Tequila is a very popular alcoholic product. It is derived from the agave plants. **The Mexican Long Tongued Bat** is responsible for the majority of the seeds being spread so that these plants can continue to grow.

In addition bats are also well known for keeping insects and bugs away from crops. They will eat tons of them annually that would be destroying such crops. Some of the critters that they consume include June Beetles, Stink Bugs, and Corn Worm Moths. Without their help the use of harmful pesticides would significantly increase and be dangerous for humans.

Bat Pollination (Chiroptirophily)

Night-blooming (nocturnal)
White & aromatic flowers

believed that over 500 different types of tropical plants are pollinated
ssfully every single year through the bats role

Entomophily: These flowers are pollinated by Insects.

- Petals are bright and are attractive (Fragrance)
- Broad stigmas or anthers to allow the insect to perch on it.
- Many of the insect-pollinated flowers also secrete nectar which attracts bees, butterflies, moths or other similar insects to the flowers
- **Examples: HW**

Zoophily: The pollinating agents are animals like human beings, bats, birds etc.

- Flowers have pollen that is designed to stick on to the body of the animal
- Less weight
- Examples: *Galium aparine* (Catchweed or sticky bud)

Anemophily: These flowers are pollinated by the agency of Wind.

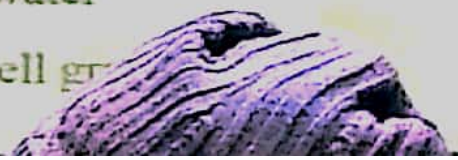
- These flowers are small and inconspicuous.
- Pollens are non-sticky
- The pollens are very light so that they are easily carried by the wind.
- Examples: oaks, chestnuts

Cross Polination: The pollen is transferred from the anthers of one flower to the stigma of another flower. The two flowers are genetically different from each other and is always dependant on another agent to cause the transfer of pollen.

Based on the agent of pollination, cross-pollination can be of different types:

Hydrophily: These flowers are pollinated by means of Water.

- The flowers very small in size
- Do not have any fragrance(Odorless)
- Colorless petals
- The pollen is adapted to be able to float in water
- Example: *Vallisneria spiralis*(tape grass or ell gr



Self Pollination: These plants depend on wind or other smaller insects that visit the flower regularly. In self- pollinating flowers, the anthers, and stigma are of similar lengths to facilitate the transfer of pollen.

Further divided into two types:

- *Autogamy*—The pollen is transferred from the anthers of one flower to the stigma of the same flower

- *Geitonogamy*—The anthers are transferred from the anthers of one flower to the stigma of another flower but on the same plant

TYPES OF POLLINATION

CROSS POLLINATION

when pollen is delivered from the stamen of one flower to the stigma of a flower on another plant of the same species

SELF POLLINATION

when pollen is delivered from one flower pollinates the same flower or other flowers of the same individual

Pollination is the transfer of pollen from the male anther to the female stigma either by self or through an agent

FLORAL SYMMETRY

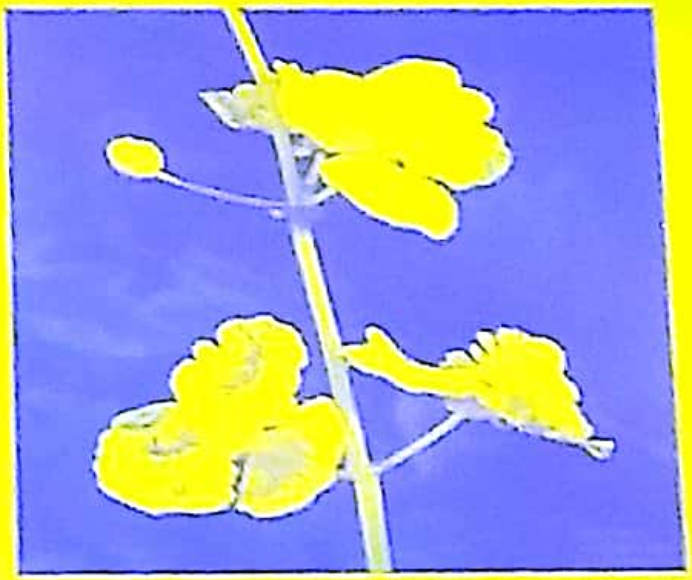
Two types of floral symmetry:

1. **Regular (Actinomorphic):** In which the pistil(s), stamens and segments of the perianth radiated out uniformly from the central axis. Furthermore, all segments of each organ type were equal in size and form. (*Primula, Pyrola*)
2. **Irregular (Non-Actinomorphic):** In which any parts of the perianth or sexual organs did not meet these criteria. (*Cassia, Salanum*)

* Honeybees have been the subject of many studies related to symmetry preferences

Some flowers sexually dimorphic: Either pistillate (with Pistil only) or staminate (having stamens only)

Pistillate flowers of *Sagittaria*



Staminate flowers of *Sagittaria*

FLORAL VARIATION

Parts may be fused

Connation (petals to petals)
Adnation (stamens to petals)

Fusing of petals can form floral tube (nectar present at bottom)

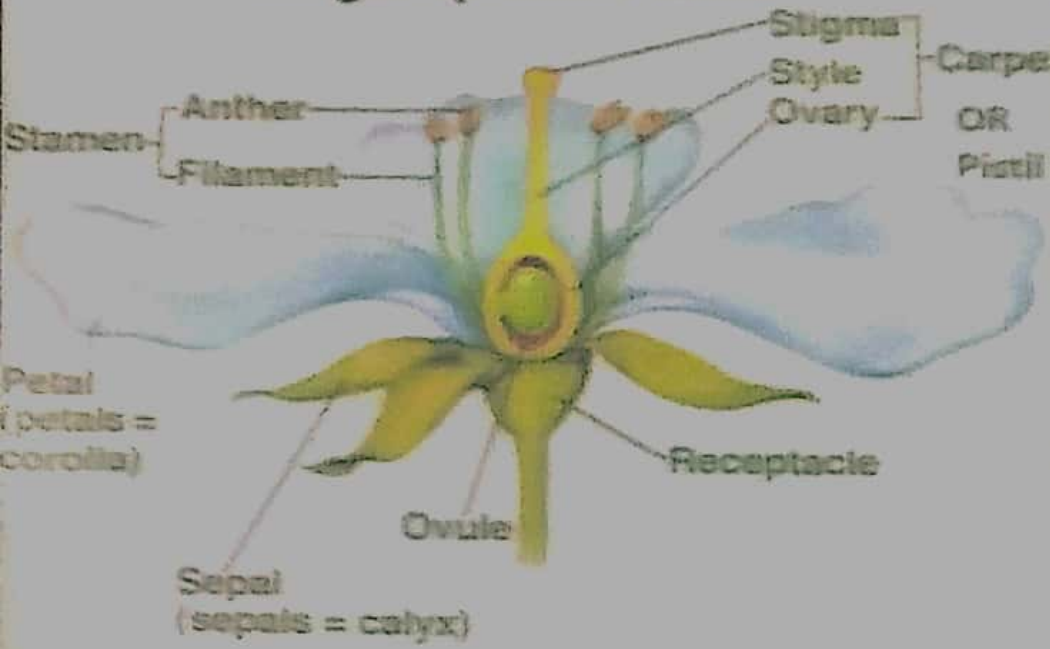
Only long-tongued pollinators can reach it

