BIO202 : Behaviour & Ecology
Dr. Manjari Jain

→ ECOLOGY:
- Natural History - starts & ends with observing rather than experiments.
- Ernst Haeckel.
- Scientific study of interactions between organisms and their environment

- Levels of ecological studies:
  (i) Organismal
  (ii) Population
  (iii) Community
  (iv) Ecosystem

- ecology and evolution:
- Ecology & evolutionary biology are closely related sciences.
- E & E are intimately related 'cause, organisms ecological situation directs its evolution and the organism's response to its ecological situation may be evolutionary.

- Nothing special about the white moths, they are just white.
- Organisms can evolve a response?
  a mutant with ← adaptive a selective advantage evolution because of the environment

- Organisms are adapted to PAST environment, and if the current environment is similar to the past, then the organism can successfully survive and reproduce.

↳ Evolution is always a step behind.

- Selection acts on an individual, not at a gene level.

- Can selection happen at a species level?
  ↳ Parsimony - shortest path
- Each individual tries to maximise its own fitness
- Group selection -
- Worker bees feed the non-own young ones because they share the genes.

- Variation: individuals of a species are not identical.
- Heritability: Some of this variation is heritable. - common descent.
- Fitness.
- Evolved perfection - no!

a single individual is not the fittest, typically a set of individuals of a type.

- Delineating species
  1) Biological species concept:
     ↳ Dobzhansky, Mayr
  - Reproductive isolation mechanism

- How can a continuous process creates discontinuous entities such as species that live in same habitats?
  2) Morphological species concept

- Reproductive isolation:
- Diverse set of traits that prevent gene flow between taxa.
- Premating isolating barriers
  (i) Behavioral isolation

[If a cricket's song diverged a lot that the female does not recognize the mate call.]

- (iii) Ecological isolation

- Postmating, prezygotic isolating barriers: gametic isolation.
- Postzygotic isolating barriers: hybrid sterility and viability.

Allopatric — seperated in space

Parapatric

Sympatric

- Early Indians

- Allopatric speciation:
  - A part of the pop. becomes geographically isolated from the main population.

↓

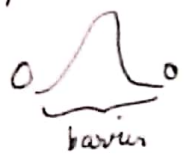
Reduced gene flow → Accumulation of genetic differences

↓

evolve into two seperate species.

- How much difference is enough for the populations to diverge into seperate species?

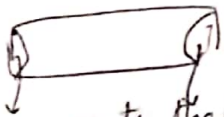
- Allopatric



- Peripatric
- Sympatric

→ Sympatric :

- together
- organism whose ranges overlap



segments that can potentially come into contact [no geographic isolation], but do not move around a lot

↳ non-random mating

- evolve into two seperate species
- process of diverging, but not different species yet → subspecies.
- common in plants and bacteria

→ Parapatric :

- occurs within broadly continuous habitat
- when a population of a species enters a new niche or habitat
  ↳ become biologically functionally different.
- some organisms have gone to the canopy
- Rainforest : heterogenous population
  ↳ canopy : high ✓ layered

Dry deciduous forest :

- Phytotelmata -
- Imagine you're a frog and you go to the canopy. Genetic difference may accumulate between diff species

- Biological species concept

(i) Impracticality of applying the concept - can't really test the individuals potentially interbreed

(ii) How much reproductive isolation is needed ?

(iii) How to apply this to asexual organisms ?

→ Measuring Abundance and Density :

- Density estimation Techniques : Size and mobility

- Absolute density
  - Total count

Human Population Census
Territorial birds all males in an area.
Gathering of animals in breeding colonies, migrating animals

- Sessile invertebrates

- Pseudoreplication -

- Using vocal signs : territorial males.
- Blue wildebeest
- Christmas island red crab migration.

- Pugmark analysis

- Canines & Felines
  ↳ (i) claw marks ✓ ✗

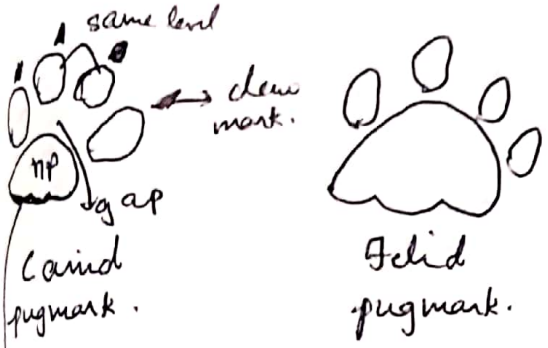
- Canid pugmarks:

(i) Claw marks are generally visible in front of the toe pads.

(ii) Toes pads are larger compared to the heel pad.

(iii) Distance of the two middle toes from the top of heel pad is greater.

- Hyenas being exception to point 3.

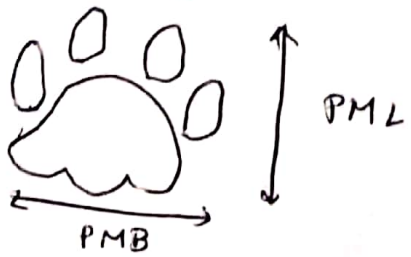


MP is smaller.

- Stride analysis

Key identification of tiger and leopard:

i) PML → pug mark length
PMB → pug mark breadth



: Pugmark analysis : Race on glass

(i) PML < 6cms – likely to belong to lesser cats

(ii) PML : 5-7cms – leopard cubs

(iii) PML : 7-9.5cm : adult leopards

(iv) PML : 7-10 cms : by Tiger cub

(v) PML : 9-17 cms : adult tiger

all are could be (s)

{ Distinguish between cub [tiger] and leopard adult → depth, stride length

↳ or, cub is almost always dependent on the parent (adult)
↳ absence of finding adult marks.

- Hind paw vs front paw.

Hind – smaller than front
Front : forward two point about same level

Hind : distinctly at two diff levels.

