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Paper No. : 11 Ecological Anthropology: Cultural and Biological Dimensions

Module : 30 Ecological Rules & their application to human population

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Description of Module	
Subject Name	Anthropology
Paper Name	Ecological Anthropology: Cultural and Biological Dimensions
Module Name/Title	Ecological Rules & their application to human population
Module Id	30

Contents:

Learning Objectives:

1. To study the different ecological rules
2. To study the the applications of the different ecological rules in relation to human populations

ECOLOGICAL RULE

1.0 What is Ecology?

Ecology is the scientific study of the interaction between organisms and their surrounding environment. It largely includes the study of communications of the organisms which they have with each other or similar species or with other organisms and their relationships with abiotic components of the environment. Ecology has been a focus for the human race for as long as we existed as a species; our survival and environmental adaptations depended upon how well we could analyze and observe the variations in the surrounding milieu and predict the responses of various organisms to those variations. Earliest human hunters and gatherers have to know about the habitat of their prey and where to find the food plants in seasonal variations. Later, farmers had to be aware of the variations in weather and surrounding abiotic conditions and their effect on crop plants and livestock for better yields. An ecologist studies the diversity, distribution, population of particular organisms, cooperation and competition between the organisms within an ecosystem and among different ecosystems. Ecological measurement also includes study of physiological and anatomical differences among the species with the change of climatic conditions like temperature and geographical variation.

The word ecology was coined by the German scientist Ernst Haeckel (1834 – 1919) in 1886. Ancient Greek philosopher such as Hippocrates and Aristotle first laid the foundation of ecology in their studies on Natural History. Modern ecology had come in scenario in the late 19th century(Laferriere and Stoett, 2003). Evolutionary adaptation and natural selection of different species according to the environment has become the main cornerstone of modern ecological theory.

2.0 What is Ecological Organization?

Ecosystems can be studied at the organizational arrangement or on the basis of stratification. The levels of organizations can be described from the smallest to the largest as follows:

Species:A species is a group of individual in which two individual of distinct sex male and female are capable of reproducing a fertile offspring through reproduction.

Population: A population is a group of organisms of the same species or individuals living in a particular geographical area with the capability of interbreeding.

Community: All the organisms or a social unit living in a given geographical area which shares common values.

Ecosystem: Ecosystem is a community of organisms living in conjunction with non-living components of the particular environment (air, water, soil) and interacting as a system.

Biomes: A large naturally occurring community of flora and fauna occupying a major habitat, adapting to their environment.

Biosphere: This is where all living things on Earth live. The biosphere is the biological component of earth system including lithosphere, hydrosphere, and atmosphere (Huggett, 1999).