Snapdragon flower

Amasconthus (Acanthaceae) flower

THE FLOWER

Angiosperm Flower



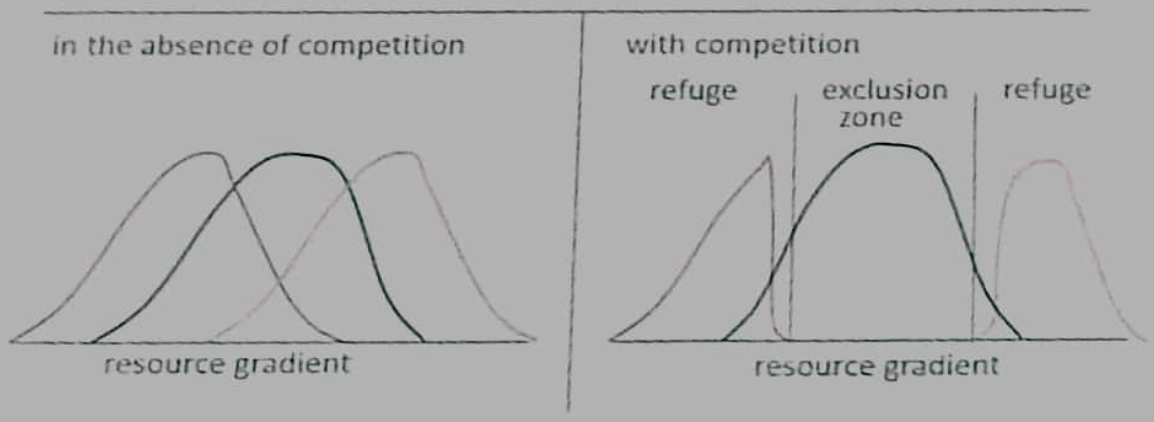
Outer part of the flower consists of petals and sepal

- Ghost of competition past (J. H. Connell 1980) describes one possible reason for observed differentiations in niches.
- Individuals of **competing** species may be less fit than individuals of species which avoids **competing** because it occupies a fundamental niche which does not overlap that of others.

Dominance hierarchy

dominant sp. A

subdominant sp. B C



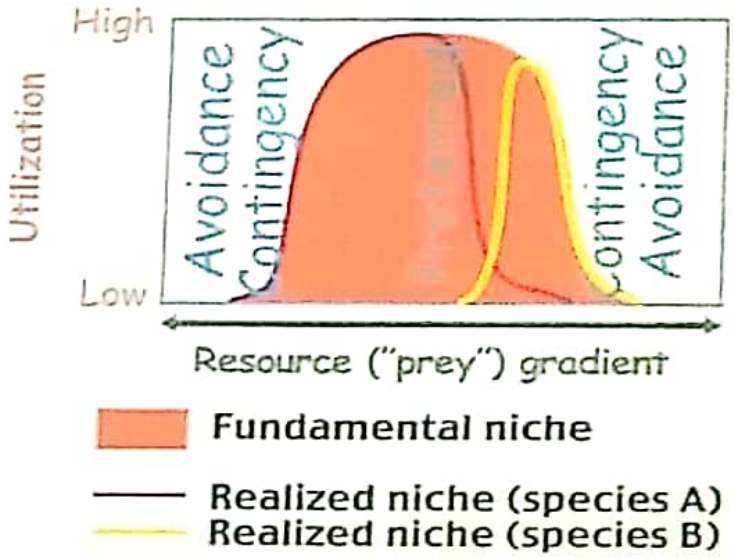
Fundamental vs realized niche

- Fundamental niche represents all of the conditions in which a species could potentially exist.
- Realized niche represents those conditions in which it *does* exist in the presence of interacting species.

Niche compression

- Realized niches are narrower than fundamental niches, therefore the species occupies a narrower range of habitats than it would in the absence of competition.
- The realized niche can be regarded as a 'competitive refuge'.

