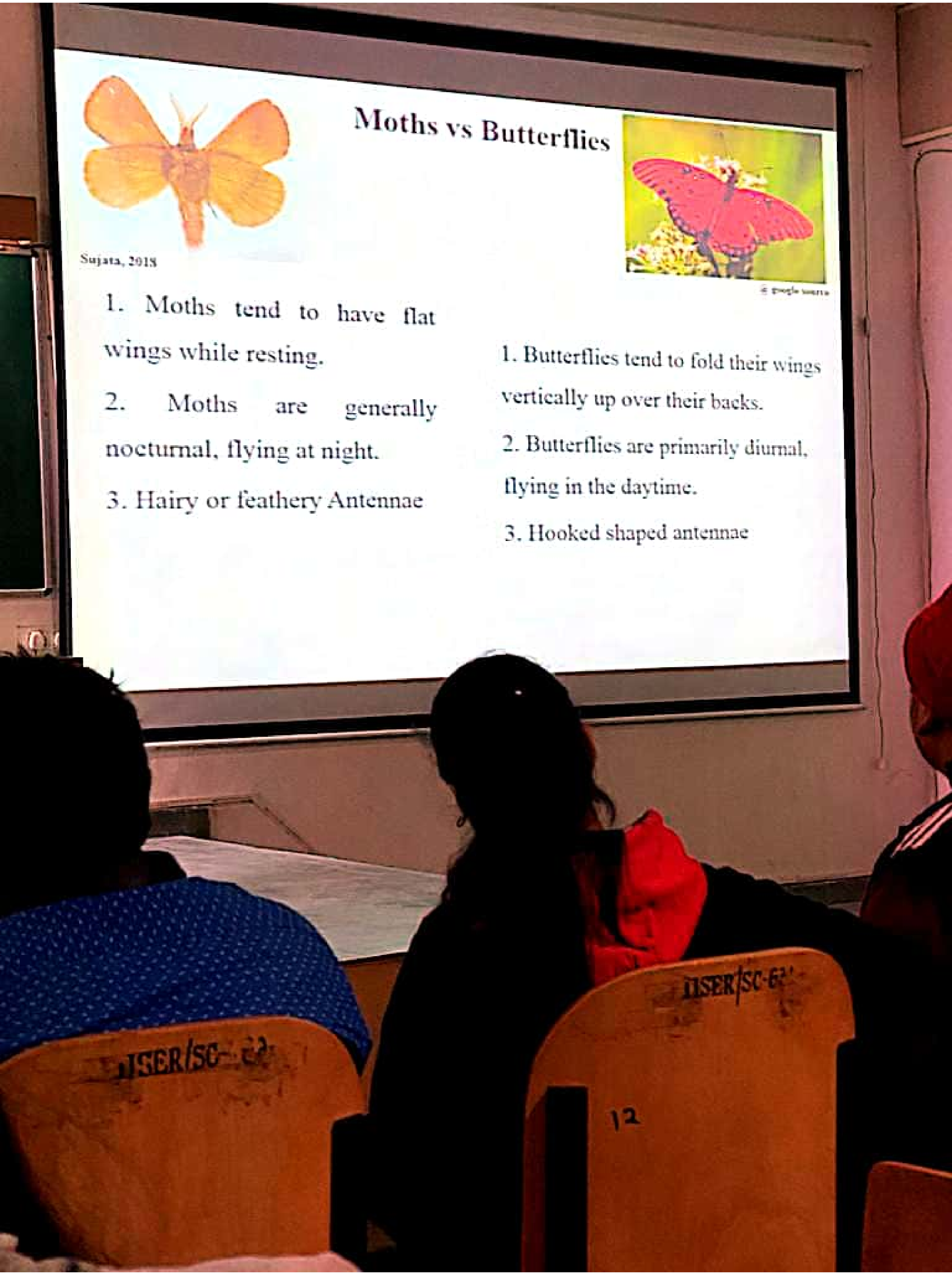
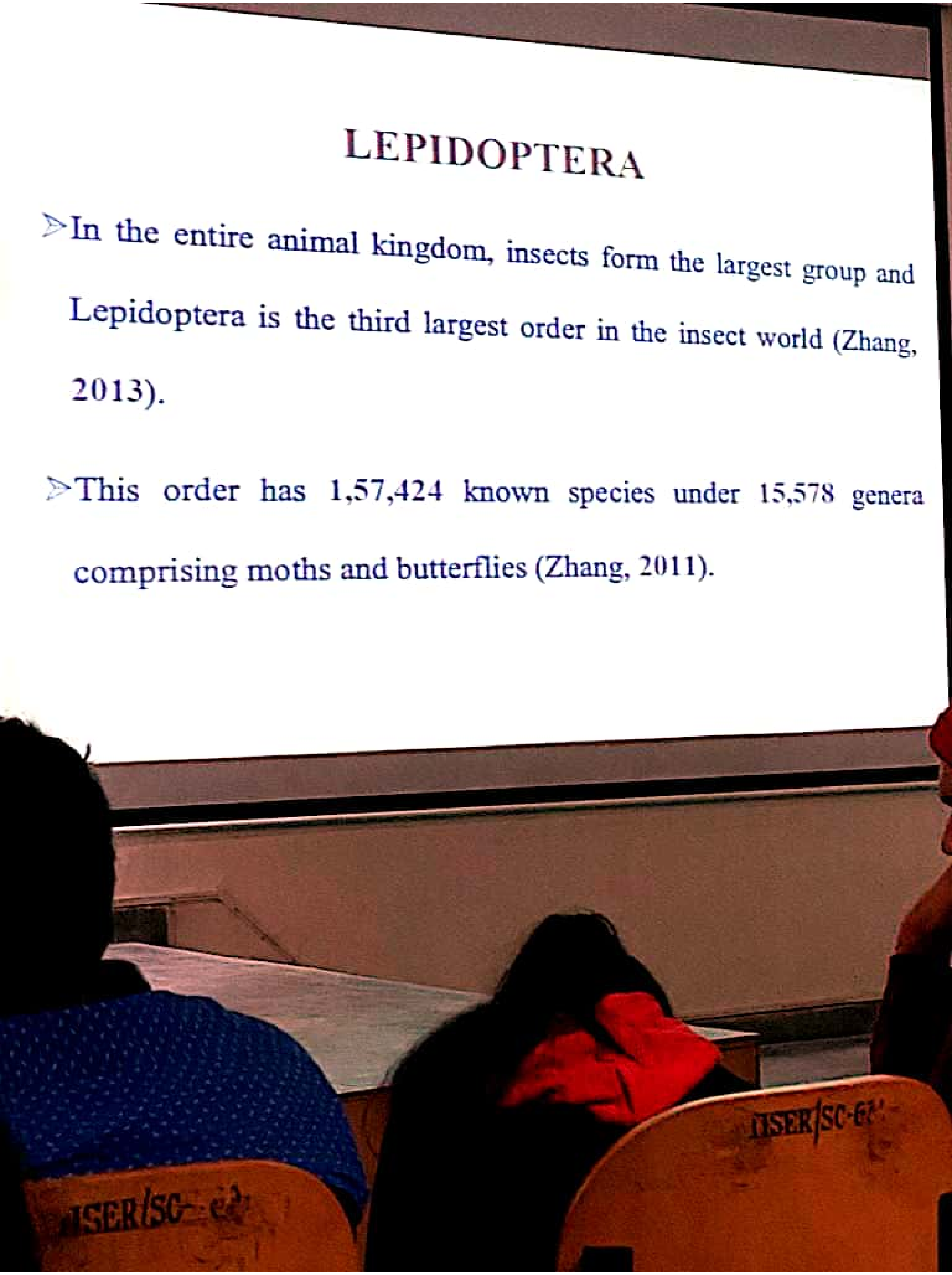
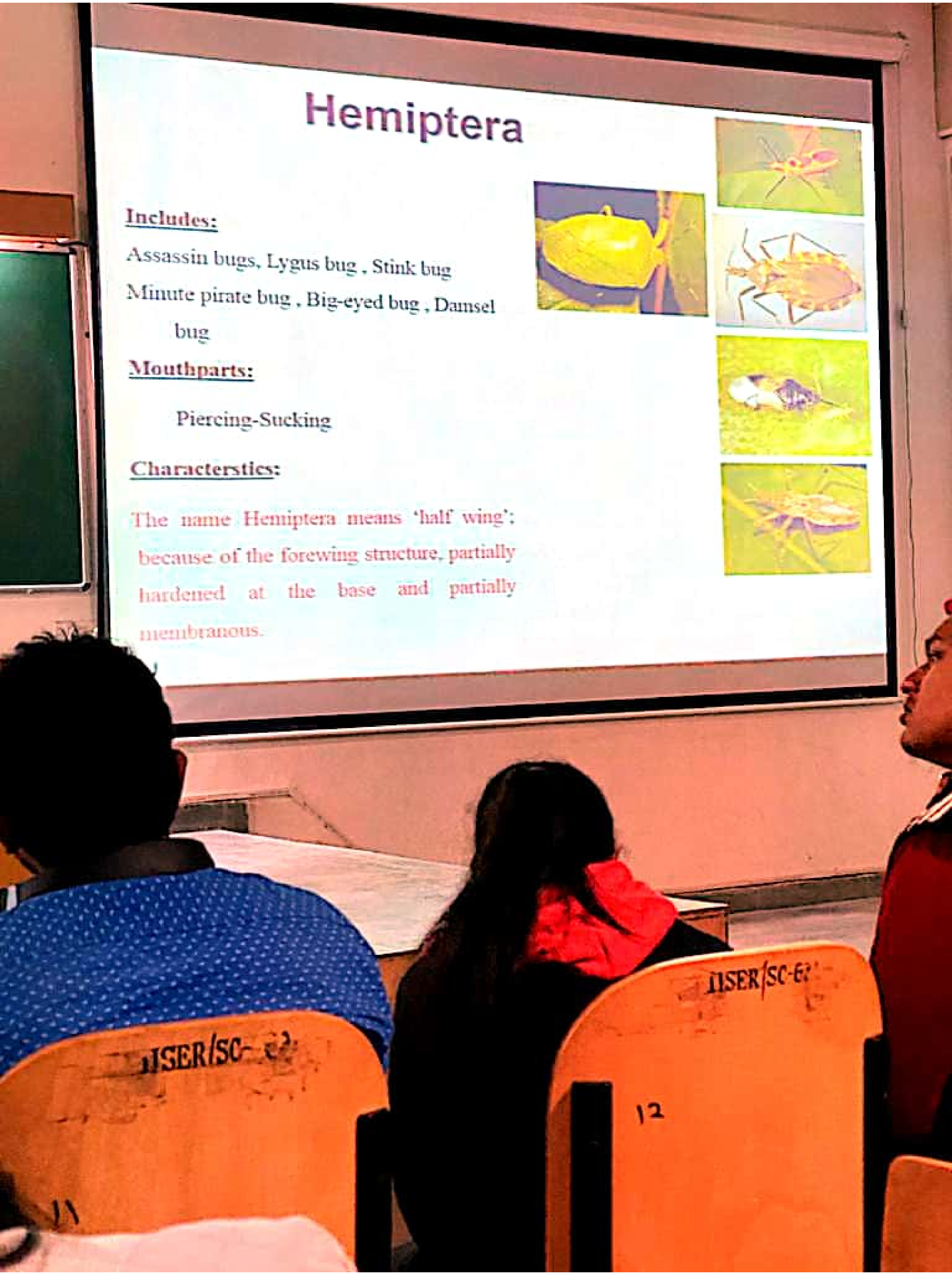
WING VENATION

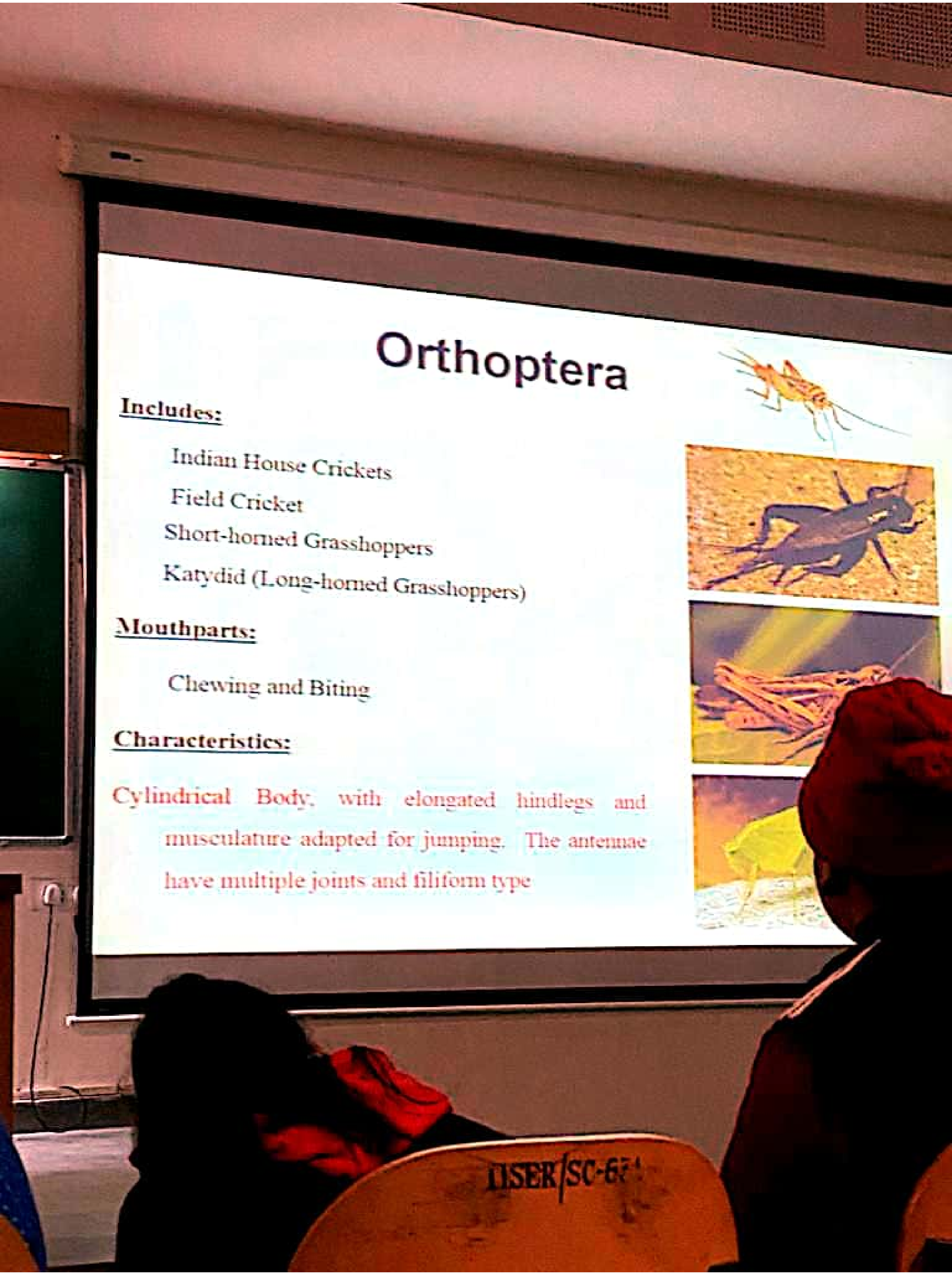
Wing venation is considered a stable and one of the diagnostic character for identification of moths and butterflies for the last 210 years.

The procedure includes the separation of wings from the adult of a species by giving an upward jerk with the help of a fine needle. The detached wings were dipped in 70% alcohol to make them soft. Descaling was done with the help of sodium hypochlorite (approx. 4% w/v available chlorine solution). The descaled wings were then washed with distilled water and stained in 70% alcoholic eosin for 12-14 hours. After staining, the wings were passed to the upgrading series of alcohol before mounting in Canada balsam. The diagrams of fore and hindwing venation were drawn with the help of trisimplex projector which were later on scanned so as to make these available for showing venation.


Moths vs Butterflies
Sujata, 2018
1. Moths tend to have flat wings while resting.
2. Moths are generally nocturnal, flying at night.
3. Hairy or feathery Antennae
1. Butterflies tend to fold their wings vertically up over their backs.
2. Butterflies are primarily diurnal, flying in the daytime.
3. Hooked shaped antennae

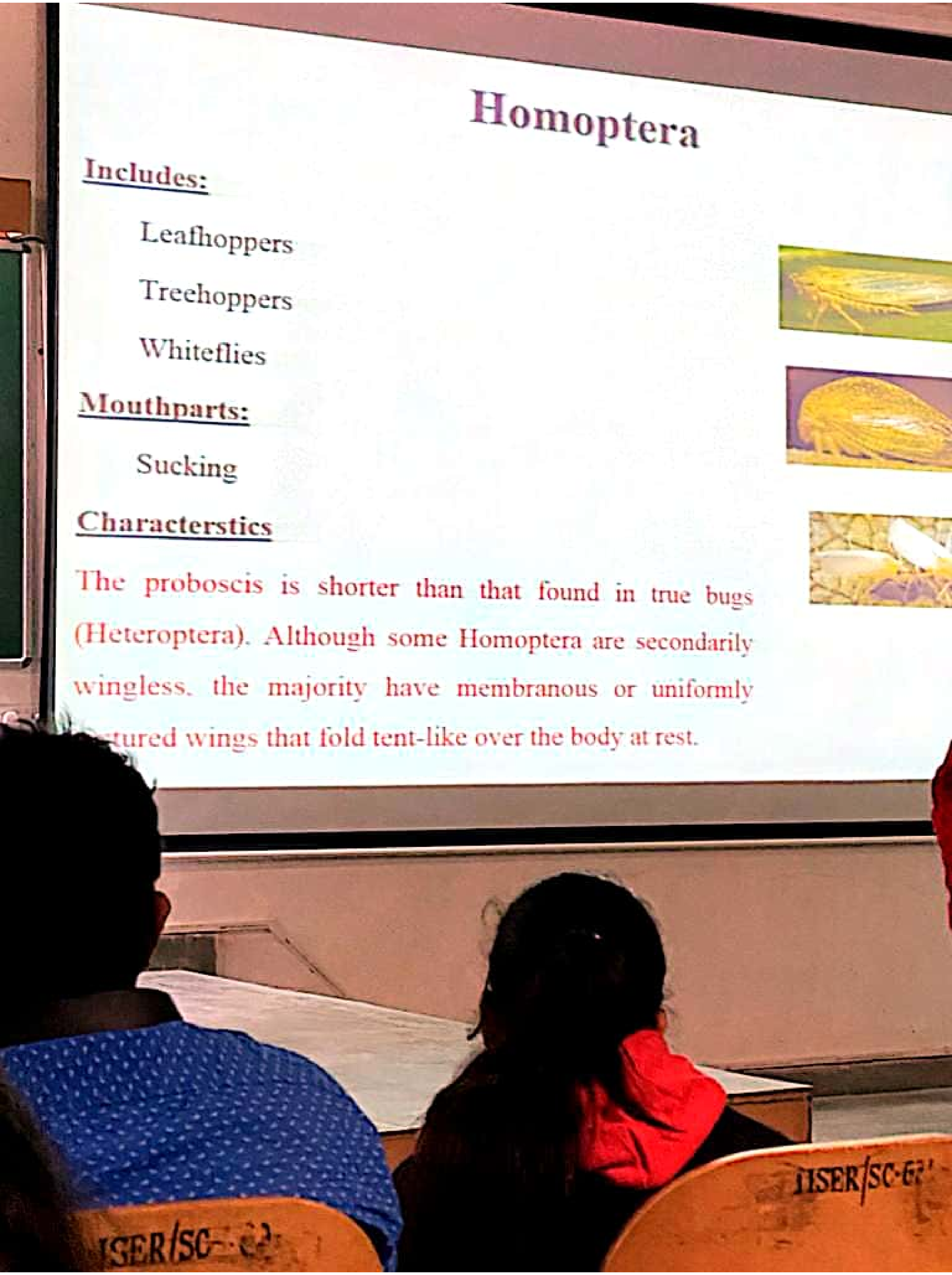

LEPIDOPTERA
➢In the entire animal kingdom, insects form the largest group and Lepidoptera is the third largest order in the insect world (Zhang, 2013).
➢This order has 1,57,424 known species under 15,578 genera comprising moths and butterflies (Zhang, 2011).
ISER/SC-6
ISER/SC-6


Hemiptera
Includes:
Assassin bugs, Lygus bug , Stink bug
Minute pirate bug , Big-eyed bug , Damsel bug
Mouthparts:
Piercing-Sucking
Characterstics:
The name Hemiptera means 'half wing'; because of the forewing structure, partially hardened at the base and partially membranous.
12


Orthoptera
Includes:
Indian House Crickets
Field Cricket
Short-horned Grasshoppers
Katydid (Long-horned Grasshoppers)
Mouthparts:
Chewing and Biting
Characteristics:
Cylindrical Body, with elongated hindlegs and musculature adapted for jumping. The antennae have multiple joints and filiform type
IISER/SC-6


Hemiptera
Includes:
Assassin bugs, Lygus bug , Stink bug
Minute pirate bug , Big-eyed bug , Damsel bug
Mouthparts:
Piercing-Sucking
Characterstics:
The name Hemiptera means 'half wing'; because of the forewing structure, partially hardened at the base and partially membranous.


Importance of Taxonomy
To uniquely identify organisms: begin with giving a name
Understanding evolutionary biology (species, traits,
with other organisms)
In conservation biology understanding patterns of
critical to policy making
IISER|SC-648
10

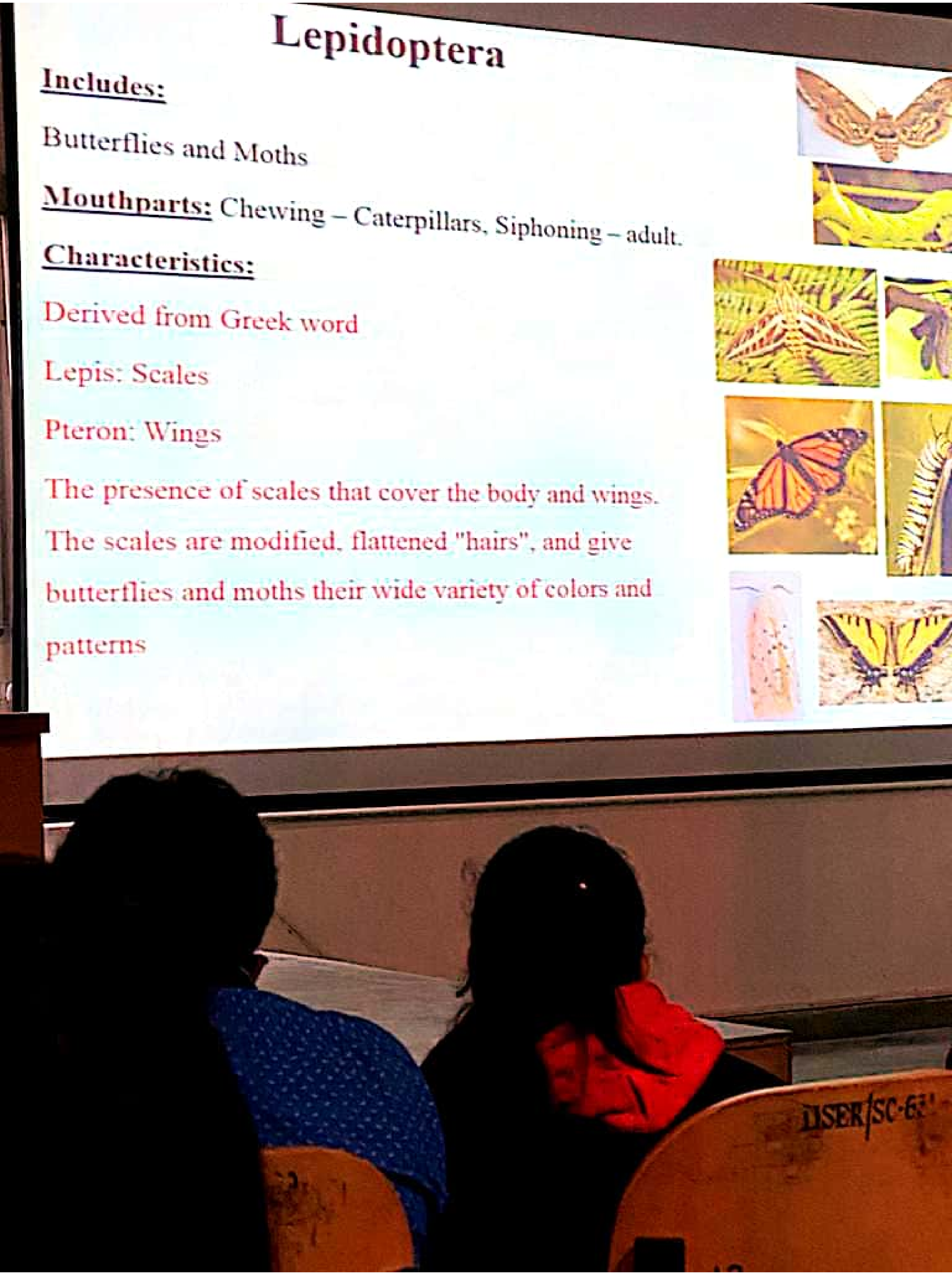

Homoptera
Includes:
Leafhoppers
Treehoppers
Whiteflies
Mouthparts:
Sucking
Characterstics
The proboscis is shorter than that found in true bugs (Heteroptera). Although some Homoptera are secondarily wingless, the majority have membranous or uniformly
tured wings that fold tent-like over the body at rest.

