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Some New Facts About the Migration of Birds ^a

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WHAT becomes of our summer birds? Where do they spend the winter? By what routes do they travel to their destinations? How do they find their way? For many centuries these and similar questions have puzzled the brain of man. In default of exact knowledge, fanciful theories have been advanced, such as that swallows hibernate in the mud, and that small birds cross the Mediterranean as passengers on the backs of cranes. Such notions have held their own well into modern times. Scarcely a hundred years have elapsed since systematic knowledge on the subject began to accumulate, and only in the last half century has there resulted any noteworthy progress toward a solution of the questions of migration.

For nearly twenty years the Biological Survey has been accumulating data on the migration of birds. Its own field naturalists, whose visits have extended over the North American Continent from Guatemala to the Arctic Circle, have furnished voluminous notes, besides which the assistance of ornithologists throughout the country has been enlisted, so that reports are received in the spring and fall of each year from hundreds of observers. These reports give, for each species, the date when the bird was first seen, when it became common, and when it disappeared. Light-house keepers also have supplied valuable information concerning the destruction of birds at their lights. The facts thus gathered

^a From Yearbook of Department of Agriculture for 1903. This article is of such general interest and contains so much new information, that it is here reprinted, with little alteration, for the benefit of readers of THE CONDOR, and with the consent of Prof. Cooke and the Biological Survey.—ED.

from these various sources form the largest amount of material on bird migration ever collected in this country, and permit broader and safer generalizations than have heretofore been possible.

CAUSES OF MIGRATION.

For more than two thousand years the phenomena of bird migration have been noted; but while the extent and course of the routes traversed have of late become better known, no conclusive answer has been found to the question, why do birds migrate? Some dismiss the subject with the statement that fall migration is caused by failure of the food supply, spring migration by love of home. All are familiar with the rush of waterfowl northward so early that they are often forced by storms to retrace their flight; and all know that robins, bluebirds, and swallows, following closely in the rear, sometimes lose hundreds out of their flocks by cold and starvation. If strong home love causes these birds thus to hazard their lives, why do they desert their home at the earliest possible moment; and if fall migration is caused by lack of food, why does it commence when food is most abundant? Data recently collected at the Florida light-houses by the Biological Survey show that southward migration begins at least by the 10th, and probably by the 1st of July, insect-eating birds departing when their food supplies are most plentiful, and seed eaters just before the heyday of harvest.

The broad statement can be made that the beginnings of migration ages ago were intimately connected with periodic changes in the food supply, but this motive is at present so intermingled with others unknown, or but imperfectly known, that migration movements seem now to bear little relation to the abundance or absence of food.

HOW DO BIRDS FIND THEIR WAY?

How do birds find their way over the hundreds or thousands of miles between the winter and summer homes? Among day migrants sight is probably the principal guide, and it is noticeable that these seldom make the long single flight so common with night migrants. Sight undoubtedly plays a part in guiding the night journeys also; on clear nights, especially when the moon shines brightly, migrating birds fly high, and the ear can scarcely distinguish their faint twitterings; if clouds overspread the heavens, the passing flocks sink their course nearer to the earth, and their notes are much more distinctly heard; and on very dark nights one may even hear the flutter of vibrant wings but a few feet overhead. So far as known, birds never intentionally migrate above the clouds, and when suddenly formed vapor cuts them off from sight of the earth, they lower their flight until the friendly landscape is again visible. Nevertheless, something besides sight guides these travelers in the upper air. In Alaska a few years ago members of the Biological Survey on the Harriman expedition went by steamer from the island of Unalaska to Bogoslof Island, a distance of about sixty miles. A dense fog had shut out every object beyond a hundred yards. When the steamer was half way across, flocks of murres, returning to Bogoslof after long quests for food, began to break through the fog wall astern, fly parallel with the vessel, and disappear in the mists ahead. By chart and compass the ship was heading straight for the island; but its course was no more exact than that taken by the birds. The power which carried them unerringly home over the ocean wastes, whatever its nature, may be called a sense of direction. It is probable that this faculty is exercised during migration.

