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LV.—*Observations on the Flight of Flying-fish*
(*Exocoetus*, *sp. incertæ*). By G. E. H. BARRETT-HAMILTON.

IN reply to a request for advice on the subject, Mr. Boulenger has been good enough to inform me that, despite what has been already written, there is still room for a small contribution to the literature of the flight of flying-fish. Hence arose the following notes, the result of much study of these beautiful creatures during several ocean voyages.

The precise use of the so-called "wings" of flying-fish and the nature of their flight have given rise to much discussion amongst naturalists, some of whom, as Professor C. O. Whitman *, hotly maintain that the wings are flapped, while others, amongst whom are Professor K. Möbius *, deny that genuine muscular movements ever occur. Although I have never enjoyed the opportunity of observing the flight of the flying-gurnards (*Dactylopterus*), I have frequently and carefully watched and studied that of the flying-herrings, with the result that I can thoroughly corroborate the late Professor Moseley's observation † that in this genus at all events the wings are never moved as organs of true flight. They may vibrate or quiver under the action of air-currents or the shifting a little of their inclination by the fish; the whole motive power is supplied by the powerful tail. The wings are a parachute to augment the action of this propeller. Their motions are in no way comparable to those of the wings of a bird.

Whatever objections may be raised against observations taken from the artificial height of the deck of an ocean-going steamer, this method affords an unrivalled opportunity of overlooking the expanded pectorals as the fish emerge from the water almost directly beneath the observer. Again, since the cause of the numerous flights which take place in the immediate proximity of the ship is undoubtedly fear at her approach, the fish which thus come under observation invariably use their utmost powers of flight, and, could any single one of them voluntarily flap its wings, it would certainly do so to the extent of its entire ability. A careful observer

* See K. Möbius, "Die Bewegungen der fliegenden Fische durch die Luft," *Zeitschrift für wissenschaftliche Zoologie*, Suppl. vol. xxx. p. 343 (1878); and C. O. Whitman, 'American Naturalist,' vol. xiv. p. 641 (1880).

† H. N. Moseley, "Notes by a Naturalist on the Voyage of H.M.S. 'Challenger,'" new edition, 1892, p. 495; an opinion formed also by Mr. W. L. Distant, 'A Naturalist in the Transvaal,' 1892, pp. 2-4.

should therefore with practice be able to assure himself of the correctness of his observations.

Some naturalists further declare that these flying fish can fly only against the wind, and no doubt the assistance thus derived enabled those which I have seen to leave the water more numerously to windward than to leeward of the ship. My experience shows, however, that while the larger fish can fly in any direction, the smaller only possess the power of flying down-wind. Rising in the air with a leap against the wind, they turned over before its force, and were carried before it for a short distance like a piece of paper until they touched the water, when they restarted their flight by another active leap. There could be no doubt that the highly muscular tail supplied the motive power, and a high wind is probably needed for the most successful flights. On one occasion I observed a fish accomplishing a far longer flight than usual, rising straight up against the wind in its course, and once again quite a large individual came aboard and was shown to me. It reached about a foot in length, and though partially dried up and moribund exhibited well the muscular power of the tail when placed in a pan of salt water.

I find it a little difficult to reconcile a statement like the following from the pen of Mr. Alfred Russel Wallace* with my own very careful observations. Writing of a species which he found numerous on December 30th, 1856, near the Island of Teor, in the Banda Sea, he declares that it is both smaller and "more active and elegant in its motions" than that of the Atlantic. "As they skim along the surface they turn on their sides, so as to fully display their beautiful fins, taking a flight of about a hundred yards, rising and falling in a most graceful manner. At a little distance they exactly resemble swallows, and no one who sees them can doubt that they really do fly, not merely descend in an oblique direction from the height they gain by their first spring."

It seems likely that this description applies to some species not of *Exocætus*, but of *Dactylopterus*. It is, however, not altogether inapplicable to *Exocætus*, which turns on its side frequently when struck by currents of wind, and, when skimming along the surface of the water, renews its flight whenever contact takes place by an almost imperceptible muscular effort. I have often observed this, as well as the resemblance to the flight of a swallow. This results from the perception of the up-and-down movements of several fish, which, moving in company, the eye is unable to separate.

* 'The Malay Archipelago,' &c., ed. of 1898, p. 316.

The flight of two or three individuals, one falling, another rising, is thus blended into one apparently continuously undulating movement, while the sudden leap which precedes each rise in the air escapes notice. The fish is, in fact, so silvery and difficult to follow with the eyes, especially when of small size, that I would on no account trust the casual observations of an ordinary observer. I suspect that even Mr. Wallace, who had no especial scientific purpose in view when he saw the flying-fish, may have been deceived by their rapid motions. This is the more likely since Professor Kukenthal, who took particular trouble to investigate the flying-fish of almost the same seas, and who used a small boat in order that his observations should be the more accurate, is quite convinced that he never saw an instance of true flight amongst them.

More positive and inexplicable are the statements of Professor Whitman, who declares that he was able to see "distinctly the individual flaps of the large pectorals, while the ventrals were held in quiet expansion. The flapping movement, which is quite regular and rapid—so rapid that it is not easily recognized at any great distance until experience has sharpened the eye,—may be continued for the whole or part of the flight, but it is generally discontinued after the first few rods, and the course completed by a pure skimming or sailing movement. In some cases I have seen the flapping of the fins renewed once or twice after short intervals of the sailing movement" *.