Taxa, community, assemblage, guild, e

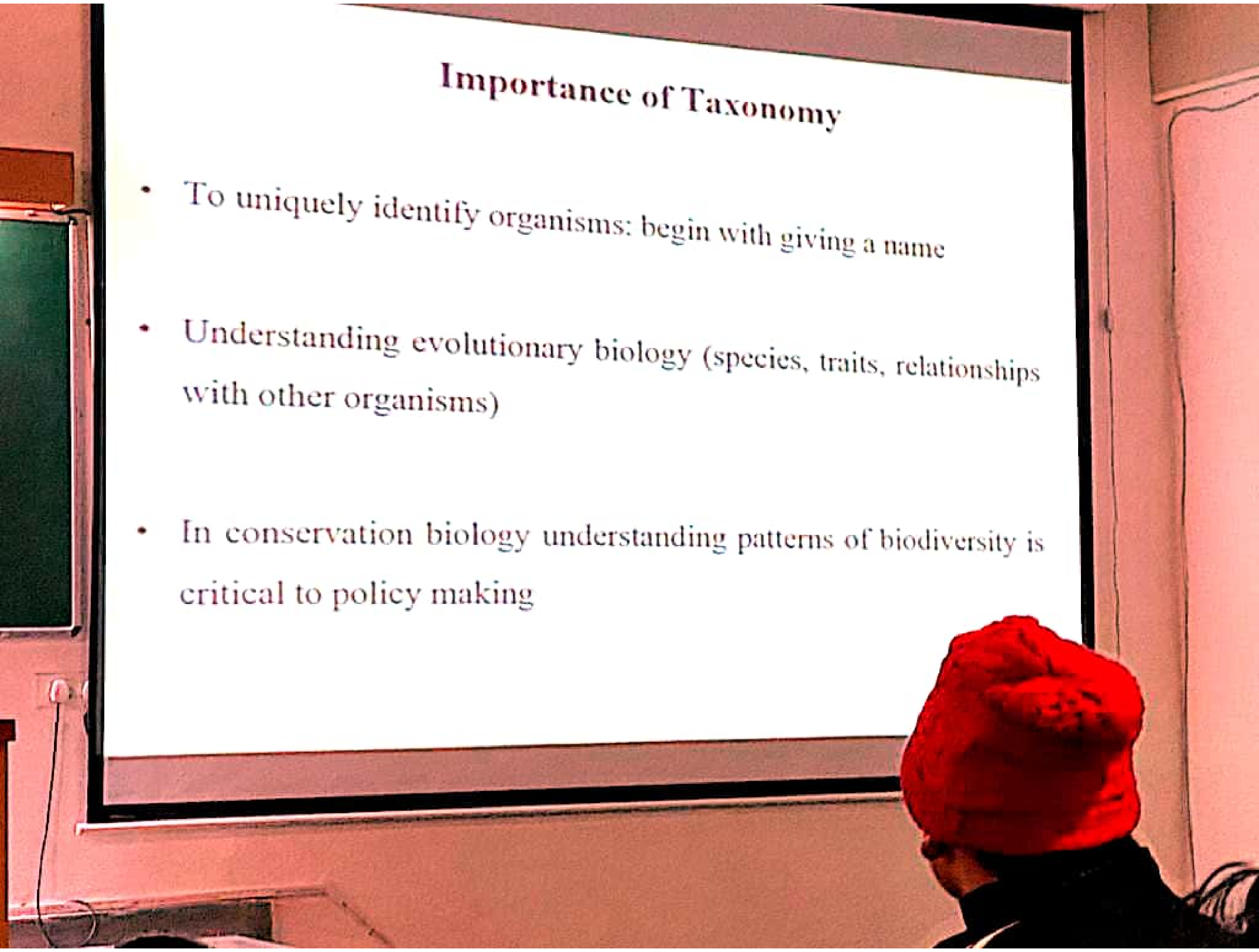
- **Taxa:** Species of common descent. Forms a taxonomic unit. Co level of classification. Phylum, Class, Order, Family, Genus or sp
- **Community**: collection of species that occur together in space Ecological interactions occur between species as a consequenc coexistence in time and space. They need not be species that s resources.
- **Assemblage**: collection of phylogenetically related members of community.
- **Guild**: Organisms that exploit the same set of resources in a sin manner.
- **ocal guilds:** comprise of species that share resources AND bel ommunity
- **Ensembles**: Interacting species that share resources as well as

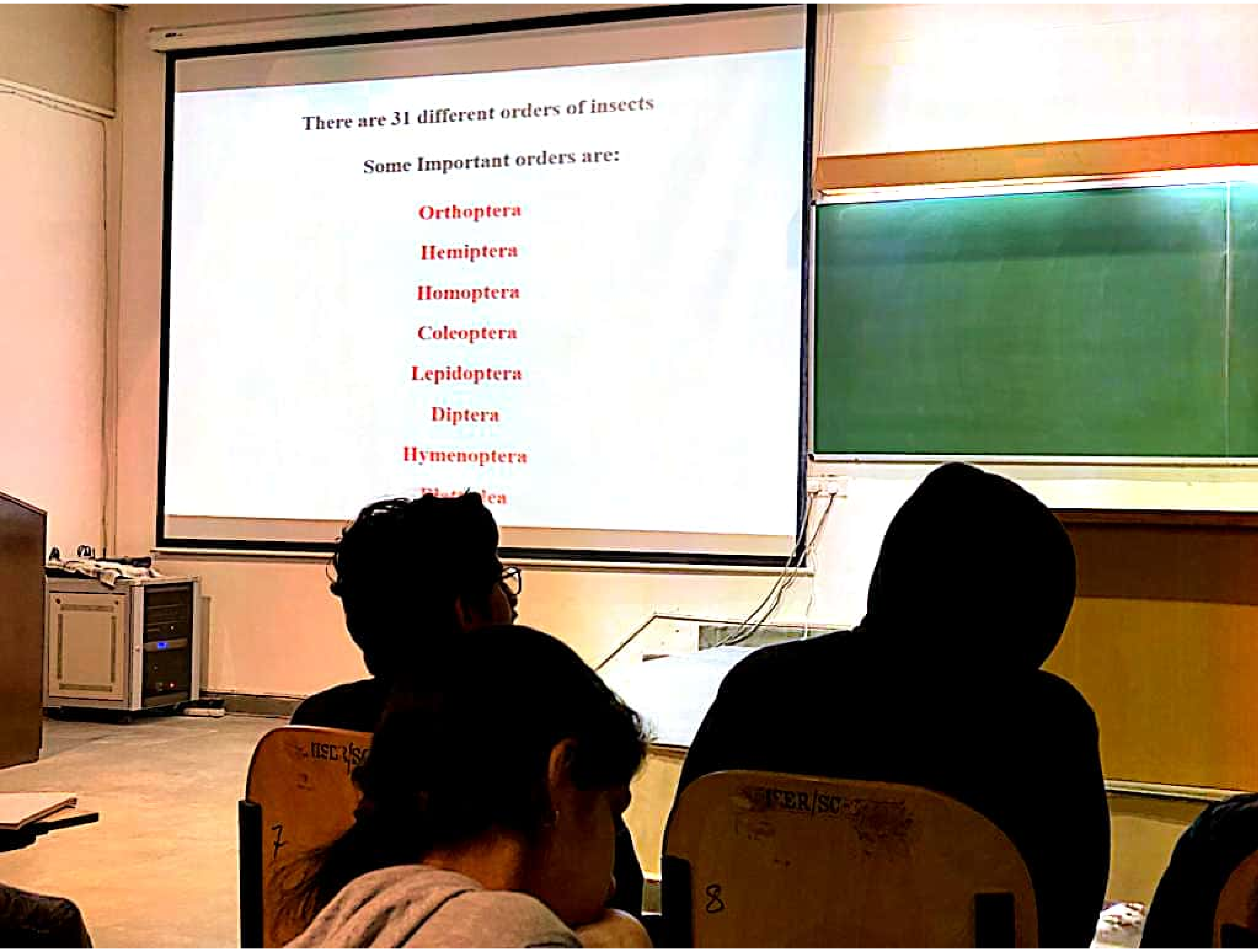
Taxa, community, assemblage, guild, en

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


Lepidoptera
Includes:
Butterflies and Moths
Mouthparts: Chewing – Caterpillars, Siphoning – adult.
Characteristics:
Derived from Greek word
Lepis: Scales
Pteron: Wings
The presence of scales that cover the body and wings.
The scales are modified, flattened "hairs", and give butterflies and moths their wide variety of colors and patterns
IISER/SC-63


Coleoptera
Includes:
Blister beetle, Boll weevil, Darkling beetle, Dermestid beetle , Dung beetle, Lady beetle (Ladybird beetle), Striped June beetle
Mouthparts:
Chewing, Weevil- Piercing Sucking
Characteristics:
Coleoptera, derived from the Greek words "koleos"- sheath and "ptera"- wings, refers to the modified front wings which serve as protective covers for the hind wings. Largest order. At rest, both elytra meet along the middle of the back, forming a straight line, the most distinctive characteristics of the order.
12


Importance of Taxonomy
• To uniquely identify organisms: begin with giving a name
• Understanding evolutionary biology (species, traits, relationships with other organisms)
• In conservation biology understanding patterns of biodiversity is critical to policy making


There are 31 different orders of insects
Some Important orders are:
Orthoptera
Hemiptera
Homoptera
Coleoptera
Lepidoptera
Diptera
Hymenoptera

Includes:

Indian House Crickets

Field Cricket

Short-horned Grasshoppers

Katydid (Long-horned Grasshoppers)

Mouthparts:

Chewing and Biting

Characteristics:

Cylindrical Body, with elongated hindlegs and musculature adapted for jumping. The antennae have multiple joints and fi[illegible]pe

measuring abundance (evenness)

* evenness = ratio of observed diversity to maximum diversity

$$= \frac{H}{\ln(S)}$$, S = all species recorded.

* Sorenson's Coefficient of similarity

$$C_1 = a/(a+b+c)$$ Jaccard diversity.

$$C_2 = 2a/(2a+b+c)$$ Sorenson's coeff.

a = no. of species common in site 1 & site 2.

b = no. of species ~~common~~ recorded in site 1

c = no. of species recorded in site 2

* Co-exists of species.

what affect the abundance & distribution of species.

1) ~~Species~~ organisms have phylogenetical limits to tolerate a range of physiochemical and environmental conditions.

2) Resourse abundance & distribution

3) interaction with other species

Eurythermal organisms → these organisms can tolerate a wide ~~vari~~ range of temperature.
eg mamals.

Steno thermal → these organisms can tolerate only a narrow range of temperature
eg reptiles.

ecological niche → It is the place or the role of a given species in its eco system.
It talks about limits, for all environmental feathures in a given eco system where a given species can potentially survive, grow and reproduce
e.g → grasslands for graseaters.

niche differentiation → Two species differ in their niche requirements.

niche divergence → ~~Ta~~ a evoluntionary process by which niches of two species become less similar.

~~feat~~
General list organism.
These organisms are adapted to wide ~~Vaity of~~ range of environment conditions and exploits broad range of resources. They have large niches. These organisms have wide range of motor skills.

Biodiversity → diversity in living organism.

Biodiversity

two aspects of biodiversity

(i) richness → different type of species present in a habitat.

(ii) evenness → abundance of those species.

alpha diversity → diversity among species in a local habitat.

beta diversity → diversity among species among b/w two different ~~specie~~ habitats. but same geographical area.

gamma diversity → diversity among species in two ~~ge~~ different geographical area.

Taxa → organisms with same decent

it can be at any level, species, family. order, Kingdom etc.

Community → Species co-exist in space & time and a ecological interaction between them.

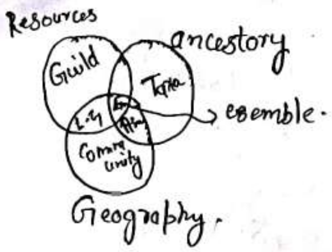
Guild ~~Assemble~~ → Collection of species which exploit same resources in similar manner.

~~Guild~~ →

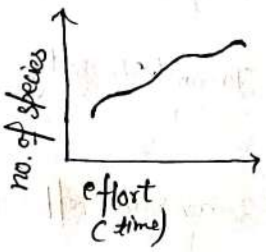
Assemble → Collection of phylogenetically related members of a community.

Local Guild → Collection of species which exploit same set of resources in similar manner.

Esembles → Collection of species of same community which exploit same set of resources in similar manner & are phylogenetically related. (have same ancestory).



* Species accumulation curves.



* measuring diversity.

measuring richness

$H = -\sum p_i \ln p_i$

$p_i = \frac{n_i}{N}$ → prop. inal abundance of given species.

n_i = no. of individuals of given species.

N = Total no. of species.

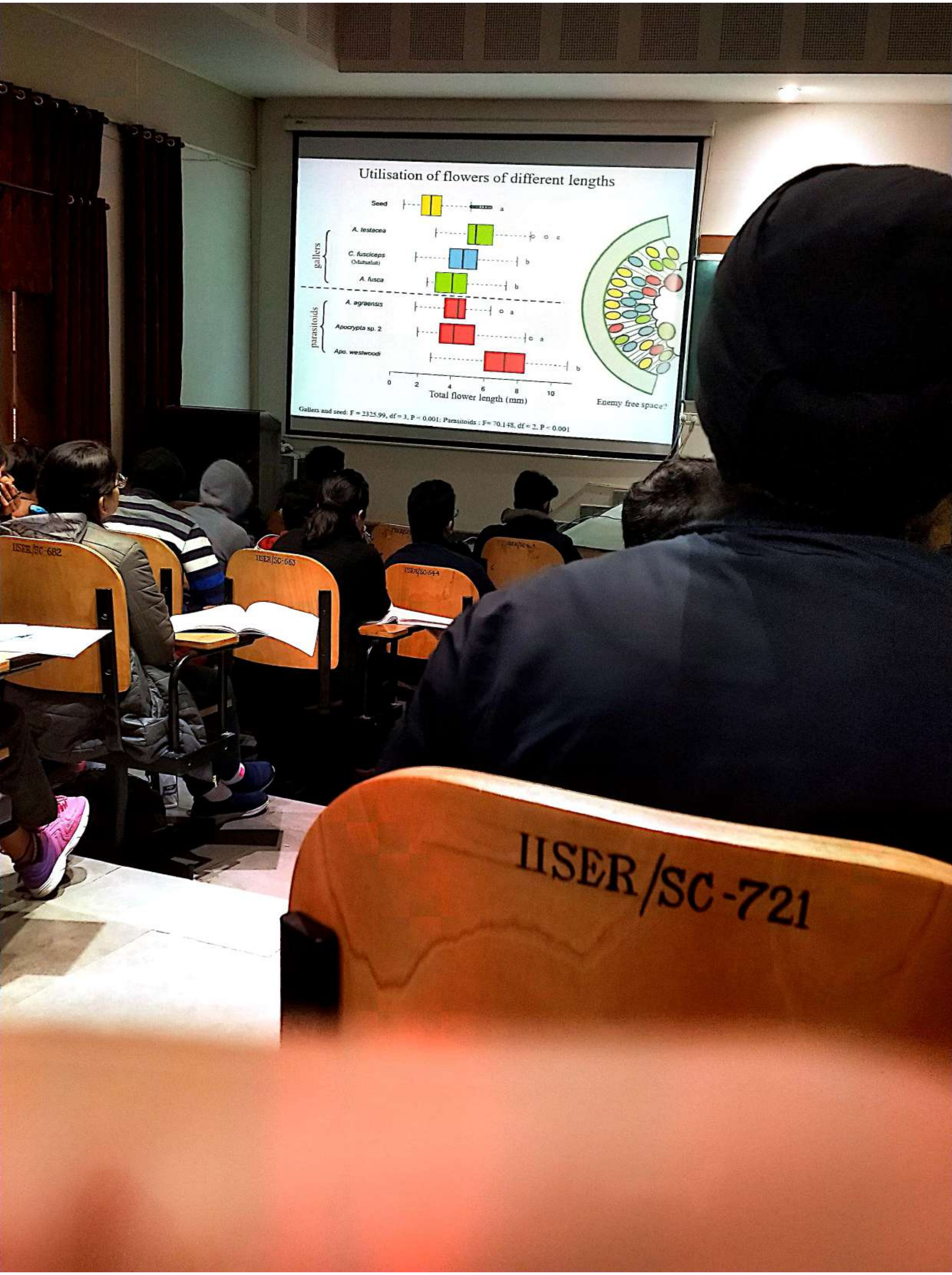
* Simpson yale diversity index.

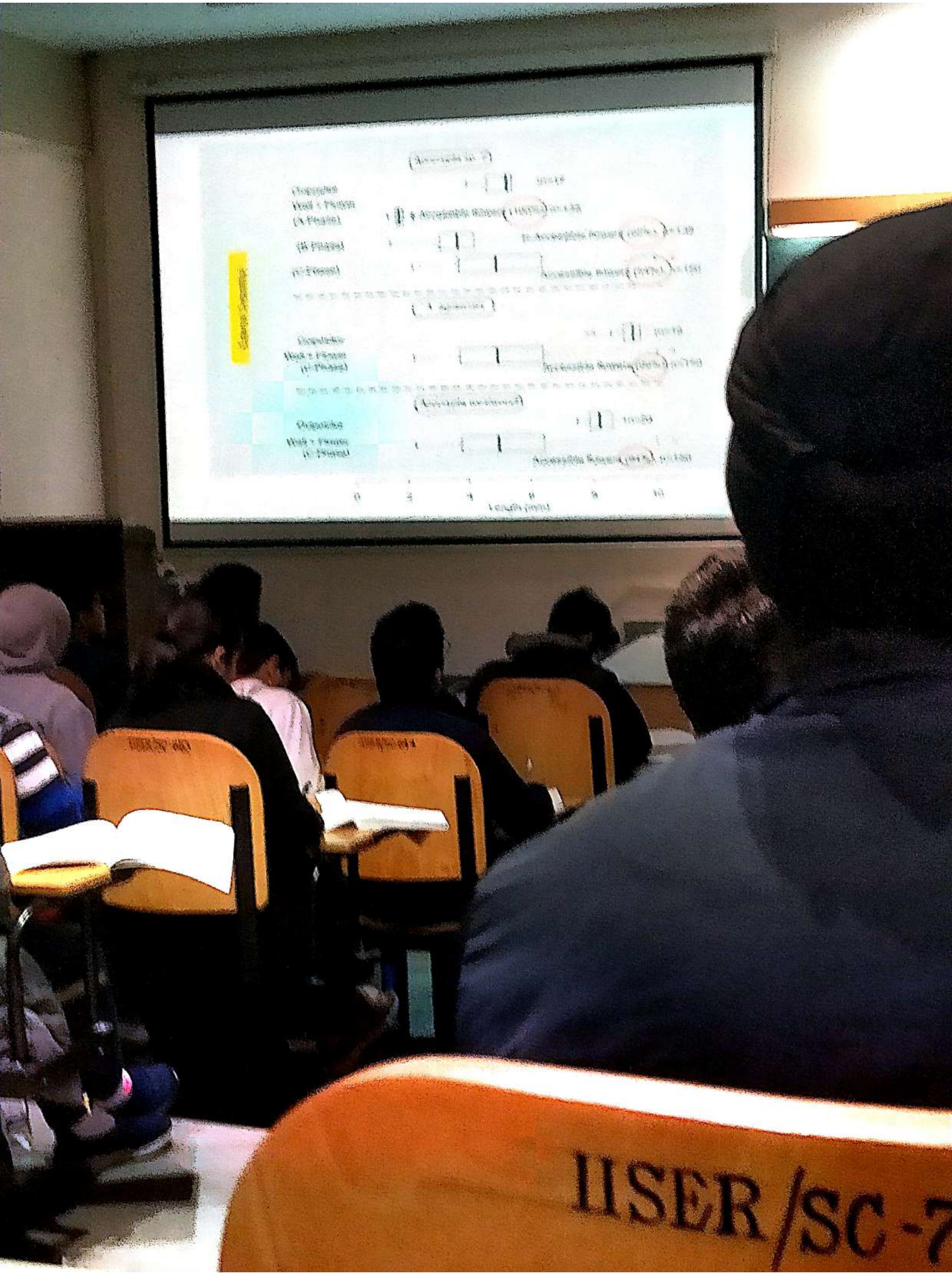
if two individuals are taken randomly from a given hibitat what is the proprability that they belong to same species.

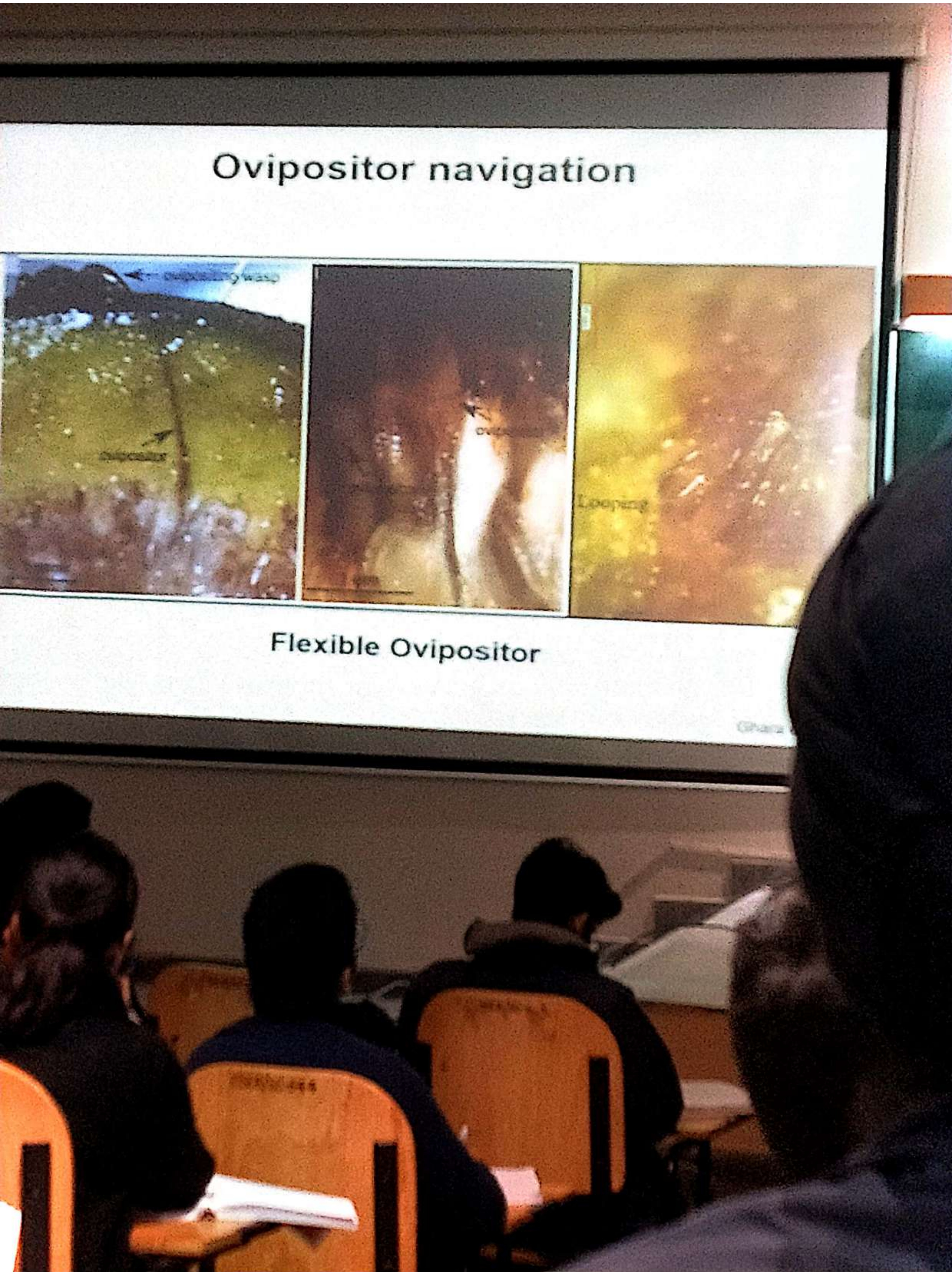
$D = \frac{\sum n_i(n_i-1)}{N(N-1)}$, n_i → no. of individuals of given species.

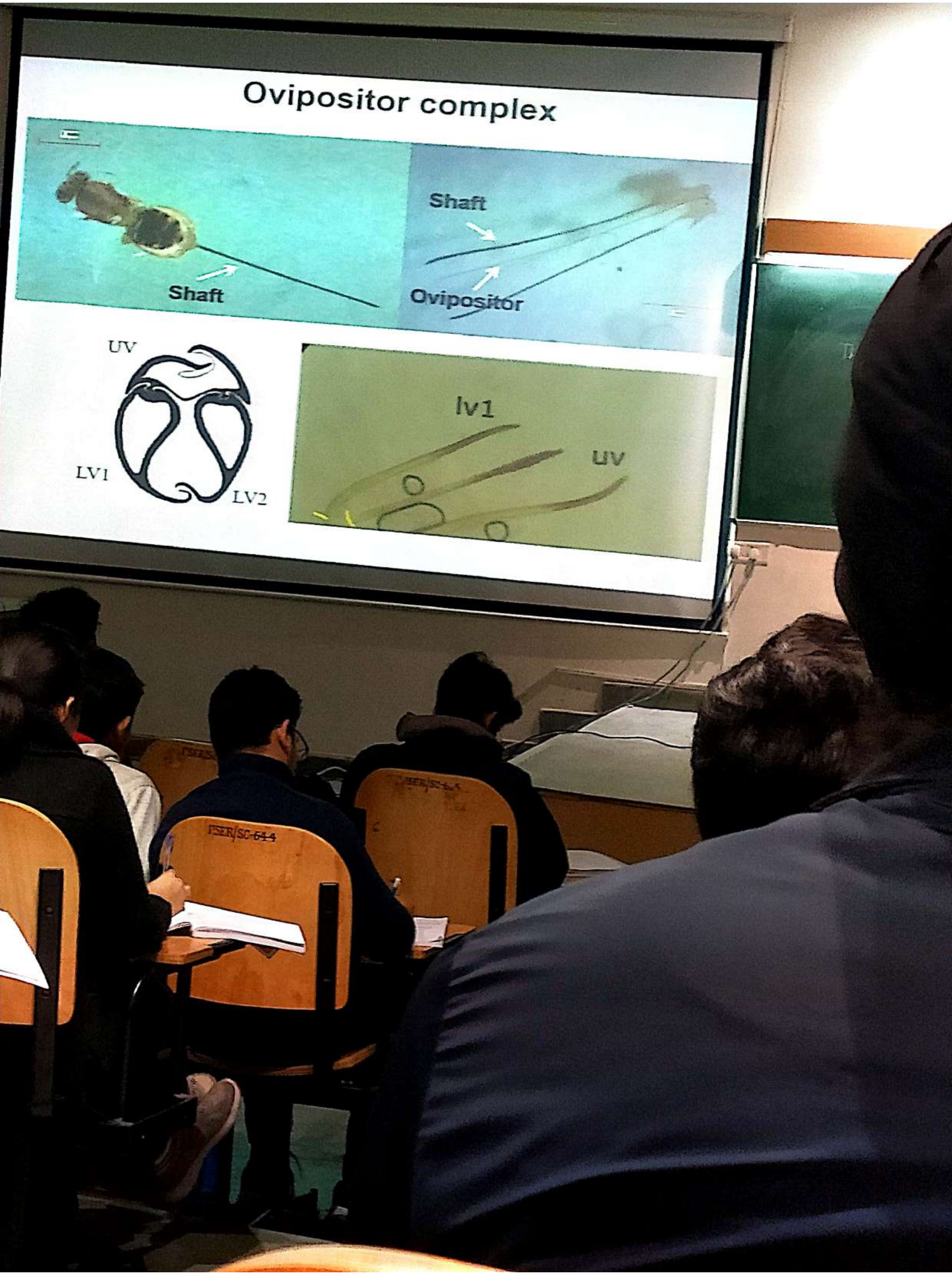
⇒ Req. Probability be $1-D$

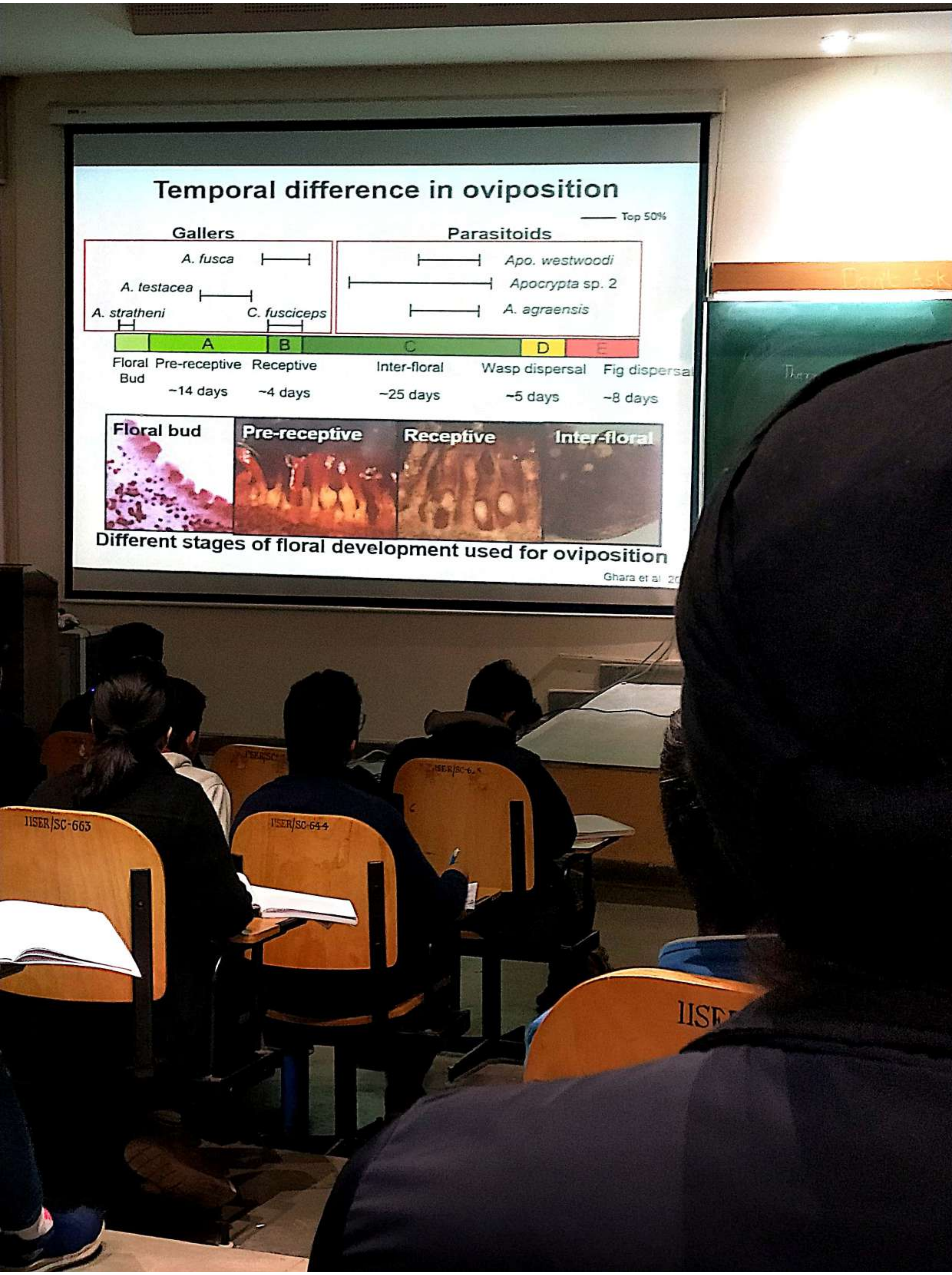
high the value of $1-D$ more diverse the ecosystem.


