



ANIMALS *on the Move*

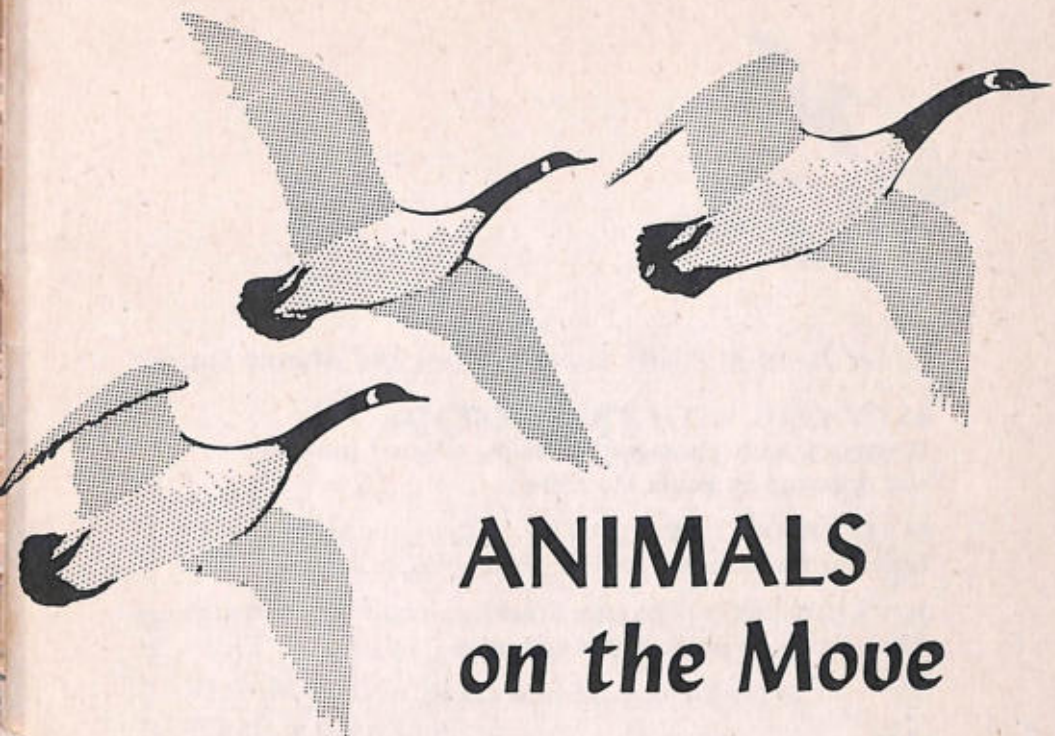
By ANN and MYRON SUTTON

Illustrated by Paula Hutchison



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THE MOVEMENT OF LIFE

Each year, in nearly every part of the world, a tremendous movement of life takes place. In ways that are strange to man, thousands of different living creatures—birds, whales, caribou, and butterflies among them—go from one place to another and back again.

Some fly, some crawl, some swim. Some go far and some do not. Some die on the way, or at the end of their journey. Others go back and forth every year for several years. Still others take several years to go back and forth just once.

We marvel at these mysterious comings and goings partly because it seems as though each animal "knows" exactly what it is doing. It seems to "know" just when to leave, where to go, and how to get there. Yet animals very likely do not "know" such things in the way that human beings know them. Scientists do not believe that animals think things out or "reason" as we do. Therefore, we are often surprised that certain animals can depart on their travels when they need to, go in the right direction,

and find the tiniest spot, though it be thousands of miles away in the middle of the widest ocean.

Human beings have needed maps and clocks and compasses to find their way around the earth. But animals have no maps. They have no clocks or compasses. Some cannot rely on their mothers or fathers or friends to set for them an example of which way to go, or when, or how far.

Yet year after year they find their way so perfectly

Migration of a herd of caribou



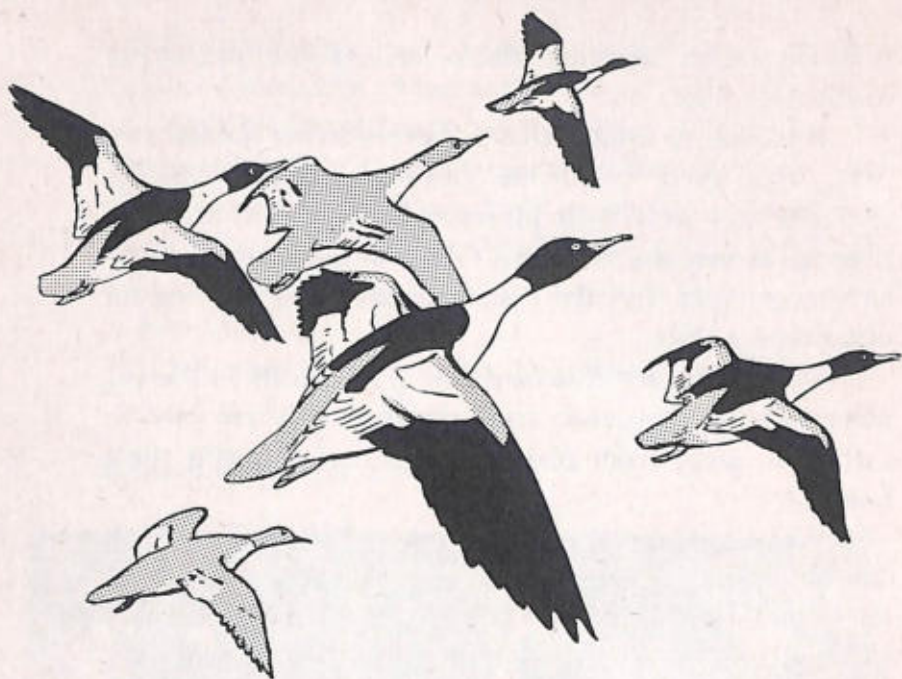
that, even with his finest efforts, man is only beginning to discover how.

It is true, of course, that not every living animal embarks upon these worldwide journeys. Prairie dogs, for example, stay near their places of birth and in all their lives never venture far away. Other animals travel regularly every year, but the distance they cover may be no more than a mile.

One reason for this could be that travels to distant places take animals away from the food they are used to eating, or away from places in which they build their homes.

Worse yet, travel means trouble. Danger and death may be waiting beyond the horizon. Some birds fly thousands of miles over land and ocean. In their journeys they must often meet storm after storm, with wind, rain, lightning, and perhaps even ice and snow. Against these, the birds have little chance of flying very far, and hundreds of thousands have perished in severe storms.

If they find a ship and seek a refuge, they are lucky, but if not, they flee the storm as best they can. They may be pelted with hail. They may be forced to land in cities. They may have to wander, cold and exhausted, through the streets. If the wind blows too hard they may find themselves carried over land or water that they have never seen before. Every year some American birds are blown from their usual paths all the way to Europe or Asia, and birds from other lands are blown to American shores.



Merganser ducks flying

There are heavy fogs in which not even airplanes, with all their instruments, can fly. There are telephone poles or electric wires, towers, buildings, and mountains that get in the way of the flight of birds. Predators such as foxes, hawks, and owls lie in wait, ready to prey on weak or careless birds. Boys with slingshots and hunters with guns wait for the birds in order to shoot them down.

After days or weeks or months have passed—with most of these dangers behind but perhaps new ones ahead—the birds successfully reach their destinations. A

new part of their life begins and continues until, once again, as regularly as the coming of spring and autumn, they start again on their travels to distant places. The next year, if they are able to avoid the dangers that beset them, they will go back again—and the next year, and the next.

So will certain of the fish and seals and whales return to the waters or islands where they were born. Unless they are shot or harpooned or caught by hook and line, or unless they die of disease or are eaten by sharks, they will return as they always have.

Each winter, elk and deer may gather in herds and travel from higher to lower parts of mountains, where the food they eat is less likely to be covered with snow. With the coming of spring, however, they will go back up the mountain to spend the summer as usual among the forests and crags they know so well.

Such is the way of life for animals on the move—back and forth, again and again, night and day, good weather and bad. To human beings, these animals are special creatures, and many are the strange experiments that men have conducted upon them. For they possess urges and abilities that take them on some of the most unusual travels known to man.

This is the story of animal migration—and of men who tried to find out something about it.

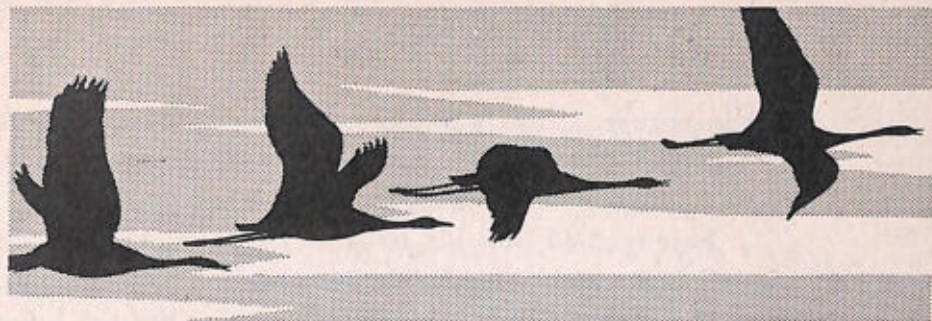
STRANGE BELIEFS OF LONG AGO

One of the earliest records of animal migration is found in the caves of Altamira, in Spain, where pictures of migratory birds were drawn by cave men 20,000 years ago. In those days there were no cities and farms as there are today and the cave men, living in wild forests and mountains, probably saw birds more often than we do.

What those prehistoric hunters thought of birds that came and went each year, we can only guess. They may have thought of them only as food. If that is so, then flocks of birds arriving in spring would have been a joyous sight at the end of a long, cold winter.

The movements of animals may have helped these cave men tell the seasons of the year. Migrations in spring would have meant that it was time for the planting of crops (if they planted crops), and the autumn migrations would have signaled the time for the storing of food and wood to last through the winter.

Thousands of years after the time of the cave men, men began to write and to put their thoughts on scrolls or tablets. Among the writers of Greece were some who



Flying cranes

had ideas about migrating birds. The famous poet Homer, who lived 3,000 years ago, wrote of "cranes which flee from the coming of winter and sudden rain, and fly with clamor towards the streams of ocean."

Aristotle, the great Greek writer and teacher, went even further. He said that some wild animals went all the way to other lands, that they spent the summer in cool places and the winter in sunny places.

But even though people of ancient days knew about migration, they were also puzzled by it. Unable to travel far themselves, they grew most curious to know where birds went in the winter.

To the sun? To the moon? To the stars? To Africa, Persia, the other side of the world?

Although some persons believed that birds flew away to distant lands and spent the winter there, others said that they did no such thing at all. The fact that some birds vanished in winter did not seem to these people to be proof that they had flown away. No, said the "unbelievers," if you wished to find out where the birds had gone, you needed only to remember what other animals

did in winter. If bears went to sleep in caves, and frogs and turtles buried themselves in mud, it was logical, thought these early people, for birds to do the same.

This seemed possible to Aristotle, too. Animals do not all migrate, he wrote. "A great number of birds also go into hiding." He spoke of swallows that hunted holes in which to spend the winter. Since Aristotle was considered the voice of wisdom, people for years believed in the hibernation of birds. (Not until 1947 were any birds actually found in hibernation and described by scientists, and that story is told on page 49.)

Bears sleeping in a cave



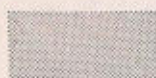
In the year 1555, a Swedish author named Olaus Magnus heard fishermen tell strange tales of pulling feathery balls out of the water. Not knowing what they were, the fishermen said, they carried these balls to a stove and warmed them, whereupon they melted and dissolved into real, live swallows!

But how could the breathing of the swallows be explained—or rather, their *not* breathing? Magnus went on to say that older fishermen would put these feathery balls back into the water because they knew that the balls were swallows in hibernation. The only trouble was that neither Magnus nor the fishermen nor anyone else explained how the birds could live all winter under water, where they had no air to breathe.

According to a story told by Aristotle, the redstart did not fly away when winter came; it simply changed into a robin and stayed where it was. This idea was as easy as any other to believe, despite the fact that not a soul had ever *seen* a redstart changing into a robin.

People of long ago also believed that high-flying birds flew wherever they wished, and naturally chose to go where the air was thin and where they could fly much faster—high in the sky. Thus arose the belief that birds flew very high when migrating. In addition to that, when other people saw birds pass in front of the moon at night, they thought that birds flew all the way to the moon and stayed there for the winter. Even the Reverend Cotton Mather, a well-known minister in New England during Colonial times—around the year 1700—said that wild

Breeding range



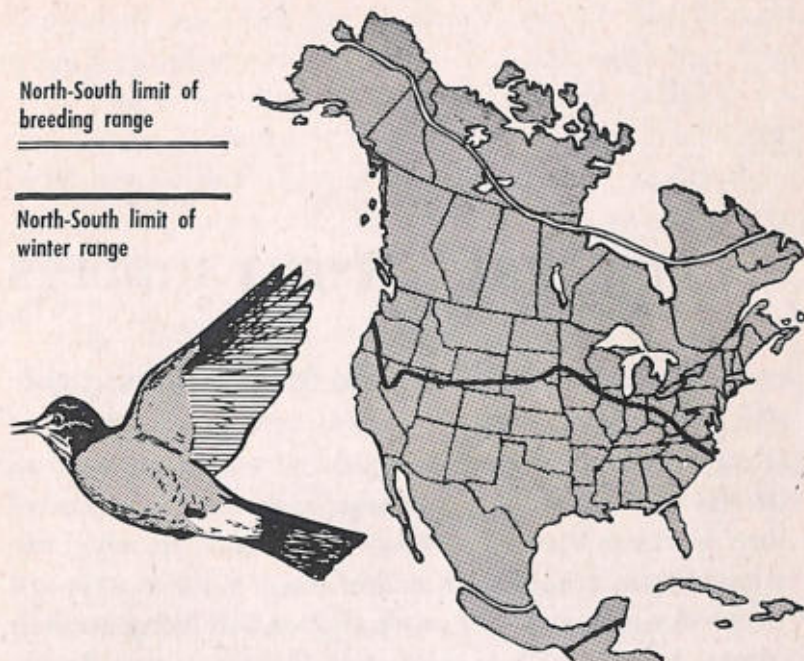
Winter range



Redstart and its breeding and winter range

Pintail ducks flying across the moon





Robin and its breeding and winter range

pigeons flew each autumn to an undiscovered satellite of the earth.

Do not for a moment think that all these things were said by unwise men. They simply did not know some of the things we know today. Few of them perhaps had ever dreamed that man himself would someday fly. Few had traveled to warmer lands. Fewer still had studied the birds and other animals and written about them.

Then came the King of Sicily—and times began to change.

Breeding range



Winter range



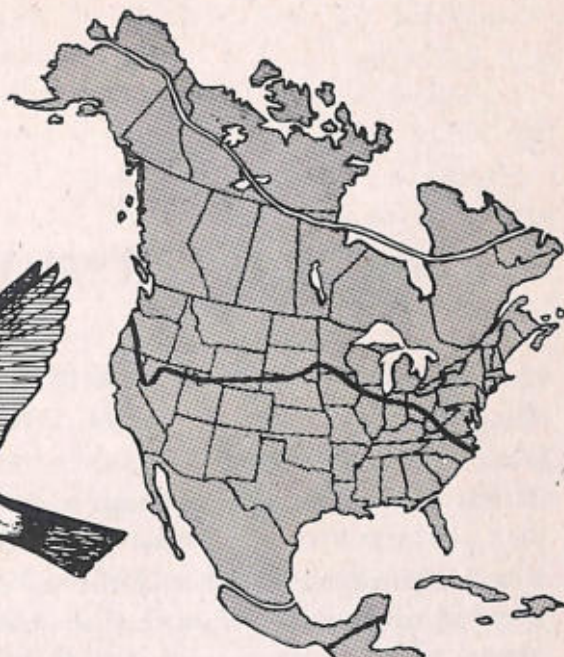
Redstart and its breeding and winter range

Pintail ducks flying across the moon



North-South limit of
breeding range

North-South limit of
winter range



Robin and its breeding and winter range

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SOLVING THE ANCIENT RIDDLES

Frederick II, Emperor of Sicily, ruler of the southern provinces of Italy in the thirteenth century, was a falconer, but he worked with other birds in addition to falcons and hawks. He was also a traveler. He visited such places as Vienna, in what is now Austria, and Jerusalem, beyond the eastern end of the Mediterranean Sea. Everywhere he went, he watched the birds flying on their strange travels. He saw thousands of them as they flew to and from distant lands. He watched them come and go each year with the change of seasons. Some flew away in the autumn and were not seen again until the following spring. Others flew only from mountains to valleys and back.

Of all who admired the works of Aristotle, apparently none did so more than the Emperor. He had had the Greek works of Aristotle translated into Latin so that he could read them. But as he read, he got a surprise—he found he knew some things about the birds that not even the all-wise Aristotle had known.

The evidence was there for all to see. It showed the

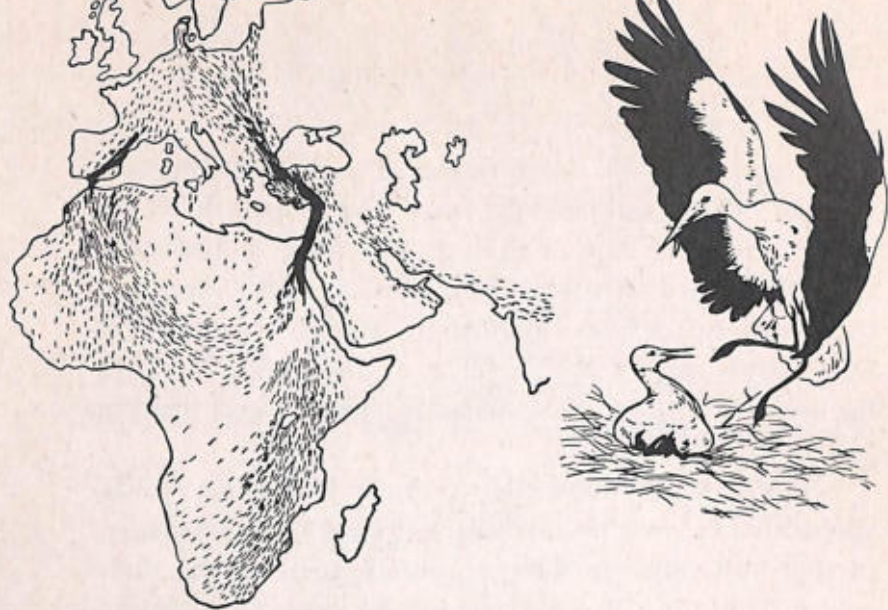
Emperor that birds did migrate, after all. He thought that they did so either to get away from places that were very cold or very hot, or to find more food, or both. For example, a bird that usually lived on insects found that there were fewer to eat as autumn came. In winter there were hardly any at all. To get more food, therefore, the bird needed to fly to warmer lands where insects lived in plenty.

But if birds found plenty to eat in warmer lands, why did they ever fly to colder regions? That was easy, thought the Emperor. They migrated north to raise their young. Why they did not lay eggs and raise the young in warmer lands was a question that Emperor Frederick did not solve.

He had not seen one bird change into another, as Aristotle had said it did, nor had he seen any bird hiber-

Falcons





Storks and their migration routes

nate. So he wrote a book and told the world about what he had seen and what he had learned about birds. The Emperor himself was not always correct in what he said, but the important thing was that he dared to question the writings of Aristotle. Times were changing! People's ideas were changing, too.

Two hundred and fifty years after Emperor Frederick, there lived in France a naturalist named Pierre Belon, born in the year 1517. Belon had traveled, just as Emperor Frederick had. He journeyed—probably by foot and camel and horse—across the lands of Asia Minor and around the eastern end of the Mediterranean Sea, a journey that, in those days, must have taken many months.

He carefully watched the comings and goings of birds. In every land he visited, he studied the flights, examined the nests of birds, and listened to people's legends about migration. He watched as swallows and storks flew over Africa going south, and then he thought he knew why birds went there.

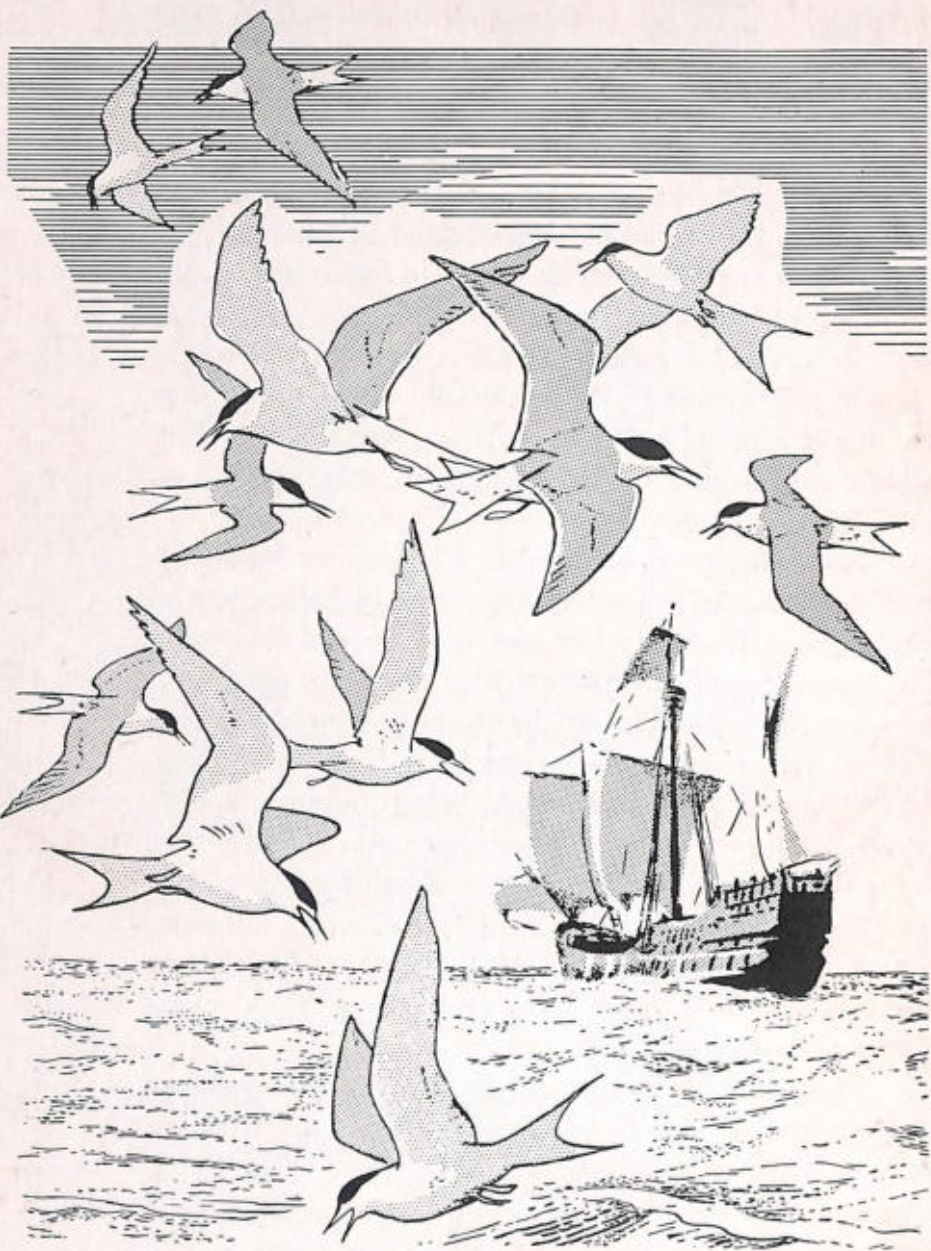
"As swallows cannot spend the winter in Europe," he wrote, "because of the great cold and because they would not find food, they go to Africa, Egypt, and Arabia, where, since winter resembles our summer, they have no lack of nourishment."