- Male vs female

Front : PMB > PML → male
Hind : dance → male
Hind : Rect. and smaller → female.

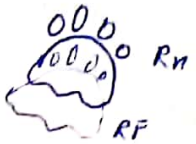
Walk sequence of a tiger :

- Stride measurement
  - less likely to find impressions of hind pug [Overlapping front and hind pugmarks].
  - help in distinguishing between tigers with similar size pugmarks
  - helps in distinguishing tiger cub & adult leopard pugmarks

Track plot

- Trails - lay down soil to make track plots → look at the pug marks : tiger census. Absence does not mean anything

- Normal walk :



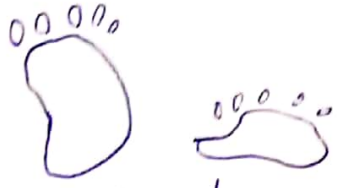
Slow walk :

LH behind LF

Fast walk :

LH in front LF

Mainly use pugmark and for presence / absence.



Sloth bear

- Other methods : looking at their shit

- Absolute density :
  - Total count
  - Sampling : (i) Quadrat
    (ii) Mark Recapture

- Relative density :
  - Pellet count + ₹
  - Vocalization Frequency
  - Traps

- Camera trap

↓

Individual identification

- Cheetah, Leopard, Jaguar

- CLASSIFICATION OF SPECIES (2)

■ Taxonomy
• Binomial nomenclature [genus and species].
• Species - morphologically similar, reproductively isolated
• Biodiversity

■ Types of taxonomy:
• Alpha taxonomy - discipline of identifying, describing and classifying new species, classification of previously described species.
• Beta taxonomy - arranging taxa into higher categories
• Gamma taxonomy - biological aspects of taxa; using phylogenetic studies.

■ Importance of taxonomy
• Uniquely identify organisms
• understanding evolutionary biology.
• In conservation biology understanding patterns of biodiversity is critical to policy making

■ Scientific classification

■ Arthropoda (Arthron - joint; podos - legs).
- Characterised by having segmented bodies and jointed appendages.
- Diagnostic features:
• Triploblastic (3 germs)
• Chitinous exoskeleton.

■ Classification of Arthropoda
↳ Hexapoda
- Insecta
- Entognatha [White two]

- 31 diff orders of insects -
Tera

■ Orthoptera:
• Includes:
(1) Indian stone cricket
• Mouthparts - chewing & biting
• Characteristics: Cylindrical body, elongated hindlegs and musculature adapted for jumping. Antennae have multiple joints and filiform type.

Antennae
Filiform
Bipectinate
Quadripectinate
Unipectinate

■ Hemiptera:
• Includes: Assam bugs, Lygus bug, stink bug
• Mouthpart: piercing-sucking
• Characteristic - half wing - hardened, other half?

■ Homoptera
• Includes: hopper
• Mouthpart: sucking
• Proboscis is short, tent like structure
secondary wingless,

Coleoptera :
- first largest order - bugs

Lepidoptera
- Scaly wings
- Siphonates

- Coleoptera
- Diptera
- Lepidoptera

] largest orders

- Moth vs butterflies
- Moths tend to have flat wings
- Moths are generally nocturnal
- Hairy or feathery antenna

Butterfly :
- Hook shaped antennae

Moth collection techniques (light trap).
Basket, vertical sheet (killed)

- Diff between male & female.
  - antennae & abdomen.

Wing venation :
Ls all the practical ka stuff

- Precostal spur

Biodiversity & Conservation

- Refers to the variety of life and includes all living things and their unique characteristics
- can refer to genetic, ecosystem or species diversity.
- Biodiversity indices
- Two aspects - richness and evenness.

Alpha, beta & gamma diversity

- Within habitat or α : refers to group of organisms interacting and competing for the same resources or sharing the same environment.
- Between habitat or β : refers to the response of organisms to spatial heterogeneity. High β diversity implies low similarity between species composition of diff habitats. It is usually expressed in terms of similarity index between communities in diff habitats in same geographical area.
- γ diversity

Fauna, community, assemblage, guild, ensembles-

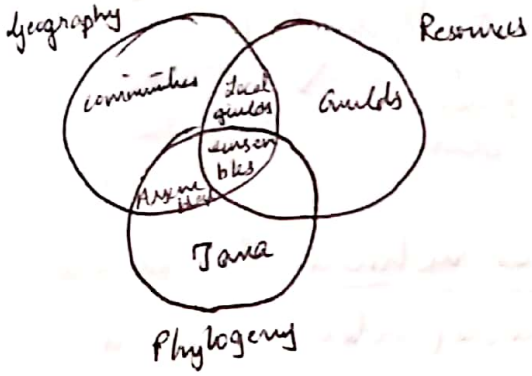
- Fauna : species of common place Forms a taxonomic unit
- Community : collection of species that occur together in space and time - ecological interactions occur as a consequence of their co-existence

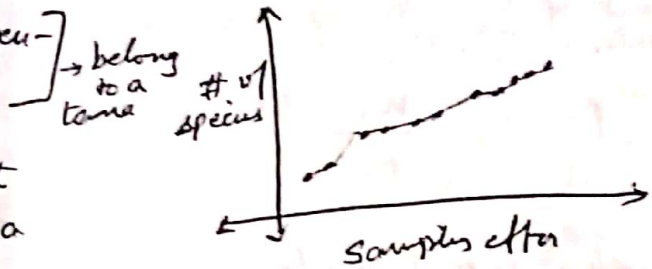
• Assemblage: collection of phylogenetically related members of a community. → belong to a taxa

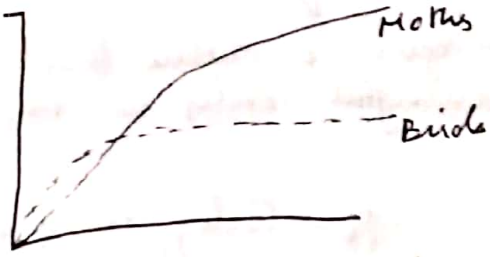
• Guild: organisms that exploit the same set of resources in a similar manner.

