Animal Ecology of Torrential Streams.*

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ECOLOGY is that branch of biological science which deals with the responses of organisms to the physical and biological factors in their environment Such responses are popularly known as adaptations , and for their proper understanding it is of the paramount importance that the structure and the behaviour of an organism should be correlated with the factors in its habitat Just as an animal organisation is very diversified and thereby we are enabled to recognise genera and species on the nature of certain morphological characters, similarly an environment is composed of a large number of factors, which show an unlimited range of gradations Adaptation signifies correlation of an animal organisation with its habitat and so long as the varying gradations in a particular environment are not thoroughly understood, the finer adjustments of the animals to their respective external conditions cannot be grasped In certain cases, where there are marked differences between the habitats of groups of animals generally belonging to distinct genera, or families or to distantly related species, it is easy to indicate that the characters separating one from another are adaptive , but when closely allied species living in an apparently homogeneous environment are studied then it becomes difficult to realize that the minute differences separating them possess any adaptive significance, for though our knowledge of the classsification of species has made great progress, our knowledge of their habits and habitats is very meagre The fact should not be overlooked that habitats are as difficult to define as are the species

I have been working on the fauna of Torrential Streams in India for about seventeen years and I confess that it was only when I undertook the study of the Invertebrate fauna, that I became aware of the gradations in this specialized environment This knowledge has clearly indicated to me the marvellous correlation that exists between the organisation of a torrential animal and its habitat A field collector usually sweeps the bed of a shallow stream with his bag net and transfers his catch to a tube containing some alcohol and labels the entire lot from a clear, rapid running stream with rocky bed and little vegetation This material in the hands of museum workers is misleading and suggests that in a single habitat all kinds of forms are met with so that the obvious conclusion is reached that there are no adaptations for particular habitats For instance a student of mayfly nymphs would find the shrimp like larvæ of *Baetis* and the disc like larvæ of Heptageniidæ, such as *Iron*, living together in a hill stream, and unless the conditions under which these two forms live are known it would be difficult to speak of either of the two forms as being adaptive

Just as the study of an organism as a whole is of the greatest value, similarly I would strongly advocate that in all ecological work the environment should be studied as a whole But there are limitations In classifying animals we rely on certain characters which we consider to be of paramount importance, similarly in the classification of habitats we have to rely on certain factors in an environment Just as importance of characters varies with different taxonomists, similarly the importance of environmental factors ' varies with different ecologists Hubault[1] in his treatment of the invertebrate fauna of the torrents has relied on the oxygen contents and the low temperature of the water, and has attached a secondary rôle to the rate of flow of water In the course of my work I[2 3] have been impressed by the fact that the swiftness of the current and the nature of the substratum are the main factors and the

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[1] Hubault, E Contribution à l'etude des Invertébrés Torrenticoles *Bull Biol France Belgique Suppl*, 1927, 9, 388

[2] Hora S L Ecology Bionomics and Evolution of the Torrential Fauna, with special reference to the organs of attachment ' *Phil Trans Roy Soc London*, (B) 1930 218, 171 282

[3] Hora S L Nature of Substratum as an important factor in the ecology of Torrential Fauna " *Proc Nat Inst Sci, India*, 1936 2, 45-47

others, though of great value, for the existence of the animals, are themselves in a great measure dependent on the rate of flow of water To utilise the advantages afforded by the physico chemical properties of the cool and highly oxygenated waters of brooks, in the first place it is essential that the animals should be able to maintain their hold in swift currents The following classification has therefore, been based on the rate of flow of water at different strata and it has been observed that animal organisation shows a definite correlation to this factor in the environment

A brook consists of a series of rapids, falls and pools, and generally flows over a rocky bed with tufts of mosses and weeds covering rocks and stones here and there The fauna of the pools is different from that of the rapids and again the animals that live on rocks in a rapid are different from those that live in moss If there is sand in the bed then we find burrowing animals which are different from the rest Let us confine our attention to the shallow, rocky part of the stream and here again we must remember that the current at the bottom and sides is much less than that in the centre at a point about three fifths of the depth from the bottom We meet with a gradation in the fauna corresponding with the gradation in the flow of the current Let us select a small portion of the bed in swift current for more thorough investigation The stones are loosely placed on one another so that interspaces are left between them through which water flows at a considerably slower rate and the current at the bottom among shingles and pebbles is probably negligible The rock inhabiting animals of the brooks can thus be divided into 3 strata (i) those that live on the exposed surfaces of rocks, (ii) those that live in the interspaces and crevices among rocks and stones, and (iii) those that live among shingle at the bottom Thus according to their positions in the currents the animals are provided with elaborate means of attachment and are correspondingly modified in several ways to offer minimum resistance to the current The plant inhabiting animals of the torrents are also of three kinds Those, like the larvæ of *Tipula* that live among roots are sheltered from the current and are the least modified for this habitat Others like the larvæ of *Phalacrocera* and *Nephelopteryx* entangle themselves among plants by means of chitinous processes and lastly the larvæ of *Simulium*, Chironomids, etc, live on plants attached by means of their extremities so that they dangle freely in the current Though these animals are differently modified for attachment, which is due to the various ways in which they are affected by the current, yet in response to the high percentage of oxygen in the water they have all reduced their gills The animals of each habitat can be further divided according to the nature of their food Most members of the torrential fauna feed on algæ and slime covering rocks and stones, but some have evolved highly complicated devices to strain microplanktonic organisms out of the rushing currents and there are few, like the nymphs of *Perla*, which are predaceous