Not many years before this, Christopher Columbus had been guided by migrating birds on his voyage of discovery to America. After him, new kinds of birds were discovered by other explorers who watched their movements and wondered where they went, and how, and why.

One who had an answer was Mark Catesby, the English naturalist. He visited the American colonies in 1712 and was bold enough to suggest that some of these birds went all the way from America to Brazil for the winter.

It may seem odd that by the time of the founding of the American colonies men still knew very little about the movements of animals, and especially of birds, whose flights anyone could see.

This was due in part to the fact that not as many men were studying science in those days as are studying it now. More popular than science were religion, literature, and art. Scientific discoveries were made slowly; yet each new step in human knowledge about animal



Columbus was guided by migrating birds—common terns among them

movements depended on those discoveries. Not until the telescope was invented, and not until field glasses, or binoculars, were manufactured, could men who studied birds be certain of which were which when seen from afar.

There were pioneers in the study of bird migration just as there were in the other sciences, and in literature and art. One such pioneer in the American colonies traveled through wild forests from northern lands to southern, and from cold lands to hot. He kept a list of the birds he saw, and wrote down notes on when and where and how they moved.

Alone with his horse, he rode through wild meadows and dark forests, and through dangerous Indian country. He swam across streams. He paddled a canoe. For a bed he had only a blanket. For food, he hunted and fished and gathered fruits.

His name was William Bartram. For many years he traveled, and for thousands of miles. He observed and listened at the seashore, in the mountains, out on meadows, and deep in the woods. To him the birds and their travels were most exciting and, as a result, he was one of the first to write about them in the United States.

Bartram knew what the Greeks had known. He, too, had read what Aristotle wrote. Now he was seeing for himself. In Florida, hundreds of familiar birds—whose summer nests he'd seen in his Pennsylvania home—went past him, flying from north to south. They must be flying south to spend the winter, he decided. Either they



Starlings

would remain in Florida, or would keep on flying, perhaps as far as South America.

Meanwhile, explorers in ships were sailing farther than they ever had, searching for distant lands. Naturalists such as Charles Darwin went on these expeditions and brought back hundreds of new ideas. Darwin, aboard the exploring vessel, *Beagle*, saw a strange sight off South America in 1833.

He wrote: "Several times when the ship has been some miles off the mouth of the Plata, and at other times

Monarch butterflies

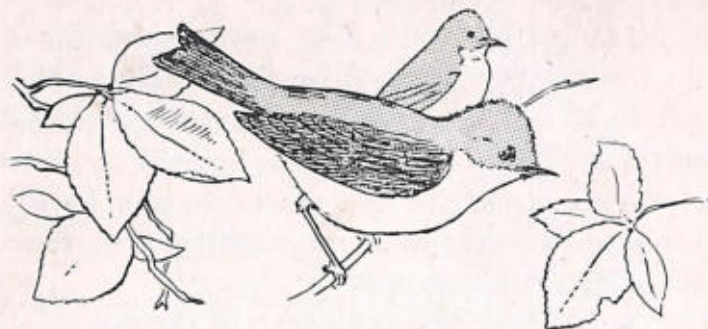


when off the shores of Northern Patagonia, we have been surrounded by insects. One evening, when we were about ten miles from the Bay of San Blas, vast numbers of butterflies, in bands or flocks of countless myriads, extended as far as the eye could range. Even by the aid of a telescope it was not possible to see a space free from butterflies. The seamen cried out 'it was snowing butterflies,' and such in fact was the appearance . . .

"The day had been fine and calm, and the one previous to it equally so, with light and variable airs. Hence we cannot suppose that the insects were blown off the land, but we must conclude that they voluntarily took flight."

In a way, these new ideas and discoveries were like the pieces of a puzzle: the more that were found and fitted together, the more eager were men to find other parts of the puzzle. Because of the need to find more pieces, the famous naturalist of Sweden, Carolus Linnaeus, urged every traveling scientist and explorer of his day to study bird migration.

One who did was John James Audubon, an early frontier artist, who traveled in the wilderness between 1809 and 1824 and painted some of the finest pictures of wildlife in America. He knew the birds as few men before him had and, in his eagerness to discover facts about their movements, he became one of the first men in history to attach tags to, or "band," the birds. As early as 1803 he tied silver threads to the legs of baby phoebes before they left their nests to fly away for the winter.



Baby phoebes

Much to Audubon's delight and satisfaction, two of the "banded" phoebes came back in the spring.

After Audubon, the study of birds and migration increased rapidly everywhere. Bird banding stations, set up around the world, revealed migration flights that were hard to believe. Airplanes enabled man to fly beside the birds and to discover not only the directions in which they went, but also how high and how fast they flew.

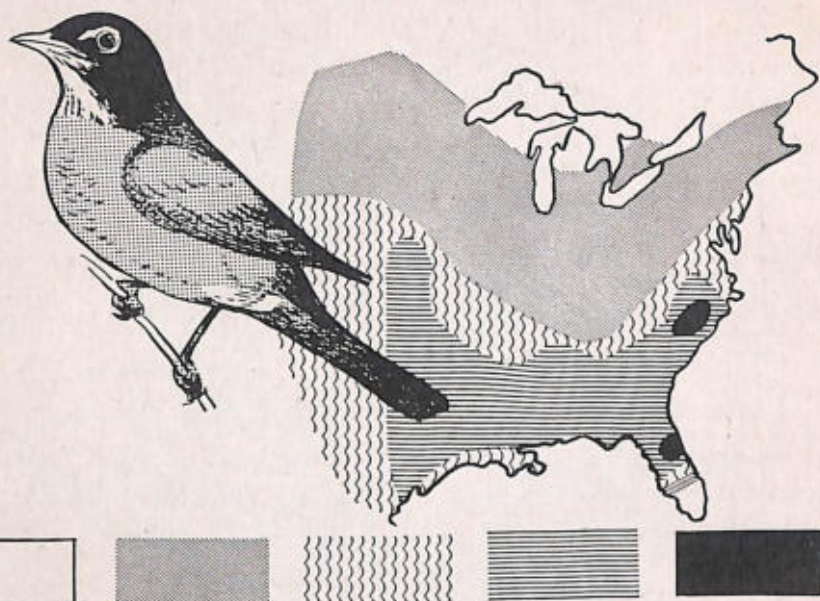
In recent years, radar has revealed some things the Greeks had difficulty seeing, such as the migrations of birds at night. Exciting facts have also been discovered about the migrations of animals other than birds and about unexpected ways in which animals may be able to navigate by the stars. Today we have answers that Aristotle, Emperor Frederick, Belon, Bartram, and Audubon never dreamed of. But these pioneers in the study of migration helped to lay the foundation for discoveries to come.

WHY ANIMALS MIGRATE

In the ocean, on land, in the air—wherever they are—hundreds of thousands of animals return each year to their places of birth. This is their home. For a part of the year, perhaps for most of it, they have lived away from that home. They have traveled, or wandered, or stayed for a while in some other place, near home or as far away as the other side of the earth. But then, as surely as the coming of spring, they return to the place where they were born.

Of course, some animals do not migrate at all. Prairie dogs do not. Bobwhites do not. Cardinals do not. A few ruffed grouse remain all year in colder lands. Some animals, such as certain turtles in inland ponds, may not in all their lives travel more than a few hundred yards from home. All these are examples of animals that do not migrate.

They are therefore said to be “non-migratory.” Call them “permanent residents” if you wish. They live, or reside, more or less in the same place all their lives. This means that they must be able to find enough to eat



The differently marked areas, from white to black, show the increase in density of robin migration. In other words, no robins migrate to the all-white areas, and the most robins migrate to the all-black areas

throughout the year, or at least have a way of storing food.

Within some groups of animals, there are those that migrate and those that don't. Some Mexican freetail bats migrate hundreds of miles, but others hibernate in caves where they have lived all summer. Some redwings migrate, and some do not. Some horned larks do, and some do not. Some robins do, and some do not.

The robins that live in warmer lands generally stay where they are all year. They are joined in the autumn

by robins from colder lands. As a matter of fact, so many arrive that, in Florida, for example, one may see winter roosts of 50,000 birds—migrants and non-migrants together.

Most birds that live in North America migrate for at least a short distance. More than a hundred kinds of birds that nest in the United States or Canada migrate to the islands of the Caribbean Sea, or to Central or South America for the winter.

This migratory cycle happens over and over, every spring, in thousands of places, and among hundreds of different kinds, or *species*, of animals. But why?

It would be tempting to say that an animal returns to the region of its birth because it wants to go back home again. But if animals do not think as we do, we cannot expect them to be as "homesick" as we sometimes are away from home. Scientists, therefore, seek to discover animal, rather than human, causes for migration.

Migratory movements may be a result of heredity, just as the color of your hair and eyes is inherited from your parents or grandparents. As we have seen, migration has occurred for at least as long as men have had written records. If we consider the cave paintings of Spain, then migrations have been taking place for 20,000 years or more, since the earliest cave men saw them. Very likely, migrations were going on for thousands of years before that. We shall talk about that in the next chapter.

If these animal movements, so ancient in origin, have become such a natural part of the birds' lives, it is

little wonder that migratory animals of today still follow the routes of their ancestors.

Scientists have conducted experiments on birds that they knew were preparing to migrate, and have found that the birds' internal sexual organs were in a swollen condition, which meant that they were approaching the time of breeding. This seemed to indicate that the travels of animals were part of a "sexual cycle"—a time of breeding when the parents meet and mate and then the mothers give birth to a new generation.

Breeding must thus be a part of the animal's migratory cycle. Birds, as if to prove this fact, nest and hatch their young at the end of migratory trips, and after the young are raised, they go back to the place from which they came.

Of course animals do not "know" that they should migrate. They are not told that this is the thing to do. They do not read books. They do not go to school. They probably never have magic dreams that tell them when to fly away and start another family.

More than a hundred years ago it was thought that birds were led to migrate by some "sixth sense"—some inner ability less easy to describe than the known five senses of seeing, hearing, smelling, feeling, and tasting.

This strange "sixth sense" is sometimes said to be instinct. But instinct is a word that has been given different meanings, and perhaps it is better to say that an animal inherits, or is born with, abilities that have come down through its parents from generations in the past.

To prove or disprove this, some scientists once took, all the way to Finland, eggs of non-migrating mallard ducks that lived in England. The ducks were hatched and raised in Finland. That November they flew southwest as though they were Finnish mallards and returned the following spring to breed in Finland. In other words, they became migratory though their parents were non-migratory!

This experiment, repeated with other kinds of birds in Germany and the United States, seemed to disprove the idea that heredity—and therefore instinct—had much to do with the migrations of those birds tested. A similar experiment was carried out with storks in Europe, and there it was seen that young storks flew with the adults. These young birds seemed merely to imitate, or copy, the flights of older birds.

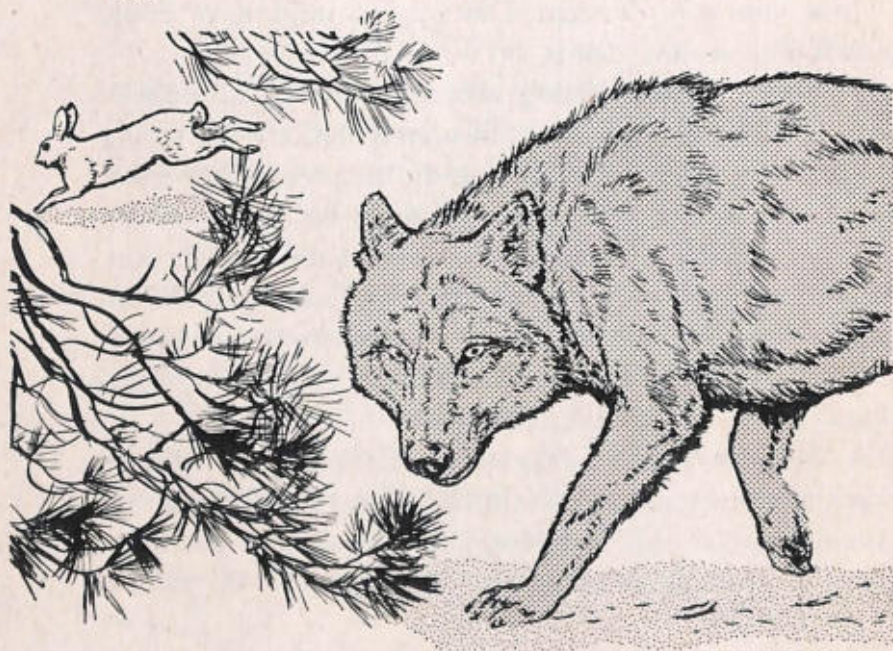
So we are not getting very far with our idea about instinct, but perhaps the difficulty is that we are trying to give migration a single cause. In the present imperfect state of scientific knowledge, we must be careful in answering questions about the causes of animal migration. There are probably several answers: among them instinct, heredity, and imitation. But experiments and observations show that different animals migrate in different ways and for different reasons.

Hunger may be a very strong factor indeed. Animals such as wolves and mountain lions hunt for a living and need to make a kill only every few days. Since there are usually animals available for eating, even in winter,



Mountain lion

Wolf

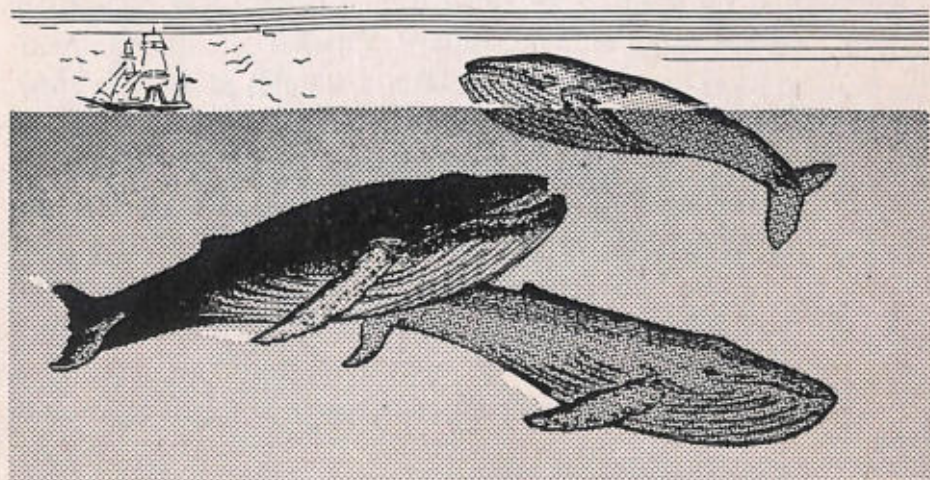


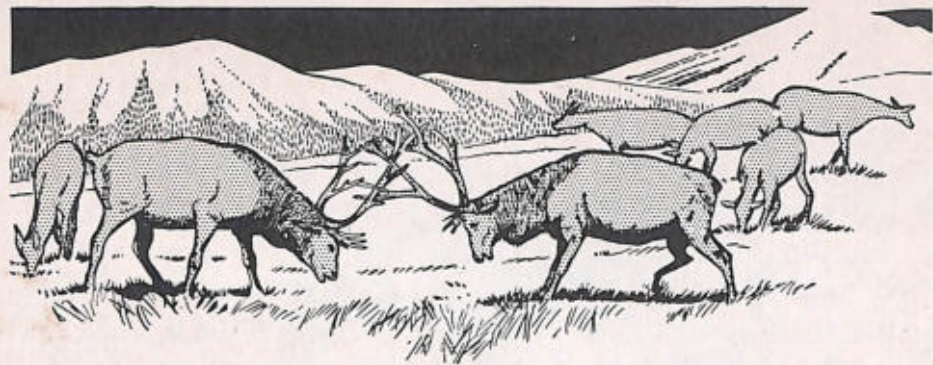
wolves and lions have little or no need to migrate, even though they may hunt quite a while before a successful attack is made.

Grazing and browsing animals, such as deer, may need to go farther. They must eat often because the grass and leaves upon which they feed are not rich foods. Many grazing animals in Africa follow the rains and eat new grass that springs up afterward. Their migrations are not very regular.

The food of certain whales is *plankton*, which consists chiefly of millions of tiny plants in several shapes and sizes, and some very small animals, such as jellyfish, snails, worms, and shrimp. The main food of the baleen, or whalebone, whales is a special kind of plankton known as *krill*, made up chiefly of shrimp-like creatures. Where krill is found, these whales are found, except that when

Whales





Elk

the seas grow cold the whales must move. The skin of newborn whales is thin, and the young cannot survive where water temperature is too low. By habit, therefore, mother whales move away from meals of krill and swim to warmer waters where they give birth to the young and nurse them until they are old enough to swim to colder waters.

This suggests that not only food but also temperature plays a part in the migration of animals. The year's first snow in mountains causes elk and deer to wander slowly down into the valleys. This is called the fall migration because it takes place in the fall of the year, usually fairly late. The following spring, when the snow is melting, the elk and deer go back up to the high lands where new grass and browse is growing. That is the spring migration.

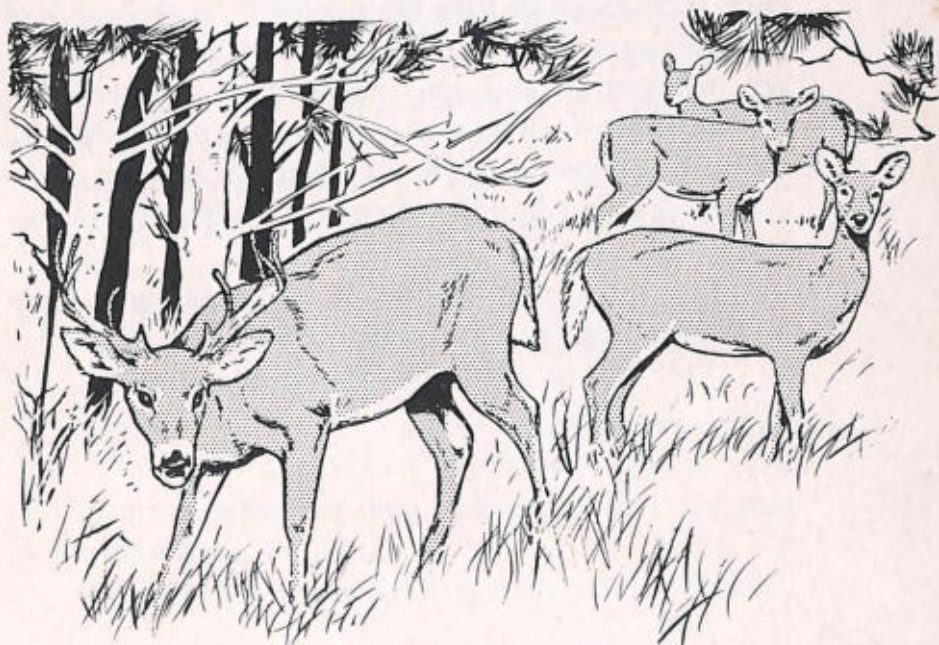
The major reasons for elk migration appear to be the falling of snow (which covers up their food supplies and forces them to look elsewhere) and the melting of snow, which enables them to return to feeding grounds

where food begins to grow as soon as the snow has gone.

The caribou of the far North migrate even farther north in an endless search for food. In winter, caribou do not move about much. They eat as best they can, but in the spring they start a long trek out of the forests and onto the barren grounds. These grounds are not as barren as their name suggests. Each spring they come to life with tiny plants. There are also lichens and shrubs that caribou eat. (See picture of caribou on page 10.)

Caribou may travel 500 miles each season over routes that change from year to year. Their urge to move

Deer



compels them sometimes to enter flooded rivers. They are powerful swimmers but, though it is exceptional, they may occasionally drown by the hundreds.

Some birds, such as shearwaters, are also thought to migrate partly in search of food. Between their times of nesting, shearwaters stay almost wholly over the ocean. Scientists are puzzled about the movements of these birds, but it may be that shearwaters follow ocean currents because these carry fish and other food. Perhaps they also depend on the movements of winds to help them fly from place to place. (See picture of shearwaters on page 65.)

What it all comes down to is this: animals probably migrate because it is their way of life to do so and because their ancestors have been doing it for thousands of years. Migration has therefore become a habit. Sex, hunger, temperature, and other factors all have some effect on migration. Each animal is different, and migrates to different degrees, or not at all. (Some of the tiny hummingbirds migrate greater distances than waterfowl many times their weight.)

There is a great deal yet to be learned and, when we do make further discoveries, we may be able to solve one of the first riddles: how did migration begin?