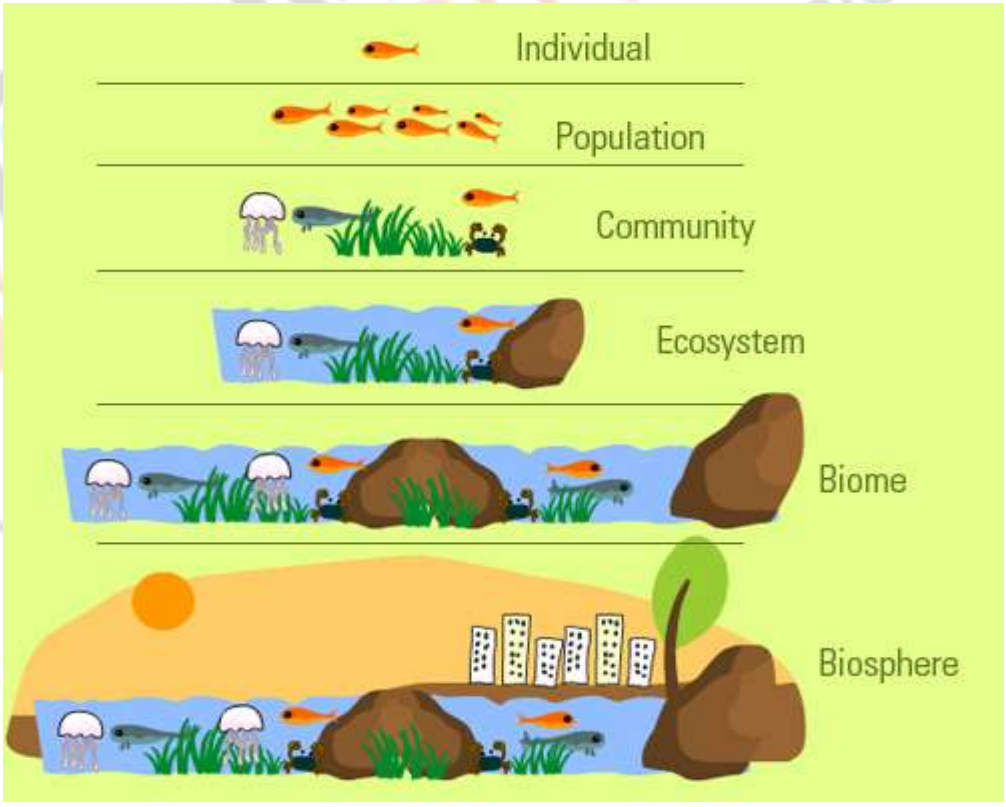

Fig. Levels of Ecological Organization.

3.0 What is Ecological Rules?

Several ecologist has tried to explain the interaction between organism and their environment in a different perspective of analysis. In this section, we have mentioned some major concepts which laid the foundation of close observation of environment and the impact of the environment on the living organisms residing in the milieu.

3.1 Allen's Rule:

Heat loss is a major problem for animals residing in cold climatic conditions. Most of the body heat is lost near the surface or skin. Therefore, the lesser the surface area of a body relative to its total size, it will lose less heat from its surface and vice versa. In all of the geometrical forms, the one with least surface area relative to its total size or unit volume is basically a sphere; so the people living in cold climatic conditions will find certain advantages for being short and thick which is essentially the case for different living species like walruses, snowshoe, hares and Eskimos.

Joel Asaph Allen, an American Biologist in 1877 put forward the Allen's rule. According to this rule, the body shapes and proportions of endotherms vary by climatic temperature so by either minimizing the exposed surface area to minimize the heat loss in colder places or by maximizing the exposed surface area to maximize the heat loss in hot climatic conditions (Allen, 1877). In endothermic animals from hot climates usually have long and thin ears, tails, limbs, snout etc. whereas equivalent endotherms from cold climates usually have shorter and thicker ears, tails and limbs (Lopez, 1986; Nudds and Oswald, 2007).

3.1.1 Does this rule hold true with modern Humans?

Allen's rule in practice can be found with Eskimos who have stockier body build and shorter limbs in comparison to East African tribes like Masai who have long and linear body build. In Peru, individuals of the same population who lived at higher altitude tended to have shorter limbs whereas those who inhibited more low-lying coastal areas generally had longer limbs and larger trunks (Weinstein and Karen, 2005). Katzmarzyk and Leonard in 1998 similarly noted that indigenous human population

living in colder regions have proportionately shorter legs and people who have their origin in the hotter region have proportionately longer legs for their height (Katzmarzyk *et al.*, 1998).

Fig. 1.2 Eskimos

3.1.2 Does this rule hold true for Animals?

The Black-tailed Jack rabbit, an inhabitant of hot arid areas always have long legs, long ears, and a long head while the Arctic hare's ears are much shorter relative to their head size and head is more spherical besides being long (Fig. **1.3**) (Griffing, 1974). The polar bear has always stocky limbs and short ears that can also be correlated with the Allen's rule (Hogan, 2008).

Fig. 1.3 (a) Arctic Hare and (b) Black Tailed Jackrabbit.

3.2 Bergmann's Rule

This rule was named after a German Biologist Carl Bergmann, who described the physiological differences in Organism according to their climatic conditions in 1847. According to Bergmann's rule, geographic races of a species possessing smaller body size are found in the warmer regions and race of larger body size are found in cooler regions (Timofeev, 2001; Tarraga *et al.*, 2006). Endothermic animals like Birds and Mammals of colder areas are found to have less surface area: volume ratio *i.e.* heavier body as compared with warmer areas. Evidence to support the rule can be found in Polar bears who are much larger size than the spectacled bears living closer to the equator. Another example can be cited for Penguins, Penguins living in Arctic areas are generally 1m long in length as compared to the 0.5m long penguins of Galapagos Island.

3.2.1 Bergmann's Principle in Human

Human population living near the arctic poles like Inuit, Aleut, Sami people are on average heavier than populations from mid-latitudes is consistent with Bergmann's rule. They also tend to have shorter limbs and trunks which validate the Allen's rule (Holliday et al., 2010). Marshall T Newman in his report in the Journal of American Anthropologist in 1953, mentioned that Native American populations are generally consistent with Bergmann's rule and he also added that populations of Eurasia also holds with Bergmann's rule (Marshall, 1953).