Utilisation of flowers of different lengths
Seed
A. testacea
C. fusciceps
(Mutualist)
A. fusca
gallers
A. agraensis
Apocrypta sp. 2
Apo. westwoodi
parasitoids
Total flower length (mm)
Enemy free space?
Gallers and seed: F = 2325.99, df = 3, P < 0.001; Parasitoids : F= 70.148, df = 2, P < 0.001
IISER/SC-682
IISER/SC-663
IISER/SC-721

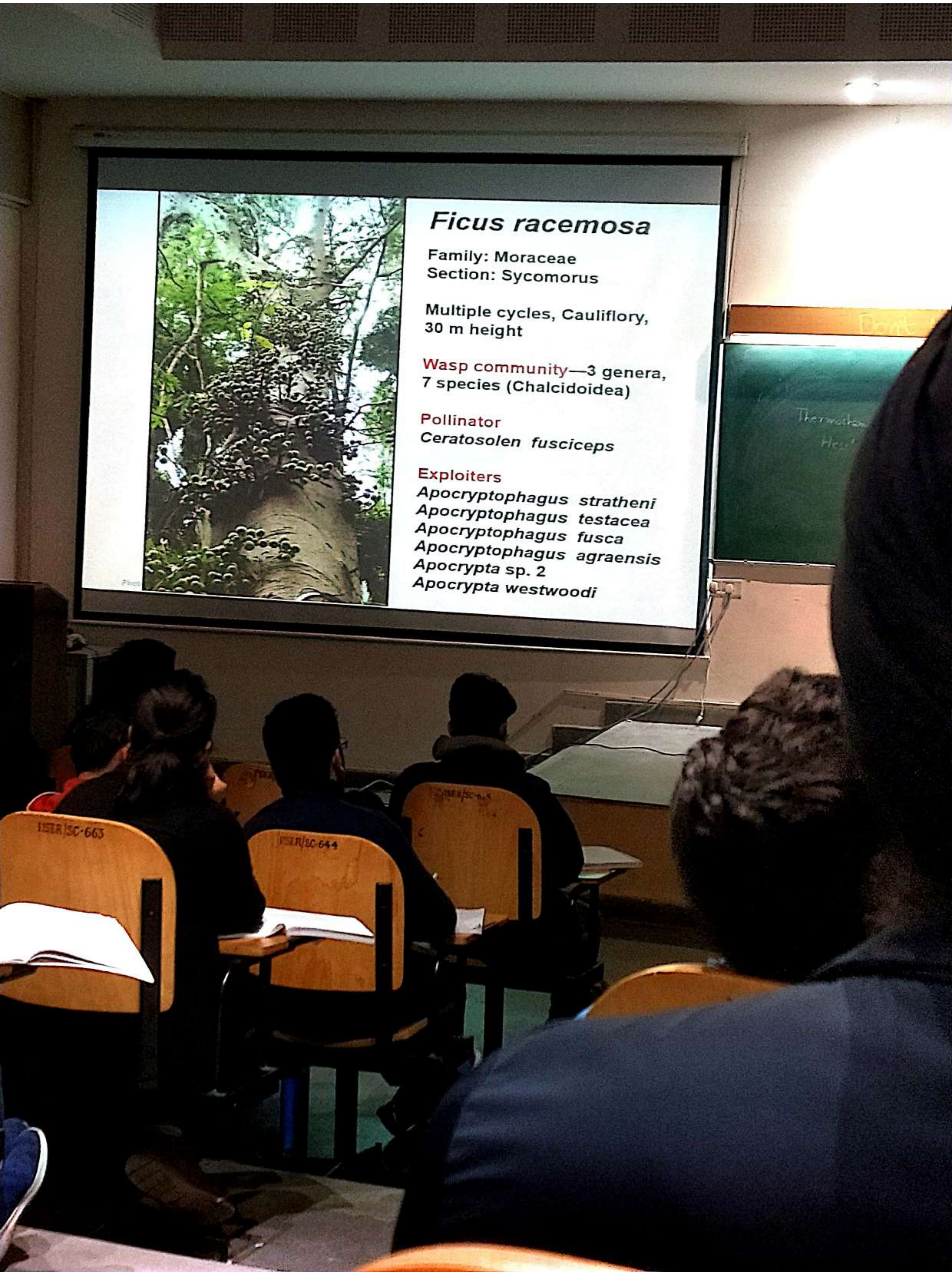

IISER/SC-

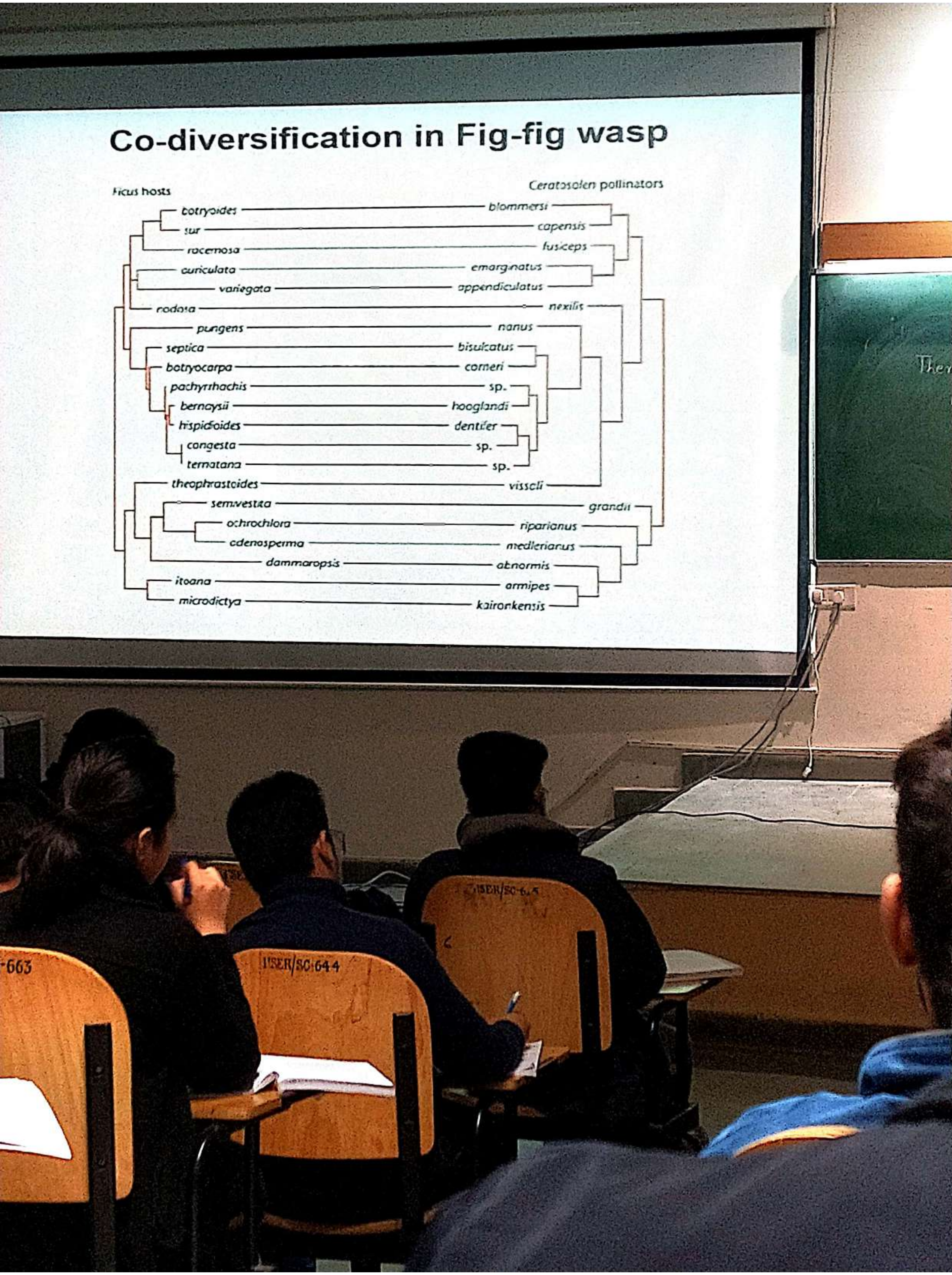

Ovipositor navigation
Looping
Flexible Ovipositor


Ovipositor complex
Shaft
Shaft
Ovipositor
UV
LV1
LV2
lv1
UV

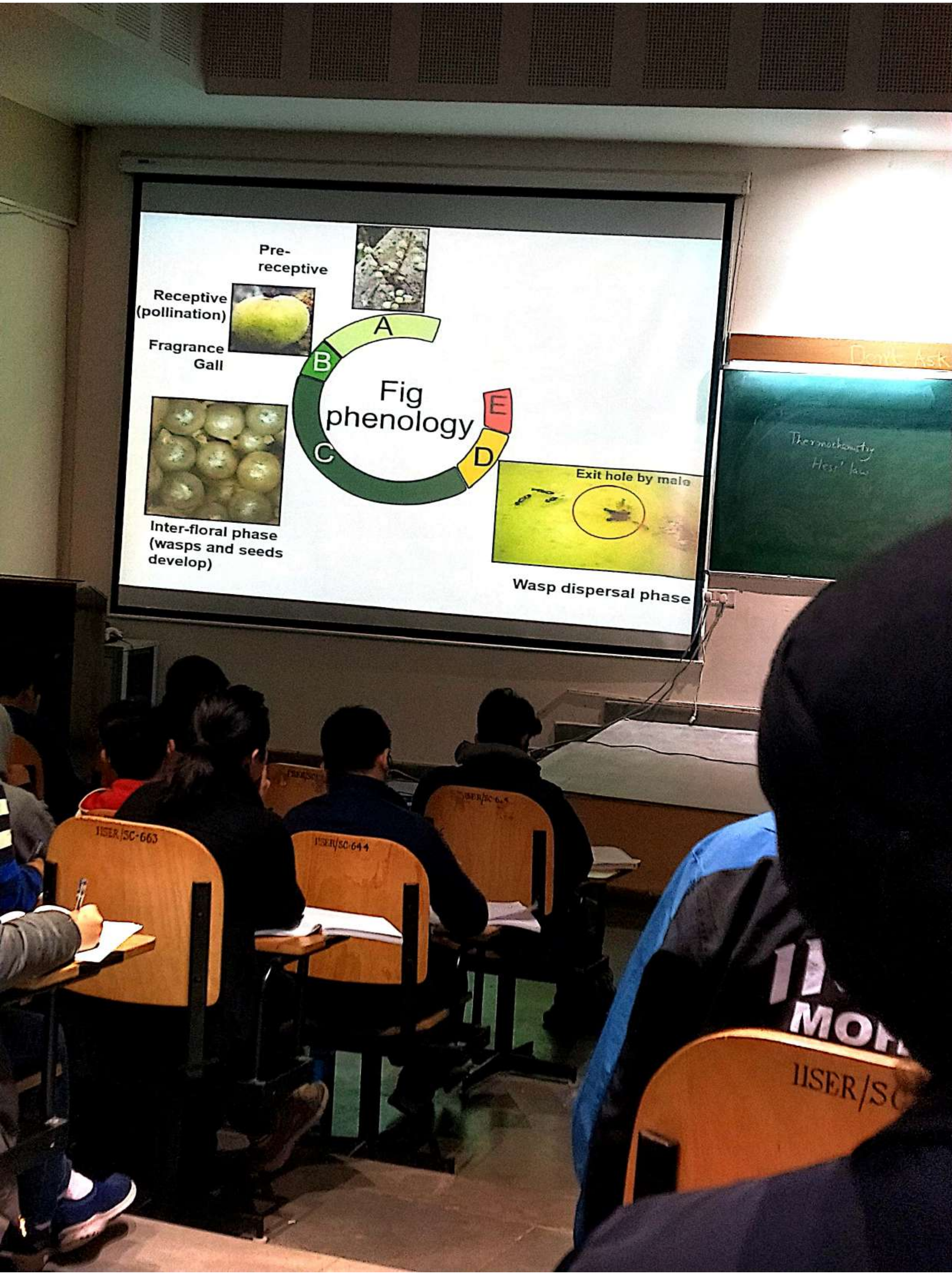

Temporal difference in oviposition
Top 50%
Gallers
Parasitoids
A. fusca
A. testacea
A. stratheni
C. fusciceps
Apo. westwoodi
Apocrypta sp. 2
A. agraensis
A
B
C
D
E
Floral Bud
Pre-receptive
Receptive
Inter-floral
Wasp dispersal
Fig dispersal
~14 days
~4 days
~25 days
~5 days
~8 days
Floral bud
Pre-receptive
Receptive
Inter-floral
Different stages of floral development used for oviposition
IISER/SC-663
IISER/SC-644


Community members of F. racemosa
♀
C. fusciceps
A. stratheni
A. testacea
A. fusca
A. agraensis
Apo. sp. 2
Apo. westwoodi
♂
Scale = 1 mm

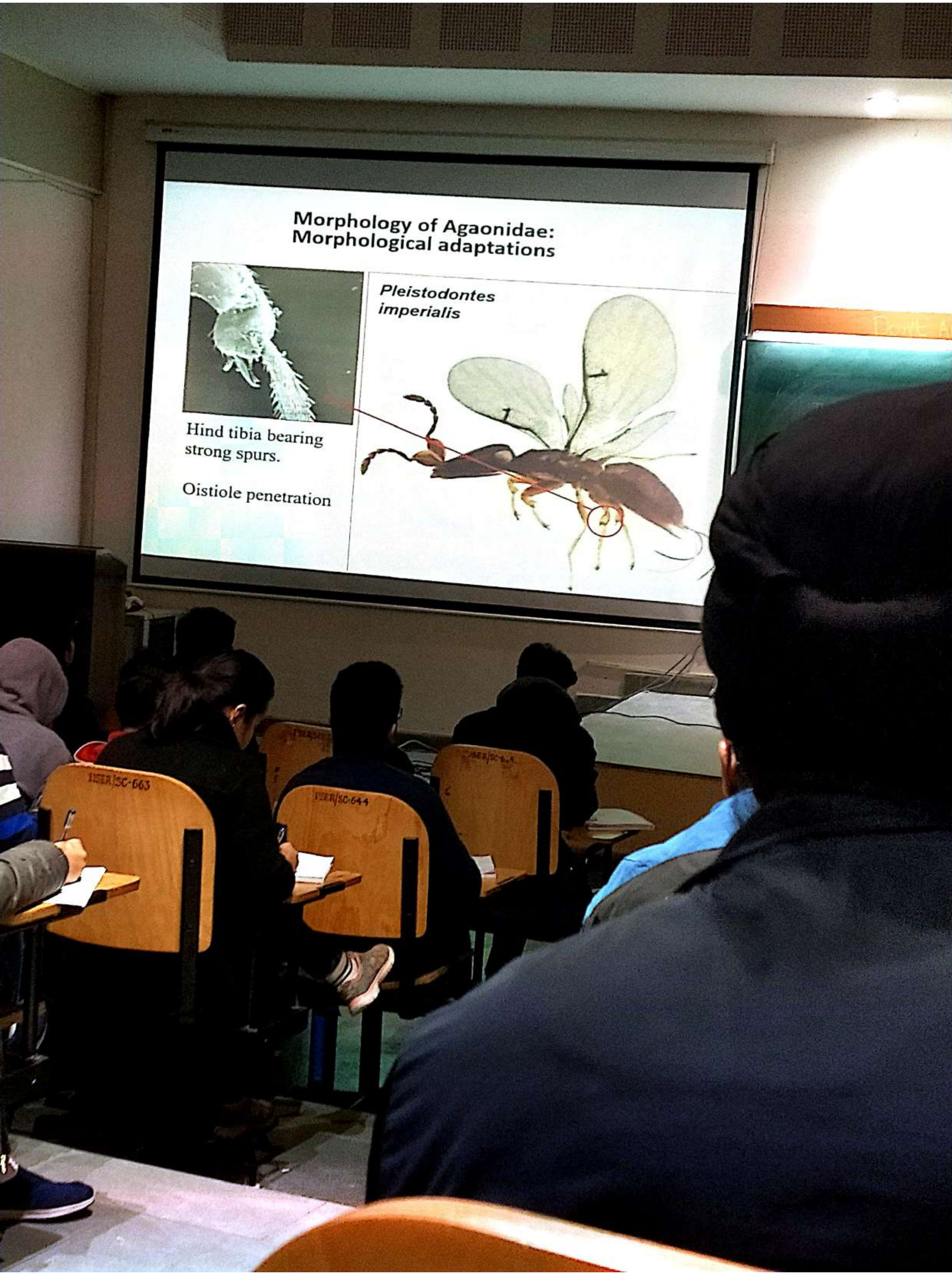

Ficus racemosa
Family: Moraceae
Section: Sycomorus
Multiple cycles, Cauliflory,
30 m height
Wasp community—3 genera,
7 species (Chalcidoidea)
Pollinator
Ceratosolen fusciceps
Exploiters
Apocryptophagus stratheni
Apocryptophagus testacea
Apocryptophagus fusca
Apocryptophagus agraensis
Apocrypta sp. 2
Apocrypta westwoodi
IISER/SC-663
IISER/SC-644

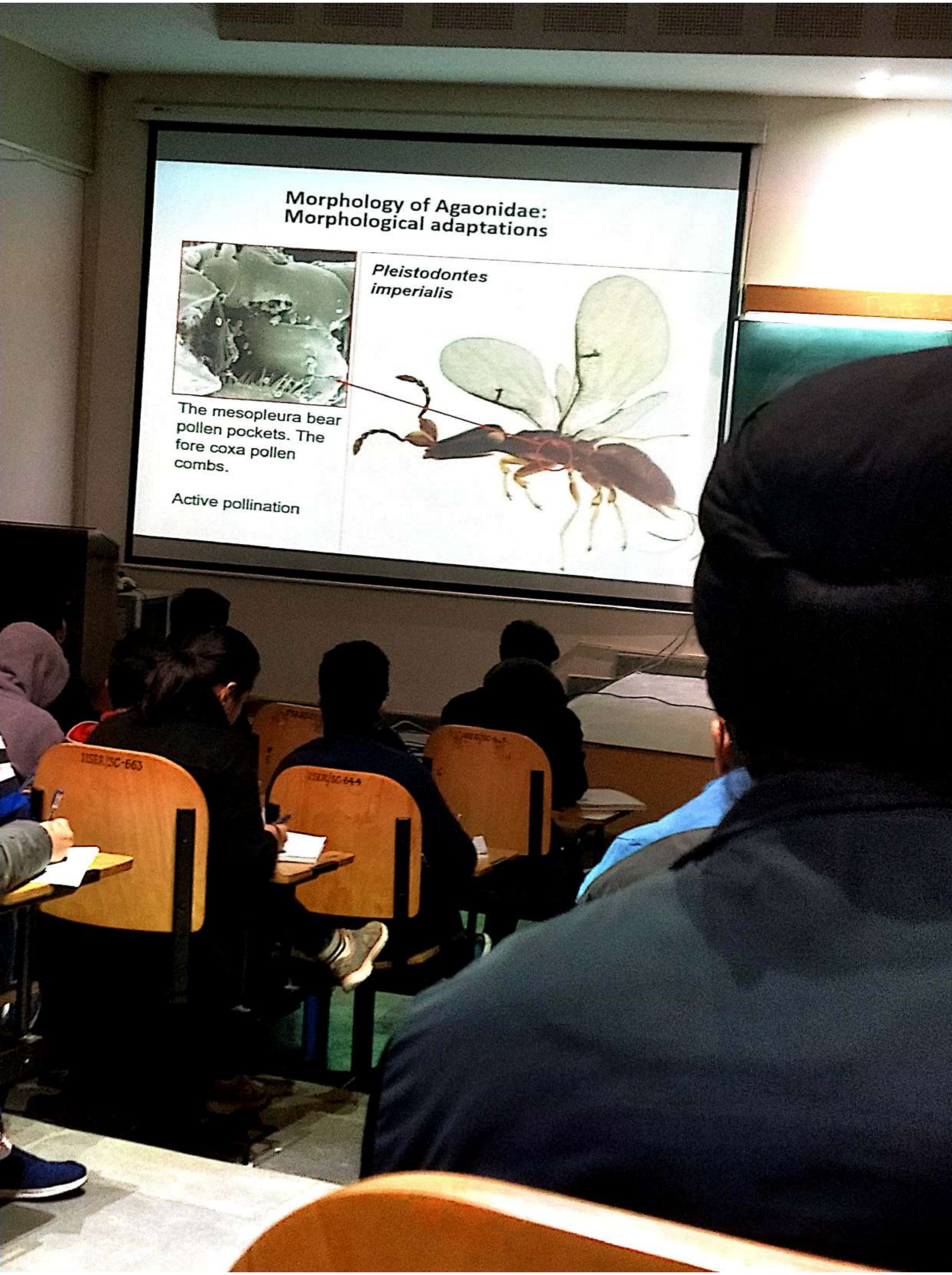

Co-diversification in Fig-fig wasp
Ficus hosts
Ceratosolen pollinators
botryoides
blommersi
sur
capensis
racemosa
fusiceps
auriculata
emarginatus
variegata
appendiculatus
nodosa
nexilis
pungens
nanus
septica
bisulcatus
botryocarpa
corneri
pachyrrhachis
sp.
bernaysii
hooglandi
hispidioides
dentifer
congesta
sp.
ternatana
sp.
theophrastoides
vissali
semivestita
grandii
ochrochlora
riparianus
adenosperma
medlerianus
dammaropsis
abnormis
itoana
armipes
microdictya
kaironkensis

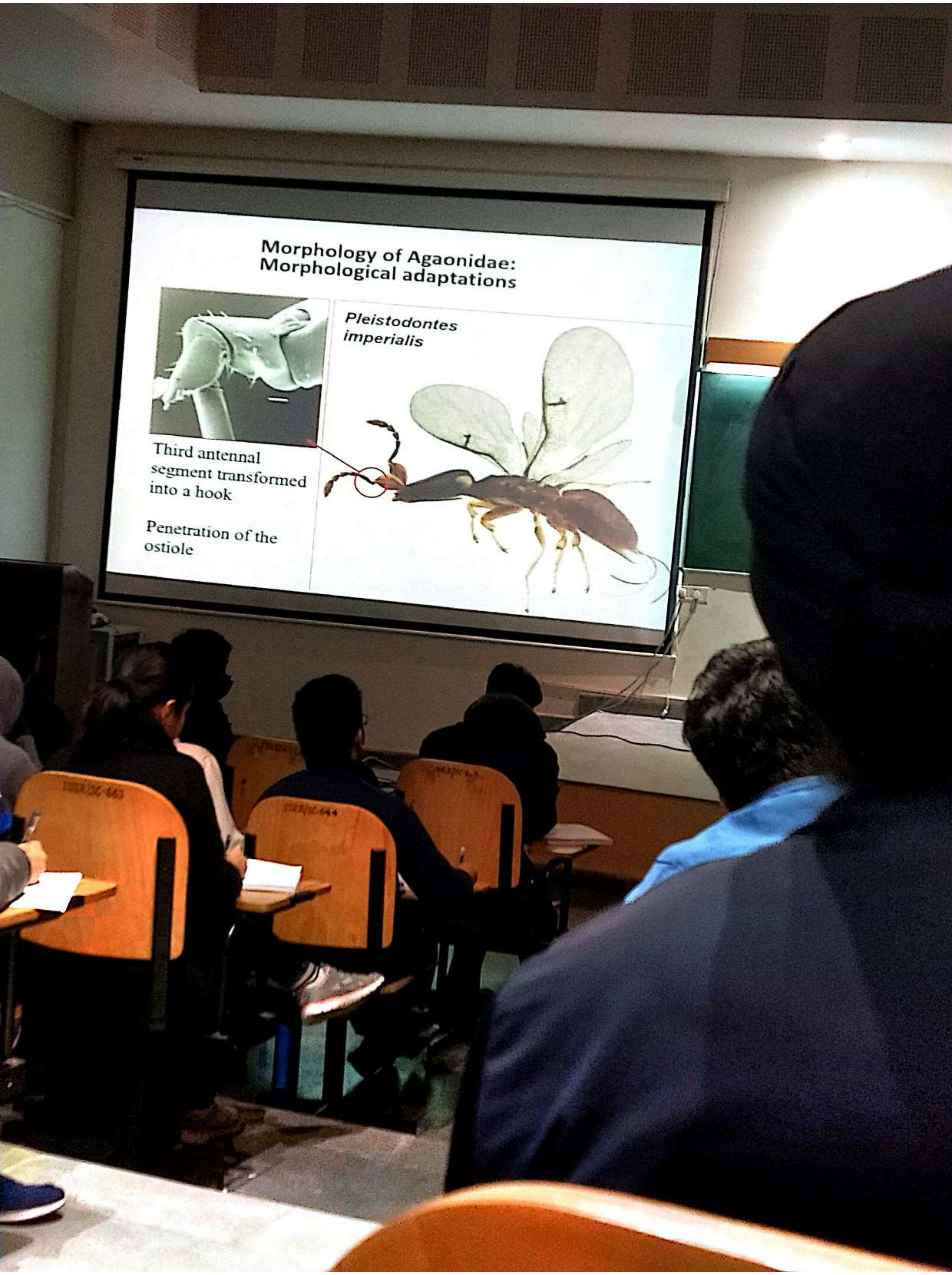

Pre-
receptive
Receptive
(pollination)
Fragrance
Gall
A
B
C
D
E
Fig
phenology
Seed dispersal phase
Exit hole by male
Inter-floral phase
(wasps and seeds
develop)
Wasp dispersal phase
IISER/SC-663
IISER/SC-644

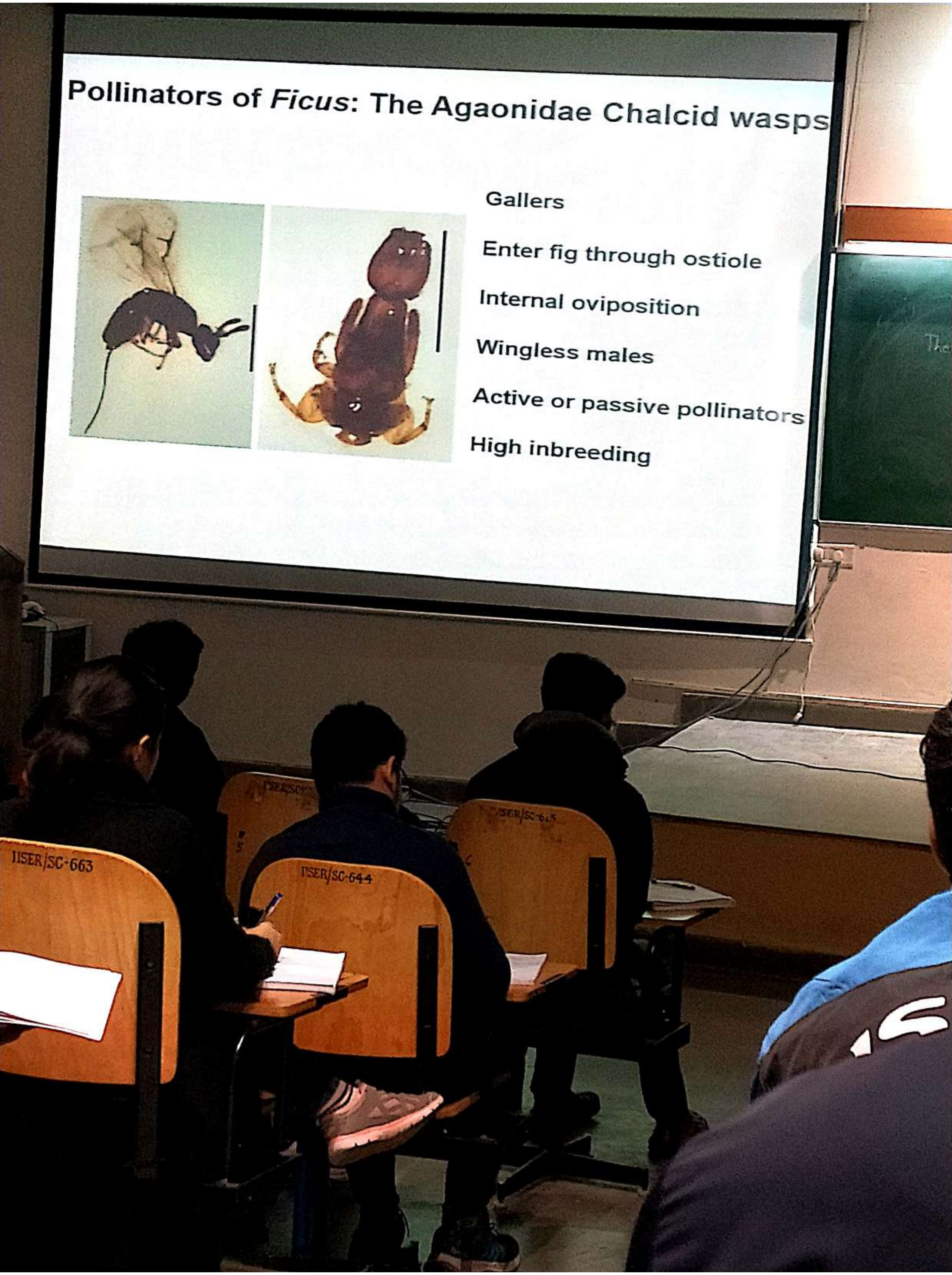

Pre-
receptive
Receptive
(pollination)
Fragrance
Gall
A
B
C
D
E
Fig
phenology
Exit hole by male
Inter-floral phase
(wasps and seeds
develop)
Wasp dispersal phase
IISER/SC-663
IISER/SC-644

