HABITAT AND NICHE

HABITAT :

The word habitat is a Latin word which literally means 'it inhabits' or 'it dwells'. Habitat is the place where an organism or a species population lives. It represents some physical area at some specific part of earth surface.

Example:

- The low land gorilla (Gorilla gorilla) has as its habitat lowland tropical secondary forest.
- A pond is habitat of zoo-planktons, phytoplanktons, fish etc.
- The fungus *Hericium abietis* is found on coniferous logs and trees in the specific north-west of the USA.

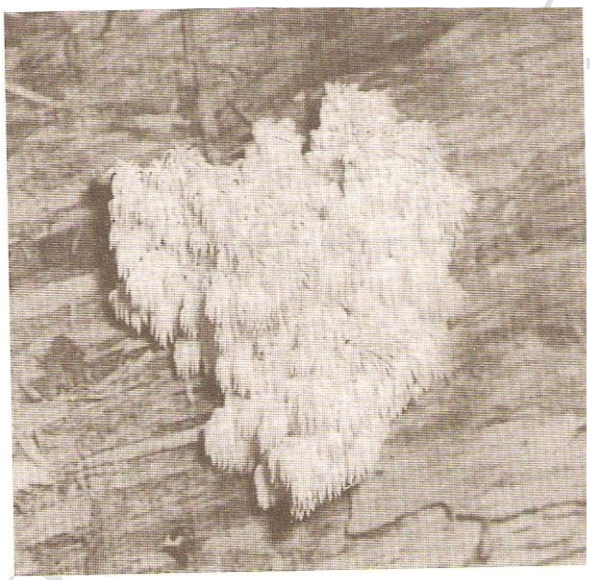


Fig 1. The fungus *Hericium abietis*

- Some species have several habitats such as the tiger (Panthera tigris) found in tropical rain forest, snow covered coniferous and deciduous forests and mangrove swamps (Sunquist, 1985).

MICROHABITAT:

The subdivision of habitat is called a microhabitat and any one habitat contains many possibly thousands of microhabitats. J. Grinnel (1917) considered the niche to be a sub region of a habitat and treated it as a distributional unit. The specific environmental variables in the microhabitat of a population is called microenvironment or microclimate.

ECOLOGICAL NICHES:

The term niche was for the first time used by Joseph Grinnel (1917) to explain microhabitats of California thrashers. According to him, " niche is the ultimate distributional unit, within which each species is held by its structural and instinctive limitations…………..no two species in the same general territory can occupy for long identically the same ecological niche".

The ecological niche includes not only the physical space occupied by an organism but also its functional role in the community and its position in the environmental gradients of temperature, moisture, pH, soil and other conditions of existence.

Thus the ecological niche of an organism not only depends on where it lives but also includes the sum total of its environmental requirements i.e., a complete description how the organism fits into its physical and biological environment.

A niche represents the range of conditions and resource qualities within which an individual or species can survive and reproduce (Futuyma, 1998; Ricklefs and Miller, 2000)

DEFINITION:

Kendeigh (1961) defined ecological niche as 'a particular combination of physical factors and biotic relations required by a species for the normal course of its life activities'.

Ecological niche of a species can be defined as – **"the specific position and the functional status or total role of the species with in community"** (Smith, 1977; Whittaker, 1976).

According to Mayr and Ashlock (1991) 'the multidimensional resource space of a species, its ecological requirements and its specific way of utilizing the environment is called niche'.

According to Chapman and Reiss (1992), 'the sum total of all the ecological requisities and activities of a species'.

According to Mackenzie et al. (1999),'the ecological niche of an organism is the position it fills in its environment, comprising the conditions under which it is found , the resources it utilizes and the time it occurs there'.

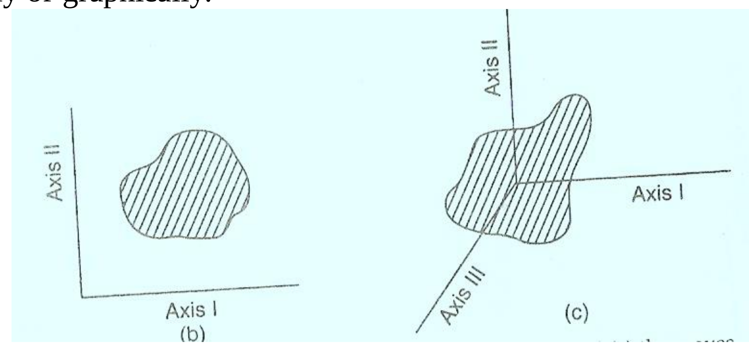
According to Ricklefs and Miller (2000),'the ecological role of a species in the community, the many ranges of conditions and resource qualities within which the organism or species can persist, often conceived as a multidimensional space'.

DISTINCTION BETWEEN HABITAT & NICHE:

1. A habitat is a description of where an organism can be found, but its niche is a complete description of how the organism relates of its physical and biological environments.
2. Ecologist Charles Elton described the niche as a profession. He said that where a species lives is its habitat, but what it does for a living – its profession – is its ecological niche. The general profession of a flour beetle is eating flour. A squirrel's profession is eating seeds of trees. Suppose you have a neighbor who is a bus driver. Where your neighbor lives and works is your town; what your neighbor does is drive a bus. Your neighbor's niche is bus driving; your neighbor's habitat is your hometown.
3. The different species may have a common habitat but their niches are always different and they differ in (a) period of activity, (b) breeding seasons, (c) in cover, and (d) in feeding behaviour. For example the two species of water bug namely *Notonecta* sp. and *Corixa* sp. live in same habitat i.e., in littoral zone of pond and lake. But the two species occupy very diversified trophic niches. *Notonecta* sp. is an active predator, whereas, *Corixa* sp. feeds on decaying organic matter. Although the species coexist they use different energy sources.
4. Many organisms may have same address (habitat) but they should have different professions (niche). Otherwise, there will be competition.

