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American Crocodile	Cuvier's Cayman	Mugger Crocodile
Cuban Crocodile	Paraguayan Cayman	Siamese Crocodile
Central American Crocodile	Schneider's Cayman	Malayan Gavial
Orinoco Crocodile	Nile Crocodile	Chinese Alligator
Central American Cayman	West African Crocodile	Salt-water Crocodile
Spectacled Cayman	Rough-backed Crocodile	Australian Crocodile
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BULLETIN

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Members of the Zoological Society are entitled to all Publications, Reports, Bulletins, Zoologica, etc. (Zoologica mailed by request only) and no effort will be spared to ensure their delivery. Changes of address, forwarding points and non-delivery of mail should be stated promptly. Contributions pertinent to the objects of the Bulletin cordially welcome. Stamped and return envelope should accompany communications. Editorial and Subscription Offices, Zoological Park, New York City, Elwin R. Sanborn, Editor.



American alligators in the Reptile House in the Zoological Park. The alligator pool of the Reptile House is a constant source of attraction to visitors. Cypress logs, spanish moss, and a background of tropical vegetation provide a realistic setting.



BULLETIN
NEW YORK ZOOLOGICAL SOCIETY

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Vol. XXVI

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No. 1

The Crocodilians of the World

The Alligators, Caymans, Crocodiles and Gavials of today, by C. RALPH DE SOLA,
with a Foreword to the paper by RAYMOND L. DITMARS, Curator
of Mammals and Reptiles, Zoological Park

The illustrations in this article are from photographs in the collections of the New York Zoological Society, and unless otherwise noted, many of these are studies of living crocodilians taken in the New York Zoological Park and the New York Aquarium

Foreword

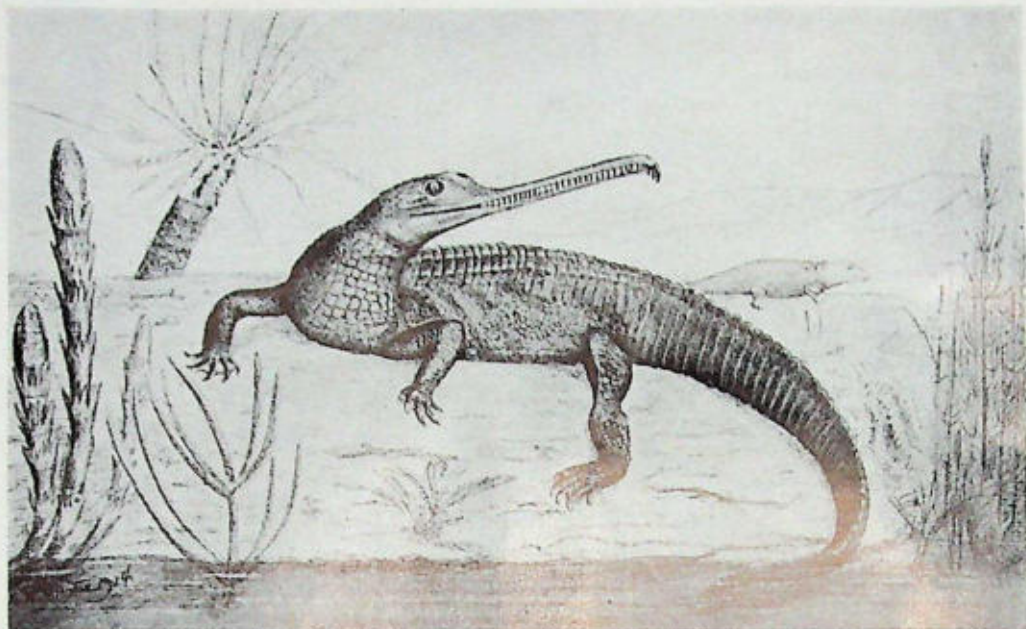
WHILE the crocodilians are by far the smallest order of the reptiles in regard to the number of species, there being, in fact, less than twenty-five different kinds, they form the most impressive grouping. In their massive proportions, they far exceed average weights and lengths of the Chelonians (turtles and tortoises), with over two hundred kinds, both land and marine, and the average from among the larger members of the great order of scaled reptiles, with nearly five thousand species of lizards and snakes.

From numerous fossil remains in Europe and North America, it is indicated that crocodiles, caimans and alligators formerly existed in a much greater variety of species than at the present, but that their size did not much exceed that of the surviving kinds. This condition renders the group particularly interesting, in pointing to the crocodilians being the most ancient types of existing reptiles, surviving remnants of life from past ages, carrying through an illustration of the size and curiously plated forms of remote times.

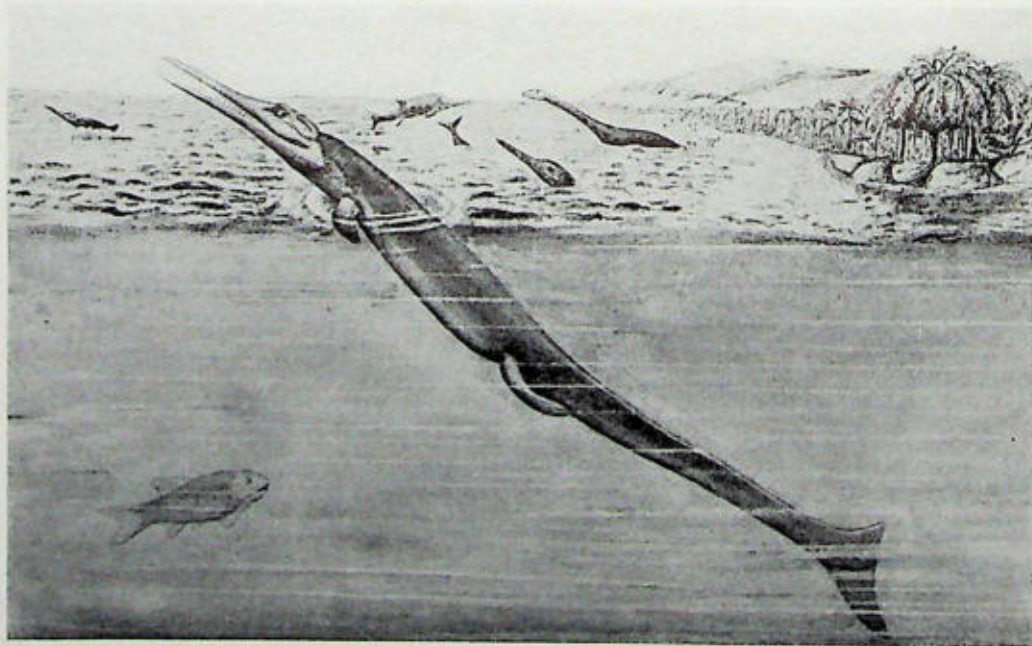
In the reptile collections of the Zoological Park, crocodilians have always formed an important part, both from the standpoint of exhibition value and of scientific study. With care-

fully designed, heated tanks, of commodious proportions, in which we have figured that conditions closely approach the natural environment of these creatures, we have made numerous studies concerning their growth. It has been determined that they grow faster than previously alleged, and that maturity may be reached within a period of ten years, although they continue to grow slowly after attaining a breeding age. It is probable, however, that crocodilians attain the greatest age of any living creatures of the world, surpassing the ages of tortoises, which, by recent observations, develop much faster than crocodilians.

The longest record of any specimen in the Zoological Park collections is that of an American alligator, which is still living, and was acquired by the writer approximately forty years ago. Two alligators, continuing to thrive in the Park collection, were hatched in the Reptile House from eggs brought from South Carolina in October, 1900. These three record specimens are slightly in excess of seven feet in length, and may never attain additional length, as all came from an area where impressive dimensions of alligators are seldom recorded. Truly large alligators, twelve feet and over, were well beyond the average, even many years ago when alligators were



Fossil Crocodile *Mystriosuchus*. The crocodylians of the Lower Jurassic period in the great Reptilian age, the Mesozoic, were well armored, related to the dinosaurs, and somewhat resembled our contemporary gavials in appearance. A specimen of this species exhibited in the British Museum shows quartz pebbles in the stomach-contents which are stained black with the sepia ink of cuttlefishes it devoured. This restoration was drawn by the late Dr. S. W. Williston and is reproduced from his "Water Reptiles of the Past and Present".



Fossil Crocodile *Geosaurus*. The adaptation of a crocodile for marine life is depicted in this crocodile taken from the European rocks of the Upper Jurassic. Williston after Fraas.

numerous in southern rivers. This American species is considerably surpassed in size by the average dimensions of crocodiles.

The following article has been prepared by Mr. C. Ralph De Sola, and is the result of an examination of a considerable number of scientific

articles and papers relating to crocodilians, checking changes in taxonomy, hence the presentation of a modern *resumé* of the group, in readable terms. The article also serves as a vehicle for the presentation of a valuable series of photographs of the crocodilians.

Introduction

THE very remote ages of geologic antiquity witnessed the appearance of the crocodilians. It is believed that this group of present day reptiles has sprung from the dinosaurs and their congeners the geosaurs. They are comparable to these fossil orders in both size and strength. They are the largest of living reptiles as to proportions of bulk and length, one species attaining a length of approximately thirty feet.

Less than a hundred years ago travelers and scientists of reputed veracity testified to the wonderful abundance of the order throughout the tropical world. Today every swamp and marsh, river and estuary, pond and lake of the tropical latitudes gives its toll of these reptiles to hunters.

Regarding their ferocity and danger to man it may be broadly stated that while their predatory instincts are strongly developed, many species are timid and flee at the approach of man. Unless cornered or captured during a hunt these reptiles are most wary and make every effort to escape from the vicinity of the hunter. Crocodiles, however, show a distinctly fierce and sulky temper as compared to alligators. In many localities of Africa and Asia it seems that certain old and wily individuals turn into man-eaters in much the manner of tigers and lions.

New World Crocodilians

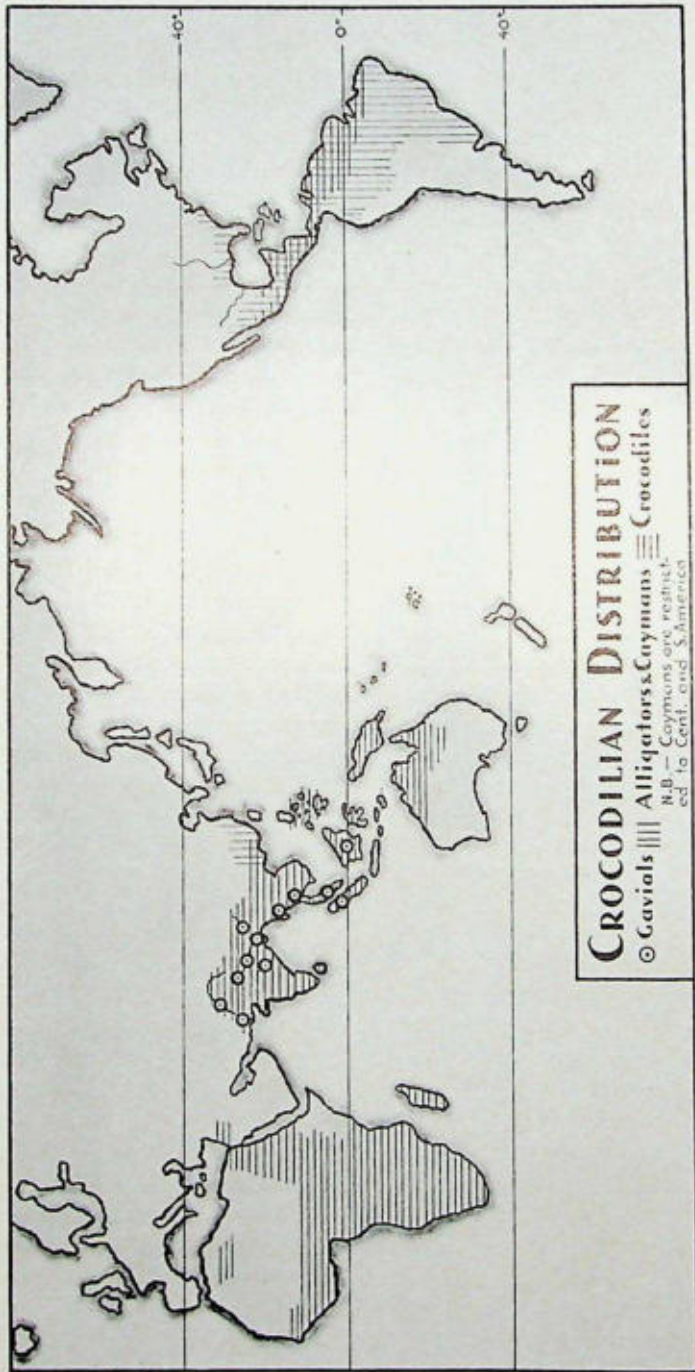
Perhaps the most valuable member of the reptilian fauna of the United States is the American alligator, *Alligator mississippiensis*. It is not surprising that the early Spanish *conquistadores*, filled with mythological lore of dragons and lizards, mistook it for a great lizard and in this connection it is interesting to note that the name "alligator" is a corruption of the Spanish word for lizard—*el largato*. The name "alligator" is used indiscriminately in many parts of the world to denote a crocodile, particularly in Australia.

In some of the coastal parishes of Louisiana the outlawing and killing of these harmless creatures has resulted in their near decimation and both Florida and Louisiana have found it necessary to pass conservation laws to restrict the hunting seasons and protect the eggs. The food of the alligator is diversified, consisting for the most part of crustaceans, but fish, turtles, birds or small mammals are a welcome change of diet, as well as insects, these last forming about twenty-five per cent of the food of young individuals.

The American crocodile, *Crocodilus acutus*, has a range more extensive than any of the New World crocodilians. Habitat records and personal observations show that it is found in southerly Florida, throughout the Greater Antilles, except Puerto Rico, and is known from both coasts of Central America where it ranges from Mexico into northern South America. In Cuba the *caiman*, as it is locally known, is actively pursued for its valuable hide and this practice has rendered the animal almost extinct in that Island, as well as in Haiti and in Jamaica, where it has retreated to the northern and eastern coasts, especially near the mouths of the Milk and Black Rivers.

Prior to my expedition to Cuba in 1929, the New York Zoological Society lacked an example of the Cuban Crocodile in their collection of live reptiles at Bronx Park. The notes contained in the field log book of this trip follow with an account of the capture and transportation of the crocodiles obtained from El Tesoro, a freshwater lagoon in the heart of the Zapata Swamp of southern Cuba.

"Cienaga de Zapata, April 20: Near the open part of the lagoon we caught five small crocodiles in an eroded limestone stream bed. Up on a mud flat and near the sluggish water, our quarry were sleeping and we had quickly secured them in a



Map of Distribution. It will be seen that crocodilians never are found in latitudes exceeding the fortieth parallel, this being their northerly and southerly limit and that almost all tropical countries claim one or more species of crocodilians in their faunas. Map prepared by the author.

burlap bag before biting could begin. Went out into the lagoon in a small boat of native manufacture, a *chalana*. The lagoon is a tremendous lake with many inlets that branch into the swampy reed beds. These are not more than four feet wide. The noon temperature was 101 degrees F., and the water registered 81 degrees on the same scale. Hot strong glare and little shade is encountered in the great vista of tall and sharp swamp grass. Many small birds are aloft and seem to chirp a noise not unlike the accentuation of, *cocodrilo, cocodrilo*, a pause and then again, *cocodrilo, cocodrilo*. (*Cocodrilo*, strangely enough, is the local name for this species, *C. rhombifer*.) We burned the reed beds of the lagoon so as to drive out our quarry. Later in the morning at a nearby inlet we walked into the still and muddy water up to our waists. We saw a movement ahead of us and almost instantaneously saw a large crocodile slide and crawl from its sunny reed couch and disappear into the deep channel of water. We followed close and I cast my lasso that was affixed to the end of a four-foot pole over its gaping jaws. My helpers secured its fast-swinging tail and with a lot of struggling we landed our catch in the reed beds. Here we tied the limbs and jaws fast and slinging the crocodile to a pole made off for camp. Arrived at the camp about 4 P.M. and hired some charcoal burners to transport the specimens to the nearest railroad station. Our route was over a single track road and our means a hand car. A steady push of thirty miles got us into Jaguey. Here I placed my specimens in my hotel room and retired. The night was not very restful, as I was frequently disturbed by the struggles of the big crocodile which was constantly getting loose. I finally lashed her to my bedstead and slept until dawn. April 21: Found the local carpenter and built two crates. Accompanied them on the Havana train and wired to Dr. Blair to notify him of their projected arrival on the *Toloo*."

For many years the Central American crocodile, *Crocodylus moreletii*, had been cast in the synonymy of the Cuban crocodile, *C. rhombifer*, when Dr. K. P. Schmidt of the Field Museum, rediscovered it. In the Sibun Swamp, near Belize, British Honduras, it is found on the shores of the lakes and irrigation ditches that fill it. In skull and body outline the Central

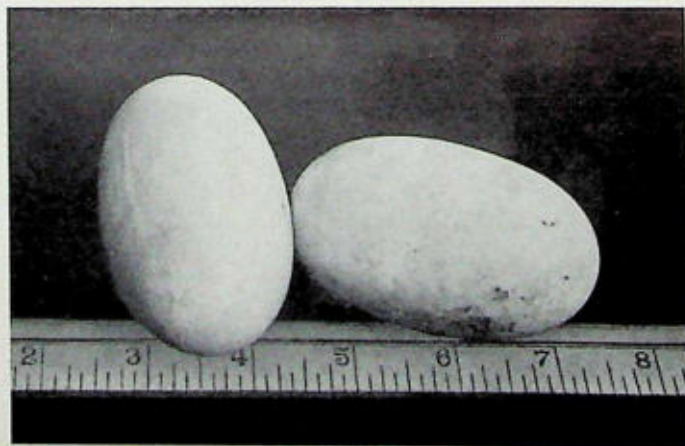
American crocodile is strongly suggestive of its Cuban ally and only very slight cranial differences serve to distinguish them. Little is known concerning the range of this crocodile, although Schmidt gives it as being from "Tampico to Belize." Possibly it is restricted in much the manner of the Cuban crocodile and will eventually disappear under the machete and gun of hide hunters.

The crocodile of the Orinoco, *Crocodylus intermedius*, is noted for its ferocity and great length. Baron von Humboldt in 1800, reported seeing specimens of twenty-five feet. However, a recent expedition of the National Geographic Society to this region records finding nothing over ten feet in length and strongly discredits Humboldt's observations as being the result of his helper's imaginations. This crocodile is endemic to the entire area of the Orinoco delta and the adjacent Guianas. It does considerable damage to the natives who retaliate by destroying its nests. Its presence has a decided effect on convicts quartered in the bush of French Guiana whose attempts at freedom are inhibited or suddenly frustrated by the dreaded man-eater. Death from this crocodile is indeed terrible:—a side-swipe of the powerful tail, a crackling report of closing jaws, a few bubbles rising from the river bottom—the prey is finished. The body is dragged off to some submerged hole and the reptile returns to eat it when decomposition has set in. Over 200,000 skins of this species and its neighbors, the caymans, were exported during 1930 and still the crocodilians remain in sufficient numbers to menace the local population.

The seven crocodilian species of caymans live in the great, warm pools formed principally by the Magdalena River of Colombia, the Orinoco of Venezuela, the Amazon and its tributaries in northern South America, and the Plate of the Argentine. Flowing through tangled, tropical vegetation for thousands of miles, eddying and swirling past fallen trunks, lazily lapping the sandy mud-flats of their mouths, these fluvial waters provide the natural habitat for the alligator-like caymans, spectacled caymans, smooth-fronted caymans, the former with horny ridges around the eyes, the latter less professorial in appearance. The spectacled type is distinguishable from all other crocodilians by the presence of a transverse, bony ridge between its eyes. Both



Crocodilian Respiration. The most remarkable feature in the physiology of crocodillians is their manner of breathing when eating under water or partly submerged. Skull examination reveals that their posterior nostrils are set so far back in the head and are so well separated from the cavity of the mouth by a bony palate that it is impossible for water to enter their breathing passage. Two valves at the back and sides of the mouth prevent water from running down their throat into the gullet. A study of the circulatory system reveals the highest state of development found among reptiles. The heart is four chambered and supplies blood to the head, trunk, and tail through an aorta in much the manner of higher vertebrates. Photograph by Raymond L. Ditmars.



Alligator Eggs. Crocodillians lay hard white eggs about two and one-half inches long by one and three-quarter inches in diameter. In most cases the nest is prepared during the day by heaping together masses of dead vegetation and placing a hollow in the center. The eggs are laid in this and carefully covered with earth and twigs making a hard compact mass. The sun's heat plus the moisture generated inside the nest by the decaying vegetation incubates the eggs in about nine weeks. In some dry sandy localities the eggs are laid in holes during the wet season. Photograph by Raymond L. Ditmars.

types are abundant and cover vast geographical divisions of the southern continent.

Through southern Mexico, the Central American republics and eastern Colombia ranges the smallest present-day crocodilian known to man. This four-foot loricate is the Central American cayman, *Caiman fuscus*, the species so often seen by travelers passing through the Panama Canal. Here the wake of the passing steamer stirs the shore line, a muddy shore line with occasional log-like objects breaking its monotony. With the wake, metamorphosis takes place—the log becomes a reptile and the reptile turns for the deep turbid waters of the Isthmus. Some hundreds of miles southward we find the cayman in the Magdalena. The river indians of Colombia's great stream call it *babilla* and while they do not fear it their capture of it seems courageous. Lashing two pointed stakes crosswise and attaching a raw-hide rope to the intersection, they coil its free end about their waist and stalk through the reed beds, half-submerging themselves below the river bank. In one hand they hold the outthrust stakes while the other hand quietly slaps the water in a manner calculated to imitate a domestic animal's drinking. Thus they await their prey. Several hours' patience brings its reward—a hungry *babilla*, over-anxious to gorge. Rushing to the point of the sound, tail lashing, jaws agape, the cayman closes on the extended arm. The stakes are firmly implanted and wedged in its oral cavity, the indian is up the bank, and tugging. A stroke of the machete and another valuable hide is made ready for export. This is rubbed with salt on the flesh side while the tail is carried home to the al fresco kitchen and provides a delicacy.

The dark-olive, brown-skinned cayman of northern South America, *Caiman sclerops*, the spectacled cayman, ranges from Eastern Panama to northern Brazil where it is spoken of as *jacare-tinga*. The pronounced, horny protuberances about its eyes give it its name.

The young of most crocodilians are hard to tell apart; however, the juvenile representatives of this species are of a golden-brown body color, speckled with black, the underparts being muddy colored.

The largest and most powerful representative of the caymans is the *jacare-assu*, *Caiman niger*,

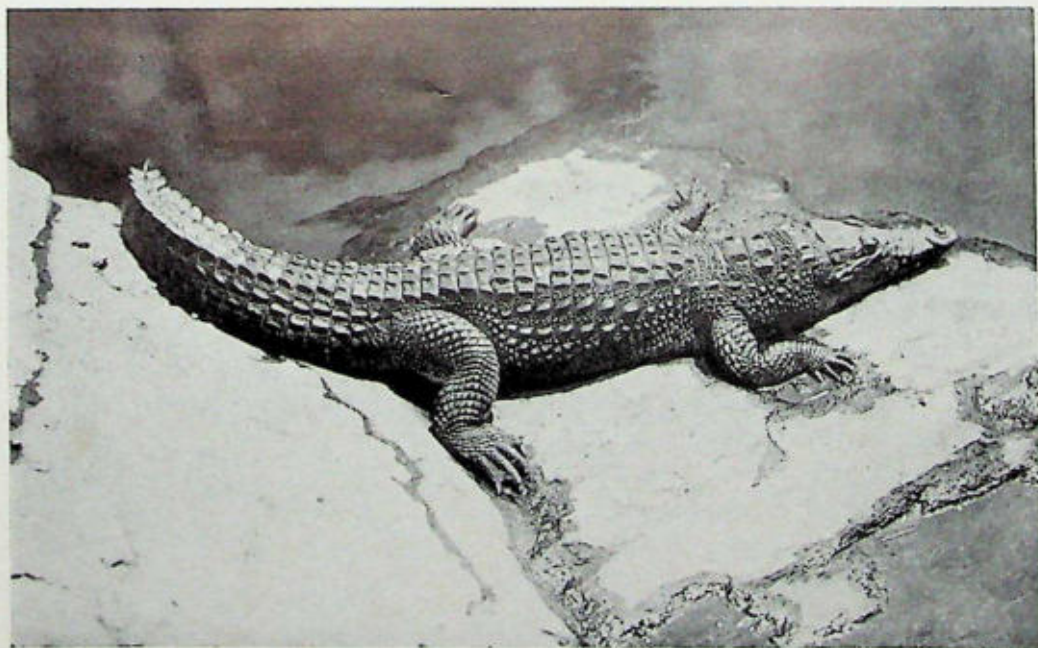
of the Amazon Basin. The body is evenly scaled, black colored above and yellow beneath; the coloration of the body and the distinct, alligator-like skull, at once distinguish the Black cayman from all others. Occurring in the heart of the little known and unexplored interior of Amazonica the Black cayman is feared by the natives who are ever ready to tell tall tales concerning its size, prowess, boldness, and voraciousness. The females lay from thirty to forty eggs in a hole which they form with leaves, river slime, and the reeds of the river shore. The food of the species consists of fish, of which there are many in the Amazon, large river turtles, and mammals which are seized when they come down to the water to drink.

Two species of caymans, lacking spectacles and hence "smooth-fronted", are known from northeastern South America. From the Orinoco to the Amazon they may be seen in great numbers along the river banks, especially during the dry season. The smooth-fronted caymans were originally described by two eminent European naturalists of the early nineteenth century and are known respectively as Cuvier's smooth-fronted cayman, *Paleosuchus palpebrosus*, and Schneider's smooth-fronted cayman, *P. trigonatus*. At the end of the prolonged dry season, many river turtles, emerging from the mud in which they have aestivated, are actively pursued and consumed by these caymans. Such food might seem meagre fare were it not for the fact the species eaten is the largest of fresh-water turtles known, *Podocnemis expansa*. It is about three feet long and so abundant that thousands may be seen at one time on the cayman-infested river islets.

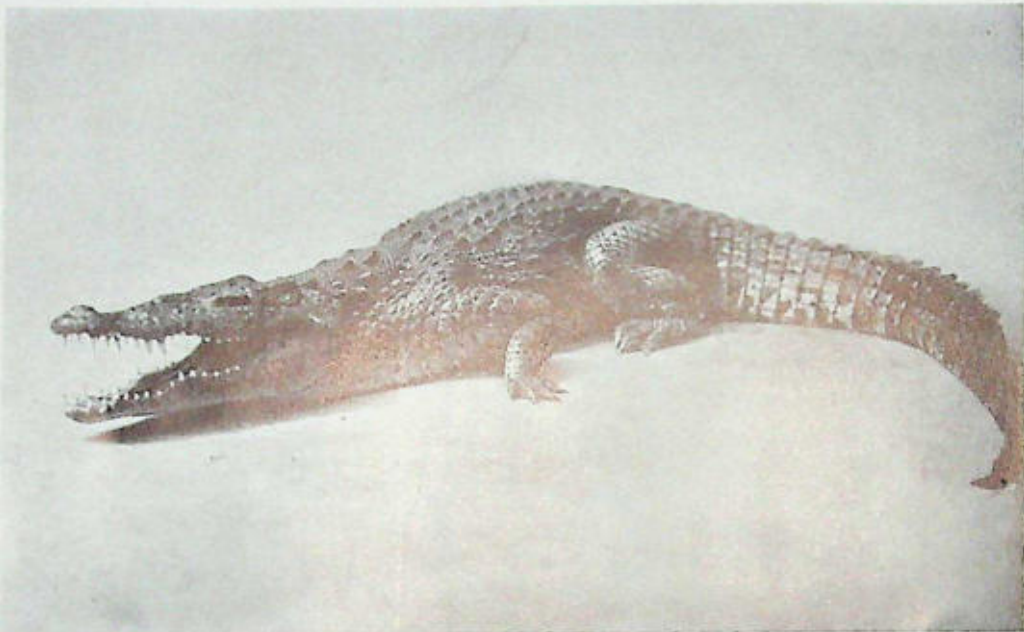
The Paraguay River, above the junction of its confluent, the Parana, is the home of a large species of black cayman, *Caiman yacare*. From this region the species extends through northern Paraguay into eastern Bolivia where it is well known in the river country. Its black markings and length of ten feet, with a fifty-six inch waistline are typical of adults. Both a robber and a cannibal, the Paraguayan cayman's habits have been recorded to some degree of length and with some amount of truth. Less likely tales are told of the females that form a circle about their young and fight off the hungry males; also of the females carrying the young, cat fashion, and placing them in small and sequestered pools



American Alligator. In captivity small specimens thrive and grow to adult proportions when kept in a sunny room with a constant temperature of at least 75 degrees Fahrenheit. Food best suited to growth and development includes raw beef and fresh fish.



American Crocodile. Unlike its neighbor the alligator, the crocodile has a vicious disposition. When cornered it will give battle. It is feared by its captors and respected by its keepers. In pre-Columbian times the Mayas of Yucatan held the crocodile to be sacred and frequently propitiated its wrath with offerings of members of the tribe who were elected to give the community a fitting sacrifice. The creature is well represented in sculpture and pottery designs executed by the peoples of the Isthmian region.



Cuban crocodile. Restricted to Cuba and the adjacent Isle of Pines, the Cuban Crocodile offers a problem in zoogeography. In Cuba its range has been narrowed down in recent years to the almost inaccessible interior of the Zapata Swamp. One of the few specimens shown in captivity is to be seen in the Reptile House of the New York Zoological Park. It was captured by the author in 1929. Photograph by Edward R. Osterdorff.

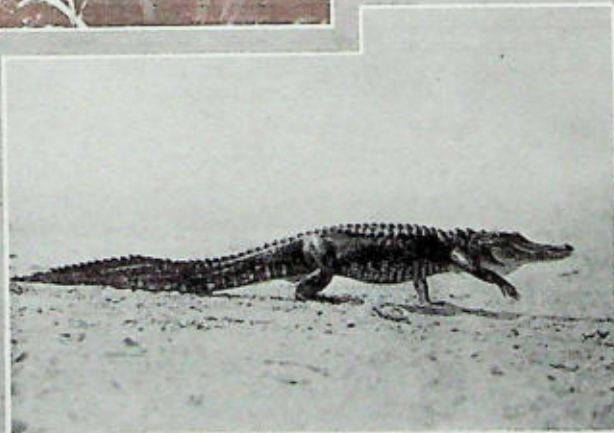
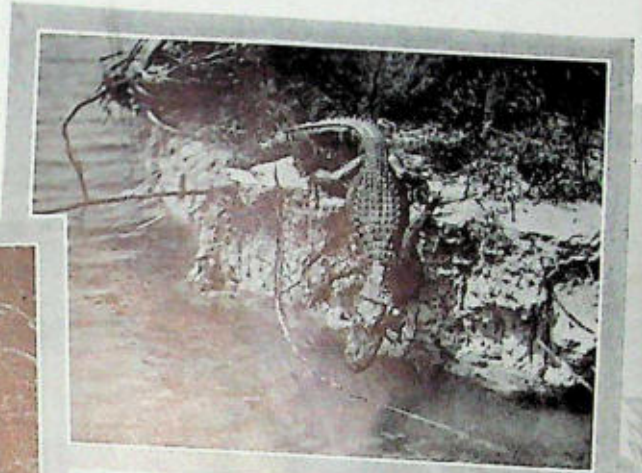
where they will be safe from the powerful male cannibals of their family.

Caiman latirostris, so named because of its extremely broad-snouted appearance, is common on the east coast of Brazil from Pernambuco to the southern state of Rio Grande do Sul and extends into northern Argentina where it has been taken near Buenos Aires. It also may possibly be found in the upper courses of the Parana in the Paraguayan Basin but its location there awaits definite verification. The flesh of the creatures, especially that of the tail is reported to be excellent eating and Schomburgk is quoted as relating that their food is made up of fish and water-birds as well as the tender roots of aquatic plants.

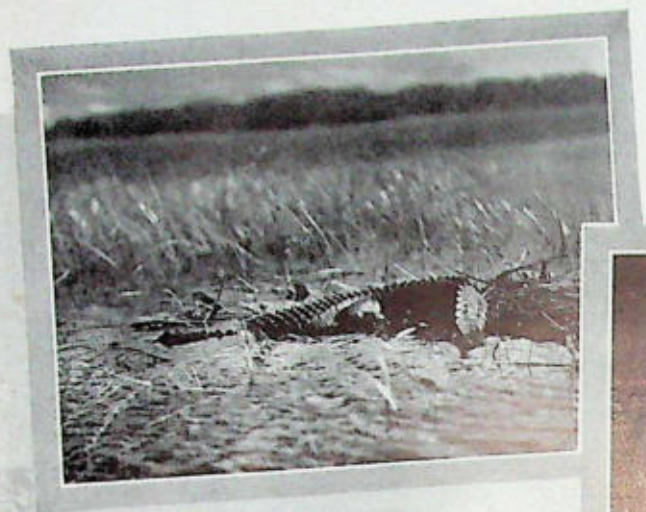
Old World Crocodylians

The records of antiquity are replete with references concerning the Nile crocodile, its activities and the methods of its capture. Mummies of this crocodile are to be found in every archeological museum that houses an Egyptian collection. The technique used by the primitive hunter has changed but little since it was so entertain-

ingly described in the forty-first chapter of the Book of Job. Historians have traced the land of Uz where Job lived as being on the eastern border of Palestine in Arabia. Here the tributaries of the Jordan, especially the Wadi Zerka, still harbours the beast of antiquity, the Nile crocodile, *Crocodylus niloticus*. The oft-repeated story of the plover that picked the reptile's teeth and gave it warning of approaching danger dates back to the fifth century before Christ when Herodotus in "Euterpe" wrote of his travels in Egypt. The belief concerning this custom has not been verified by actual accounts in the last fifty years but many African explorers still report that a plover, the *trochilus* of Herodotus, *Pluvianus aegyptius*, is often seen in close proximity to the Nile crocodile and it is not altogether impossible that it might dart into the open mouth of the monster to remove the leeches that infest its oral cavity and thus render it service. The crocodile's eggs seem to require a warm, dry bed of sand for incubation and, unlike most other species, unless this condition is possible the embryo is unable to develop, moisture causing it to rot. However, the species is so hardy that it breeds in places where



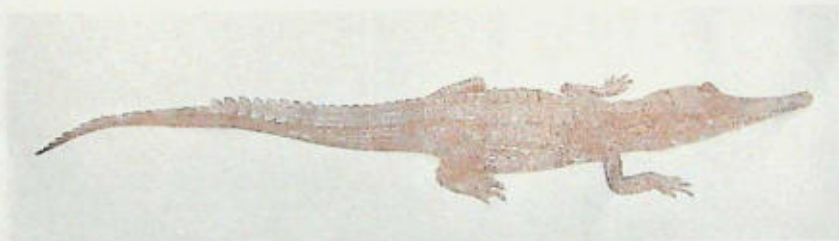
The reproductions of Crocodilians on these late A. W. Dimock, and represent a labor of merely photographs. To the photographer's exhaustless patience. The charm of such pictures, which characterize these ungainly saurians, is that they illustrate well the great purposes; a distinct proof of his limitless patience. Good pictures of wild-life in their habit are included among the very best. In each instance, the presence of the photographer, who was engaged in scientific research. *Published by courtesy*



o pages are from photographs made by the
 of many weeks. To the layman they are
 ey are the badge of painstaking effort and
 collection of pictures, if we may so charac-
 represent natural habitat manners of the
 ill of Mr. Dimock in securing unconscious
 e and knowledge of his very wary subjects.
 re rare, and the ones shown here may be
 e, the subjects apparently were not aware
 lds to their value in the class of truthful,
the American Museum of Natural History.



Central American Crocodile. In the summer of 1928 this species was rediscovered after a lapse of nearly a century. Dr. Karl Patterson Schmidt working near the Sibun Swamp of Guatemala found the species in relative abundance. *Photograph courtesy Field Museum of Natural History.*



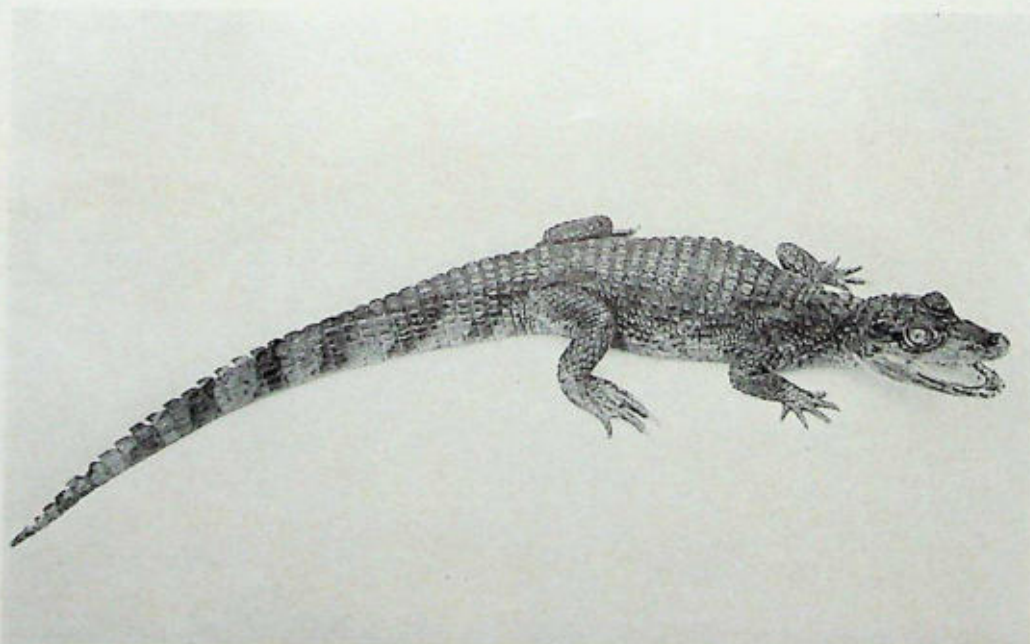
Orinoco Crocodile. A prolific species that lays from forty to fifty eggs in a clutch. These clutches are laid on the sandy river shores of Venezuela and the eggs, used for food by the natives, must be dug up from a depth of about a foot and a half.



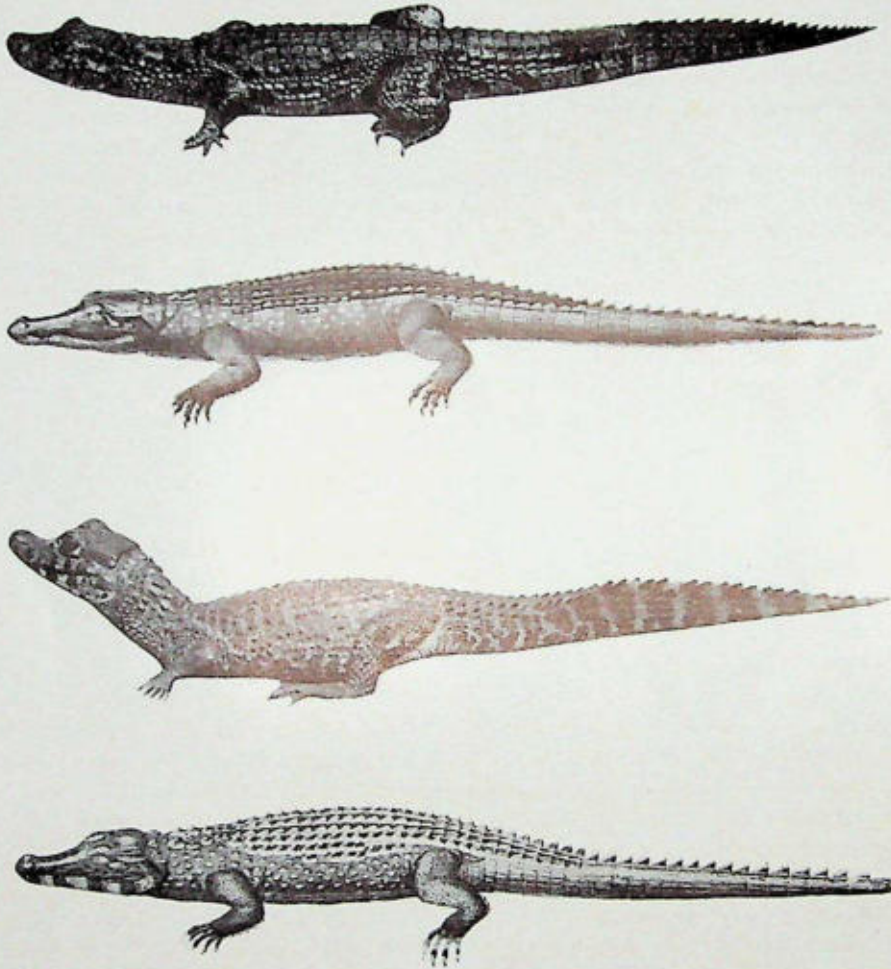
Central American Cayman. A small species inhabiting the tropical rivers of southern Central America and northern South America. Although well known to scientists and common in its habitat no photograph was available. In lieu of this a plate from the "Zoologia" of Dr. Perez Arbaelaez is reproduced. His background is that of the Magdalena River of Colombia.



Spectacled Cayman. A tropical American species.



Black Cayman. A specimen lately received from Brazil by the New York Aquarium measured eleven feet, eight inches. The one figured here is a juvenile example.



Reading from top to bottom. South American Caymans. a. Broad-snouted Cayman. b. Cuvier's Smooth-fronted Cayman. From Tiedemann. c. Paraguayan Cayman. Courtesy Field Museum Natural History. d. Schneider's Smooth-fronted Cayman. From Tiedemann.

the dry season is of only two months' duration. The number of crocodile eggs laid and hatched every year in Tanganyika (formerly German East Africa) is most surprising. Mr. Arthur Loveridge, who visited that country in 1922, shows that during the first six months of the year, 120,502 eggs were brought in for a bounty. The Tanganyika Government records that deaths from crocodiles in the whole of its vast territory do not exceed fifty natives a year. This is a very small percentage of fatality in a population of three and a half million inhabitants. Equally significant are the records of African expeditions that have spent many years in the field. Such an expedition,

led by Mr. Herbert Lang, of the American Museum of Natural History, ten years in the Congo region, dealt with several hundred thousand natives "and yet in all that time not one authentic case of loss of human life due to crocodiles came to our attention".

The West African sharp-nosed crocodile, *Crocodilus cataphractus*, is a large species which, true to its name, is restricted to the western portion of the Dark Continent. In general, its habits little set it apart from its relative of the Nile. Like that species, it has long been associated with a bird that supposedly tends to its dental ailments. This avian surgeon is the spur-winged

plover, *Hoplypterus spinosus*. Again, no direct evidence bears on the validity of the many tales concerning this bird, but the same line of argument exists. Rumors to the contrary, the beast is little feared by the African natives of the great river systems.

The West African rough-backed crocodile, *Osteolaemus tetraspis*, shares the common habitat of the foregoing Ethiopian species. It is one of the smallest individuals of the order of Crocodilia and seldom attains to five feet. It is respected, however, by the local tribes who erect palisades around their bathing spots in the rivers so as to ensure a tranquil bath. This crocodilian is often found in salt or brackish-water where its upturned snout is useful in keeping its head above choppy waves. Little is definitely known concerning its habits and much remains to be learned about its breeding, food and growth.

The West African smooth-backed crocodile, *Osteoblepharon osborni*, named in honor of Prof. Henry Fairfield Osborn, is a recently discovered species. Inhabiting the forest region of the north-eastern Congo it is characterized superficially from its ally, the rough-backed crocodile of West Africa, by a flatter and slenderer snout. Fish is its principal food. While it is known that natives loot the nests of this species and utilize the eggs for food, nothing further is recorded concerning its habits.

The Indian gavial, *Gavialis gangeticus*, the giant of the crocodilian world, is found in the water systems of British India and commands front-rank position for size in the order of Crocodila. Adults are said to attain a length of thirty feet and fossil finds of this genus are more than fifty feet long. The newly hatched representatives of this gavial measure some fifteen or sixteen inches, nine of which is taken up by their slender and emaciate-looking tail. The eggs are deposited in tiers of twenty above and twenty below, separated by a foot of sand.

The Indian mugger or swamp crocodile, *Crocodilus palustris*, a medium-sized monster of twelve feet, is found in almost every bog and swamp from Baluchistan in northern India to lower Burma and the Malay Peninsula, as well as in Ceylon and Java. However, during severe drought, it has been observed that they leave the dried up water courses and traverse considerable areas in search of water. It is dark-olive or black-

ish above, the young a pale olive spotted with black. While the species is cannibalistic it does not molest man and is noted for its remarkable timidity. During the long dry season it aestivates in the mud where it remains in a state of torpor until the recurring rains release it.

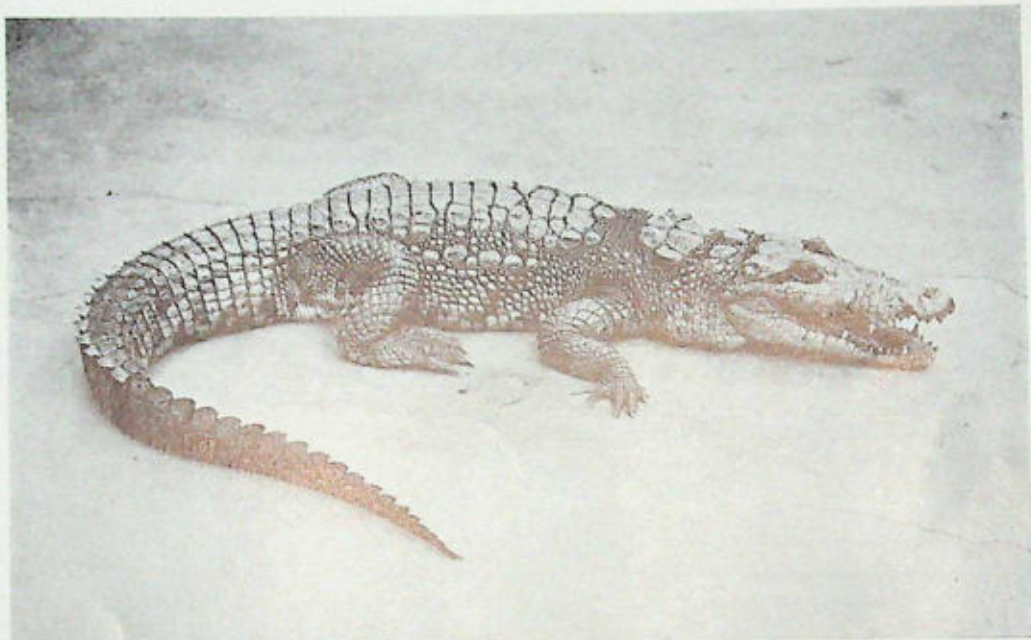
Siam, among the many curiosities of natural history, harbours a crocodile, *Crocodilus siamensis*, which is also known in French Indo-China and Java. It is a small species, about seven feet in length, and is native to the rivers and swamps of the Malay Peninsula. In these countries it is equally at home in both fresh and salt-water. Little or nothing is known about its habits and much remains to be studied in the region of its habitat. It is of dark-olive coloring, spotted with black and grows to about seven feet.

The salt-water crocodile, *Crocodilus porosus*, is an estuarine species frequently seen swimming in the ocean, many hundreds of miles from land. Undoubtedly this natatorial activity accounts for its presence in many distant countries of the East and is the reason for its wide distribution. This reptile is common from the Philippines to South China, through the East Indies to New Guinea and the Solomon and Fiji Islands. In India it is restricted to the Malabar coast and to the tidal waters of Ceylon.

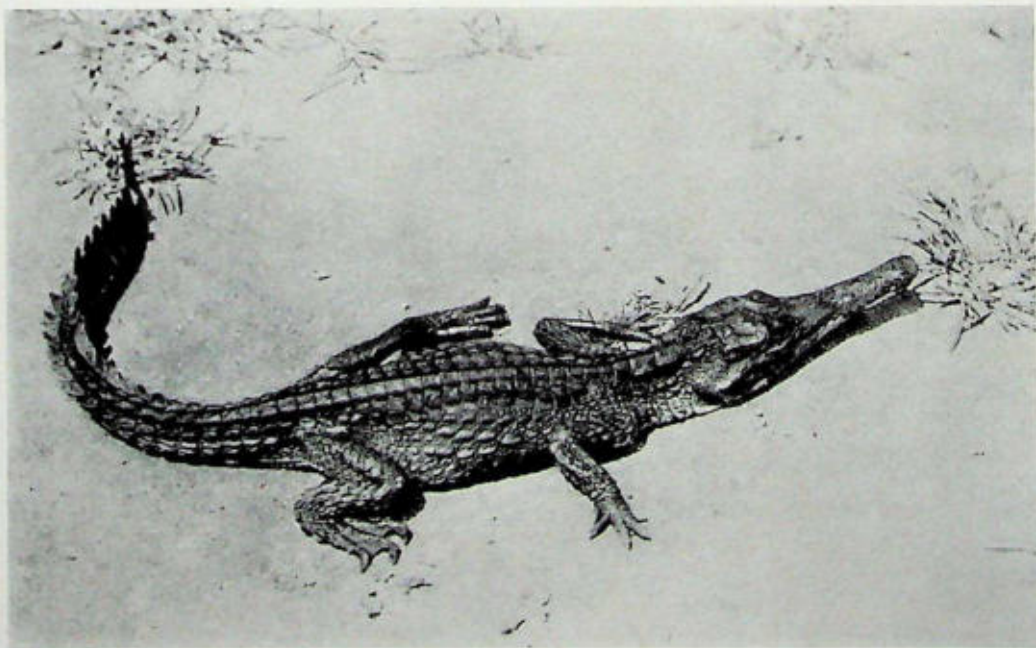
A recently described and little known species is one from New Guinea. In 1908, Dr. George A. Dorsey of the Field Museum, in undertaking some ethnological studies in Melanesia secured several crocodilian skulls from the territory around the lower Sepik River of northern New Guinea. It was not until 1928, however, that this material was examined and described by Dr. Karl Patterson Schmidt as a new species of crocodile, *Crocodilus novae-guineae*. Schmidt's diagnosis is clear, pointing out that the species is intermediate between the salt-water crocodile and the Australian one.

The bushmen of Queensland regard the Australian crocodile as harmless. Its salt-water neighbor, *C. porosus*, however, is man-eating. Charles Barrett, the Australian naturalist, records its reptorial activities and gives some hint of its annual toll of human lives.

Many specimens of the Australian species are shipped to zoological parks all over the world and the method of their capture is as follows: A spring trap, made from bent mangrove branches,



Nile Crocodile. The crocodile of the Nile is the largest species found on the African continent and has a distribution nearly equal to the widespread salt-water crocodile of the Orient. It is found in all parts except in the Sahara and certain parts of arid North Africa. In the island of Madagascar it is the most common vertebrate known and a denizen of nearly every body of water.



West African Crocodile. The jaws approach the narrow head outlines of the Indian Gavial. Stomach content shows that the species lives on fish, shrimp and frogs.



Rough-backed Crocodile. A West African species that enters into the salty river mouths of its habitat.



Smooth-backed Crocodile. A recently discovered species named in honor of Prof. Henry Fairfield Osborn by Dr. Karl P. Schmidt. Taken by Mr. Herbert Lang in West Africa. Photograph courtesy American Museum Natural History.

is set; a running noose is then attached to this trap and placed near a watercourse that is known to be a favorite run of the animal. A loop of the noose suspends some bit of game or meat and the crocodile, in its efforts to get this morsel, fastens himself in the noose, thus facilitating the capture of live and uninjured individuals.

The Malayan gavial, *Tomistoma schlegeli*, approaching a length of fifteen feet, is the third largest crocodylian in Asia. This gavial is an olive-green color, spotted with pale brown above; its tail is banded. The iris of the eye is a yellowish-brown. Its evolutionary position closely parallels that of its Indian relative and owing to the fact that it has a somewhat broader skull, it is often assigned a place between the gavial of India and the true crocodiles. In appearance it greatly resembles the fossil restorations of its prehistoric ancestors. It is hard to believe that a creature of such terrible countenance can be harmless, but again its elongated jaws determine its diet of fish and so unfit it to prey on man.

It is always interesting to contrast attitudes of native peoples with those of their more civilized

brethren. Some of the Malay people venerate their *gharial* to the point of ascribing to it a divine origin. Washerwomen, beating their clothes in its rivers, utter prayers of gratitude to the animal whose presence protects them from evil spirits, while in our own country, the alligator is looked upon with mingled feelings of fear and loathing; curiously enough, it is quite as harmless to man as is its Malayan and Indian allies.

The Chinese alligator, *Alligator sinensis*, is one of the smallest of Asiatic crocodylians. It frequents the waters and tributaries of the Yang-tse River, living on fish and whatever water-fowl it can capture. In character and habits it closely resembles its American relative. Its skin is greenish-black above, speckled with yellow and green beneath. These river people of China regard the reptile as a pest rather than an enemy inasmuch as it constantly preys on ducks and becomes ensnared in fish-traps. This same habit has been observed in Africa where game hunters complain that crocodylians frequently fill traps set for other animals.

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The following works are listed either because of their bibliographies, their illustrated texts, or a happy combination of these factors. As over five hundred papers were consulted in the preparation of this review of the crocodylians it is not feasible to list them all. However, this selected list will lead the inquisitive reader far into the field of crocodylian literature.

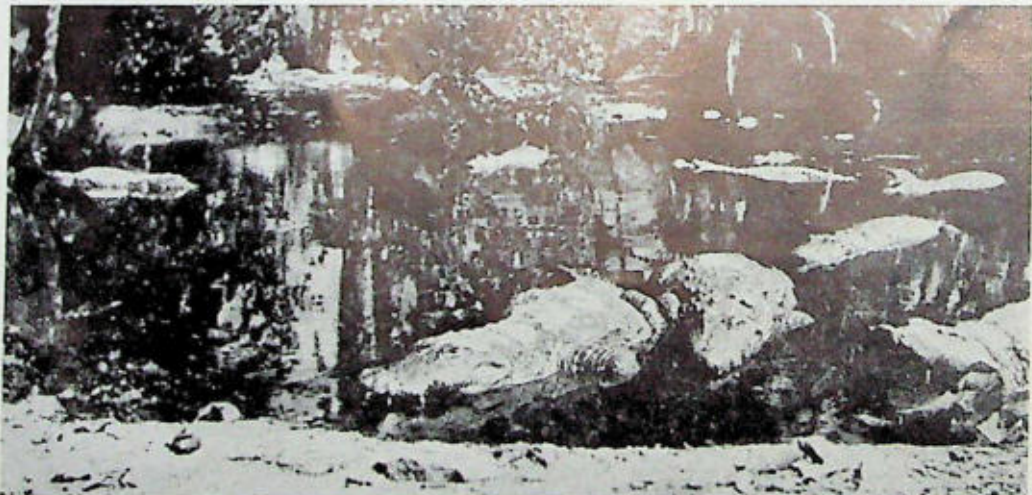
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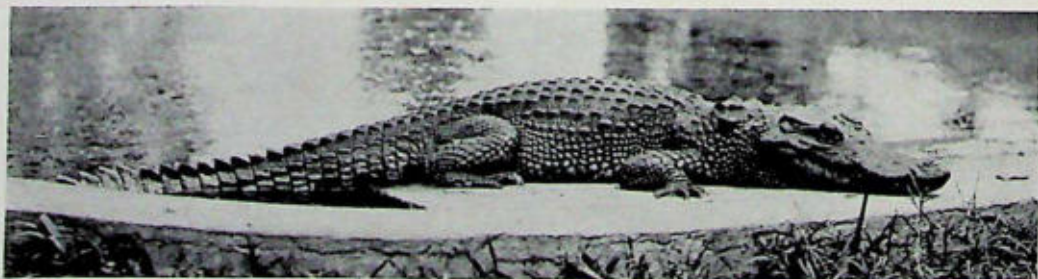
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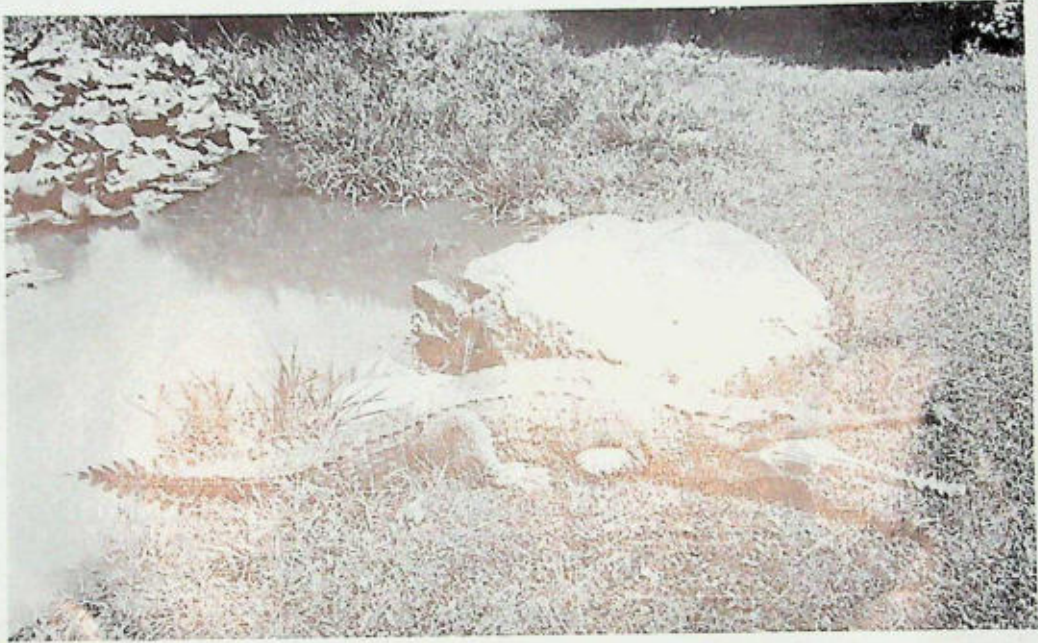
Indian Gaviel. Said to be one of the most primitive types of reptiles. Inhabits the Ganges River, and is so designated by its name, *Gavialis gangeticus*. The generic name, 'gaviel', is a corruption for 'gharial', a Hindustani word signifying a fish-eater. From *Rechnis* after *Berridge*.



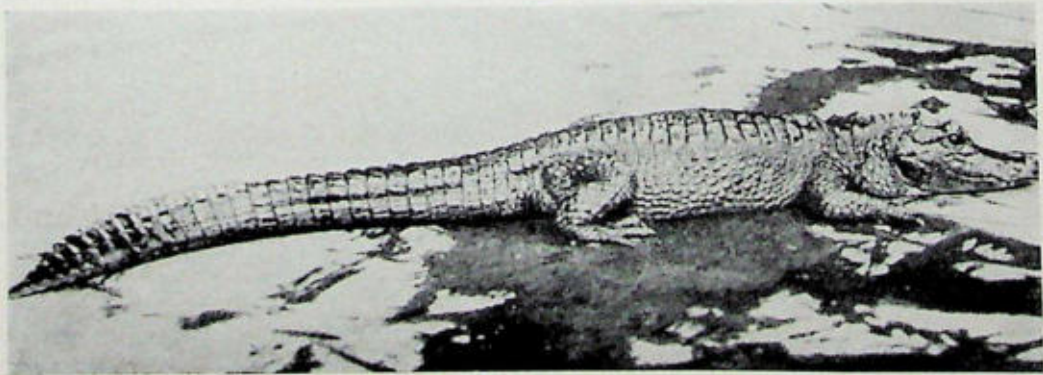
Indian Muggier Crocodile. The Muggier is venerated by the Hindus and in the past was frequently kept in temples. Here, as in other tropical lands, the 'stomach stones' are used as charms and are supposed to have curative as well as preventative virtues. From *Flower*.



Siamese Crocodile. It is related that the Annamites of Indo-China tether specimens of this species to the piles on which their houses are built. The flesh is relished and sold in the same manner as pork. Photograph courtesy of Dr. Malcolm A. Smith.



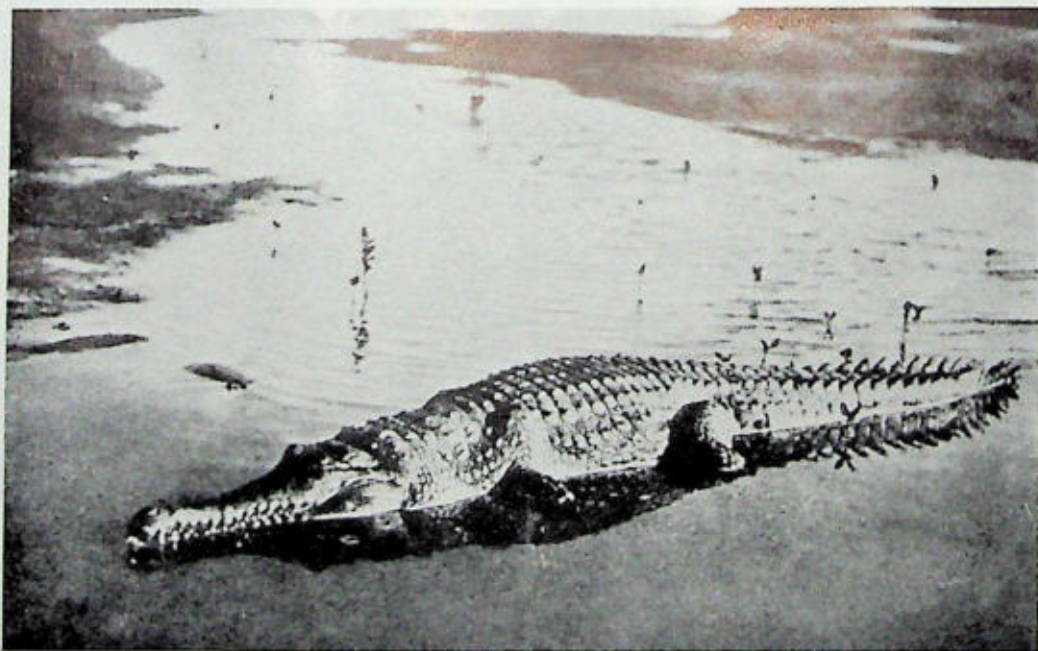
Malayan Gaviel. Its elongated jaws indicate its diet to consist largely of fish.



Chinese Alligator. The Cantonese use the skin of their native alligator for the percussive heads of their stringed instruments and collect its teeth for their alleged medicinal properties. Its scales are also used for treating fevers, goitre and skin diseases. *From Brehms after Reridge.*



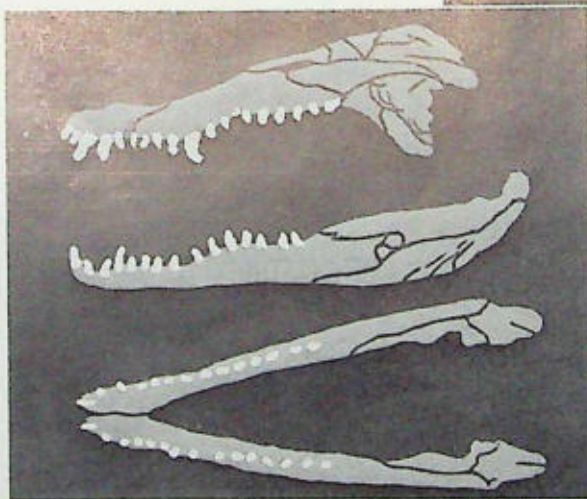
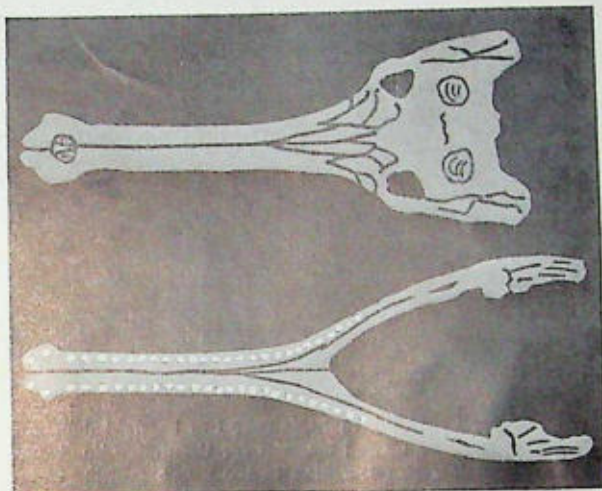
Salt Water Crocodile. In India over two hundred deaths a year are said to be caused by this species. The British have offered bounties for the destruction of this crocodile and its eggs. In size and bulk it is the second largest crocodilian in the world, growing to over twenty feet. *From Beclous after Berridge.*



Australian Crocodile. Northern Australia is the home of *Crocodylus johnstoni*. Eight foot specimens are common throughout the freshwaters of northern Queensland and, in days past, larger sizes were reported. *From National Geographic.*

1. Indian Gavial skull showing the typical conformation of the Gavial group.

2. Jaw of Indian Gavial showing the fusion of the two halves of the lower jaw extending beyond the fifteenth tooth. This is a diagnostic characteristic of the Gavial group.



1. American Crocodile skull showing the exposed notch for the fourth tooth of the lower jaw. This is a diagnostic characteristic of the Crocodile group.

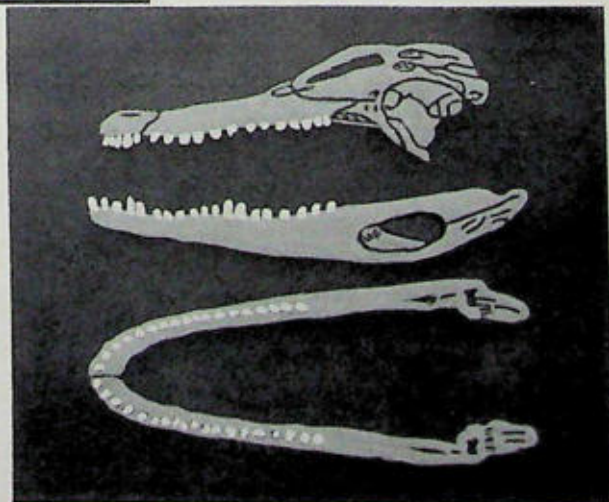
2. American Crocodile jaw, lateral view showing the much enlarged fourth tooth typical of the Crocodile.

3. American Crocodile. Lower jaw showing fusion of the two halves extending to the fifth tooth.

1. American Alligator skull showing space between the fifth and sixth tooth. This pit is characteristic of the alligators and caymans.

2. American Alligator. Lateral view of the jaw showing the elongated fourth tooth which fits into the pit mentioned above.

3. American Alligator. Lower jaw showing the broad spade-like shape, characteristic of most members of this group comprising the alligators and caymans.



Osteology of the Principal Crocodylians. (Top) Skull and jaw of the Indian Gavial, *G. gangeticus*. (Center) Skull and jaw of the American Crocodile, *C. acutus*. (Lower) Skull and jaw of the American Alligator *A. mississippiensis*.



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BULLETIN

NEW YORK ZOOLOGICAL SOCIETY

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THE BONGO IN THE ZOOLOGICAL PARK

From a painting in oil colors by Miss Margaret S. Johnson

A portrait of Doreen painted in January 1933, shortly after her arrival at the Zoological Park. The reproduction shows to good advantage the truly beautiful color of this graceful antelope, one of the rarest of the varied and abundant African faunal-life. The vertical, white striping, typical of the harnessed antelopes, stands out vividly against the rich chestnut-brown of the body, greatly enhancing the warmth of the varying tones. Oddly enough these stripes, which prevail in both sexes, are of unequal number on opposite sides. African antelopes in captivity have rather garrulous dispositions. Frequently they are both savage and aggressive. Doreen is a perfect antithesis. She is both placid and tractable, and so perfectly calm as to convey the impression of an inheritance of domesticity of primeval origin. The picture has been purchased by the New York Zoological Society for the Gallery of Animal Paintings in the Zoological Park.

BULLETIN

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The Quest of The Bongo

From "The Illustrated London News" of August 27, 1932

Permission to re-print the story by Col. E. Percy-Smith of the capture of Doreen, as related in the Illustrated London News, was made possible through the kindly offices of Mr. Bruce Ingram, the Editor. He also forwarded to me the original photographs illustrating the article, with the rights of reproduction granted by The Cambridge Literary Agency, the London Agents of Col. Percy-Smith. Photographs, except mounted specimen of the British Museum, exclusive to "The Illustrated London News." World copyright strictly reserved.—Ed.

"IN the course of a fairly adventurous life," writes Colonel E. Percy-Smith, "I have been fortunate enough to secure, at different times, a good deal of big-game shooting and of specimen-collecting for various museums. My interest in wild animals, thus aroused, has continued to grow; but I find, as so many other shikaris have done, that my desire to kill them has vanished in proportion. And so it came about that I thought of attempting the capture of some really rare creature, which had never as yet been seen in Europe. For that reason it could be readily disposed of, and my hobby would then, to some extent, be self-supporting—no small consideration in these hard and uncertain times.



"I had known Kenya Colony well for many years, and enjoyed in the past much kindness from my many good friends there. This fact, with its unique facilities for big game and the possession of a delightful climate, combined to make it the most suitable country under the British flag for my purposes. And once Kenya was decided upon, the bongo inevitably became the object of my quest. The rarest, as it is almost the largest, of East African antelopes, it has its home in the dense mountain forests, at the height of some nine thousand feet or so. Its horns make a massive and yet gracefully spiralled trophy.

It has a brilliant chestnut coat, with curiously striped markings; in short a beautiful and imposing creature, entirely belieing its uncouth zoological appellation, '*Boöcercus Isaaci*'.



"As the animal lives in the thickest forest, where a noiseless approach is well nigh impossible and is endowed as well with a hearing uncannily acute, one cannot wonder if it is rare even to catch a glimpse of it. How much more difficult then, was the problem of catching one alive and uninjured, and that within the limits imposed by the Game Laws, which rightly prohibit such cruel, if effective, methods as running wild game down with dogs or snaring them in promiscuous pits? The forest terrain also put out of the question the idea of driving them into nets. I decided, therefore, to attempt two methods; the first and more promising to build a stockade round a favourite salt-lick, at the edge of the forest, to which their fondness for this delicacy would, I felt sure, inevitably attract the bongo; the second, to set nooses at a suitable height along some trails that they were wont to frequent. Knowledgeable friends on board the steamer were helpful with their advice, and enabled me to decide on the eastern slopes of the Aberdare Mountains as the scene of my endeavours. This magnificent mountain range lies half-way between the Great Rift



A Bongo—rarest of antelopes, and never seen alive in Europe—A young female recently captured in the mountain forests of Kenya.

The capture of a living bongo, the rarest of East African antelopes, of which no living specimen has yet been seen in Europe, is an event of exceptional interest. In an article with further photographs given on succeeding pages in this number, Colonel Percy-Smith describes how, after great difficulties and vicissitudes, he succeeded in snaring the beautiful creature shown above, in the forests of the Aberdare Mountains, half-way between the Great Rift Valley and Mount Kenya. This bongo is a young female, and has been named Doreen. Colonel Percy-Smith describes her brilliant chestnut colour and curious striped markings, with a thick ridge of hair along the spine.

Valley and the even more imposing *massif* of Mount Kenya itself. Thither, after collecting my safari in Nairobi, a routine proceeding which is as familiar to the general reader nowadays as its Swahili name, I proceeded by motor-car, and very easily covered the 150 miles in two days.

founded my hopes. But to succeed it was clearly essential that my preparation should be completed before the advent of the rains, and the construction of a solid log stockade, nearly 200 yards in circumference and nine feet in height, and that by the aid of raw native labour only, was



The only form in which the animal is at present known in England: A mounted specimen of a bongo (*Boocercus eurycerus*), four feet four inches high at the shoulder, in the Natural History Museum at South Kensington. Photograph by Courtesy of the British Museum (Natural History Department).

"I was fortunate enough to find an ideal site for my standing camp, seven thousand five hundred feet above sea-level, a most beautiful spot on the edge of the forest, with wonderful perspectives overlooking the game-haunted plains, which stretch away towards the snow-clad summit of Mount Kenya in the far distance.



"Now the bongo possesses this curious and almost human idiosyncrasy—that he intensely dislikes the perpetual drip from the sodden leaves on his coat during the rainy season, and tends, therefore at such times to come out into the more open country: it was on this trait that I had

clearly no light task. Incessant work, however, enabled me to complete it within two months, and, had the rains been normal, I should have had time sufficient for my purposes; but alas! these largely failed, and when I was ready for the bongo they had long since reverted to their haunts in the heart of the jungle; my labours were utterly wasted.



Mounted head of a male Bongo. National Collection of Heads and Horns, Zoological Park.



"There still remained however, the noosing of the game trails. Large stout posts were driven deep into the ground alongside the well-worn tracks, and to them I attached a stout rope. The end, looped and terminating



Colonel Percy-Smith's captive bongo, suckled by a cow simultaneously with a calf (whose fore feet appear beneath the bongo's head), and trying to get "more than her fair ration"; An interesting example of foster-motherhood.

in a slip knot, hung suspended tight in the fairway from small forked branches especially planted on either side, and the whole device was carefully concealed beneath cut bush and creepers.



"For this scheme the omens seemed slightly more favourable. True, I had never actually achieved success, but I had come within measurable distance of it several times. On one occasion a fine specimen had his head almost within the noose, when his eagle eye must have noticed the rope as of a slightly different tinge to the camouflage of creepers, and in an instant he was off; a vivid example, this, of the difficulties by which the hunter is perpetually confronted. Still I persevered; the most likely trails were daily beset, and duly visited the next morning by natives whom I had carefully trained.



"At last—one never-to-be-forgotten moment—I was aroused at crack of dawn by a great hubbub in camp. The scout had hurried in to report that a bongo had been snared. My luck was in at last. In the thrill of success it seemed no time before I had covered the mile which intervened, and there, sure enough, to my intense relief and delight, I saw a most beautiful half-grown female bongo securely held round the neck. Fortunately, she did not show so much fear as I had anticipated; I was able to approach her without undue difficulty, and, with the help of a dozen natives, to rope and put her bodily into the back of my big 7-seater tourer, from which I had previously removed the back seats and leather-work. Thus we got her safely to camp, and then at once transferred her to a darkened loose-box, within a roomy stockaded enclosure, so that she might rest quietly awhile, and gradually accustom her-

self to the sight, sound, and smell of mankind.



"Now, at last, it seemed right to celebrate success with a few friends who had foregathered to offer congratulations. I had carefully kept, against such an occasion, a last bottle of cham-

pagne, thinking perhaps to break it over my capture for luck at the start of her new voyage in life. But when it came to the point I feared that it might alarm her, and, anyway, it would be a sinful waste of good liquor in the heart of Africa. So, though 'Doreen,' as I had decided to call her, was not formally christened, at least her health was well and truly drunk, with musical honours.

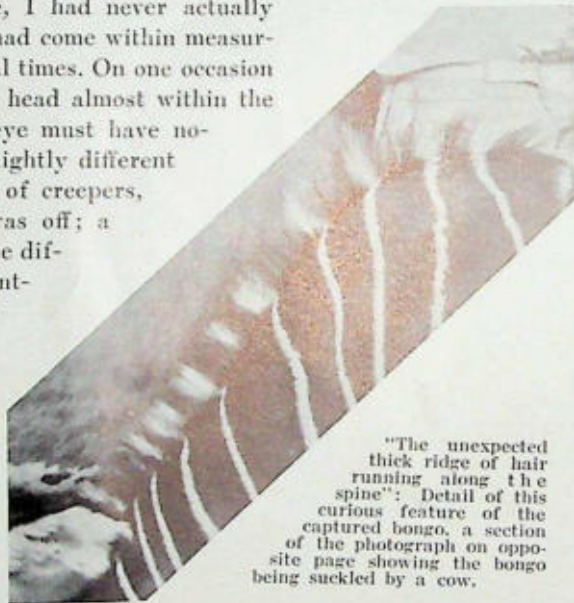


"I had expected to have to keep her in

this semi-darkness for several days at least, but so unexpectedly docile did she prove to be that I was able to move her the very next day out into the encircling enclosure, and here she found waiting for her a cow and calf to serve as foster-mother and boy-friend. "Doreen's" education proceeded apace. I had some difficulty in persuading her to suck from the cow, and she had to be held down to the udders at the start, but once she had got the trick no more compulsion was necessary; indeed she was soon trying to get more than her ration, to the disadvantage of the calf, who took his meals at the same time on the fifty-fifty basis.



"The next step towards weaning her was achieved when she began to drink milk direct from a basin; for, of course, like all antelopes,



"The unexpected thick ridge of hair running along the spine": Detail of this curious feature of the captured bongo, a section of the photograph on opposite page showing the bongo being suckled by a cow.

she was already accustomed from her earliest days to graze as well. She is now at a most attractive stage; has little fear of human beings, and will allow herself to be stroked and handled without difficulty.



"It is a perpetual interest to be able to study this most attractive creature at close quarters,

with wonderful fidelity, and they clearly show what a bongo is really like at last.



"My story is only finished. Sooner or later will come the difficult journey by rail or car over the hundreds of miles that separate us from the coast. Next, the long sea journey must be faced, and lastly, saddest of all, the inevitable parting



"A beautiful and imposing creature", with brilliant chestnut coat and curiously striped transverse markings: The young female bongo, caught in the mountain forests of Kenya, and remarkably docile in captivity.

and to admire the gorgeous chestnut hue; the unexpected thick ridge of hair running along the spine—nature's protection and warning against the overhanging boughs of her natural haunts; and the white transverse stripings of the coat, all the more curious because, for some mysterious reason, there is one less on one side than on the other. But there, her fascinations have no end—at least, for me.

"Photographs can give no conception of the wonderful colouring; but her markings, shape, the curiously low carriage of her head, and the generally graceful appearance are reproduced

when I leave her at her new home in some Zoological Gardens—Whipsnade, may be—who can tell?



"She, I am sure, will settle down in comfort and security, and be happy, free at last from the perpetual fear of attack by a pack of ruthless wild dogs or a prowling leopard. As for me, it will be a long time before I forget the enjoyable and interesting time spent in the 'Quest of the Bongo'."



Upon viewing Doreen head-on one is immediately impressed by the extraordinarily large ears. The slightest of strange noises never fails to gain their attention as they immediately turn toward the source of the sound. In their native forests, bongos undoubtedly rely largely upon their keen sense of hearing to tell them of impending danger.

The Bongo Comes to the Zoological Park

CLAUDE W. LEISTER

Illustrations from Photographs Made in the Zoological Park in April by E. R. Osterndorff.

THE New York Zoological Society has ever been in the field to secure specimens of animal life that ordinarily, because of their rarity and the inaccessibility of their homeland, are seldom seen in Zoological collections. The director of every zoological park or garden always has lists of animals which he hopes sometime to exhibit; animals that never before have been seen in captivity. The bongo, one of the most striking of all antelopes, and a native of the dense mountain forests of Africa, has had a prominent place on all the lists of greatly desired specimens.

Knowing that Col. Percy-Smith was going into bongo country in the Aberdare mountains of Kenya Colony, and that he might possibly capture one of these rare animals, Dr. Blair immediately communicated with him and made a tentative offer for a bongo to be delivered alive in New York. Fortunately, as readers of these pages already know, Col. Percy-Smith's venture

was successful, and on June 6, 1932, he captured a young female bongo. Negotiations for her purchase were continued, and "Doreen", as she had been named, was finally acquired by Dr. Blair for the Society.

Few persons are aware of the many difficulties that attend the transportation of a wild animal from Africa to the United States, especially one of unknown disposition and traveling ability, and the following, very brief, account of Doreen's journey may be of interest to all those who at times have wondered how animals are brought to the Zoo.

To prepare Doreen for the journey, it was first necessary that she be weaned and accustomed to a dry grain and hay diet. This was successfully accomplished and when about eleven months old she was ready to travel and in perfect physical condition, due in particular to the great pains taken by Col. Percy-Smith in arranging for and anticipating every detail con-



cerning her needs. Finally everything was in readiness for the actual start of the trip. Doreen was placed in quarantine for a month and granted a certificate of health, certifying that she was "disease free and without injury". She was taken safely to the coast (Mombasa), part way by motor truck and part way by rail.

Here arrangements were completed for the ocean trip to New York. Doreen was installed in a comfortable shipping crate, furnished with enough food to last for the trip, and accompanied by detailed feeding instructions and a quantity of milk of magnesia for possible indisposition.

Thus equipped, on November 26, 1932, she was loaded on the *S. S. Durham Castle*, bound for London. Captain and crew were so keenly interested in the venture that she was more than well taken care of, even to the extent that suitable awnings were erected to protect

her from sun and weather. The *Durham Castle* arrived in London on December 22, 1932 and Doreen was transhipped to the *S. S. American Banker*, leaving for the United States the following day. Dr. Blair boarded the *American Banker* at Boston and accompanied Doreen to New York, where she was quickly unloaded and taken in a comfortable van to the Zoological Park.

She survived her long journey in perfect condition, accepted her roomy quarters in the Antelope House without fuss or bother and at once seemed to make herself at home. At this writing

she continues in good health, has grown appreciably, and now enjoys the sunny days of spring in her corral. Doreen is a lovely animal and we hope that she may stay with us for many years to come.



The white lateral stripes of the bongo are frequently unequally produced on opposite sides of the animal. Doreen possesses this characteristic, having twelve stripes on the right side (*top*), and eleven on the left (*bottom*). The last short stripe at the base of the tail does not show in the lower photograph. Other white markings may vary in size and shape, and old bongo bulls, instead of being red, the usual color, are almost black.



Map of Africa showing the distribution of the races of the bongo, which is indicated by the darkened areas marked respectively 1, 2 and 3. Area 1, *Boocercus eurycercus eurycercus*; Area 2, *Boocercus eurycercus isaaci*; Area 3, The General locality marking the habitat of two other races, *Boocercus eurycercus katanganus* and *Boocercus eurycercus cooperi*. Doreen was captured in the Aberdare Mountains of area 2. Map prepared under the direction of Dr. Blair by the Engineering Department.



Doreen, in a characteristic attitude, photographed in her corral at the Zoological Park. The dorsal ridge of hair, or mane, running the full length of the back, shows to advantage in this photograph. It will be noted that the white lateral stripes are carried across this mane and marked by white tufts of hair. The white markings on the legs and white collar on the lower neck are typical of the bongo.



The two upper portraits of Doreen show her large intelligent eyes and general appearance of docility, and in addition the white facial markings characteristic of the bongo. In the lower photograph the unsymmetrical arrangement of the stripes can readily be seen and it will be noted that the sixth stripe on the left side is missing. The prominent ridge of hair on the back is also seen to advantage.

The Harnessed Antelopes and Their Allies

RAYMOND L. DITMARS

Curator of Mammals and Reptiles, Zoological Park

Illustrations from photographs made in the Zoological Park.

AFRICA, south of the Sahara, has the greatest variety of hoofed animals of any area in the world. From the southerly border of the great desert, to the Cape, this life is also characteristic in form, embracing an impressive number of species of antelopes. Africa practically represents the sole locality of these animals, as only a few species are found outside the continent, and they are confined to a small area of Asia. Another peculiarity about the hoofed animals of Africa is the absence of any species of deer throughout the vast antelope domain.

As is natural with an array of animals like the antelopes, several groupings are indicated, and these have been scientifically accorded separation into subfamilies. This article relates to one of these subfamilies, the *Tragelaphinae*, with but a moderate number of species, but of particular interest because of unique markings, and the large size of several of the members.

From the viewpoint of the collector of trophies, the harnessed antelopes are commonly known as bushbucks, and are grouped as five species. They are recognized by white, ring-like markings circling the body. Technically, there are six additional species, some with ringed markings. Two of the species occur in India.*

From the standpoint of etymology, the harnessed antelopes are poorly named. To call them ringed antelopes would seem more fitting, owing to their encircling markings. It is true that one species, the bushbuck or guib, (*Tragelaphus scriptus scriptus*) has both ringed and longitudinal markings, in form as if the animal were encased in harness. As it precedes the others in some of the technical lists, and as its markings are really harness-like, while the related species are similar to it in their transverse striping, the common title for the group probably came into being from this condition. The ring-like markings of the various species vary in number among individuals, and with some examples are no more than transverse stripes, separated by the verte-

bral ridge, and may even differ in number on either side of an animal. Among specimens of several kinds exhibited in the Park, we have noted a curious tendency toward one or two lesser number of rings on the left side of the body. Of the entire grouping, the Society has exhibited the bongo, sitatunga, greater kudu, eland and nyilghai, all of which are now living in the Park's collection, with the exception of the sitatunga.

With the greater number of the species of this group, only the male members have horns. These are slightly ridged and spirally twisted upward and outward. With some of the species, the horns are rather short and stout. With the bongos and the elands, the females are also horned, those of the latter species practically as long-horned as the males. The proportionately longest horns among all the species are possessed by the greater kudu. With this animal, the horns sweep upward in flaring spirals.

By far the largest of the antelopes with ring-like markings, are the elands, which are also the largest antelopes of Africa. The more common species, inhabiting southerly Africa, is a truly impressive animal, attaining a weight up to 1500 pounds among adult males. Large females, however, seldom exceed 1100 pounds. Body hue of individuals varies from blue-gray to tan or reddish. A large example recorded by Lydekker stood five feet, nine inches at the withers. The average length of horns is about two feet, although they have been recorded up to thirty inches. Adult specimens, as a rule, show little or no striping, but the stripes are vividly marked on immature individuals and are retained longest on female examples. Specimens in the northerly portion of the range—in the vicinity of the Zambesi—show the greater tendency to retain the stripes into maturity.

With its fine build, extremely long and spirally sweeping horns, and attractive markings, the greater kudu, inhabiting a large part of Africa south of the Sahara, is the handsomest of the *Tragelaphinae*. It is long-bodied, slender-limbed and high-headed, rather like a large deer in outline and actions. The neck is maned, and

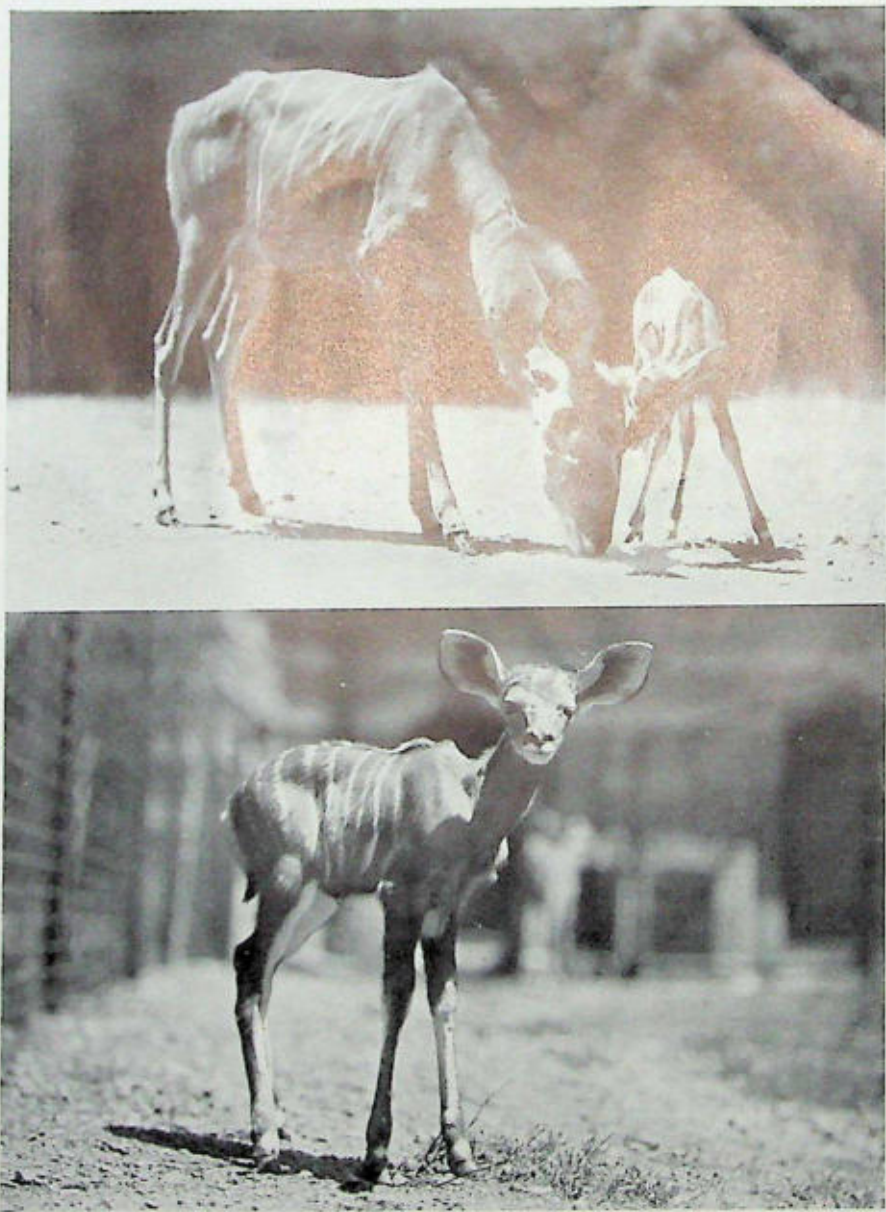
*The inconsistency of "popular" names is indicated in the listing of bushbucks, which, separately, are as commonly known under other titles. See page 45.



Greater Kudu, *Strepsiceros strepsiceros*. (Adult male). Ranging from the Cape to the central portion of Africa, the kudu is among the largest and handsomest of the many and varied antelopes of that country. A good pair of horns will measure slightly over five feet along the curve.



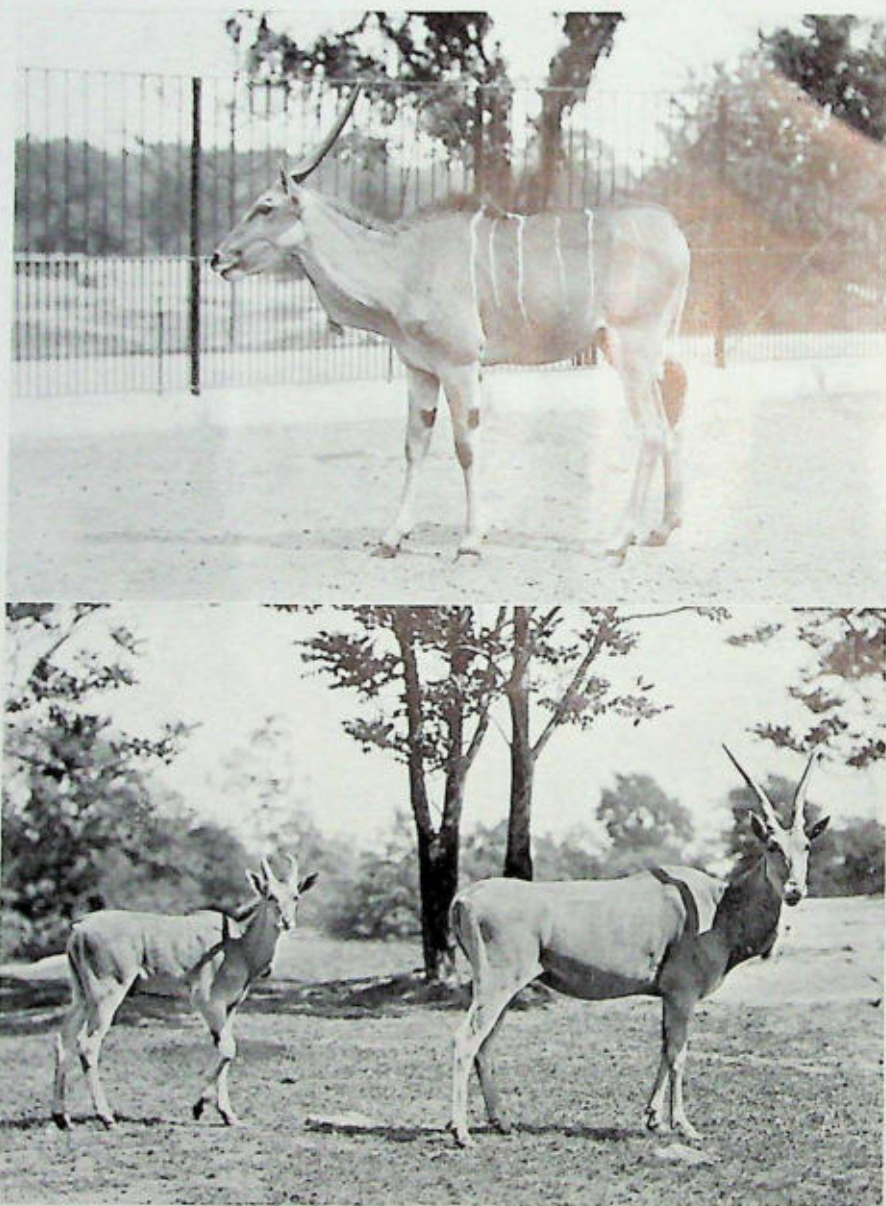
Greater Kudu, *Strepsiceros strepsiceros*. Adult female, showing opposite sides. There is a tendency, among the ringed or "harnessed" antelopes, for the stripes to vary in number on opposite sides. It can be noted in these illustrations that the right side of the animal has the greater number of white markings.



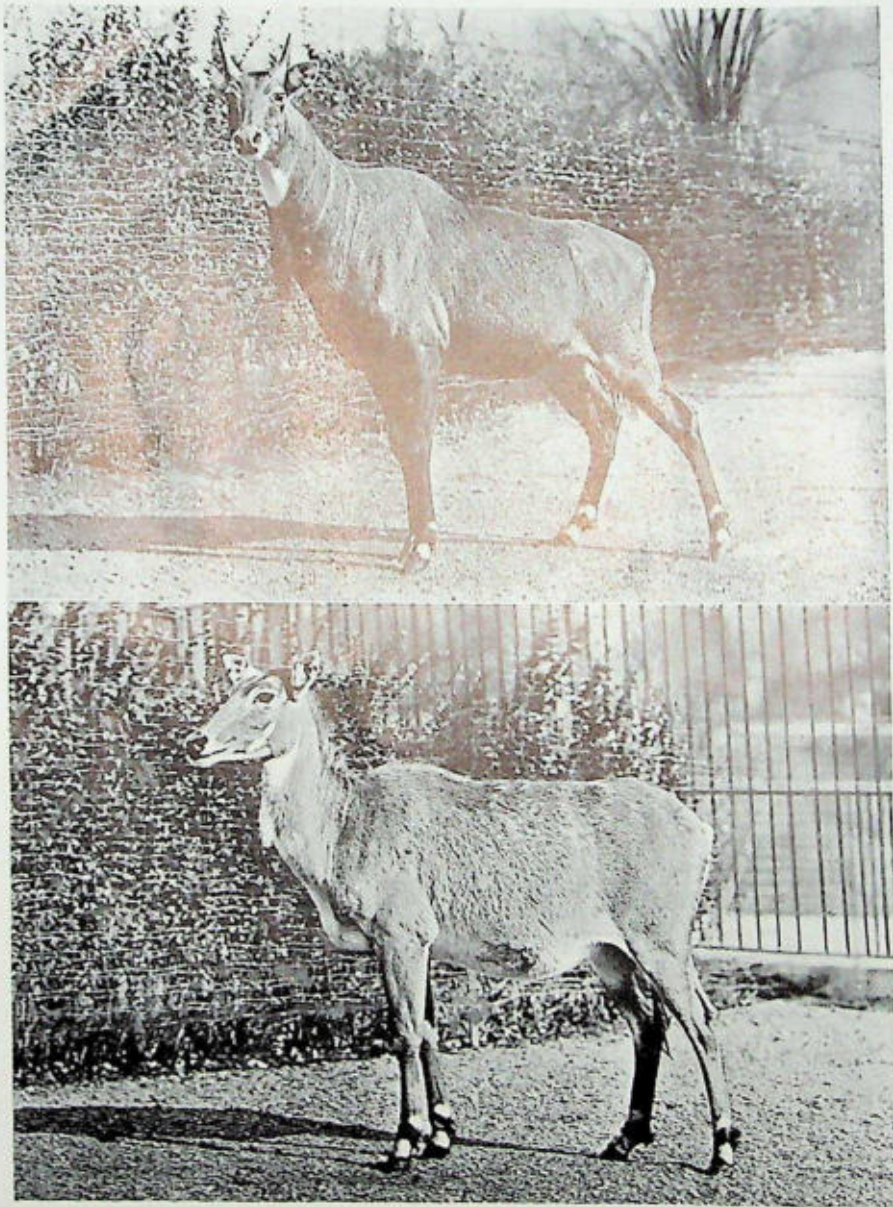
Greater Kudu, *Strepsiceros strepsiceros*. *Upper*: Mother and young a few days old. *Lower*: Calf figuring in upper scene. Among a fair number of the antelopes, the females are quite hornless. Both horned and hornless females, however, occur in the subfamily containing the ringed or "harnessed" antelopes.



Eland, *Taurotragus oryx*. An adult male, in his prime, and impressively illustrating the massive build of this species, which is the largest of all antelopes. It attains a height at the withers of over five and one-half feet, and a weight in excess of 1500 pounds.



Eland, *Taurotragus oryx*. Upper: Striped female, of northerly race. Lower: Female, without stripes, and young. As with the greater number of the species of antelopes, both the male and female eland have horns, although with the latter, the horns are lighter and shorter. The striped, northerly race is designated by the subspecific title of *livingstonei*.



Nylghai, *Boselaphus tragocamelus*. Upper: Adult male. Lower: Adult female. The nylghai is the largest of the comparatively few species of Asiatic antelope. Its distribution embraces a considerable portion of India, although it does not occur in Ceylon. It is related to the harnessed antelopes, but lacks ringlike markings. The indicated stripes on the neck of the animal in the upper picture are actually folds of the skin.

the throat usually furnished, in maturity, with a fringe of long hair. The female is hornless. Accompanying illustrations show male, female and young of this species, and indicate the variation of the ring-like markings among individuals. Length is about eight feet. The horns range in length from forty to fifty inches in a straight line, and to slightly over seventy inches along the curve. A large male weighed 705 pounds. Ring markings usually remain well defined on the adults.

Bringing together the grouping popularly known as harnessed antelopes or bushbucks, we note animals of smaller size, although two of the species, the bongo and nyala (also known as inyala), are approximately within a foot the height of the kudu. These two kinds are also the most vividly ringed and the rarest in captivity.

So far as we are aware, the only specimen of the nyala, *Tragelaphus angasi* (of easterly Africa) to be exhibited alive, is now in the collection of the National Zoological Park, at Washington, D. C., and the only captive example of the bongo,

Boöcerus eurycerus isaaci (also of easterly Africa), is now in the collection of the New York Zoological Park. One reason for the difficulty in obtaining these species is the character of their *habitat*. They frequent dense forests, during the day hiding in what to humans would be impenetrable places, and are said to come from such tangles at night, to feed. The character of the country which they inhabit is described in detail, in an accompanying article.

The other species of bushbucks, some of the better-known sub-species of which are indicated in the list included in this article, have been exhibited in various zoological gardens. They are smaller and more slender than the bongo and nyala, and one of them, the sitatunga, particularly so. It inhabits the swamps of central, south central and eastern Africa, and the development of the feet, in elongation of the hoofs, shows specialization for traversing soft places. The horns of male sitatungas—the females are hornless—measure on an average of twenty inches in a straight line. A record pair shows a measurement of twenty-seven inches.

Subfamily *Tragelaphinae* Harnessed Antelopes or Bushbucks

Bushbuck (*Tragelaphus scriptus*)

West African Bushbuck (*Tragelaphus scriptus scriptus*). Bright rufous; stripes very conspicuous. West, Central and South Central Africa.

Abyssinian Bushbuck (*Tragelaphus scriptus decula*). Rather short-legged and heavy-bodied; the stripes are indistinct. Abyssinia and Somaliland.

Cape Bushbuck (*Tragelaphus scriptus sylvaticus*). Dark brown, with no transverse stripes. Cape Colony.

Mountain Bushbuck. (*Tragelaphus burtoni*). Sahatu Mts. of northwestern Gallaland to Lake Zwai. Nyala (*Tragelaphus angasi*). Nyassaland, Delagoa Bay, Zululand.

Sitatunga (*Limnotragus spekei*). Semi-aquatic, inhabiting dense swamps. Elongated hoofs.

Eastern Sitatunga (*Limnotragus spekei spekei*). Uganda and the Sudan.

Zambesi Sitatunga (*Limnotragus spekei selousi*). South Central Africa.

Western Sitatunga (*Limnotragus spekei gratus*). The Congo, Gabun, Nigeria.

Bongo (*Boöcerus eurycerus*)

West African Bongo (*Boöcerus eurycerus eurycerus*). West Africa: Liberia, Gabun, to Uganda.

East African Bongo (*Boöcerus eurycerus isaaci*). Kenya Colony.

Uele Bongo (*Boöcerus eurycerus cooperi*). Belgian Congo.

Related Species

Greater Kudu (*Strepsiceros strepsiceros*). Several races. Greater part of Africa, south of Sahara.

Lesser Kudu (*Strepsiceros imberbis*). Southern Abyssinia, Somaliland to Kenya and Tanganyika.

Eland (*Taurotragus oryx*). Zambesi to the Cape.

Derby Eland (*Taurotragus derbianus*). Senegambia, Gambia, the Guineas and Upper Congo.

Nylghai (*Boselaphus tragocamelus*). India.

Four-horned Antelope (*Tetracerus quadricornis*). India.



Two of the elephants which were employed by trainers and keepers in an endeavor to capture Sirl Nan, one of the two Royal elephants that ran "amok."