• Local guilds: comprise of species that share resources and belong to same community.

• ensembles: Interacting species that share resources as well as ancestory.

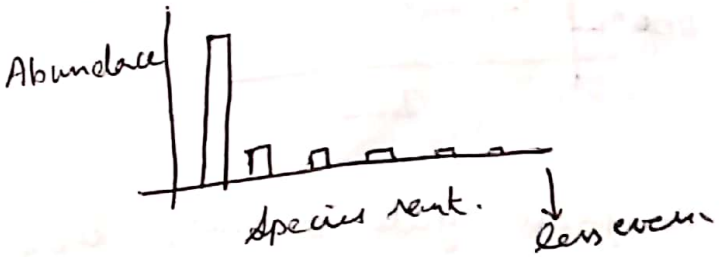


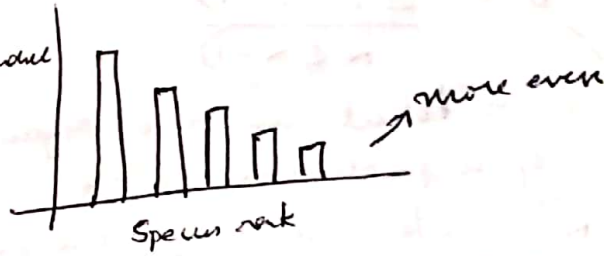




• Temporal effects and species richness

■ Rank abundance plots: Whittaker plots.





[linear vs logarithmic]. Abundance ln Cabundance.

— If we have more even distribution in one and more number of species in another community, how do we decide which is more diverse

— Species diversity: Shannon wiener index, alpha diversity

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

■ Species richness:

• simplest measure of biodiversity

• Most common type of biodiversity index - number of species in a particular place: given by 'S'

• Can be measured in time and space

• It does not include abundance of species.

■ Species accumulation curve:

• sampling effort: Area sample (m^2); No of sampling points/quadrats/transects/traps, no of sampling days.

$i = 1 \rightarrow n$, p_i

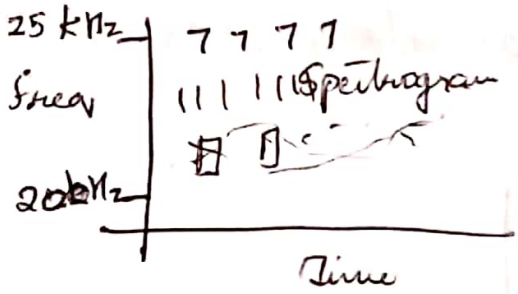
$$p_i = \frac{n_i}{N}$$

↙ plug into formula

↙ give a value that is meaningful only in the relative sense.

p_i – factor for proportional abundance.

Σ – factor for number of species



- Simpson Yule diversity index.

$$D = \frac{\Sigma n(n-1)}{N(N-1)}$$

n = total number of organisms of a particular species

N = total number of organisms of all species.

$\boxed{1 - D}$ → ↑ the value, greater the diversity

- Diversity indices are most valuable

- Species evenness

- Relative abundance of diff species

- Shulbert proposed a measure of evenness which considers it as a ratio of the observed diversity (H) to maximum possible diversity.

- Max pos diversity – all species are equally abundant:

↳ $\ln(S)$ [S = all the species recorded]

$$E_H = H / \ln(S)$$

observed diver ↘ Max. pos diversity

Species richness & evenness independent factors of diversity

- Sorenson's coefficient of similarity — β diversity

Jacard coeff : $C_J = \frac{a}{a+b+c}$

Sorenson coeff $C_S = \frac{2a}{2a+b+c}$

where:

a = no of common species between site 1 and site 2

b = number of species in 1.

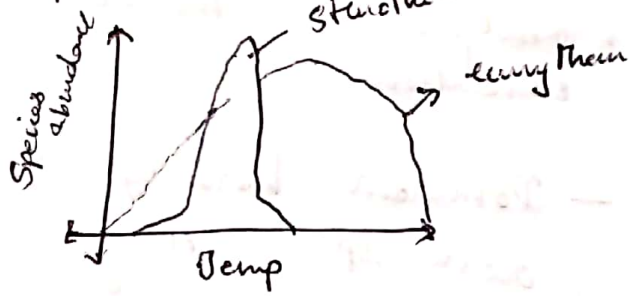
c = number of species in 2

- Biological diversity:
  - How do so many different species coexist?
- what determine distribution of species?
  - Individual organisms have a physiology that limits them - dictates their need for specific resources.
  - Depends on physiological ecology, and for animals - behavioral repertoire.
  - Resource distribution and abundance.
  - Biological interactions with other individuals / species.

- Thermal tolerance:
  - eurythermal, stenothermal
    - ↳ tolerate wide range of temp.: mammals & cakes

narrow range of temperature: Penguins, reptiles

- Specialized habitat occupancy



- 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 - tendency for coexisting species to differ in their niche requirements

- Niche divergence: An evolutionary process whereby the niche of two species become less similar [potentially specialize for or set of resources] 3

Canopy versus ground dweller

Tendency for a lot of species
↓ ↓ ↓ ↓
utilize diff. resources

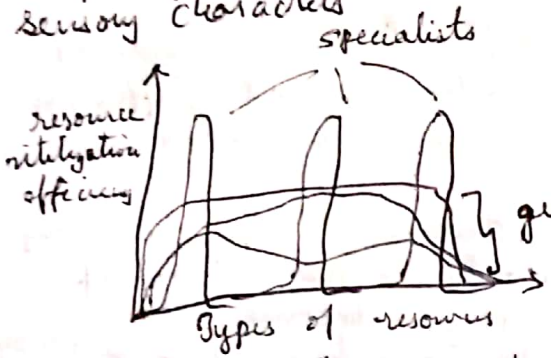
- Niche diff:
  1) Temporal - day & night / seaso
  2) Resource: utilize diff sets of resources.
  3) Spatial: avoid crowds - move in space (horizontally or vertically)
  4) Differential utilization of same resources.