Reports from light-houses in southern Florida show that birds leave Cuba on

cloudy nights when they can not possibly see the Florida shores, and safely reach their destination, provided no change occurs in the weather. But if meantime the wind changes or a storm arises to throw them out of their reckoning, they become bewildered, lose their way, and fly toward the light-house beacon. Unless killed by striking the lantern, they hover near or alight on the balcony, to continue their flight when morning breaks, or, the storm ceasing, a clear sky allows them once more to determine the proper course.

Birds flying over the Gulf of Mexico to Louisiana, even if they ascended to the height of five miles, would still be unable to see a third of the way across. Nevertheless this trip is successfully made twice each year by countless thousands of the warblers of the Mississippi Valley.

A favorite belief of many American ornithologists is that coast lines, mountain chains, and especially the courses of the larger rivers and their tributaries, form well-marked highways along which birds return to previous nesting sites. According to this theory a bird breeding in northern Indiana would in its fall migration pass down its own little rivulet to the nearest creek, along this to the Wabash River, thence to the Ohio, and finally reaching the Mississippi, would follow its course to the Gulf of Mexico; and would use the same route reversed for the return trip in the spring. The fact is that each county in the Central States contains nesting birds, the different species of which at the beginning of the fall migration scatter toward half the points of the compass. Indeed, it would be safe to say "all the points of the compass," as some young herons preface their regular journey south with a little pleasure trip to the unexplored North.

In the fall thousands of birds reared in Indiana, Illinois and northwestward visit South Carolina and Georgia, cutting directly across the valley of the Ohio and the main chain of the Allegheny Mountains. Palm warblers from New England and others from the Northern Mississippi Valley both pass in the fall through Georgia, but by courses approximately at right angles to each other; and the Connecticut warbler seeks variety by choosing different routes for the spring and fall, each course in part being at right angles to the other. The truth seems to be that birds pay little attention to natural physical highways, except when large bodies of water force them to deviate from the desired course. Probably there are many short zigzags from one favored feeding spot to another, but the general course between the summer and winter homes is as straight as the birds can find without missing the usual stopping places.

CASUALTIES DURING MIGRATION.

Migration is a season full of peril for myriads of winged travelers, especially for those that cross large bodies of water. Some of the shore birds, such as the plover and curlew, which take long ocean voyages can rest on the waves if overtaken by storms, but woe to the luckless warbler whose feathers once become water-soaked!—a grave in the ocean or a burial in the sand of the beach is the inevitable result. Nor are such accidents infrequent. A few years ago on Lake Michigan a storm during spring migration piled many birds along the shore. If such a mortality could occur on a lake less than 100 miles wide, how much greater might it not be during a flight across the Gulf of Mexico. Such a catastrophe was once witnessed from the deck of a vessel 30 miles off the mouth of the Mississippi River. Large numbers of migrating birds, mostly warblers, had accomplished nine-tenths of their long flight and were nearing land when they were caught by a "norther" with which most of them were unable to contend, and falling into the Gulf were drowned by hundreds. During migration, birds are

peculiarly liable to destruction by striking high objects. A new tower in a city kills many before the survivors learn to avoid it. The Washington monument has caused the death of many little migrants; and though the number of its victims has decreased of late years, yet on a single morning in the spring of 1902 nearly 150 lifeless bodies were strewn around its base.

Bright lights attract birds from great distances. While the torch in the Bartholdi Statue of Liberty in New York Harbor was kept lighted, the sacrifice of life it caused was enormous, even reaching a maximum of 700 birds in a month. A flashing light frightens birds away and a red light is avoided by them as if it were a danger signal, but a steady white light looming out of the mist or darkness seems to act like a magnet and draws the wanderers to destruction. Coming from any direction, they veer around to the leeward side, and then, flying against the wind, dash themselves against the pitiless glass.

DISTANCE OF MIGRATION.

The length of the migration journey varies enormously. Some birds do not migrate at all. Many a cardinal, Carolina wren, and bobwhite rounds out its whole contented life within ten miles of its birthplace. Other birds, for instance, the pine warbler and the blackheaded grosbeak, do not venture in winter south of the breeding range, so that with them the fall migration is only a withdrawal from the northern and a concentration in the southern part of the summer home—the the warbler in about a fourth and the grosbeak in less than an eighth of the summer area.

