The "Flight" of Flying-fish.

I HAVE on frequent occasions (in the Mediterranean, the Red Sea, and the Indian Ocean) carefully observed with a field-glass (×8) the supposed "flight" of flying-fish, and have always concluded that the "leap and glide" theory is the correct one, with one or two modifications. Dr. J. McNamara, in NATURE for June 3, p. 421, cites five facts in support of the theory of true flight, but I may point out that all these five facts can be otherwise interpreted. Flying-fish undoubtedly leap out of the water and gain their initial impetus by tail action, and when out of the water the pectoral fins serve as planes. While gliding the fish can not only renew its impetus to a limited extent by an occasional flick of its tail against the crest of a wave, but, as your correspondent says, can also change the direction of its glide. I have, however, never observed a fish "come back in a direction opposite to the direction in which it set out," and I am tolerably certain that it could not do this without re-immersion in the water, unless perhaps a strong wind were blowing in this opposite direction. Flying-fish can certainly rise and fall during the glide, but this, as well as change of direction, can be easily explained by assuming inclinations of the planes of the fins—a very different process from actual "wing"-flapping sufficient to cause flight. The fins can, like those of most fishes, move on their bases, but I fail to understand how, in the absence of the required musculature, it can possibly be supposed that the fins show "rapid movement, as in the case of hovering flies and humming-birds." If seagulls can glide for hundreds of yards, rise and fall, and change direction without wing-flapping, why not flying-fish? In gliding the outlines of the pectoral fins naturally appear to be indistinct, because, compared with the rest of the body, the fins are thin and irregular in outline on their posterior edge.

Granting that the body can gain fresh impetus by an occasional flick of the tail against a wave-crest (and this can be easily seen to occur, and is certainly less difficult to understand than the initial tail action which enables the fish not only to emerge from the water, but also to acquire an impetus which carries it the greater part of its glide), and that the planes of the wings can be inclined, all the movements of flying-fish which I have observed are fully intelligible.

W. N. F. WOODLAND.

"Kismet," Lock Mead, Maidenhead, June 4.

As another observer of Nature at sea I must beg to differ entirely from Dr. McNamara's conclusions on the "flight" of the flying-fish.

(1) Turning at an acute angle can be brought about by an extra puff of wind, and indicates no power on the part of the fish.

(2) It is impossible for a flying-fish to flap its pectoral fins as a bird does its wings.

(3) The rise and fall over waves are due to the forcing up or lowering of the air immediately over the surface of the water.

(4) The impetus is quite sufficient to send flying-fish up to a height of 50 ft. or even more, and to extend the soar to 300 yards. They naturally flop about on deck until dead.

(5) It is quite possible (though I have never seen it) for the tips of the fins to be vibrated by the wind during flight.

The matter has been dealt with more fully in "Nature Notes for Ocean Voyagers," by Capt. Alfred Carpenter and myself, and also in the *Nautical Magazine* for May, 1894, and in the *Shipping World* for April, 1901. The late Capt. Cromie, at my request, made a series of very careful observations from torpedo-boat destroyers and submarines, and was most emphatic that they did not "*fly*."

As in many other interesting problems, the help of a super-kinema camera fitted with a telephoto lens would be of great service.

DAVID WILSON-BARKER.

Fellow-Workers.

IN NATURE for June 3, p. 416, Prof. D'Arcy Thompson refers to me and to my "fellow-workers" who helped me to bring our "hopes to fruition" in connection with the old malaria-mosquito business. My own memories remind me of seven years' almost continuous solitary labour, during which time my numerous "fellow-workers" had many opportunities, as good as mine or better, for doing the same work, but, oddly enough, did not use them; and it was not until I had solved the problem that they arrived on the scene in a body, fully armed with paper, pens, and cameras, and resolved "to join the victory group" at any cost. Prof. Thompson puts one of these gentlemen in the place of honour next to Pasteur—who, by the way, had little to do with the development of animal parasitology. The true history of the subject is given in my "Prevention of Malaria" (Murray), and still more trenchantly in Robert Koch's letter to me, dated February 10, 1901, and published in *Science Progress* for April, 1917.

But this is a detail; and I should like to thank Prof. Thompson for his kindly references to my medical verses, and for his interesting conspectus of the medical poets. Oddly enough, the day after it appeared in NATURE I lectured at the Royal Institution on "Science and Poetry," and upheld the thesis that a higher view of both will show how frequently and how closely they are connected. But honesty compels me to add that my own interest in medical matters is quite secondary, and a matter of duty rather than of predilection.

RONALD ROSS.

36 Harley House, London, N.W.1, June 4.

The Approximate Evaluation of Definite Integrals between Finite Limits.

(1) THE four-ordinate rule given in my letter published in NATURE of May 20, p. 354, viz.

$$\int_0^1 F(x)dx = \tfrac{1}{4}\{F(\tfrac{1}{10})+F(\tfrac{4}{10})+F(\tfrac{6}{10})+F(\tfrac{9}{10})\},$$

is obtained by dividing the range into two and to each half applying the simple two-ordinate rule,

$$\int_0^1 F(x)dx = \tfrac{1}{2}\{F(\tfrac{1}{5})+F(\tfrac{4}{5})\},$$

the parabolic or cubic approximation for two ordinates being

$$\int_0^1 F(x)dx = \tfrac{1}{2}\left[F\left(\frac{3-\sqrt{3}}{6}\right)+F\left(\frac{3+\sqrt{3}}{6}\right)\right]$$
$$= \tfrac{1}{2}[F(0{\cdot}2113)+F(0{\cdot}7887)]. \quad . \quad . \quad (a)$$

(2) Closer approximations may be obtained by dividing the range into a greater number of parts and applying this rule to each, thus:

$$\int_0^1 F(x)dx = \int_0^{\frac{1}{3}} F(x)dx + \int_{\frac{1}{3}}^{\frac{2}{3}} F(x)dx + \int_{\frac{2}{3}}^1 F(x)dx$$
$$= \tfrac{1}{3}\left\{\int_0^1 F\left(\frac{x}{3}\right)dx + \int_0^1 F\left(\frac{1+x}{3}\right)dx + \int_0^1 F\left(\frac{2+x}{3}\right)dx\right\}$$
$$= \tfrac{1}{6}\{F(\tfrac{1}{15})+F(\tfrac{4}{15})+F(\tfrac{6}{15})+F(\tfrac{9}{15})+F(\tfrac{11}{15})+F(\tfrac{14}{15})\}$$

The following table shows for several functions the value of the integral and the approximate evaluations from two, four, six, and eight ordinates: