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ROUTES OF BIRD MIGRATION.

BY WELLS W. COOKE.

I. MIGRATION ROUTE FROM MEXICO TO TEXAS BY WATER.

THROUGHOUT the broad expanse of level land between the Allegheny and the Rocky Mountains, bird migration is so uniform that a species is expected always to appear first at the more southern localities. An apparent exception to this rule is noted in the case of several species whose recorded dates of spring arrival in northern Texas are earlier than the corresponding dates many miles to the southward.

Thus the first Black and White Warblers (*Mniotilta varia*) were seen near Corpus Christi March 21 (average of five years), near San Antonio March 15 (average of seven years), and in northeastern Texas March 13 (average of four years). The distance from Corpus Christi to latitude 33° in northern Texas is 350 miles, a distance that ordinarily is passed over by the Black and White Warbler in about 17 days, since its average rate of travel in the Mississippi Valley is not far from 20 miles per day. This species therefore arrives in northern Texas some three weeks earlier than would be expected from the records of its spring appearance in southern Texas. The records for ten years give March 21 as the average date of arrival of the Parula Warbler (*Compsothlypis americana*) at San Antonio, while the corresponding date 300 miles farther north is March 14.

A probable explanation of such sets of records is that these early birds in northeastern Texas, have reached the northeastern coast of Texas by a flight across the Gulf of Mexico, and this long journey, performed in a single night, has carried them north earlier than their fellows which reach southern Texas by a slow land journey from Mexico.

The Worm-eating Warbler (*Helmitheros vermivorus*) is a not uncommon migrant in northeastern Texas and is well-known as a winter resident of eastern Mexico, north to Alta Mira. But this species is unknown in southern Texas, though the region from Corpus Christi to the Rio Grande has been carefully searched by competent ornithologists. Here then the birds apparently fly over water to northeastern Texas from the coast of the Gulf of Campeche, though the distance to their destination by land through northern Mexico and southern Texas would be but slightly longer. Evidently the birds do not shun a long trip over water.

The Chestnut-sided Warbler (*Dendroica pensylvanica*) is not uncommon along the whole coast of Texas, but is almost unknown in Mexico; the Mourning Warbler (*Geothlypis philadelphia*) is as common on the coast of Texas as anywhere in the United States, but has no certain record for Mexico; the Green-crested Flycatcher (*Empidonax virescens*) breeds in eastern Texas to Corpus Christi, and is known as a migrant south to the Rio Grande, but has only one record in Mexico west of Yucatan; the Red-eyed Vireo (*Vireo olivaceus*) is common in eastern Texas south to Corpus Christi, then its numbers become rapidly less, until south of the Rio Grande it has been but twice recorded west of Yucatan. Such records seem to show conclusively that the larger portion of the birds of these species reach the northeastern coast of Texas by a flight across the Gulf of Mexico.

The above remarks show three different kinds of records, each of which leads to the conclusion that some individuals of the species fly across the Gulf of Mexico to northeastern Texas. More or less strong reasons of a similar nature exist for believing that some individuals of each of the following species, use this same migration route.

Migration Route from Mexico to Texas by Water.

Kingbird (*Tryannus tryannus*).
Green-crested Flycatcher (*Empidonax virescens*).
Bobolink (*Dolichonyx oryzivorus*).
Scarlet Tanager (*Piranga erythromelas*).
Red-eyed Vireo (*Vireo olivaceus*).
Black and White Warbler (*Mniotilta varia*).
Prothonotary Warbler (*Protonotaria citrea*).
Worm-eating Warbler (*Helmitheros vermivorus*).
Golden-winged Warbler (*Helminthophila chrysoptera*).
Parula Warbler (*Compsothlypis americana* subsp. ?).
Cerulean Warbler (*Dendroica cerulea*).
Chestnut-sided Warbler (*Dendroica pensylvanica*).
Bay-breasted Warbler (*Dendroica castanea*).
Kentucky Warbler (*Geothlypis formosa*).
Mourning Warbler (*Geothlypis philadelphia*).
Wilson Thrush (*Hylocichla fuscescens*).
Gray-cheeked Thrush (*Hylocichla aliciæ*).