3.3 Gause's Hypothesis

Gause's law or Gause's Hypothesis is often referred to as competitive exclusion principle (Hardin, 1960). According to the law two species competing for the same resource cannot coexist at constant population values, if other ecological factors remain constant or in simpler terms when two competing species attempt to occupy the same niche, only one outcome is possible; one species will drive out the other. When one species gain even the slightest advantage over the other species one will overcome the other leading to either the extinction of this competitor or develop an evolutionary or behavioral shift toward a different ecological niche. Therefore, the principle can be proposed into "Complete Competitors cannot coexist" (Gause, 1934; Hardin, 1960).

If we had explained this with an example, here in stage 1: A smaller yellow bird species which is native to the place are foraging for insects across the whole tree, in Stage 2: A large invasive red bird species were introduced into the environment and competes with the Yellow bird species for resources. As time passes the invasive larger red species dominates over the yellow species in competition for the middle part of the tree and for more abundant food resources. In Stage 3: the yellow bird species then adapt to the new niche and both bird thrives without competition. For example, red Squirrel (*Sciurus vulgaris*) is a native bird to Britain but its population was constitutively decreasing for competitive exclusion, disease, and the disappearance of conifer forests in lowland Britain which were their native habitat. In 1876-1929, Grey Squirrel (*Sciurus carolinensis*) was introduced in 30 different sites of lowland Britain and it has been observed that with few years the grey squirrel overtook the red squirrel by adapting to the park and garden environment.

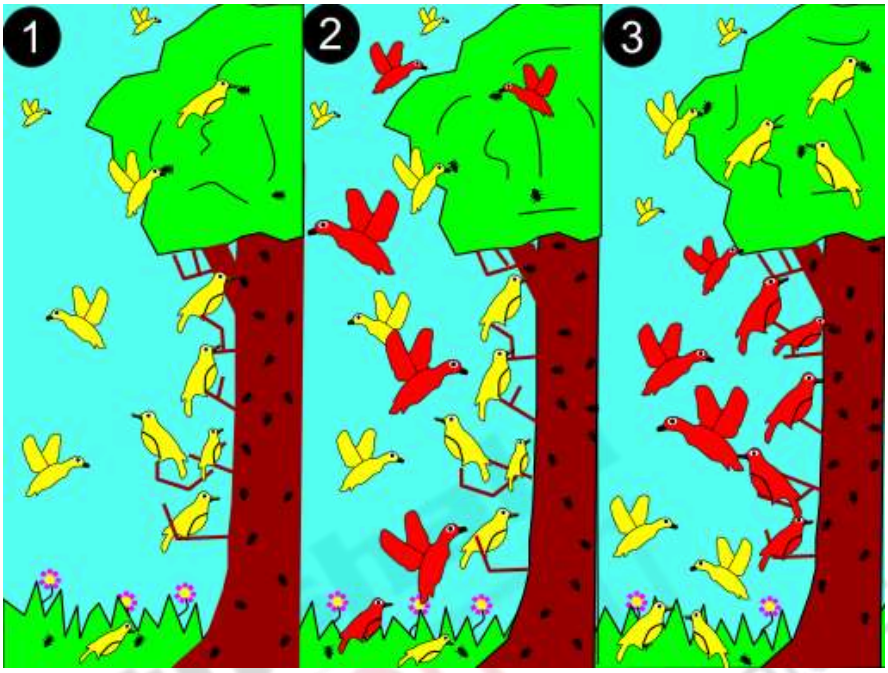

Fig. 1.4: Yellow and Red bird relationship for competitive exclusion principle.

3.4 Gloger's Rule

This rule was remarked after the name of zoologist Constantin Wilhelm Lambert Gloger, who put forward the rule in the year 1833 based on covariation of climate and avian plumage color. According to this rule skin pigmentation is higher in animals living in warm and humid habitats in comparison to animals living in cold and dry places. During his study,Gloger found that birds in more humid habitats are darker than their relatives living in the regions with higher aridity (Gloger, 1833). More than 90% of 52 North American bird species has been observed to confirm this rule. For example, the song sparrow (*Melospiza melodia*) living in high humid regions shows darkly colored wings and furs comparison to pale colored living in low humid regions (Stresemann et al., 1975). Edward H. Burtt in a report in 2004 suggested that dark colored feathers are also resistant to bacterial degradation, which is a major problem in humid habitats as bacteria thrives less in arid habitats (Burrt *et al.*, 2004).

