

and method. Progress, if it is to be real and permanent, must spring from the hearts of the people and the function of statesmen must be to provide the means of stimulating and directing it for the greatest common good. In the reformed administration of the country, where it is proposed to introduce adult franchise, we really wonder whether the education of the people has been of such a character as to enable the general electorate to make the right selection, to weigh between two opposing political issues, or to formulate clearly their public duties and obligations. The primary want of the people which is a condition precedent to their general progress is a wider diffusion of scientific education which would also

include a knowledge of those branches of learning, leading to a practical appreciation of an enlightened and well-ordered social and political life, the observance of the laws of public health and principle of hygiene, the inculcation of the deeper meaning and purpose of humanity and the ideals of the higher values of individual and corporate life. In order to secure the attainment of these objects in any measure, the reform of education, the revision of medical ethics and alteration of the complexion of administration should form the immediate consideration of the reformed government. It seems to us that what political philosophy has not succeeded in achieving for mankind, science may yet fulfil.

Unemployment in India.

WE have received a copy of the booklet by Sir M. Visvesvaraya, K.C.I.E., LL.D., on "*Unemployment in India*," which formed the subject of a public address delivered in Bangalore on the 8th September. The address commences with a critical examination of the present economic situation in India, and contains an analysis of the causes which have led to the unemployment among the general masses of the people and among the educated community. It will be remembered that the Government of India in their circular, after having enumerated the causes which have contributed to the serious state of unemployment on an extensive scale, practically gave up the case as being far too complex to admit an easy or immediate solution. A public

pronouncement, setting forth suggestions of practical remedies for relieving the tension of the situation, by a distinguished and responsible citizen, with wide administrative experience and knowledge of practical affairs of men and things, must possess, at the present moment, more than ordinary interest. Our main object in announcing the publication of this important booklet is to focus the attention of the public in general, and of the authorities and men of science in particular, on what may commonly be called the burning topic of the day. We intend to return to this in the next issue of *Current Science* when we expect to be able to deal with the subject from stand-points other than those already examined by us in the editorial for the August Number.

Waterfalls as Habitats of Animals.*

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IN an earlier paper (1) the animals of the bed of a rapid flowing, shallow, rocky stream were divided into two "sub-associations" and each of these was again divided into three "strata". Further work on the ecology of the torrential streams has made it clear that the habitats should be classified into still finer divisions in order to realize the full

significance of animal adaptations, *e.g.*, the correlation of an animal organization with its habitat. So long as the varying gradations in

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A short account of waterfalls as habitats of animals is given by Pearse in *Animal Ecology*, p. 194, New York, 1926.

a particular environment are not thoroughly understood, the finer adjustments of the animals to their respective external conditions cannot be grasped. It has already been indicated (2) that a portion of a small stream can be classified according to the strength of the current and the nature of the substratum. It was then pointed out that the animal associations vary in accordance with the nature of these factors in an apparently similar environment. Following this line of research I have now subjected waterfalls to an intensive study, and have been greatly struck by the diverse associations of animals that inhabit this perilous situation. By a waterfall I do not mean only the spout of water that falls, but I include in it the vertical cliff of rock, the black pool at its base and the neighbouring parts of the gorge that receive a spray from the waterfalls. Thus defined, a waterfall can usually be divided into the following possible habitats of animals:—

1. Water spout.
2. Lip of waterfall.
3. Vertical rock behind the spout and not directly influenced by the current.
4. Usually habitat 3 is replaced by a slanting or vertical rock over which the water flows.
5. Rocks at the base of waterfall over which water crashes.
6. Rocks at the edge of the current intermittently splashed with the eddies of the turbulent waters.
7. Rocks in the neighbourhood of waterfalls which receive a constant spray of water.
8. Deep pool at the base of waterfall.

Even a casual consideration of this classification will show that the conditions of life in different situations must be different, and consequently, the association of animals inhabiting each division must also be different. It may, however, be indicated that there are no hard and fast limits, and that where the habitats grade into one another, the animal associations also overlap one another. I shall now define the possible divisions of waterfalls in terms of ecological factors.

The waterspout lacks solid substratum and in the column of falling water there are no permanent inhabitants, but occasionally fish, such as salmon, mahseer, etc., when ascending streams for the purpose of spawning leap through waterfalls. Large water-

falls or cataracts, however, form effective barriers for the ascent of even these muscular fishes.

