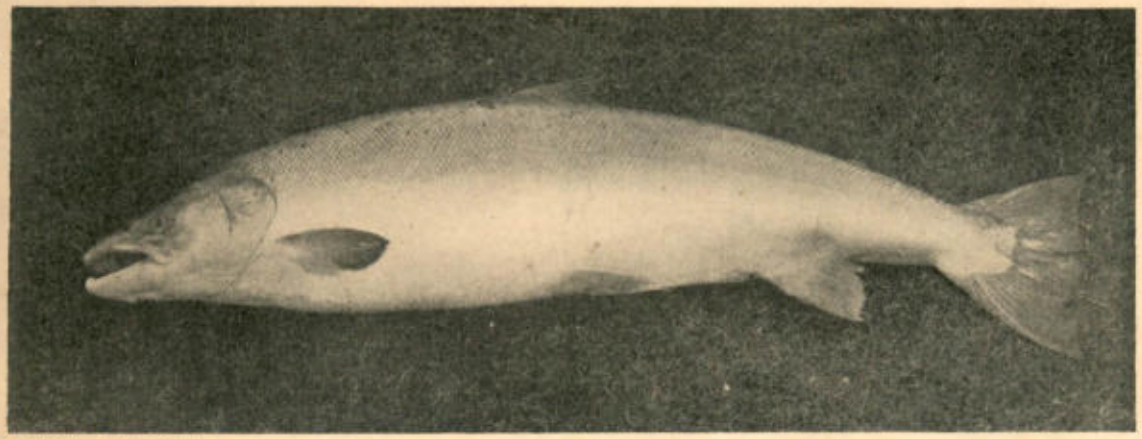


Photo: J. Arthur Hutton.

An unspawned male salmon, a spring fish, weighing thirty-six pounds. There are very few spots on the gill-covers, and not many on the body, none below the sensory lateral line.

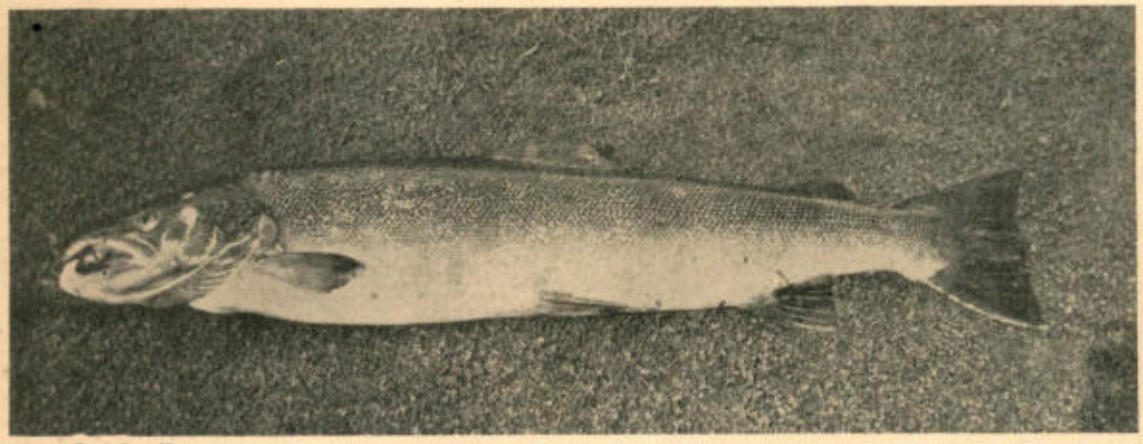


Photo: J. Arthur Hutton.

A male salmon in full "spawning livery," an autumn fish, weighing thirty pounds, just before spawning. The lower jaw is turned up into a "beak," a mark of a mature male.

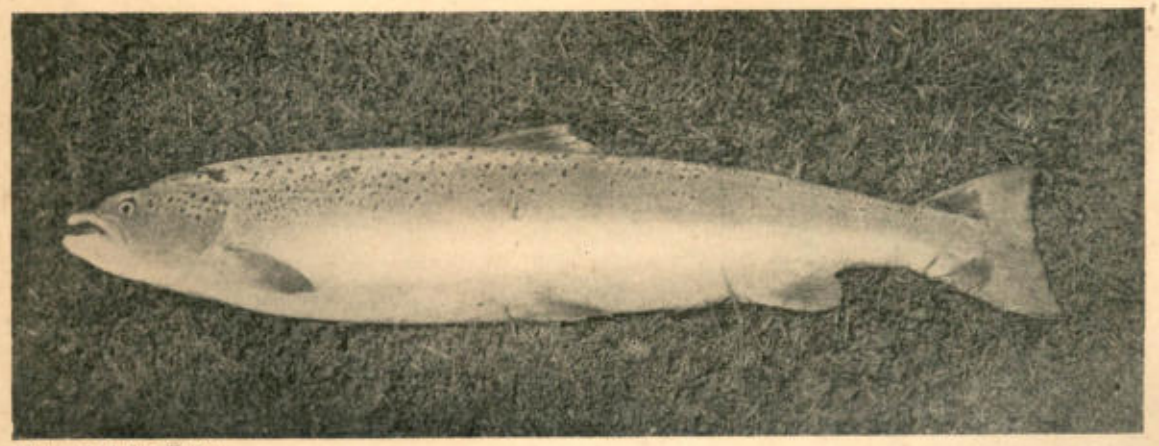


Photo: J. Arthur Hutton.