Fig. 1.5: The Song Sparrow (*Melospiza Melodia*). Feather color differentiation from arid (Most left) to the high humid range (Most right). **(Source**: http://www.universityofalaskamuseumbirds.org)

3.4.1 Gloger's rule in Human

Mammalian species including humans also showed the tendency to have a darker skin color living in equatorial and tropical regions. This can be explained in terms of better adaptation against excessive solar ultraviolet (UV) radiations at lower latitudes. Some exception have been observed among Tibetans who have darker skin color living in the colder region and in their native latitude far away from the equator. This is apparently an adaptation towards the extremely high UV irradiation due to ice crystal on the Tibetan Plateau (Ember *et al.*, 2001).

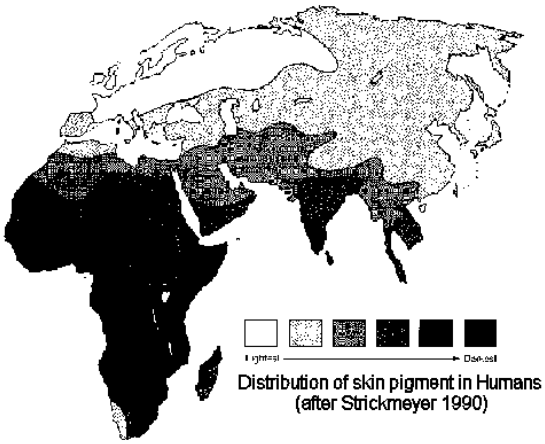

Fig. 1.6(a) A Tibetan Boy (b) Distribution of Skin pigment in Human.

3.5 Jordan's Rule

According to Jordan's rule number of marine fish vertebrates increases along a gradient from the tropics to cooler water at higher latitudes. This law is widely attributed to ambient temperatures during ontogeny of individual vertebral fishes. Other aspects of fish development and ecology like fish size, phyletic position, body shape, swimming mode are also found in corroborating with this law (McDowell, 2008). The number of vertebrates is a meristic character widely used in fish taxonomy and diversity study.

3.6 Lindeman's Law of Trophic Level

Lindeman's law is generally known as Ten percent Law. It was introduced by Raymond Lindeman in 1942; according to this rule only ten percent of the total energy from organic food transfers from one trophic level to the next. The remaining energy is used by the organisms to regulate their metabolic processes (Lindeman, 1942).

Plants absorb 1 percent of the sun energy for primary production and 10% of the energy is stored by the plant as net production available for the herbivores. When the plants are consumed by the herbivores of the 10% of the energy in the food is fixed into the animals and when the herbivores are consumed by a carnivore of next trophic level only 10% of the net production will be transferred.

This law has been considered as a primitive and obsolete and regarded as a myth in ecological rules. Christensen and Pauly (1992) summarized many studies with a fairly wide range of values from a few % to the 20 %.

3.7 Shelford's Law of Tolerance

Growth and development of organisms may be limited not only by too little of an element or too low of an environmental factor but also by too much of that element in high intensity. For example, carbon dioxide is necessary for the growth of all the green plants and a small increase in the concentration of carbon dioxide in the atmosphere will increase the rate of plant growth under certain circumstances but considerable increase in the concentration of carbon dioxide decreases the water use and lowered tissue concentration of nitrogen and protein, which will impact the agricultural production and yield.

The idea that an environmental factor could be limiting at their maximum and minimum quantities was incorporated by V. E. Shelford in 1911 as Shelford's law of Tolerance. It states that an organism's success of survival is based on a complex set of conditions and each organism has certain minimum and maximum limiting effects for ecological factor and between maximum and minimum lies a range or gradient that is known as thelimit of tolerance or Optimum environmental ecological factor (Shelford, 1931; Allaby, 2004).

