ORGANISMS AND POPULATIONS

1.0 INTRODUCTION

The term ecology was coined and described by **Ernst Haeckel.** The term ecology was first authentically used by **Reiter.**

Father of ecology – **Reiter.**

Father of Indian Ecology – **Prof. Ram Deo Misra**

The study of interactions or inter-relationships of organisms with their environment is called ecology.

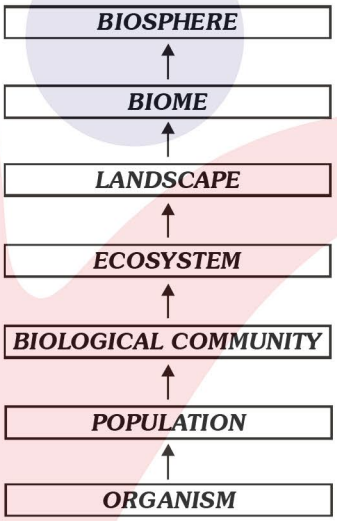
Organism and environment are always interdependent, inter-related and mutually reactive.

Branches of Ecology – It is based on organism level

(i) **Autecology –** Study of the interactions of a population with its environment is known as autecology.

(ii) **Synecology –** Study of the interactions of a community with its environment is known as synecology.

Ecological Hierarchy



2.0 TERRESTRIAL BIOMES

Biomes– A large regional unit delimited by a specific climatic zone, having a particular major vegetation zone and its associated fauna, e.g., tundra desert, temperate deciduous forest, tropical rain forest, ocean etc.

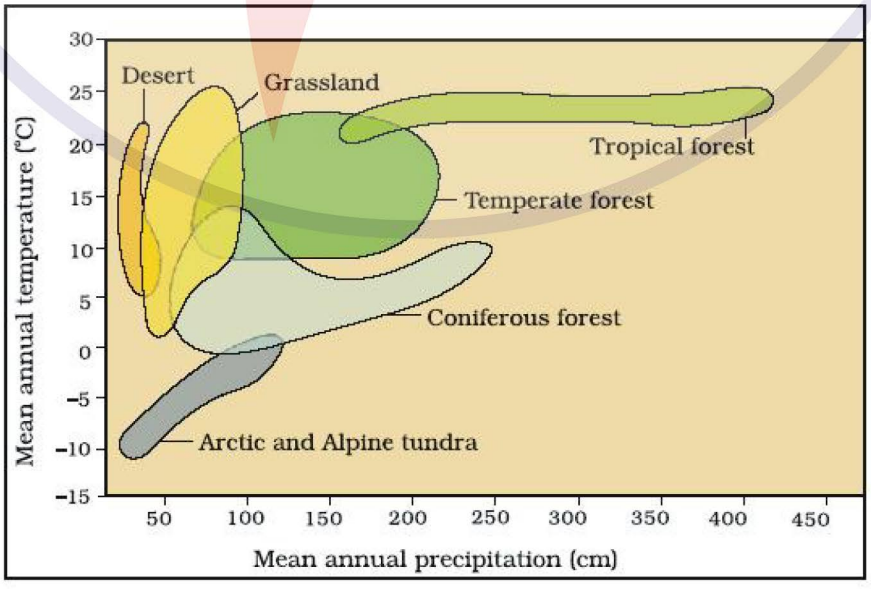
On the basis of variation in mean temperature along latitude the main climatic regions are

(1) **Tropical =** $0^0 - 20^0$ latitude

(2) **Subtropical =** $20^0 - 40^0$ latitude

(3) **Temperate** = $40^0 - 60^0$ latitude

(4) **Arctic and antarctic =** 60^0 and above latitude



3.0 ABIOTIC ENVIRONMENTAL FACTORS

3.1 Temperature

- Temperature is the most ecologically relevant environmental factor.
- Average temperature on land varies seasonally, decreases progressively from the equator towards the poles and from plains to the mountain tops.
- It ranges from subzero levels in polar areas and high altitudes to >50°C in tropical deserts in summer.
- A few organisms can tolerate and thrive in a wide range of temperatures they are called ***eurythermal***.
- A vast majority of them are restricted to a narrow range of temperatures such organisms are called ***stenothermal***.
- The levels of thermal tolerance of different species determine to a large extent their geographical distribution.

3.2 Water

- Next to temperature, water is the most important factor influencing the life of organisms.
- The salt concentration (measured as salinity in parts per thousand), is less than 5 ppt in inland waters, 30- 35 ppt the sea and more then 100 ppt in some hypersaline lagoons.
- Some organisms are tolerant of a wide range of salinities - ***euryhaline.***
- Some organisms are restricted to a narrow range of salinities - ***stenohaline***.
- Many freshwater animals cannot live for long in sea water and *vice versa* because of the osmotic problems, they would face.

3.3 Light

It is a complex physical environmental factor.

- In solar radiation 400–700 nm is also called photosynthetically active radiation (PAR).
- Except for the deep sea hydro-thermal ecosystem, sun is the only source of energy for all ecosystems on Earth.
- Of the incident solar radiation (ISR) less than 50 per cent of it is photosynthetically active radiation (PAR). Plants capture only 2-10 per cent of the PAR (approximately 1 – 5% of total) and this small amount of solar energy sustains the entire living world.

3.4 Soil (Edaphic Factors)

- **Soil –** Soil is the uppermost layer of earths crust formed by weathering of rocks. It is the mixture of living or non living materials.
- A typical soil consists of Minerals 40% + Water 25% + Air 25% + Organic matter (living + non living) 10%.
- **Pedogenesis** – Process of soil formation. It is a slow process (1 inch soil is formed in 500-1000 years).
- **Pedology** (Edaphology) – study of soil
- **Soil organic matter:** The dead organic matter present in soil is called humus, which is formed by decomposition of organic remains. Freshly fallen plant and animal material is called detritus or litter, partially decomposed litter is called duff. Fully decomposed litter is called humus.

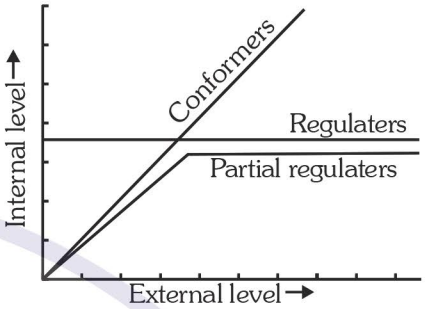
Litter → Duff → Humus

4.0 RESPONSES TO ABIOTIC FACTORS

The organism should try to maintain the constancy of its internal environment (a process called *homeostasis*) despite varying external environmental conditions that tend to upset its homeostasis. On the basis of response to environmental factors organisms are mainly of two types– Regulaters and Conformers.

4.1 Regulaters

Some organisms are able to maintain homeostasis by physiological (sometimes behavioural also) means which ensure constant body temperature, constant osmotic concentration, etc. All birds and mammals, and a very few lower vertebrate and invertebrate species. Evolutionary success of mammals is largely due to their ability to maintain a constant body temperature and thrive whether they live in Antarctica or in the Sahara desert.



4.2 Conformers

Organisms which cannot maintain a constant internal environment with the changing external environment are called conformers. An overwhelming majority (99 per cent) of animals and nearly all plants cannot maintain a constant internal environment.

Some of the organisms maintain constant internal environment but only up to a certain limit, beyond which they simpliy act as conformers, such organisms are called ***partial regulaters.***

4.3. Migrates

Many animals, particularly birds, during winter undertake long-distance migrations to more hospitable areas. Every winter the famous Keolado National Park (Bharatpur) in Rajasthan host thousands of migratory birds coming from Siberia and other extremely cold northern regions.

Note : Thermal Migration – Thermal migration has been seen in birds (Siberian Cranes, Arctic tern), mammals (Bison, Caribou), fishes (Salmon) etc.

4.4 Suspends

In animals, the organism, if unable to migrate, might avoid the stress by escaping in time.

Examples :-

Hibernation **-** Winter sleep e.g Bear

Aestivation **-** Summer sleep e.g some Snails and Fishes.

Diapause **-** A stage of suspended development of zooplanktons under unfavourable conditions.

Seed dormancy in higher plants, thick wallted spores in bacteria, fungi and lower plants.

5.0 ADAPTATIONS

Adaptation is a quality of the organism (morphological, physiological, behavioural) that enables the organism to survive and reproduce in its habitat.

