Laws of Limiting factor

The term *limiting factor* may be defined as an environmental factor or variable that has the capacity to confine the growth, abundance, or distribution of a population of organisms in an ecosystem. These are available in limited supply. Hence, organisms compete for their limited availability in the ecosystem. The principle of limiting factors may be defined as the principle whereby a factor that is in shortest supply limits the growth and development of an organism or a community. There are three laws, viz. Liebig's *law of the minimum*, Blackman's *law of limiting factor*, and Shelford's *law of tolerance* that explain the principles of limiting factors.

1. Liebig's *law of the minimum*

This law was originally developed by Carl Sprengel and later popularized by Justus von Liebig. This law states that the growth is regulated by the scarcest resource rather than by the total resources available. It means that the growth of a population is constrained by the scantest factors and not by the abundant factors. This law is based on the observation of crop growth where addition of abundant nutrients did not give increased growth. But, the addition of rare nutrients, which is the limiting factor here, did give increased crop growth. This means that even if some of the nutrients in the soil are abundant but if the other nutrients are limiting or relatively fewer then crop growth will not increase. When we apply this principle to other biological populations, this implicates growth occurs only as dictated by the most limiting factor. This principle was used by William Cumming Rose as a basis in identifying the essential amino acids.

2. Blackman's *law of limiting factor*

A British plant physiologist, Frederick Frost Blackman (in 1905), proposed this law. According to this law, a process depending on multiple factors is rate limited by the pace of the slowest factor. For example, Photosynthesis. Photosynthesis is a biological process that depends on many factors. The general chemical reaction of photosynthesis is

$$6CO_2+12H_2O+energy=C_6H_{12}O_6+6O_2+6H_2O$$

Here, carbon dioxide, H_2O, and light energy (sunlight) are the limiting factors. If any of them become accessible at a pace slower than the usual, the rate of photosynthesis becomes slow. For example, if CO_2 concentration becomes scarce (e.g. due to closure of stomatal openings in response to elevated temperatures in the environment), the rate of photosynthesis becomes slow even if H_2O and light energy levels are available in ample. The same result will occur if light energy becomes less available or less intense.

3. Shelford's *law of tolerance*

This law was developed in 1913 by American zoologist **Victor Ernest Shelford**. According to this law, the success of an organism depends on a complex set of environmental conditions or factors. organisms would have definite *minimum*, *maximum*, and *optimum* environmental factors determining the success. These signify the limit of tolerance of that organism. However, the tolerance ranges may vary within the same organism, for example depending on the life stage (larval vs. adult).

Types of limiting factors

Density-dependent limiting factor definition

Density-dependent limiting factor refers to the factor restricting the size of a population based on density. A large, dense population are more strongly affected than a small or less dense population. For example, a dense population would have higher demands for food and water compared to a small population. In this case, food and water supply is the limiting factor and it depends on density. Disease as a factor is also density-dependent. It spreads faster in dense population than small ones.

Density-independent limiting factor definition

Density-independent limiting factor refers to the limiting factor that is not dependent on density. The limiting factor can restrict population size independent of how dense the population is. For example, a catastrophic event, such as an earthquake or a volcanic eruption, could cause a population decline regardless of population density.

Single-limiting and co-limiting

A *single-limiting factor* is when there is one factor that limits the system. A *co-limiting factor* is when a factor affects the population of organisms in an ecosystem indirectly but increases the limitation of the factor directly affecting the population.