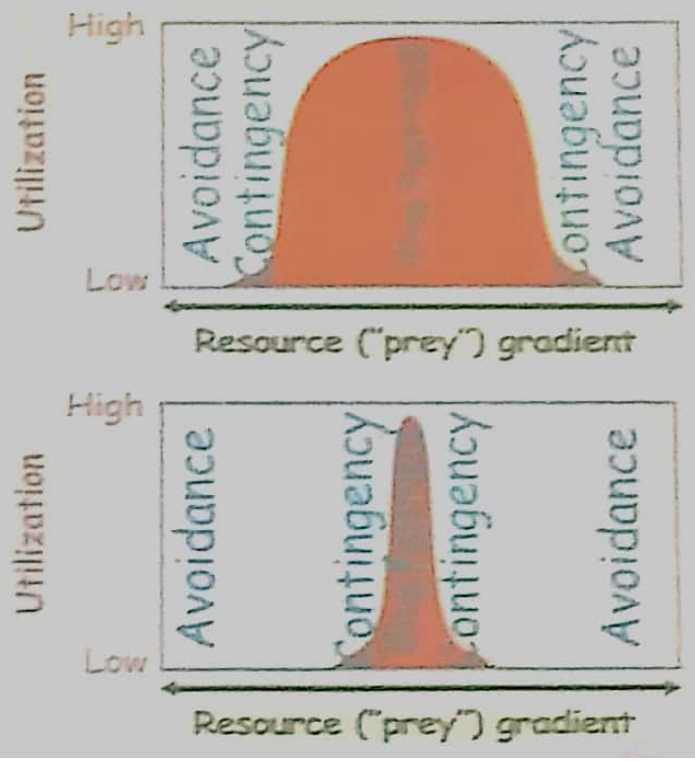
Fundamental
vs. realized niche

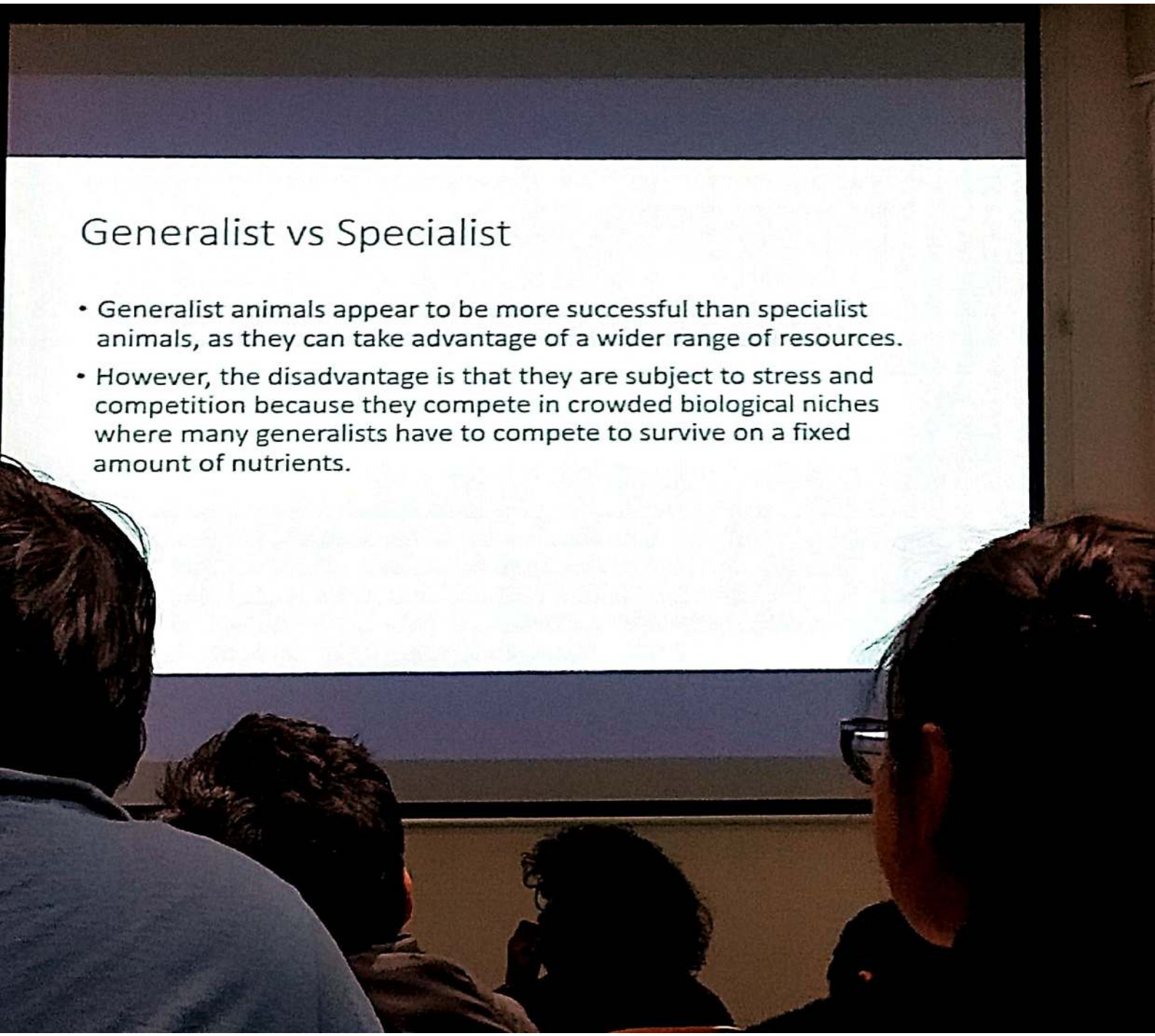


Resource partitioning

- Resource partitioning is the differential use of resources, such as food and space, and has been evolved so that each co-existing species develops dissimilar resource requirement and avoid competition
- Resource partitioning is a consequence of competition and may result in shrinking of the niche breadth of organisms resulting in the creation of specialist species.

Niche breadth: generalist vs. specialist




Generalist vs Specialist
• Generalist animals appear to be more successful than specialist animals, as they can take advantage of a wider range of resources.
• However, the disadvantage is that they are subject to stress and competition because they compete in crowded biological niches where many generalists have to compete to survive on a fixed amount of nutrients.

Generalist vs Specialist

- **Generalist:** Generalist animals are those adapted to a wide range of environmental circumstances and food sources. They occur in radically different habitats and eat a broad range of food items. Thus they have broad niches and a wide diet. This requires them to have a broad range of sensory/motor skills and ability to adapt to radically different habitats and environmental conditions. Example, Common crow, mice.
- **Specialists:** Animals that preferentially utilize of a small set of resources and/or are evolved to adapt to unique niches or environmental conditions. Thus they have narrow niches and dietary preference. Such animals evolve special morphological, physiological and sensory characters that allow them to adapt to unique niches, particular environmental conditions or habitat type and help them in utilization of particular food resources. Koala bear that exclusively consumes Eucalyptus leaves or polar bears that exist only in polar regions of the world.

Resources

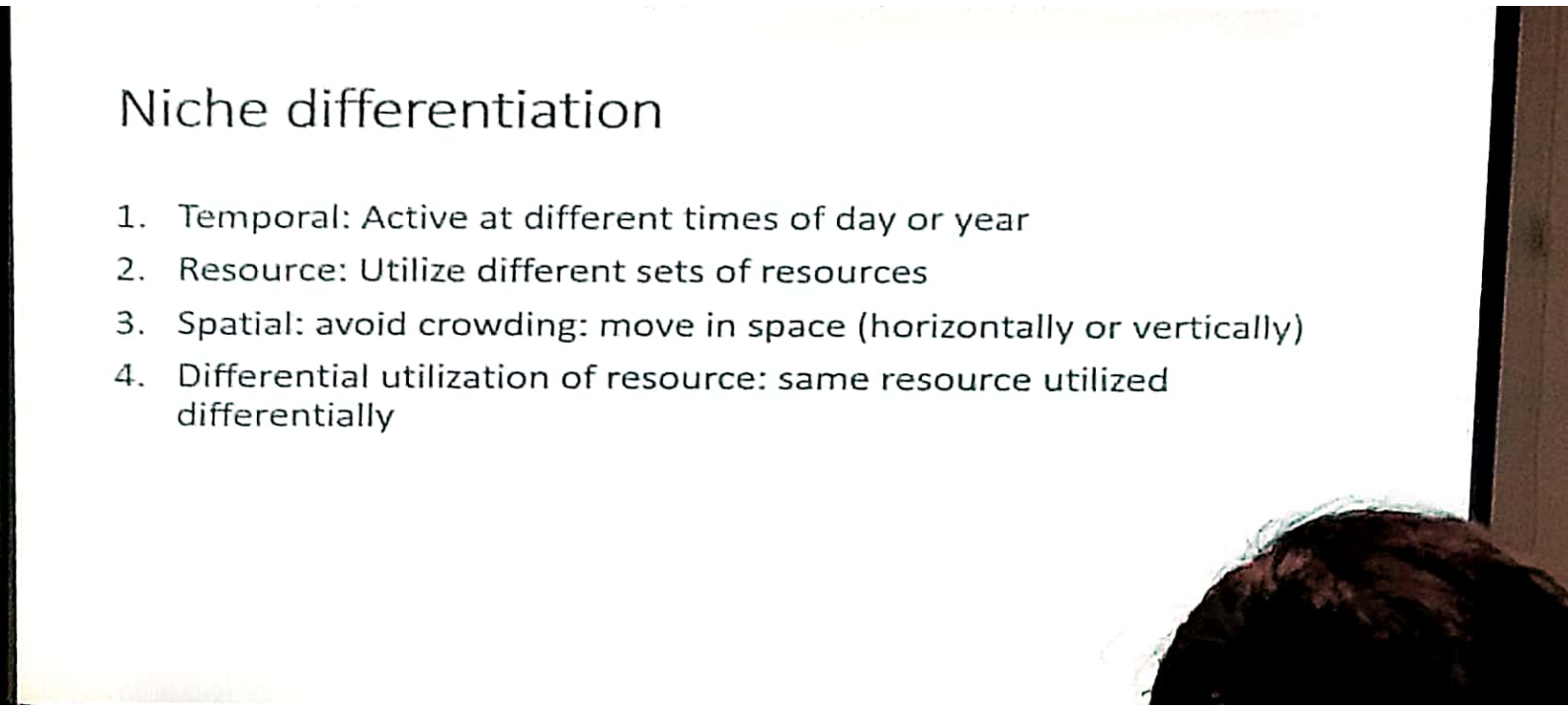
- Anything that can be consumed by organisms
- Solar radiation
- Water
- Habitat (space)
- Food
- Mate