- In the polar seas aquatic mammals like Seals have a thick layer of fat (blubber) below their skin that acts as an insulator and reduces loss of body heat.
- Thick cuticle, deep seated and sunken stomata, pinnately compound leaves and CAM pathway in most of the xerophytes to minimise water loss through transpiration.
- Desert lizards lake the physiological ability. They bask in the sun and absorb heat when their body temperature drops below the comfort zone, but move into shade when the ambient temperature starts increasing. Some species are capable of burrowing into the soil to hide and escape from the above-ground heat.
- Anti freezeing protein compounds allow the fishes in Antarctica region to remain active in sea water.
- In the absence of an external source of water, Kangaroo, Rat in north American deserts is capable of meeting all its water requirements through its internal fat oxidation (in which water is a by product). It also has the ability to concentrate its urine so that minimal volume of water is used to remove excretory products.

- Some organisms possess physiological adaptations which allow them to respond quickly to a stressful situation. If we go high altitude place we experienced altitude sickness. Its symptoms include nausea, fatigue and heart palpitations. This is because in the low atomospheric pressure of high altitudes, the body does not get enough oxygen. Our body solves this problem by increasing red blood cell production, decreasing the binding capacity of haemoglobin and by increasing breathing rate. People living in high altitudes have a higher number of red blood cells than people living in the plains.
- **Adaptations for Temperature**

  Temperature affect the absolute size of an animal and its body parts.

  (i) **Bergman rule–** Birds and mammals attain greater body size in cold region and lesser in warm region.

  (ii) **Allens rule**– Mammals from colder climates generally have shorter extremites such as ears and limbs to minimise heat loss. Heat loss or heat gain is a function of surface area. Since small animals have a larger surface area relative to their volume, they tend to lose body heat very fast when it is cold outside; then they have to expend much energy to generate body heat through metabolism. This is the main reason why very small animals are rarely found in polar regions.

6.0 POPULATION

A group of individuals (members) of same species living in an area (geographical / political) constitute a population or local population or deme. eg. Humans inhabiting hills, plains etc.

6.1 Population Attributes

(i) **Birth rate or Biotic potential or Fertility or Natality**

$$\text{Birth Rate} = \frac{\text{No. of births in a year}}{\text{Unit population (Capita)}}$$

(ii) **Mortality or Death Rate**

$$\text{Death Rate} = \frac{\text{No. of deaths in a year}}{\text{Unit population (Capita)}}$$

(iii) **Population Density (P.D.)**

$$\text{P. D.} = \frac{\text{No. of persons}}{\text{Area in sq. Km.}}$$

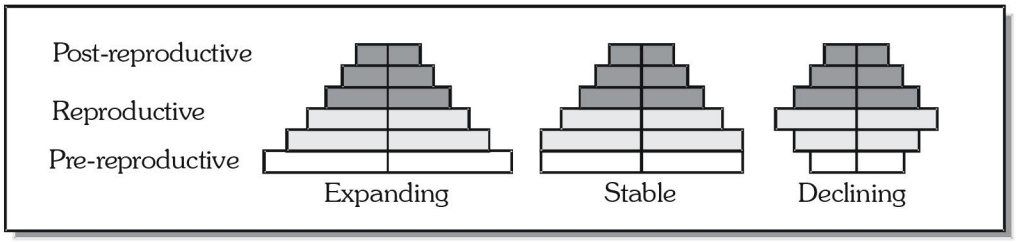
- Population density is measured in terms of biomass when there is large diffrence among the size of individuals of different species.
- Indirect count- By counting faecal pallets and pugmarks for Tiger and by traps for fishes in a pond.

(iv) **Age and Sex Structures**

- Age structure of a population can be depicted in the form of a pyramid diagram.
- Age pyramids are particularly important in **understanding future growth.**

Population has 3 age groups.

(a) Pre-Reproductive individuals – < 15 yr
(b) Reproductive individuals – 15 – 44 yr
(c) Post-Reproductive individuals – > 45 yr



Representation of age pyramids for human population

6.2 Population Growth

Human population growth rate is measured as the annual average growth rate which can be calculated as follows

Growth of population = (Natality + Immigration) – (Mortality + Emmigration)

