

forms it must provide the right kind of surface; burrowers, for instance, need a fairly soft and fine substratum; animals living in moving water need a firm surface to which to attach themselves, and some require also crevices or other recesses in which they can take shelter.

The biotic features of a habitat are complex and less easily understood than the physico-chemical ones. Obviously the right kind of food must be available in adequate quantity. Many animals require different foods at different stages in their lives, and in their habitats all must be available to them at the appropriate times. Negative biotic characters include predation and inter-specific competition. These must obviously not exceed certain critical limits if a species is to survive. Inter-specific competition seems

to play an important part in limiting the habitat range of species which are adapted to withstand unfavourable environmental factors such as water movement.

Although size of the water-body has been suggested as a basic criterion in classifying freshwater habitats, the chief effect of increasing size is to increase the variety of habitats which can occur in the body of water.

The purpose of this paper is to urge that any scheme for the classification of freshwater habitats should be based on the environmental factors which are of the greatest direct influence on the animals concerned. These factors include water movement, temperature, oxygen concentration, pH, substratum and food supply.

Marine Environments

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The idea behind this symposium stems from a general paper by Elton and Miller on the ecological survey of animal communities in which a practical scheme for classifying habitats by structural characters is discussed. In this paper outline classifications are given for terrestrial and freshwater habitats and it is inferred that a classification of marine habitats based upon the same principles could easily be built up. It is my task in this symposium to attempt to stimulate discussion upon the possibilities of evolving a scheme of classification for marine habitats that will be acceptable to all ecologists.

The difficulties arise from the qualification—"acceptable to all ecologists."

We all know the difficulties involved in drawing up any ecological scheme that involves definition, and of course a habitat classification is one long definition. Part of the difficulty arises because working ecologists often mix two aspects of the study. We all try to be descriptive and interpretative at the same time. Interpretations of data are as varied as are the workers in the

field and it is because descriptive schemes do not fit the varied interpretations that much of the criticism is levelled at them.

Habitat classification must fit into place with biogeographical classification. There is perhaps no need to stress this aspect but mention should be made that there are at least four major types of habitat in the sea whose biogeographical classifications are largely independent:—

1. *Littoral* in the wide sense, forms confined to coasts and shallow water habitats where the classification is based on coastlines and shallow water areas.
2. *Deep Sea Benthos*, forms confined to the deep water basins of the world.
3. *Pelagic forms*, classification based largely on water masses.
4. *Bathypelagic forms*.

Broad biogeographical subdivisions of these four habitat types are fairly well accepted and Ekman's book deals mostly with the subdivision of these types. The habitat classification as sketched by Elton and Mil-

ler for land and freshwater habitats is concerned with classification within biogeographical areas. The two criteria used for subdivision by Elton and Miller were Formation type and Vertical layers. These criteria have been used in arranging a classification of marine habitats in the past, but they are seldom codified—or at least the divisions under Vertical layers are seldom codified. There is general agreement both about the major divisions of the marine habitat and the factors that require consideration in drawing up finer divisions.

In the discussion that follows planktonic habitats will be largely neglected, and the main theme will be those organisms that live attached to or buried in a substratum, the benthos and associated forms. The following factors seem to be those by means of which this habitat can most readily be defined.

1. *Depth*, in the broadest sense, including relative position between tidemarks, and depth of overlying sea.
2. *Type of substream*. This is of undoubted significance, and a series from rock, through gravel, shell gravel, sandy gravel, sand, muddy sand and sandy mud to mud or ooze would probably give a sound basic subdivision.
3. *Habitat in relation to substratum*. (The Vertical Layers of Elton and Miller). Here some such basis as the following might serve:—
 - (a) Burrowing;
 - (b) Beneath surface litter, loose stones, shells, etc.

- (c) On interface surface;
- (d) On attached vegetation or animals;
- (e) Free living but confined to the surface.

To follow through Elton and Miller's fresh water scheme the following divisions would also be required:

- (f) Water Mass
- (g) Water Surface
- (h) Air above.

This seems to give too little scope for subdivision of the planktonic element, and this would probably be best dealt with separately. There is no doubt that this is where it would be logically classified and in shallow water it might best be so classed.

Elton and Miller use the rather useful concept of "qualifiers" and in the marine field the most important of these would be wave action which might be graded on a scale of 1 to 5, and salinity which might best be treated under the heads of normal, reduced, greatly reduced.

By using depth and substratum as major variables a scheme of classification could be built up similar to that used for fresh-water habitats, and this in conjunction with the subdivisions of the vertical layers and the qualifiers should give a method of recording habitat that would be a big advance on present methods in use in New Zealand. The actual subdivisions to be used would need to be drawn up by a group and then circulated to all marine workers for comment and criticism. Such a classification could undoubtedly be evolved, and it could almost certainly be made acceptable to at least a majority of ecologists.

REFERENCE

- EKMAN, S., 1953. *Zoogeography of the sea*. London. Sedgwick.