DETERMINATION OF NICHE:

A great deal of field work is needed to determine the niche of a species in any detail. According to Hutchinson, the activity range of any species could be described along all the dimensions (parameters) of the environment. These parameters include physical and chemical parameters (such as temperature, humidity, salinity, oxygen concentration etc.) and biological factors (such as prey species). each of these dimensions are represented as dimension in space. Supposing there are 'n' numbers of dimensions, then the niche would be described in n-dimensional space. As it is not possible to visualize a space of more than three dimensions, the multidimensional aspect could only be represented mathematically and statistically, and then depicted by their essence physically or graphically.



A graphical representation of a biological activity to a single environmental gradient representing the distribution of a species activity along one niche dimension is given in Fig-a. it depicts the degree to which the environment can support that species in relation to a particular parameter. Fig-b shows 2-dimensions where the species niche may be depicted as a hill, with contours representing the various levels of biological activity. A 3-dimensional aspect can be visualized as a cloud in space whose density conveys niche utilization (Fig-c).

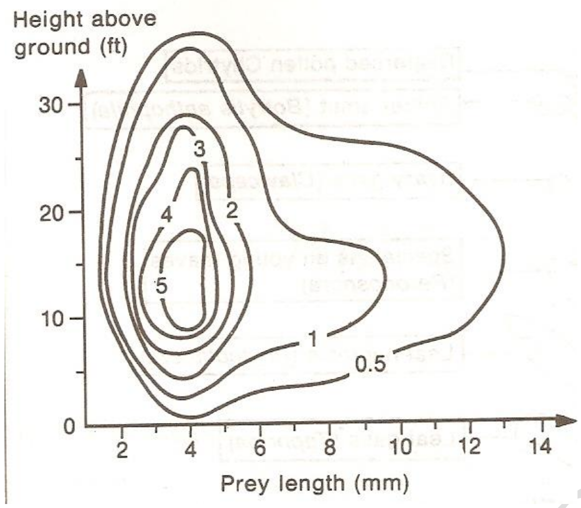


Fig-d

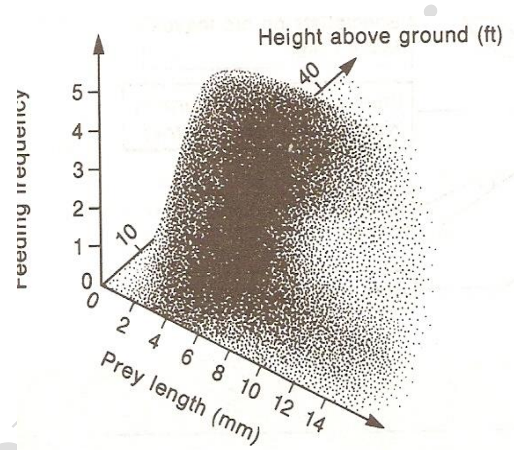


Fig-e

As an example of the above, Fig-d shows a two dimensional representation of the feeding niche of the blue-gray gnatcatcher's (*Polioptila caerulea*). The length of its prey is represented along the horizontal axis and the height above the ground at which the blue-grey gnatcatcher feed is shown along the vertical axis. The contour lines on the figure represent the frequency with which the birds fed at a particular height and on a particular length of the prey. We can see that the birds concentrated on prey about 4 mm in length which they caught about 10 to 15 feet off the ground.

The data of Fig-d can be plotted as a three dimensional volume in Fig-e. Here the feeding niche of the birds is represented as a hill. The species can only be found on the surface of or inside the hill; the peak of the hill shows where the birds are most likely to be found.

In Fig-d and Fig-e only two axes are plotted. In principle, other axes could be added. Ambient temperature might be a third, risk from predation in different times of the year a fourth and so on. It becomes almost impossible graphically to represent niches when more than two environmental variables are involved. However, computers can easily hold and analyze the data. Hutchinson suggested that the niche of a species could be defined as an n-dimensional hypervolume, where the number of different environmental variables equals n-1.

EACH SPECIES HAS ITS OWN UNIQUE NICHE:

Ecology has few laws. One of them is that each species has its own unique niche (Grinnell, 1924). The idea that each species occupies its own niche is all very well in theory, but is it true in practice?

- **MacArthur (1958)** concluded a detailed study of the population ecology of five species of warblers in USA. These five species are very similar in size and beak length, are all mainly insectivorous and all belong to the same genus *Dendroica*.
- The following table shows that within the five species, average beak lengths differ by only a few percent. MacArthur chose to study these species precisely because earlier ecologists studying them had been unable to find any differences in their requirements.

Table showing the mean beak lengths of the five species of warblers studied by MacArthur (1958)

Species	**Mean beak length (mm)**
Dendroica coronata	12.47
D. virens	12.58
D. tigrina	12.82
D. fusca	12.97
D. castanea	13.04

- MacArthur's warblers fed on firs (*Abies*) and spruces (*Picea*). Most of the trees in which the birds fed were 50-60 feet tall.
- MacArthur classified the trees into six vertical zones, each approximately 10 feet in height. He then divided each branch into three horizontal zones:
    1. a bare or lichen covered base (B)
    2. a middle zone of old needles (M)
    3. a terminal zone of needles and buds less than 1.5 years old (T)
- It is apparent from the above that the five warblers occupy different feeding niches and also have differentiation in their nest position. Observations by MacArthur on the winter feeding behaviour of the birds also showed differences between the species.

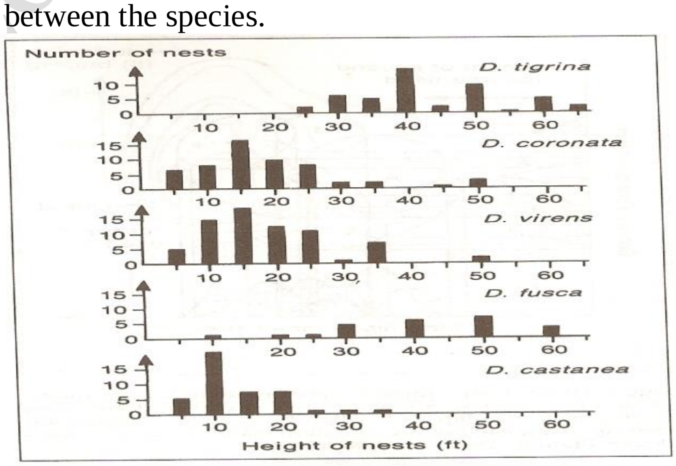


Figure showing the heights at which the five species of warblers studied by MacArthur (1958) made their nest.

ASPECTS / TYPES OF ECOLOGICAL NICHES:

The ecological niche is an inclusive term that involves not only the physical space occupied by an organism, but also its functional role in the community (i.e., trophic position occupied) and its position in environmental gradients of temperature, moisture, pH, and other conditions of existences. The three aspects of ecological niche are generally designated as –

1. Spatial Niche or Habitat Niche (the physical space occupied): where does it live?
2. Trophic Niche (the functional role i.e., trophic position): what does it do?
3. Multidimensional Niche or Hypervolume Niche (the position in the environmental gradients).

1. **Spatial Niche / Habitat Niche**: the physical space occupied by the species.

    i. Joseph Grinnel (1928) thought of a niche in terms of microhabitat that a species occupies – it is now called as the spatial niche or habitat niche.
    ii. Such niche represents the physical space occupied by an organism. Thus, in a habitat occupied by many species, each species is confined to a microhabitat. No two species can occupy the same habitat.
    iii. An interesting example of habitat niche was provided by O'Neill (1967). He identified 7 species of millipedes living in forest floor of a maple oak forest. All the seven species occur in the same basic trophic level (all are detritus feeder). The log of maple oak has several gradients in decomposition stage from the centre to the position underneath the leaf litter. These gradients constitute distinct microhabitats and each species of millipede occupies a distinct microhabitat (niches) in the same general habitats, the forest floor. The seven species are -

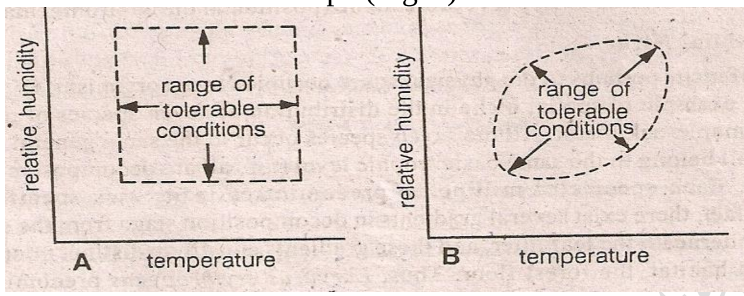
    1. *Euryurus erythropygus* – within decomposition heard wood at centre of logs.
    2. *Pseudopolydesmus serratus* – on superficial wood of logs.
    3. *Narceus americanus* - on the outer surface of the logs beneath the bark.
    4. *Seytonotus granulatus* – under log but on the log surface.
    5. *Fontaria virginiensis* – under the log but on ground surface.
    6. *Cleidogonia caesioannularis* – within leaves of litter.
    7. *Abacion lacterium* – beneath the litter on ground surface.

2. **Trophic Niche:** the functional role i.e., trophic position of the species

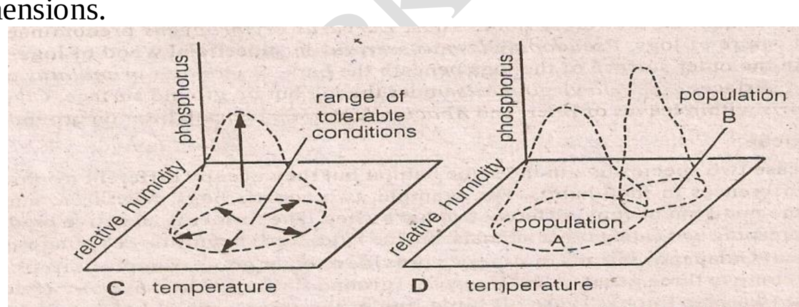
    i. Charles Elton (1927) was the first who used the term niche as the 'functional status of an organism in its community'. He emphasized the importance of energy relations and thus the concept is designated as trophic niche.
    ii. Trophic niche is concerned with the trophic position (functional role) of an organism or species in relation to food habit in the community.
    iii. In this case two species live in the same habitat but they occupy different trophic niches, because of differences in food habits.
    iv. For example, the habitat of the water backswimmer (*Notonecta*) and the water boatman (*Corixa*) is the littoral region of ponds and lakes, but, the two species occupy very different trophic niches. The *Notonecta* sp. is an active predator that swims about grasping and eating other animals, whereas the *Corixa* sp. feeds mainly on decaying vegetation.
    v. Finches of Galapagos Islands in America provide another good example of trophic niche. these birds belong to 3 genera, viz,
    Geospiza: Ground finches, seed eaters.
    Camarhynchus: tree finches, insect eater except one species (*C. crassirostris*) is vegetarian
    Certridia: warbler finches
    These all birds live in the same general habitat, but differ in terms of their trophic position.

3. **Multidimensional Niche/Hypervolume Niche:** the position of species in environmental gradients
    i. In 1957, G. E. Hutchinson suggested that the niche could be visualized as hypervolume within which the environment permits an organism or species to survive indefinitely. This is the multidimensional niche concept which refers to the population of species in the environmental gradients.
    ii. The niche is considered as an abstract n-dimensional inhabitated hypervolume and Hutchinson suggested that the niche of a species could be defined as an n-dimensional hypervolume, where the number of different environment variables equals n – 1.
    iii. Suppose that we measure the range of some environmental factor (such as temperature) over which a particular species can live and reproduce (in effect, its range of tolerance) and we put this on a graph against another environmental factor (such as relative humidity). The space that is enclosed will represent the niche of the species. if the effects of two variables (or factors) i.e., temperature and relative humidity are independent , the space would be two-dimensional box

(Fig A). However, in fact, temperature and relative humidity are not independent in their biological effects, the niche instead of being the box-like would be an oval in shape (Fig B).



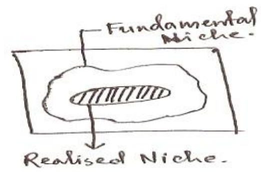
Now suppose that the tolerance to levels of a third factor (i.e., available phosphorous) was affected by interactions with both temperature and relative humidity. We would now have a niche representing three variables of three-dimensional, volumetric figure (Fig C). If there is present a fourth variable, the space enclosed would be a hypervolume with four dimensions. Since there are a large number (n) of other environmental factors, both abiotic and biotic, that affect the population, the niche is n-dimensional hypervolume, an abstraction since one is able to draw only with respect to three dimensions.



FUNDAMENTAL NICHE & REALISED NICHE:

In 1965, Hutchinson introduced the terms fundamental niche and realized niche. He suggested that the niche an organism could occupy in the absence of competitors and predators be called its fundamental niche, while the role it actually played in the community should be called its realized niche.

- Fundamental niche is the maximum abstractly inhabited space occupied by an organism in the hypervolume in absence of competitors and predators. It is determined by abiotic or climatic factors. When the fundamental niches of two species overlap, then the two species are said to be competing with one another. However, two species do not overlap or compete for food, even if they eat the items of the same size, as they can look for them in different places.



- Realized niche is the actual space in the hypervolume where individuals live under biotic constrains. It is determined by biotic factors such as presence of food / prey, predator, disease etc. the realized niche of an organism is the role actually played by it in the community. In nature the realized niche of an organism is smaller than its fundamental niche.

Example:

⇒ A study was made of two species of tiny flatworm in Great Britain, where it was found that some streams contained one species, some the other, and still other streams contained both.

⇒ The stream waters are cold at their source in the mountains and become progressively warmer as they flow downstream. Each species of flatworm occurs with in a specific range of water temperatures.

⇒ In streams where species A occurs alone, it is found from 6 °C to 17°C (42.8° – 62.6°F)[Fig a].

⇒ Where species B occurs alone, it is found from 6°C to 23°C (42.8° – 73.4°F) [Fig b].

⇒ When they occur in the same stream, their temperature ranges are much reduced: A occurs in the upstream sections where the temperature ranges from 6°C to 14°C (42.8° – 57.2°F), and B occurs in downstream areas where temperatures are warmer, from 14° C to 23° C (57.2° – 73.4°F)[Fig c].

⇒ The range of temperature over which species A occurs when it has no competition from species B is called its **fundamental temperature niche**. The set of conditions under which it persists in the presence of species B is called its **realized temperature niche**

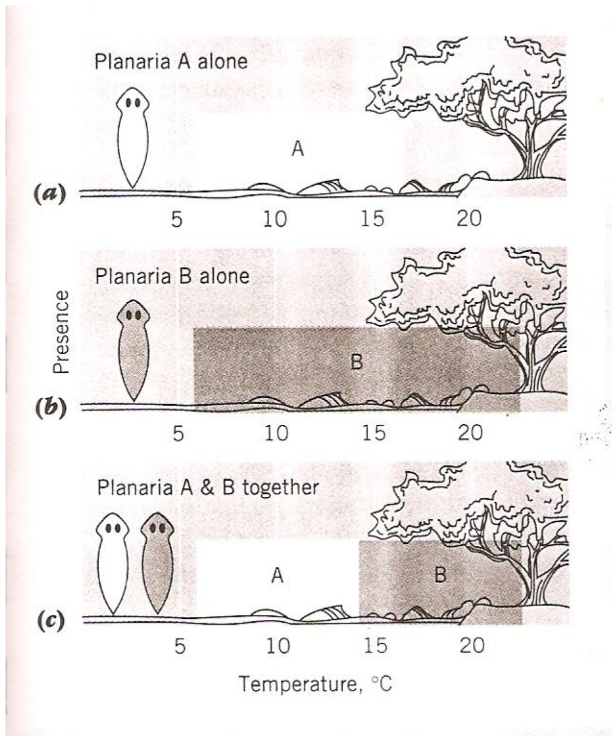


Fig. the occurrence of fresh water flatworms in Cold Mountain streams in Great Britain. (a) The presence of species A in relation to temperature in streams where it occurs alone. (b) The presence of species B in relation to temperature in streams where it occurs alone. (c) The temperature range of both species in streams where they occur together.

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NICHE OVERLAP:

- Fundamental niches of the two species may overlap to some extent for utilization of resources or tolerance of conditions is called niche overlap.
- Niche may overlap with respect to or few resources.
- Some individuals of species 'J' may overlap for the utilization of resource of some individuals of 'K' species. The shaded area in the figure represents niche overlap, which is a proportion of resource that is used by both species.
- If the two peaks of the distribution of species 'J' and 'K' are moved closer together, the niche overlap will increase and vice versa.