Tragedy Among Royal Pachyderms in Siam



Being an account of the death of two tuskers in the Royal Elephant Stables in Bangkok under most unusual circumstances.



DR. EDWIN B. MCDANIEL

The illustrations for this article, with the exception of the head and tail pieces, were resurrected from cuts in the Bangkok (Siam) Daily Mail.

"THONG KHAM is crazy again" was the cry on every tongue as excited crowds ran panting toward the elephant stables in Siam's capital city. More or less they were used to the pranks of this elephant as he went back and forth to his daily bath.

For nearly a week now he had been growing worse, until his great rage finally became so overpowering that early one afternoon of that fateful week, he gave a mightier heave than ever and snap went the great chain that had held him captive. He was in an ugly fighting mood. Nearest him was a somewhat smaller tusker, the "Pride of Nan." He would pick a quarrel with him. Covering the few yards between them he struck the unsuspecting beast amidships with his great tusks. Backing away he prepared for another rush.

Now he had for some time been picking on his smaller stable-mate as they went together to their bath. Usually "Nan" had shown fear, but for some reason today he showed fight and naturally this increased the wrath of the burly aggressor.

For a moment it was "give and take" with the keepers rushing in to stop the conflict. And then another chain snapped and

"Siri Nan," who had already enough, turned tail and sought the open road. The aggressor tried to follow but the keepers had been reinforced and for the moment he was prevented from doing so.

Siri Nan was free! It was a novel experience for him to be out on the street without that dark bunch perched on his neck and directing his every move. It reminded him of the

days before his capture when he ran with the herd away up beyond Chiangmai. He hoped it might continue though he didn't like the wild shouts of so many people. And where was Thong Kham?

A great many Government offices are in this vicinity so Siri Nan made their rounds. Trumpeting shrilly he raised his trunk in seeming salute to the High Officials and humble clerks who in answer to his trumpeting now filled all the windows. Work for them was not to be thought of, but they were glad they were inside and not outside with him.

Like magic the crowd grew. Such a spectacle as this was unusual and one could shout as well. The keepers who had trailed their charge were shouting, why should they not lend a friendly mouth also. And so the noise grew until Siri Nan became thoroughly fright-



Siri Nan, before his fall posing unconsciously for the photographer who risked his life to get a picture of the mad elephant.



Siri Nan, shown in the position which led to his untimely death, when he fell into the river.

ened. He thought only of his stable with its great bundles of green fodder waiting for him there and, best of all, the quiet. But the crowd hemmed him in on every side except toward the river. He would go there.

At this juncture the head keeper of the elephants appeared on the scene with two other tuskers, hoping to entice Nan back to his stall. Nan's ribs were aching where Thong Kham had rammed him and he was watching for his enemy out of the corner of his eye. Unfortunately he mistook one of these new comers for his late oppressor and bolted again.

Halting not far from the river bank, he faced it, evidently considering it as a possible avenue of escape from all this turmoil. In front of him was this broad expanse of water, behind and on all sides the curious, noisy, growing multitude.

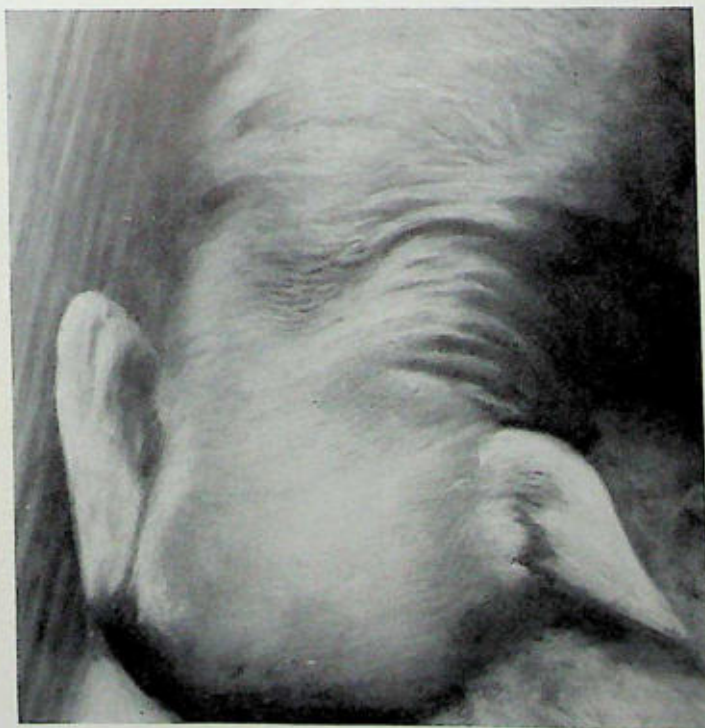
Growing bolder, and pushed forward by the mass of humanity behind them, the crowd came nearer and nearer. Sensing this possible danger, Siri Nan wheeled suddenly and trumpeting loudly made

as though to charge right into the thick of the crowd, but held his place. Time and again he went through these threatening maneuvers, the crowd giving way to flight each time. With angry shakes of his great head, rapidly fanning ears and nervous pawing of the earth with his big feet, he faced them all.

They were not the folks he knew—not the inoffensive creatures he had so often seen calmly crouched by the roadside as he had moved majestically along in great State Processions. Then he carried a beautifully inlaid howdah on his back and was

resplendent with trappings of silver and gold.

These creatures struck terror into his heart. They must be enemies and they were far too many for him to fight. He must flee. He would



Siri Nan with his head in the water and unable to move, following his fall into the Menam Chao Phya in front of the Rajini Girls' School.

plunge into the river which was always friendly to him. Did he not bathe in it every day and did he not always return refreshed?

A short and frail bridge led to a boat house landing. It was only a step. Under normal circumstances he, sharing the wisdom of his kind, would not have ventured upon so frail a structure. But things were not normal; most decidedly they were not, and he had grown desperate. He ventured, and just as he set foot on the narrow landing it collapsed, throwing him head first into the shallow water and imbedding both tusks in the stiff mud of the river bank. His head was thus literally pinned beneath the muddy water. His huge body moreover was jammed tightly between many large piles deeply sunk into the river bed to anchor the nearby boat houses. The impact was terrific.



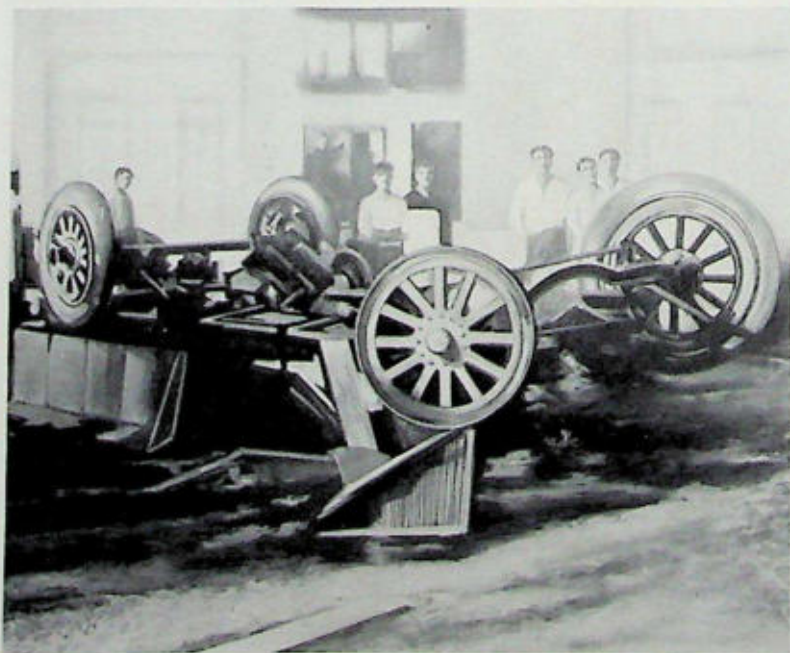
Thong Kham, dead, in front of his corral after orders had been issued to poison the elephant if he proved uncapturable, following his trampling to death of Nai Jun.

The poor beast screamed with pain and terror. He tried with mighty struggles to free himself. But with his head pinned to the river bed, his movements cramped by the piles, he could not use his mighty strength to free himself. As it was he snapped off several of the big posts. The occupants of the house, gathering their babies, fled in terror.

Whatever was to be done to rescue him must be done quickly. A long hawsers was procured and divers placed it around his hind quarters. A hundred willing hands pulled mightily and long, again and again. A motor car was hitched on to help. Other elephants lent their strength, but it was no use. Only a crane or derrick of great lifting power could have saved him and neither was at hand.

He was caught in as cruel a trap as any enemy could

possibly have devised. Perfectly at home in the water, yet he was, under these pathetic circum-



What happened to a motor car in front of the Ministry of Justice which stood in the way of Thong Kham, after he had broken loose for the second time.

stances, literally drowned and his cries grew weaker, his frantic struggles soon ceased. This was death number one.

But what has the "musth"* beast been doing all this time? Rushing past his keepers, he too took to the open road and while only a moment behind Siri Nan he fortunately took a different direction, but *he* was bent on mischief.

An inoffensive old man, perhaps a little deaf, did not hear his approach and was speedily knocked down and trampled to death.

A motor truck was the next object of his fury. It had only just arrived loaded with soldiers to assist in his capture. Seeing the fate of the old man they took to their heels. Thong Kham pushed and dragged the truck a hundred feet or more and then turned it upside down as easily as though it had been an empty packing case. He was on a rampage and having a great time!

Apparently growing tired of this sport he ambled back to the stable grounds where for two hours he amused himself by knocking the keepers' houses to pieces.

One man offered to capture him for ticals three hundred (\$150 Gold) provided he was furnished with two elephants larger than Thong Kham. But no elephants of such size being available his offer was not accepted.

The authorities therefore, in order to avoid the probable loss of more lives, decided that

* Male elephants on attaining maturity are subject to peculiar periodic paroxysms of excitement, to which the name "musth" is applied by the natives of India. This condition undoubtedly has some connection with the sexual function and is probably analogous to the rut in Wapiti and certain other species of deer.—W. R. B.

the outlaw should be poisoned. Liberal doses of strychnine were put in bananas and the task of feeding them to the elephant fell to his old keeper. His eyes streaming with tears, his frame shaken by sobs, he fed them to him one by one. Despite Thong Kham's wickedness, the keeper still loved him. Soon the powerful poison took effect and death came to end the danger.

Thus perished in the short space of a single day these two splendid Royal tuskers and under circumstances tragic in the extreme.

Thong Kham was twenty-eight years of age, eight and one-half feet high and bore tusks five feet long. When not in "musth" he was very docile and, like Siri Nan, had taken part in many State processions.

Siri Nan was a smaller animal and his ivory was somewhat lighter.

After nightfall the two carcasses were towed by boat to the elephant burying ground far below the city. Perhaps never before had this great river borne on its waters at the same time the huge bulk of two such victims with ends so pitifully tragic.

No more sugar cane from the hands of admirers. No more gorgeous howdahs and cloth of gold. No more pride in carrying Royalty in great State Processions.

It is of interest to learn that, according to regulations, there must be delivered to the Elephant Department the tusks, the bones of the front and hind legs, the toe nails and the tips of the trunks as proofs of disposal.



"Field Book of the Shore Fishes— of Bermuda"

By WILLIAM BEEBE and JOHN TEE-VAN

AS the title indicates, this volume presents a concise, but at the same time inclusive, outline of fishes found off the shores of Bermuda. It is practically a general introduction to the further and more detailed study of many of the Bermuda and West Indian fishes, whose life histories are as yet incomplete. According to the authors, so far not one complete life history of a Bermuda fish is known. The book accomplishes a useful purpose in that it contains within a limited space a great quantity of needed and little known information concerning the fish life of the waters surrounding the Bermudas.

The material presented in the volume is based upon the results of four years of work by the staff of the Tropical Research Department of the New York Zoological Society on Nonsuch Island and Bermuda, as well as the laboratory studies continued in New York in the intervals between field expeditions. This research included also comparative studies of West Indian and Bermuda fishes found in the collections of various museums in the United States.

The main text of the book is prefaced by an introduction which contains a brief statement concerning fishes in general, — answering such questions as "What is a fish?" and among other things telling about their numbers, distribution, migrations, their size and weight (always an important consideration with fishermen), coloration, teeth, food, poison glands, courtship, nests and eggs, and their psychology,—since this timely

topic appears to have invaded even the field of ichthyology.

It is interesting to find, in connection with the origin of Bermuda fish fauna, that approximately seventy-five per cent comes from the West Indian islands, nine per cent of which is found only in the waters adjacent to the island of Bermuda, while the remaining twenty-five per cent are pelagic, with world-wide distribution near shore or with distributions including the eastern Atlantic and the eastern Pacific Oceans.

The manual describes 335 species of fish, these representing the shore fishes and the more common pelagic forms about the island, such as dolphins and flying fish. Each species is illustrated by an outline drawing, accompanied by data giving field characters, diagnosis and distribution. In addition the

volume contains four colored plates, sixteen pages of photographs, and numerous maps and diagrams, all of which enable the reader to obtain a very clear and accurate idea of the identity of these various fishes. As an aid to the student of ichthyology and the field worker, the book contains complete keys for the determination of species, as well as a bibliography of the more important works on Bermuda fishes. An index for ready reference appears at the close.

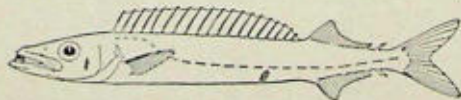
The book is to be highly commended for the careful and accurate manner in which this great amount of information has been brought together and made available for the lay reader, the student and the field worker. Possibly even the Bermuda tourists who flock to the Island in such numbers and whose knowledge of fishes is perhaps rather limited, to whom a sharksucker might signify some species



Frontispiece and title page of "Field Book of the Shore Fishes of Bermuda."

Bermuda Catfish

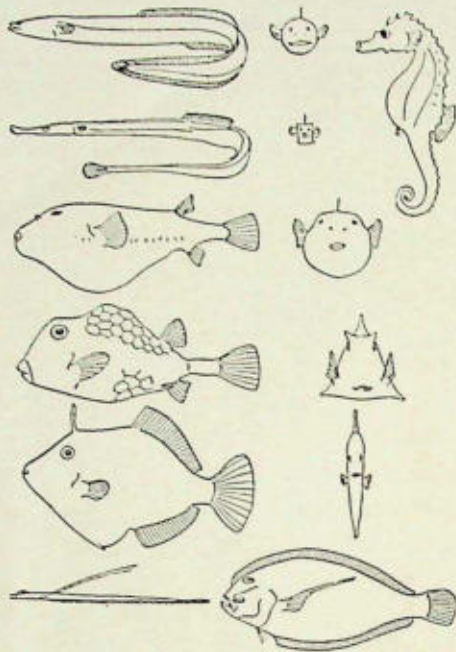
Promethichthys prometheus (Cuvier and Valenciennes)



Field Characters.—Medium sized, elongate, slender, compressed, fusiform fishes; mouth large, with strong fang-like teeth in front of each jaw, both jaws with an outer

Section taken from the book showing the method of presenting the various species.

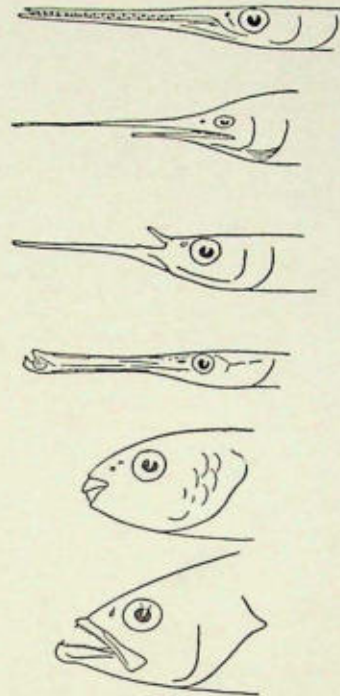
10 FIELD BOOK OF SHORE FISHES



Various Forms of Fish

Eel, Pipefish, Puffer, Trunkfish, Triggerfish, Flounder and Seahorse.

FIELD BOOK OF SHORE FISHES



The Mouths of Fish

Gar, Spearfish, Halibut, Trumpetfish, Parrotfish and Snapper.

Two pages from the book showing in outline the various forms of fishes and their characteristic mouths.

of "racket" rather than a creature of the deep, would find the book useful.

The "Field Book of the Shore Fishes of Bermuda" is one of the natural history series of

field books issued by G. P. Putnam's Sons and is published under the auspices of the New York Zoological Society.

—W. R. B.



Through the courtesy of the American Museum of Natural History, the Department of Tropical Research of the Zoological Society held an exhibit in the Educational Hall of the Museum, showing the Bathysphere, deep-sea apparatus, scientific collections and paintings from the field work of the Department, made at Nonsuch in Bermuda.

On the night of the opening of the exhibit, January 27, the Director delivered an illustrated lecture in the auditorium. The exhibit was on view to the public from January 28 to February 21, and attracted a great deal of attention. Dur-

ing this time it was visited by 26,426 visitors.

After the exhibit the Bathysphere was shipped to the Century of Progress Exposition at Chicago where, with a model of the *Arcturus* it will be shown, beneath Prof. Piccard's gondola.

On the recommendation of Doctor Gregory and Doctor Sherwood of the American Museum of Natural History, the Executive Committee of that Institution have unanimously appointed Doctor William Beebe a member of the Staff of the Department of Ichthyology, with the title *Research Associate in Oceanography*.

THE picture on the cover is the photograph of a rare fish—*Pantodon buchholzi*—from equatorial west Africa. It is reported to be a flying fish and a casual glance at the enlarged lacy fins might support this theory, but it is probable if the fish leaves the water at all it is only to skitter along the surface, snapping up whatever insects it may find. The specimens on exhibition at the Aquarium are rather particular about their diet, refusing anything but cockroaches. These, however, are eaten with avidity. The hairlike processes extending from the ventral fins are used as stilts when the fish is resting near the bottom of the water, supporting the body, motionless, an inch and a half or two inches above the floor of the aquarium. The total effect of the extremely odd fins is one of bizarreness rather than of beauty although each, as a part, is very attractive.

—C. W. Coates.

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NEW YORK ZOOLOGICAL SOCIETY

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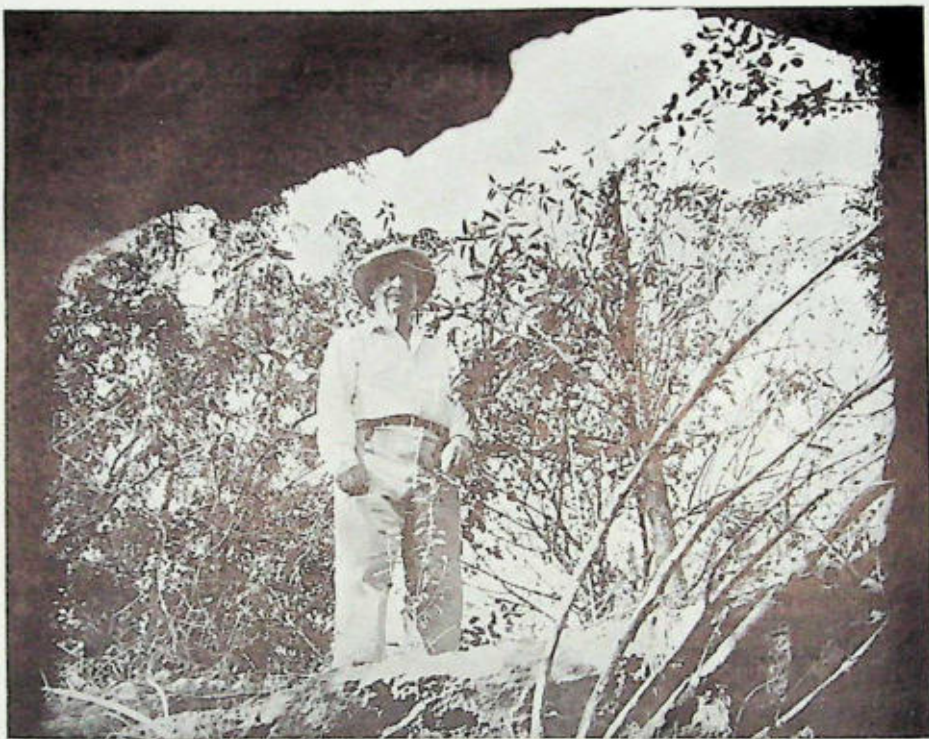
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Editorial and Subscription Offices, Zoological Park, New York City, Elwin R. Sanborn, Editor.



Mr. Daniel Bacon exploring a thicket on South Andros. Mr. Bacon, good friend to the Aquarium's interests and life member of the New York Zoological Society, has sponsored and ably lead three expeditions to the Bahamas and numerous shorter trips in local waters. The chief purpose of each has been the furthering of biological research. Although not as spectacular as the collecting of specimens for public exhibition, the work of these trips has been of great importance to the institution. The field observations made on them, coupled with subsequent laboratory study, has resulted in genuine improvements in the methods of maintaining fishes in captivity as well as increasing our understanding of the interactions between aquatic organisms and their environment. Field studies concerning the effects on fishes of chemical variations of natural waters have occupied a prominent part on these trips. The information so obtained has been used to much advantage for properly conditioning water for the Aquarium displays. The accompanying article tells something of the more general observations made and experiences met with in the process of gathering such data on the two most recent of the Bahama expeditions; those to Andros Island. The above photograph taken from within a small cave on South Andros in the Grassy Creek region, does not show a tangled wilderness, as one might suppose, but is actually a sisal farm.



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The Bacon-Andros Expeditions

C. M. BREDER, JR.

Assistant Director, New York Aquarium

Illustrations from photographs made by the author and various members of the Expeditions.

CRUISING with an able and experienced yachtsman is an event that most of us consider something to be looked forward to, and later to be long remembered. When the yachtsman happens to be Commodore Daniel Bacon, and the occasion of the cruise the pursuit of natural history in Bahama waters, there can be little left for the desire of most naturalists. Thus it develops that there lives in my memory two delightful trips to Andros Island in the successive years of 1932 and 1933. The memories are twofold: One being that of the companionship of the genial host and sponsor of these trips, and the other the inherent biological interests.

Andros Island, the largest of the Bahamas, according to the charts, is actually an archipelago of numerous islands ranging from mere rocky points to masses sufficiently large to support fresh-water lakes. Taken as a whole the group is about as long as Long Island, New York, and in places twice as wide. The seacoast and reefs are well known to naturalists. On the west side are shoal waters covering extensive marl beds which support a very considerable sponge industry. On the east side the deep waters of the Tongue of the Ocean reach to the most extensive, fringing reef in the northern West Indies. It is here that Dr. R. W. Miner has collected the material for his elaborate habitat group, depicting a typical coral reef which is now under construction at the American Mu-

seum of Natural History. Inland Andros, on the other hand, is not nearly so well known to naturalists; consequently, for this and other reasons, it was selected as a site for biological exploration.

The first trip (1932) was directed to an area farthest from any coast, in order to learn just how much of a fresh-water habitat might have been developed on such a purely oceanic island composed, as it is, of limestone basically originating from coral reefs. In order to reach the desired location it was necessary to enter the inland waters from the west side of the island. Most of the drainage is to that shore since the highest land is along the east coast. Arriving at the latter shore by launch from Nassau, which lies east of the Tongue of the Ocean, it was thus imperative to pass around the island or go through one of the numerous passes. The latter course was selected. These passes, in this case North Bight, are smoothly floored with soft calcium mud, the marl of the region, which is in part triturated coral and shell and in part the products of precipitative processes.

The passes are all very shallow and of remarkably uniform depth, due to the leveling effects of the silting marl. Since our launch, the *Escape*, drew four feet of water, and many of the so-called channels were of just about an equal depth, it meant long hours of travel at reduced speed in which the hull actually plowed



A small tree frog of Andros (*Hyla septentrionalis*). These were very hard to find since the country was arid and the breeding season not nearly ready to begin. The natives state that in April and May the fresh-water ponds and lakes are noisy with frog choruses.

a large lake-like rain pool within a few hundred feet of the camp. Doubtless, at the proper season, this is the site of a brilliant frog chorus. All about the mangrove roots, which in part fringe the River Lees, could be seen the ubiquitous West Indian puffer (*Tetraodon testudineus*), or the lurking shadows of the gray snapper (*Lutianus griseus*). All of this increased our enthusiasm for a pleasant camping trip amid a splendid variety of animal life both above and below

chattered at us. Our first camp was made on the shores of the River Lees, a narrow, relatively deep, canal-like passage between the Wide-opening and Turner Sound. Here the night was spent in a pleasant grove of mahogany trees. Small lizards (*Anolis*) scampered about, and a tree frog (*Hyla*) was found. The latter suggested the proximity of fresh water. In the morning before leaving, a scouting trip found

A curly-tailed lizard at the Berry Islands. This small and friendly lizard permitted considerable familiarity, but all the while we were at close range displayed nervousness by tightening and relaxing its spring-coiled tail. The movement was regular and not unlike that of the hair-spring of a watch, except being very much slower. The photograph caught probably the most relaxed position of the tail that we noted. Taken on a previous expedition to the Bahamas with Mr. Bacon.



the surface. Little did we dream at the time that this camp site was the only one to be replete with such forms. Passing on to Turner Sound we encountered large tarpons leaping where the River Lees joins the Sound. This brought to mind the perennial question that has pestered naturalists for years—"Where do they breed and what do the early stages look like?" The problem was not solved but some significant data were subsequently uncovered that give a further lead. Crossing the Sound was uneventful. In most places it could comfortably float our tiny craft, but then only

One of the small lizards of Andros. This one, *Leiocephalus carinatus*, did not show the curly tail of the Berry Island *Leiocephalus*.

with an occasional objection in the form of a kick-up of the outboard motor.

Finding another creek, variously known as the Haul-under or Milk River, we left Turner Sound and gave up the use of the outboard motor in order to pole into its shallow mouth. Here we were embarrassed by a dense tangle of mangrove and other bushes, as lush as any to be seen on Andros. Only the free use of machettes made a passage relatively simple. It was noted that there was a distinct flow, this "river" actually being a flowing stream, and not a mere tide-way as are most of the Andros rivers. Due to various causes, it was distinctly turbid, with marl nearly the color of well-watered milk. At least the first part of the name, Milk River, is entirely appropriate. The significance of the other name, Haul-under, would be evident to all who, even with the aid of a bush knife, might go through it. A scrambling out on the bank revealed that this dense growth forms an arcade along the waterway and is flanked on either side by flat, prairie-like country that supports only stunted and sparse vegetation. The soil is thin and poor and much of the surface is either an outcropping of eroded limestone, or plains of the ever evident desiccated marl. The periodic hurricanes that rake this low country from time to time distort or kill most of the growth and sweep off into the sea much of the slowly accumulated soil; thus, vegetation never really gets away to an adequate start. It seems to be always aborted by the force of storms, against which there is an insufficiency of protection, or starved by being robbed of a sufficient depth of soil.

Once through the Haul-under, we broke upon the silent fastness of Lake Forsyth and were again able to employ the outboard motor. This body of water at first glance appeared not to be very different from the recently traversed Turner Sound, except that not unattractive copices of pine relieved the dimly flat landscape. The lake had been named for the Commissioner of Andros and the Berry Islands, Mr. E. W. Forsyth. One of our first stops before going inland was to pay our respects to this kindly gentleman at his residence on Mangrove Cay. He is one of the very few white persons living on Andros. Most of the small settlements, nearly all of which occur on the east coast, are exclusively Negro, to the number of some 5,000 per-

sons. We are deeply indebted to Commissioner Forsyth for his cordiality and helpful advice.

After having well entered the lake we looked about for a suitable camp site. This was discouraging business and nightfall nearly overtook us before we were established. The shore line consisted of but two kinds; either it was of the increasingly annoying, soft and pasty marl and quite impossible, or it was of limestone so eroded that it presented the general appearance of Swiss cheese. Finally a spot of the latter type was selected, which seemed to be less objectionable than the rest. While it cannot be described as either especially comfortable or particularly delightful the writer, at least, found it to be distinctly the most curious camp site in which he ever settled.

The following morning when we arose to take stock of the place to which we had come for the purposes of biological study, we were for the first time in a very receptive mental state. It seemed something was wrong. The place was altogether too quiet. The air was still, yet the quiet was not that of a breathless morning. A few lizards scampered about but that was all. A swift shadow prompted looking up. Two buzzards were circling over the camp. Then it dawned on us that the missing element was that usual one of bird voices. What had become of the ducks, herons and kingfishers that were so abundant in the inlet? Why were there no warblers or sparrows in the bushes and why were those buzzards so attentive? Breakfast prepared by the skillful hands of Mr. Bacon's man, Fred, helped considerably, but by this time those two buzzards found a perch on a stark, dead tree and kept an interested eye apiece on us. These death-watchers are certainly fascinating enough on the wing, when considered as master aviators, but their concern over our activities was anything but enlivening.

As we later went about our proper collecting pursuits this pair of birds followed our skiff, and when we returned to camp circled their way over us as a convoy. On investigating the shores of this lake exactly one other bird was seen—a single wintering Maryland yellow-throat, and once at night a single call of some heron passing over was heard. The only terrestrial vertebrates to be found were a fair number of lizards, small

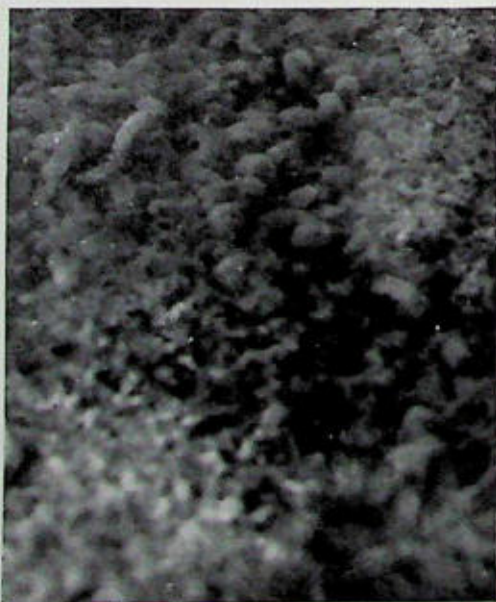


Anolis and slightly larger *Leiocephalus*, and by tearing open stunted palms two kinds of frogs (*Hyla septentrionalis* and *Eleutherodactylus ricordi*) were taken in small numbers. Probably the latter are fairly abundant but during the dry, winter months remains, for most part, well hidden.

Milk River. This milk-white stream connects Lake Forsyth with Turner Sound and for much of its length is so overgrown with vegetation as to make the use of machettes essential for passage.

The turbid waters of this shallow lake, six feet in the deepest part

sounded, were somewhat of a surprise. The first setting of seine yielded an abundance of fish-life. Eleven species in all were caught. As these same species were taken again and again in various places, we believe the number gives a representative sample. The striking part of it



The bottoms of the fresh-water lakes are covered with a curious worm-like algae (*Batophora*). This, in turn, is generally dusted with the precipitating white marl, toning the color down to a pastel tint.



An aquarium view of the algae (*Batophora*), and some of the fishes, (*Gambusia mowbrayi*), that live amid its fronds. The milky appearance of the water and the precipitated marl is evident here.



is that they are all marine or at least brackish-water types, although this water was quite potable and on chemical analysis showed itself to be so slightly contaminated with salt as to be considered thoroughly fresh. It was, of course, saturated with calcium, being bedded in coral rock and holding much marl in suspension. Incidentally, no young tarpon were to be found, as at first was hoped. Three of the eleven fishes have been described as new.¹ Although they greatly resemble species

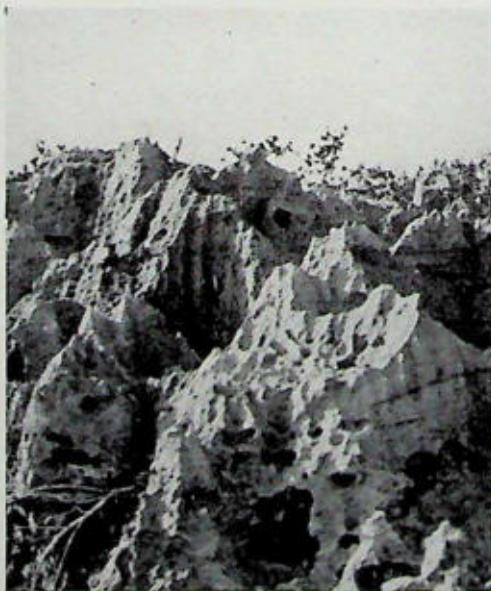
The soap-suds-like froth of Andros fresh waters. Every cove into which the wind blows for some little time acquires such a layer of suds.

from other West Indian localities they have apparently un-

dergone a sufficient change to render them recognizable in this unusual type of habitat.

If the camp was depressing by day it was positively eerie by night. A new moon silhouetted the two buzzards on their scraggly perch of dead wood and cast long shadows around the perforations in the desolation of eroded rocks that shored

¹Breder, C. M., Jr. An annotated List of Fishes from Lake Forsyth, Andros Island, Bahamas, with the Descriptions of Three New Forms. Amer. Mus. Novitates, No. 551, August 15, 1932.



Some of the more rugged landscape near the mouth of Grassy Creek. The effects of wind and rain on the comparatively soft and readily soluble portions of this calcareous rock is especially notable in this region.



A detail of the firm meringue-like suds that piles up on lee shores. When this size is reached great masses are torn off by the wind and driven inland to cling to the shrubs like great tufts of cotton.

the milk-white lake. So much did the place remind us of Doré's sketches of the nether regions that our dwelling was unanimously dubbed Camp Inferno. The reasons for this curious condition are not far to seek. The cover of soil and vegetation is very scant and as previously pointed out is not infrequently torn up by hurricanes. At such times, also, there is usually an inundation of sea water. Thus few organisms incapable of more or less protracted emersion in sea water are able to survive. Evidences of hurricanes are everywhere, although no strictly recent one has apparently flooded this particular region.

Insects and small fruits are not abundant. There is, consequently, a rather meager foundation on which a food-chain can be built up. One of our companion buzzards, while waiting for us to expire, succeeded in catching a lizard. Although such behavior is not entirely unknown it is distinctly unusual and gives a hint of the poorness of the region. With conditions such as these a question may be properly asked concerning the source of sustenance of such an abundance of fish life in waters where there is naturally a small influx of food from the land. It so happens that a peculiar algae (*Batophora*) floors the bottom of Lake Forsyth to a considerable extent. Examination of the stomach contents of the smaller fishes showed them all to be feeding on this plant or the micro or near-micro-organisms dwelling in its fronds. The larger and less numerous predaceous fish feed, in turn, on these fishes making the lake practically self-contained in this respect. As previously indicated these fishes represent an invasion from the sea although the abundant marine invertebrates have not made a similar invasion. Except for a few land or semi-terrestrial crabs the macroscopic invertebrates present are definitely of fresh-water origin. These are mostly insects, such as dragon-fly nymphs, which in the adult form are often carried long distances on the wings of strong gales. The only form not of this type is a single species of pond snail (*Physa*) which occurs sparingly. Thus it becomes evident that in this geologically-young, fresh-water region but one strictly fresh-water form, not possessing ready means of travel, has established itself. Just how this form got across from the mainland is certainly not clear.

Leaving Lake Forsyth with its disappointed

buzzards, after not having seen a single, stray, prowling Negro since we left the spongers on the west coast, it was a considerable relief to board the patiently waiting *Escape* and make our way back to the more friendly parts of the island.

Before going on to other parts of Andros, however, there is one item, concerning the efficiency and energetic capability of our guide that cannot pass without mention. Due to some maladjustment in the outboard motor, we used much more gasoline than was expected; in short, we found there was not nearly enough to get us back to the *Escape*. That meant rowing, poling and struggling, five men in two heavily laden, small boats, a matter of some thirty-five miles. The only alternative was for one person to go light and bring back the needed gas. Hepburn thought he could do it in two days; one to go and one to return. We thought, more likely, that it would be three. Finally, after some discussion, he was sent off with the skiff, a blanket and some food, at noon on January 24. He rigged a sail of his blanket but we knew he could only go with the wind, by means of this crude outfit, and most of the way the wind was unfavorable. It was mostly a matter of sheer man-power for about seventy miles, there and back. We wondered considerably just how long it would take him. That night I was awakened by Mr. Bacon, who was peering out into the darkness. He said he thought he heard some one prowling about—the last thing we expected in this lonely spot. Just then there emerged into the dying glow of our old fire, a figure. It was Hepburn. We all were up, and by now wanted to know what had happened; why he had turned back, and so on. Hepburn seemed surprised. He had not turned back, he had gotten the gasoline. There it was in the skiff. A glance at our watches showed it was 3.00 A.M. He had made the complete trip in fifteen hours! If he was tired, he showed no evidence of it next day. Mentioning the fire makes it necessary to recall that the nights were amazingly cold, mostly with the damp chill from fresh water. Only by building a large fire before our open lean-to, prior to turning in, could we remain warm enough to stay asleep. Even so we not infrequently awoke in the early hours before sunrise, chilled through because the fire had died down too low.



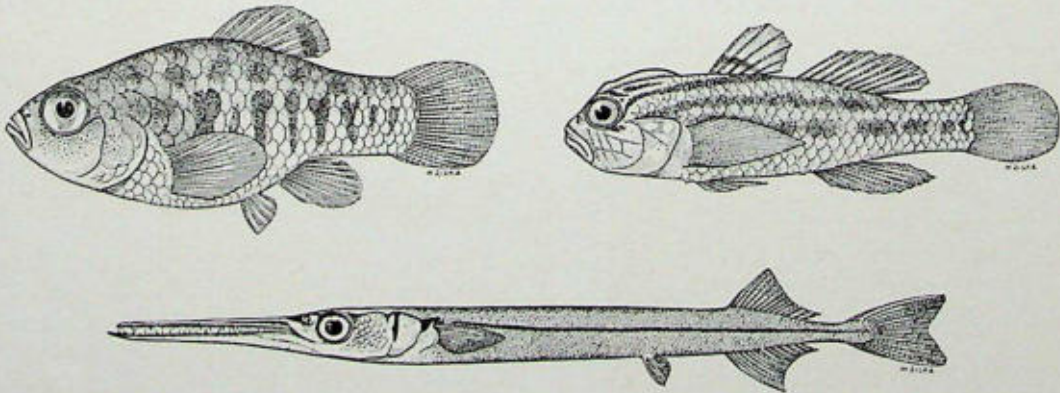
The more southerly parts of Andros Island, visited on the second trip (1933), were found to be essentially similar to the northern. We encountered more friendly country by spending a greater part of our sojourn near the eastern coast, with only excursions into the interior for purposes of comparison with the previous year. A fresh-water lake entered by way of South Bight presented a similar general appearance to

The camp on the shore of Lake Forsyth. The eerie nature of this locality can be well visualized from this photograph, which was taken late in the afternoon on the return from a fishing trip. The buzzard which circled all day over our heads can be seen preceding us to its post of vigilance for the night—the dead tree immediately in front of our tent. These watchful waiting harbingers of death helped to emphasize the dreariness of the landscape.

the material collected on the second trip has not been fully studied, so these remarks must be confined to the more

general aspects of this visit.

One place on the shores of Grassy Creek we thought especially interesting. The formation was unusually rugged and the vegetation unusually dense. Some of the cavities were large enough to be considered small caves and could have been used as very satisfactory shelters. A



Lake Forsyth, although it must be admitted that it had a

more genial atmosphere and life, such as small birds, was much more in evidence. Samples of the fish found appeared to be substantially the same, and still no young tarpon. At this writing

The three new fishes from Lake Forsyth, *Cyprinodon baconi*, *Strongylura notatus forsythia* and *Lophogobius androsensis*. From pen drawing by H. Ziska.

few places showed evidences of stalactite formations in their initial stages. Travel was difficult due, in part, to the irregular and deeply pitted nature of the terrain, and partly because of the density of the low but intricately tangled



The pupae of a small white moth (*Alarodia sloxsoniae* Packard) are common on the mangrove leaves of interior Andros. These are deceptively similar in appearance to the eggs of various small lizards that are to be found in the same environment.

growth. We noted there were many small sisal plants in the underbrush the spikes of which, at ankle height, did not increase the pleasure of our prowl. On our return to the anchored launch we remarked on the jungle-like nature of that patch of Andros, only to elicit the information that we had been wandering through a sisal farm! It seems that these plants were placed in small rock holes wherever there was room, in the hope of harvesting the sisal on maturity. A drop in the market price of this product rendered such a harvest unprofitable. The latter

The stunted and tempest-torn mangroves, fringing the shores of interior Andros, support numerous epiphytes of the type here shown. These are, at times, nearly the only green things to be seen on these bushes.



was extremely easy for us to understand.

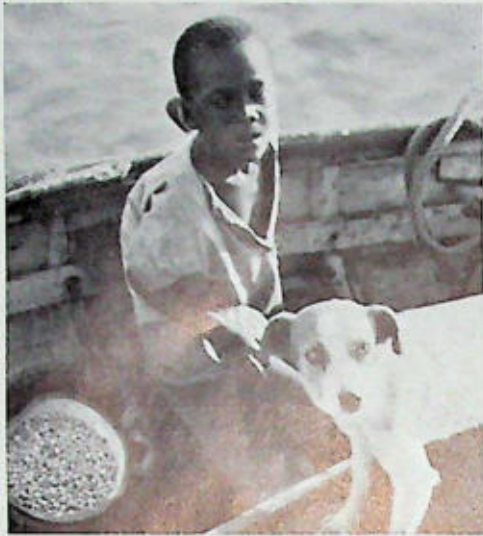
This region is not far from the breeding site of the flamingoes, for which Andros is probably best known. At the season of our visits none was to be found, as at such times they are wintering in Cuba, according to the natives who always speak of them as Fili-mingoes. Also, the Andros iguana (*Cyclura*) ranges these southern parts but is reported to be so scarce that we decided to spend none of our limited time to hunt for them. Here as in other regions they are



caught with the aid of dogs that run them down.

By this time the highly dissected nature of Andros was thoroughly evident, while from both observation and the description of natives it became apparent that relatively great quantities of fresh and almost fresh waters were to be found. There was such a marked uniformity of for-

Receding waters frequently leave mangroves high and dry. The aerial roots of these plants, when they reach a sufficient length under the influence of gentle breezes, then start to excavate a circular hole. As it requires a nearly perfectly still air for some time, to enable the growing tip to "dig in", these excavations may reach a considerable size. It will be noted that the one illustrated has destroyed all the low-growing vegetation and has exposed the dried marl beneath. The angle that the root makes to the perpendicular is due to the amount of wind pressure at the instant of photography.



A young resident of South Andros and his dog. The latter, answering to the name of "Scorpion", is used by his master to run down and catch iguanas for food. Behind the boy is a bucket of pigeon peas, one of the chief articles in the diet of these people. The price of the portrait was the "ship's biscuit" which the little fellow holds.

We were about to return to Nassau without having seen anything of young tarpon, and had stopped at Mangrove Cay just to pay off some small boys employed as lizard collectors. These, to our delight, had made a collection of about 1,000 specimens in a remarkably short time, under the guidance of Bert Bowlin who rendered valuable service in engineering this operation in our absence. It was at this time that Hepburn said he thought that small tarpon might be gotten in a nearby pond. Without much hope we went ashore to scine another hole; probably to no particular purpose. One look at it gave mixed feelings. So tangled was it with



The village of Deep Creek. A typical Negro village of the better sort. The houses are of coral stone and sun-baked marl, thatched with palm leaf. Most of them are scrupulously clean.

mation and fauna in the places examined, that there is every reason to suppose that the unvisited places are similar. One of the striking features of these fresh waters that also seems of constant occurrence is the formation of large quantities of white soap-suds-like froth to be found in every corner into which the wind blows. Chemical analysis of this will be made, but on a basis of physical appearance and action it would seem to be a natural soap formation that can be accounted for well enough by the peculiar details of these waters.

A sponger on his way to the Andros sponge banks. Note the loose footed sail. In a rough sea this frequently drags in the water. These small boats often ship a crew of nine spongers, under the most unlivable conditions, especially when the vessel is filled to overflowing with damp and reeking sponges.



dead buttonwood bushes as to be almost unscinable, and so filthy as to preclude practically any fish life. However, it was different than any other pool, salt or fresh, so far seen on the islands. Recalling that Evermann and Marsh in Puerto Rico, and Beebe in Haiti caught small tarpon in pools that were reported as foul, our interest revived. Here was opaque red-brown water covering knee-deep mud, mostly of decomposing vegetation which reeked of sulphureted hydrogen; nearly fresh water and different than any other pool in the area.

After much difficulty the seine was set, torn, twisted and finally brought together, encmeshing some sort of fish—sure enough, a seven inch tarpon gleaming and glistening with all the brilliance of a seven foot specimen. Here again were young tarpon, now recorded from three West Indian localities, similar in physical condition. After further struggles with the mud, net, sand flies and broken branches, more were captured; but the fish had all the advantage. The details of this observation will be discussed in another article. Suffice to say, we left in a most

satisfactory frame of mind and reached Nassau just in time to find shelter before a nasty blow.

Some of the more interesting, preliminary results of these trips follow. The fresh waters of Andros Island while invaded by marine fishes apparently are geographically still too young to have developed a truly fresh-water fauna of vertebrates, although they seem to be in the process of so doing. The fact that so many marine forms have been able to accommodate themselves to these fresh waters appears to be associated with the large amounts of calcium present. Laboratory experiments, still in progress, tend to substantiate this. The fact that no true fresh-water fishes are present is certainly due to ocean barriers, as various fresh-water fishes can be made to live and thrive in synthetic "Andros fresh water." Marine invertebrates have made negligible progress in the invasion of these waters which is understandable on the basis that they are generally much more intolerant of chemical modifications of the waters in which they live than are fishes.

YOUNG TARPON ON ANDROS ISLAND

C. M. BREDER, JR.

THE destructive hurricane of 1926 inundated a portion of Mangrove Cay, Andros Island, Bahamas. A low portion, well back from the beach and near the settlement, retained a standing pool of water of considerable size. This standing water drowned a dense tangle of buttonwood bushes, the existence and size of which demonstrate a prior lack of water in this depression for a considerable period of years. Since the time of formation this pool has been shrinking, although augmented from time to time by rain. In 1932 there was still no connection with the sea and the water was practically fresh. Recently a drainage ditch has been dug through the beach to draw off this standing water, in the interests of mosquito reduction. There is, apparently, no flooding at high tide and the water is still fresh.

In February, 1933, nine tarpon were caught in this pool and ranged from about seven and five-eighths inches to thirteen and three-eighths inches in total length¹. Absolutely no other

fishes, or for that matter any aquatic life, could be found except a few stray semi-terrestrial crabs. Examination of the stomach contents of these fish showed them to have been feeding chiefly on these crabs. One aquatic beetle was found (*Dytiscus?*) and fragments of a few, small minnows (*Cyprinodon baconi?*). The latter, of course, proves that there were at least some of these present even if we could not catch or see any. The water was opaque, red-brown in color, and smelled strongly of hydrogen sulphide. It was not over a foot and a half deep at any place and was bottomed by a soft mud, so that in wading one would sink nearly to knee depth. This mud, unlike the usual white marl of Andros, was a dark brown and apparently rich in organic matter, the remains of the once dense cover that nestled in this depression. The dead buttonwood bushes still stand, a considerable handicap to seining operations. It was evident to us that many more tarpon could have been caught were it not for this condition. The accompanying illustration shows the condition above the surface. Below it, the brush was of even greater density. Further seining could have resulted only in a completely ruined net. Sand

¹15.5 to 28.0 cm. in standard length; 19.3 to 34.0 cm. in total length.

flies were abundant, but no mosquitoes, adult or larval, were encountered.

The local story has it that tarpon came in on the hurricane in 1926 and have been breeding

Rico record of Evermann and Marsh³ states that they "were seined in a small brackish pool of dark-colored water, not over five feet deep in a corner of a mangrove swamp . . . entirely sep-



there ever since. At times they have been very abundant but are now about "running out." Many, much

smaller than any we obtained, were formerly to be seen along the shores and some have been caught as large as four feet. Not having any proper net, the boys would use old gunny sacks to catch them, which, of course, indicates a very considerable abundance. Our guide tells that in the late spring, or early summer, very small specimens have been seen, which at least checks fairly well with the known time of ripeness. Mr. L. L. Babcock², in his very informative book, "The Tarpon", states in summary: "The indications are that the time of spawning on the west coast of Florida is from late June to August." Whether or not the natives are correct in stating that this body of water, until the recent ditch was dug, has not been connected with the sea since 1926, it is undoubted that tarpon have been there for some time, especially as they have been used by some as food.

The most striking part of the entire matter is that the two other tarpon records of this sort describe habitats essentially similar. The Puerto

²Babcock, L. L. *The Tarpon*. 3rd edition, 1930. pp. 1-135. Privately printed.

Seining for tarpon on Mangrove Cay. Some idea of the difficulty of these net operations may be gained by the number of snags above the surface. Much more was broken off completely below the surface. The man in the foreground is struggling with such a piece and is standing in only a few inches of water, his feet having sunk in the soft mud until they encountered some completely buried branches or old roots.

arated from the ocean by a narrow strip of land scarcely twenty-five feet wide." The Haitian record of

Beebe⁴ describes the habitat in part as follows. "From the waters of the Gulf, the lagoon is separated only by a narrow dike built up, apparently, by the action of the storm waves at high water. I walked into the ooze at the edge of the lagoon and out to the center. There I found half a foot of mud and about eighteen inches of water. This was green and muddy but not slimy. It was impregnated with sulphur and the odor of this element rose strongly from the disturbed bottom . . . This unprepossessing liquid was filled with innumerable small insects, which, upon examination, proved to be water boatmen . . ." With the exception of one small snook all fishes Beebe collected were tarpon.

One other record of small tarpon does not describe the habitat as foul. Eigenmann⁵ obtained small tarpon at Pinar del Rio, Cuba, "from a deep pool" which was presumably clear,

³Evermann, B. W. and Marsh, M. C. "The Fishes of Porto Rico". *Bull. U. S. Fish Comm.* 1909. Vol. XX, Pt. 1, 1902.

⁴Beebe, W. "A Tarpon Nursery in Haiti". *Bull. N. Y. Z. S.* Vol. XXX, No. 5, Sept.-Oct. 1927.

⁵Eigenmann, C. H. Report on the fresh water fishes of western Cuba. *Bull. U. S. Fish Comm.* 1902 (1903) 211-236.

fresh river water. Since the tarpon is a fairly abundant fish in its range, its population must be supported by a large number of juvenile fishes. While the present record will tend to support the idea that these foul backwaters act as tarpon nurseries, the writer does not believe that this is necessarily the case. In the first place, such swales are certainly not sufficiently numerous in the West Indies to accommodate the number of young necessary to maintain the known population. For example, only a single such locality was found after two seasons on Andros Island, during which time most of the activity was confined to examining brackish and fresh pools. Also this is a relatively recent body of water, being simply the aftermath of an unusually violent hurricane. In the second place, in at least two of the three "nursery" records, the fish were landlocked, or at least their egress to the sea was not easy.

An alternative suggestion is offered. If, as Babcock summarizes, "the fish probably spawn somewhere off shore in shallow water or in sheltered brackish waters," the young fish must either migrate to these lagoons or be hatched in them. If the pool becomes foul enough, because of local conditions, possibly other fishes so trapped that have not so great a tolerance die off and cease to be a competitive factor. It would seem that young tarpon are most unusually tolerant of such suffocating environments. At Andros no other fishes were caught at all, although a few *Cyprinodon* were found in the stomachs of the tarpon as already noted. In a clear pool not two hundred feet away, both *Cyprinodon* and *Gambusia* were abundant and no tarpon were present. Other fishes trapped with the tarpon may have formed food for the latter while they lasted. At any rate only the tarpon remained in abundance in the landlocked, foul pool. On the other hand, pools open to the sea may permit early passage of young tarpon back to the ocean, or in clear, landlocked pools the successful survival of other forms may present too much competition for them. Germane to this is the fact that there are numerous records from Florida, Texas and Panama of slightly larger tarpon in clean salt or brackish water as well as the Cuban record already mentioned. At least on Andros Island all other fresh, brackish

or salt pools hold a good variety of species, and a large number of individuals of other fishes.

The question then resolves itself into the following: If the young tarpon are not trapped and go back to the sea, where are they to be found; or, if these foul pools are actual nurseries, why are there so few of them, and how do the young tarpon get out in sufficient numbers to keep up the supply? There is the promise on the part of certain Andros Islanders to collect smaller tarpon this summer when they are sure such will appear. Considerable hope is held that this promise will develop, to assist in the eventual solution of this aggravating question.

A cursory examination of the scales of the specimens was made, with the thought of determining the age. The marks, however, proved to be difficult of determination, although for the size of the fish there were an unexpected number of the scale-rings which are usually to be interpreted as the result of seasonal variation. Thus they may be actually older than their sizes would suggest and badly stunted, or the marks may represent violent and non-seasonal fluctuations in the food supply, or other factors. The largest specimen suggests an age of three and a half to four years, and the smallest, one and a half to two years. These figures carry with them no conviction that such is the case, but are mentioned only to call attention to possibilities.

Since the above was written, Mr. E. W. Forsyth, the Commissioner of Andros Island, has written a letter to me from which the following is extracted. "I have known of these fish (young tarpon) for about thirty years and they are found in some completely landlocked ponds where only very unusual tidal waves could account for their existence. One such pond at Mangrove Cay has yielded them, to my knowledge, for a very long time before the hurricanes of the past decade. At times this pond goes dry with only a few moist places on the surface and one little hole the size of a well that retains water. Yet from year to year they re-appear in considerable numbers with the rains. I have seen the bottom of this pond a mass of sun-cracked mud from end to end, with the exception of the above-mentioned well. The pond in which you got your specimens also goes quite dry, at least on the surface."

BEHAVIOR OF A PAIR OF LEAF-FISH,
Monocirrhus polyacanthus Heckel

C. W. COATES

Illustrations from photographs by
S. C. Dunton.

ON Friday, March 17, 1933, the Aquarium received from Mr. Carl Griem, a professional fish collector, three specimens of the curious leaf-fish, *Monocirrhus polyacanthus* Heckel. These were three of the first five specimens ever brought into this country. Their habitat is the

tab of flesh on the chin, completes the dead leaf appearance by its simulation of a stalk. The photographs illustrate this very clearly.

Mr. Griem informed us that he had to examine closely numberless leaves before he found any of the fish, for so close is the resemblance of one to the other that it is not possible to distinguish between them without a careful scrutiny. However, when the fish chooses, it can move with astounding rapidity, jumping several inches from the water with little effort. An examination of the fins explains the anomaly. The



smaller streams and tributaries of the Amazon, and their habits would indicate that they are only at home in water which is always quiet and still.

The common name of the fish is a tribute to its peculiar color and methods of swimming. The color is a monotone of dead brown; the pectoral fins and parts of the dorsal and anal fins are quite transparent. Its method of progress, on the face of it, appears very mysterious, for hanging head down in the water the fish lies at an angle for all the world like a dead leaf, and drifts about at the whim of every little current of water. The compressed form of the animal heightens the illusion and the "beard," a slender

The leaf-fish returning to its eggs after a foray to the other side of the aquarium. The eggs are to the right of the fish which, while facing the other way, drifts rather rapidly and in a straight line, backwards and sideways, to its charges.

pectoral fins, and dorsal and anal fin-tips are quite colorless and are in constant motion.

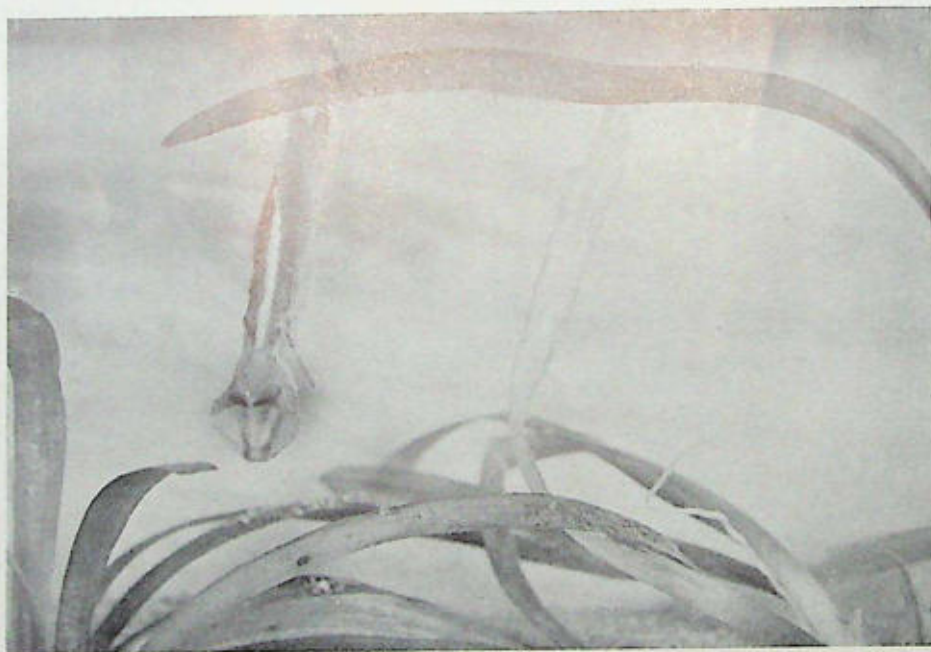
They cause a considerable current of water to flow, but so nicely are their effects balanced that the fish can remain absolutely motionless in a small current of water; or the combined effects of the fins will drive it through the water in a swift dash. The movement of the fish should be remembered as it will be referred to later.

The leaf-fish is carnivorous, and subsists, seemingly, solely upon living fish of a suitable size. These are apparently deceived by the motionless leaf-like appearance, allowing the fish to drift, by well regulated movements of the

transparent fins, to within a few inches of it, when suddenly the end of the slowly moving leaf opens—a swift dart of the same leaf, and the little fish is interred within the larger one. In proportion to the size of the fish, the mouth is very large and evidently can form a strong in-flowing current, for the small food-fish seems to be quite helpless to evade the yawning jaws, and in one gulp disappears entirely.

While the fish itself is interesting in the extreme, its spawning is still more so. Two of the three fishes mated within a week of their ac-

aquarium in the vicinity of the leaf where the second fish had taken up its position, we discovered a number of transparent eggs hanging from the underside of the leaf. These were hanging at the end of individual stalks, each about the length of the diameter of the eggs, and seemed to be in constant motion, moving in more or less regular waves. The current from the fins of the fish stationed nearby was responsible for this, and it was apparent that the stalks of the eggs were being turned and twisted about themselves, by the ceaseless flow of water,



quisition. The third died, probably having been destroyed in the pre-nuptial activities

of the mating pair. As the initial spawning took place during the night, we had no idea of what occurred; that is, we did not see any fighting at all but we did see, early on the following morning, one fish by itself in the furthest corner from the other, this latter hanging motionless by a leaf of *Sagittaria* towards the back of the tank. On the slightest movement of the first fish away from the corner, the second opened its jaws in a most threatening manner and swam over, driving the first fish before it back to its corner. Such unneighborly behavior, in the fish world, usually implies eggs, so after a little examination of the

The terrific mouth of the Leaf-fish, opened in a yawn, or perhaps a threat. The fish, which is compressed, seems to extend its mouth both upwards, which is to be expected, and sideways too. The eggs are in evidence here, on the leaf above and to the right of the fish.

to such an extent that after an hour or two many of the eggs seemed to be in clusters

at the end of a common stalk.

Since the fish is so rare, and as absolutely nothing is known about its breeding habits, this occurrence opened up a number of possibilities and necessitated a certain amount of cogitation. The eggs could be taken away from the fish, for examination into their structure and the stalk to which they were attached, which is an important biological question, or the eggs could be left with the fish in an effort to see how long they took to develop, and how, if at all, the parent fish looked after them. This, too, is an important question. Both could not be done at once



A pair of Leaf-fish with eggs. The mottled appearance of the fish to the right seems to be characteristic before, during and after spawning. The eggs may be seen in a cluster hanging from the leaf just above the nose of the fish to the right. The clear golden-brown of the fish to the left of the picture is the normal coloration at times other than at breeding.

and the fact that we were not sure that the eggs would develop at all in the waters of an artificial aquarium had some bearing upon our reasoning. Against this we had to offset the importance of having a few specimens of this species alive in our collection, and since the fish is so rare in North America it was reasonably argued that it is perhaps of a somewhat delicate constitution and does not live long. We decided, however, to leave the fish with the eggs and see if we could raise a few young ones.

Our calculations were almost completely upset in this regard because the fish, hanging so motionless in the aquarium, made many of our visitors doubt that they were alive, and occasioned a constant tapping on the glass in an effort to ascertain the nature of these dead leaves. So much so, indeed, that the fish were almost frightened to death. At least they were sufficiently scared to lose their appetites. However, in spite of all these difficulties, during the fourth night after spawning the eggs hatched, and the threatening gestures of the parent fish nearest the eggs toward the other parent, increased to such an extent that it was deemed prudent to remove the now useless fish.

A few of the babies were still resting upon the leaf to which the eggs had been attached, but the majority of them were on the sandy bottom of the aquarium immediately beneath the "nest." A few more were scattered about the tank, but most of these were lying on the sand too. The parent fish left in the tank made no effort to round up these wanderers, but still stayed by the "nest", fanning the empty shells which could be observed on the leaf. This continued for a day, when the second parent was removed, for it did not seem to be of any assistance to the fry and it was necessary to feed it. This was difficult to do in the original tank for we did not know whether the fish would eat anything or not and it was risky in the extreme to throw into the same tank with the babies a few living fish; for these would undoubtedly eat at least some of the babies before they in turn were eaten. The removal of both parents, however, did not seem to interfere in any way with the growth of the youngsters which within a day or so of hatching

lost their yolksac and readily took small *Daphnia*. This neglect of the young immediately after their hatching is interesting. Other species of the same family will care for the helpless fry for several days before completely ignoring them.

The parent fish were placed together again, and after one or two days of amicably drifting around the aquarium, one of them was observed fanning and scraping a leaf of the same kind of plant as was used before. This was closely observed and we saw that the fish would lie under the leaf and then swim backwards, drawing its back along the leaf. At this time the other fish, which stayed nearby but apparently evinced no interest in these proceedings, was the same dead brown color as when it arrived. The fish working at the leaf was entirely different, however. It was generally a lovely golden-tan color, with a few mottlings of dark brown.

After several hours of scraping and fanning the leaf, the fish came together and a number of eggs were spawned. It was then observed that the fish which had been so industrious about cleaning the leaf was now the outsider, the other taking complete charge of the eggs and again driving the first one away. This fish was the same that had nursed along the first batch of eggs. The color pattern had changed too. The fish which was so bright before was now the dead color, the fish with the eggs assuming the golden hue. Whether it was the male or female we do not know for both fish look exactly alike, but in the battle previously referred to, one of the fish had lost its beard and for this reason was identifiable. This particular fact is interesting for, again, in the other members of the family, it is the male which selects the site for the nest and which also looks after the eggs.

With such an immediate and favorable response to our attentions in the matter of housing and food, it may be suggested that the fish is not particularly delicate, its rareness being entirely due to the fact that it had never been brought into the country before. The lack of inhibitions regarding spawning, and the availability of the eggs, make the fish one which is very suitable material for experimental investigations.

Echinoderm Enemies of Fishes

How Starfishes and Sea Urchins Catch and Eat Fishes

E. W. GUDGER

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Introduction

TO the naturalist, probably the most interesting things in the lives of animals are their relationships, friendly or inimical, with those animals with which they are intimately associated. As a student of animals at the sea shore for many years, I found my greatest interest in their unusual structures, associations and habits, particularly those of fishes. Of later years, as a bibliographer of fish literature, I have collected great numbers of references to these out of the ordinary matters, among them accounts of unusual enemies of fishes. Some of these have from time to time been brought together in unified form in various articles, others are projected.

With regard to the invertebrates under consideration, I have long known that the various classes of Echinoderms harbored either internally or externally, as symbionts or probably more correctly as inquilines, fishes of the family *Fierasferidae*. That they are sometimes inimical to fishes I have found in the last few years on cataloguing various articles in which they are described as attacking and eating fishes. Interestingly enough each author thought his observation an isolated one, since none seemingly knew of the observations of anyone else.

STARFISHES ATTACKING FISHES

Recently my attention has been called to the earliest account of all, one written twenty-six years ago but which, buried in a large paper on the behavior of a starfish, had escaped me. With it and the other accounts at hand, and since this habit is as interesting as it is unusual, it has seemed worth while to bring all the various observations together into a short paper under the title set out above. Perhaps this article may serve as an incentive to others to put similar observations on record.

It is well known that starfishes feed on live mollusks such as whelks and oysters—in fact they are great pests to the oyster planter. It is also commonly understood that they are scavengers, feeding

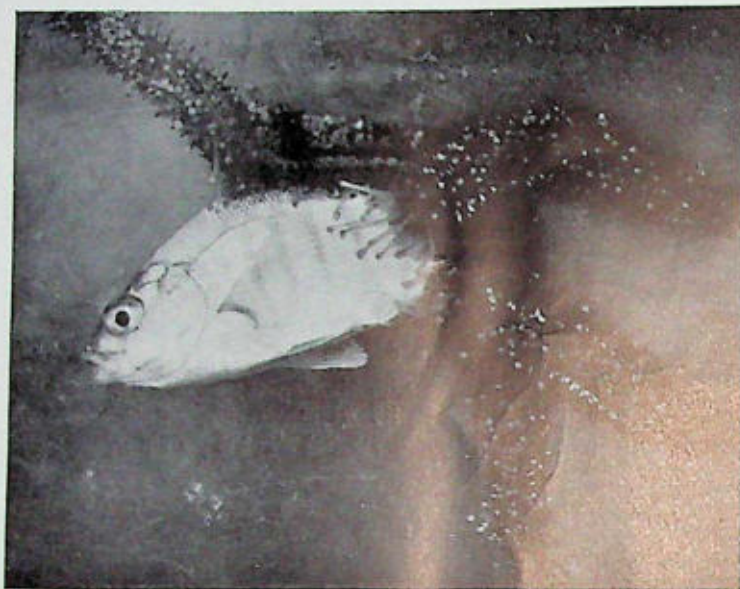
among other things probably on dead fishes. That they also capture and feed on live fishes was first made known, so far as I can ascertain, by Prof. H. S. Jennings in 1907.¹

For study of the behavior of *Asterias forreri*, a Pacific coast form, at the laboratory of the Marine Biological Association at La Jolla, California, large numbers of starfish were kept in aquariums and their feeding habits observed. They were forced to feed on a variety of animals in order to test such habits. Since this is the first account of their catching and feeding on live fishes, and the only one of their catching fully active fishes, it will be well to quote Jennings verbatim. He writes that:

"It seems surprising that the starfish can capture such active, swift animals as fish. But

Fig. 1. A starfish has caught a living fish, is holding it with the pedicellaria and tube-feet of one arm and is moving it toward the oral aperture. From an unpublished photograph by Prof. H. S. Jennings.





in our tanks this often occurred. They captured and devoured fish having a length equal to the diameter of the starfish, from the tip of one ray to the tip of the opposite one. In one of our tanks a large number of starfish crawled about over the sides and bottom. At times numbers of fish of various sorts were kept in this tank, and it was soon found that the starfish were capturing them. The fish, swimming about, seemed to have no mistrust of the brown patches on the walls; when frightened they would even attempt to conceal themselves upon or against the starfish. The tail or a fin strikes in its motion the surface of the starfish. At once the rosettes rise, the pedicellariae open, and when the edge of tail or fin comes against them anew, it is seized by a hundred little jaws. Of course the fish gives a leap and attempts to pull away; the jaws hold, the fish struggles, and in struggling strikes other parts of its body against the starfish. Wherever there is a thin edge of fin, tail, or gills, the pedicellariae seize it, and the fish soon finds itself held tightly. Now the tube feet extend, the cruel suckers plant themselves over the smooth surface of the body, and the fish is transported to the mouth. In all cases observed it was the tail that was first brought to the mouth. The lobes of the stomach then come forth, press themselves against the tail and proceed to digest it, though the fish still makes at intervals violent efforts to escape. In the course of six or eight hours the posterior one-fourth of the body of the fish was usually quite digested, and the remainder of the fish was dropped. Figures 5 and 6 show photographs of the capture of fish by the starfish."

Through the kindness of Professor Jennings, I am privileged to reproduce his illustrations as my figures 1 and 2, and also to publish (figure 3) a third photograph never before utilized. So far as I know these are the first figures and indeed the only photographs ever published showing this remarkable capture of food on the part of a starfish.

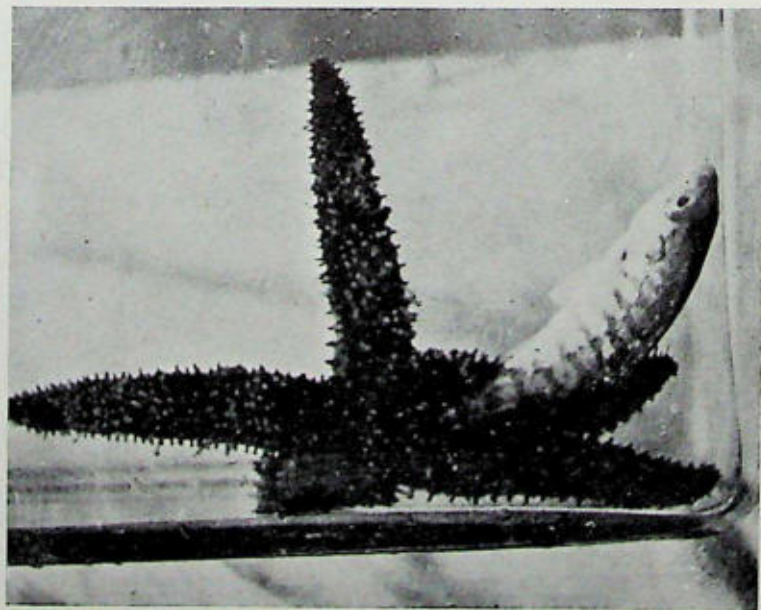
Not all fishes were equally readily attacked by the starfish. Those with which it was more or less associated out in the ocean did not seem to be in danger, but other forms were liable to be seized. Here follows Jennings' statement as to

this interesting discrimination:

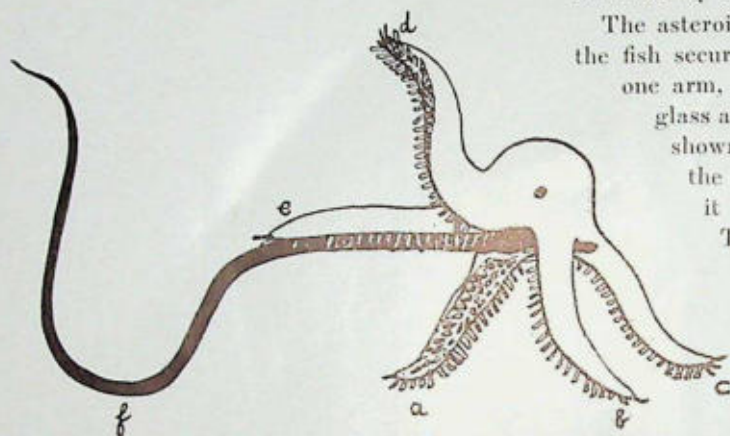
"When there were placed in the starfish tank fish that in their normal existence spend their time swimming about in the open water, not coming against stones or other objects save when they attempt to hide from actual danger, these were readily caught by the starfish. When these fish came in contact with the animals, their movements were strong, sudden, incautious, so that the pedicellariae were soon roused to attack. But

Fig. 2. *Upper.* The starfish is beginning to ingest the living fish tail foremost.

Fig. 3. *Lower.* The fish is now almost half ingested by the starfish. Note how the tube-feet are holding it fast. From photographs by Jennings, 1907.



the fish that in their normal existence live in rocky pools and under stones, resting much of the time against the surface of the rocks, were not captured by the starfish. Such fish are very abundant about the shore, and many of them were kept in the tanks with the starfish. Such fish frequently came against



the starfish, resting upon it or hiding behind it as if it were a stone. But their movements were so gentle and deliberate that the pedicellariae were not roused, and such fish were not seized."

In 1915, H. N. Milligan, keeping starfishes and various syngnathid fishes in the same aquarium at the Horniman Museum (?) in England, three times saw the starfishes attack and eat three different kinds of pipefishes—fishes covered with hard horny plates and hence not ordinarily eaten and probably avoided as prey by most other fishes. The first account² records how two starfishes caught and ate nearly dead specimens of the aequoreal pipefish.

Two medium-sized healthy starfishes had been kept in an aquarium for several months. In with these were placed two active broad-nosed pipefish (*Siphonostoma typhle*) and two of the aequoreal species which were half dead. One of the latter fell near one of the starfish. This (not fed that day) at once moved over to the pipefish, placed itself over its head, which was the first part it touched, and humped its body as if about to feed. The starfish handled its ten-inch prey in the following fashion; supporting itself on three arms (see fig. 4 herein) *a*, *b*, and *c*, and holding fast to the glass front of the aquarium with the

fourth (*d*), it laid hold of the fish with arm *e* (the fifth), the stiff bent body of the pipefish resting at the bottom at *f*. The arm *e* was laid parallel with the body of the fish, which was held fast by the encircling tube-feet.

The asteroid was apparently not able to hold the fish securely enough with the tube feet of one arm, so it disengaged arm *d* from the glass and with it laid hold of the fish as is shown in figure 5. Held thus securely, the fish offered no resistance, indeed it was probably dead by this time.

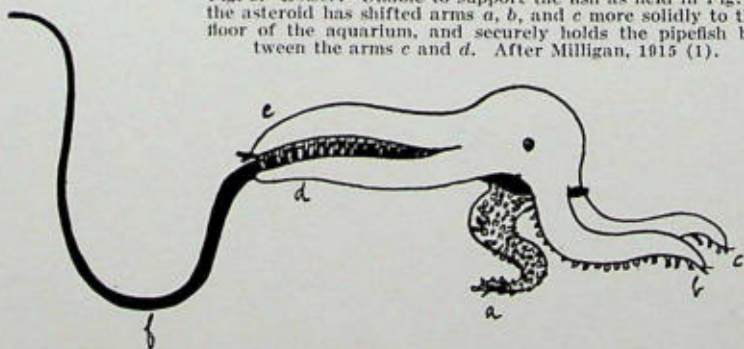
The starfish then partially everted its stomach and wrapped this around the body of its prey. Digestion evidently went on through the night, for next morning, the anterior end of the fish was bare of skin and flesh and the asteroid had shifted

toward the tail of its prey.

In the meantime the second starfish had been at work on the second *Nerophis* and over certain areas had completely skeletonized this fish clad in horny buckler-like plates—this in about sixteen hours. Tiring, it then moved over to where the pipefish number 1 was being eaten by starfish number 1 and laid hold of the tail of this *Nerophis*. However, it did not stay here long.

Fig. 4. Upper. A starfish, supporting itself by the arms *a*, *b*, *c*, and holding fast to the glass of the aquarium with the arm *d*, has laid hold of a half-dead pipefish (*Nerophis aequoreus*) with the arm *e*. The body is humped up preparatory to everting the stomach on the head of its prey, which is partly supported on the floor at *b*.

Fig. 5. Lower. Unable to support the fish as held in Fig. 4, the asteroid has shifted arms *a*, *b*, and *c* more solidly to the floor of the aquarium, and securely holds the pipefish between the arms *c* and *d*. After Milligan, 1915 (1).



Contrasted with the behavior described above, it is interesting to note that though the starfishes actually walked over the bodies of the healthy pipefishes, these were for some reason not attacked.

A month later Milligan³ put a sick broad-nosed pipefish into the aquarium with the same starfishes. This specimen, 12 inches long by five-sixteenths of an inch broad and three-eighths of an inch deep, was larger and more difficult to handle than the smaller fish referred to in the preceding account. One asteroid, however, in order to hold it fast, grasped it as shown in figure 6. It held the fish with the tube feet of four arms, anchored itself to the side of the aquarium with one arm (A), and, with its body humped up and its stomach (st) partly everted, began to feed on its prey. Apparently the fish was too heavy a load for the asteroid to support. It presently disengaged arm D and with it laid hold of the aquarium, in the meantime curling arm E about the pipefish so as to hold it about as securely with one arm as with two. (See figure 7 herein).

Then a surprising thing happened. The second starfish seemed to smell the pipefish at a distance of two feet, for it (white) travelled directly toward this and settled itself on top of starfish number 1 (black) as may be seen in figure 8. This so amazed the latter that it left the fish and retreated to the floor of the aquarium. However, it presently returned and laid hold of the prey. Asteroids and fish then fell to the floor of the aquarium, where they assumed the position shown in figure 9. Starfish number 2 (in white) though smaller than number 1 was certainly more aggressive, as was again shown by its again driving number 1 away.

Finally, the pipefish had to be removed since the water was becoming foul. This fish, however, was not so well cleaned off as the smaller form had been. Probably its bucklers were

thicker, and then too the asteroids had so disturbed each other that neither had been able to press its stomach closely enough and long enough to carry digestion very far.

The accounts just given are of attacks by starfish on sick or half-dead pipefish of rather small size. But some months later, Milligan⁴ gave a brief account of how a starfish made an attack on a strong and vigorous great pipefish eighteen inches long. Perhaps it will be well to let the author describe in his own words what took place:

"The pipefish, which threw its body into vigorous contortions when it was taken in the hand, was dropped into an aquarium containing two starfishes, as it was not deemed possible that the latter could or would attack so large and strong an animal. The pipefish, as it fell through the water, passed a starfish, which was clinging to the vertical rockwork of the aquarium. When the fish reached the bottom it lay still, perhaps a little fatigued with its four hours journey in a collecting can from the coast. The starfish, which was about six inches away, almost immediately began to descend quickly and directly towards the fish, with

the slender terminal tube-feet of its foremost rays waving in the water in the manner characteristic of these tube-feet when the starfish is advancing towards food. When the starfish reached the pipefish it moved upon the latter in such a way that it embraced the whole head and fore-part of the fish with two rays. The pipefish did not move until the starfish had affixed a number of tube-feet of each ray to its body. The pipefish then gave several violent jerks, but to the astonishment of myself and another observer it was unable to get free. The two animals were lifted out of the water and separated, the pipefish being placed in another aquarium."

The next account of this extraordinary behavior on

the part of an asteroid is from the pen of Professor F. E. Chidester.⁵

One morning at the Marine Biological Laboratory at Woods Hole, Massachusetts, he observed an *Asterias forbesii*, with rays eight centimeters long (2.25 inches) which had attacked

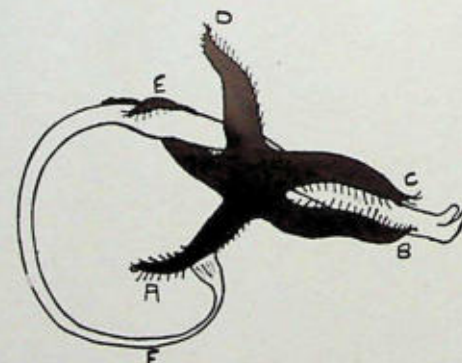
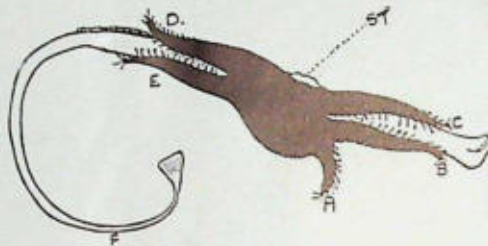
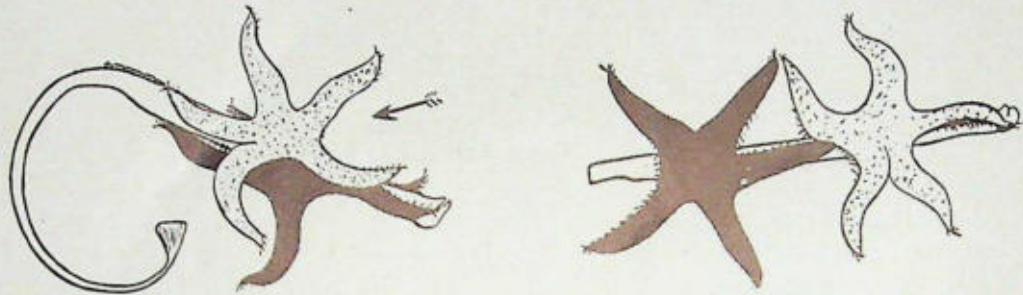


Fig. 6. Upper. Another starfish in a later experiment has laid hold of a great pipefish (*Siphonostoma typhle*) with the four arms, b, c, d, and e, in pairs, while it supports itself on the arm a. The stomach, st, is partly everted. The tail of the fish is on the floor, f.
Fig. 7. Lower. To support itself better while feeding on the fish, the asteroid is bracing itself with arm d, as well as arm a. Note how arm e is curled around the fish. After Milligan, 1915 (2).

a full-grown *Fundulus* ten centimeters (4 inches) long. It grasped the fish with the tube feet of two rays, while it held on to the wall of the aquarium with those of the other three. The body of the starfish was humped up about one

flexible exoskeleton are much slower and more unwieldy in their movements. But despite their handicaps they catch and eat fishes, as will now be shown.

This was, so far as I can ascertain, first made



and a half centimeters (0.6 inches). The head of the fish was ingested by the everted stomach

of the asteroid which covered about two centimeters (0.9 inch) of it. In preserving the two animals, the stomach was partly withdrawn but even then the head of the fish was held firmly in the mouth opening of the starfish. The asteroid must have caught the fish during the night and Chidester thought that the fish must have been a dead one since he could hardly conceive the starfish's catching a live *Fundulus*.

Notice should here be called to the fact that the asteroid took in the fish head first, whereas Professor Jennings' starfishes always operated on the tail as shown by his photographs. Why this difference in behavior, is a question which cannot be answered. Furthermore Jennings' starfish caught live, active fishes and then ate them.

SEA URCHINS FEEDING ON FISHES

Starfishes are after all pretty active animals, comparatively speaking; but their near relatives, the sea urchins, almost round and encased in an in-

Fig. 8. Left. A second starfish (in white) is disputing with asteroid No. 1 (in black) for possession of the prey. Fig. 9. Right. The two starfish have compromised their contest for the pipefish and the newcomer takes the head. After Milligan, 1915 (2).

known by Milligan, who, as seen, has carried extensive studies on the feeding habits of

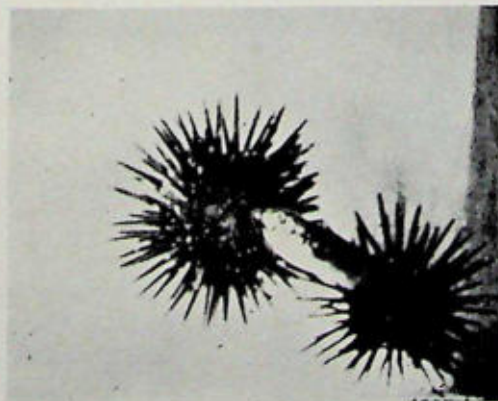
echinoderms. Having previously observed that sea urchins had settled down on and had apparently tried to eat the eggs of the sea-bullhead, *Cottus bubalis*, he made more definite experiments covering three years, and reported his results in 1916⁴

The following species of fishes died in his aquariums and were devoured wholly or partly by the purple-tipped urchin: *Echinus miliaris*; the striped wrasse (*Labrus mixtus*), common goby (*Gobius paganellus*), gattorugine blenny (*Blennius gattorugine*), and plaice (*Pleuronectes platessa*). The sea urchins ate fins, flesh,

and viscera of these fishes. These were dead fishes, but if dying ones were caught they were tenaciously gripped and were eaten. Perhaps it will be well to let Milligan describe in his own words a typical case as follows:

"A striped wrasse of forty mm. in length, which was thought to be dead, was removed from an aquarium in order that it might be used as food for the sea urchins. When, however, the tail of the fish was thrust beneath the body of one of

Fig. 10. A *Fundulus* is being held against the glass front of an aquarium by two sea-urchins (*Arbacia punctulata*) which are devouring it head and tail. After Parker, 1932.



the sea urchins, 38 mm. in diameter, which was clinging to the vertical side of the aquarium, the fish suddenly began to struggle. The sea urchin held it tightly by pressing a number of spines not only around but also upon the body of the fish, those spines which were pressed on the prey being used with such effect that they made deep indentations in its body. The sea urchin now raised one part of its body from the side of the tank, and with spines and tube-feet gradually urged its prey towards the mouth, the fish, in spite of several efforts, being unable to get free. As soon as the prey had been brought into such a position beneath the mouth that the teeth could conveniently work upon it, the sea urchin attached a number of tube-feet to, and also pressed spines upon, the side of the tank in such a way that the victim was imprisoned as in a cage. The sea urchin remained for several hours upon the wrasse, of which it ate about a third part, afterwards allowing the remainder to fall to the bottom of the aquarium."

The only other observation known to me was made on this side the Atlantic by Professor G. H. Parker,¹ after noting that the sea urchin is generally considered a scavenger, feeding on dead plants and animals on the sea bottom, says that "... it is not always limited to so tame a diet. Occasionally, it rises in its quest for food to almost sportsmanlike activities."

Here is Professor Parker's account in his own words, and here is his figure showing how the echinoid acted.

"If a number of sea urchins are put in an aquarium in which there is a goodly supply of mummichugs, *Fundulus heteroclitus*, one or more of these fishes may be caught and eaten by the sea urchins. The capture usually takes place at night, and the prey is almost always a partly spent fish. I doubt if a fully vigorous *Fundulus* is ever taken by a sea urchin. I have never witnessed the first steps in the capture. What I have seen, on first arrival, is a fish, usually a small one, whose head or tail is largely covered by the sea urchin. The spines and ambulacral feet of the captor are used to hold the prey against either the bottom or the sides of the aquarium, while the jaws of the sea urchin are vigorously plied on the flesh of the fish. Not infrequently, a fish once caught is beset by a second sea urchin and the two together complete the demolition of the *Fundulus*, as shown in the accompanying figure. The fish, when caught, often offers some resistance,

but it soon succumbs to the sea urchin as though it had been poisoned by its captor. However, I have no direct evidence that the sea urchin can exert such influences. The main point that this note is intended to record is the capture of live fish by the sea urchin, *Arbacia punctulata*."

SUMMARY

(1) There are brought together herein accounts of thirteen echinoderms feeding upon fishes.

(2) Eight +* of these pertain to the feeding activities of starfishes, five + to sea urchins.

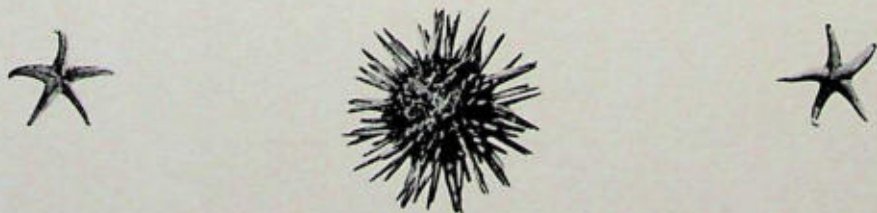
(3) In several cases the starfishes caught and ate live active fishes. In most cases, however, they caught sick or dead fishes. The fishes caught by the sea urchins were also at least partly disabled.

(4) Echinoderms must (in some circumstances at least) be classed as enemies of fishes.

*The sign + means that in addition to statements of definite attacks by echinoderms, others were indicated but not definitely enough to be counted.

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The Barracuda, illustrated in the Bulletin for July-August, 1932, continues to thrive, and since that photo was taken has more than doubled in length. If this rate of growth continues for any time it bids fair to become one of the Aquarium's larger exhibits. The length is about two feet, two inches. The maximum size for this species is about six feet. Photo by S. C. Dunton.

A PEARL FISH FROM NASSAU

C. M. BREDER, JR.

WHILE waiting for supplies preparatory to the second Andros expedition, previously discussed, some time was spent at Mr. Bacon's Nassau residence. This place, known as Pirate's Nest, is an island forming part of the seaward side of Nassau Harbor.

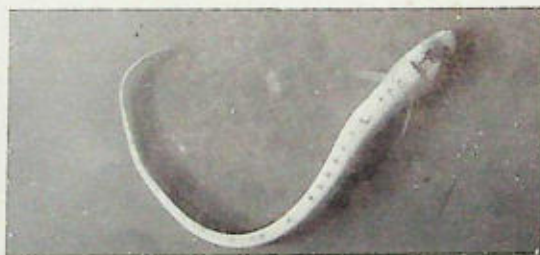
In rough weather various samples of the sea

a foot. This is easily understood when it is explained that the fish was large in relation to the size of the holothurian, that it has a large head and tapers gradually backward to a sharply pointed tail. The action seemed to be somewhat like that produced when an orange pip is squeezed between forefinger and thumb.

In preservative the fish is a milky white with a few brown marks, but in life its appearance was decidedly different. It had a length of nearly



The Pearl Fish, *Carapus bermudensis*, found at Nassau.
Side and top view.



bottom, such as shells, corals, sea-fans and the like, are cast up on the beach. Consequently, after a storm or heavy sea, a stroll along the shore line is always of interest. On one such occasion a large holothurian, or sea-cucumber, was thus found. These creatures are

little more than long, softish tubes and although related to the starfishes show few superficial resemblances. They are not attractive animals but in certain quarters are much valued as a delicacy. They are known to commerce in the Orient as trepang and to the French as beché de mer.

It so happens that a small fish uses the body cavity of these animals as a refuge, entering tail first into the rear opening of the sea-cucumber. Ordinarily one may examine a great many of these sluggish creatures without finding a single pearl fish, as they are sometimes called. The case in question was thus somewhat of an exception as a glance revealed the head of such a fish protruding as if to look around at the exceptional environment in which it suddenly found its home. A slight pressure on the side of the expiring sea-cucumber caused it to contract violently in such a fashion that it ejected its recent tenant with sufficient force to propel it for a distance of over

five and one half inches (139 mm. in total length) and showed the following appearance, the description of which is transcribed from notes made at the time. The fish appeared to be much smaller than it actually was, as the flesh was quite transparent

and glass-like. The outlines that were noted were those of the skeleton. The true bodily limits of the fish could only be seen by viewing it from certain angles. The vertebral column was notably evident as it was heavily pigmented with a Van Dyke brown. Radiating from this, many of the numerous haemal and neural spines were similarly colored. This coloration presented no pattern or regularity whatever. The rest of the body was quite transparent, save for the head and vital organs. The former was suffused with bronze while the peritoneal covering in addition had marked silvery reflections.

This fish, *Carapus bermudensis* (Jones) has been recorded from Florida, Cuba and various Bahama localities and is usually taken in the cavities of sea-cucumbers or large marine molluscs. So far as known it uses these invertebrates merely as a shelter and is not parasitic.



A LOBSTER BURIAL

Illustrations from photographs made at the Aquarium by S. C. Dunton.

AN unsuccessful attempt to shed the shell resulted in the death of an Aquarium lobster. Such an eventuality is not unusual among crustacea, and there is doubtless a considerable mortality even in a state of nature whenever this periodic event occurs which is necessary to growth. The peculiar behavior of one of the tank mates prompted the accompanying photographic records. At the time of the demise another lobster proceeded to bury its unfortunate fellow. Both the cast shell and the lobster itself were included in the burial heap.

The explanation of this behavior, which the uncritical might like to consider anthropomorphically, seems to be that of protecting a reserve food supply. At least the related fresh water crayfish will at times bury pieces of aquatic plant and later, when they have decomposed, dig them up for food.—*C. M. Breder, Jr.*



WILD DOG TYPES *Frontispiece*

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Fig. 1. Great Grandfather of Dogs Fig. 3. Giant Dog, Restoration

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St. Kitts	Dolphins
Martello Tower	Devilfish
Barbudan Village	Anglerfish
Saba	School of Anchovies
Oysters on Mangrove Boughs	Pacheca Forest

CRUISES OF THE ANTARES Sketch Map—*John Tee-Van* 98

TIMBER WOLF *Cover*

BULLETIN

NEW YORK ZOOLOGICAL SOCIETY

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1, Eskimo Dog; 2, Cape Hunting Dog; 3, Jackal; 4, Dingo; 5, Red Fox; 6, Coyote.



BULLETIN

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Nature's Wild Dog Show

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Illustrations from photographs made in the New York Zoological Park unless otherwise indicated.

EVER since the Azilian phase of the Old Stone Age the dog has been devoted to man. In return for this devotion man has saved the dog from the extermination meted out to the wolf, who is practically the ancestor of at least the Eskimo dog, the "police dog" and related strains. Moreover, man has taken such pride in his dogs that from the time of Assurbanapl the Assyrian, various breeds of dogs have been recognized and their points noted. Through thick and thin the dog-buying public has stood by the dog-breeders, who in the past few hundreds of years have produced creatures so amazingly different as the squat bulldog and the wraith-like borzoi.

A modern metropolitan dog show with its hundreds of entries and dozens of classes is a brilliant and imposing, even if fleeting, event. But Nature's dog show has been running steadily for millions of years, its stage, the world, its prizes, survival, its penalties, starvation and death. On the whole it has been rather a grim and grisly affair. Moreover Nature has cleverly run two vast shows at once, her dog-and-cat show on one side of the big tent and her horse-and-cattle show on the other, with no pens or barriers between. It has been great fun for the dogs, cats, lions and other flesh-eaters, but not so good for the peaceful herbivores, except that it has encouraged them to become fleet of limb and to develop defensive horns.

The mute records of this age-long pursuit and carnage, of this triumph of cruel and fleet predators, are now to be found in the museums of the world, where the skulls and bones of fossil carnivores and fossil herbivores have been gathered in from many a locality: from the Western States, from the Tertiary deposits of Europe, from the Siwalik Hills of India, from the caves and other surface deposits of Brazil, California, Ohio, England, Continental Europe, China, Java, and even from far-off Australia. These supplement the collections of skins and skulls of the numerous recent species of wild Canidae, which have been studied and classified by Huxley, Mivart,¹ Oldfield Thomas and later authors, especially Cabrera.²

The oldest fossil Canidae or members of the dog family are found in the Lower Oligocene of North America, their estimated age about thirty-eight million years. At that remote time the family, according to the late Dr. W. D. Matthew,³ was already represented in North America by two genera: (1) *Cynodictis* (Fig. 1), the common ancestor of all the modern dogs, wolves, foxes, dholes, etc., as well as of the raccoon family, and (2) *Daphoenus*, the common ancestor of the giant dogs (Fig. 3) and the bears.

¹Mivart, St. George. 1890. *Dogs, Jackals, Wolves and Foxes: A Monograph of the Canidae*. London.

²Cabrera, Angel. 1931. *On Some South American Canine Genera*. *Journ. Mammalogy*, XII, No. 1, pp. 54-67.

³Matthew, W. D. 1930. *The Phylogeny of Dogs*. *Journ. Mammalogy*, XI, No. 2, pp. 117-138.

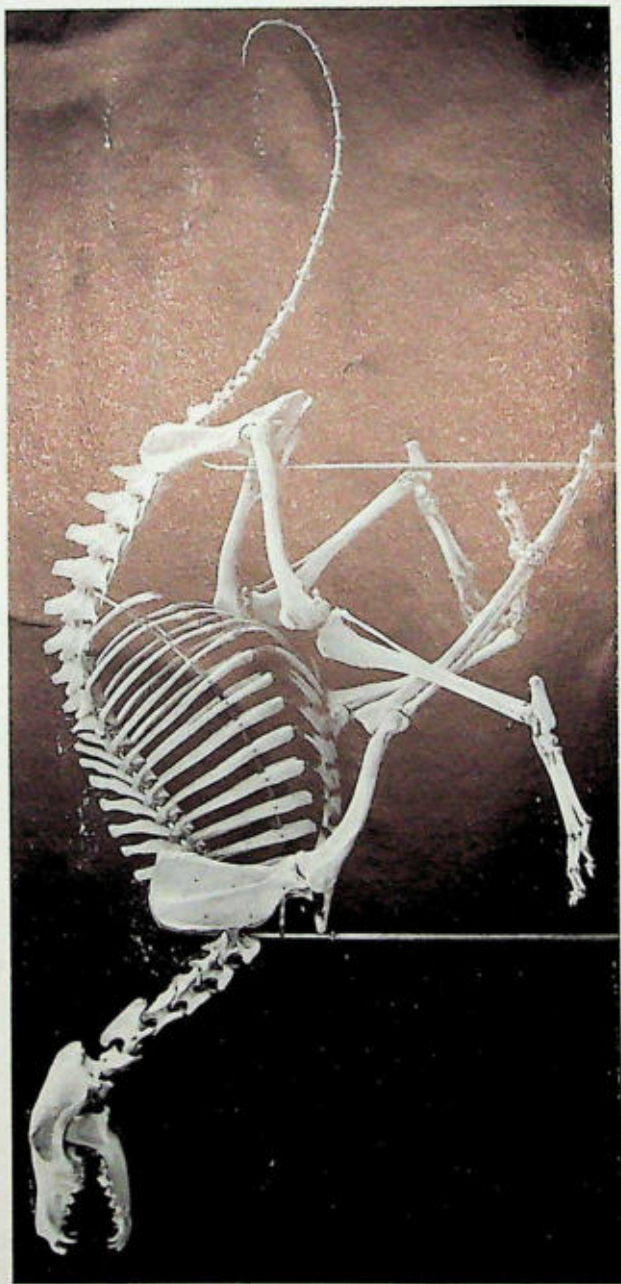
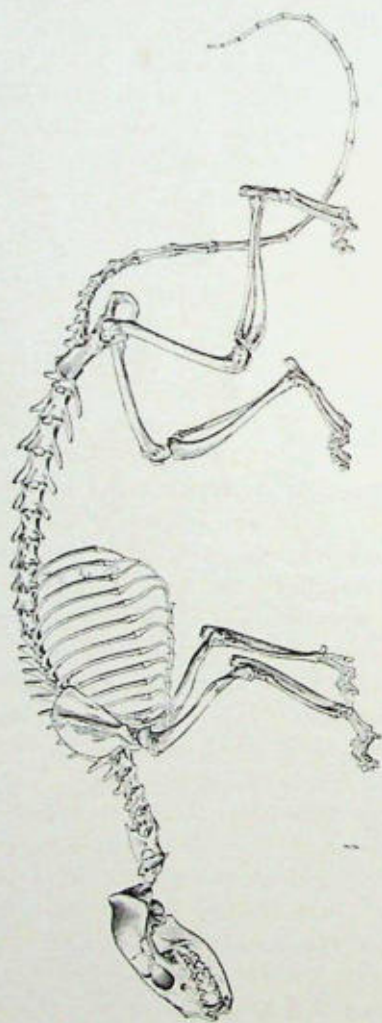


Fig. 1. Upper: *Cynodictis gregarius*, the great grandfather of the dog family. Restoration of a nearly complete fossil skeleton from the Oredon Beds of Cedar Creek, Colorado. After W. D. Matthew, American Museum of Natural History, Fig. 2. Lower: Skeleton of Russian wolf-hound, illustrating extreme adaptation to swift running in a modern dog. Mounted by S. H. Chubb, American Museum of Natural History.

Cynodictis was not yet either a dog, a wolf, or a fox, and had somewhat of the long-bodied, slinking habit of the civet. Its feet were less compressed than in later dogs, the claws slightly retractile and more like those of a civet. The predecessors of *Cynodictis* in the Eocene of Wyoming had been still less dog-like. These were arboreal mammals, somewhat like a raccoon, with spreading hands and feet. In fact, the entire skeletal anatomy of the earliest known true carnivores, as interpreted by Dr. Matthew, indicates arboreal, forest-living habits. The fast-running dogs were evolved much later, as the plains replaced the forests in both Western North America and Europe.

Daphoenus, the contemporary of *Cynodictis*, had a more massive skull, with upper molars of the crushing type. The carnassial, or shear tooth, had a strong blade. The bears, according to Matthew, are only gigantic short-tailed dogs which have become secondarily plantigrade and have greatly increased the size of their crushing molars, while reducing their upper carnassials. The extinct *Hyaenarctos* of the late Tertiary of western North America, Asia and Europe, is regarded by many high authorities as tending to connect the bears with the dogs.

In the Miocene epoch (about twenty-odd million years ago) there were many genera and a still greater number of species of dogs, which by this time had become swift-running forms with narrow, compressed feet. One of the smaller Miocene dogs, *Temnocyon*, was regarded by Wortman and Matthew as at least a structural ancestor of the modern dholes, or wild dogs of India.

The steps by which these Miocene and Pliocene dogs gave rise to the numerous types of modern wolves, dogs, foxes and fox-like animals have not yet been satisfactorily worked out, but they are now being actively studied by a specialist whose report may be expected to confirm the relatively high geological antiquity of the phyla, or lines of descent, leading to certain of the modern genera.

Among recent Canidae the most difficult to determine with reference to their broader relationships are the various genera and species of

South American dogs. For many millions of years South America was isolated and thus developed its own peculiar types of hoofed mammals and carnivores, all very unlike their distant relatives of the Northern World. But at the close of the Miocene age a land bridge with North America was established, hordes of immigrants from that country gradually seeped in and eventually crowded out the old South American mammals. Among these immigrants were members of the dog family; it is now evident that the numerous species of South American canids, which offer so many confusing resemblances to true dogs on the one hand and to foxes on the other, are "living fossils" and that they represent surviving relicts of the old dogs of the Miocene and Pliocene ages of western North America.

During the long evolution of the family the shearing and crushing teeth became modified in different directions. In certain ancestral lines, such as the wolves (Fig. 4) and dholes, the length of the blade of the upper shear tooth usually exceeds the combined lengths of the first and second upper molars. In other lines, the shear tooth diminished while the molars became larger, as in the large-eared Cape dog, *Otocyon megalotis*. In the latter the molars have also increased secondarily in number, by budding of the dental germ during development, until there may be as many as four molars on each side in the upper and four in the lower jaw. In the South American Bush Dog (*Icticyon venaticus*), on the other hand, the number of upper molars on each side is reduced to one above and one below. In the lines leading to the bears the first and second upper molars grew longer, the second finally becoming enormous, while the shear tooth dwindled to small size and degenerate characteristics.