Similarly, Captain A. R. S. Anderson † describes "a very rapid fluttering of their wings, lasting for two or three seconds," and has "very occasionally . . . observed these fish fluttering their wings without touching the water with their caudal and ventral fins."

Such diametrically opposing statements repeated by well-qualified observers make it seem extremely likely that the fish which came under the notice of Professor Whitman, Captain Anderson, and myself were (as is more than possible) totally distinct. But amongst so much apparent contradiction there is really almost complete accord on the one important point—namely, that the so-called "fluttering" or "flapping," if it does occur, is almost invariably discontinued after the

* *Op. cit.* p. 646.

† 'Administration Report of the Marine Survey of India for the Official Year 1898-1899.' Bombay: Government Central Press, 1900. Noticed by R. L. in 'Nature,' February 28, 1901, p. 427. I have *not* been able to see the original. A like observation has been made by the editor of the 'Royal Natural History.'

flight has really commenced. It is in nearly every case merely an accompaniment of the initial spring into the air.

In this fact I venture to think that agreement may be found; but I feel no misgivings as to the accuracy of my own observations, which were not confined to a single voyage, but extended to many in the most diverse oceans, such as the Atlantic, the Pacific, the Indian, as well as the China Sea. And yet, although constantly on the look out, I have never once seen anything at all approaching Professor Whitman's "flapping movement." Further, I find myself in the excellent company of Moseley, of Professor Kukenthal* (whose careful study leads him to lend his complete support to those who declare that the wings of the flying-herrings are of mere parachute-like function), and of the American ichthyologists†, Messrs. D. S. Jordan, B. W. Evermann, and C. H. Gilbert, who have studied flying-herrings under the most favourable conditions, and who describe the "rapid vibration" of the pectorals as "apparent only, due to the resistance of the air to the motions of the animal." Movements of the fins there certainly are, as I too admit, but they are merely connected with the initial muscular spring, with balance, or, perhaps, even with alterations of direction. The originating and only cause of the flight, as it came under my eyes, is the muscular leap from the ocean.

When we come to deal with other genera of flying-fish, however, there are undoubtedly very different grades of perfection of flight, since Moseley distinctly observed rapid "buzzing" of the wings in the case of a species of "flying-gurnard." The flight of this species appeared to him "to be closely similar to that of many forms of grasshoppers, which cannot fly for any great distance, but raise themselves from the ground with a spring, and, eking out their momentum as much as they can by buzzing their wings, fall to the ground after a short flight." If this represent the acme of perfection of flight reached by a fish, we have at the other end of the scale species such as that which the sailors aptly name the "Skipjack" (probably a member of the genus *Hemirhamphus*). This is a small silvery fish, which I have seen in the Atlantic a few days south of the Canaries on the run to Cape Town. It occurred in large numbers on particular areas of the water's surface, from which it constantly leapt to a height of a few inches. It was impossible to tell the cause of the disturbance

* See 'Abhandlungen herausgegeben von der Senckenbergischen naturforschenden Gesellschaft,' Band xxii. 1896, pp. 9-11.

† "The Fishes of North and Middle America," Bulletin U.S. National Museum, no. 47, part i. 1896, pp. 730-731, footnote.

or whether the fish were pursuing or being pursued by some other creatures. Food must have been abundant, since a good many birds of some unknown species were present in the near distance, and there were great herds of small dolphins which made the water boil again around the ship. Annectant between the skipjacks (*Hemirhamphidæ*) and the flying-herrings (*Exocætidæ*) is Mr. H. W. Fowler's genus *Hemioxocætus* *. Less skilful again, but still, perhaps, foreshadowing the flying leaps of *Exocætus*, are the shoals of herrings and mackerel which on calm nights stir British waters into phosphorescence.

Instances of the jumping of fish of numerous kinds above the surface of the element in which they live are, as is well known, frequent.

One of the most interesting is that afforded by a close ally of the flying-fish, the little gar- or needle-fish (*Belone*), which came under the observation of Moseley †. These fish, he writes, when hotly pursued by the "skipjacks," "dashed out of the water, and by violent lashing of their tails managed to keep themselves above the water in a nearly upright position for a distance of several yards as they moved swiftly from the danger." The leap of the gar-fish as well as those of the whip-ray and king-fish have been beautifully figured by Mr. J. Turner-Turner ‡.

LVI.—*New Species of Indian Aculeate Hymenoptera.*

By Major C. G. NURSE, Indian Army.

THE insects dealt with in the present paper form part of a collection made by me during the last eighteen months. The greater part of the collection was made at Deesa, where I was stationed most of the time; but a number of Hymenoptera obtained during a two months' leave to Kashmir are also included, as well as a collection made by a native, whom I employed for two months at Mount Abu in 1901.

Deesa is situated at the extreme north of the province of Gujarat, being about 40 miles distant from Mount Abu. The climate is very hot and dry, and the rainfall, which in ordinary years averages from 25 to 30 inches, has been very

* 'Proceedings of the Academy of Natural Sciences of Philadelphia,' April 1901, pp. 293-294.

† *Op. cit.* p. 414.

‡ 'The Giant Fish of Florida,' 1902, plates opposite titlepage and pages 66 & 142.