Co-existing species and individuals of a species often share resources

This may lead to competition for resources (if resources are limiting)

Niche differentiation

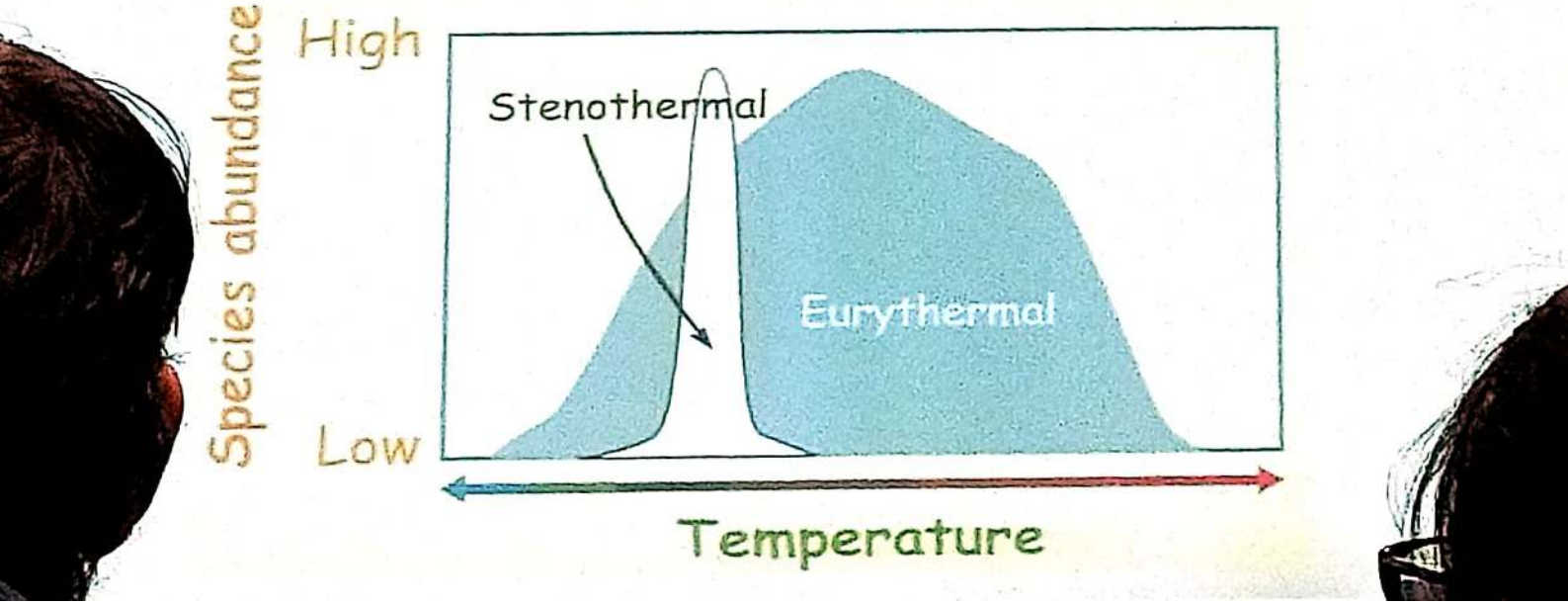
1. Temporal: Active at different times of day or year
2. Resource: Utilize different sets of resources
3. Spatial: avoid crowding: move in space (horizontally or vertically)
4. Differential utilization of resource: same resource utilized differentially



Important definitions and their difference

- **Ecological Niche** The limits, for all important environmental features, within which individuals of a species can survive, grow and reproduce. It defines the place or function of a given organism within its ecosystem.
- **Niche differentiation** The tendency for coexisting species to differ in their niche requirements.
- **Niche divergence** An evolutionary process whereby the niches of two species become less similar.

Specialized habitat occupance



Thermal Tolerance

- With respect to temperature tolerance there organisms can be classified as Eurythermal or Stenothermal

- Eurythermal: Organisms that can tolerate wide range of temperatures. Mammals; oaks
- Stenothermal: Organisms that can tolerate narrow range of temperatures. Penguins, reptiles; equatorial plants

What determines distribution of species?

- Individual organisms have a physiology that limits them to tolerate particular ranges of physicochemical conditions and dictates their need for specific resources.
- The occurrence and distribution of species therefore depends fundamentally on their physiological ecology and, for animals, their behavioral repertoire too.
- Resource distribution and abundance
- Ecological interactions with other individuals/species

Sorenson's Coefficient of similarity (1948) ß-diversity

Jaccard coefficient:

$C_j = a / (a+b+c)$

Sorenson's coefficient:

$C_s = 2a / (2a+b+c)$

Where

a= number of species common between site 1 and site 2

b= number of species in site 1

c= number of species in site 2

Note

- The distribution of individuals over species is called evenness.
- While diversity is a measure of heterogeneity/unpredictability
- Species richness and species evenness must be used as two independent characteristics of biological communities that together constitute its diversity (Heip, 1974).