II. Migration Route between Florida and Yucatan.

The senior editor of 'The Auk' in reviewing my paper on 'Some new Facts about the Migration of Birds' makes this statement in regard to the routes of migration across the Gulf of Mexico: "It would be interesting to know to what extent some of these generalizations rest on negative evidence, for stations along the eastern coast of Mexico, including Yucatan, where observations have been made bearing on the migration of birds are certainly few and far between, and cover only short periods."

The paper in question did not seem the proper place for presenting the original data that served as the basis for these statements. These data are now given that each one may judge for himself as to the correctness of the conclusions.

As a preliminary it may be stated that the dates of spring arrival in Louisiana and Mississippi are, for most species, earlier than the time at which these same species appear in northern Florida and northern Texas. This seems conclusive evidence that the Louisiana and Mississippi birds reach the United States by a flight across the Gulf of Mexico. Indeed, except in the case

of the Swallows, there is no evidence to show that any birds migrate to the mouth of the Mississippi overland by way of Florida or Texas.

The Yellow Warbler (*Dendroica æstiva*) is one of the most common breeders throughout eastern North America, from the limit of tree growth in the north to central Georgia. Then to the southeast its numbers rapidly diminish, the species is practically unknown in Florida in spring migration and the numbers that occur in that State in the fall are but a tithe of those found to the north and west. The Yellow Warbler is a common migrant in eastern Mexico, especially in Yucatan and the islands off its east coast, but no farther east. It is unknown in Cuba or any other of the islands of the Greater Antilles and the avifauna of these islands has been sufficiently studied so that it is certain that this species can exist on them, if at all, only as a rare straggler.

A line drawn from Savannah, Ga., to the islands off the east coast of Yucatan marks approximately the eastern edge of the district in which the Yellow Warbler is common,— to the westward ubiquitous, to the eastward scarcely known. While no one has tagged a Yellow Warbler in the Carolinas and captured that same individual in Yucatan, it is a stretch of the imagination not to believe that the Yellow Warblers of the eastern United States pass in fall southwest, following the general trend of the Atlantic Coast, and continue this same direction to Yucatan. It is certain that they cross the Gulf of Mexico ; it is unlikely that they take any unusual course when the shortest and most direct offers congenial conditions.

The case of the Yellow Warbler has been given in full because it is one of the commonest and best known species. The line of reasoning is just the same for a number of other species that are common in eastern United States and in Yucatan, but are rare or unknown in southern Florida, Cuba, and the other West Indies.

It is not meant, of course, that no individual of these species ever passes through Florida to Cuba and on thence to Central or South America. But what is meant is that the avifauna of Florida and Cuba has been so thoroughly studied for so long a period that the failure to find these species there except as stragglers is proof positive that the large majority of the individuals choose some other migration route.

Kingbird (*Tyrannus tyrannus*).
Wood Pewee (*Contopus virens*).
Green-crested Flycatcher (*Empidonax virescens*).
Orchard Oriole (*Icterus spurius*).
Rose-breasted Grosbeak (*Zamelodia ludoviciana*).
Blue Grosbeak (*Guiraca cærulea*).
Indigo Bunting (*Cyanospiza cyanea*).
Dickcissel (*Spiza americana*).
Purple Martin (*Progne subis*).
Red-eyed Vireo (*Vireo olivaceus*).
Blue-headed Vireo (*Vireo solitarius*).
Yellow Warbler (*Dendroica æstiva*).
Magnolia Warbler (*Dendroica maculosa*).
Black-throated Green Warbler (*Dendroica virens*).
Hooded Warbler (*Wilsonia mitrata*).
Olive-backed Thrush (*Hylocichla ustulata swainsoni*).

All of these sixteen species pass on south and southeast to South America or proceed at least as far in that direction as Panama.