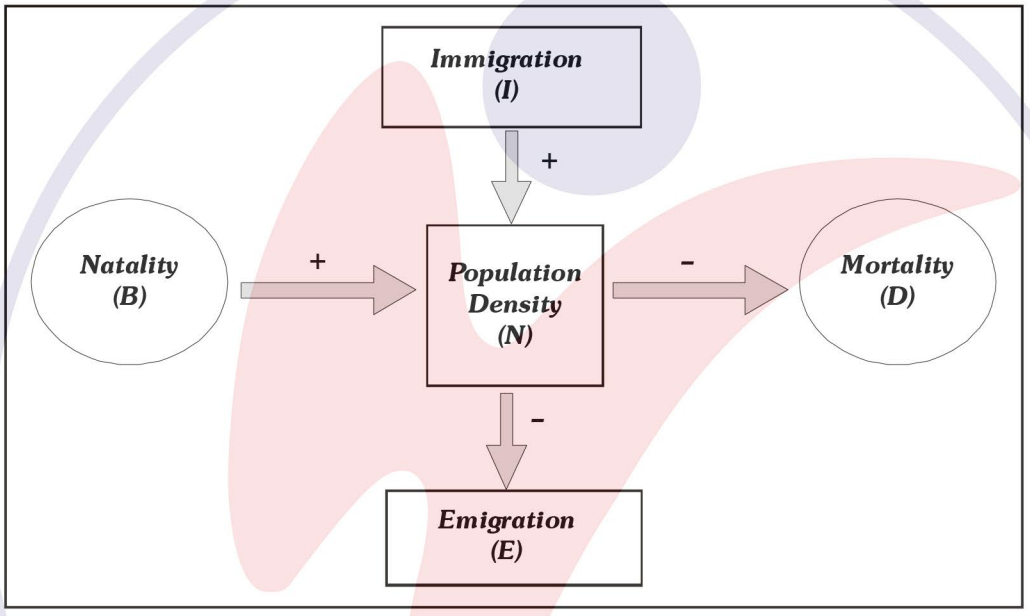
$$N_{t+1} = N_t + (B + I) - (D + E)$$

Positive growth – Natality + Immigration > Mortality + Emigration

Negative growth – Mortality + Emigration > Natality + Immigration

Zero growth – Natality + Immigration = Mortality + Emigration

Note : Migration is the movement of individuals into (immigration) or out of (emigration) a place or country. Immigration minus the emigration is called Net immigration.



6.3 Population Growth Models / Curves

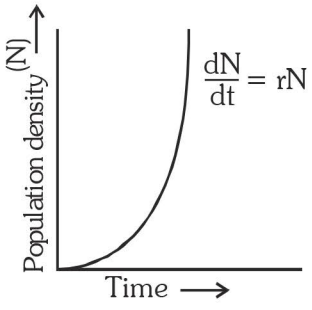
There are two types of growth curves

(i) **Exponential growth (J-Shaped Curve) :**

Any species growing exponentially under unlimited resource conditions can reach enormous population densities in a short time. If in a population of size "N", the birth rates are represented as b and death rates as d, then

$$\frac{dN}{dt} = (b - d) \times N \text{ , Let } (b - d) = r, \text{ then}$$

$$\boxed{\frac{dN}{dt} = rN}$$ r = Intrinsic or Natural rate of increase or Biotic potential or Growth rate.



The integral form of exponential growth equation is :-

$N_t = N_0 e^{rt}$

where : N_t = Population density after time t

N_0 = Population density at time zero

r = intrinsic rate

e = the base of natural, logarithims (2.71828)

Note : r values for the Norway rate is 0.015

r values for the flour beetle is 0.12

r value for human population in india (1981) is 0.0205

- In the case of J-shaped growth form the population grows exponentially, and after attaining the peak value, the population may abruptly crash.

(ii) **Logistic growth curve (Sigmoid / S-shaped curve):**

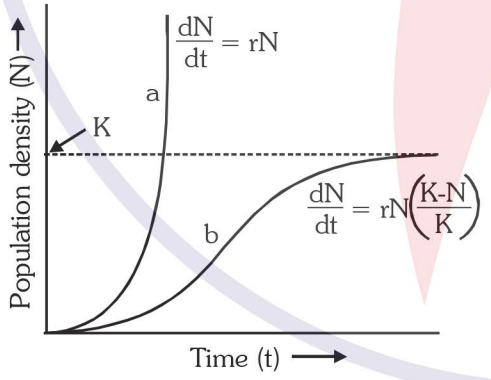
The S-shape / sigmoid growth form is represented by the following equation

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right) = rN\left(1-\frac{N}{K}\right)$$

