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The distribution of aquatic plants and Animals

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Hence, in the area north-east of the Start (Stations XIII. and XIV.), which is the most typical case, the smallest annual range of temperature in the whole Channel is observed. Station XIV. gave both in 1891 and 1892 absolutely the lowest summer temperatures, while in November 1891 the readings were sensibly higher at XIII. and XIV. than at the surrounding stations. A further result of the comparative isolation of the water in this region is the liability of the surface layer to sudden changes of temperature. Thus in June 1891, after several days of calm, hot weather, the readings at Station XIV. were the highest of the whole Channel, to a depth of five fathoms, and the lowest below seven fathoms (*vide* Figs. 2 and 3, Plate 2).

Any discussion of the bearings of these facts on the climates at different parts of the coast, or on fishery questions, is beyond the scope of this paper. It may be remarked, however, with reference to the latter subject, that the region of isolated water just noticed coincides almost exactly with the Brixham fishing-grounds. It is true that the fishing is largely prosecuted on that ground by trawlers, the nature of the bottom being specially suitable for trawling, perhaps on account of deposits which have taken place in the comparatively undisturbed water. But the region is known to abound in the young of various kinds of fish; and if we compare the results obtained in the Channel with the fact that observations on the east coast of Scotland show a tendency for large catches of herring to be made in local cold areas, or areas where the water is probably welling up from below, it seems worth while to inquire whether these quiescent areas are not specially spawning-grounds, and whether the regions in more active tidal communication with, in the case of British waters, the Atlantic are not specially feeding-grounds. Much light must be thrown on the problem by an inquiry into the distribution of Plankton in the two cases.

My best thanks are due to Mr. Frank Hughes, formerly chemist to the Marine Biological Association, for invaluable assistance, particularly in the chemical part of this investigation.

THE DISTRIBUTION OF AQUATIC PLANTS AND ANIMALS.

By H. B. GUPPY, M.B., F.R.S.E.

A SATISFACTORY explanation of the distribution of fresh-water organisms, extending as it would by implication to problems of much greater complexity, becomes of the highest importance to the student of nature. Our pond-weeds and duck-weeds, our *Infusoria* and other minute aquatic creatures, our fresh-water crustaceans, insects, and molluscs, occurs often over extensive areas of the globe. Lyell, Darwin, Hooker, De Candolle, and many other eminent men of science, have discussed this question, and their various opinions would afford material for a separate paper. Here, however, I can only briefly indicate the line of reasoning that seems likely to prepare the way for the investigation of the problem.

Darwin, in his *Origin of Species*, mainly relied on the exceptional means of dispersal possessed by fresh-water organisms. Semper, in his book entitled *The Natural Conditions of Existence as they affect Animal Life*, took exception to this explanation as not generally applicable, but he laid down principles of great value to the impartial inquirer. Wallace, in his *Geographical Distribution of Animals*, pointed out the two-fold nature of questions affecting distribution, or rather the two sets of opposing facts as he terms them when speaking of insects, viz., the powers of dispersal on the one hand and the frequent dependence on special conditions of life on the other hand. To put it in other language, an insect, in order to possess a wide range, requires not merely unusual means of dispersal, but also the frequent occurrence of the conditions necessary to its existence. In his later work on *Island Life* Wallace introduces into the discussion the element of time, and remarks, with regard to plants generally, that they have existed long enough in most cases to have been carried to all suitable localities on the globe, and that the determining factor of their distribution is to be found in their powers of adaptation to the new conditions. In plain words, this simply means that *time has long since discounted the means of dispersal, and that as regards explaining plant distribution the study of their means of dispersal is often superfluous.*

If this is the correct view of the matter it must apply to fresh-water organisms generally, and the problem of their distribution, deriving thereby a very different aspect, will be solved not so much by the study of their means of dispersal as by patient investigation of the conditions in which they live. The teachings of Semper should here come into great prominence.