In addition to these, there are several other species that are common in the eastern United States and migrate across the Gulf of Mexico to Central America and continue to South America or Panama, avoiding southern Florida and the West Indies, but at the same time they are not yet known to occur both on the northeastern coast of the Gulf of Mexico and regularly in Yucatan, so that they can be included in the preceding list. Their routes of migration will be discussed later in this article. For the present it is sufficient to enumerate them :

Nighthawk (*Chordeiles virginianus*).
Crested Flycatcher (*Myiarchus crinitus*).
Olive-sided Flycatcher (*Nuttallornis borealis*).
Yellow-bellied Flycatcher (*Empidonax flaviventris*).
Alder Flycatcher (*Empidonax trailli alnorum*).
Least Flycatcher (*Empidonax minimus*).
Baltimore Oriole (*Icterus galbula*).
Scarlet Tanager (*Piranga erythromelas*).
Cliff Swallow (*Petrochelidon lunifrons*).
Philadelphia Vireo (*Vireo philadelphicus*).
Prothonotary Warbler (*Protonotaria citrea*).
Blue-winged Warbler (*Helminthophila pinus*).
Golden-winged Warbler (*Helminthophila chrysoptera*).
Tennessee Warbler (*Helminthophila peregrina*).

Cerulean Warbler (*Dendroica cerulea*).
Chestnut-sided Warbler (*Dendroica pensylvanica*).
Bay-breasted Warbler (*Dendroica castanea*).
Blackburnian Warbler (*Dendroica blackburniæ*).
Kentucky Warbler (*Geothlypis formosa*).
Mourning Warbler (*Geothlypis philadelphia*).
Wilson Warbler (*Wilsonia pusilla*).
Canadian Warbler (*Wilsonia canadensis*).

The two lists together present thirty-eight species that regularly pass from the eastern United States to South America or Panama, avoiding the West Indies.

Certain species occur in the eastern United States and in the West Indies, but are known so rarely in Yucatan and adjacent parts of Central America as to make it practically certain that the species as a whole passes to South America by way of the West Indies. Among these are:

Yellow-billed Cuckoo (*Coccyzus americanus*).
Chuck-will's-widow (*Antrostomus carolinensis*).
Florida Nighthawk (*Chordeiles virginianus chapmani*).
Gray Kingbird (*Tyrannus dominicensis*).
Bobolink (*Dolichonyx oryzivorus*).
Black-whiskered Vireo (*Vireo calidris barbatulus*).
Black-throated Blue Warbler (*Dendroica cærulescens*).
Black-poll Warbler (*Dendroica striata*).
Connecticut Warbler (*Geothlypis agilis*).

To South America via the Bahamas:

Gray-cheeked Thrush (*Hylocichla aliciæ*).

In addition to the above-mentioned species there are eighteen species from the eastern United States that pass in winter to South America or Panama. The Mangrove Cuckoo (*Coccyzus minor*) is resident throughout so much of its range in the West Indies, Central and South America that no migration route for it can be outlined. At the present, there seem to be no data to prove or indicate that the Kingfisher (*Ceryle alcyon*), the Barn Swallow (*Hirundo erythrogastra*), the Bank Swallow (*Riparia riparia*) and the Cedar Waxwing (*Ampelis cedrorum*) ever cross the Gulf of Mexico. It is practically certain that some Black-billed Cuckoos (*Coccyzus erythrophthalmus*) from the eastern United States pass

across the West Indies, and it is equally probable that the individuals from the Mississippi Valley cross the Gulf of Mexico and reach South America by way of Central America. The Wilson Thrush (*Hylocichla fuscescens*) is unknown in migration east or west of a narrow belt extending north and south between central Cuba and Yucatan and thence southeast to South America.

There remain the following eleven wide-ranging species that winter both in the West Indies and in Central America and pass south to South America or to Panama.

