riam and Mr. Chapman were diligently counting the young pelicans in the rookeries. And when, finally, the work was done, and we went back to the boats and our Indians rowed us away from the curious bird cities on the island, it was nearly night, and long before we had crossed the seven miles of water that lay before us the wonderful evening fell, the almost peacock blue of the water faded and became purple, violet, and at last, as the full moon rose over the jagged horizon all settled into the cool gray night of the desert.

Ithaca, N. Y.

Do Birds Migrate along their Ancient Immigration Routes?

BY LEONHARD STEJNEGER

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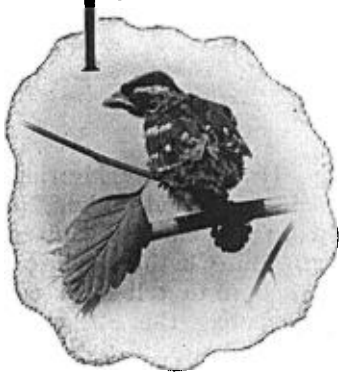

IN THE last number of THE CONDOR Prof. W. W. Cooke has an article entitled "An Untenable Theory of Bird Migration" intended as a refutation of Palmen's theory, which in a paper not specially devoted to bird migration I had briefly stated in its generality as follows: "The annual migration route of a species indicates the way by which it originally immigrated into its present breeding home." His laudable aim is to stop this "*error*" before it makes further headway "in this country."

And wherein consists this *refutation* of this *untenable theory* and *error*? The negative example of *Protonotaria citrea* which, it is claimed, cannot have immigrated into its present breeding home by a *portion* of its migration route, viz., that part which lies between southern Mexico and the mouth of the Mississippi River! He gives an explanation of how it may have happened that the prothonotary warbler now apparently makes a direct flight across the Gulf of Mexico, and if examined closely it will be found that this explanation, so far from being a *refutation* is merely a slight modification of the theory.

But even if Prof. Cooke's example were shown to be diametrically opposite to Palmén's theory, the latter was never meant or never said to include all and every kind of migration route kept by the thousands of species. No doubt many routes have been deeply modified by comparatively recent topographical and hydrographical changes. In others the modifications have been less marked, in few perhaps there have been no modifications in details. But that does not affect the truth of Palmén's generalization in its wider applicability, nor make it an "untenable" theory, much less an "error." To "refute" this hypothesis which has stood the test of nearly forty years, it is not enough to prove that there are some birds which go to their breeding grounds by other routes, but it must be shown that the vast majority do not go by the original immigration route. Even were it demonstrated that the theory holds only for a limited number of species it could not be dismissed as untenable and erroneous.

I may also call attention to the fact that when I referred to Palmén's theory

as quoted above, it was worded in general terms, because the theory in its details is so well known—and moreover it was not done in an attempt to give an independent presentation of it but simply to apply it to a given case. And yet I was careful to use the word "*indicate*" as I was not unmindful of the fact that there are cases which cannot be explaimed on this theory alone, whether the reason be that they are simply so great modifications that we are as yet unable to see through the the complication, or cases for which another theory must eventually be framed.

Prof. Cooke at the outset calls attention to the "several species" which have different migration routes spring and fall and by the annihilating remark that "*evidently* both routes cannot be the original path[a] of migration" he seems to think that he has refuted Palmén's theory at least so far as these species are concerned. But, pray, why "*evidently*"? It is quite *thinkable*, at least, that the two routes are simultaneous. Suppose, namely, that a species extended its range northward with a broad front along a wide stretch of land bounded east and west by the wide sea. It is conceivable that the climatic and food conditions were so different spring and fall on the two opposite coasts that it might have been highly beneficial for the bird to migrate alternately along the east and west shores, and I, at least, can see no impossibility in some migration routes originating in this way. On the other hand, one of the migration routes, probably the one in spring, may *indicate* the original way of immigration, while the other may be a much later modification.