HOW MIGRATION BEGAN AND HOW IT CHANGES

In the beginning, perhaps, no animal needed to migrate. The first fish in the ocean must have lived where there was ample food. The giant dinosaurs must have spent their lives in swamps where food was plentiful all year long. Tropical birds must have had all the warmth and shelter and nearly everything else they needed. About the last thing they required was a trip of thousands of miles for food when so much grew around them every month in the year.

But as the years went by, some birds that lived in the Tropics began to migrate. You would think that those that stayed where they were would have thrived and become stronger, while those that journeyed across the dangerous world would suffer hardship and death and finally die out altogether.

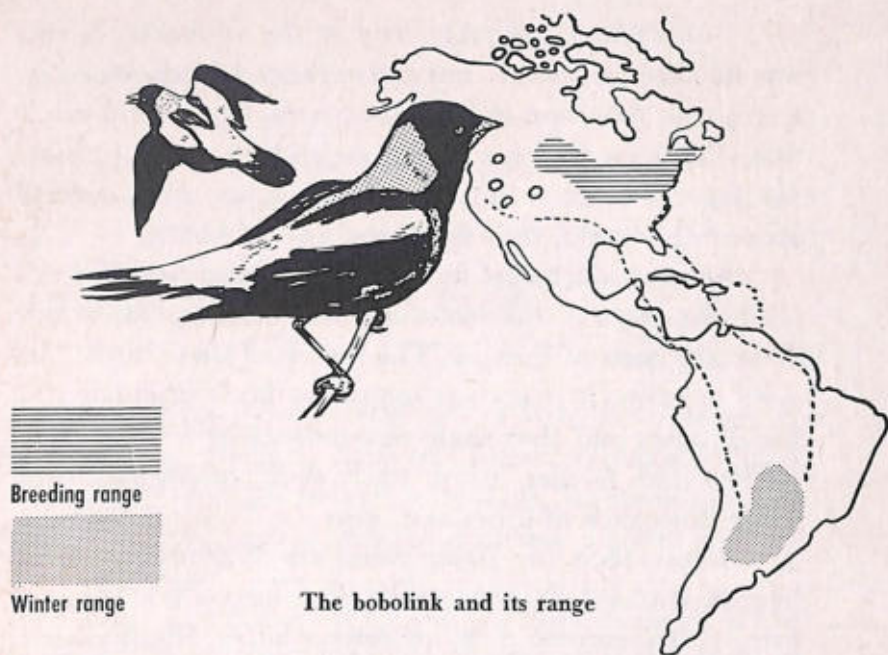
Not so. The evidence of many years shows otherwise. Migratory animals have survived in greater numbers than non-migratory ones, and migration is the rule rather than the exception.

If man has no way of really knowing how migration

came about, at least he can guess. One guess is that as more and more birds were born and lived in the Tropics, the Tropics must have become very crowded. Some of the newcomers were forced to move away. They went as far to the North or the South as they could to find more land. But the farther they moved, the colder the weather became, and they were, after all, birds of the Tropics. So every year they had to return to the Tropics at the approach of winter.

Another guess, or theory, is that migration began when birds that had once lived near the poles of the earth were forced, by the coming of the great Ice Ages, to move toward the Tropics. As great ice sheets covered their original homes, they moved toward the Equator. Each year, at breeding time, they returned as close as they could to home, and when the ice began to melt nearer to the poles, their return flights grew longer. Thus they established a pattern of migration.

These are only theories, but there is some evidence, however slender, to support them. For example, we can observe from the movements of certain birds that their areas of migration are slowly changing. The bobolink—called *goglu* by the French Canadians—nests in Canada and in much of the northern United States. It is a familiar bird that perches on sticks and stalks in fields and meadows. Each year it migrates to the south, flying non-stop across open water between Cuba and the coast of South America, a distance of 500 miles. This is quite a task for a land bird, but the bobolink does it and spends



the winter in marshy regions of Bolivia, Brazil, and Argentina. In spring it returns the way it came, to nest in the tall grass meadows and clover fields of northern lands.

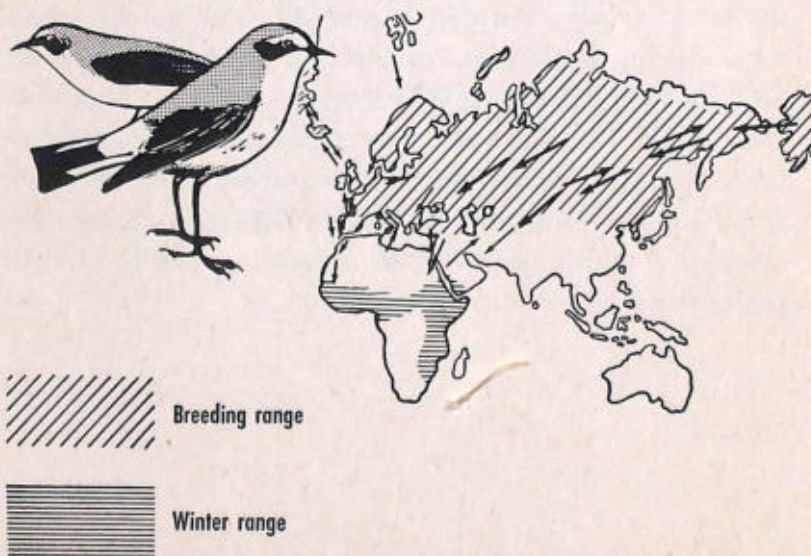
Bobolinks have been nesting farther and farther to the west each year, which is probably due to the westward-moving settlements of man, or to the advance of fields of hay and alfalfa, which crowd these birds out of their natural nesting sites. To reach new sites, the bobolinks fly along slightly different migration routes as time goes by. This means that we can actually see a change, or evolution, taking place in the migration habits of this particular bird.

The same is probably true of the wheatear. Africa was its ancestral home, but today there are wheatears in Europe, in Asia, and in North America. One would think that Alaskan wheatears would migrate to sunny California for the winter. But not at all. Like their cousins around the world, they fly all the way to Africa.

Alaskan wheatears fly southwest across Asia. Greenland wheatears go southeast over the Atlantic Ocean and down the coast of Europe. The travels of these birds thus seem to prove that certain migratory birds originated in the Tropics and that their descendants have since gone farther and farther away, until their migrations now cover thousands of miles each year.

These, then, are living examples of changing habits in animal travel. However migration began, one thing is sure: it has become a commonplace affair. Although we know that not every animal has to migrate, so many do that different kinds of migration have come into being, some of them as strange as the very act of migration itself.

The wheatear and its range



KINDS OF MIGRATION

Migration comes from the Latin word *migrare*, which means "to move from one place to another." Nowadays, as mentioned earlier, migration has come to mean a regular movement of animals from one place to another *and back again*.

Some animals, such as buffalo, used to move about regularly but not return often, if ever, to their places of birth. We call them "nomadic," because nomadic means wandering. Like wandering tribes of Indians, they roamed across the land and seldom returned to the place where they were born.

When animals move from one place to another and do not return to the starting place, that is not migration. A better word for such travels would be "emigration."

We hear of "lemming migrations," but these are not migrations at all. Lemmings are small rodents of the far North. They are closely related to rats and mice but have long fur, small ears, and a short tail. From time to time lemmings gather in considerable numbers and begin to travel across the land. They are joined by other lemmings

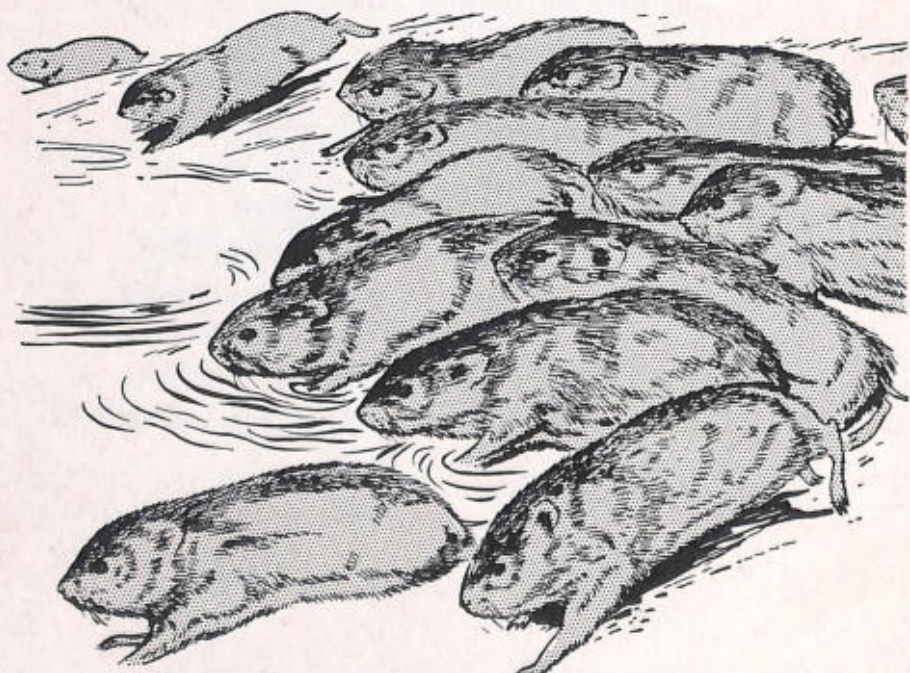
as they go, until a "parade" of millions of lemmings may be formed. Foxes prey upon them. Disease weakens them. Hunger strikes them, for in such numbers they cannot find enough food to eat. But only death stops their relentless march.

So powerful is the lemmings' urge to go on that, when they reach the ocean, a pile-up occurs, and the pressure from behind is so great that they are forced into the water, where they drown.

Similar marches of springboks in South Africa took place between 1887 and 1896. Springboks moved westward by the thousands and sometimes kept on going until they reached the Atlantic Ocean, where millions of them died. In one march, it was reported that their bodies formed a wall for thirty miles along the edge of the ocean.

No one knows exactly why such creatures march so

A "parade" of Scandinavian lemmings



blindly to their deaths. At least this much *is* known: the lucky lemmings and springboks that are left behind find life much easier. They have more food to eat and more space in which to live. Perhaps that is the meaning behind whatever force it is that compels their fellow animals to travel to the ocean.

There are other examples of animal travels that seem to be migrations, but very likely are not. The natives of Africa believe that elephants migrate to the shelter of the forests in summer and then move into the open as the rainy season begins. They seem to follow the same pathways each year, usually at the same time of year. One reason could be that elephants, who are fussy about their food, move back and forth in search of the tender leaves and tiny trees they like to eat. Perhaps these wanderings in search of food are related to those of the whale, the caribou, and the shearwater, which have already been mentioned. But if they are simply random movements

March of springboks



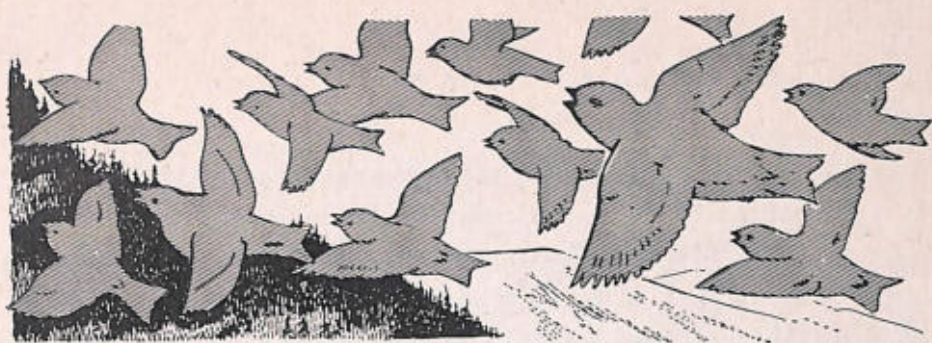
into and out of a forest, they are not real migrations.

Some moose move, too, but they do not travel as far as caribou do. They go and come from the mountains. They wander from place to place in search of food. They gather at lakes and streams in the spring, where new water plants are growing. Their travels, therefore, cannot be truly called migration.

Years ago, when there were far more bison (buffalo) than there are today, and when the great plains were much more wild, these shaggy animals roamed in enormous herds. They moved each year in paths that were much like circles, and even though they might occasionally have returned to places they had visited before, this may not have been a real migration. Perhaps in winter the bison were merely trying to escape the cold and thus moved southward. Perhaps in summer they wandered north to escape the heat of southern lands, or to search for grass. We have seen that, for other animals, these are reasons for migration, and perhaps the bison actually did migrate. We may never know, for today few of them are left and, because of fences, highways, farms, and cities that block their way, they are no longer free to wander as their ancestors used to.

American buffalo, or bison





Vertical migration of finches in the mountains

Some animals merely scatter into nearby forests at certain times of the year. This scattering is called "dispersal," meaning that the animals disperse, or spread out, over a certain area. Perhaps this could also be called "local migration."

Some birds go uphill and downhill. In the Rocky Mountains, for example, these "vertical," or up-and-down, migrations are carried on by finches, juncos, chickadees, and grosbeaks. Their nesting sites lie on the cool mountain peaks above them. Other birds, such as Clark's nutcracker, nest on mountain slopes, then move farther uphill with the coming of summer. Such birds need not fly hundreds of miles to the Arctic.

We have seen how elk move up and down the mountain slopes in vertical migrations. Another vertical migrant, though on a smaller scale, is the rattlesnake. These reptiles move into their dens in fall and out of them in spring. The dens are often high on slopes, so that the spring migration is downhill. In the fall they go up again. Rattlesnakes do not go very far, perhaps no farther than a mile. Nevertheless, they move regularly, and although regular movements alone are not enough to qualify an

animal as a migrant, rattlesnakes do return to their place of birth and so are considered migrants.

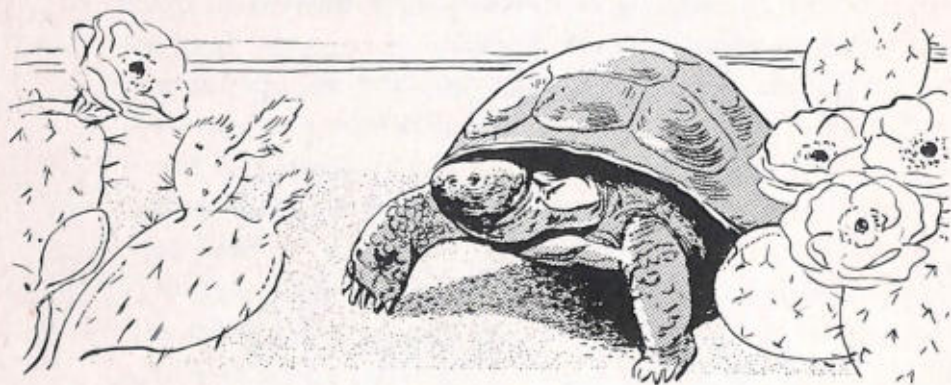
The same is true of desert tortoises, which gather in dens for the winter and move out into open country for the summer.

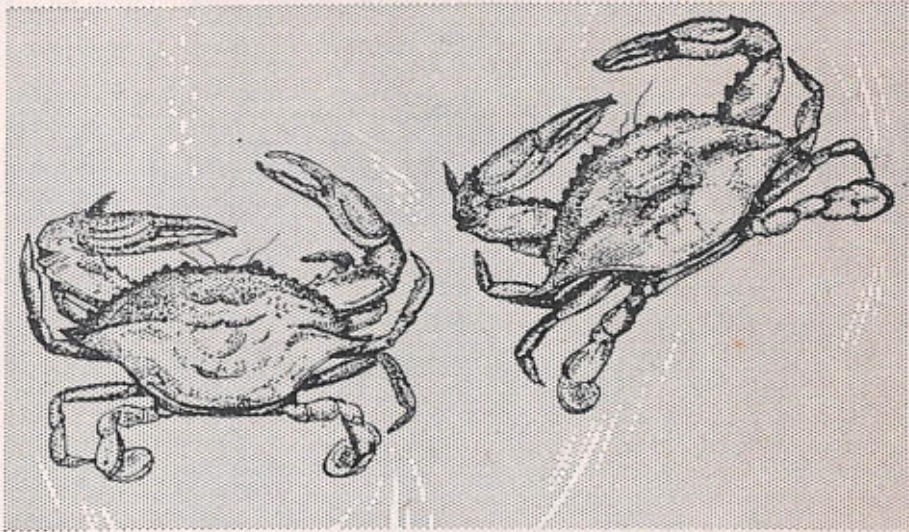
In the ocean there are also vertical migrations. Certain shrimp-like creatures, called crustaceans, move from far down in the water up toward the surface and back again every twenty-four hours. Some fishes, lobsters, crabs, and squids that live along the ocean shore rise toward the surface in summer, and go down to the lower levels in winter.

These travels of birds, elk, rattlesnakes, tortoises, and crustaceans are examples of what is called short, or local, migration.

Another kind of migration is that in which the ani-

Desert tortoise





Vertical migration of blue crabs

imals require more than a year to complete a single round-trip journey. This is called secular migration. California gulls, on leaving their nests in Utah, fly to the Pacific coast and stay there for nearly three years before returning to the place of their birth. After the first trip, their migrations are made every year.

And what of animals that do not move regularly at all? Aristotle, we know, believed that swallows went into holes in the bottoms of lakes and rivers and spent the winter there. No bird lives very long under water, of course, so that part of the ancient story is false. Nevertheless, in the winter of 1946-47, several North American

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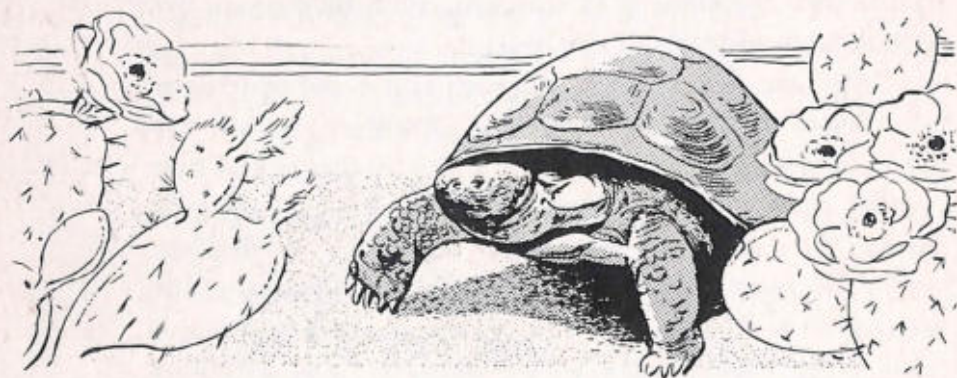
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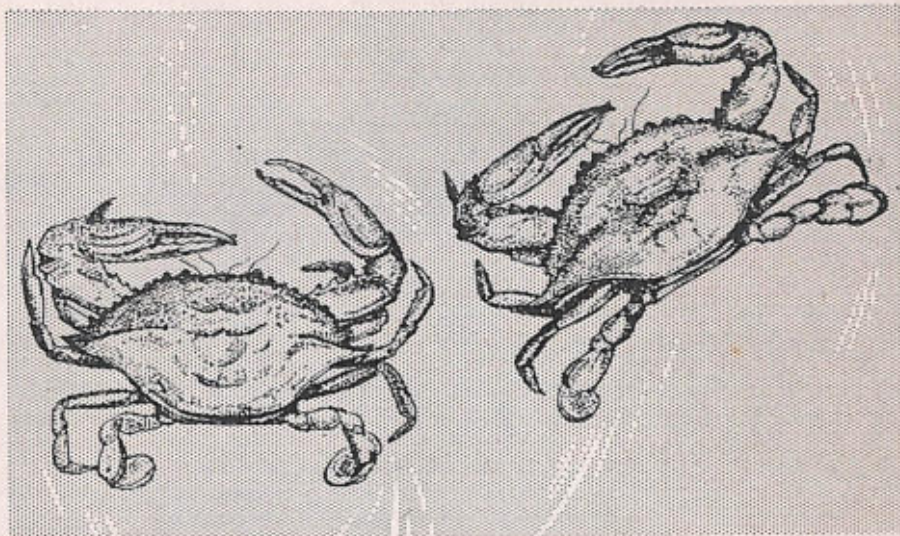
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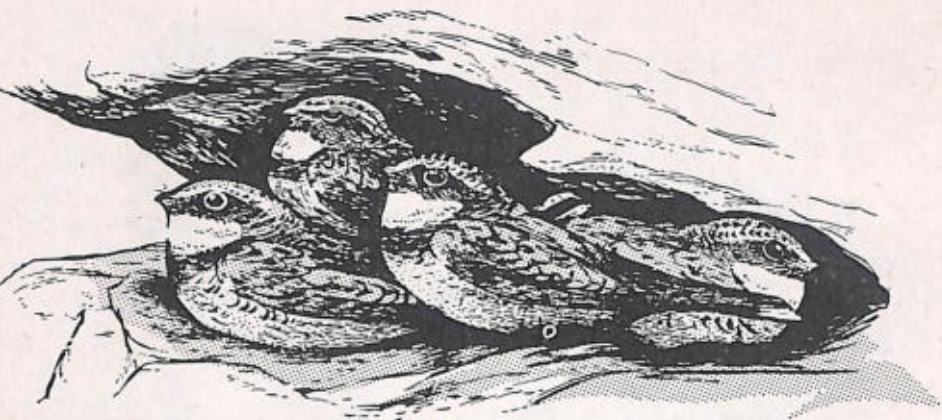




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Poor-wills in crevices of rock

poor-wills were discovered in crevices of rock in the California desert. They were huddled together and were still and cold, without apparent heartbeat. They did not appear to be breathing. When lights were shown into their eyes, they did not blink.

But they were not dead! They were seen several times that year, and since then others have been observed. It was true, after all, that birds could hibernate. At least these poor-wills could. Aristotle had been partly right, and it had taken 2,300 years to prove him so.

Not only are there birds that hibernate and birds that migrate. The same is true of bats. The Mexican free-tail bat is found, sometimes by the millions, in large caves such as Carlsbad Caverns, New Mexico. These and other

bats have been banded by small tags attached to their wings—the tags containing the date and place of banding—and then have been set free. A number of the banded bats were recaptured in places as far as 800 miles from their starting place—usually in Mexico.