After this introduction we may pass to a selected but fairly representative list of the principal types of living Canidae, illustrated with photographs from the files of the New York Zoological Society. In compiling this list I have had the benefit of the advice of Mr. Harold E. Anthony, Curator of Mammals in the American Museum of Natural History.



Fig. 3. Head of fossil giant dog (*Dinocyon giddleyi* Matthew) from the Miocene of Texas. Restoration by Charles R. Knight, American Museum of Natural History.

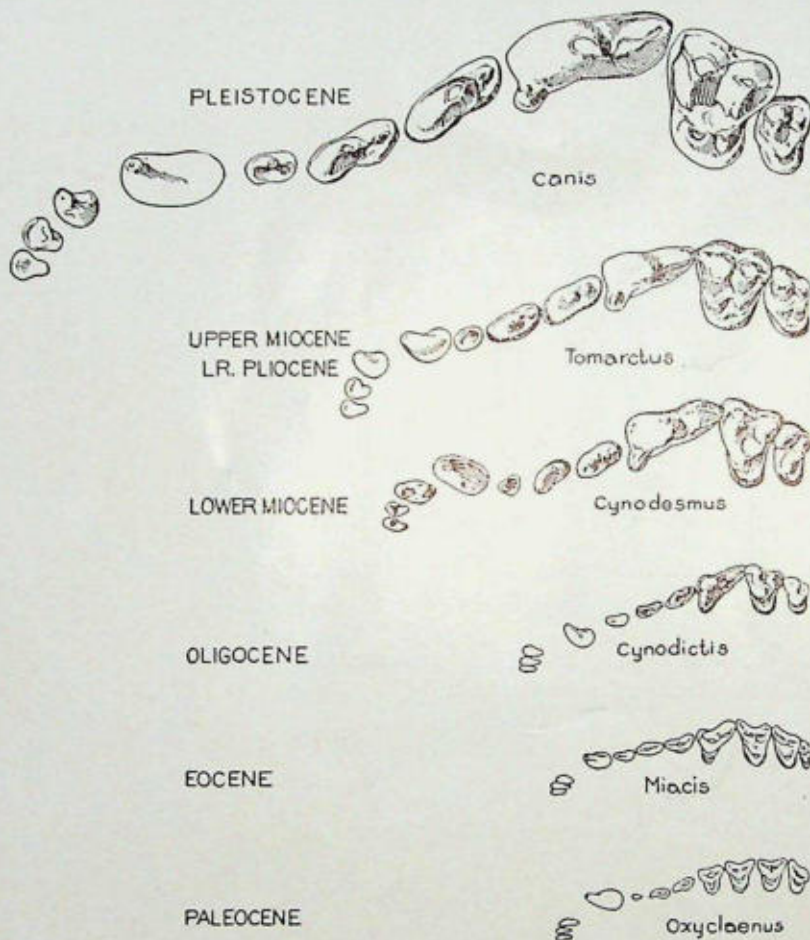


Fig. 4. Evolution of the upper teeth, leading to the true dogs.
After W. D. Matthew.

LIST OF PRINCIPAL TYPES OF DOGS

Canis familiaris.

Canis dingo. The dingo of Australia.

Closely related to the true dogs and probably brought to Australia by the earliest Australian aborigines.

*Canis poutiatini.**

Azilian to Russian Neolithic.

*Canis palustris.**

Neolithic. Ancestor of Spitz, Samoyeds, Lapps, Terriers, etc.

Canis aureus, etc. Jackals.

Canis latrans. Coyote.

Canis lupus. Wolf.

*Fossil.

Nyctereutes procyonoides. Raccoon Dog.

Vulpes vulpes (Linn.). Red Fox.

Vulpes velox. Kit Fox.

Vulpes corsac. The Corsac. Asiatic steppes.

Alopex lagopus (Linn.). Arctic Fox.

Brown in summer, white in winter. The Blue Fox is a variant.

Megalotis zerda Zimmermann. The Fennec.

Very large ears. African and Asiatic deserts and steppes.

Chrysocyon jubatus Hamilton Smith. "Maned Wolf."

South America. Very inappropriate name, according to Lydekker, as it is neither wolf nor

definitely maned. Long legs, big ears, round pupils, flesh-tooth small and exceptionally short; m^1 , m^2 , exceptionally long in proportion. Solitary in habits. Skull recalls that of coyote.

Cerdocyon thous ($=$ *Canis azarae* Wied). Crab-eating Dogs.

South America. Several species, including *cancricivorous*.

Pseudalopex magellanicus ($=$ *Canis magellanicus* Gray). The Culpeo.

The Andes, Peru, Bolivia, etc. Wide range and many species.

Skull very coyote-like with low depressed forehead.

Lycalopex vetulus Lund. ($=$ *Nothocyon* Wortman and Matthew; *Eunothocyon* Allen). Small-toothed Dogs.

South America. Very short face, very small carnassials, upper molars not wide transversely.

Dusicyon australis darwini Thomas.*

Darwin's Dogs of the Falklands, now extinct. May belong in lupine series near coyote.

"*Canis*" *microtus*. Small-eared Dog.

Lycaon pictus Temm. African Hunting Dog.

Allied with lupine series. Only four toes on each foot.

Lycaon anglicus.*

Pleistocene of Wales.

Cyon javanicus. Dholes.

Oriental region of Central Asia. Third lower molar wanting.

Regarded by Matthew as descendant of the Miocene *Temnocyon*.

Icticyon (*Speothos*) *venaticus* Lund. Bush Dog. Guiana and Brazil. Molars remarkably cat-

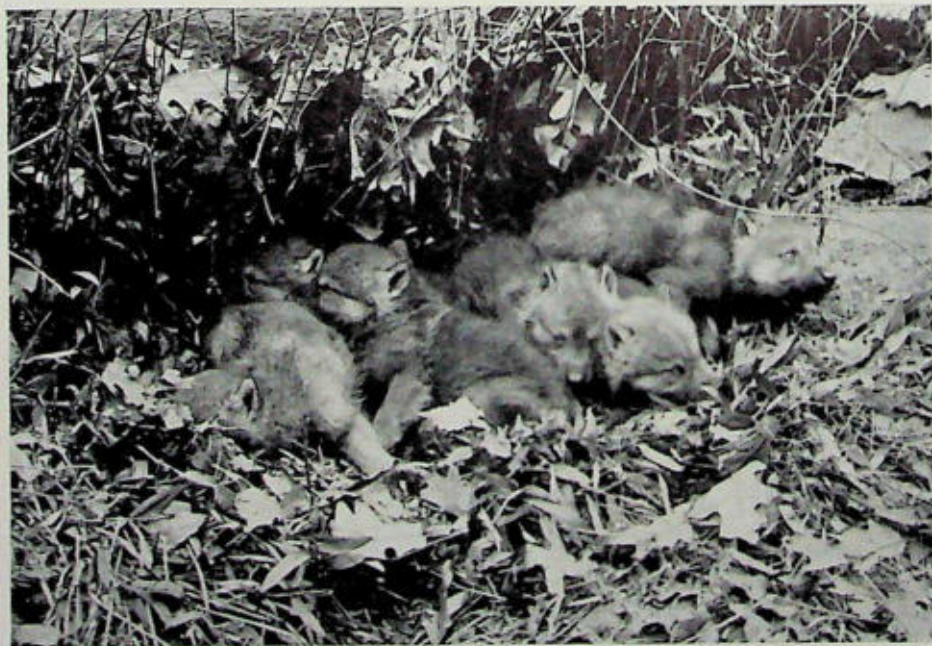
like, reduced to $m \frac{1}{2}$. Short-legged. Also in

Pleistocene of Brazil.

Otocyon megalotis.

Molars $m \frac{3 \text{ or } 4}{4}$. Total, 46 or 48 teeth.

Lower carnassials with 5 cusps. Skull like that of small fox. Limbs long, ears extremely large, auditory bullae very large.



Wolf pups born in the New York Zoological Park. The young of the gray or timber wolf are usually five in number. They are sooty-brown in color and are distinguishable from coyote puppies by the large size of the head.



Eskimo dogs. Very near to the wolf, but a faithful servant of Arctic explorers. One of these dogs was Bridge, Peary's lead dog on his last polar trip.



The dingo, dog of the Australian aboriginals. Has been in Australia since the days of its giant cave animals but may have been brought in by the proto-Australians, who probably came down from Southeastern Asia.



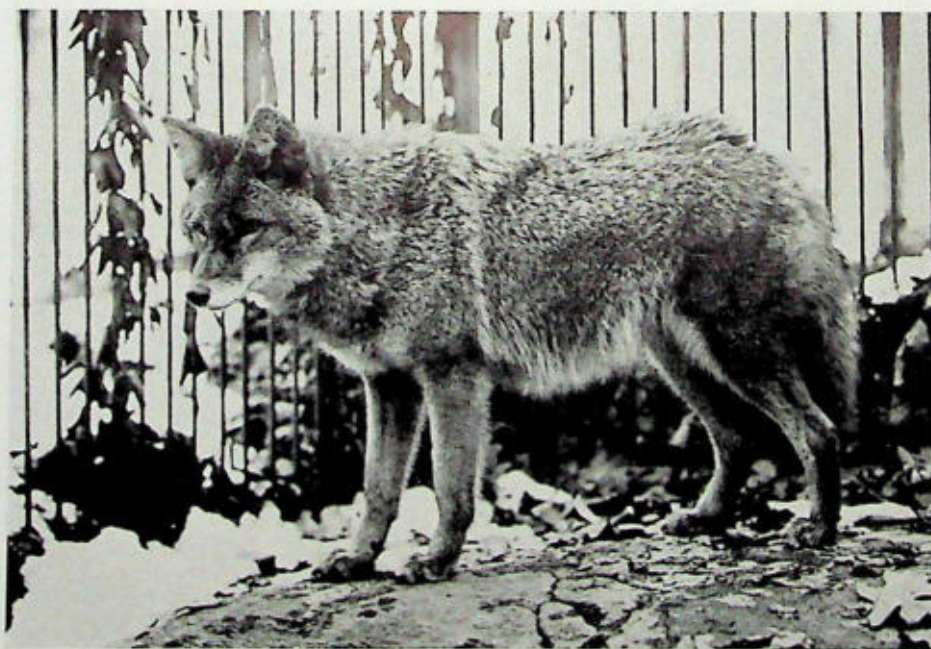
Black-backed jackal, *Canis mesomelas* of Africa. It is very much like the dark phase of the Azara Dog of South America and is the handsomest of the jackals.



Indian jackal, *Canis aureus*, the common jackal of Asia. He is light in color, with a bushy tail. In the large towns in India, jackals prowl about the streets and act as scavengers. The jackal will mix with domestic dogs, and the crossing of these animals with so called wolf-dogs is supposed to account for existing varieties of dogs. Aureus (Latin) means yellow.



The coyote, *Canis latrans*. A typical wild dog, descendant of a long line of fossil ancestors of North America. Albino phase. The specific name of this animal (*latrans*) means barking.



The coyote or prairie wolf is about one third smaller than the gray wolf, but in form and color the two look much alike. While the timber wolf is a dangerous animal to man, the coyote is the reverse. He is bold only in the persistence with which he clings to the outskirts of civilization.



Timber wolf, *Canis rutilus*. The type of this species is a strong, robust animal, cunning and merciless. It is shaggy and coarse haired. Called the timber wolf, it is equally at home on the treeless plains of the West, the evergreen forests of British Columbia and the barren grounds of Arctic America.



The Japanese and Chinese raccoon dog (*Nyctereutes procyonoides*). The distant resemblance to a raccoon is illusory, as this animal is true canid. It is said to hibernate like a badger.



Red fox, *Vulpes fulens*. The famous cunning and intelligence of the fox must be of use to him in nature in outwitting the birds, rabbits, etc., upon which he feeds.



The gray fox is the fox of the South although it ranges northward well into the territory of the red fox. This species is distinctly smaller and more lightly built than the red, and the pelage is not so luxuriant.



The swift or kit fox, *Vulpes velox*. Some of the smaller Canidae, like the fennecs of Asia and Africa, even surpass the swift fox in the enormous size of their ears.



The Arctic fox, *Alopex lagopus*, in its white winter dress, affords a classic case of adjustment to the environment.



The crab-eating dog, *Cerdocyon* sp., of South America. The various species of South American canids exhibit a puzzling mixture of fox-like and dog-like characters. Some are probably nearer to the dogs.



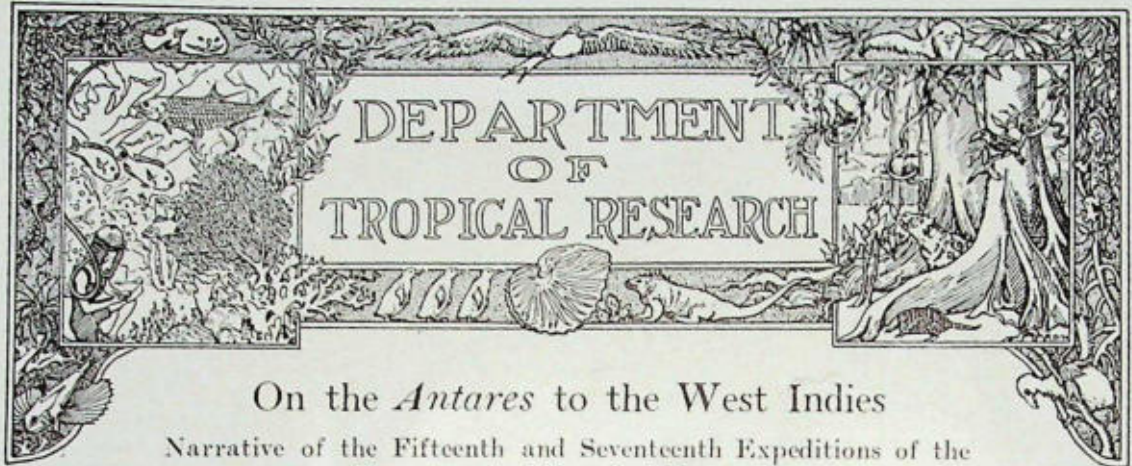
The small-eared dog, *Canis microtus*, of South America. A very rare form.



The Cape hunting dog, *Lycaon pictus* of East and South Africa, is a blood-thirsty hyaena-like dog that hunts in packs.



The bush dog, *Istiegon*, of South America. One of the most curious of all living Canidae, distinguished by his short muzzle and by the loss of his second upper and lower molars, so that his dentition is almost cat-like. He may be remotely related to the Dholes (*Cyon*) of India.



On the *Antares* to the West Indies

Narrative of the Fifteenth and Seventeenth Expeditions of the
Department of Tropical Research

WILLIAM BEEBE

Illustrations from photographs made by Col. E. M. Chance, William Beebe and Gloria Hollister.

FOR the past two years members of the Zoological Society's Department of Tropical Research have been enabled to take short trips of exploration to little-known places in the West

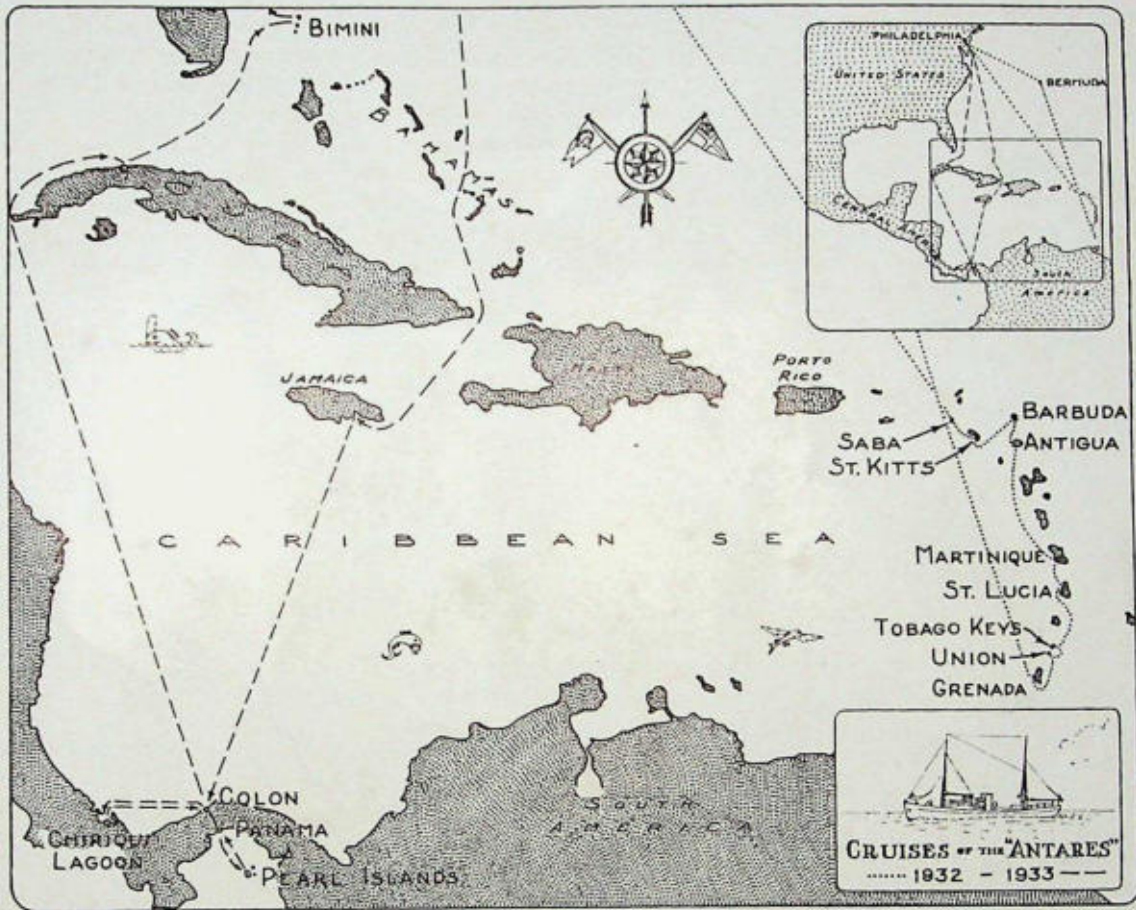
Indies, for the purpose of studying the fish life of those waters. This has been through the courtesy of Colonel Edwin M. Chance of Philadelphia on his diesel yacht—the *Antares*—which meas-



The *Antares* at sea. From a photograph by E. M. Chance.

ures 105 by 22 feet, ably built, well-manned, with every inch of space put to ingenious use, so that we have been as comfortable as on a ship of much larger size.

In 1931 Colonel and Mrs. Chance came to Bermuda on the *Antares* and spent some time with us on *Nonsuch*, and in 1932 Miss Hollister and I were invited to meet them at the Corinth-



Route of the 1932 and 1933 Cruises of the *Antares* from Philadelphia to the West Indies and Panama. From a drawing by John Tee-Van.

ian Yacht Club in Philadelphia and start thence on a West Indies trip, with abundant opportunity to increase our knowledge of fish.

We could have gone to Porto Rico or Cuba, to Haiti or to Trinidad, but any tourist vessel would have taken us there, and instead, we chose little-known islands, such as Union, Tobago Keys, Barbuda and Saba.

One of the most amazing things about these trips is their slight cost. We found that, given a boat of this size, one may sail away over tropical seas, with a maximum comfort, covering from 4000 to 5000 miles, and, with fuel oil at ten cents a mile, crew's wages, harbor dues, food,—all expenses for five weeks will amount to less than \$1500.

Our first venture was the Grenadines. We sailed down the length of the Leeward Islands,

each distinct and with a special beauty of its own, and then, beyond St. Lucia, these larger islands suddenly spatter out into a long line of tiny dots and dashes, getting smaller and smaller, until the chain ends abruptly in the solid mountain ranges of Grenada. All tourist vessels hurry past these and carry their cargo of impatient minds to the next port where some city offers alien similarities of sorts to their home towns.

The names of these little Grenadines reach back to the days of Caribs and pirates—Bequia, Mistique, Marquis, Kickem-Jenny, Carriacou, Frigate, Les Taintes, Mayero, Batovia, Adam, Union, and Isle de Caille.

We steamed straight for Grenada where we were watered, laundered, provisioned and armed with permits to land anywhere on the tiny islets

to the north. Our first Grenadine stop was Union, and except for the call of time and duty and home ties we would be there yet, for few lovelier places exist. A deep, incurved bay rose up and up to a majestic, thousand-foot range, with flowers and strong, spicy scents and the voices of strange birds delighting our senses. Later we made the acquaintance of the inhabitants—gentle, courteous, colored folk to whom the visit of a yacht was rarer than an eclipse.

On the first day of our search we found a coral-filled lagoon behind an islet draped with

of the bay teemed with life—pelicans, gulls, ospreys and frigate-birds, dolphins, bonitos and great leaping tunnies. After the raucous beggars and shrieking automobile horns of Grenada we called this the Subdued Island, and learned to love it.

Our next stop was at Martinique—an old friend in a new dress—the morning of Bastille Day, forty-eight hours of continuous fête of color, noise and absinthe as only French Colonials can combine them. From the frantic heart of Fort-de-France we motored through many



Exploring Tobago Keys in the Grenadines. This group of Islands was the first stop in the 1932 cruise of the *Antares*.

night-blooming cereus. Here we dived and fished and in less than three days captured or recorded one hundred and ten species of fish. Our work was not made easy by the presence of tidepools for there was only a scant eighteen inches of tide. Many of the parrotfish and wrasse were old Haiti and Bermuda friends, but such things as scarlet-backed demoiselles and a flock of a dozen young devilfish were sights strange to us. Again and again a quartet of big tarpon, at least six feet in length, would swim close to us when we were walking about, two to three fathoms down, and yet no bait or lure ever tempted them. Beautiful blue and yellow demoiselle fishlets were everywhere, together with flaming angelfish and smug little blennies.

From early dawn to dusk the air and water

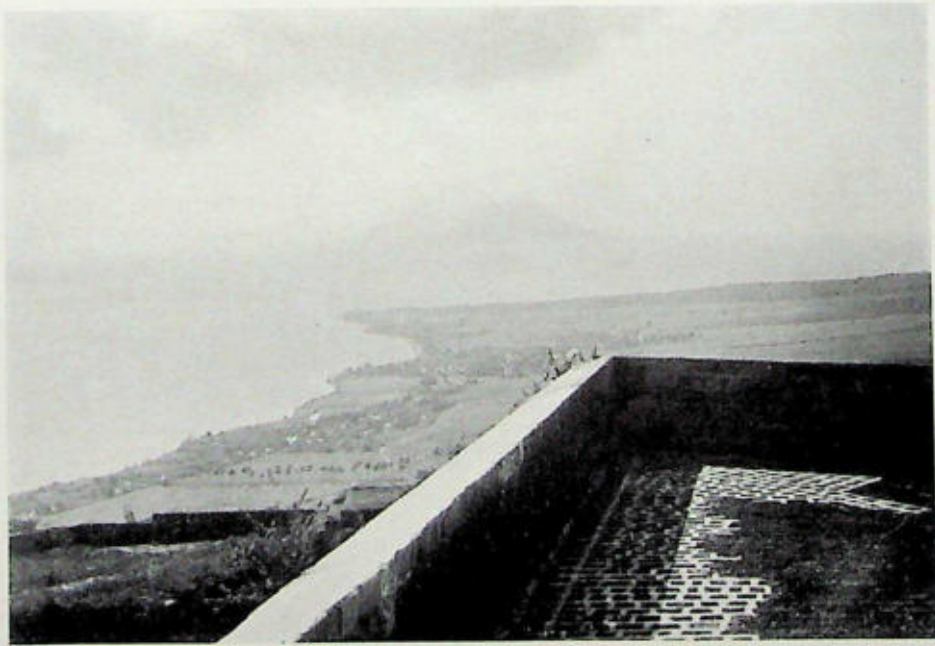
miles of wonderful tree-ferns to the quiet majesty of Pelee. A place of colorful interest and source of desirable specimens was the fish market of St. Pierre—a pitiful village still in the weird process of digging itself out of the lava and ashes.

We had a thousand laughs at the happenings of those two joyous days, but on the last day the natives had their turn, when we caught sight of a sturdy fisherman staggering along under the weight of an enormous fish—a rare tuna over six feet in length. To the amusement of the Martinicans we pursued the fisherman at full speed and persuaded him to stand and slowly revolve in the middle of the street as we made notes on measurements and colors.

At Antigua we stopped long enough to collect



The Island of Martinique. The peak in the background is Mount Pelee, with its last lava flow stretching down to the sea.



The great chain of the Leeward Islands is all connected visually. This view is from a mountain fortification on St. Kitts northward to St. Eustatius, beyond which is Saba.

in the tidepools of Deep Bay, and to swim over the old wreck which has been here for thirty years. Fifteen years ago when en route to Kar-tabo in British Guiana we used to land here, and today as then, the ancient, sunken hold was filled with snappers, groupers, tarpon and angel-fish, swimming in and out of the skeleton cabins.

We used Antigua as a stepping-off place for the strange, isolated island of Barbuda, thirty miles to the northeast. Barbuda is the terror of navigators, and a gruesome map shows a double or triple line of dots all around its shores, each dot representing a vessel—from coastwise schooner to battleship—which failed to detect the low lying shores and piled up, a complete wreck, on the sand or jagged reefs.

A lonely Martello Tower, built centuries ago by unknown hands, is the only landing mark. We shot through the surf and slithered up a beach of untold myriads of tiny shells, which tinkled in the breeze and, in the sun, glowed with a warm pink lustre. We found this one of the strangest of all islands, filled with hints of the original ideas of past British owners—the Codrington family. They loved sport and so they stocked their new home with guineafowl, wild boars and fallow deer, and today we heard or saw all three. To keep these creatures from destroying their gardens, the natives have had to build wattled fences and now we come upon groups of conical huts and wattled kraals and compounds which might well have been built in the heart of Africa. Most interesting of all were the natives themselves, magnificent negroes, six feet three and four, with the shoulders and muscles of heavy-weight fighters, but gentle of voice and courteous of manner. They are the results of the breeding for superslaves which the Codringtons carried on for generations, bringing the finest types of black men and women to the island and breeding them for size, bone, and sinew. I can imagine no better place to study human genetics.

Here we had to fight for a glimpse of the coral reef fish. The breakers pounded in and swept us off our feet, and only by quick dashes forward with the water-glass could we see the great green parrots grazing on the coral branches, and the bright colored wrasse and surgeons swept back and forth by the swell of the open sea.

Our last port of call had nothing to do with fish. It was Saba, the tiny volcanic peak which thrusts up from mid-water between St. Croix and St. Eustatius and is pointed out to every passenger to the West Indies. For no reason at all, we must pronounce it Sayba, not Sahba. To all tourists it is as inaccessible as the sea bottom over which they are passing. For no steamers touch there, and the single volcanic peak rising abruptly from the waves offers no harbor, wharf, beach, or anchorage. We go ashore in a dory, slithering up through the surf to a temporary hold on large black pebbles, and then rush the boat up out of the way of the next roller.

Pleasant half-Dutch boys greet us, and we wait for the customs officer, who finally comes riding down the eight hundred steps on a pony. We climb and climb, view after view opening and closing behind us, until at last we turn a mighty spur and find ourselves on the bottom of the island crater, with the tiny capital spread out before us—the village of Bottom.

It is like nothing else in the world; its charm is wholly its own; narrow high-walled lanes or streets (there is not a wheel or a cart in the island), red and white houses, spic and span as if from a Christmas morning's toy village; shy women offering delicate lacework for "anything you like to give"; the pleasant Episcopal rector, eager for real conversation, whose diminutive house shelters a marvelous collection of brasses, three brown doves, a black cat, and a green parrot. The adjoining church, which had once been a barn, and the cemetery might be translated direct from a typical English village.

I sit in the cool dim light and read the memorials on the walls. Each tells its own story of the perils of life of these people. Here is one, revealing the toll of life taken by a single storm:—

IN LOVING MEMORY OF
 JOHN SIMMONS, AGE 52 YEARS
 DAVID SIMMONS, AGE 40 YEARS
 RICHARD R. SIMMONS, AGE 22 YEARS
 ISSAC SIMMONS, AGE 16 YEARS
 LOST AT SEA, SEPTEMBER, 1918
 WE CANNOT, LORD, THY PURPOSE SEE,
 BUT ALL IS WELL THAT'S DONE BY THEE.

The Governor and his charming wife change our status within a few minutes from visiting strangers to friends. They love the island and apparently their only regret is that high lobs on their tennis court are inadvisable, since the ball might go down a quarter mile into the sea. Even in our three hours' visit we destroy many silly myths which have grown up around this fairy isle of five square miles, but we find that the men actually do build most excellent boats, up to eighteen feet, in the lofty crater, in Bottom, boats which are subsequently carried down

hardened in formaline it is impossible to spread them open again without injury. A method occurred to me, quite new as far as I was concerned, of cutting off the pectoral and pelvic fins of the left side, spreading and pinning them on white paper. They dried and adhered, and were described, labelled and filed away as easily as pressed flowers.

One night, about two hundred miles north of Sombrero, a three-inch flying-fish came aboard, which possessed a black, fleshy barbel as long as itself. I named this in honor of the *Antares*.



Island of Barbuda. The lonely Martello Tower built centuries ago by unknown hands is the sole landing mark.

the hundreds of steps on the shoulders of a score of sturdy natives.

We steamed regretfully away and as the afternoon sun lighted up the greens and grays and illuminated the mists swirling about the uttermost summit, a great Pan-American plane came into view and steered her course directly over the crater of Saba.

On all these trips flying-fish came on board almost every night, and as a matter of course we described and preserved them. Accurate descriptions of the delicate wing pattern and pigmentation is not easy, yet it is necessary to record this at once, because when the wings have

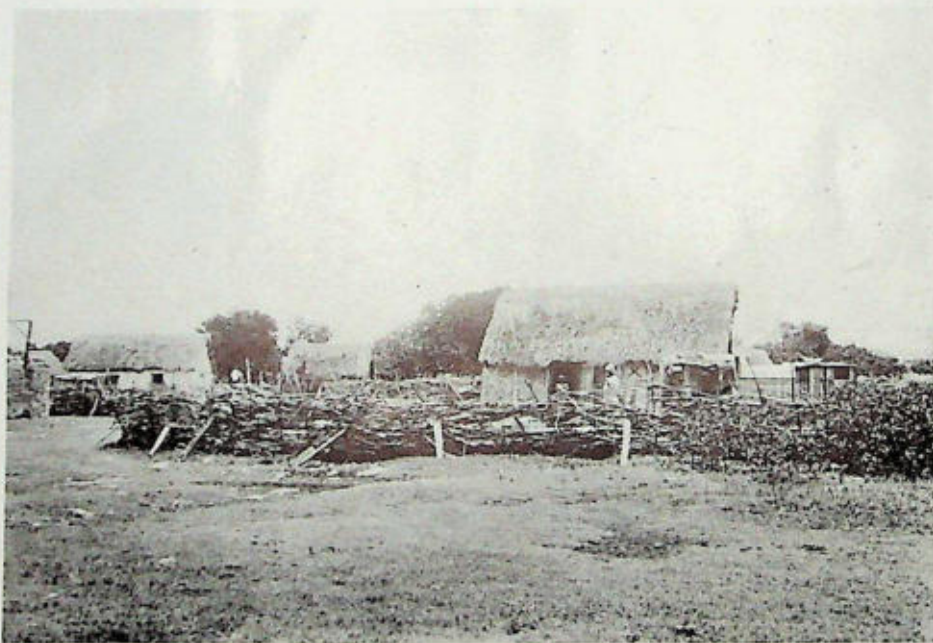
In the case of one fish the patterns of the two pectorals were quite unlike, so much so that they might almost have belonged to two different species. The left wings had much less black pigment than those of the opposite side and it seemed more than coincidence that also on the left side a large parasitic crustacean had taken hold. This was, in general appearance, like a large, black arrow which had been shot into the side of the fish, the head being buried, but the long shaft and a strongly feathered butt in full view. It was inserted close to one of the left wing fins and may in some way account for the small amount of black pigment on that side.

In opportunity for scientific work our 1933 trip on the *Antares* equalled that of the year before, while as to the places visited and our adventures nothing could be more different.

On June fourteenth of the present year we dropped down the Delaware River and on out to the open sea. The southward trip is always the same and always different; from bitter fogs we pass to velvet winds and sunshine; from chilled steel waters to those of turquoise and ultramarine; factory chimneys are exchanged for slender palms; mazes of shapeless clouds

motored clear across the Blue Mountains and back. In memory I need only three things to reconstruct the island—a colored man, a banana tree and a cocoanut palm. Two government officials have begun a study of the long neglected fishes of Jamaica.

With our wake stained by the splendour of a tropical sunset, our diesels going full speed and sails filled with the augmented trades, we flew southward, while giant, clear-winged flying-fish rose before us or skimmed on board. Early on Sunday, the twenty-fifth, we passed the Colon



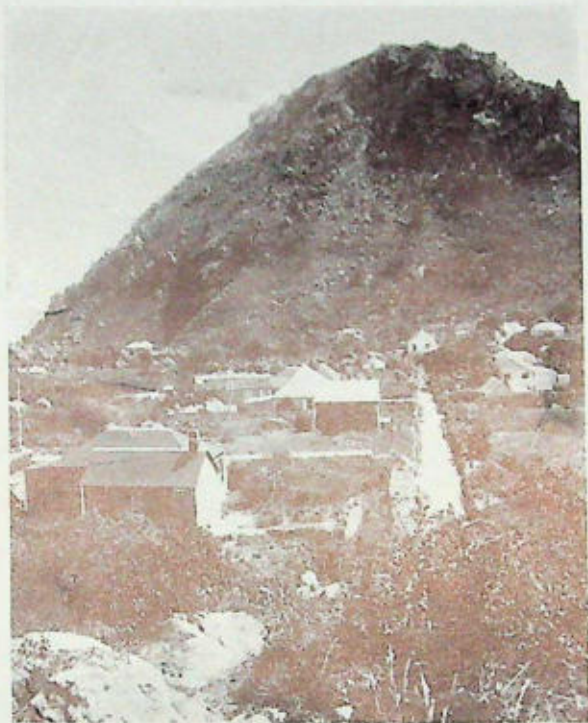
A village in Barbuda. Groups of conical thatched huts, encompassed by watted fences, that are strangely similar to a native kraal in the heart of Africa.

give way to the stately galleon ghosts of trade-winds; clots of eel-grass and floating flotsam are replaced by golden sargassum, while stormy petrels and herring gulls drift behind and vanish, their places taken by unbelievably graceful tropic- and frigatebirds and harlequin-plumaged sooty terns.

On the afternoon of June eighteenth we swung around Watling's Island, and on the twentieth anchored off Kingston, Jamaica. I had always avoided this island in my trips to the West Indies on account of its over-abundance of population, but I had never realized its supreme beauty of mountain trails and dashing torrents. We

lighthouse, and broke the trans-American record from sea to sea by going through the Panama Canal in five hours.

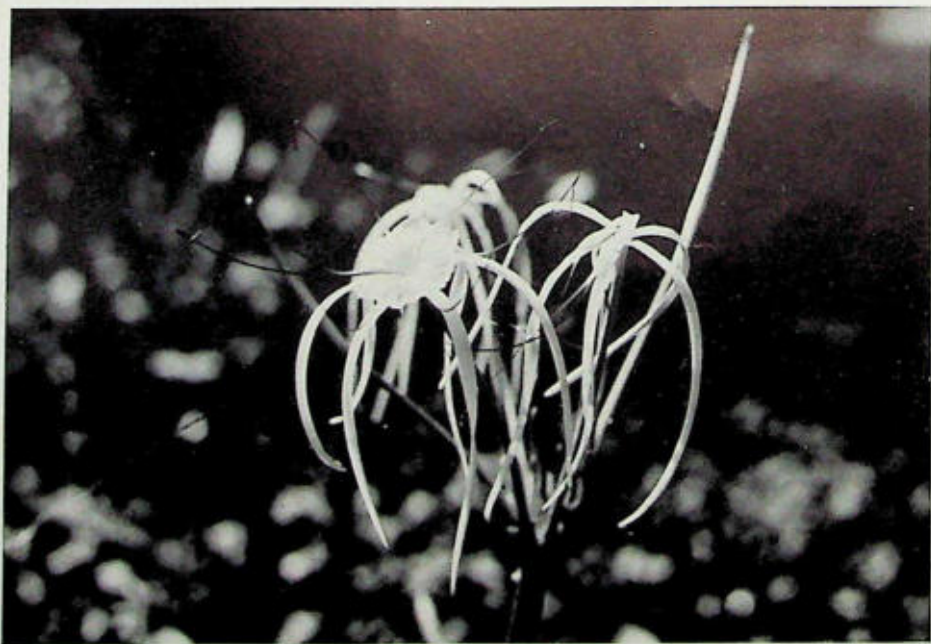
Looking north from the breakwater I saw the edge of the jungle where, ten years before, I had spent a long, rainy night searching for yap-ocks or water opossums (*Zoological Society Bulletin*, Vol. XXVI, No. 6, pp. 150-156). It was on this occasion too, that I shot a five-foot bushmaster. What Dr. Ditmars has recorded of the rarity of this serpent in the Panama area of the isthmus seems to hold good for the Colon side, for this was the first bushmaster my guide had seen for eight years. (Continued on page 110)



Saba, a tiny volcanic peak rising from the sea between St. Croix and St. Eustatius. As there is neither harbor nor anchorage, it is totally inaccessible to tourists. The upper picture shows the little village of Bottom, lying in the bottom of the extinct crater, and reached by a flight of 800 steps.



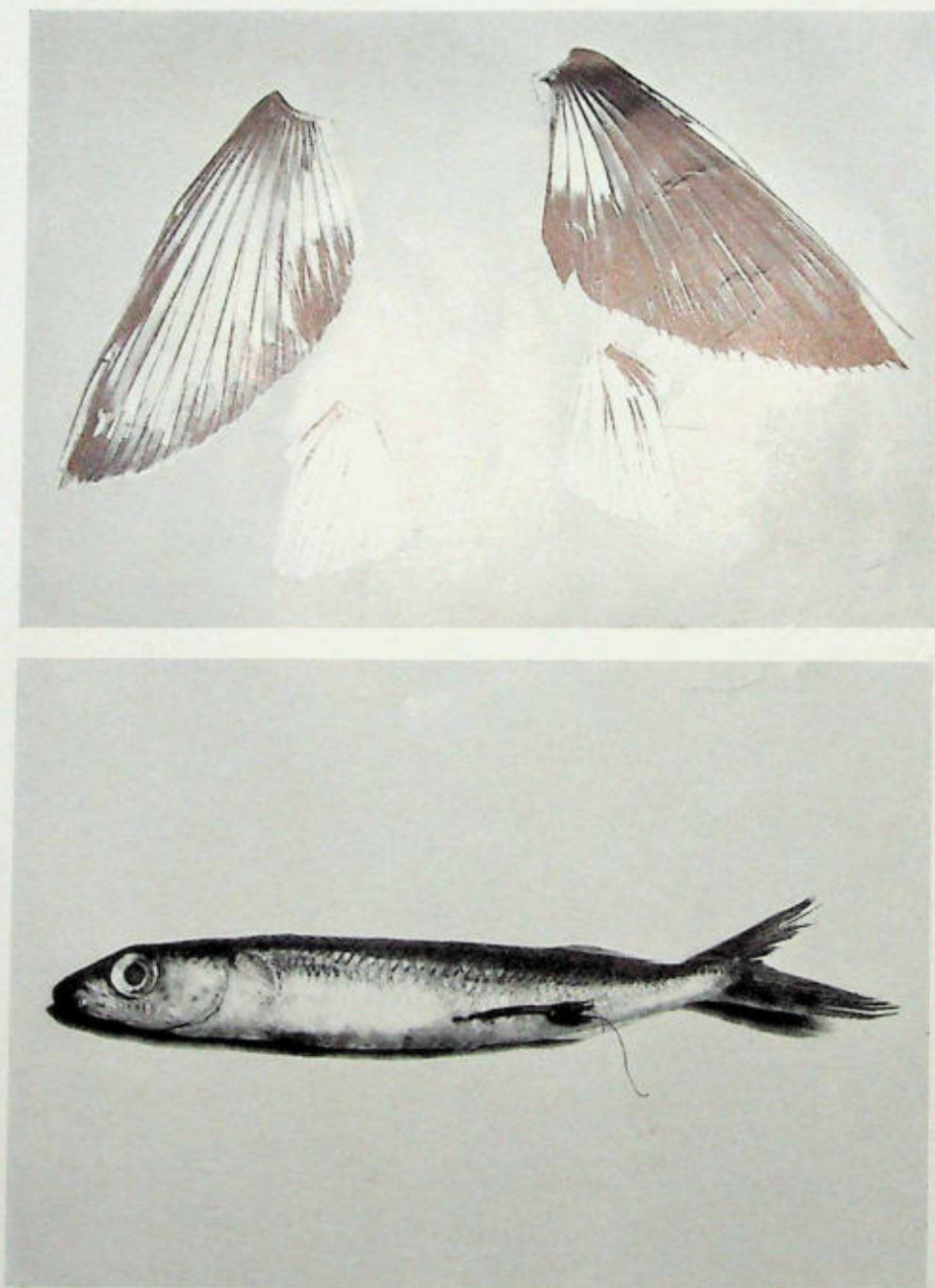
Oysters are in season. An old desert island myth comes to life as a reality. Bunches of oysters clinging to a mangrove branch, exposed by the ebbing tide, Chiriqui Lagoon.



The spider lily. This is one of the commonest flowers of the tropical jungle. Chiriqui Lagoon.



- A. Short-barbelled Flyingfish *Cypselurus furcatus* (Mitchill). This is a common flyingfish. Our specimens show great variation in the wing pattern.
- B. Two-winged Flyingfish *Halocypselus obtusirostris* (Günther). Note the very small pelvic fins quite useless for flight. The pectoral wings are very large, three-fourths as long as the whole fish. The pattern on the wings of this individual is quite unlike any published record.
- C. Black Butterfly Flyingfish *Cypselurus* sp? This is probably an immature flyingfish of some undescribed species. The body was banded with brilliant golden-bronze and silvery.



Reddish-winged Flyingfish *Exocoetes rubescens* (Rafinesque). The fore and hind wings are very unlike in color in this species. Notice the variation in the left and right pectorals of this individual, due perhaps to the presence of a large parasite crustacean. Lower. Reddish-winged Flyingfish *Exocoetes rubescens* (Rafinesque). This fish is seven inches long. The wing fins have been cut off and are shown. Upper. Growing from the side is a parasitic crustacean, not yet identified, looking exactly like the shaft and butt of an arrow.



Dolphins swimming under the bow of the *Antares*. Two may be seen at some depth and a third, as indicated by the foamy area, is breaching.



Four dolphins crossing the bow of the *Antares*. These graceful swimmers maintain their pace with a precision almost mechanical.

In Balboa and Panama I renewed old acquaintances and motored both north and south through the jungle, stopping once to help a two-toed sloth in his painful passage across the smooth surface of the road. It was the rainy season and the worst time of the year for land creatures—birds were molting, animals shedding, butterflies bedraggled, flowers gone and fruit still to ripen. I realized, as I had so often in British Guiana, how strongly marked are tropical springs and autumns, in spite of sempiternal foliage and uninterrupted warmth. But anywhere, under any conditions, there is no place

fear, and for whom they will breed at any time. Here were tinamous dropping their turquoise eggs about and hatching them out at the slightest encouragement; young, recently fledged motmots, Galapagos doves and callistes nesting in any place they could find. If this wonderful aviculturist had sufficient space and facilities there is hardly any species of bird which she could not raise.

On June twenty-sixth we weighed anchor and started westward across the waters of the Bay of Panama. This was my ninth trip, but this time we did not continue to the Galapagos but



A devilfish swimming a short distance below the surface. There are two great remoras or suckingfish attached to its wings. One may be seen quite distinctly against the black wing at the left.

in the world so wonderful as the jungles of tropical America, and to sniff the pungent odors, hear the weird cries of birds and frogs, and again watch the great blue morphos and the slow heliconia butterflies after eight years of watery submergence,—all this was like the sheer renewal of some past incarnation.

One memorable visit was to Mrs. Bryan's aviaries, a tangled hodge-podge of cages rambling in all directions about her house, but with an amazing collection of birds of many groups in splendid condition. Mrs. Bryan is one of those natural born bird lovers of whom birds have no

anchored close to Saboga, one of the most northern of the Pearl Islands.

In past years powerful Caciques have ruled their Indian tribes on these islands, and the name was warranted by the abundance and size of the pearls taken by divers, but now they are fallen from their high estate and support a meagre, miserable population who grow a few bananas and vegetables, but have no ambition even to fish for a living.

As the crow, or more appropriately, the cormorant flies, we were only a half hundred miles from the Atlantic coast, but there was no doubt

of this being a different ocean. Instead of one or two feet of tide, here we found eighteen feet and in consequence tidepools were available, the inmates of which we proceeded to poison with unsportsmanlike joy. Even on the first day I was impressed with the remarkable resemblance to the fishes of the Galapagos compared with the forms recorded from Panama and this was confirmed again and again. We collected species after species which I had taken from Tower and Indefatigable Island five hundred miles to the west, which appear to be absent from the Panama coast, within sight, forty miles east.

day, as it swam, or rather flew, slowly back and forth between two islands. It was not a large one, only about six feet across the wings, but to it were attached two relatively enormous remoras or sucking fish. These were at least two and one-half feet in length, and were adhering to the upper side of the wings near the body—the shoulders we might say. In this position, fastened as they were by the disk on top of their heads, they were upside down, and whenever the manta came near the surface of the water their gaping gills would protrude. Yet they never shifted their position.



The devilfish rising and swimming near the surface. The gills of the remora may be seen protruding at the right of the picture, just forward of the black triangular wing-tip of the devilfish.

The tiny islets scattered about proved to be much more interesting than the larger of the Pearl group and on our various trips to and from those we found that the water and air hereabouts abounded in life.

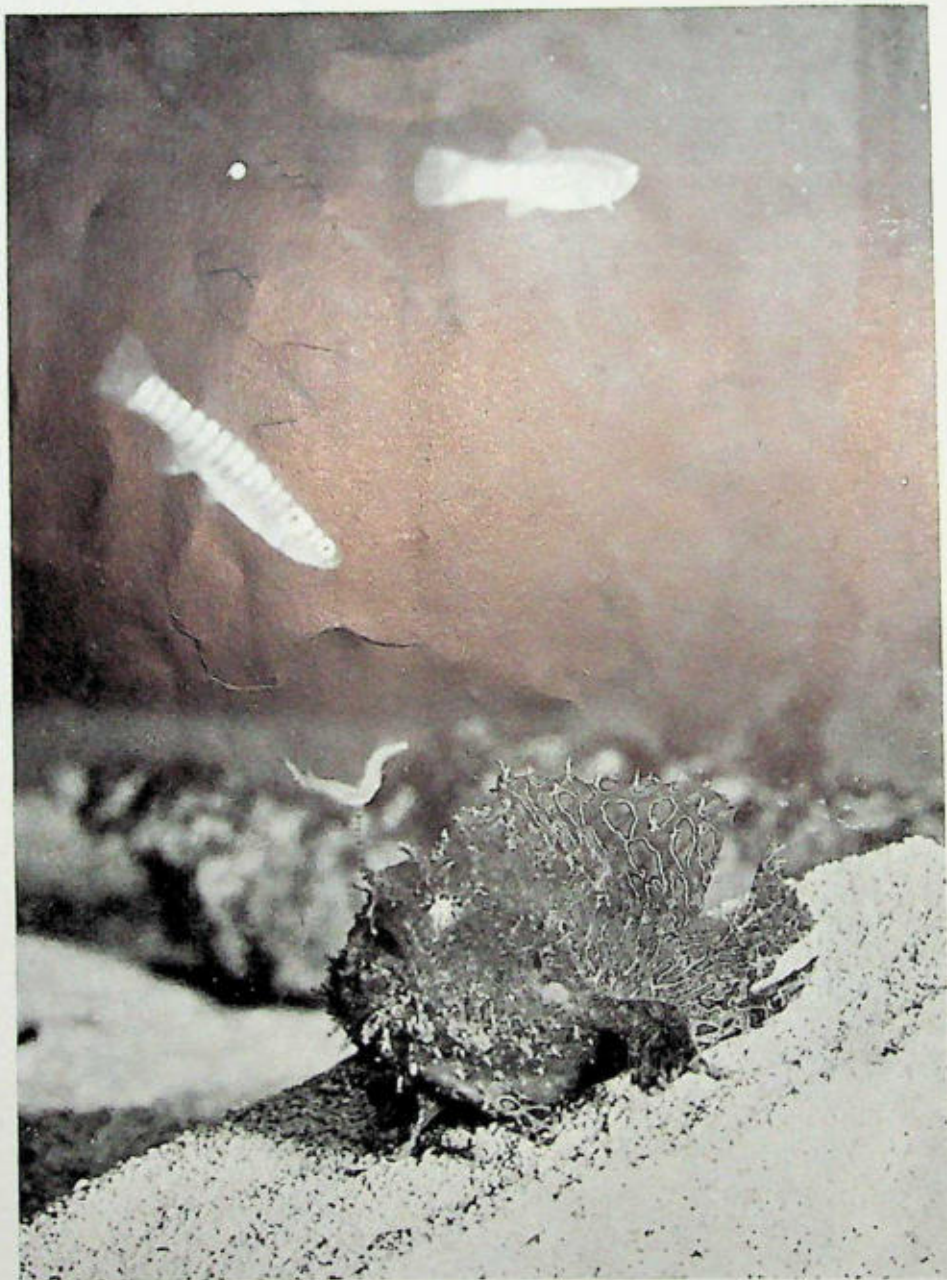
The excellence of the fishing drew launchfuls of young army officers from Balboa, and every few days a plane would circle down, bringing several navy men to try for a sailfish. But far more skilful fishers were present in thousands—cormorants, pelicans, boobies and frigate-birds, each with its particular methods.

We followed a manta or devilfish about, one

Wherever we fished or set off dynamite caps we found interesting fish. With our eyes fresh from those of Bermuda we found strange replacements. Instead of blue-headed wrasse we caught one with a head of royal purple, a greenish yellow band at the neck, and the rest of the body clear magenta (*Thalassoma duperrey*).

Our big-game fishermen caught bonitas, barracuda and dolphin until they were weary, but showed anything but ennui when they came back with a giant sailfish and a wahoo.

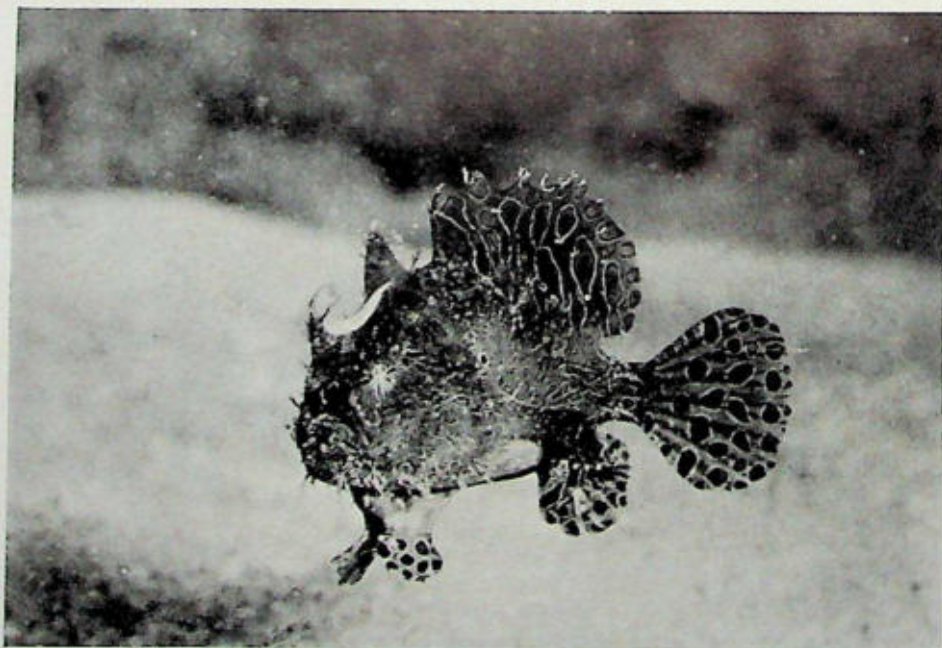
Dramatic occurrences came and passed with incredible speed. One day when trolling stead-



Spotted anglerfish, *Antennarius scaber* awaiting his prey. Directly above the nose of the angler is the lure, a perfect imitation of a wriggling gray worm, attached to a short, flexible jointed tentacle.



The anglerfish attracting its prey by violently moving the worm-like lure. When the object has moved into the direct sphere of possibility, the great mouth of the angler opens, and in the current created, the minnow is engulfed so quickly that it deceives the eye.



The anglerfish with all fins spread. All the photographs of the anglerfish were made by L. C. Dunton at the New York Aquarium.



Immense schools of anchovies in the Pearl Islands are attacked by dolphin fish and mackerel from beneath, and by hosts of brown boobies and cormorants from above. The boobies are in turn robbed of their prey by frigate-birds which wait for them high in the air. From a drawing by Helen Tee-Van.

ily ahead over a quiet sea, without warning the waters suddenly were troubled as in a tide rip. Through the clear depths we saw thousands of tragedies going on, mackerel and bonitos pursuing hosts of anchovies. Then, from nowhere five or six hundred boobies materialized, dropping out of the sky on all sides, head first into the water like a flight of arrows. As they rose, heavy weighted with their prey, gaunt frigate-birds appeared, and nonchalantly but inexorably bore them down and seized the hard-earned fish.

So for a week we gleaned our harvest of specimens and notes from the Perlas, then back and through the Canal, and north to Chiriqui Lagoon, the wildest place we had yet seen. This Mosquito Coast is saddled with one of the worst reputations in the world. Even the sane "Coast Pilot" tells of the constant dangers from sharks

and sting rays and reports the adjacent jungle as being infested with poisonous snakes. Yet during the week we were there we saw only two sharks, each of which desired earnestly to escape, and in many miles of walking and cutting through the jungle we saw but a single, small coral snake, so young that it was quite innocuous and could be picked up with impunity.

We took many rare fish around our submarine light and one evening, after capturing a young flying gurnard, five of us verified the aerial ability of these armored fish, watching them rush at the light, emerge and glide along at least five feet above the surface.

We made friends with the Valiente Indians, their smiles enhanced by their filed teeth, and we collected the ever interesting heliconid butterflies and their amazing mimics; we listened to the

weird chorus of the big, black, howling monkeys, and after a week of steady study of the fish, we started northward for Havana.

Our homeward voyage was anything but peaceful, for we had to dodge four July hurricanes, one of which drove us back to Colon for shelter. But no day at sea was wasted, and we caught sargassum weed and the fish therein, and took the flyingfish manna which came in darkness, and watched and saw again the strange unnamed flying squids (Zoological Society Bulletin, Vol. XXXV, No. 5, pp. 177-178).

On mirror-like days we took photographs of dolphins playing under our bow, and in Havana with the revolution casting its shadow a week ahead, we secured one of the most interesting of the Angler fishes, *Antennarius scaber*, and brought it back alive to our New York aquarium.

Its lure was, in size, shape, color and movement, a perfect imitation of a wriggling, grayish-white worm. While still on board the

Antares it devoured three of its own cousins, and a beautiful blue-starred demoiselle. Twice I watched the process, and both times while the prospective prey was at least two inches away, the frogfish opened its mouth and with no apparent effort, created such a maelstrom, such an irresistible current, that the human eye could not see the fish disappear. It simply vanished from sight, the lure was tucked away and we imagined a gleam of satisfaction in the fishy eye.

In the aquarium, *Antennarius* was housed with a herd of sea horses, but their armor proved no protection and three were forthwith devoured. Truly this is a worthy daylight, surface cousin of the great deep-sea-devils which I bring up in my nets with glowing blue and white flares for lures.

On July thirtieth we tied up at the Corinthian Yacht Club in Philadelphia, and the New York Zoological Society's Seventeenth Expedition came to an end.



MIGRATION OF FISHES

Introduction by WILLIAM BEEBE

THIS volume is concerned with the Travels and Migrations of Fish, and the very able author, Dr. Louis Roule, has condensed into the space of nineteen chapters the sum of present day knowledge of these subjects. But best of all, he has put this into understandable language and has brought out all the mystery, the drama, the amazing actions, many of them still unexplained, which accompany this phase of the lives of fish. What is known of this fascinating aspect of life in the waters of the earth has hitherto been locked up in technical books. So here we find a double translation—first from the dry recitation of facts into a moving, living account, and secondly from the original French into most excellent English.

The translator has wisely kept as much as possible to the clear style and the pleasant indi-

viduality of writing of the author, and has made use of an amazingly extensive English vocabulary to cope adequately with the delicate shades of meaning for which the French language is deservedly famed.

This is one of a series of popular volumes which the author has published for the French reading public, and their welcome has been most cordial. Dr. Roule is a well-known scientific student of fish, with many authoritative researches to his credit, so he brings to this popular work a sound background of knowledge, leavened with an emotional appreciation of its wide appeal.

The subject of the Migration of Fish is here given the play of imagination in the recording of actual facts which it deserves, and the layman will find an astonishing field of interest in an aspect of life which is as dramatic and absorbing as it is new to the scope of popular literature.

*Fishes: Their Journeys and Migrations". By Louis Roule 270 pp., 54 text illus. Published by W. W. Norton and Co., New York, N. Y.



The tropical forest of Pacheca in the Pearl Islands. The jungle grows down to the water's edge. It is a labyrinth of vines and lush foliage that forms a barrier that nearly defies penetration.



REPRESENTATIVES OF FOUR FAMILIES OF CARNIVORES.....	<i>Frontispiece</i>
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Binturong	American Badger
Meerkat	Canadian Otter
Suricate	Crab-eating Raccoon
Fisher	Eastern Raccoon
Black-footed Ferret	Ring-tailed "Cat"
Eastern Weasel	Coati Mundi
American Black Footed Ferret	Ring-tailed Coati
American Mink	Kinkajou
Wolverine	Panda

PANDA	<i>Cover</i>
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BULLETIN

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THE SMALLER CARNIVORES

Representatives of four families. 1. American black-footed ferret, *Putorius nigripes*, Mustelidae; 2. American badger, *Taxidea taxus*, Mustelidae; 3. African civet, *Civettictis civetta*, Viverridae; 4. Coati mundi, *Nasua narica*, Procyonidae; 5. Raccoon, *Procyon lotor*, Procyonidae; 6. Himalayan Panda, *Ailurus fulgens*, Ailuridae.



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The Smaller Carnivores

RAYMOND L. DITMARS

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All of the illustrations accompanying this article were made from photographs taken in the Zoological Park.

WHILE some of the world's most spectacular types of animals are members of the Carnivora, the larger species of this extensive order form a scant minority. Such carnivores as the lion, tiger, leopard, cheetah, ounce, jaguar and puma greatly dominate the feline family in size, and some Alaskan bears attain a weight of over twelve hundred pounds, but the great array of carnivorous animals remains, these of moderate or small size, ranging down to the diminutive weasels.

There is considerable variety in form among carnivores, but phases of adaptation are not so marked as with members of some other orders. The greater number are terrestrial; some are semi-aquatic and show fair specialization. A number are arboreal, but in following such habits have not acquired the marked structural characteristics of mammals of other groups.

Carnivores are widely distributed, from within the Arctic circle through the tropical latitudes. They are lacking in Australia and New Zealand, with the exception of the dingo, in the former; and actually, the status of Australia's wild dog is clouded by the thought of it having been introduced by pioneering human races.

In the common definition of the Carnivora as the "flesh-eating animals," a weak title has been established. True enough, the greater number are flesh-eating, but a fair portion vary such diet with fruits and herbs. Then again, there are many mammals of unrelated orders which are flesh-eaters. However, there is no grouping

of mammals so generally carnivorous as that figuring in the present article.

There are eleven distinct families making up the Carnivora, and of these the collections of the New York Zoological Society have contained representatives of eight. While the Lion House is limited to exhibition of species of the *Felidae*, and the Bear Dens, also the Wolf and Fox Dens, have represented two additional families, the greater number of our species of carnivores are exhibited in the Small Mammal House. Here the majority have been members of two families, the *Fiverridae* and the *Mustelidae*, and the accompanying illustrations largely relate to members of these families. The tendency, with both groupings, is toward elongate and rather sinuous bodies, with short limbs. The *Fiverridae*, containing the civets, genets, mongooses and palm "cats," is strictly an Old World family. Members of the *Mustelidae* occur both in the Old and New World and among them are the weasels, badgers, otters, martens, sable, mink, skunks and wolverine, the latter indicating the largest size these animals attain.

Some scientific writers are inclined to the belief that there should be a considerable separation in classification between the *Fiverridae* and *Mustelidae*; that the latter show skull characters indicating relationship with the bears and raccoons. The similarity of forms among both families is hence accounted for as parallel development, without relationship. Other students, however, contend that evidence furnished by



Indian civet, *Viverra zibetha*. This species attains a length of approximately fifty inches, of which eighteen are occupied by the tail. It lives in thick, brushy areas and is nocturnal.

forms of extinct carnivores point to the viverrines representing the ancestral stock whence the mustelines were derived. The illustrations with this article are grouped to afford a comparison of the species of both families.

The most interesting viverrine we have exhibited has been one of the smallest—the Indian mongoose. This animal is really a necessary part of a collection of living animals, owing to its fame as the enemy of the deadly cobra. It is not, as has been alleged, immune to the poison of the cobra, but depends upon its agility in dodging the serpent's rather slow and sweeping stroke and darting in to fasten its teeth in the reptile's neck, thus severing the spinal cord. It is difficult to obtain a mongoose for exhibition. While the species is common enough, the United States government has imposed laws against its importation, owing to the possibility of its escaping, breeding, and becoming a menace to poultry and wild birds, a condition sadly demonstrated in the West Indies where the mongoose was introduced and has become a formidable pest.

The common mongoose of India represents a considerable group of very similar animals, all of which savagely prey upon reptiles, small mammals and birds. A dozen species of the mongoose genus extend over southerly Asia, much of Malaysia, and Africa; in the latter country is a species three times the size of the Indian mongoose. The immediately allied suricate and meerkat, of Africa, have also been exhibited in the Park. The government ban relates to the exclusion of all of them. Similar laws are in effect in the tropical American countries.

The genets are larger than members of the mongoose group, several kinds inhabiting Africa and one extending into southerly Europe. The form is cat-like, but much elongated, while the limbs are short. In slinking gait, with bodies pressed to the ground, these animals are singularly serpentine in aspect, the impression being heightened by the vividly blotched body, the prevailing pattern among genets being large, dark spots upon a body hue of brown or yellow. Genets, like members of the mongoose clan, are readily tamed as pets, but remain ferociously combative among small mammals. Hence, like other small viverrines, they are often kept in houses for the purpose of killing rats and mice—

although their depredations may extend to the destruction of innocuous, rodent-destroying snakes and luckless birds succumbing to sinuous stalking and agile rush.

The palm civets form a connecting link between the slender-bodied viverrines and the rather stout-bodied civets, of which two species stand rather prominently. One of these is the Indian civet, with a total length from snout to tip of tail of about fifty inches. It is of rather cat-like form, gray, with blackish rings. The African civet is of similar length, but of stouter form and more heavily haired. The pattern consists of a mixture of bands and blotches. It is illustrated among the accompanying photographs. These animals have assumed prominence owing to a secretion in glands near the base of the tail, used in the production of some types of perfumes to retard the volatile action of the respective scents. As a base to such perfumes, the secretion of the civets renders the odors, even in small quantities of the perfume used, extremely persistent. The secretion of these glands is sometimes disagreeably apparent when a series of living civets is exhibited. A heavy and sweetish odor may be associated with the animals, and this is particularly accentuated when the air contains a high percentage of humidity.

The largest of the viverrines is the binturong, also called the bear-cat. It is arboreal and by some authors is designated as a big tree civet. Its distribution embraces India, the Malay Peninsula, Sumatra and Java. Its tail is long and bushy, and the total length from snout to tip of tail of a large example is approximately five feet. To the writer, its domination in size over the other viverrines, is analogous to that of the wolverine among the musteline types.

Among our exhibits of mustelines, there has been a series of species closely matching in size the collection of viverrines. We have found, however, that the smaller mustelines, of the weasel, ferret and mink types, are nervous and delicate as captives and require great care as to diet, requiring the flesh of small mammals and birds. They are unable to long survive upon a diet of meat with heavy muscular fiber, such as beef.

Possibly the most interesting among our mustelines is the otter. It lives for years upon a diet of fish. This particularly keen and intelli-

(Continued on page 127)



African civet, *Civettictis civetta*. One of the larger members of the *Viverridae*, an old world family, of which the well-known mongoose is a member.



Binturong or bear "cat", *Artictis binturong*. Largest member of the *Viverridae*. The combined head and body of a large example are close to a yard in length. The species occurs from southeastern Asia to Sumatra, Java and Borneo.



Meerkat, *Suricata suricatta*. There is a fair variety of small viverrines in Africa. This species inhabits the southerly portion. It is characterized by its elongate and pointed snout.



Suricate, *Cynictis penicillata*. A South African viverrine, immediately related to the mongoose group, although the limbs are comparatively longer. It preys upon snakes, lizards and small rodents.



Fisher, *Mustelus pennanti*. A North American mustelid, occurring in northerly latitudes from the Atlantic to the Pacific coast. Its color varies from lustrous black to dark brown.

gent animal, in its rapid and graceful swimming antics, and its play, forms a most attractive exhibit. The several kinds of otters are strongly characteristic among the carnivores in the elongate, flattened body, wide and flattened head on stout neck, showing little differentiation between the two and the webbed feet. Here is ideal adaptation of the musteline form for a semi-aquatic life. Similar forms of otters occur in both the Old and New Worlds, in North and South America, Europe, Asia and Africa, all embraced within a single genus (*Lutra*) except a remarkable sea otter inhabiting both shores of the northern Pacific.

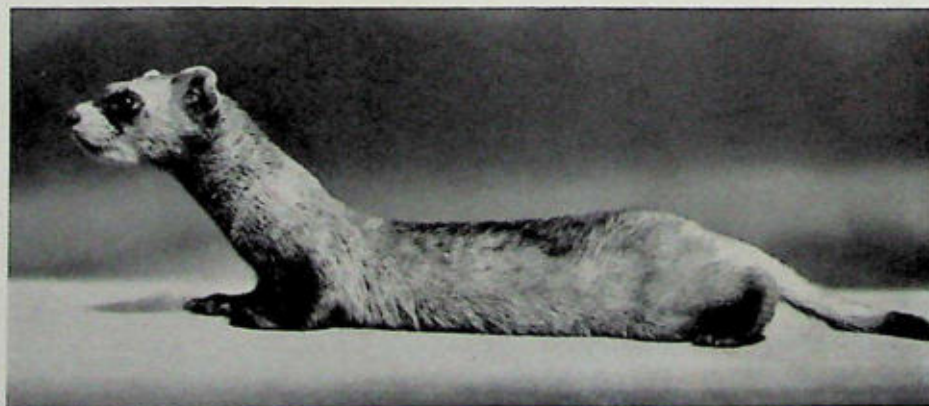
In contrast to the prevailing influence among the mustelines to develop slender, elongated forms of the weasel, mink, marten, fisher and otter types, are the badgers, New and Old World, with stocky bodies and powerful limbs for digging. The honey badger or ratel of Africa and southerly Asia, is a particularly strong and stout species. The wolverines of northerly North America and Europe, are the largest of the mustelines, savage and particularly strong; the length of body, including relatively short tail, is slightly in excess of forty inches and the weight up to thirty-five pounds. The strength of jaw of an adult specimen is astonishing. An example exhibited in the Zoological Park so strained and tore the heavy meshwork of its cage that it escaped. The cage was of a character that would have been estimated to have safely held a medium-sized bear. During our efforts to capture it—which were successful only after great difficulty—this animal fought with a strength and fury, and emit-

ted growls worthy of a creature three times its size. Despite its goodly proportions and stocky form, the wolverine is closely related to the cosmopolitan genus containing the small and slender weasels.

Another family of small carnivores closely follows the mustelines in classification. This is the *Procyonidae*, containing the raccoons and their allies. They are more closely related, however, to the family of bears, which borders them on the succeeding descent of technical listing. This is an exclusively American family, containing the ring-tailed "cats" or bassarisks, raccoons, coati-mundis and kinkajous. There is much versatility in form among them, as evidenced by the stout-bodied raccoons, the excessively long-snouted coatis of tropical America, and the cat-like kinkajous, with their dexterously prehensile tails.

The Panda, one of two species forming the family *Ailuridae*—closely allied to the bears—may be said to be the most attractive small carnivore ever exhibited in our collections. The head of this species appears on the cover of the present number of the Bulletin. This animal is much the size of a raccoon, but with long, luxuriantly-haired tail. Its general coloration is bright reddish hue, the tail vividly ringed with black. The face is in startling contrast, being very white, as if the animal had thrust it into a flour barrel. The panda is an exceptionally gentle animal.

It occurs in the eastern Himalayas. The illustrations, following a nearly similar continuity of the order of the text, are from photographs of the smaller carnivores exhibited in the Zoological Park.



Black-footed ferret. *Putorius nigripes*.



Eastern weasel, *Mustela novboracensis*. A number of species of weasels inhabit the United States, Canada and Alaska. The genus is also well represented in the Old World. The above example is in winter pelage. In southerly latitudes the weasel remains brown throughout the year.



Upper. American Black-footed ferret, *Putorius nigripes*, in pose showing the characteristic elongated form of many members of the Mustelidae. Lower. American mink, *Mustela vison*.



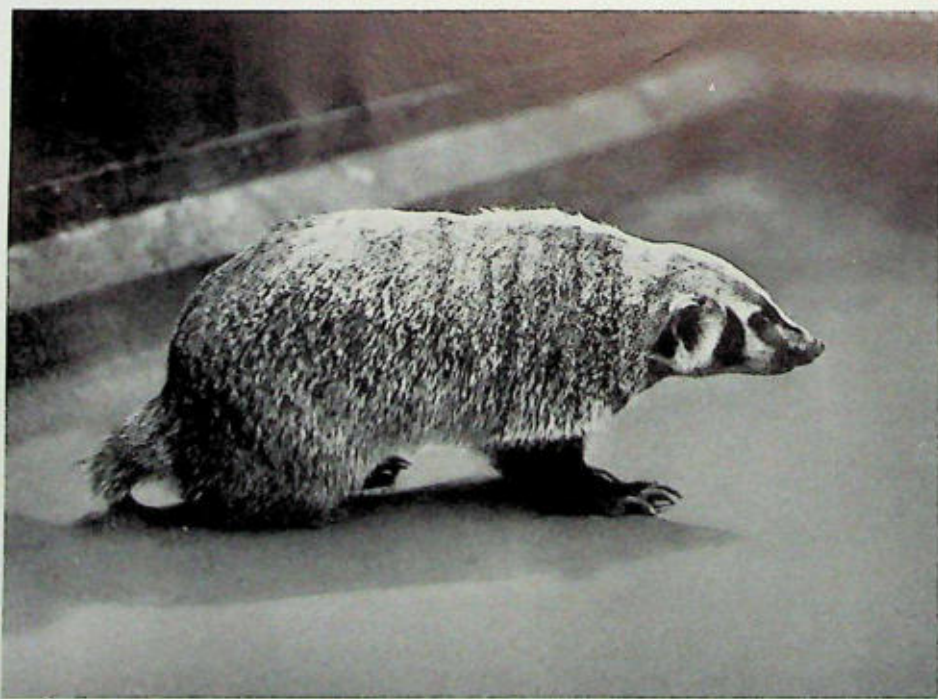
Wolverine, *Gulo luscus*. Largest member of the weasel family (the *Mustelidae*). Its form is robust and bear-like. The total length of a large male is about forty inches and the weight around thirty-five pounds. The species is savage and extremely powerful in proportion to its size.



Upper. Common skunk, *Mephitis mephitis*. Typical examples of a species inhabiting the greater part of the United States and Canada. Allied species occur in various parts of North America. The skunks are members of the *Mustelidae*. Lower. Common skunk, *Mephitis mephitis*. Indicating variation in the white markings.



Honey badger; Ratel, *Mellivora otter*. A nocturnal and powerful, burrowing musteline, of South Africa. The total length of a large example is about a yard.



American badger, *Taxidea taxus*. Badgers represent the *Mustelidae* and inhabit North America, Europe and Asia. They are heavy-bodied, strong animals excavating deep burrows. Note the digging claws on lower figure.



Canadian otter, *Lutra canadensis*. A number of species of otter inhabit North and South America, Europe, Asia and Africa. They are characteristic among mustelins in being largely aquatic, with extensively webbed feet.



Crab-eating raccoon, *Procyon cancrivorus*. The family *Procyonidae*, containing the raccoons, ring-tailed "cats", coatis and kinkajous, is represented only in the New World—North and South America.



Eastern raccoon, *Procyon lotor*. *Upper*. The typical form shown above inhabits North America, east of the Rocky Mountains, from southern Ontario and Manitoba to Florida. There are a number of subspecies. *Lower*. Albino example of the eastern raccoon.



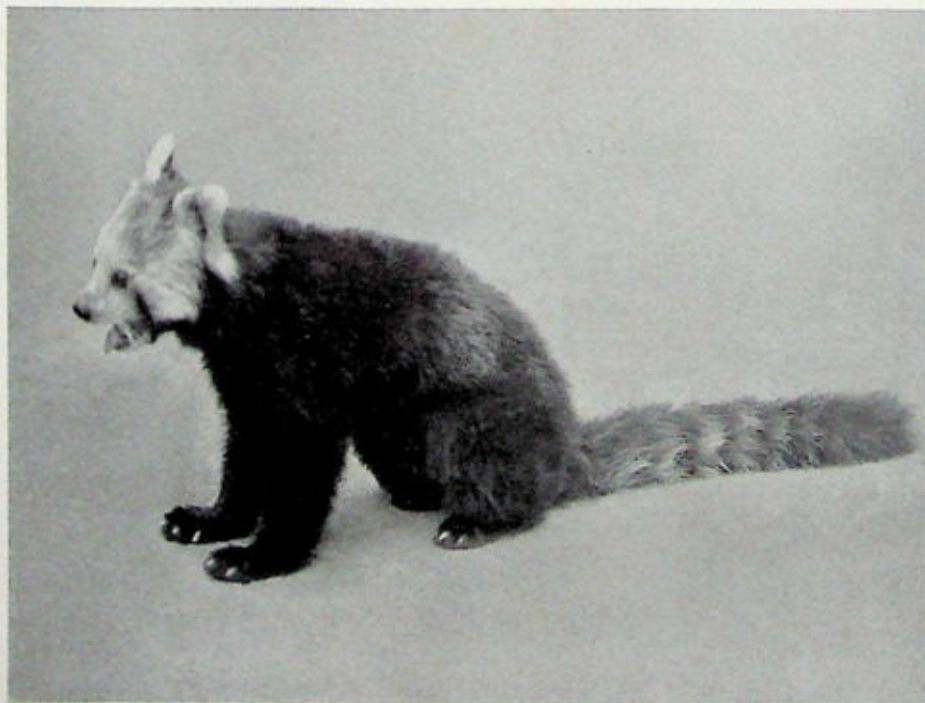
Ring-tailed "cat"; cacomistle, *Bassariscus astutus*. A small ally of the raccoon inhabiting the southerly United States from Louisiana to California.



Upper. Coati mundi, *Nasua narica*. (Immature example). Occurs from southerly Mexico to Peru. Lower. Ring-tailed coati, *Nasua nasua*. A species confined to tropical South America.



Kinkajou; Honey "Bear", *Potos flavus*. A prehensile-tailed member of the family including the raccoons and coatis. A particularly docile animal, of soft fur and cat-like form. It inhabits Central and South America.



Panda, *Ailurus fulgens*. Considered to be closely related to the bears. It is raccoon-like in form and size and inhabits the Eastern Himalayas. The white, fluffy hair of the head and upstanding ears, form a sharply contrasting note against the dark pelage of the body.

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Egyptian Jerboa	Capybara
Spring Hare	Texas Jack Rabbit

BRAZILIAN TREE PORCUPINE*Cover*

BULLETIN

NEW YORK ZOOLOGICAL SOCIETY

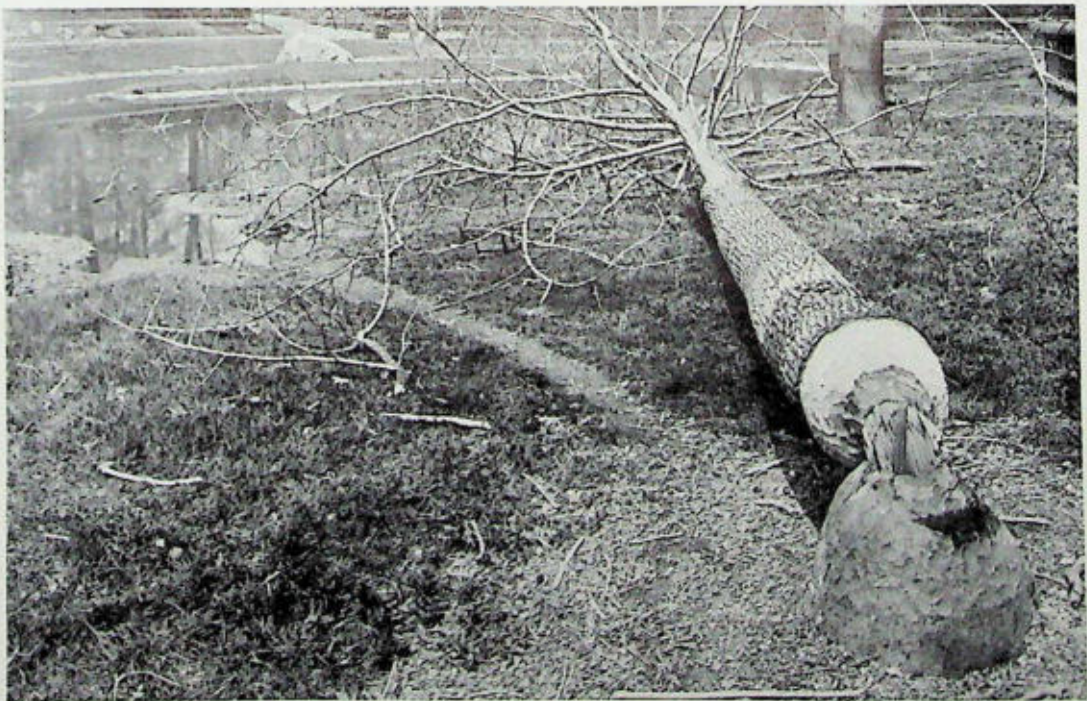
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Editorial and Subscription Offices, Zoological Park, New York City, Elwin R. Sanborn, Editor.



Tree-cutting by the American beaver, *Castor canadensis*, in the Zoological Park. This is an interesting feature of beaver life, and in all logging operations if the conditions are favorable, beavers seldom fail to cut trees upstream and float them down. Should it be possible to choose the tree, he will demonstrate that he is a conservationist of energy by picking them of small diameter, but there are records of beaver-cut trees of over thirty-six inches in diameter. The skeleton of the beaver in the picture was prepared for Mr. Sanborn for the purpose of comparing the size of the beaver with the task that he might attempt. The beautiful precision of cutting and instinct of proper felling direction are apparent.

BULLETIN

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The Rodents or Gnawing Animals

By ELWIN R. SANBORN

Legends, and Photographs (except as otherwise noted), by the Author

THE order *Rodentia*, including the rodents or gnawing mammals is by far the largest, well-defined group of the world's mammals. The order is so definitely characterized by peculiarities of the teeth that, with one or two exceptions, even a casual inspection of the skull is sufficient to decide whether or not an animal is a rodent.

The teeth are of but two kinds, incisors and grinders—or molars, and the number of efficient teeth of the former is never more than two in each jaw. There are no canine teeth and since there are but two incisors, the front pair, there is a toothless space between them and molars on each jaw. But two exceptions occur among the order in this arrangement and distribution of the teeth: The hares and the little chief pika, have two extra incisors in the upper jaw, lying directly in back of the top pair, but they are quite useless in the process of gnawing for which the latter are so admirably suited. Their presence is of interest as a possible indication of the direction in which an alliance with other forms might be traced. The great incisors possess no roots, but spring from a permanent pulp, so that they continue to grow throughout the whole life of the animal. Their shape and that of the cavity which makes their socket, is invariably a segment of a circle, consequently they protrude from the jaws always in the same direction and meet at the same angle. To the layman, the great power of the rodent jaw must be apparent, as it might quite naturally be the creative pattern for the jaws of mechanics' plyers. The tremendous cutting force of the beaver's jaw is quite clearly shown in the frontispiece. On occasions, sometimes through injury, these great incisors fail to meet at the proper angle, and as a result the overlap finally prevents the use of the jaws altogether, usually resulting in the death of the animal from starvation. They must meet, grind and be worn down to a chisel-like edge.

There is an extraordinary variety of rodents

quite generally scattered over the greater part of the world. The order *Rodentia* includes more genera and species than any other existing order of Mammals. The reason for this may be because so many of these animals are of small size and timid ways. They secrete themselves in holes, hide in forest depths, in marshes or on the dry plains. They are generally nocturnal and invariably shrink from observation.

The largest and most typical family of the *Rodentia* is the *Muridae* which includes the rats and mice and their allies. There is a great variety in this assemblage of species but it may be said without fear of useless contradiction that the common rats and mice are characteristic types of the entire gamut of forms. The family also includes jumpers, leapers, swimmers, arboreal and burrowing species, and is practically cosmopolitan in its distribution. Most interesting of the *Muridae* is the lemming, numbering but a few species, one of northern Europe and the rest confined to the circumpolar regions of both hemispheres. The migrations of the Norway lemming is one of the most remarkable demonstrations of animal impulse yet known. They start in vast swarms from their mountain homes, thousands upon thousands, and make their way chiefly by night, obstinately in one direction, crossing mountains, swimming rivers and scorning any obstacle in their course. Even if they should reach the sea, they heedlessly plunge in, and the thousands of the army perish in the march of mystery.

The purpose of this article and this number of the Bulletin is not to give a complete history of the order of rodents, merely to set forth simply, some interesting facts concerning them, and present in picture a few of the species exhibited on occasion in the Zoological Park. Many others have been shown, but some of the *Rodentia* are next to impossible as photographic subjects.



The flying squirrel, *Glaucomys volans*, is one of "the most graceful and exquisite little mammals in North America", but its aversion to daylight and its nocturnal habits are a barrier to common acquaintance. The fur is soft and delicately fine. It differs from the ordinary squirrel principally in possessing a thin skin connecting the fore and hind legs which serves as a parachute and enables it to make long gliding leaps from one tree to another. The flying squirrel and certain lemurs similarly equipped do not fly, but rather soar, the stretched membrane giving lifting power against the air. A straight out flight is impossible. They are classed in the order of Rodents, family *Sciuridae*.



The gray squirrel, order of Rodents, family *Sciuridae*, *Sciurus carolinensis*, is one of the most commonly known of these lively and playful rodents. Because of his guileless and friendly manner he is the very king of beggars. He has adapted himself to a life in public parks, and accepts without reserve or fear the proffered hand of good fellowship of man, as well as any food that might be offered. So fixed has become this habit that he has abandoned the custom of his ancestry in providing a store for winter, and lives a life of ease, almost wholly dependent on his supply of food from the cheerful giver. During the period of depression, it was even said of him by some modern Demosthenes, that the order has been reversed, he had turned to feeding the visitors. Photograph by E. R. Osterndorff.



Here is a familiar visitor to the officers and keepers of the Zoological Park, who in common with several others makes at least weekly, if not daily trips to the Park with a bag of food principally to feed the squirrels. By frequenting the same localities, the squirrels in that neighborhood not only depend on this friendly woman, but have learned to recognize her as well. In a brief time, once she appears, they usually assemble in considerable numbers, climb over her shoulders, and even enter her pockets and bag to find the food and if possible to get the principal part. The gray squirrel, *Sciurus hudsonicus*, is an indifferent antagonist and prefers the peaceful life, which is a contrast to one of his relatives, the chickaree, the red squirrel, *Sciurus americanus*, who makes up in activity what he lacks in size. Fortunately, the latter species does not frequent public parks, which is quite to the gray's good fortune since he is their relentless foe. Photographed by E. H. Osterndorff.



The gray squirrel is the most prominent squirrel of Southern Canada, New England and the eastern and southern states southward to Florida, and ranges westward to Minnesota, Kansas and Texas. Usually it nests in hollow trees and also builds an open round structure of leaves and bark high among the branches. The young are born in the spring and are solicitously cared for by the parents. While the food of the squirrel is chiefly roots, nuts and buds of trees, some species suck the eggs of birds and even eat the young. Australia, that land of anomalies, is one place in which the squirrel is not found. The albino squirrel in the upper picture lived for a number of years in the office of the late G. O. Shields on 5th Avenue, New York. A gray squirrel is found in California and Southern Washington which is somewhat larger than the eastern types. Lower photograph by E. R. Osterndorff.



A distinguishing feature of this squirrel, the fox squirrel, *Sciurus niger*, is the white nose and ears. Dr. Hornaday in one of his books says, "no matter how much the animal may vary in color from the standard, the adults invariably have the white nose and ears." It is a large squirrel, the largest of the American species, having a combined length of two feet or more, one half of the length being the very bushy tail. The range of its habitat is east of the Allegheny Mountains, from Virginia to Florida and west along the Gulf as far as Louisiana. Its northern relative is slightly smaller, somewhat similar in color, but the nose and ears are never white. At times specimens have been liberated in the Zoological Park, where they have thrived for a while only to eventually wander off or die. The range of this species is northerly as far as New York and Michigan.



The brilliance of the tropics extends to the mammals as well as to its other living forms, and while the color patterns may not be of so extensive a prismatic range, they are brilliant against the somber shades of the temperate zones. Besides being gayly colored, the squirrels of the tropics also excel in size those of colder climes. The Malabar, *Sciurus malabaricus*, one of the most attractive species, inhabits the Nilgiri Hills of India and the nearby territory and attains a length of over three feet, the tail being at least eighteen inches of that measure. The general color-pattern of the body is a rich maroon-chestnut shade with the under parts of warm yellowish buff. Parts of the legs and the magnificent tail are glossy black. Several closely related species are brightly colored. The Malabar is most amiable in captivity, is gentle, sociable and altogether a satisfactory charge.



The chipmunk, an Indian name, is a small squirrel-like rodent, somewhat smaller than the true squirrel, from which it also differs in having internal cheek-pouches and stripes on the back and sides. It is further characterized by its somewhat subterranean habits, living either in a burrow which it constructs under the bases of trees, a huge boulder or some site which its keen instinct prompts as a safe shelter. The chipmunk is a prodigious and persevering worker, and lays up a great store of nuts, grain and fruit pits for the winter months. These he collects in his cheek-pouches and empties into his storehouse. As soon as the cold seasons approach, this wise little animal goes into winter quarters and there he remains until the warm suns of spring beckon to him to appear. In the very depth of winter they lie dormant in their nests, warmly lined with leaves and grass. The young are born in the spring. The specimen shown is the common eastern chipmunk, *Tamias striatus*, Photograph by E. R. Osterndorff.



The chipmunk has so many persistent enemies that pursue him both above and below the ground, that it is quite natural for him to be shy and suspicious. But constant practice in dodging danger has given him, not only uncanny skill in evading peril, but some measure of discernment of the intentions of the supposed friendly hand. So insidious is habit that he has learned to be a conservator of his own energy, set aside instinctive suspicion and accept the fellowship of man in satisfying the immediate need and possibly, if the charity is ample, laying up a store for winter. In the Zoological Park, where these two pictures were made, it is quite common to observe visitors feeding this usually very timid animal. The generic name *Tamias*, is from the Greek, meaning steward and refers to the chipmunk's habit of laying up food.

Photographs by E. R. Osterdorff.



The word spermophile is derived from two Greek words—*sperma*, seed and *philos*, loving, and as this very appropriate term implies, the animals so designated feed chiefly on seeds and grains. Because this little animal does not discriminate between the wheat and the tares, he has created trouble for himself and found an enemy in man. It is the common name for an extensive group of ground-squirrels found throughout western North America, living by preference on the open prairies in deep and extensive burrows. They are social animals, laying up food for the winter, and in cold latitudes hibernating throughout the period. Besides seeds and grains, the spermophile consumes enormous numbers of insects, and, from actual observation, it has been ascertained that in season insects form the major part of their food. Nature has so adjusted the life of this animal that it can survive the rigorous winter of its habitat in the strange condition known as hibernation. In a specimen examined there was no visible breathing, the heart beat reduced from 200 to 4 feeble beats the minute, and the nerves were insensitive. The picture is the thirteen-lined spermophile, *Citellus tridecemlineatus*, the latter name indicating the number of stripes along its sides.



The prairie "dog", *Cynomys ludovicianus*, probably acquired the common name from the French Canadians who designated him "petit chien", little dog, because of the similarity of its sharp bark to that of a dog. Otherwise he is quite unlike a dog. Entirely gregarious, they dwell together peaceably and often in colonies of considerable numbers. He is a burrower of ability and persistence. The mouth of the burrow is a mound like a miniature volcano, and during the social hour the owners perch thereon and survey their small world. Some of the "dog" villages on the open prairie are almost unbelievably denuded of grass and the soft vegetation upon which they feed. It is not true that rattlesnakes and owls live in harmony with the "prairie dog". The snakes would devour the young, and any mammal instinctively avoids a rattlesnake. Possibly owls dwell in deserted burrows, but it has been proved that they cannot live in the same burrow with the prairie dog. Dr. Hornaday mentions a burrow actually dug out that went down vertically fourteen and a half feet, then turned abruptly a horizontal distance of thirteen and a half feet. Photographs by E. R. Osterdorff.



A portion of the prairie "dog" village in the Zoological Park. This was one of the first outside installations constructed in the Park, and for nearly thirty-five years it has endured the test of time, climate and interest of visitors. A free colony was established in the antelope range which thrived beyond the aims and the restrictions which the Society expected. The open country proved too great a temptation for the industrious and ambitious "dogs", who commenced to wander beyond the edges of the domain of which they were unaware and heedless. Flower-beds and lawns soon erupted into "dog" mounds and the neighbors complained. Capturing the runaways was not so simple. It was easy to get one into his burrow, but to extract him was something else. Eventually this was accomplished by placing a small cask, open at both ends, over the hole and partially filling it with dry sand. When the occupant of the burrow dug himself or the sand was in the hole and the "dog" was in the barrel. Just a fair change. Photograph by Ernest Keller.



The woodchuck, *Marmota monax*, is our most perfect type of marmot, from which the prairie "dog" or prairie marmot is but slightly removed; the difference an anatomical detail. The woodchuck or ground "hog" as he is commonly called, is quite generally known from Hudson Bay to Virginia and westward as far as Nebraska, and is the most common of several species found in North America. He is a good burrower and digs deeply in the fields, sides of hills or under rocks in the woods, making several apartments slanting upward to keep out the water and most usually with more than one entrance. In his diet he is strictly a vegetarian, partial to red clover, but will accept any green food, which he eats sitting erect like a squirrel. They are both nocturnal and diurnal in their habits, feeding time being determined by the period and the temperature. When taken young they are easily tamed and being cleanly in their habits they make interesting pets. The name *monax* means solitary, an indication of its habits. Upper photograph by E. R. Osterndorf.



The woodchuck hibernates in the winter, the duration depending on the latitude. It is one of the earliest to go into winter quarters and one of the first to come out in the spring, the length of its hibernation varying, being longer in its northern habitat than in the south. It is possible that in certain latitudes, the woodchuck lays up a store of food for winter consumption, but when the hibernating period is protracted nature provides a better way. If the living is good throughout the summer, when fall comes around he has acquired a great store of fat next to his skin, and when the first chill winds give warning he cowers his burrow and goes to sleep. His coat of fat not only acts as a blanket, but serves to nourish his body throughout the long dormant period. According to tradition, he does not emerge until February, second, when if he sees his shadow, it indicates more winter and he retires for another six-weeks sleep. Albino plagues often occur among mammals and birds; this is a good example.



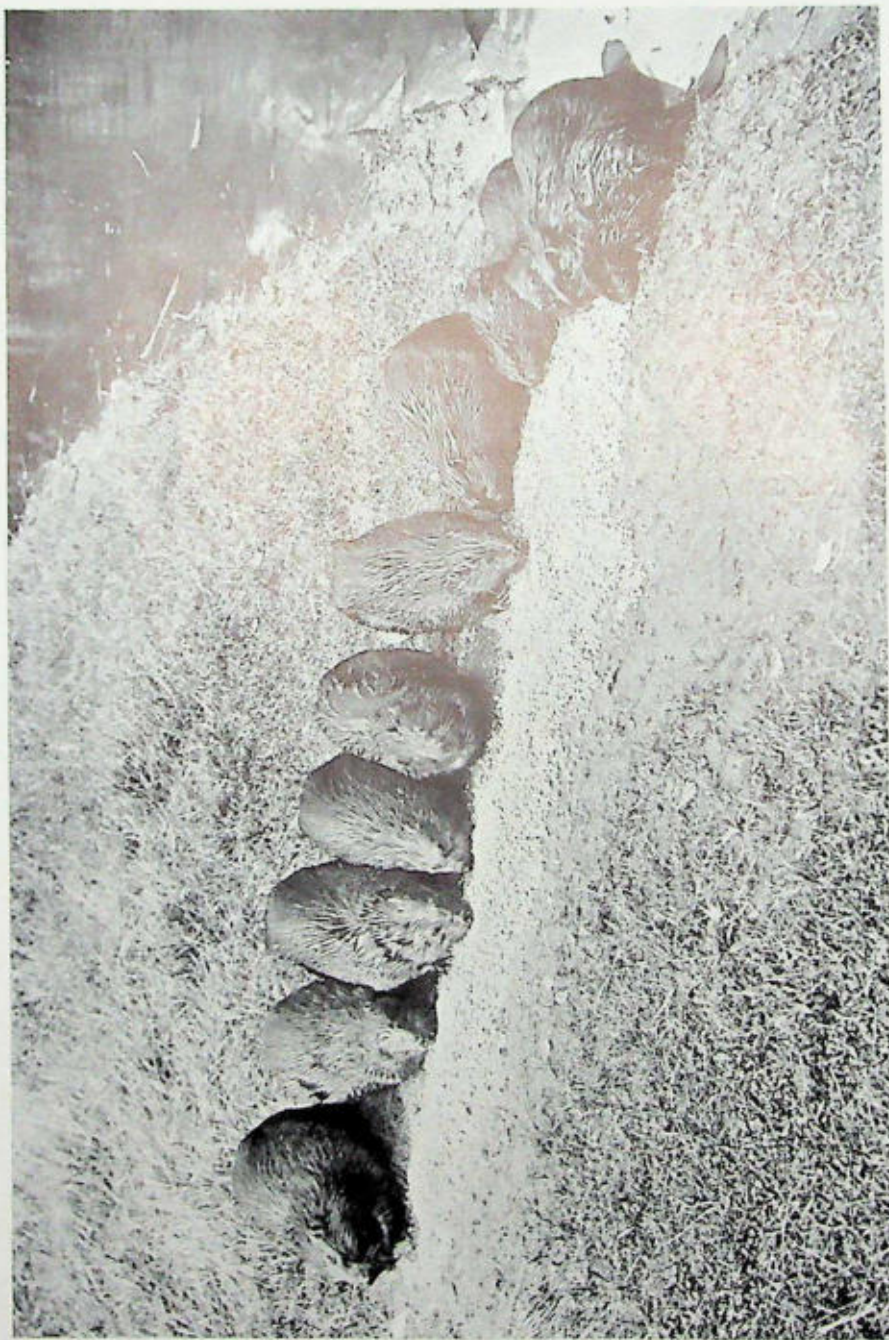
The sewellel, *Aplodontia rufa*, is a little known and rarely seen marmot-like burrowing rodent, found along the Pacific coast north of California, and exhibited but once in the Zoological Park. It is a small animal about twelve or fourteen inches in length, with a head much like the beaver, and strong short legs adapted to its burrowing habits. It is not aquatic, but feeds like the beaver, usually on water plants. They are shy and timid, live sociably in colonies in burrows constructed in moist ground where water is plentiful. Indians greatly prize the skins, and capture the animals by setting traps in the water, taking advantage of its aquatic feeding habits. Sewellel is the Indian name, but it is also called mountain beaver, showtl and boomer. Several other species are known in the Sierra Nevada Range. A distinguishing anatomical feature is the structure of the molar teeth, which are simple and not grooved.



"The beaver easily leads the mammals of the world in mechanical and engineering skill and also in habits of industry". It is the largest gnawing animal in North America, specimens having been known to weigh fifty pounds or more. It is so exceedingly shy and timid that the opportunities of seeing the beaver at work in the wilderness have been given to those only who have exhaustless patience and time, even in the Zoological Park where it might be supposed that animals would become accustomed to observation, the beaver is known usually only by the traces of his work that he leaves behind, or the labels that briefly state his history. The broad, flat and usually hairless tail is distinctly a beaver feature, and by it he may be easily recognized. Many stories have originated concerning its purpose to the beaver, but its use as a trowel in dam-building, which is one, is quite surely a myth. The large hind feet are webbed and used for swimming, the tail aptly aiding to change direction, and also to give warning by a quick hard slap on the water.



Top left: shows a beaver idly floating as they do when sensing danger. *Top right:* young beaver coming out of the pond. *Center left:* a beaver dragging small timbers into the dam. *Center right:* alarmed beaver diving, the geyser indicates the warning slap of the tail. *Lower:* how the beavers filled the sluiceway in the dam.



The food of the beaver consists chiefly of the inner bark of the wood of the aspen, willow, birch, alder and a few other trees, and also on occasion berries, mushrooms, grasses and the leaves and stalks of plants. Beavers are vegetarians, eating no flesh of any sort. Their supply of food for the winter consists of cut lengths of their favorite food-woods sunk in the pond around their dwelling, and to which they have access by diving under the ice surrounding the lodge. He is a most skilful diver and swimmer and can remain under water for several minutes. When swimming the forepaws are folded against the body, the hind legs doing the propelling while the tail acts as a rudder. This unusual picture of beavers—eleven in number—was made in the Zoological Park by Dr. R. L. Ditmars, using good field corn for bait. Different beaver families do not mix well together, which makes this collection seem like relations.



The beaver is very cleanly in his habits and reserves time out to work over his toilet. When not feeding or working, he sits soberly on the bank and gives much attention to combing his fur which is done with the long claws of the fore-feet. Beavers do not hibernate, but in the winter months they sleep longer and move about less frequently than in other seasons.



The muskrat, *Fiber zibethicus*, an American rodent is also known as musquash and musk beaver. It is quite rat-like in appearance, but its flat, hairless tail is carried on its edge. It is found all over North America from one side to the other and invariably near streams, ponds or any bodies of water as it is entirely aquatic. It raises mound-like houses of vegetation in marsh lands in which several families live quite peacefully together. The muskrat breeds rapidly and prolifically which is quite lucky for him as many rapacious animals love his musky flesh and his pelt under various disguises is sold as a costly fur. He will never be found far from water and although the feet are slightly webbed, the tail seems to furnish the motive power in swimming. The name *Fiber* means beaver and the specific name refers to the rat's musky odor.



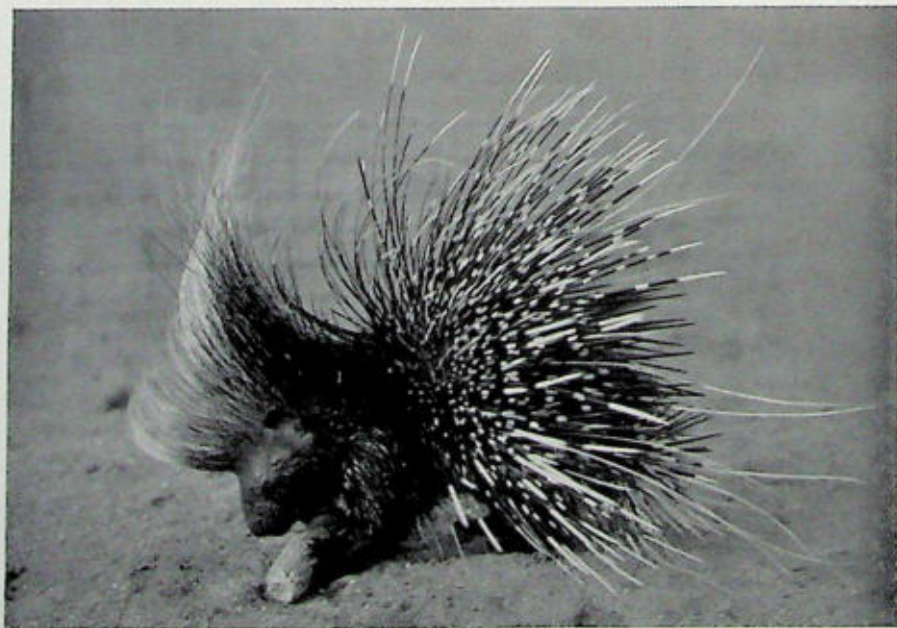
The cheek-pouch or pocket mice and rats comprise a family solely of the American west and southwest, its members being found only beyond the borders of Arkansas, Iowa and Minnesota. Many of the species are desert dwellers and are distinguished from other North American mammals, except two species, by the external, hair-lined pouch which is part of the skin of the cheeks. This very useful feature is sufficient at least for recognition of any member of the family. The Kangaroo Rat, *Dipodomys agilis*, which is in a genus including over forty species and races, is a most graceful and attractive little rodent. Dr. Hornaday says, "In the dry and sterile regions of the great Southwest where seemingly the deserts produce nothing but sand, cacti, yucca and sage-brush, these pert little creatures hold forth". Apparently they are both fire-proof and water-proof, since no amount of heat affects them, nor are they inconvenienced by the lack of water. Some species build large mounds of dirt and gravel often of large proportions which are filled with galleries and runways. Desert rattlers frequent these mound dwellings, no doubt finding the owners a good item of food. The large external cheek pouches are clearly shown in the upper picture.