Species Evenness

- Evenness is a measure of the relative abundance of the different species making up the richness of an area
- It takes into account abundance (both absolute and relative)
- A community dominated by one or two species is considered to be less diverse than one in which several different species have a similar abundance
- Hurlbert (1971) proposed a measure of evenness which considers evenness as a ratio of the observed diversity (H) to the maximum possible diversity
- Maximum possible diversity is when all species (total S) are equally abundant and is given as ln (S) (S= all species recorded)

$E_H = H / \ln (S)$

Simpson Yule Diversity Index (1949)

- In ecology, it is often used to quantify the biodiversity of a habitat.
- It takes into account the number of species present, as well as the large quantity of each species.
- It measures the probability that two individuals randomly selected from a sample will belong to the same species.
- It can be measure with the following formula: 1 - D
- Where D is calculated as: $$D = \frac{\Sigma\, n(n-1)}{N(N-1)}$$

- n = the total number of organisms of a particular species
- N = the total number of organisms of all species

Species Diversity: Shannon-Wiener index alpha-diversity

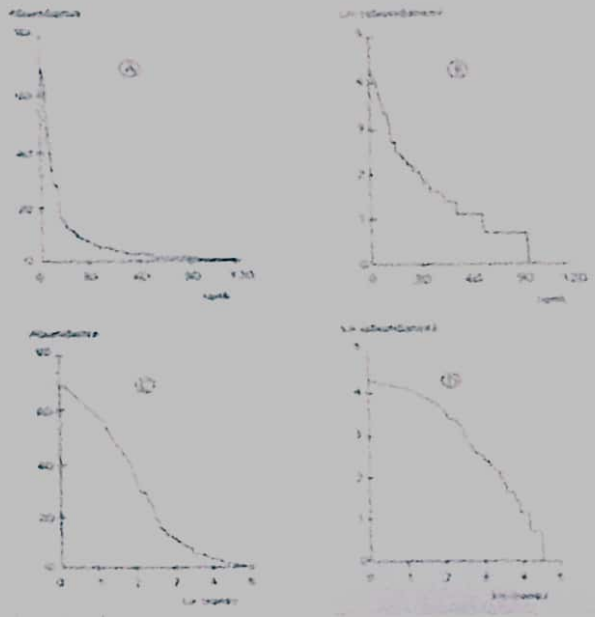
- Proposed initially by Claude Shannon as a measure of entropy in a string of text. The more different letters present, and the more equal their proportional abundances in the string, the more difficult it is to correctly predict which letter will be the next one in the string.

- It is most often calculated as follows:

$$H' = -\sum p_i \ln p_i$$

Where p_i represents proportional abundance of a given species (i)

Rank-Abundance plots (linear vs logarithmic)



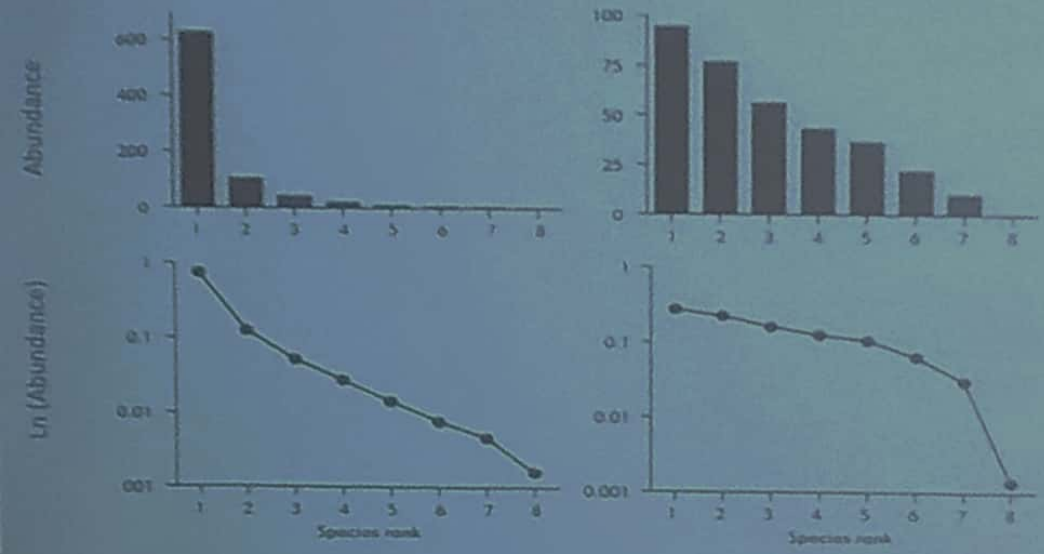
Whittaker Plots with neither axes, Y axis, X axis and both axes on logarithmic scale

Choice depends on the scale of data

Variance between abundances of different species high or low

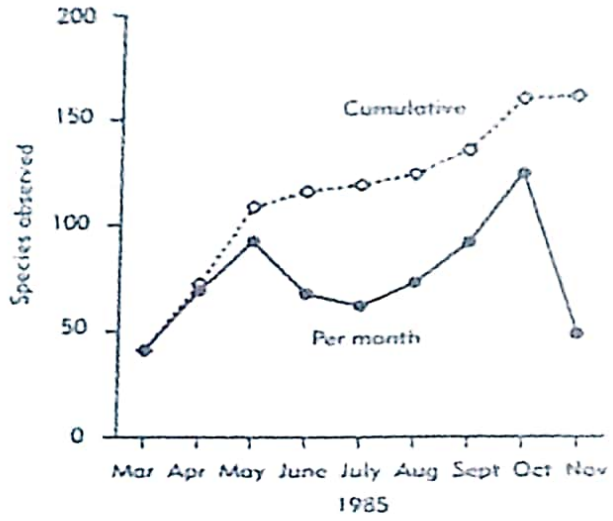
Number of species in the community high or low

Rank Abundance Plots: Whittaker plots

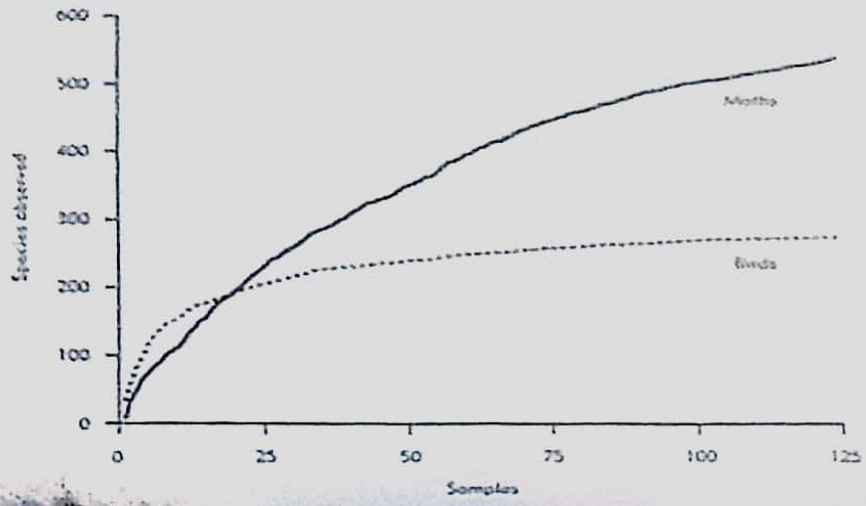


A rank abundance curve or **Whittaker plot** visualizes relative species abundance, one of the two components of diversity (the other being species richness)