At the same time, however, hundreds of thousands of Mexican freetail bats remain behind to hibernate in caves—including Carlsbad Caverns—where for months they hang upside-down on the ceilings of underground rooms.

Mexican freetail bats



WHEN TO LEAVE

Now let us see what discoveries have been made about the actual goings and comings of animals on the move.

Who has not heard it said that animals lead a free and easy life? We hear that birds, because they fly, are able to fly anywhere at any time, and that whales, because they can roam the ocean at will, swim wherever the urge may take them.

But all this is not as simple as it sounds for, if a migrating animal leaves on its travels at the wrong time, it can encounter serious dangers. A bird that leaves the Tropics and migrates north too soon may arrive too early at its nesting grounds and there be caught by a late winter storm that will trap it and cause it to freeze to death.

If, on the other hand, a bird leaves the Tropics too late and arrives in the nesting grounds too late, when autumn comes, the young birds will not have learned to fly before the first snowstorm of winter traps and kills them.

The fact is that most birds leave at exactly the prop-

er time, so that it is unusual for them to freeze or for a storm to overtake them. Now and then, storms do cause terrible damage to migrating flocks of birds, as we shall see when we take up the dangers of migration, but for the most part the animal leaves at the time best suited to get it to its destination safely.

Human beings who wish to go somewhere at a certain time of year may consult a calendar, or read about the climate of the place they intend to visit, and they can ask the Weather Bureau if they are likely to meet any storms along the way.

Animals cannot read printed calendars or books that describe the troubles they may face in a strange new land. Nor can animals pick up a telephone and ask the Weather Bureau about the best time to leave.

Then what tells them when to go?

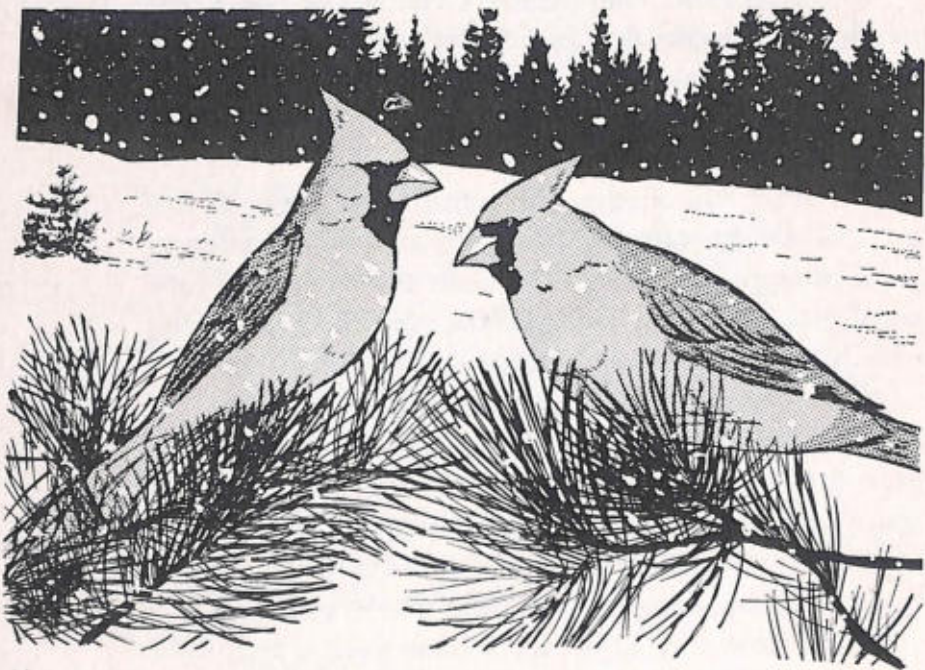
Do other animals give the signal? The young of certain animals do migrate with their elders—a matter of simple imitation. But the old birds have to have some way of picking the day of departure. And there are young animals that migrate separately from the older ones.

Certain father ducks in North America leave the mothers before the young are even born, and the mothers sometimes leave on their migratory travels before the young are ready to go. That means that the younger animals have to find their way across thousands of miles of what is to them strange land before they reach their winter home. How they do it, and do it so well, is one of the wonders of migration.

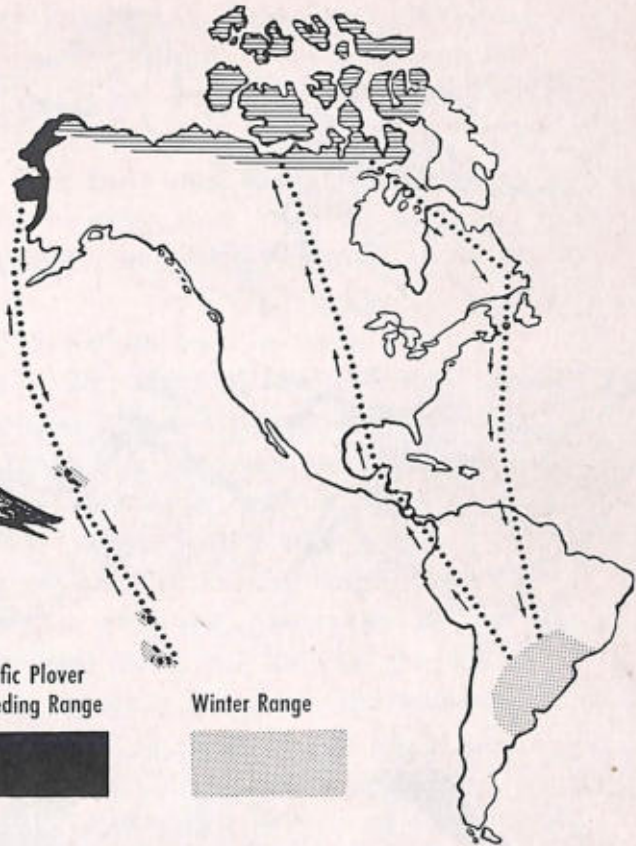
Nor do all birds of each kind always go on their journey together. Some European swallows start traveling early and arrive in their African winter homes while other swallows are still raising their young back in Europe.

Do they leave when the weather gets too cold or too hot? Some birds, such as the cardinal, are non-migratory and so remain where they are, winter and summer, cold or hot. Others, such as the American golden plover, leave colder regions long before summer has turned into

Male cardinals—non-migrating



Range of Atlantic and Pacific golden plovers



Atlantic Plover
Breeding Range



Pacific Plover
Breeding Range

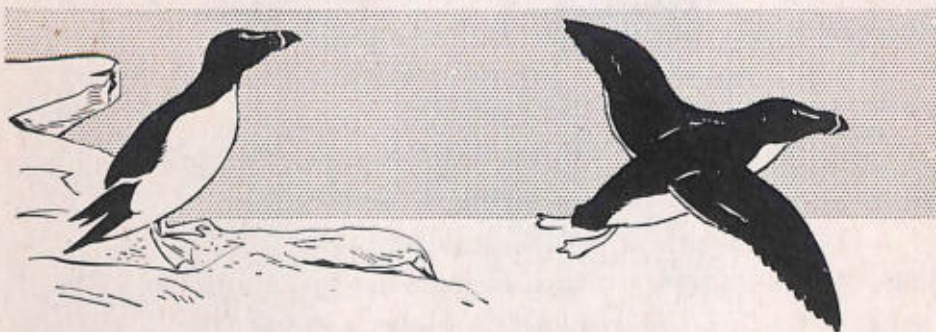
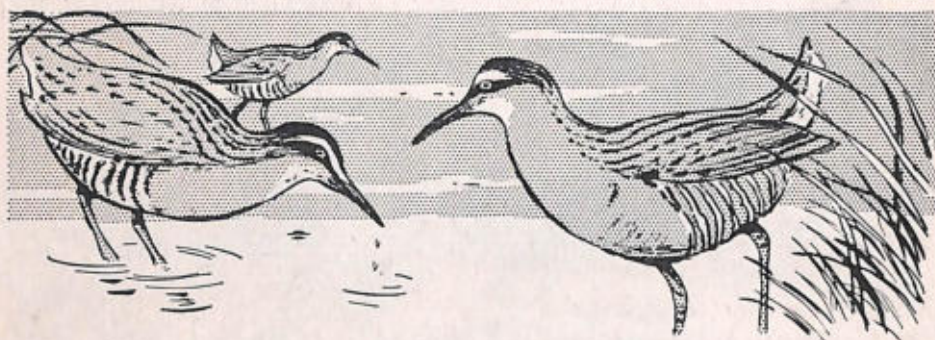
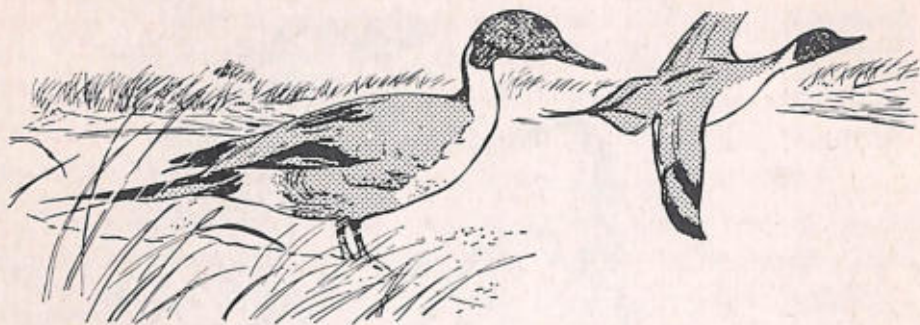


Winter Range



autumn. Thus the temperature may not have very much to do with an animal's time of departure.

Do animals use as a signal the turning of tree leaves into brilliant autumn colors? Science has not found any evidence of this. Colors apparently play a minor role, if any, in migration.



Pintail ducks (top), rails (center), and razor-billed auks (bottom) are all birds that must grow new feathers before migrating

Until they have grown new feathers, some birds, such as ducks, auks, geese, and rails, cannot start on migration flights. The shearwater is also one of these. The flight feathers of the shearwater molt, or fall out, while it is in the far North. The bird must then remain on the water while new feathers grow. Only then can it resume its southward flight and complete its annual circle of travel.

Migrating birds are often seen in the autumn just before a storm arrives. The sight of birds "fleeing" before a storm has for ages tempted people to think that migrating birds foretold the coming of storms—that some birds knew a great deal about the weather.

It seems that way, perhaps, but birds do not, as far as is known, have secret ways of sensing coming storms. When the weather is bad, when the clouds come low and rain sweeps over the land, birds stay on the ground or close to it. For them, migration is much easier and safer when they can begin flying in clear skies, with helping winds behind them.

Even if they leave when everything seems to be in good order, trouble can follow them to warmer lands.

Once in a while, for example, they may fly so fast that they run into or overtake a storm. If that happens, they may be able to fly safely through it, but if not, they can be caught and dashed to earth. What is more likely, however, is that they will land and wait for the storm to pass.

In 1899, unusually cold weather struck the southern

United States and thousands of sparrows, bluebirds, juncos, and warblers that had gone there for the winter perished.

The secret of when to leave, then, lies elsewhere than in weather. Birds depart both before and after the coming of storms, and it is likely that storms have even less to do with the migrations of whales or turtles in the ocean.

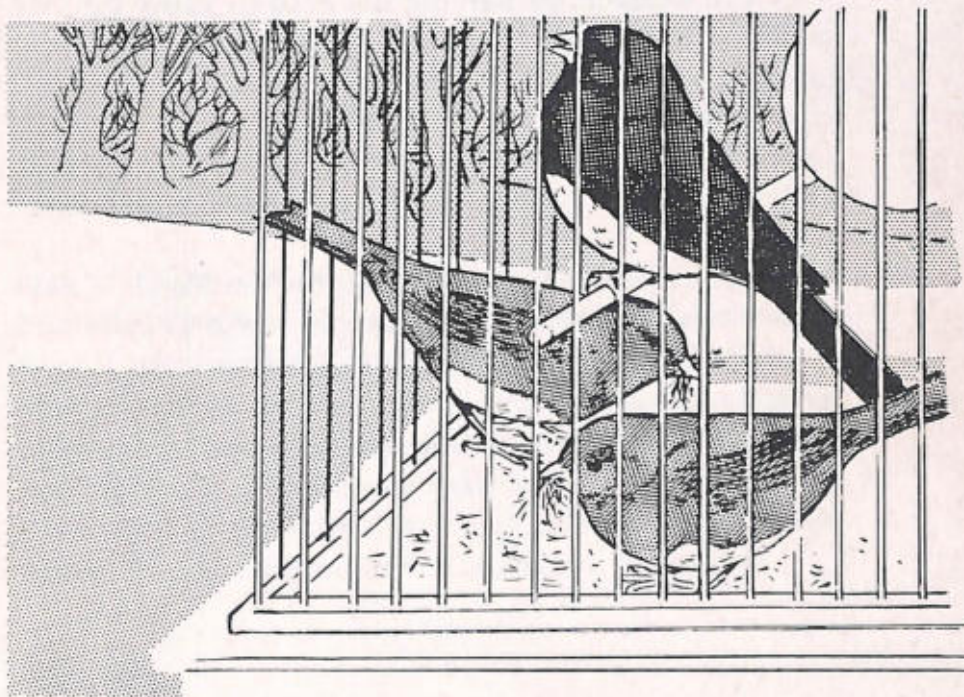
Then let us examine another possibility. William Rowan, a biologist at the University of Alberta in Canada, thought the changing length of daylight might have something to do with migration. Everyone knew that, in the northern temperate zone, daylight decreased daily each year after the 21st of June, and by Thanksgiving time there was always much less daylight than there had been in the summer. After December 21, or "winter solstice," daylight increases again until, in the summer, there is much more daylight than dark.

Where Rowan lived, the winter was fairly severe and since there was little for birds to eat, most migrated far to the south. Rowan wanted to know whether the changing length of daylight made these birds start on their travels, and one way to find out was to play a trick on them. He therefore captured a number of slate-colored juncos, relatives of the sparrows, and put them in two cages. In one cage only he mounted electric lights. Both cages were placed outdoors where the birds were subjected to the increasingly cold and windy weather of autumn.

Early in November, when the amount of natural daylight was less each day, Rowan began to turn on the electric lights in the cage that already had them, increasing the amount of light that cage received. The other cage he left alone. By the middle of December, the juncos in the cage with electric lights were getting fifteen hours of light per day, as if it were spring. The juncos in the other cage were getting about nine hours of natural autumn daylight.

The results were striking. The birds in the cage without electric lights remained in their usual winter

Male and two female juncos in cage, for experiment



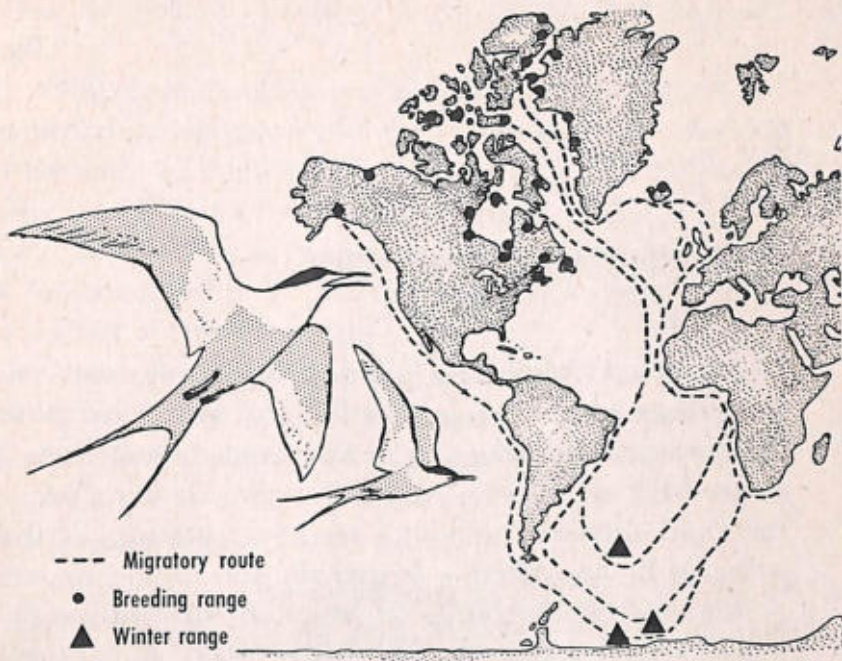
condition, without any sign of change. But the birds in the cage with the electric lights showed signs of preparing for breeding. The males sang in mid-December as they normally did in spring to "protect" a nesting territory. Due to the "lengthening day" the birds had begun to prepare for the breeding that usually came at the end of their return trip to this region in spring.

Rowan then released the birds to see if any would fly to the North, as they usually did in spring. Most of them stayed near the cages or disappeared and were not recaptured. He repeated the experiment with 69 crows, getting similar results. With still other birds he had even less success.

And so, while Rowan did not entirely prove his theory that the changing length of day starts birds on their migratory travels, he did show that it had *some* effect. It brought some of his experimental birds to a mating condition, and we know that mating is part of the sexual cycle that certainly seems to be connected with migration.

But it must be borne in mind that the length of daylight varies very little with the seasons in the Tropics, and some birds leave from there on migratory travels. Moreover, birds such as the Arctic tern, migrate from the northern hemisphere to the southern and thus spend nearly all their lives in regions where the days are lengthening.

Perhaps it is a characteristic of the study of migra-



Range and migratory route of Arctic terns

tion, or of the study of any science, that when we think we have an answer, there are bits of evidence that seem to go against it, and even seem to contradict it. Nevertheless, we are getting closer to solving the mystery of how animals determine when to leave on their migratory flights. Thanks to William Rowan, another small piece of the migration puzzle has been fitted into place.

WHICH WAY TO GO

In graceful flight, the pigeon wings its way over vale and village to the cage or the loft that is its home, and though it may be taken miles away and then set free, it comes back almost every time. Somehow it starts out in the right direction and flies on an accurate path that brings it home. Whether it uses the sun to find its way, or the land, or special senses unknown to man, no one knows for sure. That is the pigeon's secret. But the pigeon is an animal easy to study, and if man learns more about migration in the future, the pigeon will help him learn it.

One man who has learned a great deal from pigeons is Geoffrey Matthews, of Cambridge University, England. During the 1950's Matthews loaded pigeons into trucks or cars and drove out into the English countryside. The pigeon boxes were closed, so that the birds saw nothing of the country through which they rode.

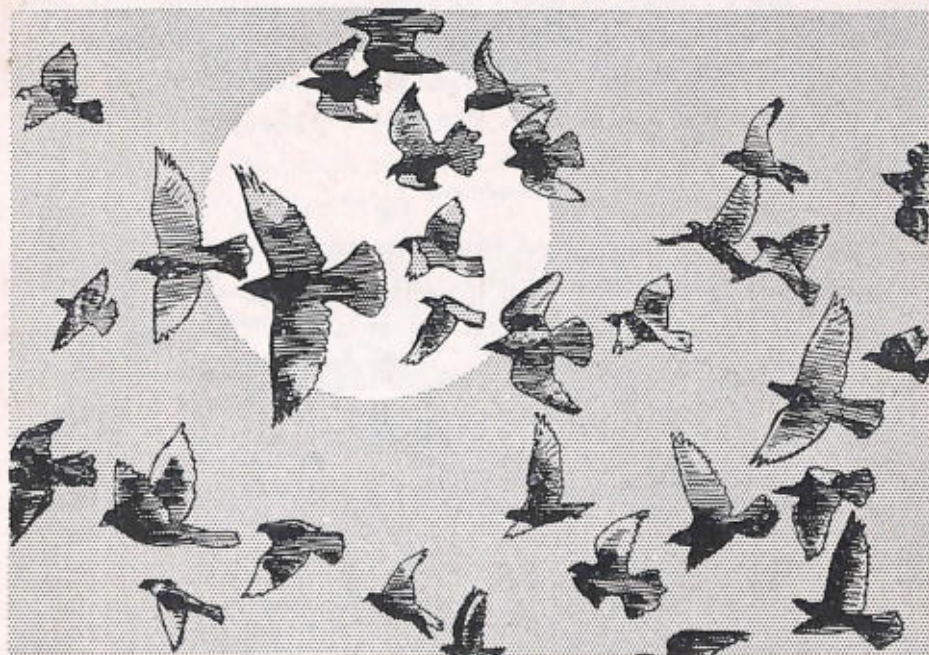
First he took them north of Cambridge, whence they had to fly back south in order to get home. They did very well, and promptly made their way to Cambridge.

Next, he took them farther north. Again they did very well.

There was nothing very surprising about this. It was known that pigeons could find their way back home—often with amazing speed. This was called “homing,” and pigeons that were trained to return to their starting place were known as “homing pigeons.” Dogs have some of the same ability to find their way back home, and so to a lesser extent do certain people.

What was surprising was the discovery Matthews made. Every time he set his pigeons free on a sunny day, most of them started off in the correct direction. But

Homing pigeons flying on a sunny day



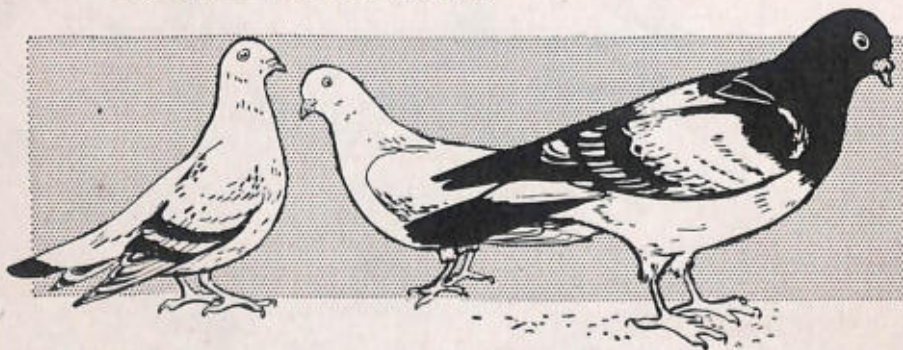
when the day was cloudy, and the birds could not see the sun, they appeared to be confused and lost. It seemed as if the sun were a kind of compass to them, and that without it they did not know what direction to take.