The jerboas, family *Jaculidae*, are mouse-like rodents with tail and hind legs nicely developed for leaping. The forelegs are of hardly any use except for holding purposes. They are natives of Asia and Africa, and some range into southern Europe. The Egyptian jerboa, *Jaculus jaculus*, the most thoroughly known, is gregarious, living in colonies in northern Africa, which extend as far as Syria and Arabia. The fur is delightfully soft and silky and a pleasing color combination of pinkish gray and fawn accented by snowy white and rich blacks. Ancient people called this little animal "two-footed mouse" because the legs are held so close to the body in leaping that they are almost invisible and lend a bird-like appearance. Even a casual examination of these pictures would be sufficient to convey the impression of unusual leaping powers; indeed the body seems overpowered when it is compared with the hind legs and the spring-like tail. The large luminous eyes and the gentle expression would disarm the hardest hearts, yet the Arabs who are fond of its flesh slay them in numbers. It is indeed so "that a hungry stomach hath no eyes".



The jumping hare, African spring-hare, *Pedetes cafer*, is the only representative of the family *Pedetidae*. The spring-hare differs in so many respects from the true jerboas that it has been made a separate family. It is way beyond the size of the jerboas, being at least two feet in length, about one-half included in the bushy tail. Its habits are much like those of the jerboa and the range is quite general over South Africa. The flesh is greatly esteemed by the Dutch of South Africa and the fur which is long, soft and of pleasing color is used in making wearing apparel. The ease and grace with which these kangaroo-like mammals move is truly an interesting performance and the speed attained when they are thoroughly alarmed is quite astonishing. For short distances they barely touch the ground, this interval only a fraction of the time of the long smooth leap. Once in motion, they skim low above the ground with a bird-like flight.



Porcupine, derived from two Latin words, *porcus*—hog, and *spina*—thorn is the common name for an interesting group of rodents, dwellers of both the old and new worlds. The true porcupines of southern Europe, middle and southern Asia, and also Africa, live in burrows of their own construction or in caves among the rocks, and next to the beavers are the largest rodents of the old world. They are terrestrial, living altogether on the ground; in this characteristic they differ from their American relatives, many of which are entirely arboreal, and all climbers of ability, slow but positive. The crested porcupine, family *Hystrichidae*, is the common porcupine, *Hystrix cristata*, of North Africa. If disturbed, the quills which are ordinarily somewhat depressed, instantly become erect, presenting a formidable barrier to an enemy. The species shown at the top is the crestless porcupine, *Hystrix longicauda* of India.



The Canada porcupine, family *Erithizontidae*, the common porcupine, *Erithizon dorsatum*, is the most generally known of the American species. Native of the forest of eastern North America, from Labrador south to Virginia and westward to the Rockies. The porcupine is clumsy, slow, an easy climber, and inoffensive until it once gets its back up. Easily captured or killed by man, one would think him doomed to quick extinction. He is not very formidable, having neither dangerous claws nor jaws. Living in the vicinity of flesh-eating mammals, he continues placidly indifferent and quite undisturbed. A bear, lynx or any other predatory animal would sooner take the big risk in a farmer's barnyard, rather than trifle with a fat easy-going porcupine, and all because of the host of sharp barbed spikes thickly set among the hairs of his coat and tail. These quills are so fastened to the skin, that they readily detach and stick in quantities into hostile jaws and paws, clinging tenaciously and painfully. Pumas and other predatory animals have often been killed in starving condition with their lips, tongue, jaws and roof of mouth so filled with quills that they were unable to eat. The porcupine is not an attractive morsel to any forest prowler.



The young of the porcupine are born in the spring, usually two in number, but occasionally there are three or four; the nests being in hollow trees or holes among rocks. The little ones appear with their eyes open and bodies covered with soft flexible spines, which harden soon on exposure to the air. If taken from the nest they are readily tamed and soon learn to know the persons caring for them and become docile and interesting pets, and never show their spines. As infants, they instinctively know the dog as an enemy, and instantly erect their tiny quills and swell with anger when one approaches. The dog that once has had his nose filled with quills from a porcupine's tail, seldom cares to try it a second time.



The quills of the porcupine are really thick, sharp and pointed hairs, and plainly are not useful as covering, but are solely a defensive armature. They are so distinctly a striking feature that it has created in imaginative minds strange ideas of the reason for their existence and the powers that the porcupine might possess in their management. A popular theory is that they can be cast in any direction. The owner can do nothing more than erect the spines and rattle them briskly, and possibly when he does so some may fall out or be tossed aside by the vigor of the movement. When irritated or badly frightened the quills are erected and present a formidable barrier to an enemy. The Canada porcupine strikes a quick sideways blow which if it lands drives the quills into its enemy. The legend that the porcupine shoots his quills is utilized in the coat-of-arms of the French king, Louis XII, which bore armorially a porcupine with the motto, "*Comminus et enimus*"—prepared for enemies close at hand and at a distance.

The pictures show rear and side views of an immature albino Canada porcupine.



The yellow-haired porcupine, *Erethizon epimelaum*, ranges beyond the Missouri river westward to the Pacific slopes. It may be smaller than the Canada porcupine, but unless the subject of this photograph was an unusually large specimen, that statement seems to be incorrect. By comparison with the cap which was put there for that purpose, a very definite idea may be had of his truly huge size. Also it shows the typical form and the well-developed coat of hair, much more ample than that of the Canada porcupine on page 166. The food of these porcupines is entirely vegetable, and it is especially partial to the inner bark and tender twigs of the elm, basswood and hemlock. Once they climb into a tree to feed they seldom leave it until the bark is entirely denuded. In riding the trails in the mountains of the far west, these gaunt, white, bark-stripped trees stand out as monuments of porcupine perseverance. They love to prow around hunters' camps, where they will devour scraps of any food, bits of leather or even greasy boards.



The tree porcupines are found wholly in America, and differ from the old world porcupines in many ways, but chiefly in their arboreal habits. There are several species all with somewhat slender forms, usually having long tails which in most cases are prehensile. The Brazilian tree porcupine *Coendou prehensilis* (upper), as its name indicates, is found in Brazil and also in Guiana and Bolivia. The spines of this species are thick and project well above the fur. It is almost entirely arboreal, seldom leaves the trees and is quite inoffensive. The natives hunt them for their flesh which they regard rather highly. The lower picture is the hairy tree porcupine, *Coendou villosus*, and is found in Brazil. A species of tree porcupine, *Coendou mexicanum*, is found also in Mexico. It attains a rather large size with a tail about twelve inches in length which is prehensile. Lower photograph by E. R. Osterndorff.



The hutia or tree rat, *Capromys pilorides*, from the West Indies, resembles the coypu in general appearance but is more rat-like and arboreal in habits. There are several species in Cuba, one in Jamaica and one in the Bahamas. The hutia lives in dense forests and subsists mainly upon fruit, leaves, insects and small animals, especially lizards. It is frequently kept as a pet and its flesh is eagerly sought by the natives. Photograph by E. R. Osterndorff.



The coypu rat, *Myocastor coypus*, is a South American aquatic rodent of the family *Myocastoridae*, frequenting the lakes and rivers on both sides of the Andes from Peru southward. The coypu is about two feet long, has a long rounded tail, scaly and nearly hairless, and webbed hind feet like the beaver. With the exception of the tail, the body is covered with long dusky and brownish yellow fur with a dense and soft under coat. It is an excellent swimmer, lives in burrows in the banks of rivers and lakes, feeding on the foliage, seeds and roots of water plants. Quite prolific breeders, the female sometimes has been observed, with eight to ten young, some riding on her back and the balance swimming along behind. Great numbers are killed for the fur much used by hatters and known as nutria, the name of the coypu in the Argentine.



Branick rat, *Dinomys branickii*, is the sole representative of a family of paca-like animals. It closely resembles the paca but differs externally by having a rather long, hairy tail, four toes on each foot, and a cleft upper lip. It was described from a single specimen found in a courtyard in Peru. Nothing further concerning this animal was learned for over a quarter of a century. Recently, several specimens have been on exhibition at the Zoological Park.



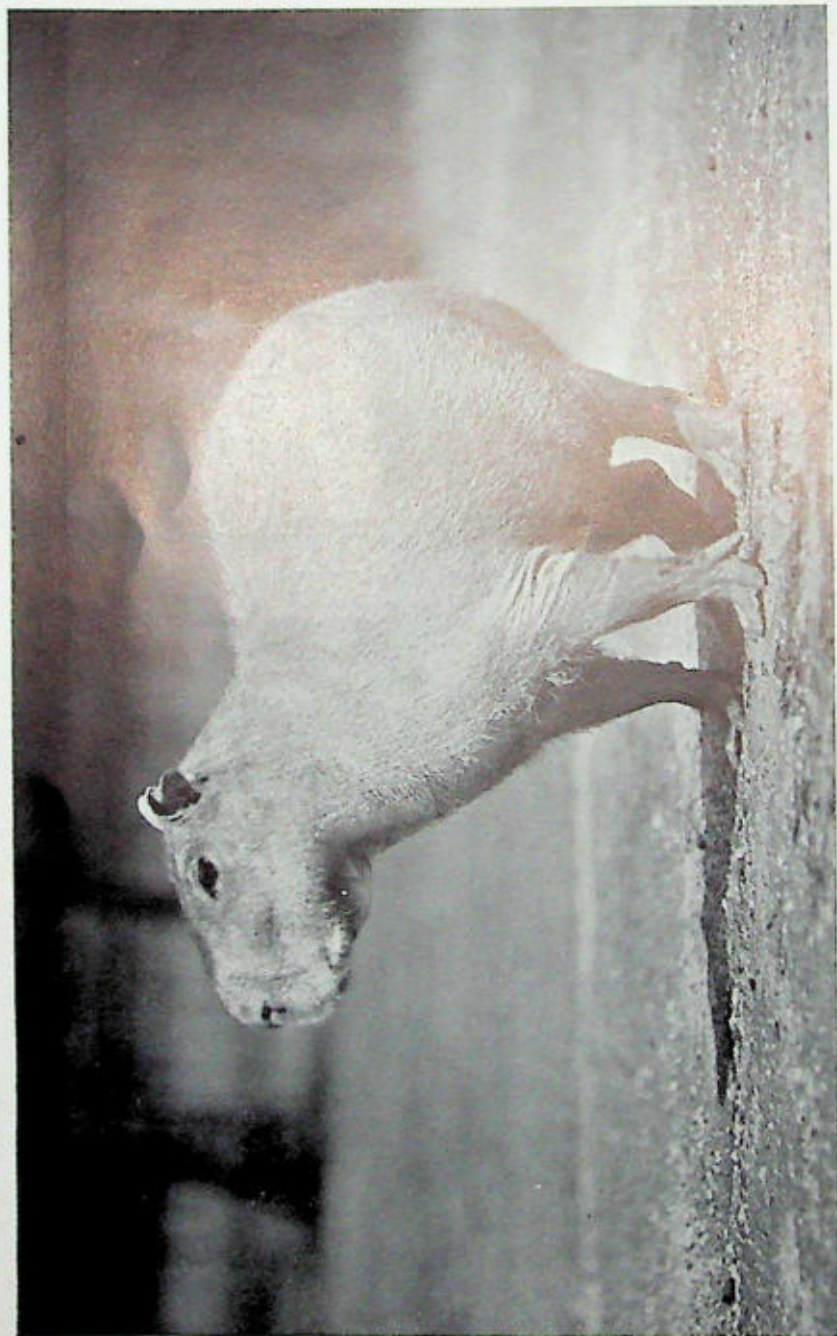
The paca, sometimes called cavy, is a stout-bodied rodent allied to the agouti, indigenous to tropical America. It ranges generally over South America east of the Andes as far south as Paraguay and is found also in the islands of Tobago and Trinidad. It is a stout-bodied animal weighing fifteen pounds or more, with short stout legs, with five toes on each foot. The fur is coarse and short, yellow-brown above and tawny-white below, marked by five rows of yellow spots extending in rows from the shoulder to the rump. Its habits are like those of the agouti. He is strictly a vegetarian, living on fruits, leaves and the stems and bulbs of water plants; and when the opportunity is at hand invades cane fields and melon plantations. The natives trap him industriously, and he is hunted with hounds in Brazil as a sporting proposition. He is classified as *Cuniculus paca*, the generic name signifying that he is rabbit-like. Photographs by E. R. Osterndorff.



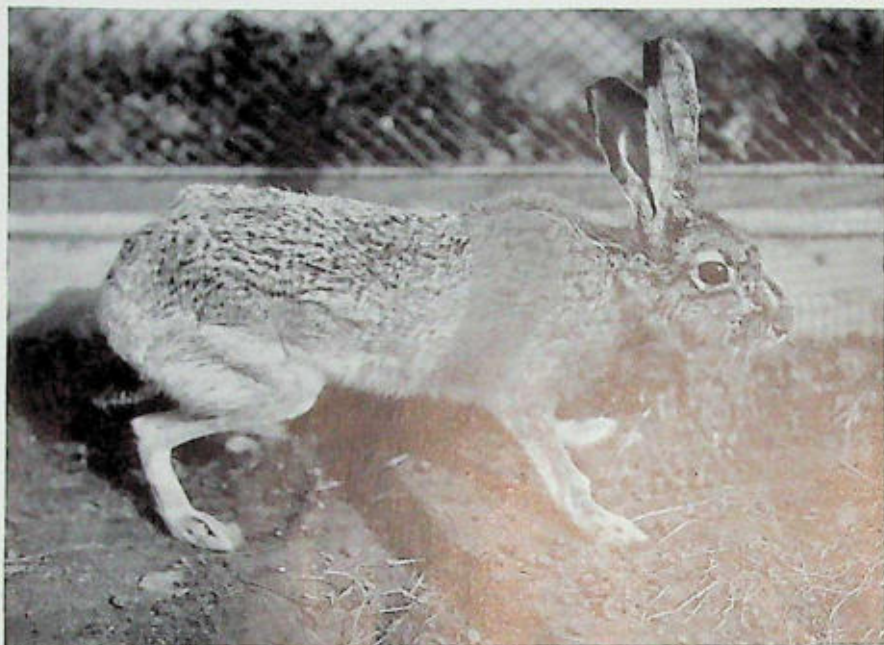
The golden agouti, *Dasyprocta aguti*, family *Dasyproctidae*, is a small rodent found in the tropics of Central and South America and in some of the West Indian Islands. It is a bit larger than a rabbit, with slender legs, five toes on the forefeet and three on the rear, with strong claws and has just the suggestion of a tail. The fur is a rich olive above, yellowish-white beneath, and the long hair on the rump is bright orange. Agoutis are forest-dwellers, nocturnal in habits and hiding out during the day in hollow trees or cavities in the ground. Their food is chiefly leaves, roots, fruits and nuts; their sharp teeth enabling them to cut the hardest shells. They are very graceful and strangely enough, excellent swimmers, an accomplishment acquired by the necessity of escaping from their enemies, particularly the ocelot. The flesh is prized for food and they are freely hunted. They quickly become tame if taken young and it is quite common to see them about South American dwellings.



The Viscacha, *Viscacia viscacia*, of the family *Viscaciidae*, is a small rodent of South America related to the chinchillas. Unlike the chinchilla, the viscacha dwells in colonies, in burrows on the vast grassy pampas east of the Andes, from Buenos Aires to Patagonia. The burrows are associated in numbers to form veritable cities, called viscacherias arranged to provide for the number of individuals in a family and with many entrances to make escape easy in times of stress. Though the colonies burrow in deserted places, they are usually near cultivated areas and the occurrence of these little viscacherias is an indication of the near-by settlement. These burrows render travel on the pampas very dangerous to horses and their riders, and the viscacha consequently is hunted mercilessly, the grass being burned to destroy their food and their burrows flooded to make them a prey for dogs. The Indians eat the flesh and use the skin, but the latter are not as valuable as those of the chinchilla.



Capybara is a native name for a huge aquatic rodent of South America, ranging over the eastern section from Guiana southward to the La Plata and in the lower parts of Peru and Bolivia. It is essentially aquatic in habit, and also has the distinction of being the largest living rodent, attaining a weight of at least one hundred pounds. He carries a ponderous variety of names of local derivation, such as carpincho, water pig, water hog, and water cavy. The body is thinly covered with coarse bristle-like hair, reddish brown in color. He has no tail and the feet, which are small by comparison with the great weight they support, four toed in front and three in the rear, have short webs. Capybaras are peaceful and quiet and as their sober solemn countenance would signify not in the least playful or sportive. Their natural food necessarily is indigenous to the river banks and marsh lands which they frequent, but they will take a chance when convenient to make raids on plantations of melons, maize, rice and sugar cane. It would indeed be a worthless creature for which man could not find a use. The capybara seems to fit this case; he has nothing much to offer but his incisor teeth, which the Indian girls string and wear as bracelets and necklaces. The capybara is classified as *Hydrochoerinae hydrochoeris*, family *Hydrochoeridae*. Photograph by E. R. Osterndorf.



All the American members of the family *Leporidae* may be divided into two groups—the hares and the rabbits. A typical hare is a large, attenuated creature, long eared, long legged and a naturally swift runner. The young are reared in a nest. The rabbit is small, short eared, short legged, not a good distance-runner. Rabbits are gregarious living in colonies in "warrens" formed of many burrows. Hares are distributed generally over the world, except the Australian region, but are mostly confined to the northern hemisphere of both worlds. The species shown is *Lepus californicus texianus*, of the Southwest United States.

Development of the Silky Marmoset

RAYMOND L. DITMARS

THE following notes, so far as the writer is aware, cover the first observations on the birth and growth of the Silky Marmoset, *Leontocebus rosalia* (Linnaeus), in an American zoological garden.

In January, 1932, we acquired a fine pair of silky marmosets, and as this beautiful species is allegedly delicate in captivity, the pair was installed in a large cage, of light construction, in the Reptile House, near a double window with southern exposure. This arrangement gave the little animals long hours of sunshine, and during the winter months provided high and even temperature, and humidity approaching tropic conditions. A varied diet was provided, as in a wild state marmosets have been noted to feed on fruits, small reptiles and insects—in fact they are definitely insectivorous and the chitinous covering of insects appears to be a necessary part of the diet. Small lizards were also regu-

larly supplied to the marmosets. They devoured them ravenously.

Under these conditions the marmosets thrived, and early in March it was noted that the heavy condition of the female indicated that she was carrying young. As manifestations of breeding had been lacking, we were unable to figure on a period of gestation.

On the 26th of April, 1933, twin marmosets, a male and a female, were born. They were surprisingly large in comparison to the size of the mother, my estimate of the combined length of head and body being approximately three inches. The head was relatively large and heavy, the body weak and slender. The young were clad in lustrous yellow hair, of paler hue than that of the parents. They clung tightly to the mother, the inclination being to encircle her lower body. From this commonly observed position, they intermittently crawled to her breast to nurse, grasping her long pelage with hands and feet, retaining a tenacious hold.

In less than a week after birth, the young

were more active, seeking various clinging positions upon the mother, and within ten days we were disturbed at their restless crawling, as we had already observed one clinging to the father. Seeing this, I was inclined to remove the male, figuring that this wandering from one parent to another would interfere with the infant animals receiving regular and sufficient nourishment. Watching them closely, however, it was noted that the father transferred them from the mother at regular intervals. This developed into a systematic process, whereby the father took them from the female after short periods of nursing.

The practice was regularly established within two or three days and from this period the father took over entire care of the young, carrying them at all times, even during the night, except when they were nursing. The young appeared to comprehend the process of transference. At approximate periods of two to two and one-half hours, the parents, otherwise nimbly leaping about the cage, would settle together. The female would raise her arms and the male push and shove at the infants, until they had crawled upon the mother, when they immediately started nursing. If they were hesitant about the transfer, the male would bend downward and nip them with enough vigor to induce squeaks of protest, but the disciplinary measure was, as a rule, immediately effective. Nursing periods were approximately a quarter of an hour, when the transference process was reversed. During the periods the male was carrying the young marmosets, the mother paid no attention to them.

When six weeks old, the twins had greatly increased in size, and their pelage was markedly longer, thicker and of darker hue. Their inclination now was to climb upon the father's back, from which position they took a lively interest in what was going on about them. As they grew heavier, the father was literally borne down with his burden, and grew noticeably thinner from the task he had assumed. The burden had greatly decreased his opportunity for exercise and frequent picking over food to obtain variety, which is a marmoset characteristic.

About two months after birth, one of the young could be observed for a moment, sitting beside the father, but upon the least disturbance would hop upon his back. Transfer to the fe-

male, at regular nursing periods, continued. Day by day, inclination developed for the twins to leave the father for longer periods, but to remain close by and leap upon him at the slightest disturbance. He was not well rid of carrying them greater part of the time until they were close to four months old, and even after that time there were periods of hours when they would roost upon his back, grasping his long hair with tightly clenched hands. The inclination of the male was to savagely rush at strangers who too closely approached the cage. The mother evinced no such disposition.

When the young were three months old, we observed the male squeezing bits of a banana through his fingers and permitting the offspring to nibble at the soft fruit. Soon after this, as he visited the feeding trays, the clinging young would bend downward for experimental nips. That task of thus introducing them to solid food fell entirely upon the male, and was conducted with what appeared to be systematic care.

At a full five months of age, the young were half grown and leaping as nimbly about the large cage as their parents. Paternal solicitude was undiminished, however, as indicated by the changed feeding habits of the adults. Before the appearance of the young, both marmosets had leaped to the cage front upon the presentation of such favorite food as large grasshoppers and lizards of the *Anolis* type. Food was grasped in selfish spirit, often to the accompaniment of noisy squabbling. It was as quickly and greedily devoured. As the young began feeding upon practically all items consumed by the parents, the feeding habits of the female remained the same. She would greedily rush to the cage front, seize and immediately devour all special foods to be offered. The feeding habits of the male, however, were greatly modified. He would also rush for insect food, decapitate a grasshopper, then hold it until it had been taken by one of the young. This continued until both young had received their share. Any interference with such actions by the female, was savagely resented.

Eight months after birth, the young marmosets are three-quarters grown and their pelage as long and silky as that of their parents. From the rate of growth, it would appear that this species attains adult size in about a year's time.



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Burrhel	Astor Markhor
Mouflon	Himalayan Tahr
Aoudad	Nilghiri Tahr
Punjab Urial	Serow
Ladak Sha	Chinese Takin
Dall's Sheep	Chamois

Rocky Mountain Goat



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The herd of oudads (Barbary mountain sheep) in the Zoological Park. If all animals thrived as well in captivity as these representatives of a foreign clime we would be greatly overstocked. There is always something new on the aoudad section of Mountain Sheep Hill.



BULLETIN

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Wild Sheep, Goats and Rock Antelopes

CLAUDE W. LEISTER

Curator of Educational Activities, New York Zoological Park.

Illustrated by photographs made in the Zoological Park and from specimens in the National Collections of Heads and Horns

IN its collection of hoofed animals a Zoological Park offers an interesting opportunity for the visitor to compare familiar domestic varieties with their fore-bearers and relatives of the wild. Unfortunately, due to quarantines and embargoes designed to prevent the spread of disease, and the ever increasing rarity of these animals in a wild state, such exhibits are more and more difficult to obtain. The New York Zoological Park maintains a representative collection of hollow-horned hoofed animals, and an additional opportunity to examine some of the rarest species, which have never been exhibited alive, is afforded by the specimens in the National Collection of Heads and Horns.

The family *Bovidae* contains a number of lesser, well-marked divisions or sub-families. One of these, the *Caprinae*, contains the sheep and goats and is the subject of our present discussion. These animals are connected to each other by plainly evident relationships, but their relation, that of sheep especially, to other members of the family is not so evident. Because of certain structural characteristics shared in common with antelopes, and since there seems to be no close affinity with cattle, it can safely be presumed that both sheep and goats evolved from some early antelope ancestor.

The group (*Caprinae*), is not an ancient one from a geological standpoint, and in North America no fossil remains of either of the typi-

cal genera, *Ovis* or *Capra*, have been found in the Tertiary deposits, and remains of our present-day bighorn sheep have been found only in the late Pleistocene. Goats have never reached North America. In this connection it will be remembered that our so-called mountain goat is not a true goat.

The ancestral home of both sheep and goats may be located in the mountains of Central Asia, and today that region is still their stronghold. There has been a general dispersal of representative species along the closely connected mountain systems of the world, with the exception of the outlying continents of Africa and South America.

Since they are of such recent origin, neither sheep nor goats have been greatly changed through evolution. All of them are still essentially mountain dwellers. "No species frequent by choice either level deserts, open plains, dense forests or swamps." Thus in North America, having neither the time nor the inclination to do so, the bighorn sheep has never crossed the great central plains region to the Appalachian mountain system of the east, and in its spread southward has never reached South America, extending no further than the mountains of Mexico and Lower California. Only two species, the aoudad and the ibex, are to be found in Africa, and they occur in but a small portion of the northern part. Not a single species has been



Two fine specimens of the Rocky Mountain sheep or bighorn. These photographs portray this North American sheep to good advantage. Note the stockily built body and the gracefully curled horns. The upper figure shows the characteristic lighter-colored rump patch.

able to cross the great Sahara, or the intervening tropical forests, swamps and plains, to the mountains of South Africa. Sheep are northern animals and with one or two exceptions have never penetrated the tropics, where they have done so their habitat is, of course, confined to the mountains. Goats do not range so far north as sheep, nor did they do so in earlier times and thus were not in position to enter North America by the land connection then existing in the Behring region, the route followed by the bighorn sheep.

Both sheep and goats have been domesticated since very early times. The origin of the domestic sheep is lost in antiquity and possibly several races of wild sheep were the fore-runners of our present-day domestic breeds. The Swiss lake dwellers possessed sheep but they were totally different from any of the wild species living today. The domestic goat (*Capra hircus*), was first described by Linnaeus from a Swedish specimen. It is most like the Persian wild goat, although undoubtedly many crossings with other wild species were made during the early period of domestication.

The horns of wild sheep are more or less triangular in section and while they may be spirally curled they are never arched over the back. With the single exception of a race of the mouflon, where the females are hornless, both sexes of all wild sheep possess horns, although those of the male are considerably the larger. In some domestic breeds, such as the Dorset, both sexes have horns, but in the majority of them the males alone bear these appendages. There is usually a small gland on the face below the eye and between the hoofs of both fore and hind feet.

It is interesting to note that no wild sheep bears a coat of wool. Wool, as we are accustomed to see it on domestic sheep is a product of domestication and has been developed through selective breeding. Some wild animals, especially fur-bearers, possess two distinct coats of hair. There is an outer coat of long, rather coarse hair which serves to protect from wear and tear an undercoat of finer, more or less woolly hair. In the domestic sheep the undercoat has been excessively developed and the guard hairs have disappeared.

Goats (including ibexes and markhors), are

very similar to sheep although, unlike the latter, they do not have a gland below the eye, nor do they possess glands between the hoofs of the hind feet. The males have a strong odor and generally a beard. The horns are usually round in section and, in the long-horned species are never spirally curled outward but sweep over the back. Ibexes have long, scimitar-shaped horns, carried in a graceful arch over the back. The front surface of the horns is decorated by a series of regularly spaced, transverse knobs. Markhors have spirally twisted or turned horns, the spire being either open or closed.

Wild sheep are usually found in small bands consisting of a number of ewes and their young. During the greater part of the year the rams are more or less solitary, go about in small groups by themselves, and are found with the flock only during the breeding season. At that time each ram strives to hold together a coterie of females as his own, and numerous fights result. In fighting they not only fence with their horns but meet in vicious, head-on charges that only the thickest of skulls and strongest of neck vertebrae could withstand. The loser retires as gracefully as possible or else, perhaps, is pushed over a cliff to his death on the rocks below.

Some species, mountain sheep especially, are remarkably wary and possess a keen sense of sight and smell. Because of their habit of frequenting exposed and inaccessible areas, usually with some member of the band standing watch, they are exceedingly difficult and well nigh impossible to approach within short ranges. Hunting these sheep requires a considerable amount of skill and physical ability and even the hardest sportsmen pursue them with varying degrees of success. Other species are not particularly wary and the difficulty in hunting them is due to the remoteness of their habitat and the ordinary hardships of the chase that are to be encountered in such localities.

Generally speaking, goats are better mountaineers than sheep and most species inhabit the roughest of mountain regions. Like sheep they congregate in small bands, composed of ewes and younger rams, the old rams keeping apart by themselves, in some species staying at higher altitudes and above the snow-line, and associating with the herds only during the breeding season.



A bit of the wild transported to the Zoological Park. A pair of highhorn sheep on the alert. Both sexes of wild sheep usually possess horns but those of the females are small and poorly formed, never seriously rivaling the handsome structures borne by the male.



Two of the world's finest trophies of the chase. Representatives of the argalis, Asiatic mountain sheep closely related to our bighorns. Littledale's argali above, Marco Polo argali below. None of the argalis has ever been exhibited in any of our American Zoological Parks.
From the National Collection of Heads and Horns.



Two Asiatic wild sheep. Above, the burghel or blue mountain sheep from Central Asia and Tibet. Below, the Punjab urial from India. The former animal is seldom seen in our Zoological Parks.

Sportsmen have always taken a great interest in hunting certain sheep and goats, especially the argalis, the bighorns and the markhors. It follows that considerable popular interest has developed concerning these animals.

The bighorns or Rocky Mountain sheep are well distributed over the Rocky mountain region of North America and two races occur in similar country of north-eastern Asia. Their most evident characteristic is their massive, curled horns. While formerly found in relatively open country they have been hunted so assiduously that they now occur only in the higher and more inaccessible ranges. There are several species and races. Typical *canadensis* is grayish brown in color; *dalli* is white; and *stonei*, sometimes called the black sheep, is a blackish brown. Bighorns are agile, wary and excellent climbers.

The argalis constitute an interesting group of sheep from the mountains of Central Asia. In general appearance they resemble our bighorns but are slightly larger, being the largest of the sheep. The horns are more strongly marked by ridges and the tips have a stronger tendency to grow outward. The best known species is the Marco Polo argali (*Ovis ammon poli*), from the Pamir plateau. This sheep was first described in the travels of Marco Polo but was unknown to science until 1838 when the first specimens were brought to England. The romance attached to this sheep and its massive and wonderfully curled horns have caused it to be one of the most sought after trophies in the world. The weight of a large ram's head has been recorded at forty pounds and the neck of the sheep is unusually strong in order to support this weight. The Marco Polo sheep formerly occurred in the Pamirs in great numbers where it is said that as many as six hundred have been seen in the course of a day's hunt. It frequents open plateau country rather than the mountains.

Markhors are in many respects the most remarkable of all the wild goats. Their horns are spirally turned or twisted in a cork-screw-like fashion. In the Astor race (*Capra falconeri falconeri*), the spire is open, while in the Suleman (*Capra f. jerdoni*), it is tightly closed, forming what is practically a straight horn with spirally turning ridges. In the other races the horns are intermediate between these extremes.

Sportsmen look upon the horns of the markhor as one of the most highly prized trophies of the chase.

ROCK ANTELOPES

Another sub-family of the *Bovidae*, the *Rupicaprinae*, contains a number of goat-like animals called rock antelopes or goat antelopes. The various members of this group are commonly regarded as being goats but in reality they are more closely related to true antelopes. Two well-known representatives are the mountain goat, from the Rocky Mountain region of north-western North America, and the chamois, from the mountains of southern and central Europe. The remaining members are the takin, goral and serow, native to south-eastern Asia.

The *Rupicaprinae* form more or less of a connecting link between goats and antelopes. Members of the group are somewhat goat-like in form but their horns, which are more like those of antelopes and relatively small in comparison to the size of the animal they adorn, are slender, moderately curved and generally black in color. The horns of the chamois are abruptly curved at the tip, while the takin's resemble those of the gnu.

There is a great variation in the size and color of the various rock antelopes. The takin weighs about three hundred pounds while some gorals and the chamois weigh only sixty. The mountain goat is white or whitish in color and several races of the goral are almost black. The mountain goat, chamois and gorals possess a woolly underfur, the serows a crest of long hair along the back.

In North America, the mountain goat, like the bighorn sheep, is evidently a late immigrant from Asia, having crossed the Behring land bridge which existed during the middle Pliocene. In spreading southward it never extended its range very far beyond the northern boundary of the United States and therefore never reached South America.

Members of the *Rupicaprinae* are not particularly wary, on the other hand they are sometimes regarded as being rather stupid, possibly because they have learned to rely so implicitly upon the general safety from intruders afforded by the inaccessibility of their domain. They are sturdy climbers. Our mountain goat,



The mouflon herd at the Zoological Park. A characteristic winter scene on Mountain Sheep Hill.



Old male aoudads possess a striking adornment in the fringe of long hair which extends from the throat along the middle line of the neck to the chest where it divides and continues along the upper part of the fore limbs. Several other sheep exhibit this tendency which is shown here at its best development. Below, a fine mouflon, the leader of the Park herd.



An excellent portrayal of the statuesque *oudad*. This animal is younger than the individual shown on the preceding page and his hirsute adornments have not attained such a luxurious growth. The scene might well be in North Africa but the photograph was taken in the Zoological Park.



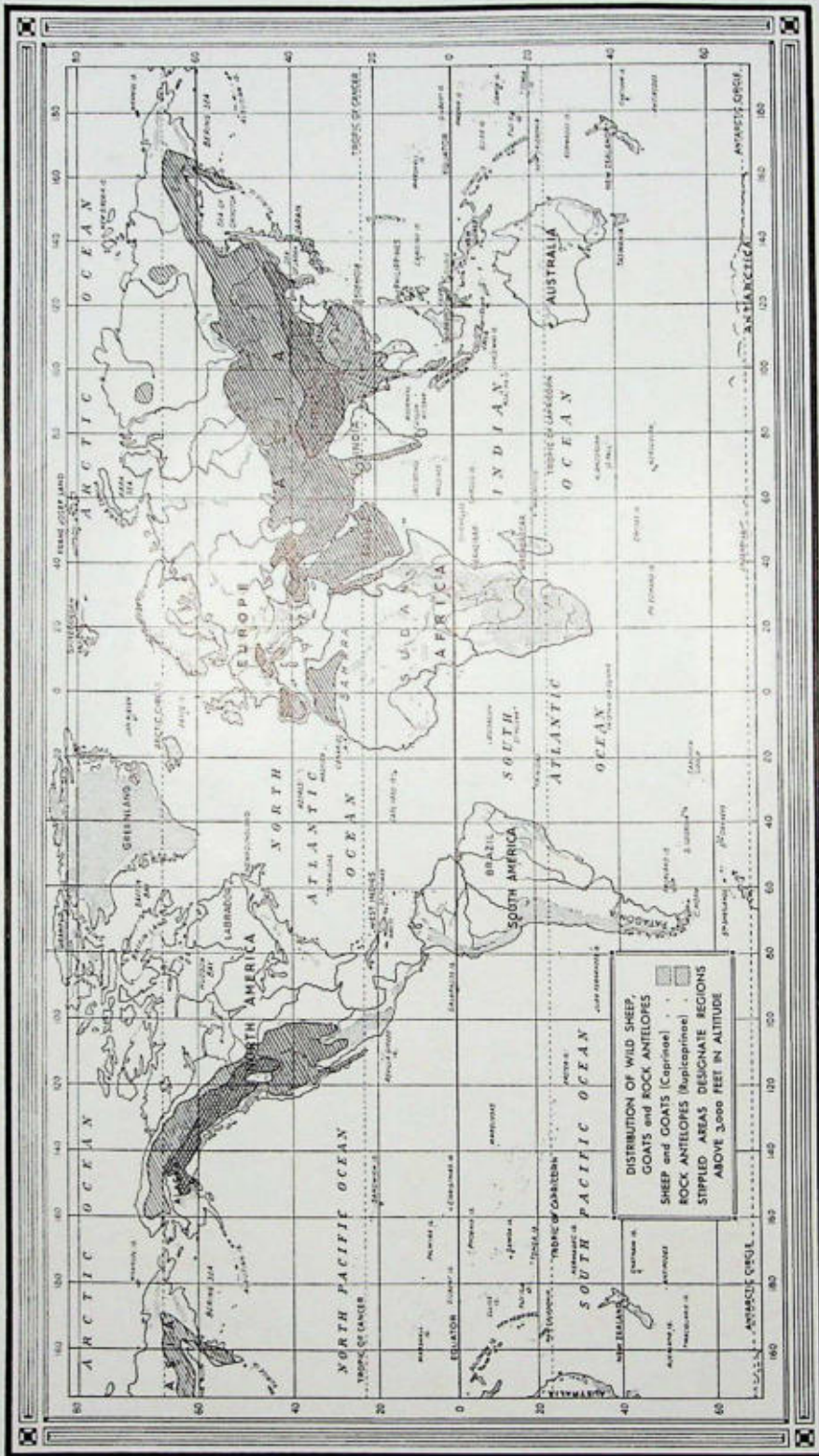
Aoudads are good climbers and like to occupy an elevated perch from which they can look out over the surrounding territory. They are here shown on the roof of their shelter-house at the base of Mountain Sheep Hill. Below, a family of Punjab sheep. Our present male is seemingly a friendly sort and receives many a tid-bit from visitors to the Park but workmen, whose business causes them to enter his corral, will tell a different story.



Various sheep of the world. (1) Ladak sha, (2) mouflon, (3) aoudad, (4) Dall's sheep; white mountain sheep, (5) bighorn; Rocky Mountain sheep. From the National Collection of Heads and Horns.



Asiatic ibex above, and the Spanish ibex below. The latter perhaps possesses more of the characteristics generally ascribed to goats than to ibexes but the horns show the transverse knobs, which are so typical of the true ibexes, decorating the front edge.



for instance, is neither agile nor fleet of foot, but it is entirely at home among precipitous cliffs and broken rocks, and at the approach of danger slowly but surely makes its way over narrow shelves and ledges to heights where few other animals can follow. The chamois is apparently the most agile and wary animal of the entire

group. Its leaping powers are legendary and in old engravings it is sometimes portrayed leaping from crag to crag and across yawning voids with an abandon that completely ignores the laws of gravitation.

The following list includes the principal sheep, goats and rock antelopes of the world.

Wild Sheep, Goats and Rock Antelopes.

	SHEEP	Habitat.
Principal species and races.		
<i>Ovis aries</i>	Domestic Sheep	The origin of the domestic sheep is lost in antiquity.
<i>Ovis musimon</i> . Apparently two races, in one the ewes are hornless, in the other they have short horns.	Mouflon	Sardinia and Corsica.
<i>Ovis orientalis orientalis</i>	Cyprian Red Sheep	Cyprus.
<i>gmelini</i>	Armenian Red Sheep	Armenia, parts of Asia Minor and Transcaucasia.
<i>erskinei</i>	Persian Red Sheep	Elburg Mts. of Persia.
<i>Ovis vignei vignei</i>	Urial: Ladak Sha	Astor and Ladak.
<i>cycloceros</i>	Afghan Urial	Afghanistan, Baluchistan.
<i>punjabiensis</i>	Punjab Urial	Cis-Indus Punjab.
<i>Ovis ammon ammon</i>	Siberian Argali	Now chiefly in the Altai Mts.
<i>hodgsoni</i>	Tibetan Argali	Plateau of Tibet.
<i>mongolica</i>	Mongolian Argali	Southern Mongolia and the Ta Ch'ing Mts.
<i>littledalei</i>	Littledale's Argali	Central and Eastern Tien Shan.
<i>poli</i>	Marco Polo Argali	The Pamir Plateau.
<i>Ammotragus lervia</i> . Several local races, the typical form from Mauretania.	Aoudad: Barbary Mt. Sheep	Mountains of North Africa.
<i>Pseudois na hoor</i> . A race has been described from Shen-si.	Burrhel: Blue Mt. Sheep	Central Asia, Tibet.
<i>Ovis canadensis canadensis</i> . Nine forms have been described. Principal ones are	Bighorn: Rocky Mt. Sheep	Alberta south to New Mexico. E. Washington and Oregon.
<i>texiana</i>	Texas Bighorn	Guadalupe Mts. of Texas and Arizona.
<i>nelsoni</i>	Desert Bighorn	S. Nev., S. Calif. and N. L. Calif.
<i>nivicola</i>	Kamchatkan Bighorn	Kamchatka.
<i>borealis</i>	Siberian Bighorn	Parts of Eastern Siberia.



Above, the Suleman markhor and a young kid of the same species below, the latter now on exhibition at the Zoological Park. Since this photograph was taken, about two years ago, an additional complete turn has been added to the horns.

<i>Ovis dalli dalli</i>	White Mt. Sheep	Alaska and Yukon, south-eastward in the Mackenzie Mts.
<i>kenaiensis</i>	Kenai Bighorn	Kenai Peninsula, Alaska.
<i>stonei</i>	Black Mt. Sheep	Northern British Columbia to the Yukon.
<i>fannini</i>	Fannin Mt. Sheep	Yukon.

GOATS

<i>Capra hircus hircus</i>	Domestic Goat	Feral in many parts of the world.
<i>aegagrus</i>	Persian Wild Goat. Apparently the ancestral form of the domestic goat.	Persia and Caucasus.
<i>Capra severtzovi</i>	West Caucasian Tur	Western Caucasus.
<i>Capra caucasica caucasica</i>	East Caucasian Tur	Eastern Caucasus.
<i>cylindricornis</i>	Pallas' Tur	Eastern Caucasus.
<i>Capra pyrenaica</i> . There are four local races.	Spanish Ibex	Pyrenees, Central Spain, Andalusia and Portugal.
<i>Capra ibex</i>	Alpine Ibex: Steinbok	Now found only in Italian Monte Rosa.
<i>Capra sibirica sibirica</i> . Eight races are recognized.	Asiatic Ibex	Central Asia, N. into Siberia.
<i>altaica</i>	Altai Ibex	Altai Mts.
<i>almaysi</i>	Tien Shan Ibex	Tien Shan Mts.
<i>skyn</i>	Himalayan Ibex	Himalaya.
<i>Capra walie</i>	Abyssinian Ibex	Abyssinia.
<i>Capra nubiana nubiana</i>	Nubian Ibex	Parts of N.E. Africa.
<i>mengesi</i>	Arabian Ibex	Southern Arabia.
<i>sinaitica</i>	Sinaitic Ibex	Sinai.
<i>Capra falconeri falconeri</i>	Astor Markhor	Astor, Baltistan and Chilas.
<i>jerdoni</i>	Suleman Markhor	Suleman Mts., Afghanistan and Baluchistan.
<i>Hemitragus jemlahicus</i>	Himalayan Tahr	Middle Himalayas.
<i>Hemitragus hylocrius</i>	Nilghiri Tahr	Mountains of Southern India.
<i>Hemitragus jayakari</i>	Arabian Tahr	South-eastern Arabia.

ROCK ANTELOPES

<i>Rupicapra rupicapra tragus</i>	Chamois	Alps.
<i>pyrenaica</i>	Izard	Pyrenees.
<i>parva</i>		Cantabrians.
<i>ornata</i>		Apennines.
<i>caucasica</i>		Caucasus.
<i>asiatica</i>		Trebizond.



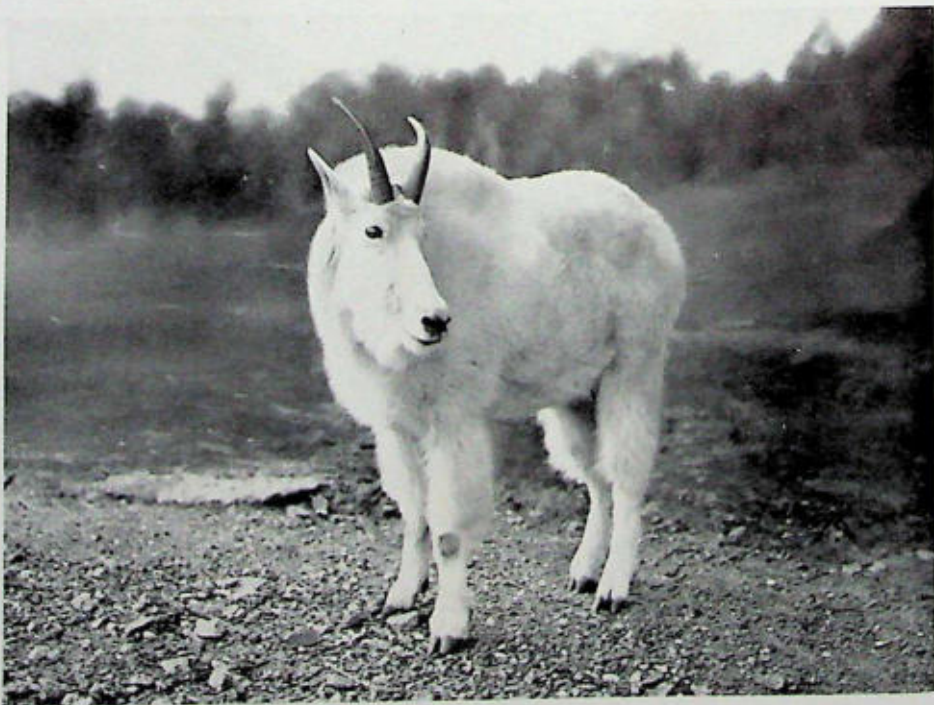
The Himalayan tahr is completely at home in the Zoological Park. They are excellent climbers and a few years ago amazed visitors by climbing around in the branches of an oak tree then occupying their corral. In the lower photograph they are shown on their range in winter, a scene reminiscent of their native Himalaya.

<i>Capricornis sumatraensis</i> .	Nine	Serow	Yun-nan, E. Himalayas, Assam, Siam to higher parts of Malay Peninsula, W. Sze-chuan and S.W. Kansu.
races are recognized.			
<i>s. milne-edwardsi</i>		West China Serow	
<i>Capricornis argyrochoetes</i>		White Maned Serow	S.E. China, Che Kiang Province.
<i>Capricornis crispis</i>		Japanese Serow	Japan.
<i>Capricornis swinhoei</i>		Formosan Serow	Formosa.
<i>Nemorhaedus goral</i>		Gray Himalayan Goral	Western Himalayas.
<i>Nemorhaedus griseus</i>		Sze-chuan Goral	Sze-chuan and Upper Burma.
<i>Nemorhaedus hodgsoni</i>		Brown Himalayan Goral	Eastern Himalaya.
<i>Nemorhaedus caudatus</i>		Long-tailed Goral	Sze-chuan.
<i>Nemorhaedus raddeanus</i>		Korean Goral	Korea.
<i>Budorcas taxicolor taxicolor</i>		Takin	Northern Assam.
<i>whitei</i>		White's Takin	Bhutan.
<i>Budorcas tibetanus</i>		Sze-chuan Takin	Sze-chuan Yun-nan, Tibet.
<i>Budorcas bedfordi</i>		Golden Takin	S. W. Shen-si.
<i>Oreamnos americanus americanus</i>		Rocky Mt. Goat	Cascade Mts. of Washington.
<i>columbae</i>			Northern British Columbia.
<i>missoulae</i>			Montana and Idaho.
<i>kennedyi</i>			Mouth of Copper River, Alaska.





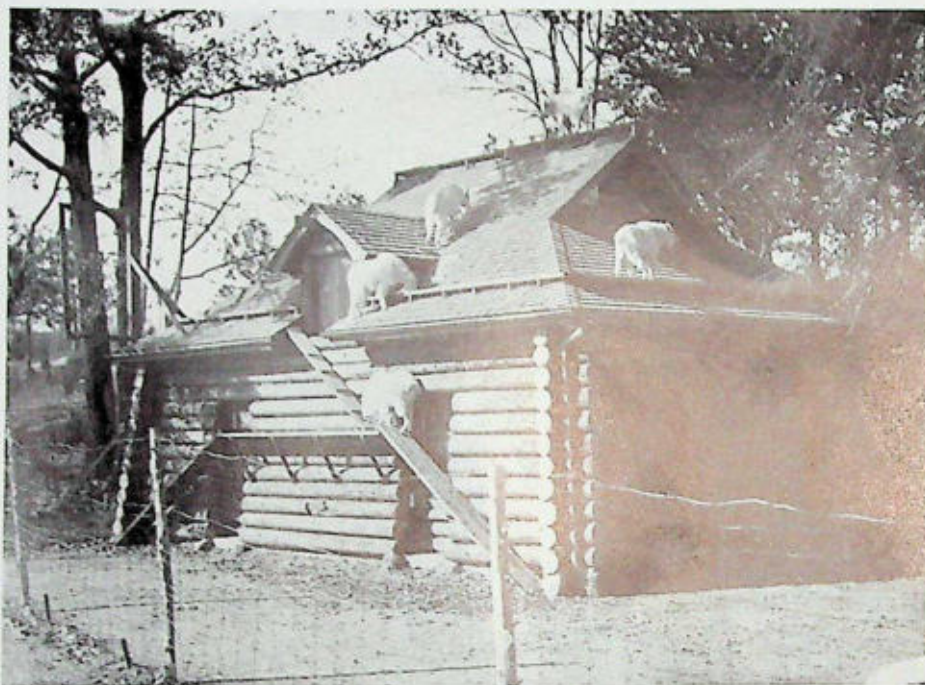
A group of rock antelopes and aberrant goats. (1) serow, (2) Chinese takin, (3) chamois, (4) Astor markhor, (5) Rocky Mountain goat, (6) Nilghiri tahr, (7) Himalayan tahr. From the National Collection of Heads and Horns.



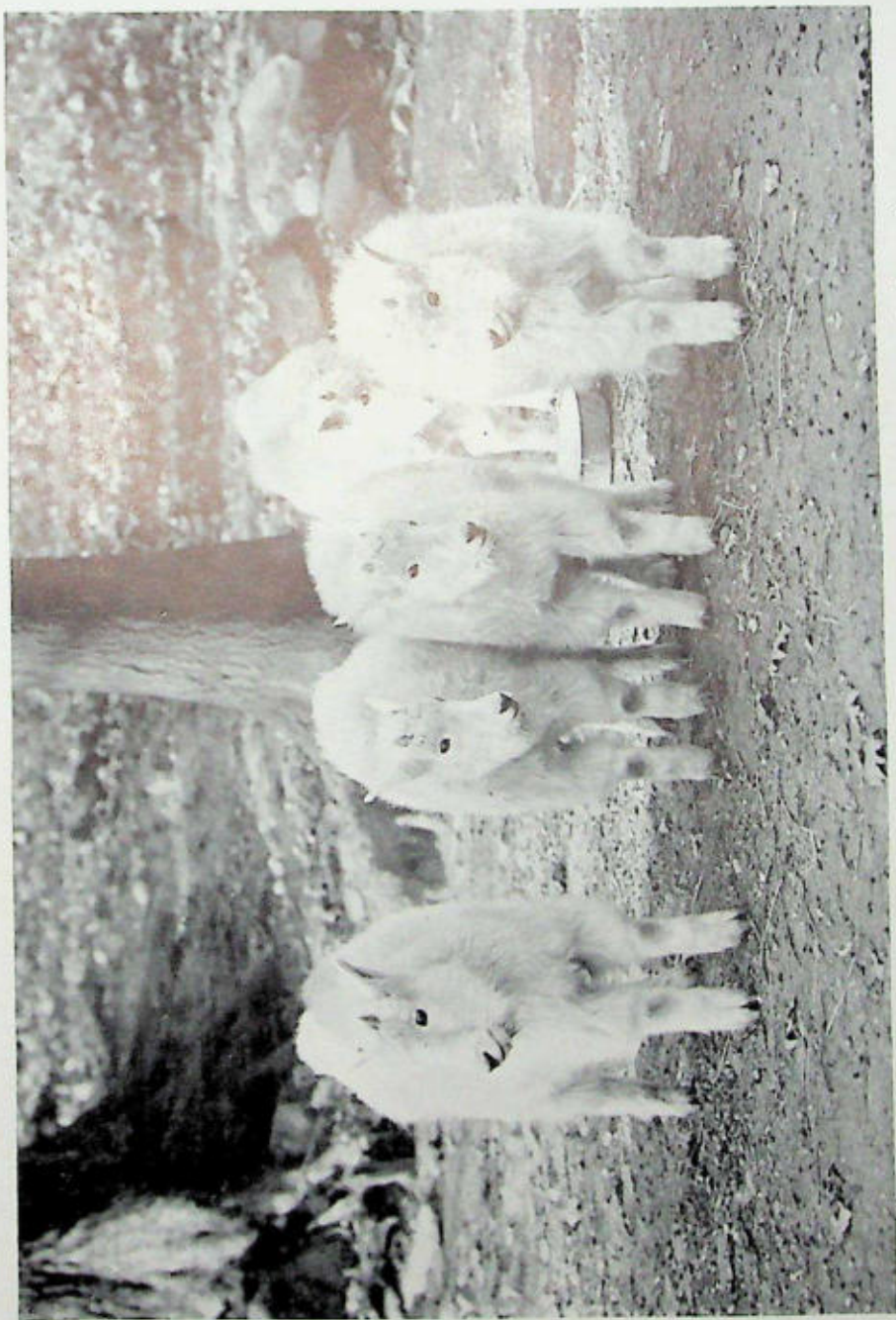
Two well-known representatives of the Rupicaprinae, the Chamois above, and the Rocky Mountain Goat below. These animals show the great divergence in form and color exhibited by the members of this group.



A magnificent specimen of the Rocky Mountain goat formerly exhibited at the Zoological Park. It is unfortunate that these fine animals do not thrive for long in the climate of New York City. Our present specimen, a female, is an exception, now in her ninth year at the Park.



The inclined runways reaching to the roof of the shelter house in the upper photograph were used by the young mountain goats to climb to the top of the structure where they presented an interesting sight to our visitors. Below, a Mountain goat and her young kid born in the Zoological Park.



This interesting quintet of young Mountain goats, was secured in British Columbia and afterward exhibited in the Zoological Park. It is needless to say that they evoked an extraordinary amount of public interest.

The London Conference for the Protection of African Fauna and Flora

October 31-November 8, 1933

J. C. PHILLIPS

THESE are many Americans who look back on their travels, hunts or collecting trips in Africa as the brightest interlude in an otherwise rather ordinary sequence of experiences. To these men and the many thousands of others who consume the Sunday supplement pictures of Africa and sit through animal films with a kind of vicarious shiver, it will be good news to hear that very definite progress has recently been made in the better protection of vanishing African wild life.

There has recently been held in London the second international conference on the preservation of the fauna and flora of Africa. All parts of that great continent, now fast losing its primitive characteristics, were represented and at the conclusion of the conference all delegates from the interested powers signed a well-thought-out draft convention. Lord Onslow, president of the Fauna Society, was elected president of the conference, and Baron de Cartier de Marchienne, the Belgian Ambassador, its vice-president. Mr. Francis Hemming, joint secretary of the Economic Advisory Council, was secretary-general for the conference.

The British were of course well represented with five delegates and many official advisers. Egypt, Southern Rhodesia and the Anglo-Egyptian Sudan had representation while the Union of South Africa had an able spokesman in Hon. C. de Water, High Commissioner for the Union in London. The Belgians had a delegation of five headed by that veteran diplomat, Baron Cartier, formerly at Washington but now Ambassador at the Court of St. James. One of the best informed of all delegates was Dr. Van Straelen, director of the Brussels Museum, who had much of importance to contribute.

The Italian delegation, with Dr. Tullio Zedda as its principal spokesman, was prominent in most of the discussions, while the Portuguese sent only two delegates, one of whom was Dr. Ulrich, Ambassador at London. France sent six delegates at first headed by Dr. Gruvel of

the Committee for the Protection of the Fauna and Flora of the Colonies, and later by M. Rufat, director of the Bureau de la Chasse in the Colonial Ministry. Spain sent two delegates; Don Ramon Perez de Ayala, the Ambassador to England, and Don José da Casa Calzada, agricultural attaché at the Spanish Embassy.

This conference was most fortunate in the choice of its chairman, who acquitted himself well in a situation which might at times have been very difficult but which never reached that point. There was a general feeling of good fellowship and the delegates were made to feel the importance of their mission through a well-arranged series of luncheons, receptions and excursions. The writer had the honor to represent the United States as an Observer selected by our State Department. There were observers also from Holland and from the government of India. Dr. Van Tienhoven of Holland, although only an observer, took a very active part through his position as president of the Administrative Commission of the Brussels office for International Nature Protection, and as usual was able to impress his hearers on several most important points.

The first conference on African fauna was held in London in 1900, and although it was good as a first step it did not have far-reaching results because it was not ratified outside Great Britain. It did result in a certain amount of education among the powers which up to that time had shown little sense of responsibility, but only in British territories were real reforms begun. The period 1900 to 1933 saw a great increase in game reserves, in protection of rare species, in more efficient warden service, and in the establishment of game departments which more than paid for themselves from the revenue derived from the sale of sportsmen's licenses. East Africa made much more progress than the West African colonies such as Nigeria and the Gold Coast.

It would take far too long to enumerate all the accomplishments of the present convention, nor is this necessary, for much of the time was occupied with the machinery of the treaty act and the difficulty of harmonizing somewhat vague terms in two languages,—French and English.

We in America who are working for the pres-

ervation of foreign game animals through our American Committee for International Wild Life Protection, are much pleased to see included provisions for confiscating animals alive or dead (or the parts thereof) where they have been taken illegally in another or neighboring colony. This valuable provision in the treaty is aimed at the illegal traffic in various animal products but especially ivory and rhino horn. Not many people know that Asiatic rhino horn, because of its use in a certain Chinese medicine, is now nearly worth its weight in gold (as high as £18 per pound, and £150 has been paid for a single horn). Fortunately African rhino horn, for some reason unknown to us, is worth less in the Calcutta market. But even so, it now brings double the price of ivory.

Looking ahead twenty-five or fifty years it seems certain that very little animal life of the larger sort will survive in anything approaching its former abundance in Africa outside of parks and reserves. The realization of this rather sad fact has led to an agreement among the participating powers to provide at least four different kinds of nature reserves within their respective territories and to begin the survey of such areas within a short time of the ratification of the convention. Such areas are described in the paper somewhat as follows: (1) "national parks," used in the American sense as areas set aside for public use and enjoyment; (2) "strict natural reserves," areas not open to the public and primarily for the preservation of a "primitive area" as such; (3) "ordinary reserves" for the protection of all game found within them but not on the permanent status of a national park; (4) "special reserves" for the protection of certain rare species of animals or plants found therein.

Attached to the convention is a long list of species which are recommended for special protection under article 8 and these are divided into two Classes, A and B, according to the strictness of the protection considered necessary. Among the more familiar animals in Class A are the following: gorilla, Madagascar lemur, giant sable antelope, nyala, mountain nyala or giant bush-buck, okapi, Barbary stag, pigmy hippopotamus, mountain zebra, wild ass, white rhinoceros, bubal hartebeest (probably extinct), Abyssinian ibex, elephant (when tusks are

less than 5 kilograms each), water chevrotain.

In Class B is placed a group of animals which, although not to be subjected to hunting under an ordinary license, may be taken under special license limited as regards the period and area for taking them. Some of the more familiar of these are: chimpanzee, Derby eland, giraffe, white-tailed gnu, bontebok, black rhinoceros and elephant (when tusks are over 5 kilos each).

Our American Committee have for some years urged that a kind of international blacklist be prepared of all those persons who, by their sportsmanlike behavior while in Africa have given cause for unfavorable comment. Such a list is now provided for and it is hoped that Americans will be conspicuous by their absence from its rolls!

Special attention should be called to article 17 which provides for governments not having possessions in Africa to accede to the principles of the convention either wholly or in part. In the "final act" the hope is expressed that the governments who sent observers (Netherlands, India, United States) will at some future time decide to adhere to the present convention.

This convention comes into force three months after ratification by at least four of the contracting governments. It ceases to exist when, by a series of denunciations, less than four governments adhere to the convention as signed. However, no denunciations can take effect until five years from the time the convention comes into force.

Let us hope that nothing will interfere to delay the bringing into operation of this treaty which marks the first serious attempt to preserve for all time (albeit only in a few favored areas) those remarkable African mammals and birds which have been so greatly depleted in the past 25 years. And it should be understood that only a small part of this reduction of game has been due to the visiting sportsman. The opening up of great regions to white settlement, which always results in game extirpation, the use of guns in the hands of natives who never before had deadly weapons, the control of certain areas in the attempt to limit the spread of tsetse fly-borne diseases, the penetration of good roads into the wilderness of yesterday; these and a score of other happenings underly the disappearance of African game.

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BULLETIN

NEW YORK ZOOLOGICAL SOCIETY

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A sketch chart of the 1934 Caribbean *Atlantis* cruise, with notes on flyingfishes. The daily mean positions are indicated by black dots from January 21 to March 4. The hydrographic stations are indicated by small circles from No. 1935 to No. 2098. The area marked between Bermuda and Haiti shows the region in which the eggs and nests of the four-winged flyingfish, *Exonantes*, were found. The area marked north of Panama shows the region in which the eggs and nests of the two-winged flyingfish, *Exocoetus*, were found. The elliptical area in the same region represents the locality in which the primitive flyingfish *Oxyporhamphus* was found, a form new to the Caribbean.

BULLETIN

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No. 2

The Oceanographic Vessel *Atlantis* in the West Indies

An Account of the Second Joint West Indian Expedition, Sponsored by the Bingham Oceanographic Laboratory and the Woods Hole Oceanographic Institution

C. M. BREDER, JR.

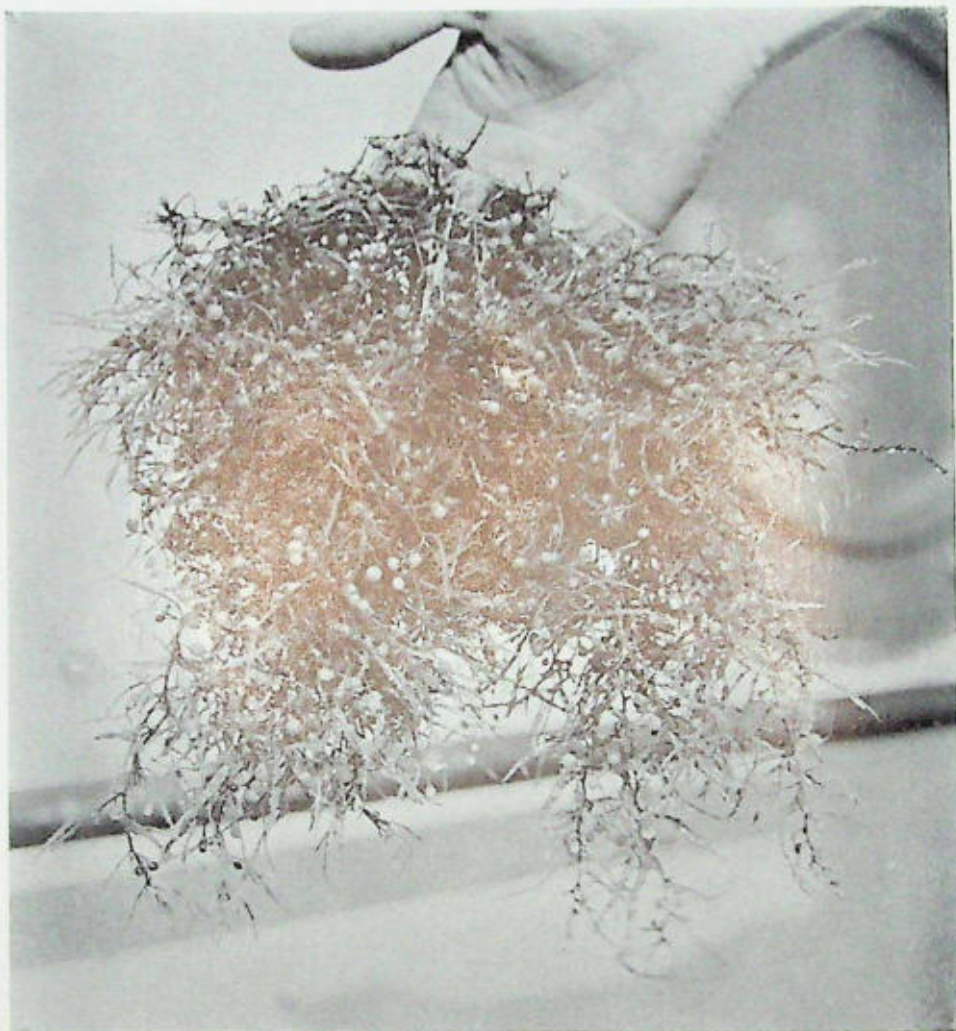
PURSUANT to an extensive survey of the biological conditions represented in the much discussed but still poorly understood Sargasso Sea, the auxiliary ketch *Atlantis* recently cruised through various West Indian waters in search of critical data. The curator of the Bingham Oceanographic Collection and Laboratory, Yale University, Prof. A. E. Parr, led the expedition—the third which he has managed in his present intensive study of the Central American seas, and the second to which the Woods Hole Oceanographic Institution has lent its cooperation and the facilities of its excellent research ship.

Although many naturalists have visited regions in which sargasso weed occurs, there has previously been no attempt to work out the problems in a detailed quantitative manner. While an accompanying article by Professor Parr explains his problem and program, it may be pointed out here that it entails the consideration of many diverse fields, both biological and physical. The various organisms associated with sargasso weed, and their ecological relationships, are all embraced by the program. The writer's scientific connection with all this is conditioned to a considerable extent by his long standing interest in flying fishes, certain of which enter into the sargasso weed complexities, while the holding of a research associateship with the Bingham Laboratory facilitated arrangements. Incidentally, it is of considerable sentimental satisfaction to him that the first Bulletin of the

Bingham Laboratory was prepared under his hand in 1927. Since then, thanks entirely to the indefatigable and intelligent efforts of Professor Parr, the organization has grown in importance until now its publications, collections and program have attained acclaim wherever oceanographers and ichthyologists foregather.

The interests represented by the scientific party on the cruise give a fair idea of the diversity of subjects that require special attention in order to work out the sargasso weed problem in a properly scientific manner. In addition to Prof. Parr the party consisted of Dr. A. Forbes, Harvard University and Trustee of the Woods Hole Oceanographic Institution, neurology; T. S. Greenwood, Woods Hole Oceanographic Institution, hydrography; M. D. Burkenroad, Bingham Laboratory, carcinology and sargasso epizoa; M. Bishop, Peabody Museum of Natural History, Department Zoology, collection and preparation; H. Sears, Woods Hole Oceanographic Institution, ichthyology.

The cruise covered about 5,000 miles with but four ports of call: Kingston, Jamaica; Colon, Panama; Miami, Florida and New York City. Most of the time was spent on the open ocean, well out of sight of any land. The general itinerary was as follows: Woods Hole, Mass., to off the Bermudas to Turk's Island, through Turk's Island Pass and Windward Passage to port at Kingston, Jamaica; to port at Colon, Panama; along the Mosquito Bank off Nicaragua, to off the north coast of Jamaica, to off the



A clump of sargasso weed bound together by the white threads of a flyingfish nest. These lines are most evident near the upper part of the picture, and more or less radiate from the band.

south coast of Cuba, to Bartlett Deep, to off the Isle of Pines, to Yucatan Channel, to off Key West, Florida, to off Havana, Cuba, to port at Miami, Florida; to port at New York City; to Woods Hole. The accompanying chart gives a better idea of the actual course. The writer's efforts on the trip were directed to the following ends: To obtain further data and specimens of flying fish, especially in connection with their relation to sargasso weed; to obtain data on open ocean conditions looking toward improvements

at his home institution, the New York Aquarium, and to obtain such living specimens as might be useful to the collection of the latter place.

The collection and study of the ever fascinating flying fishes was pursued primarily by two methods, chiefly observation by day but actual collection by night. Every sea voyager, who has traveled in any of the tropical waters of the world, has probably seen these piscine aviators and at least speculated on the mechanism of their flight. These fishes display their soaring

proceed wherever the water is warm—in a band girdling the world at the equator, and extending north and south of it to an irregular boundary on either side, extended or contracted in accordance with the influential ocean currents of differing temperatures. Considering the daylight activities first, one of the studies involved the statistical observation of the numbers of fishes flying in different localities and under varying atmospheric and wave conditions. In all exactly forty-four hours, in half hour periods, were so passed. It is undeniable that this sort of work becomes tedious after the first few days, especially when it has been engaged in on previous sea trips, to say nothing of the eye strain involved. Consequently it was with much gratitude that I accepted the offer of both Dr. Forbes, Mr. Sears and Mr. Burkenroad to relieve me at times. While it is not the proper time or place to discuss the data so obtained, as it requires analysis and statistical study, it may be mentioned that the largest number of fliers counted in a single period (one-half hour) was one hundred and thirty. This was off Cape

San Antonia, Cuba. The longest timed flight amounted to not quite twenty seconds, during which time a surprising distance can be covered. However, much longer flights are sometimes to be observed. The above facts are mentioned merely to give the reader some idea of the extent of this kind of fish activity existent in the West Indies.

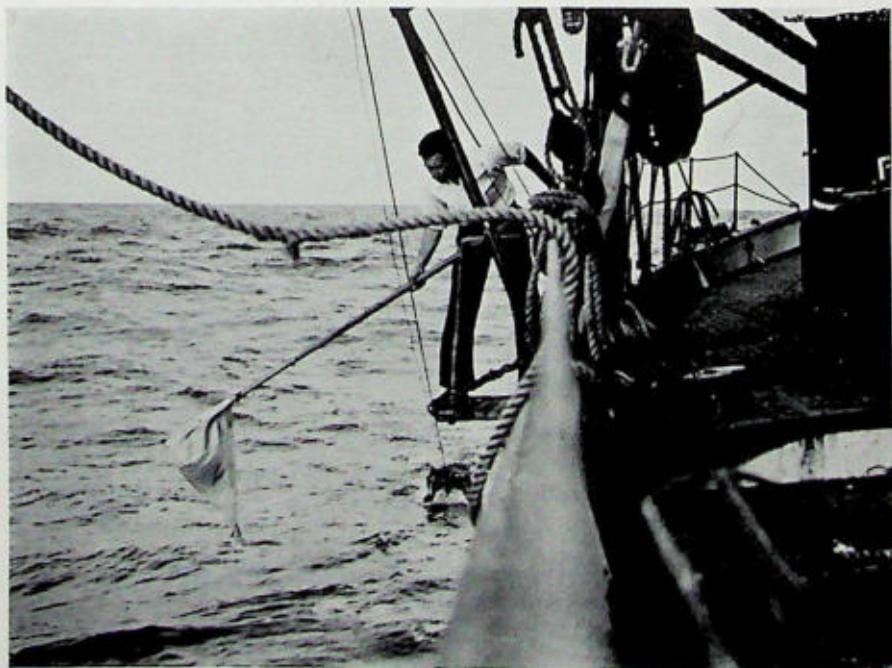
The actual collection of specimens took place mostly at night. Flying fishes on the high seas are notoriously difficult to obtain in any quantities for scientific studies as the more ordinary methods of fish-catching do not work out very well with these exceedingly mobile creatures. At each hydrographic station made after dark, a waterproof electric light was dropped a foot or so below the surface. The effect of such a light on various kinds of fishes is not unlike that of a lamp on insects. As they come swimming about the light it is a relatively easy matter to dip them out of the sea with a long handled hand net. The flying fishes are apt to swim slowly in toward the light, usually with their "wings" spread out to their full extent. At such times



The tow-net used for collecting extensive samples of sargasso weed. This net was practically in continuous operation. A quantitative measure of the weed's abundance was obtained by weighing the amount taken over a given distance.



Professor A. E. Parr and Harry Sears sorting a load of sargasso weed just brought on board by the tow-net. Numerous interesting invertebrates are frequently encountered, and now and then a flyingfish nest.



In addition to the tow-net, numerous interesting specimens were collected by dip-net.

they "loaf" about in a resting position but are off in a flash, either above or below the surface, on any false move on the part of the netter. At these times the exceedingly active and unbelievably fast pelagic squids also come about the light and prey on such fishes as may be there. On various occasions such squids took exceptionally choice specimens from under our very noses, because they are simply more skillful and more experienced at catching flying fishes. There is a distinct fascination to this method of collecting and practically everyone, crew and scientific staff, took a try at the overboard light method. Mr. Bishop and Chief Engineer Backus were especially intrigued, and I have them to thank for many choice specimens. While there is nothing new about the use of the overboard light, previously most such collecting has been done in harbors, or anchored close to shore. No extensive collecting of the kind has been done in the West Indies with the vessel simply hove-to in the open sea. This probably accounts for the surprising amount of material obtained of rare and little-known forms—species that probably lead a life entirely away from even insular shores. A study of this material is now under way, but it would be premature to attempt a discussion of its biological significance at this time. One of the more interesting items, however, may be mentioned in passing.

There lives in the Pacific Ocean a primitive flying fish with very short wings that is incapable of any protracted flight. This fish, *Oxporhamphus* (*Evolantia*) *micropterus*, has been considered close to the ancestral line of the worldwide two-winged or monoplane flying fish, *Exocoetus* (*Halocypselus*). On the other side it shows unmistakable relationship to the half-beaks, prominently in that the young possess the elongate lower jaw of that group. Nothing of the sort had ever been taken in the West Indies before, but we found that in the region southwest of Jamaica, but well offshore, this fish or a species scarcely differentiable from it is fairly common. In fact a developmental series was obtained that shows the loss of the juvenile beak and includes specimens fully adult. It is difficult to understand why at least some material had not been taken by earlier parties.

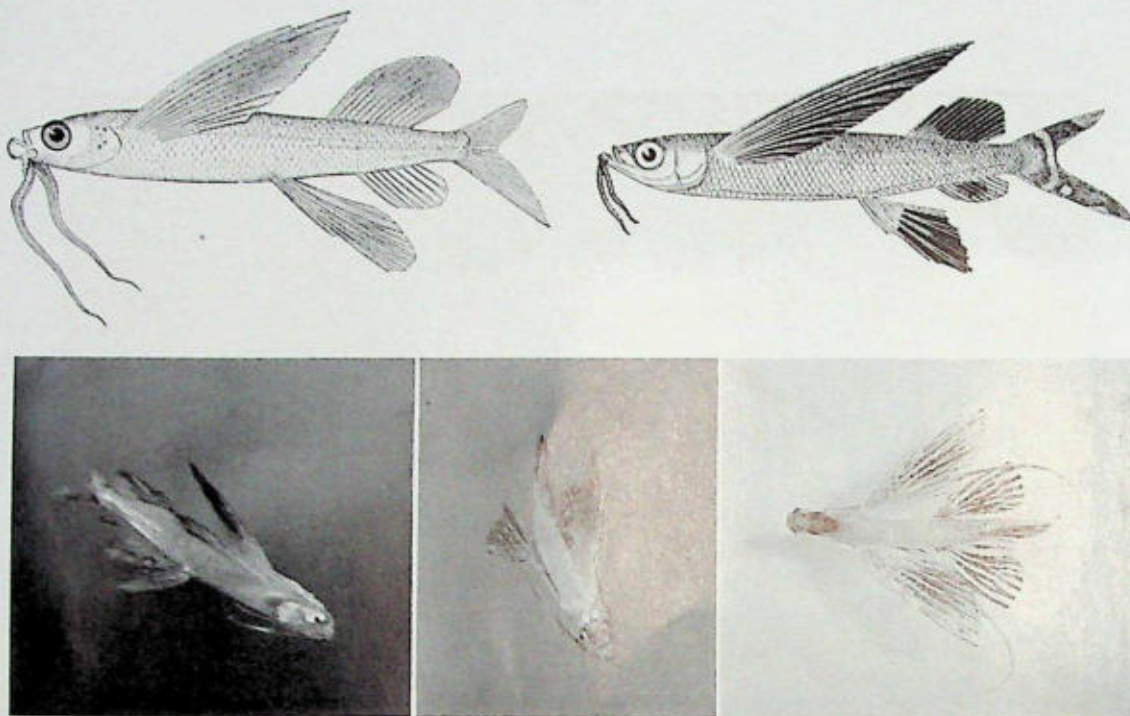


These fishes, taken in a small stream on Barro Colorado Island, are here seen at home in the New York Aquarium. This species, *Rivulus brunneus* Meek and Hildebrand, were formerly known only from the type locality, another Panama stream not on the island. This is the first photograph of the species that we know of, and they are apparently the first to be brought back alive. The younger fish are covered with deep red dots that fade as size increases, while a party-colored bar on the tail becomes more prominent. Photo by S. C. Duntou.

Two striking specimens of fish, described some years ago as *Cypselurus monroci* by Mr. J. T. Nichols and the writer, were caught which represent a remarkable stage in development not seen before. This species is characterized by two long barbels on the chin. In the two obtained on this expedition, the barbels actually reach a considerable distance beyond the tip of the tail! It is difficult to imagine any important value that such trailers might have to a flying fish, especially as they are living side by side with numerous other species that survive satisfactorily with no barbels at any stage. There is also a single specimen of the fish that Dr. Beebe described from east of Puerto Rico as *Cypselurus antarei*, this flying fish having a single chin barbel.



A tame Panama deer comes to the laboratory door just before sundown, in the expectation of being fed, at the Barro Colorado Research Station.

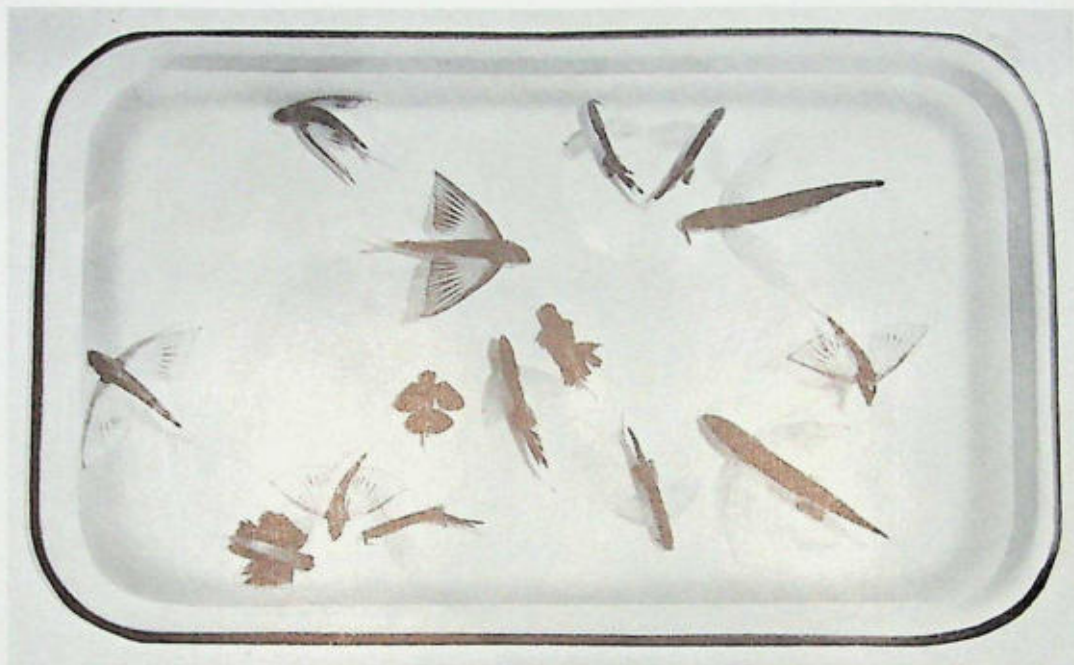


The long-barbeled flyingfish *Cypselurus monroei* Nichols and Breder. The upper left drawing represents the type specimen, a fish of only 48 mm. from the Florida Keys. (Drawn by Louise Nash.) The upper right drawing represents an adult of 151 mm. from off the Dry Tortugas. (Drawn by Jean Roddan.) The lower photographs represent three postures of an intermediate size (58 mm.) taken on the *Atlantis* expedition between Jamaica and Panama. Note the excessively long barbels in the dorsal view.

Students of flying fishes, for long puzzled by the presence or absence of barbels, have in some cases been led to believe that "whiskers" are grown, or not, with little system, and that their presence or absence is of little significance. The present material, it is believed, will be able to prove, in several cases at least, that these structures are as regular in occurrence as they are in other groups of fishes. This will either mean the reestablishment of various species now resting as synonyms, or the creation of new species. A discussion of this would rapidly carry us into technicalities that only a specialist would care about.

A considerable collection of flying fish nests and eggs was made by virtue of the sargasso collecting net. These are curious structures. The fish wind a long tough cord of a dead white color tightly about a single clump of sargasso weed. The eggs themselves occur in small clusters at intervals along this cord. Both the eggs and the cord are heavy structures and sink in sea water. Their attachment to the buoyant sargasso weed

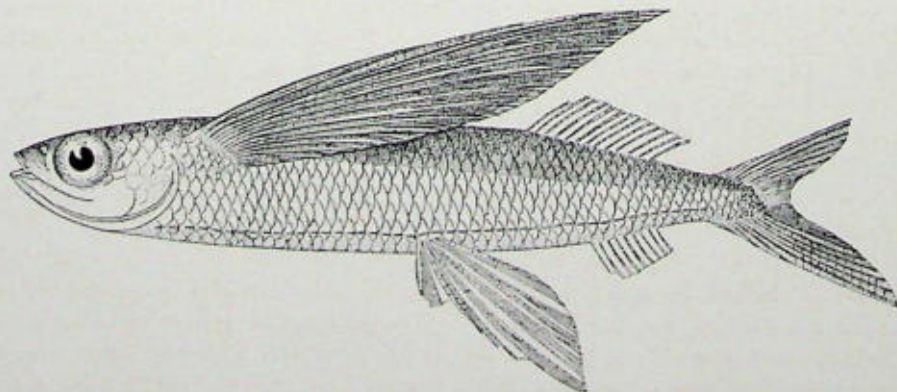
alone keeps them from sinking into the cold abyssal waters underlying the open ocean. Most other pelagic fishes produce buoyant eggs that float of themselves but the flying fishes have to seek some support for theirs, if the eggs are to remain within the environment in which they are capable of surviving. The eggs of one species, *Eronautes rondoletti*, were hatched on shipboard and allowed to develop to a recognizable size. This species, at least, hatches at a fairly advanced stage and soon feeds readily on small organisms. A continued supply of food was provided in a rather novel manner. Eggs of the brine shrimp *Artemia* may be dried and kept for years as a fine dry powder. When sprinkled on salt water they hatch out as tiny shrimp in about a day. The eggs of this curious crustacean may be taken in quantities in brine pools of salt-collecting establishments. Some time ago the San Francisco Aquarium Society began packing these eggs commercially for the use of home aquarists, and they have been used for such purposes with considerable success. This is the first case we



A basin full of flyingfishes. There are three species here which represent part of a night's collection of young fish. Three, with the solid black fins, are a species of "four-winged" flyingfish *Exocoetidae*. Those with the large, single pair of wings showing some pattern are *Exocoetidae*, and the rest, with the smaller transparent wings, are *Paroxocetus*. This latter kind possesses barbels on the chin, which may be seen in some of the specimens.

know of, however, where this method has been used as an aid to the scientific study of the development of ocean fishes. It may be pointed out that one of the chief difficulties in rearing pelagic fishes is in the matter of supplying the first food to the larvae just after they have absorbed the last of the yolk carried over from the egg. It is suggested that this technique might prove to be a valuable method for other similar fishes. At least it worked exceedingly well in the present case.

This species of flying fish apparently only uses one kind of weed, *Sargassum natans*, although other kinds may be just as available. In addition to selecting this certain species of weed, in all cases noted by us there were small sprigs of a relatively small and rare weed woven into the nest, *Sargasso myriocistum*. These small pieces occurred in the nests in numbers much out of proportion to the normal, relative quantities, as measured by the quantitative weed collector. How these odd bits were agglomerated



Lutkens flyingfish *Cypselurus lutkeni* (Jordan and Evermann), a species more common in the Caribbean than generally supposed. From a drawing by Jean Roddan.



A basin of flyingfishes taken on another night presented a quite different assortment than those shown in the other picture. Note that the three "two-winged" fishes *Erococtus* have a different wing pattern. The others with four large wings bearing elaborate patterns are *Cypselurus*.

in the nest is a puzzle. Why the nests were so built is also a puzzle. It has been suggested that the berry-like floats of this small weed resemble fish eggs and are thus a protection. Actually they bear little resemblance in size or color and it is hard to believe that any animal bent on a meal of flying fish eggs would be deceived.

Although almost the entire trip was spent on the high seas in the pursuit of matters similar to the items above referred to, visits at two Caribbean ports did much to prevent monotony. At Jamaica various fresh-water fishes were collected, some of which were brought to the Aquarium alive. The curious semifresh-water pipe-fish *Oostethus lineatus* made an interesting addition. Other small fishes, from both the lowlands and high hill streams of this most beautiful of the Caribbean Islands, are also now living on lower Manhattan.

At Panama a visit to the Canal Zone Biological Station, Barro Colorado, is especially memorable. This station, an island paradise in Gatun Lake, also yielded some interesting living material. A small but handsomely marked fish *Rivulus brunneus* was brought to New York for

the first time. The visit to this bit of jungle caused a rush of memories, for it was just ten years ago that the writer saw Panama, at that time part of an expedition to some of the little known hinterland. The Panamanian jungles are such that only an exceedingly obtuse person could forget. The spell of charm they cast is something one carries with one indefinitely.

After leaving Panama we all returned to our respective ocean problems, and had a steady run of it from there to Miami (Feb. 14 to March 5). This was the last port of call before the party broke up at New York, each member returning to his home institution with scientific plunder and profit.

Problems of the Sargasso Sea

A. E. PARR

Curator, Bingham Oceanographic Collection, Yale University

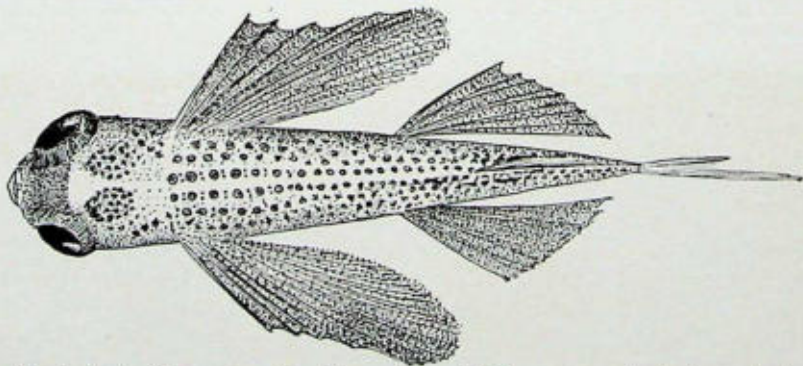
FOR centuries the domain of the floating weeds on the high seas has been the subject of curiosity and superstitions among the seafaring man and travelers. Many weird tales of the sea have arisen around the mysterious forces supposed to be at work in the Sargasso, have



The battery of jars used for the study of Sargasso invertebrates, and the development of flyingfish eggs and larvae. Martin Burkenroad is seen washing small forms from a clump of weed.



A fresh-water pipefish *Oosteus lineatus* living in a balanced aquarium in New York. This particular specimen was collected in a small creek near Kingston Harbor, Jamaica, but they are also common at Barro Colorado in Gatun Lake, Panama, as well as in marine localities. Photo by S. C. Dunton.

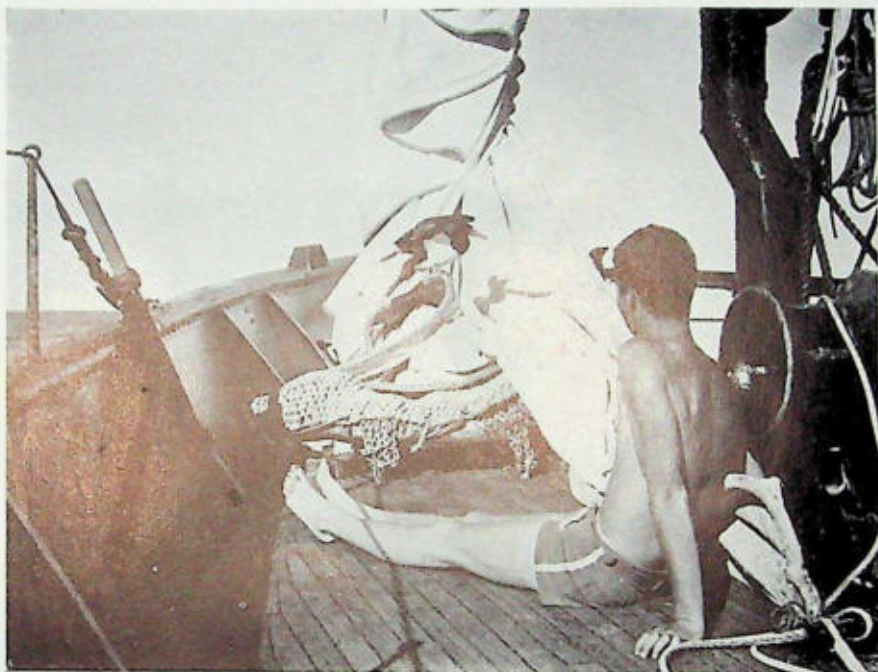


A typical nest of *Exonautus*. The white cords to which the eggs are attached are clearly visible, a little above the center of the picture, against the darker weed. The larvae which hatch from these eggs in a few days appear as shown in the line drawing of a specimen a little over a half inch in length. (Drawn by Louise Nash.) Larger specimens are shown in one of the accompanying photographs of a pan full of fish.

made the rounds of the forecastles and the ports of the world, often finding their way at last into the literature and the movie drama.

And yet the Sargasso Sea, technically defined, is simply a part of the North Atlantic in which floating weeds very much like the common brown seaweed we may find any place on the rocks along our coast occur in sufficient abundance to make them a common sight from a ship passing through the region; and the mysteries it contains

exist only in the biological problems of the weeds themselves and the many small animals and fishes that drift around with it, making up an entire floating world of their own. This world is unique among biological environments in water or on land in that it provides opportunity for an existence which is neither that of the bottom animals growing or crawling about on the ground, nor that of the pelagic animals swimming or drifting around free in the water or at



A friendly booby bird visits the *Atlantis* off the coast of Nicaragua. These birds sometimes visit ships in large numbers.



Collecting Poeciliids in the high hills of Jamaica. Marshall Bishop and the guide are examining the catch, while Harry Sears endeavors to capture more specimens.



The mountains forming the ridge of the continental divide run close to the San Blas coast of Panama and may be seen on approaching Colon Harbor. This view had poignant memories for the writer, as ten years previous he crossed the isthmus from the Pacific to the Atlantic through the virgin jungle a little to the south of this photograph.

the surface, but a strange mixture of both. A world in which animals by nature intended for bottom life drift around on an artificial, shifting and discontinuous "false" bottom of living, floating plants, often miles above the true bottom of the ocean, which they would probably never be able to reach without perishing on the way except in a narrow zone of shallow water along the shores.

Yet the Sargasso Sea, with its plants and animals in their precarious existence, stretches right across the North Atlantic from the Antilles and the Gulf Stream up to about 40° N in the west to the Azores in the east, with its southern boundary approximately along the parallel of 20° N, a distribution which corresponds very well with the area of the clockwise North Atlantic surface circulation with its convection centre.

When Columbus, on his westward voyage, first

encountered the floating Sargasso weeds, his men mutinied in the belief that the weeds must be a sign of dangerous rocks being near, and this belief in a modified form has been the basis of much scientific theorizing and exploration concerned with the origin of the floating weeds, and is very hard to eradicate even today. Since similar weeds floating in great masses at the surface of the sea had never before been seen except close to shores where they were also growing on the bottom, the sailors' assumption that bottom must be near was perfectly natural and it was also natural that science at first should take the same view, looking upon the Sargasso Sea merely as a region of floating fragments torn loose by mechanical forces from enormous fields of bottom weeds with which they imagined the sea to be surrounded. When it later was discovered that the floating weeds



Deep jungle on Barro Colorado Island. The daylight strikes through the trees in places, but only poorly illuminates the forest floor.



After the sargasso weed is sorted, Bishop (left) and Greenwood (right) discuss some particularly curious specimen.

are never reproductive, but, if at all, merely multiply by growing at the tip of the branches and falling apart at the base, the belief gained further strength that the floating weeds were only short-lived fragments and that the Sargasso Sea itself was dependent upon a rapid and continuous replacement of its weeds from bottom fields.

But difficulties soon began to develop for this theory. In spite of considerable search, one has never as yet been able to discover any bottom fields of a size which would be at all significant for the Sargasso Sea. The bottom fields remain as hypothetical as ever, and it is one of the hopes of the writer to get an opportunity for a sufficiently thorough search of the shallow water areas of the Central American seas to be able to state definitely in the negative or affirmative whether any such fields are present at all. A further difficulty has arisen from the fact that among the many related weeds growing on the bottom none have been found to be entirely like the floating ones (*Sargassum natans* and *fluitans*), and it has thus been impossible to say definitely that even a single specimen of the

floating weeds have been shown to exist in any other condition than afloat at the surface. In explanation of this, it has been suggested that the tearing loose of the weed constituted such a radical change in its mode of living that it would also cause a change in its external appearance, making it impossible to establish the identity of the floating and attached stages.

It is one of the objectives of the investigation now under way to attempt to test experimentally whether such a change would occur and to try to reverse it, in case it does happen, so that it may become possible to tell whether or not the floating weeds actually might be identical with any of the forms growing on the bottom.

One obvious objection against the assumption that the floating weeds represented short-lived fragments only, with no independent growth and existence, can be raised from the fact that it would in any event take a very considerable time for such fragments to be distributed over such a tremendous area (over two million square miles) and they would at least have to be able to live independently for as long as this process

of distribution would require. It is furthermore well known that plants may go on multiplying by growth only, without any fructification, and there is no reason why we might not in the floating Sargasso weed find an extreme development of this condition, with normal reproduction completely suppressed. Another school of thought therefore developed around this idea of the Sargasso Sea as something probably derived from the bottom sometime in the dim past but developed into an entirely independent world today, able to maintain its existence by simple growth and mechanical division without significant contributions from the bottom. Although this is the viewpoint which has gained the greatest support in recent years among the scientists actually undertaking a serious study of the Sargasso weed problem, it has received almost no recognition outside of the narrow circle of specialists, and the Sargasso Sea still remains in the minds of most people an enormous eddy of flotsam from the surrounding shores and shallow waters.

Already as early as in the 1880's, the Germans began to require the captains of their merchant marine to record the frequency with which they encountered the floating weeds on their crossings of the ocean, and in 1891 appeared in print the first analysis, by Krümmel, of the tremendous amount of data thus accumulated by the "Deutsche Seewarte." From this material it has been possible to show that the floating Sargasso weeds are subject to a seasonal fluctuation in abundance, increasing sharply from a minimum during the summer to a maximum during the fall, followed by a slower decline during winter and spring to a new minimum again next summer. Since the increase occurs simultaneously over the entire area, it may be taken as evidence of an actual growth and multiplication of the floating weeds themselves and not of a sudden contribution from the surrounding shallow waters, since such an addition to the circuit would of necessity appear successively and not simultaneously at the various points of the Sargasso circulation. These statistics can therefore also indirectly be taken to support the theory of the independence of the floating weeds as recently pointed out by Winge.

The figures obtained by the "Deutsche Seewarte" were not truly quantitative, however, but merely expressed the frequency with which the

weeds were sighted from ships. As to actual weights and volumes, no observations were available. It is perfectly clear, however, that the true place of the floating Sargasso weeds in the household of the ocean cannot be determined until we have some sort of an idea as to its actual quantity, the amounts of its requirements, and of its contributions to the sea. To this end the research ship *Atlantis*, on two cruises sponsored jointly by the Woods Hole Oceanographic Institution and the Bingham Oceanographic Laboratory of Yale University, has been making continuous tows over long distances with a net cutting out exactly a two-foot wide strip of the surface. When a sufficient amount of tows have been made, we shall be able to begin to make accurate estimates of weights and volumes. So far the surface tows made by the *Atlantis* on the two Central American cruises add up to a total towing length of more than two thousand miles, but we still feel that we are only at the beginning and many more figures must be obtained before we can begin to work out reliable quantitative averages of abundance for the different seasons and different areas and to arrive at an accurate total for the entire Sargasso Sea. We are probably entitled to say, however, that the total amount of floating weeds must be in the order of magnitude of ten million tons fresh (wet) weight; that is, it must be somewhere between 5 and 20 million tons. Although this is as close as we dare to make our estimate today, it nevertheless represents a great step forward from the previous state of our knowledge, when there was no information available from which we might even decide whether it was a question of thousands or millions or billions of tons. To determine what these millions of tons of floating weeds may mean in the household of the sea, it is further in the program of our investigations to have a complete chemical analysis of the weeds made and to undertake a series of biological experiments to determine the demands they make upon the ocean when alive.

Parallel with the investigation of the Sargasso weeds themselves, Mr. M. D. Burkenroad of the Bingham Oceanographic Laboratory is also carrying on a study of the intricate biological problems of the many invertebrate animals growing upon or living among the floating weeds.

Coelenterates as Enemies of Fishes

II. Jellyfishes as Fish-eaters*

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IN paper No. I of this series, it has been shown that such a simple Coelenterate (hollow-bodied animal) as Hydra catches and eats baby fishes; and that the related Polypodium is parasitic in the ovarian eggs of the sturgeon of the Volga River. Of the colonial forms, two species of Hydriechthys (the fish-hydroid) are parasitic on fishes as far removed from each other as Durban Bay, South Africa, is from Narragansett Bay, New England. Then it was shown that two colonial forms catch little fishes with their tentacles and prey upon them. In this article, it will be demonstrated that, among the free-swimming Coelenterates, the Medusae also feed on fishes.

MEDUSAE AS ENEMIES OF FISHES

Medusae in their intimate structure are composed like the simple coelenterate, Hydra, of an external ectoderm, an internal endoderm, with a structureless layer, the mesogloea, between. However, in them the nervous system (very rudimentary in Hydra and its allies) is quite well developed. As in Hydra, the netting cells are largely confined to the tentacles.

Looking at the Medusae or Jellyfishes in the water, they are seen to consist of dome- or umbrella-shaped contractile bells fringed with tentacles, and depending from the center of the under side of the bell, like a clapper, is a hollow process or manubrium having a mouth at its extremity. The Medusa, with its circle of fringing tentacles dependent from the rim of the bell, gets its name from the mythical Medusa whose ringlets consisted of writhing serpents. And we shall presently see that the tentacles of our Medusa (armed with poisonous whiplash cells) are quite as deadly as the serpent ringlets of the mythical one.

Medusae do catch and swallow and digest

fishes as many observers testify. But the presence of fishes under the bell and even in the stomach-cavity does not necessarily mean that these fishes are the prey of the jellyfishes. They may be in either place for shelter and protection. Doubt as to the inimical status of such a relationship was, I believe, first expressed by the great Cuvier. The relationship is in many cases a matter of doubt, but there is a considerable literature dealing with the undoubtedly friendly protection afforded by Medusae to various kinds of fishes. These fishes are generally few under a Medusa, but William Beebe and John Tee-Van in their "Fishes of Port-au-Prince Bay, Haiti" (*Zoologica*, 1928, vol. 10, p. 11), have recorded the amazing fact that from under a large jellyfish they took the prodigious number of 304 young fishes varying in length from 12.5 to 47 mm. (0.5 to 1.75 in.). This medusa with some of the sheltered fish is figured by Beebe in his "Beneath Tropic Seas" (New York, 1928, p. 30).

Jellyfishes do eat fishes, and in turn some of the fishes eat medusae; but it is in the predatory activities of the jellyfishes that we are interested here and to these we will now turn. And first of all it may be said that nearly all the writers of faunistic or general systematic works on the Coelenterata say that jellyfishes feed on fishes, but very few say "I have seen such and such a medusa eat a fish." Only those whose observations have been at first hand, will be quoted.

The jellyfish catches the fish by paralyzing it with the poison-cells with which its tentacles are thickly studded. It then enwraps the fish in its tentacles and transfers it to the mouth at the open end of the manubrium or bell-clapper.

THE DISCOVERY OF THIS HABIT

There is doubt as to who recorded the first observation of medusae as fish-enemies. Aristotle

*Part I of this article appeared in "Annals and Magazine of Natural History," 1934, 10. Ser. 13 Vol., pp. 192-212, 2 pls., 7 text-6.

is often so credited but the latest and most critical English version of the "Historia Animalium" of the Father of Natural History, that of D'Arcy W. Thompson (Oxford, 1910), very clearly states that the sea-anemone is the organism in question.

LuNel and others state that the Abbe Spalanzani (1776) was the first to observe a medusa catching a fish, and that Otto Mueller (1776) was the first to figure a jellyfish with a fish entangled in its tentacles. Further they allege that this figure has been much copied. Both statements are in error, since both apparently refer to the work of the old Dutchman, Martinus Slabber, whose figure and description will now be set forth.

MEDUSA CYMBALOIDEA THE FIRST JELLYFISH FISH-EATER

Slabber was so far as I have been able to find, the first to see, describe, and figure a medusa in the act of eating a fish. His observation was made in 1768 and ten years later he described and pictured this feeding in his "Natuurkundige Verlostingen" (Haarlem, 1778, p. 101, pl. 12). His figures (A in natural size, and B much enlarged) are reproduced as Fig. 1. herein. Since these are the very first, it seems well not only to copy the figures but to give a translation of Slabber's brief statement. He thus records the facts concerning what he calls *Medusa cymbaloidea*—the cymbal-shaped medusa:

As soon as I had caught it, I placed it under the microscope [probably a simple affair] and found that it had caught a very small fish [Fig. 1A shows this in natural size] for its prey, which could still be seen outside of the body [Fig. 1B] . . . [the fish] was very lively when I looked at it, and one could see plainly that it was being drawn in. This drawing-in was completed in two hours time and then the whole creature [was enclosed in the manubrium] . . . The mode of feeding was an interesting sight to me and it places me in a position to be able to report the real [feeding] habits of the animal, since before I had only at best been able to guess at them.