The next variation is illustrated by the robin, which occurs as a species in the middle districts of the United States throughout the year, in Canada only in summer, and along the Gulf of Mexico only in winter. Probably no individual robin is a continuous resident in any section; but the robin that nests, let us say, in southern Missouri, will spend the winter near the Gulf, while his hardy Canada-bred cousin will be the winter tenant of the abandoned summer home of the southern bird.

Most migrants entirely change their abode twice a year, and some of them travel immense distances. Of the land birds, the common eastern nighthawk seems to deserve first place among those whose winter homes are widely distant from the breeding grounds. Alaska and Patagonia, separated by 115 degrees of latitude, are the extremes of the summer and winter homes of the bird; and each spring many a nighthawk travels the 5,000 miles that lie between. But some of the shore birds are still more inveterate voyagers. These cover from 6,000 to 8,000 miles each way, and appear to make traveling their chief occupation.

ROUTES OF MIGRATION.

Birds often seem eccentric in choice of route, and many land birds do not take the shortest line. The fifty species from New England that winter in South America, instead of making the direct trip over the Atlantic, involving a flight of 2,000 miles, take a slightly longer route which follows the coast to Florida, and passes thence by island or mainland to South America. What would seem at first sight to be a natural and convenient migratory highway extends from Florida through the Bahamas or Cuba to Haiti, Porto Rico, and the Lesser Antilles, and thence to South America. The bird that travels by this route need never be out of sight of land; resting places may be had at convenient intervals, and the distance is but little longer than the water route. Yet, beyond Cuba, this highway is little used. About twenty-five species continue as far as Porto Rico and re-

main there through the winter. Only adventurers out of some six species gain the South American mainland by completing the island chain. The reason seems not far to seek—scarcity of food. The total area of all the West Indies east of Porto Rico is a little less than that of Rhode Island. Should a small proportion only of the feathered inhabitants of the eastern part of the United States select this route, not even the luxuriant fauna and flora of the Tropics could supply their needs.

A still more direct route, but one requiring longer single flights, stretches from Florida to South America via Cuba and Jamaica. The 150 miles between Florida and Cuba are crossed by tens of thousands of birds of some sixty different species. About half the species take the next flight of ninety miles to the beautiful Jamaican mountains. Here a 500-mile stretch of islandless ocean confronts them, and scarcely a third of their number leave the forest-clad hills for the unseen beyond. Chief among these dauntless voyagers is the bobolink, fresh from despoiling the Carolina rice fields, waxed fat from his gormandizing, and so surcharged with energy that the 500-mile flight to South America on the way to the waving pampas of southern Brazil seems a small hardship. Indeed, many bobolinks appear to scorn the Jamaican resting point and to compass in a single flight the 700 miles from Cuba to South America. With the bobolink is an incongruous company of traveling companions—a vireo, a kingbird, and a night-hawk that summer in Florida; the queer chuck-will's-widow of the Gulf States; the New England cuckoos; the trim Alice thrush from Quebec; the cosmopolitan bank swallow from frozen Labrador, and the black poll warbler from far-off Alaska. But the bobolinks so far outnumber all the rest of the motley crew that the passage across the Caribbean Sea from Cuba to South America may with propriety be called the "bobolink route." Occasionally a mellow-voiced wood thrush joins the assemblage, or a green-gold tanager which will prepare in the winter home its next summer livery of flaming scarlet. But the "bobolink route" as a whole is not popular with other birds, and the many that traverse it are but a fraction of the thousands of North American birds that spend the winter holiday in South America.

The main traveled highway is that which stretches from northwestern Florida across the Gulf, continuing the southwest direction which most of the birds of the Atlantic coast follow in passing to Florida. A larger or smaller proportion of nearly all the species bound for South America take this roundabout course, quite regardless of the 700-mile flight over the Gulf of Mexico. It might seem more natural for the birds to make a leisurely trip along the Florida coast, take a short flight to Cuba, and thence a still shorter one of less than 100 miles to Yucatan—a route only a little longer and with much less of exposure. Indeed, the earlier naturalists, finding the same species both in Florida and in Yucatan, took this probable route for granted, and for years it has been noted in ornithological literature as one of the principal migration highways of North American birds. As a fact it is almost deserted except by a few swallows, some shore birds, and an occasional land bird storm-driven from its intended course, while over the Gulf route, night after night, for nearly eight months in the year, myriads of hardy migrants wing their way through the darkness toward an unseen destination.