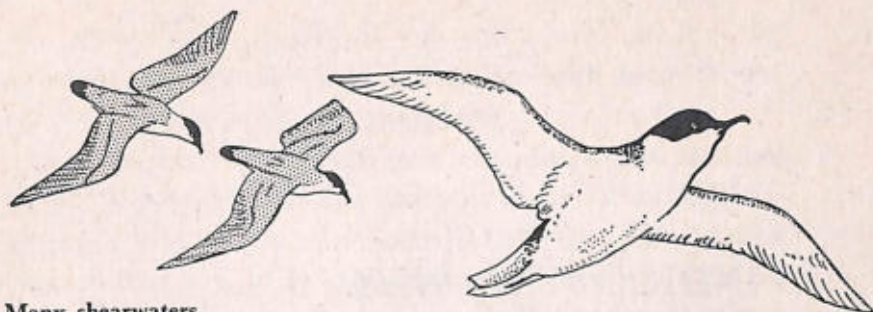
Matthews then decided to find out, if he could, whether the pigeons actually used the sun as a compass, or merely flew toward it. To do this, he carried his birds into the country again and set them free in a way that would force them to fly away from home if they flew toward the sun.

But they did not! They flew almost directly home as fast as they could, away from the sun. To Matthews this meant that the birds were using the sun not as a target but as a compass. He conducted similar experiments on birds known as Manx shearwaters and found that they did as well or better than homing pigeons.

This done, Matthews, as well as scientists in other

Pigeons, confused on a cloudy day





Manx shearwaters

parts of the world, experimented with different birds, but found none quite as able to find their way as homing pigeons and Manx shearwaters. Either these were the only birds that had such fine ability to find their way, or all birds had it but others were not able to use it as well.

Furthermore, the experimenters found that wild birds would almost certainly use other aids in addition to the sun to start them in the right direction. Perhaps there was a familiar mountain or forest or lake that helped to show them which way to go.

We still have many questions to answer about the way a bird, or any animal for that matter, is able to start off in the right direction on its migrant travels. But thanks to the homing pigeon, we have learned a little more.

And as soon as Geoffrey Matthews' discoveries were made known, scientists used them to uncover some more amazing facts.

FINDING THE WAY

The ancient people used to say that God guided animals as they moved from place to place and there was no need to look for any other explanation. But nowadays we like to have scientific answers to our questions, if possible, and we are beginning to find out that there is more than one answer.

Some animals, such as elk and caribou and birds, may find their way as we do—by going from one familiar landmark to another. These could be a valley, a river, a tree, a city, or any combination of these things. Birds flying above these things may be able to remember the peculiar curves in a river, the nature of the forest that covers a certain valley, or the size and shape of a city. Possibly these serve as guideposts along their route. The best way to find out whether or not this was true would be to go with the animal.

But that seemed impossible. How could any human being travel with wild animals as they migrated? If you approach wild deer, they scamper away. If you try to follow a butterfly, you are soon too far behind to catch

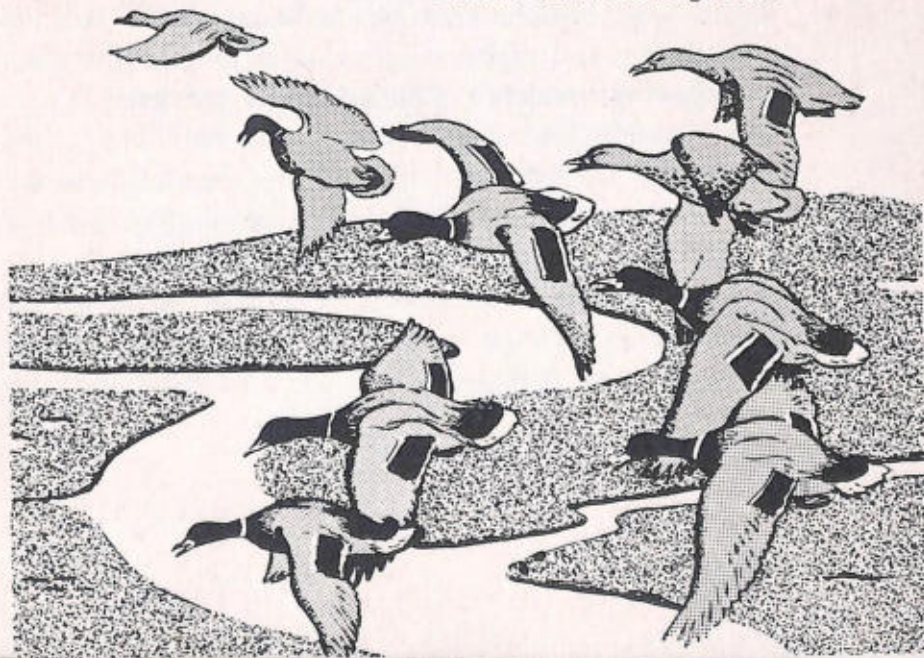
up. To go with whales and fish you would need a submarine. And the only way to keep up with birds would be to fly beside them in an airplane.

Why not? That would be a splendid way to see how birds migrated. In 1940, a scientist named Donald Griffin decided to do just that: to learn to fly an airplane, and then to follow the birds to find out where they went.

As soon as he became a pilot, Griffin began to follow birds that had been set free in homing experiments—flying as near to them as he could without frightening the birds, and circling now and then so that the faster-moving airplane would not get ahead.

First Griffin followed herring gulls which, when freed, soared aloft on updrafts—currents of rising air that lifted the gulls into the clouds. From there the gulls “coasted” to their nesting area, more than a hundred miles away.

Mallard ducks following a river



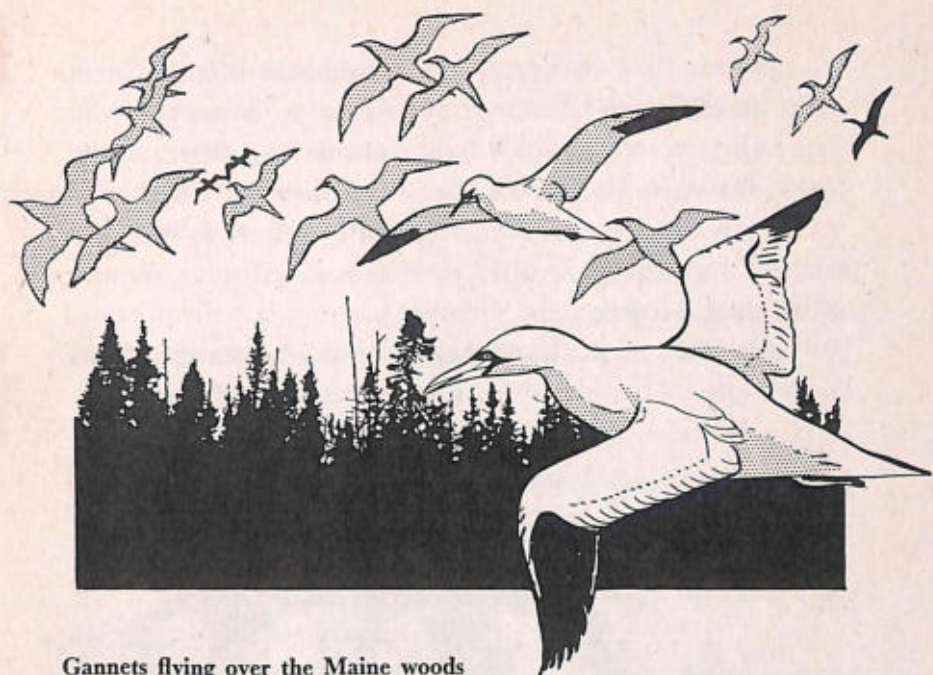
Griffin found, however, that gulls did not always start in the correct direction when they were set free. He wondered if this was because the gulls first sought an updraft, in order to gain altitude, and then took off for home.

After World War II, Griffin decided to study gannets, because they were twice as large as gulls and therefore could be seen from greater distances. Gannets, moreover, were birds of the ocean, rarely seen over land except in times of storms and, of course, on the islands where they nested. Griffin wanted to release them over land and find out how they would behave in strange surroundings.

He and a helper collected sixteen gannets from Bonaventure Island, near the Gaspé Peninsula in Canada, and took them 100 miles inland, setting them free above the fields and forests of Maine.

Like gulls, the gannets were given to soaring, but spent less time at that and more time toward forward flight. Some of them returned to Bonaventure Island in a single day and night; others took as long as four days, after having wandered. This suggested that, even though gannets were birds of the ocean, they could find their way across land if they had to. They did not, however, find their way as easily as did the gulls, and were not as good at homing as were homing pigeons.

Griffin followed gannet after gannet in his experiments. They flew in such scattered directions that he often thought they were lost. Perhaps they needed a



Gannets flying over the Maine woods

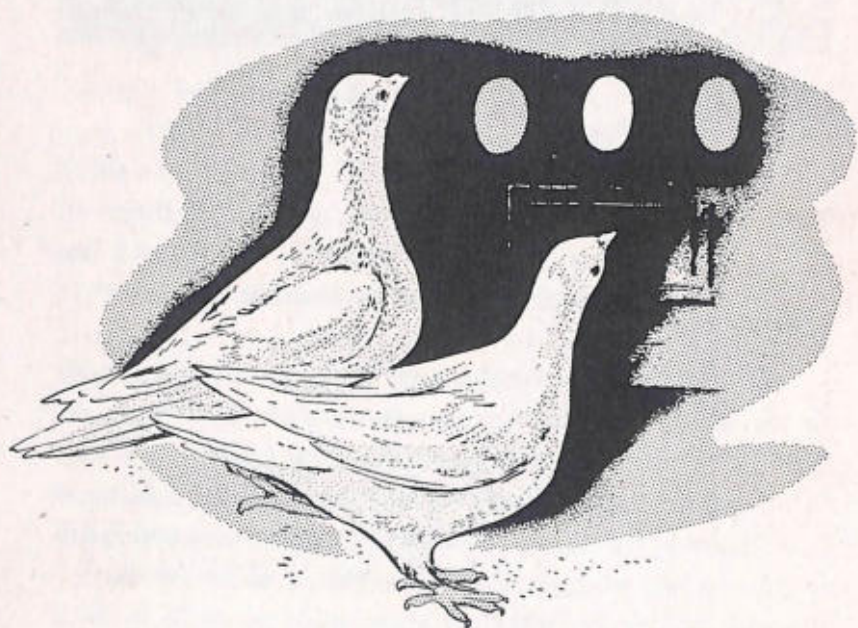
longer time to find their way than did other kinds of birds. Perhaps they were exploring the strange and unfamiliar land in an effort to find out where they were in relation to home.

It occurred to Griffin that the gannets might be having a difficult time because there were no landmarks that they knew. It was not until later that Matthews' pigeon experiments in England suggested that birds were guided partly by the sun, and hence might not need landmarks. In any case, Griffin had "flown with the birds" and had helped to find one more small piece to fit into the migration puzzle.

Does a bird really use the landmarks it sees? Birds have better eyesight than humans have. Scientists who study the eyes of animals have found that those of the hawk, for example, have a greater number of tiny visual cells than the eyes of men. Not only can the birds see farther, but they are able to make out distant objects much more clearly.

The eyes of birds are also adapted to seeing distant movements. This is fine for hawks in search of mice, and

Pigeons are also taught to peck at light in experiments on vision



may be helpful to birds that depend upon the movements of the sun—and possibly of the stars—to guide them on their migratory travels.

Birds are also known to have good memories. One scientist proved this by teaching domestic pigeons to peck at a certain place on an aerial photograph, after which he rewarded them with food. Four years later, those pigeons were given the same photograph and they pecked at the same place.

If animals can see landmarks with especially keen vision and can remember them from year to year, then landmarks may indeed be an aid in finding their way. It could be that a bird remembers whether it ought to fly across this lake and down that river, or over that mountain in the distance . . .

There are also landmarks on the ocean. Some waters are a deeper blue than others. Some have different plants and animals floating on them. Some are usually shrouded in mists or clouds. Oceanic birds, that spend their lives over water, may be familiar with different colors and be able to use them as landmarks.

Animals that wander on land could follow a river or trail, remembering every year which way to go. With their keen sense of smell they may be able to “track” other animals that have already gone ahead.

In any case, we know now that traveling by landmark is possible and may play some role—if only a small one—in animal migration.

TRAVELING AT NIGHT

In a darkened room the radio engineers gathered tensely around a tiny picture tube. The tube was like a miniature television screen except that it was round and that on its surface a line of greenish light rotated around the center.

The time was World War II and the room could have been any of dozens in which the same mysterious signals were being received on radar sets. Radar was new at that time, and since it was useful in defense against enemy planes, the warring nations were working hard to perfect it. For that reason the engineers were worried about these signals. They meant that something must have gone wrong.

From the antenna, powerful radar waves were sent out for miles across the countryside. If they struck some solid object, parts of them were reflected back to the antenna much as echoes of your voice are reflected back when you shout toward a high rock wall. These radar echoes are received by the tiny picture tube, where they are seen as a spot of light—or "blip."

As the antenna slowly turned in a circle, the outgoing radar beam "swept" the sky in all directions just as an airplane beacon or lighthouse signal sweeps the night sky with a beam of light. The line of green on the viewing tube went around at exactly the same time as the antenna. If there were aircraft approaching from any direction, the beams of radar would echo from them and be seen as blips on the little screen.

But the engineers were puzzled. Strange signals were being picked up by the antenna. "Clouds" of blips were moving slowly across the tiny screens. They were quite sure that these clouds of blips were not airplanes, because echoes from airplanes made different kinds of blips. They might be echoes from lightning and from thunderstorms in the distance, except that the clouds of blips now going across the screen moved faster than storms usually do. Some of the engineers thought that the tiny clouds were reflections from dust moving through the air.

This strange occurrence was repeated a number of times. For a while, these "angels," as the unidentified blips came to be called, were kept a military secret. No one could explain them. As the months and years went by, engineers began to realize that the "angels" were most often seen in the spring and fall. Someone then hit upon the idea that they were flights of birds in migration. Others thought that such an idea was absurd. After all, birds' bodies were soft and feathery—hardly able to reflect echoes. Even if they could, it would take echoes from thousands of birds to show up as even a faint blip on the

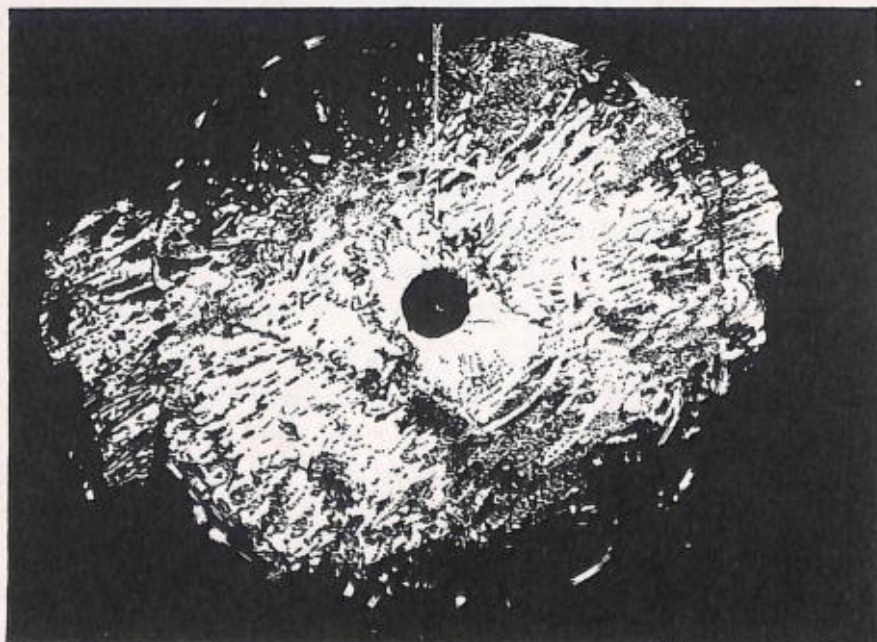
picture screen—and there were not that many birds around, especially at night.

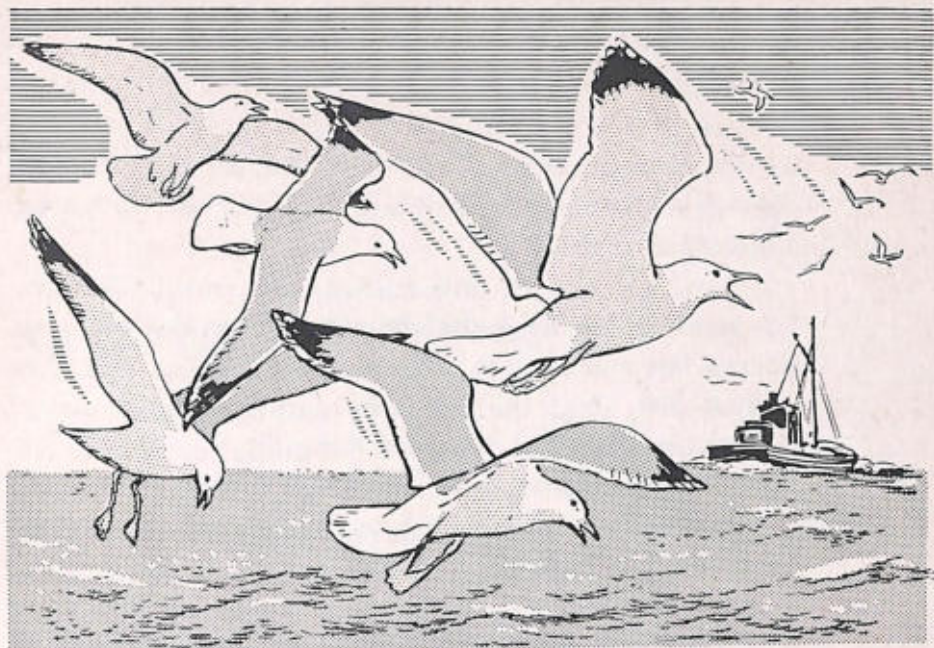
But the more the engineers watched their screens, the more they began to realize that the “angels” could not be anything else. The clouds of blips moved at the speed of flying birds and were normally at low elevations. Some of the “angels” that echoed from shorter distances were found to be coming from places where flocks of starlings roosted at night.

Several engineers mounted telescopes on their antennas. On nights when it was not too dark to see across the countryside, they saw flocks of birds flying at just about the places where radar “angels” were appearing on the tiny picture screens.

Eventually, scientists began to sit beside the radar men, to watch the screens and to take notes on echoes

The “angels” on the radar screen





A flock of gulls

from bird migrations. At last they had proved that birds migrated at night—not just a few but thousands!

Scientists today have gone a step further. They are able, under favorable conditions, to tell from radar echoes what *kinds* of birds are flying; that is, whether they are flocks of small birds such as warblers, or flocks of large birds such as gulls.

Who knows where the science of radar may take us in the future? We have already come a long way. The ancient people, as we know, saw birds pass in front of the moon and believed that birds flew all the way to the moon itself. In modern times, the number of birds seen passing in front of the moon is often used as the basis for

a migration count. Although this method of counting gives an idea of the number of migrating birds, it is not by any means accurate. Radar helped to prove that many birds flew over large areas of land or ocean, and that most migrated at night.

Birds are not the only animals that travel when the sun is down. We have already talked about the Mexican freetail bat and how it migrates into Mexico. We may assume that, since the bat is by nature a night-roving, or nocturnal animal, most of its migratory flights are made at that time.

If there are other animals that migrate at night, man has much less knowledge of their travels. We may guess that insects, seals, and whales move in darkness as well as daylight, but it is difficult to say how many migrate at night and in what directions they go. The mystery deepens when we ask how they can go anywhere when there is no daylight to see by.

The answer may simply be that night migrants do not need daylight to see by. Bats send out high-pitched notes or squeaks that echo from other objects just as radar does. These echoes apparently guide the bat through the air—day or night. But that does not answer the question fully, and once again we come to the age-old puzzle of how migrating animals “know” which way to go, and how they navigate, or find their way at night, once they have started.

Could it possibly be that they use the stars?

NAVIGATION

The use of objects in the sky, such as the sun and the stars, in finding the direction of travel is called "celestial" navigation by sailors. ("Celestial" comes from the Latin word *caelestis*, meaning "heaven.") This type of navigation is one of the most complex skills that a sailor has to learn. It is a skill that is acquired only after years of study, and it requires the use of intricate compasses and other instruments of navigation.

Therefore, the idea that a warbler, or a seal, or an insect—animals with brains only a fraction of the size of the human brain—could navigate, or find its way, by means of the stars seemed very hard to believe. Such animals couldn't even tell one star from another!

But after Geoffrey Matthews' experiments with homing pigeons showed how the sun helped animals to find their way by day, the use of the stars also seemed a possibility. If man could find out whether animals really did use the stars, he might be able to explain how they were able to find their way at night.

This would be much more difficult to prove, however. If birds were freed at night, how could human beings see which way they flew? Even with radar, it was hard to pick out the blip of a single bird and follow it on a picture screen. And even if we could follow the flight of a bird at night, how could we then prove that the direction of flight was guided by stars?

All this did not seem impossible to a German, Franz Sauer, a young zoologist who was studying animals at the University of Freiburg. Working with his wife, he had been conducting experiments on bird songs. He had shown that young birds were able to sing the songs of their parents even though the young were raised in soundproof cages and had never heard their parents—or, for that matter, any other birds—sing.

The Sauers then decided to find out whether birds could migrate in the right direction, even if they had been raised from birth by human beings rather than by their natural parents.

The young couple knew about some experiments that had been made a few years earlier—in the early 1950's—by Gustav Kramer, another German. Kramer had found out that birds in cages grew restless at migration time and appeared to want to leave the cages and start on their regular migration routes. The birds flitted back and forth in their cages, or even fluttered against the wall, usually facing—or trying to fly—in the direction taken by most of their kind at that time of year.