Slabber then argues that with millions of jellyfishes in the North Sea there must be a great consumption of little fishes with a cor-

responding reduction of fish available as food for man. This particular matter will again be referred to at the close of this article. Slabber concludes with an accurate and interesting observation concerning the tentacles, when he says that "These streamers when stretched out have . . . a great resemblance to snakes and serve the jellyfish to get control of its food."

Slabber's figure has been often copied. I find it in at least two of the works of George Brown under the name of "Medusa campanella." And since Brown makes this synonymous with O. Mueller's "Medusa hemisphaerica," I suspect that this is how LuNel and others credit Mueller with the first figure of a Medusa eating a fish. Mueller's figure, however, is on an entirely different medusa and there is no fish shown.

OTHER ACCOUNTS OF MEDUSAE AS ENEMIES OF FISHES

Having introduced the reader to this habit of jellyfishes, from this point forward the data will be collected and set forth under the names of the individual medusae. No attempt will be made to reduce these names to synonymy, since my interest is in the fish-eating habit of the medusae and not in their classification and nomenclature.

The data contained in this article have been gathered from a number of widely scattered sources but, while isolated records of this behavior are both interesting and valuable, still effectually to answer the question whether the Medusae feed on fishes, controlled experiments are needed. These have been made by Dr. Marie Lebour at the Plymouth (England) Marine Biological Laboratory, and have been reported on in two excellent papers.¹

It was realized that jellyfishes are the largest and most voracious feeders of the plankton or surface dwelling organisms and that in them were frequently found partly digested young fishes. Then the question arose as to whether these baby fishes were caught alive and eaten out in the sea under natural conditions, or whether

¹The Food of Plankton Organisms, No. 1. *Journ. Marine Biol. Assoc. U. K.*, 1922, n. s. 12, 649-677, 3 text-figs.—No. II, *ibid.*, 1923, n. s. 13, 70-92, 12 text-figs.

The second of these papers has been briefly and inadequately summarized by Louis Joubin as "La Destruction des Petits Poissons par les Animaux du Plankton", *Bull. Soc. Océanogr. France*, 1924, 4 ann., 389-382, 8 text-figs.

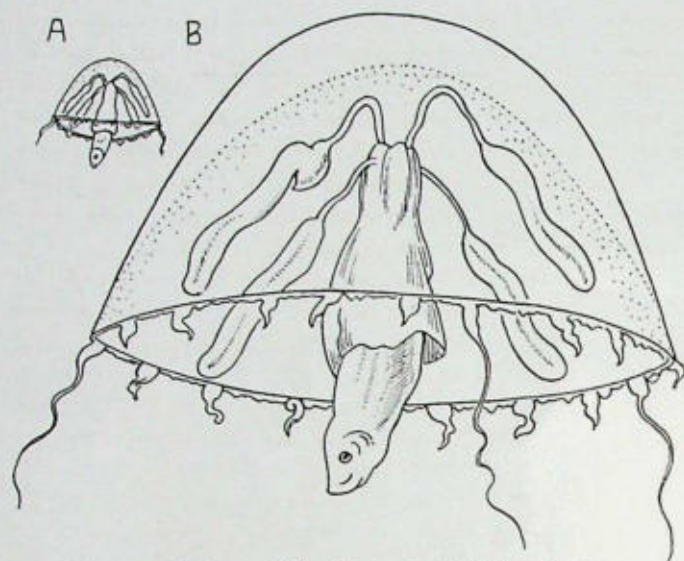


Figure 1. The first published figure of a jellyfish capturing a fish. A. *Medusa cymbaloidea* and the fish in natural size. B. The same enlarged six times to show the swallowing process. After Martinus Slabber, 1778.

the jellies swallowed the half-dead fishlets in the crowded tow-nets. To settle this question, extensive aquarium experiments were carried on for months and careful notes and drawings made. Large numbers of small medusae and fishes were kept in jars (of 50 litres capacity) and most of the medusae were seen to catch and eat fishes. The fishes caught by the tentacles were conveyed to the mouth and by it ingested, and were digested in the stomach. Of little fishes, put into the aquarium to test the feeding of the medusae, some were newly hatched ones from the hatching-jars in the laboratory and other somewhat older ones were from the tow-nets and the trawls for catching young fish.

The observations of Dr. Lebour and other naturalists will now be set out under the names of the various medusae concerned. The scientific names will have to be used since in most cases there are no common ones.

AURELIA AURITA, AN ENEMY OF FISHES

That this widely distributed jellyfish is a feeder on fishes has long been known. Thus but two years later than Slabber, Otho Fabricius, in his "Fauna Groenlandica" (1780), notes that *Aurelia aurita* feeds on little fishes, especially on the young of the sea-scorpion, which it

thrusts into its stomach. This Fabricius apparently saw with his own eyes.

That *Aurelia* feeds on fishes seems to be widely believed (and probably known) but not until 1905 do I find a positive statement confirming Fabricius. In that year Prof. C. W. Hargitt in his "Medusae of the Woods Hole Region" (*Bulletin U. S. Bureau of Fisheries*, vol. XXIV, 1905) expressly states that *Aurelia* is frequently taken with stomach crowded with fishes of considerable size, and to settle the status of the fishes he notes that these are often partially digested.

We now come to the experiments of Dr. Marie Lebour at the Plymouth Laboratory. In the first one a young *Aurelia* measuring about 5 mm. was

put in the aquarium on February 9. At first it stung the fishes with its lappets or lobes and enveloped them with the whole umbrella, but as it grew larger it caught them with the tentacles. Careful records from February 17 to March 30, showed that it was observed to catch and eat two sand-eels (*Ammodytes tobianus*), 6—7 mm. long; 8 sea-scorpions (*Cottus bubalis*) about 5 mm. long (+ 20 newly hatched ones in 30 minutes on March 13); 5 worm-pipefish (*Nerophis lumbriciformis*), about 12 mm. long; 8 young gobies (*Gobius minutus*) about 3 mm. long; and many uncounted other fishes including a 15 mm. dab. Then came a dearth of young fishes, but over four days toward the close of April it ate many gobies, and was ready for more. During May and June it ate several young pollack from 15 to 20 mm. long, and during July it ate one to three pipefish a day until near the end of the month when it died—possibly from too constant a fish diet.

The following year (1923) Dr. Lebour continued her experimental work. Young *Aurelias* fed freely on young fishes and those of 20—25 mm. in diameter were found with little flatfishes and clupeoids in their stomachs. Those above 30 mm. were not found to contain fishes. Why feeding on fishes in aquariums stopped at this stage is a matter for further study.

Another account of the feeding habits of Aurelia, I owe to the courtesy of Dr. C. J. Fish, the well-known planktonologist, who in a recent personal letter says that "At Woods Hole I have observed the young of Aurelia, even in the early stages, feeding on the larvae of winter flounders. In such places as Waquoit Bay, where both animals breed in abundance, Aurelia proved of very vital importance in depleting the flounder stock."

MEDUSA PHOSPHOREA, A FISH-CATCHER

Following closely after Slabber (1778) and Fabricius (1780), the Abbe Spallanzani made known in 1793 that this medusa also catches fishes. In Vol. IV, chap. xvii, of his "Viaggi alle due Sicilie," he records his observations on the phosphorescence of this medusa and states that he saw "... a little fish which had been caught by the viscid humor of the tentacles." Then he adds that the Sicilian fishermen reported that this was not uncommon in the Strait of Messina.

LIRIOPE SCUTIGERA, A DEVOURER OF FISHLETS

Liriope (a fountain-nymph) bearing a shield, a very transparent and rather small jellyfish, was convicted as far back as 1859 of catching fishes. In that year, John McCrady gave, in the *Proceedings Elliot Society of Natural History* (Charleston, 1859, vol. I, p. 209), the following interesting testimony (unfortunately without a figure):

It is bold and rapid in its movements and very rapacious. I have seen one of this species—so extremely diaphanous as to make the impression of nothing but a set of outlines—seize upon a small fish fully thrice as large as itself, and securing itself by spreading out its lips upon it, making them act as suckers, and then entangling about the poor animal its four long tentacula, hang on in this manner despite the violent struggles of the fish, which alarmed, swam violently about the jar, until at last apparently from sheer exhaustion, it was evident he was dying. At last changing color, the fish turned over on its side and expired.

DACTYLOMETRA QUINQUECIRRA CATCHES FISHES

The generic name, (finger-measure) of this beautiful yellowish-blue medusa seems to have

no particular significance, but the specific name designates the five rays between each pair of sense organs. Since there are 8 pairs of these, there are 40 tentacles in addition to the 48 marginal lappets or lobes. Despite these 40 tentacles armed with millions of nettle-cells, a species of clupeoid fish takes refuge under the umbrella of this medusa. As many as 20 little fish have been found under one medusa. According to A. Agassiz (*Memoirs Museum Comparative Zoology*, 1865, vol. I, No. 2), these clupeoids are so much at home that, if they are accidentally separated from their medusa they precipitately rush back, adroitly dodging in between the deadly tentacles. However, in base ingratitude, they sometime (presumably when food is scarce) feed on the pendent lobes of their protector. In turn one of these fishes every once in a while pays the penalty of this ingratitude by being stung and eaten in turn by the medusa. Agassiz says "I have seen in this way three fishes eaten during the course of as many days."

THE RAVENOUS CHARYBDEA XAMAYCANA

This formidable generic name, like many other zoological terms, has a very interesting origin. Charybdis was a ravenous woman who was transformed by Jupiter into the treacherous whirlpool off the Sicilian coast. The specific name is a West Indian word of unknown derivation. Conant, in his work on the Cubomedusae (*Memoirs Biological Laboratory Johns Hopkins University*, 1900, p. 7), notes the fitting origin of the name of his medusa, but unfortunately gives no figure to illustrate the following graphic account of the activities of this ravenous coelenterate. Here are his own words:

Some of the specimens taken [in Kingston Harbor, Jamaica] contained in the stomach small fish so disproportionately large in comparison with the stomach that they lay coiled up, head overlapping tail. The name, Charybdea, then, from the Greek . . . seems no misnomer. It is worth mentioning that the digestive juices left the nervous system of the fish intact, so that from the stomach of a Charybdea could be obtained beautiful dissections or rather macerations, of the brain, cord, and lateral nerves of a small fish.

CYANEA ARCTICA, THE GIANT OF THE TRIBE

This "arctic-dwelling" blue jellyfish is cosmopolitan in northern cold oceans and seas. It is the giant of the great group Coelenterata. According to Hargitt (1905) its flat discoid "umbrella" is sometimes several feet across, while its tentacles are 50 or more feet long when fully extended. But, great as was Hargitt's specimen, Alexander Agassiz saw a larger one, of which he writes that "I myself measured a specimen at Nahant (Massachusetts) the disk of which had attained a diameter of seven and a half feet, the tentacles extending to a length of 120 feet." Furthermore, this great medusa is multi-tentaculate, having according to A. G. Mayer about 800 tentacles.

This great jellyfish must be a voracious feeder and numerous fishes must be caught in these many long sweeping tentacles. Hence one is prepared for Hargitt's statement that these great Cyanes "are often found with their stomachs filled with fish of considerable size, some of which are often in a partially digested condition."

CYANEA CAPILLATA CAUGHT IN THE ACT

This blue jellyfish with many hair-like tentacles is also a fish-catcher, and this habit has been recorded in a series of photographs showing the stages of capture of the fish. This is most fortunate for there is a great paucity of figures showing this habit in larger medusae. These voracious activities of *Cyanea capillata* will now be shown in the figures referred to (Figs. 2 to 5 herein). These are made from photographs by C. O. Bartels at Kiel and published in his book appropriately entitled "Auf frischer Tat"—"Caught in the Act"—(Part I, Stuttgart, 1910, series 15). These figures studied in sequence make the capture of the fish so clear that little explanation is needed. The *Cyanea* photographed was a comparatively small one, only about 2¼ inches in diameter. A larger one would not have been so easy to photograph.

In Fig. 2 (Bartel's No. 1) we see that a pipefish swimming by a jellyfish strikes two or three tentacles. The batteries of nettle-cells on these erupt and throw out on the fish many nematocysts and much poison. The fish struggles but

becomes entangled in more tentacles as may be seen in Figure 3 and is drawn nearer the mouth. In Fig. 4 all resistance on the part of the fish has seemingly ceased, and, suspended in the tentacles as if in a net, the posterior part of its body is brought closer still to the mouth of the jelly. Finally, in Fig. 5, the tentacles are seen almost completely retracted, and the fish, enveloped in these, is drawn up under the umbrella and close to the mouth of the *Cyanea*.

It should be emphasized that these figures are copied from photographs—the only ones ever made of this phenomenon, so far as I know.

GONIONEMUS MURBACHII, A FISH-CATCHER

This small medusa (its bell attains a diameter of only 15 to 20 mm.) is very common at Woods Hole, Massachusetts, where it has been much studied. Professor H. F. Perkins states that though small, it is a deadly foe to all baby fishes that cross its path. In a letter he gives in detail how one medusa captured and ate a fish. He placed in an aquarium a small *Fundulus* and eight mature medusae measuring from 12 to 18 mm. across the bell and accurately timed their reactions. Here is what took place:

It took eleven minutes for the fish to blunder into a medusa. In six minutes more it was completely wrapped up in its hostess and all struggles had ceased. The medusa immediately applied its lips to the fish and in seven minutes had succeeded in engulfing it. The camera was ready and the specimens, one inside the other, were transferred to a small dish and photographed with the camera pointing vertically downward at the medusa. The last sign of any contents in the stomach was seen as late as six hours afterwards, and this was a piece of the backbone of the fish.

Professor Perkins has kindly loaned me the negative, but since he had no way of lighting the specimens from beneath and since the fish was obscured by the thickness of the disk of the medusa, the negative is very "thick." The *Fundulus* shows up in it as such a dark mass that no details can be made out and hence it hardly seems necessary to reproduce it herein.

Perkins writes further that he saw another capture. A little pipefish was dangling from the manubrium of a *Gonionemus* which had suc-

Figure 2. (Below) The Hairy Medusa, *Cyanea capillata*, catching a fish—I. A pipefish swimming by is caught by three tentacles. After Bartels, 1910.



Figure 3. (Left) The many-tentacled Medusa catching a fish—II. Caught by more than a score of tentacles the pipefish is drawn to the Medusa. After Bartels, 1910.

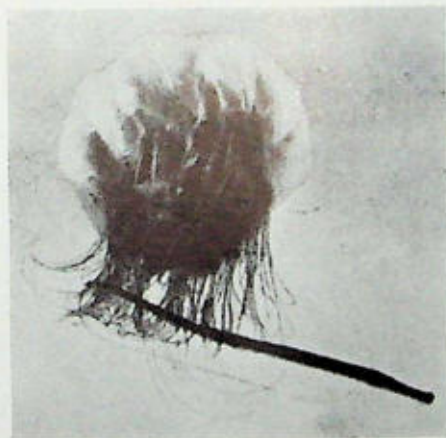


Figure 3. (Right) *Cyanea* catching a pipefish—IV. The pipefish now securely enmeshed in the tentacles is drawn close to the mouth. After Bartels, 1910.

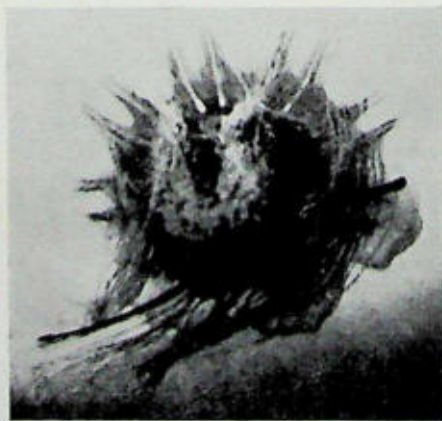


Figure 4. (Above) *Cyanea capillata* catching a pipefish—III. The anterior part of the fish's body is free, but the hinder half is enclosed in a meshwork of tentacles. After Bartels, 1910.

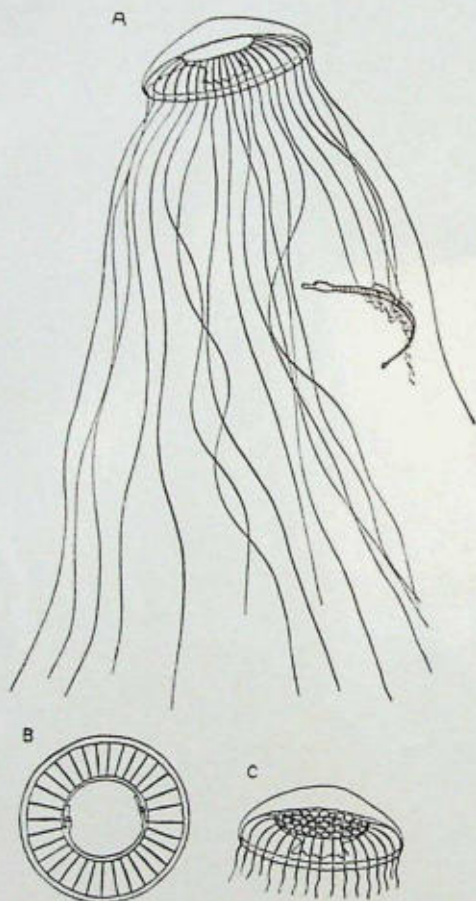


Figure 6. Young *Aequorea* feeding in an aquarium. A. A pipefish is snared by five tentacles. B. Two pipefish in a curious head and tail position in the stomach of the medusa. C. An *Aequorea* with the stomach filled with blennies. After Lebour, 1923.

ceeded in swallowing only the head. Apparently the medusa satisfied its hunger, for presently it dropped the fish.

Other like observations have been made on *Gonionemus* at Woods Hole. Thus Prof. R. M. Yerkes noted that among other things it ate small fishes, and in a letter to me he writes that he saw this take place a number of times. This is confirmed by Hargitt (1905), who states that *Gonionemus* and other small medusae often "gorge themselves with fry frequently too large to be swallowed."

THE ICHTHYOPHAGOUS AEQUOREA

Two of these flat-disked medusae (species not determined), 32-40 mm. in diameter were put in the aquarium. They caught their prey with their

tentacles (about 180 mm. long) and ate young blennies, pipefishes and *Lepadogasters*. The pipefishes were their especial *pièces de résistance*, one to three being eaten every day. Fig. 6A shows how a pipefish was caught by 5 tentacles. In Fig. 6B is shown a particularly neat head-and-tail arrangement of two others in the stomach of an *Aequorea*. The medusa shown in Fig. 6C is filled chock-a-block with blennies, and while digestion goes on it is quietly resting with retracted tentacles.

This data and much of that to follow are from Dr. Lebour, unless stated to the contrary.

ARACHINACTIS BOURNEI CATCHES FISHES

Bourne's spider-rayed medusa is so named from the long threads protruding from between the tentacles and used to catch little fishes. Dr. Lebour (1922) saw one catch a young sole and saw young sea-scorpions and blennies in its stomach. So it also must be put down as an enemy of young fishes. No figure is given.

BOUGAINVILLEA BRITANNICA A FISHERMAN

This British medusa, from a genus named for the great French navigator and explorer, Bougainville, is also a feeder on young fishes, as may be seen in Fig. 7. This very small medusa from the tow-net had caught a young sand-eel very much larger than itself, and with its lips tightly appressed was holding it fast when sketched. It must be put down as a feeder on little fishes.

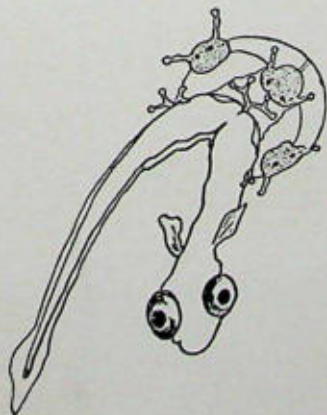


Figure 7. The British *Bougainvillea* eating a baby sand-eel. The little medusa holds the much larger fish securely. After Lebour, 1923.

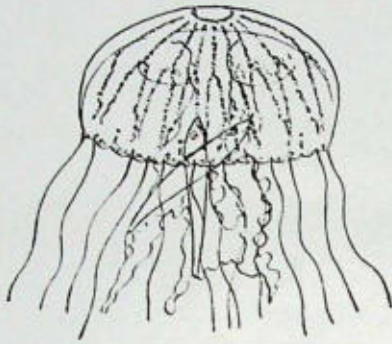


Figure 8. The Golden Sword Medusa with two captured pollack. The fishlets are held fast by *Chrysaora isosceles*. After Lebour, 1923.

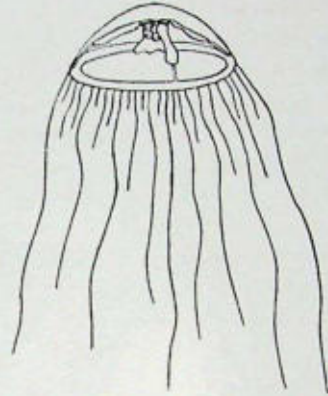


Figure 10. The Wave-riding Laodicea a fish-feeder. Three young blennies are seen in the stomach. After Lebour, 1923.

CHRYSAORA ISOSCELES FEEDS ON FISHES

This formidable name means the three-edged golden sword, probably in reference to the bright chestnut-brown tentacles of the medusa. It also is a dangerous foe to little fishes as Fig. 8 shows, for in the one figured are contained two small pollack. Specimens of this medusa were also seen (during both seasons) to feed on little cottids, blennies of two or three kinds, gobies, rocklings and even sticklebacks. They ate other plankton but preferred fishes—of almost any kind. The jellies measured about 25 to 60 mm. across, while the fishes were from 25-35 mm. long. *Chrysaora* is very voracious, rapidly catching fishes until the stomach is full—sometimes as many as four of the larger fishes were caught consecutively and within a few minutes.

COSMETIRA PILOSELLA A FISH-EATER

That the hairy (or many-tentacled) *Cosmetira* is well named, is shown in Fig. 9 where one is seen trying to swallow a Ctenophore (comb-jelly) quite as large as itself and has snared a little wrasse (*Labrus*) which would itself make a full meal for the 15-mm. medusa. The medusa also caught young cottids and Lepadogasters. When ready to feed, its tentacles are long and whiplash-like, but when digesting the prey they are very much contracted as the figure shows.



Figure 9. The Hairy Cosmetira a fish-catcher. A fishlet has been snared by the tentacles and a comb-jelly is held by the mouth. After Lebour, 1923.

THE VORACIOUS LAODICEA UNDULATA

The wave-riding Laodice is also a fish-eater. The one depicted in Fig. 10 (circa 11 mm. wide) while in the aquarium ". . . caught and ate several young blennies, *Blennius pholis*, catching them quickly one after

the other with its outstretched tentacles, until the stomach was full." At least three are contained in the stomach as shown in the figure.

OBELIA GENICULATA AN ENEMY OF FISHES

The Obelia with bent or jointed knees (referring to its whiplash-like tentacles) is very small, the one in the aquarium measuring but 4 mm. in diameter. It was not seen to catch small fishes, but from tow-net captures Dr. Lebour proved its fish-eating habits. Two contained young whittings, one a clupeoid, and three had captured baby dragonets. The Obelia with "bended knees" is a miscellaneous feeder which includes fishes in its diet. No figure was drawn.

PHIALIDIUM A DESTROYER OF YOUNG FISHES

The bowl-shaped medusa (so the name translates) was seen by Dr. Lebour (1922) to catch fishes as Fig. 11 shows. Directly a fish struck a tentacle it was benumbed and, several tentacles and the umbrella helping, was carried to the mouth. If there was difficulty the jelly would

turn upside-down and the fish would be dropped into the manubrium. Sometimes a strong fish would break away, and sometimes as much as 40 minutes were consumed in getting the prey to the mouth. In this way *Phialidium* (species not determined) was seen to eat young sea-scorpions, sand-eels, armed bull-heads, soles, blennies, gobies, clupeoids and wrasses. Various other plankton were eaten but fishes were seemingly preferred, and were digested in 5–6 hours.

Of similar habit on this side the water, Dr. C. J. Fish writes that:

During the year 1932, at the height of the herring spawning season in the vicinity of the Bay of Fundy, it was found that *Phialidium* formed an important enemy of the fry. For example, on our August cruise, at one station in the Bay of Fundy, 356 herring larvae were taken, 16 of which were in the stomach of *Phialidium* and 53 others showed signs of being partly digested before being released, probably in the net.

THE EVER-HUNGRY RATHKEA OCTOPUNCTATA

Rathke's eight-spotted medusa (named for the distinguished German zoologist), kept in Dr. Lebour's aquarium, never ate fishes but those from the tow-nets were often found attached to

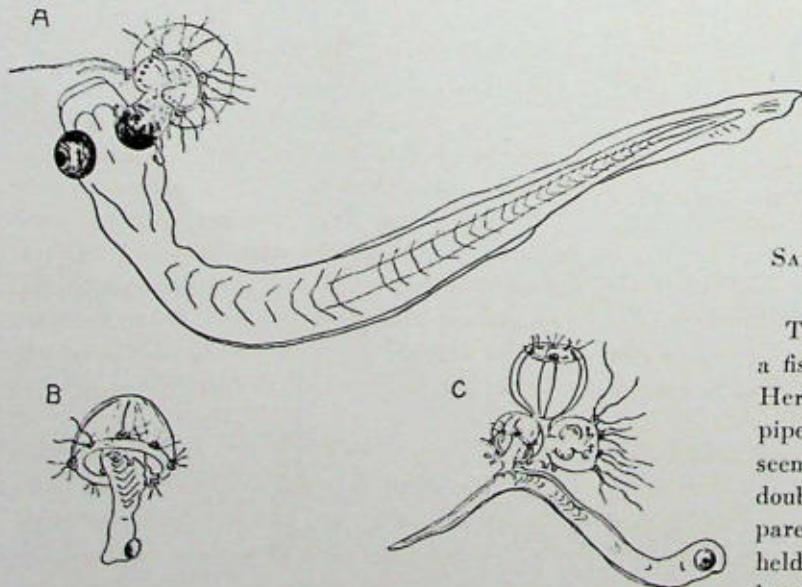


Figure 12. The Eight-Spotted Rathkea a fish-catcher. A. A very small medusa with its mouth has laid hold of a young herring many times larger than itself. B. A medusa is holding a young sprat in its manubrium. C. One of a group of medusa-buds has captured a young sprat. After Lebour, 1923.

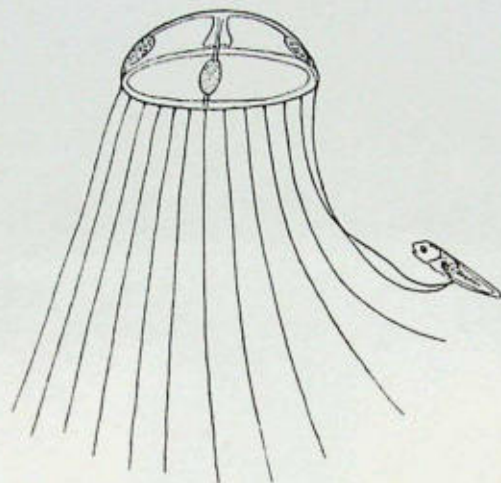


Figure 11. *Phialidium* snares a fish. Two tentacles hold the fish securely. After Lebour, 1922.

fishes, and continued to feed when placed in containers. In one case a small specimen had caught a baby herring many times too large for it, and infinitely too great to be taken into the mouth (Fig. 12A), but nevertheless was clinging fast to it with its labial tentacles. In another, which had medusa-buds on its manubrium, one of these buds had caught a young sprat as shown in Fig. 12C. Another had a young sprat sticking out of its mouth—see Fig. 12B. A few other

records are young sprat in two, young herring in one, unidentified clupeoids in six.

The voracious Rathkea does not seem to mind tackling a fish much larger than itself.

SAPHENIA GRACILIS CATCHES A PIPEFISH

The graceful *Saphenia* is also a fish-feeder as Fig. 13 portrays. Here the medusa has caught a pipefish (these various medusae seem fond of pipefishes) with a double turn of its manubrium. Apparently this would securely have held the fishlet, but one is glad to have Dr. Lebour say that after a lengthy struggle the little pipefish got away. Other prey was taken

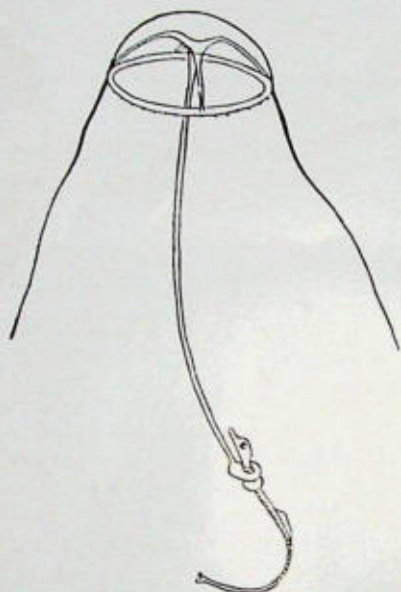


Figure 13. The graceful *Saphenia* with its prey. A pipefish is held by a double turn of the manubrium—a most unusual use of the bell-clapper. After Lebour, 1923.

with the manubrium, which was very flexible and seemed to be provided with stinging cells. The use of the manubrium as a lasso for little fishes is a most unusual one, never noted for any other medusa.

STEENSTRUPIA RUBRA A FISHERMAN

The red medusa of Steenstrup (a well-known Danish naturalist) was never seen by Dr. Lebour to feed in the aquarium, but tow-net records show several full of fish-eggs, while two other contained young sand-eels and one a young clupeoid. Hence they are not merely general plankton-feeders but fish-eaters also. No figure was given.

THE VORACIOUS TURRIS PILEATA

The spotted turret- or mitre-shaped medusa is also a fish-catcher as Dr. Lebour's figure (No. 14 herein) shows. This particular specimen has a little sea-scorpion caught on a tentacle. By vigorous efforts, lasting ten minutes, the fish broke the tentacle off and ran away with it. The two cottids in the manubrium were not so fortunate. This turret-medusa is very voracious—it caught, ate, and digested (after several days) a young squid larger than itself. Experiments in 1923 showed Dr. Lebour that

Turris pileata is a dangerous medusa to keep in an aquarium since it is both omnivorous and extremely voracious. Two from the trawl for taking young fish contained little whittings longer than themselves. In Fig. 15, one of these medusae is shown stretched to a length of 25 mm. with the little whiting almost completely filling the stomach. Another contained a 17 mm. whiting. Of two others one contained a young cottid, the other a little dragonet.

LINUICHE UNGUICULATA A FISH-KILLER

Next to be recorded as a fish-eater is that medusae noted by William Beebe in his "Beneath Tropic Seas" (N. Y., 1928, pp. 21-23) as thimble or finger-nail jelly. When brought in to the laboratory, "Not only did they paralyze and engulf some of the small fishes which I had been at pains to capture and unwisely place in the same compartment, but they somehow chose only the more succulent portions, rejecting the heads and tails." Next day when diving out on the reef in Port-au-Prince Bay, Haiti, Beebe saw



Figure 14. The Turret-Medusa a capturer of young fish. Two sea-scorpions are held in the mouth and another has just been snared by a tentacle. After Lebour, 1922.

thousands of these thimble-jellies and observed that in a number he could make out the outlines of the bodies of very small fishes.

TAMOYA HAPLONEMA CATCHES FISHES

In Port-au-Prince Bay, Haiti, Beebe (*op. cit.*, pp. 85-86) found many medusae of this genus and species. These are akin to *Charybdea*, noted earlier, and have similar habits. They not only acted as hosts and protectors for small "Bumpers" (*Chloroscombrus chrysurus*) but fed on them as well. He saw live fishes within the jellies and he also "saw four of these fish which were killed by the nettle lariat, three of them already drawn well inside the mouth. The fourth I saw caught, and after a terrific struggle it managed to snap free, but sank dying in the water."

TIMA FORMOSA AN ENEMY OF FISHES

For data on the fish-killing habits of this medusa, I am indebted to the courtesy of Dr. C. J. Fish. He writes that:

In 1924, in Massachusetts Bay, at a time when the sand-eels were filling the waters

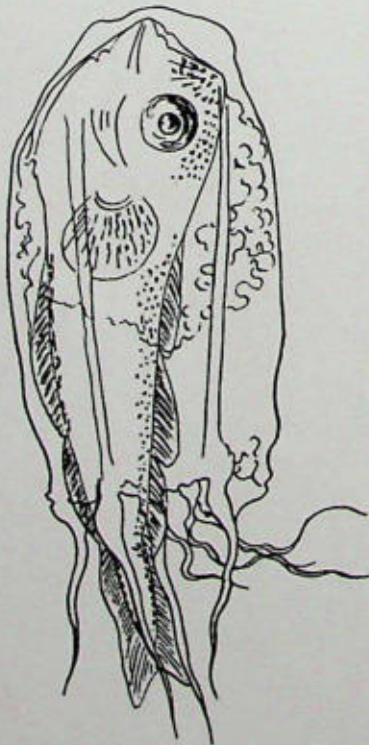


Figure 15. The Turret-Medusa with a young whiting. To accommodate a fish longer than itself, the medusa has narrowed and elongated its body. After Lebour, 1923.

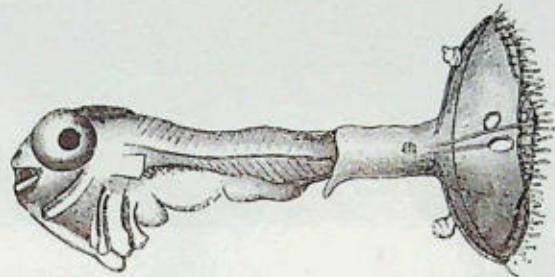


Figure 16. A *Pleurobrachia* endeavoring to engulf a little flounder and becoming everted in the process. After Masterman, 1897.

with fry, *Tima formosa* was taken in almost every haul with from 2 to 3 sand-eels (ranging from 20 to 25 mm.) in the manubrium. These could not have been taken after the specimens were confined in the plankton bucket as in each instance the specimens were partly digested.

PLEUROBRACHIA A FLOUNDER-CATCHER

McIntosh and Masterman in their "Life-Histories of British Marine Food-Fishes" (London, 1897, p. 61, fig. 11) state that jellyfishes, particularly those of this genus, are very fond of post-larval fishes and thus play a part in keeping down their numbers. Illustrative of this is their Figure 11 (Figure 16 herein) showing this jellyfish endeavoring to ingest a deep-bodied baby flounder larger than itself. The struggles of the little fish have caused the jelly to become turned inside out, a thing possible because of the simple organization and marked distensibility of the coelenterate. The representation is a rather weird one, but its authenticity is attested by the fact that it was drawn by Masterman himself.

THE EFFECT ON THE FISHERIES OF THE DEPREDATIONS OF MEDUSAE

Dr. A. G. Mayer in his "Medusae of the World" (1910) listed 737 species of Medusae (mainly marine). Of these forms, 27 are shown in this article to be fish-eaters, and presumably hundreds of others have like habits. In fact there is little reason to doubt that all of them may catch and eat small fishes. Then when one recalls the billions of Medusae large and small in the oceans one must believe, on the basis of the data set out above, that these animals play no small part in restricting the fish-food supply

of mankind. Most of these abounding medusae are small but others are very large as Hargitt and Agassiz state. The great abundance of large medusae is well known to those who have been much about the sea.

Martinus Slabber, apparently the first man to see and describe a medusa in the act of catching a fish, was also the first to remark (1778) on the effect on man's food supply of the fishing habits of the jellyfishes. He comments upon the countless numbers of jellyfishes in the sea and then says:

One here sees clearly that, however small the jellyfishes are, they are very harmful to the fishes since according to the increase in size of the jellyfish they catch larger fishes. By the great numbers of jellyfishes, which use the fish as food, an astonishing number of fishes must be swallowed as food as has been revealed by my observation of this small jellyfish.

The more or less occasional observations of various authorities quoted herein are cumulative in their evidence that medusae (mainly adults) feed freely on fishes. Then Dr. Lebour's careful experiments and observations of these habits in young medusae must convince the most skeptical that the innumerable hordes of jellyfishes, young and old in the sea must be responsible for a tremendous mortality in the young fish population therein. Then must be added the observations of Dr. Fish covering many years of work with vast collections of plankton. He states, with reference to three forms only, for which he had data immediately at hand wherewith to answer my inquiry, that *Aurelia*, *Phialidium*, and *Tima* "proved of very vital importance in depleting the flounder stock," in ravaging the hordes of young sand-eels, and in taking heavy toll of young clupeoids. Dr. Fish purposes, when time and opportunity permit, to bring together for publication his extensive first-hand observations covering many years on the fish-feeding habits of medusae. His paper will be awaited with much interest.

MUCH DATA ON COELENTERATES

Starting out on this study with but few references, I have been surprised at the large number of records of Coelenterates as feeders on fishes. First were set off, as article I of this series, the doings of Hydras and Colonial Hydroids; and

now, instead of including all the higher Coelenterates in a second paper, I have been forced to limit the story to the Medusae only. There is still left enough data on other animals of this great group to make one or more additional papers before the story is finished of "Coelenterates as Enemies of Fishes."

Another Reservoir for the Aquarium: In July 1908, the Aquarium put into operation a reservoir holding 100,000 gallons of pure sea water brought by steamer from the Ocean. The marine exhibits of the institution could no longer be maintained in the brackish and polluted water pumped from the harbor. This stored sea water system has been in highly successful use ever since, losses due to foul water being eliminated.

The Aquarium will soon use a similar stored water system for its fresh water exhibits. For many years the fresh water supply drawn from the City system has been discolored during the winter months, although satisfactorily clear in summer. This turbidity is caused by a fine semi-colloidal suspension of clay that in no way interferes with the potability of the water. It does, however, seriously interfere with visibility and cannot be removed by any ordinary or practicable filtration because of the microscopic size of the particles.

A reservoir for the storage and control of the fresh water required for the Aquarium is now under construction by the Civil Works Administration, funds previously sought for this purpose not having been secured. Half of the living exhibits of the Aquarium represent forms of life inhabiting fresh waters. The presence of clear water in the tanks devoted to them will relieve the institution of a serious drawback. The entire system is being constructed of non-metallic materials which are much more satisfactory for such purposes. —C.H.T.

Air Transportation of Fishes: The interest in small tropical fresh-water fishes suitable for domestic aquaria continues to increase, and competition for new specimens is keen.

The planes of the Pan-American Airways, flying across South America, carry shipments of these fishes on every flight from Manaus to Para, where the fish are conditioned for transportation to New York, the center of distribution.—C.W.C.

Some Notes on the Curious Behavior of Two Gymnotid Eels from South America:

Sternarchus albifrons (Linnaeus), from a tributary of the River Amazon, and *Gymnorhamphichthys hypostomus* Ellis, from a small stream near Para, Brazil, captured by Mr. Karl Griem and recently acquired from him by the New York Aquarium.

C. W. COATES

IF any credence can be placed in the superstitions of South American Indians, a rather remarkable fish has recently arrived at the Aquarium from Brazil, bringing with it the spirit of some dead person or a personal devil, either or both of which are supposed to inhabit its body.

Although of wide distribution, ranging from the Orinoco in Venezuela to the Rios Paraguay and Parana in Brazil, and reaching more than one foot in length, it is seldom seen. Travelers interested in such matters inform us that they have not found more than four or five natives of the whole territory who have ever seen one. Scientific observations are equally sparse, for in spite of the somewhat extensive fishing in these waters by representatives of museums and similar institutions, only four had been recorded by 1923. Most of the local Indian tribesmen seem to know it, by reputation at least, and it has at least three Indian names. The Guianan version of these is "Cheeogaa," the Brazilian, "Tovira cavallo," and the Indians of the region near Cuyaba call it "Man tchiogaa."

The fish is of a lovely velvety blackness with a light-colored line running from the mouth over the top of the head and along the back to almost half-way down its body. Two broad bands of a similar light color completely encircle the body near the tail, the one nearest the tail being the narrowest. These bands and the stripe are recorded as ranging from rose-pink to red. In the specimen received at the Aquarium they are all pale gold. Records also give the eye color as bright red, turning to bright china-blue in preservative, but the color of the eye of our specimen is jet black and it is almost impossible to distinguish where the eye is, so similar is it in color to the skin of the animal.

The shape of the fish is graceful, as are all its movements. Roughly eel-shaped, there is a

broad anal fin extending from just below the head to the tail. This fin is quite black except where it is crossed by the two bands referred to previously. The pectoral fins—large and well-rounded—are also jet black.

The whole appearance of the animal is very attractive, and there is nothing about the fish which would indicate any traffic with the nether regions, unless it is the fact that the creature habitually swims on its back or side, or "stands" for hours motionless, on its tail, or swims with equal facility backwards or forwards. It is unlikely, however, that even these peculiarities can be the cause of its unsavory reputation if we are to believe in its extreme rarity, for in the few times it has been viewed by natives, and the four or five times captured or killed by scientists, such odd positions of rest and locomotion would scarcely be observed. At least they are not mentioned anywhere. There is also no mention of the fish ever having been exhibited alive before.

With the *Sternarchus*, Mr. Griem brought back to us several specimens of *Gymnorhamphichthys hypostomus* Ellis. These fish were between four and a half and six inches long, and were taken in a small forest stream in the vicinity of Para, Brazil. They were translucent; almost transparent. So much so, in fact, that the vertebral column was clearly seen. A fine black line ran from behind the head to the tail parallel with the backbone, and about half-way between it and the lower margin of the body. Another broader line ran almost along this edge, and the two lines were connected by a series of fine striations about one-eighth of an inch apart. These lines are not visible in alcoholic specimens.

As with all the members of this family (Gymnotidae) the head and intestines are situated closely together and are not longer than about one-fifth of the total body length. The anal fin, which is also transparent, is broad—almost as



Stenarchus albifrons. The position, with the nose not quite touching the surface of the water, is characteristic. The head of *Gymnorhamphichthys hypostomus*, sticking out of the sand, is just visible to the left of the upper band on the tail of *Stenarchus*.
Photo by S. C. Dunton.

broad as the body in parts—and extends from just below the head to about one inch from the tail proper. This fin is in constant motion whether the animal is swimming or not.

The fish spent all the daylight hours buried in the sand at the bottom of the aquarium, only coming out into free water at dusk. Our observations tally with Mr. Griem in this, that the fish makes its first appearance above the sand at about seven o'clock in the evening, whether or not an artificial light was kept burning continually. If the sand was raked over, the fish might be driven out into the water, but it would immediately arch its "neck," and with the body held stiffly and the anal fin vibrating rapidly, make little rushes at the sand at the bottom of the tank. For some reason one spot was preferable to another although the sand was of the same texture and looseness, as far as we could judge. After several gentle dives at the sand, during which the nose of the fish would enter the sand perhaps a quarter of an inch and then be withdrawn, the fish would dive into the sand with the utmost ease and rapidity, wriggling forward until the last vestige of the slender tail had disappeared. Not always, but frequently, the nose of the creature would reappear, sticking out about one-eighth of an inch above the sand where it would remain all day unless disturbed. When the nose was visible the eyes of the fish might also be observed. From the movements of these, the fish seemed to be taking a deep interest in what was transpiring.

As many as fifteen different attempts to find some suitable spot in which to burrow were observed. If the fish was disturbed near the tail, it would first of all try to wriggle under the surface of the sand out of reach, but if the disturbance was persistent the fish would suddenly appear and after swimming about the tank for a few seconds, would go below again. If the disturbance took place near the head of the fish, it would reappear tail first. On no occasion was the fish observed above the sand of its own volition while it was light, except when it was ill and about to die. However, fish kept in a dark tank would sometimes be found swimming above the sand, only to disappear immediately a light was turned on. This was during the daytime. A light turned on at night was apparently

unnoticed, the fish proceeding with their meals of small worms quite indifferently.

All of the fish we received died after a short while for reasons we were unable to identify, for the water in which they were kept was the water in which they were captured, and the sand was brought from their own streams. The food, Tubifex worms, were also the same as they apparently were in the habit of catching, and the manner of demise was the same in each case. The fish would be observed above the sand for increasing periods during the day and the next morning be found dead.

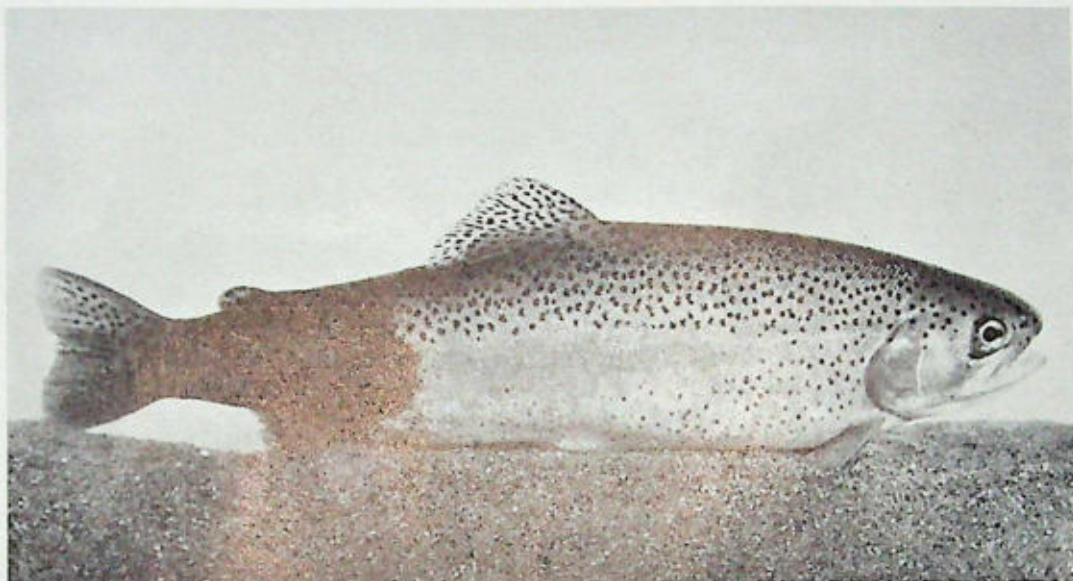
Black Tail of Trout and Salmon

ROSS F. NIGRELLI

MOST of us are familiar with the ability of certain fishes to change their color. Functionally, this reaction is due to the contraction and expansion of pigment cells (chromatophores¹) which are under the control of the sympathetic nerves. Thus, if a flounder is placed in a tank with a white background, all of the black pigment cells will immediately contract and the fish will appear pale. If the fish is placed in a tank with a black background, the cells will expand and the fish will take on a darker color. When placed in a tank with a black and white bottom, the fish will tend to assume this black and white coloration by expanding certain groups of cells and contracting others. It is interesting to note that the above reaction depends entirely on vision. A blind fish cannot vary its color with the environment.

For the past several years trout and salmon hatched and reared in the Aquarium have shown a condition in which the black pigment cells (melanophores) of the tail region become more or less permanently expanded. As a result about 25% of the fishes that have been successfully reared appear with a "black tail." This abnormal coloration first makes its appearance in 5-6 month old fingerlings, and in fully grown trout one-fourth to one-half of the body is thus affected. In year-old salmon it extends forward, midway from the tail fin and the posterior border of the dorsal fin.

¹Nerves which control organs that function unconsciously.



A rainbow trout (*Salmo irideus*) hatched and reared in the Aquarium, showing a typical "black tail." This fish is about twelve inches long and two years old, and is normal in other respects. Photo by S. C. Dunton.

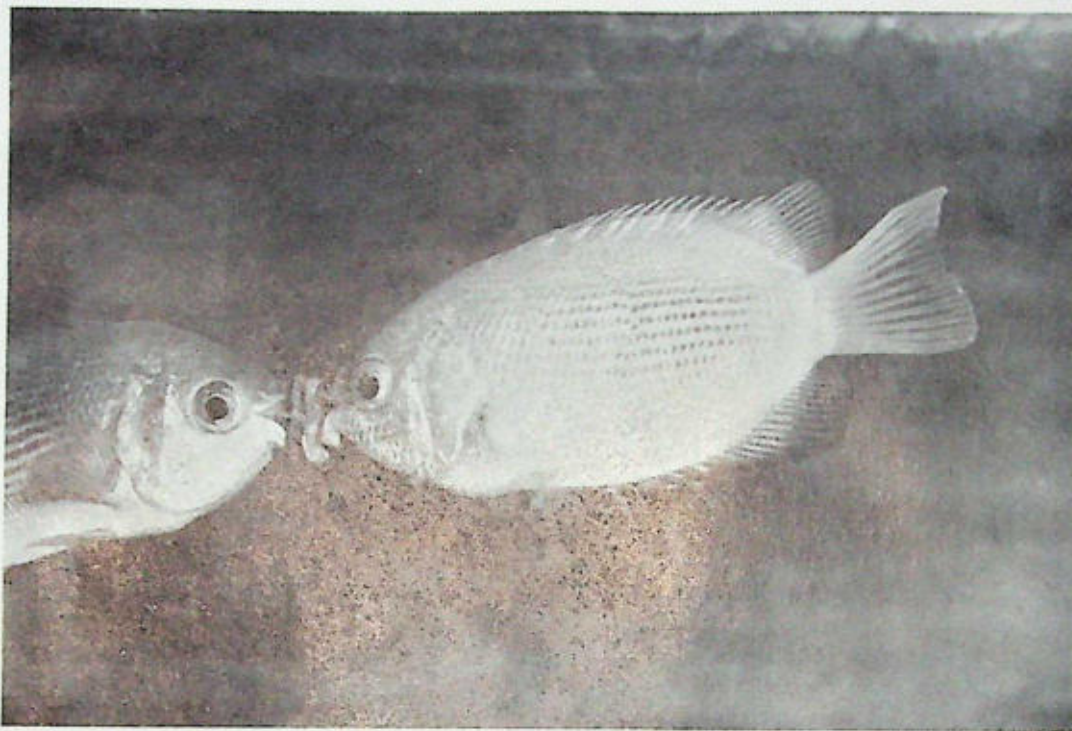
Preliminary observations as to the nature of this condition have shown the following: (1) that an injection of a small dose (0.1 cc.) of adrenalin, or the application of the drug directly on the affected area, will cause a contraction; (2) placing the fishes with the black tail in a tank with a white background does not cause a contraction of these pigment cells, but those of the trunk and head readily contract; (3) placing them in a tank with a black background will cause all of the black pigment cells to expand, but the black tail can still be distinguished. Because of such reaction it was thought that the condition might be one of melanosis or overproduction of pigment cells, but a comparative count of the pigment cells in an area about 1 mm. sq., in both black-tail and the tail of a normal fish, showed very little difference in the number and size of cells. (4) All of the black pigment cells will contract on the death of the fish.

The black-tail of the Aquarium fishes must not be mistaken for a somewhat similar condition associated with a disease known to the German investigators as "staggers," which is caused by a specific parasite. Primarily, this parasite affects the organ of equilibrium, resulting in peculiar gyrations; secondarily, it becomes lo-

calized in the tail and forms nodules which press on the sympathetic nerve fibers that control the pigment cells in this region. This results in the appearance of a black-tailed condition. But in this case the nerves controlling the muscles are also affected, so that eventually the tail atrophies, invariably causing the death of the fish.

Examinations for such an infection in Aquarium fishes affected with the black tail gave negative results. These specimens are normal in their behavior, and some of the adult trout, weighing about three pounds, still show the condition. Mr. H. Dixon, of the Aquarium staff, who has observed this phenomenon for a number of years, claims that some of the fishes have reverted to the normal pigmentation.

From the above analysis, it may be concluded that the black tail of the trout and salmon in the New York Aquarium is due to a more or less permanent paralysis of the nerves controlling the posterior pigment cells. The basic cause of the paralysis has not yet been determined. At this writing its determination represents one of the innumerable problems that concern those charged with the maintenance of a satisfactory collection of living fishes.



The "kiss" of the Kissing Gourami. The enlarged lips are contracted and not visible except at this time. Photo by S. C. Dunton.

White Kissing Gourami

C. W. COATES

A PAIR of Kissing Gourami, *Helostoma temmincki* Cuvier and Valenciennes were received by this institution in exchange with Rotterdam Aquarium. One pair of this species had already been received from the same source—a large, full-grown pair which had been on exhibition in Rotterdam for three or four years before their transfer to New York. This first pair, which antedated the arrival of specimens of the species commercially, achieved world-wide notice through motion pictures which were taken of the curious "kissing" indulged in by the fish. However, the first pair were of the type coloration of the species, a sort of brassy green-brown with darker lateral stripes throughout the body. The second pair are a very pale pinkish white, which changes according to the angle at which they are viewed, into a greenish, yellowish, or brownish silver. The actual colors are quite pale, and the fish well deserves the designation of "white."

Other than this pair, there are no records of any fish of the species of this color ever being exhibited, or, indeed, caught, and we are indebted to Dr. Kuiper, Director of the Rotterdam Aquarium, for his generosity in allowing us to acquire such rare specimens.

The "Kiss," which is such a curious development in fish behavior, is performed when both fish extend the lips of the sharp, slightly superior mouth into broad rings, and both fish swim or hover in the water with their lips in close contact for a considerable period. This may last as long as twenty-five minutes, or just a few seconds, but the longer periods are more usual. For periods of several weeks no kissing may be observed, while at other times the fish may be in juxtaposition several times a day.

The biological significance, if any, is not understood, but observation indicates some reproductive connection, for the larger of the two which is the male, apparently, may be seen during the times when the "kissing" takes place, to be driving the other which usually tries to swim out of the way. When the larger approaches too

closely, the smaller turns to face it and extends the lips in the characteristic gesture. If the larger touches the lips, either a "kiss" or a turning away takes place, but if the smaller does not turn in time and extend her lips, she will suffer a severe bite. Younger specimens under observation seem to bear out the idea of courting activity, or at least sex recognition, for when the same driving takes place between two males of different sizes, the "kiss," when made in time, is of the briefest duration and is immediately followed by an attack by the larger.

These white specimens, which have a little color as has been noted, and dark blue or black eyes, are not pure albinos in the accepted sense of the word and are the third species of Labyrinth fishes to come to notice as developing light strains. The first was the "Betta Cambodia," a pinkish white strain of the popular and colorful *Betta splendens*. This strain, either naturally or through too much cross-mating with colored members of the species, does not breed true but throws off large proportions of variously colored fish in each brood¹. Usually, too, some if not all of the fins are tinted, sometimes richly. The second species of the family to develop white strains was *Macropodus opercularis*, the attractive Paradise Fish of Southern China. A few specimens of these White Paradise Fish are undoubtedly albinos, for the eye is pink, and apart from a slight flesh-pink tinge throughout the body, the fish is colorless. However, the vast majority of the White Paradise are by far not complete albinos, for they display slightly shaded bands across the body, in place of the characteristic red or blue lines of the ordinary fish, and a dark blue or black eye, as in the White Kissing Gourami.

African Fishes: Through the courtesy of the American-South African Line, a regular exchange system of fishes has been built up between the East London Aquarium, South Africa, and this institution. The fishes are transported by Mr. A. M. Vida, radio operator of the M/s *City of New York*, with the aid and cooperation

¹This finding is based on numerous broods of the fish in this institution and is contradictory to that of Goodrich and Mercer, (*Science* 79 (2049): 318, April 6, 1934) who state that Cambodia always breed true.

of Captain George M. Wauchope and Chief Officer Paul S. Maguire.

Many valuable and rare specimens have arrived safely in New York on this modern fast liner, including zebrafish *Pterois volitans*; lungfish *Protopterus annectens*; mudspringer *Periophthalmus koelreuteri*, and blackfooted penguins *Spheniscus demersus*. In return the New York Aquarium has sent specimens of local and West Indian fishes which are highly valued in South Africa.

The officers of the ship capture fishes, in addition to those exchanged, and the Aquarium collection has been enriched by many spectacular and otherwise unobtainable specimens from the Island of St. Helena, Durban, South Africa, Portuguese East Africa and the Pungue River.

The ship has been equipped by the Aquarium with a number of tanks of different sizes, and an air pump. Most of the tanks are arranged around the back of the radio room. Here they are under the constant supervision of Mr. Vida, who is most active in the care of the creatures.

—C. W. C.

Amazon Fishes: The Aquarium received one specimen of Pirarucu, *Arapaima gigas*, from Marajo Island, Brazil, during February, 1934. This fish, which was a little over two feet long, was the sole survivor of five which were sent here; the other four, unfortunately, dying of cold in the harbor before they could be removed from the ship.

The specimen which arrived alive seemed to take kindly to its aquarium. It showed an intense interest in its surroundings, rather unusual in fishes, and was particularly interested in the flame of a match near the glass of the aquarium, following the flame about as it was moved. We were in hopes of keeping it alive until it reached full size—about fifteen feet long—but the fish did not live for more than one month, dying probably from the delayed effects of the severe chill it received on the ship. The body has been mounted and is now on display in the American Museum of Natural History.

The exportation from Brazil of this species is prohibited, but we hope to receive one or two more specimens in the near future, through the courtesy of the Governor of the State of Para, and to be able to keep them on exhibition until they have achieved full size.

—C. W. C.

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c. Stump-tailed Skink	i. Gila Monster	o. Moloch Lizard
d. Green Lizard	j. Alligator Lizard	p. Flying Dragon
e. Black Tegu	k. Glass "Snake" American	q. Armed Agama
f. Spotted Amphisbaena	k. Glass "Snake" European	r. Bearded Dragon
g. Common Boa	l. Spiny Lizard	s. Common Chameleon

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BULLETIN

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Giant Monitors, *Varanus komodoensis* in the Zoological Park. The specimen now on exhibition is a tride over eight feet in length. Photographs by Elwin R. Sanborn.

BULLETIN

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The Giant Monitors of Komodo

RAYMOND L. DITMARS

Curator of Mammals and Reptiles, New York Zoological Park

ON May 12, 1934, three Giant Monitors, *Varanus komodoensis*, arrived at the Zoological Park. They were captured on the small island of Komodo in the Dutch East Indies, during an expedition conducted by Lawrence T. K. Griswold and William H. Harkness. This is the second time that these "dragon" lizards, as they are popularly called, have been exhibited in the Park. The first occasion was in 1926, when two were delivered by the Douglas Burden Expedition. The first specimens lived only forty days.

The Komodo Monitor was unknown to science until 1914, when this enormous lizard was named by Major P. A. Ouwens, late Director of the Buitenzorg Museum in Java. It was thought for quite some time that a giant lizard of some sort inhabited Komodo Island and possibly the small islands to the west of Flores. The two mentioned expeditions found ample proof as to the abundance of lizards up to fully twelve feet in length, massive in build and attaining the weight of two hundred and fifty pounds or more—a relatively great weight for a lizard.

The natives of the islands had long feared this savage meat-eating creature, that was capable of dragging off wild pigs bodily. The "dragons" were numerous on Komodo Island, which is hilly—and rocky—in parts. They were attracted to box traps baited with wild swine. The dead swine were easily torn to pieces and gulped down.

The Griswold-Harkness Expedition obtained a permit from the Dutch Government to cap-

ture a restricted number of specimens, as the Dutch officials have taken strict measures to prevent extermination of the remarkable reptiles. Eight monitors were caught by means of a large, wooden trap. Four were deposited in the Soerabaja Zoological Gardens in Java, and four were taken out of the country. One died during the sea journey to the United States, and another died shortly after arrival in New York. A third was sent to the National Zoological Park at Washington, D. C., and the fourth remains at the New York Zoological Park.

The example on exhibition here is slightly over eight feet long. It is housed in the easterly portion of the Reptile House and has access to indoor and outdoor enclosures. The exhibition quarters have specially constructed platforms and water tanks. Apparently in fine condition, the reptile is fed about every five days, an alternate diet consisting of twelve eggs, two pigeons or a moderate size chicken. The spectacular creature can be seen by the public from both indoors and outside.

The monitors, family *Varanidae*, to which the "dragon" lizard belongs, contains a single genus made up of twenty-seven species. The distribution covers Africa, India, Malaysia and Australia. Among the members are the largest and heaviest known lizards. They are flesh-eating and voracious, and in a wild state vary their diet with the eggs of the larger birds, and some species dig up the eggs of crocodiles. The most characteristic feature of the genus is the ex-

tremely long, deeply forked tongue. In proportion to the size of the head, the tongue is much longer than that of snakes. As a monitor progresses, the tongue is kept constantly darting in evident investigation of nearby objects. Another striking peculiarity is the long neck. On this the head may be drawn back to a considerable extent, enabling the powerful reptile to make a quick dart in capturing prey. The tail is long and heavy. Among the desert species it is round, while others have a compressed tail and are excellent swimmers.

The largest known species inhabits Komodo Island. Next in size is the Indian Monitor, or Kabara-goya, *Varanus salvator*, of easterly Asia and the larger islands of Malaysia. It reaches a length of nine feet, is active and powerful, but

of relatively much lighter build than the Komodo species. The Desert Monitor of Africa and southwesterly Asia is much smaller in size.

The feeding habits of the monitors are rather characteristic. The prey is seized in the strong jaws and violently shaken, then quickly swallowed, without mastication. Eggs are delicately manipulated to be dropped down the throat without breaking the shell. Kept indoors, monitors are rather docile and can be approached without difficulty. When allowed to remain out of doors in the air and sunlight, a peculiar mental change takes place and they become savage and wild. When returned to inside cages, they soon quiet down, although high temperature, required by all the species, is steadily maintained.



Whence Came The "Dragons of Komodo"?

WILLIAM KING GREGORY

Fellow of the New York Zoological Society

AT the first sight the famous "Dragons of Komodo," one of which is now on exhibition in the New York Zoological Park, may prove to be somewhat of a disappointment to the average visitor, whose ideas of dragons are apt to be colored by the fearsome monsters embroidered on Chinese screens. Indeed, the cynic, viewing this rather sluggish saurian for the first time may well suspect that these imposing reptiles may owe a good part of their fame to the enterprising journalist, whoever he may be, who landed his story of the Komodo lizards on the front page by the simple device of labelling

them "dragons," hinting also that they might be the original of the Chinese dragon.

But the typical Chinese dragons are essentially four-footed serpents, garnished with horrendous accessories often including the clawed feet of an eagle and a malevolent devil-mask face, with horns. The poor Komodo lizards, on the contrary, are plump-bodied, sprawling things, with a vacant stare and a face devoid of evil embellishments, except of course the forked tongue.

The mysterious power of poisonous snakes to strike and instill swift-coming death into man or beast has often been regarded by the credulous



Fig. 1. The Dragons of Komodo "at home." Mounted group from the Douglas Burden expedition, in the American Museum of Natural History.

mind of *Homo sapiens* as a valid claim for the divinity of the death-dealers. But the carvings on the temples of the snake-gods, from Central America to Cambodia, apparently lend no support to the suggestion that any of the images of these deities could have been based directly or indirectly upon the Komodo lizards. However, the latter might plausibly claim a real cousinship to the dragon of St. George, since the mediaeval artists who created this reptile were probably familiar with the common lizards of Europe. The good old German dragon of Siegfried belongs to the same family, but is instantly distinguishable by his ultra bass voice and fire-spitting habits.

Another ingenious reporter started the rumor that some scientists are inclined to regard the Komodo dragons as the lineal descendants of the dinosaurs of past ages. This rumor may persist in spite of the fact that if we consider the family tree of reptilian life as a whole we see that the Komodo lizards represent only particular twigs of the great lizard group and that the nearest relatives of the lizards are not the dinosaurs but the snakes. The dinosaurs, on the other hand, sprang from a very different section of the tree and in order to find the common ancestors of lizards and dinosaurs one would have to seek far down the main stem of reptilian life.

The query, "Whence came the dragon lizards of Komodo?" can be most conveniently answered, it seems, by a brief summary of some pertinent findings of palaeontology and other branches of science that throw light upon the history of the reptiles.

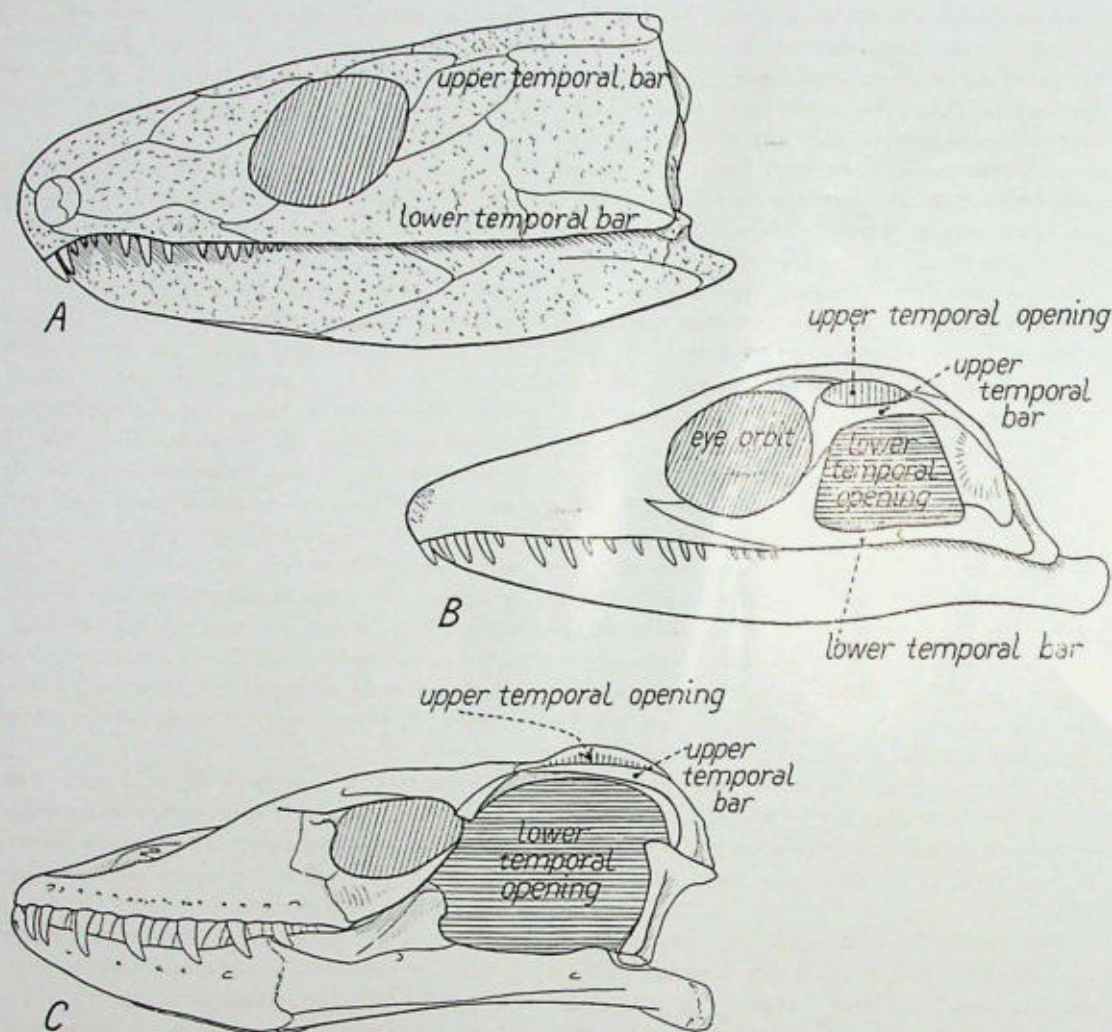
The origin of the first filterable virus is probably an affair of two billion years ago; the origin of the vertebrates would be of the order of magnitude of half a billion years; that of land-living amphibians in Lower Devonian times is estimated at 330 million years. At any rate we now have actual fossil amphibians from the Upper Devonian of Greenland which represent an early stage in the adaptation of air-breathing fishes for life on land. The earliest known reptiles, dating about 250 million years ago, from the Upper Carboniferous of Pennsylvania, Ohio, Texas, France and Czechoslovakia, were lizard-like in general appearance; but in the temporal region of their skulls there was a continuous

shell of bone covering the jaw muscles, a part of the "bony facial mask" of their fish ancestors. Some millions of years later, in the Permian age, the reptiles had already become considerably diversified.

In the remote ancestors of the mammal-like reptiles, a single round hole had been developed in the bony mask of each cheek, above the jaw muscles; but in the common ancestors of the lizards, dinosaurs and other groups, two such round openings, one above the other, had appeared. These upper and lower fenestrae, or windows, were separated from each other by horizontal strips of bone, called respectively the upper and lower temporal bars. In the lines leading to the varied dinosaurs both the upper and lower temporal fenestrae and their accompanying bars were retained; in the ancestors of the lizards, however, the lower temporal bar gradually became absorbed, leaving intact the upper part of the lower temporal opening, the upper temporal bar and the upper temporal opening. Such is the arrangement preserved to this day by lizards in general, including those of Komodo (page 71).

True lizards date back to the Upper Triassic period and are thus contemporaneous with the oldest known dinosaurs. During the later part of the Age of Reptiles, especially during the Upper Cretaceous period, beginning one hundred million years ago, the order Squamata, which includes the lizards and snakes, enjoyed a great "adaptive radiation" (pg. 80). The remote ancestors of the varanoid or monitor lizard group gave off in one direction an amphibious branch which finally culminated in the mosasaurs or true sea lizards of the Upper Cretaceous of Kansas, New Jersey, France, New Zealand and many other parts of the world. In the opposite direction, the lizard ancestors of the snakes gradually reduced their legs, even to the point of complete disappearance and at the same time absorbed both the upper and lower temporal bars of their skulls. Meanwhile the central monitor stock persisted to give rise to the recent and fossil monitor lizards of Africa, India, the Malayan region and Australia. Of these the Komodo lizards are most closely related to recent and extinct monitors of Australia.

The visitor to the Australian Museum in Sydney, New South Wales, may see in a certain



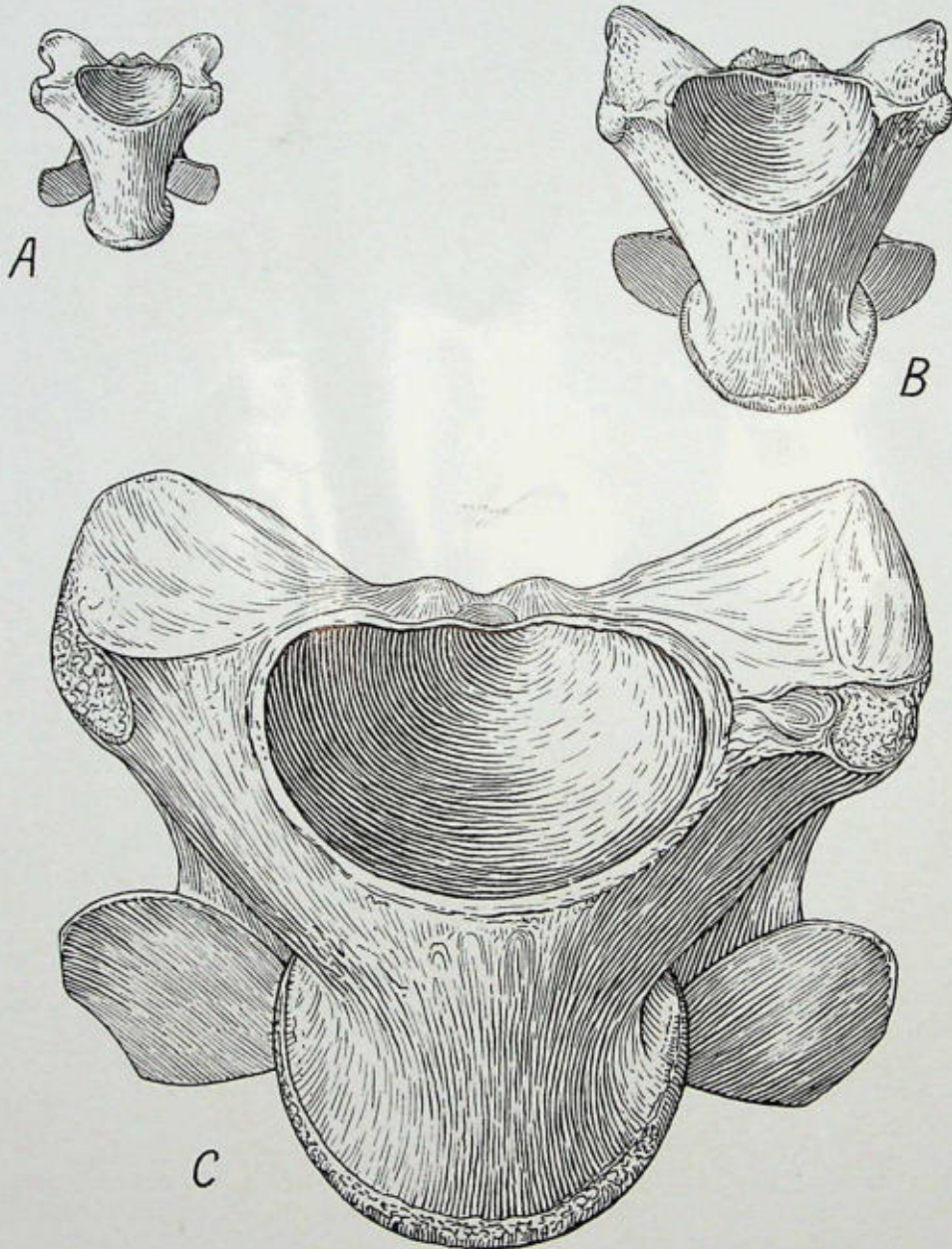
Comparative figures of skulls of (A) stem reptile, *Captorhinus* (after Broom); (B) primitive two-arched reptile, *Youngina* (after Broom); (C) *Varanus komodoensis* (original).

glass case some precious relics of *Varanus (Megalania) priscus* (Owen), one of the extinct Australian relatives of the Komodo lizards. These animals, according to Professor Emmet Reid Dunn¹, may have measured about fifteen feet in length as compared with nine feet six inches in the type of *Varanus komodoensis*. The vertebrae have extremely small tunnels for the spinal cord; the centra or bases of the vertebrae were excessively wide in proportion to their length. According to Professor Dunn's measure-

ments the vertebrae of the Komodo lizards were intermediate between the relatively narrow vertebrae of more primitive monitors and the excessively wide vertebrae of *Varanus (Megalania) priscus* (see pages 72 and 73).

Professor Dunn's careful studies of various parts of the skeleton of recent and extinct monitors afford strong evidence for his conclusion that the Komodo lizards have been derived from Australia. But how and when did their ancestors arrive in their present homes (Komodo, Flores, and adjacent islands)? Precise answers to this question may never be given but the general

¹Results of The Douglas Burden Expedition to the Island of Komodo. I.—Notes on *Varanus komodoensis*. American Museum Novitates, No. 286, Sept. 30, 1927, pp. 1-9.

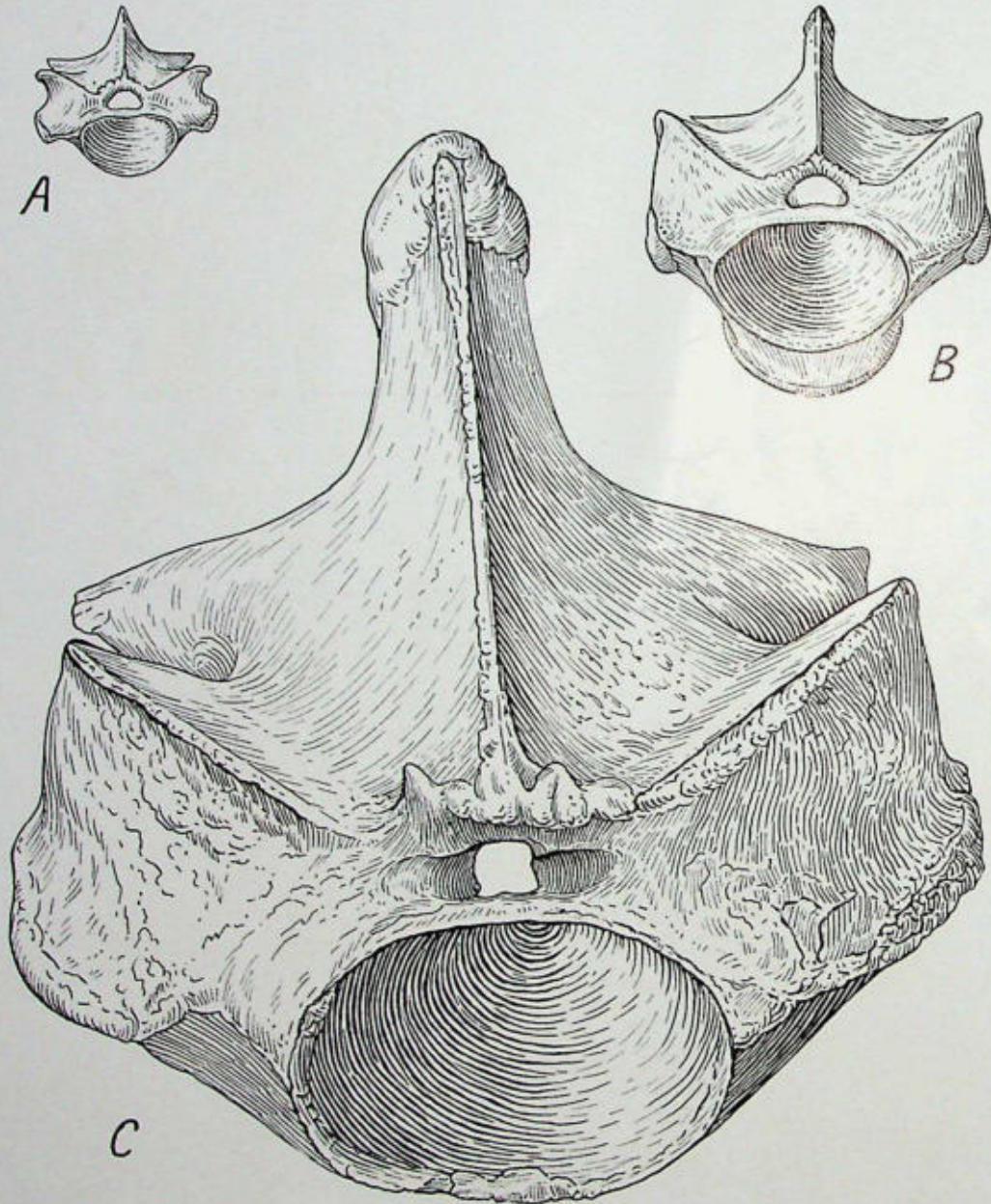


Vertebrae of (A) ordinary monitor; (B) Komodo "dragon"; (C) giant fossil monitor (*Varanus priscus*) of Australia, under side, natural size. (C. after Owen; A, B, from originals.)

geological and zoological history of southeastern Asia and Australia has been the subject of many fruitful investigations tending to show that the case of the Komodo lizards which find their nearest existing relatives in Australia is by no means unique.

The total herpetological collections of the

Douglas Burden Expedition to the Island of Komodo described by Professor Dunn numbered 1616 specimens, including seventy-three species and six sub-species. In his reports on the lizards, snakes and frogs of the East Indies, Professor Dunn was able to show (1927, p.7) that in each group there was a very large modern



The same vertebrae seen from in front. (A) ordinary monitor; (B) Komodo "dragon"; (C) giant fossil monitor (*Varanus priscus*) of Australia, natural size. (C, after Owen; A, B, from originals.)

unmodified Asiatic element, a small and rather modified Australian element, and a minute and modified old Asiatic element.

In other words, the Lesser Sunda islands, including Komodo, amid all the ups and downs of this highly unstable region have managed to catch and hold a fair selection of the streams of

animal life that were spreading from eastern Asia southeastward, and occasionally by reflex waves from Australia westward. With regard to the provenance of the Komodo lizards, we may appropriately close with a quotation from Professor Dunn (op. cit., 1927, p. 9).

"Whether *komodoensis* arrived in Komodo in



Map of the Australo-Malayan region, compiled by H. C. Raven. The arrow *A* points to Komodo Island; *B* points to the region in Queensland, Australia, where the type of the extinct *Varanus priscus* was found. The smaller living varanids (monitors, "goonas") range all over Australia, New Guinea and the Malayan region.

its present state of development and by what route it arrived at its present range are two unanswerable questions. The picture of evolution which presents itself to my own mind is one of ordinary lizards, in arid country, and free from competition from the higher mammals . . . , becoming large carnivores or perhaps carrion feeders. One of these, or one of the yet undifferentiated members of the same stock, possessing

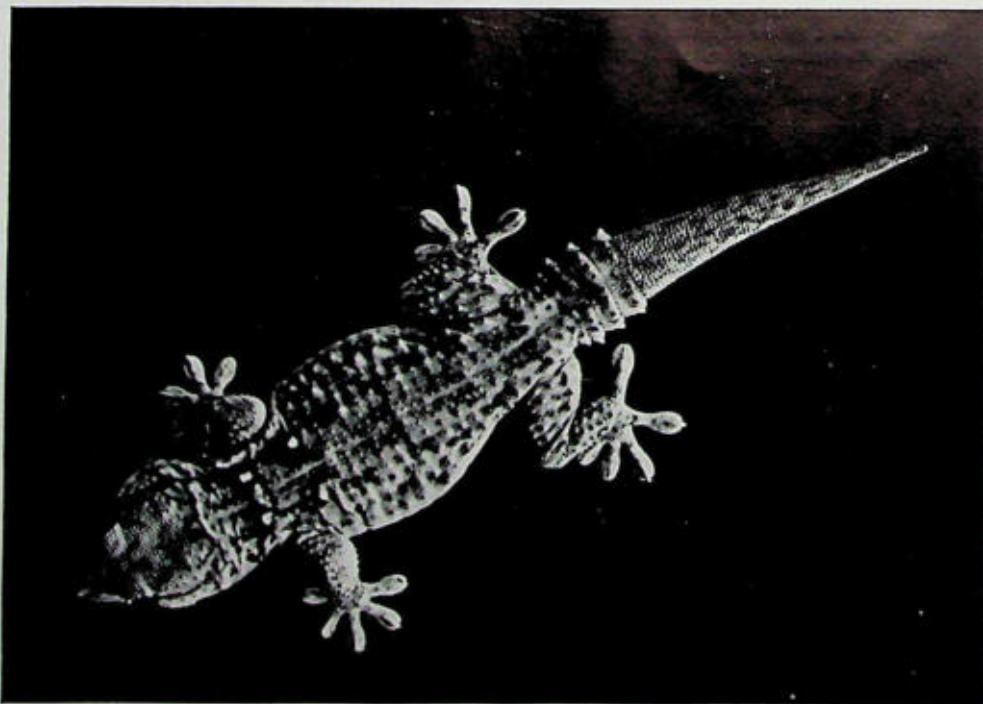
the same potentialities of development, arrived by unknown means in the Lesser Sundas and met the vanguard of the Placentals (Herbivores, as yet, and still unaccompanied by the higher and larger Carnivores, and as yet unfollowed by man). Here, these Australian emigrants persisted or developed, and here, in the same or in a latterly more restricted range, they can still be found."

KEY TO THE LIZARDS AND ALLIED FORMS

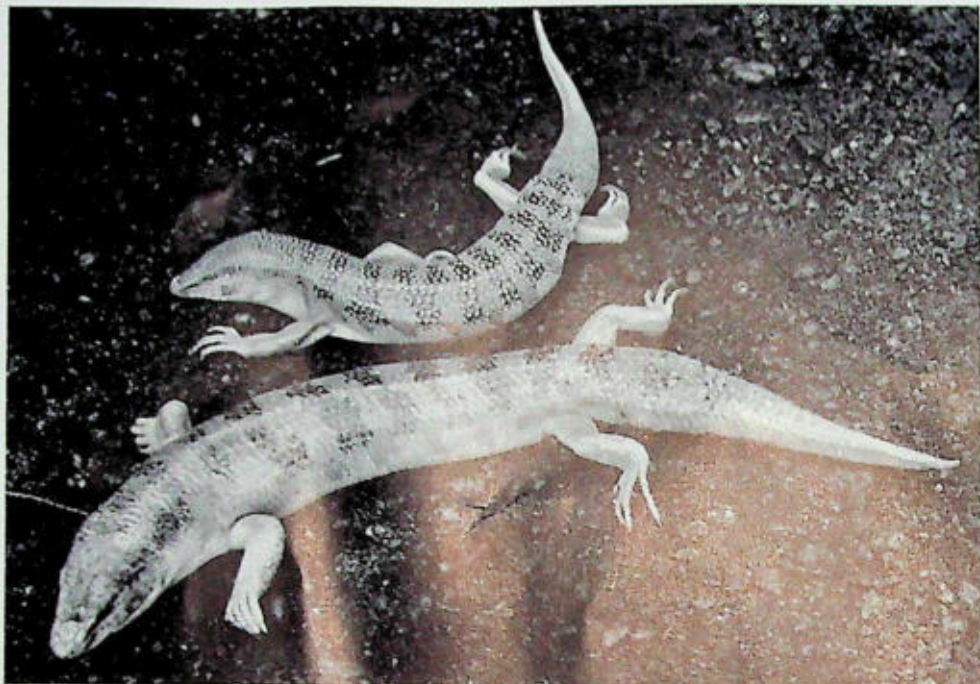
(See Chart pages 80 and 81)

The letters before the common names of each species correspond to the key-letters of the chart.

- | | |
|--|--|
| <p>I. GECKOS; FAMILY GEKKONIDAE
(a.) Ringed Gecko, <i>Tarentula annularis</i></p> <p>II. SKINKS; FAMILY SCINCIDAE
(b.) Sand Skink, <i>Scincus scincus</i>
(c.) Stump-tailed Skink, <i>Trachysaurus rugosus</i></p> <p>III. TRUE LIZARDS; FAMILY LACERTIDAE
(d.) Green Lizard, <i>Lacerta viridis</i></p> <p style="text-align: center;">FAMILY TEIIDAE</p> <p>(e.) Black Tegu, <i>Tupinambis nigropunctatus</i></p> <p>IV. DOUBLE ENDERS; FAMILY AMPHISBAENIDAE
(f.) Spotted Amphisbaena, <i>Amphisbaena fuliginosa</i></p> <p>V. SNAKES; SUBORDER OPHIDIA; FAMILY BOIDAE
(g.) Common Boa, <i>Constrictor constrictor</i></p> <p>VI. MONITORS; FAMILY VARANIDAE
(h.) Komodo "Dragon," <i>Varanus komodoensis</i></p> | <p>VII. GILA MONSTERS; FAMILY HELODERMATIDAE
(i.) Mexican Beaded Lizard, <i>Heloderma horridum</i></p> <p>VIII. SLOW WORMS; FAMILY ANGUIDAE
(j.) Alligator Lizard, <i>Gerrhonotus multicarinatus</i>
(k.) European Glass Snake, <i>Ophisaurus apodus</i></p> <p>IX. ZONE TAILS; FAMILY ZONURIDAE
(l.) Spiny Lizard, <i>Zonurus giganteus</i></p> <p>X. IGUANIDS; FAMILY IGUANIDAE
(m.) Rhinoceros Iguana, <i>Metopoceros cornutus</i>
(n.) Horned "Toad," <i>Phrynosoma cornutum</i></p> <p>XI. AGAMIDS; FAMILY AGAMIDAE
(o.) Moloch Lizard, <i>Moloch horridus</i>
(p.) Flying Dragon, <i>Draco volans</i>
(q.) Armed Agama, <i>Agama armata</i>
(r.) Bearded Dragon, <i>Amphibolurus barbatus</i></p> <p>XII. CHAMELEONS; FAMILY CHAMAELEONTIDAE
(s.) Common Chameleon, <i>Chamaeleon chamaeleon</i></p> |
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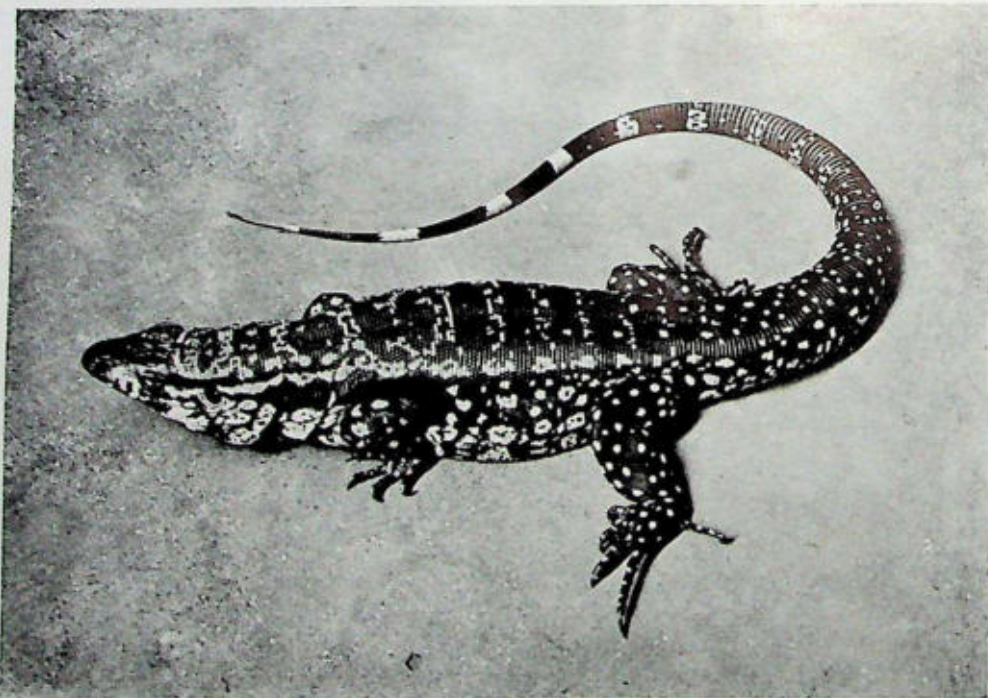
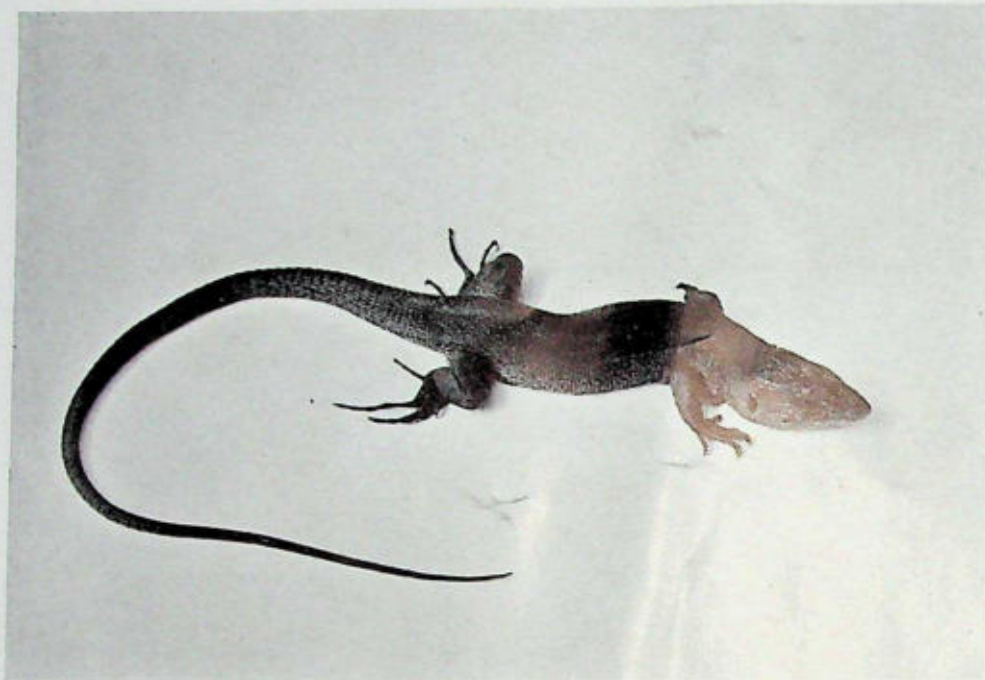
(a) Ringed Gecko, *Tarentula annularis*, Family Gekkonidae. The geckos form a large family and the greater number of species may be immediately distinguished from other lizards by their greatly dilated digits, the toes being expanded in the form of adhesive pads, the feet appearing from above somewhat like those of tree toads. These enable the gecko to cling easily to a vertical sheet of glass, and to run with celerity across a ceiling. Their scalation differs from that of the lizards in being extremely fine, or granular, and it is often studded with tubercles, giving it the appearance of a toad's skin. Photograph by Elwin R. Sanborn.



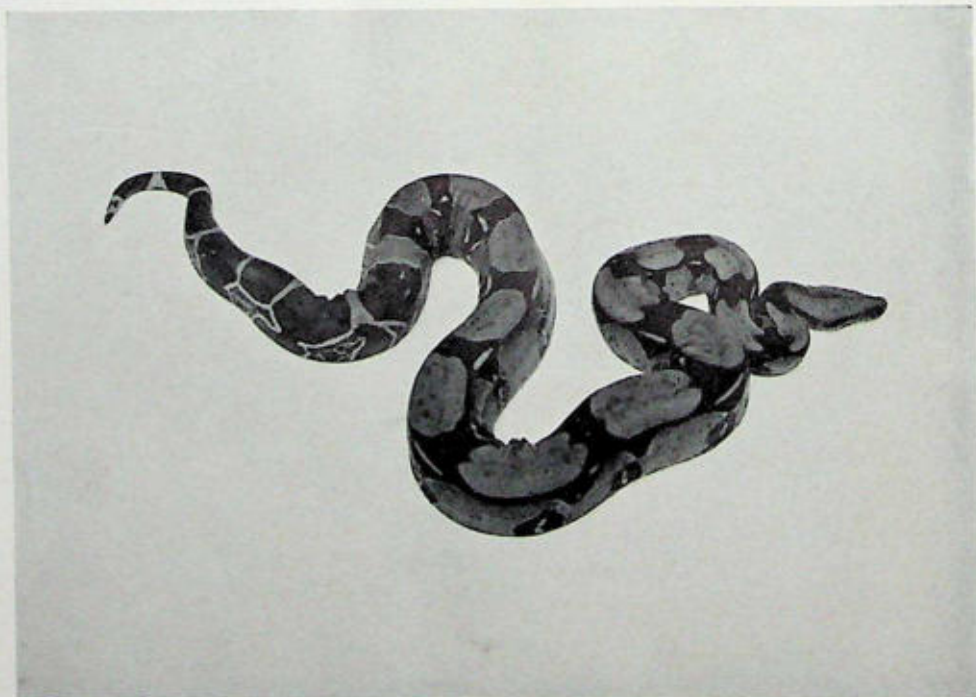
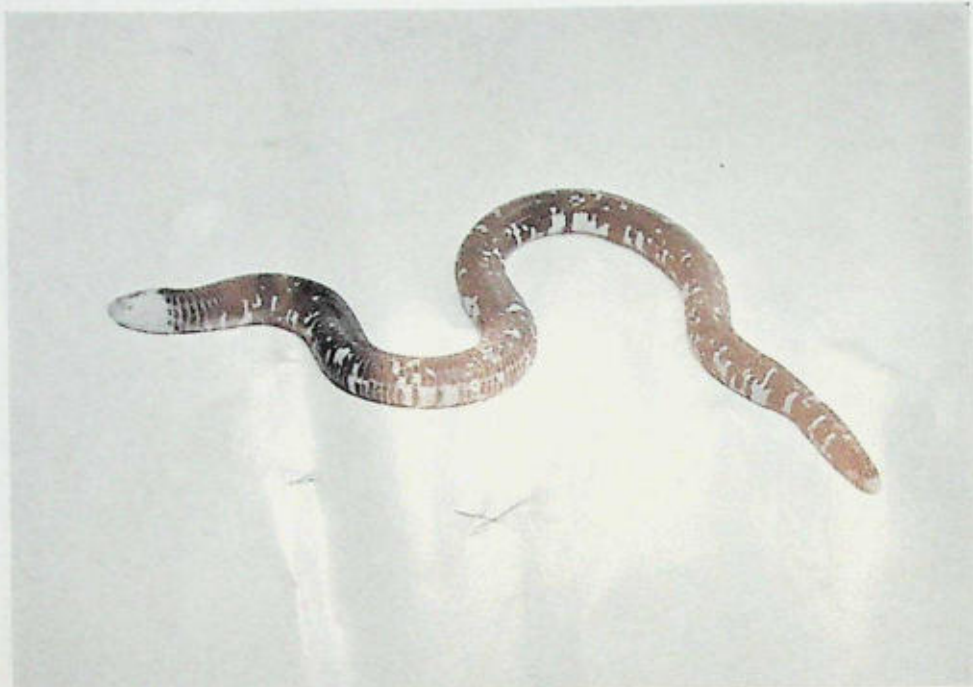
(b) Sand Skink; Sand "Fish", *Scincus scincus*, FAMILY SCINCIDAE. Close examination of this creature shows marked modification for a life in the powdery, desert sands. The snout is sharp and used as a burrow-wedge, while a fringe of scales on the toes enables it to walk on the loose surface of the sand without sinking. Photograph by Raymond L. Ditmars.



(c) Stump-tailed Lizard, *Trachysaurus rugosus*, of the FAMILY SCINCIDAE, is one of the strangest of all the Australian lizards. At a few yards distance, its tail lacks only mouth and eye-marks to be a head in appearance. It is a snake killer, a formidable enemy of the many venomous reptiles with which Australia abounds, and the reptile when seized is helpless in its bulldog-like grip. This genus is represented by but one species. Photograph by Charles Barrett.



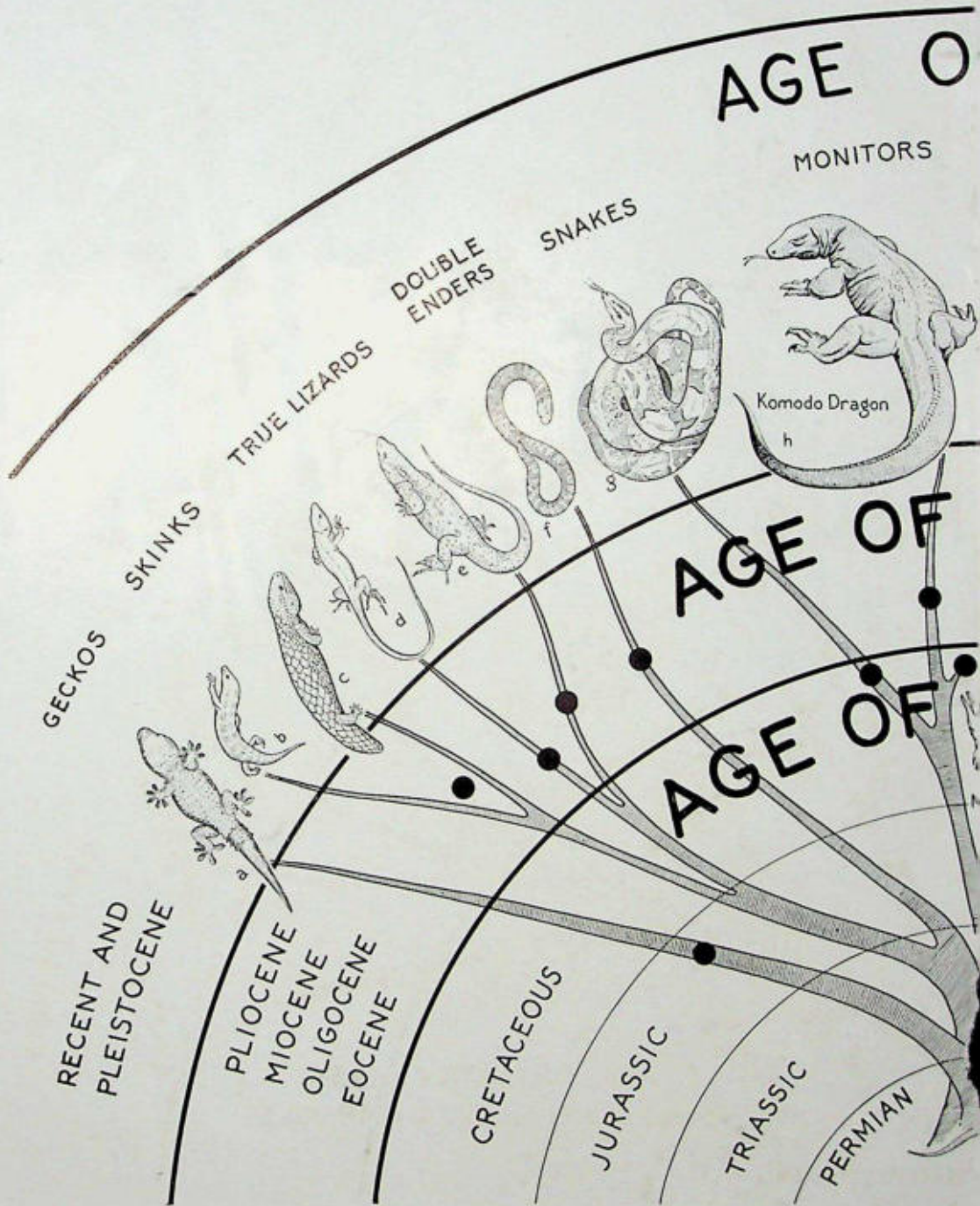
- (d) Green Lizard, *Lacerta viridis*, FAMILY LACERTIDAE. Central and southern Europe and southern Asia. Here is a typical lizard in all that the name implies. It is of moderate size, without eccentric development of scalation or body contour. Allied species of this type are abundant in central and southern Europe. An allied species, *Lacerta agilis*, is alleged to be the only reptile in Ireland, although it is said that grass snakes have been observed. Photograph by Raymond L. Ditmars.
- (e) Black Tegu, *Tupinambis nigropunctatus*, FAMILY TEJIDAE. Guianas and Brazil. A swift running and powerful lizard, with brilliant pattern of yellow on glossy black scales. The tegus are exceptionally hardy as captives. The specimen shown in the photograph lived in the Zoological Park for over ten years. Photograph by Raymond L. Ditmars.