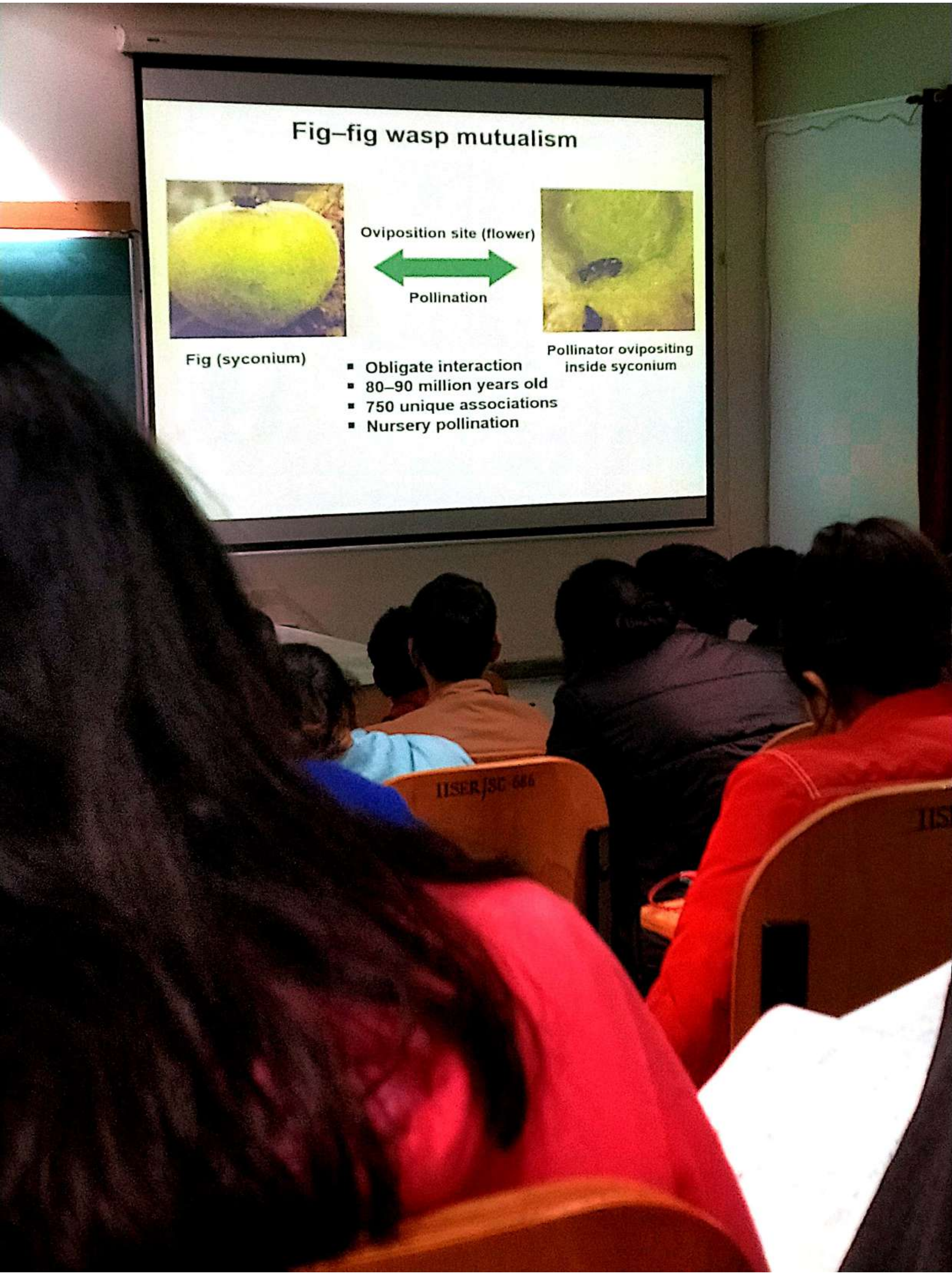

mutualist: internal oviposition
exploiter: external oviposition
Thermochemistry
Hess' law
IISER/SC-663
IISER/SC-644

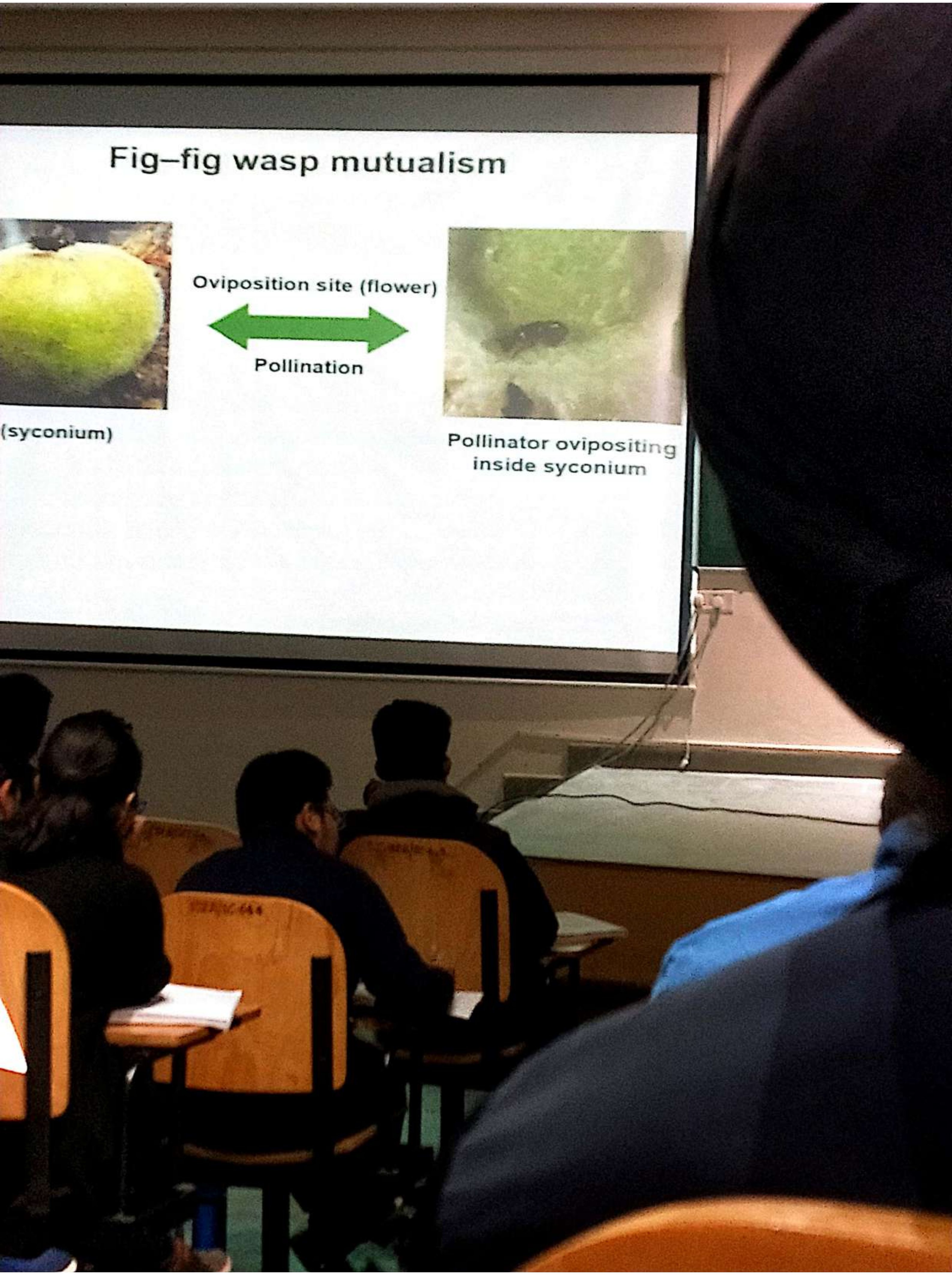

Morphology of Agaonidae:
Morphological adaptations
Pleistodontes
imperialis
Hind tibia bearing
strong spurs.
Oistiole penetration
IISER/SC-663
IISER/SC-644


Morphology of Agaonidae:
Morphological adaptations
Pleistodontes
imperialis
The mesopleura bear
pollen pockets. The
fore coxa pollen
combs.
Active pollination
IISER/SC-663
IISER/SC-644


Morphology of Agaonidae:
Morphological adaptations
Pleistodontes
imperialis
Third antennal
segment transformed
into a hook
Penetration of the
ostiole


Pollinators of Ficus: The Agaonidae Chalcid wasps
Gallers
Enter fig through ostiole
Internal oviposition
Wingless males
Active or passive pollinators
High inbreeding
IISER/SC-663


Fig–fig wasp mutualism
Oviposition site (flower)
Pollination
Fig (syconium)
Pollinator ovipositing inside syconium
▪ Obligate interaction
▪ 80–90 million years old
▪ 750 unique associations
▪ Nursery pollination
IISER/JSC 686

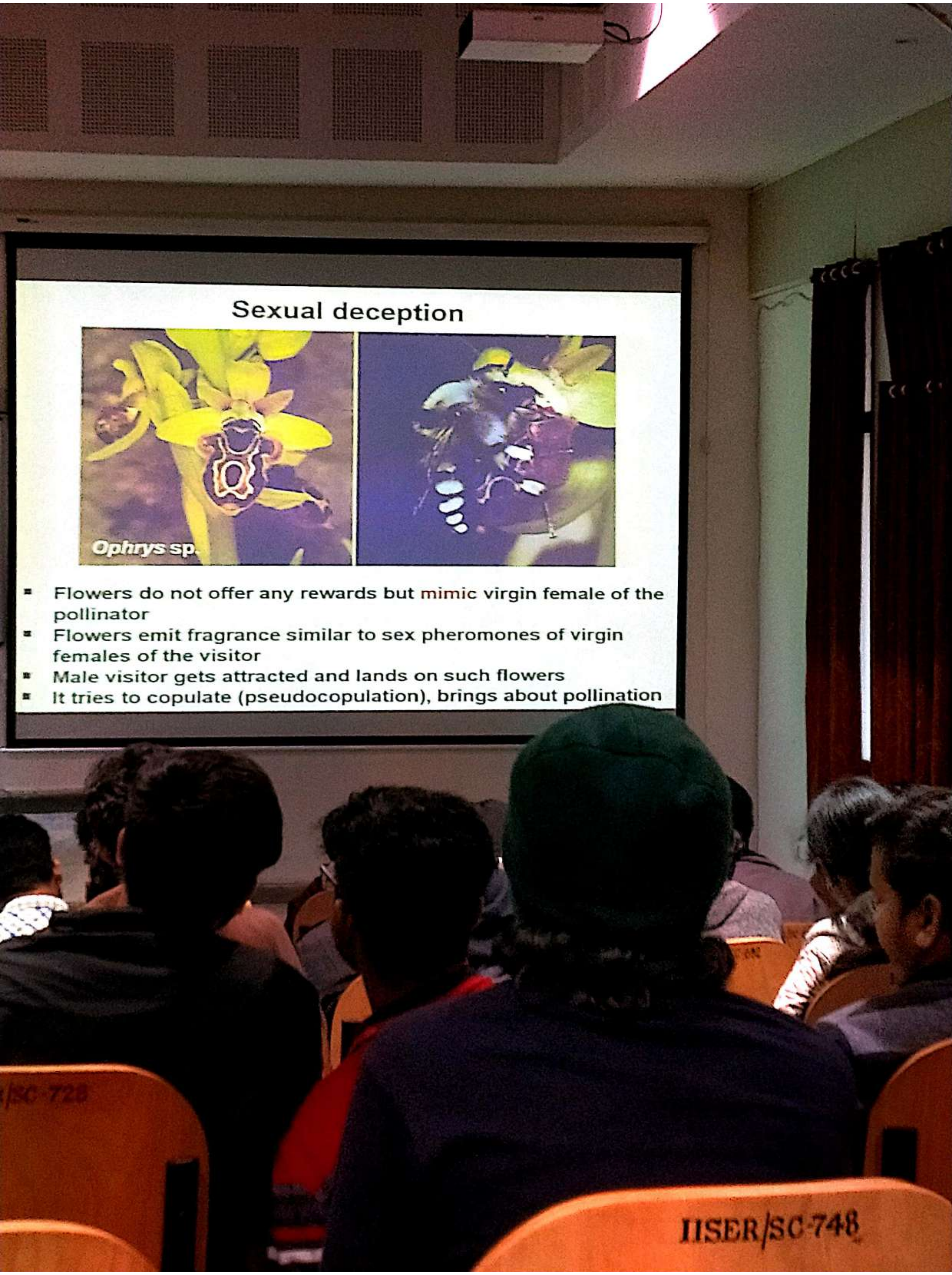

Fig–fig wasp mutualism
Oviposition site (flower)
Pollination
(syconium)
Pollinator ovipositing inside syconium

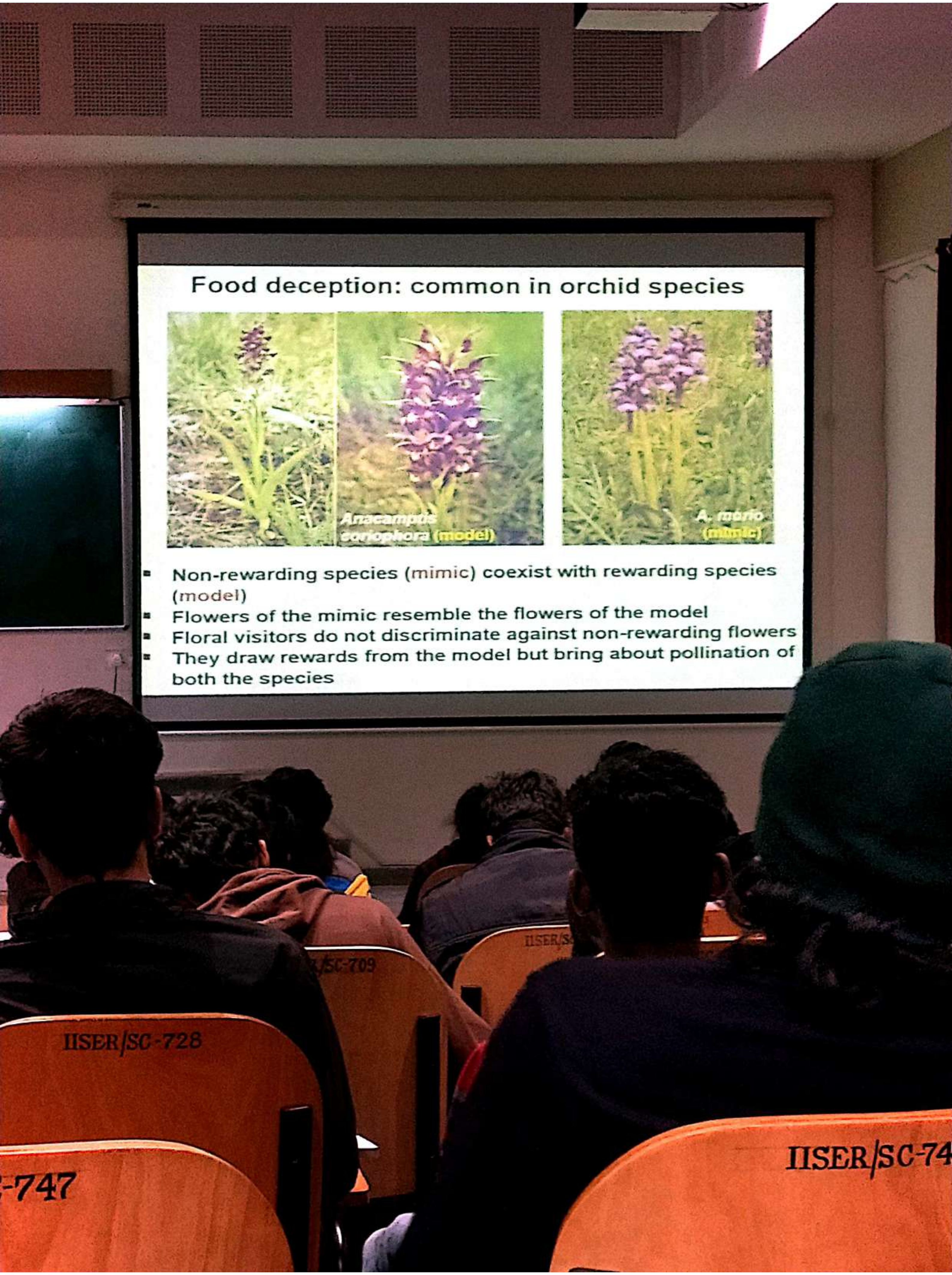

The genus Ficus (Moraceae)
Wall
Ostiole
Bracts
Stamens
Female flowers
The fig: an urn shaped inflorescence (Hypanthodium)
IISER

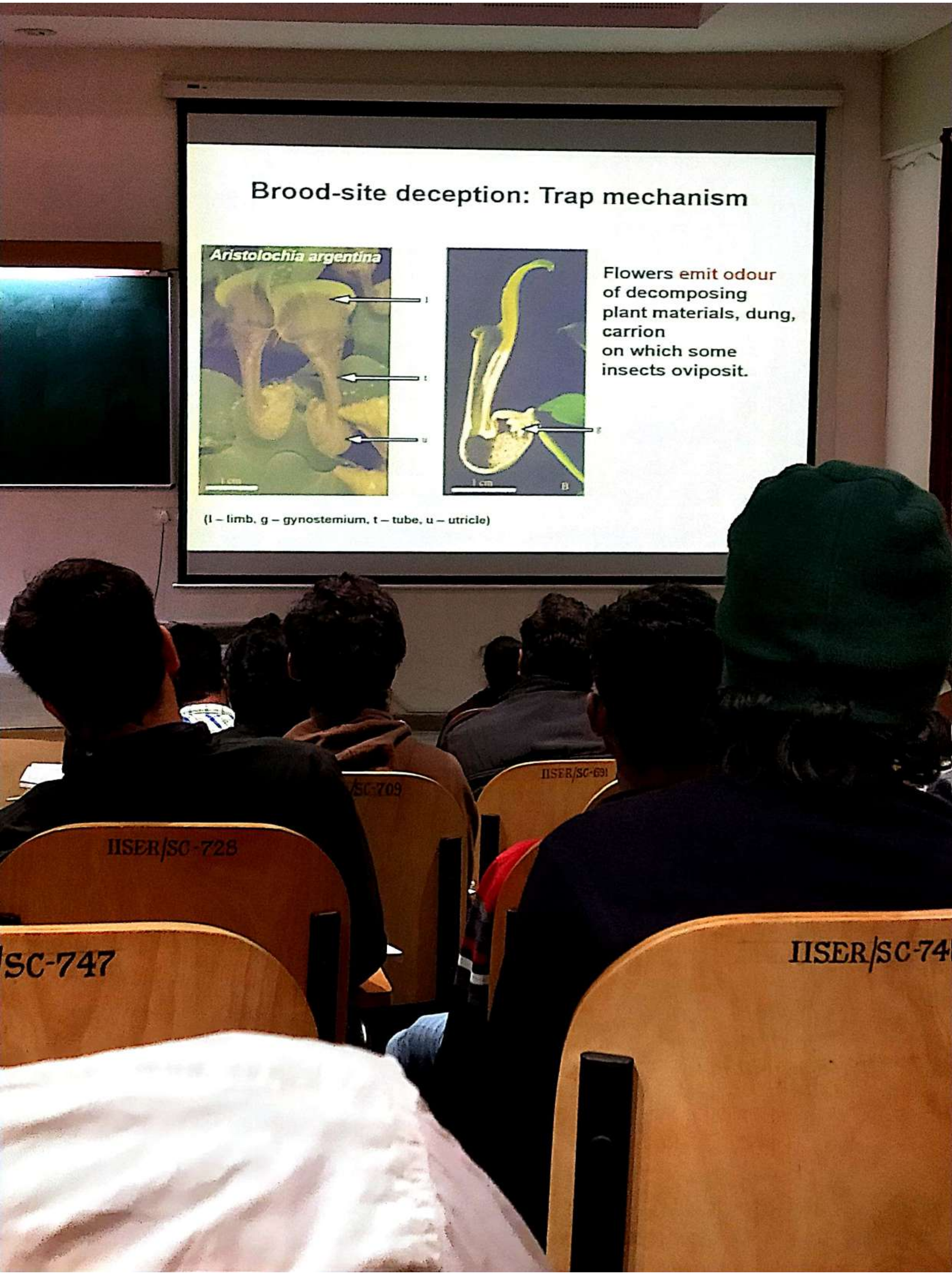

Fig syconium
stamen
short style
long style
male flower
female flowers
view inside a syconium
© W.P. Armstrong 2001
© E.M. Collins 2001
IISER/SC-721
IISER/SC-663
IISER/SC-644


The genus *Ficus* (Moraceae)
Strangler fig
Variation in life forms

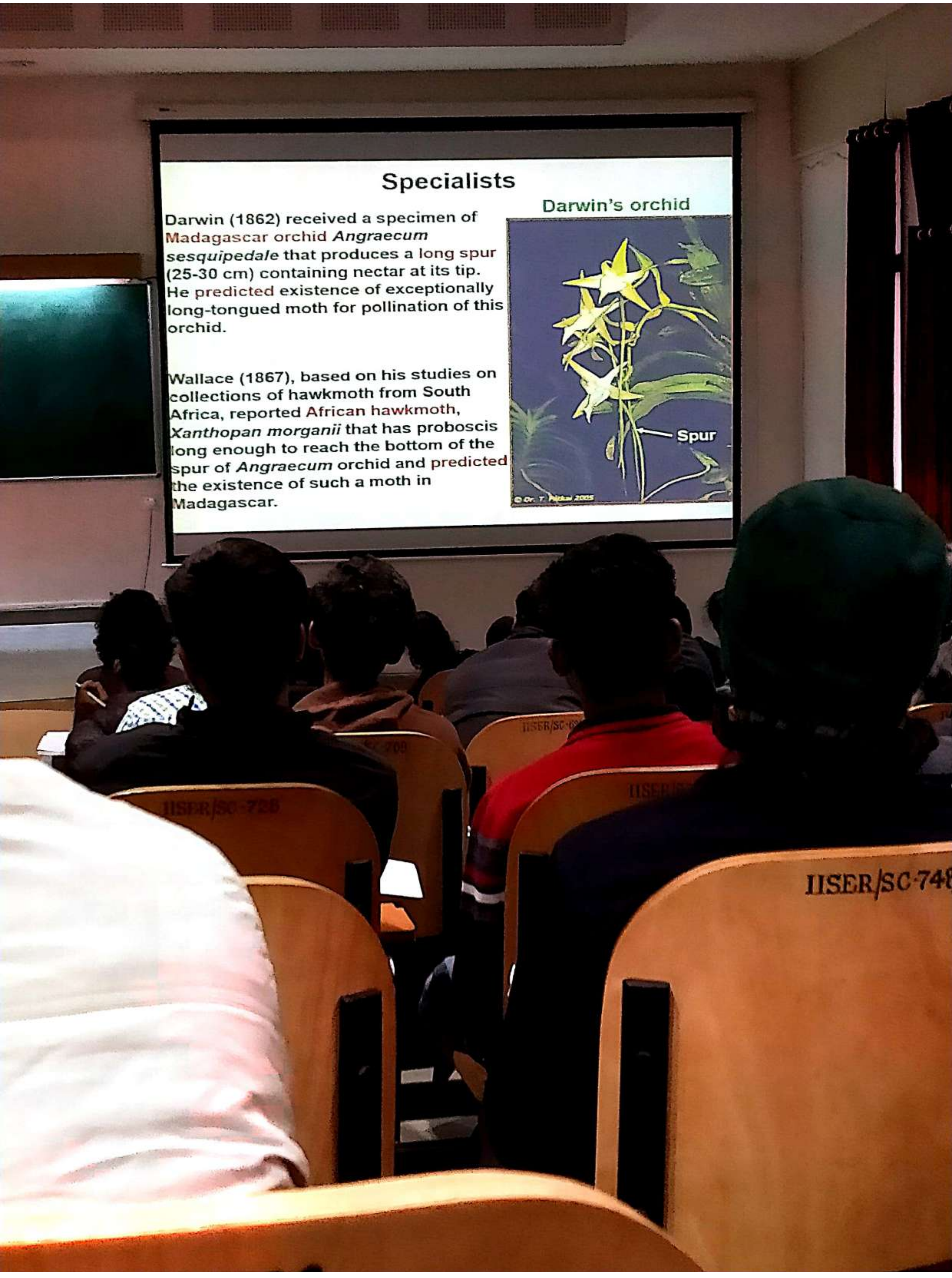

Figs belong to genus Ficus (family Moraceae)
Wind and insect pollination
Jackfruit
Mulberry
IISER


Sexual deception
Ophrys sp.
Flowers do not offer any rewards but mimic virgin female of the pollinator
Flowers emit fragrance similar to sex pheromones of virgin females of the visitor
Male visitor gets attracted and lands on such flowers
It tries to copulate (pseudocopulation), brings about pollination
IISER/SC-748


Food deception: common in orchid species
Anacamptis coriophora (model)
A. morio (mimic)
Non-rewarding species (mimic) coexist with rewarding species (model)
Flowers of the mimic resemble the flowers of the model
Floral visitors do not discriminate against non-rewarding flowers
They draw rewards from the model but bring about pollination of both the species
IISER/SC-728
IISER/SC-74
-747
/SC-709

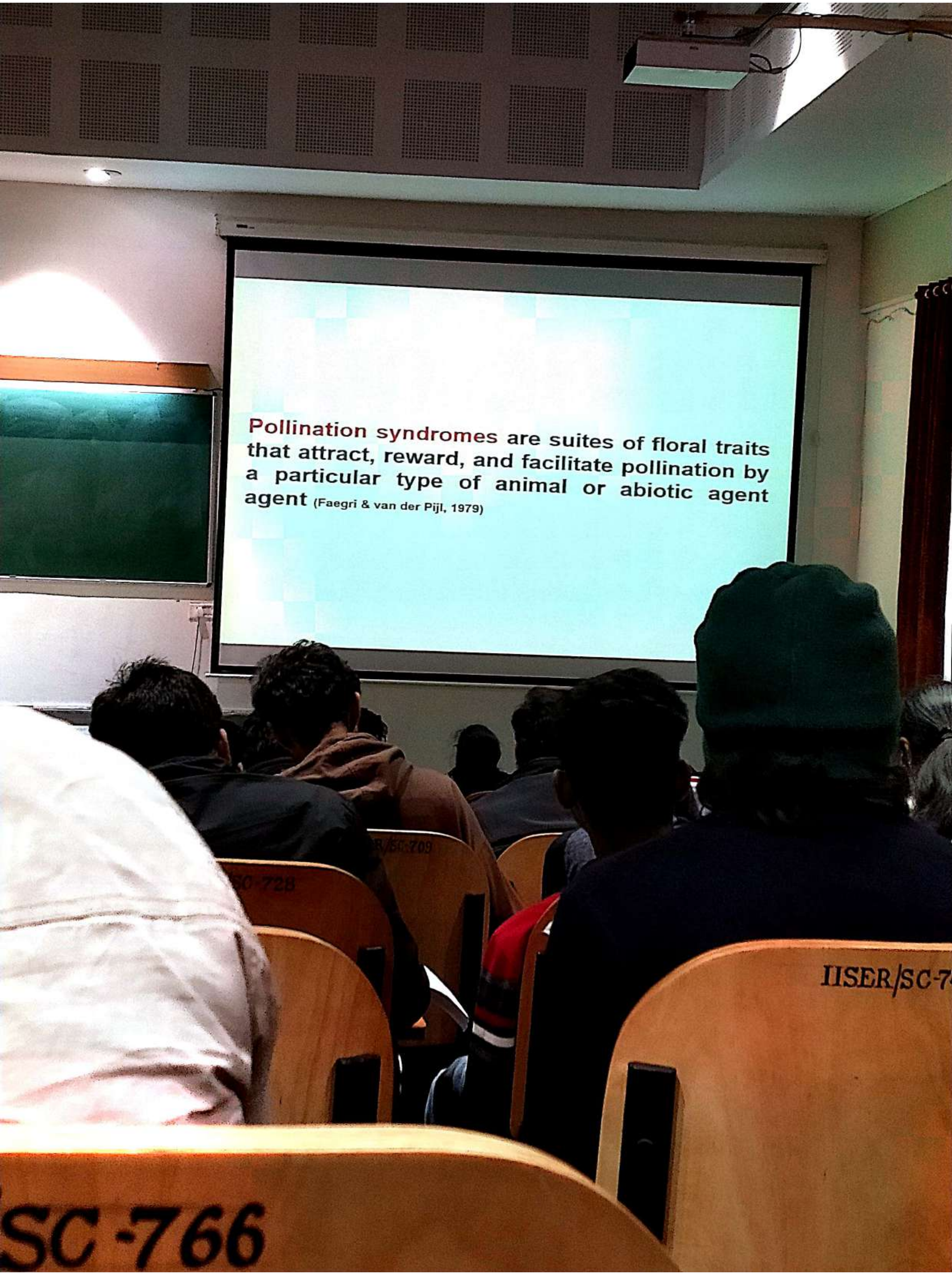

Brood-site deception: Trap mechanism
Aristolochia argentina
Flowers emit odour of decomposing plant materials, dung, carrion on which some insects oviposit.
1 cm
1 cm
B
(l – limb, g – gynostemium, t – tube, u – utricle)
IISER/SC-691
IISER/SC-728
SC-747