A female salmon—a female spring-fish that has spawned, weighing twenty-six pounds. There are numerous spots on the gill-covers, and there are also many spots and "speckles" on the body, both above and below the lateral line. These always indicate that the fish has spawned.

through their grilse stage without ascending the rivers, so that what spawns is a salmon. Moreover, some salmon remain in the sea till they are five or six years old. The fact is that salmon show notable individuality, so that the precise shape of the life-curve differs in different parts of the country, and even in the same river for different types of fish.

There is some work to be done in discriminating the structural and constitutional peculiarities of different stages in the salmon's life-history. Thus, although a grilse is well known to differ from a perfect salmon in shape and scales and teeth, the definition requires to be made more precise. The same may be said in regard to the differences between a "maiden fish" and a "kelt," spent after spawning.

The life-history of animals has often been likened to a Mirza bridge, which only a few individuals succeed in crossing. How true this is of the salmon! How many eggs are swept downstream, how many are left unfertilised. Eels seek out the alevins, trout gulp down the fry, pike devour the parr, coalfish wait for the smolts at the mouth of the river, seals harry the grilse in the sea, the kelt devours its own kind, and the otter finds the spent kelt an easy prey.

The word salmon means "leaper," and the ascent of the rapids is the climax of its life—and an emblem of the insurgence of living creatures in general. We have spoken of the salmon's individuality, and that is to be kept in mind when we discuss whether the conquest of the river is or is not achieved on an empty stomach. Some salmon coming up from the sea may have an occasional meal or be tempted by the reminiscent or merely intriguing bait; but the big fact is that the adult salmon, urged against the stream, is *in the main* living on the store of energy it accumulated in the sea. We wish we could make up our mind whether the salmon is an aboriginal fresh-water fish that has taken to colonising and exploiting the sea, or whether it is an aboriginal marine fish that has learned to seek spawning-safety in the rivers. But whichever answer is given, we must hold to the illuminating idea that the salmon is "a historic being"—a personality at a fish-level—whose present behaviour is ruled by a past that never dies.

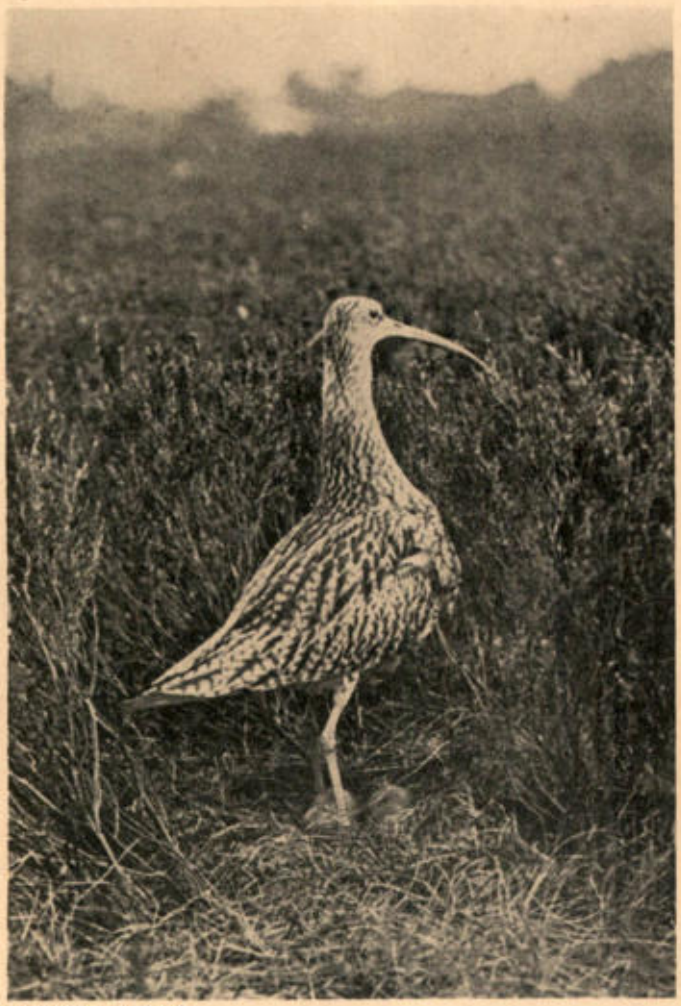


Photo: Jos. A. Speed.

CURLEW ON THE ALERT.

The Common Curlew (*Numenius arquata*) belongs to the same family as the snipe and sand-piper, and, like these birds, possesses a bill long enough to reach the small creatures on which it feeds in boggy ground. All summer it lives on the moor; but in winter frequents the sea-shore. "Cur-lee, cur-lee," is the plaintive cry to which it owes its name.