- (f) Spotted Amphisbaena, *Amphisbaena fuliginosa*. FAMILY AMPHISBAENIDAE. All members of the family to which this species belongs have a worm-like body with many circular rings or segments, which are movable and hence carry the creature along the ground in a fashion similar to that of an earthworm. All of them spend much time burrowing. The eyes are minute, hidden under the skin, and therefore almost useless. Photograph by E. R. Osterndorff.
- (g) Common Boa, *Constrictor constrictor*. SUBORDER OPHIDIA. FAMILY BOIDAE. The family containing the boas and pythons, with several related families, of smaller, more degenerate members, appear to show close relationship to lizards owing to their having vestiges of posterior limbs. These are internal, near the base of the tail, but each protrudes as a claw or spur. Photograph by Elwin R. Sanborn.



(h) Giant Monitor, *Varanus komodoensis*, FAMILY VARANIDAE, Island of Komodo and westerly portion of Flores, in the Dutch East Indies. Recently discovered, this powerful lizard astonished students of reptiles. It grows to a length of considerably over ten feet, and attains a weight of close to one hundred and fifty pounds. It is the largest existing species of lizard, although not greatly eclipsing the big Ceylonese Monitor, which, however, is of much lighter build. This and another living specimen were the first to be exhibited in the United States. They were collected by the Douglas Burden Expedition to the Island of Komodo in 1926. Photograph by Elwin R. Sauborn.



ADAPTIVE RADIATION

Family Tree and Adaptive Radiation of the Lizard
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F MAN

GILA MONSTERS SLOW WORMS

ZONE TAILS

IGUANIDS

AGAMIDS

CHAMELEONS

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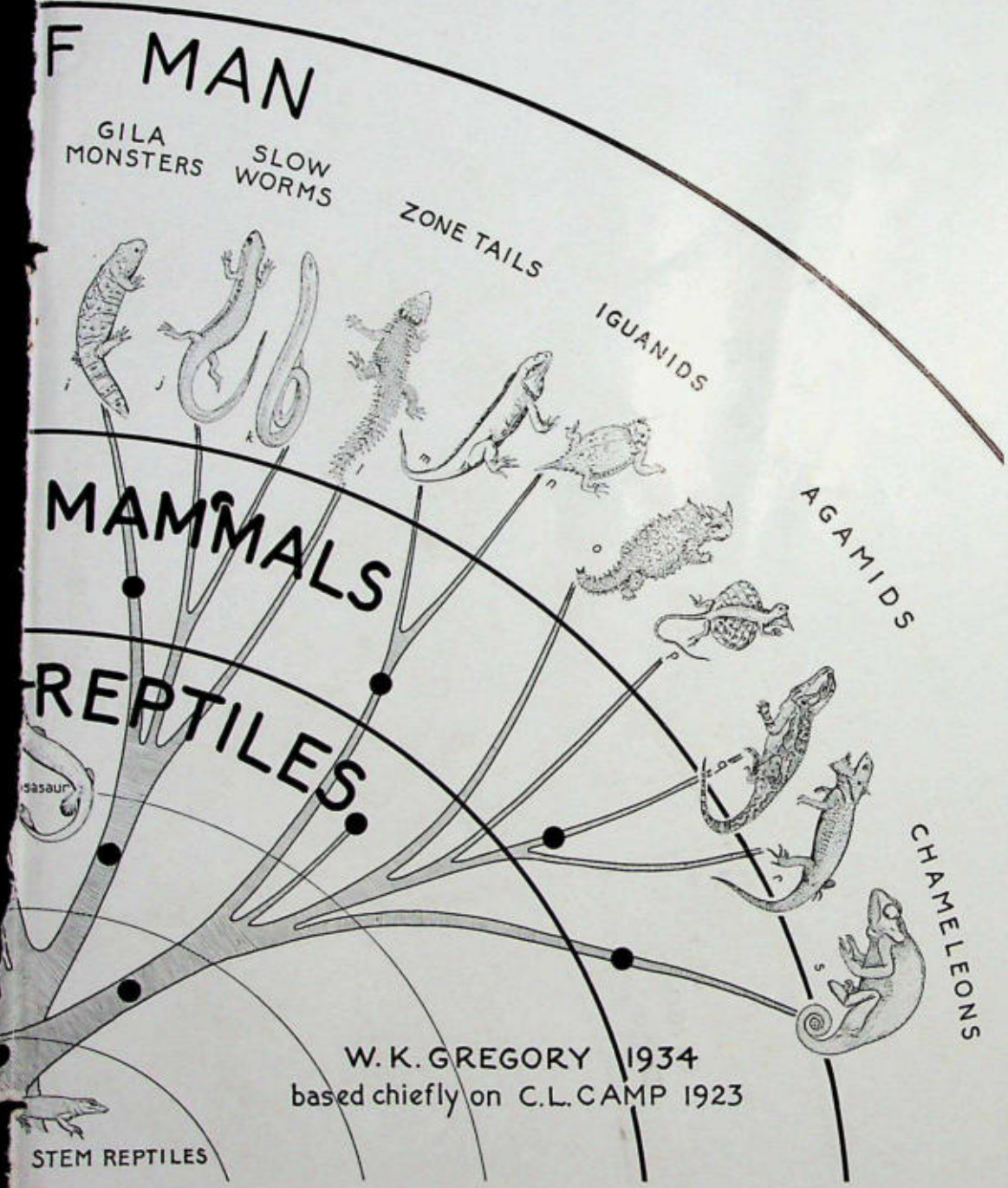
REPTILES

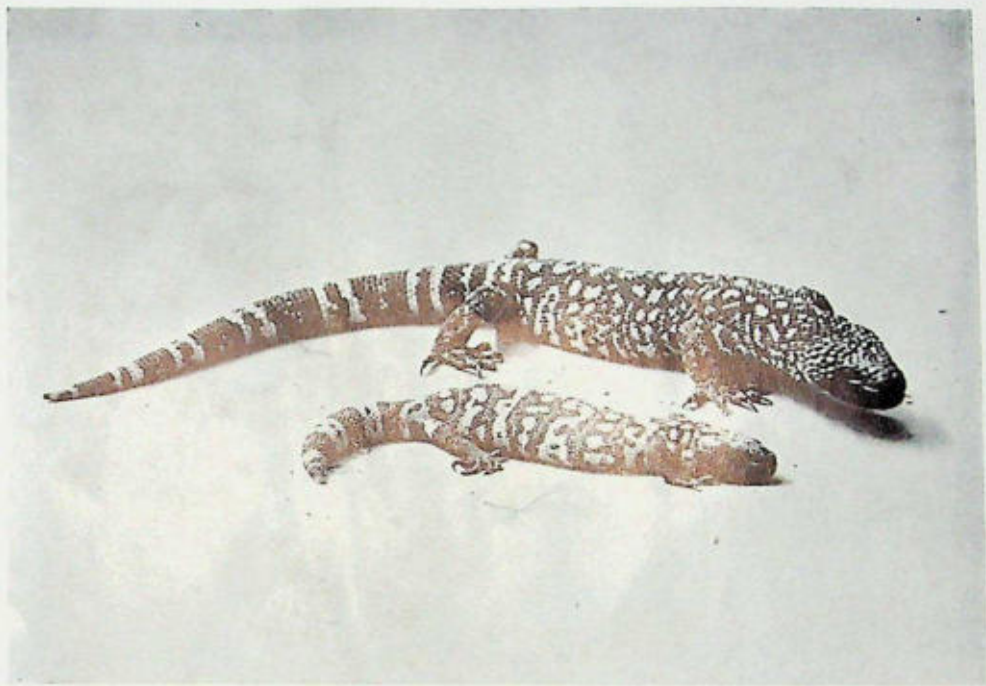
W. K. GREGORY 1934
based chiefly on C. L. CAMP 1923

STEM REPTILES

EVOLUTION OF THE LIZARDS

(Order Squamata). Based on a monograph dealing with the evolution of the lizards by C. L. Camp. The black circles record the earliest fossil of the order. The time covered by the evolution of the order is estimated to be about 100 million years. The key to the names of the forms figured is on page 75.

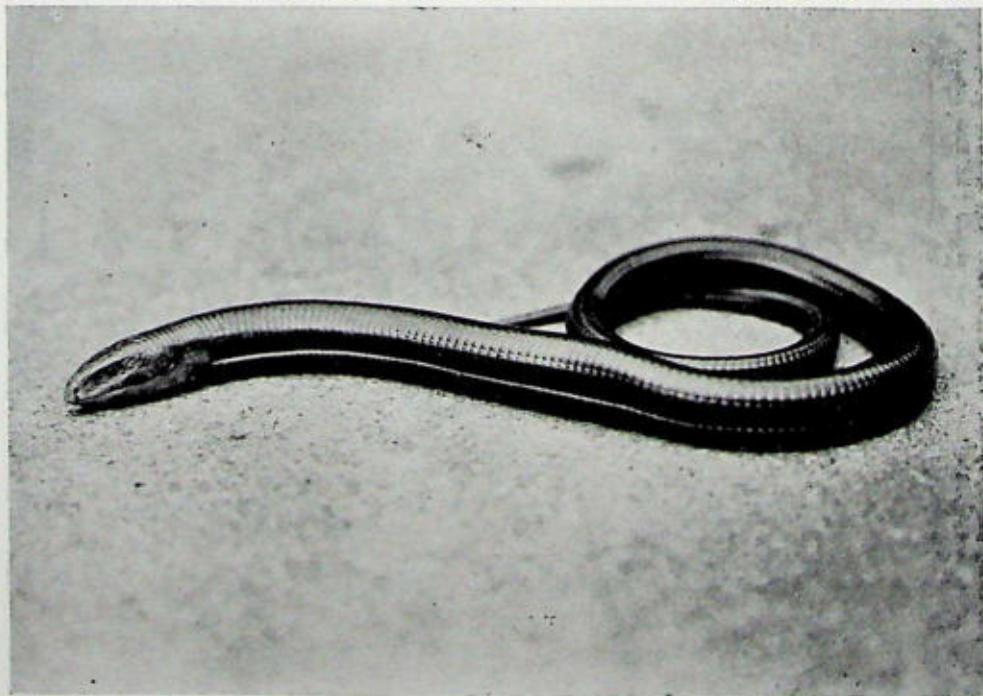




- (1) Beaded Lizards, *Heloderma*. FAMILY HELODERMATIDAE. Among the twenty-five hundred kinds of lizards, these are the only known poisonous species. They form a family containing a single genus with its two characteristic species. The larger figure above is that of the Mexican Beaded Lizard, *Heloderma horridum*, Lower-Gila Monster, *Heloderma suspectum*. Habitat is defined as extreme southern Utah, and Nevada, Arizona and Sonora. Enlarged glands and grooved teeth in the lower jaw constitute the poison apparatus. The venom is similar to that of snakes, but much less virulent in its effects. Photographs by Elwin R. Sanborn.



(1) Alligator Lizard, *Gerrhonotus multicarinatus*, California. About six inches long and covered with square, leathery-looking scales, this lizard represents a curious family—the Asacinae. The members have bony plates beneath the scales; some have well-developed limbs and others are limbless, crawling like serpents and often being mistaken for snakes. Seven species of alligator lizards inhabit the western portion of the United States and northern Mexico. One hairy species ranges northward through western Washington and Oregon to Vancouver Island. Photograph by Raymond L. Ditmars.



(k) European glass "snake", *Ophisaurus apodus*, FAMILY ANGUIDAE. This true lizard, a member of the family ANGUIDAE, is larger than the American species, attaining a length of three feet. The actual body forms about one-third its length. A pair of minute flaps at the vent are the vestiges of limbs.

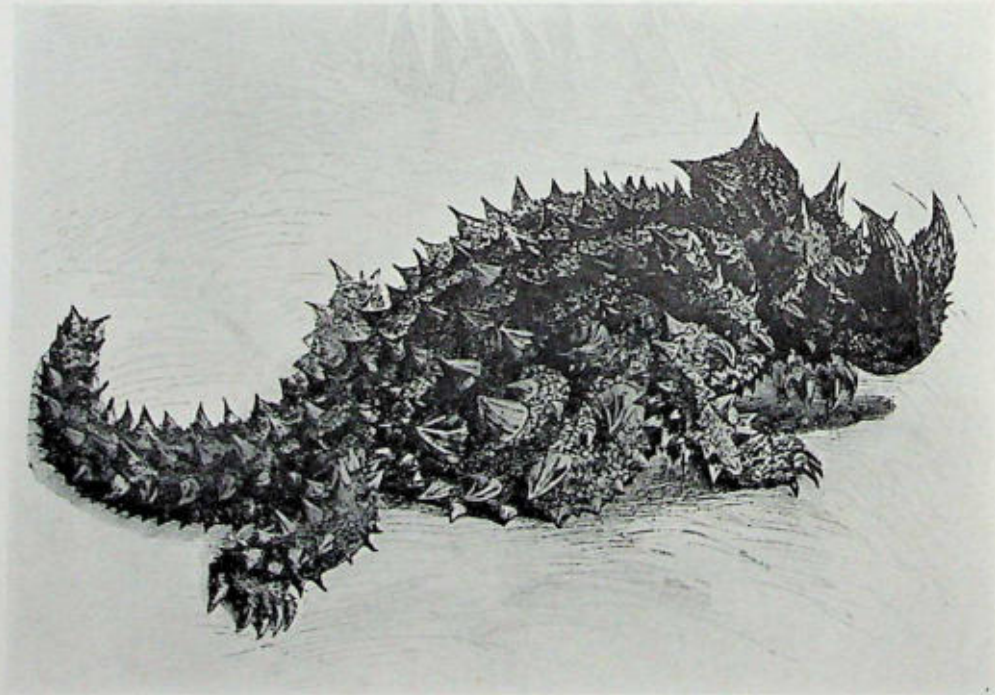
Ophisaurus ventralis, of the southern United States, is commonly alleged to break into pieces which "crawl" together and form a reunited reptile. The tail is actually brittle and may be broken off in defense, the writhing of the broken section attracting the enemy's attention. It eventually may be replaced by the growth of a new member. Photographs by Raymond L. Ditmars.



- (1) Spiny Lizard; Spine-tailed Lizard, *Zonurus giganteus*, FAMILY ZONURIDAE. Bristling with horny spines, this lizard would ordinarily appear to be quite well protected, but it is alleged to make use of this means of defense specifically by crawling into its burrow head first, leaving the formidable tail to block the passage. A large specimen will measure about eighteen inches. It may be classed also as a desert type, as it lives in dry, sterile areas. It is interesting to note that the greater number of desert lizards have acquired enlarged, spiny scales, which is the tendency of many desert plants. Photograph by Elwin R. Sanborn.



(m) Rhinoceros Iguana, *Metopoceros cornutus*, FAMILY IGUANIDAE, Haiti. There is a close rivalry between this species and the big land iguana of the Galapagos Islands as to size and bulk. It is a powerful, terrestrial animal and digs caves in the sand and coral slopes of the island. It is sometimes hunted with dogs and is a savage adversary. Dull brown in color, with wattles and protuberances upon the head, and sinister countenance surmounted by the rhinoceros-like horn, it recalls the restorations of prehistoric dinosaurs. It feeds commonly upon leaves and flowers, but will attack and devour small mammals and young birds. Photographs by Elwin R. Sanborn.



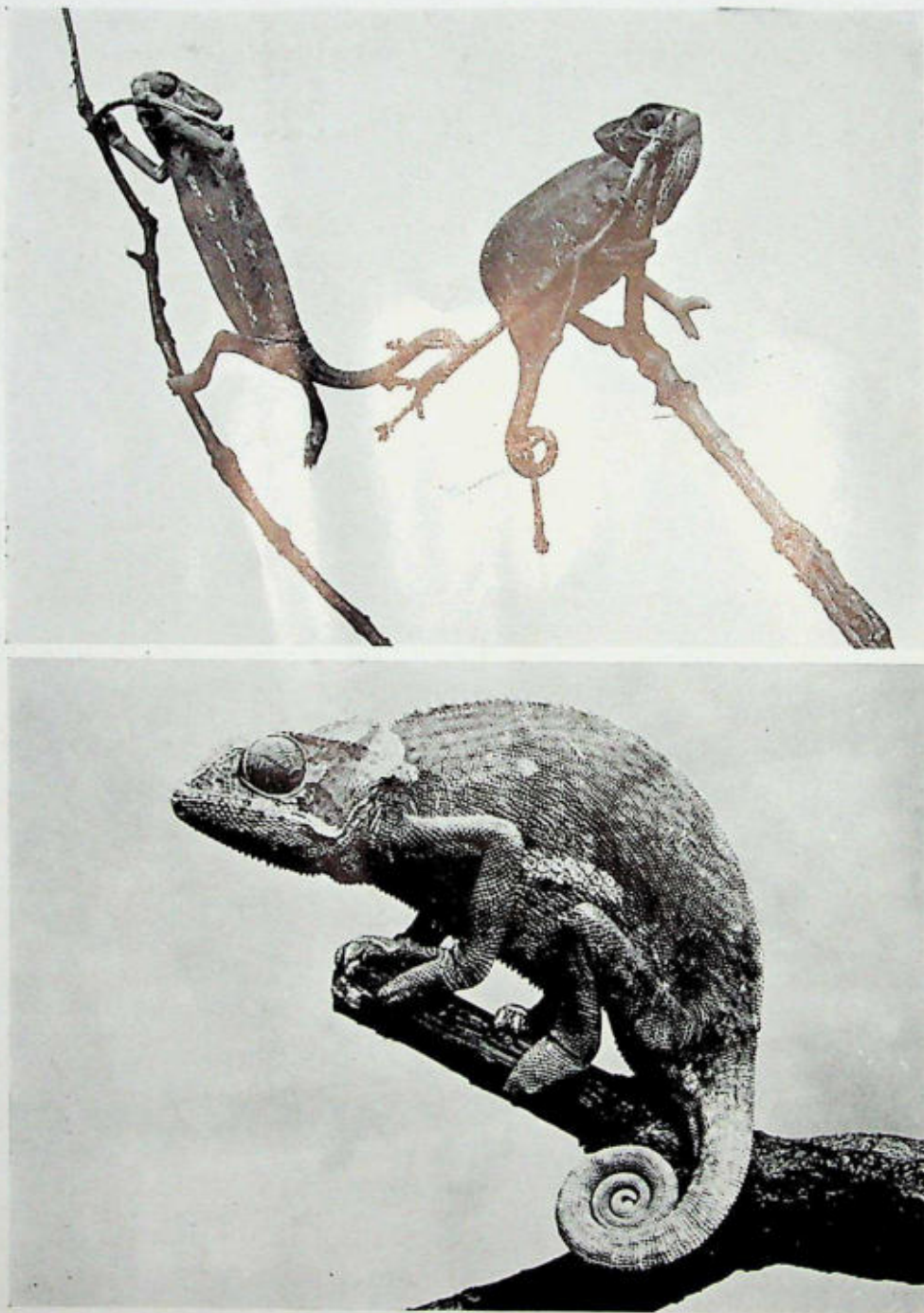
- (n) DITMARS' HORNED "TOAD", *Phrynosoma ditmarsii*, FAMILY IGUANIDAE. Region of the Mexican Boundary at Arizona and New Mexico. With this species the horns are reduced to a rudimentary stage, although the sides of the head are developed into projecting ridges. The body is rather smooth and particularly toad-like. Photograph by Raymond L. Ditmars.
- (o) MOLOCH, *Moloch horridus*, FAMILY AGAMIDAE. This member of an Old World group, the AGAMIDAE, indicates a curious parallelism in development of that family, as compared with the New World IGUANIDAE. Thus the Moloch is a form similar to the Horned "Toad". A number of the members are strikingly like the New World iguanas. Lydekker, Royal Natural History.



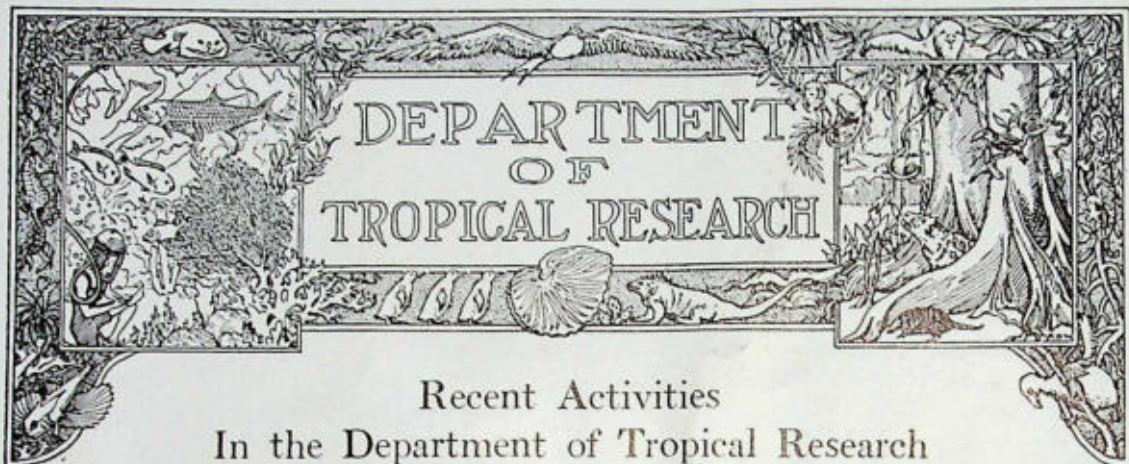
- (p) Flying Dragon, *Draco volans*. FAMILY AGAMIDAE. There are several species of so-called "flying" lizards, these scattered among unrelated groups. Some are enabled to make scaling leaps by means of folds of skin between the limbs. The present species is highly specialized in having laterally movable ribs which expand the scaling planes. Photograph by Raymond L. Ditmars.
- (q) Armed Agama, *Agama armata*. FAMILY AGAMIDAE. Another example of the AGAMIDAE, indicating its similarity in parallel forms to the New World *Iguanidae*. There are several species of *Agama*, noted for their bristling scales. They live in hot and sterile areas. Lydekker. Royal Natural History.



(r) Bearded Dragon, *Amphibolurus barbatus* of the FAMILY AGAMIDAE, is the largest of this genus and ranges over nearly the whole of Australia. When alarmed or angered it spreads its spiky neck-frill and hisses very much like a snake. They are fond of perching on tree-stumps or fence posts where they bask in the sun. Photograph by Charles Barrett.



(s) Common Chameleon, *Chamaeleon chamaeleon*. FAMILY CHAMAELEONTIDAE. There are more than fifty distinct kinds of chameleons. They are the most highly specialized among the lizards, possessing a prehensile tail, while the fingers and toes have become fused as opposable clasps to form perfect grasping organs. The eyes are remarkable in being large, rolling members, covered by tough skin, with a small opening in the center for the pupil. The eyes roll independently. The species form a distinct family inhabiting Africa, the shores of the Mediterranean and India. These lizards are noted for their remarkable changes of color. Photographs by Raymond L. Ditmars.



Recent Activities In the Department of Tropical Research

WILLIAM BEEBE

Illustrations from drawings in line and water colors by members of the Staff.

THE year 1933 was a very busy and successful one for the staff of the Department of Tropical Research. Two expeditions were undertaken, one in the yacht *Antares*, by the generosity of Colonel Chance. This lasted six weeks, and Jamaica, Panama, the Pearl Islands in the Pacific, and the Mosquito Coast were visited.

Three and a half months were spent in Bermuda, the staff boarding at the Biological Station and carrying on research at New Nonsuch, the new laboratory of the department. This is now in full working order, with an adequate building, boathouse, wharf and several acres of fields and wooded hills.

Having published the Field Book of the Shore Fishes of Bermuda, Mr. Tee-Van and I turned our attention to newly laid eggs and larvae.

When we are diving in the helmets we search for attached eggs on seaweed, in the crevices and hollows of reefs, or even inside the valves of empty seashells. But the great majority of fish eggs are pelagic, that is, they float free in the water, usually at the surface, and to secure these we draw large silk nets near the top of the water. The best time for perfectly fresh eggs is late in the evening or from four to six o'clock in the morning, for many species of fish seem to spawn in darkness. Nevertheless there is an abundance floating even at mid-day. Spring and summer are the seasons when many of the commoner shore fish breed, but at sea we found

hosts of individual eggs of a large number of species, with no signs of diminishing from August to December.

The eggs are studied and described under low and high power lenses and then placed in as normal conditions as possible until hatched, when the larvae and post-larvae are watched and drawn in turn. After we bring in a large haul we have little rest, for the eggs begin developing at once and some of the smaller hatch within twelve hours after being deposited in the water.

In a short dive in the Bathysphere thirty fathoms down, I once saw parrot-fish fully four feet in length, larger than I have ever seen them near shore. As a contrast, in one of our first nets this year we caught a half dozen infant parrots measuring one-twenty-fifth of an inch in length. Only by their skeleton and other internal characters could we tell what they were, for externally they were very unlike their parents. Even their teeth were separate and not welded together in a great beak.

The eggs of eels are usually of large size, and we constantly have most interesting larvae developing before our eyes into quite unknown species. Young eels have no fewer than three sets of teeth before they acquire their final sharp armature. It is a dramatic and exciting event to watch the formation of the first two cells, and then on and on, until we detect the first beat of the heart of the tiny embryo.

Toward the end of development the infants

become very restless in their diminutive, spherical cosmos, and they push and twist until at last they fracture the egg-shell wall and swim out into the world, often laden with a large mass of yolk and one or more oil globules whose buoyancy is so great that, for a time, they have to swim upside down.

The eyes and mouths of small eels are enormous, for these are most important from the moment of birth, to enable the weaklings to escape danger and to find food. The young eel passes through a stage known as leptocephalus, where he resembles an elongate, transparent leaf, and only later does he develop color and thickness, and acquire a resemblance to his parents. The excitement and interest never lessens of catching and hatching these minute fish and watching them develop one characteristic after another.

As I recently wrote in the "Field Book of the Shore Fishes of Bermuda," "Not one complete life history of a Bermuda fish is known." When we realize that there are at least six hundred species of fish near Bermuda we know that, with all our efforts, we can make only the slightest beginning on the problem.

In 1933 Miss Hollister completed much work on the skeletons of the tails of both shallow and deep water fish. The amazing economy of Nature was recently shown in a rare deep sea fish whose tail fin in life grows smaller and the upper and lower fins increase as the fish grows up. We do not need to see the fish using its tail fin less and less, for the skeleton itself reveals this change of function. As soon as the muscular swimming pressure is relaxed on the tail fin, its supporting bones become weaker and begin to disappear.

Miss Crane and I continued our studies of the deep-sea fish taken south of Nonsuch Island during the last four years, and constantly found new species and made new discoveries. One of the most unexpected has just come to light. A tiny fish with the eyes on enormously long stalks is called *Stylophthalmus* and has been placed in a special family by itself. We now find that in the course of growth the eyes are gradually pulled back again into a more normal position close to the sides of the head. Other radical changes take place and we have a complete series of specimens showing that these fish

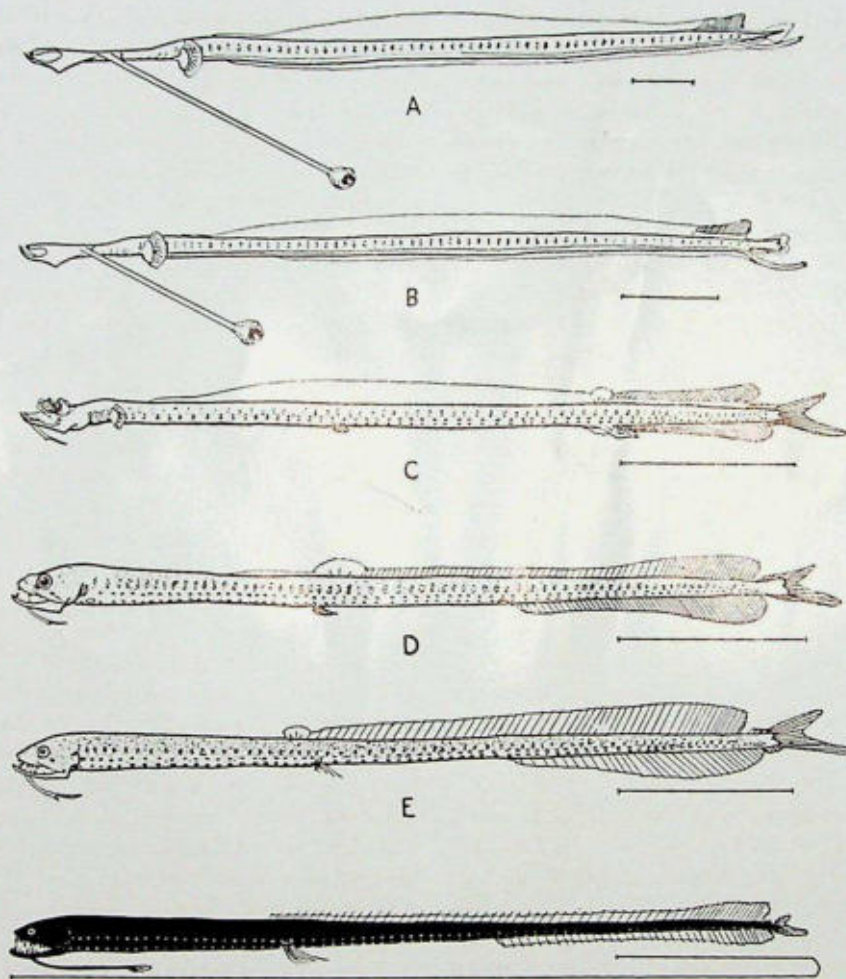
are nothing more than the larvae of *Idiacanthus*, a member of a wholly different family. In the shortening of the eyes there is absorbed not only the cartilage of the long stalk but the muscles and nerves which move and vitalize the eye. What was once the stiff cartilage stalk is finally a tightly rolled bundle which sinks into the anterior part of the eye-socket and is soon covered with skin. This is one more of the unreasonable, apparently quite unnecessary, Alice-in-Wonderland changes which characterize the weird fish living in the icy, black depths of the sea, off the shores of Bermuda.

Further study of the same creatures has revealed still more remarkable wonders. This same deep-sea fish known as *Idiacanthus fasciola*, or Gleaning-tailed Serpent Dragon, is not rare five miles off Bermuda and a mile down. We have caught over a hundred in our nets. Whenever we have examined large individuals, by which I mean those over ten inches long, they have proved to be females.

The stalk-eyed young larvae, after they have drawn in their long stalked eyes, do one of two things. They either grow a complicated barbel from the chin and a tiny, silvery-pink light beneath the eyes, or they wholly lack a barbel and develop an enormous creamy white light, blazing on each side of the head. We had great difficulty in making a reasonable, straight series of all these youngsters. Something was wrong, and they would not fall into place. Finally, we made a few careful dissections and the whole thing became clear.

The immature-looking individuals with the huge check lights are, most astonishingly, full-grown males. So here we have large, black, eel-like creatures with a curious leaf-like affair growing from the throat, and great yellow tail lights, which are the full-grown females, and, on the other hand, little chaps, not more than one-eighth as large as their sisters, with no functional stomach, no teeth, no paired fins, but with two enormous check-lights. These diminutive fish, with all their juvenile appearance, are actually the full-grown males of the species. From their weakness and small size we must consider them parasitic, but we do not know in what way.

It is as amazing as if a race of fowls should be developed, with the hens of normal size and



Development of the female Gleaming-tailed Sea Dragon. The larvae half an inch long, have enormous eye-stalks. These are gradually absorbed, a chin barbel and small pelvic fins appear, and the fish gradually grows darker. When full-grown, it is black and measures a foot in length.

the roosters only as large as new-hatched chicks, with down instead of feathers and a faint cheeping voice instead of a lusty crow. How the two sexes of the Serpent Dragons find one another, or how two fish of such dissimilar size can successfully mate is still to be discovered.

It seems certain that the lack of teeth and stomach in the tiny male indicates that he must not lose a moment in searching for and finding his mate, or death from starvation will claim him. That this death is probably the fate of many, seems indicated by the fact that the dwarf males outnumber the females four to one. Many must die after a vain search, while even

the one successful male, still not able to feed, has only the prospect of succumbing after mating. What an opportunity for a moral!

In addition to the familiar sergeant majors, slippery dicks and angel-fish of the Bermuda shallows, try to imagine, deep in the icy blackness off the shores, these Serpent Dragons swimming about—four, tiny, larva-like males ever seeking to find their single, enormous mate, gambling the carrying power of their great, yellow globes of light against the short shrift of life enforced by their lack of teeth and stomach. Why should they have to combat such handicaps?

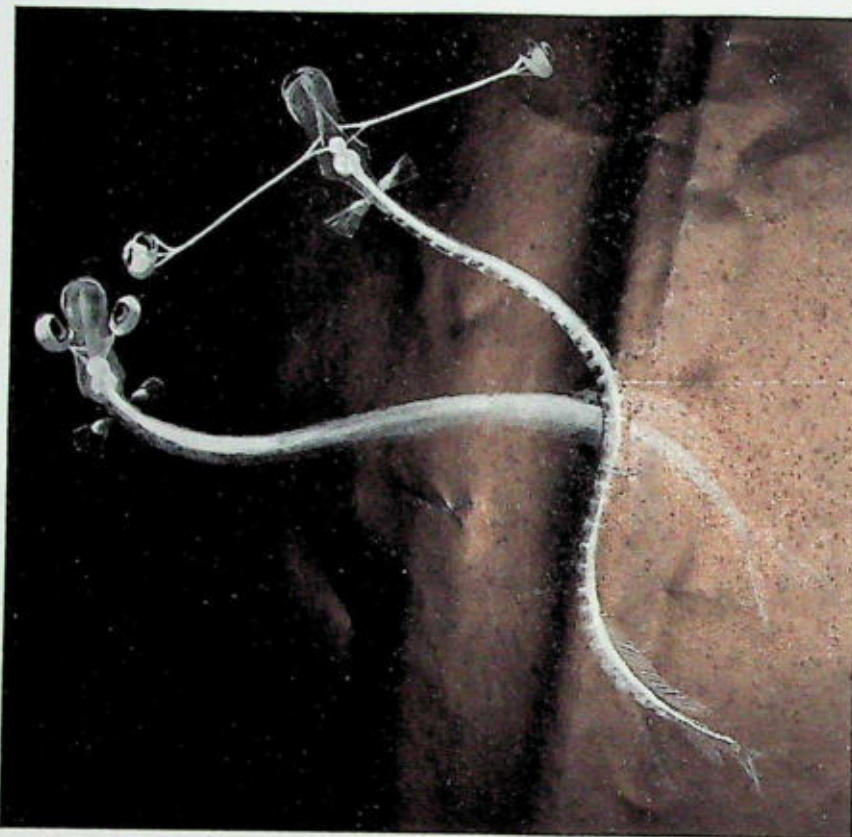


Full-grown male and female of the Gleaming-tailed Sea Dragon. When this plate was published in the Zoological Society's Annual Report for 1932 the small fish were thought to be the young. Now we know they are adult males.

A complete, technical account of the development of this fish, *Idiacanthus*, has just been published in the Zoological Society's *Zoologica*, Vol. XVI, No. 4. Its life history has been considered so amazing and unique by Dr. William K. Gregory of the American Museum that a special wall case has been provided in the hall of deep sea fishes of that institution for a per-

manent exhibition of the original drawings, enlarged models and actual specimens of both sexes and various ages of the fish themselves.

While I never like to anticipate what is not yet accomplished, yet the first three months of 1934 adumbrate a season of real achievement. The most important event is the offer of the National Geographic Society to set aside a fund



The larvae and post-larvae of the Gleaming-tailed Sea Dragon, showing how the long-stalked eyes shrink into more normal positions.

sufficient for another Bathysphere dive. This has been accepted by the Zoological Society, so this season will see two expeditions, one within the other. The Nineteenth of the Department of Tropical Research is to be called the National Geographic Society—William Beebe Expedition. This will be concerned with the actual dives of the Bathysphere and a series of deep-sea trawls from our old tug, the *Gladisfen*. These will take place during July or August, the calmest months of the year. The Twentieth Expedition of the Department will be under the direct auspices of the Zoological Society, and will begin in May in Bermuda at the New Laboratory, and continue until the autumn.

The Bathysphere, which has been at the Century of Progress Exhibition in Chicago throughout 1933, has been brought east to the factory where it was made, the Watson-Stillman Company of Roselle. Here it is being thoroughly overhauled and reconditioned by Mr. Stillman.

Kind friends have turned up on all sides, to aid in the preparations for the new dive. The Air Reduction Co. is assembling and presenting the Department with the most efficient type of oxygen apparatus, including new tanks and valves, chemicals and an electric fan for driving air through the carbon dioxide and humidity absorbers. The Bell Telephone Co. is placing the phones used in 1930 and 1932 in their museum and giving us a complete new set. We are purchasing six hundred additional feet of telephone and electric light hose.

The General Electric Company, through the kind offices of Mr. Owen D. Young and Mr. Gerard Swope has promised, as a gift, three new windows of fused quartz.

The results of all this will be that, wind and water permitting, I will be able to reach a depth of quite three thousand feet, and remain below the surface for four hours or more. Thus the hurry and the incomplete observations of former



Heads of the full-grown male and female Gleaming-tailed Sea Dragon. The male is very tiny, pale grayish-white, toothless, lacks paired fins and has an enormous cheek light. The female is relatively gigantic, jet-black, with only very small light organs, an elaborate chin barbel, and many great, curved fangs.

dives will be done away with. It is hoped we will be able to see in detail more of the inhabitants of these unknown regions.

An entirely new field of work this year is an elaborate stop-microcamera, intended to record the complete development of the fish eggs such as we found last year.

The regular staff of the Department will be in the field throughout the expeditions. Mr. Otis Barton is expected in June, in time to join the Director in the deep dives, and two graduates of Dartmouth College, Perkins Bass and William Ramsey, will be with the expedition from June on.

Two artists will accompany the expedition. One of these is George Swanson. The other is Mrs. Bostelmann whose splendid colored paint-

ings of deep sea life are so well known to members of the Zoological Society.

Postscript to "On the Antares to the West Indies" in the last number of the Zoological Society Bulletin: On page 101 of the July-August Bulletin, I reproduced a memorial from the wall of the little church at Bottom, on the island of Saba. This told of four men of the name of Simmons who met their death in a storm in September, 1918. The perils of life of the brave people of this bleak-cliffed islet are emphasized by a letter I have just received from a Miss Simmons, now in the United States. She tells me that the four men were her uncles and cousins, and that shortly after this tragedy her father and two brothers were lost in a storm when on their way from St. Vincent.—*William Beebe.*

INDIAN PEACOCK *Frontispiece*
 PEAFOWLS IN THE ZOOLOGICAL PARK *Lee S. Crandall* 99

Illustrations

Peafowl feathers in detail	White Peacock: Train developing
Indian Peafowl: Male	Tail coverts: Pied cock
Indian Peafowl: Female	Pied and Black-shouldered cocks
Indian male displaying to Peahen	Black-shouldered Peacock
Indian Peahen on nest	Black-shouldered Peahen
Indian Peahen: Eggs	Pied Peacock
Indian Peahen and Chicks	Javan Peacock
Peahen with grown brood	Javan Peahen
Indian Peacock: White	Peacock displaying to visitors
White Peacock: Detail of Train	Peacock displaying to tortoise
Detail of train support	White Peafowls and deer fawn
White Peacock: Full display	Peacocks fighting
White Peacock: Moulting	Peacock snow-bound

Peafowl and guinea-hen hybrid

DISTRIBUTION OF THE PEAFOWLS (Map) *Lee S. Crandall* 101
 INDIAN PEACOCK *Edward R. Osterndorff* *Cover*

BULLETIN

NEW YORK ZOOLOGICAL SOCIETY

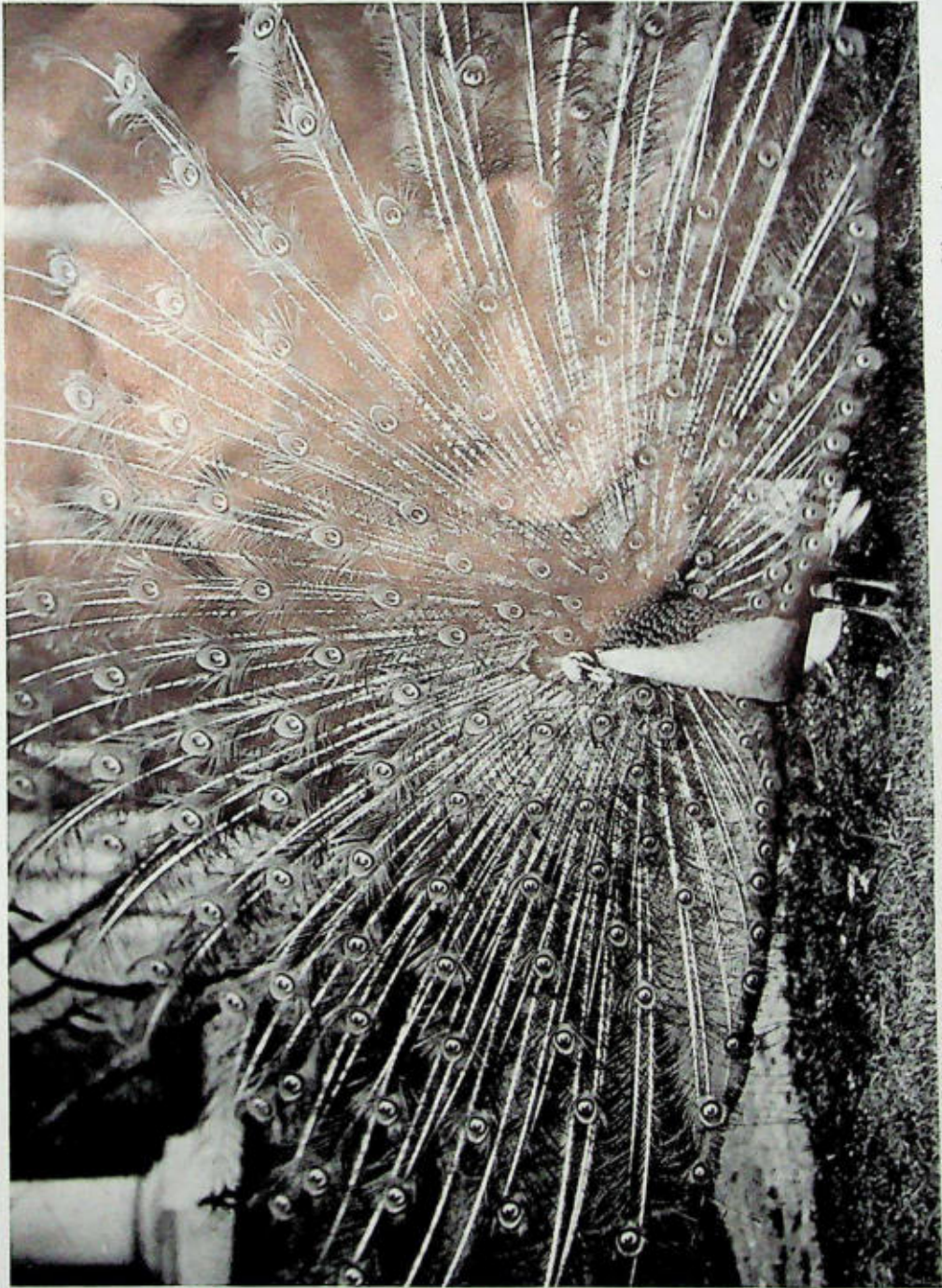
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 WILLIAM BEEBE, *Director, Tropical Research*

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Editorial and Subscription Offices, Zoological Park, New York City, Elwin R. Sanborn, Editor.



The dazzling blue of the peacock's breast, backed by the delicate tracery of the spread train, is one of the most amazingly beautiful sights to be found in nature. The bird shown is an Indian peafowl (*Pavo cristatus*). *Pavo* is Latin for "peacock" and *cristatus*, also from the Latin, means "crested." Photograph by Elwin K. Sanborn.

BULLETIN

NEW YORK ZOOLOGICAL SOCIETY

Published by the New York Zoological Society

Vol. XXXVII

July-August, 1934

No. 4

Peafowls in the Zoological Park

Presented pictorially from the specimens in the collections of the Society, with a brief introduction
by LEE S. CRANDALL, Curator of Birds.

All illustrations are from photographs taken in New York Zoological Park.

SOLOMON is credited as the first owner of a peafowl outside of India. If this is true, it is quite in line with his reputation for acumen. In appreciation of the beauty of this king of birds, the ages have followed his judgment. The readiness with which peafowl have accepted the conditions of captivity, in all parts of the world and in all kinds of climate, has made them so common as to cloud our appraisal somewhat. But the fact remains that it is difficult to find a bird to excel them in beauty of form and coloration.

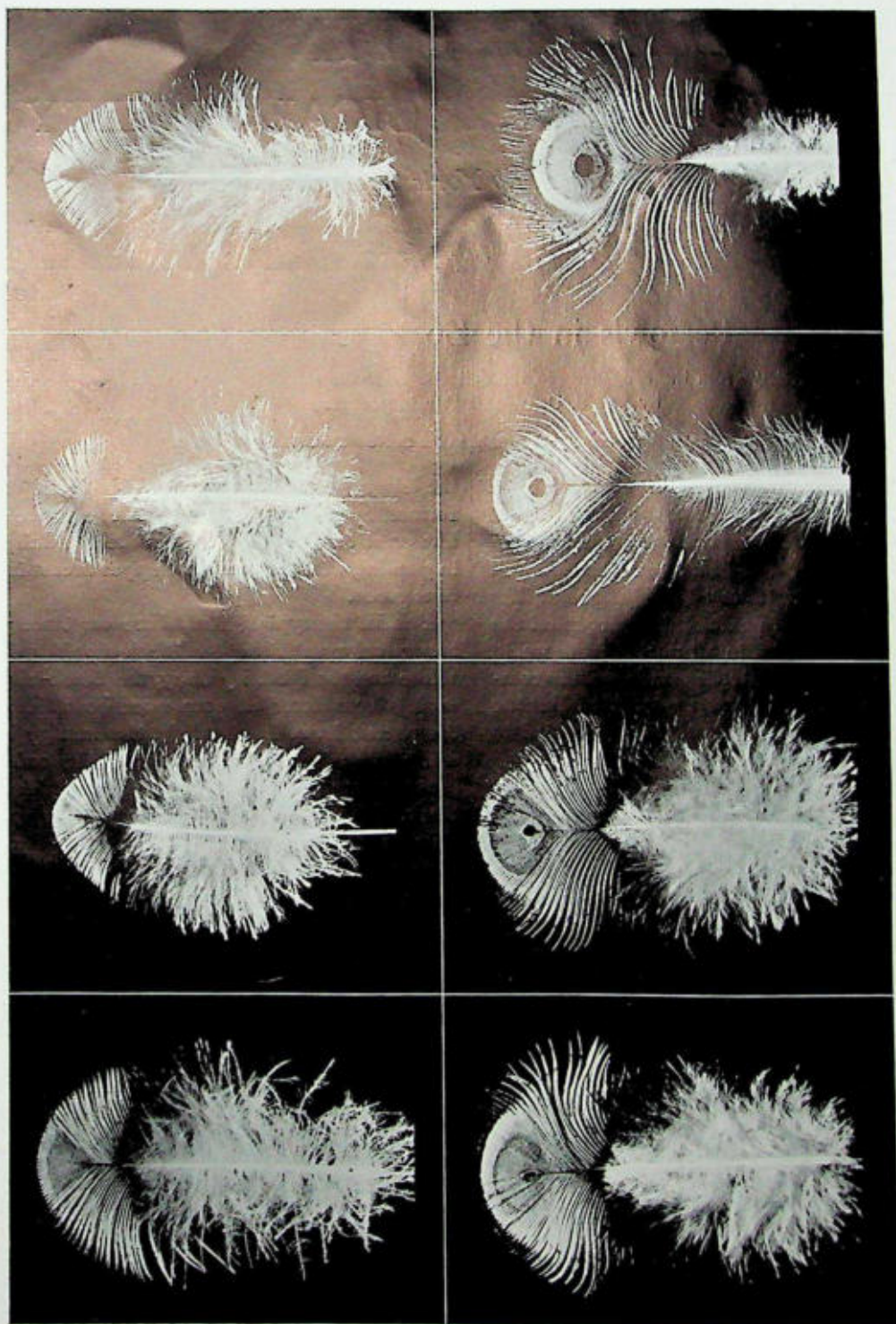
There are two species of peafowl: the Indian or blue (*Pavo cristatus*) and the Javan or green (*Pavo muticus*). They belong, of course, to the order Galliformes, and to the family Phasianidae. In the matter of subfamilies, authorities differ. It has long been customary to assign the peafowl to the *Pavoninae*, but in Volume II of Check-List of Birds of the World, published in June, 1934, James L. Peters places them in the subfamily *Phasianinae*, which also includes the Old World partridges and quails, the pheasants and the jungle fowl.

The Indian peafowl is a native of India and Ceylon. It keeps to the low country, seldom going above 2,000 feet. Although it is naturally accustomed to the steaming heat of such localities, it nevertheless has the ability to endure, without discomfort, temperatures well below zero Fahrenheit. It is this adaptability which has allowed the bird to be enjoyed in most countries of the world. The male Indian peafowl is characterized by the deep blue neck and breast,

the long, delicate and wonderfully "eyed" train formed by the upper tail coverts, and the fan-like crest on the head. The female is a dull gray in general, with the neck and upper breast iridescent green.

Besides the typical bird, there are three well-known color varieties: the Black-shouldered, the White and the Pied. By many, the Black-shouldered is considered as even more beautiful than the parent form. In the male, the smudgy black and white of the wing coverts of the ordinary peacock are replaced by intensely iridescent black. The blue of the neck and breast, also, appear to be of a deeper shade. Strangely, the female of this melanistic variation is nearly white, with rufous nape and dark edgings and mottlings on the feathers of wings and tail. This form is generally accepted as a mutation or sport. The white, of course, is an albinistic variety, now well established in captivity. The pied results from an infusion of white blood into the normal bird, patches of white appearing, most generally, on the throat and in the wings.

The Javan or green peafowl is quite distinct from the Indian species, and hails from Burma and Siam, through Cochin China and the Malay Peninsula to Java. The Burmese bird has been separated as *Pavo muticus speciferus*, but the distinction is slight and is not recognized by many authorities. The Javan peafowl is chiefly distinguished by the brilliant green of the neck, which has the appearance of being scaled, and the long, lance-like crest, as opposed to the fan



The brilliant "eyes" of the peacock's train begin to appear in the lower back and reach their perfection of size and beauty in the longer feathers. The series above illustrates varying degrees of development of this characteristic feature. Photograph by Edwin K. Striborn.

of the Indian. In the Javan, the female is as brilliantly colored as her mate, lacking only the long train. Many females are spurred, as well, so that among young birds or during the molting season, the sexes are not always easily distinguished. There is, however, a character which seems to be infallible: a small, isolated patch of velvety feathers just before the eye is always

iridescent green in males and dull brown in females.

The Javan peafowl is a more delicate species than the Indian and less able to withstand low temperatures. Another characteristic which has interfered somewhat with the popularity of the species is the savageness of adult males which, in some instances, may be really dangerous.



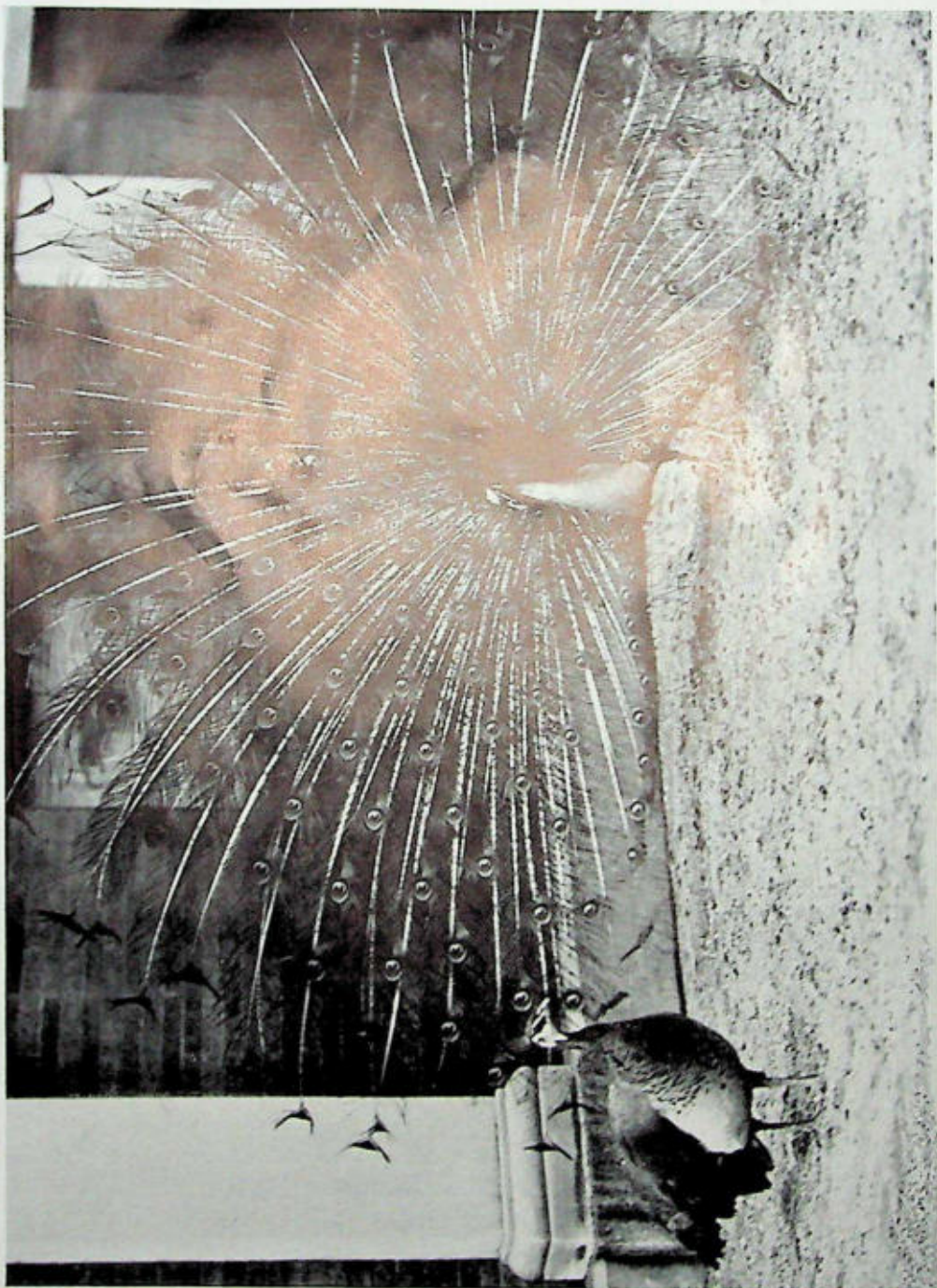
The map above illustrates the distribution of the two species of peafowl. The Indian (*Pavo cristatus*) is found in India, including the foothills of the Himalayas, and in Ceylon. The general area is indicated in medium gray. The Javan peafowl (*Pavo muticus*) comes from Burma (excepting the extreme northerly portions), Siam, Cochin China or French Indo-China, and southward through the Malay Peninsula to Java, missing Sumatra entirely. The range of this species is printed in dark gray.



Adult male Indian peafowl (*Pavo cristatus*) in repose. The long train is compactly folded, so that it causes little hindrance to its owner in escaping from its natural enemies, either by running through grass or brush, or by flight. Photograph by Elwin R. Sanborn.



Adult female Indian peafowl (*Pavo cristatus*).-Feathers of this species are dull brownish gray in general, with the neck and upper breast pale green and the lower breast light. The crest is shaped like that of the male.
Photograph by Edwin R. Sanborn.



Indian peacock displaying to female. The indifferent attitude of the peahen is typical of that of most female birds toward courting males. Nevertheless, the primary purpose is served, for it is the first step in the reproductive cycle. Photograph by Elwin R. Sanborn.



Upper. Indian peahen on her nest. As a rule, peahens do not lay until late spring or nearly summer. For nesting sites, they seem to prefer tall grass or weeds, in a fairly open situation, rather than the dense cover of heavy shrubbery. *Lower.* Eggs of Indian peafowl. When hens are at liberty and allowed to nest where they please, normal clutches appear not to exceed eight. However, if the eggs are collected as laid, a far greater number may be produced. Photographs by Edward R. Osterndorff.



Indian peahen with chicks about six weeks old. The incubation period is twenty-eight days. The wings of newly hatched chicks are well developed and they are able to fly within a few days. A precocious young male in the picture above is already testing his ability as a charmer. Photograph by Edward R. Osterndorf.

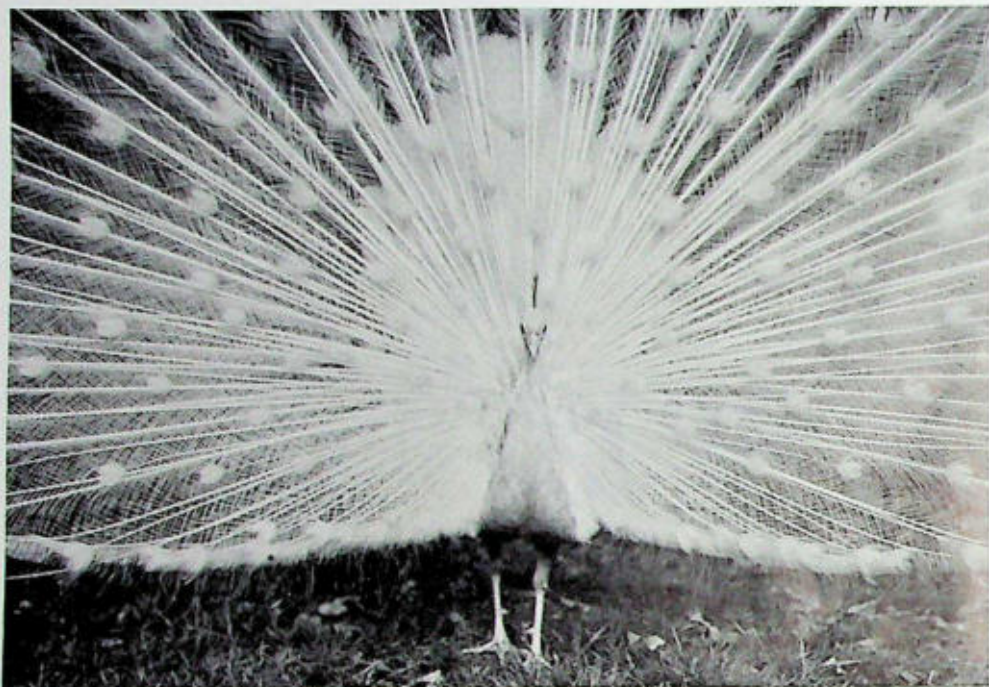


Upper. Indian peahen with her nearly full-grown brood. Peahens are excellent mothers and remain with their broods throughout the first winter. *Lower.* Another view of the same family, the mother being the bird in the foreground. Even before this advanced stage has been reached by the chicks, the males are distinguishable by the blue cast of neck and breast, as compared with the pale green of the females.

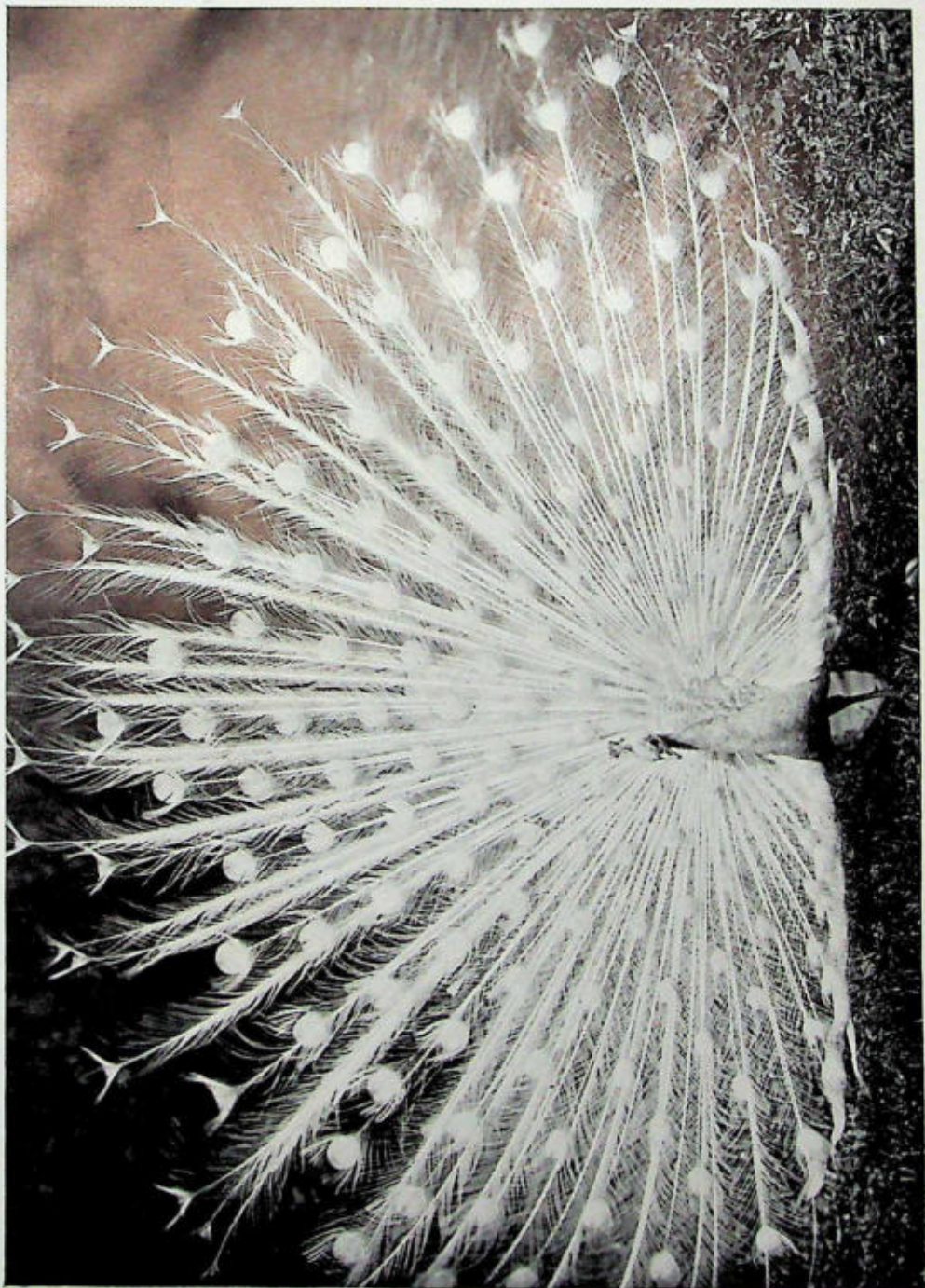
Photographs by Edward R. Osterndorff.



Male white peacock in full plumage. The white peafowl is simply an albinistic variety of the Indian bird, now well fixed and freely bred in captivity. Photograph by Edwin R. Sanborn.



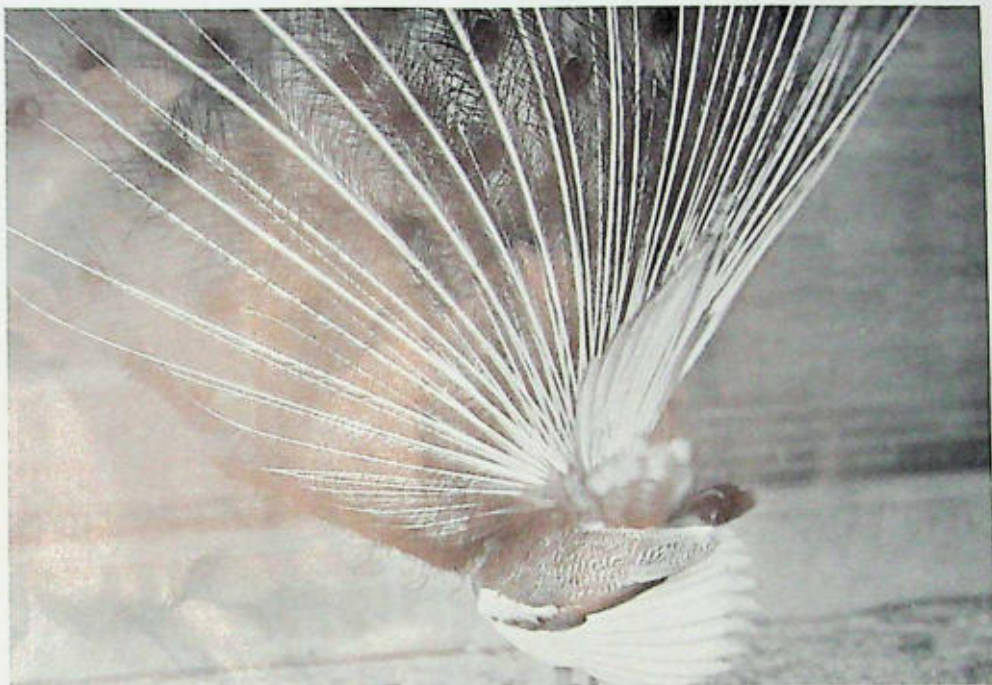
Upper. Close view of white peacock in display. The brilliant hues of the colored cock are due chiefly to the reflection of light by highly specialized feather surfaces. Close examination discloses the presence of shadow "eyes" in the white cock's train. Photograph by Edward R. Osterndorf. *Lower.* A displaying peacock is not easily discouraged but a high wind does make life rather difficult for him. This bird is battling valiantly to hold his train erect and at the same time to maintain his balance. Photograph by Elwin R. Sanborn.



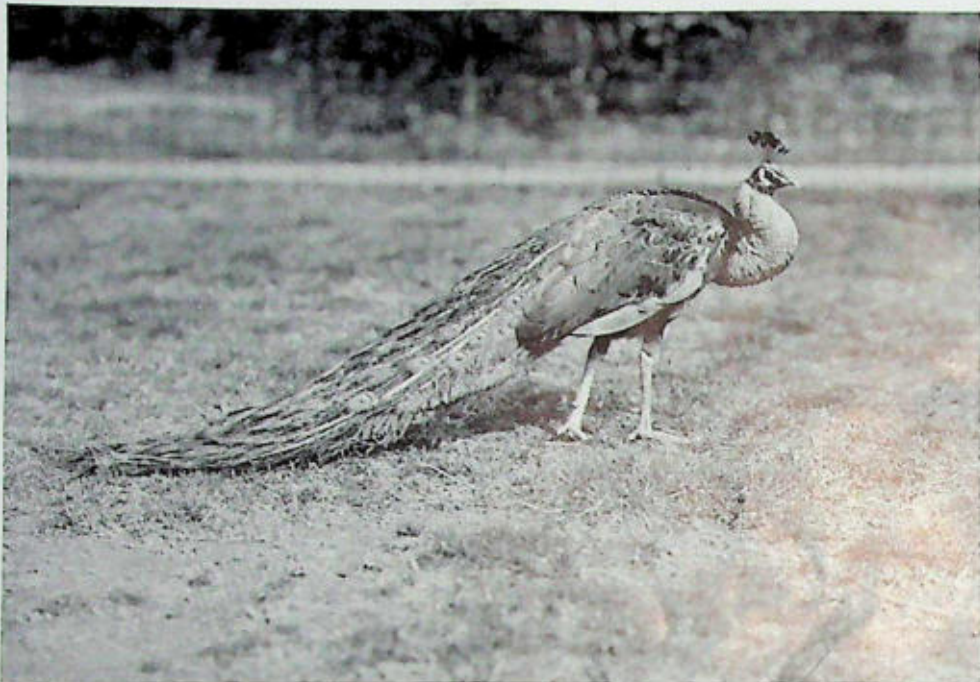
White peacock in full display. This bird possesses an ethereal beauty that compensates for the lack of pigment. The train of the peacock is not acquired until the bird has passed its second birthday and is in its third year. Photograph by Elwin R. Sanborn.



Upper. The molt is a trying period for the peacock. He drops the feathers of his train in June or early July and is seldom entirely fit to be seen before the following February. The bird figured is hardly a creature of beauty, yet he is making a tentative effort to attract attention. *Lower.* Another and more advanced stage of growth. The train is full and symmetrical in shape but at least another month will pass before the feathers reach their final length. Photographs by Elwin R. Sanborn.



Upper. The feathers of the train are not the true tail but simply elongated upper tail coverts. The tail itself is dull brown in color and functions as a support for the spread train, as seen in this photograph. The bird shown is of the pied variety. *Lower.* Besides the white, there are two other color varieties of the Indian peafowl. In the photograph above, the bird at the left is a pied or splashed, while that at the right is a black-shouldered. Photographs by Elwin R. Sanborn.



Upper. Black-shouldered peacock. This richly-colored bird is commonly accepted as a mutant from the normal Indian. It differs chiefly in having the black-and-white-barred wing coverts replaced by highly iridescent black. The general color, also, appears to be of a deeper tone. Photograph by Elwin R. Sanborn. *Lower.* Black-shouldered peahen. Strangely enough, the consort of the black-shouldered cock is very nearly white, with pale green neck, a tinge of rufus on the nape and black edgings on wing and tail feathers. The chicks are white when hatched, the young cocks becoming darker at each molt. Photograph by Edward R. Osterndorff.



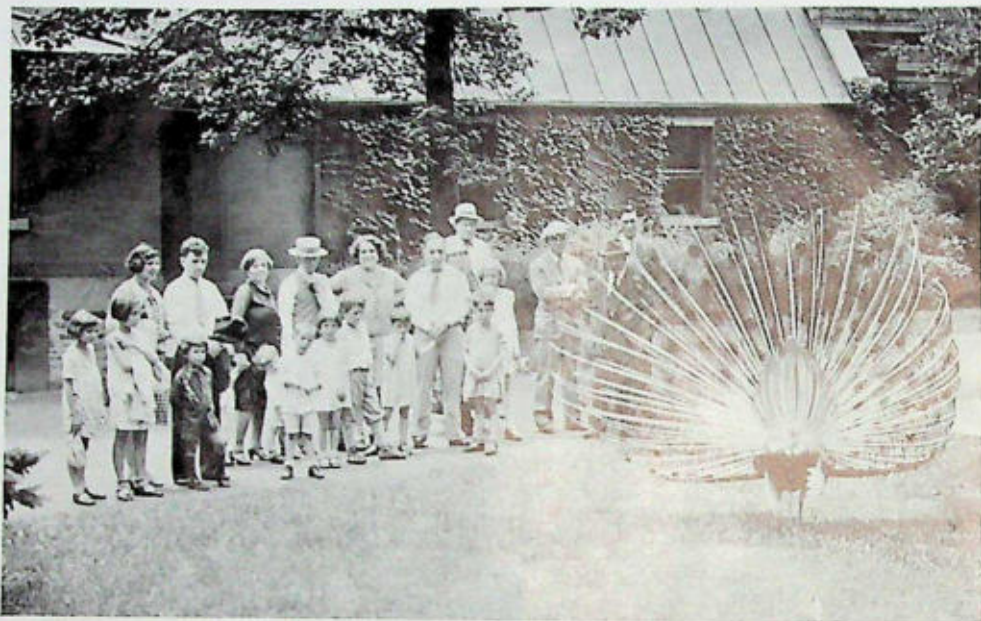
Pied peacock. This variety of the Indian appears to have been originated by an infusion of white blood. Most specimens show white in the wings, with further markings about the head and neck.
Photograph by Elwin R. Sanborn.



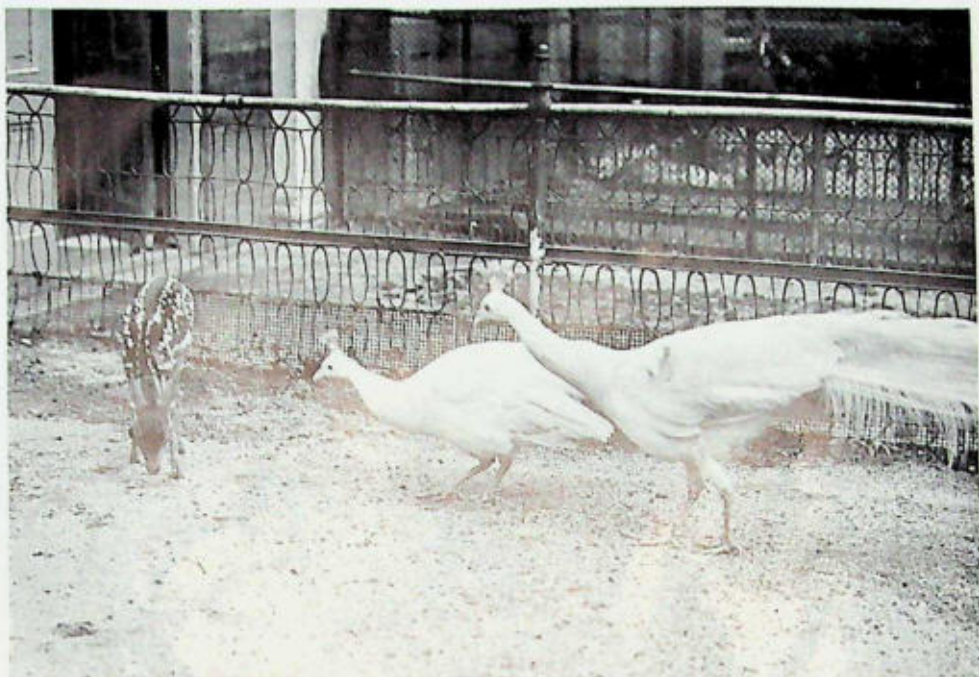
Male of the Jayan peafowl (*Pavo muticus*). This bird differs in several particulars from its western neighbor. The legs are long and the body slim, so that it stands noticeably higher. The deep blue of the neck and breast are replaced by shimmering green, with a scaled effect. The crest is long and compact, with almost the appearance of a single feather. Photograph by Edwin K. Sanborn.



Female of the Javan peafowl (*Pavo nauticus*). Unlike the female of the Indian species, the Javan peafowl closely resembles her mate, except that she does not possess the train. Often, too, her legs are spurred. Always, however, she may be distinguished by the small patch of brown feathers before the eye, which are replaced by green ones in the male. Photograph by Edward R. Osterndorff.



Upper. The peacock has become a symbol of vanity and the conception appears to have a sounder foundation than most popular interpretations of animal behavior. On any fine spring day in the Zoological Park, peacocks may be seen displaying for circles of admiring visitors, whose plaudits appear to rouse the birds to increased efforts. Photograph by Edward R. Osterndorff. *Lower.* The peacock's urge to display sometimes leads him into strange places. The bird pictured was strongly attracted by the tortoises in the runs at the eastern side of the Reptile House and during the spring he spent most of his waking hours there. There was no evidence that his interest was returned. Photograph by Elwin R. Sanborn.

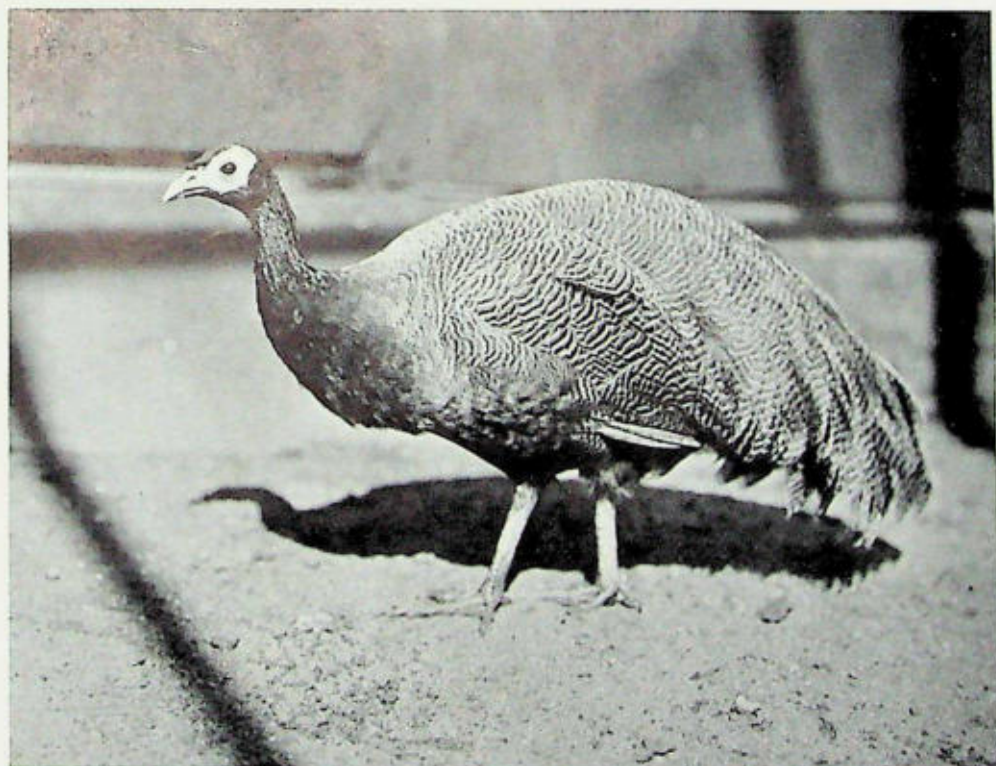


Upper. A young fawn, kept temporarily in the tortoise yards, furnishes a momentary diversion from the tortoises. Even the presence of his lovely mate, whose interest seems even to exceed his own, is not sufficient to deter the white peacock's curiosity. *Lower.* More alert than the lowly tortoises, the fawn does some investigating of his own, to the detriment of a peafowl idyll. Photographs by Edward R. Osterndorff.



Upper. Battles between peacocks are neither frequent nor very fierce. In courtship time, each keeps to his own display ground, which he guards so jealously that it is seldom intruded upon. Occasionally, however, there may be a dispute as to proper ownership but a few quick flurries usually end the argument. *Lower.* Although the Indian peafowl is properly a plains bird and seldom gets higher than the Himalayan foothills, it is almost impervious to cold and snow. The bird pictured was nearly buried in snow during the night but a flight to the ground and a few shakes of his plumage left him with no ill effects.

Photographs by Elwin R. Sanborn.



The Indian and Javan peafowl cross readily, producing handsome, fertile hybrids. Hybrids between peafowl and more distantly related species, however, are rare. The photographs above represent the offspring of an Indian peacock and a domestic guinea-hen, reared in California and until recently living in the Zoological Park. This hybrid is undoubtedly sterile. Photograph by Edward R. Osterndorff.

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BULLETIN

NEW YORK ZOOLOGICAL SOCIETY

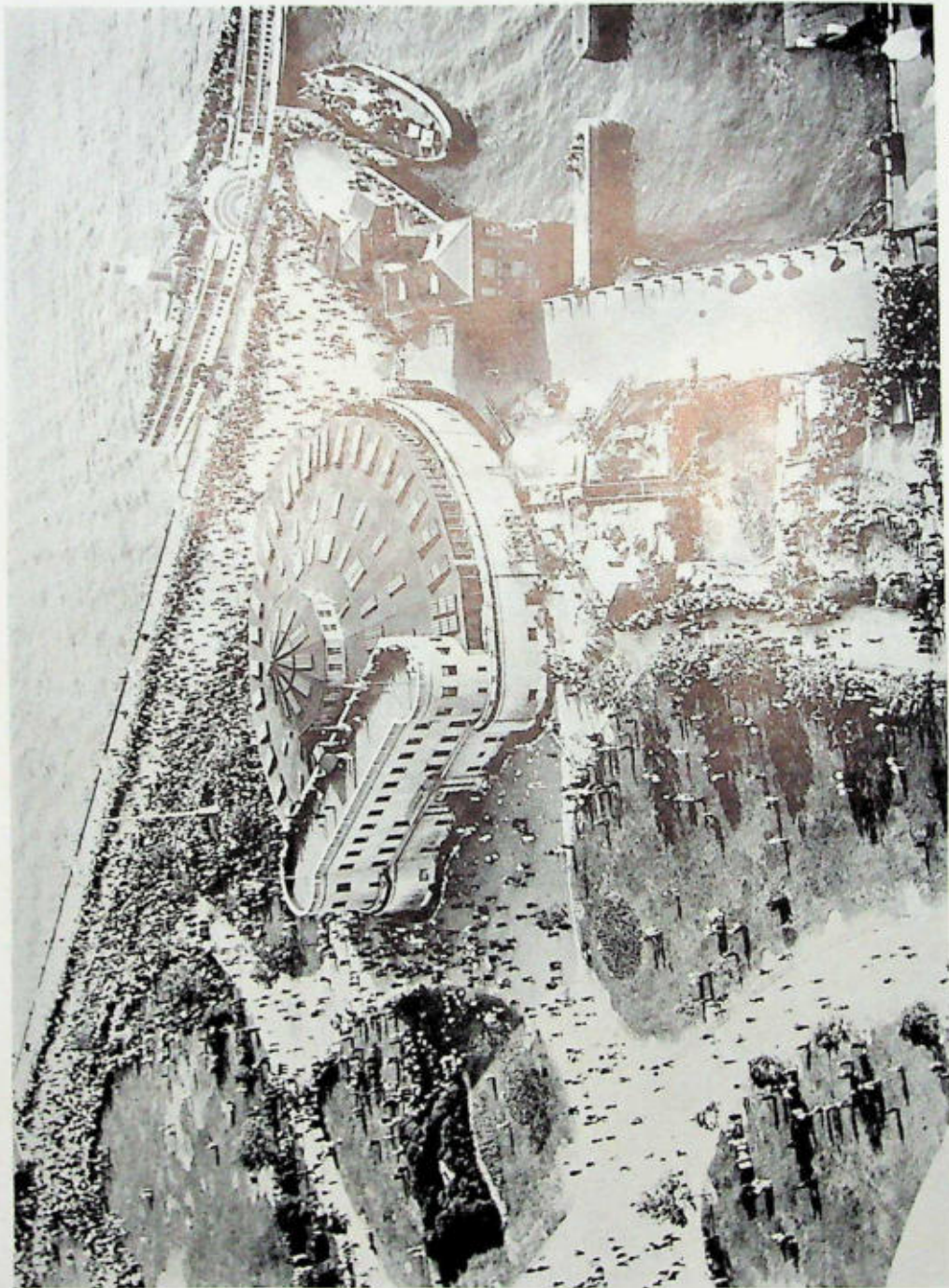
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Editorial and Subscription Offices, Zoological Park, New York City, Elwin R. Sanborn, Editor.



The New York Aquarium at the time of the Navy visit to New York City, May 31, 1934. On this day, 30,610 persons visited the Aquarium. Although such a figure is unusual for a single day, the Aquarium has averaged well over 5,000 a day for years, and between two and two and one-half million visitors per annum. The excavation in the foreground is for the fresh-water reservoir now under construction by the Civil Works Administration. Photograph by courtesy of the *World-Telegram* (New York City) through Mr. Lee B. Wood, Executive Editor.

BULLETIN

NEW YORK ZOOLOGICAL SOCIETY

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The Tide

A brief account of the new tide-recording apparatus at the New York Aquarium.

CHARLES HASKINS TOWNSEND

*"The water follows the moon, silently with fluid steps
anywhere around the globe."—Walt Whitman.*

THE Aquarium at last has a Tide-Gauge, which shows at all times the exact stages of the sea tides at Battery Park. With an explanatory label the tide-gauge will be interesting and instructive to people who have little acquaintance with the sea; who do not know that the tide rises and falls twice every day, and that navigators must reckon with it accordingly.

The stage of the tide determines the water-level along the wharves, and its flow and ebb accelerates or retards the movements of vessels entering or leaving port. Its action is perpetual because the moon in its monthly course pulls the tide with it around the world from east to west and the earth turns on its axis daily from west to east. The sun also pulls the tide but its influence is less than half that of the moon because of its immensely greater distance from the earth. When both are on one side of the earth and in line with it, the tide is at its highest. It is then called a spring (high) tide. The terms new-moon tide and full-moon tide are also applicable. When sun and moon are not in line with the earth they pull at cross purposes with the result that the behavior of the tide keeps changing until they are again in line with it. At its lowest it is called neap (low) tide, the sun being at right angles with the line of earth and moon. While there are two high and two low tides a day they are nearly an hour later from day to day.

The tide has an effect on many coastwise industries. It fixes the periods during which clam

diggers and oyster tongs may operate; fishermen in different localities along shore keep informed on its movements to get the best results with nets and lines, because fishes move inshore as the water rises. Formerly there were mills whose power wheels were turned by rising and falling tides. In rivers such as the Hudson for instance, where the influence of the tide extends above Albany, vessels can move with it advantageously. When the tide is temporarily stationary at high and low water, steamers may dock or leave without difficulty. At other times they may require the help of tugboats.

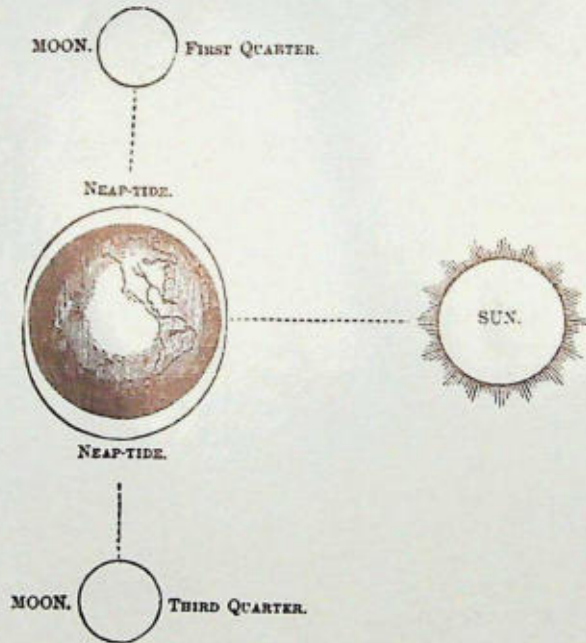
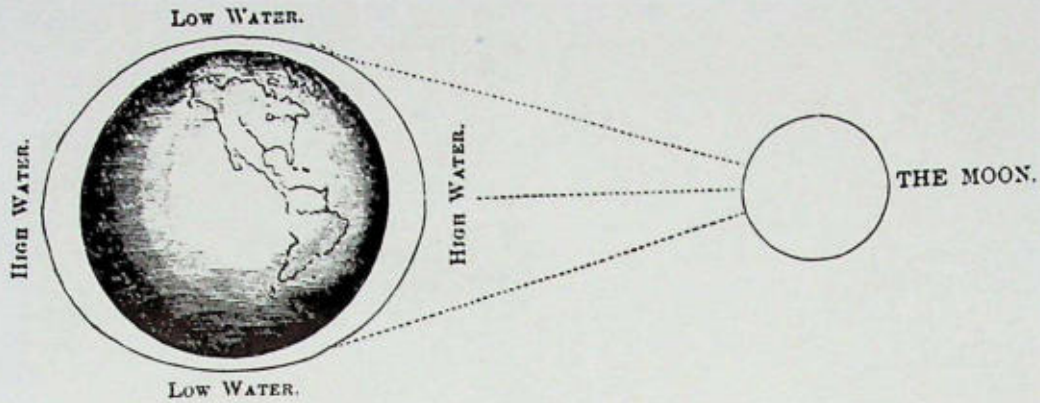
Navigators of all classes keep the run of the tides by consulting the tide-tables published annually by the government. These documents predict the movements of the tides for many localities, by day, hour and in fact, minute, for the whole year. They are obtainable at all ports, so intimately are the lives of maritime folk concerned with the behavior of the tides.

The United States Coast Survey has self recording tide-gauges at many points along the coast which automatically register the movements of the tides at each locality for scientific study. The simple tide-gauge at the Aquarium shows merely the level of the tide at the particular moment of observation.

Were the surface of the earth entirely covered with water there would be no irregularity in the movement of the tide-wave following the moon. But the presence of continents, the irregularity of coast lines and varying depths of



The tide-gauge recently installed in the Aquarium. Besides showing the height of the water, there are various other items marked on the scale, such as mean low water and extreme high water. Photograph by S. C. Dunton.



Diagrams showing positions of sun and moon in relation to stages of tides.
From Johnson's Encyclopedia.



An extreme high tide at the Battery. The water is within a few inches of the sea wall. A slight, further rise would inundate Battery Park. Photograph by S. C. Dunton.

water along shore produce complications. The tide is never the same in any two places. While its ordinary rise and fall at the Battery is only about four feet, its range is nearly twice that at the head of Long Island Sound and nine feet at Boston. There are places where owing to the configuration of the land, the tide rises to enormous heights, as in the Bay of Fundy. At the Atlantic end of the Panama Canal the tide has a rise and fall of only a foot; at the Pacific end its range is from twelve to sixteen feet. There are rivers where the rising tide sweeps in as a dangerous roaring breaker. The flood tide is not confined to the side of the earth next to the

moon—there is also high water on the opposite side of the earth at the same time, the moon attracting the earth itself, leaving the water sagging on the other side. Thus the revolution of the earth gives us two tides a day instead of one. Tides are always liable to variations caused by wind and weather.

All this is an old story to people who know about the tide. It is told here for the benefit of the really great number of persons who do not know. It is a mere sketch of a vastly complicated matter which considered in detail, would fill and has in fact filled volumes.

The Reproductive Habits of the Painted Betta

A relative of the Siamese fighting fish, new to aquaria.

C. M. BREDER, JR.

IN the pursuit of certain studies on the reproductive habits of fishes particular attention was given to forms that showed especially elaborate behavior in regard to courtship, care of young, or other features of procreational activity. One species considered in this connection

was the well known Siamese fighting fish, *Betta splendens* Regan. Prior to spawning the male of this species constructs a nest composed of air bubbles which float on the surface of the water. The bubbles are covered with some viscid secretion in the mouth which gives them sufficient



An unnamed species of *Betta* gathering its eggs. The lower fish is the female which has just ejected the eggs from her mouth for the male. Six of them may be seen as white spots immediately above her head. The male, to the left, is about to take them in his mouth where they will remain until the fishes hatching therefrom will be able to care for themselves. Photograph by S. C. Dunton.

permanence for the function which they are to serve. After the nest has been built the male induces a female to come under the construction where spawning takes place. The eggs are heavier than water and consequently sink. The male carefully gathers them up in his mouth and tucks them in the mass of froth constituting the nest. Here he guards and protects them and returns any which may fall out. This care is carried on until after hatching and until the young fish are able to shift for themselves. The above epitomized account is well known and has been discussed at considerable length by various students.

There are two other species congeneric with this one that are sometimes kept in aquaria but are not so well known. One of these *Betta bellica* Sauvage is reported to breed in a manner essentially similar to that of the Siamese fighting fish. Mr. R. W. Lanier of the Steinhart Aquarium, who has had this species under observation assures us that such is the case. The other, *Betta pugnax* (Cantor) is reputed to have the habit of incubating its eggs in the mouth of the male. Since this would appear to be a distinctly different form of reproductive habit, efforts were made to obtain some specimens for study. In this connection the good services of Mr. C. W. Coates of the New York Aquarium were drawn upon. After some effort he succeeded in obtaining two lots of fishes transmitted to him under the name *Betta pugnax*.

The first lot, four fishes, were obtained indirectly from the "Aquarium Hamburg" a commercial house. They were supposed to come from Johore. These proved to be oral incubators but they were not *Betta pugnax*. In regard to the identity of these fishes Dr. G. S. Myers of the United States National Museum was consulted, who with his superior acquaintance with labyrinthine fishes is convinced that this first lot of fishes represents an unknown species, while the second lot was not *Betta pugnax* either, but still another species, *Betta picta* (Cuvier and Valenciennes). The exact source of the latter fishes unfortunately is impossible to ascertain at this time, at least. The specimens of *Betta picta*, which we may call the painted betta, were the gift of Dr. K. Kuiper of the Rotterdam Aquarium and were brought to the New York Aquarium through the kind efforts

of Mr. J. F. Emde. To both these gentlemen this Institution is grateful once more for their continued efforts in securing rare specimens in its behalf.

The species, as yet unnamed, showed habits that rather clearly indicated the mode of origin of oral incubation in this group. The male fish would select some site, usually a tank corner and perform in it almost exactly as though the site was roofed with a bubble nest. In the pair studied both sexes picked up the eggs and carried them to near the surface of the water and there spat them out and upwards as though discharging them into a nest. The eggs, of course, simply fell to the bottom when they would be retrieved and the performance again gone through. This might go on for half an hour after which time it would be given up. In each case finally the male held all the eggs in its mouth. It seemed that at times the female deliberately transferred the eggs she had to the male. At least she was noted to spit the eggs out only near the head of the male and then to pick them up again only if he failed. It is not difficult to imagine how such a habit could have arisen. The loss of the ability to build a bubble nest or a shift in environment to a place where a fragile froth raft could not be successful would readily account for the observed behavior. The failure to find a suitable depository for the eggs could then culminate in the simple retention of them in the mouth—oral incubation.¹

An assumption that the evolution of these habits moved the other way could hardly be argued, for the group of fishes to which the *Bettas* belong are marked by their building of froth nests. This is common to many of them, whereas oral incubation, within this group, with possibly two exceptions (*Luciocephalus* and *Sphaerichthys*) is confined to the genus under discussion.

The reproductive habits of the painted betta are rather similar to those described above but they are not as clearly marked. The male simply

¹Since this was written an article by W. L. Brind has appeared in *Aquatic Life* 18(5):95-98 describing the breeding of this fish under the name *Betta pugnax*. It is in essential agreement with the above, the slight descriptive differences probably being referable to individual differences in the fishes. The specimens were received from the same source and Mr. Brind obtained a detailed description of the habitat from the collector Mr. A. Ramsperger. According to this the species inhabits flowing streams where froth nests could hardly be useful. The Siamese fighting fish on the other hand breeds in rice fields and other still waters.



Upper: The painted betta, *Betta picta*, a new fish for the home aquarium. The male in the upper left. The photographs accompanying this article are apparently the first of this species and we believe the specimens which are in the New York Aquarium to be the only ones in America at least. *Lower:* A male painted betta with a mouthful of incubating eggs. While the eggs are developing the fish spends nearly its entire time resting quietly amid water weeds.

gathered up the eggs and swam off in the actual spawnings observed. The courtship and embrace is similar to that of both the Siamese fighting fish and the undescribed *Betta*. It would consequently seem that *Betta picta* had moved further away from the nest building habit, having "forgotten" even the vestigial ceremonies previously discussed. As with all such fishes the brooding individual takes no food for evident mechanical reasons.

The painted betta is about the size and has the general appearance of the Siamese fighting fish, although the pattern and coloration is somewhat different. Since it has been demonstrated that the Siamese fighting fish will attempt to court objects far more different from it than the painted betta, some experiments were made to determine if these two species, despite their superficially different habits would attempt to cross breed. This was done not with the desire to produce hybrids but more to study the interaction of the reproductive modes. No matings occurred but there was an extensive courtship that seemed, however, only to result in confusion. The most interesting case was observed between a male painted betta and a female fighting fish. Courtship proceeded almost to the point of spawning. Here the female would back off, swim around and eye the brilliant male. The impression could not be avoided that the female was puzzled, if such a word can be applied to a fish, at the stupidity and unwarranted behavior of her suitor.

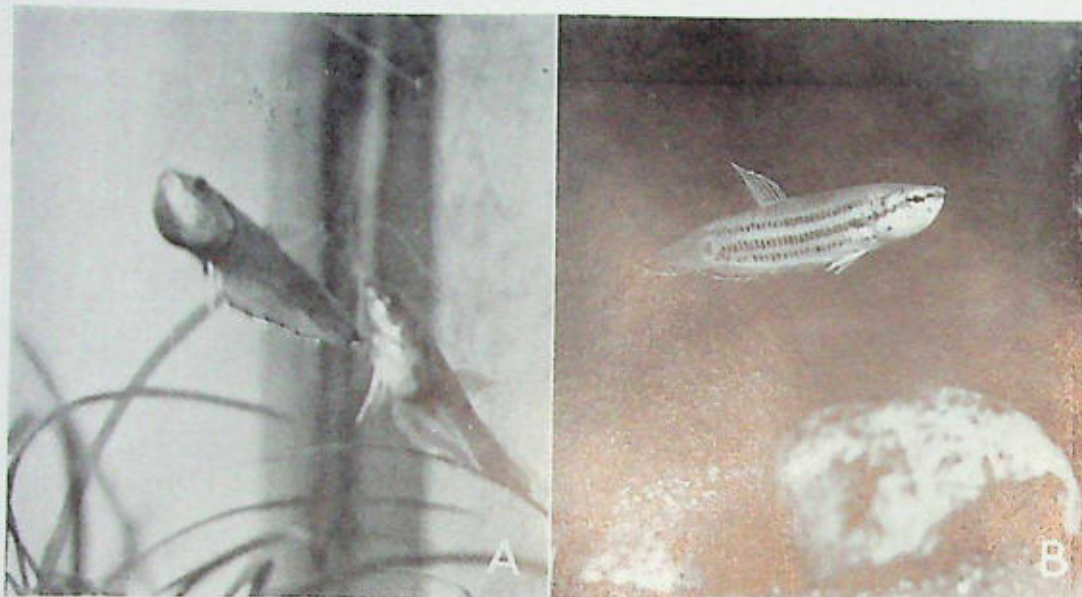
Although there are fourteen species of the genus *Betta*, not including the as yet unnamed one here mentioned, few have found their way into aquaria, but all that have seem to be well adapted for such an environment. No one apparently has ever reported on the habits of *Betta picta* in an aquarium, nor has it been previously mentioned in such connections up to this time, being merely the name of a recognizably distinct species in regional and systematic lists. The *Bettas* thus far kept in aquaria may be listed as follows:

It is thus evident that out of a possible fifteen only six have been kept in aquaria. The last one, *Betta fusca* Regan, included on the authority of Dr. Myers who informs me that he has only seen the name listed in some of the older German aquarium catalogues. Furthermore, the status of *Betta pugnax* is uncertain. Possibly the fish to which this name properly refers has never been kept in aquaria. Since the five of which the habits are known, three carry eggs in their mouths while only two incubate in nests, it is possible that eventually it may be demonstrated that oral incubation is the rule instead of the exception in this genus. This is written on the assumption that the true *Betta pugnax* actually has been kept in aquaria and that it is a valid species.

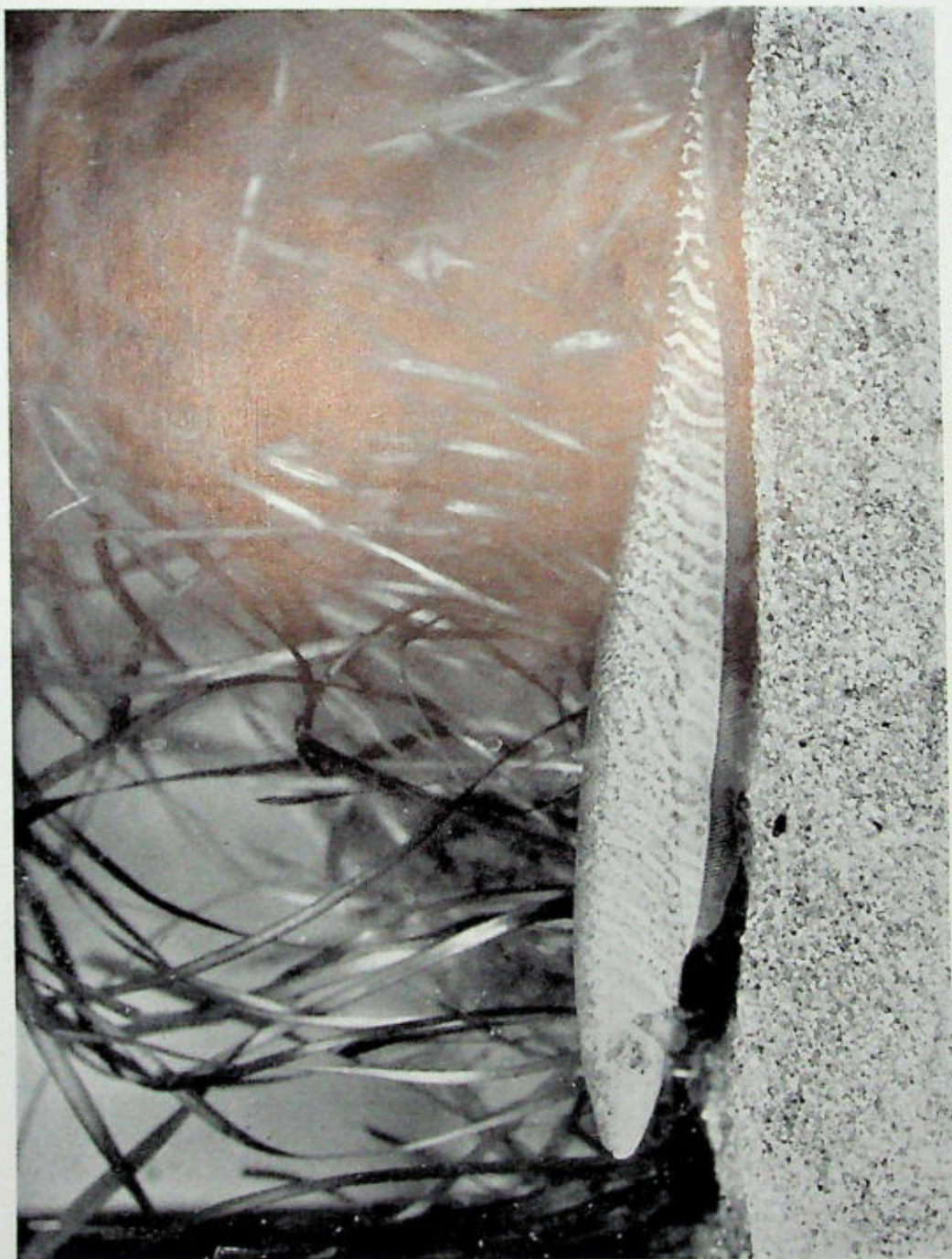
The best known species, the fighting fish of Siam, appears from time to time under a wide variety of names and fishes obtainable in American aquarium shops show much variation. These are merely varieties of a single species selectively bred for ornamental purposes. It is so well known that it need scarcely be mentioned that the common name is derived from the exceedingly pugnacious nature of the males, which are sometimes used for "sport" after the manner of game cocks.