In broad outline the factors indicated above influence groups of animals and mould them to similar lines The finer gradations of these very factors distinguish species Take for example, the three species of *Baëtis* described by Dodds[4] from Colorado living on rocks in swift currents[5] *B tricaudatus* with three caudal cerci lives in currents flowing at the rate of 5 feet per second *B intermedius*, in which the middle caudal circus is decidedly shorter, lives in waters flowing as much as 8 feet per second and finally *B bicaudatus*, in which the middle circus is represented by a vestige only lives in places where the water flows at the rate of 10 feet per second The reduction of the middle circus can thus be correlated with the increased swiftness of the current and such a reduction can be traced among the nymphs of other mayflies also The reduction of the middle circus is accompanied by the tapering of the body posteriorly so that the stream like moulding of the body is carried to the extreme posterior end It is clear then that minute difference between species can be correlated with the intensities of certain factors in the environment

Let us now consider the different body forms of brook inhabitants They are gracefully streamlined so that the water glides over them smoothly and no dead water area or eddy formation takes place in the neighbourhood of the animal The animals that swim or swing in the current, are

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[4] Dodds G S 'Mayflies from Colorado' *Trans Amer Ent Soc*, 1923 **49**, 93–114

[5] Dodds G S and Hisaw F L, Ecological Studies of Aquatic Insects I Adaptations of Mayfly Nymphs to Swift Streams,' *Ecology*, 1924 **5**, 137–148

cylindrical so as to present a stream line to the current on all sides, whereas those that lie flat on the bottom are stream lined along the exposed surface and flattened along the opposing surface The animals either become greatly elongated or they assume limpet like forms In the case of the aeroplane struts it has been found that both forms are equally effective in reducing resistance But it may be asked why some animals assume one form and the others a different form This differentiation in the ultimate form is due to the initial form with which an organism starts its life in rapid waters, for in nature it seems to be a rule that, with whatever initiative an organism may be endowed in the beginning, it is through the continuous moulding of the same material under different sets of conditions that different forms are produced New structures do not arise *de novo*, the old structures by taking on new functions are so altered, and consequently alter the entire organisation, that sometimes the genetic affinity between the two allied forms can be hardly discerned

It is sometimes advanced as an argument against adaptations that similar forms are found in different habitats, but the point to be considered in each case is whether it is adjusted to live or not in the place where it is found Two different looking dragonfly larvæ are found clinging to plants in swift currents *Macromia ida*, a flat-bodied larva, belongs to the bottom dwelling Libellulinæ and *Matrona basilaris*, to the weed dwelling Calopteryginæ Both forms being useful for reducing resistance are retained without great change, whereas in response to the pulling action of the current the legs have become elongated and are spidery The spidery legs enable the animal to swing before the current without losing hold of the substratum Here is an instance showing divergence in form but convergence in the organs of attachment

In conclusion, it may be stated that for a proper appreciation of organic evolution or adaptation it is of the greatest importance that the characters of an animal and the factors constituting its habitat should be investigated at the same time, for it is difficult to conceive of a living animal apart from its environment Ecological studies alone will help us to eliminate all chances of confusion arising out of the similarity of structures under apparently different conditions or of the divergence of characters under apparently identical conditions My studies have shown that sometimes an identical factor is found in operation under different conditions and the resu

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On Structural Variations in the Indian Leech *Hirudinaria granulosa*.*

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DURING the course of study on the anatomy of *Hirudinaria granulosa* I have come across some interesting variations It is considered desirable to record them for the information of those interested in this particular group of animals The variations have been noticed in the number and arrangement of sensillæ and eyes, the posterior sucker, the structure of the crop (stomach), the absence of some of the testes, and the extension of vasa deferentia in segments where there are no testes and where they serve no function

I *Sensillæ* (the segmental receptor organs) —Typically there are 4 dorsal and 3 ventral pairs of sensillæ on the first annulus of each somite in *Hirudinaria*, but several specimens show different kinds of variations Moore mentions, 'Not infrequently sensillæ are divided into two or three small ones, or may be absent or in a changed position, but such cases are obviously individual variations All variations in sensillæ that I have noticed come more or less under the description given by Moore

II *Eyes* —The normal number of eyes in this species is five pairs Moore states, In Hirudidæ there are almost invariably 5 pairs forming a regular arch on somites II to VI, suggesting the name ten eyed leeches' These 10 eyes are metamerically disposed in segments 1, 2, 3, 4 and 5 , a pair being present in each segment Moore accepts that eyes are variable in Erpobdellidæ

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* Read before the Indian Science Congress 1932

Gratiolet Whitman's method of segmentation is followed in this paper