West of the Florida route the Gulf is crossed by migrating birds at its widest point, from Louisiana southward. Still farther west, the numerous species of Plains and Rocky Mountains birds choose Mexico and Central America for the winter, and make a land journey of short stages that extends over several weeks.

As already stated, the longest migration route is taken by some of the wading birds, especially the American golden plover, the Eskimo curlew, and the turn-

stone. The journey of the plover, which is typical, is wonderful enough to be given in detail. In the first week of June they arrive at their breeding grounds in the bleak, wind-swept "barren grounds" above the Arctic Circle, far beyond the tree line. Some even venture 1,000 miles farther north (Greely found them at latitude 81°). While the lakes are still icebound, they hurriedly fashion shabby little nests in the moss only a few inches above the frozen ground. By August they have hastened to Labrador, where, in company with curlews and turnstones, they enjoy a feast. Growing over the rocks and treeless slopes of this inhospitable coast is a kind of heather, the crowberry, bearing in profusion a juicy black fruit. The extravagant fondness shown for the berry by the birds, among which the curlew, owing to its greater numbers, is most conspicuous, causes it to be known by the natives as the "curlew berry." The whole body of the curlew becomes so saturated with the dark, purple juice that birds whose flesh was still stained with the color have been shot 1,000 miles south of Labrador.

After a few weeks of such feasting, the plovers become excessively fat and ready for their great flight. They have reared their young under the midnight sun, and now they seek the Southern Hemisphere. After gaining the coast of Nova Scotia they strike straight out to sea, and take a direct course for the easternmost Islands of the West Indies. Eighteen hundred miles of ocean waste lie between the last land of Nova Scotia and the first of the Antilles, and yet 600 more to the eastern mainland of South America, their objective point. The only land along the route is the Bermuda Islands, 800 miles from Nova Scotia. In fair weather the birds fly past the Bermudas without stopping; indeed they are often seen by vessels 400 miles or more east of these islands. When they sight the first land of the Antilles the flocks often do not pause, but keep on to the larger islands and sometimes even to the mainland of South America. Sometimes a storm drives them off the main track, when they seek the nearest land, appearing not infrequently at Cape Cod and Long Island.

A few short stops may be made in the main flight, for the plover swims lightly and easily and has been seen resting on the surface of the ocean; and shore birds have been found busily feeding 500 miles south of Bermuda and 1,000 east of Florida, in the Atlantic, in that area known as the Sargasso Sea, where thousands of square miles of sea weed teem with marine life.

Though feathered balls of fat when they leave Labrador and still plump when they pass the Bermudas, the plovers alight lean and hungry in the Antilles. Only the first, though the hardest, half of the journey is over. How many days it has occupied may never be known. Most migrants either fly at night and rest in the day or vice versa, but the plover flies both night and day.

After a short stop of three or four weeks in the Antilles on the northeastern coast of South America, the flocks disappear, and later their arrival is noted at the same time in southern Brazil and the whole Prairie region of Argentina almost to Patagonia. Here they remain from September to March (the summer of the Southern Hemisphere), free from the responsibilities of the Northern summer they have left. The native birds of Argentina are at the time engrossed in family cares; but no wayfarer from the north nests in the south.

After a six-months' vacation the plovers resume the serious affairs of life and start back toward the Arctic, but not by the same course. Their full northward route is a problem still unsolved. They disappear from Argentina and shun the whole Atlantic coast from Brazil to Labrador. In March they appear in Guatemala and Texas. April finds their long lines trailing across the prairies of the Mississippi Valley; the first of May sees them crossing our northern boundary;

and by the first week in June they reappear at their breeding grounds in the frozen North. What a journey! Eight thousand miles of latitude separates the extremes of their elliptical course, and 3,000 miles of longitude constitutes the shorter diameter, and all for the sake of spending ten weeks on an Arctic coast!

ARE BIRDS EXHAUSTED BY A LONG FLIGHT?

During the spring migration of 1903 two skilled ornithologists spent the entire season near the coast of northwestern Florida, visiting every sort of bird haunt. They were eminently successful in the long list of species identified, but their enumeration is still more remarkable for what it does not contain. About twenty-five species of the smaller land birds of the eastern part of the United States, including a dozen common species, were not seen. Among these were the chat, the redstart, and the indigo bunting, three species that are abundant throughout the whole region to the northward. The explanation of this seems to be that these birds, on crossing the Gulf of Mexico, flew far inland before alighting, and thus passed over the observers. It would thus seem that the popular idea that birds find the ocean flight excessively wearisome, and that after laboring with tired pinions across the seemingly endless wastes they sink exhausted on reaching terra firma, is not in accordance with the facts. The truth seems to lie in almost the opposite direction. Endowed by nature with wonderful powers of aerial locomotion, under normal conditions many birds not only cross the Gulf of Mexico at its widest point, but may even pass without pause over the low, swampy coastal plain to the higher territory beyond. So little averse are birds to an ocean voyage that many fly from eastern Texas to the coast of southern Mexico, though this 400 miles of water journey hardly shortens the distance of travel by an hour's flight. Thus, the birds avoid the hot, treeless plains and scant provender of southern Texas by a direct flight from the moist, insect-teeming forests of northern Texas to similar country in southern Mexico. Under favorable conditions, birds can fly practically where, when, and how they please; consequently their choice of route and the distance covered at a single flight are principally governed by the food supply.

RELATIVE POSITION DURING MIGRATION.

The relative position of the northern and southern groups of individuals as a species during the two yearly migrations is one of the doubtful points that late investigations help to elucidate. The supposition is that in the case of species which adopt what might be called normal fall migration, birds which nest farthest south migrate first and proceed to the southern end of the winter range; those that breed in the middle districts migrate next and occupy the middle of the winter range; and finally, those of the northern part of the breeding range migrate last, and remain the farthest north for the winter. In other words, the migration is a synchronous southward movement of the whole species, the different groups of individuals or colonies retaining in general their relative positions. This has been generally believed, but only of late has it been clearly proved as to any particular species.

An example or two will make this clear. The black and white creeper breeds from South Carolina to New Brunswick. In the southern part of its range it nests in April. New Brunswick, however, is scarcely reached by the earliest birds before the middle of May, as the species occupies about fifty days in crossing the breeding range. If sixty days are considered the shortest possible time in which such a bird can build a nest, rear the young, molt, and be ready for the return journey, then no New Brunswick black and white creeper is ready to start south

before the middle of July, and fifty days for the trip will bring the earliest migrants to the Gulf States in September. Yet both old birds and young of the year have been seen by the middle of July at Key West, Fla., 500 miles south of the breeding range, on August 10 in Costa Rica, and on August 21 on the northern coast of South America. These dates prove conclusively that these early migrants south of the United States could not have been birds from the northern part of the range, but must have been those of the southern part.

Black-throated blue warblers reach Cuba in the fall at just about the time that other migrants of the species appear in North Carolina. The inference is that the arrivals in Cuba are the birds that nested in the southern Alleghenies, while those appearing in North Carolina are from the latitude of northern New England or beyond. Redstarts and summer warblers arrive on the northern coast of South America so early (August 27 to September 2) as to prove that they represent the southern breeding birds. Indeed, these representatives of the species are seen in South America at just about the time the earliest of the northern breeding birds reach Florida.

Recent investigations have also shown that many species of birds do not follow this "normal" order of migration. The most southern-bred Maryland yellowthroats are almost nonmigratory, residing throughout the year in Florida; those breeding in the middle districts migrate only a short distance, while those of Newfoundland go to the West Indies, passing directly over the winter home of their fellows in the South. The red-winged blackbirds of the middle of the range in northern Texas are almost stationary, but are joined in winter by migrant redwings from the remote Mackenzie Valley. The palm warblers of the interior of Canada, in the course of their 3,000-mile journey from Great Slave Lake to Cuba, pass through the Gulf States early in October. After the bulk of these have passed, the palm warblers of the northeastern British provinces come slowly down to the Gulf States, and settle there for the winter, content with only a 1,500-mile trip. Some of the blackpoll warblers that pass in spring through Florida proceed northeast 1,000 miles to breed in northern New England, while others, traveling northwest more than 3,000 miles summer in Alaska. Among the Maryland yellowthroats that nest in western Pennsylvania are undoubtedly individuals that during the winter are scattered in the Gulf States, the West Indies, and even Central America. Enough examples have been given to show that no invariable rule, law, or custom exists in regard to the direction or distance of migration. The winter distribution can not be certainly determined from the summer home, nor does it positively indicate that home. Although a certain general tendency is observable, yet each species presents a separate problem, to be solved for the most part only by patient, painstaking observation and by the recognition of subspecies.