$\frac{dN}{dt}$ = Rate of change in population size r = Biotic potential

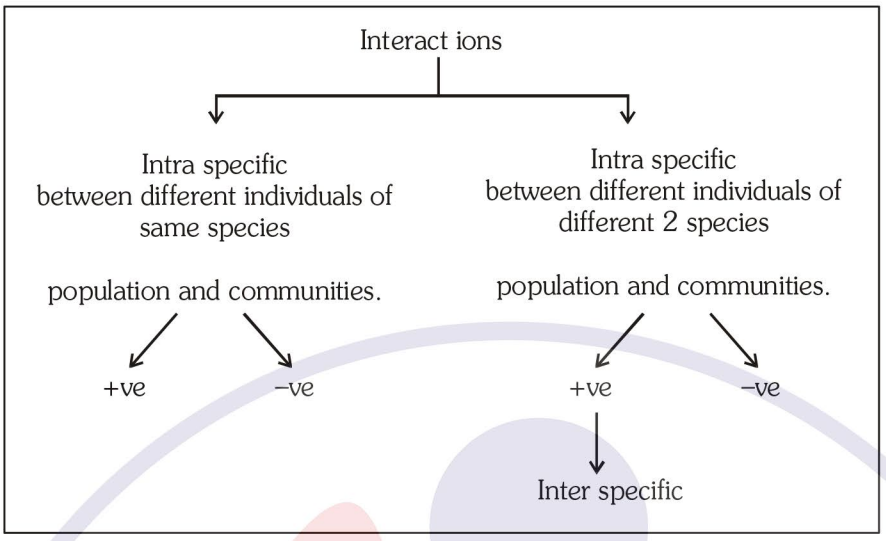
N = Popultation size K = Carrying capacity

$\left(1-\frac{N}{K}\right)$ or $\left(\frac{K-N}{K}\right)$ = Environmental resistance



Population growth curve :
a = when resources are not limiting the growth is exponential
b = when resources are limiting the growth is logistic,
K is carrying capacity

- The carrying capacity of a population means the maximum nubmer of individuals which can be supported in a given environment in healthy conditions.
- The logistic growth model is considered a more realistic one.
- S-shaped or sigmoid growth form shows an initial gradual increase in population size, followed by an exponential increase and then a gradual decline to a near constant level.



7.0 POPULATION INTERACTIONS

In a community different species interact with each other in different ways. These interactions are broadly classified into two catagories.

(i) **Positive or beneficial interactions –** Member of one or both the interacting species are benefited but neither is harmed.

(ii) **Negative interactions –** One or both interacting species are harmed.

Species A	*Species B*	*Name of Interaction*
+	+	*Mutualism*
–	–	*Competition*
+	–	*Predation*
+	–	*Parasitism*
+	0	*Commensalism*
–	0	*Amensalism*

7.1 Positive or Beneficial Interactions

(i) **Mutualism or Symbiosis (+, +)–** Co-evolution can be observed in these interactions. Positive inter specific interation in which members of two different species depend on each other for growth and survival, physical contact is present in between them. It is an obligatory relationship.

Examples

Mutualism between animal and protozoans – **Termites** and **Trichonympha** (a flagellated protozoan).

Mutualism between algae and fungi – **Lichens**

Mutualism between plant & animals -

(1) ***Yucca*** plant flowers and ***Pronuba*** **insect**

(2) **Fig tree** and **wasp** species

(3) **Bees and orchid flower–** The mediterranean orchid *Ophrys* employs "sexual deceit" to get pollination done by a species of bee, One petal of its flower beans resemblance to the female of the bee in size, colour and markings. The male bee is attaracted to what it perceives as a female, pseudocopulates with the flower and during that process is dusted with pollen from the flower, it transfers pollen to it and thus, pollinates the flower. Some orchids also show this phenomenon with wasp– *Colpa aurea*.

(ii) **Proto-cooperation (+, +) –** Association in which both organisms are benefited but can live separately, it is a facultative or optional or occasional association (non-obligatory relationship).

e.g. Hermit crab – Sea anemone

Tick bird (Red-billed or yellow billed) – *Rhinoceros*

Crocodile – Plover bird

(iii) **Commensalism (+, 0)**

- Association between members of two species in which one is benefited while other is almost unaffected.

e.g. *E.coli* bacteria in the intestine of man, Lianas, Epiphytes, Epizoans etc.

Note:- Epizoans Those animals which depends on plants or other animals.