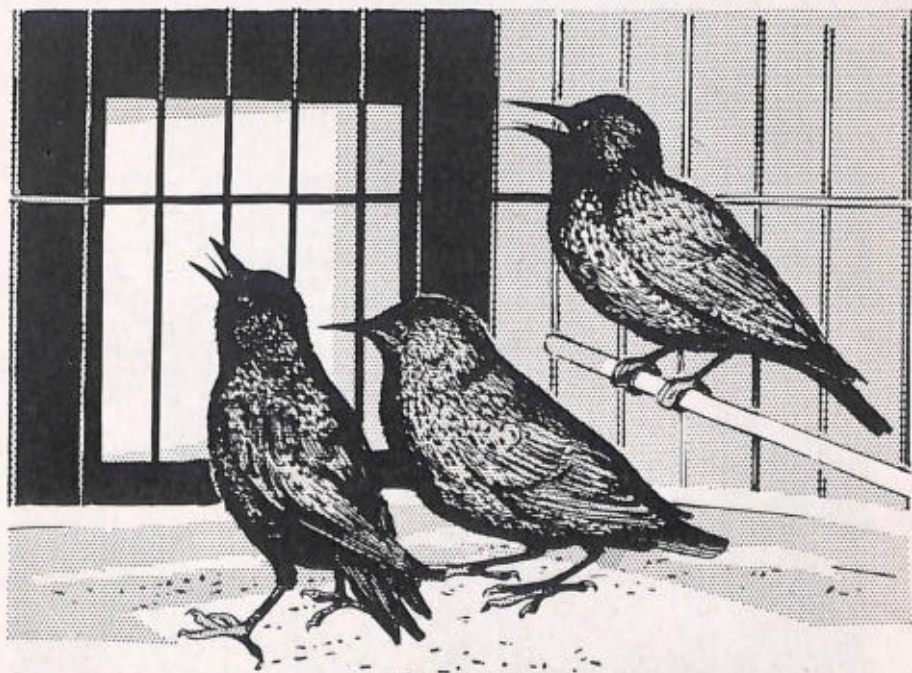
Kramer had built some circular cages with openings

that let in the sunlight. When the time for spring migration came, the starlings on which he made his observations became restless and faced toward the northwest. Kramer turned the cages around. Still the birds faced northwest. He took the cages to different places. The birds still faced northwest.

But on cloudy days the birds seemed to be confused, as if not able to decide which way to go. As soon as the sun shone again, they once more faced and fluttered toward the northwest.

At this point, Kramer did a curious thing. Believing that the direction from which the sunlight came was important to the bird, he fixed a mirror to each of the openings of the cage. The mirrors reflected the sunlight so that it entered the cage from a different direction.

Starlings faced southwest when a mirror was used



After that, the starlings no longer faced northwest. They faced southwest!

The Sauers, recalling that Kramer and Matthews had both shown how the sun helps birds navigate, decided to experiment on warblers in much the same way. But instead of using sunlight they planned to see what they could do with starlight. They realized that they would have to use warblers that had been raised indoors to make sure that nothing on the outside—not even the sun—could affect the experiment. This was easy, because they already had the birds that they needed—those raised for their bird-song experiments.

All they needed was a night sky, and that, too, was easy to obtain. They simply took their birds, cages and all, outdoors at night. Also, and better yet, they took the cages into a planetarium, where the stars could be shown

Warblers guided by the stars



on a dark dome overhead. There the pattern of stars could be made to match the appearance of the natural sky at any season of the year.

The results were as astounding as those that had been achieved by Kramer and by Matthews. The birds faced in the proper migratory direction when they were exposed either to the natural night sky or to the same star pattern on the dome of the planetarium.

Birds that had never in their lives seen the sky at night immediately faced in the proper direction when exposed to it for the first time.

Moreover, when the star pattern on the dome of the planetarium was changed to resemble the night sky as it is in the autumn, the birds no longer faced toward the north. They faced the south!

And then when the birds were exposed to the natural sky on a cloudy night—when the stars could not be seen—they became completely confused and did not fly or flutter in any one direction!

These discoveries showed that birds did not have to learn from their parents, or from any other source, how to migrate, or which way to go. They already "knew," as if the power of celestial navigation had been built into their brains—into their memory systems—over the hundreds of thousands, or even millions, of years that birds have lived. It is a skill or instinct handed down from one generation of birds to another.

It seemed clear that if birds had this instinct, other animals also had it. It is known that ants and bees use

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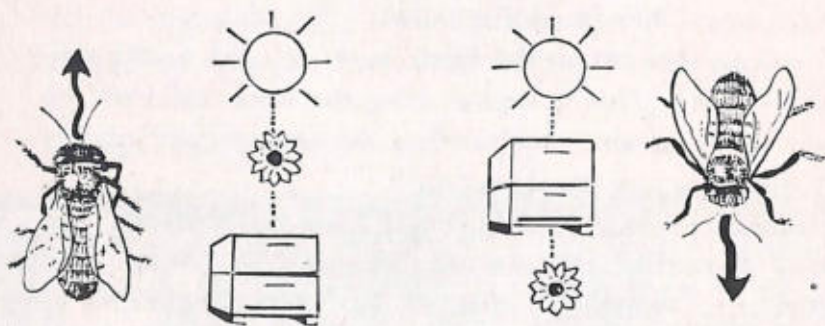
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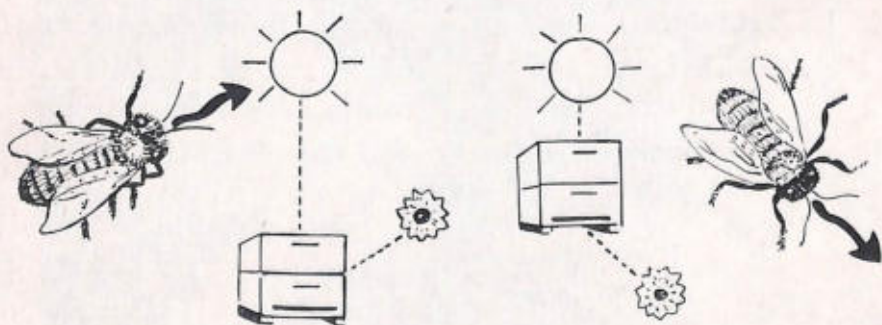
the sun in finding their way. The German scientist Karl von Frisch discovered that honeybees use the sun in finding their way from flower to beehive and back to flower again.

The European pipistrelle bat and the Mexican free-tail bat may fly a distance of as much as 1,600 miles each year, in their migrations. Red bats are often seen off the Atlantic Coast of North America as they fly from Cape Cod toward the Bermuda Islands. If bats fly like birds, they may also find their way as birds do—by use of the stars, or landmarks, or both.

It is now believed that this is what happens—but bats probably do not see as well as birds, so the mystery



Bees' honey "dance": from flower to beehive and back again, with the aid of the sun

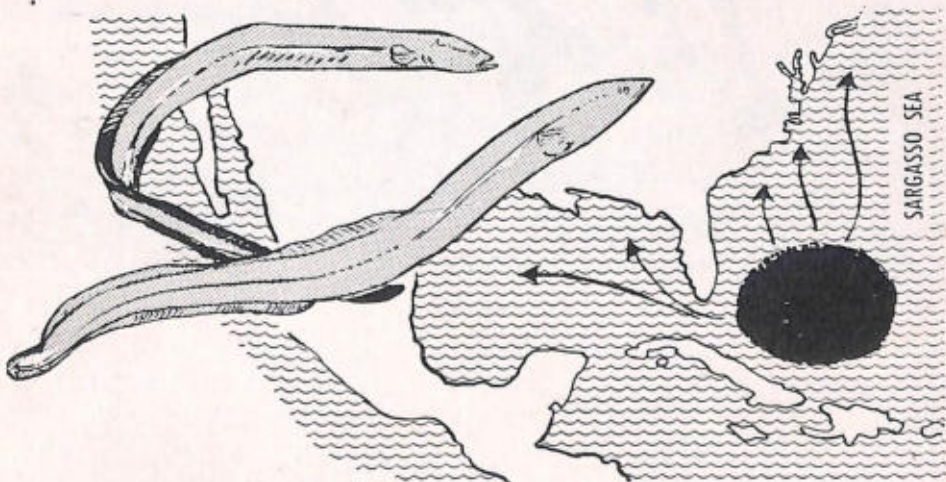


is even greater. There is a great deal about bat flights (and bird flights, too) that scientists yet have to find out, but the results of the Kramer, Matthews, and Sauers experiments will lead to new work along these lines.

In the ocean there may be rules of animal navigation entirely different from those followed by animals that fly through the air. Among the fish, for example, there are many migrants. Some swim down rivers to reach their spawning, or nesting, places in the ocean. Others do just the opposite. They come to shore and go up rivers to spawn, or lay eggs.

Certain fresh-water eels, after from seven to fifteen years in a river, swim non-stop all the way to the Sargasso Sea, a part of the Atlantic Ocean lying over 1,000 miles from the coast of the United States. There they spawn and die and, in the year that follows, the young find their way back to the coast. The females then migrate upstream, and the circle of life begins again.

Fresh-water eels swim non-stop to the Sargasso Sea, and the young find their way back to the coast

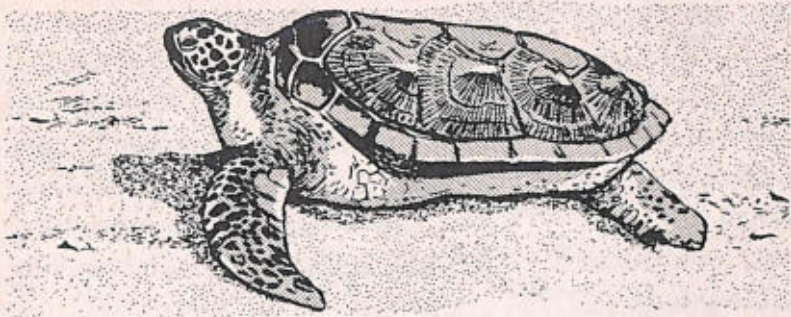


Some fish do not travel very far. Some migrate vertically—from shallow to deeper water and back again. Others, such as the salmon, travel for thousands of miles, and regularly return to their spawning place, or even to the river in which they were born. Salmon, in going up a river, leap waterfalls as high as ten feet, and may have to leap over many such waterfalls until they reach the end of their journey.

How they are able to find their own river out of many is hard to say. Do they use the sun? Do they use

Salmon leap waterfalls when going upriver





Green turtles go ashore to lay their eggs

the stars? Do they remember the taste of the water in this home stream?

It may be that they can detect and follow chemicals in the ocean which have come from the river system in which they were hatched.

Wherever the migrants of the ocean go, they have the world in which to move. Yet most of them swim toward their feeding or nesting places along what are possibly narrow routes of travel. Their "home," or place of birth, may be a tiny island, but they are able to come back to it year after year.

This is true not only of fish but of ocean-going reptiles as well. Some green turtles swim all the way from South America to Ascension—a very small island in the middle of the Atlantic Ocean. They arrive in April, go ashore to lay their eggs, and then cover the eggs with sand. By June they have gone—swimming back across the

ocean to Brazil—their yearly task of laying eggs complete. When the young are hatched, weeks later, and emerge from beneath the sand into the light of day, there are no parents there to guide them. This doesn't seem to stop them for a moment. Without delay they make their way across the sand and into the ocean, and somehow are able to return to Ascension Island every year as long as they live.

Is it possible that animals use other aids to navigation besides landmarks and celestial objects? We know, for one thing, that magnetic waves surround the earth. These waves are not very often seen or felt by man, but instruments can measure them. Perhaps the flying animals can feel these waves and thereby find their way over thousands of miles of land and ocean.

It is definitely known that these animals can feel radar. Some waterfowl, on entering beams of radar waves, suddenly fly in a crazy way and nearly drop from the sky. The earth's magnetic waves are much less strong than radar, so we cannot be sure whether birds can even feel them, let alone be guided by them, but they may.

Other ideas have been brought forth to explain the navigation of birds. One is that birds can sense a change in their position by "feeling" the earth rotate beneath them as they fly. Or that they find their way by means of infra-red light waves, which we are unable to see. But as yet we have no evidence that animals can detect such things and, in view of recent knowledge about celestial

navigation, perhaps some further experiments are needed.

Such experiments may help to explain the navigation of shearwaters. Greater shearwaters nest on Inaccessible Island in the Tristan da Cunha group in the South Atlantic Ocean. After flying thousands of miles across the oceans, they return to that same island every year.

Shearwaters roam the whole Atlantic in a circular migratory path. They nest from January to March and then fly north to Greenland, across to Europe, and south again to Tristan da Cunha, completing a "loop migration." The short-tailed shearwater flies on a similar migration around the Pacific Ocean.

These circles of travel are easy for us to trace on a map. But it is far different to fly them.

The short-tailed shearwater makes a "loop migration" around the Pacific Ocean



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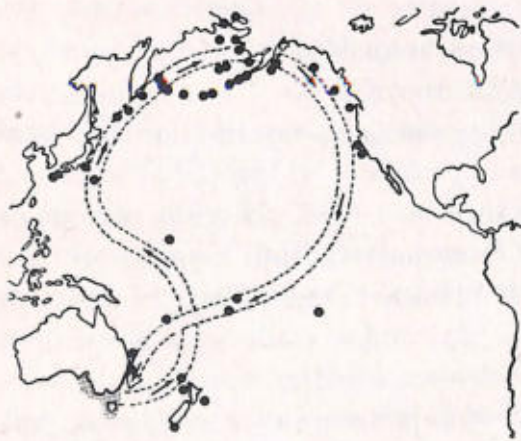
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DANGERS

Starting off in the right direction, and keeping on course, are only the beginning for migrating animals. They must face many dangers during their travels.

Animals that spend their lives on the surface of the earth must do the best they can with anything that gets in the way while they are traveling. If they cannot swim, they may have to end their migration at the edge of the nearest river. If they come to a desert, they may not find enough food on it to make it possible for them to go all the way across.

Thus, earthbound animals may have to go along trails as caribou do, or over ridges and into valleys as elk and deer do, or—if they can swim—up and down rivers as migrating fish do.

A mountain range may block the path of animals that fly as well as of those on land. Birds have to work very hard to cross a high mountain range. There is not much oxygen high in the sky, and animals need oxygen for breathing—more of it when working.

Men in airplanes have seen vultures, godwits, cur-

lews, and jackdaws at nearly 20,000 feet above the level of the ocean. Geese have been seen at 29,500 feet, higher than the highest mountain, but no birds have been seen higher than that.

Most birds do not fly very high when migrating—usually going no higher than 3,000 feet. Many fly no higher than 300 feet. These are the ones that have trouble, especially at night.

Though radio towers have flashing signals, though buildings and monuments are lighted at night, though lighthouse beams may be seen for miles, birds are either confused by these lights, as on foggy nights, or are curious about them. As a result they fly directly into them. Because they fly so fast, the crash is likely to break their necks or skulls, and that usually means death. Hundreds of migrating birds have been found on the ground around the Washington Monument, in Washington, D.C., and around tall buildings in many places.

Another danger is an airport "ceilometer." This bright white beam of light shines into the sky so that airport men can see how high the "cloud ceiling" is and inform pilots. The ceilometer beam is so bright that birds appear to be blinded by it, and fly into nearby buildings or into the ground.

Birds do not always fly so rapidly into a lighthouse that they kill themselves. Some flutter around the light, as if trying to find out what it is. Then they may be blown against the window by a sudden wind, or they may drop, almost exhausted, to the rocks below. Some light-

houses have perches under the window where the birds can rest until they are able to go on.

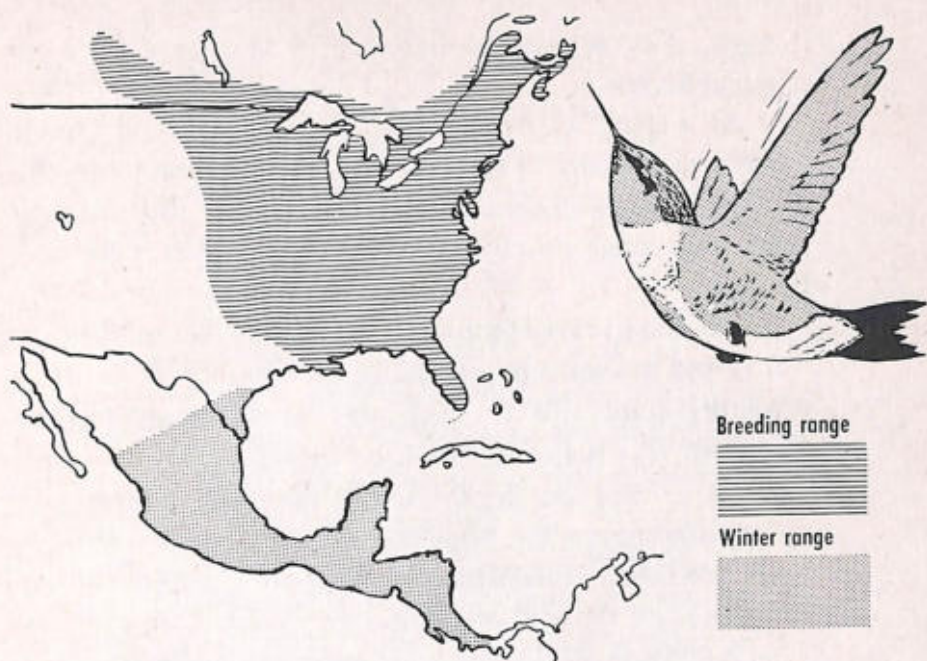
Perhaps storms are the greatest danger met by migratory animals. Lightning can bring instant death. Rains cause heavy floods. Deep snows cover food supplies. Once, in the state of Minnesota, migrating longspurs flew into wet and heavy snow. Unable to keep flying, they began to fall and to strike objects on the ground. So rapidly did they crash into buildings, wires, poles, and the frozen ground, that great numbers died.

One man saw longspurs lying everywhere and tried to count them. There were so many that he had to make a guess, and he guessed that 750,000 had been killed in that single storm.

Ground-dwelling animals may find shelters such as

Birds flying directly into a lighthouse beam





Ruby-throated hummingbird and its range

burrows and caves. But birds and insects out in the open can find little protection.

To the tiny hummingbirds, storms are often fatal. In the autumn, ruby-throated hummingbirds of the eastern United States begin to move south. Some migrate to Mexico or Central America. Some stop in Texas or Florida for the winter. Others fly all the way across the Gulf of Mexico and, for a bird so tiny, that is quite a trip.

There are hundreds of different kinds of hummingbirds, but most of them are tropical birds. A few kinds travel as far north as Canada and Alaska. Every winter,

though, they return to the warmth and food of their tropical homes.

At a speed of from 45 to 60 miles an hour, hummingbirds take about ten hours to fly 500 miles across the Gulf of Mexico—if they fly in a straight line. But we may guess that their lonely flights are zigzag ones that take longer.

Unable to carry food, hummingbirds live on fat that was stored in their bodies during the summer. Like other migrants along this route, hummingbirds may meet a hurricane. If caught by such a large and dangerous tropical storm, they are blown many miles off course and either become too tired to fly on, or they may be forced down into the ocean, which could mean the end of their journey—and the end of them.

Migrating animals may have to face danger from human beings as well as from natural forces. They may be shot by hunters, or may alight on waters covered with oil, which seeps into the feathers, causing the feathers to stick together as if glued. This opens patches of skin to the cold wind. Worse yet, the birds pluck out their feathers in an effort to get rid of the oil and then, unable to fly or keep warm, they become helpless. Hundreds of migrating birds may die this way.

Though laws forbid the dumping of oil in certain parts of the ocean, especially close to shore, some people are careless or do not know of the laws. Anyone who sees oil where it should not be, should tell the police or other local authorities.

SPEED

No animal is better fitted than the bird for long and rapid migrations. Not even an airplane can compare with the bird in ease of flight. Weight for weight, an airplane is not even equal in strength.

The secret is in the feathers and bones, which make the bird an almost perfect flying machine. Feathers weigh only part of an ounce, but they are so well formed and linked together that they easily hold birds in the air and can be moved or twisted as desired. Body bones are strong and many are nearly hollow. Powerful muscles in the wings enable birds to fly for long periods at a time and for thousands of miles.

The birds' own fat is the source of energy for these long migratory travels, when they cannot stop often for food. Golden plovers, in two days' time, travel 2,400 miles non-stop on only two ounces of body fat.

