Laws of limiting Factor

B.Sc. Part-I

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In biology, the term *limiting factor* is defined as an environmental factor or variable that has the capacity to restrict growth, abundance, or distribution of a population in an ecosystem. These factors are present in limited supply. Thus, organisms tend to compete for their limited availability in the ecosystem.

The principles or laws that help to analyse limiting factors in an ecosystem are

Liebig's *law of the minimum*

Blackman's *law of limiting factor*

Shelford's *law of tolerance*

In *law of minimum*, the growth of population could be the growth of population could be regulated by the scarcest resource, not by the resources in abundance.

In *law of limiting factor*, a biological or an ecological process that depends on multiple factors will tend to have a rate limited by the slowest factor.

In *law of tolerance*, the survival success of an organism is suggested to depend on a complex set of environmental factors.

Limiting factors may be- density-dependent or density-independent.

Limiting factors may also be

***single limiting*-** when only one factor limits the system.

Co-limiting factor- When a factor causes an indirect restrictive effect or increases the effect of a direct limiting factor.

Examples of limiting factors that could limit the size of a population are food, nutrients, shelter, and mate. These resources are limited in the ecosystem, and as a result, they could drive living things to compete for them.

Principles and laws

The principle of limiting factors is defined as the principle whereby a factor that is in shortest supply will limit the growth and development of an organism or a community. Liebig's *law of the minimum*, Blackman's *law of limiting factor*, and Shelford's *law of tolerance* are the laws that explain the principles of limiting factors.

Liebig's *law of the minimum*

Law of the minimum was originally developed by Carl Sprengel and then later popularized by Justus von Liebig. This law states that the growth is regulated by a limiting factor, i.e. the scarcest resource, rather than by the total resources available. In biology and ecology, this means that the growth of a population is restricted by the factors that are scarcest and not by the factors that are abundant. This was based on the observation of crop growth. Accordingly, the addition of nutrients in abundance did not result in increased growth. Conversely, the addition of nutrients that are scarce, which in this case is the limiting factor, did lead to 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. Applying this principle to other biological populations, this implicates growth occurring only as dictated by the most limiting

factor. This principle was used by William Cumming Rose as a basis in identifying the amino acids that were labelled as *essential*.

Blackman's *law of limiting factor*

The law of limiting factor was proposed in 1905 by the British plant physiologist, Frederick Frost Blackman. According to this law, a process that depends on multiple factors will have a rate limited by the pace of the slowest factor. Photosynthesis, for example, is a biological process that depends on multiple factors. The general chemical reaction of photosynthesis is $6CO_2+12H_2O+energy=C_6H_{12}O_6+6O_2+6H_2O$. Based on this equation, CO_2, H_2O, and light energy (sunlight) are the limiting factors of this reaction. If any of them become accessible at a pace slower or lower than the usual, the rate of photosynthesis is expected to become slow based on the pace of the slowest factor. 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 amply available. The same result will occur if light energy becomes less available or less intense, the rate of photosynthesis will be slower despite the abundance of CO_2 and H_2O. Light becomes a limiting factor in photosynthesis when the plant is unable to collect light, for instance, due to shade resulting from the dense population of plants.

Shelford's *law of tolerance*

The *law of tolerance* was developed in 1913 by American zoologist Victor Ernest Shelford. It states that the success of an organism depends on a complex set of environmental conditions (environmental factors). And that organism would have definite *minimum*, *maximum*, and *optimum* environmental factors that determine 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.

Limiting factors examples

In the law of the size of a population, a population will grow exponentially as long as the environment from where all individuals in that population are exposed to remains constant. Thus, if the environmental conditions are kept the same, the population is expected to grow. However, there will come a time when the population will reach the maximum at which the environment can sustain. This is called the *carrying capacity*, the maximum load of the environment.

Carrying capacity is the number of individuals that an environment can sustain without ending in damage or destruction to the organisms and the environment. Thus, population size may increase until carrying capacity is met.

Above this capacity, the population size will eventually decrease. The determiners of carrying capacity are limiting factors.

The common limiting factors in an ecosystem are food, water, habitat, and mate.

The availability of these factors will affect the carrying capacity of an environment.
As population increases, food demand increases as well. Since food is a limited resource, organisms will begin competing for it. The same thing goes for space, nutrients, and mate.

Since these resources are available for a limited amount over a given period, inhabitants of an ecosystem will compete, possibly against the same species (intraspecific competition) or against other group of species (interspecific competition).

While a biotic factor includes the activities of a living component of an ecosystem, an *abiotic factor* includes the various physio-chemical factors in an ecosystem. These physio-chemical factors include sunlight, humidity, temperature, atmosphere, soil, geology of the land, and water resources. Temperature, for instance, is a major limiting factor primarily due to the fact it affects the effectiveness of enzymes and catalysts, which are essential in an efficient system, both biological and chemical.