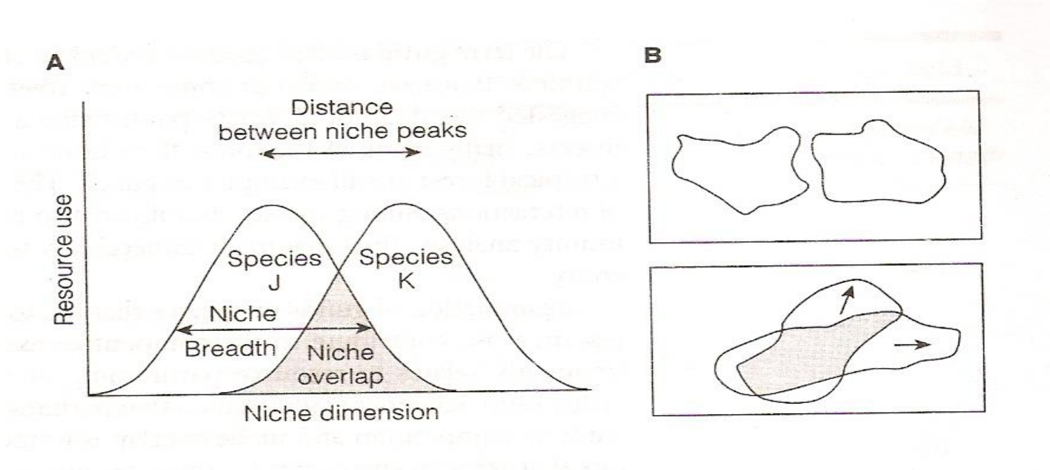


Fig (A) Activity curves for two species along a single resource dimension illustrate the concepts of niche breadth and niche overlap. (B) In the upper diagram, two species occupy non overlapping niches, whereas in the lower diagram, niches overlap so much that severe competition results in divergence, as indicated by the arrows.

- Even niche of one species may be contained in that of another. Rarely do two species have exactly same niche requirement with total niche overlap.

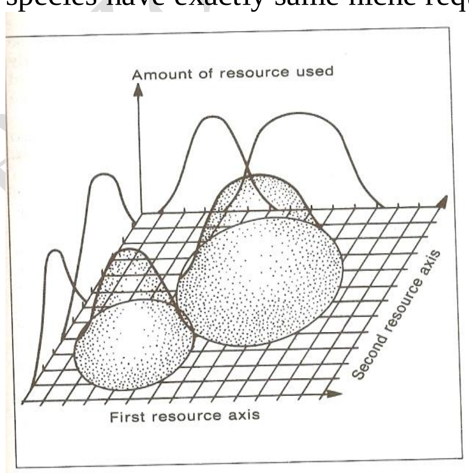


Figure 10.5a Diagrammatic representation of the niches of two species. Note how on each of the two resource axes there is considerable overlap between the two species. Despite this, the two species occupy three-dimensional niche volumes which overlap only slightly. (From Pianka, 1976.)

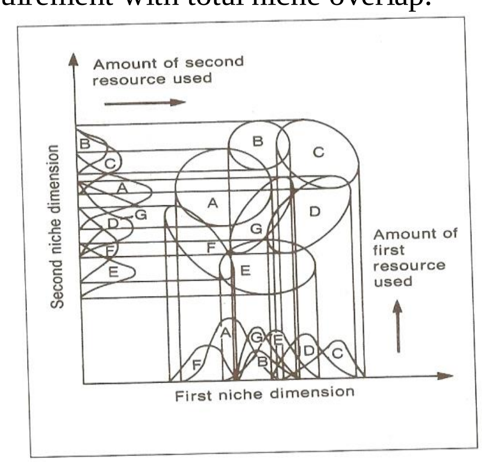
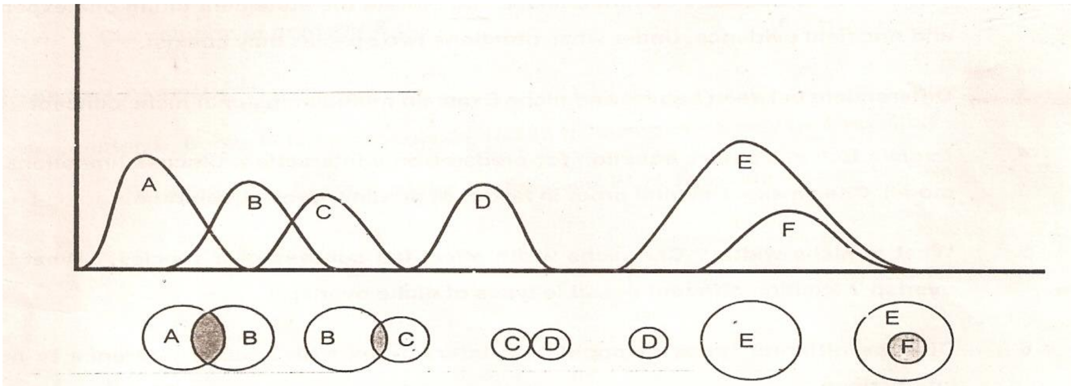


Figure 10.5b Diagrammatic representation of the niches of several species, showing how in two dimensions niches may overlap only slightly, despite considerable overlap along each of the one-dimensional resource axes. (From Pianka, 1976.)

- The following diagram shows different types of niche overlap.