Colonel Richard Meinertzhagen, of the British Army, in order to learn how fast birds fly when migrating, compared an airplane's flying speed to that of the

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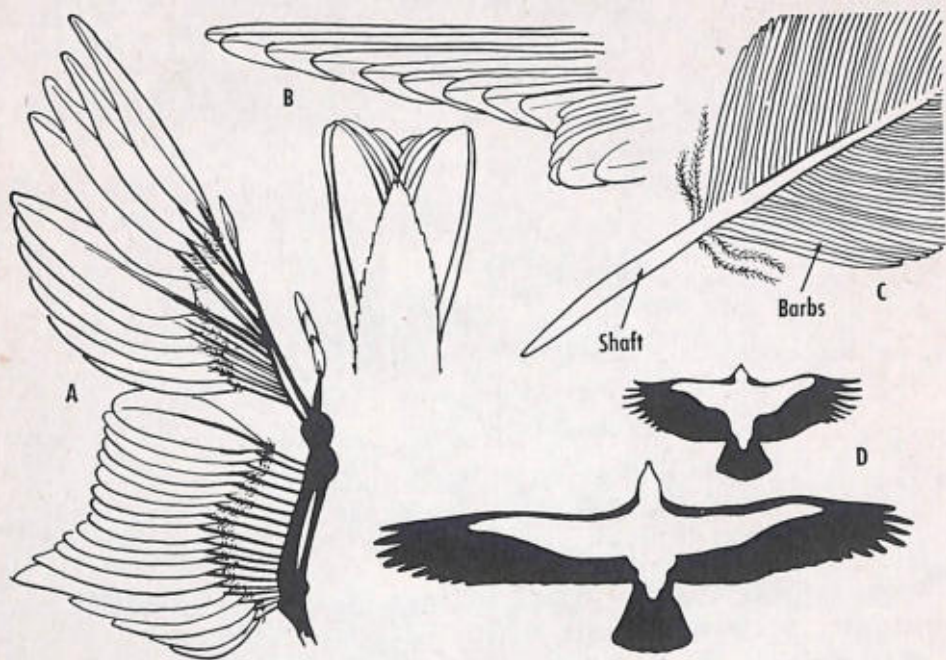
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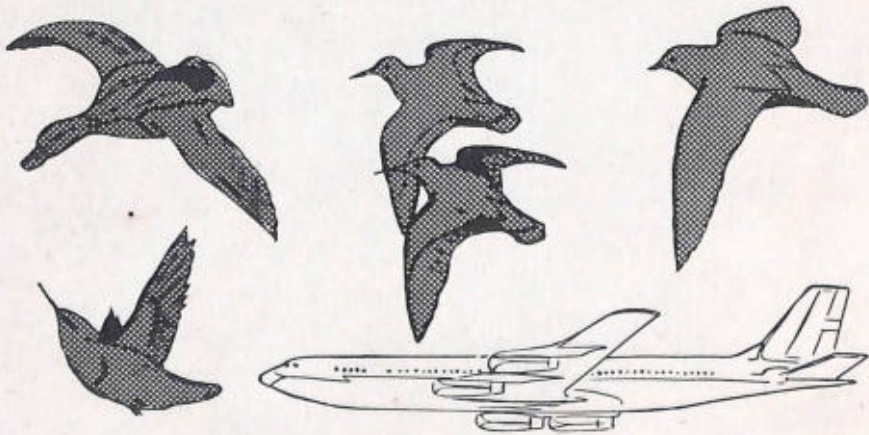
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A: wing construction; B: swallow's wing and tail; C: shaft and barbs of a feather; D: body and wing spread of hawk (above) and eagle (below)

Top, left to right: mallard, sandpipers, American golden plover;
 Bottom: Hummingbird

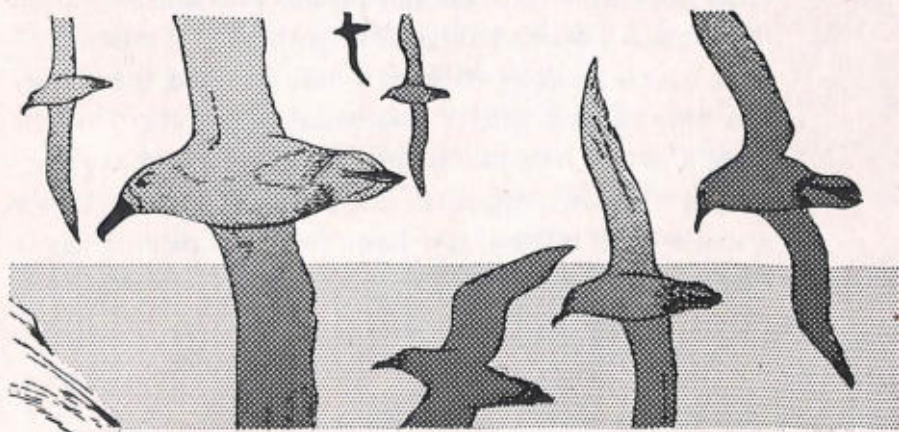


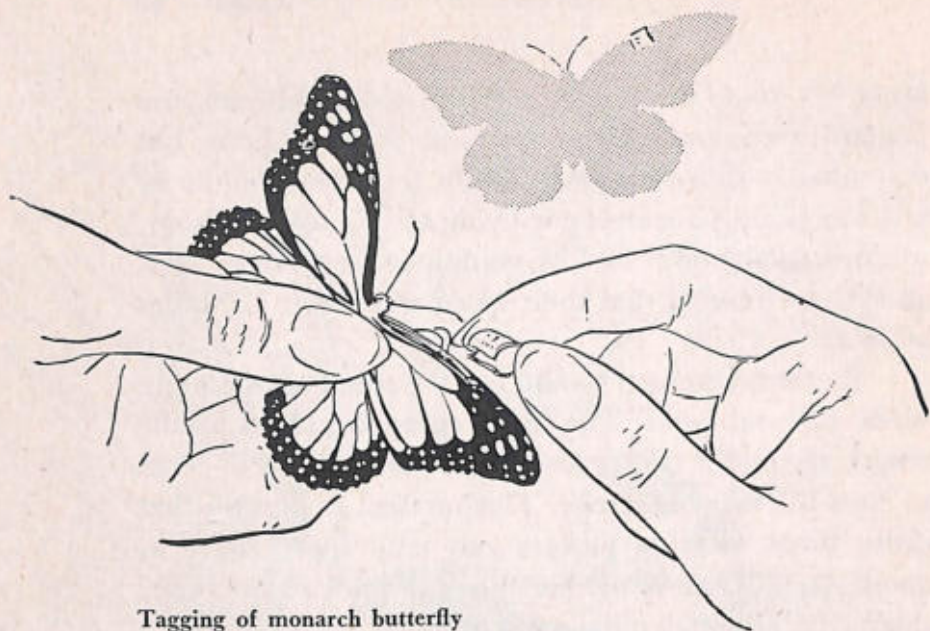
birds. He found that hummingbirds, golden plovers, and mallard ducks could fly as fast as 60 miles an hour, but that usually they flew less rapidly than that—about 40 miles an hour. One airplane, flying at 100 miles an hour, was overtaken and passed by sandpipers or small plovers, and it was thought that their speed was about 110 miles an hour.

Radar is also used to find out the speed of migrating birds, day and night. The birds' speed is judged by the length of time it takes radar echoes from flocks of birds to cross the viewing screen. This method has shown that shore birds, such as plovers and sandpipers, move at about 45 miles an hour. Songbirds are not so fast; they migrate at about 30 miles an hour.

The wind can either increase or decrease speed. Oceanic birds may fly with the wind at their backs for hundreds of miles. The albatross, with the largest wing spread of any bird (up to 12 feet), rides along on strong ocean winds and may even circle the earth in migration. On the

Black-footed albatross can circle the earth in its migrations





Tagging of monarch butterfly

other hand, some birds fly against the wind, and that delays them.

It is sometimes hard to be sure how rapidly birds migrate, because some stop to eat, or to avoid rain and fog, and may stay on the ground for several days.

Very little is known of the speed of migration of other animals. One of the few records of whale migration tells us that a blue whale once migrated 1,900 miles in 47 days, which is nearly 40 miles a day. A monarch butterfly was once tagged with a numbered paper glued to the wing and set free in Ontario, Canada. Forty-two days later it was picked up in Texas, 1,345 miles away. This is a speed of 32 miles a day. For a butterfly that zigzags in flight as much as a bouncing football, that is fast flying.

DISTANCE

The entire migration of an animal is seldom, if ever, seen by man. No person has followed a whale or a seal or a turtle during all of its journey. No one has stayed with a butterfly or a bird to see how far it travels and where it goes. Men in airplanes have followed gulls and gannets and perhaps a few other kinds of birds, but only for short distances.

Nevertheless we do know a little about the distances traveled by animals because of tagging (which will be described in the next chapter). We also have radar reports, and the records of bird watchers who list the kinds of birds they see and the dates of their coming and going.

Some birds migrate such great distances that most of their lives are spent in flight. Others, though they fly very well, may go no farther than 20 miles a day.

Migrating ducks do not fly much more than 300 miles a day. Red-backed shrikes migrate from sunset to sunrise, sometimes covering more than 300 miles a night.

A ruddy turnstone has been known to fly more than 500 miles in 24 hours.

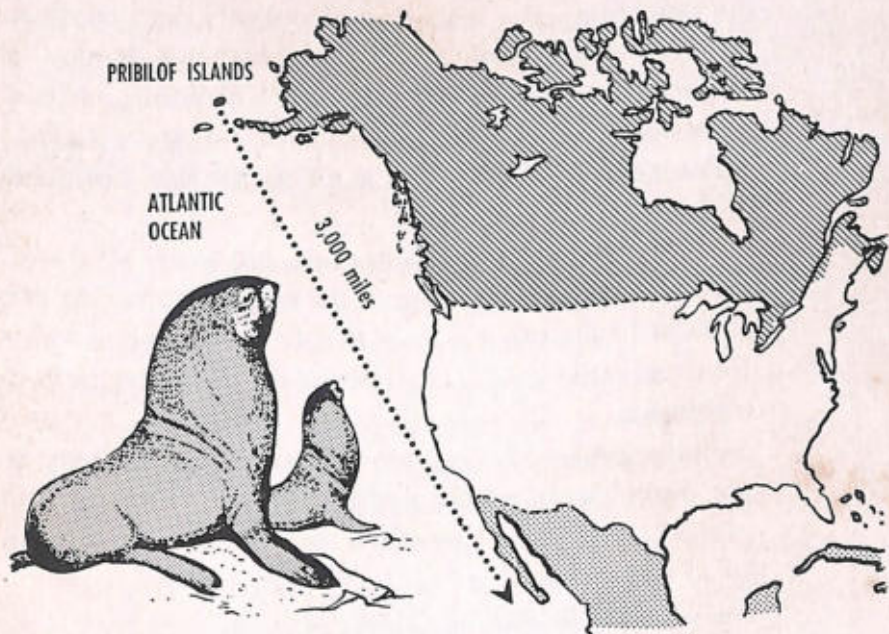
Some whales, such as the humpback, swim as far as 4,000 miles during migration. As far as is known, seals and porpoises migrate much as whales do. How they find their way from colder oceans to warm and back again is still not clearly understood. The constant search for food must keep them on the move, for porpoises eat anchovies and, where anchovies are, porpoises are.

Alaskan fur seals give birth to their young on the Pribilof Islands, in the Bering Sea. With the coming of November the fathers and other male seals remain behind to spend the winter in the Gulf of Alaska or in waters near the Aleutian Islands, but the mothers gather the young and migrate some 3,000 miles to the south.

The record for distance of fish seems to be held by an albacore, cousin to the tuna. Several albacore were

Porpoises may swim as far as 4,000 miles during migration





Alaskan fur seal mothers and young migrate some 3,000 miles south from the Pribilof Islands

once tagged in California and one of them was recaptured in less than a year near Japan—4,900 miles away.

Of the hundreds of kinds of butterflies in the world, about fifty are known to migrate. The champion is the monarch butterfly.

During their southward journeys in the fall, when nights grow suddenly cool or when strong winds blow against them as they fly, thousands of monarchs gather in the trees that are their roosting sites and wait until better weather before going on.

Not much else besides wind and cold can stop them. They fly across lakes and mountains, even as high as 11,000 feet in the Sierra Nevadas of California, and also have been seen far out over the ocean. Great numbers of them have crossed the Pacific Ocean to Asia, and some have even reached Europe.

Most monarchs go to Mexico, but many remain in the United States. They spend the winter in trees that are sheltered from the wind and that have the kind of leaves they can easily grasp. They prefer the Monterey pine in California.

In spring they migrate north, seldom stopping to eat. Some never complete this journey. They stop and breed and lay their eggs—then die. But the young fly on

Monarch butterflies winter in Monterey pines



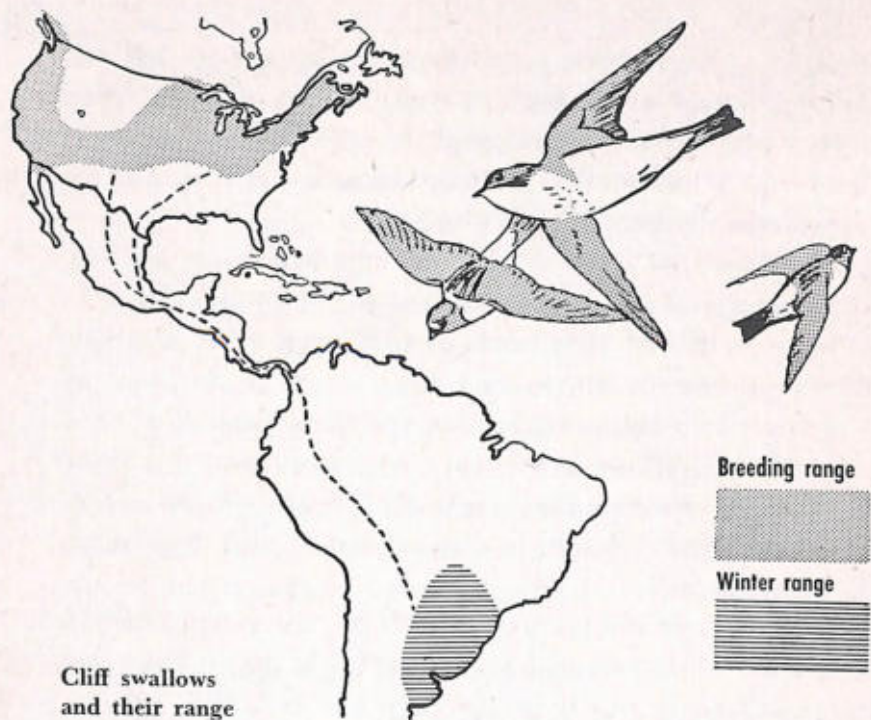
toward Canada, taking up where their parents left off, guided by some sense of navigation that has not been fully studied. The longest flight of which we have record is that of a monarch tagged in Canada and captured in Mexico—a distance of 1,870 miles.

Wheatears, as we have seen, migrate across Asia or the Atlantic Ocean to return to their ancestral Africa. It is hard to believe that birds so small can cross so much land and ocean. Yet they have been known to fly as far as 300 miles in a single night. (See picture, page 42.)

Some swallows are highly migratory and fly great distances in their yearly travels. Cliff swallows nest across most of North America and fly to Brazil and Argentina for the winter.

The wings and body of these birds are so constructed as to make them graceful and powerful in flight. Yet even though they fly much better than the bobolink or the hummingbird, they do not cross the Gulf of Mexico, except perhaps by accident. Instead, cliff swallows migrate around the edge of the Gulf, and down through Mexico.

These, by the way, are the famous swallows that come back every year to the Mission of San Juan Capistrano, in southern California. Cliff swallows are strong and are not troubled very much by weather. Therefore, they arrive at the Mission every year about March 19. Some people claim that they return at the same hour of the same day each year, but actually the time of arrival varies within a span of a week. The birds stay until about the 23rd of October, when they leave for the south.



Cliff swallows
and their range

Cliff swallows return yearly to the Mission of San Juan Capistrano



One of the most striking migration flights of any living shore bird is that of the American golden plover. After nesting on the Arctic tundra of Canada, plovers gather in Labrador and fly 2,400 miles across the ocean to Brazil. Going on, they spend the months of September to March in Argentina. The following season, plovers return by a different route—across the Gulf of Mexico and up the Mississippi Valley to Canada, 8,000 miles from Argentina.

Pacific golden plovers nest along the Arctic coasts of Siberia and Alaska and spend the winter on coasts and islands of the Pacific all the way to Australia. It takes great skill in navigation to find such tiny islands in so large an ocean. Some of them make a non-stop flight of 2,000 miles from Alaska to Hawaii, which lasts for 35 hours. (See plover pictures on pages 55 and 94.)

Arctic tundra of Canada



Greatest of all migrants are the Arctic terns. These slender, fleet-winged birds nest from the northern United States northward, and from the northern seacoasts of Europe and Asia all the way up to points within the Arctic Circle. No birds nest any closer to the North Pole than some terns. They winter as far to the south as the Antarctic Continent. (See picture on page 61.)

Their migration route is the longest known for any animal. Altogether, some Arctic terns must fly about 22,000 miles each year. Since they almost never fly in a straight line, we may add the twistings, turnings, and circlings that must mean hundreds of miles extra.

The terns that fly south every autumn fly above cold ocean currents as long as they can. This takes them east across the Atlantic Ocean to Europe, and then to the south. On the return flight they come back north along both sides of the Atlantic.

In all these travels, they see more of the sun and enjoy more hours of daylight than any other animal, for they live near each of the Poles when it receives twenty-four hours of sunshine a day. For eight months of every year, some of them must not see the sun set at all. In the other four months they live or fly where there is more daylight than darkness.

ROUTES

How much we know about routes that different animals take in their migrations depends on how well men have been able to watch them on various parts of their journeys. We know where seals, dolphins, whales, and fish leave from and perhaps where they go, but are less well informed about the routes they follow. The travels of bats are not well known because those animals fly at night when they are seldom seen by human beings.

On the other hand, the routes of elk and caribou are known, and a little is known of butterfly routes. But the best-known routes are those of birds.

Birds do not always, if ever, travel in a straight line. Some birds follow rivers, perhaps because rivers are landmarks that their ancestors followed for years. If they are water birds and if they stop to eat on their journey, they are more apt to find familiar food along a river than anywhere else. The same may be true of certain birds that follow the coasts of continents.

Since most birds migrate, several kinds may fly along the same rivers, or ocean shores, or across the same prai-

ries at the same time. One October morning on a lake in Canada, a scientist saw great numbers of waterfowl overhead. He counted as best he could and by noon guessed that more than 200,000 birds had flown by. The explorer Matthew Flinders said that in a flight of shearwaters in Australia, in 1798, 150 million birds passed by in an hour and a half.

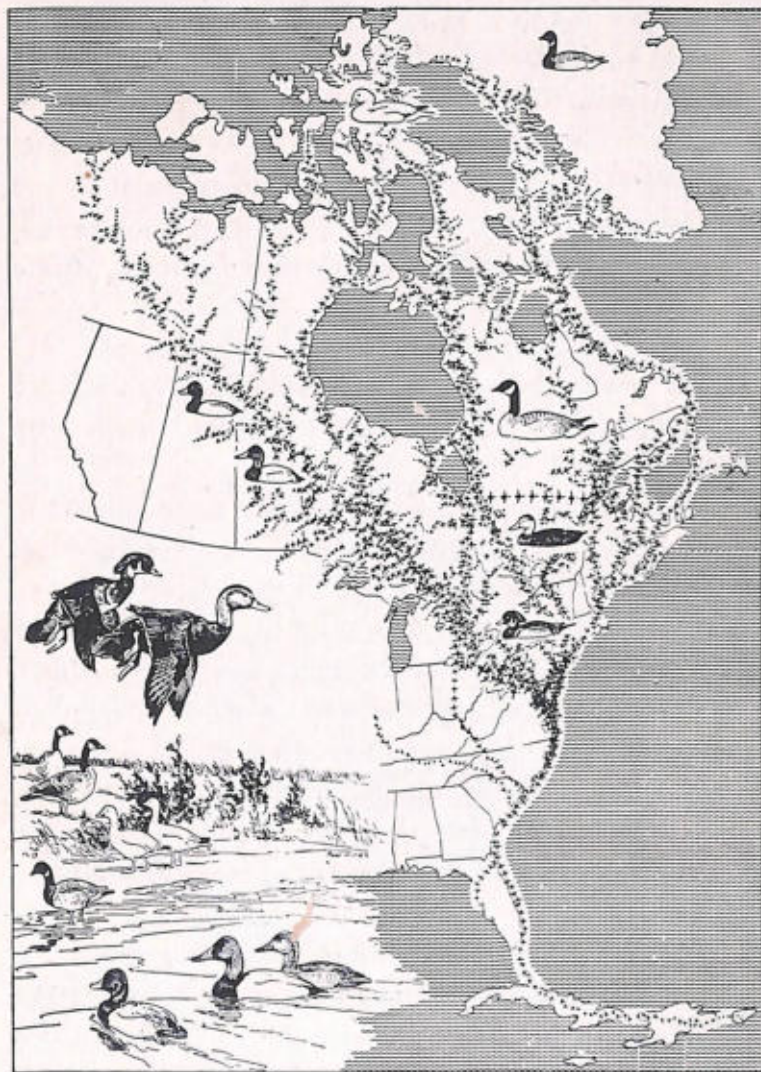
Any "path" over which many birds migrate is called a "flyway." Flyways have no real "length"; only the flights of birds have length. Flyways have no width either. They are merely routes most often used by different kinds of birds in their migrations.

In North America, there are four main flyways in a north and south direction: the Atlantic, Mississippi, Central, and Pacific Flyways.

Along the Atlantic Flyway, many birds follow the edge of the ocean. Great numbers of them collect at such places as Cape Cod, in Massachusetts; Cape May, in New Jersey; and Cape Hatteras, in North Carolina.

Some stop in the southern United States or on islands of the West Indies, but others go on to South America, flying across the Caribbean Sea. So many bobolinks use this flyway to their winter homes south of the Equator that it is sometimes called the "bobolink route."

Farther inland, but still on the Atlantic Flyway, birds such as hawks migrate along mountain ridges, which are excellent lookout points from which human beings can watch great flights of birds. Hawk Mountain, in Pennsylvania, is one such ridge. When cold weather



Atlantic flyway

comes down out of Canada, it drives before it thousands of hawks and other birds. These pass over the mountains and valleys of Pennsylvania, and especially over Hawk Mountain, creating one of the finest views on any flyway.

The Mississippi Flyway extends from the northern coast of Alaska to the southern part of South America. It is not likely, however, that any bird follows it all the way.

The Mississippi Flyway is an easy route to travel because there are no mountain ranges in the way—not even many low hills. Moreover, forests and rivers offer shelter and food.

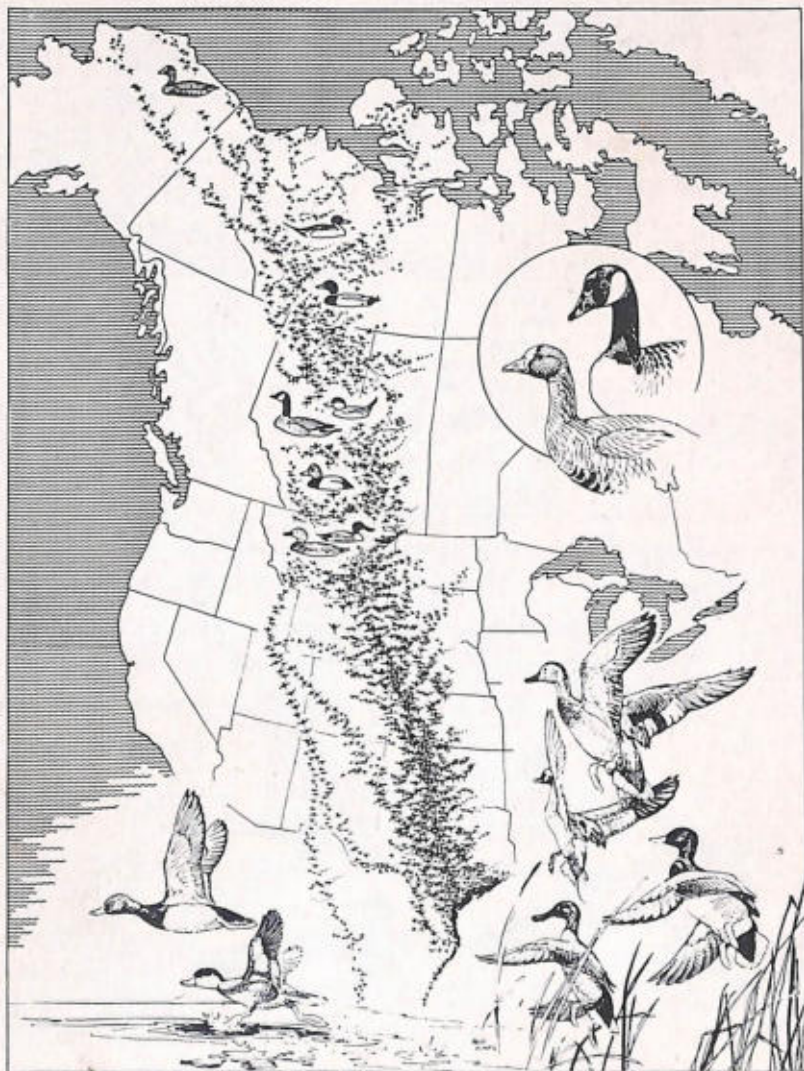
Along the Central Flyway, birds fly south from Canada or the United States over plains and deserts and beside the Rocky Mountains to spend the winter in Texas, perhaps, or in Mexico. Not as much water is found along this flyway as along the others, which is why birds sometimes gather in very large numbers on the few lakes and rivers—a thrilling sight to human observers.

