Ecology Part I (H)

Zoology · P.G II nd semester XII th Paper

Limiting Factor in Terrestrial Ecosystem

Includes : Leebig's Law of minimum and Shelford's Law of Tolerance
: Various interspecific & Intraspecific relationship

All Living Organisms, Plants or animals have a range of tolerance for every environmental factor such as temperature, humidity or salt contents of the aquatic environment. If an environmental factor exceeds the maximum tolerable level or it comes down to the minimum tolerance in any given area, it becomes a limiting factor. It prevents the distribution of particular animals or animal groups in that area.

For Example, in aquatic medium the Concentration of salts is often a limiting factor.

Justus Liebig and V.E. Shelford have profounded two different Laws governing the distribution of animals and growth of organisms.

Liebig Blackman's Law of Minimum

Justus Liebig, 1840 While studing the relationship between the available amounts of essential elements and plant growth, discovered that the Crop yield was

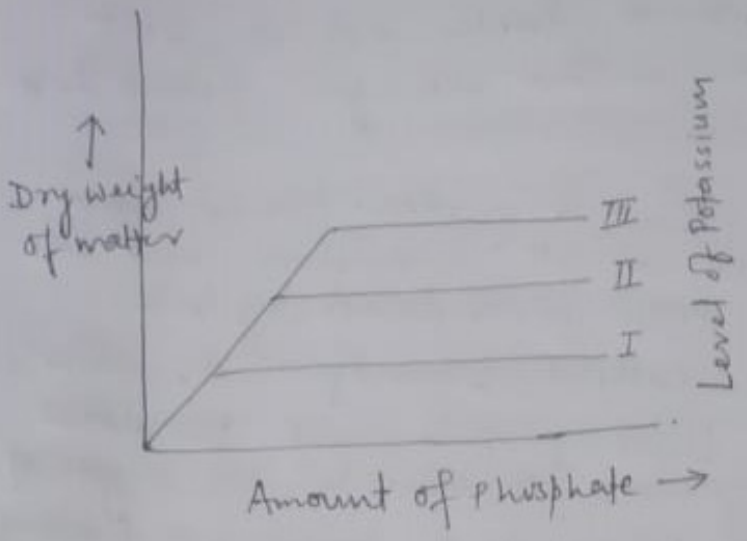
was frequently limited by such elements which are utilized in low concentration. This Concept is described as Liebig's Law of minimum. It holds that the growth is dependent on the amount of foodstuff that is present in minimum quantity.

The hypothesis of Liebig was originally concerned with the chemical material required by Plants in their natural environment.

Later workers have expanded to include animals and all of the abiotic environmental factors. A number of environmental factors like temperature, atmospheric gases, humidity, amount of light and many other similar biotic factors are able to act as limiting factors with respect to the organism. Therefore, F.F. Blackmann, a British Physiologist incorporated the Law of minimum with the law of limiting factors.

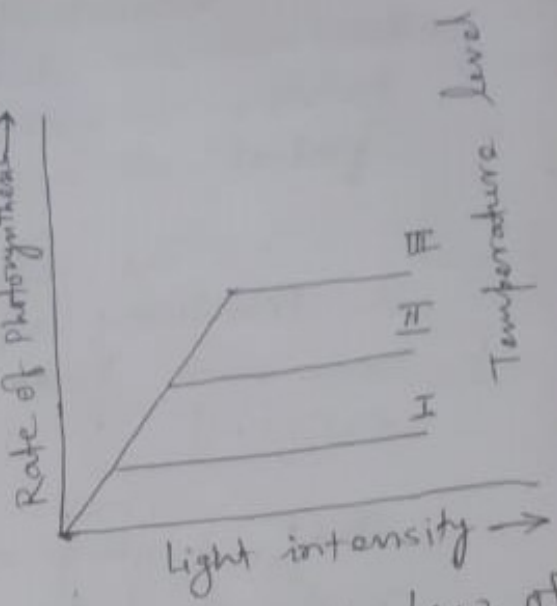
Blackman, while studying the factors affecting the rate of photosynthesis discovered that the rate of Photosynthesis is governed by the level of the factor that is operating at a limiting intensity.

Further work on limiting factors and subsistance has shown that a high level of one factor will modify the limiting effect of second. The phenomenon has been described as "factor interaction."



A. Liebig's Law of minimum

" The amount of phosphate Plotted against the dry weight of matter produced at three different levels of the supply of Potassium which becomes a limiting factors.