- Resources:
  - Food, solar radiation, water, habitat, food, mate-

- generalist vs specialist
  - G: adapted to a wide range of environmental circumstances and food sources. Radically diff habitats and eat a broad range of food - broad niches - requires them to have a broad

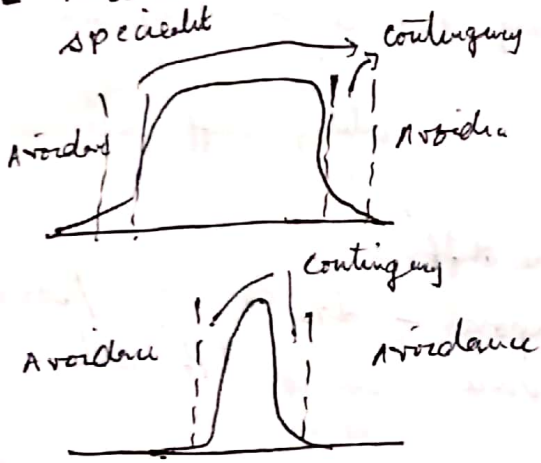
range of sensory / motor skills

- S: Preferentially utilize and narrow set of resources - evolved to adapt to ecinque niches, have narrow niches - special morphological, physiological and sensory characters



- Generalist ↑ at a disadvantage

- Niche breadth : generist vers specialist



- Resource partitioning:

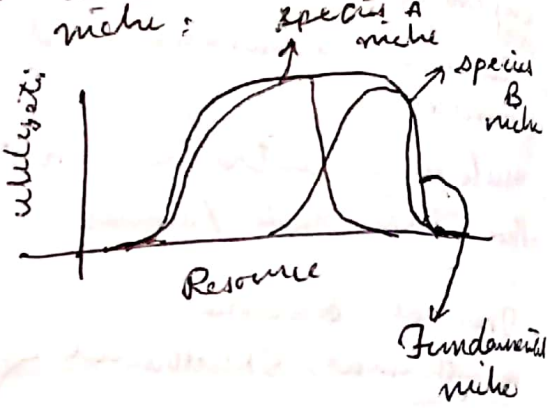
- Differential use of resources, such as food and space, and has been evolved so that each co-existis species develops diminish resource requirent and avoid competition.

- Is a consequence of competition and may result in shrinking of the niche breadth of organisms resulting in creation of specialist species.

- Reducing niche overlap through habitat segregation:

habitat segregation

- Fundamental vs realised niche:



- Niche compression: The than in absence of compet

- Realised are narrower

- Competitive refuge → regarded as

- Fundamental niche represents all of the condition in which a species can exist

- Realised : the actual conditions

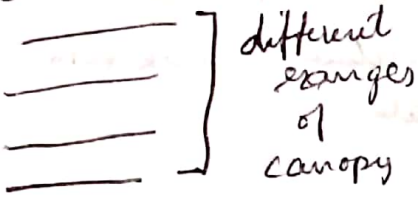
- Dominant hierarchy:

dom sp : A

subdom sp B C

- Ghost of competition part: describes one possible reason for observed differentiation in niches.
- Individuals of competing species may be less fit than individuals of species which avoid competing because it occupies a fundamental niche which does not overlap that of others.

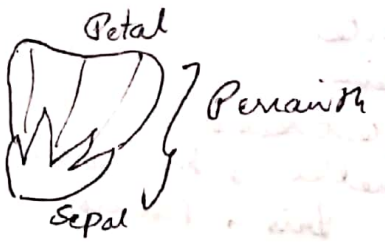
- Rainforest crickets and katydids.



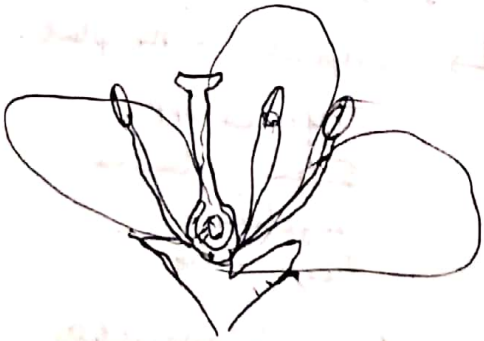
↙ mating competitions - songs reach in a sphere.

- Ecological interactions plant traits, pollination, dispersal

- The flower -



- All parts



Floral variation:

- Parts may be fused
  - connation (petal to petal)
  - Adnation (stamen to petal)
    - Snapdragon flowers
      - only long tongued pollinators can reach -
- Some flowers sexually dimorphic
  - pistillate & staminate
    - Sagittaria

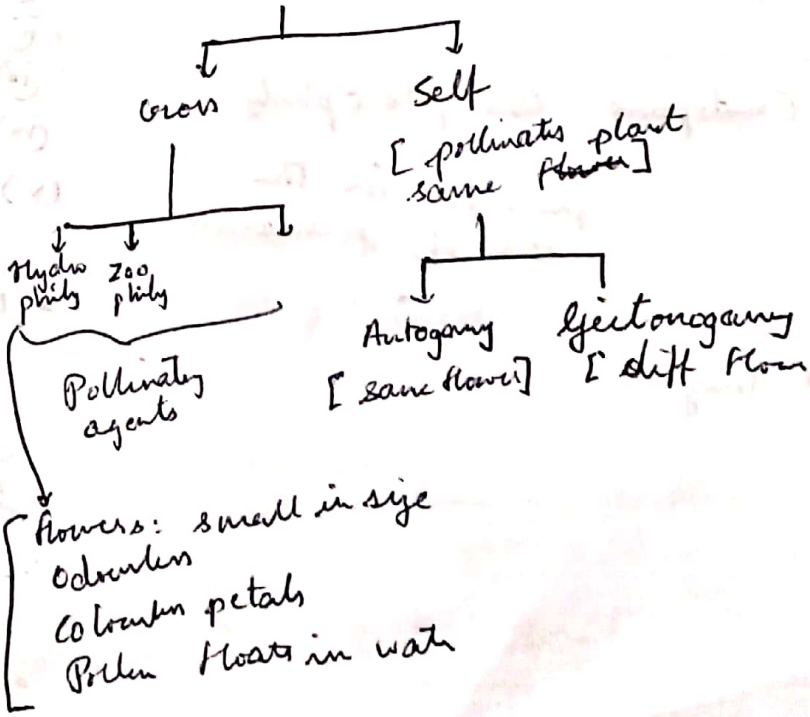
- Regular (Actinomorphic)
- Irregular (non-actinomorphic)