The existence of animals on the lips of waterfalls must seem very precarious. It has, however, been shown (1) that the lips of waterfalls can be divided into two categories ecologically, those in which the rocks are covered with vegetation and those in which the rocks are bare. Vegetation, besides affording shelter, provides a secure substratum which enables animals to cling to it by means of hooking devices. On a bare rock much firmer grip is required for stability of movement, and consequently the fauna is relatively poorer. Blepharocerid larvæ (Diptera) and nymphs of *Iron* and *Baetis* (Ephemeroptera) are found on bare rocks, while among vegetation the fauna is much richer and varied, and mainly consists of the torpedo-shaped clinging larvæ of Diptera, Plecoptera and Ephemeroptera. According to the strength of the current, the fauna varies considerably in this habitat.

The vertical face of rock behind the column of falling water, but not affected by it, is a place of safety for several kinds of insects, watermites and other small animals. The mosses that grow in this situation afford protection and substratum for anchorage to a number of small organisms. There are certain species of birds that make nests in this habitat. The fauna here varies with the amount of moisture available, and if there is a regular flow of water over the rock (as in habitat 4), fishes may be observed sucking their way up the cliff.

Sometimes the falling column of water flows over smooth, slanting rocks and in such cases the nature of the fauna depends upon the rapidity of the current. If the current is not very fast Caddis-worms of several types are found, but in swift waters Blepharocerid and *Simulium* (Diptera) larvæ abound. Fishes, such as *Garra*, and tadpoles, as those of *Rana afghana*, are also found climbing upstream in this habitat.

The animals that live at the base of a waterfall must be able to withstand a tremendous crash of water. I have collected chiton-like larvæ of the Blepharoceridæ at the base of small falls. It is presumed that the chiton-shape of these larvæ enables them to take the firmest possible hold. The only other animals that were found in this situation were the pupæ of Caddis-flies, but they occurred on the sides of stones and not

on their upper surfaces over which the water fell. According to Dodds (3), the nymphs of *Bætis bicaudatus* live on rocks where water pours upon them with considerable force.

The rocks in the immediate neighbourhood of the current constitute a very important habitat in this environment, for they afford places of safety for the pupæ of insects and also provide substratum to the adults for egg-laying. In this situation the animals are less liable to be swept away by the current, though they are kept moist by an intermittent splashing or by the dribbling of water from the lip of a waterfall. From here the larvæ migrate into swifter waters, and the pupæ can let out the adults in comparative safety.

The rocks at a little distance away from the waterfall are kept moist by a spray. A large number of moisture-loving animals live in this habitat, but the most striking are the larvæ and pupæ of Psychodidæ which were very common in streams round about Tista Bridge below Darjeeling. These insects live on bare rocks and their earlier stages resemble those of the Blepharoceridæ superficially. Some interesting Copepods have been collected from among mosses. The fauna varies according to the nature of the substratum in this habitat.

The fauna of a pool at the base of a waterfall is very different. The water does not flow very rapidly in it, but it is highly oxygenated. Migratory and other fishes are found in it. Frogs, insects and their larvæ, leeches, molluscs, etc., are all found in these pools.

From the above it is clear that the habitats of animals are as specific as the characters of the species, and probably equally difficult to define. Though our knowledge of the classification of animals has made great progress, unfortunately our knowledge of their habits and habitats is very meagre. It is generally conceded at the present time that "Structural modifications shown to be adapted to particular habitats or modes of life seem to be more characteristic

of genera or groups of higher ranks than of species" (4). Generally speaking, the factors strength of current, nature of substratum, amount of moisture, etc., used above for classifying waterfalls, influence groups of animals and mould them to similar lines. Possibly the finer gradations of these factors distinguish species. As an illustration we may take the three species of *Bætis* described by Dodds (3 & 5) from Colorado living on rocks in swift currents. *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 cercus is decidedly shorter, lives in waters flowing as much as 8 feet per second and finally *B. bicaudatus*, in which the middle cercus 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 cercus (as well as the modification in the shape of the posterior part of the body) can thus be correlated with the increased swiftness of the current and the modification is useful in imparting to the animal perfect stream lines. It is clear, therefore, that minute differences between species, when studied ecologically, can be correlated with the *intensities* of certain factors in their environments.

The study of Animal Ecology is growing in importance, and it is reasonable to expect that some international standards of the classification of habitats and of nomenclature will be fixed before long to save the new branch of science from the fate that has overtaken Taxonomy.

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