Different types of niche relationships visualized as graphs on a resource gradient. Species A and B have overlapping niches of equal breadth but are competitive at opposite ends of the resource gradient. B and C overlapping niches of unequal breadth. Species C shres a greater proportion of its niche with B than B does with C.(In this example, however, B shares its niche also with A at the other end of its resourece niche.) C and D occupy adjacent niches with little possibility of competition. D and E occupy disjunct niches with no overlap and no competition. Species F has a niche contained within the niche of E. If F is superior to E competively, it persists and E shares that part of its niche with E.

NICHE WIDTH / NICHE BREADTH / NICHE SIZE / NICHE RANGE:

- ✓ The extent of the variety of resources used or the extent of conditions tolerated by the individuals in the population is represented by the width in the figure when plotted on a resource axis, and is referred to as the niche breadth or niche width.
- ✓ The width is measured by the length of the axis intercepted by the curve.
- ✓ Measurement of niche width usually involves some morphological trait such as bill size or some ecological variables as food size or habitat space or type of food.
- ✓ Niche width is generally described as narrow and broad. The wider the niche more generalized the species is considered, the narrower the niche, the more specialized is the species. Consequently a species may be classified as eurycoeious (wide range of ecological niche) and stenocoeious (narrow range of niche).
- ✓ Niche width depends on (a) food, (b) predation, (c) parasites, (d) reproductive potential and mortality, (e) development of offspring, (f) seasonal activity, (g) inter and intra specific competition.

NICHE SHIFT / NICHE DIVERSIFICATION:

- A change in some pattern or process (such as eating pattern) in niche for avoiding competition can be referred to a niche shift.

- Niche shift is seen dramatically in the case of two species of warblers on Mt. Karimuri in New Guinea (Diamond, 1978). One warbler, Crateroscelis murina, occurs in increasing abundance from about 300 m to 1642 m, where it is abruptly replaced by C. robusta. The later species has a decreasing abundance from this level to the top of the mountain (2432 m).

- Similarly, four species of fruit pegions on the islands of the Bismark Archipelago segregate in their niches according to the size of fruit they eat: larger pegions eat larger fruit with the largest birds (average body weight 722 g) eating plum-sized fruits and the smallest birds (average weight 91 g) eating blueberry-sized fruits. Numerous examples of niche diversification abound.

ECOLOGICAL EQUIVALENTS:

- Species that occupy the same niches in different geographical regions (continents and major oceans) are termed ecological equivalents.
- Ecologically equivalent species, which occupy similar niches in different geographical regions, tend to be closely related taxonomically in contiguous regions, but are often not related in noncontiguous regions.
- Thus, a grassland ecosystem develops wherever there is a grassland climate, but the species of grasses (producers) and grazers (consumers) may be quite different, especially when the regions are widely separated by barriers.
- Thus, grasses in temperate, semi-arid parts of Australia are largely different from those of a similar climatic region of North America, but they all are basically primary producers in an ecosystem and are thus to be the ecological equivalents. Similarly the grazers, the kangaroos of Australia are ecologically equivalent to the bison and pronghorn antelope of the North American grassland.

GUILDS:

- ✓ The term was originally coined by Cornell ecologist Richard Root (1967) in his studies of birds and was meant to describe a group of species that fed on the same resources and in the same way. Groups of species with similar or comparable roles and niche dimensions within a community are termed guilds.
- ✓ **What is guild?**
  A guild is defined as a group of species that exploit the same class of environmental resources in a similar way. This term groups together species without regard to taxonomic position that overlap significantly in their niche requirements. The guild has a position comparable in the classification of exploitation patterns to the genus in phylogenetic schemes.
- ✓ **Why should we be interested in guilds?**
  There are two main reasons. First, guilds are a valuable analytical tool because they focus attention on groups of species most likely to be competing for resources. Secondly, guilds might represent the basic building blocks of communities.
- ✓ **Distinction between niche & guild:**
  Guild denotes a functional attribute and thus may be, as it has been, easily confused with the term niche. Niche would continue to apply to the habitat requirements, due to function or role of an individual species, whereas guild would apply to the functional role of a group of species.

- ✓ **<u>Example of guild:</u>**

  There are five insect species that feed by boring into the stems of salt-marsh cordgrass (*Spartina alterniflora*) on the Gulf Coast of North America.

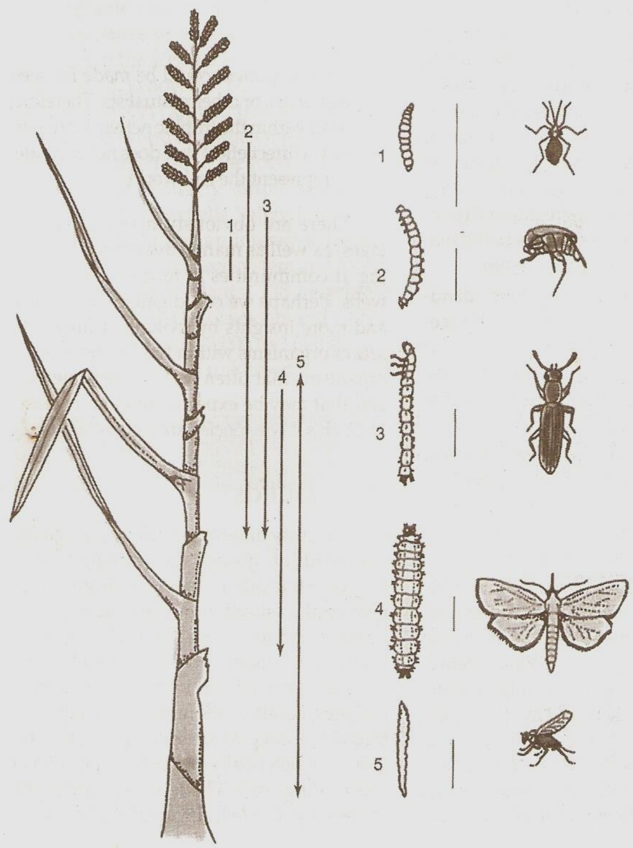


Figure 20.7 The stem-boring guild associated with salt-marsh cordgrass (*Spartina alterniflora*) on the Gulf Coast of North America. (1) *Calamomyia alterniflorae* (Diptera). (2) *Mordellistena splendens* (Coleoptera). (3) *Languria taedata* (Coleoptera). (4) *Chilo plejadellus* (Lepidoptera). (5) *Thrypticus violaceus* (Diptera). Arrows indicate where in the stem the larva of each species is found and the direction it bores. Adults, shown at extreme right, are free living. The length of each scale line between the larva and adult of each species represents 0.5 cm in the drawing.