↓

- stamens and segments of the perianth radiated out uniformly from the central axis [primula, pyrola].

- Honeybees - symmetry preference

- Pollination



Flowers: small in size
odourless
colourless petals
Pollen floats in water

Mutualism

Zoophily:
Pollinating agents are animals like human, bats, birds
Sticks to body
Less weight
eg: catchweed or sticky bud.

- Pollination:
  - more pollinators birds, bats, lizard, snail
  - insects
    - bees
      - wild
      - manage
    - Butterfly
    - Fly
    - Wasp

- Anemophily:
  - By wind
  - Are non-sticky
  - very light - easily carried by the wind
    eg: oak, Chestnut.

- Entomophily
  - Petals are bright & attractive
  - Broad stigma's / anthers
  - Secrete nectar which attracts insects.

- Niche seperation in pollination
  wasp vs bee
  ↳ wasp waist
- Nocturnal: hawk moth, rodent, bats.

- Bat pollination (Chiroptiophily)
  - Night - blooming
  - White & aromatic flower
  - Tequila - mexican long tongued bat

- Chiroptérophily
  presented for the case of pollination
- Image

- Pollination syndromes are suite of floral traits that attract, reward and facilitate pollination by a particular type of animal or abiotic agent.
- Colour perception in pollinators
- Rewards for pollination service:
  (i) Pollen
  (ii) Nectar
  (iii) Resin
  (iv) Host reward
  (v) Shelter → bee hotels
  Iris → flowers
- Nursery pollination mutualism
  ↳ oviposit in the plant
  Yucca spp
  Silene Heelena
  Tegeticula
  Ficus - fig.
- Generalists & specialists pollinators & flowers

- Darwin's orchids - hawkmoth
Darwin's orchid is pollinated by Wallace' hawkmoth.

Deception by plants for pollination

- Brood site deception
- Food deception (mimic existing with model)
- Sexual deception
  ↳ emit fragrance similar to sex pheromones.

- Fig - fig wasp pollination mutualism

Recap:
- Pollination mutualism
- cheaters

- Figs belong to genus Ficus →
  - Jackfruit, Mulberry (wind pollinated)
  - Super pollinator
- The genus Ficus (Moraceae)
  - Strangler fig.

Variation

- Fig syconia - male & female flowers (Unisexual flowers).
  ↓ in the same fig.

A collection of flowers: inflorescence

Term shaped inflorescence (Hypanthodium)

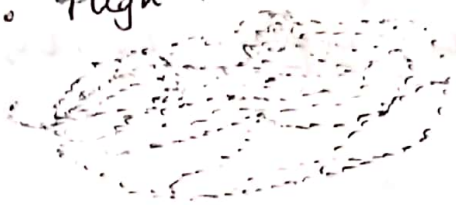
Fig syconia

ovipositor site ↔ Pollinator

insect in fruit

- Obligate interaction (One-one interactions)
- 80-90 million years old
- 750 unique association
- Nursery pollination

- Pollinators of ficus: The agaonidae chalcid wasps
  - Galls
  - Enter fig through ostiole
  - Internal oviposition
  - Winged males
  - Active or passive pollination
  - High inbreeding



- Morphology of Agaonidae: Morphological adaptations
- Third antenna - hooked
- Mesopleura bear pollen pockets
- Flat tibia
- Width of head - width of ostiole - similar

Pleistodontes imperialis

- Fig phenology:

Pre receptive

Receptive (Golden) → Fragrant gall

Enter - Floral phase

mutualist : internal oviposition
exploiter : external oviposition

Cytoplasm — offspring grows in the same

- asynchrony in blooming
  - Keystone species.
- Codiversification in fig - fig wasp
  Fig host

pollinator species

- Ficus racemosa
- Temporal diff in oviposition.
- Oviposition cycle: LV1, UV1, LV2.

- oviposition navigation
  - Enemy free space
- ultrastructure of ovipositor

exploiter : external oviposition

cytoplasm — offspring grows in the same

- asynchrony in blooming
  - Keystone species
- Coadvisipeate in fig - fig wasp
  Fig host — pollinate species

- Ficus racemosa
- Temporal diff in oviposition
- oviposits cospls: LV_1, UV_1, LV_2.

