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FACTORS IN AQUATIC ENVIRONMENTS.[1]

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There is little in nature which is hard and fast; few distinctions are clear-cut. Therefore, in a study of environments we must not expect to be able to draw definite lines even at the most evident boundaries. On first thought it would seem easy to classify environments into aquatic and terrestrial, but, not only are some animals distinctly aquatic at one stage of their existence and just as distinctly terrestrial at some other, but certain situations such as the mud along a pond's edge are intermediate in more senses than one between water and land.

Considering the former difficulty, we find that whenever an insect has both terrestrial and aquatic stages, the larval condition is always aquatic. The terrestrial stage, the adult stage, is used merely for the perpetuation and spread of the species. In fact, it will greatly simplify matters throughout the study of the relations of insects to physical environments if we keep in mind that the presence or absence of the environment suited to the immature stages determines the presence or absence of the species much more than does an environment especially suited to the adult.

For the most part, but not exclusively so, aquatic animals are

[1] During the past winter the N. Y. Ent. Society has been conducting a series of symposia upon the Relations of Insects to their Environment. The papers on Aquatic Insects published here were given at the first symposium of this series.

primitive and primitive animals are aquatic. Among the invertebrates, with the exception of the dubious Mycetozoa, all the Protozoa spend the active part of their lives in fluid surroundings; sponges, jelly-fishes and their allies, star-fishes and their allies, and most worms are aquatic; while only the higher arthropods are at all terrrestrial. Among the vertebrates, on the other hand, only the most primitive, the fishes, are typically aquatic, the vast majority being terrestrial. Returning to the invertebrates and considering the insects, we find that low in the scale whole orders—Plecoptera, Trichoptera, Odonata, and so on—have exclusively aquatic larvæ. Here again the distinctions are not clear cut. The Thysanura are not aquatic and the Isoptera are also both terrestrial and primitive, but, in general, there seems to be at least the shadow of a rule.

Even when we consider the higher orders, we find that the aquatic Diptera, Coleoptera and Hemiptera are the more primitive members of their respective orders while aquatic Hymenoptera are exceedingly rare. The Orthoptera come in to disturb us by being both primitive and terrestrial but here also the more nearly aquatic, the now distinct order of earwigs and certain of the cockroaches, are the more primitive.

All this may seem foreign to the purposes of our symposia. Still it seemed to me interesting to note that in a very general way the division into aquatic and terrestrial insects is also a division into primitive and modern. The division is not distinct but it is probably as distinct as most of those we will be able to draw. Admitting it, the question of cause now looms large as it always should. The answer that would be given by most theorizers is that life originated in the water and that our present day aquatic fauna is a survival of the early origins. Nevertheless, the very most primitive insects are very far removed indeed from the origin of life. I suspect that a better reason may be that in early times certain insects took to the water and that aquatic environments, although variable, are less variable than terrestrial and have therefore not given rise to a series of modifications resulting in great changes from the primitive types.

Consider the factors of the aquatic environments as contrasted with terrestrial. There is no variation in *absolute* humidity since water is always as wet as it can be. There is, however, a variation in physiological humidity. That is, when the water contains certain

salts, as does the ocean, or certain acids, such as the humic acids of peat bogs, the water is not fully available for organic life. In fact, if an insect larva be taken from a brook and put in a brackish pool it will actually lose water through its skin; it will partly dry up. However, peat bogs and salt meadows make up only a small part of the homes of aquatic insects. In large part we can say that there is no variation in even the physiological humidity of aquatic environments. The humidity of terrestrial environments, on the other hand, varies every few feet.

The temperature is also more constant in aquatic environments than in terrestrial, although it is somewhat variable from place to place and month to month. In the summer, a spring hole is cooler than a rainwater puddle and the opposite is apt to be true in the winter. In general, a running stream is apt to be cooler in summer than a stagnant one. In the spring a deep pond is generally cooler than a shallow one and the opposite is true in the autumn. But aquatic insects are never subject to the sharp daily fluctuations of temperature that most of their terrestrial relatives must bear, and even the annual range of temperature variations are slight. Admitting all this, it may still be true that such differences as there are among the various aquatic abodes have an influence in determining the kinds of insects to be found there.

The variation of light is probably more nearly equal in the two major environmental divisions, although, since the light is never so intense below the surface as above and since it can never be darker than the absolute darkness of a terrestrial insect's burrow, aquatic environments are probably more uniform with respect to this factor also.

There is one important factor which varies more among aquatic environments than among terrestrial ones. This is the oxygen. Now to be of influence in modifying form or distribution, a factor must be both important and variable. Oxygen is undoubtedly important for all insects, but since it is not subject to a great deal of variation in truly terrestrial environments, it can be neglected there as far as these problems are concerned. We would not expect this to be true in the aquatic and indeed we find that not only is the fauna of well aerated mountain brooks very distinct as to its species from that of the pools along its edge, but we note that the most striking modifica-

tions of aquatic insects are concerned with the respiratory system.

Current is an important factor of aquatic environments which finds its terrestrial counterpart in winds. That it is a very important factor is shown by the numerous devices aquatic insects have to keep their position and it varies from nothing in puddles to the rush of Niagara.

Food is a factor which is always both important and variable. It is, however, a secondary factor in that, whatever the food habits of the insects may be, the analysis always leads us back to plants which have their own primary relations to the organic factors of the environment.

Enemies are also important and variable. The abundance or absence of fish in a pool will go a long way toward deciding whether mosquitoes will breed there or not.

Summarizing the factors of aquatic environments with respect to their effects upon the distribution of insects: Humidity is important only in the case of salty water and where there is a great decay of humus as in peat bogs. Temperature is probably only slightly more important. Light is probably important chiefly on account of its influence upon vegetation, hence food. Oxygen would seem to be of great direct importance. It should be noted in this connection, however, that many of the insects which live in the water breathe atmospheric air. Finally, among the inorganic factors current is not only of direct importance but has an additional indirect effect through its influence upon the oxygen content of the water. The organic factors of food and enemies are, of course, of prime importance.

RELATIONS OF TRICHOPTERA TO THEIR ENVIRONMENT.

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Trichoptera are almost exclusively confined to aquatic environments during the larval and pupal stages. The larvæ of one species of Limnephilidæ is reported to live in mosses at the roots of trees but the group as a whole is typically aquatic. As far as I know,