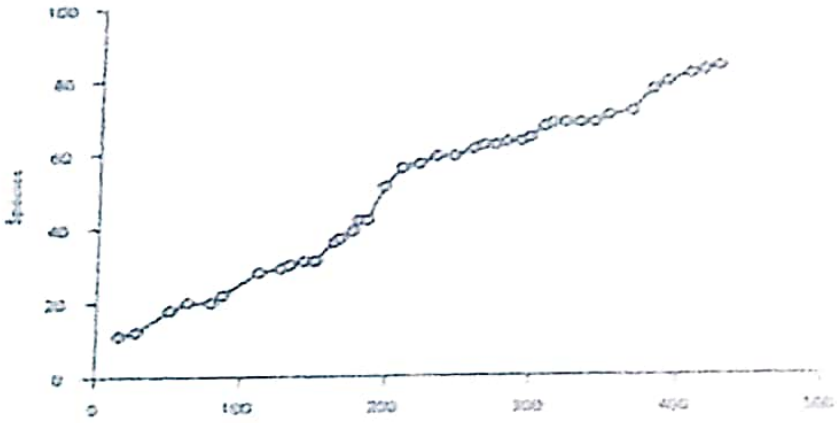
Temporal effects and species richness



Species accumulation curve



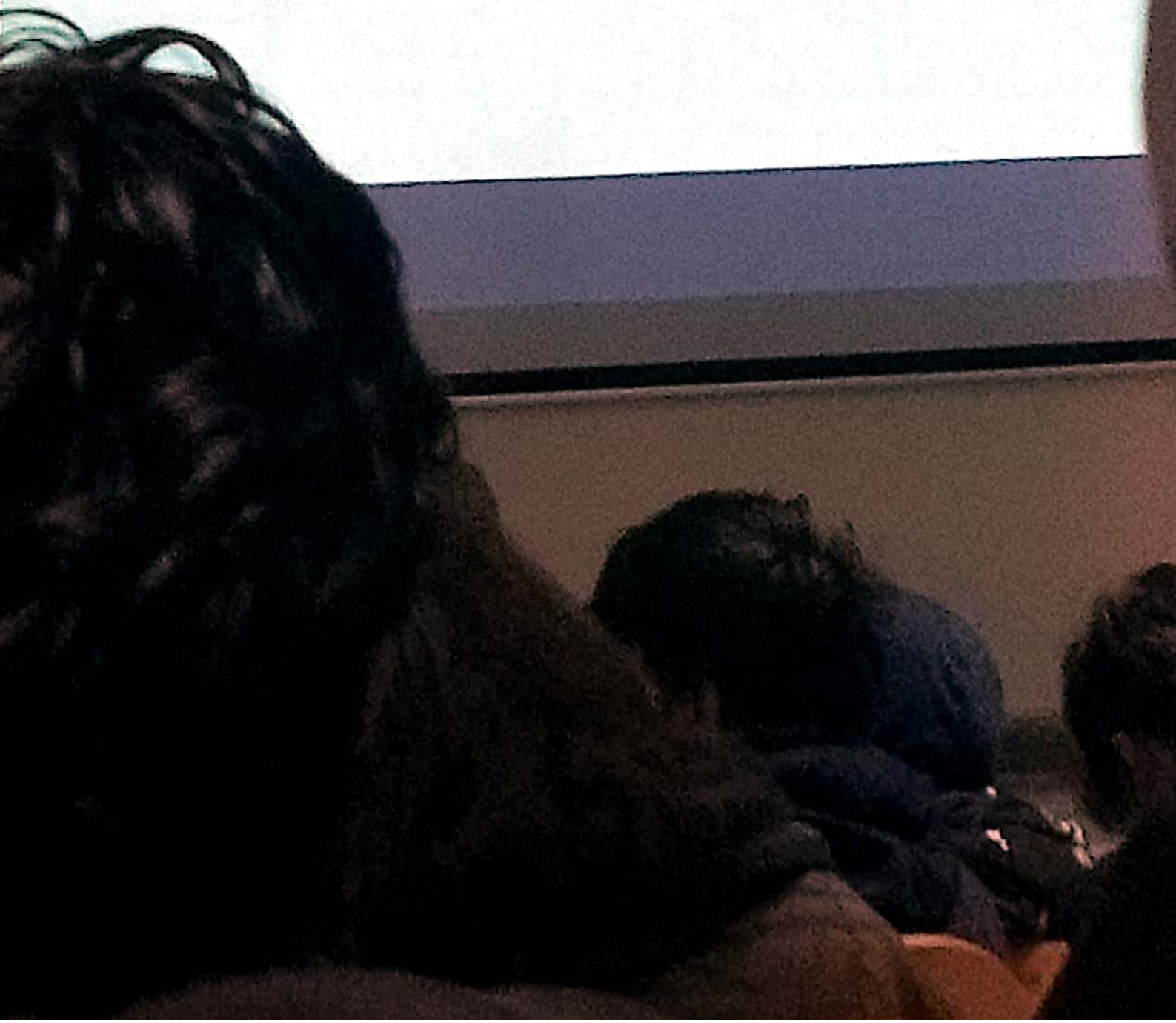
Species accumulation curve



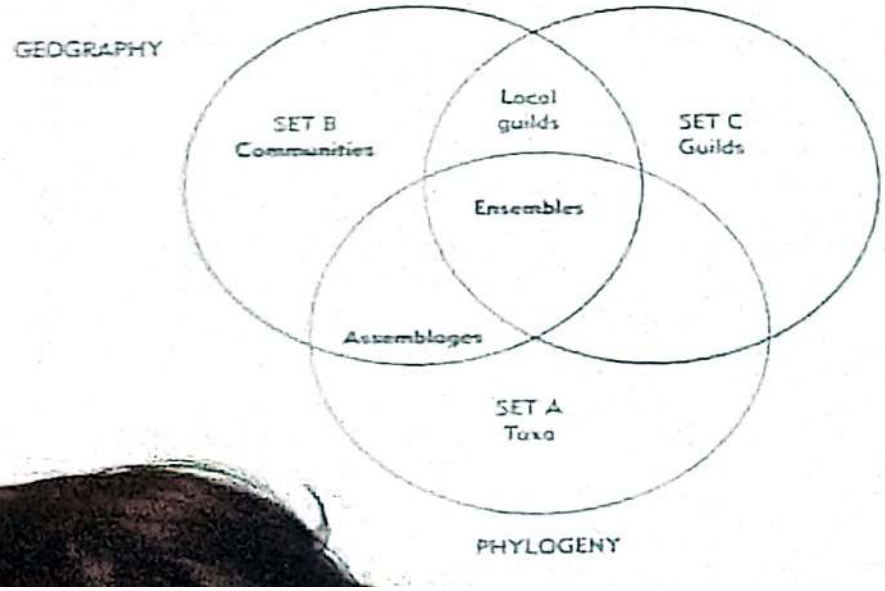
Sampling Effort: Area sample (m^2): No. of sampling points/quadrats/transects/traps; No of sampling Days

Species Richness

- Simplest measure of biodiversity.
- The most common type of biodiversity index and refers to the number of species in a particular place. Give by 'S'
- Species richness can be measured in time and space
- It does NOT include abundance of species



Taxa, community, assemblage, guild



Fauth et al, 1969

Taxa, community, assemblage, guild, ensembles

- **Taxa:** Species of common descent. Forms a taxonomic unit. Could be at any level of classification. Phylum, Class, Order, Family, Genus or species
- **Community**: collection of species that occur together in space and time. Ecological interactions occur between species as a consequence of their coexistence in time and space. They need not be species that share resources.
- **Assemblage**: collection of phylogenetically related members of a community.
- **Guild**: Organisms that exploit the same set of resources in a similar manner.
- **Local guilds:** comprise of species that share resources AND belong to same community
- **Ensembles**: Interacting species that share resources as well as ancestory