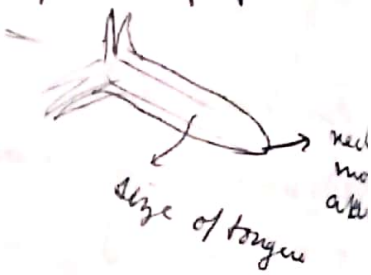
- oviposition navigation
  - Enemy free space
- ultrastructure of oviparth

Ecological interactions:
- Competition
- Mutualism
- Parasitism
- Commensalism
- Predation

- Chiroptera (hand wing)

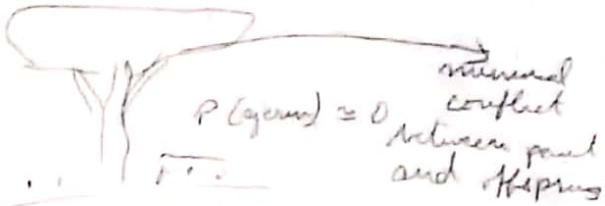
Megachiroptera	Microchiroptera
• Fruit bat	• Insectivorous bats
• Single family	• 17 families
• Big eyes, small ears	• Small eyes, big ears
• No echolocation, high olfactory sensitivity	• Have echolocation ability
• Helps in pollination &	• Helps in pest control

- 1300 sp of bats — 123 from South Asia, 111 microchiroptera, 12 megachiroptera
- Feeding mostly in bats - either Feeding
- Both Megachiropteran & Micro pollinate
  - Ball - badminton tree
- Nocturnal anthesis - Madhuca Latifolia
- Flowers bloom only at night time
- Flowers are pollinated exclusively by bats.
- Nectar bat - extraordinarily long tongue - may have co-evolved with the flower which it pollinates.
- Length of tube of flower



- Chiropterochory: Seed dispersal by bats
  - size of fruits
  - Germination of seeds promoted by bats - high chances of germination
- Ripe and unripe fruits
  Greenish color - diff. smell

are bats better dispersers than birds ?



- Plants have strategies to encourage ex-situ feeding - Big, heavy fruit away the small
- Dominant - subordinate bat interaction
- smaller bats take the fruit out

- Commensalism : A relationship where one organism benefits and other does not benefit but is not harmed either
  - Shark & remora fish attached Free ride & left over food
  - Orchids - root on larger trees - not drugs

- Parasitism
  - Cuckoo nest - negative interaction

- Predation
  - Visual predator - search image : pattern matching
  - For prey - countering a search image in predators
  - Countering associative learning → becoming nocturnal

- Predator avoidance

Activity	Prey adaptation
- Search for Prey	- Cryptic
- Prey recognition	- Mimicry + Polymorphism
- Pursuit / catch prey	- escape flight stealth response weapons of defense & poisonous
- Handling prey	- Active defense, spines, shell, toxin

optimal foraging theory

- Cryptic avoiding detection
  (i) Male shale grasshopper
  (ii) Lichen ( ) Spider
  (iii) satanic leaf tailed Gecko

- Mimicry
  - Honest and dishonest signals represents true heart value
  - Mimicks an organism :
    (i) Batesian mimicry
    (ii) Mullerian mimicry
  - A palatable, harmless species resembles an unpalatable/ toxic species that is common to predators
  - Relies on associative learning of predators
  - Venomous vs poisonous mastem coral dna

- Mullerian mimicry : two aposematic models forms conform to the same coloration / patterns of warning signals in order to avoid a common predator
  - shared cost and benefit

- Polymorphism predator search image.

1) Visual predator that exploit polymorphic prey suffer from reduced performance.
2) Reduction of predator's ability for associative learning due to an overabundance of form.
3) Prey colour polymorphism may afford protection again predator.

Non-visual predators:

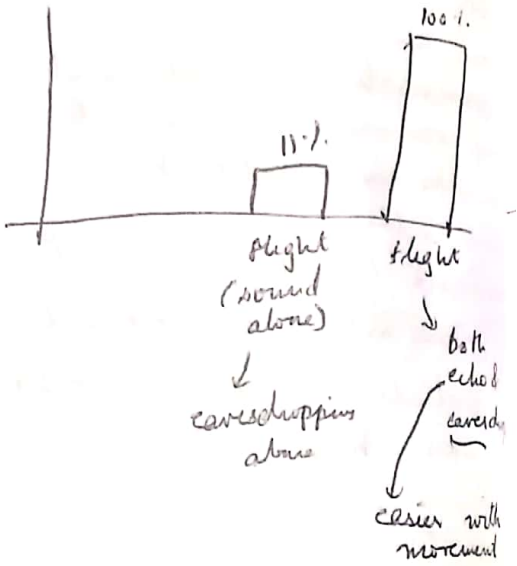
- Indian false vampire bats:
  Bats as predators of katydid -
  (i) Who is at higher risk? Singing males or silent females.
  (ii) Katydid males produce loud and conspicuous calls for mate attraction - putting them at high risk of predation.
  (iii) Silent females approaching signalling males - higher mortality
- Hearing sound of prey - eavesdropper. - Are the bats using echolocation or eavesdropping?
  ↓
  Rig a speaker (one-choice paradigm -)

- Katydids reduce signalling in presence of bats.

what about the Palaeotropics,

- Assessing relative predation risk posed to male and female katydids using diff analysis.

- Analysis : indicated that female katydids were consumed in higher numbers.
- eavesdropping on calls as well as ~~sound of flight~~
- Calling males face $\frac{1}{3}$rd of bat attacks faced by females



- Echolocation is the primary mode of locating prey
- Bat-moth interactions

Bat
- uses echolocation to navigate & find food - shows shape, size & texture

More many
- Moths are eared
- use to hear their hunter
- Scales can be dusted off
- Escape flight in moths - erratic, zig-zag patterns, hard sharp turn

Each moth escapes its own way
- Theresa Nagel

each moth signal is different

- Some bats hunt noctuid moths by reducing their echolocation to a whisper.

- startle predator:
- underwing moths flash bright hindwings when perked.
- Many animals scream.

- Aposematism:
- Beneficial to both prey and predator.

- Adaptations and counter adaptations

Predator Activity	Predator Adaptation	Prey Adaptation
Search for Prey	(a) improved sensory acuity	(a) hyping
	(b) Search in prey abundant area	(b) Spacing
Prey Recognition	Learning pattern recognition	
Pursuit/ catch prey	Motor skills, speed, hunting techniques	
Handling prey	Methods to deter.	

