THE SOARING OF BIRDS.[1]

SO much for sails. Now I want to make some suggestions, or suggest some queries, as to the *skimming* flight of birds, in reference to which a good deal of fresh observation has been possible during the voyage.

You perhaps recollect that when the British Association was at Glasgow, you asked me to put into writing, briefly, as a paper for your Section, some remarks on this subject which I had made to you in conversation, but that, owing to my hasty departure to attend the trial of H.M.S. *Shah*, I omitted to do this.

I had better briefly recite the above particulars here in order to make more clear the bearing of the new observations we (I and Tower) have made.

The view was that when a bird skims or soars on quiescent wings, without descending and without loss of speed, the action must depend on the circumstance that the bird had fallen in with, or selected a region where the air was ascending with a sufficient speed. In still air the bird, if at a sufficient height, could continue to travel with a steady speed, using his extended wings as a sort of descending inclined plane, the propelling force depending on the angle of the plane and on the equivalent of "slip,"—that is to say, on the excess of the angle of actual descent compared with the angle of the inclined plane. The steady speed would be attained when the weight of the bird and the sines of the angle of the plane = the bird's *air resistance*, including skin friction of wings – in fact one might say = simply the skin friction of the whole area, for the bird's lines are fine enough to justify this statement, since there is no wave-making to be done, and indeed experiment shows that the statement is true for "fish-formed" bodies moving wholly and deeply immersed in water. Of course the bird's angle of actual descent is greater than that of the quasi-inclined plane, owing to the equivalent of "slip" in the wings. Under these simultaneously acting and correlated conditions there is of course—or probably—some total angle of descent which enables the bird to minimize his rate of approach to the earth in still air. If when there is a wind the configuration of the ground or any other circumstances can produce a local ascent of air more rapid than the bird's minimum rate of descent when soaring in still air, he may continue to soar indefinitely by keeping in the region where the air is thus ascending.

Now, in most cases where one sees birds "soaring," it is easy to see that they have plainly selected such a region, and for a long time I felt confident that the only two even apparent exceptions I had encountered were such as to *prove* not to *invalidate* the rule. One of these exceptions was that once, when the sea in Torbay was in a state of glassy calm, I noticed a large gull thus soaring at some distance from the shore,—watching it with a pair of binoculars, so that I was sure of the quiescence of the wings. But here the riddle was at once solved by the observation of what I had not at first noticed—the dark trace of the front line of a fresh sea-breeze advancing all across the bay. Such an advance with a definitely marked front, encountering an extended body of quiescent air, involved of course an ascent of air in the region of the encounter, and this was where the bird was soaring. The other exception was that when at sea I had often noticed birds thus soaring near the ship. The solution was that, so far as I had then noticed, the birds always selected a region to leeward of the ship, where the eddies created by the rush of air past her hull, &c., might readily have created local ascending currents.

The new exceptions we have seen since we have approached the Cape entirely set these two solutions at defiance.

[1] Extract from a letter of the late William Froude to Sir W. Thomson, of February 5, 1878, received after Mr. Froude's death. Reprinted from the Proceedings of the Royal Society of Edinburgh, March 19, 1888.

The first exception we noticed was in the flight of some albatrosses. We were sailing, and steaming (at low speed, being short of coal), nearly due east in the latitude of the Cape, with the wind light and variable abaft the beam, and with a well-marked south-west swell of about 8 to 9 seconds period, and varying from 3 or 4 feet to 8 or 9 feet from hollow to crest. The speed of such waves would be from 24 to 27 knots.

Under these conditions the birds *seemed* to soar almost *ad libitum* both in direction and in speed; now starting aloft with scarcely, if any, apparent loss of speed; now skimming along close to the water, with the tip of one or other wing almost touching the surface for long distances, indeed now and then actually touching it. The birds were so large that the action could be clearly noted by the naked eye even at considerable distances; but we also watched them telescopically, and assured ourselves of the correctness of our observations. The action was the more remarkable owing to the lightness of the wind, which sometimes barely moved our sails, as we travelled only 5 knots before it, by help of the screw.

After long consideration the only explanation of at all a rational kind which presented itself was the following, which indeed presents the action of a *vera causa*, and one which was very often certainly in accordance with the birds' visible movements, though it was often also impossible either to assert or to deny the accordance; and anyhow the question arises, Is the *vera causa* sufficient? I will try to trace its measure

When a wave is say of 10 feet in height and say 10 seconds period (a case near enough to ours to form the basis of a quantitative illustration) the length of the wave from crest to crest is just 500 feet, the half of which space, or 250, the wave of course traverses in 5 seconds, and assuming the wave to be travelling in a calm, it must happen approximately that during the lapse of this 5 seconds the air which at the commencement of the interval lay in the lowest part of the trough has been lifted to the level of the crest, or must have risen 10 feet, so that its mean speed of ascent has been 2 feet per second (10 feet in 5 seconds). And since (as is well known) the maximum speed of an harmonic motion is $\frac{\pi}{2}$ times, or nearly $1\frac{1}{2}$ times its mean speed, it follows that along the side of the wave at its mid-height the air must approximately be ascending at the rate of 3 feet per second, and if the bird were so to steer its course and regulate its speed as to conserve this position he would have the advantage of a virtual upward air current having that speed.

NOTES.

THE Berlin Academy of Sciences has presented 2000 marks (£100) to Prof. Leopold Auerbach (Breslau), and the same amount to Dr. Franz Schütt (Kiel), to aid them in their physiological researches. Dr. Freudenthal, Professor of Philosophy at Breslau, and Herr von Rebaur-Paschwitz, the astronomer, have received 1500 marks (£75) each.

AT the last meeting of the Scientific Committee of the Royal Horticultural Society, Mr. Henslow called attention to the fact that the year 1889, besides being the centenary of the chrysanthemum in Europe, is that of the dahlia in England. It was introduced by the Marchioness of Bute in 1789, and figured with single and double forms in the *Botanical Magazine*, vol. xliv., t. 1885, and the *Botanical Register*, vol. i. t. 55.

THE death of Mr. J. J. Coleman, F.R.S.E., is announced. He died at the age of fifty. For some time he was manager of the works of Young's Paraffin and Mineral Oil Company, Glasgow; and in this capacity he carried out some important experimental investigations for the utilization of so-called waste