But now for the route of the prothonotary warbler and the route it follows. Prof. Cooke, in the article alluded to, says that it is known that those of the Mississippi Valley "pass neither to the west along the coast of Texas, nor to the east through Florida[b] but on arriving at the coast they make a flight across the Gulf of Mexico, here nearly at the widest." He then goes on to show how he thinks the route once was further west at a time when the sea stood much higher and that the birds wandered along the coasts (then far inland) of Mexico and Texas; that as the land rose the birds straightened out the kink in the route and thus came to cross the Gulf where it is at the widest. He next makes the admission that others think the birds once migrated farther east, in the direction of Cuba, and later straightened out that kink by moving the route farther west. Apparently Prof. Cooke is willing to take either horn, for both "refute" Palmén's theory. But this admission proves conclusively that Prof. Cooke does not know just where the route of the prothonotary warblers lies across the Gulf of Mexico once they are out of sight of land. In his "Distribution and Migration of the North American Warblers" (Bull. 18, Biol. Surv., 1904) he plainly shows that the bird in question probably passes along the coast of Campeche, and also that during migrations it, occasionally, at least, touches Cuba and Florida, though he does not believe it passes *through* southern Florida, as it only becomes more numerous farther north.

The great stumbling block in Prof. Cooke's way apparently is the improbability of there having existed formerly a "chain of islands" from southern Mexico to the Mississippi, because of "the fact that the Gulf of Mexico off the mouth of the Mississippi River is a vast abyss, with no indication that any of its central portion has been above water since bird life appeared on the earth."

This seems to be a very risky statement for a non-geologist to make, since it

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a Path is Prof. Cooke's nomenclature. I spoke of the 'way" of immigration which in many cases undoubtedly involves a wide tract of territory. Birds might *immigrate* with a very broad front and yet they may migrate along comparatively narrow routes. It is essential to maintain this distinction.

b Note well the difference between the expressions, "*along* the coast of Texas" and "*through* Florida."

is one of the very "facts" about which the geomorphists are now holding the most diverging views. Let me quote a few sentences from a paper by Dr. J. W. Spencer as late as May, 1898: "It would thus appear that these regions (West Indian region) stood from ten thousand to twelve thousand feet, or in some localities fourteen thousand feet, higher than now;" and further on: "The time of greatest elevation and development of the West Indian continent was during the early Pleistocene period." This brings us surely to the time of the origin of bird migration. *If* conditions were as Prof. Spencer thinks, there is no impossibility of the prothonotary warblers' migration route, no matter how it lies across the Gulf of Mexico[c] indicating the way by which they originally immigrated into the United States.

Now, Prof. Cooke will probably answer that there are geologists who hold quite opposite views and that he sides with them, because *if* they are right, it would be easy to "refute" Palmén's theory. But would it? Prof. Cooke speaks of the "central portion" of the Gulf as being involved. There is no necessity for such an assumption, however. Do away with an elevation of twelve thousand feet and let us be satisfied with 100 fathoms![d] Take any map showing the 100 fathom contour in the Gulf of Mexico and the drowned valleys from the Mississippi to the Tampa, and it will be found that the whole distance from land to land, if it were raised up to this level, would be 183 miles! Now draw a hypothetical migration route from the northeastern corner of the thus enlarged Yucatan (Campeche Bank) northeasterly until it strikes the westwardly extended Florida, and let this line proceed in a northerly to northwesterly direction along the 100 fathom curve to the mouth of the Mississippi sending off side routes up the drowned valley of the Tampa, Suwanee, Appalachicola and other rivers, and you have a route which would explain many features of the migration of the prothonotary warbler, which now are mysterious, and at the same time *indicate the way by which it may have originally immigrated into the United States.*

It would have been very interesting to have gone into these questions in greater detail, but, unfortunately, time and space are limited. All I wanted to show is that Palmén's theory cannot be disposed of in this off-hand manner. To stop the error from making further headway in this country will require weightier arguments than those I have tried to meet today.

Washington, D. C., Jan. 23, 1905.

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c It must be distinctly understood that this quotation of Dr. Spencer's views does not indicate my adoption of them.

d An elevation of 600 feet is necessary to bring the 100 fathom line on the west side of Florida up to the present sea-level, if the rise is supposed to be horizontal. Dr. W. H. Dall has indicated, however, that the last rise of the peninsula (subsequent to the one I refer to) "elevated the Atlantic border with its reefs more than the gulf shores." In case of such a tilting it will be sufficient for my purpose to assume a mean elevation of less than 200 feet in order to insure a shore line 140 to 150 miles west of the present one during that period of the Pleistocene when "the rhinoceros, the wild horse, the llama, the Columbian elephant, the mastodon, the glyptodon, and various enormous tortoises wandered along the shores of the lakes and through the marshes (of Florida) while the sabre-toothed tiger lay in wait." Surely, the landscape suggested by this quotation might well invite the invasion of the prothonotary warbler in the United States!