Sucker fish (*Echeneis*)	–	Shark
Pilot fish	–	Shark
Clown fish	–	Sea anemone
Barnacles	–	Whale
Cattle egret birds	–	Cattle

7.2 Negative /Detrimental Interactions (Antagonism)

(i) **Parasitism (+, –)** → This association involves individuals of two species of different size in which smaller (Parasite) is benefited and larger (host) is harmed. The parasite gets nourishment and shelter from host but does **not kill** the host.

Majority of the parasites harm the host; they may reduce survival, growth and reproduction of the host and reduce its population density. They might render the host more vulnerable to predation by making it physically weak.

Types of Parasites

Ectoparasites → Live on the body of host

Endoparasites → Live in the body of host

Hyper parasitism → A parasite living on another parasite

e.g. Bacteriophages on bacteria, *Yersinia pestis* on ratflea.

Brood parasitism → Parasitism in which the parasitic bird (Cuckoo) lays its eggs in the nest of its host (Crow) and lets the host incubate them.

(ii) **Predation (+, –)** Organisms which kills another organisms for food.

e.g. Tiger and the Deer, Sparrow eating any seed may also considered as a predator.

(a) Predators acting as 'conduits' for energy transfer across trophic levels, predators play other important roles. They keep prey populations under control.

(b) Predators also help in maintaining species diversity in a community, by reducing the intensity of competition among competing prey species.

In the rocky intertidal communities of the American Pacific Coast the starfish *Pisaster* is an important predator. In a field experiment, when all the starfish were removed from an enclosed intertidal area, more than 10 species of invertebrates became extinct within a year, because of interspecific competition.

(c) ***Prudent predator-*** If a predator is too efficient and overexploits its prey, then the prey might become extinct and following it, the predator will also extinct due to lack of food.

(d) Prey species have evolved various defenses to lessen the impact of predation. Some species of insects and frogs are cryptically-coloured (camouflaged) to avoid being detected easily by the predator. Some are poisonous and therefore avoided by the predators. The Monarch butterfly is highly distasteful to its predator (bird) because of a special chemical present in its body. This butterfly acquires this chemical during its caterpillar stage by feeding on a poisonous weed.

(e) Many plants produce and store chemicals that make the herbivore sick when they are eaten, inhibit feeding or digestion, disrupt its reproduction or even kill it. The weed Calotropis produces highly poisonous **cardiac glycosides** and that is why you never see any cattle or goats browsing on this plant.

(iii) **Amensalism (–, 0)**

Amensal = (–), Inhibitor = (0)

In this interaction one species is inhibited by toxic secretion of another species. Inhibitor species is neither benefited nor harmed. eg. Parthenium, Antibiotics secreted by microorganisms.

(iv) **Competition (–, –)**

Process in which the fitness of one species is significantly lower in the presence of another species.

(a) It is generally believed that competition occurs when closely related species compete for the same resources that are limiting, but this is not entirely true.

Firstly, totally unrelated species could also compete for the same resource e.g. in some shallow South American lakes, visiting Flamingoes and resident Fishes compete for their common food, (the zooplankton in the lake)

Secondly, resources need not be limiting for competition to occur; in interference competition (indirect competition), the feeding efficiency of one species might be reduced due to the interfering and inhibitory presence of the other species, even if resources (food and space) are abundant.

(b) Competitions is relatively easy to demonstrate in laboratory experiments, as Gause and other experimental ecologists did, when resources are limited the competitively superior species will eventually eliminate the other species. The Abingdon tortoise in Galapagos Islands became extinct within a decade after Goats were introduced on the island, apparently due to the greater browsing efficiency of the goats.

(c) Another evidence for the occurrence of competition in nature comes from what is called 'competitive release'. A species whose distribution is restricted to a small geographical area because of the presence of a competitively superior species, is found to expand its distributional range when the competing species (Superior species) is experimentally removed.

(d) **Gause's 'Competitive Exclusion Principle'** states that two closely related species competing for the same resources cannot co-exist for long period and the competitively inferior one will be eliminated eventually. This may be true if resources are limiting, but not otherwise.

(e) **Resource Partitioning–** More recent studies do not support such gross generalisations about competition.

While they do not rule out the occurrence of interspecific competition in nature, they point out that species facing competition might evolve mechanisms that promote co-existence rather than exclusion. One such mechanism is 'resource partitioning'. If two species compete for the same resource, they could avoid competition by choosing, different times for feeding or different foraging patterns. MacArthur showed that five closely related species of Warblers living on the same tree were able to avoid competition and co-exist due to behavioural differences in their foraging activities.