B. Blackman's Law of limiting factor.

" The rate of photosynthesis plotted against the light intensity at three different temperature, each of which limits the rate of photosynthesis

Shelford's Law of Tolerance

It is observed that organisms are limited in their growth and their occurrence both by too little of an element or two low an intensity of the factors, but also by too much of the element or too high an intensity of the factor ie; the amount of a substance below or above certain limits proves to be harmful to the organisms.

For example, CO_2 increases the rate of Plant growth, because small increase in its Concentration increases the rate of Photosynthesis in green plants. But, when it is increased Considerably it becomes toxic.

Similarly, small addition of arsenic to human diet has a tonic effect, but further increase in the dosages proves to be fatal.

The idea that a factor could have a limiting effect at its maximum and the minimum quantity was introduced by V. E. Shelford in 1913 & called "Law of Tolerance".

Thus the law of tolerance postulates that ecological factor to which an organism responds has maximum and minimum limiting effects and a value below a critical minimum or quality above the critical exclusion.

The range between the critical minimum and critical maximum is known as limits of tolerance. Any value lying between these critical limits will naturally fall in the limits of tolerance for an organism. If the limits of tolerance are exceeded for a particular species, it will lead to the disappearance of the species from that area as long as such condition exists.

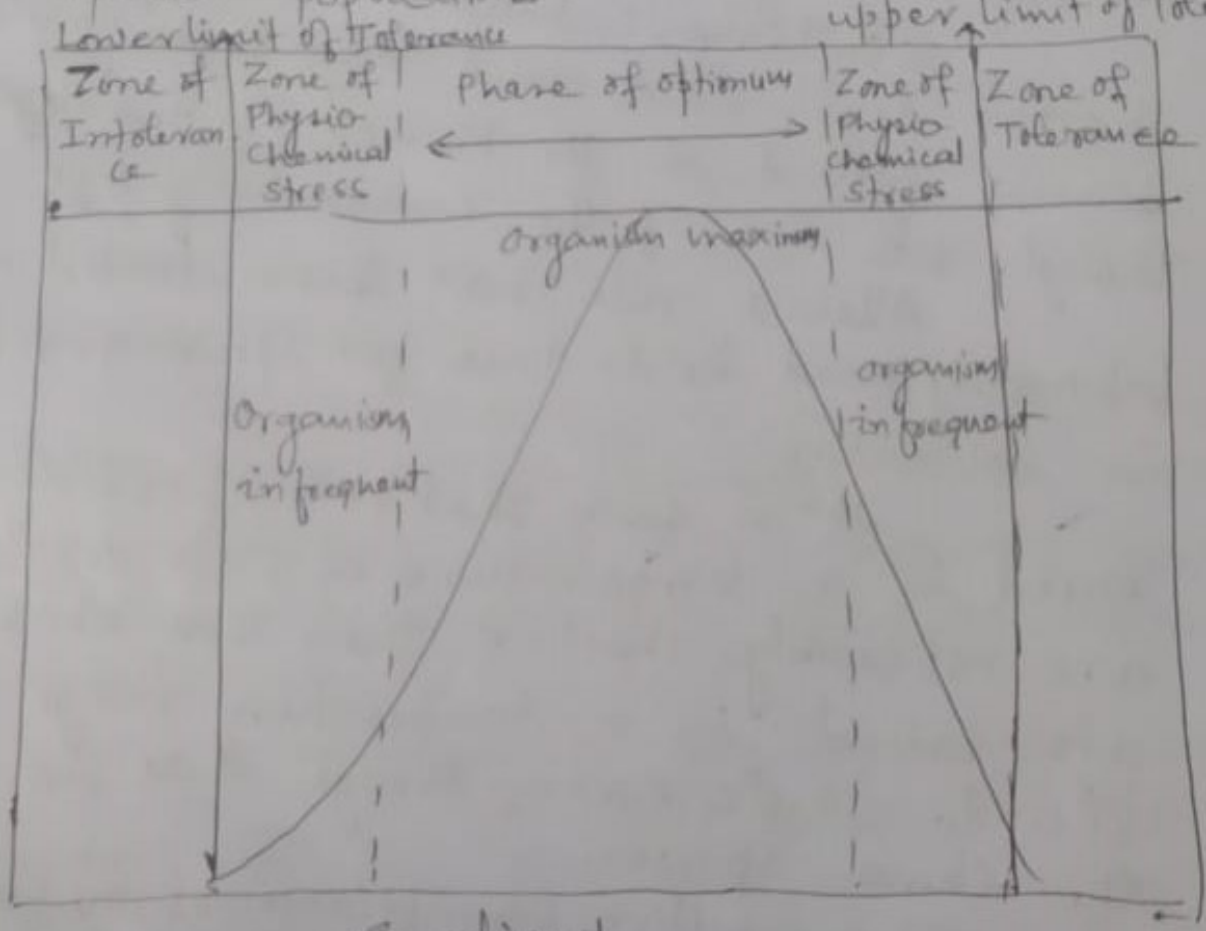
The Concept of optimum is that point within the limits of tolerance at which a given factor is acting at a level best suited to the requirements of a given ~~organism~~ organism.