Spring migration has its own special features. No such synchronous movement occurs in the spring as has been described as "normal migration" in the fall. With many birds, possibly the majority of land birds, the first individuals of a species to appear in spring at a given locality are supposed to be old birds that nested there the previous year. The supposition is that these birds are followed by those that nested in the region just to the north; and that later, those of still more northern homes pass by; and that the last to appear will be those whose homes are in the most northern part of the breeding range. If, then, for any species, the southern nesting birds lead the van in both fall and spring migration, and the near guard in each case is composed of northern breeding birds, it follows that some time between October and April a transposal of their relative positions occurs; and that the more southern birds pass over the more northern ones, which

delay their migration, knowing that winter still holds sway in their summer dominions. Just when and where this transposal of relative position occurs is one of the problems of migration reserved for future solution. Nor is it yet settled whether the northern-bred birds remain strictly within their winter range until after their more southern congeners have passed by, or whether they begin an early migration at so slow a speed as soon to be overtaken and passed by their impetuous cousins.

Still later in the spring another transposal occurs. The northern birds pass across the southern portion of the breeding range, where the southernmost birds are already busy with their domestic duties. Spring migration seems to be therefore for some species a game of leapfrog—the southern birds first passing the northern, and the northern passing them in turn.

RELATION OF MIGRATION AND TEMPERATURE.

A popular notion exists that birds push northward to their summer homes as soon as weather conditions permit. This may be true of a few species, but certainly birds in general have no such habit. Some summer warblers that return to the Great Slave Lake region to breed, after spending the winter in Central and South America, arrive at their nesting grounds when the average daily temperature is about 47° F. According to the notion mentioned, these birds might be expected to move up the Mississippi Valley and on to their summer homes at the same time as the northward moving temperature of 47° F. But were this so, they would never leave the United States, for the average of the coldest month of the year at New Orleans is 54° F. As a matter of fact, the summer warblers of Great Slave Lake are probably too well content with the warm, humid, insect-laden air of the South to brave the arctic blasts before necessity compels. They linger in the Tropics so late that when they reach New Orleans, April 5, an average temperature of 65° F. awaits them. They now hasten; traveling north much faster than the spring does, they cover 1,000 miles in a month, and find in southern Minnesota a temperature of 55° F. In central Manitoba the average temperature they meet is 52° F., and when they arrive late in May at Great Slave Lake they have gained 5° more on the season. Thus, during the whole trip of 2,500 miles from New Orleans to Great Slave Lake, these birds are continually meeting colder weather. In fact, so fast do they migrate that in the fifteen days from May 11 to 25 they traverse a district that spring requires thirty-five days to cross. This outstripping of spring is habitual with all species that leave the United States for the winter, and also with most of the northern birds that winter in the Gulf States. Careful examination of the migration records of each species of the Mississippi Valley shows only six exceptions—Canada goose, mallard, pintail, common crow, red-winged blackbird and robin.

The robin as a species migrates north more slowly than the opening of the season; it occupies seventy-eight days for its trip of 3,000 miles from Iowa to Alaska, while spring covers the distance in sixty-eight days. But it does not follow that any individual bird moves northward at this leisurely pace. The first robins that reach a given locality in the spring are likely to remain there to nest, and the advance of the migration line must await the arrival of other birds from still farther south. Therefore, each robin undoubtedly migrates at a faster rate than the apparent movement of his species as a whole, and does not fall behind the advancing season. This is true of most, if, not all, of the other seemingly slow migrants. Late and rapid journeys of this kind offer certain advantages; fewer storms are encountered, the mortality rate is lowered, food is more plentiful along

the way, and the birds reach the nesting site full of energy, bubbling over with song, and in good condition to assume the cares and labors of house building and brood raising.

VARIATIONS IN THE SPEED OF MIGRATION.