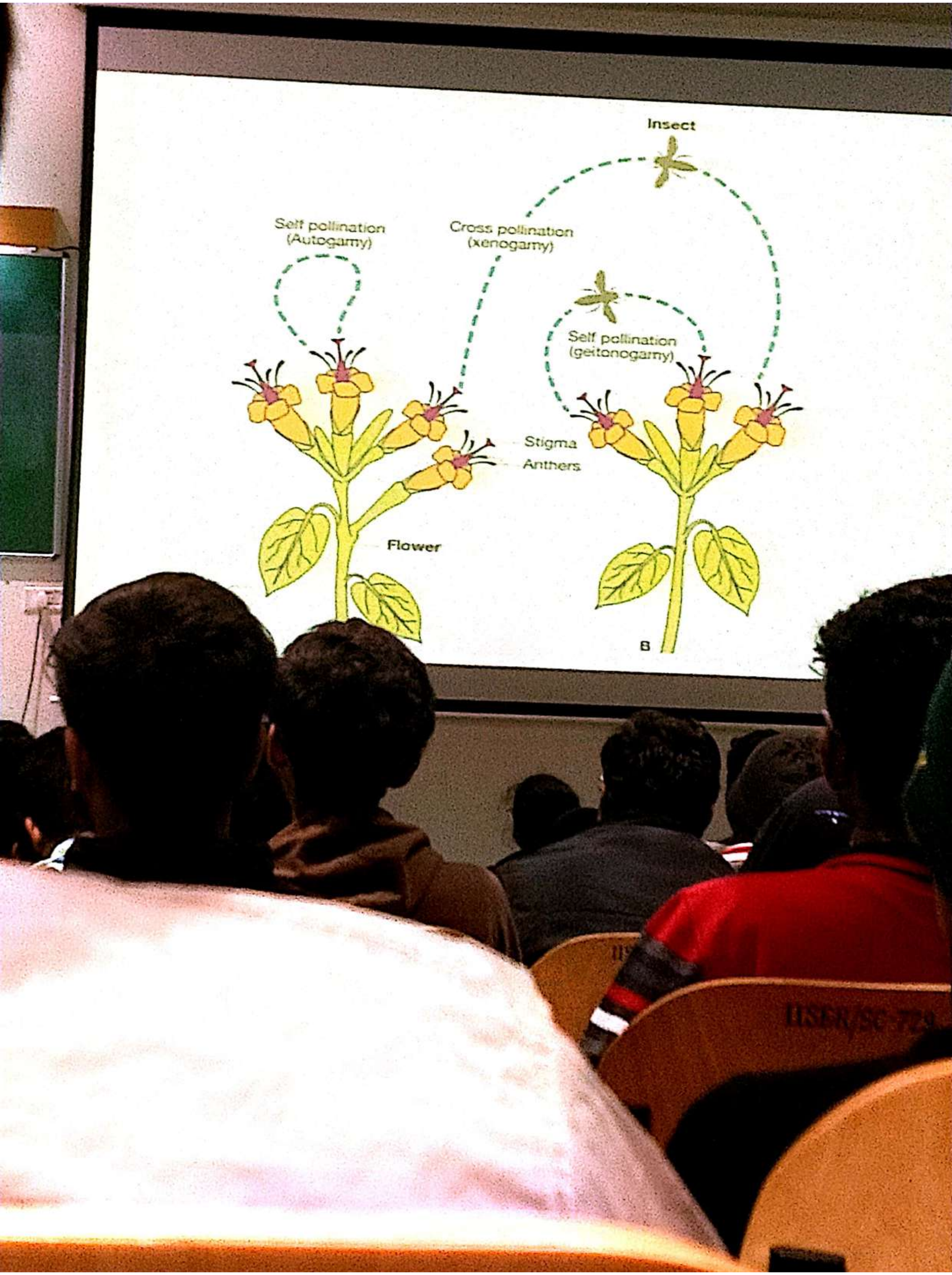

In 1903, a hawkmoth with a tongue length of 22 cm was discovered in Madagascar. It was named (Xanthopan morganii ssp. praedicta), in honor of Wallace's prediction.
It was only in 1997, this moth was shown to be pollinator of Angraecum orchid.
IISER/SC-748
IISER/SC-766


Specialists
Darwin's orchid
Darwin (1862) received a specimen of Madagascar orchid *Angraecum sesquipedale* that produces a long spur (25-30 cm) containing nectar at its tip. He predicted existence of exceptionally long-tongued moth for pollination of this orchid.
Wallace (1867), based on his studies on collections of hawkmoth from South Africa, reported African hawkmoth, *Xanthopan morganii* that has proboscis long enough to reach the bottom of the spur of *Angraecum* orchid and predicted the existence of such a moth in Madagascar.
Spur

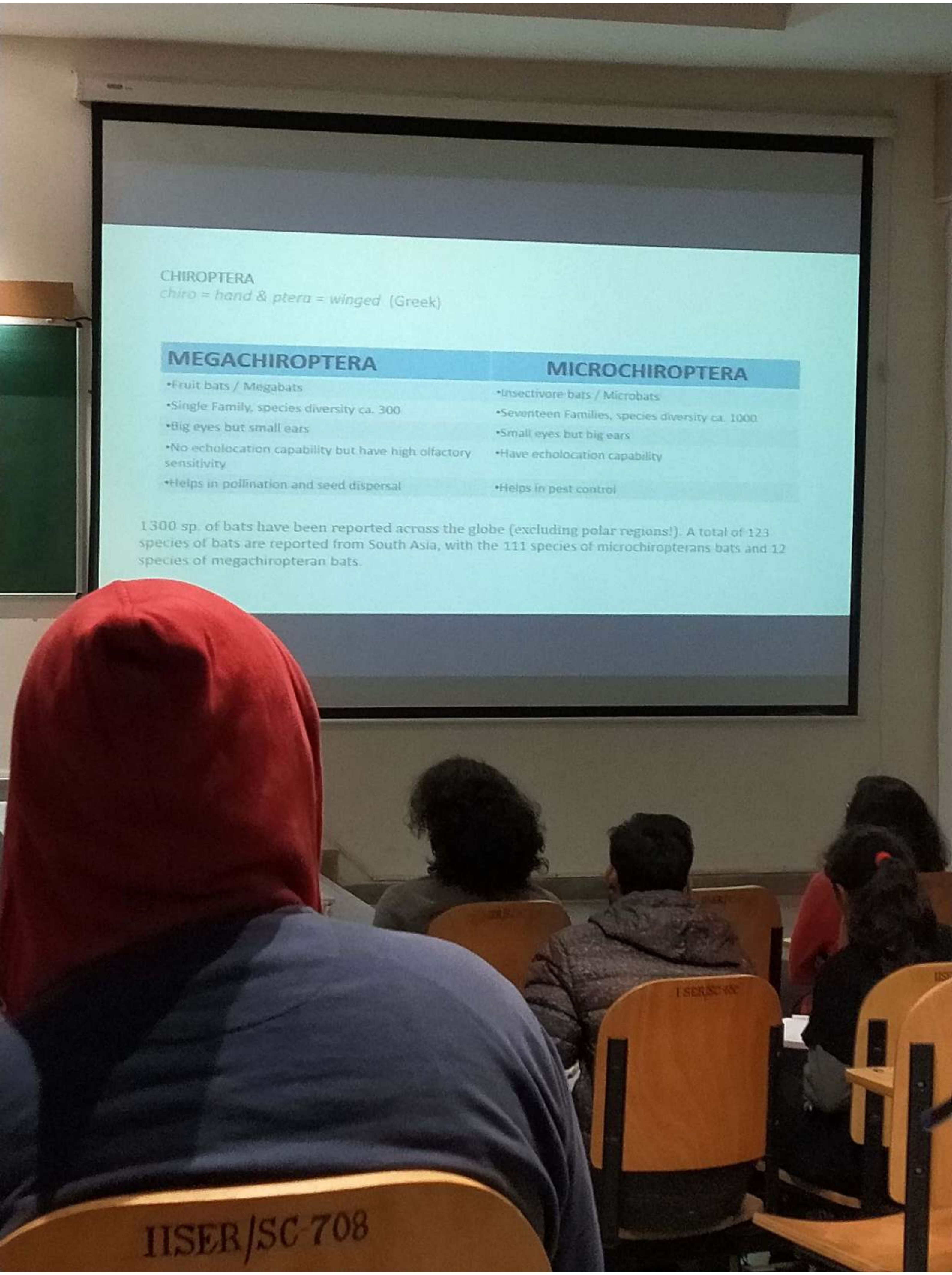

Generalists and specialists
Generalists pollinators: can visit many species of flowers
Generalist flowers: attract many species of pollinators
SC-709
SC-728

Rewards for pollination services
Pollen
Nectar
Resin
Heat
Philodendron
sp. - scarab
beetle
Cyclocephala

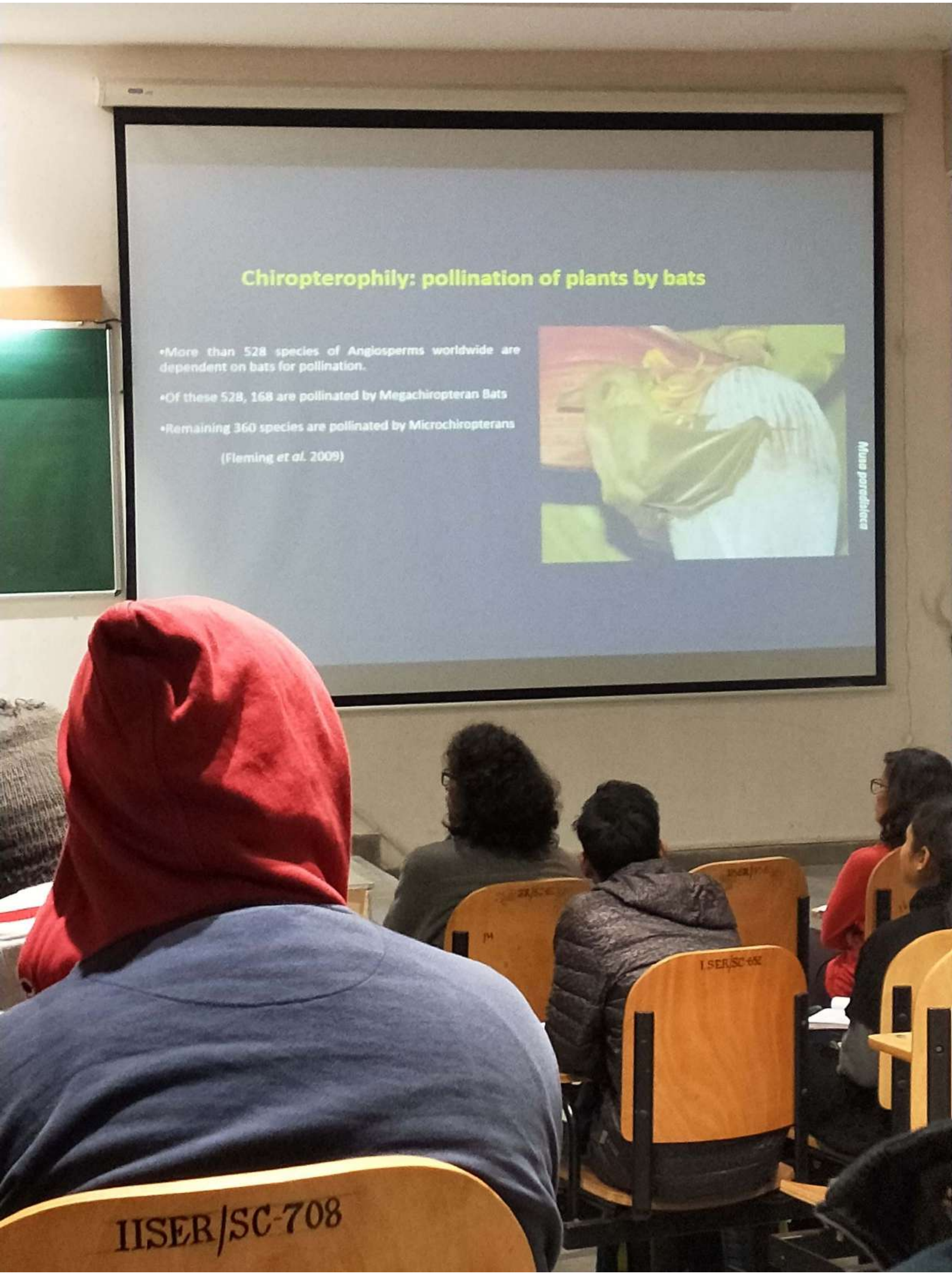

Pollination syndromes are suites of floral traits that attract, reward, and facilitate pollination by a particular type of animal or abiotic agent agent (Faegri & van der Pijl, 1979)
IISER/SC-7
SC-766


Insect
Self pollination
(Autogamy)
Cross pollination
(xenogamy)
Self pollination
(geitonogamy)
Stigma
Anthers
Flower
B
ISER/SC-729


Pollination
Transfer of pollen to the female reproductive organs of a plant, thereby enabling fertilization to take place.
IISER/SC-728

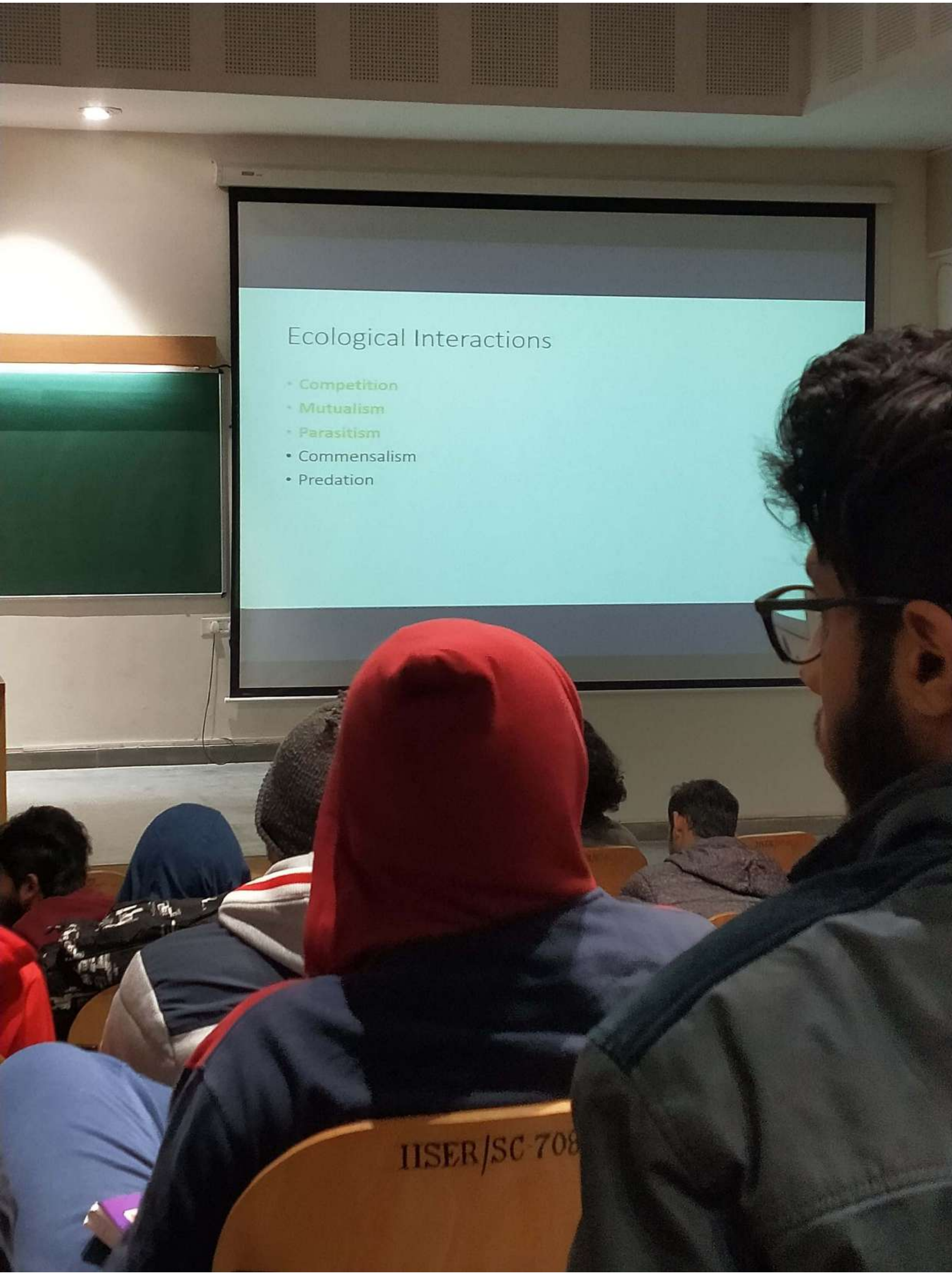

CHIROPTERA
chiro = hand & ptera = winged (Greek)
MEGACHIROPTERA
MICROCHIROPTERA
•Fruit bats / Megabats
•Insectivore bats / Microbats
•Single Family, species diversity ca. 300
•Seventeen Families, species diversity ca. 1000
•Big eyes but small ears
•Small eyes but big ears
•No echolocation capability but have high olfactory sensitivity
•Have echolocation capability
•Helps in pollination and seed dispersal
•Helps in pest control
1300 sp. of bats have been reported across the globe (excluding polar regions!). A total of 123 species of bats are reported from South Asia, with the 111 species of microchiropterans bats and 12 species of megachiropteran bats.
IISER/SC-708

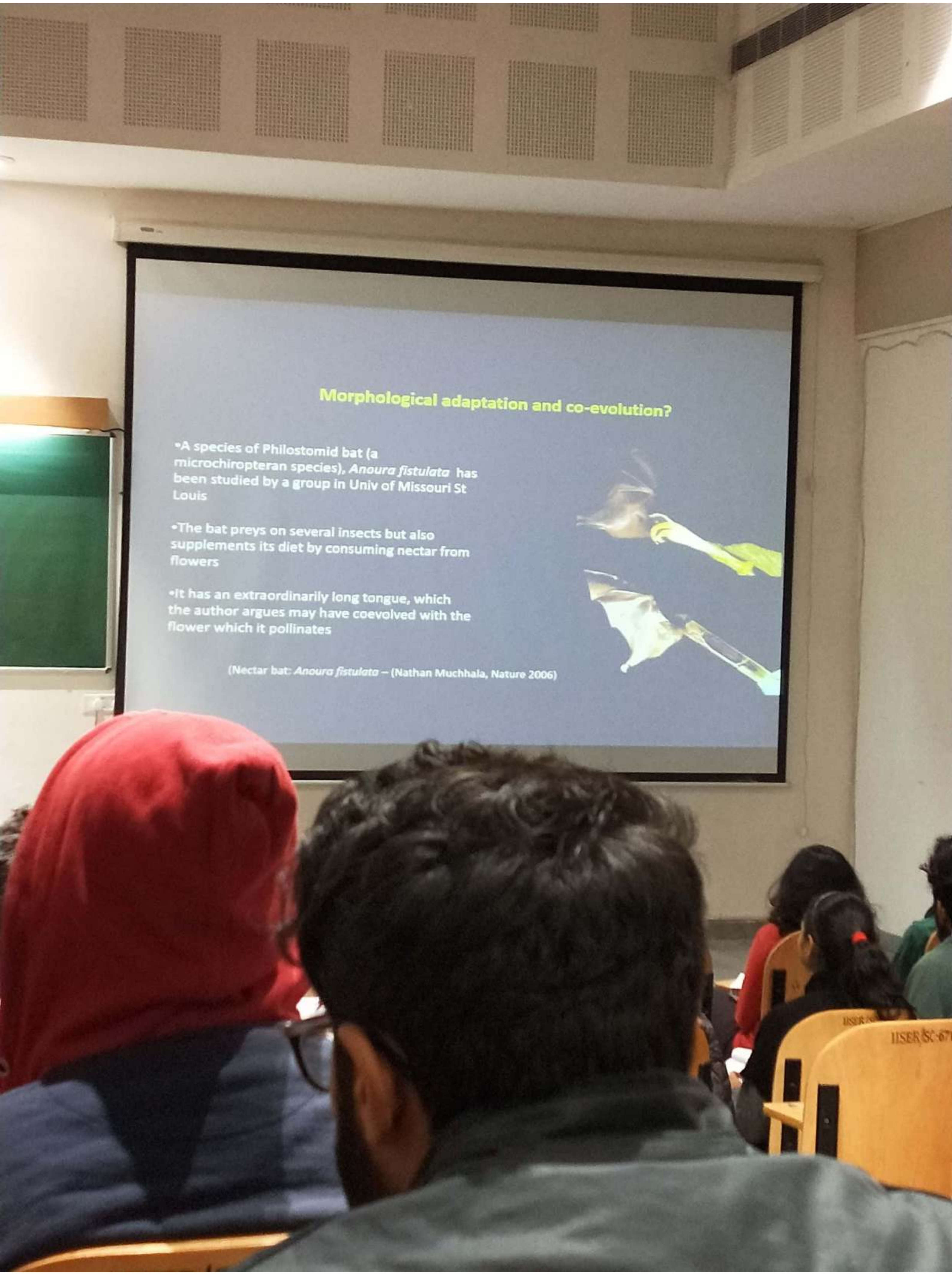

MEGACHIROPTERA
(fruit bats)
MICROCHIROPTERA
(insectivorous bats)
Pic: Google Images
IISER/SC 708

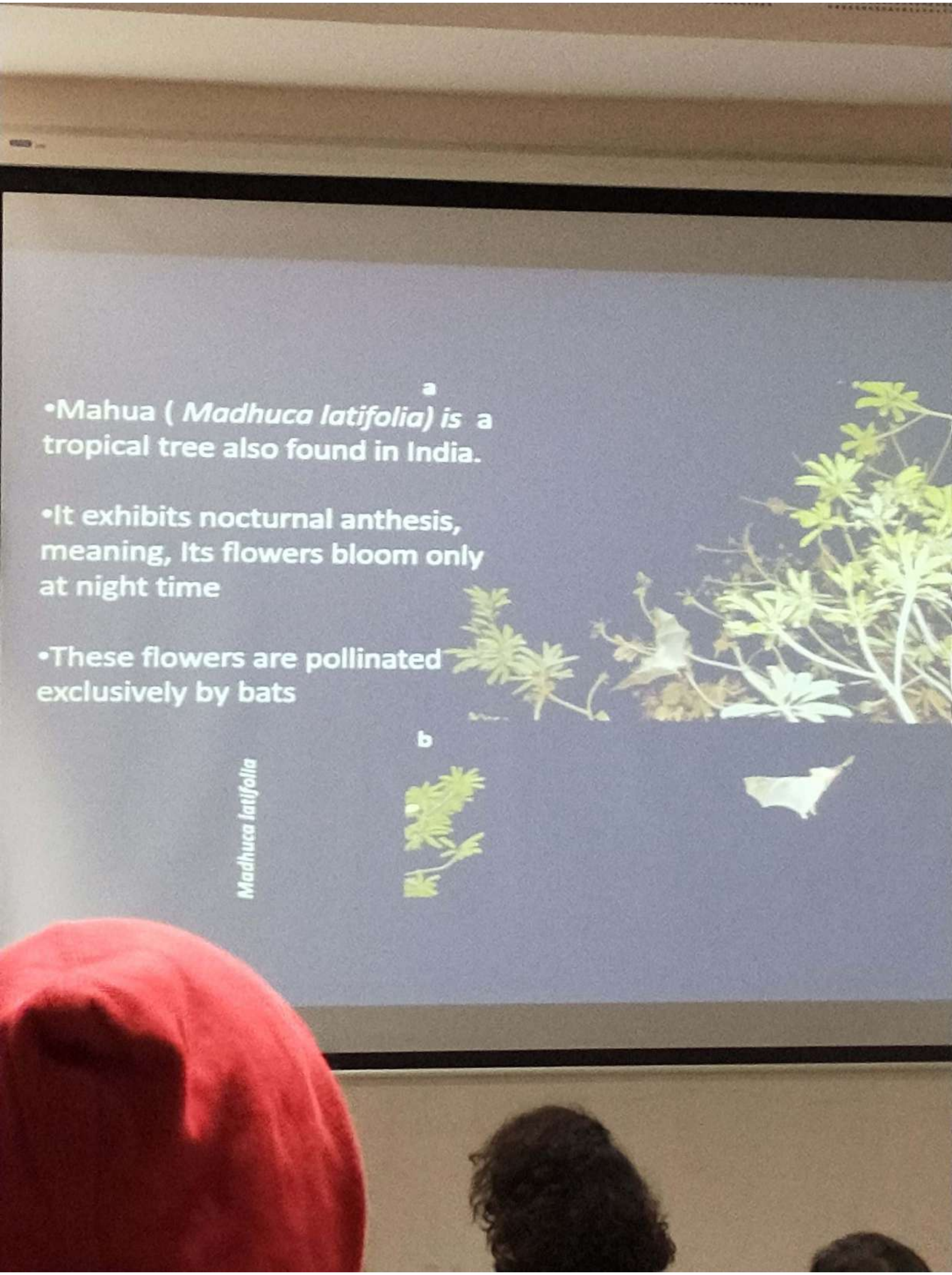

Chiropterophily: pollination of plants by bats
•More than 528 species of Angiosperms worldwide are dependent on bats for pollination.
•Of these 528, 168 are pollinated by Megachiropteran Bats
•Remaining 360 species are pollinated by Microchiropterans
(Fleming et al. 2009)
Musa paradisiaca
IISER/SC-708

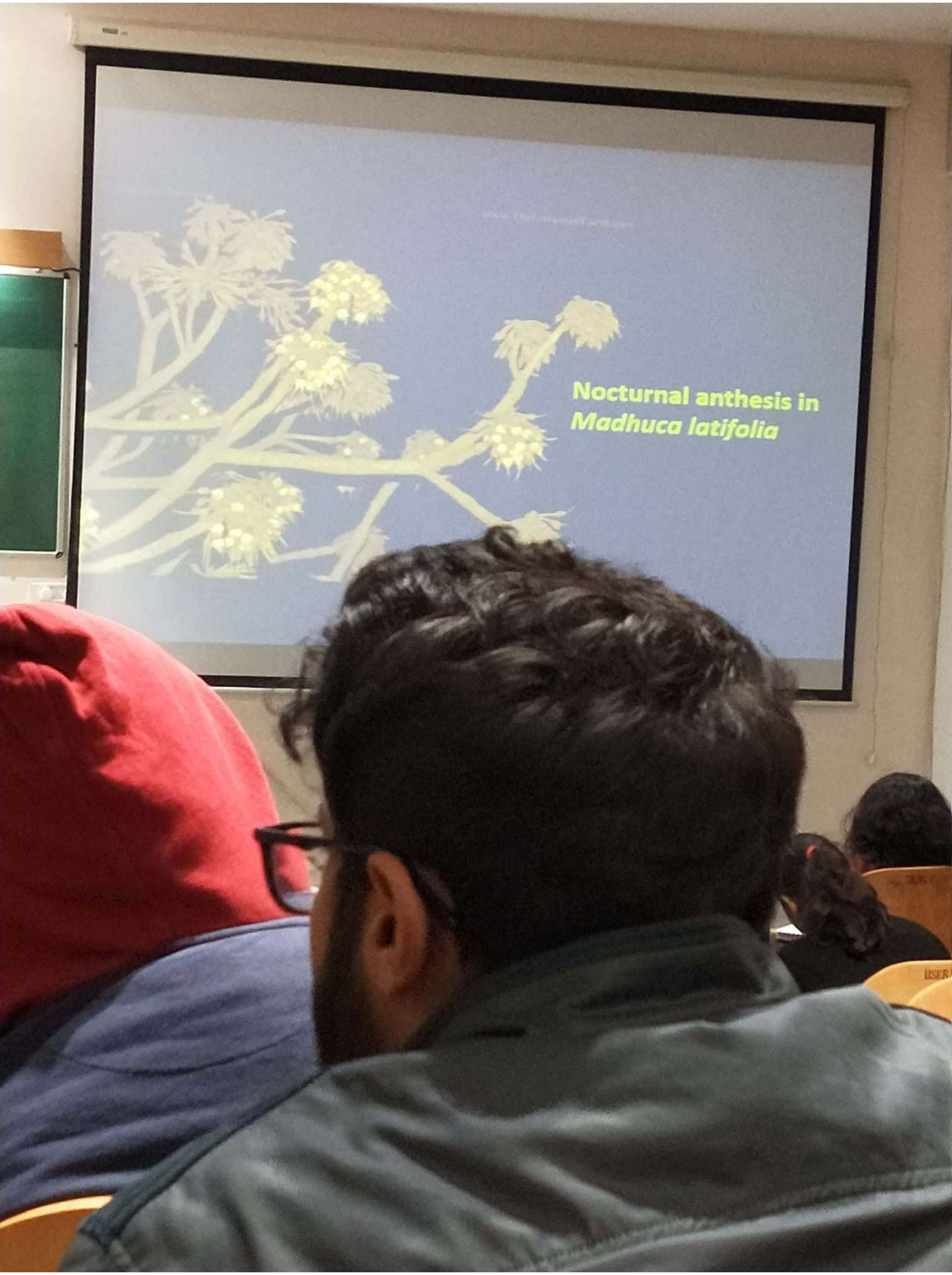

IISER/SC-671


Commensalism: sharing a table
Commensalism: A relationship where one organism benefits and other does not benefit but is not harmed either.
Shark and Remora fish interaction
Remora fishes are commensals
Free ride and left over food from their hosts
Shark unaffected by their presence