NICHE COMPETITION AND COMPETITIVE EXCLUSION:

The competitive exclusion principle states that two species that have exactly same requirements can not coexist in exactly the same habitat. One species will always win out over the other. The reason that most species don't die out from competition is that they have developed a particular niche and thus avoid competition.

Gause's competitive exclusion principle:

Statement: It states that no two species can coexist if they occupy the same niche.

Experimental Proof: Two species can not permanently occupy identical ecological niche. In doing so one species will be excluded by another species. This was first experimentally demonstrated by G. F. Gause (1934) while working on two species of Paramoecium, – *P. caudatum* and *P. aurelia.*

- **Experiment 1:** Gause first grew the two closely related species of Paramoecium – *P. caudatum* and *P. aurelia* in separate culture tube which contained bacteria on which the Paramoecium fed.

- **Result:** After few days, he found that the number of Paramoecium has increased in both the test tube and they reached in equilibrium. Each species grew in numbers according to the logistic equation and exhibited typical sigmoid population growth. It is clear from the Fig 1&2 that *P. aurelia* grows in numbers in more quickly than *P. caudatum* and ends up with more individuals in the same volume of culture medium. In other words, the carrying capacity of the culture medium is greater for P. Aurelia than it is for *P. caudatum* and *P. aurelia* has the greater rate of natural increase of the two species. These differences make sense as *P. caudatum* is larger than *P. aurelia.*

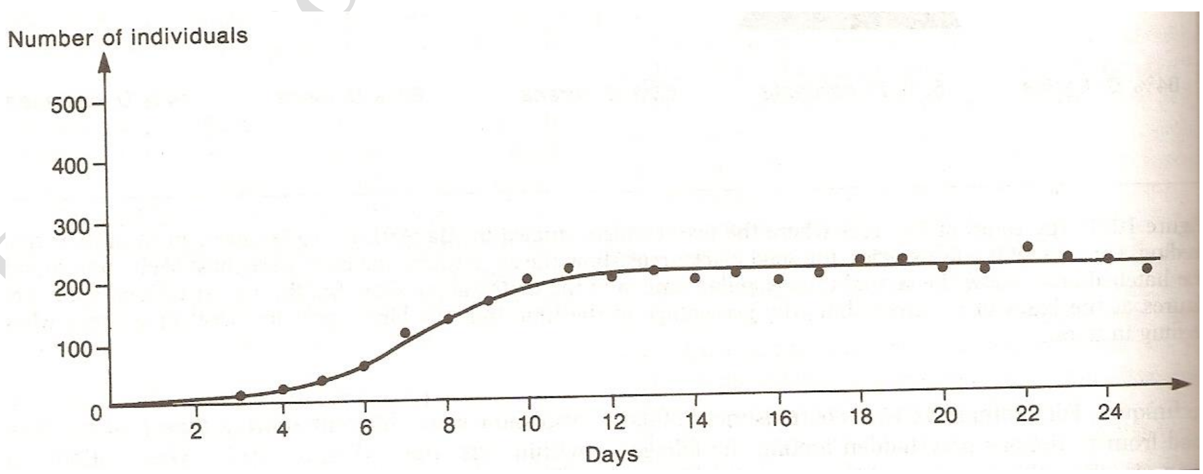


Fig 1. The growth in the population size of *Paramoecium caudatum* in a laboratory culture (From Gause, 1934).

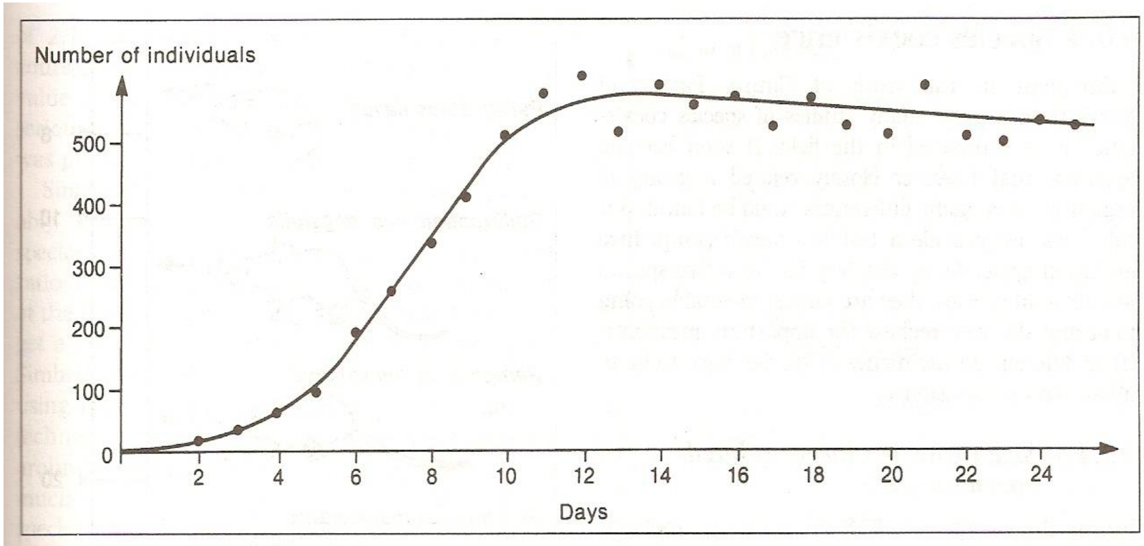


Fig 2. The growth in the population size of *Paramoecium aurelia* maintained on its own in a laboratory culture (From Gause, 1934).