The immense variation in the speed with which migrants travel different parts of the broad bird highway that extends from Gulf to Arctic Ocean, by way of the Mississippi and Mackenzie valleys, is a recently ascertained fact of special interest. The black-poll warbler furnishes one of the best examples of this. It winters in north central South America and migrates in April across the West Indies to Florida. From here some individuals pass on northwest to the Mississippi Valley, thence north to Manitoba, thence northwest to the valley of the Mackenzie, and thence almost due west to western Alaska. From the Gulf of Mexico to Minnesota a fairly eniform average speed of 30 to 35 miles per day is maintained; southern Indiana and Missouri are reached the first week in May, southern Iowa early in the second week, and southern Minnesota is entered by the middle of the month. Then comes a "spurt;" within another week the black-polls appear in the central part of the Mackenzie Valley, and the following week they arrive in northwestern Alaska, many individuals undoubtedly averaging more than 200 miles per day during the latter part of the journey. Thirty days are thus occupied in traveling the 1,000 miles from the Gulf of Mexico *north* to southern Minnesota, and scarcely half that time in traversing the 2,500 miles thence *northwest* to Alaska. The direction of migration is emphasized because this change of direction is intimately connected with the great increase of speed, as will be shortly explained.

A similar increase of speed is shown by many other species. The average speed of migration from New Orleans to southern Minnesota for all species is close to 23 miles per day. Sixteen species maintain a daily average of 40 miles from southern Minnesota to southern Manitoba, and from this point 12 species travel to Lake Athabasca at an average speed of 72 miles a day, 5 others to Great Slave Lake at 116 miles a day, and 5 more to Alaska at 150 miles a day.

The reason for these remarkable differences is not far to seek. The speed increases as the birds move northward because the advance of the seasons is more rapid in the northern interior than on and near the southern coast. The farther removed a district is from the ocean, the greater the extremes of its temperature. At New Orleans, La., the average daily temperature of January is 54° F., and that of July is 82° F., while at Winnipeg, Manitoba, the corresponding average temperatures are: January, -7° F., July, 66° F. Hence, while the temperature at New Orleans is rising 28 degrees, that at Winnipeg rises 73 degrees. Consequently, any given isotherm, as it moves north during the spring in the Mississippi Valley, continually increases the speed of its advance. The isotherm of 35° F., corresponding to the commencement of spring migration, advances north at a rate of 3 miles per day from January 15 to February 15, 10 miles daily during the next month, and 20 miles daily during the following month.

But an additional explanation must be sought for the wonderfully quickened speed with which the birds pass northwestward from Minnesota to the Mackenzie Valley. Along the eastern foothills of the Rocky Mountains isotherms travel north faster than at corresponding latitudes farther east. From February 15 to March 15 the isotherm of 35° F. (the line of spring) passes along the foothills from New Mexico to northern Colorado at the rate of 12 miles per day. During the next month, under the influence of the chinook winds, its rate of northward progress is

increased to 40 miles a day, so that by April 15 it has reached Lake Athabasca. Spring has come with a rush on this western interior country. The result is that during the height of the migration season, from the middle of April to the middle of June, the southern end of the Mackenzie Valley in the Province of Athabasca has just about the same temperature as the Lake Superior region 700 miles farther south.

These conditions, coupled with the diagonal course of the birds across this region of fast-moving spring, necessarily exert a powerful influence on bird migration. On March 1 the earliest robins reach southern Iowa, where they find an average daily temperature of about 34° F.; a month later they appear in central Minnesota and find the same temperature, birds and spring each having gone northward at the rate of 13 miles per day. Those robins that fly from eastern Minnesota and western Wisconsin to Lake Superior and Keewatin, by increasing their speed to 25 miles per day, arrive on April 21 at latitude 52° in southern Keewatin, still closely following the temperature of 34°. But by this date the 34° F. isotherm has reached central Athabasca, and the central Minnesota robins that travel to the Mackenzie Valley and Alaska must double and quadruple their speed as they take a northwestward diagonal, if they are to keep up with the season. Though robin migration does not quite do this, yet a speed of 70 miles per day is reached by the species in this northwestward flight²—more than three times the speed attained by the Keewatin birds.

THE UNKNOWN.