The painted betta is far less quarrelsome and is an exceedingly timid and nervous little fish, in fact, being so shy that a close study of its habits is not easy. While not as brilliantly colored as the domestic varieties of its quarrelsome cousin it compares favorably with the wild ancestors of that species. Then too there is a very marked change of pattern and color with emotional disturbance. Most prominent and permanent is a broad iridescent blue band along the edge of the long anal fin. This color is on the membrane of the fin and the rays which cross it are a deep maroon. Sometimes rows of bright bluish green dots are present on the sides but more often they are replaced with four broken black stripes on a light background. The tail is most frequently edged with maroon and the dor-

Common Name	Scientific Name	Breeding Habits	Origin
Siamese Fighting Fish	<i>Betta splendens</i>	Builds froth nests.	Siam
—————	<i>Betta bellica</i>	" " "	Perak, etc.
—————	<i>Betta pugnax</i>	Carries eggs in mouth.	Borneo—a questionable species.
Painted Betta	<i>Betta picta</i>	" " " "	Singapore, etc.
—————	<i>Betta sp. (?)</i>	" " " "	Johore
—————	<i>Betta fusca</i>	?	Sumatra, etc.



(a) An incubating male painted betta with an unusually large mouthful. The swollen basket-like "jowls" give mute testimony of the apparently uncomfortable proceedings. A female, to the right, has been pursuing the male. It may be noted that this fish is distended with roe that it seems desirous of shedding. (b) A male painted betta showing its striped phase. This coloration is more commonly seen on female fish but occasionally the males also display such a pattern. (c) The bubble nest of the common Siamese fighting fish in the corner of an aquarium. This male, which is close to the wild uncultivated fish is guarding its nest full of eggs. Photographs (B) and (C) by S. C. Dunton.



Gymnocephalus carapo, a non-electric relative of the electric eel. This fish occurs over most of northern South America and depends upon its well developed teeth for food and defence.

sal with an iridescent green. As in most such fishes the female is comparatively somber, being most frequently a pale tan with horizontal dark stripes. Since the painted betta is easily

bred and the young hardy, of a peaceful disposition and rather attractive, it is not unlikely that this species might gain considerable popularity among home aquarists.



Electric eels, *Electrophorus electricus*, from Brazil. The swellings near the heads of these fish indicate full stomachs. These fish are fully conscious of discharges of electricity by each other but are not adversely affected by it.

SOME ELECTRIC FISHES AT THE AQUARIUM

C. W. COATES

Illustrations from photographs by S. C. Dunton

FROM time to time the Aquarium receives and exhibits specimens of the various electric fishes. There are a number of these but, in general, they have not a great value as exhibits, for they are given to hiding in the sand or rockwork in their tanks. If they have neither sand nor holes in which to hide, they usually die. Their electric powers are quite curious and not entirely understood, although all of these fishes have been the subject of much scientific consideration for many years, and we know where they generate and store the electricity.

In the electric eel *Electrophorus electricus*, from northern South America, of which the Aquarium exhibits a specimen about five feet long, the electric organs are known to be three pairs of muscle-like tissue, the chief of which extend from just behind the head almost the whole length of the body on each side of the back-bone. The secondary organs, called Hunter's organs, are smaller and run parallel to

these, but closer to the anal fin. The third electric organs are called the Bundles of Sachs and are located along the large electric organs in the latter half of the body.

Dr. Carl Sachs made a series of experiments with this fish in its natural environment—on the rios Orinoco and Apuré—in the latter half of the nineteenth century, but unfortunately he died before he had time to make a full report on his observations. He does state, however, that a shock may be received in four different ways—by completing the arc; by conduction; by direct contact, and from the water in which the eel is discharging shocks. Where electricity is produced by ordinary means, it is necessary to make some contact with the ground, if the circuit is not complete, before any shock is felt. In the case of all the electric fishes handled, we have found from our own experiments with these creatures that one may be securely insulated in every way, except one contact with the fish itself, and still feel a very considerable shock. One report of somewhat doubtful authenticity gives the value of the shock of the electric eel at about six hundred volts, and while this report may be doubtful it is a fact that a shock

is sufficient to completely paralyze the muscles while the current is still flowing. Faraday, the famous physicist, found that the average shock of a fish about four feet long was comparable to that given by a battery of fifteen Leyden jars with a surface of 2.258 square metres loaded to their maximum capacity.

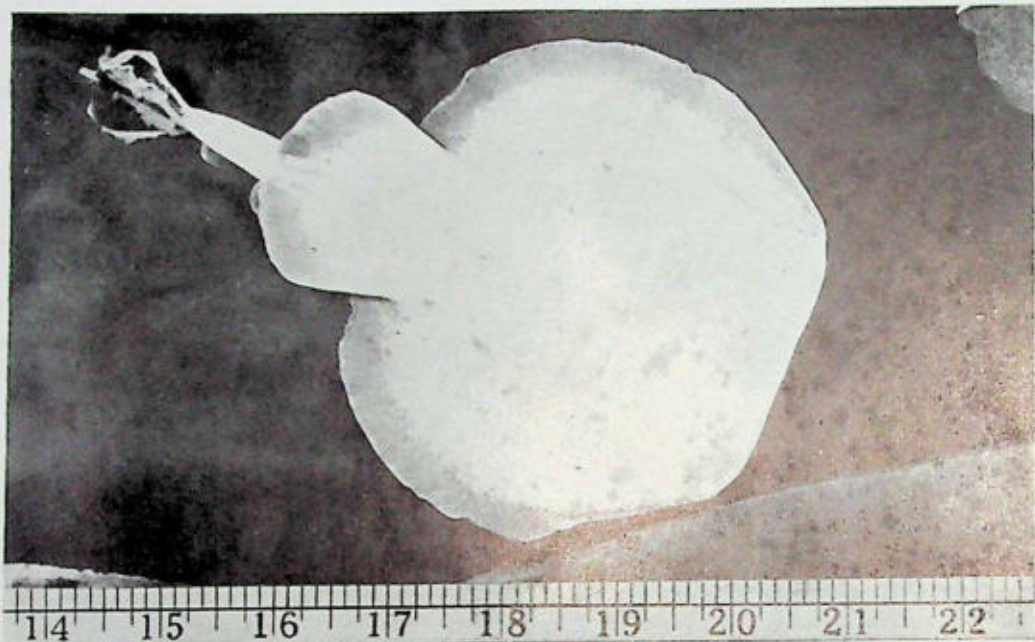
An interesting thing about the eel is that it can, apparently, regulate the power of the current it releases. This may be demonstrated by using an eel which is comparatively tame, in which case the eel will release a small shock if it is stroked or pushed about in the water by its keeper, but will release a paralyzing shock if it is fearful, as when it is about to be moved and finds itself in a net. The only successful way to move such a fish, whose electricity will flow along an apparently perfectly dry wooden net-handle, is to sufficiently disturb the eel for a period of an hour or so to stimulate it into giving off all its electricity, when it may be handled with impunity before it can generate any further supply. This may take about two hours. Further evidence of the regulatory powers is offered when the feeding habits of the fish are watched. It will not eat dead fishes at all, but will send out merely enough electricity

to paralyze its potential food. When food fishes with varying degrees of tolerance against electricity are used, the eel after two or three attempts will determine the correct amount of electricity to discharge to paralyze the food, and not kill it, or stimulate it into swimming rapidly away. The eel, in the Aquarium at least, will seldom, if ever, swim after its food, but will lie in wait until the food fishes approach under their own power. After one or two shocks have been released by one eel, in an attempt to feed, all the eels in the tank will swim about the same spot in great excitement, and any food fish which swims out of the immediate vicinity of the active eels is quite safe until it swims before the nose of an eel again.

The eels have, apparently, some special receptor organs for receiving electric shocks and locating their source, for if one eel is stimulated into releasing a shock it will swim rapidly away, and return later, perhaps, to investigate. Before the first one returns, however, all the other eels in the tank will have received the shock and come to the place of its origin to investigate. This was noticed repeatedly, for it was found necessary, because of the lack of interest in searching for food, to wait until one eel was



Dorsal aspect of the electric torpedo brought to the Aquarium from East Africa by A. M. Vida.



Ventral aspect of the same specimen shown on page 131. Brought from East Africa.

within reach and then drop a bit of meat or fish on its nose. It would discharge, seize the food, and decamp; but the other eels, no matter how dormant, or how far away in the tank—which was twenty-eight feet long—would immediately come to the spot where the food was dropped and regular feeding would then take place. A check on this was made repeatedly by dropping a small pebble on the back or tail of an eel, causing it to discharge and swim away, and in every case all the other eels immediately would be swimming about, under the exact spot where the pebble was dropped. There can be no question of markers being noticed by the eels, for the pebbles were dropped through iron grill-work and in different places—sometimes at the head, the back, or either side of the original eel—and the small splash of the falling pebble, or the rings caused by its entrance in the water, had no effect at all unless the pebble actually touched the eel and caused it to discharge. The discharge of electricity by one eel does not otherwise affect the other eels, they probably having a tolerance for each other's shocking power.

The discharge of electricity by the electric catfish, *Malopterurus electricus* of Africa, how-

ever, causes considerable disturbance to other electric catfish within range. This phenomenon has been noticed from the first that electric catfish have been observed in aquaria, and all subsequent observations seem to bear it out. Recently, tank space being somewhat at a premium, we tried keeping two of these creatures in the same tank, giving them aquaria which were quite large in comparison to the size of the fish and with many caverns and holes arranged in which to hide separately. We also tried to keep one male and one female together in comparatively large aquaria, but whenever more than one electric catfish were kept in the same aquarium the net result was the same—within a week there was only one alive. In a state of nature the fish must at least pair for mating, but whether they then develop a tolerance for each other's electric powers, or cease discharging electricity, we have no present means of knowing.

The value of the electric power of these fish is somewhat different from those of the electric eel which uses electricity both as a means of catching food and as a defense. The catfish does not, apparently, use its electricity for catching food, but merely as a defense. There is a distinct difference between the feel of the shock



The electric catfish, *Molopterus electricus*, from Africa. Although the tank was very large the fish congregated in one small cavernous structure of the rocks, a dangerous massing for them since they apparently have no tolerance for each other's electricity.

of the electric eel and the electric catfish. The former is vigorous and prolonged, and if one seizes hold of the fish with the hand, the muscles are contracted and one will be unable to let go again, whereas the shock of the catfish is similar to that from a high tension medical battery—sharp and stinging, but of the shortest duration. In respect to the former kind of shock we have been informed by sailors and collectors of fishes who have brought electric eels to us, that they have lost a good proportion of the collection through persons who doubt the electric powers of the fish and catching hold of the animal are unable to let go. As the muscles of their hand and arm contract, the fish discharges more electricity, which in turn causes a further contraction, only to be broken when the fish has been almost squeezed in two and dies.

The shocking power of the torpedo or electric ray of East Africa, seems to resemble that of the catfish, although this fish uses its power, to some extent at least, in its search for food. One specimen recently exhibited in the Aquarium would stun a small fish with electricity, then

dispose its own flat body over that of the victim, and gradually work the stunned fish into its mouth by a series of vigorous undulations of its fins. Specimens of the torpedo are also difficult to procure alive, because of the doubt in the minds of curious persons aboard the steamers which carry the fish back, for the rays are invariably poked and handled until they are exhausted.

In aquaria the electric eel is undoubtedly the best exhibition specimen of these peculiar electric creatures, although it is impossible to exhibit publicly its strange powers.

FISH-TRADING WITH SOUTH AFRICA

CHARLES HASKINS TOWNSEND

Illustrations from photographs by S. C. Dunton

ON October 7, 1932, a telephone call was received at the Aquarium asking if we would accept a small jumping-fish from Africa. We said we would be glad to have such a fish and were then instructed to call for it at a pier in Staten Island. The fish was the well-known

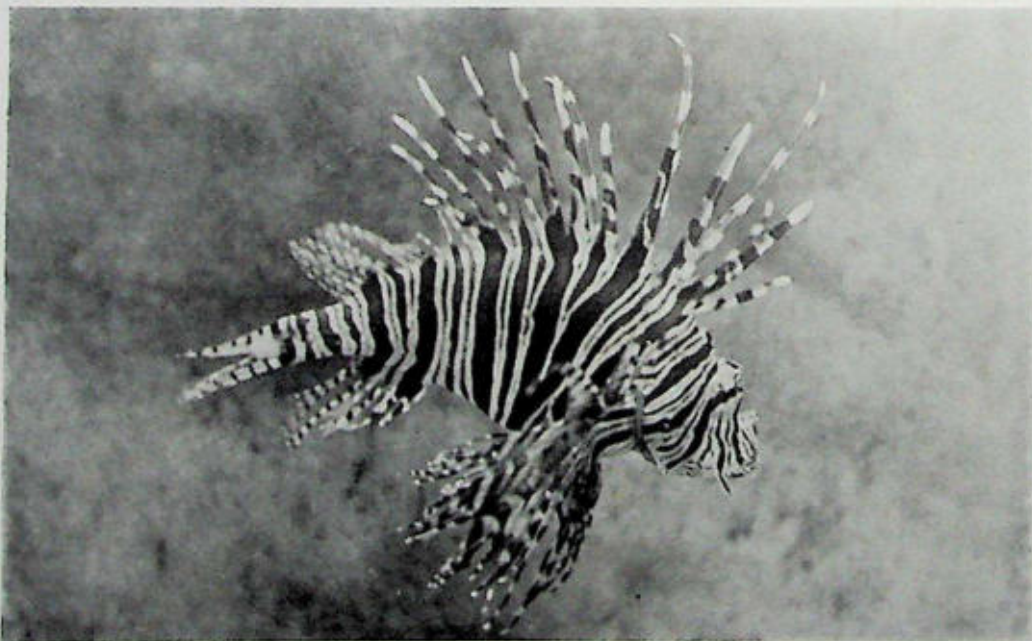
mudspringer, *Periophthalmus koelreuteri*, which spends most of its days hopping about mudflats and mangrove swamps catching mosquitoes, and the donor Mr. A. M. Vida, chief radio operator of the American-South African Line Motor Ship *City of New York*, and thus began a most profitable friendship for the Aquarium.

Mr. Vida had carried a number of animals of one sort or another back to New York from his various ports of call. Some of these animals have found their way into American zoological collections, but this was the first time he had attempted to bring back any fishes. He offered to bring any other small fishes he could catch and handle if we would like them. We were, of course, delighted to accept his offer and the ship sailed back to Africa with our high hopes of acquiring African fishes on its return.

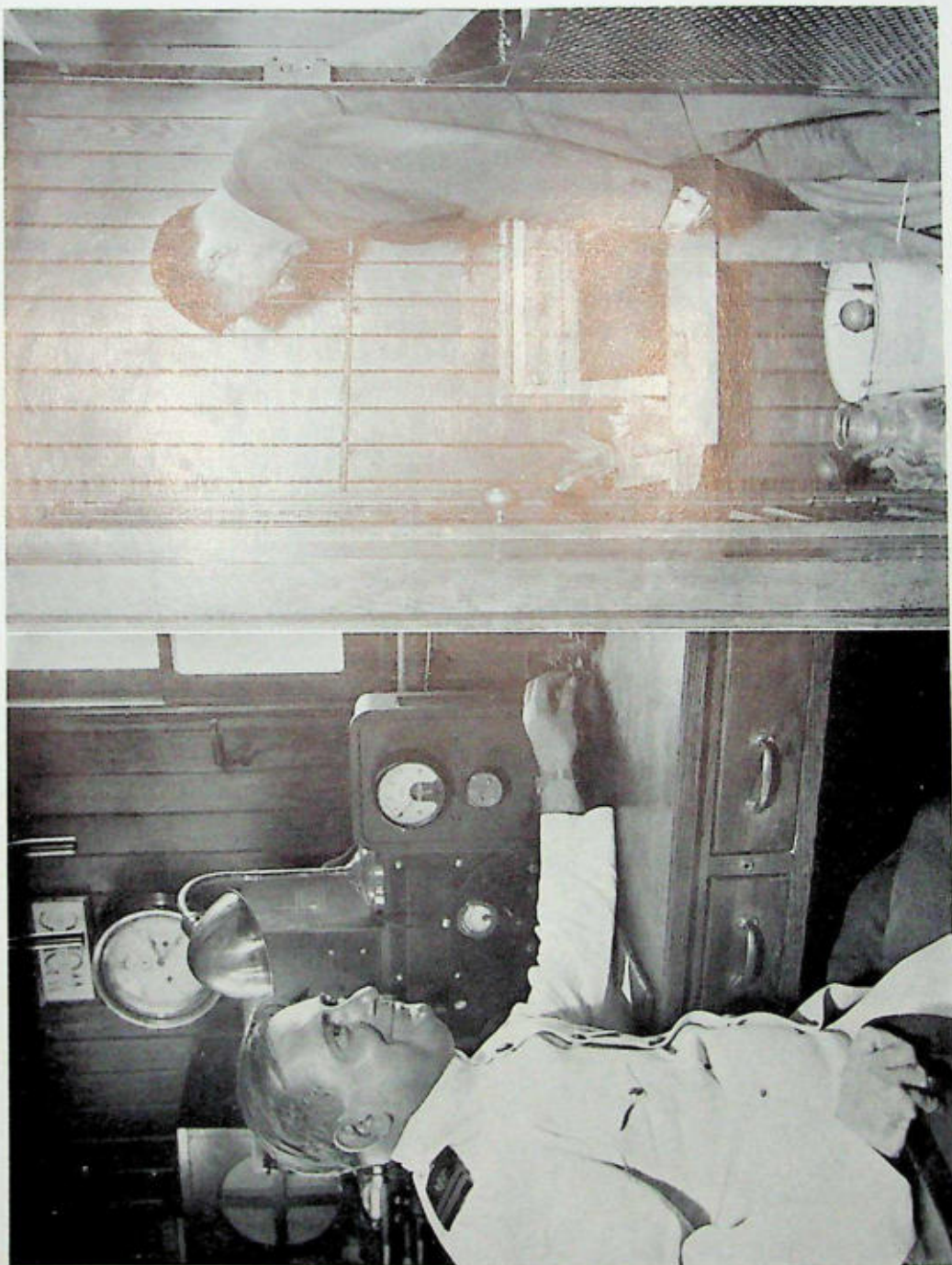
A few small species of African fresh-water fishes are available through commercial channels, the fishes being taken to Germany and either bred there or re-shipped to North America, but it is quite impossible for us to acquire large fishes or marine forms through these professional collectors so that Mr. Vida's offer was highly appreciated.

The *City of New York* returned December 19, 1932, bringing eleven more *Periophthalmus* and one clawed frog. Nothing further was heard from Mr. Vida until June, 1933, when we had a radio message offering us a *Varanus niloticus*, a large lizard. This we accepted and sent to the Zoo, and in discussion with Mr. Vida we found that he had discovered what many other travellers have discovered—that fishes are exceptionally difficult subjects to transport. He had attempted to bring back a number of fishes for us but all had succumbed to the vicissitudes of ocean travel, the only creatures to arrive safely being those which required little water. However, Mr. Vida was still willing to try and was confident that he could successfully carry fishes back for us.

With the permission of the ship's officers, Captain George M. Wauchope and Chief Officer Paul S. Maguire, the Aquarium installed a series of six twelve-gallon aquaria on the ship, the American-South African Line kindly building a wooden rack in the radio room to carry these. The Aquarium also installed a small air pump so that the water might be easily aerated, and another attempt to carry fishes was under way.



Zebra fish, showing the highly spectacular and attractive markings. The tips of the dorsal spines are reputedly poisonous. The sharp spines on the dorsal fins of the bullheads cause acute pain if they are held in a way to allow the flesh to be punctured



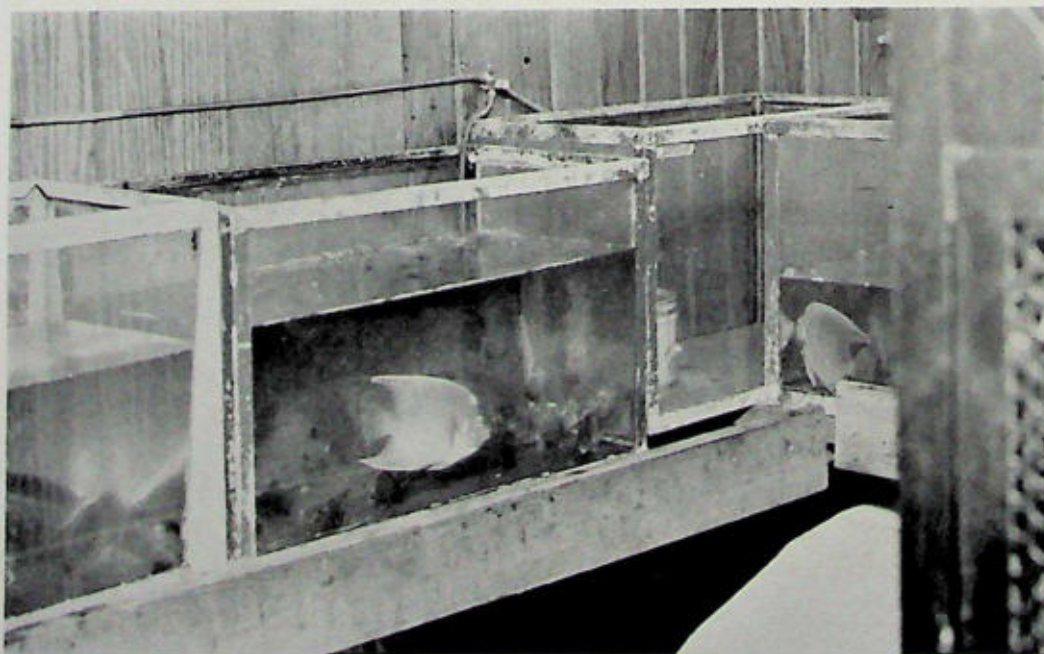
Left: Mr. A. M. Vida, chief radio operator of the Motor Ship *City of New York* sitting at the radio key. *Right:* One of the series of aquaria built around the radio room. A corner of the radio transmitter at the right indicates the close quarters in which Mr. Vida works.

On this trip, Mr. Vida took with him a number of small local marine fishes as a gift to the East London, South Africa, Aquarium. This institution was desirous of obtaining American forms. These fishes were successfully transported and in return, Dr. Nanni, Director of the East London Aquarium, gave Mr. Vida some fishes for us. These included the spectacular zebra fish, *Pterois volitans*, and it was on this trip that Mr. Vida had the difficulty in feeding them referred to elsewhere in this issue. The zebra fish are exceedingly rare in North America and have a high cash value. At present the zebra fishes at the Aquarium are about eight inches long and make an exceptionally attractive display. Besides the zebra fish, a number of glass fish—small transparent creatures that look as if they are made of glass—and an assortment of rare cichlids which Mr. Vida caught in the tidal waters near Beira, Portuguese East Africa, were donated. One lung fish also was received. This fish, which breathes air, was carried from the African interior in a gunny sack and immediately demonstrated his pleasure at being in the water again by eating a smaller lung fish which was already in the tank in which he was placed.

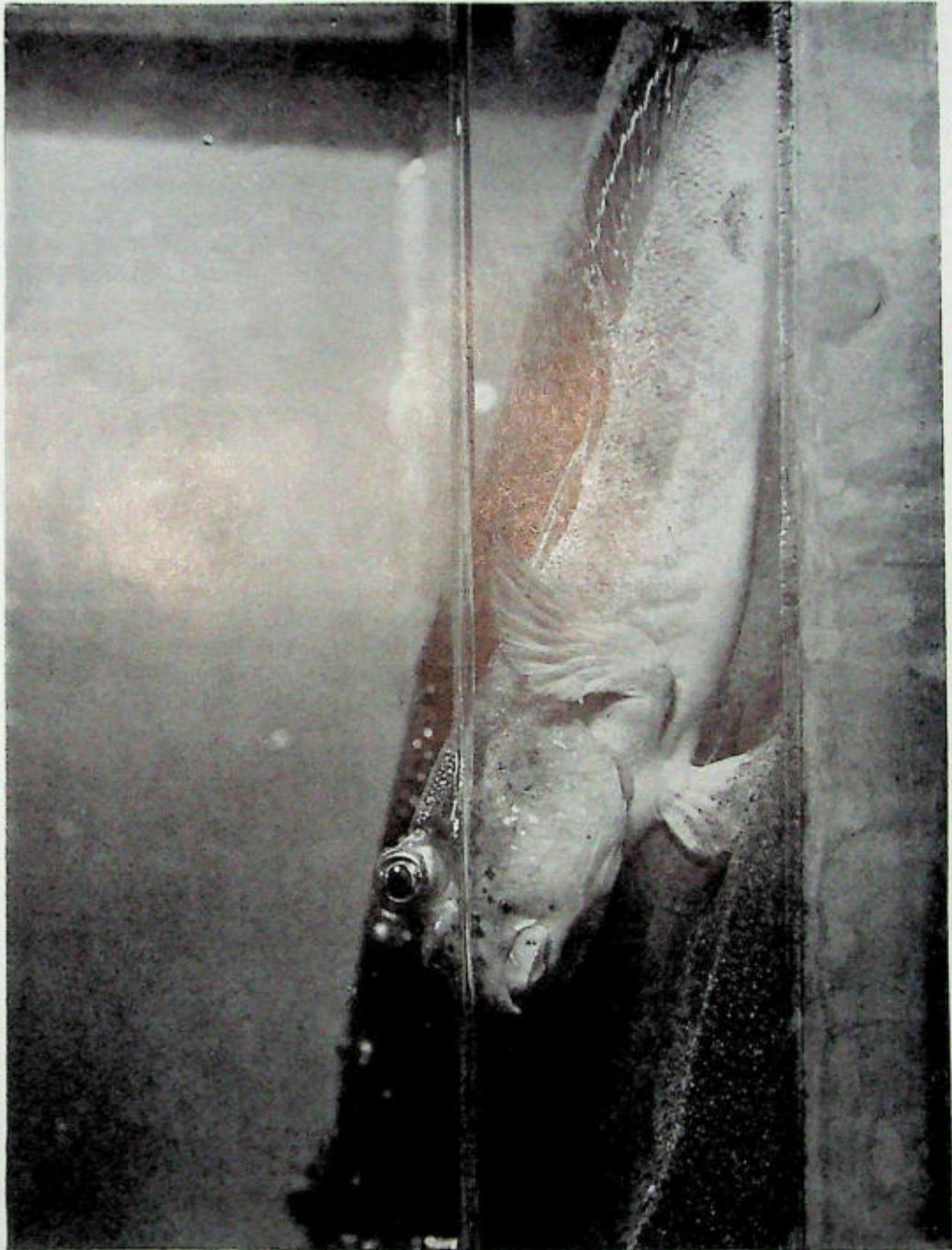
On Mr. Vida's return to Africa after this

trip he took with him another small collection of West Indian and local marine fishes for Dr. Nanni's collection. During this eastward leg of the voyage, the ship called at the Island of St. Helena and Mr. Vida added a number of local fishes to his tanks. Part of this collection was given to the East London Aquarium and part brought back to New York. Our share of these included a number of Five Fingers—a species of *Abudefduf* which derives its local name from the grayish bands across its body which look as if they were the imprints of a clutching hand;—two very lovely green fishes, and a number of terapon. In exchange for our fishes, Dr. Nanni gave Mr. Vida two black-footed penguins and a number of fishes. This consignment arrived safely in spite of a very stormy and cold crossing, reaching the Aquarium, via Boston, in December, 1933.

A further collection of African and St. Helena fishes reached us in March, 1934. This, comprising 138 specimens of eighteen species, was the largest to come to hand, and included one lung fish, one electric torpedo, some new climbing perch, and a collection of young fishes of species rarely, if ever, exhibited in America. Mr. Vida, however, reported that he had not enough



A corner of the radio room of the Motor Ship *City of New York* showing part of the series of aquaria and some Angel fish from the New York Aquarium enroute to the East London, South Africa, Aquarium.



The odd-shaped mudspringer, *Periophthalmus koereuteri*, showing the position assumed by the fish when at rest. The weight of the body is supported by the ventral fins and tail. One of the angulated pectoral fins, on which the fish jumps about, is clearly visible just behind the head, bent backwards and upwards.

tanks to carry the fishes available to him, and so, with the permission of the ship's officers, two fifty-gallon tanks were installed on the after part of the bridge deck of the liner.

Again a small collection of local fishes were sent to East London Aquarium, and Dr. Nanni reciprocated with an octopus and six small zebra fish. Mr. Vida also made a collection of fishes in St. Helena, Beira, Lourenço Marques and Durban, but this trip was not so successfully completed for the radio apparatus went out of order and the fishes could not be attended to as much as they required. The zebra fish, some clown fish, an African porgy, a carabella, and some infant groupers being all that travelled safely.

At the various ports of call a number of na-

tive fishermen have been enlisted by Mr. Vida to collect fishes for us. These men will be paid in the most valued medium of exchange in their locality, which varies from cigarettes and candy to old overcoats and suits of dungarees, such articles apparently having greater value than currency. Already several outworn garments have been changed, through the agency of Mr. Vida, into very attractive exhibits.

At the present writing four penguins and a number of fishes are aboard the Motor Ship *City of New York* en route to the New York Aquarium. These are due here about mid-October. We are very much indebted to Mr. Vida for his efforts on our behalf and to the owners and officers of the vessel for their interest and assistance.

THE ULTIMATE IN TAILLESS FISH

C. M. BREDER, JR.

PERSONS that are concerned with the handling of fishes in one way or another encounter from time to time individual specimens that evidently have been seriously injured and recovered with only a scar or some deformation to tell of some old time misadventure. Among such cases are specimens that have lost the tail fin completely or in part. Superficially these are rather striking since the caudal appendage is so intimately associated with underwater locomotion. It is evident that, nevertheless, these fishes are able to survive despite this apparent handicap. Scattered through both scientific and lay literature pertaining to fishes may be found numerous references to specimens mutilated to this extent that were caught along with normal members of their kind. Probably every ichthyologist has seen one or more case of this sort and many have considered them of sufficient interest to warrant a report. The present contributor in looking over old papers finds that he has previously mentioned two such cases, one a Panamanian creek fish, *Piabucina festae*¹ and the other a mention of numerous instances of the kind in the pearl roach, *Scardinius erythrophthalmus* which appeared nine years ago in

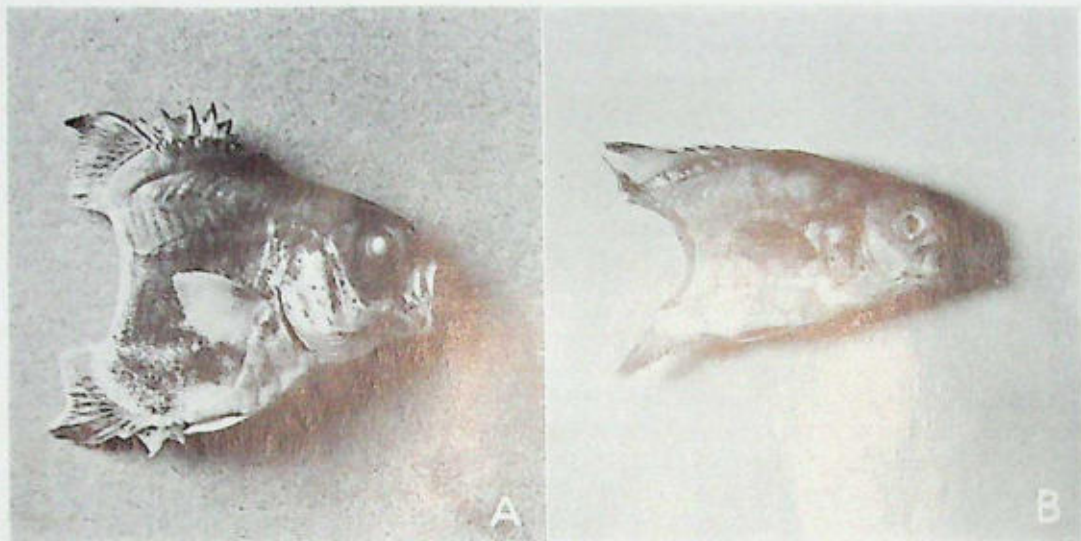
this BULLETIN.² One of the most interesting of such instances was mentioned by J. T. Nichols³ concerning a large tarpon, to mention only one reference to the literature of the subject.

The origin of these injuries is clearly caused in the main, if not entirely, by predatory forms biting entirely through the posterior portion of a fish they had attempted to catch. The dying fore parts of a fish is not an uncommon sight where predatory forms are active, as can witness any West Indian fisherman, who frequently, to his dismay, draws up part of a fish on the end of his line. Usually this is evidence that some passing shark has helped itself. Sometimes the fisherman gets only a head and sometimes sharks are too abundant and active to make continued fishing worth while. Fishes injured this way were clearly in distress, having been hooked before being attacked, but it is not an uncommon sight to find similar cases of free fishes sharing a like fate. This is especially evident in the case of schooling fish when active predators slash right and left among them. Of course only those few with no vital organs destroyed stand a chance of surviving. Of the latter, it would

¹ Breder, C. M. Jr., 1927. The Fishes of the Rio Chucunaque Drainage, Eastern Panama. Bull. Amer. Mus. Nat. Hist. 57 (3):91-176.

² Breder, C. M. Jr., 1925. Tailless Pearl Roach. Bull. N.Y.Z.S. 28 (3):72-74.

³ Nichols, J. T., 1921. The Miami Aquarium. Nat. Hist. 21 (4):359-366.



(a) A tailless round pompano, *Trachinotus falcatus*. The injury resulting in the loss of the tail had completely healed and the fish was active and alert. It swam rapidly by employing the dorsal and anal fins for purposes of propulsion. This fish measured 38 mm. over all. (b) A specimen of the common pompano, *Trachinotus carolinus* wounded by a young bluefish. This specimen was found in a dying condition as were several others after the passage of a school of snappers. Note the similarity to the injury on the round pompano that survived. (c) A tailless red hind, *Epinephelus guttatus*. This specimen taken at Key West, Florida, had evidently lost its tail in its early youth. Note how both the dorsal and anal fins have grown backward and form a substitute for the lost tail fin. This fish lived for about a year and a half in the Aquarium, and was able to hold its own with normal tank mates. Photographs (A) and (C) by S. C. Dunton.

seem that few of those could compete with whole, uninjured fishes but the fact is, nevertheless, a percentage evidently do. Bearing on this are some observations made on the relative speeds of tailed and tailless pearl roach. At no time could any difference in speed of swimming be noted by the writer between two such fishes. The difference noted was that the tailless one swung its stump through a wider arc which it could more easily do, being minus the resistance of the fan-like tail. This was discussed with some hesitation in a technical paper on fish locomotion.⁴ Since then this subject has been studied in experimental detail involving the use of motion pictures for analysis by Dr. J. Gray⁵ of Cambridge, England. It is with considerable satisfaction that it may be reported that his studies have borne out these superficially unlikely observations.

Since the above mentioned matters were discussed in print, two other cases came to the author's attention on looking over incoming specimens at the New York Aquarium. One, a hind, *Epinephelus guttatus* (Linnaeus), is illustrated herewith and shows the deformation very well. In this case the posterior portions of the dorsal and anal fins grew longer and drew around rearward, replacing to some extent the lost tail fin. This occurs only in fishes of the "ordinary" fish form such as the one illustrated. The other case noted above was a large green moray, *Gymnothorax funebris* Ranzani. This fish with its simple eel-shape presented no such peculiarity but was simply truncate behind and nearly a third shorter than others of its same diameter.

The occasion of the present remarks, however, does not concern the above fishes but refers to a truly remarkable specimen received at the Aquarium during the preparation of this BULLETIN. As the title suggests it is certainly the ultimate in tailless fish. This specimen, a young pompano, *Trachinotus falcatus*, as shown in the accompanying photograph, not only lost its tail but the major portion of the posterior part of the body as well, and parts of the

dorsal and anal fins. If the wound had been ever so slightly forward of where it is, the vital organs would have been involved and no such curiosity would have reached us. The skin had completely covered the wound caused by the severance of the after parts of the fish.

The outline diagram illustrates the physical difference between this abbreviated specimen and a normal pompano of like size. It is to be noted that the depth of the body has increased somewhat, due presumably either to a bunching of the muscles after their severance or to their greater development because of some unaccustomed strain being placed upon them. The forehead thus appears to be somewhat concave. The form of both the dorsal and anal fins differ from the normal, so that most of their extent is along a vertical line. In this position they are able to offset the loss of the tail fin to an effective extent. This fish had completely healed its wound when it was brought to the Aquarium in a living, active state from Islip, Long Island, by Mr. K. Atwood 3rd. Although it died a few days later there is no reason to associate its demise with the fully healed wound. It may be mentioned that fishes brought in by persons unfamiliar with the technique of caring for marine specimens, although always appreciated, frequently die in a short time.

Some years ago the writer discussed the growth and behavior of young bluefishes in these pages.⁶ In this connection there was figured a young common pompano, *Trachinotus carolinus*, that had been nearly bitten in half. This specimen was nearly dead when found as were numerous others. The illustration is here repeated for comparison with the specimen under discussion. It is difficult to avoid the conclusion that this one too was snapped at by a "snapper blue." It so happens that in local waters there are no other common fish that would be likely to snap a fish in two in just such a fashion.

The development of the remaining vertical fins in fishes so injured is, perhaps, the most interesting feature of them. If the dorsal fin is far forward and only the anal fin far back enough to be involved, this tends to turn up and replace the lost caudal fin. The tarpon, pearl roach and *Piabucina* previously referred to rep-

⁴ Breder, C. M. Jr., 1926, The Locomotion of Fishes. Zoologica 4 (5):159-297.

⁵ Gray, J., 1933, Studies in animal locomotion III. The propulsive mechanism of the whiting (*Gadus merlangus*) Journ. Exp. Biol. 10 (4):391-400, 1933. Directional Control of Fish Movement. Proc. Roy. Soc. London, 113, 115-125, 1933. The muscular movements of fishes. Proc. Roy. Instit. Great Brit. April 28:1-32.

⁶ Breder, C. M. Jr., 1925, Growth of young bluefish. Bull. N.Y.Z.S. 38 (6):181-183.



The featherback, *Notopteryx azer*, a fish that has the anal fin fused with the caudal in such a fashion as to suggest the direction in which a tailless fish with a long anal tends to develop. Photograph by S. C. Dunton.

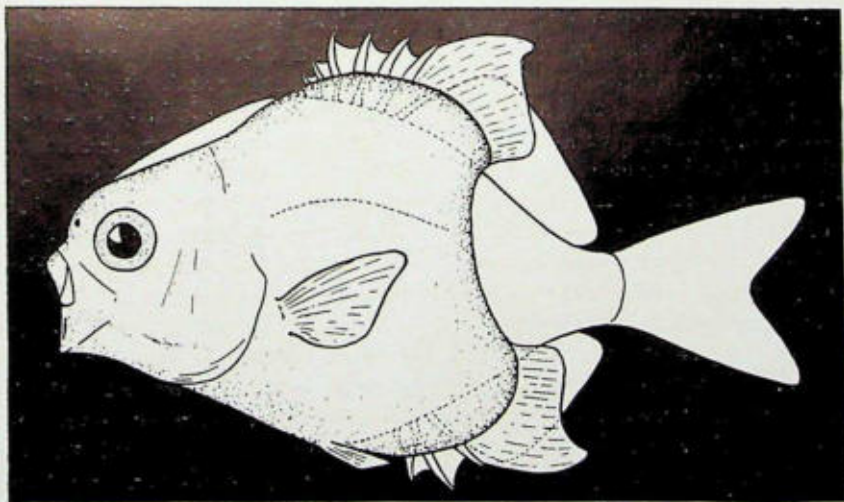


Diagram of the tailless round pompano (a) shown in the accompanying photograph on page 142. This is overlaid on the outline of the normal fish for purposes of comparison.



A tarpon, *Tarpon atlanticus*, that has lost its tail and in which the anal fin serves in its stead. Compare this figure with that of the normal featherback above. After Nichols (1921).

resent such cases. Fishes in which both dorsal and anal are involved as the hind and pompano, here illustrated, show the anal growing up and the dorsal down. In the first type the vertebral column deflects upward but in the second it remains horizontal, being acted upon about equally from both directions. As Mr. Nichols has pointed out the tipping up of the vertebral column suggests the mode of evolution of the normal fish tail. In primitive bony fishes this column extends along the dorsal edge of the tail and while relatively retracted in the advanced forms still retains the tipped up condition internally.

In various fishes that have a pointed or acuminate tail the regeneration is usually quite normal if the severance has not been too far forward. The African lungfish, *Protopterus aethiopicus*, and the knife-fish, *Gymnotus carapo*, are examples of this sort. All this would suggest a study in the stresses and strains of a mechanical nature set up in a body composed chiefly of structural supports (bones), lashed together with elastic thongs under tension (muscles). The parts left, when some elements are removed, then realign themselves according to physical laws, upon which are superimposed a development along new lines dependent on what way the organism attempts to exercise its remaining parts to compensate for those lost. Any cripple, human or otherwise, operates along this same pattern with the consequence that both bones and muscles become developed in unexpected ways. These are "unexpected" only in so far as we are unable to follow the structural significance of the numerous interlocked parts of a vertebrate. If these were sufficiently understood we could doubtless prognosticate just what development would follow the removal of a given element. In this connection the form of the featherback, *Notopterus afer* is pertinent in that it normally bears a marked superficial resemblance to tailless fish in which the anal fin only replaces the caudal. This fish has a notably small and forwardly placed dorsal and a long anal fusing with the tail fin. Very likely if the mechanics of the deformations discussed were thoroughly understood such information could be applied with profit to the study of the development of the great diversity to be found in the body form of fishes.

THE NEWFOUNDLAND SEAL FISHERY

CHARLES HASKINS TOWNSEND

IN *Science* for August 24, Dr. C. Hart Merriam called attention to an announcement by the secretary of the Society for the Preservation of the Fauna of the Empire that the Newfoundland sealing industry is steadily declining and recommending that a sanctuary be provided for the protection of the seals. Dr. Merriam very properly pointed out that these ocean-dwelling seals breed only on ice floes and that a land sanctuary would not be possible.

Having before me the official records of the catch of the Newfoundland seal fishery for over 100 years, it does not appear that the fishery has declined to a serious extent. During the period from 1860 to 1930 the average annual catch was 196,019. Due to unfavorable weather conditions in 1931 and 1932 there was a falling off, but in 1934, 223,708 seals were taken.

Prior to the middle of the nineteenth century large numbers of sailing vessels engaged in this fishery. At one time in the 'fifties, there were 400, it is said. The annual catch occasionally exceeded half a million seals. Later, when the sailing vessels were replaced by steamers, the hunting season was officially shortened with a view to conservation.

Sealing operations are now permitted only between March 10 and April 15. Owing to the present low price of seal skins and oil only nine steamers were employed in making the large catch of 1934,—223,708 seals.

This long established seal fishery is unique in that it is based on the taking of *young* seals only, the number of adults captured being negligible. Adults take to the water at once, upon the approach of the hunters, the extremely fat, nursing young being unable to leave the ice floes on which they are born.

The catch has always been made on ice floes not far from Newfoundland. Doubtless both harp and hood seals, the two species on which the fishery is based, bring forth their young on ice fields more remote and impenetrable by vessels. It is evident that the survival of great numbers of breeding seals has hitherto sufficed for the notably prolonged maintenance of the fishery. I have records of catches dating back to 1795. With no heavier killing than that of the past decade the fishery may last indefinitely.



Upper: Two female red wrass, *Labrus ossifragus* showing a light and dark color phase and in the background two ballan wrass. *Lower:* A male red wrass, *Labrus ossifragus* (upper center). The very differently colored female is seen to the extreme left. There are two ballan wrass below.

We have for some time urged that the control of sea lions on the Pacific Coast be brought about by commercial use of the nursing young before they are old enough to take to the water, rather than by wanton destruction of breeding sea lions that sink when shot. Young sea lions represent a resource in usable leather and oil that has hitherto been wasted, the skins of adults not being utilized.

A COLLECTION OF FISHES FROM SWEDEN

CHARLES HASKINS TOWNSEND

Illustrations from photographs by S. C. Dunton

IN the Marine Museum of Gothenburg, Sweden, there is located a public aquarium. This display occupies the basement floor of the Museum building and has on view a variety of local and foreign fishes and a collection of local invertebrates.

From time to time this institution, which is directed by Dr. H. Ostergren, has exchanged specimens with the New York Aquarium. Usually these exchanges have consisted principally of invertebrates, the European institutions being particularly interested in obtaining the common Atlantic coast horseshoe crab which is not native to European waters and which has a significant scientific interest because of its resemblance to the long extinct trilobites.

It so happened this summer that one of the Aquarium employees, Mr. A. Olsen, arranged to visit Sweden. From New York he took a variety of marine fishes as well as horseshoe crabs as a gift to the Gothenburg Aquarium. On his return he brought to New York an interesting number of specimens of northern European species that heretofore had not been exhibited in our Aquarium.

The wrasses (*Labridae*) which are represented in local waters by only the drab tautog and the bergall on the northern coasts of Europe are represented by a variety of species, many of which compare with the more brilliant tropical members of this family found only about coral reefs.

One of these the so-called red wrass (*Labrus ossifragus*) is a long slender fish of a rather pleasing shade of maroon. That is the females are so colored. The males, however, until not

so very long ago thought to be a different species, are most decidedly not red. Instead they are marked with a number of irregular brilliant green stripes.

Among the invertebrates was the large crab (*Eriocheir*) a rather striking crustacean superficially resembling our stone crab of the Florida coast, as well as a variety of sea anemones and starfishes. We are greatly indebted to Dr. Ostergren for his kindness in making possible the display of these fishes in the New York Aquarium.

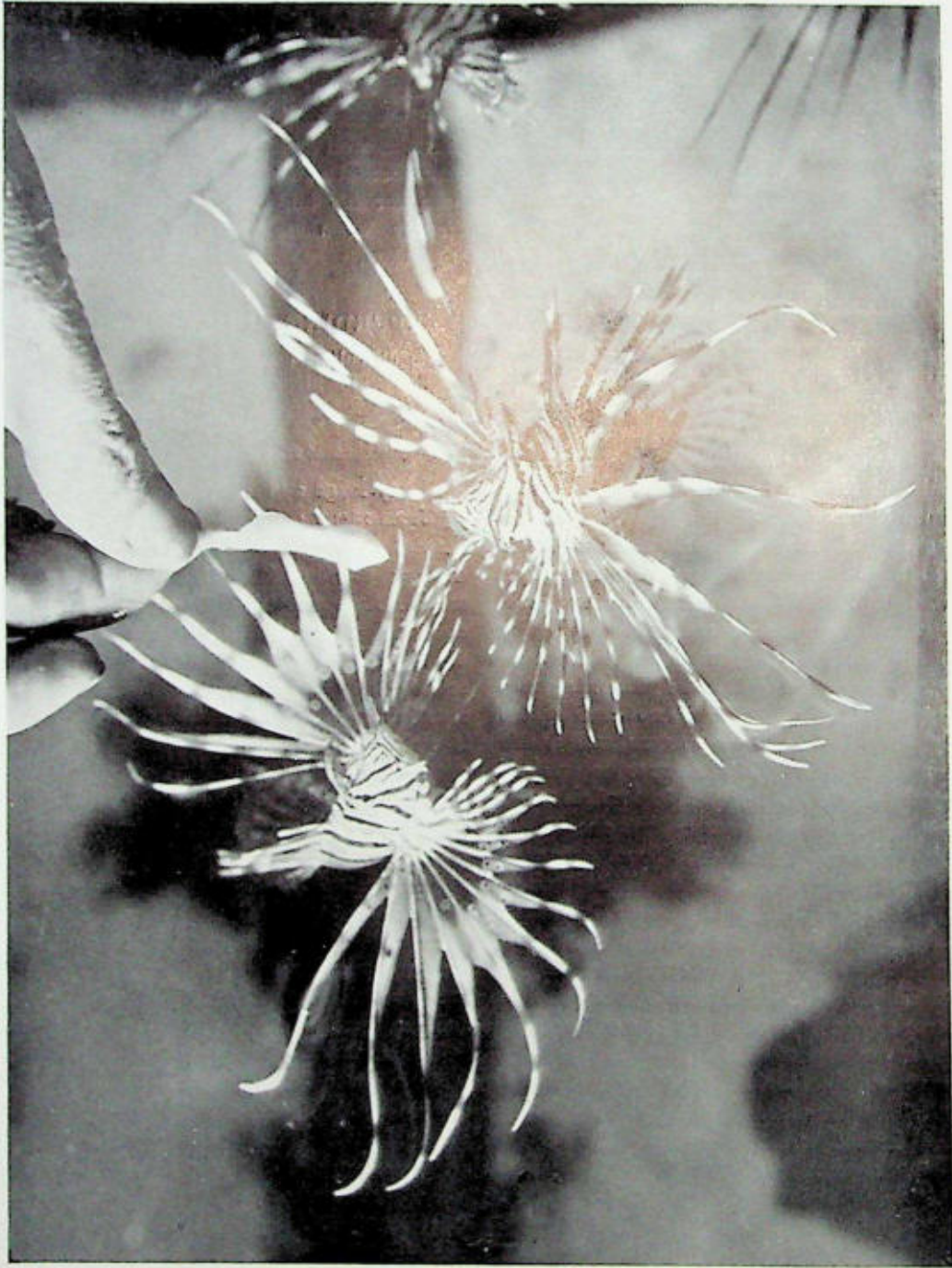
FEEDING AQUATIC ANIMALS

The difficulties experienced in the selection and maintenance of a proper diet

C. W. COATES

Illustrations from photographs by S. C. Dunton

IN any large and diverse collection of animals from many different localities there must of necessity be a considerable adjustment of the dietary requirements of the creatures maintained. It is not possible to reproduce in any one spot on the earth conditions obtaining in all the others. To secure the food which each animal finds in its own habitat is out of the question from a practical standpoint, although, if such foods were available it would be a good deal easier for the keepers of the animals than it sometimes is for them to find a suitable substitute. If they are not successful in finding a suitable substitute food they must stand by helplessly while the animal endeavors to make its own adjustment to the food available;—a most unpleasant situation for the good animal man. However, most animals can be trained to eat the foodstuffs available with a little care and coaxing, or if they cannot be coaxed into eating before they are in actual danger of starvation, may be forcibly fed until they find that the food offered them is palatable and their natural will-to-live is stimulated. One example which is frequently before us in the Aquarium is afforded by the small alligators brought us from Florida by well-meaning tourists. A great many of these are unintentionally badly treated and are in extreme straits when they are offered to us, and, invariably will eat nothing. However, after their mouths have been opened gently and a bit of raw beefheart pressed on



Feeding zebra fish. The photograph was taken from above the surface of the water. These fish, which normally will eat only living food, have been conditioned to dead food and take it readily. These were the first of this species to be brought to the Aquarium by Mr. Vida.

their tongues three or four times, they start to eat everything offered and will then fill out and grow rapidly. So many of these are received *in extremis* and saved by this short period of forcible feeding, that we frequently have sufficient to ship some off to public aquaria in Europe in exchange for native fishes of one sort or another.

Baby cayman, which are sometimes received, are much more difficult to handle. These South American beasts are exceptionally vicious and ill repay the care they get. They will refuse food for months. Very young creatures have no reserve to carry them through these long periods of fasting and must be fed forcibly, although unless the food is passed behind the epiglottis and well into their throats they will eject it consistently. However, after six or eight weeks of this sort of feeding they recover their health and unpleasant temperament and then present another problem, for they cannot be kept with other crocodilians of similar size without continually fighting with them. Even large cayman are just as difficult, with the added disadvantage that they cannot be forcibly fed so easily. One fourteen-foot cayman recently exhibited here refused all food for six weeks after and about eight weeks before he arrived at the Aquarium. This particular problem was solved by treating him to about thirty minutes of ultraviolet rays and then offering him a beefheart. He would take it immediately after being treated with the special light, but it was not until after six weeks of this treatment that he would take food which was offered without the preliminary light bath.

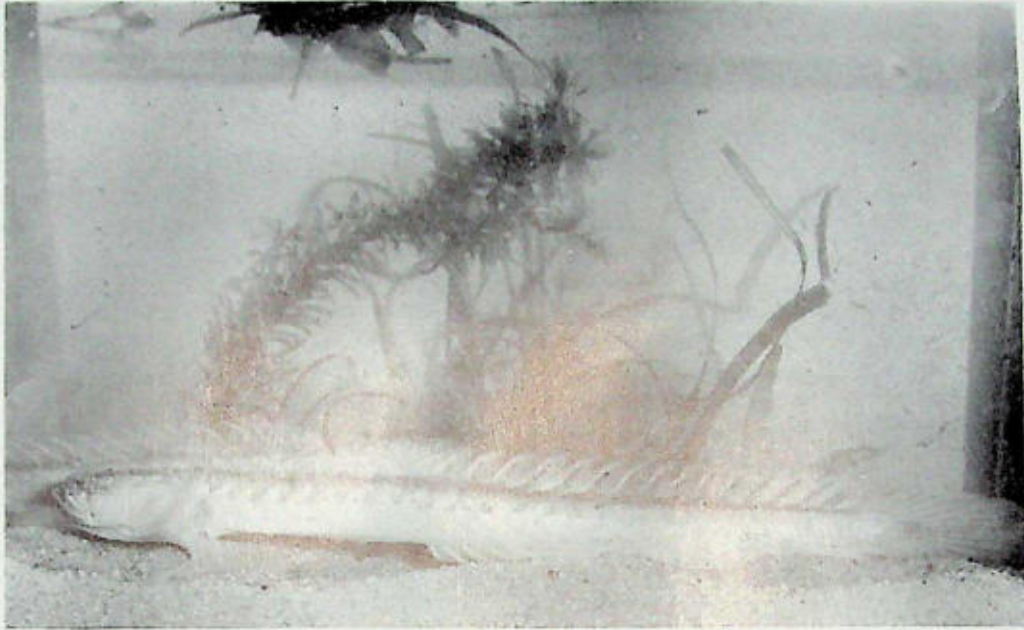
Some of the fishes present different problems. Many of these are accustomed to catching their own food alive, and since this is usually out of the question in the Aquarium, other devices must be resorted to. When the Zebra fish now on exhibition were brought from South Africa, the supply of killifishes on board ship ran out and Mr. A. M. Vida, who was looking after the fish for us, radioed frantically for instructions. Various types of food were offered and refused until strips of the white of hard-boiled eggs were dropped into the tank. These slowly sank through the water with a wavy motion and effectively deceived the fish. They arrived here in good condition and are now so tame that

they will take any food offered from the attendant's fingers. Incidentally they have grown, in less than one year, to about four times the size they were when received.

Some other predatory fishes never become accustomed to dead food, although the savage piranhas are successfully deceived by a bit of fish or beefheart suspended from a length of string and kept moving a little. Sometimes recently acquired piranhas will not eat unless the food is moving, although two or three specimens which have been in the Aquarium for two years or longer will take anything offered, even if it is lying on the bottom of the aquarium, and ignore moving food if the pieces are larger than they are in the habit of getting.

Fishes that are not predators also cause some difficulty and may easily be starved to death with food all around them unless care is taken that they are sufficiently supplied with the proper type. The *Loricariates* will starve unless they have a large supply of algae to graze over. We have found that the most practical method of providing this is to keep several pieces of rock in water where there is a great deal of light until the rock is covered with algae. These are then placed in the tanks with the fish, the cleared pieces being removed. Such a piece of rock will be cleaned of algae within a day or so and will then have to be replaced. We had hoped, at one time, to use these fishes with their large sucking mouths to clean algae from a number of different exhibition tanks, but found that they could not condition themselves to the different waters rapidly enough to be of much value.

Some of the fishes, such as the blue scalare, feed only at night and from the bottom of a tank. Since it is impossible to give each species of fish a separate tank, it is necessary to find tank companions which will not interfere with these feeding habits, so fishes which feed primarily on floating or swimming foods during the day are the most suitable. Fortunately the related and similarly shaped silver scalare fulfill the requirements in this particular case. They are fed on food which floats, while the blue scalare finds its nourishment in the food that sinks. In tanks in which there are many different kinds of fishes all eating approximately the same food, those fishes which are



A *Gobioides* from western South America. The vicious-looking mouth is apparently quite deceptive, as far as we have been able to discover, since it is used apparently for nothing more dangerous than scooping up quantities of detritus from which the fish separates the foods that it requires.

most active will take everything offered and the slow ones will not find enough to eat. This is remedied by feeding all the fishes as much as they will consume immediately and then, in five or ten minutes, returning with a little more food. Almost invariably the fast feeders have gorged themselves and do not interfere with the second feeding. It might be necessary to explain here that it is dangerous to the fishes to leave uneaten food lying in most tanks, for this will sometimes form the nucleus of serious infections.

Some of the fishes which are apparently carnivorous require at least some vegetation. If this is not supplied to them they will tear up and eat any growing plants they find, or die if they find none. Like cattle, however, the fish do not seem to mind whether the vegetable matter is fresh or dried, for they will eat the yellowed leaves of dried aquatic plants as readily as they do freshly-growing ones. These latter keep them in the best condition. Most of the small fishes may be fed on chopped beefheart or fish, although they do not always thrive on this diet. Living worms of various sorts and sizes have proved to be the best staple diet for the majority of our fresh-water tropical specimens, but

adjustments and differences in kinds of food and time of feeding must be continually made.

Many specimens of one species, *Pantodon buchholtzi*, from Africa, will starve to death unless living cockroaches are given to them, although wherever they acquired such a taste no one knows. Most of the specimens ever brought to this country have steadfastly refused other food as a steady diet, but will take an occasional earth-, meal- or wax-worm. These worms are not always completely eaten by the fish and will cause serious trouble if left in the tank. Other fishes which catch winged insects flying above the water may be successfully trained to a diet of dried foods by feeding them for a week or two on mosquito larvae, for another period with larvae mixed with dead food, and then dead food or worms alone. Losses among these fishes will occur unless each individual is watched to see that it is taking its share.

Some specimens, no matter how peaceable the species, will eat their companions unless they are especially treated. When such cases develop the fish which shows the slightest ill-will toward other fishes in the tank must be removed at once.

FEEDING YOUNG FISHES

The Cultivation of Minute Crustaceans as an Important Part of Foods for Fishes

R. F. NIGRELLI

Illustrations from photographs by S. C. Dunton

THE question of obtaining minute living organisms in sufficient quantities to feed very young and small fishes, has long been an important problem at the Aquarium. For many years *Daphnia*, brought in by professional collectors from ponds in nearby areas, has been used extensively for both the northern and tropical fresh-water fishes present in the Aquarium. Such collections, although very plentiful during the summer months, become very scarce in the winter, due for the most part to the freezing over of the ponds.

For the past year or so we were successful to a certain degree in cultivating this small crustacean. Employing the standard method of cultivation the yield was not very great, but sufficient numbers of them were obtained all through the winter to feed a few of the more delicate species. However, more recent experiments on growing these crustaceans gave us greater yields. Thus, two large reserve tanks were filled with water. Several liters of hay and oat infusion were introduced, and when a heavy growth of infusoria had developed, the tanks were inoculated with *Daphnia* collected from a pond. In a short time (four weeks) the organism had reproduced in large numbers. It is a well-known fact that crowding has ill effects on reproduction; the excretory products being very injurious. To avoid these effects part of the heavy growth of *Daphnia* were inoculated into fresh tanks. In this manner we were able to keep a large supply growing constantly. Suspensions of yeast cells, as was suggested by Bond (1934),¹ were introduced at intervals of every three days, as a constant source of food for the *Daphnia*.

This season the Aquarium has again attempted to hatch and grow several species of fishes which are very difficult to bring to full development. With such a source of food on hand we were particularly successful in carrying several species of fishes over their critical

period of growth. Most all fishes that survive the larval stage require some small organism as food. Although dry food will suffice in many instances, it was found that the fishes would grow more rapidly when fed live *Daphnia* and tubifex worms. This was especially true in the case of catfish, spawned and hatched in the Aquarium. Incidental feeding experiments with dry and live food showed a large difference in the size of these fishes at the end of one month. Mr. C. W. Coates has reported similar results for many of the small fresh-water tropical fishes. Again, the Aquarium was successful in hatching and rearing whitefish and the European bitterling. Our first attempt at hatching muskallunge eggs was also successful. The latter individuals are very delicate, and in their initial growth period such food as *Daphnia* is very important for survival.

For the marine fishes that are plankton feeders, the Aquarium collector brought in *Gammarus* from the shores of Long Island and Sandy Hook regions. This crustacean, although much larger than *Daphnia*, is caught one by one among the rocks washed by the surf. This is a rather slow and tedious procedure, and the organisms never could be obtained in very large numbers. This problem, however, was solved when the Steinhart Aquarium in San Francisco introduced eggs of the brine shrimp, *Artemia*. These are obtained from an almost inexhaustible supply in the brine pits along the California coast. The eggs will hatch in ordinary standing seawater (slightly concentrated by heating or evaporation) within twelve to twenty-four hours. If a rich growth of algae is present continuously in the jars or trough in which they are hatched, the organisms will grow and metamorphose very rapidly to the adult stage (one to one and a half inches long). These adults have been kept for as long as three months, and in some of our experimental jars two and three generations were obtained from the original parent stock.

One of our most important exhibition fish, the Sea-horse, is entirely a plankton feeder. Heretofore, it has been very difficult to keep these alive during the summer and winter months, at which times they are very scarce. With this new source of food on hand we hope

¹ Bond, R. M. (1934) Science, 79:66.

to retain many individuals on exhibition throughout the entire year. The pipefish, a close relative of the seahorse, is another fish that is difficult to keep alive because of this fact. On many occasions seahorses in the Aquarium have

given birth to large numbers of individuals, but due to lack of available food we were unable to keep them alive. With a large supply of brine shrimp eggs on hand, we may be able to raise some of these to the adult stage.



Upper: This specimen of the sea-horse is one of many born in the tanks of the Aquarium last year. Due to the lack of an abundant food supply (such as we have this year) they were kept alive for only a very short time. This individual measured about 4 mm., three days following birth. *Lower:* Fully grown individuals of *Artemia* which were hatched and reared in the Aquarium. These small crustaceans make suitable food for many of the small marine fishes.

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The *Queen of Bermuda* saluting the Zoological Society's *Ready*, returning from a Bathysphere Dive of 2510 Feet.

BULLETIN

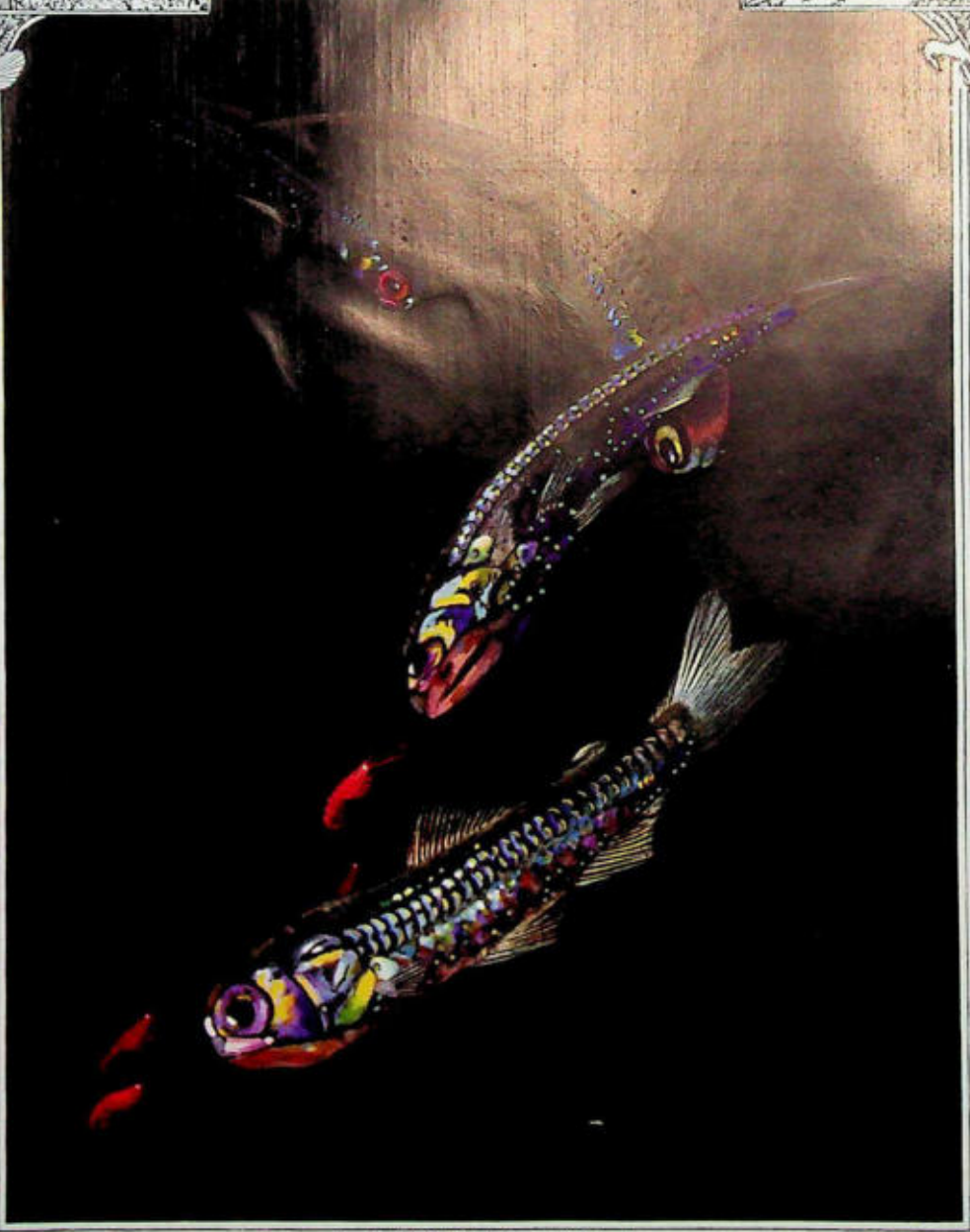
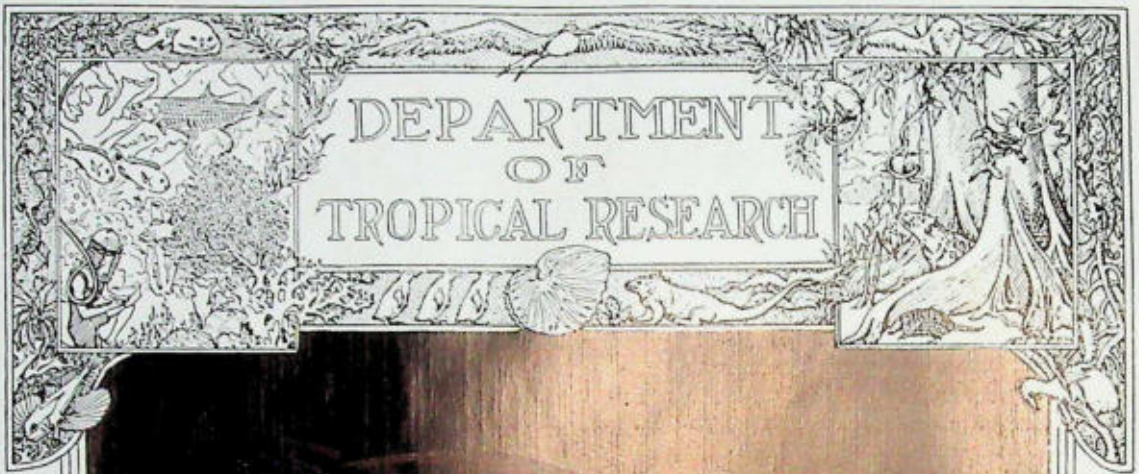
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LANTERN FISH



BULLETIN

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No. 6

Activities of the Department of Tropical Research

Season of 1934

WILLIAM BEEBE, *Director*

OUR department of the Zoological Society undertook two major achievements during the present year, and we have had the good fortune to accomplish both. The first was to remain at least three hours in the bathysphere and attain a depth of over half a mile, and the second was to obtain a motion picture record of the development of the giant, pelagic eel eggs which we obtain several miles off shore. Far more important than the actual diving record were the many observations on deep-sea creatures which we obtained, and of far more scientific value than the film record, were the notes which we accumulated on the development of the eggs and larvae.

I had planned in connection with this work, to experiment with vitamins and other substances, in an endeavor to keep the larvae of pelagic fish alive beyond the period of yolk absorption. This investigation was interrupted at an early stage by preparations for the deep dives, so that it will have to be postponed until another season.

Miss Crane, with Mr. Swanson's help as artist, so far advanced the systematic work on larval and adult deep-sea eels, that I will soon be able to carry it on for early completion and publication. As a change of work I had Miss Crane make a thorough quantitative analysis of the contents of a typical, six-net, deep-haul, which appears in this BULLETIN.

Miss Hollister is well on with the Isospondyl tail studies, and her viability results with salt

and fresh-water fish, outlined in the following pages, have brought out many interesting facts. Mr. Tee-Van has been responsible for all the mechanical details of the bathysphere, which have turned out so perfectly, and has taken as his own special problem the operation of the new stop motion picture camera. Mrs. Bostelmann completed the major number of sixteen colored plates for the National Geographic Magazine bathysphere article, besides dozens of other paintings. Mr. E. J. Geske of Florida has made several exquisite marine studies for our work.

There are ready for publication: the special bathysphere article in the National Geographic Magazine for December; the present BULLETIN and a volume dealing with all the bathysphere dives, under the title "Half Mile Down." This is being published by Harcourt, Brace and Co., under the auspices of the Zoological Society.

The dives, both vertical and contour, are over for the present year, and the bathysphere has been brought back for exhibition at the American Museum of Natural History. Before we stopped operations in the field it seemed only right to let all the staff, after their strenuous, nerve-racking work on deck, see something of the under-sea sights for themselves. As records seem to be considered so important in the public mind, I append a table of present record descents in the bathysphere;

3028 feet—Beebe and Barton

1533 " —John Tee-Van

- 1208 " —Gloria Hollister
 1150 " —Joecelyn Crane
 550 " —Perkins Bass and
 William Ramsey
 525 " —The world's previous record
 descent for a living man.

Our laboratory at New Nonsuch answered every requirement. Never in the course of our twenty expeditions have we ever been so comfortable or worked with such facilities or among such delightful surroundings. Our fleet of five boats have all been in constant use, from the canoe and dinghy, to the *Monocle* or glass-bottomed boat, and the twenty-six foot launch, the *Skink*, the generous gift of William Delano five years ago, which has never ceased to function.

Our visitors have been numerous, totalling about two hundred for the six months. Thanks

to hints to the hotel managers and carriage drivers, all casual tourists are driven past. Those who have come were inspired by real interest in our researches, and were more than welcome. A few among them were:

Mr. and Mrs. John M. Schiff, Mr. and Mrs. Childs Frick, Mr. and Mrs. John S. Gibbs, Jr., all of whom spent some time with us and who enjoyed diving with the helmet in six fathoms of water. Mr. and Mrs. M. B. Flynn, Mr. and Mrs. Herman Oelrichs, His Excellency the Governor and Lady Cubitt, Lord Carew, Mr. Grover Whalen, Mr. Roland Young, Dr. and Mrs. R. C. Bevens, Mr. and Mrs. Keats Speed, Mr. and Mrs. John Stratten, Miss Blanche Yurka, Mr. and Mrs. Hal Fletcher, Commander and Mrs. Morrison, Sir Stanley and Lady Spurling, and Colonel and Mrs. Thomas Dill and Vice-Admiral Sir Reginald and Lady Drax.



Tropical Research 1934 Staff at the Entrance of New Nonsuch, Bermuda. From left to right: Beebe, Crane, Tee-Van, Bass, Ramsey, Swanson, Bostelmann and Hollister.

Five Hundred Fathoms Down

WILLIAM BEEBE

ON the 8th of February, 1934, Dr. Gilbert Grosvenor on behalf of the National Geographic Society offered to finance a season of deep dives in the bathysphere. This was generously in cooperation with the Zoological Society, with many equal advantages for both. This was agreed to by the Trustees of the Zoological Society and preparations were begun at once for the new expedition. The bathysphere, which is now the property of our Society, was recalled from the Century of Progress Exposition where it had been on exhibit for the past year, and was thoroughly overhauled at the factory where it had been built. The old windows were found to have deteriorated and the oxygen apparatus was considered inadequate for the new adventure. Generous friends came forward and helped in every way, as I have indicated in detail elsewhere in this BULLETIN.

The Department of Tropical Research started for Bermuda on its Twentieth Expedition on April 28. The staff this year consisted of William Beebe, John Tee-Van, Gloria Hollister, Jocelyn Crane, Else Bostelmann, George Swanson, Perkins Bass and William Ramsey. Of the new members, Mr. Swanson was an artist whose work supplemented that of Mrs. Bostelmann's, while Bass and Ramsey, recent graduates of Dartmouth, volunteered as general assistants in the season's scientific work.

By the kindness of Dr. E. G. Conklin and the Trustees of the Bermuda Biological Station we were again permitted to board and mess at the Station. Seven minutes' walk to the east of this Station is our New Nonsuch Laboratory. This we occupied at once and used as our headquarters of operations. With its position on open water, and the boat-house and wharf completed, and its complete laboratory outfit, we found it an ideal place for work.

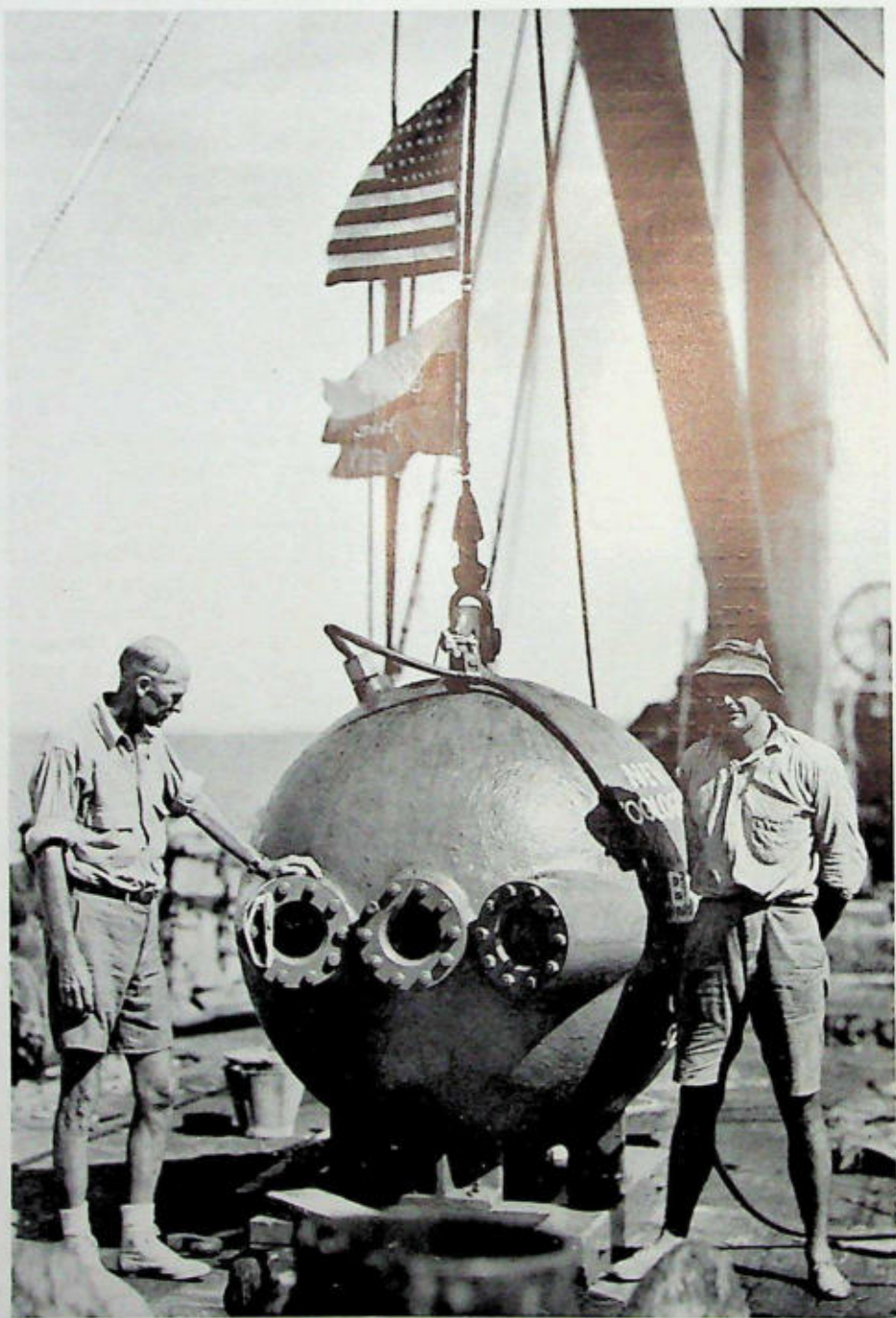
The outfitting for deep diving of the bathysphere was a slow and careful operation. The participants realized that in an investigation of this kind only a single error is necessary. If anything broke down, no parachute would be of any avail, and if the windows or door proved faulty, there could be no second attempt. At

last we received word that everything was ready, and on July 5 the bathysphere arrived in Bermuda. I had cabled to Otis Barton in Panama to join me if he so desired. He accepted and asked that his part in the dives might be that of photographer.

There was further delay at the Bermuda end, for the tug *Gladisfen* had been laid up for two years and had to be overhauled, while the ancient barge *Ready* had suffered from the weather, and the installation of the winches and boilers entailed new piping and even parts of the deck itself.

On the 6th of August we were at last ready for the take off. Our slogan "Three Hours and a Full Half-Mile," had worked on the nerves of our grand, conservative Captain Jimmie Sylvester and he asked for a rehearsal while we were still at anchor. This proved to be a comic interlude, for we crawled inside, and John Tee-Van, knowing the bottom was only twenty-two feet down, screwed on only four out of ten door bolts, and sent us over. Four feet under, as I was watching a silvery host of fry sweeping back and forth, my feet and ankles suddenly felt chilly, and reaching down I found about a foot of water in the bottom of the sphere, and the door showed a healthy stream of water pouring in from three sides. We were lifted clear, and back on deck, opened up, dried out and again sealed up properly. The result of this dive was a joking matter, but valuable as showing how necessary it is never, for an instant, to relax precautions. The first fraction of a second after I discovered the in-pouring flood aroused a subconscious reaction all its own, which will never quite be eradicated by the instantly succeeding ones of reason and humor.

On August 7, I disregarded the prophecy of squalls and uncertain winds, and we put to sea, and sent the bathysphere down empty for a test dive, from which she returned dry and in perfect condition. After several days of bad weather, I again threw my dice against unsettled conditions, and on Saturday, August 11, at half past nine in the morning I looked about from the deck of the *Ready* and saw the long,



At the Upper End of the Half Mile Dive.
Photo by David Knudsen.

low swells of a calm day at sea. We were well within our magic circle, where all previous dives had been made, and where we had pulled more than fifteen hundred nets, from the surface to a depth of two miles. Nonsuch Island was six and a half miles to the north. Here we slowed down, headed upswell, and prepared to dive.

More than three and a half years ago we dived to a depth of 1426 feet, and here I was on the selfsame ancient barge, with the identical bathysphere, and within a mile and a half of the very spot where we made the former descent. An equal distance marked the spot of two years ago, when we touched 2200 feet.

On the present dive we went down to a depth of 2510 feet, and returned safely, with a maze of impressions of the life of a world, as new and as strange to me as if I had not twice visited it before. I was able not only to recognize many of the deep-sea fish I had caught during the past six years, but even to record and reproduce in words, and by proxy in paintings, many details of wholly new forms. Three of these I have described in this BULLETIN.

In the never ceasing excitement of watching abounding life I had completely forgotten the idea of a half-mile record, and when on deck, three hours and ten minutes after we had been sealed up, we were reminded that an additional hundred and thirty feet would have done the trick. I had no regrets. A man-made unit of measure is of far less importance than my Three-starred Angler which otherwise we should surely have missed.

Late in the afternoon, as we reached the entrance of St. George harbor, the mighty *Queen* of the Furness Line passed close to us, and Captain Davis, seeing the 2510 chalked on our bow, roared out a salute of congratulations.

The following day, Sunday, we devoted to translating and augmenting our notes with added remembered details, and getting everything ready for the next dive. Believing that the best kind of rest is a change of activity, on Monday, August 14, we took the *Skink*, our launch, and went ten miles out from shore to North Rock, the last forlorn hope of Bermuda's dry land, still standing far out against the eternal beating of the open sea. Diving in the helmet in seven fathoms at the edge of a magnificent reef, I had the amazing luck of seeing all the so-called dangerous fishes of Bermuda, sharks,

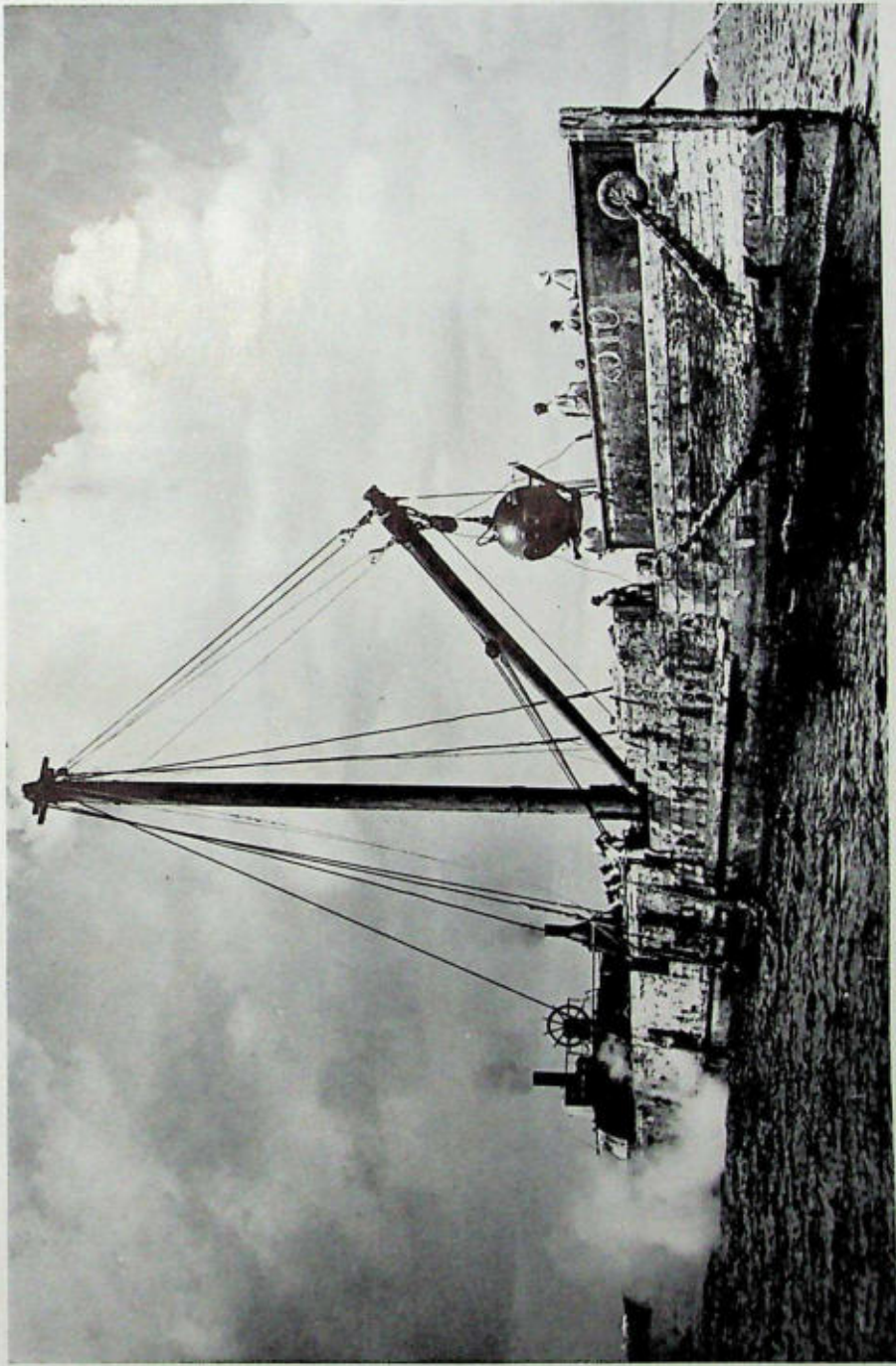
barracudas, and green moray eels, within a half hour and a space of twenty square feet.

All, as usual, were harmless, and only when a five-foot shark stoutly contested the possession of a rare puffer which I had just stunned with a dynamite cap, was I compelled to bang it on the snout and drive it away. To an onlooker from above, as in this case Mr. John Long of the National Geographic staff, it appeared to be material for full-sized headlines; from down below, the fact that the shark was only another fish was true simply because experience had taught us its harmlessness. On the final dive five sharks were gathered and interested in everything I did, but only as vultures are drawn at the sound of a hunter's gun, by the hope of a feast.

The following day we went to sea in the *Gladisfen* and drew deep-sea nets across the very place I had dived in the bathysphere so few hours before. As always, we were delighted with the sight and touch of beings from the icy depths, and at the same time amazed at the meagreness of the haul compared with what I knew of the abundance of life through which the nets had passed. However, each net was filled with interesting creatures, some of which were still to be named. Best of all, instant transference into iced salt water revived many of them.

Here again, John Tee-Van was in charge of the deck machinery, with Bass and Ramsey as aides. I was winchman except at the actual incoming of the nets, when Miss Crane and I watched and took notes of the movements and colors of the living and just dead catch. A pair of ten-inch Scimiter-Mouths, such as I had seen on the last dive at a depth of four hundred fathoms, were alive, and for the first time we had a Black Swallower, *Chiasmodon niger*, swimming full speed about his jar. Unlike most of his kind, his stomach was empty and not distended with one of his unbelievably enormous meals. Another treasure was a living, gay-colored, semi-transparent, telescope-eyed *Dolichopteryx*, the Long-finned Ghostfish, probably a new species. It was the sixteenth of the whole genus to be taken by man, and the first ever to be seen alive.

Day after day my weather held good, and Wednesday, August 15, as I have written in



The Barge *Ready* returning from the Bathysphere dive of 2510 Feet.
Photo by David Knutson.



Final Consultation before the Half Mile Dive.
Photo by David Knudsen.

the National Geographic Magazine, was no exception. At 6:45 in early morning we were arranging to leave St. George's anchorage, the barge *Ready* with the bathysphere and ourselves, and the tug *Gladisfen* towing. Three hours later, Mr. Barton and I were dropped overboard far out at sea. As well as we could determine from sights on the two lighthouses, we submerged at the identical spot into which we had splashed four days before.

The same spot, but far from the same visible life. Surprises came at every few feet and again the mass of life was totally unexpected, the sum total of creatures seen, unbelievable. Although I delayed very little at the hundred-foot stops, when the guy ropes were attached, yet I dictated page after page of observations. I used the light as little as possible and carefully shielded my eyes, so that very soon they became dark-adapted. I was watching for two or three things which I wanted to solve. Large Melanostomiid dragon-fish with their glowing port-hole lights showed themselves now and then, and more than at other times, in our electric light, we had frequent glimpses of small opalescent copepods, appropriately called *Sapphirina*, which renewed for us all the spectrum of the sunlight.

I consider the three outstanding moments of a bathysphere diver to be, the first flash of animal light, the level of eternal darkness, and the discovery and description of a new form of fish. There is a fourth—lacking definite level or anticipation, a roving moment which might very possibly occur near the surface or at the greatest depth, or even as one lies awake, long after the dive, thinking over and reliving it. It is, to my mind, the most important of all, far more than the new species. It is the explanation of some mysterious occurrence, the solution of some remarkable habit, which has taken place before our eyes, but which, like the sublimated trick of some master fakir, has, so far, evaded understanding.

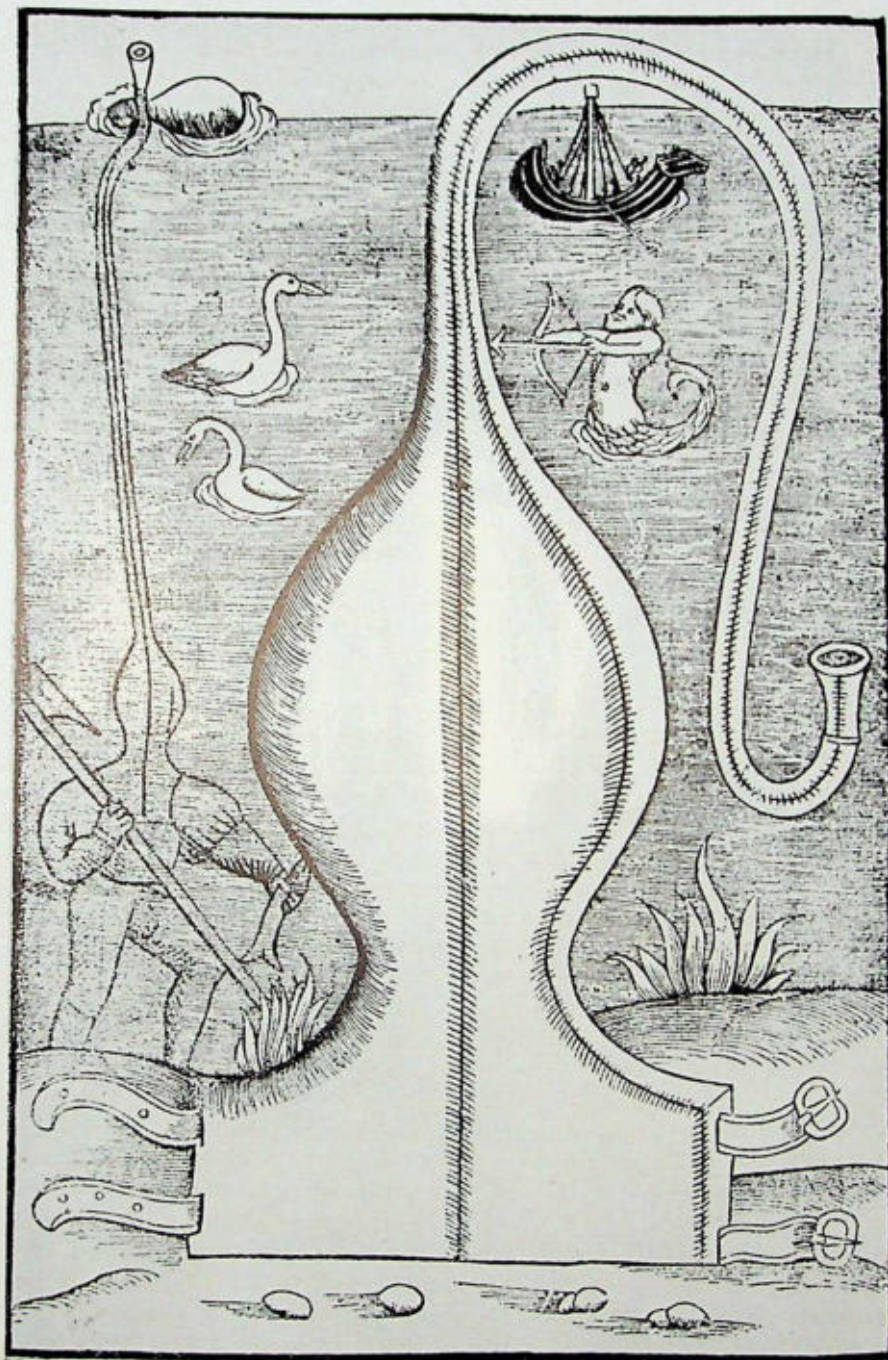
This came to me on this last dive at sixteen hundred and eighty feet, and it explained much that had been a complete puzzle. I saw some creature, several inches long, dart toward the window, turn sideways and—explode. This time my eyes were focused and my mind ready, and at the flash, which was so strong that it illumined my face and the inner sill of the window, I saw the great red shrimp and the outpouring fluid of

flame. This was a real Fourth Moment, for many "dim, gray fish" as I have reported them, now resolved into distant clouds of light, and all the previous "explosions" against the glass became intelligible. At the next occurrence the shrimp showed plainly before and during the phenomenon, illustrating the value in observation of knowing what to look for. The fact that a number of deep-sea shrimps have this power of defense is well known, and I have had a glass aglow with the emanation. It is the abyssal complement of the sepia smoke-screen of a squid at the surface.

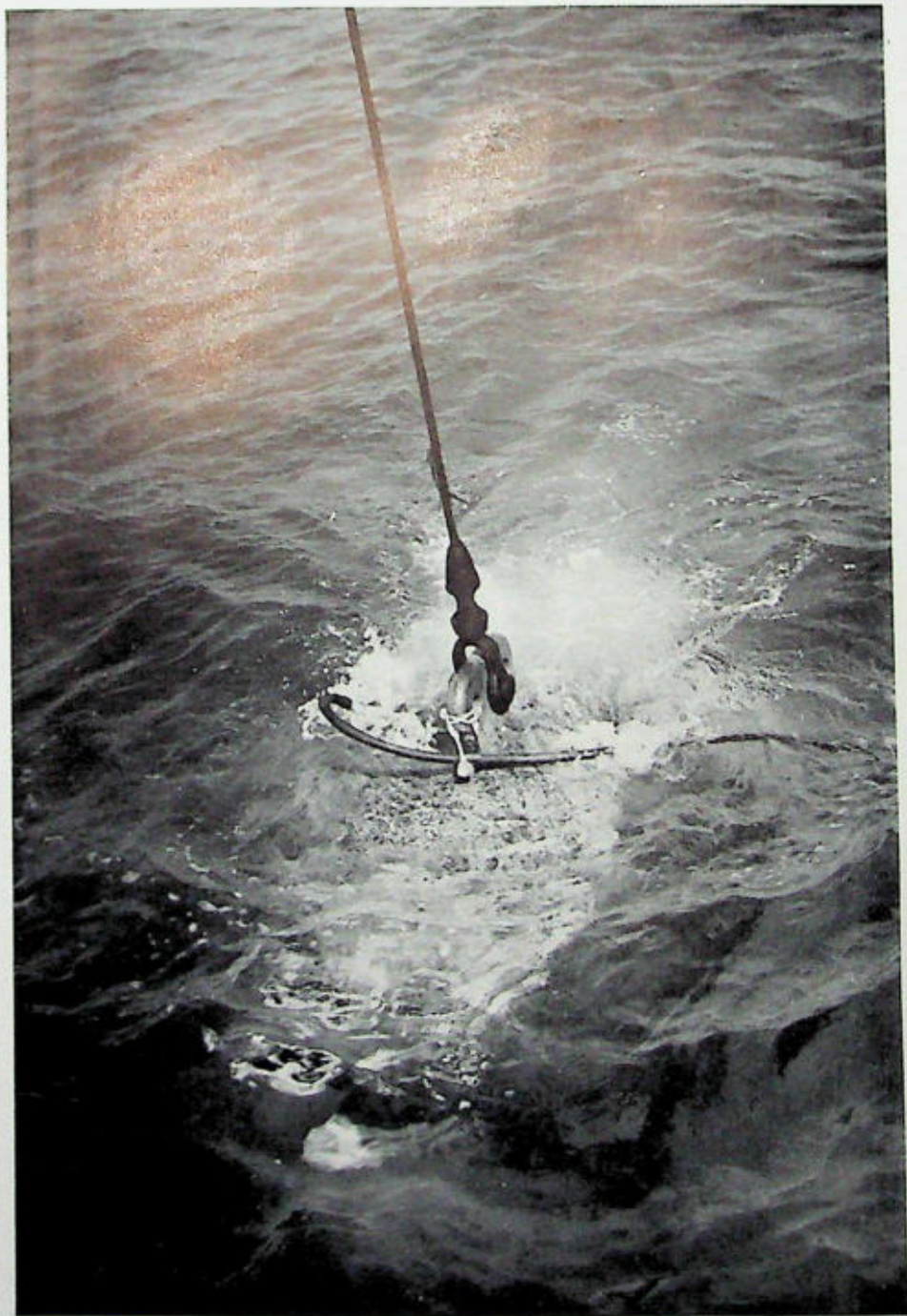
Before this dive was completed, I had made a still greater refinement in discernment, perceiving that there were two very distinct types of defense clouds emitted, one which instantly diffused into a glowing mist or cloud, and the other which exploded in a burst of individual sparks, for all the world like a diminutive Roman candle. Both occurred at the window or near it a number of times, but it was the latter which was the more startling.

Another advance in bathyspheric educational technique was unconscious and was only accidentally brought to conscious realization. On a succeeding dive, I went down fifteen hundred feet and took Mr. Tee-Van, and he wondered at my ability to identify organisms which to him, on the first part of this descent into the dark zone, were only individual lights. As we compared notes I realized that I had learned instinctively to ignore the light as soon as possible and look to left or right of it. Exactly as the spiral nebula in Andromeda can be seen most clearly by looking a little to one side, so the sudden flashing out of a light is less blinding when viewed indirectly, and simultaneously its author may more than likely come into focus. Before we returned to the surface Tee-Van had followed this method and saw eye to eye with me in subsequent identifications.

At eighteen hundred, I saw a small fish with illuminated teeth lighted from below, with distinct black interspaces; and ten feet below this my favorite sea-dragons, *Lamprotozus*, appeared, they of the shining green bow. Only sixteen of these fish have ever been taken, seven of which came up in our own nets. The record size is about eight inches, while here before me were four individuals all more than twice that length, and very probably representing new spe-



One of the First Published Designs for a Diving Helmet.
From Vegetius, 1553.



Breaking Through the Surface at the End of the Deep Dive.

cies. The green side glowed, but the long chin tentacle was quite invisible, certainly giving out no light. At twenty-one hundred feet two large fish, quite three feet over all, lighted up and then became one with the darkness about them, a tantalizing glimpse which made me, more than ever, long for bigger and better nets.

At twenty-four fifty a very large, dim, but not indistinct outline came into view for the fraction of a second, and at twenty-five hundred a delicately illuminated ctenophore jelly throbbled past. Without warning, the large creature returned and this time I saw its entire length as it passed through the farthest end of the beam. Twenty feet is the least possible estimate I can give to its full length, and it was deep in proportion. The whole creature was monochrome, and I could not see even an eye or a fin. For the majority of the size-conscious human race this "*Marine Monster*" would, I suppose, be the supreme sight of the expedition. In shape it was deep oval, it swam without effort, and it did not return. This is all I can contribute, and while its unusual size so interested me that for several hundred feet I kept keenly on the lookout for hints of the same or another large being, I soon forgot it in the (very literal) light of smaller, but more distinct organisms.

What this great creature was I cannot say. A first, and most reasonable guess, would be a small whale or blackfish. We know that whales have a special chemical reaction in their blood which makes it possible for them to dive a mile or more, and come up without getting the "bends." So this paltry depth of twenty-four hundred and fifty feet would be nothing for any similarly equipped cetacean. Or, less likely, it may have been a whale shark, which is known to reach a length of forty feet. Whatever it was, it appeared and vanished so unexpectedly and showed so dimly that it was quite unidentifiable except as a large, living creature. It surely shows what still remains for the pioneer explorer of the depths of the sea.

Anyone, who from an airplane high above the earth, has tried to spot another plane somewhere near, in full view, will appreciate the even greater difficulty of focusing in this three-dimensional, stygian blackness, upon some creature, small or large, suddenly appearing six inches from our faces, or forty-five feet away.

Again and again before the eye can refocus, the flash and its owner have vanished.

Mr. Barton saw no trace of the large creature I have mentioned, although I called out to him and got him at the window immediately. Soon after, when we were both looking out, he saw the first living *Stylophthalmus* ever seen by man, which completely escaped my vision, although it must have been within a foot of the window. My missing this fish was all the more disappointing because I had recently thoroughly studied these strange beings, and in fact had abolished their entire family, after proving that they were the larvae of the Gleaming-tailed Sea-Drum, *Idiacanthus*.¹

The next fish of unusual size was seen at twenty-nine hundred feet. It was considerably less than three feet, rather slender, with many, elongate luminous spots on the body, and a relatively large, pale-green, crescent-shaped light under the eye. Near it were five lanternfish, unlike all others I had seen. They swam so slowly that I was able to make certain, before they disappeared, that they were of the genus *Lampadena*.

At 11:12 A. M. we came to rest gently at three thousand feet, and I knew this was my ultimate floor. The cable on the winch was very near its end. A few days ago the water had appeared blacker at twenty-five hundred feet than could be imagined, yet now this same imagination worked to show it as blacker than black. It seemed as if all future nights in the upper world must be considered only relative degrees of twilight. I could never again use the word *black* with any conviction.