An independent but somewhat circuitous line of research has led me to adopt a similar view. Whilst engaged for eighteen months in experimenting on the floating capacities of the seeds and seed-vessels of river-plants, uncomfortable doubts kept frequently interrupting the harmony of my reflections. An inquiry into the "How" did not at such times seem to me to be of much immediate interest when I knew nothing of the "When"; and on finding ultimately that I had been long engaged in experimenting on plants that flourished, in what is now Norfolk, before the Glacial Epoch,—for such is the story of the Forest-Bed,—my interest in the study of plant dispersal, as explaining distribution, sensibly waned. I then perceived that plants that had been existing so long had probably had their seeds carried over the world many times over, and that it was not so much a question of their ability to reach distant localities as of their capacity of maintaining themselves in a new region, and I soon saw that this must largely depend, in the case of widely distributed plants, on the frequent occurrence over the globe of the same conditions. This conclusion, however, only promises to lead to the solving of the problem by opening up vast fields of observation and experiment.

What, then, is the character of the conditions that cause fresh-water faunas and floras to be so similar over the globe, whilst the terrestrial organisms are frequently so diverse? It is the *uniformity of the conditions in which they live.* The fact that in a warm August day the temperature of the Thames at Kingston ranged only from 64° to 66° F., whilst the

air in the shade varied between 50° and 72° F., opened my eyes to a feature in aquatic life which previously I had completely ignored. As far as I can judge at present, the annual range of Thames temperature above the influence of the tide would be 35° to 70° F., but the small diurnal range is a constant feature, and the most important one. Of course, thermometric observations of river-temperature have been frequently made in various parts of the world, and I am touching here on no novel subject. Local conditions affect the absolute temperature more than the daily range; and, amongst numerous observations relating to these matters, I have found few so instructive as an analysis of those made many years ago by Hooker in the Himalayas. The general subject, however, of the temperature of rivers, ponds, and ditches, I hope, when my year's observations are complete, to consider in a future paper. But the point I wish here to dwell upon is the equability of river-temperature and of large bodies of fresh water generally, in connection with aquatic life.

Let us contrast the thermal conditions of aquatic life in the Thames with that in which land organisms live in this part of England. In the Thames there is an extreme annual range of, probably, from about 35° to 70° F., and a diurnal variation of 1° to 3°. ¹ The air in the shade ranges in the course of the year between 20° and 90° F., but this does not include the direct sun-heat on the one hand and nocturnal radiation on the other hand, the diurnal variation being usually between 8° and 25°, sometimes, however, more, and sometimes less. The annual range of the daily means of the river-temperature will probably prove to correspond roughly with the range of the monthly means of the temperature of the air in the shade, though in summer the river-temperature is a few degrees higher than the monthly means.

But the comparative equability of river-temperature is scarcely the most striking of the conditions that constitute the uniformity of aquatic life. Water organisms in rivers are scarcely affected by a great variety of physical influences that so largely determine the stations of plants and animals, such as diversities of soil, humidity, nocturnal radiation, wind, and many of those complex agencies that give endless variety to climate and to terrestrial life. A strictly aquatic plant is but slightly affected by conditions that completely change the character of the terrestrial vegetation. Thus we are not surprised to find many of our English river-plants amidst very different surroundings: *Potamogetons* in Australian rivers that drain regions mainly characterised by the *Eucalypti*; *Ceratophyllum* in the tepid waters of the rivers of Fiji and New Guinea; whilst the small genus of *Myriophyllum* is represented in the fresh waters of the greater part of the globe. Therefore, the wide

¹ Dr. Mill, who has much experience in taking sea-temperatures, kindly suggested a specially-constructed box containing maximum and minimum thermometers as most fitted for these river observations. Anglers and barges are, however, very inquisitive in such matters, so I found the best plan was to find the usual times of maximum and minimum temperatures by taking observations every four hours with an ordinary thermometer. Then, by taking the temperature at sunrise and in the afternoon (early in winter and later in summer) I was able to get the daily range without much trouble.

distributions of aquatic organisms causes no astonishment, and it may subsequently be found that the more complete the submergence of an organism during its whole life-history, the more extended will be its range. River plants and animals find much the same conditions over the greater part of the globe, and in time as well as space these conditions would preserve their uniformity. For these reasons we should expect to find that fresh-water organisms have changed far less in geological time than the forms of terrestrial life. In the never-ceasing changes that have often revolutionised the earth's surface aquatic organisms would have but little participated.