Painted Bunting (*Cyanospiza ciris*).
Yellow-throated Vireo (*Vireo flavifrons*).
Black and White Warbler (*Mniotilta varia*).
Worm-eating Warbler (*Helmitheros vermivorus*).
Myrtle Warbler (*Dendroica coronata*).
Oven-bird (*Seiurus aurocapillus*).
Water-Thrush (*Seiurus noveboracensis*).
Louisiana Water-Thrush (*Seiurus motacilla*).
Northern Yellow-throat (*Geothlypis trichas brachidactyla*).
American Redstart (*Setophaga ruticilla*).
Catbird (*Galeoscoptes carolinensis*).

The above tables may be recapitulated as follows:

Species from the Eastern United States that range to South America or Panama.

That cross from Florida to Yucatan	16
That cross the Gulf of Mexico on their way from the Southeastern United States to Central America	22
That cross the West Indies	10
Whose migration route is unknown or not classified	7
Wide-ranging species	11
Total	66

The above summary makes clear the facts that the large majority of land birds from the eastern United States bound for South America, cross the Gulf of Mexico in preference to journeying via the West Indies or by Florida and Cuba; and that hardly a sixth of these species are known to reach South America across the West Indies. It is believed that the facts here presented justify the statement: "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."

But it is probable that the case is stronger than so far stated. If one will study the distribution and migration of birds around the Gulf of Mexico, he will come to believe in what I call 'parallels of migration.' There is no single fact or series of facts that proves this, but many facts are explained by it that are difficult to explain otherwise. An example will show what I mean by parallels of migration. The western edge of the regular range of the Kingbird (*Tyrannus tyrannus*) extends from Corpus Christi, Texas, to the State of Tabasco in Mexico; the eastern edge from Florida to Yucatan. The whole path of migration crosses the Gulf of Mexico. It is a fair presumption that the individuals that are farthest west in Texas are the ones that fly to Tabasco, and that the Yucatan Kingbirds come from Florida. Between Florida and Texas, it is practically certain that the Kingbirds in the fall, as they reach the coast of the Gulf of Mexico from the north, launch out across the Gulf from the place where they came to the coast, without migrating either east or west along the north coast before undertaking their water flight. Thus each Kingbird starts across the Gulf in an approximately southerly direction and so their lines of migration across the Gulf are approximately parallel.

As already stated, this theory is not at present susceptible of proof, but it seems the most reasonable explanation of the known facts. It is not meant that all the individuals of a species follow these parallel lines, because it is known that there are wanderers, from choice or accident, in most species, but that these parallels represent the normal and usual lines of flight of the larger portion of the species.

If this theory of parallels of migration is correct, then it follows that, in the case of a wide ranging species, like the Black and White Warbler, occurring in the Bahamas, Cuba, Yucatan and most of Mexico, the individuals from eastern Florida probably pass to the Bahamas, from central Florida to Cuba, from northwestern Florida to Yucatan, from the mouth of the Mississippi southward across the Gulf, and from central Texas to Mexico by land.

It is a well-known fact, that it is the individuals from the eastern United States, rather than from the western United States, that pass to South America. When a species is so variable that the eastern individuals can be distinguished from the western, it is found in most cases that the individuals wintering in South America are similar to those of the eastern United States, while those from the western United States winter in Mexico and Central America. Since then it has already been shown that few species or individuals pass through the West Indies to reach South America, it follows that the individuals that pass to South America are for the most part those that have flown across the Gulf of Mexico.

If the above reasoning is correct, then the eleven species given in the preceding list as 'wide ranging species', can be added to those that cross the Gulf of Mexico on their way to South America or Panama. The recapitulation would then stand: —

Species that reach South America or Panama	
by way of the West Indies	10
by an unknown route	7
by way of the Gulf of Mexico	49
Total	66

In other words, it is practically certain that 60 per cent — more probably at least 75 per cent —of the species of land birds from the eastern United States that winter in South America or Panama, take a flight across the Gulf of Mexico on the way to their winter home.