- **Experiment 2:** Gause then grew the two species together in same small 5 cm^3 volume culture tube.

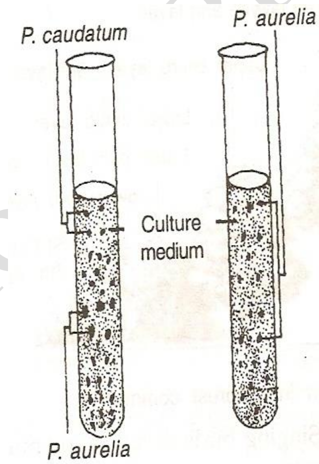


Fig 3. Left tube. *P. caudatum* and *P. aurelia* were cultured in the same cultured tube. Right tube. After 16 days, only *P. aurelia* is found but no *P. caudatum* population.

- **Result:** After few days it was found that none of them has reached the carrying capacity level and after some times, the *P. caudatum* became eliminated.
- **Inference:** Gause concluded that initially both species grew in numbers, but *P. caudatum* declined and became extinct as a result of competition between both the species. *P. aurelia* always won the competition and continues to increase in number while *P. caudatum* declines in number and became extinct. Gause attributed the inevitable extinctions to the existence of 'but a single niche in the conditions of the experiment'.

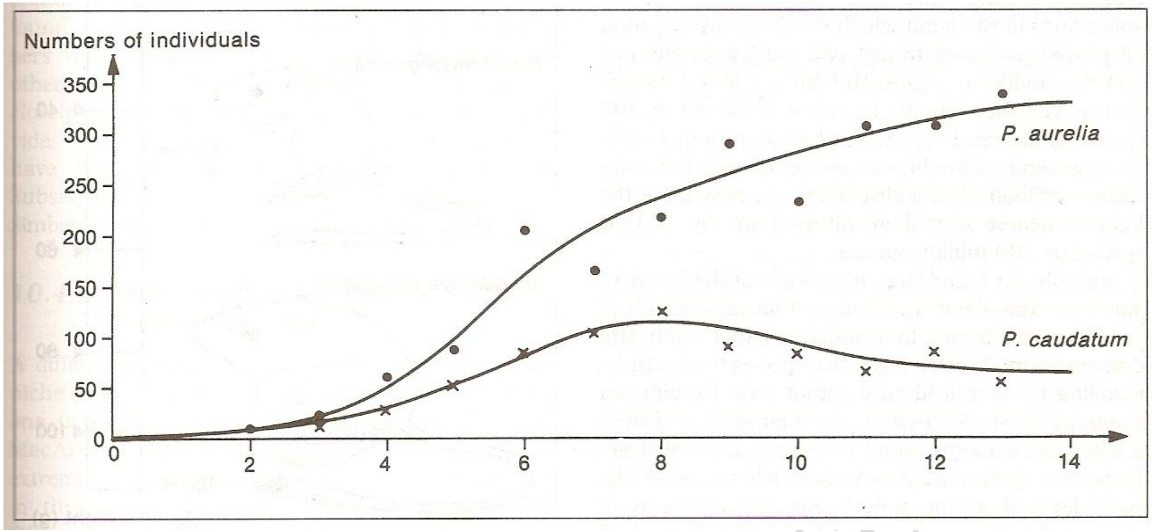


Fig 4. The changes in the numbers of *P. caudatum* and *P. aurelia* when grown together in a laboratory culture. At first, both species grow in numbers. Eventually, however, *P. caudatum* declines in number and *P. aurelia* continues to increase its population size. (Data from Gause, 1934).

- **Experiment 3:** He then grew together *P. caudatum* and *P. bursaria* in a same culture tube.

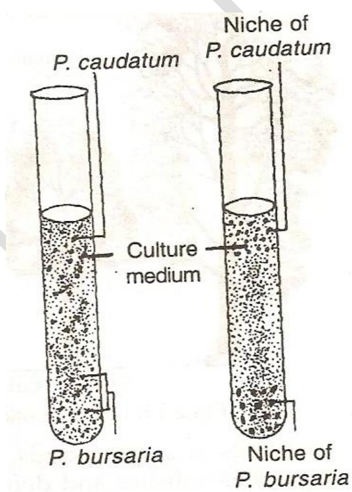


Fig 5. Left tube. *P. caudatum* and *P. bursaria* were cultured in same cultured tube. Right tube. Both *P. caudatum* and *P. bursaria* were survived because they occupied different niches although their food requirements were same.

- **Results:** Astonishingly both the species survived.
- **Inference:** when he further investigate the matter he found that in the culture medium *P. caudatum* consume the yeast which remain suspended in the tube and *P. bursaria* consume the yeast which settled in the bottom. As they occupy different niches, there was no competition. Thus competitive exclusion could be avoided if environmental heterogeneity was provided.

Does the Competitive Exclusion Principle Always Work?

It is also likely that competitive exclusion principle doesn't work when there are several competing species rather than two. When there are so many competitors and the chance is very low that one of them could win against all other competitors in the area.

Another Example of Competitive Exclusion