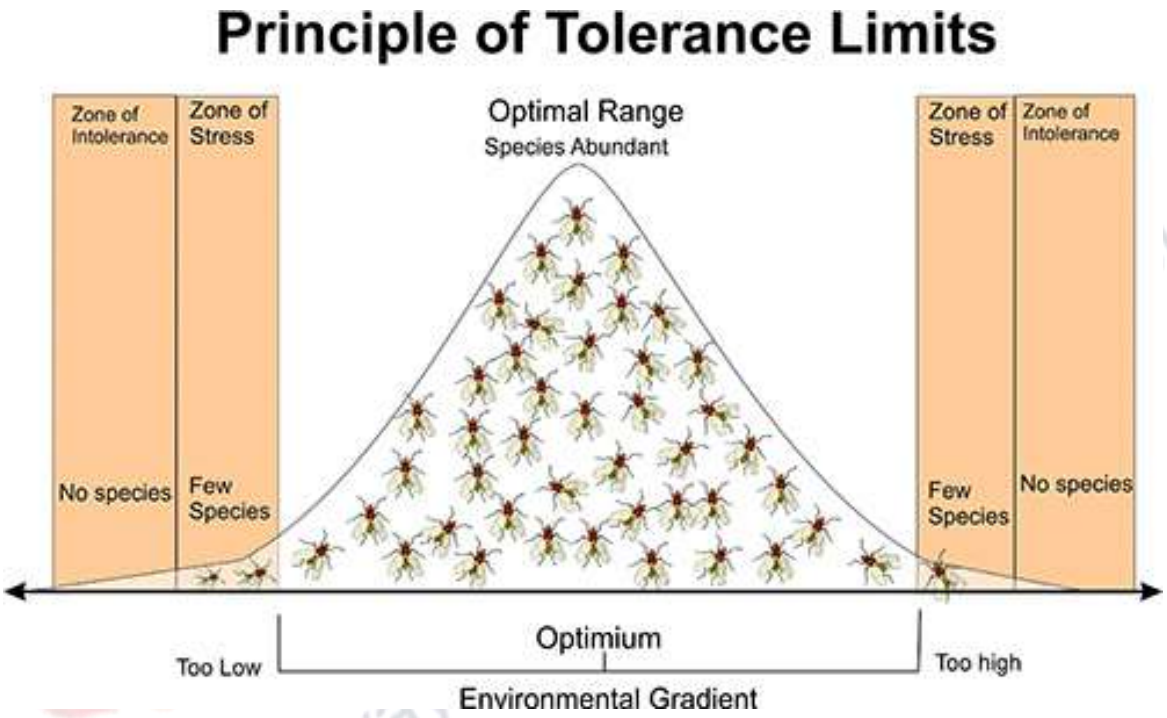

Fig. Graphical illustration of the law of tolerance.

(Source: https://www.tes.com/lessons)

Maximum and minimum limits of tolerance are intensity levels of a factor at which only half of the organisms can survive. These limits are sometimes difficult to define, as for example with low temperature, organisms may pass into an inactive, dormant, or hibernating state from which they may again gain functional state when the temperature rises above a threshold at high temperatures, there may be similar inactivation or aestivation before the lethal level is attained. Even without dormancy occurring, there are normally zones of physiological stresses before the limits of tolerance are reached.

The species as a whole is limited in its activities more by conditions that produce physiological discomforts or stresses than it is the limit of tolerance themselves. Death verges on the limits of tolerance and the existence of the species would be seriously endangered if it is frequently exposed to these extreme conditions.

Summary

Ecology is the scientific analysis and study of interactions among organisms and their environment, it is also an interdisciplinary field which includes geography, earth science and biology. All living Organisms on the earth, no matter their size, their species, or where they live, should interact with each other organism in their neighborhood and with the environment in order to survive. Different species from different climatic condition bears a different structure in their shape and size, like species living in cold climate have certain advantage in being somewhat spherical being short and thick- which is essentially the case for Eskimos, walruses, snowshoe hares. The Arctic hare's ears and legs are much shorter than the Black-tailed Jackrabbit's of hot, arid areas. To understand it deeper, numbers of concepts were proposed by different ecologist to explain simple truths that determine the interaction between organism and their environment. Their interests were mainly based on the diversity, distribution, and number of population of a particular organism as well as cooperation and competition between organism, both within and among ecosystems.

Allen's rule states that certain extremities of animals are relatively shorter in the color parts of a species range than in the warmer parts. Bergmann's rule states that geographical races of species possessing smaller body size are found in the warmer parts of the range, and races of larger body size in cooler parts. Gloger's rule states that dark pigments increase in races of animals living in warm and humid habitats. Jordan's rule is widely attributed to the ambient temperatures during ontogeny of individual vertebral fishes, number of vertebrate in marine fish increases along a gradient from the tropics to cooler water at high latitudes.