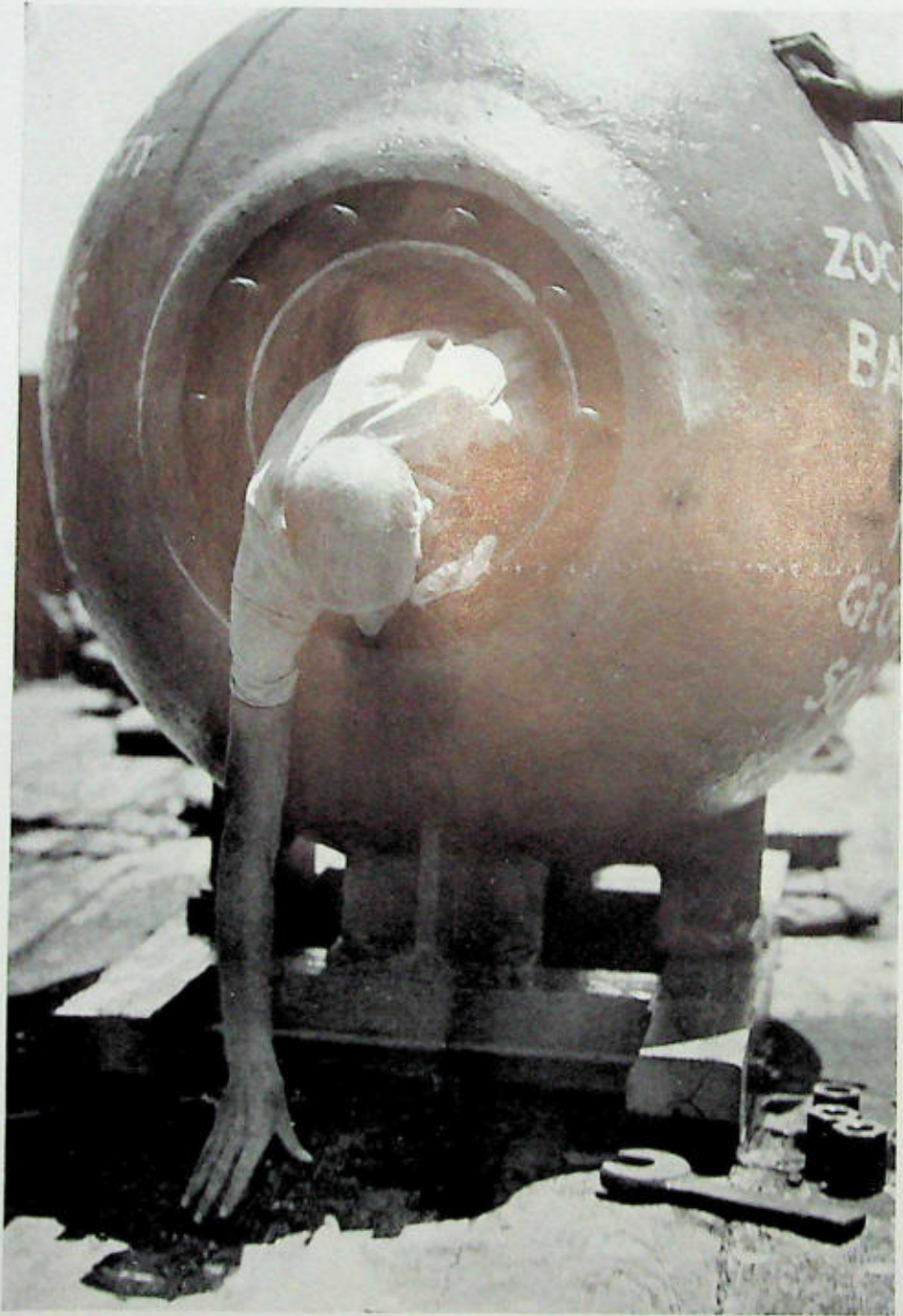
I looked out and watched an occasional passing light and for the first time I realized how completely lacking was the so-called phosphorescence with which we are familiar at the surface. There, whenever an ordinary fish passes, it becomes luminous by reflection from the lights of the myriads of minute animals and plants floating in the water. Here each light is an individual thing to our gross vision, often under direct control of the owner. A gigantic fish could tear past the window, and if unilluminated might never be seen.

My eyes became so dark-adapted at these depths that there was no possibility of error;

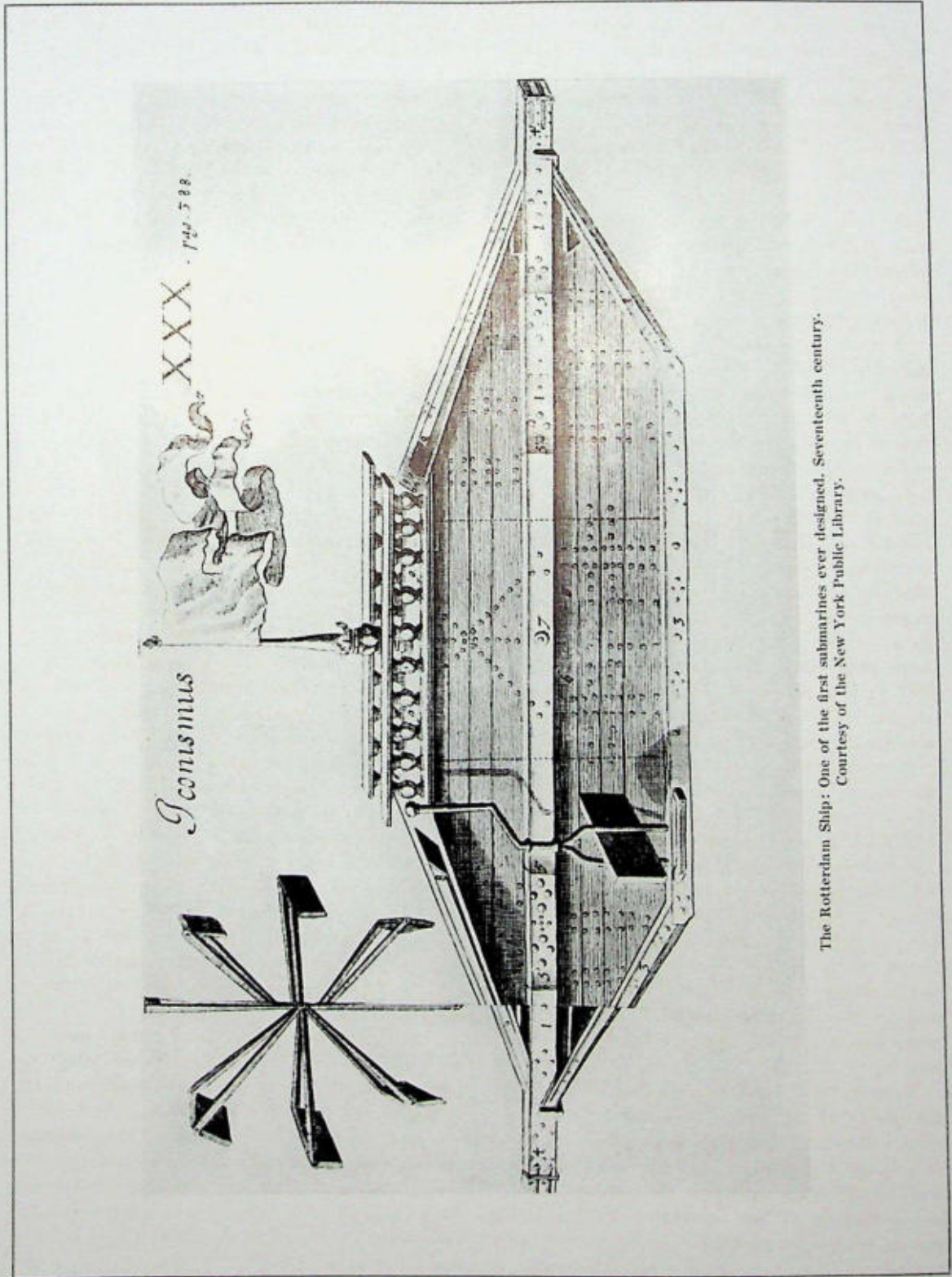
¹Bull. Zool. Soc., Vol. 37, No. 3.



Slowly Unscrewing the Central Wing-bolt to Equalize the Air Pressure after Three Hours of Sealing. Photo by David Knudsen.



Into the Sunlight and Air again after a Three-Hour Dive.
Photo by David Knudsen.



The Rotterdam Ship: One of the first submarines ever designed. Seventeenth century. Courtesy of the New York Public Library.

the jet blackness of the water was broken only by sparks and flashes and steadily glowing lamps, all of appreciable diameter, varied in color and of infinite variety as regards size and juxtaposition. But they were never dimmed or seen through or beyond any lesser mist or milky-way of organisms. The occasional, evanescent defense-clouds of shrimps stood out all the more strongly as unusual phenomena, and quite apart from the present theme. If the surface light is emitted chiefly by single-celled plants, the explanation of its abyssal absence is easy, for all plant life of the sea has died out hundreds of feet overhead.

A second thing which occurred to me as I sat coiled in the bathysphere, more than half a mile down, was the failure of our powerful beam of light to attract organisms of any kind. Some fled at its appearance, most seemed wholly unconcerned, but not a single copepod or worm or fish gathered along its length or collected against the starboard window from which it poured. We sometimes kept the lesser beam on for three minutes, so there was abundance of time for the plankton, which abounded in all parts of the path of light, to feel and react to its influence. The reason for this demands far more observation than several dives can give. One factor, doubtless, is not only the lack of all rhythm of day and night, but the eternal absence of all except animal light.

Now and then, when lights were thickest and the watery space before me seemed filled with life, my eyes peered into the distance beyond all I could see, and I thought of the lightless creatures forever invisible to me, those with eyes which depended for guidance through life upon the glow from the lamps of other organisms, and, strangest of all, those inhabitants of the deeper parts of the ocean, blind from birth to death, whose sole assistance to food, to mates, and to escape from enemies, were cunning sense organs in the skin, or on long, tendril-like fin-rays.

Even in this extremity of blackness I sensed the purity of the water, its freedom from sediment and roiling; six miles from shore and a full mile from the bottom insured this. So there was no diffusion of light, no luminous trails, no refraction. When sparks or larger lights moved, they were as distinct as when they were motionless. But reflection was noticeable, as

upon the eye or skin from a subocular or a lateral photophore, or upon my face when a shrimp exploded close in front.

* * *

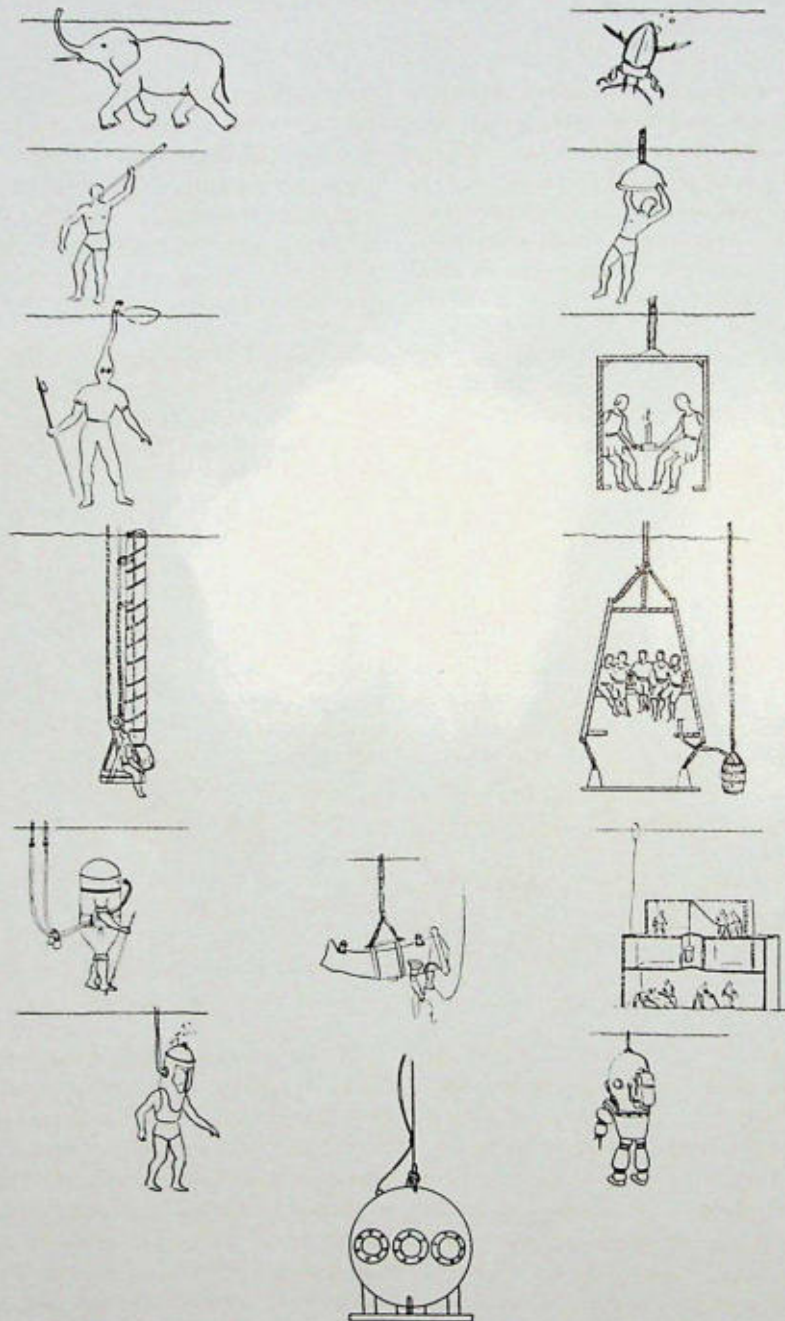
Now and then I felt a slight vibration and an apparent slacking off of the cable. Word came that a cross swell had arisen and when the full weight of bathysphere and cable came upon the winch, Captain Sylvester let out a few inches to ease the strain. There were only about a dozen turns of cable left upon the reel, and a full half of the drum showed its naked, wooden core. We were swinging at three thousand and twenty-eight feet, and, would we come up? We would.

Whatever I may think about the relative value of intensive observation as compared with record breaking, I had to admit that this ultimate depth which we had attained, showed a decided increase in the number of large fish, more than a dozen having been seen. There was also a corresponding greater number of lights, though not in actual size of their diameters.

Before we began to ascend, I had to stop making notes of my own, so numb were my fingers from the cold steel of the window sill, and when I shifted from my cushion to the metal floor, it was like sitting on a cake of ice. As to pressure, there seemed no reason why we should not be outside in a diving helmet, as well as in. I thought of a gondola sixty thousand feet up in the stratosphere with a pressure of one pound to the square inch. And then through the telephone we learned that at this moment we were under a pressure of thirteen hundred and sixty pounds to each square inch, or well over half a ton. Each window held back over nineteen tons of water, while a total of seven thousand and sixteen tons were piled up in all directions upon the bathysphere itself.

Yes, we had heard clearly, we were ready to be pulled up at once, thank you.

At twenty-nine hundred and twenty-nine feet I heard a metallic twang through the telephone, and asked what it was. I got some non-committal answer. I found out later that one of the guy ropes used in spooling the incoming cable on the drum had suddenly given way with a terrific report, a ghastly shock to everyone on deck until they realized it was a rope and not the cable. Truly, we in the bathysphere had the best of it at all times!



The Evolution of Human Diving. The left column shows the various attempts at drawing air down from above to the diver, from the elephant's trunk to the modern helmet and hose. The right column illustrates the gradual attainment of success in actually conveying a supply of air beneath the surface. The water beetle does this, and points the way, from the inverted vase of Aristotle to the self-contained bathysphere.

Drawing by George Swanson.

The Bathysphere of 1934

JOHN TEE-VAN

IN the year 2034, the Zoological Society's bathysphere will be looked upon as we now gaze at Stevenson's "Rocket," for our descendants will be acquainted with super bathyspheres; spheres resembling ours even less than the modern giant locomotive resembles its famous prototype, and capable of descending to the deepest bottom of the ocean.

the dream of what Martian machinery ought to be like. The illustration on page 172 shows the present distribution of the apparatus; an arrangement quite unlike that of 1930 and 1932. Although apparently complicated, in reality it is very simple, and can be divided into machinery for purifying the air, for producing light and for transmitting speech.



Instruments and Tools Used in the Bathysphere. Photo by John Tee-Van.

In the four years of its life, a number of alterations have been made in the bathysphere and its operation.* These are of interest as being the first steps in the advance toward the bathysphere of the future.

Externally the sphere is the same as when built, although new quartz windows and window frames have been installed, the former because of partial failure of the old windows and their subsequent cracking during removal, and the latter for additional strength. The old copper washers of the doorway, because of the tremendous pressures exerted upon them, had crystallized, lost their resiliency, and had to be replaced.

Internally the bathysphere is approaching

In the figure the left hand apparatus is the chemical blower. This consists of a small electric fan on top of a cone that connects with four tightly-fitting, brass, wire-bottomed trays. When in operation the air of the bathysphere is sucked in by the fan and forced through the chemicals in the trays,—soda-lime in the upper two and calcium chloride in the lower pair, and thence back into circulation, the soda-lime having retained the carbon dioxide breathed out by the divers and the calcium chloride the moisture. The blower passes the entire air of the bathysphere over the chemicals about once in ninety seconds.

* The bathysphere and its early operation is described in the Bulletin of the New York Zoological Society, Vol. XXXIII, No. 6, November-December, 1930.

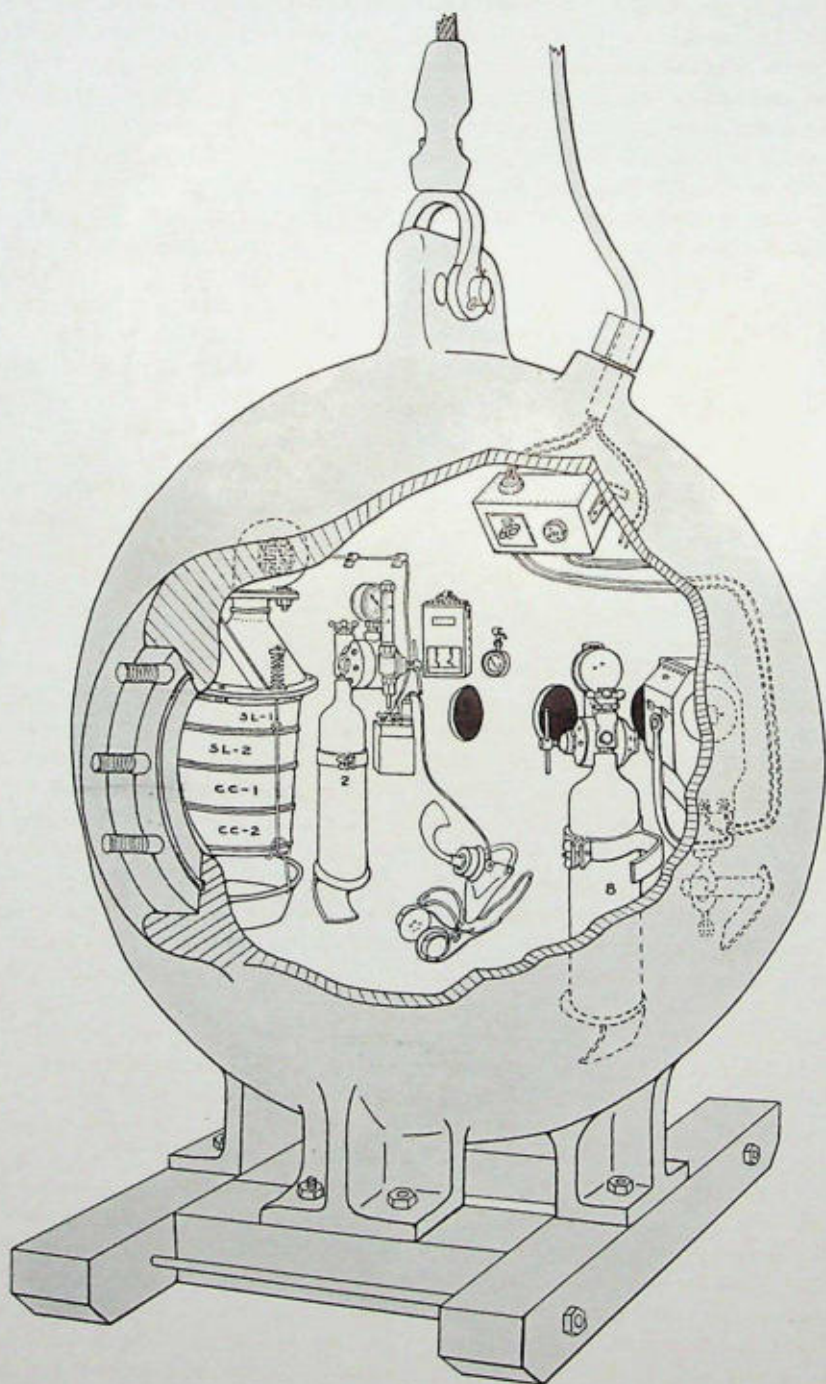


Diagram of the Bathysphere of 1934. Above: clevis for attaching supporting cable to sphere; above to right, communication cable entering sphere through stuffing-box, two of its wires passing to the telephone box, and two to the switch box that distributes power to the searchlight and the chemical blower. Middle section of bathysphere, from left to right, chemical blower apparatus, oxygen tank and valve, telephone box and instruments, temperature-humidity recorder, barometer, emergency oxygen tank and valve, and searchlight. Drawing by John Tee-Van.

Next to the chemical blower is an oxygen tank and valve like those on the opposite side of the sphere. The tanks are similar to those used before, each containing about 80 gallons of oxygen, but the valves are of a totally new design. These insure, first, accuracy of oxygen discharge, correct to within one half of one per cent. of the gauge reading, and secondly, ability to discharge accurately against external pressure. Neither of these factors was attained in the single valve used in previous years.

Two other instruments, to the right of the left hand oxygen tank, are of use in checking the atmosphere; a recording thermometer and humidostat and a barometer. Temperature in the sphere is not controllable, except as the bathysphere descends into colder water. The percentage of humidity can be lowered by increasing the amount of calcium chloride and by running the blower at greater speed.

The small circular device next to the thermometer is a barometer whose only use is to indicate too great a flow of oxygen.

With the blower purifying the air many times more often than necessary and with oxygen supplied at a rate slightly greater than necessary, the bathysphere this year has an atmosphere that is slightly more oxygenated than ordinary air, a temperature of 68 to 85 degrees, humidity of 48 to 76 per cent, and carbon dioxide practically absent. This approaches our idea of the modern air-conditioned room.

The light-producing section of the bathysphere consists of a single searchlight controlled by the large switch of the switch-box. The bulb is of 1500 watt 110 volt capacity. Under usual circumstances the voltage in the sphere is about 72 to 76 volts, this reduction in voltage causing the lamp to produce about one-quarter its normal amount of light. This, however, was more than enough for visual purposes and the reduced light was especially advantageous as it generated very little heat. To run the lamp at full power, a shift from one generator to another at the surface resulted in 110 volts or more and full light capacity in the sphere.

The switch-box mentioned above (upper part of figure) is so arranged that the electric wires as they come from above are divided so that the current is distributed through separate switches to the searchlight and to the motor of the chemical blower.

The sound-transmitting part of the sphere consists of a set of telephone instruments that plug into a small box containing battery and coil. This box is then connected by wires that pass around the upper rear part of the sphere to the two telephone wires in the communication hose. On deck two telephones are available. The telephones used this year are the latest type adopted by transoceanic telephone operators. Conversation through them is infinitely easier than over the average instrument.

The communication cable through which the telephone and electric wires run was lengthened this year to a total length of 3,600 feet.

On deck the electrical equipment, exclusive of telephones, consists of two generators; an automatic 110-volt generator supplying most of the current, and an auxiliary one of higher and controllable voltage that was used when required for photography.

Close to the generators and part of the electrical circuit is the emergency signalling apparatus. This is a small box with suitable switches and lamps so arranged that in case of failure of the telephones, the lamp above can be thrown into the circuit with the searchlight in the sphere. Signalling can then be effected by blinking the lights on and off.

Beyond replacing all bolts and fastenings for holding the winches and pulleys to the deck, no changes have been made in the deck machinery, except for installing a small winch to pull the boom from side to side.

Lastly a change to simplicity has been made in fastening the electric hose to the main cable. In 1930 this was done with double-jawed brass clamps,—one jaw holding the cable, the other the hose. In place of these a six foot length of rope is now used, fastened to each cable at its ends by a clove hitch. This method has a number of advantages,—it is easier and more rapid to fasten the two cables together in this way; in case of a twist in the main cable the rope takes up the twist and not the communication cable; and lastly, in an emergency the ropes can be slashed by a knife and the bathysphere brought to the surface without stopping.

Thus, in the bathysphere of today, we can show progress in terms of simplification, making more certain the performance of the machinery necessary for the preservation of the lives of those who go down into the sea in bathyspheres.

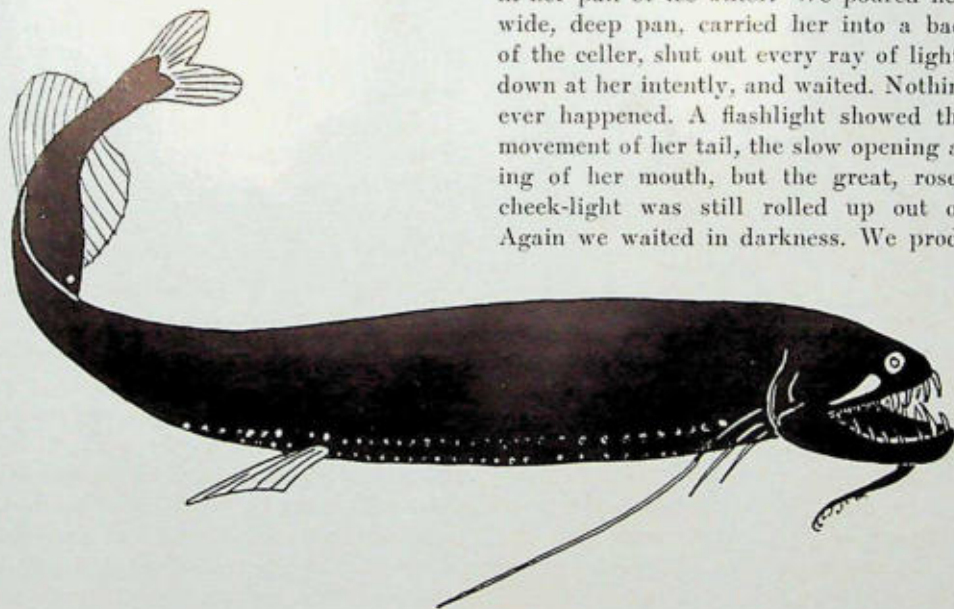
Deep-sea Creatures of Six Net Hauls

JOCELYN CRANE

WE crowded around the long table with that special sort of feeling that belongs to Christmas morning. Outside was July, and Bermuda, and the warm radiance of a sunny five o'clock. But for us, that was all a pallid other-world. We were conscious only of those shining things of black and scarlet that spilled into the whiteness of the pans. New shapes; strange, fast-fading tints; weird creatures never

prolonging their lives than the most efficient pressure tanks.

When all possible first-aid rescues had been made and the study of the rest of the catch was well under way, we turned our attention to the prize of the haul, a foot-long, Rose-lighted Dragonfish (*Echiostoma*) from five hundred fathoms. She—we knew it was a she-dragon from her great size—was still waving her fins in her pail of ice-water. We poured her into a wide, deep pan, carried her into a back room of the celler, shut out every ray of light, stared down at her intently, and waited. Nothing whatever happened. A flashlight showed the slight movement of her tail, the slow opening and closing of her mouth, but the great, rose-colored cheek-light was still rolled up out of sight. Again we waited in darkness. We prodded her



seen alive before—no wonder that we pushed and peered and worried over slipping minutes. The first haul of the year was up from the depths of the ocean.

After our first brief survey for special treasures, we saw that an unusual number of animals were still alive. On the tug we had sunk each jar, as it was unfastened from the long, silk net, in a tub of cracked ice. Now, emptied out into the pans, the water was cold as its source a half mile and more below the surface, and many small shrimp-like forms were still tearing madly around in the water or feebly kicking at the bottom. These we carefully transferred to small dishes and placed in the refrigerator, for we had found that a familiar temperature was of much more importance in

gently with a pencil. Suddenly she gave a mighty flip and her light winked out, illuminating fish, pan, and our excited fingers. Twice more the flash blazed up, and a pale glow showed the rows of body lights. Then one more magnificent display, and every movement stopped.

Feeling for a moment as though I had myself been half a mile down, I brought her out into the laboratory and carefully straightened her cold, soft, satiny blackness. It was only then, I think, that I realized the creature was a fish. Because they are so hard to catch, so delicate, and so very literally expensive, we treat our specimens with a kind of Hindoo reverence. Most would be irreparably damaged if we handled them with our fingers; instead, the finest of forceps, lifters and needles are used. Con-

sequently we miss that odoriferous physical contact with our prey which is the privilege of other fishermen. The first time I touched and felt and actually smelt a fresh-dead, jet-black, purple-lighted sea-dragon, and realized that it was *fish*—that was an experience I shall never forget.

There was a satisfying variety of fish today, most of them dwarfs compared with the dragon-fish. Cyclothones, or Round-Mouths, were there in their usual abundance. We catch twice as many of these deep-sea fry as of all the other fish put together; more than a hundred frequently come up in one net. Why they should be so abundant in our area is one of our unsolved riddles. Most of those in the four-hundred-fathom net were grayish Pallid Round-mouths, and the whitish young of dark-brown Abyssal Cyclothones. But in the deeper nets the majority were well-grown fish of the abyssal form.

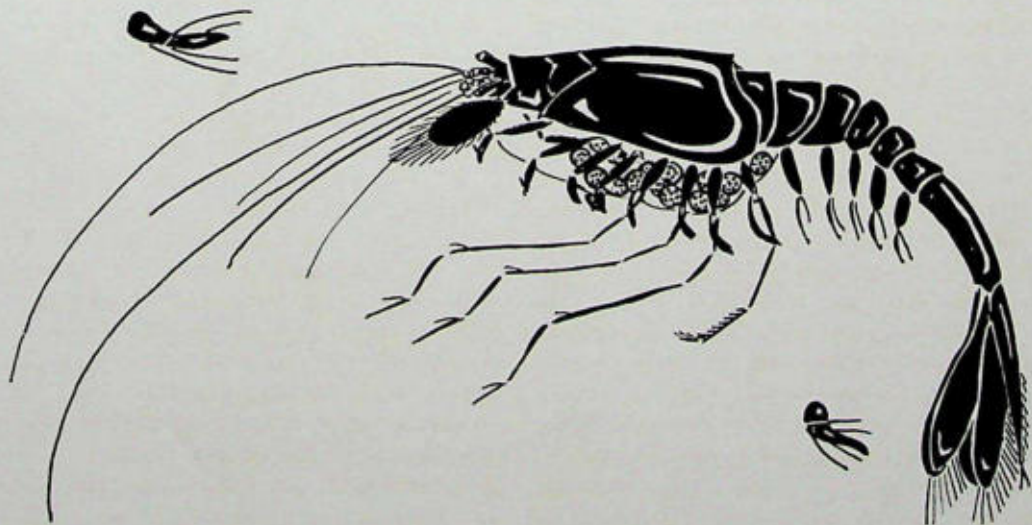
Myctophids or lanternfish, from a half-inch to two inches long, were next in number. All of these have small lights scattered over their bodies, forming characteristic configurations as constant within each species as the constellations of the Zodiac.

In one net was a small cousin of the Rose-lighted Dragonfish. It was a *Photonectes* only an inch long, but as black as the giantess, with the usual double rows of violet port-hole lights along its side, and a blazing green barbel bulb dangling under its chin. This faded to white within an hour of its capture. There was a rare black anglerfish, a *Melanocetus*, which carried



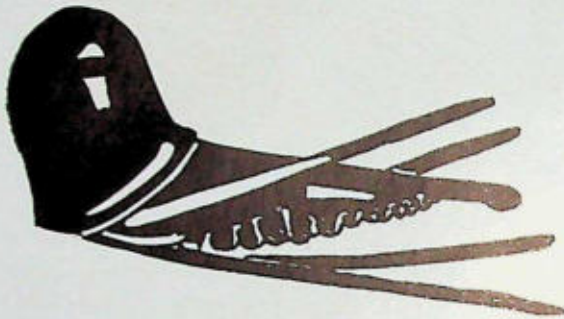
a silvery-white lamp on a stalk arising from the middle of his snout. There were a couple of young Thread Eels, slender as angle-worms. Their jaws were drawn out to a wiry fineness, with the tips curving away from each other without the least apparent reason. Yet in the stomach of each we found a good-sized shrimp. Whatever their hunting handicap, these fish are successful; they are among the most common of the deep-sea eels.

Finally, there were numerous small, pale, larval fishes. As in all the other large groups, young fish predominate, and for two very good reasons. Our nets, which must be drawn with a pitiful slowness at only two knots an hour, are less likely to miss weak young animals, whatever their phylum. Also, just as there are



more human children under twelve than old 'uns over seventy, so more young sea creatures than old have escaped the fate of being eaten.

I almost missed one of these youngsters. Only a round silver eye and three black spots showed in the bottom of the pan, and yet I



lifted out the larva of the Thread Eel. And I wondered again at the transformation that changes a broad, flat, glassy sliver of a fish into the slim, round, black creature that is the full-grown eel.

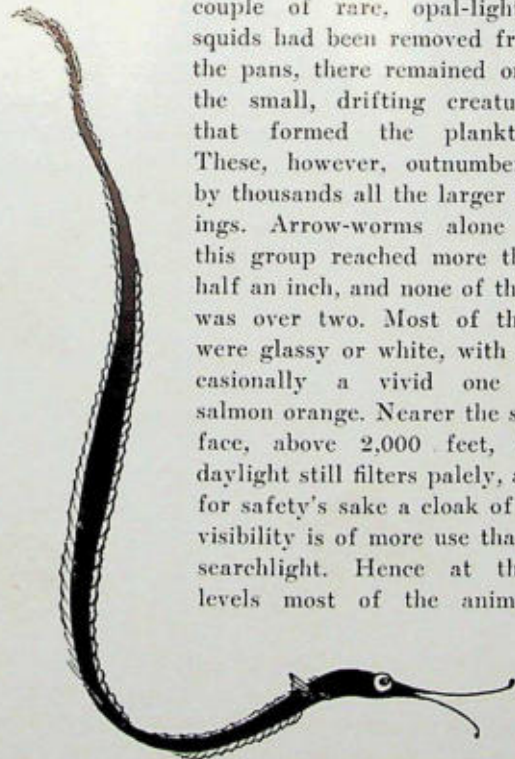
How relatively unexciting is this "coming of age" in humans! Suppose that useful abstraction, the ant-man from Mars, suddenly swooped down over Africa and gathered a miscellaneous collection of jungle mammals. Obviously, he would have no difficulty in separating all the infant Hottentots from the monklets and lion cubs and three-weeks-old elephants; and without so much as one wrong guess he could add them to the jar that held their dusky parents.

On the other hand, many of the so-called lower animals, especially ocean-living ones, transform themselves completely in the ordinary course of growing up. The story of even the least remarkable puts to shame the imaginations of the old frog-into-prince school of storytellers. While no human baby ever grew even one extra leg, the merest shrimp starts with six and grows thirty more in due succession. Furthermore, those original six change from capable legs into equally efficient feelers and jaws. Again, most deep-sea fish are little different, when they leave the egg, from newly-hatched herring. They are weak and white and their fins are nothing much to speak of; they have only their first set of teeth and not a trace of a light organ is anywhere upon them. Great fangs and flashing lamps are yet to be formed, and the fact that their development is a very

usual process down there in the darkness does not make it any less wonderful. Could we for a season change places with the dragonfish, keeping with us only our present mentalities, think of the thrill attending the first flash of small Jimmy's cheek-light, and Mrs. Johnson's pride in Susie's blackening complexion!

I jerked out of this unscientific day-dream at the Director's call to come and watch more fireworks. He had brought a prawn (*Systellaspis*), much revived, from the ice-chest, and it was still of that glorious shade of brilliant scarlet that is peculiar to deep-sea shrimps. In the dark room we watched its last display, as it shot out a small, defiant cloud of luminous fluid. In spite of its brightness, I knew this was but a shadow of the shrimp's performance in the blackness of the ocean.

When all the fish, the larger shrimps, and a couple of rare, opal-lighted squids had been removed from the pans, there remained only the small, drifting creatures that formed the plankton. These, however, outnumbered by thousands all the larger beings. Arrow-worms alone of this group reached more than half an inch, and none of these was over two. Most of them were glassy or white, with occasionally a vivid one of salmon orange. Nearer the surface, above 2,000 feet, the daylight still filters palely, and for safety's sake a cloak of invisibility is of more use than a searchlight. Hence at these levels most of the animals,



from the youngest lobster to the largest of the dolphinfish, have either bodies of crystal or coats of blue and silver, and the glassy worms are no exception. The entire catch today, however, was made between 2,400 and 5,400 feet, and so there were orange worms, red shrimps, the blackest of fish, and many lighted forms.

These white arrow worms, although they carry no lights, thrive at all levels. They shoot through the water with flicks of their tail fins, and seize their prey with tufts of scythe-like brown bristles which grow around their mouths. More than once we have found small fishes in their stomachs—always, somehow, a disconcerting discovery. It upsets one's New England sense of logical order. Fish should eat worms, not worms fishes. Anyway, the fact remains that arrow worms are more numerous in our nets than any of the non-crustaceans.

Running these a close second are the jelly-fish-like colonies known as siphonophores. Most of these have one or two glassy swimming bells, pointed, many-sided and rather like a bishop's mitre. From below dangles a short chain of pale gold polyps, some adapted for catching and devouring prey, some concerned solely with the production of the next generation. The large, complicated forms, represented at the surface by the Portuguese-men-o'-war, do occur in the deep-sea also, but in our nets we find only the broken fragments of their bells.

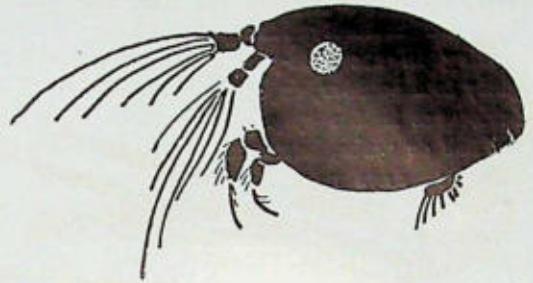
At last only a soup-like pinkish fluid was left. I placed a spoonful in a watch-crystal under my microscope, felt the familiar cold of the steel against the sides of my nose, pressed my eyes to the oculars, and settled to the happiest part of the evening's work. I do not know of an easier way of changing worlds. It is simply a



question of spectacles. But all your scales of size and values vanish; your own five-foot-something-or-other of height never existed; your coarse Brobdingnagian perception of "pink soup" is forgotten completely. Instead you are an unimportant something hovering just above a zool of unbelievable creatures, all with waving legs and shining eyes and bodies crystal-clear, or glowing with every color of the rainbow.

There are small, bivalved crustaceans, akin to barnacles and known as ostracods. Superficially at least they resemble shrimps that never

grew up, for after hatching they add only eight limbs to the six with which they started. From the first, they shut themselves, oyster-like, within a pair of shells grown from the chitin of their backs.

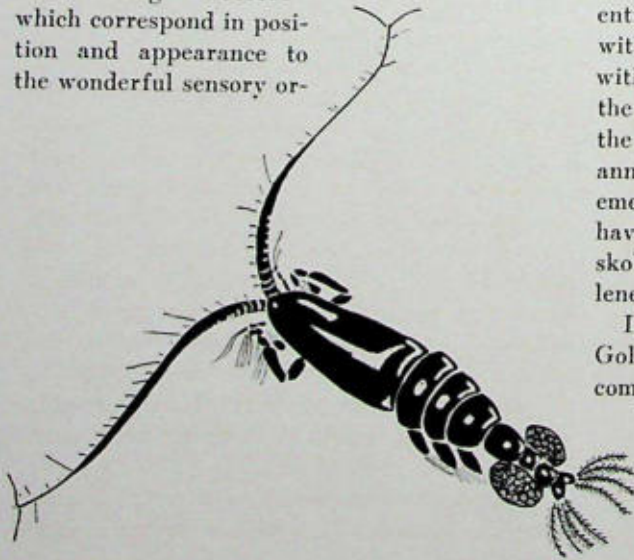


Somewhat resembling these are flying snails, the pteropods. The shells of some are burnished shields, others are flattened spirals tinged with violet, and still others are slender cones of alabaster. Most of the bottom of the Atlantic ocean is covered with clay, or with the skeletons of minute, one-celled radiolarians or foraminifera. Off Bermuda, however, there is a small patch of Pteropod Ooze, the only one in all the northwestern Atlantic. Why these snails should thrive exceptionally well in this particular spot is only one of the innumerable puzzles which we have not solved.

Amid the welter of legs and eyes I caught sight of a full-fledged anachronism a tenth of an inch long. If a pan-American airman should trail a net behind his plane and, five thousand feet higher than the jungle treetops, catch a curled-up infant armadillo, this would be scarce-

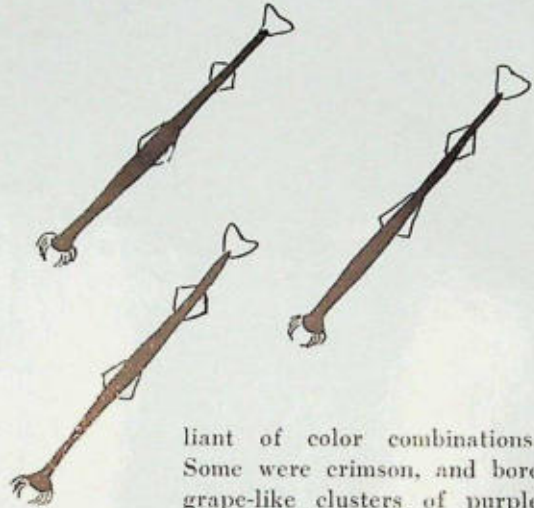
ly more absurd than our netting a starfish a mile above the nearest solid ground. Only because we are somewhat used to the idea can we with scientific calm catalogue a baby crab caught swimming in mid-ocean. We have long known, however, that many animals which pass a staid and tame maturity lazing among the reefs, crawling in the tide-pools, or even fastened tightly to a boulder, enjoy an obviously exciting adolescence in the open sea. Most of them, be they fish or crabs, barnacles or lobsters, live in these free days near the surface. But some, like the leptocephalid larvae of our fresh-water eels, are probably spawned hundreds of feet down. To this latter group the small starfish may belong. More probably, however, it was one of the few animals captured by the net on its way to the top.

In my study of the pink spoonful in the dish, I purposely ignored, until the last, the copepods, the ubiquitous small crustaceans which have justly won the name of "insects of the sea." I ignored them because I knew that once they had distracted my attention, I would quite forget snails, starfish and everything else. The longest of them measure less than half an inch; the smallest are only a twenty-fifth as large as these. They are of all forms, but most have a torpedo-shaped body with a slender, jointed, legless tail ending in a few feathery bristles. Almost all have only a single eye, set Cyclops-like in the middle of their foreheads. They row themselves along by jerks of their antennae, those long "feelers" which correspond in position and appearance to



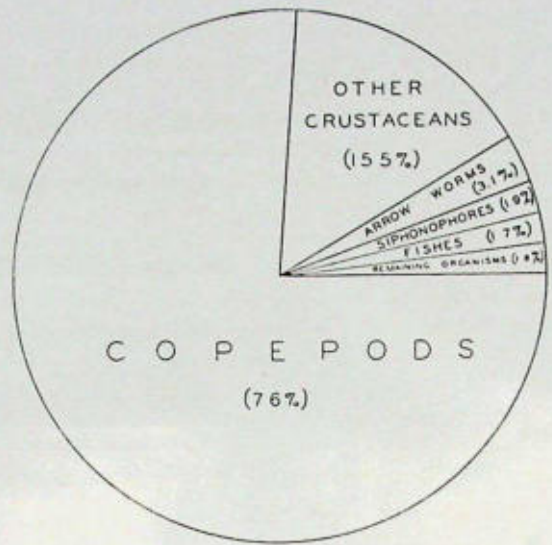
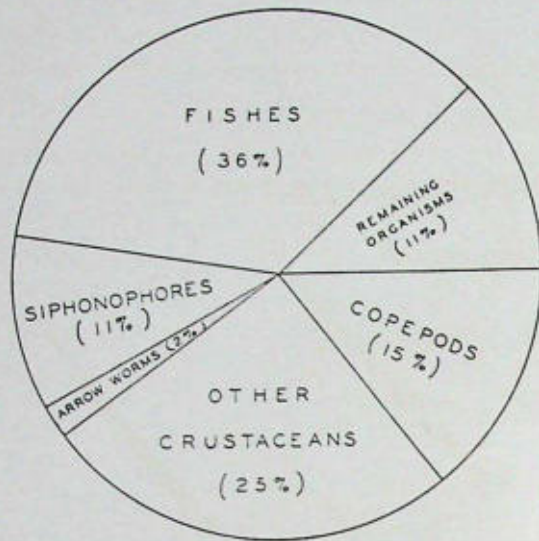
gans of ants and butterflies. Suddenly to find such organs used as oars is as astonishing as it would be to see a donkey swimming with his ears.

Many of the mites under my microscope were transparent, but others flaunted the most bril-



liant of color combinations. Some were crimson, and bore grape-like clusters of purple eggs; some were clear ultramarine, with ruby eyes and legs of gold; and one was flame scarlet in front, but had tail and underparts of livid magenta. In the audacity of contrast, in the brazen effrontery of clashing hues, they reminded me of the costumes in some old medieval tournament; considered analytically the discords were atrocious; accepted emotionally, the effect was perfect. Luckily for scientific accuracy, we have a book of color samples with every shade catalogued and labeled, and with this we match the almost nameless colors of the copepods. But although I faithfully make the proper records in my notes, it never fails to annoy me when a creature all sapphire and emerald and delicate heliotrope turns out to have its "cephalothorax smalt blue, abdomen skobeloff green, and antennae pallid naphthalene, shading into Schoenfeld's purple"!

In the ocean there is no such thing as privacy. Goldfish globes are stone-walled hermit-cells by comparison. No jointed-legged being, from a queenly scarlet shrimp to the smallest of the copepods, could ever find a safe place to leave her eggs. She cannot, wasp-like, choose a likely space and dig a hole; neither can she glue her eggs to a food-



The Proportions of the Principal Groups of Animals Caught in a Typical Deep-sea Haul. In the right hand circle the percentages are based on the numbers of individuals; in the left circle, on the relative bulk of the various groups. These proportions are derived from a single haul of six Michael Sars metre nets, drawn at two knots an hour for four hours, at 400, 500, 600, 700, 800 and 900 fathoms, from eight to ten miles off Nonsuch Island, Bermuda, on July 25, 1934. With the single important exception that almost all protozoans slipped through the meshes of the nets, and so are not shown in the above diagrams, the latter give an approximate idea of the proportions of the various groups in the deep sea. If the protozoans could have been caught and counted, the representation of their numbers would probably have occupied almost all of the right hand circle; the divisions of the left one, however, would scarcely have been affected.

filled slice of water, like moth-eggs to a leaf. And so she quite wisely carries them around with her in a pouch beneath her breast, or attaches them firmly to her swimmerets, or, as in the case of many copepods, she slings a packet pannier-wise on each side of her tail. Fish are not so careful: most of them scatter their eggs anywhere, in great numbers. But the following list shows how comparatively few are the fish and other organisms in comparison with the crustaceans. It is based on a single, typical haul of six nets drawn between 400 and 900 fathoms. Except that the minute one-celled animals, almost all of which slip through our nets, probably lead all the rest, this list gives a fairly accurate idea of the relative numbers of the principal types of organisms:

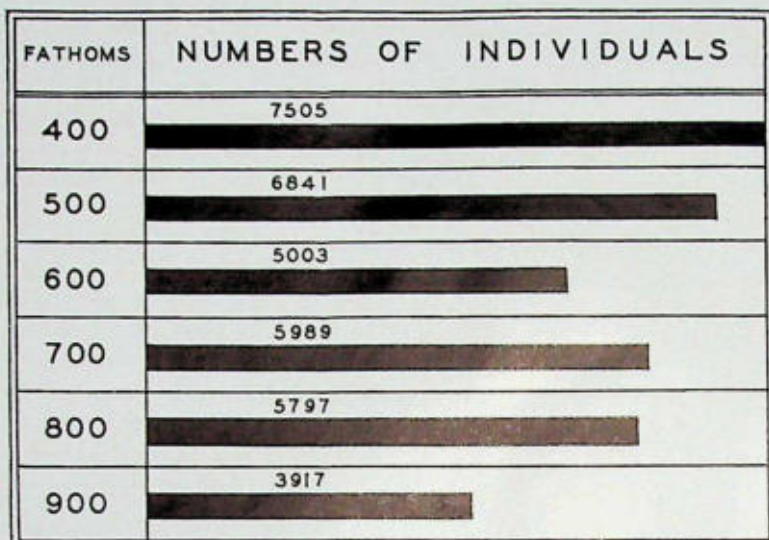
Copepods	76. %
Other Crustaceans	15.5 %
Arrow Worms	3.1 %
Siphonophores	1.9 %
Fishes	1.7 %
Radiolarians	1.2 %
Segmented Worms	0.3 %
Mollusks	0.08 %
Peridinean Shells	0.07 %

Tunicates	0.07 %
Echinoderms	0.05 %
Jellyfish	0.027 %
Comb-jelly	0.003 %
Total	100.000 %

The circle at the right shows this list in diagrammatic form, the left circle the relative amount of space the individuals of the same groups occupy. Even in this latter arrangement, with large and bulky fish as rivals, the crustaceans still lead. This order is practically invariable at all depths, although the relative proportions of the smaller groups vary slightly.

It is now clear that the copepods are the most important of the middle-men in the deep-sea, the links between the plants, the ultimate producers, and the large fish which are the last consumers. The wonder of it is that so many copepods, sought by innumerable hungry enemies, live to grow and carry their small parcels of eggs. The key to their abundance lies of course in the rapidity of their development. Some are known to complete their entire life cycle in a week.

We capture a minimum of several thousand copepods in each net, and this is but a small



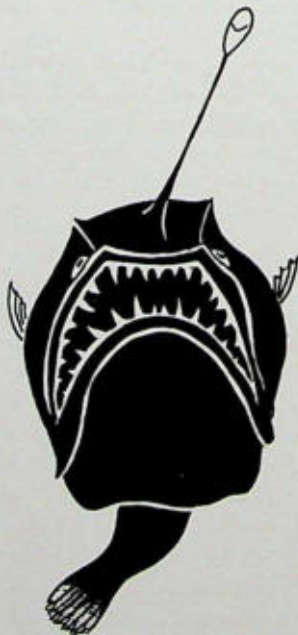
This chart shows the gradual decrease in the numbers of deep-sea animals caught between 400 and 900 fathoms. It is based on the single Bermuda haul described.

fraction of the numbers our nets fail to catch. Once I devoted hours and days to the task and sorted and counted all the copepods in a single haul. Then, after an astronomically involved calculation full of pi's and decimals and ciphers, I found that in spite of these counted thousands, each small copepod apparently swam lonesomely in a cube of water measuring twenty-one inches on a side. With the counts of other regions in mind—I recalled that at the surface of the North Sea a distribution of one copepod to the cubic inch was not uncommon—I carried my calculations to the Director. I rather expected him to be impressed with the scantiness of life in his deep-sea cylinder, and was puzzled when he merely grinned and said, "All right. That's fine. But wait a bit." Two weeks later I had the joy of going down in the bathysphere and seeing things for myself. When I returned I took all my calculations and quietly tore them up. The multitudes of swirling copepods I had seen from the window brought home to me as had nothing else the inefficiency of the best of deep-sea nets, not

only in capturing large fish, but even in retaining the small planktonic animals.

I have said that the copepods are the most numerous of the mid-links in the oceanic life-chain. The microscopic plants, dependent as is all vegetation upon the sunlight, form ultimately the food of even the largest deep-sea dragon. But sunlight penetrates only a little way into the sea, and no plant can live much below 600 feet. Visible daylight dies out completely at 2,000. All of the creatures in our nets lived from 500 to 3,500 feet below the last glimmer of daylight. The copepods, although they are noted as scavengers of all kinds of organic rubbish, are mainly vegetarians. Consequently the thousands we caught in the middle depths must have depended principally on the remains of dead plants drifting downward toward the bottom.

We find that below half a mile the plankton, and consequently the larger animals, gradually become less numerous (chart). This, viewed in relation to the distribution of the plants, is quite understandable. A diatom-plant,



living at the lowest possible level in a minimum of light, somehow escapes being eaten and dies of old age. Its beautifully adjusted floating organs promptly cease to function. It becomes water-logged, and begins its long, slow fall to the bottom, a mile and a half beneath it. Every yard of its journey it passes tens of hungry copepods, and the chance of its escaping consumption long enough to reach the lower levels is slight. It follows that as there are considerably fewer defunct diatoms at the depths of a mile than at half a mile, there is an even scantier assortment of lanternfish, and so on. But between 2,000 and 3,500 feet the life of the deep-sea thrives. Here the blackness is of full intensity, and the cold nears its maximum, so that all the lanterned black and scarlet creatures of the mid-depths swim, feed and find their mates in the environment for which their outlandish characters are developed; yet the sunlight is not so far above them that they lack an abundance of food.

I realized suddenly that it was very late and I was tired. Rows of shiny glass vials, each

with its own typed label, had replaced the chaos of pans and pails and dishes. I had covered my microscope and pushed in the final cork when I saw a small dish sitting forgotten in a corner, holding *Omosudis*, the subject of the artist's last color sketch. It was a frightful, two-inch, monster of a fish, with sabre-sharp fangs, a mild blue eye, and a stomach literally bursting with the knobby bulk of an inchling Silver Hatchetfish. I knew that inside the Hatchetfish was probably a mass of copepods, and inside each copepod a bit of oceanic vegetable, and inside that—but I was too sleepy to look up formulae in bio-chemics. I transferred the Sabre-tooth to a round, squat jar, and placed him, bulging, on the shelf. And through my head danced the lines:

"Oh, I am a cook and a captain bold,
And the mate of the *Nancy* brig,
And a bo'sun tight, and a midshipmite,
And the crew of the captain's gig."

I could have sworn that through the curved, distorting glass, *Omosudis*, alias "the Elderly Naval Man," licked his fishy chops and grinned.

American Fresh-water Eels in Bermuda

WILLIAM BEEBE and JOHN TER-VAN

ARISTOTLE and his pupils were perplexed by the mystery of the life history of the European Eel, and more than two thousand years passed before this was solved. Dr. Johannes Schmidt devoted eighteen years of his life to the problem, and before he died, last year, had the satisfaction of having discovered all the important facts of this almost unbelievable life history.

The eels of the North American continent and of Europe, when they become adult, all make their way from the ponds and down the rivers in which they have been living for years, and when they reach the sea they swim thousands of miles south until they come to the deep waters of the open ocean near the West Indies. There they mate and spawn, after which every eel dies. The young eels, minute and transparent as glass, work their way slowly northward. Weak swimmers as they are, they manage some-

how to travel on and on. Beginning life five hundred fathoms or more beneath the surface, and four thousand miles away from their parents' rivers in Europe, they push on. The American eels breed somewhat to the westward, but not so far but that the two leptocephalids or larvae commingle. I have taken both in the same net.

Bermuda holds a unique position in relation to these young eels, for it stands at the dividing point of their migration. Somewhere in the vicinity, the two great hordes of glassy celled split to east and west, the European ones taking two years or more on their journey, and the American eels reaching their home rivers in half that time. As little, pink, fingerling elvers they swim up into fresh water, and remain there from six to eleven years. Then the utterly mysterious call comes, and they all start down, out to sea, and south to the tropics, and dive into complete blackness (I know, for I have been



American Eels Recently Caught in Brackish-water Ditch, Bermuda. Photo by John Tee-Van.

there!), where they in their turn, go through who knows what ceremonies of courtship and mating, lay their eggs and die. I have overlapped the circle intentionally, for only by reiteration can we really come to believe this astounding round of life.

For years we had heard rumors of fresh-water eels in Bermuda, but they always turned out to be blackish morays, or else references to twenty years ago. On page forty of our recent volume on the Shore Fishes of Bermuda*, we limited ourselves, concerning these eels, to one sentence, "In Bermuda recorded from brackish ponds." We had seen no specimen except in a collection at Harvard, where a two-inch individual was said to have been taken in these islands. Besides this, there seem to be no recent records, verbal or published.

In 1876 Brown Goode wrote of the eel, "Common in the ditches and dikes of the salt marshes," and quoted Mr. J. M. Jones "that it attains the weight of two or three pounds, and is very destructive to ducklings. It is not eaten." By diligent inquiry I found people who had speared or jigged for eels, ten or twelve years ago, at night in The Lane near Hamil-

ton. Mr. Scarritt Adams had caught full-grown eels, three feet long, at the same place, and said that they were considered a great delicacy.

At present, so many salt marshes and ditches have been filled in, there would seem no suitable places for fresh-water eels to live when they had passed the larval stage. I gave some eel pots to my young ichthyological enthusiast, Thatcher Adams, and bade him try to catch eels. He set them without success in a mangrove swamp at Spanish Point, and then tried in a ditch tributary of the swamp, in Hamilton itself, not far from the Hamilton Hotel. The next day there were six in the trap, twelve to fourteen inches in length, and all perfectly good American Eels (*Anguilla rostrata*). There is not much external difference between eels from opposite sides of the Atlantic, but the number of the vertebrae is characteristic. The American eel has from 103 to 113 segments in its backbone, while in the European form there are 111 to 119. In our Bermuda specimens the vertebrae average 105.

Our eels were well-colored, rich bronzy green above, changing through golden yellow to white below. The iris of the eye was iridescent bronze gold, thickly dotted on the upper half with black. The water in the ditch in which they

* *Field Book of the Shore Fishes of Bermuda* by Beebe and Tee-Van.

were taken rose and fell with the tide, but a bottle-ful taken at the time and place of the eels' capture was quite blackish, with a salinity exactly half-way between salt water from the sea, and rain water.

The most interesting thing about this discovery of half-grown eels, in this back-water of Bermuda, one mile from the open water, is that these few individuals, out of all the uncounted hosts of larval eels which pass Bermuda every year, are the only ones to be deflected to this first available, but unattractive and barely possible living haunt. If we are to judge

this event by the habits and instincts of all other eels, the parents of the eels now living in Bermuda must have spent their existence, from larval to adult life, in this same ditch.

We are today as ignorant as ever of how the European Eels know where to go to breed (retracing their juvenile journey of years before), or how the young know to go back to the same waters from which their parents came: We know as little about all these things as Aristotle, more than two thousand years ago, knew of North America or Bermuda.

Salt and Fresh-water Viability of Fish

GLORIA HOLLISTER

POPULAR conception naturally divides the world of fishes into two big groups:— those living in fresh and those in salt water. We are always surprised to read of the long journey of the eel from its fresh water home far into the open sea to spawn. Annually there is an economic record of the number of salmon that are caught as they travel one thousand and more miles from the sea to inland mountain streams to spawn. With both stories, it is the distance traveled that impresses us rather than the fact that the fish has changed its chemical environment. The salmon and the eel are examples of direct antitheses.

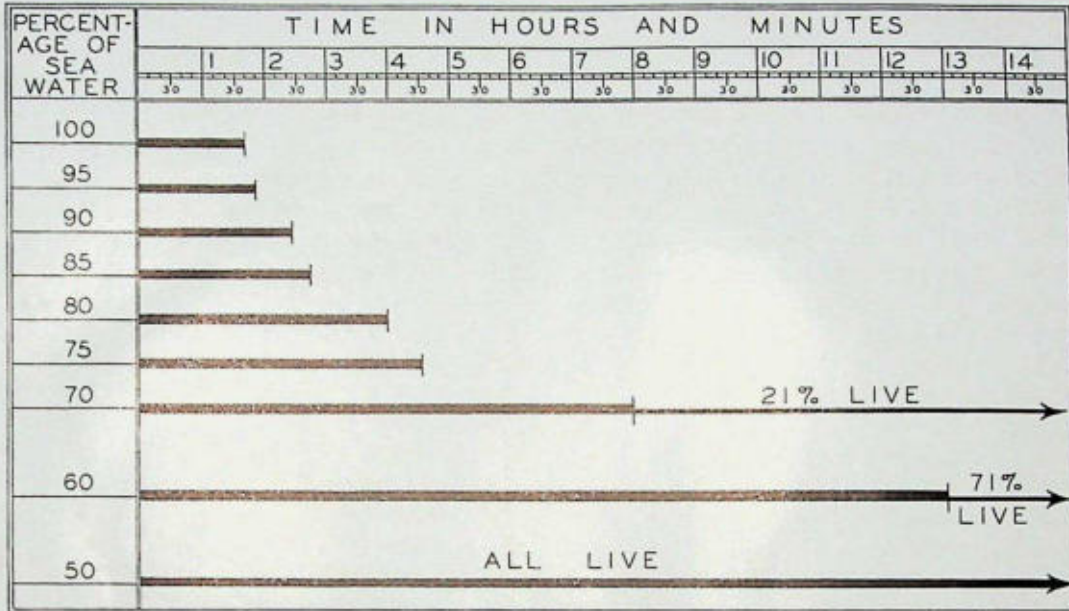
Besides these, there are many fish, representing various families, that live in brackish water but are sometimes found in the sea or in fresh water. Cyprinodont minnows may be found in fresh water, brackish water, or even bays of the sea. The ancestors of the handsome black molly is found in all these haunts and could be kept in any water that is convenient. Other very adaptable minnows are those belonging to the *Fundulus* group which has species living under all conditions. Some are bottom fish, burying themselves in the mud of estuaries, others swim freely in rivers and bays, and still others are surface swimmers in swamps and streams and brackish water. Certain ones are found in inland lakes and ponds.

The amazing powers of rapid adaptation of three species of minnows have been observed in

our Nonsuch laboratory. Two of these are residents in the brackish water of Bermuda, the degree of salinity of which is variable, depending on the amount and frequency of rainfall. An available analysis of the Devonshire Marsh water gives a pH of 6.9 as compared with 8. plus of the surface sea water. The two minnows mentioned are *Fundulus bermudae* a native, and *Gambusia holbrooki*. The latter was imported from fresh water pools near Washington, D. C., in May, 1928, and planted in the brackish marshes where they are thriving, and are valuable as feeders on mosquito larvae. The third form observed is the guppy, *Lebistes reticulatus*, a tropical fish, recently introduced into a few garden pools in Bermuda.

Fundulus bermudae, known also as the mangrove mullet, or mangrove minnow, is found in secluded mangrove bays as well as brackish pools. As far as we know it has never been reported swimming freely in the sea along the shores. In all these brackish water localities there is a definite rise and fall of tide. Our specimens came from a shallow mangrove swamp inland from Castle Harbor on the western tip of St. Davids Island. This small, flat-headed minnow is valuable as an enemy of mosquitoes and adapts itself quickly to fresh or salt water, without any intermediate steps in half and half solutions. It lives peacefully in fresh water pools with goldfish.

The *Gambusia* coming from the brackish



Guppy Viability Diagram. Average viability in hours and minutes of guppies plunged into solutions of salt-water, ranging from 50% to pure salt-water.

marshes will also live in either salt or fresh water, but differ from *Fundulus* in rapidity of adaptation. *Gambusia* need a few days (1 day was successful) in a 50-50 per cent solution, before thriving in pure salt water. Placed directly in salt water they survive about 3 hours. Later it was found that of the cyprinodont minnows the guppy is the least adaptable to salt water, needing gradual changes over a period of about a week.

Probably the best known of the minnows is the guppy, which for generations has been reared in fresh water tanks in many homes. Serious fanciers have developed the rainbow colors of the male far beyond that of its ancestors in Trinidad and northern South America.

During several years of personal observation the guppy has lived up to its reputation of a remarkably hardy little fish, surviving extreme sudden cold or heat, shifts into unseasoned water and travel in crowded and unacrated quarters. Last winter, finding my aquariums in New York City over-stocked with guppies I used this minnow first in a series of viability tests in solutions of salt water. Half grown fish were the subject in a constant total of two quarts of water, in both jars and open rectangular tanks. Repeated experiments have shown

that the differences of surface area of these two containers have had no appreciable effect on the longevity of the guppies. No plant life or aeration were introduced. Salt water was supplied through the courtesy of the New York Aquarium from December 1933 to May 1934 when all the experimental fish, as well as the stock, were transported to our Bermuda Laboratory with the 20th Expedition of the Department of Tropical Research. Here this work was continued, and in addition, a number of the commonest types of Bermuda shore fishes were observed during the summer. I was ably assisted in the constant care of the aquariums by Perkins Bass and William Ramsey, Jr., and in collecting specimens by Thatcher Adams and Robert Hartley.

The salt water fish will be described after we see how the guppies take to their changed water world.

The experiments with the guppies were divided into two groups. First, plunging the fishes directly into definite percentages of salt water, ranging from 50 per cent to pure salt water, to determine their reactions, exact time of survival, and the point where immediate adjustment would occur and life continue indefinitely. This method was used first, starting with pure salt

water and working down into the weaker solutions. Only a few tests were necessary to show that in a half and half solution most of the fishes lived indefinitely. The few that were lost died of other causes, such as over heating the water by placing it too near a radiator during the cold weather. There have been no losses in Bermuda where the temperature is comfortably constant for tropical fishes.

One guppy, in a two quart jar (Experiment No. 1), which was returned to fresh water after feeling the effects of immersion for one hour in pure salt water, fully recovered in seventeen hours and a half and was then placed in a 50 per cent solution. This guppy, after eleven months (in November), is still living in the original solution of half fresh and half salt water. In spite of the fact that there is no aeration and no plant life in the container, and only food is added, this fish has doubled his size and promises to live on to old age, or until the water evaporates. The experiment was repeated with another specimen which was placed directly in a half and half solution (Experiment No. 4), and this fish, too, after eleven months, is still thriving. Several more tests were made in Bermuda with the same results. The chart shows at a glance the average longevity in the various percentages. It is interesting to note that the greatest differences occur between 50 and 75 per cent and that the longevity in each of the weaker solutions is approximately twice that of the next stronger solution.

The other method and the more tedious one, sometimes taking months for results, but one which, with the guppies has proved successful, is that of gradually increasing the percentages of salt water, starting with a solution of 50 per cent.

The female of a half grown pair (Experiment No. 5) started in a 50 per cent solution, and after many weeks in increasing amounts of salt water reached pure salt water in seven months and two days' time. She survived for only two days, having, several weeks prior to this last step, contracted a white fungus disease on the fins. The male died in a 65 per cent solution after three months and a week. Six young were born in a half and half solution (Experiment No. 6) but only two survived to come to Bermuda the first of May. They were

healthy young males but unfortunately one killed the other. The remaining one was placed with the original female, its mother, with the hope of more readily establishing a salt water adapted race of guppies from those born in a solution of sea water. But this fish died, at the same time, and of the same disease that killed the parent. Another group of five, four half grown and one adult female (Experiment No. 7), was started in Bermuda on April 20 in 50 per cent salt water, and run up in half the time of the first pair, in increasing amounts of 10 per cent at each step. They finally reached pure sea water in three months and two days. During this time the adult fish had one young born on June first in 65 per cent salt water and five more born on July first, and one on August 28 in pure salt water. All the young are now living in 100 per cent salt water. All of the original group are living on the date of writing, November 20, and the large female has had another family.

Finally, having a group of nine guppies, of all sizes and both sexes, live in salt water after many weeks of prolonged stays in each progressive per cent, I was interested to find out how rapidly the guppies could adjust to salt water. So, a half grown pair was started in a 50 per cent solution and every twenty-four hours the fish were changed to a solution which was increased ten per cent. In six days this pair was in pure salt water. For three months they have thrived. The fish are given a weekly change of salt water but no plant life or aeration. This experiment was successfully repeated (Experiment No. 39) with a group of twelve fish, young to half grown.

Now that the guppies are breeding in salt water it will be of great interest to see what structural or color changes may occur in future generations. In the present generation there is one marked abnormality. This we have called "the spirals." All fish show this strange way of swimming, first being effected when in the higher per cents of salt water. "The spirals," which is what the word implies, is swimming around and around, either right side up or upside down, or sometimes alternately one way or the other. This occurs regularly when the fish are startled and lasts for some seconds after the first stimulus. The sudden flash of a light

will start all the fish swimming in spirals, some more violently than others.

With the knowledge of this ability of certain fishes to live in water varying from salt to fresh, and the comparative adaptability of *Fundulus*, *Gambusia*, and the guppy, it is of interest to study strictly salt water groups and test their capacity for adaption to fresh water. Through extensive experiments there might be gained some hint of ancestral relationships. The potentiality for adaptation may be preserved through heredity or lost through generations of constant conditions, in the latter case sudden changes of physical environment might mean extinction.

In the salt water fishes more specimens and repeated experiments carried on over a longer period of time are required before any conclusive data is possible. But what has been observed in these few scattered groups is indicative of possibilities in this field. Adaptation of species of salt water fish to fresh water would facilitate their being kept by aesthetic fanciers, their use for aquarium exhibits, and ultimately and more particularly for scientists who are interested in studying life histories.

A greater number of Demoiselles were studied than any other group. Two species were observed, the commonest of Bermuda salt water shore fish, the sergeant major, *Abudefduf marginatus*, and the blue and yellow beau gregory, *Eupomacentrus leucostictus*.

The sergeant major was tried in plunging experiments and also in a series of gradual changes over a period of weeks. The average longevity of fish plunged into 100 per cent fresh water was one hour and twenty minutes. The average of those plunged into 90 per cent was twenty-nine hours and a half. Seventeen specimens were started in the 90 per cent plunge and one-third are still living after two weeks, with only one showing the first signs of unadaptability, the loss of balance. After a week in 90 per cent all developed a progressive fungus on the fins. But none show any signs of eye abnormality which was experienced with the fish that had reached 90 per cent after gradual changes over a period of weeks. The fungus is a factor to be reckoned with and combatted in less specialized experiments. It has no place in the present scope of this thesis dealing only

with healthy normal fish. Several other species in the same tank with the badly infected fish have not been affected by this fungus.

With two sergeant-majors, the fresh water solution was increased 10 per cent every twenty-four hours and in six days they had shifted from a solution of half salt and half fresh to one of all fresh water. They lived one hour and a half in the fresh water which was only ten minutes longer than the average time of those plunged directly into fresh water. Another fish was given an intermediate change of 95 per cent instead of going directly from 90 to 100 per cent. It lived twice as long as the pair that were jumped directly from 90 to 100 per cent. These fish remained healthy with no sign of fungus, which appears after an elapse of time in the higher per cent of fresh water. Three fish reached 92 per cent, one 94 per cent and two 95 per cent in the experiments allowing four weeks and more with a 1 per cent increase from the 90 per cent step upward.

Seven young specimens of beau gregory were experimented with, measuring between 9 and 20 mm in length. In the gradual changes from half salt and half fresh water to all fresh water the following summary will show briefly the longevity of each fish:

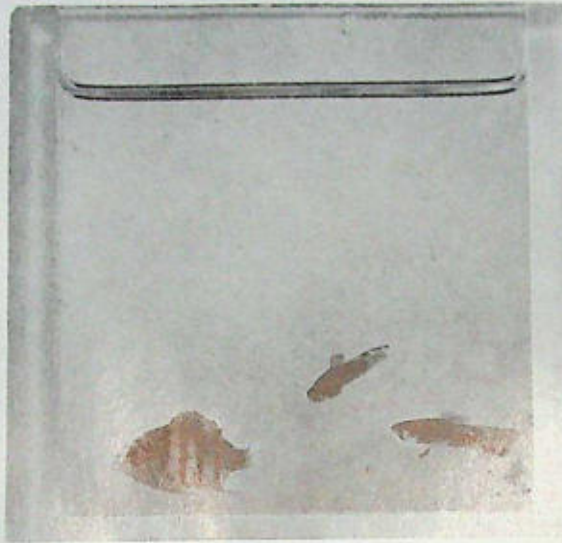
Two fish reached 60 per cent, one fish reached 80 per cent, two fish reached 85 per cent, one fish reached 96 per cent. Only one showed traces of fin fungus on the tips of the pectorals. There is one fish still living in 96 per cent fresh water.

Three specimens of silvery salt water mullets, *Mugil curema*, went into fresh water over a period of four and five weeks. One lived only four days. The mullets do not feed in captivity although tempted with a choice variety of organic material which they naturally would nose from the bottom.

One blue-striped grunt, *Haemulon sciurus*, went to 70 per cent, and one to 95 per cent. The latter was in splendid condition until changed from 90 to 95 per cent when it was affected immediately. It was returned to salt water where it revived temporarily.

Two breams, *Diplodus argenteus*, reached 75 and 80 per cent.

Several "shad," *Eucinostomus californiensis* are now living in fresh water. Only one died



Salt-water and Fresh-water Fish Living Together in the Same Aquarium: Sergeant Majors *Abudefduf marginatus*, and Guppies *Lebistes reticulatus*.

during the gradual change and this was in 90 per cent. This species feeds readily and several may be kept in the same tank, which is inadvisable with most groups, especially the demoiselles.

Two species of wrasse, the common slippery dick, *Iridio bivittata*, and a very young blue-head, *Thallasomma bifasciatum*, reached 90 per cent, excepting the young blue-head, which reached 85 per cent. The wrasse show a lack of ability to adjust the air bladder which condition was not seen in any of the other groups. They become very light with a noticeable swelling of the abdomen.

In the goby group, one specimen each of two genera and three species were observed. A translucent goby, *Lophogobius glaucosraenum*, after five weeks reaching 85 per cent by very gradual steps, jumped out of its tank when the cover was off at feeding time. This fish was vigorous and showed every indication of successful adjustment to fresh water.

A full grown sheepshead goby, *Bathygobius saporator*, reached 95 per cent and lived on for almost a week.

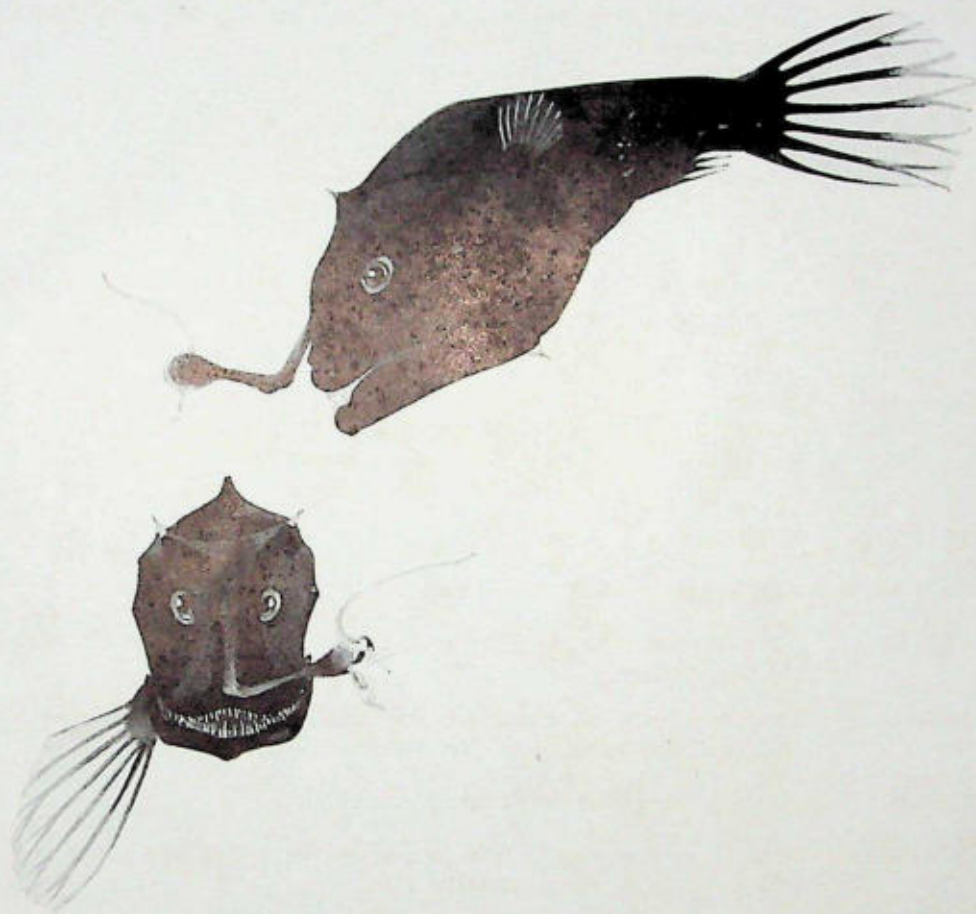
A large crested goby, *Lophogobius cyprinoides* is now in fresh water after two months and a week of gradual shifting from salt water. It is feeding and apparently comfortable and happy.

In the blenny group ten specimens were ob-

served, which represented two families, three genera, and three species. Two large *Labrisomus nuchipinnis* reached 80 and 93 per cent and one is still thriving in 93 per cent fresh water. One scaleless blenny, *Blennius cristatus*, reached 95 per cent in seven and a half weeks. Six young tide-pool blennies, *Salariichthys textilis*, reached 90 per cent in a week.

Of the pelagic fish only the amusing little angler or devil-fish, *Histrio gibba*, was tested. Under normal conditions the pelagic fish would never have to adjust to a sudden influx of water which shore fish experience at times of torrential rains. These *Histrios* reached 70 and 75 per cent in two weeks' to four weeks' time and one lived eight days. This dead line of 75 per cent is consistently lower than the 90 per cent which was the average life mark for the inshore fishes.

No attempt has been made to adjust the water chemically according to the needs of the various fishes. The water was kept fresh by constant changes of solutions and no plants were introduced which might foul the aquariums. Constant aeration and changes of the water kept both experimental and stock tanks in good condition. The object of these tests was to determine whether Bermuda brackish and salt water fishes could adjust to Bermuda fresh water which is rain water from whitewashed roofs.



Silver-whip anglerfish *Dolopichthys tentaculatus* Beebe,
from Six Hundred Fathoms.

Painting by Else Bostelmann.

SAMPLE OF UNEDITED TELEPHONE NOTES
FROM DIVE THIRTY-TWO

GLORIA HOLLISTER and WILLIAM BEEBE

<i>Feet</i>	<i>Time</i>	<i>Observations</i>
2450	11.00 A.M.	Big fish or cetacean came quite near; could just see outline. Was at least 20 feet long, one-third of this deep. It is icy cold in here.
2500	11.01.18	Beam off. Oxygen 1,500 pounds, humidity 63%, barometer 76.
2540	11.04	Another luminous shrimp. Ctenophore completely lighted up. Another big shrimp at window; whole thing very clear now about the luminous substance they shoot out.

- 2600 11.05.01 Beam on and off.
- 2650 11.06.29 Myriads of sparks when hit window. Big 12-inch heteropod, like *Firola*. Luminous all over, but no luminous spots. Another big shrimp shooting out luminous material which looks like a veil.
- 2690 11.07.50 Walls of bathysphere are ice cold.
- 2700 11.07.58 Hose in one-half inch. Oxygen 1,450 pounds, barometer 76, temperature 80.
- 2775 11.10 So black outside, and what lights! A fish with long, slender, pointed tail, this is a big fish.
- 2800 11.10.59 Here's a telescope-eyed fish; it is *Argyropelecus* and its eyes are very distinct. Barton sees something like necklace of silvery lights. Now another big shrimp. Beam off. Marvelous outside lights. Water filled with lights more so than on our last dive at 2,500 feet.
- 2900 11.13.31 Now a curved, pale-green under eye, eye lighted up by it. It is crescent-shaped. The fish at least 3 feet long. Five inch Myctophids, swimming so slowly that I can see whole light pattern. Several close lines of lateral lights, and constantly lighted plates. *Lampadena*, try to look up species.
- 2940 11.15 Not a flash in sight.
- 2950 11.15.30 Now a light coming toward me.
- 3000 11.16.25 Siphonophore, a big one. Oxygen 1,400 pounds, barometer 76, temperature 77, humidity 62%.
- 3028 11.19.14 Beam on. Beam off. Long lace-like things again. Salpa-like with big head and long, slender tendrils. Now another one.
- 3000 11.22.35 (Guy ropes shifted for winding in cable.)
- 2990 11.24.45 Animals seem to stay in field longer than at higher levels, but here comes a flash like mad! Heard metallic snap.
- 2905 11.25.15 (Guy rope broke with terrific snap; I learned after.)
- 2900 11.26.38 A lovely light. (Guy rope re-rigged, but broke again with sickening thud.) Oxygen 1,300 pounds, still coming at one liter a minute. Barometer 75½, temperature 73, humidity 6. Now three, very round fish, saw no lights at all on them. It is bitter cold inside, hand feels icy when touching window ledge (100 on deck, report).
- 2880 11.28.30 A squid, 8 inches, with one pale blue light and could see whole body when it passed by other lights.
- 2830 11.29 Now many things again, as thick as I have ever seen them.
- 2750 11.30.15 Mass of copepods and other plankton, can see them indistinctly 40 feet away from bathysphere. Can see a mass of little lights given out. Barton sees a big body with 1 light on each end. It may be a *Melanostomiid*.
- 2600 11.34.28 Beam on. Saw a fish with literally hundreds of lights, about 8 inches long, from head to tail its body was peppered with very brilliant but small lights. Color of lights pale lemon-yellow.

Three New Deep-sea Fish Seen from the Bathysphere*

WILLIAM BEEBE

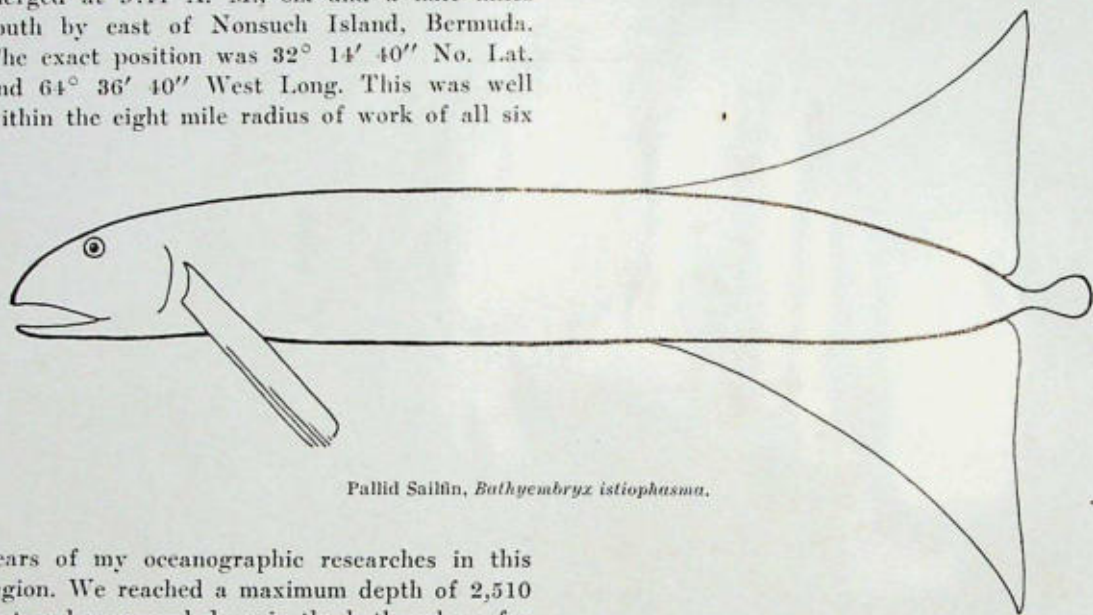
ON August 11, 1934, I made a descent in the bathysphere under the auspices of the National Geographic and the New York Zoological Societies. Mr. Otis Barton accompanied me and on the deck of the *Ready* from which we made our dive, was my staff, John Tee-Van in charge of deck machinery, Gloria Hollister, recording my observations at the telephone, and Jocelyn Crane responsible for exact time and depths.

It was Dive Number Thirty and we submerged at 9:41 A. M., six and a half miles south by east of Nonsuch Island, Bermuda. The exact position was $32^{\circ} 14' 40''$ No. Lat. and $64^{\circ} 36' 40''$ West Long. This was well within the eight mile radius of work of all six

of proposing for them *nomina nuda*. I have only our recorded observations, very carefully prepared outline drawings, and colored paintings for evidence, but in lieu of physical types I feel the unusual conditions and possible future, continued explorations warrant the definite establishment of these few fish.

Bathyembryx istiophasma gen. et sp. nov.

Seen from window of bathysphere, August 11th, 1934, six and a half miles south by east



Pallid Sailfin, *Bathyembryx istiophasma*.

years of my oceanographic researches in this region. We reached a maximum depth of 2,510 feet and were sealed up in the bathysphere for the duration of three hours and ten minutes.

It will be recalled that on Dive Number Twenty in 1932 I was able to make detailed observations on a pair of fish six feet in length at a depth of 2,100 feet. Locating them near the family Melanostomiidae, I gave them the name *Bathysphaera intacta* (Bulletin of the New York Zoological Society, Vol. XXXV, No. 5, pp. 175-176.)

On the present dive, Number Thirty, we had the good fortune to observe three new fish so clearly and for such an appreciable length of time, that I shall again chance the accusation

of Nonsuch Island, Bermuda, at a depth of 1,500 and again at 2,500 feet. The fish first became visible when I turned on the powerful electric light at the starboard window. Its body was half in, half out of the light, and it showed no fright, nor indeed of consciousness of the unusual illumination. I could see the shaded anterior half of the fish by the reflected light in the rich blue penumbra of the beam.

It was at least two feet in length, wholly without lights or luminosity; the body rather elongate, the sides almost parallel in lateral profile, tapering slowly to the tail, and with a very abrupt downward curve to the anterior profile of the head; the depth was not great,

* Contribution, New York Zoological Society, Department of Tropical Research, No. 461. Published November 20, 1934.

about six or seven in the length; the eyes were near the dorsal profile, small but not degenerate; the mouth horizontal and fairly large, the gape extending below or back of the eye; no teeth were observed; the pectoral fins long, at least twice the length of the mouth, apparently rather soft, if not filamentous, broad, and abruptly rounded at the tips. The color was peculiar, an unpleasant, pale, olive drab, like water-soaked flesh, an unhealthy-looking buff.

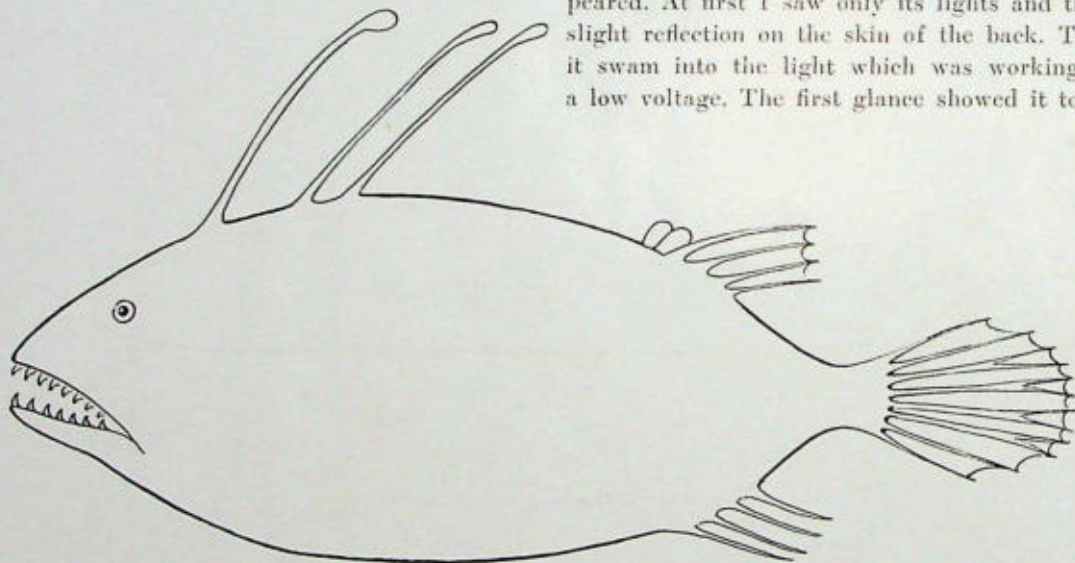
The vertical fins were alike and very large and sail-like, arising on the second third of the fish and lengthening rapidly in a concave curve high above and far below the body. Posteriorly they were truncated and described a sharp,

was the same, or another individual *Bathyceratias*, or Pallid Sailfin as we may call it.

Taking all the characters into consideration, I should place this fish in or near the family Cetomimidae, although it is a very distinct form. The characters of the species may be taken as those of the genus.

Bathyceratias trilychnus gen. et sp. nov.

The data of observation exactly as in the preceding species, except that the fish was seen at a depth of 2,470 feet. We had reached an extreme level of 2,510 feet and had begun our ascent to the surface. The cutting of a tie rope delayed us for a short time, when this fish appeared. At first I saw only its lights and their slight reflection on the skin of the back. Then it swam into the light which was working at a low voltage. The first glance showed it to be



Three-starred Anglerfish, *Bathyceratias trilychnus*.

vertical line from the extreme height, ending on the peduncle, close to the origin of the caudal. The latter fin was very small, decidedly degenerate, a small, rounded button, evidently of very little functional value.

During all the time the fish was in sight, the tall sail-like fins were in slight, but constant movement. These fins were either fleshy, or at least opaque, for I could distinguish no hint of rays.

At 2,500 feet, with the light full on, as I was getting ready to hold Mr. Barton's camera for a possible exposure, I had a distinct if brief glimpse of a fish which came down the light, head on. When it turned quickly, I saw that it

close to *Ceratias* and *Cryptosparas*, perhaps somewhat closer to the last, but with trenchant characters separating it from both.

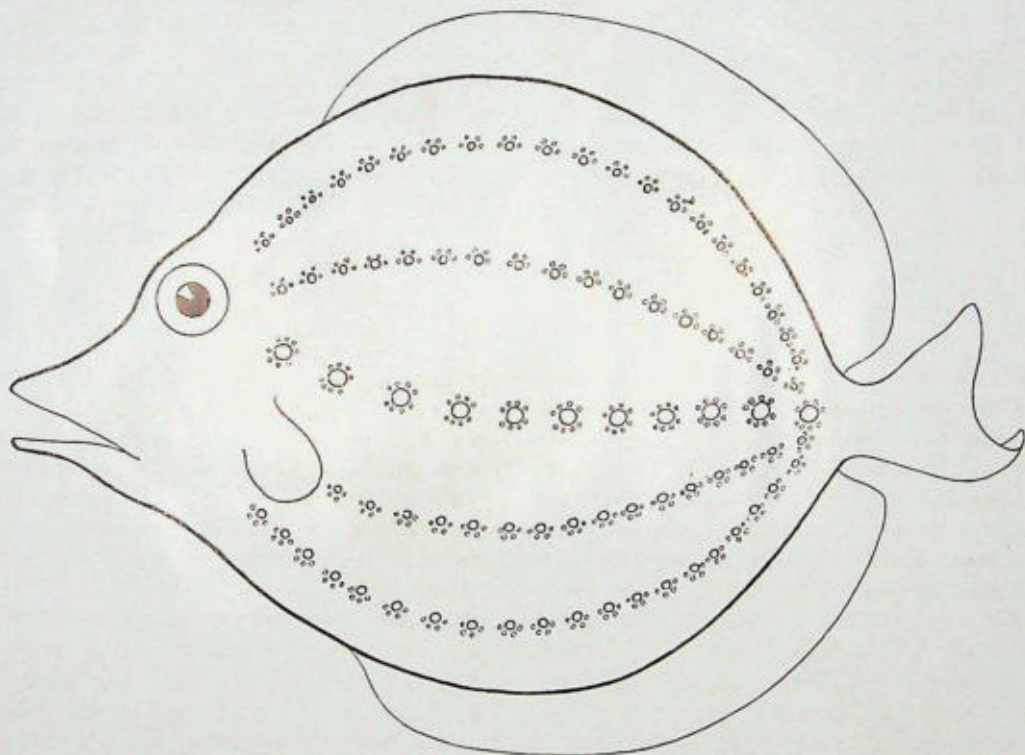
It was six inches or a little longer in length, a deep, almost regular oval in outline, black and with small eyes. Paired fins were not seen, but pectorals at least were undoubtedly present. The remainder of the webbed fins were typical for this group, dorsal four, and anal four. But close in front of the dorsal were two oval, sessile bulbs like those of *Cryptosparas*.

Half-way between the bulbs and the eye was the posterior of three tall illicia, slender, apparently stiff, each about one-third the length of the fish. The anterior one originated almost

half-way between the second and the eye, the two posterior ones arising closer together. The anterior was somewhat stouter but of the same length as the others. Each had a slightly enlarged tip. These tips gave out a strong, pale yellow light, powerful enough to illumine the adjacent, dorsal skin when the fish was not in the direct path of my beam. The most distinct character was the mouth, which was only slightly oblique and furnished with short, even,

ceratias, this fish, one of the most unexpected and most gorgeous deep-sea inhabitants I have ever seen, appeared, quite as abruptly as the preceding. This too I saw both in the dark and in our light, thus showing almost all its principal characters. It swam slowly past and then turned broadside on, very close to the sharp boundary of the beam.

At the surface it would have passed for a strange *Chaetodon* or *Acanthurus*, but it was



Five-lined Constellationfish, *Bathysidus pentagrammus*.

sharp teeth, these characters setting it well apart from all known genera of Ceratiidae. This Three-starred Anglerfish remained in full view, in the darkness and in the light, for fully five seconds, long enough for me to see and fix in mind the recorded proportions and characters.

Bathysidus pentagrammus gen. et sp. nov.

Again the observational data is the same for this as for *Bathyembryx*, with a change in depth to 1,900 feet. On the way to the surface, 470 feet higher than where we had seen *Bathy-*

assuredly far from being either, unless a distant relation wholly adapted for life at three hundred fathoms. It was almost round—I estimated about five by six inches—with long, moderately high, continuous, vertical fins and a deeply concave tail, all exactly like the fins of *Acanthurus*. The eye was very large and interrupted the dorsal, cephalic profile. The mouth was large, the jaws projecting. The teeth and the pelvic fins were invisible to me, if any were present. The pectorals were rounded and rather short.

The bathysphere swung a few degrees to star-

board and left the fish in absolute darkness, and I suddenly saw the amazing beauty of the photophores. There were five rows of these, one along the median line from the eye to the peduncle. Two others divided the upper half of the body into unequal thirds, curving downward along their whole length, and two more occupied the same relative positions below the center line.

The equatorial line consisted of larger lights than in the other four lines. The chief light in each of the numerous units was a bright, but pale yellow, shining from a large central photophore. Each of these in turn was surrounded with a circle in the median row, or a half circle in all the other rows, of tiny, brilliant purple lights. This formed a wonderfully beautiful pat-

tern of illumination, resembling that of no other abyssal fish I have ever seen.

Before it left, it turned and faced me, its movement being perfectly distinct, even in the darkness, from the shifting of the lines of lights and their gradual foreshortening. I now saw that the breadth of the fish was not great, again about as in a surgeon-fish. Even in the partly front view, the sides were distinctly lighted by a soft reflection from the photophores.

I can assign this fish to no known family, but the Five-lined Constellation-fish assuredly deserves a name, pending the time when, with improved trawling nets, we will be able to bring one to the surface, alive or dead, and by dissection allot it more definitely to some known or unknown group.

Courtesies of 1934

THE courtesy and kindness of a multitude of friends encouraged us from the inception to the end of our adventure during the present year. The actual dives of 1934 have been made possible by a grant from the National Geographic Society. Further contributions are from Childs Frick, Herbert L. Satterlee, Irving Taylor, Ogden Mills, C. W. Wickersham, John B. Clark, William A. Read, Silas W. Howland, Sidney A. Mitchell, Edwin S. S. Sunderland, Edward W. Mallinckrodt, Jr., Danforth Miller, Charles A. Marshall, Auguste Richard, Newbold L. Herrick, Robert P. Bass.

Dr. Gilbert Grosvenor, President of the National Geographic Society, was most considerate in the details of his offer of making possible the 1934 dives. He demanded no condition of a new record, which is why I gave it to him. Mr. E. John Long of the Geographic Society's staff, spent many weeks with us, a welcome guest who took full charge of the publicity, thereby relieving us of a most onerous task. Permission has kindly been granted to use duplicate electros of five colored plates which have appeared in the National Geographic Magazine.

Mrs. Else Bostelmann gave of her best in the colored paintings of deep-sea creatures, and when there is only my memory to assist and check, the artist must indeed be good. George

Swanson was of constant help with sketches and pen-and-ink drawings. Perkins Bass and William Ramsey, just out of Dartmouth, made places for themselves and filled them worthily, saving us no end of time and lightening the thousand and one details which are never considered in any prevision of an undertaking such as this.

The Air Reduction Company designed and made for us new types of oxygen tanks and valves, an electric blower and four copper and brass trays for chemicals, and provided for six hundred feet of hose cable; the Bell Telephone Company in exchange for our old ear-phones, which they wanted for their museum, gave us three sets of their latest models of telephone outfits; the General Electric Company, through Mr. Gerard Swope, had three, new, fused quartz windows made to replace the old ones which had degenerated, and broke under dangerously low pressure tests.

The Watson-Stillman Company, thanks to Mr. E. A. Stillman, overhauled the bathysphere, replacing all worn-out parts, and fitted the new windows in place, so perfectly that not a drop of water entered. The Julien P. Friez Company loaned us one of their automatic temperature-humidity recorders, enabling us to use our eyes every moment for invaluable observation.



The Burroughs Wellcome Laboratory provided a complete medical outfit, and elaborate first-aid kits.

Others who have our gratitude for gifts of uncommon usefulness are: William Delano for our launch the *Skink*, Vivian Drake for a winch and wire, J. A. Roebing for miles of trawling wire, Maurice Ricker for the invention and construction of a stop motion picture camera, L. R. Smith for the first successful deep-sea pressure gauge, Siebe, Gorman for a complete diving

suit, Herbert Satterlee for a binocular telescope, and for two refrigerators which have kept alive some of our most amazing abyssal fish.

The Furness Line granted our usual low rates and took especial care of the bathysphere in transit. In Bermuda, Dr. E. G. Conklin allowed us to board at the Biological Station, where for six months we were comfortably lodged and fed, only seven minutes away from our laboratory at New Nonsuch.

Commander Moorehead of the Meteorological Station, put all his knowledge and the daily weather reports at our disposal, and aided our selection of propitious days for the dives. The Bermuda and Halifax Cable Company through Mr. Rickwood, took care of all our messages at press rates, and in addition generously allowed one of their experts Mr. A. P. Skinner, to splice the new six hundred foot hose cable on to the old, making a perfect connection. Mr. Thatcher Adams and Robert Hartley caught many interesting specimens for us.

Hon. William E. Meyer let us have the *Ready*, the *Powerful* and the *Gladisfen* for our work. W. R. Perin chief oversaw all the host of details of machinery installation, and Captain James Sylvester for the third year, spent a worried month, responsible for the capable working of the crew of the *Ready*, the efficient interdigation of the boilers and winches, and especially the smooth running out and in of the main steel cable itself, once almost off the drum, and down to three thousand and twenty-eight feet.

THE FLIES OF KARTABO

WILLIAM BEEBE

IT IS a matter for satisfaction on the part of the Director and Staff of this Department of the Zoological Society that not only is the present scientific work being carried on, and little by little, brought to completion, but the collections and investigations of as many as twenty years ago are still in course of active study.

The most recent proof of this is a paper which has just appeared in the *BULLETIN* of the American Museum. It is by Dr. C. H. Curran and is entitled "The Diptera of Kartabo, Bartica District, British Guiana." Although our interests in those days at the Zoological Society's station at Kartabo, were chiefly with the vertebrates, yet we neglected no opportunity to collect and study other forms of life. Flies are abundant and conspicuous in tropical jungles and exhibit most amazing courtships and other interesting phases of their lives, which are very little known.

We gathered many hundreds of specimens of flies in Guiana between the years 1916 and 1924 and these have now been thoroughly

studied by Dr. Curran and form the subject of this present paper which occupies 236 pages and 8 plates. In the Zoological Society's collection there have proved to be representatives of 38 families and no fewer than 420 species. Of these, 396 were collected by us at Kartabo, the station under intensive observation, an area which comprised only a quarter of a square mile. The remaining 24 species were taken within the surrounding six-mile radius of Bartica District. One hundred and twenty-three species are here described as new to science.

After a short introduction, Dr. Curran presents as Part I a list of the species, while Part II is the Systematic Account with, first, a key to the families. Throughout the succeeding treatment are descriptions of new species, notes on old ones, together with keys to genera and species. The account begins with the Crane Flies, *Tipulidae*, and ends with the curious family *Streblidae*, the members of which are found only in the fur of bats. The *Tabanidae* or horse flies will be reported upon later. Certain of the groups have been determined by Doctors Alexander, Bequaert, Walley, Bromley and Cresson. The types of new species have been presented by the Zoological Society to the American Museum.

The paper is not only of great value in itself, but the identifications have liberated for publication a host of notes on life histories which we made through past years, and which up to the present have been catalogued only under field numbers. Dr. Curran has done an excellent piece of work and the thanks of the Zoological Society are due him for the determination of this collection. The paper is Number 453 of the Contributions of the Department of Tropical Research of the New York Zoological Society.

ANNUAL MEETING

At the next annual meeting of the New York Zoological Society on January 8th, 1935, the department of Tropical Research will show a short film of the half mile dive, some of the new deep-sea fish observed, and a motion picture record of the complete development of a giant deep-sea eel in the egg, from a very early stage to the final hatching.

ПРИРОДА И ЛЮДИ

1928 г.

ВИЛЛЯМ
БИБ

НА КРАЮ СВЕТА

ИЗД-ВО „П.П.СОЙКИН“ ленинград,

Cover of a Russian Translation of *Galapagos: World's End*. The new title reads, "Nature and People at the Edge of the World."