III. Inferential Migration Routes.

The following supposed migration routes are based largely on negative evidence, that is, on the absence of proof that the species use other routes. Thus, for instance, in the case of the Canadian Warbler, it is a common bird of the northeastern United States and breeds in the mountains south to North Carolina; it is practically unknown in Honduras, Yucatan, the West Indies, Florida, South Carolina, Georgia, and Alabama; but it is known in eastern Mexico and Guatemala, whence it proceeds through Central America to its winter home in South America. There are so

many thousands of these birds in the northeastern United States that they could not all pass through the Gulf States unnoticed, and so one is led to believe that having passed to the southern end of the mountains, they start at once on their journey across the Gulf, flying *over* the Gulf States. Since they are also unknown in the lower regions of Yucatan and Honduras, but are known in the higher regions of Guatemala, the same line of reasoning leads to the belief that the birds do not alight as soon as they reach the south shore of the Gulf, but continue their flight to the mountains beyond. The case is not so clear on the south side of the Gulf as on the north, since so few competent ornithologists have visited this section, and since the birds' stay would be limited to the few days of passage in migration spring and fall.

Future observations may show that a few Canadian Warblers occur in northwestern Florida, and also along the coast of the Bay of Campeche, but as the record now stands it indicates that the principal route of migration of the Canadian Warblers of the northeastern United States is from the southern Allegheny Mountains across the Gulf of Mexico to the highlands beyond.

Along the route thus outlined it seems probable that the individuals from the northeastern United States of the following species pass in their migrations:

Olive-sided Flycatcher (*Nuttallornis borealis*).
Yellow-bellied Flycatcher (*Empidonax flaviventris*).
Philadelphia Vireo (*Vireo philadelphicus*).
Blue-winged Warbler (*Helminthophila pinus*).
Golden-winged Warbler (*Helminthophila chrysoptera*).
Bay-breasted Warbler (*Dendroica castanea*).
Canadian Warbler (*Wilsonia canadensis*).

If the southern part of the above route is carried eastward to include Honduras, it agrees with the present records of the eastern individuals of the Chestnut-sided Warbler (*Dendroica pensylvanica*).

If at the same time the northern part is supposed to start from the western slope of the Alleghenies, the route accords with the known facts concerning the migration of the eastern individuals of the Tennessee Warbler (*Helminthophila peregrina*).

If the southern end is shortened, making the flight from the

southern or southwestern Alleghenies to Yucatan, it becomes the route probably traversed by the eastern individuals of the Alder Flycatcher (*Empidonax trailli alnorum*), Least Flycatcher (*Empidonax minimus*), Blackburnian Warbler (*Dendroica blackburniæ*), Wilson Warbler (*Wilsonia pusilla*).

Along the same general course, it seems probable that the eastern individuals of the Crested Flycatcher (*Myiarchus crinitus*) cross from Florida to Honduras; of the Baltimore Oriole (*Icterus galbula*) and the Prothonotary Warbler (*Protonotaria citrea*) from northern Florida to southern Yucatan or Honduras; of the Cerulean Warbler (*Dendroica cerulea*) from the western slope of the Alleghenies to an unknown destination in Central America; of the Kentucky Warbler (*Geothlypis formosa*) from the southern Alleghenies and northern Florida to an unknown district south of the Gulf of Campeche, and of the Mourning Warbler (*Geothlypis philadelphia*) from the coast of Louisiana and Texas to the highlands of Central America.

So few certain records are known in Central America of the Nighthawk (*Chordeiles virginianus*) and of the Cliff Swallow (*Petrochelidon lunifrons*) that only the broad statement can be made that the bulk of these two species cross the Gulf of Mexico, avoiding the West Indies, southern Florida, and Yucatan.

Almost all of the individuals of the Scarlet Tanager (*Piranga erythromelas*) seem to pass south in a narrow belt between central Cuba on the east and Yucatan on the west.

It will thus be seen that all of these twenty-two species cross the Gulf of Mexico, the difference arising from the carrying of the eastern edge of the route more or less to the west, and the variations in the length of the flight.