Alpha, beta and gamma diversity

- **Within-habitat diversity** or **alpha-diversity:** refers to a group of organisms interacting and competing for the same resources or sharing the same environment. Measured as # of species within a given area
- **Between-habitat diversity** or **beta-diversity:** refers to the response of organisms to spatial heterogeneity. High beta-diversity implies low similarity between species composition of different habitats. It is usually expressed in terms of similarity index between communities (or species turnover rate) between different habitats in same geographical area (often expressed as some kind of gradient)
- **Geographical or landscape diversity** or **gamma-diversity**

Whittaker 1960

Techniques

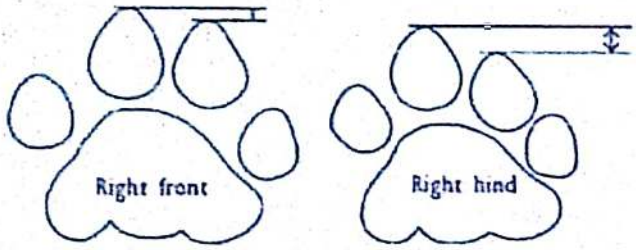
Absolute Density

- Total Count
- **Sampling: i) Quadrat ii) Mark Recapture**

Relative Density

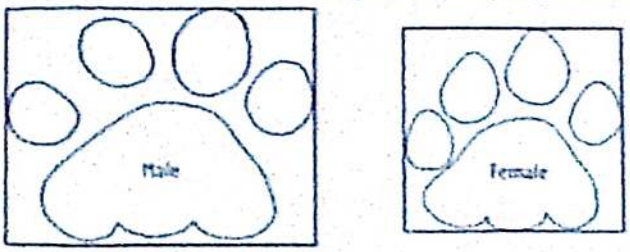
- Pellet count: hare, deer, field mice
- Vocalization frequency: frog, crickets, cicadas, birds
- Traps: Light trap, Pit fall, mouse trap, mist-nets

