for existence many centuries ago, fled from their persistent enemies to the high and inaccessible cliffs of the arid southwest, and there, in rapidly dwindling numbers, eked out a meager and miserable existence until all were gone.

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REMARKS ON THE MIGRATION OF SOUTHERN HEMISPHERE ALBATROSSES AND PETRELS.

BY LEVERETT MILLS LOOMIS.

No other migratory movements illustrate the migration of birds better than those of the albatrosses and petrels breeding in the Southern Hemisphere. With the close of the season of reproduction, there are northward movements that stop short of the equator, transequatorial ones to northern latitudes, and movements that lead in a southward direction.

The migratory movements that fall short of the equator are well exemplified in the Antarctic Fulmar (*Thalassoica antarctica*), Snowy Petrel (*Pagodroma nivea*), Lesson's Petrel (*Pterodroma lessoni*), and White-chinned Petrel (*Procellaria aequinoctialis*).

Transequatorial migration to northern latitudes is typically illustrated in the Juan Fernandez Petrel (*Pterodroma externa*), Neglected Petrel (*Pterodroma neglecta*), Mottled Petrel (*Pterodroma inexpectata*), Great Shearwater (*Puffinus gravis*), Cooper's Shearwater (*Puffinus creatopus*), Flesh-footed Shearwater (*Puffinus carneipes*), Sooty Shearwater (*Puffinus griseus*), Slender-billed Shearwater (*Puffinus tenuirostris*), and Wilson's Petrel (*Oceanites oceanicus*). The Sooty Shearwaters occurring in myriads on the Pacific Ocean off Point Pinos, California, shed a flood of light upon this phase of bird migration. On their arrival in spring, the adult ones are in worn plumage, and have dormant

gonads. As the season advances, they undergo a complete moult, and in autumn, at the time of the departure of the hosts, they are in fine feather, and display great functional enlargement of the gonads. The period of absence of this petrel from California waters coincides with its breeding season in the South Temperate Zone. It has long been a matter of record that there are breeding stations of this petrel in the New Zealand area, and recently Mr. R. H. Beck has located such a station on Wollaston Island, near Cape Horn.[1] Transequatorial migration from the Southern Hemisphere finds a counterpart in transequatorial migration from the Northern Hemisphere.

Migration after the breeding season in a direction leading away from the equator is well shown in the Galapagos Albatross (*Diomedea irrorata*), which breeds, so far as known, only on Hood Island (lat. 1° 25′ S., long. 89° 42′ W.), and journeys at least as far as Independencia Bay, Peru, lat. 14° 16′ S.[2] This migratory movement corresponds to that of the Black-vented Shearwater (*Puffinus opisthomelas*) of the Northern Hemisphere.

The various types of migration occurring north and south of the equator adjust the bird population of the world to the seasons. It is therefore in the evolution of existing climatic conditions that we find the remote cause of present-day migration. In accounting for the immediate cause, it does not seem necessary to place heavy additional burdens upon heredity. The traveling habit, formed from the example of older birds, would seem incentive enough to cause an adult Galapagos Albatross to make the round trips between Hood Island and Independencia Bay. If the young are endowed with an innate desire for travel, the traveling habit would not be less readily formed. In short, bird migration is viewed as an inheritance in the species and as an acquired habit in the individual.

In considering the return journeys of the Galapagos Albatrosses to Hood Island, we are confronted with the question, how do migrating birds find their way over the ocean. Are they guided

[1] Amer. Mus. Journ., 1918, p. 111.

[2] Cf. Coker, Proc. U. S. Nat. Mus., Vol. 56, pp. 461, 462: cf. Proc. Calif. Acad. Sci., Ser. 4, Vol. 2, Pt. 2, pp. 75, 76.

by an unexplained sense of direction, or are they guided in their course by landmarks when near the land and by persistent water and air currents when remote from the land? The question is fairly before us, and we must answer it with evidence. Apparently direct evidence is found in the behavior of shearwaters beset by fog off the California coast. The following is selected from the record of a series of observations made by myself some years ago:[1]