The Curlew's Year.

As another creature to follow through the year take a very attractive bird, the curlew. All through the long winter in the North there are great flocks of curlew about the low-ground fields and along the shore. Often we have counted fifty together—a merry throng, though

Photo: John Armitage.

THE CURLEW BROODING.

The Curlew makes a rough nest of leaves or dried grass in a tuft of rushes or among thick heather, and there lays its three or four large eggs. The plumage, which has much the same colour as the lark's, blends perfectly with the surroundings, making the bird very inconspicuous as she sits.

their cry is plaintive—"Cur-lee, cur-lew, cur-lee." It is in the wet sand and in the shallow pools that they probe so successfully for all manner of small shore animals. The curved bill is about six inches long, and very sensitive at the tip, as is usual among wading birds, for the food is felt rather than seen.

When there is much snow on the hills and on the moorland the curlews in the North of Scotland do not leave the shore till the beginning of April. They hurry away when the weather changes for the better, and with their courting calls they make glad the lonely places of the hills. Of the summer calling, Burns said: "I never hear the loud, solitary whistle of the curlew in a summer noon . . . without feeling an elevation of soul like the enthusiasm of devotion or poetry." But what we hear in spring is not the sober summer call; it is exuberant and joyous; it has a beautiful trill; it is a rippling song. The male bird climbs high in the air and poises like a hawk; he sinks and rises, he circles and hovers again, and through all the aerial evolutions he hardly ceases to cry "Courlie, courlie, courlie."

The nest is simply a depression in the ground, with a lining of dead grass; and there are four large olive-brown or greenish eggs with cinnamon spots. There are often several false "nests," which may distract the enemy's eye. Possibly, however, they only mean that the birds began to sit and then saw a place they liked better.

The parents are quite alike, except that the hen-bird is slightly larger; both brood, and they often sit very close, their variegated brown plumage being well suited for concealment among the heather or withered herbage. When danger draws very near the nest, the bird slips off and runs a bit, or, if that is not practicable, takes wing at once. When the fluffy grey-buff young ones hatch out, the parental care becomes even more intense. As we approach, we may hear the slightly sibilant danger note, and the male rises, making the moorland ring with his protestations. They say curlews have about

ten words altogether. When we pass out of sight the alarm-cries cease, and the male settles down beside his mate, with " a musical utterance of satisfaction, a long gurgling and quavering note, exceedingly wild."

People sometimes ask how anything like the proportionate length of the curlew's bill can be accommodated inside the egg during the month of development, and the answer is biologically interesting. The young curlew has a short, straight bill, like a plover's. Here is a hereditary character which does not find expression for some weeks after the chick has stepped out into the world. The young curlews are charming; their mottled brown suit hides them; they have the instinct to scatter and squat when the danger-note is sounded.

Photo: T. M. Blackman.

YOUNG CURLEW, THREE OR FOUR DAYS OLD.

Like the chicks of the domestic fowl, the young Curlew can run and peck as soon as it is out of the egg, and at three days old, the age here represented, it is already a quick traveller and very independent. It well deserves to be called "precocious."

The birds spend the summer on the moorland, searching for insects and worms, snails and slugs, with berries as dessert. But as the food becomes scarce and the daylight short, the birds begin to congregate in flocks. For they are as gregarious in winter as they are solitary in summer. In August we see the V-shaped flying phalanx, making for the shore. The flight is very rapid, for the wings are long and the breast-muscles powerful, but as the birds come near we can see the trailing, slate-grey legs and the long decurved bill against the sky. We know that another summer is over as we hear them cry " Gur-lech, gur-lech."

Compared with the Virginian Plover's flight from Labrador to Brazil, or the Pacific Golden Plover's flight from Alaska to Hawaii, across the waste of seas, how small the curlew's migration seems—from the moorland to the shore. Yet it is in principle the same seasonal mass-movement from a breeding and nesting place to a feeding and resting place. Be the journey long or short, birds always breed in the colder part of their migratory range. Moreover, although some of the British curlews have a very short migratory journey, there is often an autumnal influx of large flocks which reach our shores from the more northern parts of the Continent.

The curlew's first cousin, the whimbrel, is chiefly a bird of passage in Britain, breeding further north, and wintering further south. It is about ten inches shorter than the curlew (which is about twenty-six inches long), and it is less of a shore-bird. To its rippling whistle, often seven times repeated, it owes its name, " Seven Whistler," and another name, " Titterel," is also suggestive. Dr. Masefield writes:

" And like the shaking of a timbrel
Cackles the laughter of the whimbrel."

Burns and Robert Louis Stevenson and many others have expressed their love for the curlew, and who will not join in the tribute? The plumage is beautiful, and so are the hazel-brown eyes; the long bill seems to balance the long legs; the flight is perfection, and the birds can swim as well as run. They are courageous creatures, not hesitating to attack intruding birds of prey; they " feign injury " when driven off their eggs; they have a good vocabulary. In every way they are admirable and attractive.