- Evolutionary Arms Race
- Red Queen hypothesis

- Singing and dancing for love: [Animal attraction]:

- Signal diversity and function:

(i)

- Animal communication
- Gestural / Tactile
  - ie push, nudge, etc.
- Acoustic
- Visual
- Olfactory

Functions
- Mate attraction:
  - Strategies:
    (i) Follow female
    (ii) Perform to attract
  - Nuptial gifts
    (i) sperm sac → nutritious protein → cooked katydid
    (ii) kingfisher - fish
    ± Bower bird's
  - Perfumed gifts.
    P. ornata
    P. araneus - enc

- Anisogamy -
- Mate attraction song of lyre bird:
- Same as before - Courtship dances:
  - Peacock
  - Visual displays - Birds of Paradise
    [some birds - songs need to be learned]

- Why should the idiosyncratic female prefer the elaborate displays of the male?
- Darwin's Theory of sexual selection.
- Sexual selection: advantage that some have over others of the same sex & species - with exclusive relation to reproduction

- Driven by male - male competition (OR) female choice.

  ↳ why should they choose males with such traits?

- Fisher's runaway selection:
  - slightly exaggerated characters - indicator for male quality.
  - Female preference ↗
  - sexy sons and choosy daughters.
  - This feedback loop continues resulting in superlative exaggeration even at the cost of survival of male.

  ↳ exaggeration vs cost at natural selection

- Beauty vs Honesty:
  - extreme exaggeration is merely selected for beauty → makes it idiosyncratic once again.

- The Handicap principle:
  - Signals are honest when they signal the true quality of signaler.
  - Honest signals must be costly.
  - only high quality signalers can 'afford' to produce costly signals.
  - Peacocks with elaborate trains have been found to be better survivors with larger fat reserves and higher levels of immunocompetence.
  - elaborate train is an honest indicator of male quality

- Conclusion:
  - Adaptive / Utilitarian (?)

↳ Paper: Is the peacock merely beautiful or also honest.

- Population ecology

- Interaction of organisms with the environment
  - needs to translate into effect on fitness because of these interactions

- In PE → focus is much broader
  - on entire populations
- Characterizing attributes of an individual or population

— Interested in:
- Population density and distribution
- Age structure
- Variations in population size

- Density
- Dispersion
- Age structure
- Growth

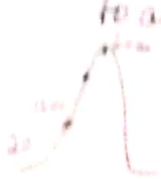
→ How these can change over time?

- Defining an individual
  - Are you an individual or a community?

- A population: Individuals of one species simultaneously occupying the same general area utilizing the same resources influenced by similar environmental factors

- No population can continue to grow indefinitely.
  - Many remain stable
  - Other populations show dramatic increase & decrease

— Reindeer Alaska
  - Population constrained to an island



Why do some populations remain stable and oscillate at other times?

1) Two imp charac. – density and spacing of individuals (dispersion)

- Measuring density
  - Impractical to count all individuals
    - ecologists use sample techniques

  Area large, organisms small
  [illegible]

  - May count all individuals.
  - Indirect indicators: nest, burrows, droppings, tracks
  - Mark recapture

  $N = \frac{\text{number marked} \times \text{second catch}}{\text{no. of marked recaptures}}$

- Conditions:
  - Marking must not harm individuals
  - Mark should not be washed away.
  - No immigration, emigration, no mortality
  - Must not make an individual more or less likely to be recaptured

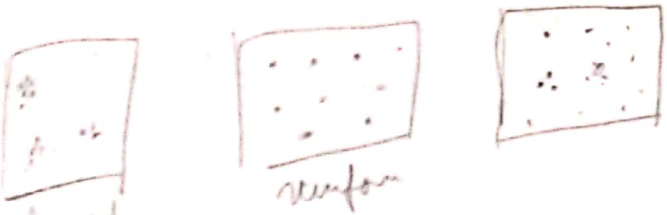
2) Patterns of dispersion:

- A population's geographical range is the geographic limits within which a population lives.
- How resources are distributed
  - Local densities may vary substantially because not all areas of a range provide equally suitable habitat.
  - exhibit a continuum of three general patterns of spacing: clumped, uniform & random

clumped :
- Environment is heterogeneous with resource concentration in patches
- mating or social behaviour
- Defense against predators

uniform — even :
- Antagonistic interaction between individuals of the population
- Set up individual territories for feeding, breeding or nests.

- Random pattern - unpredictable
- seems in the absence of strong attraction or repulsion among individuals
- Not very common



clumped

random

in case of no social hierarchy in resting

- Number based
- Distance based

] dispersion

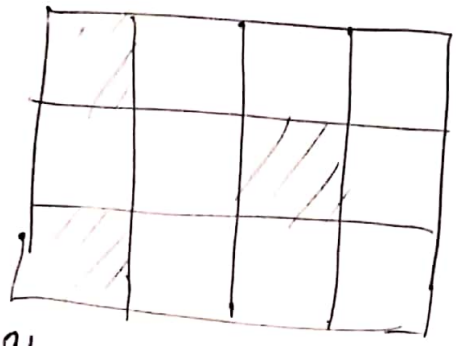
- Patterns of dispersion.
  - Uniform, clumped, random.

not for life, though.

- Quadrat sampling method for population estimation

Q	x
Q_1	x_1
Q_2	x_2
Q_3	x_3
⋮	

$\bar{x}, s^2$ → Mean, variance → independent



Q

Poisson distribution:

$$p(x) = \frac{e^{-\mu}\mu^x}{x!}$$

μ should be $= \sigma^2$

$$\frac{s^2}{\bar{x}} \leftarrow \begin{cases} \frac{\sigma^2}{\mu} = 1 & \text{random} \\ > 1 & \text{clumped as } \sigma^2 \text{ is } \uparrow \\ < 1 & \text{uniform as } \sigma^2 \text{ is low.} \end{cases}$$

- The above applies to local dispersion patterns within populations
  - Population Ecology within species -
  - Biogeography

(ii) Demography:

- Study of factors that affect birth & death rates in a population.
  - Age structure & sex ratio
  - Usually pop. have overlapping generation.

exception: annual plants, insects.