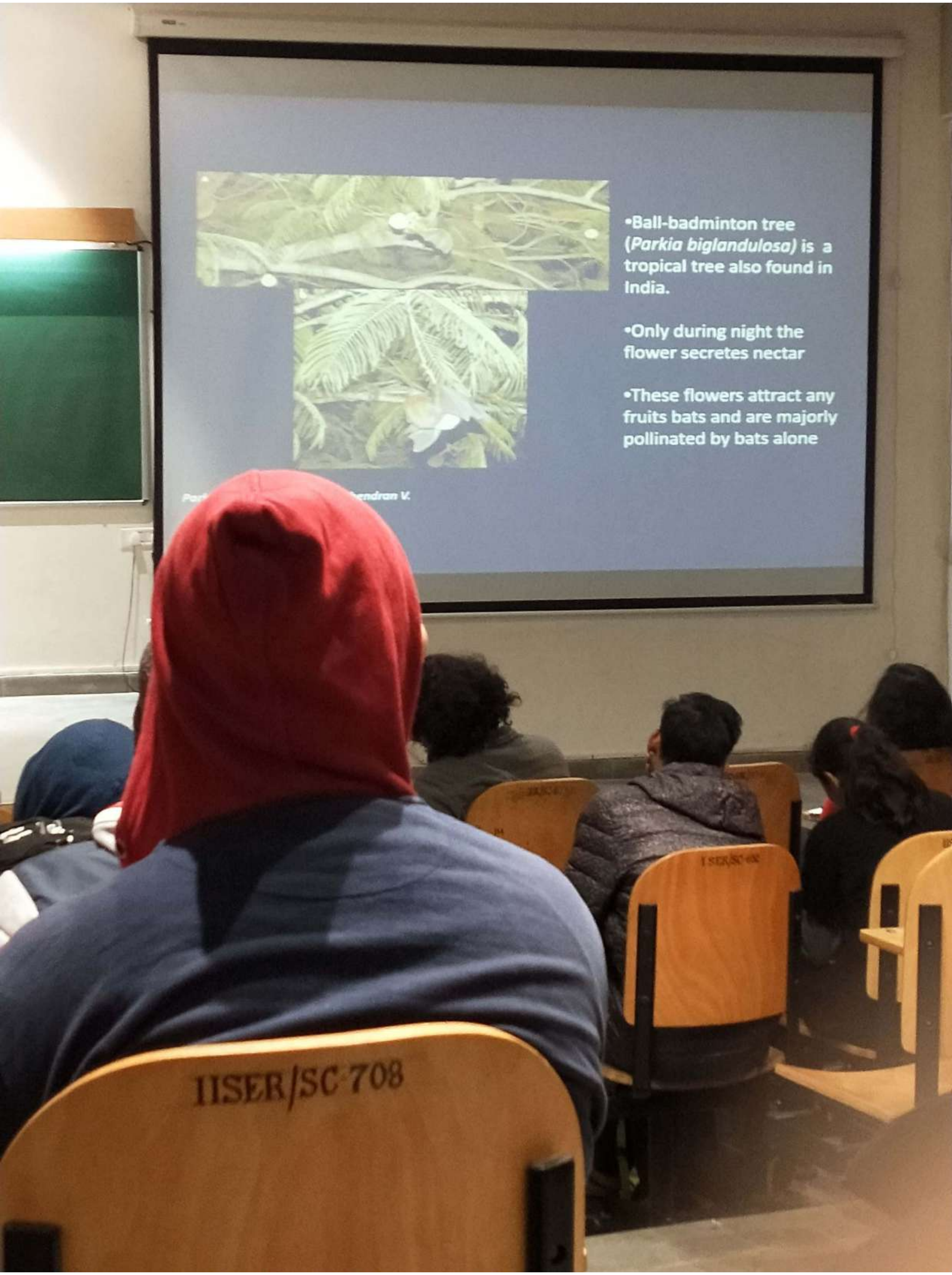

Ecological Interactions
• Competition
• Mutualism
• Parasitism
• Commensalism
• Predation
IISER/SC-708


Morphological adaptation and co-evolution?
•A species of Philostomid bat (a microchiropteran species), Anoura fistulata has been studied by a group in Univ of Missouri St Louis
•The bat preys on several insects but also supplements its diet by consuming nectar from flowers
•It has an extraordinarily long tongue, which the author argues may have coevolved with the flower which it pollinates
(Nectar bat: Anoura fistulata – (Nathan Muchhala, Nature 2006)
IISER/SC-67

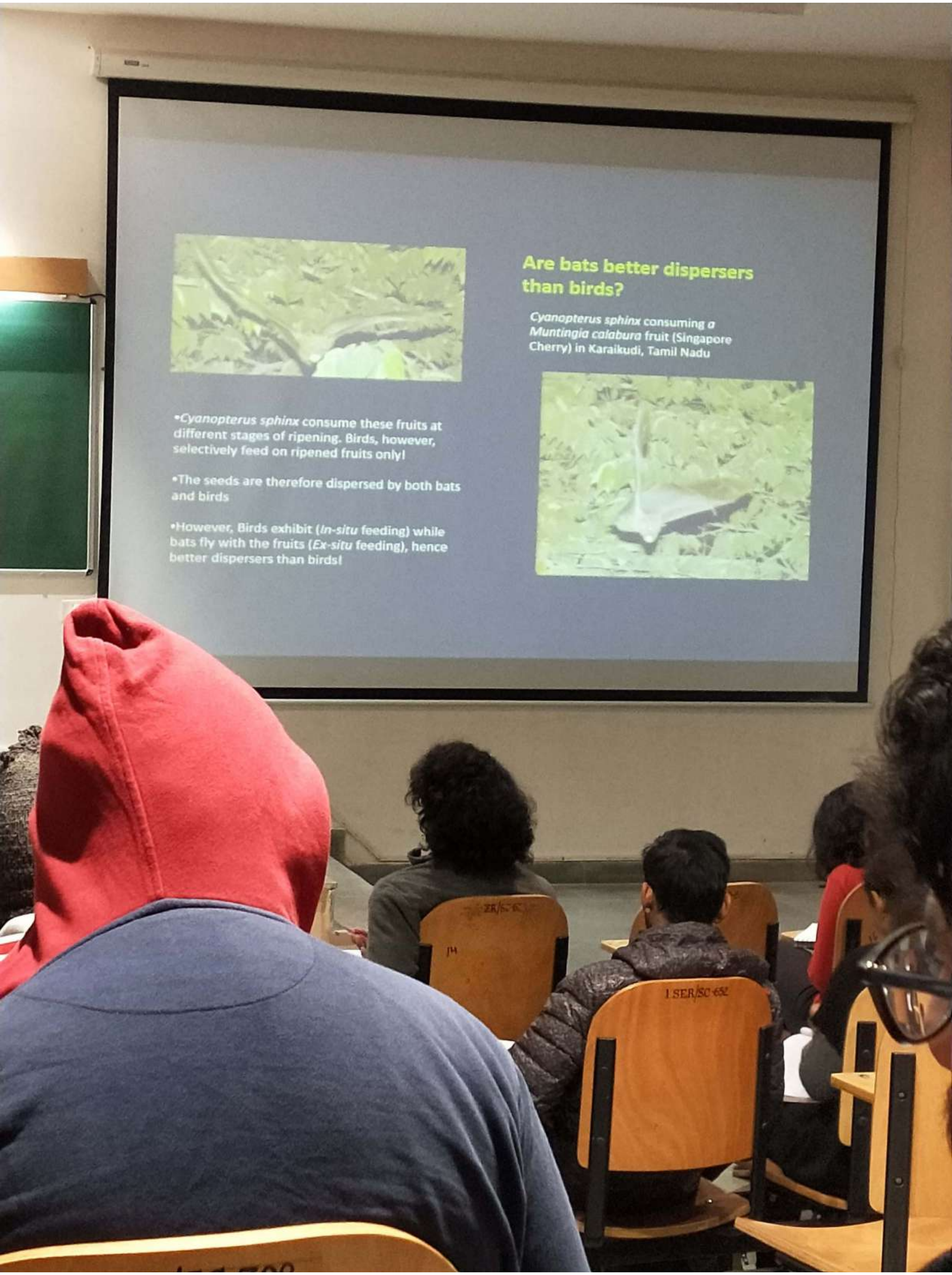

•Mahua (*Madhuca latifolia) is* a tropical tree also found in India.
•It exhibits nocturnal anthesis, meaning, Its flowers bloom only at night time
•These flowers are pollinated exclusively by bats
a
b
Madhuca latifolia


Nocturnal anthesis in
Madhuca latifolia

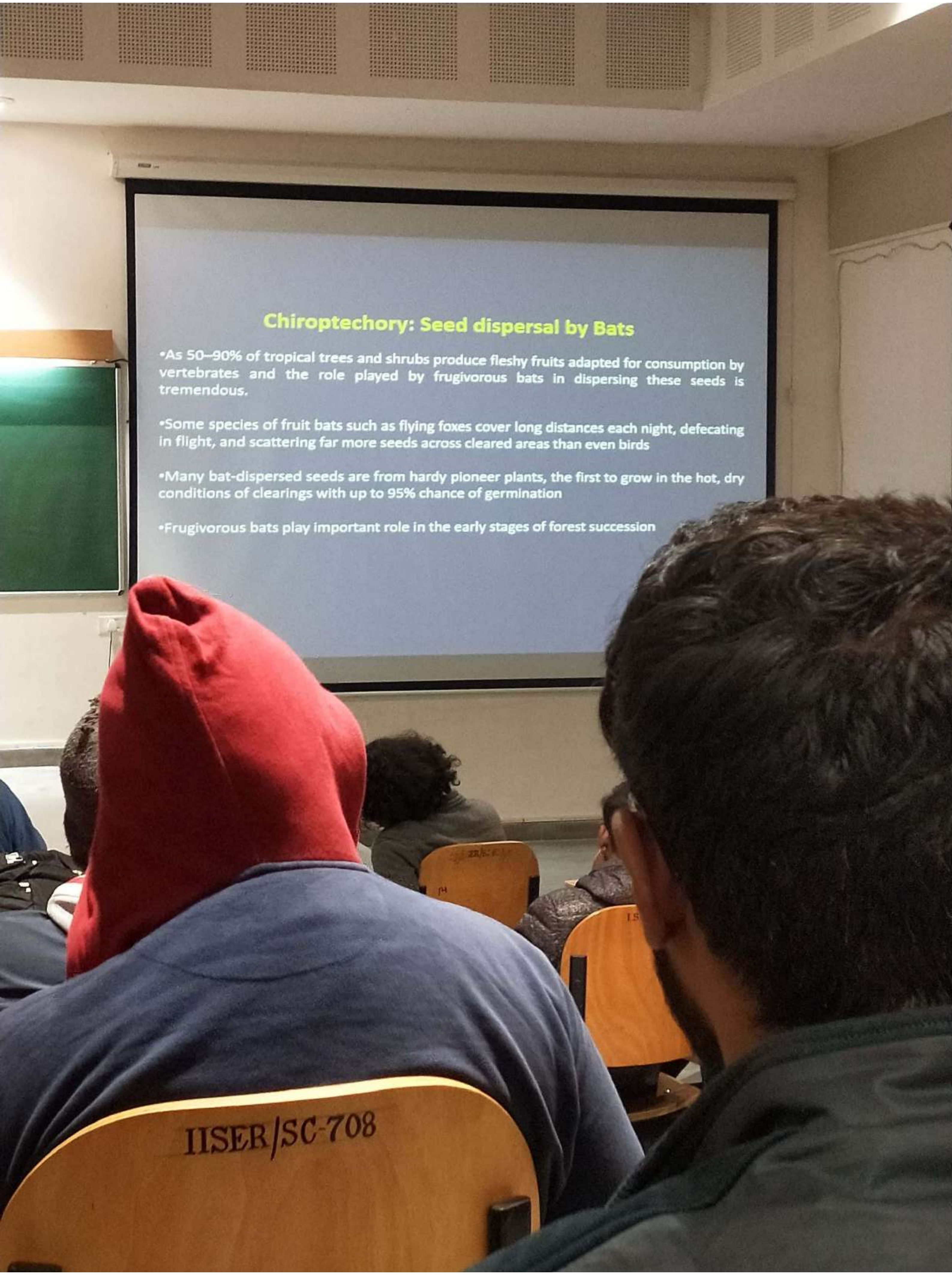

Parasitism
An ecological interaction in which one species benefits at the cost of the other. It is a negative interaction
IISER/SC-708

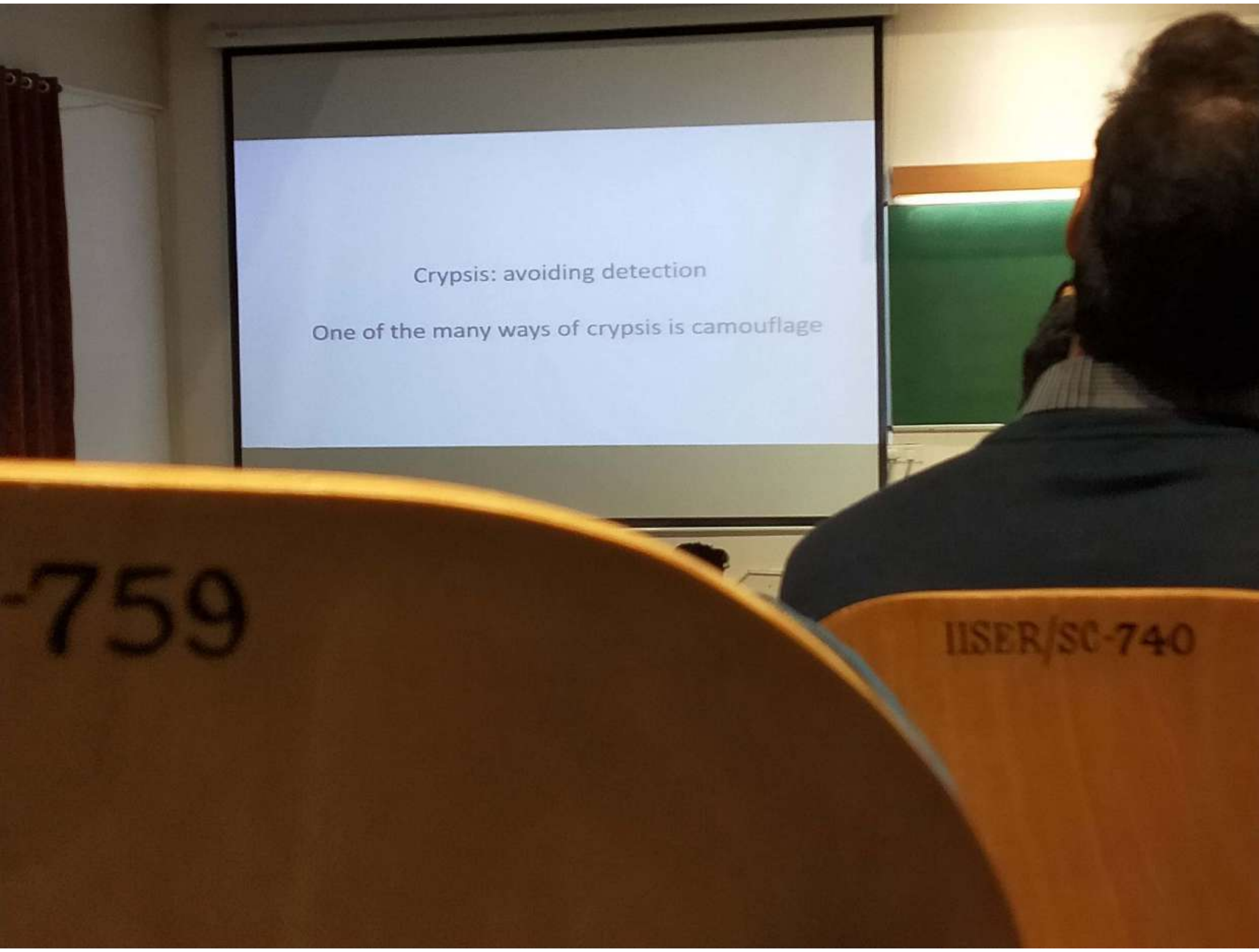

•Ball-badminton tree (*Parkia biglandulosa*) is a tropical tree also found in India.
•Only during night the flower secretes nectar
•These flowers attract any fruits bats and are majorly pollinated by bats alone
IISER/SC 708

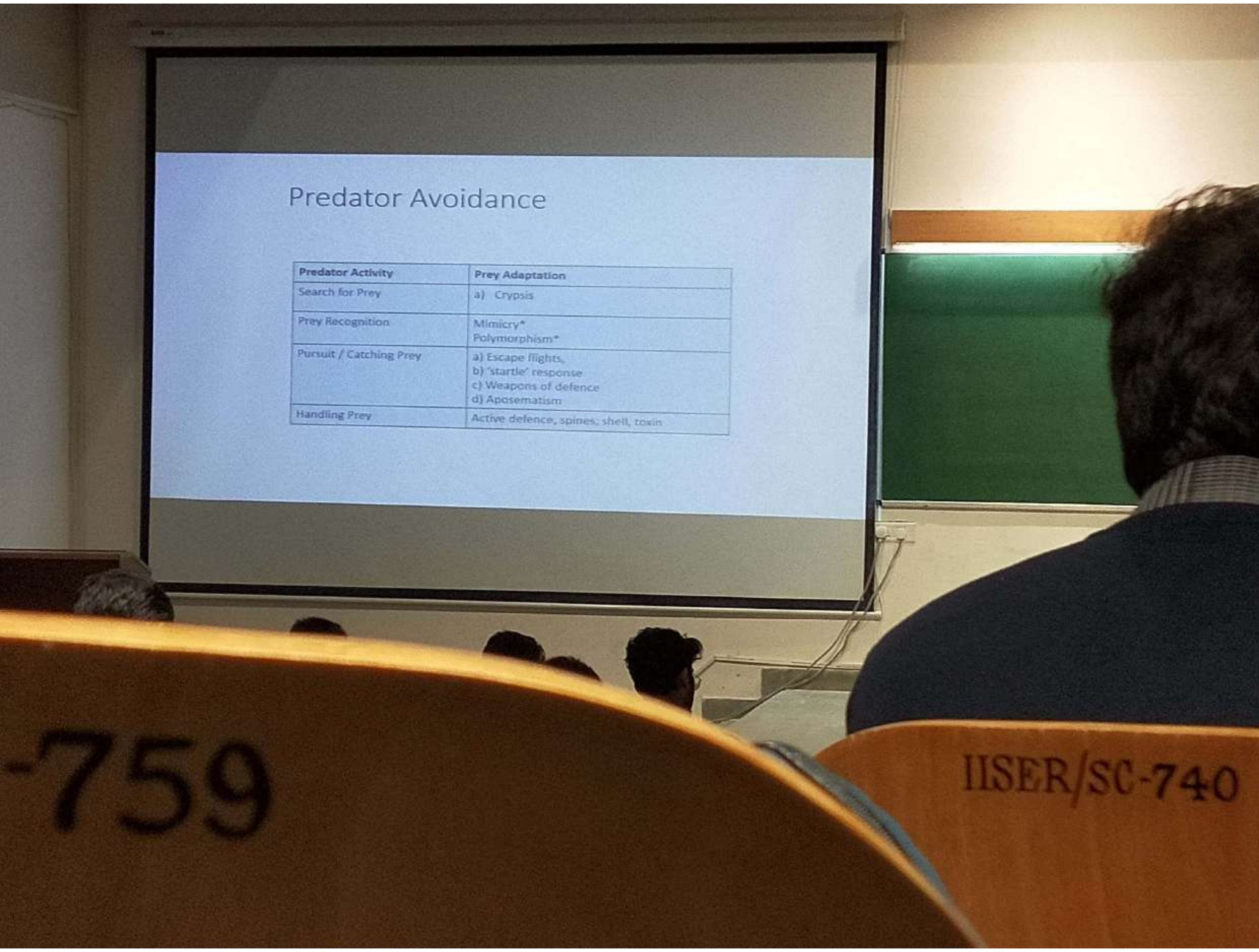

Orchids growing on branches of trees
• Orchids are usually found in dense tropical forests.
• They form their base of attachment on the branches of trees, and benefit by getting adequate sunlight and nutrition that flows down the branches.
• The orchids do not grow to a large size, and thus the host tree is not harmed in any way.
IISER/SC-708


Are bats better dispersers than birds?
Cyanopterus sphinx consuming a Muntingia calabura fruit (Singapore Cherry) in Karaikudi, Tamil Nadu
•Cyanopterus sphinx consume these fruits at different stages of ripening. Birds, however, selectively feed on ripened fruits only!
•The seeds are therefore dispersed by both bats and birds
•However, Birds exhibit (In-situ feeding) while bats fly with the fruits (Ex-situ feeding), hence better dispersers than birds!

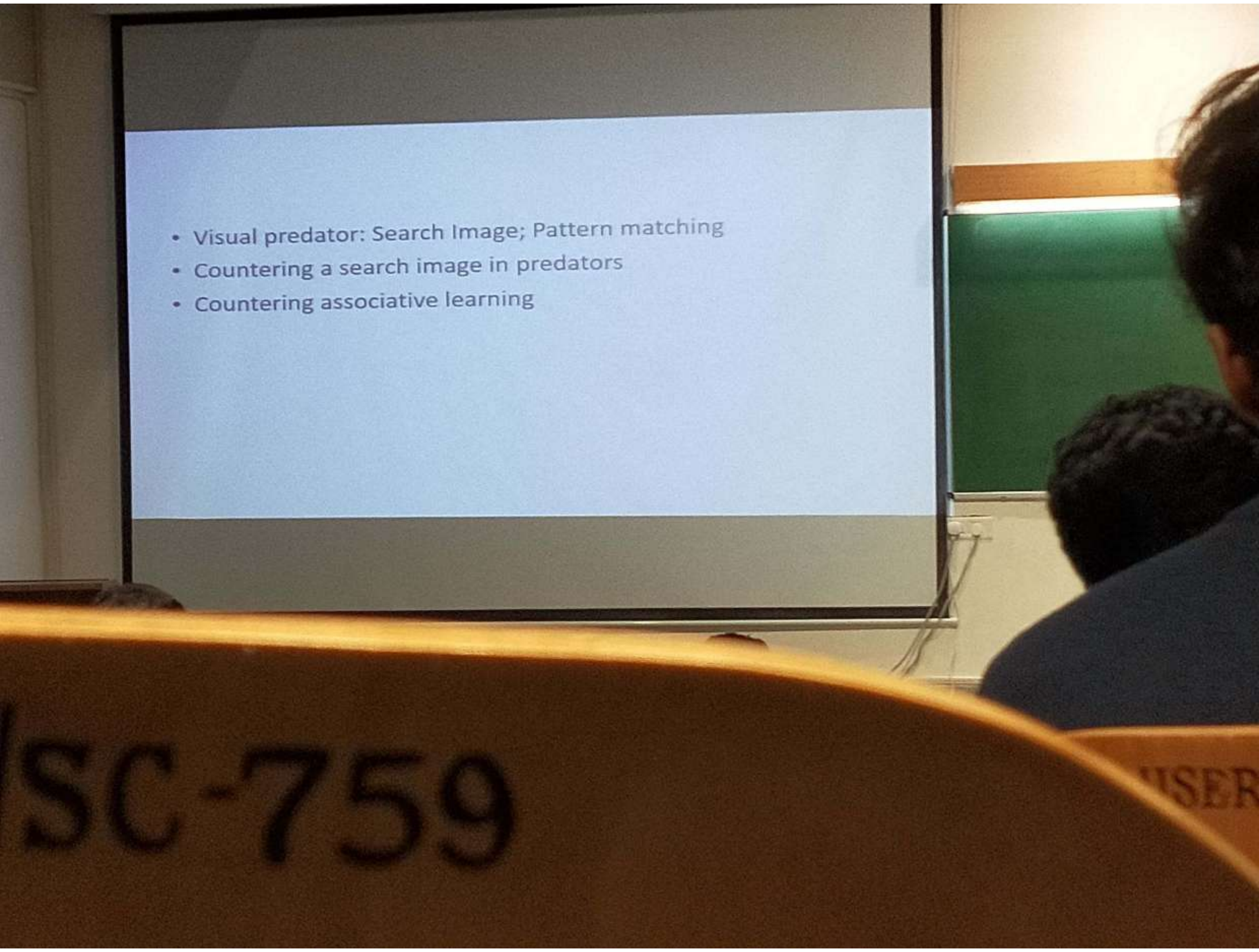

Seeds of Madhuca latifolia,
(Mahua) are also dispersed
exclusively by bats.


Chiroptechory: Seed dispersal by Bats
•As 50–90% of tropical trees and shrubs produce fleshy fruits adapted for consumption by vertebrates and the role played by frugivorous bats in dispersing these seeds is tremendous.
•Some species of fruit bats such as flying foxes cover long distances each night, defecating in flight, and scattering far more seeds across cleared areas than even birds
•Many bat-dispersed seeds are from hardy pioneer plants, the first to grow in the hot, dry conditions of clearings with up to 95% chance of germination
•Frugivorous bats play important role in the early stages of forest succession
IISER/SC-708

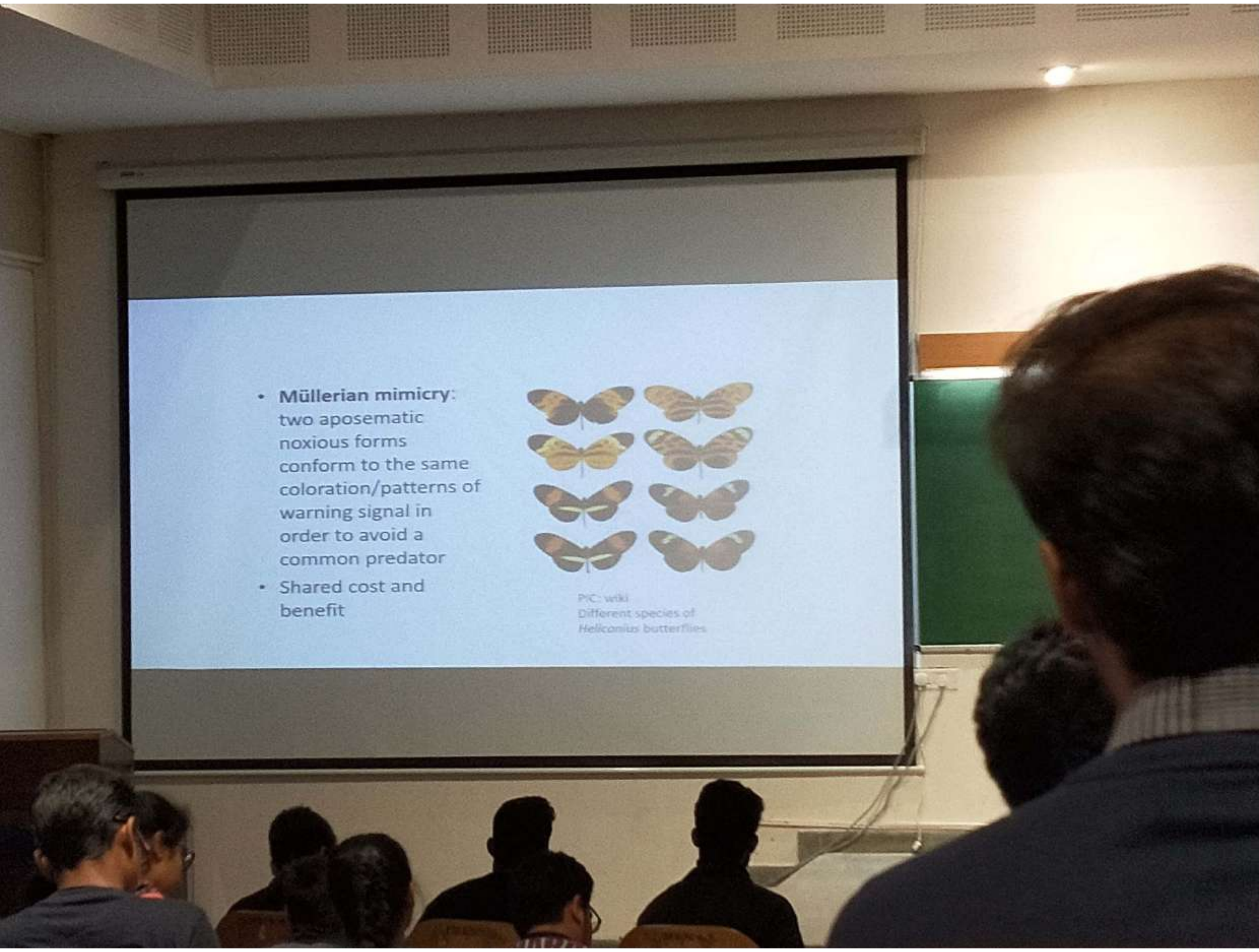

Crypsis: avoiding detection
One of the many ways of crypsis is camouflage
-759
IISER/SC-740