The extensive means of dispersal possessed by fresh-water plants and animals would not explain their wide distribution, if the conditions of aquatic life were not very similar over a large portion of the earth. To take the case of plants. The process of dispersal is ever going on in the case both of land and water plants; but its results are mainly determined by the reception the plant receives in its new country. If the conditions are not very different from those of its home, it will flourish and produce its kind. Now one can scarcely doubt that the countless migratory birds that visit this land must bring with them great numbers of seeds of plants that would never become permanently established here. Physical conditions affecting germination, foliation, flowering, fruiting, and the fall of the leaf may, as we can readily imagine, be found by a new arrival to be antagonistic to its establishment. Soil, elevation, temperature, radiation, humidity, rainfall, sunlight, not to mention the presence or absence of other forms of life on which the plant may depend, afford an ever-varying combination of conditions which are represented in the diversification of the land flora. Hence, whilst a particular region is able to preserve through ages its peculiar land flora, its rivers and ponds are stocked with plants that are found over a large part of the globe.

These principles, however, involve other questions. Bearing in mind that plants have existed long enough to reach, in the great majority of cases, all suitable stations on the earth's surface,—for this is the great lesson of the pre-glacial Forest-Bed of Norfolk,—it follows that the alpine floras of the mountain tops of temperate and tropical regions may be accounted for on similar grounds. It cannot be denied that, like the widely-ranging plants of tropical rivers, these plants have chosen a suitable station, and the only point at issue is as to how they got there. To go back to the glacial ages in order to find an answer to this query, is to acknowledge the antiquity of these alpine plants, an admission which dispenses with the necessity of any other explanation. But these principles would be of far wider extent. They imply not only a great range of species where the conditions are uniform, as I have shown to be the case with aquatic organisms, but they involve a large number of convertible species where the conditions are diverse, as on the land.

Take, for instance, *Bidens cernua*, a land plant in the strictest sense, though it grows in marshes. Its achenes are provided with recurved prickles, by which it attaches itself to passing bodies even more firmly than the burrs of *Galium aparine*. In the course of ages it must have

had an enormous number of opportunities of establishing itself in the tropics, but it is not included as a tropical plant, though there are widely ranging tropical species of the genus. The inference, therefore, is that this plant has one habit in the tropics and another in temperate regions, differences to which specific values have been applied. Years of observation and experiment alone can settle this point; but I may remark that I have grown these plants in a very small greenhouse under the hottest and driest of conditions, in fact in some cases in sandy soil, the chief differences, as far as I could judge, in the first generation being a diminution in the length of the achene and greater firmness of the stems. Specific and even generic characters may directly depend, as Semper points out, on external conditions; and it would be difficult to imagine a more striking case than that exhibited in the experiments of Schmankeewitsch, where a salt-water crustacean of the genus *Artemia*, was transformed by gradual dilution of the water during successive generations into a crustacean possessing the characters of the fresh-water *Branchipus*.

How patient we have to be in such investigations is well illustrated in two of my own experiments. In testing the buoyancy of the carpels of *Ranunculus sceleratus* in sea-water, I found that they germinated there after floating several months, and it was elicited by the second experiment that these carpels require months of soaking in sea-water before they can germinate there. In fresh-water they germinate in a few days or weeks, but the sea-water seedling has a strikingly different appearance from the fresh-water seedling. Then, again, I find that it would not be very difficult to convert *Ranunculus repens* into an aquatic plant. I have two small plants that have passed the whole of their existence of five or six months under water; they have produced in each case four or five leaves. *Atriplex patula*, however, is unable to do more under water than protrude its cotyledons above the mud.