September 26. As soon as the boat was fairly clear of the land, flocks of shearwaters, hurrying along the south shore of Monterey Bay, were dimly discernible through the fog. Before Point Pinos was reached, it was manifest that there was an extensive movement in progress. At the outset Sooty Shearwaters were well represented, but in a little while only the Black-vented appeared in force. After passing Point Pinos, instead of altering their course and heading south as is their wont when the coast is clear, all the shearwaters proceeded directly out to sea. The fog was so thick, that the outlying rocks at Point Pinos could scarcely be perceived from the kelp. The coast-line to the southward of Point Pinos was invisible, and the ocean seemingly boundless space, where the birds apparently lost their bearings and became bewildered, for a return movement set in when the fog was densest. At the same time others continued to arrive from up the coast; the outward-bound ones passing close to Point Pinos and the inward-bound ones in the vicinity of the whistling buoy, anchored several hundred yards offshore. After a while many flew about at random and a large flock congregated on the water. When the shore-line south of Point Pinos became visible, the birds immediately resumed their journey southward.

October 2. At seven in the morning, flocks of Black-vented Shearwaters were passing along the south shore of Monterey Bay, almost at the surf, a thick fog hiding the land. They came from the east and disappeared in the west. Following in their wake, I soon discovered that close to the shore an avenue of flight was established, along which many flocks were heading toward

[1] Proc. Calif. Acad. Sci., Ser. 3, Vol. 2, pp. 281, 284.

the ocean at Point Pinos. They displayed an unusual timidity, sheering wildly from the boat as it loomed up before them out of the fog. The belt of kelp and the land seemed also to fill them with fear, those happening between these bugaboos being in especial straits, shunning first the one and then the other. By the time I reached Point Pinos orderly movement had nearly ceased, confusion reigning. The birds were flying about in all directions— those in extreme bewilderment, in circles. Between half past nine and ten, the fog lightened sufficiently to reveal the shore-line south of Point Pinos, and immediately order was restored, and regular progress southward resumed.

If migratory birds are endowed with a superhuman sense of direction, tantamount to a sixth sense, why were these shearwaters bewildered when the land was hidden by fog? Why did they immediately proceed on their journey when the fog was dispelled sufficiently to reveal the landmarks? If they had possessed any directing faculty other than the faculty of locating position by observing physical phenomena, it would not have failed them in these instances.

The Brandt's Cormorants nesting in the vicinity of Point Pinos and my boatman had no difficulty in finding their way in the fogs that bewildered the shearwaters. They were at home on this bit of coast, and in consequence kept their bearings in the fog. But the shearwaters migrating down the coast had no opportunity of determining their position by local landmarks, and consequently lost their way like the captain of a coaster who beached his vessel, on a still, foggy night, two miles south of Point Pinos, supposing that he was entering Monterey Bay.

It is clear that Galapagos Albatrosses in returning from mainland waters to their rookery on Hood Island must have other means of guidance than landmarks. A glance at a current chart reveals that the cold Humboldt Current, "with its steadily and visibly flowing waters," leads directly to the Galapagos Islands. A physical means of guidance is therefore not wanting.

In plotting the metes and bounds of all the albatrosses and petrels, it has been disclosed that the trade-winds apparently form habitat boundaries. For example, in the Southern Hemisphere,

away from the influence of the land, the northward range of certain species appears to end at the southern limits of the southeast trades; as in the Wandering Albatross (*Diomedea exulans*), Long-winged Petrel (*Pterodroma macroptera*), and White-chinned Petrel (*Procellaria aequinoctialis*). In the Northern Hemisphere, a corresponding restriction of range seemingly occurs in the Black-footed Albatross (*Diomedea nigripes*).

The behavior of the Shearwaters in the fog off the California coast, the existence of a definite waterway between the mainland and Hood Island, and the apparent influence of the trade-winds in limiting habitats, seem to justify the conclusion that migrating birds are guided by physical phenomena, and not by a mysterious sense of direction. In fine, the solution of the problem is not found in the marvelous.

It has been well said: "The day is passing when scientists seek to employ striking or extraordinary phenomena in the solutions of their problems; rather are they looking to that which appears insignificant and commonplace."

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THE ABBREVIATED INNER PRIMARIES OF NESTLING WOODPECKERS

BY JAMES P. CHAPIN

Plate XIX

WHILE examining nestlings of Woodpeckers, some years ago, belonging to the African genera *Chrysopicos*, *Campethera*, and *Dendropicos*, I noticed that the innermost primary of the first or "juvenal" set of remiges was always remarkably small and weak, (Fig.1) and thus utterly unlike its representative in the adult plumage. There, on the contrary, the first primary is nearly as long as the second and third, thus filling its place normally in the graded series of wing-quills. The young of another African wood-peck-