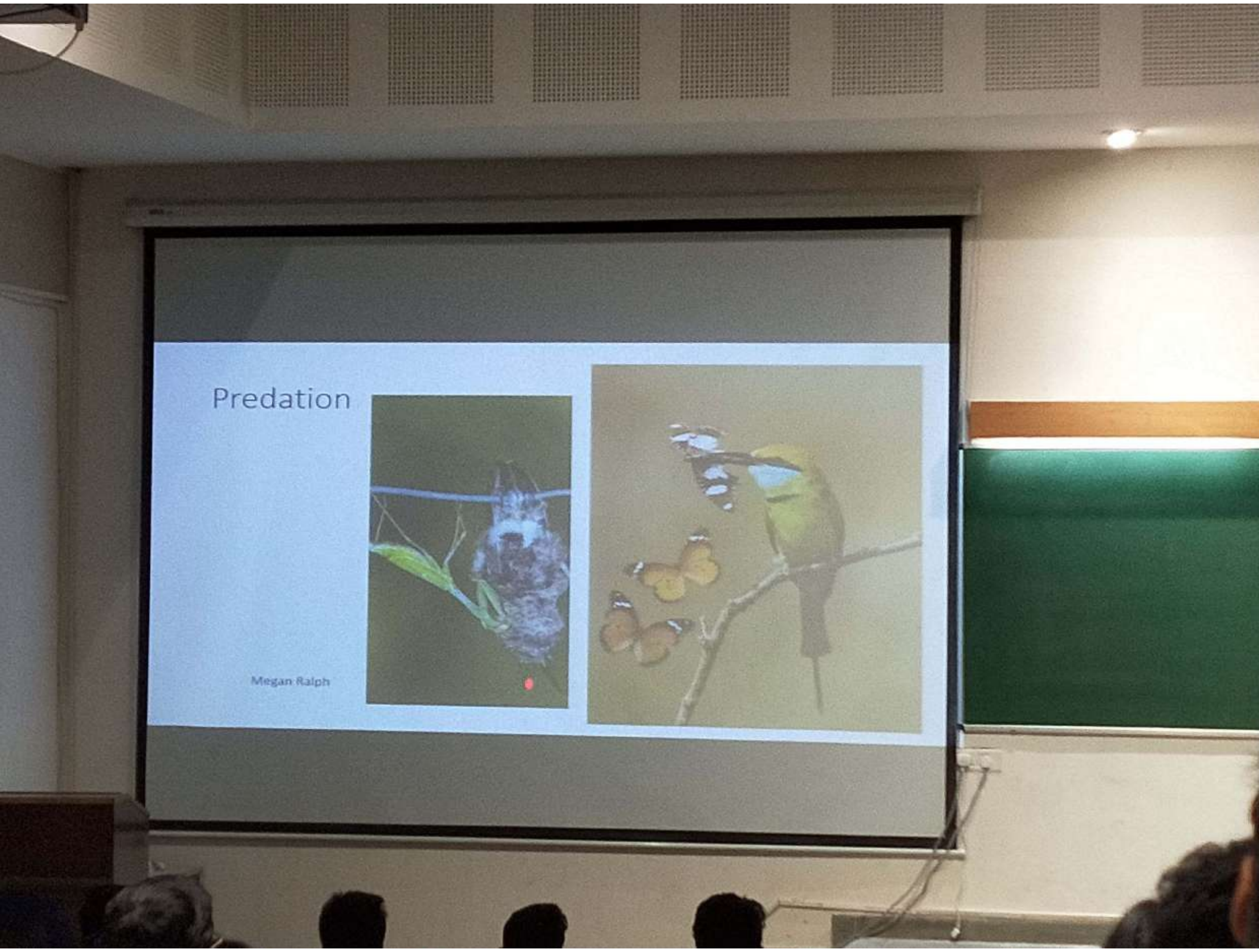

Predator Avoidance
Predator Activity
Prey Adaptation
Search for Prey
a) Crypsis
Prey Recognition
Mimicry*
Polymorphism*
Pursuit / Catching Prey
a) Escape flights,
b) 'startle' response
c) Weapons of defence
d) Aposematism
Handling Prey
Active defence, spines, shell, toxin
-759
IISER/SC-740

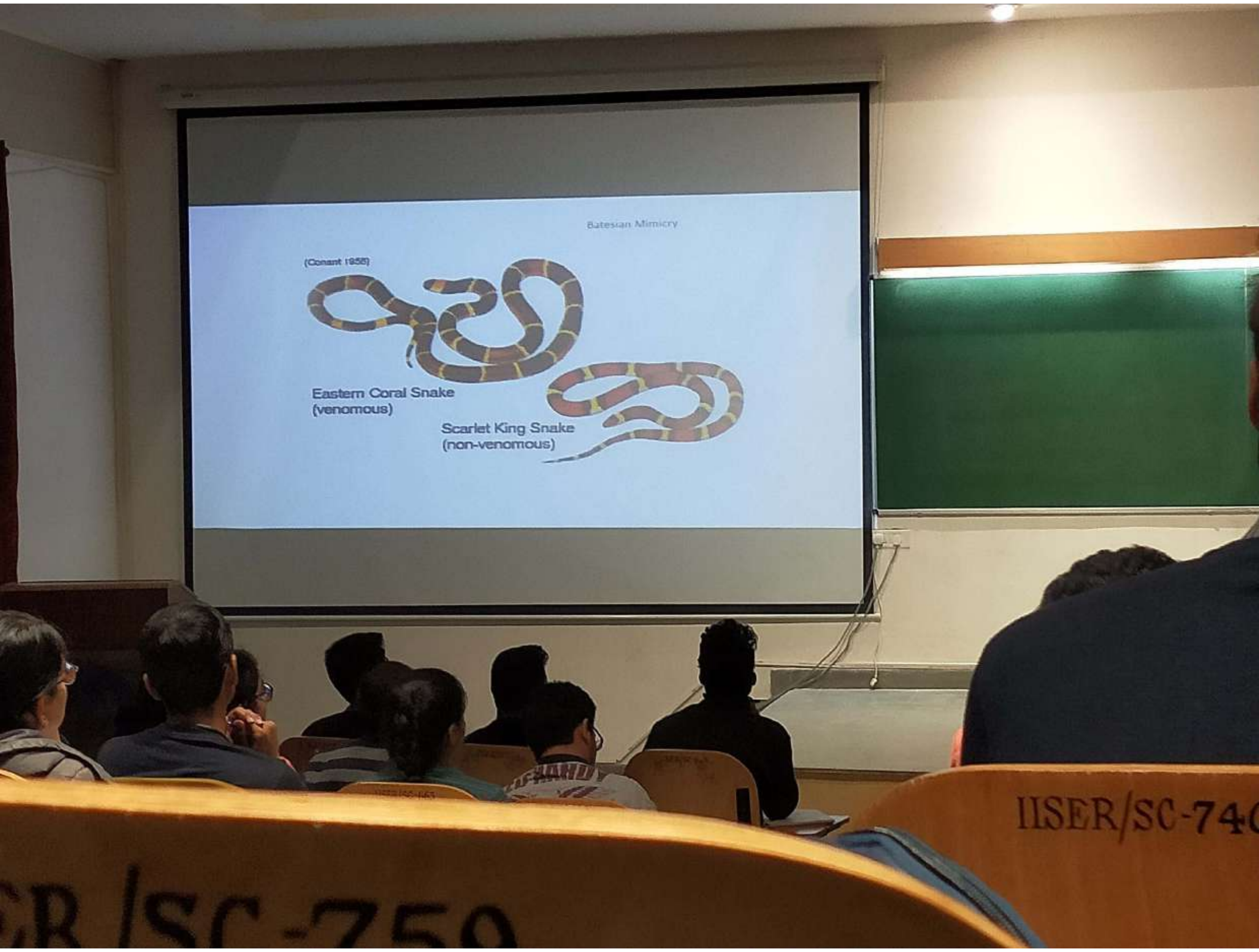

Polymorphism: predator search image
1) Visual predators that exploit polymorphic prey suffer from reduced performance
2) This happens due to the reduction of predator's ability for associative learning due to an overabundance of form
3) Support for hypothesis that prey colour polymorphism may afford protection against predators for both individuals and populations.
4) This protective effect provides a probable explanation for the longstanding, evolutionary puzzle of the existence of colour polymorphisms.
Karpestam et al 2016

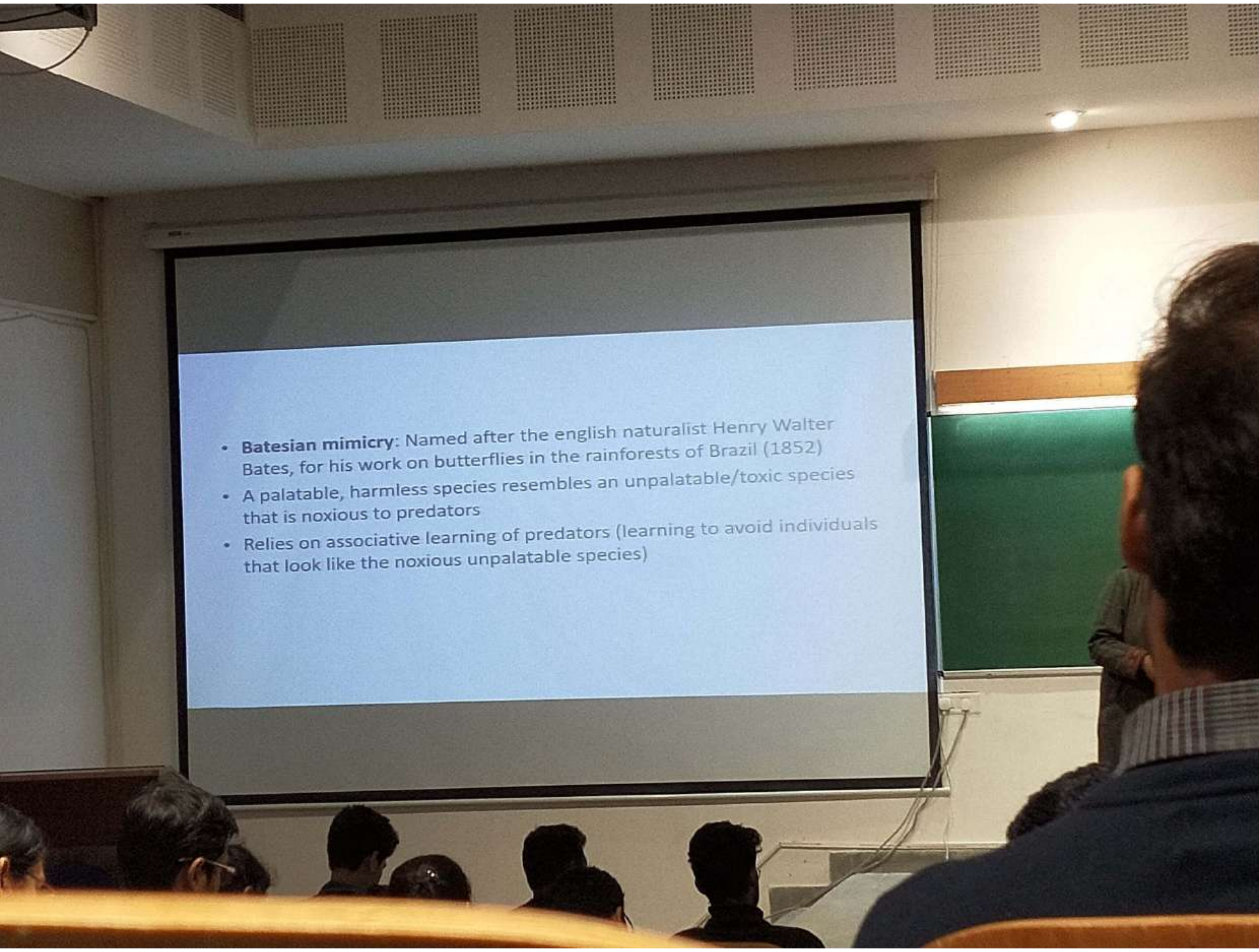


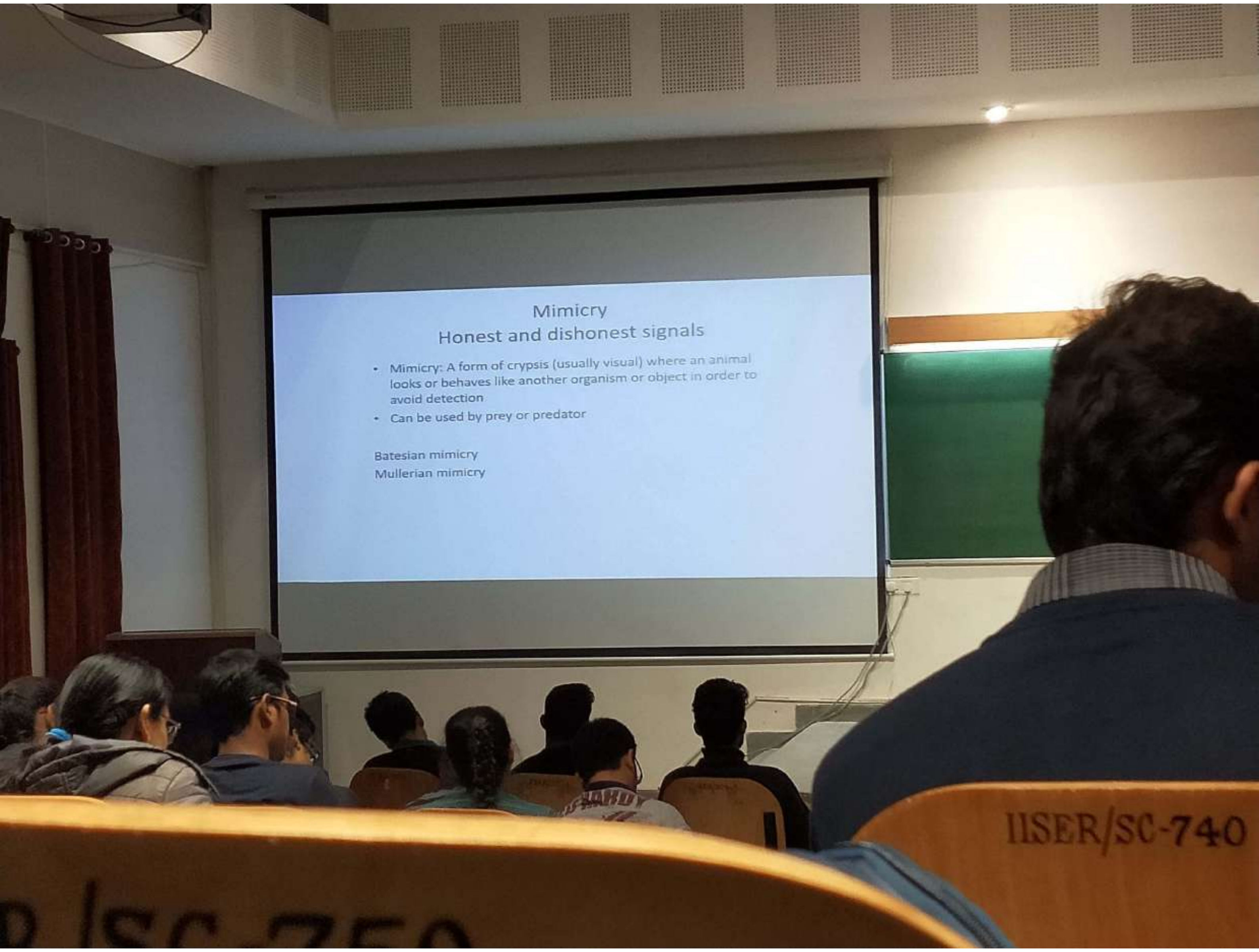
• Visual predator: Search Image; Pattern matching
• Countering a search image in predators
• Countering associative learning
ISC-759


Müllerian mimicry: two aposematic noxious forms conform to the same coloration/patterns of warning signal in order to avoid a common predator
Shared cost and benefit
PIC: wiki
Different species of
Heliconius butterflies

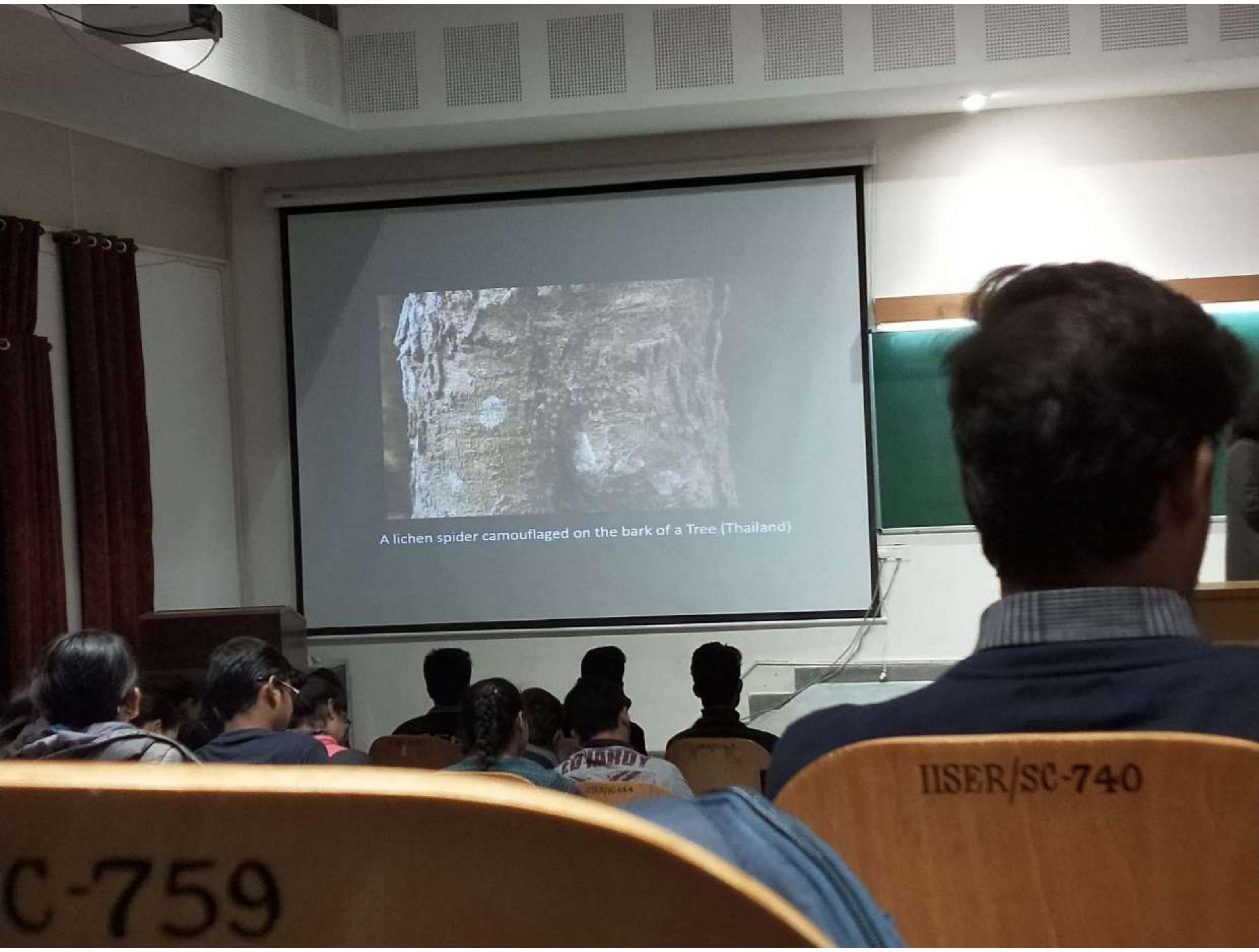

Predation
Megan Ralph

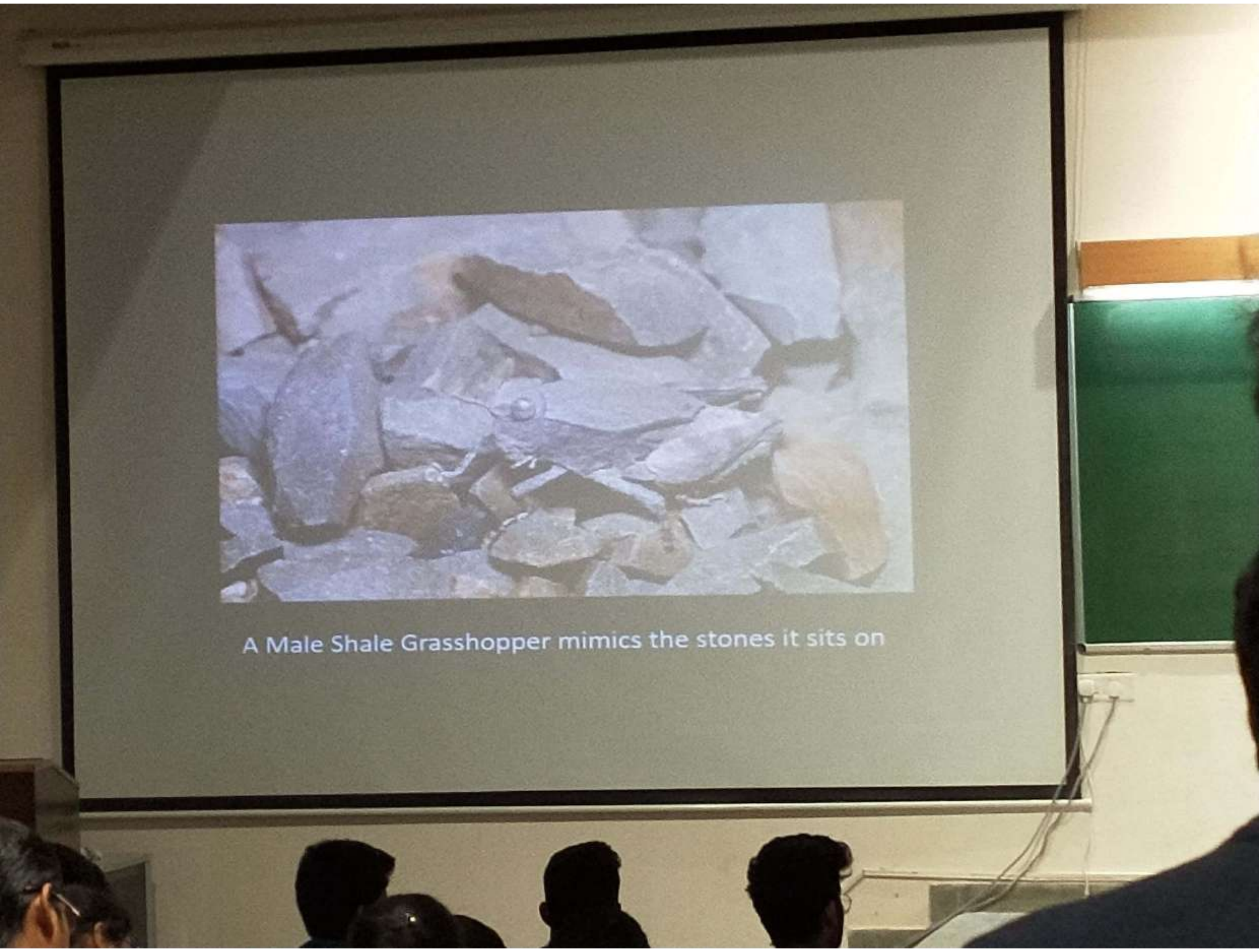

Batesian Mimicry
(Conant 1958)
Eastern Coral Snake
(venomous)
Scarlet King Snake
(non-venomous)
IISER/SC-740
IISER/SC-759

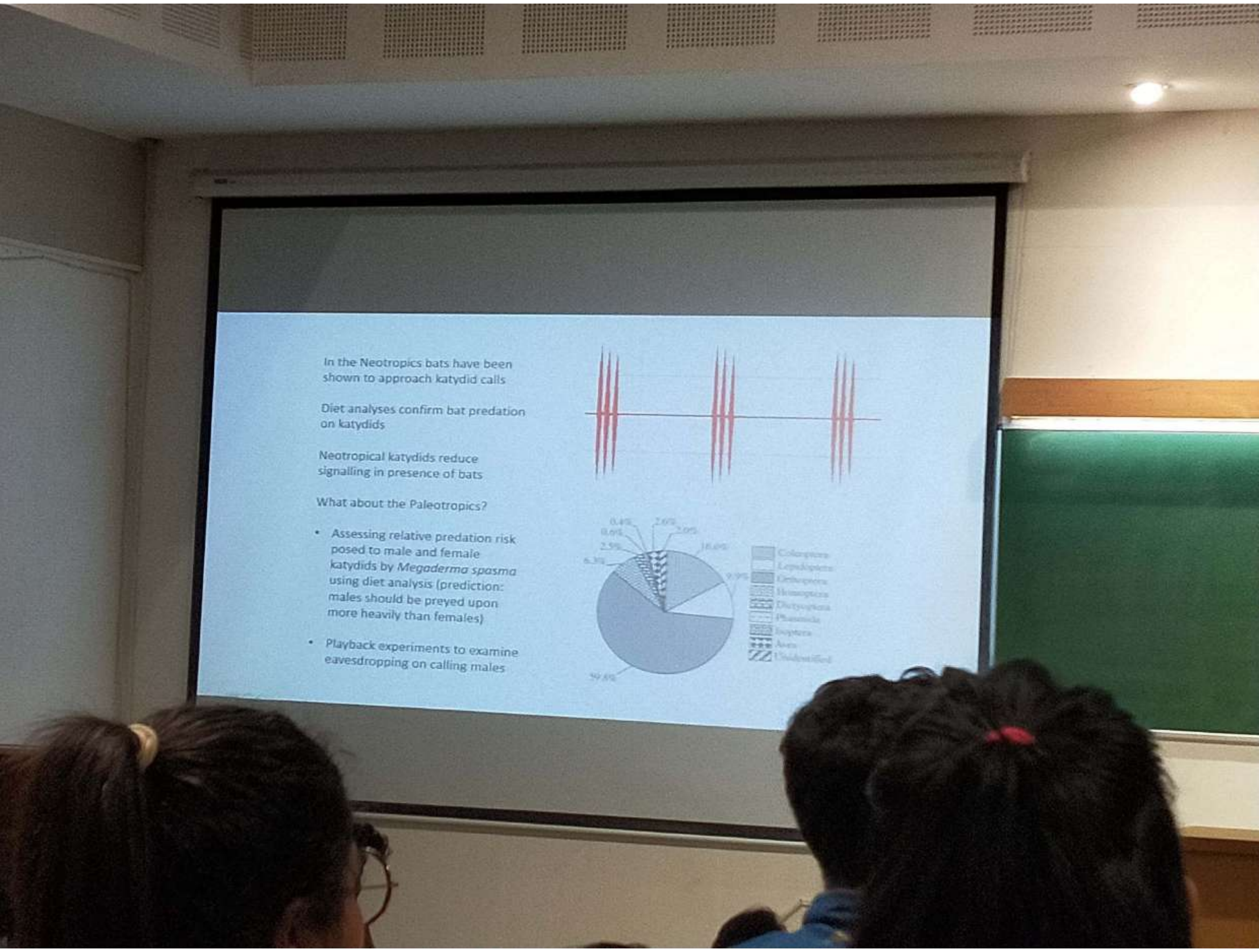

• Batesian mimicry: Named after the english naturalist Henry Walter Bates, for his work on butterflies in the rainforests of Brazil (1852)
• A palatable, harmless species resembles an unpalatable/toxic species that is noxious to predators
• Relies on associative learning of predators (learning to avoid individuals that look like the noxious unpalatable species)

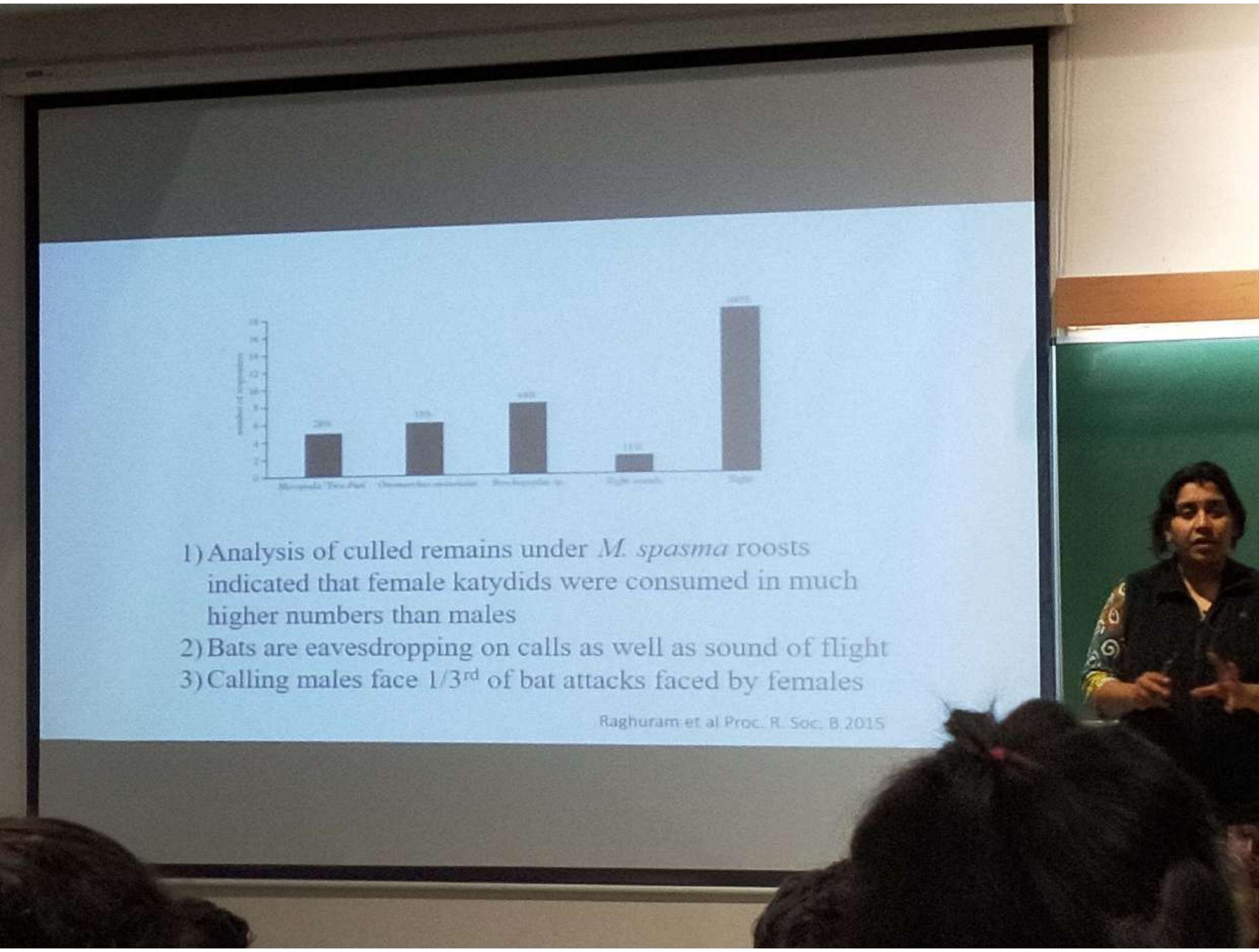

Mimicry
Honest and dishonest signals
Mimicry: A form of crypsis (usually visual) where an animal looks or behaves like another organism or object in order to avoid detection
Can be used by prey or predator
Batesian mimicry
Mullerian mimicry
IISER/SC-740