The Pacific Flyway, along the western shore of North America, is usually warm and wet in winter, and some birds spend the winter there instead of going to southerly regions.

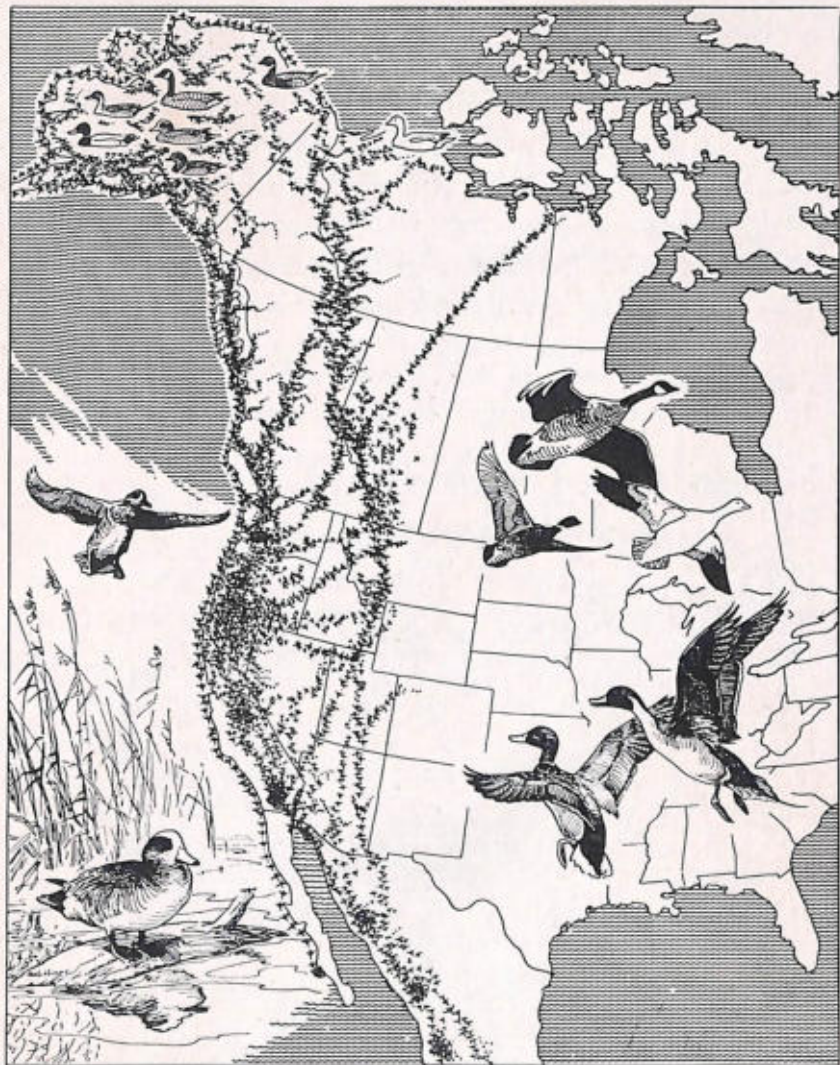
East and west of these four flyways are the ocean routes. Flyways across the ocean are much harder to describe because few people ever see the birds that migrate over water. Petrels, shearwaters, auks, and murrees spend so much of their lives over the ocean that men usually do



Mississippi flyway



Central flyway

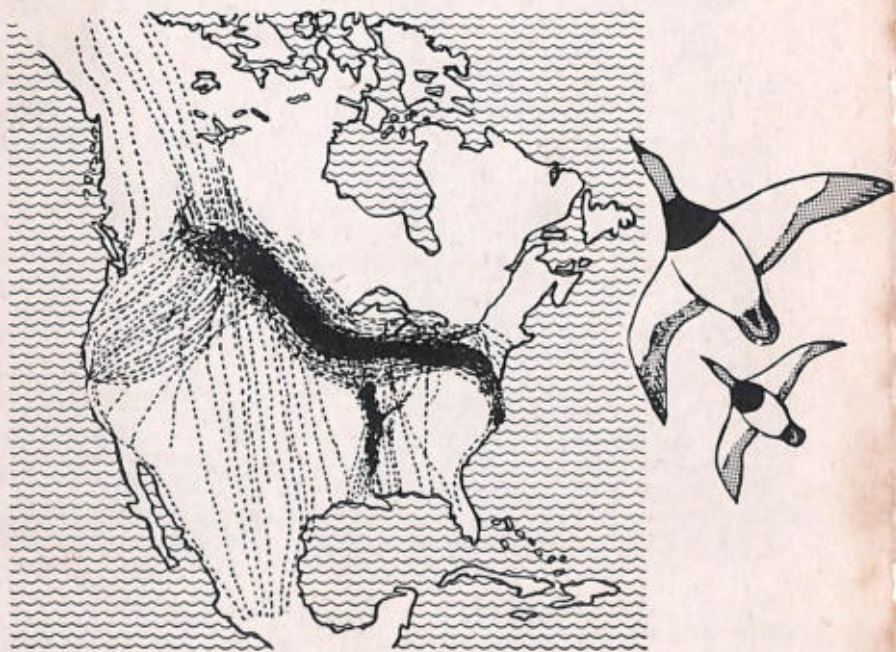


Pacific flyway

not see them until they come to land to nest. The flyways they follow are little known.

While the four main flyways in North America lie in a north and south direction, there are several birds, such as the canvasback and the evening grosbeak, that migrate east and west as well. Young California gulls raised at Great Salt Lake, in Utah, migrate westward to the Pacific coast. As they do not go far to the south, they do not strike much change in temperature during their migrations.

Canvasback ducks and their migration route

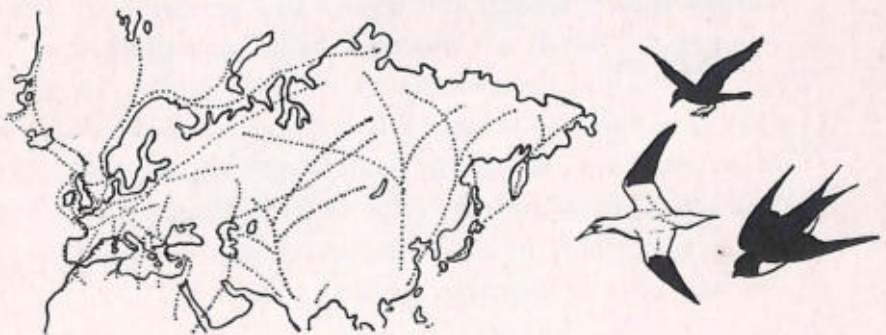


In Europe, the major flyways run from north to south and from east to west. Birds that migrate mostly over land on their way to Africa cross the Strait of Gibraltar or the Suez Canal. To reach these places they must fly either toward the east or toward the west. Certain wheatears migrate west and southwest over thousands of miles of Asia to get to Africa. Other birds, of course, migrate from Europe directly south across the Mediterranean Sea.

Whether they fly across water or around it depends upon the habits of each kind of bird. In the course of evolution, many groups of animals have taken on certain habits of migration. Therefore, one does not always migrate as another does, or follow the same routes.

White storks of Europe, for example, are birds with split routes of migration, one around the eastern and one around the western end of the Mediterranean Sea. Most

Starling, gannet, and swallow and European-African flyway

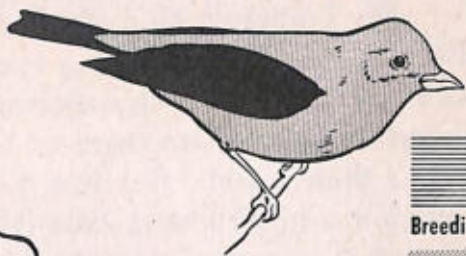
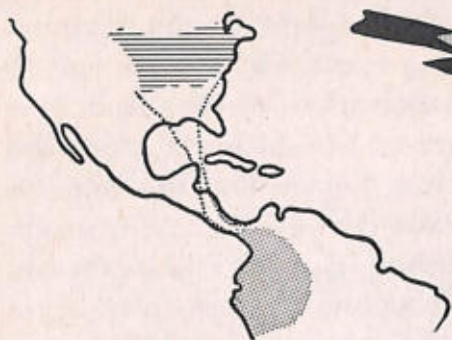


storks use the eastern route, through Turkey and Egypt. They would go straight south except that they are not used to crossing large bodies of water. As a rule, storks do not go out over water unless the other shore is in sight, and with good reason. They do not often flap their wings, but fly with their wings spread out, making use of rising currents of air to stay aloft. There are many such currents above the land, but fewer above the ocean.

Some white storks go all the way to South Africa, but most spend the winter in the central part of Africa. They wander in search of locusts, one of their favorite foods, and in spring return north by the same routes used in going south.

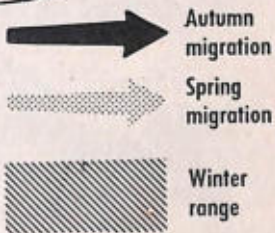
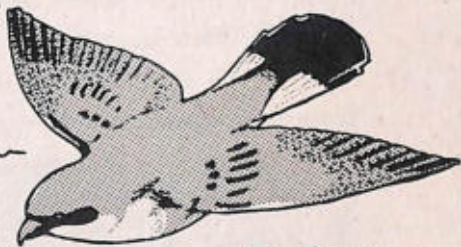
Besides the split migration routes of storks, there are wide and narrow routes of other birds. The bobolink, for example, has a wide migration route, but that of the scarlet tanager is narrow. Tanagers nest as far north as Canada, in a region 2,000 miles wide but, when migrating south, their route in Central America narrows to a width of only 100 miles. After crossing the Isthmus of Panama, they spread out again and scatter over their wintering grounds in Colombia, Ecuador, and Peru.

Terns and shearwaters, as we know, make "loop migrations" over the ocean. The red-backed shrike does the same over land, flying out from Africa across Arabia and Turkey, and around the Alps to its nesting place in Europe, and then, in autumn, across the Mediterranean Sea and back to southern Africa.



Scarlet tanager and its range

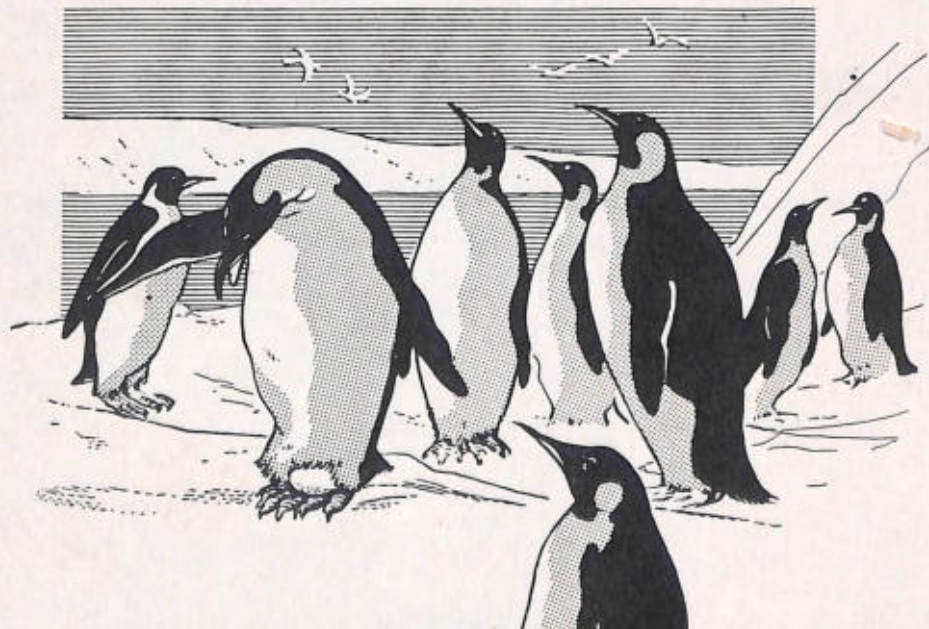
Range, and autumn and spring migration routes of red-backed shrike



For a different kind of route, consider the penguins. Because they cannot fly, they migrate by walking and by swimming on and under the surface of the ocean. It is therefore hard to see them or to find out a great deal about their travels. But it is known that the emperor penguin, a giant among Antarctic penguins, does its migration "backwards." Most birds lay their eggs at the end of winter, but the mother penguin lays hers when winter begins. The father keeps the egg warm by placing it on top of his feet so that a fold of skin protects it.

For nine weeks he incubates the egg and then, as winter wanes a bit, the penguins and their young migrate northward, riding on rafts of ice or swimming with the icy currents. They spend the summer on the ocean. With the approach of winter they once again come back toward the ice on shore and begin another of their strange migrations.

Emperor penguins, with the male keeping the egg warm



SCIENCE AND CONSERVATION

In almost every month of the year it is possible to see migrating birds in North America. There are not as many, of course, as there used to be. Millions of birds, such as pigeons and waterfowl, have been shot. Certain kinds of birds, such as passenger pigeons, have been so widely hunted and killed that they are gone forever. They have become extinct.

Millions more, in swamps, marshes, and forests, had to leave because their homes were destroyed by men to make way for houses, highways, and factories.

Today, however, there are enough other birds on the flyways to make the study of migration interesting and exciting. One of the best ways to study migration is to run, or help to run, a station for banding birds. This is a place, very possibly in one's own back yard, where birds are captured alive in nets or cages so that they may be banded. Once this is done, they are set free.

A band is a lightweight metal ring that is attached to the leg of the bird. Printed on it are tiny numbers that tell when and where the bird was banded.

Each year, more than half a million birds are banded in North America, and a larger number in Europe. Only a few of these birds are ever captured again, but when they are, the time and place of capture may tell us the distance each bird flew and perhaps how quickly it arrived. That information is helpful in making maps of the travels of birds across the surface of the earth. Banding may tell us how long birds live, how far they fly, how strong is their homing ability, and how migration routes are changing. But banding tells us nothing of the bird's adventures along the way, and these we must learn more about.

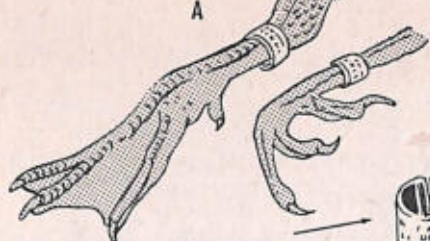
Banding may not be done by persons less than eighteen years of age, and they must obtain a permit from the Bird Banding Laboratory, Migratory Bird Population Station, Patuxent Wildlife Center, Laurel, Maryland. This is part of the Fish and Wildlife Service, United States Department of the Interior.

To obtain a banding permit, the bander must know by sight what kinds of birds are found in the region where he lives. Instructions for trapping, handling, and banding must be read and understood before anyone tries to band wild birds.

Birds are not the only animals that are banded. Fish famous for their migrations are salmon, shad, alewife, cod, halibut, bluefin, tuna, and albacore, and their migrations are studied by tagging. Tags of metal or plastic are fixed on the fish in such a way that they will not be

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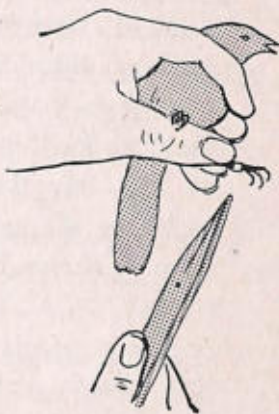
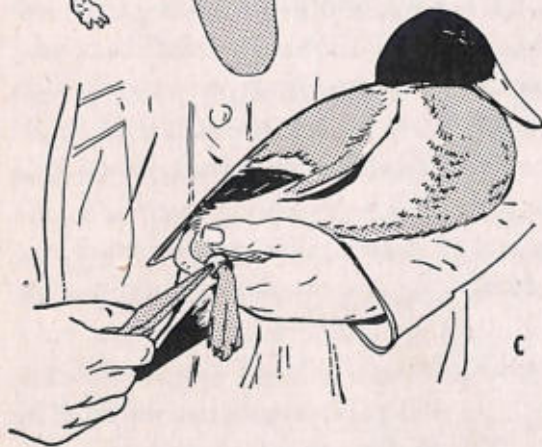


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A: sizes and types of bands for different-sized birds; B: penguin bands, flipper bands, and, at far right, a leg band;
C: methods of banding

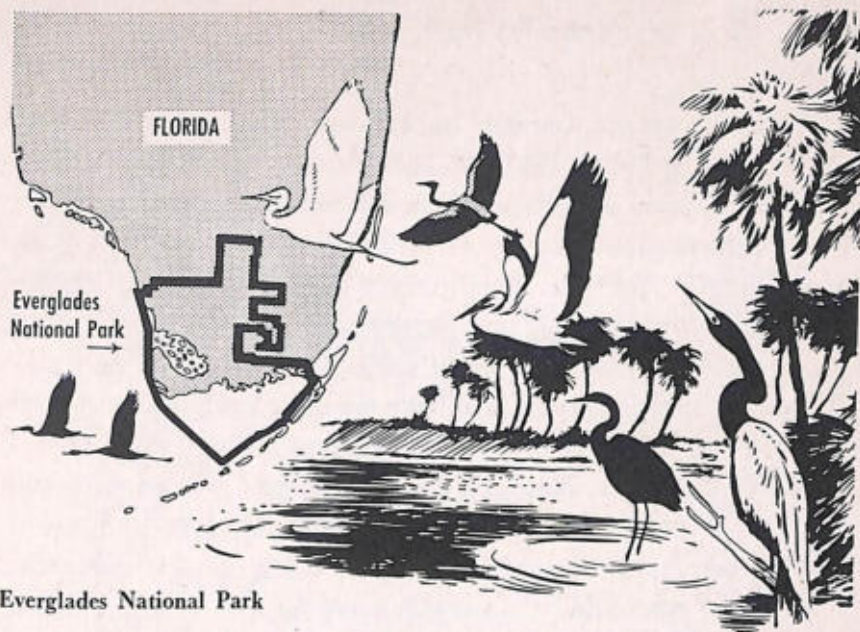
lost. There have also been experiments with tags that contain small radio transmitters.

Tagging by means of harmless harpoons has helped men to find out more about the travels of whales. And we have already mentioned the tagging of bats and butterflies.

New ways of tagging are being tried these days. The California Fish and Game Department has colored the feathers of geese a brilliant pink, green, or yellow in order to follow their flight. Within a season, of course, the birds will molt and shed their feathers, but until they do they are easy to see and can be studied as they come and go.

As long as there are migratory birds and other animals in the world, they will probably travel back and forth on their amazing journeys. And yet, even though migrations have been going on for thousands of years, they can be stopped by careless or thoughtless men who do not remember that to save an animal we must save its home. If too many of their homes are destroyed, the animals themselves will be destroyed and thus become extinct.

Fortunately, some of the wild lands to which migrating animals go to nest or to live are being saved. The United States has 300 wildlife refuges, most of which have been established to safeguard migratory birds. The 300 refuges cover nearly 28,000,000 acres of land, and there are refuges in most states of the nation. (Further



Everglades National Park

information about wildlife refuges in the United States may be obtained from the Fish and Wildlife Service, Department of the Interior, Washington, D.C. 20240.) The Tule Lake and Klamath refuges of Oregon and California, for example, protect some 7,000,000 waterfowl that gather there on annual migrations.

But as more people move into forests or drain the water from marshes where birds live, more refuges will be needed to protect the homes of the animals.

The national parks also contain lands that are kept in their natural state. People are urged to visit these parks, but their actions and visits are regulated by law so that the animals and their homes are not destroyed. There are more than 210 parks and other sites, all of which add up to 26,000,000 acres. Yellowstone in Wyo-

ming, Grand Canyon in Arizona, Great Smoky Mountains in North Carolina and Tennessee, and Everglades in Florida are examples of national parks, about which information may be obtained from the National Park Service, Dep't of the Interior, Washington, D.C., 20240. In addition, there are more than 2,000 state parks. Ask the State Park Service in each capital about these.

Other nations also have set aside national parks and refuges. Turkey, for one, has established the Manyas Bird Paradise National Park to protect places where 2,000 pairs of birds nest and where birds may be seen both in winter and during migration. Perhaps some of these have descended from birds seen by Emperor Frederick and Pierre Belon so many years ago.

All these efforts to save the homes of wild animals are not enough, however. It takes the work of Audubon Societies, wilderness clubs, and of other groups and individuals to do the job well and to let the United States Congress know about animals that are in danger of being shot or crowded out of their homes.

This is not an easy task. It is necessary for many persons to read, to learn, to observe, to band, to join or to form clubs, and to do other work on behalf of the animals. If we would save and study animals on the move, or for that matter if we would save any animals at all, then we must move, too. Every hour of effort will be worthwhile if, as a result, the animals of the world remain free to come and go, as they have for thousands of years, on their marvelous journeys of migration.

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