Certain additional information has been incorporated with the law of Tolerance A plant or animal may have a wide range of tolerance for one factor in the environment but relatively low range of tolerance for ~~one~~

another factor. In such a case, if conditions are not suited to one condition, the limit of tolerance may be reduced with regards to the other also.

For example, some species of freshwater fishes are eurythermal (having a wide range of tolerance for temperature), but are stenohaline (having a narrow range of tolerance for salt). Lowering of temperature of brackish water resulted in the reduction of tolerance of estuarine species to low salinity.

Not only this, the range of tolerance and the optimum condition vary for geographical ranges of the same species. Therefore, the law of tolerance and limits of tolerance help in understanding the biological distribution under natural conditions and also in the appearance of variations within species populations.



Graphical representation of Law of Tolerance

ALLen's rule

* Allen observed that the extremities of homoeothermous animals tend to reduce in proportion to the trunk as they move from equator towards the pole ie, from warmer to colder region. This is known as Allen's rule.

This rule shows differences in the ear size of three different species of fox, an arctic fox (Alopex legopus), red fox (Valpus Vulpes) of temperate region and desert fox (Megalotis zerda).

Eskimos have shorter arms and legs in proportion to their trunk size, which is comparatively larger than in any other contemporary group.

Similarly, Gazella of Himalays has shorter legs, ears and tails than Gazella bennetti found in the planes of Himalays, though both are of the same body size.

Allen's rule has been tested in laboratory and holds true for species reared in laboratory.

It is seen that tails of individuals reared in a temperature of 15.5°c to 22°c are noticeably shorter than those which are raised in a temperature range of 31°c to 33.5°c even though these are of the same species.

The adaptive significance of the feature is obvious that short extremities reduce exposed surface which reduces loss of heat from body

Bergmann's rule

The morphological variations in the individuals of homoeothermic animals (birds & mammals) in response to changes in the temperature also includes variation in size. It has been noted by Bergmann that the birds and mammals in the colder ~~species~~ regions are much larger than the related species which live in warmer areas. This is known as Bergmann's rule, which suggests that as the temperature decreases from the equator towards the poles, the body size of the individuals living there increases gradually. The significance of the increase in size is explained by presuming that a larger animal has less surface area per unit of weight than the smaller one and thus proportionately less heat is lost by radiation than in a smaller animal.

In warmer zones, on the other hand, the large size will be harmful to the animals since loss of heat by radation is beneficial to these animals, hence they are comparatively short statured.

The rule can be supported by factors obtained by the study of nature. The largest bears are the Polar bears and Kodiak bears which are found in the far north, the smaller bear is found in more temperate region. Penguines of Antarctica attain body length of 100 to 2000 mm, whereas of Galapagos islands are 400 mm long

Short notes

Antibiosis

It is the production of harmful secretions by the organisms which are harmful to other organisms.

Fungi produce different kinds of antibiotic substances such as Penicillin, streptomycin etc. These are helpful in destroying the pathogenic bacteria Microcystis, a blue green alga, produces a toxic substance, the hydroxylamine, which causes the death of fish and cattle that drink water of that Ponds.

Microenvironments

The climate in which an animal actually lives is very much different from the gross environmental conditions. The immediate environment of the animal is called effective climate or the microclimate. It includes habitats of animals. For example, crevices of barks of trees is a microenvironment for insects living there.

The concept of microenvironment is particularly important in relation to moisture because relative humidity ® Varies widely with in short distances in an irregular habitat.

The ® characteristics of soil determines where grasshoppers and tiger beetles will lays their eggs. The vertical change in moisture and other vertical gradient influences distribution of organisms.