- Coexistence of generations - age structure.

discrete generation cycle

- Age structure determines how a pop grows:

(1) every age group has a characteristic birth & death rate

↓

recruitment & attrition

↓

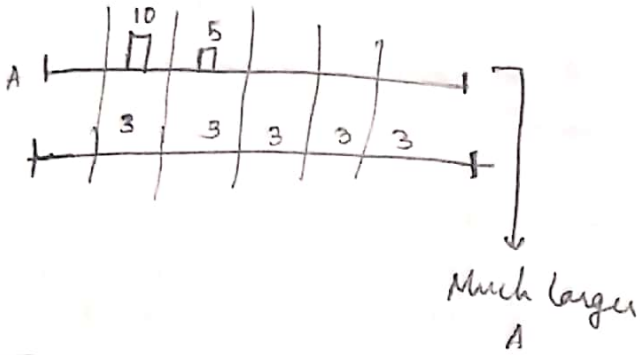
feeds on to how many individuals produced in next gen.

- Population pyramids:
  - Expansive
    - Lot of recruitment in the young age classes.
  - Stable pyramid:
    - All age groups are almost equally distributed - numbers are stable over time.
  - Constrictive pyramid
    - Aging population - declining number

- Generation time: Span of time between birth of individuals and birth of their offspring

↳ strongly correlated with age

- shorter generation time → results in faster pop growth, assuming BR > DR & everything else const



Sex ratio: Proportion of individuals of each sex found in a population

- Male skewed:
- Female skewed: not a huge problem as
- In strictly monogamous species, the no of males is more significant in affecting the birth rate than in nonmonogamous species

- Sex-role reversal

- Life tables and survivorship curves:
  - How birth and death rates vary with age over a time period:
    (1) Cohort:
      - Survivorship
      - Cumulative mortality
        Age specific mortality
      - Fecundity: number of fledgling per female per breeding season ↙ are released sperm survive & fly away

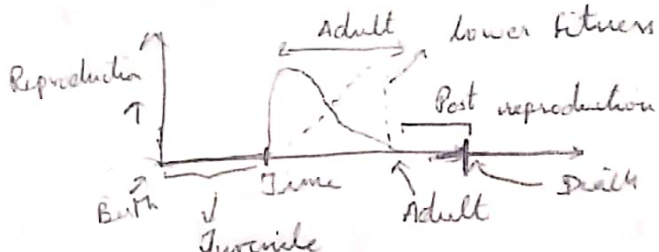
- Survivorship curve:
  (i) Type I: flat & const at start, sudden drop
  (ii) Type II: constant over ages - linear
  (iii) Type III: high mortality rate at start, [young age], that don't receive care, have low mortality after they reach a critical age

- Some have more complex curves:
  - Great tits: high mort in young (Type III), fairly constant in adult - Type II)
  - Invertebrates - stair stepped curve: brief periods of high mortality during molts - followed by low mortality

- The traits that affect an organism's schedule of reproduction and death make up its life history:

∧ Variation in life histories:

- Life history traits:



↓ Juvenile

↓ By definition, does not reproduce

- Grandmother hypothesis

- There is a diversity in life histories due to the varying pressures of natural selection:
  - Salmon
  - Lizard, birds

- There are still some patterns:
  - often vary parallel with environmental factors:

- Tropical birds lay fewer eggs than those in higher latitudes
- Clutch size variation
&
- Partitioning of resources.

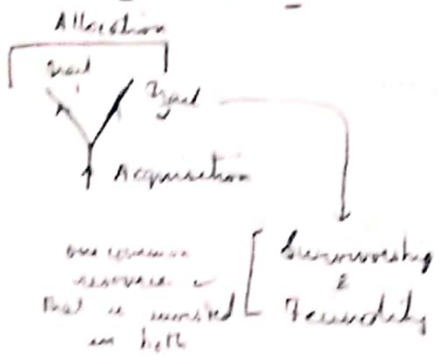
Life and Campbell

• Traits fecundity and mortality tend to covary

Delayed maturation and high parental investment tend to be correlated with low fecundity and low mortality

• Why?
↳ Allocation of limited resources

Y model resource allocation



If a common resource is required for trait 1 & 2 - if amount of resource for t1 is ↑, it will be reduced for t2

↳ trade off
- Physiological
- Genetic

— Number of reproductive episodes per lifetime.

• Semelparity - organisms invest most of their energy on growth & development to expend energy in a single reproductive effort

• Iteroparity.

• Semelparity is expected when there is a high cost to parents staying alive between broods, & if there is a trade-off between fecundity and survival
- Annual plants
- Century palms
- 17 year cicadas
- Unpredictable climate

• Iteroparous - fairly steady climate

— Clutch size
• low prob of surviving to a season - large no of offspring
• clutch size ↑, smaller eggs
Smaller clutch size, larger eggs

• Number & size of offspring

— Age at first reproduction
• Balances the cost between current reproduction & survival plus future reproduction
• Reducing it may reduce a female reproductive potential by reducing the amount of energy available for growth & maintenance.

— Models of population growth

N, $\frac{dN}{dt}$ →

$\frac{dN}{dt}$ = Births − deaths

$\frac{dN}{dt} = B - D$

Birth = Per capita birth rate (b) × N

= B

Death = (d) × N = D

$\frac{dN}{dt} = N(b-d)$

$r_{max} = b - d$

↳ Intrinsic rate of growth

$\frac{dN}{dt} = N r_{max}$

ideal conditions. r_{max}

N_0, N_t, N

$N_t = N_0 e^{rt}$, exponential model

$k \rightarrow$ carrying capacity

$r_{realised} = r_{max}\left(\frac{k-N}{k}\right)$

When $N = k$, $r_{realised} = 0$.

$N_t = \frac{N_0 e^{rt}}{1 + (e^{rt} - 1)\left(\frac{N_0}{k}\right)}$

↳ logistic model of pop growth.