Interest in bird migration goes back to a remote period. Marvelous tales of the spring and fall movements of birds were spun by early observers, yet hardly less incredible are the ascertained facts. Much remains to be learned of migration; and it may be of interest to note a few of the mysteries which still occupy attention.

The chimney swift is one of the most abundant and best-known birds of the eastern part of the United States. With troops of fledglings, catching their winged prey as they go, and lodging by night in some tall chimney, the flocks drift slowly south, joining with other bands until on the northern coast of the Gulf of Mexico they become an innumerable host. Then they disappear. Did they drop into the water and hibernate in the mud, as was believed of old, their obliteration could not be more complete. In the last week in March a joyful twittering far overhead announces their return to the Gulf coast, but the intervening five months is still the swift's secret.

The mouse-colored bank swallows are almost cosmopolitan, and enliven even the shores of the Arctic Ocean with their graceful aerial evolutions. Those that nest in Labrador allow a scant two months for building a home and raising a brood, and by the first of August are headed southward. Six weeks later they are swarming in the vicinity of Chesapeake Bay, and then they, too, pass out of the range of our knowledge. In April they appear in northern South America, moving north, but not a hint do they give of how they came there. The rest of the species, those that nest to the south or west, may be traced farther south, but they, too, fail to give any clew as to where they spend the five winter months.

The familiar cliff swallow, which swarms over the western plains and breeds from Mexico to Alaska, spends the winter in Brazil and Argentina. It would be expected to reach the United States in spring first in southern Florida and Texas, later in the Rocky Mountains, and finally on the Pacific coast. As a matter of fact, the earliest records of the bird's appearance in spring come from northern central California, where it becomes common before the first arrivals are usually

noted in Texas or Florida. The route the species takes from Brazil to California is one of the yet unsolved migration puzzles.

The red-eyed vireo, the commonest and best known of its tuneful family, winters in Central America, from Guatemala to Panama. The advent of the species in spring at the mouth of the Mississippi and its even-paced passage at 20 miles per day for six weeks to the headwaters of the river are well attested by numerous records. But just about the time northern Nebraska is reached, and before they have appeared in any of the intervening country, red-eyed vireos are noted in south British Columbia, 1,000 miles to the northwest. Is the presence of the red eye in British Columbia to be explained by the theory that it suddenly flies 1,000 miles in a single night?

It is such problems as these that continually vex and fascinate the investigator.

Washington, D. C.

Pelicans Nesting at Utah Lake

BY REV. S. H. GOODWIN

EIGHT miles southwest of the Provo Resort, on Utah Lake, lies a small, low crescent-shaped ridge of land known as Rock Island. During the period of unusually high water, of the past spring, the major portion of this island was barely two feet above the water, while a part of it was considerably less. When visited by our party it was about two hundred yards in length by about thirty yards in width, at the widest point, while fully one hundred yards of the western horn of the island was under some three inches of water, above which rose a broken line of detached boulders. The principal part of this island is a limestone ledge with loose rocks and boulders scattered over the surface; about one-third of the eastern end is of gravel. The only vegetation consists of a few clumps of stunted willow, and a narrow, ragged fringe of tules along the northern edge.

Equipped with glass, gun, and camera a party of four of us laboriously made our way toward this island one June morning, for reports had come that hundreds of pelicans (*Pelecanus erythrorhynchos*) were nesting there for the first time in the history of the island. From time immemorial these strange, solemn birds had foraged on Utah Lake—where a few years ago many hundreds of them were killed for the small bounty offered by the state—but never before had they nested here. Apparently they preferred the larger and more secluded islands in Salt Lake, fifty miles to the north. We had loaded our plunder into a small, water-soaked sail-boat, made everything ready and set sail—but we did not sail, as not so much as one breath of air was stirring and as there was no promise of an immediate change for the better, we rowed the entire distance. After the two preachers had bent to the oars for more than an hour and a half, and the sun had painted flame-color exposed wrists and unprotected necks, our sailing-master—who by the way is an old "salt," and a descendant of generations of Scandinavian sea-rovers—cast his weather-eye toward the yet distant island and quaintly remarked: "I dinks ve vas nearder dot island dan ven ve started—I don' know." Encouraged by this heartening observation, the oarsmen renewed their efforts, and an hour later the boat touched the pointed end of the island.