Returning to the subject proper of this paper, I may remark that merely from the point of view of the thermal conditions affecting fresh-water plants and animals, many interesting matters await investigation, and not the least interesting will be the effect of the diurnal range of temperature on these organisms. Beginning with the "splash" and the rivulet, where the daily changes of temperature approach those of the air, the diurnal range diminishes until it almost disappears in the lake and the river. At some future time I hope to deal with these questions in a separate paper. They must be closely connected with the stations of aquatic organisms, and also with their distribution. As a general rule, the larger the bulk of water the more equable the temperature, and the nearer the approach to the thermal conditions which fresh-water organisms enjoy in warmer zones.

Here I can only touch lightly on these subjects; but if it should prove, as I think it will, that the plants and animals of our rivers live in thermal conditions nearer to those of tropical rivers than in the case of the respective land plants, then some rather curious speculations would suggest themselves. Take the northern hemisphere, for instance. Since the tropical river plants and animals would extend further from the equator than the land plants, they would, when the climate of the

northern hemisphere became warmer, be the first to reach us; they would also be the last to retire as the climate cooled. It would, in fact, require a less change of climate to introduce tropical water-plants and water-animals into our rivers than in the case of land plants. I cannot here enter into the various geological questions that these speculations would affect; it will be sufficient merely to indicate a line of inquiry.

In conclusion, I would point out that in my use of the term of uniformity as applied to aquatic conditions, I have employed it in the sense of their uniformity as compared with land conditions.

OBITUARY: 1892.

By J. W. McCRINDLE, M.A., M.R.A.S.

BELLEW, DR. HENRY WALTER, C.S.I., Surgeon-General, Bengal Army.—This distinguished Indian officer died at Farnham Royal, on the 26th of August last, about six years after his final retirement from service in the East. He was born in India in 1834, the son of Major H. W. Bellew, who perished in the disastrous retreat from Kabul in 1842. He studied medicine in this country, and after acquiring some practical knowledge of the art during the Crimean War, obtained a commission as an Assistant-Surgeon in the Bengal Service, and went out to India, in 1856. He was sent, soon after his arrival, to the Peshawar frontier to take medical charge of the Guides, and not long afterwards was selected to accompany Major (now Sir Henry) Lumsden on his famous mission to Kandahar. Of this mission he published an account, under the title of *Journal of a Mission to Kandahar in 1857 and 1858*. This work, which showed how keen was its author's insight into the subtleties of the Oriental character, was pronounced by the Government of India to be a useful contribution to our knowledge of Afghanistan. His next publication was *A General Report on the Yusufzais*, the material for which he had collected during the Ambeyla Campaign, and while he was Civil Surgeon at Peshawar; and this was followed by his *Grammar and Dictionary of the Pukhto Language*, which long continued to be a work of standard authority. In 1871, and from time to time afterwards, he was employed on political missions, as, for instance, Pollock's mission to Seistan, Goldsmid's to Persia, and Forsyth's to Kashgar and Yarkand. During the Afghan War in 1879, he acted as Chief Political Officer at Kabul, a post for which his intimate knowledge of frontier affairs, as well as his friendship with the Amir Sher Ali, to whom he had acted as interpreter at the Umballa Durbar, peculiarly qualified him. He embodied the knowledge which he acquired by serving on missions in works which are of permanent value. The best known are those entitled *From the Indus to the Tigris*, and *Kashmir and Kashgar*. The elaborate paper on the *Ethnography of Afghanistan*, which he submitted to the International Congress of Orientalists held in 1891, we reviewed at some length in the May number of this Magazine.

Dr. Bellew was married to the sister of a man of kindred spirit and