Distinguishing the hind from the front pugmark

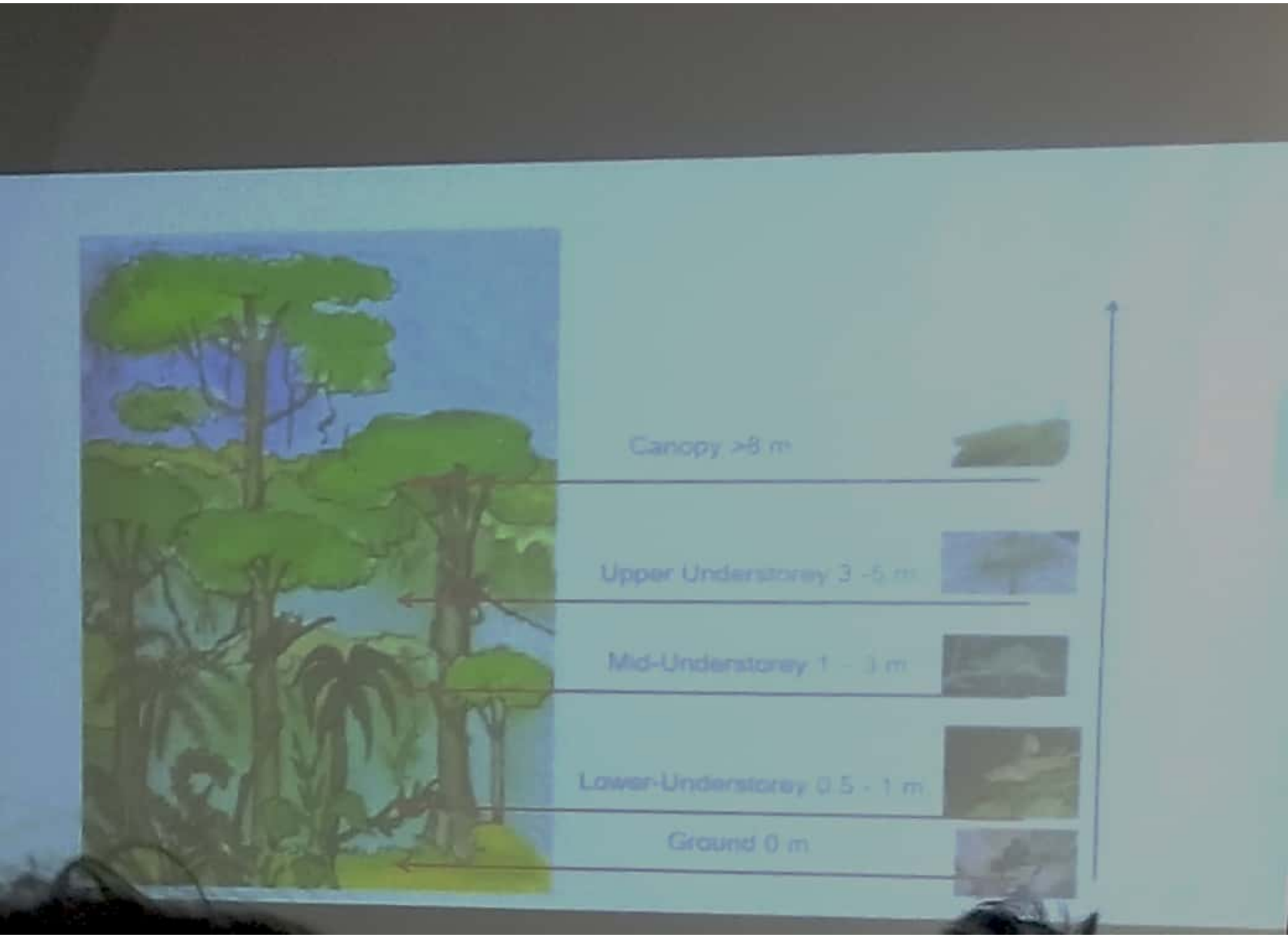


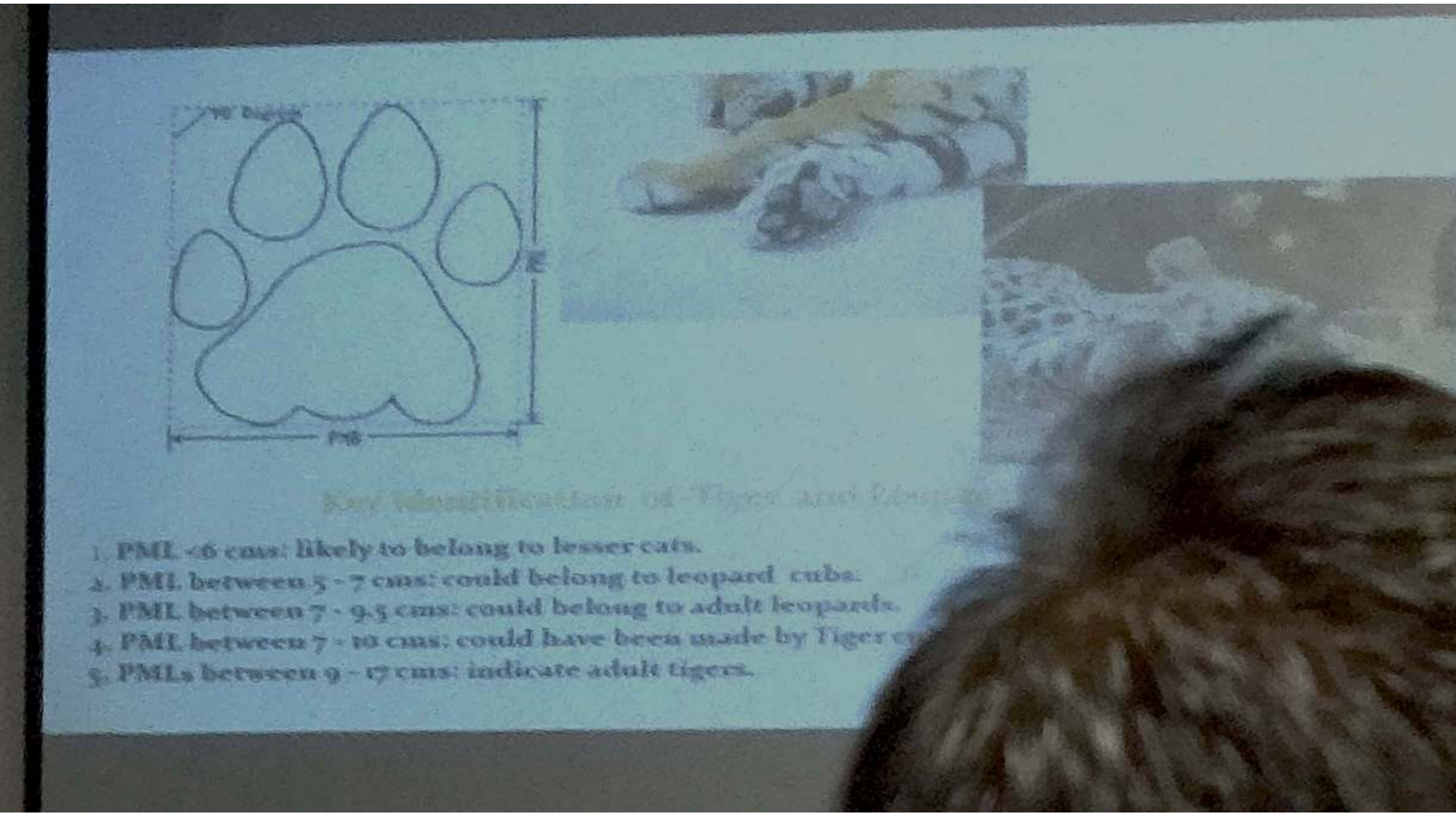
HIND vs FRONT PAW
Hind paw: smaller than front paw
Front paw: forward two point almost at same level
Hind paw: distinctly at two different levels

Determining sex of tiger from pugmark



MALE vs FEMALE
Front paw: PMB > PML -> MALE
Hind paw: Square -> MALE
Hind paw: Rectangular and smaller -> FEMALE


Canopy >8 m
Upper Understorey 3 - 5 m
Mid-Understorey 1 - 3 m
Lower-Understorey 0.5 - 1 m
Ground 0 m

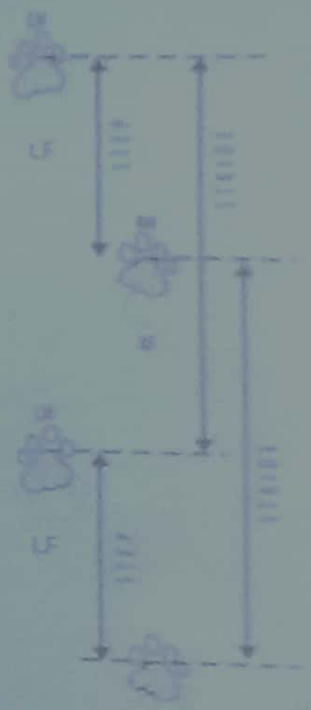


1. PML <6 cms: likely to belong to lesser cats.
2. PML between 5 - 7 cms: could belong to leopard cubs.
3. PML between 7 - 9.5 cms: could belong to adult leopards.
4. PML between 7 - 10 cms: could have been made by Tiger
5. PMLs between 9 - 17 cms: indicate adult tigers.

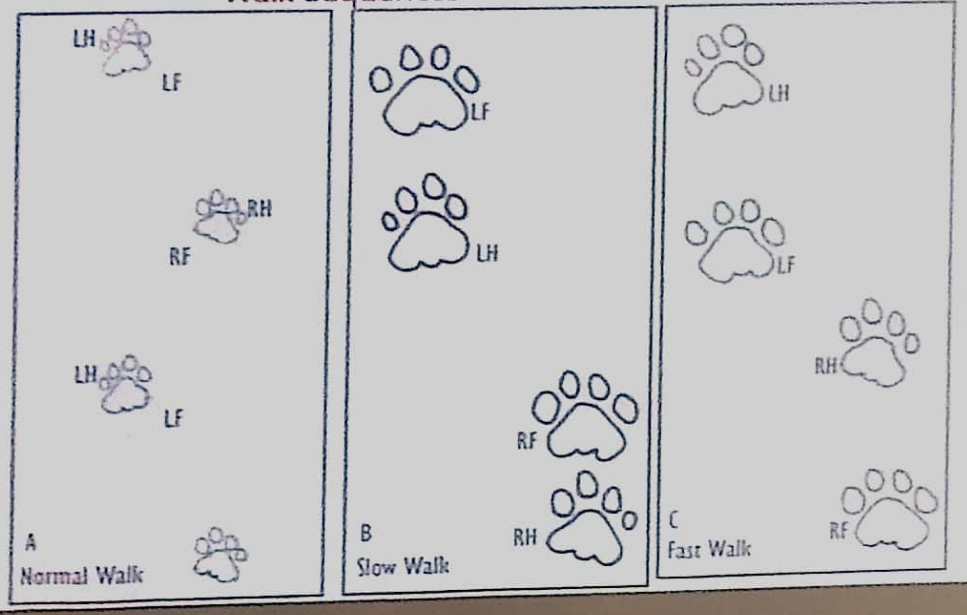
Walk sequence of tiger

Stride measurement

- **Stride measurements help in distinguishing between tigers with similar size pugmarks**
- **The length of stride helps in distinguishing pugmarks made by tiger cubs from those made by adult leopards**



Walk Sequences



HIND and FRONT overlapping
Normal pace

FRONT ahead of HIND
Slow pace

HIND ahead of FRONT
Fast pace