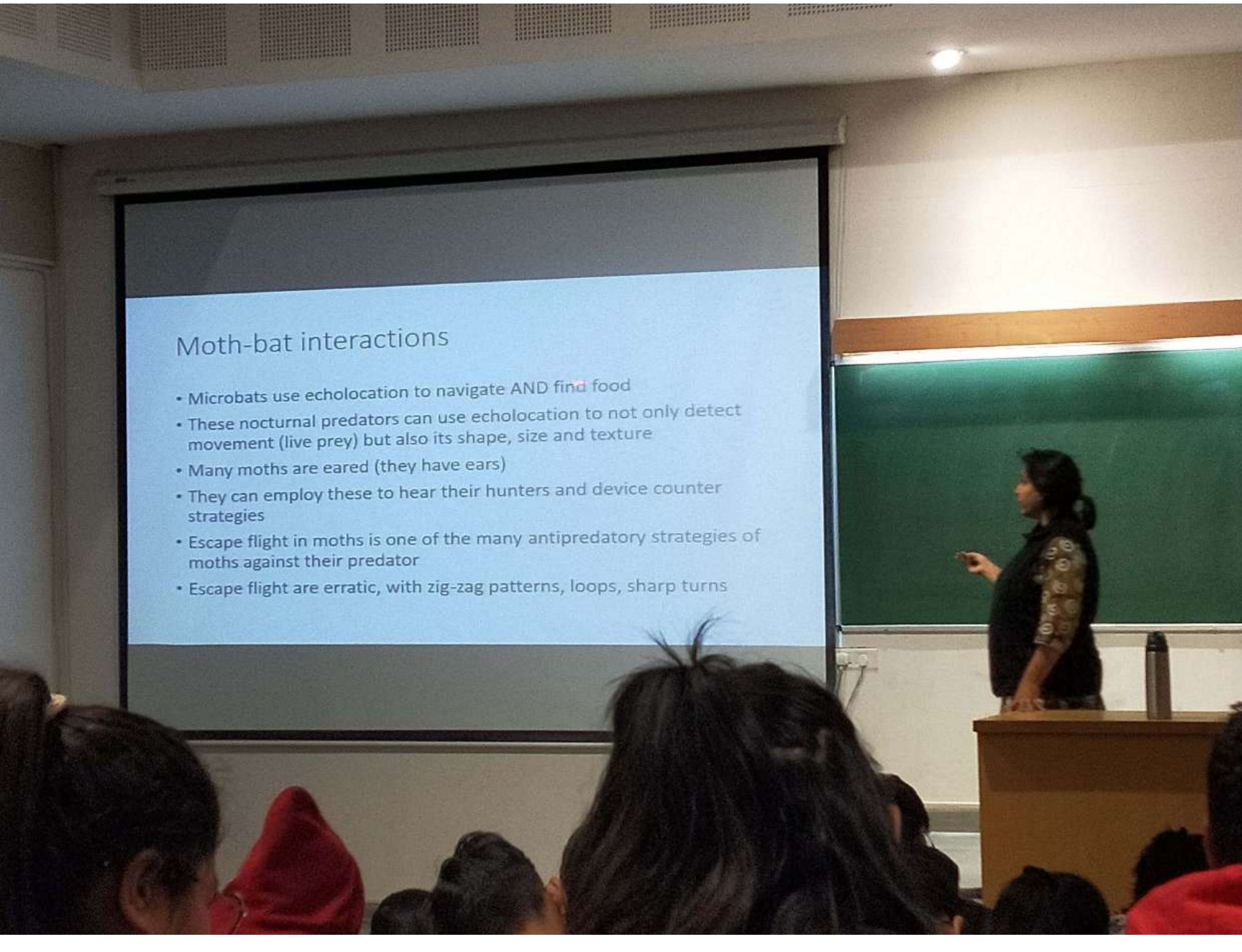

Satanic Leaf-tailed Gecko (Madagascar)
IISER/

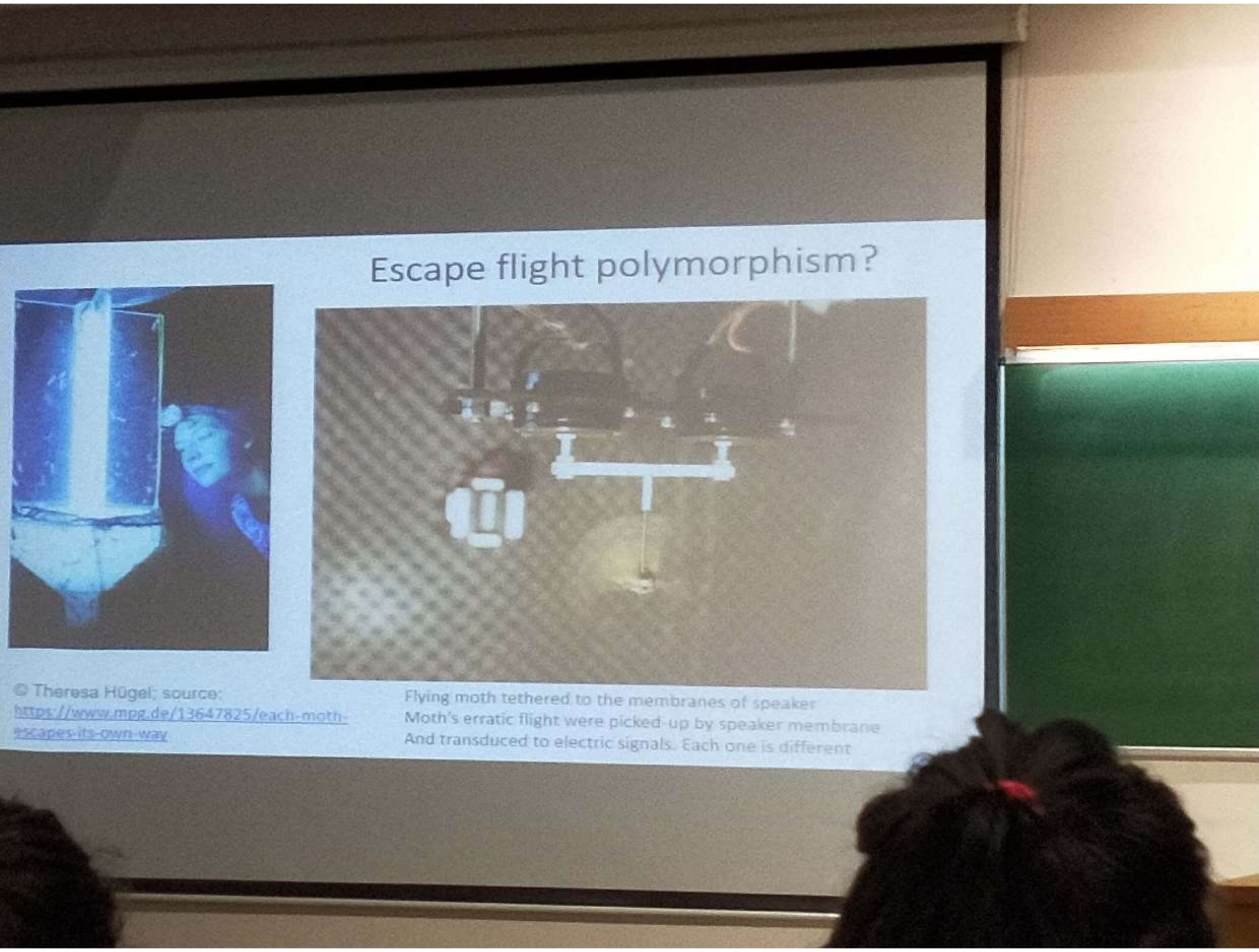

A lichen spider camouflaged on the bark of a Tree (Thailand)
IISER/SC-740
C-759

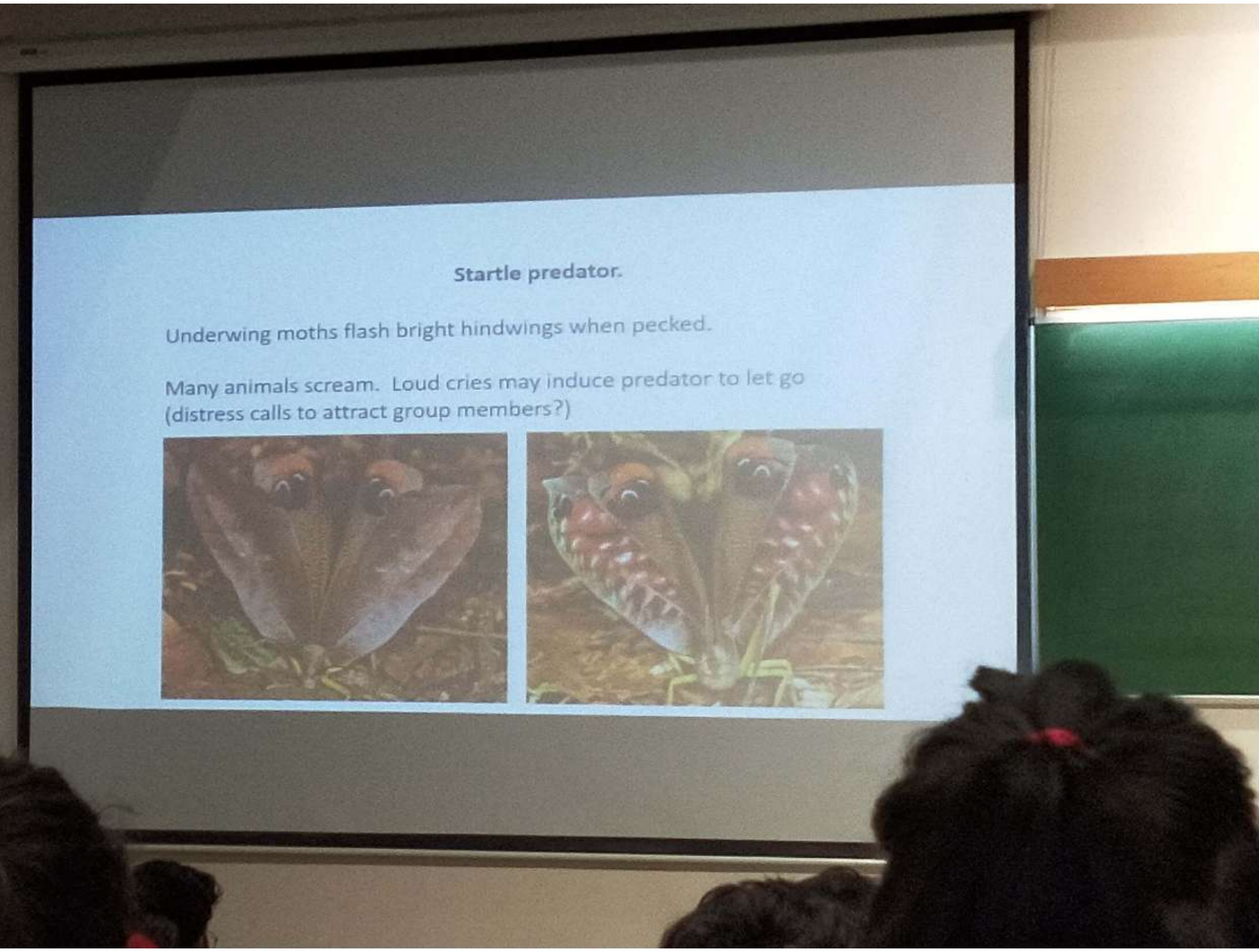

A Male Shale Grasshopper mimics the stones it sits on

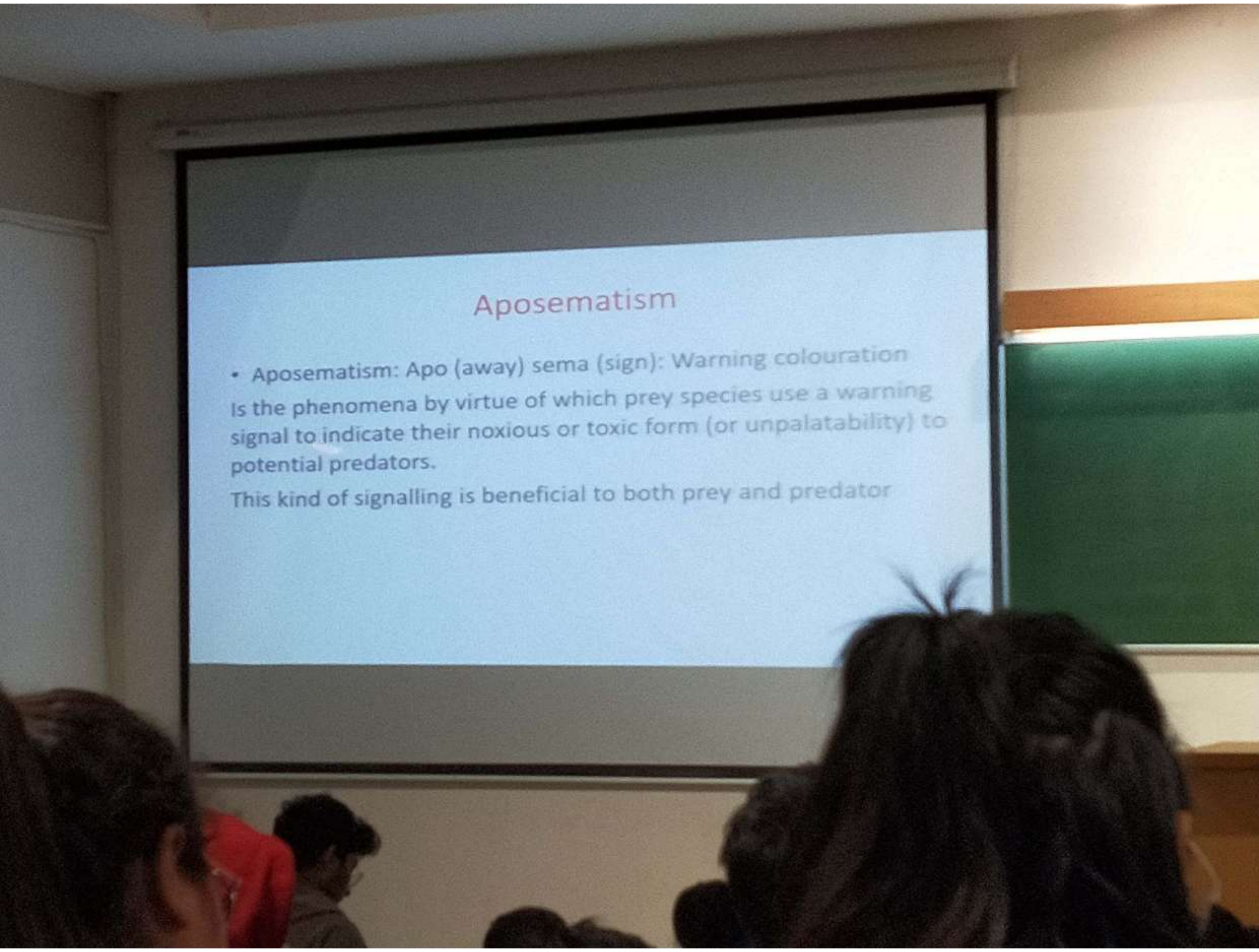

In the Neotropics bats have been shown to approach katydid calls
Diet analyses confirm bat predation on katydids
Neotropical katydids reduce signalling in presence of bats
What about the Paleotropics?
• Assessing relative predation risk posed to male and female katydids by *Megaderma spasma* using diet analysis (prediction: males should be preyed upon more heavily than females)
• Playback experiments to examine eavesdropping on calling males

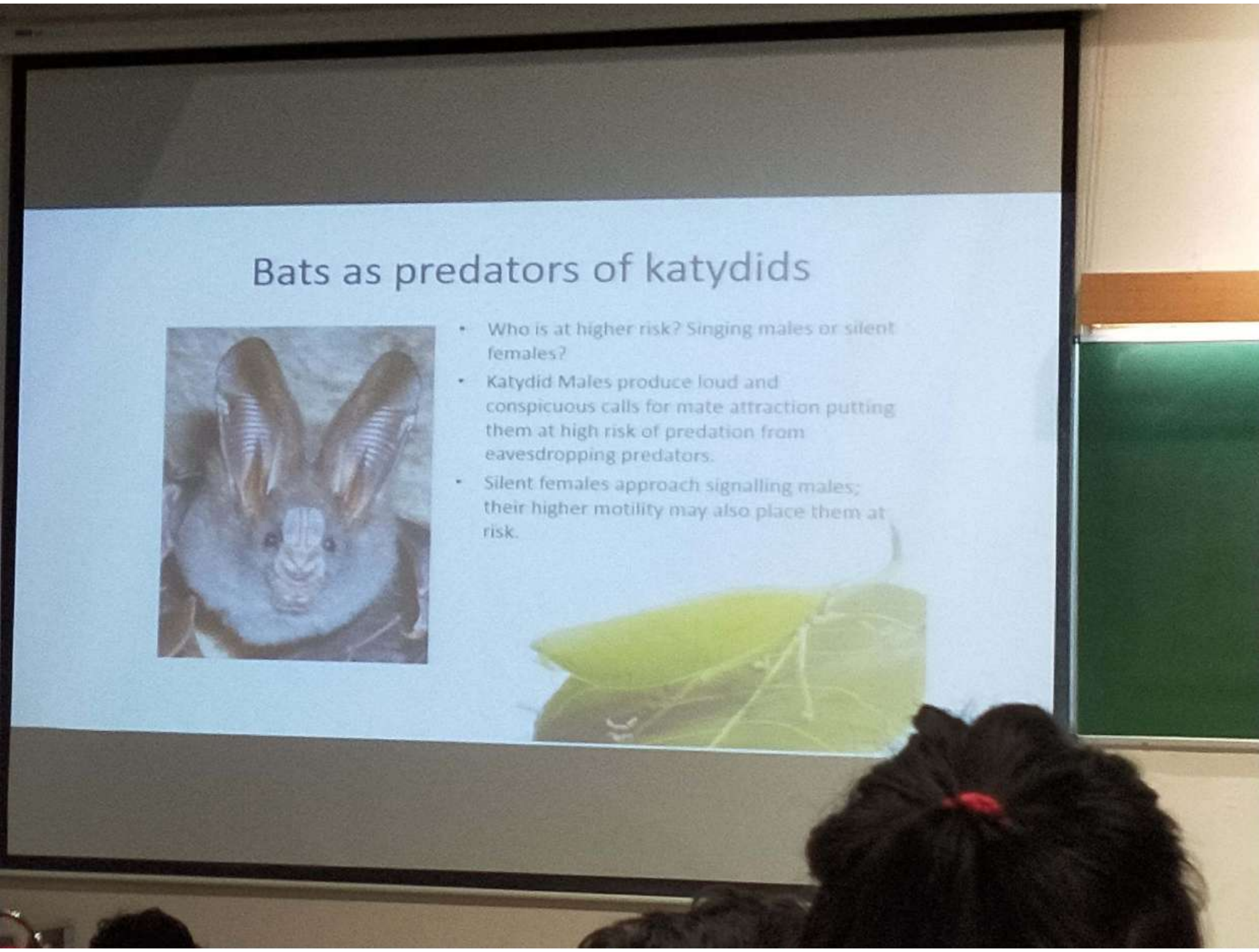

1) Analysis of culled remains under M. spasma roosts indicated that female katydids were consumed in much higher numbers than males
2) Bats are eavesdropping on calls as well as sound of flight
3) Calling males face 1/3rd of bat attacks faced by females
Raghuram et al Proc. R. Soc. B 2015


Moth-bat interactions
• Microbats use echolocation to navigate AND find food
• These nocturnal predators can use echolocation to not only detect movement (live prey) but also its shape, size and texture
• Many moths are eared (they have ears)
• They can employ these to hear their hunters and device counter strategies
• Escape flight in moths is one of the many antipredatory strategies of moths against their predator
• Escape flight are erratic, with zig-zag patterns, loops, sharp turns

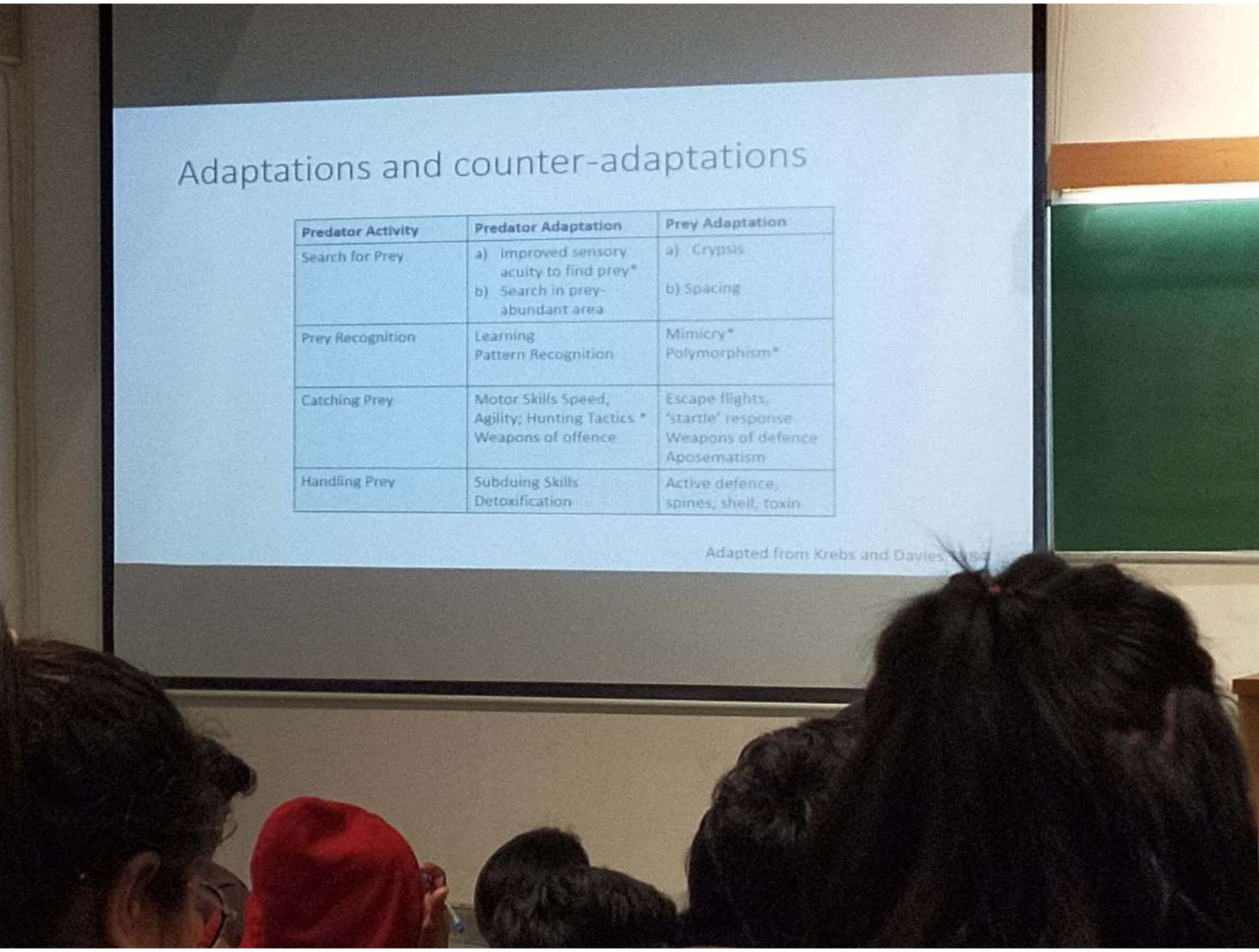

Escape flight polymorphism?
© Theresa Hügel; source:
https://www.mpg.de/13647825/each-moth-escapes-its-own-way
Flying moth tethered to the membranes of speaker
Moth's erratic flight were picked-up by speaker membrane
And transduced to electric signals. Each one is different

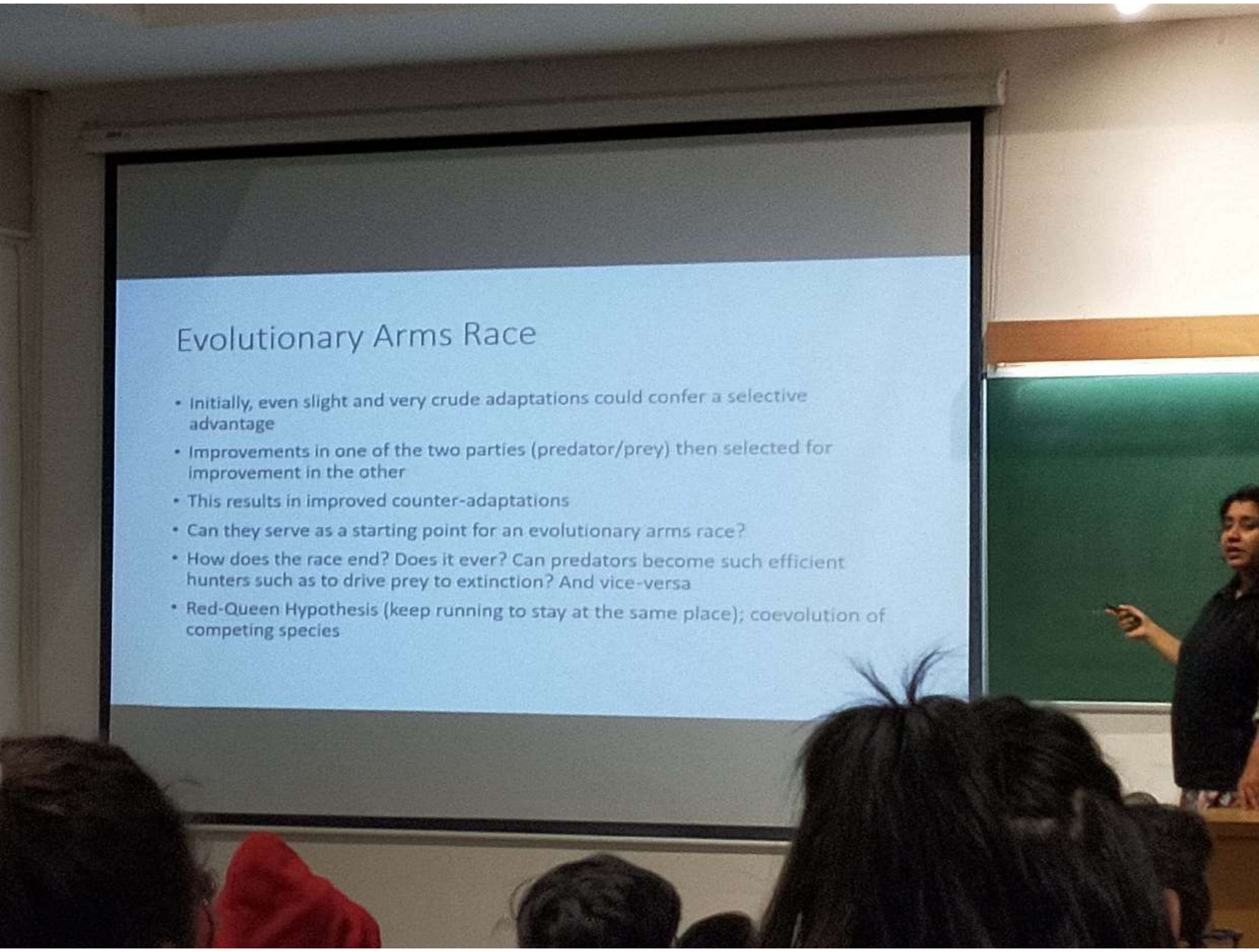

Startle predator.
Underwing moths flash bright hindwings when pecked.
Many animals scream. Loud cries may induce predator to let go
(distress calls to attract group members?)

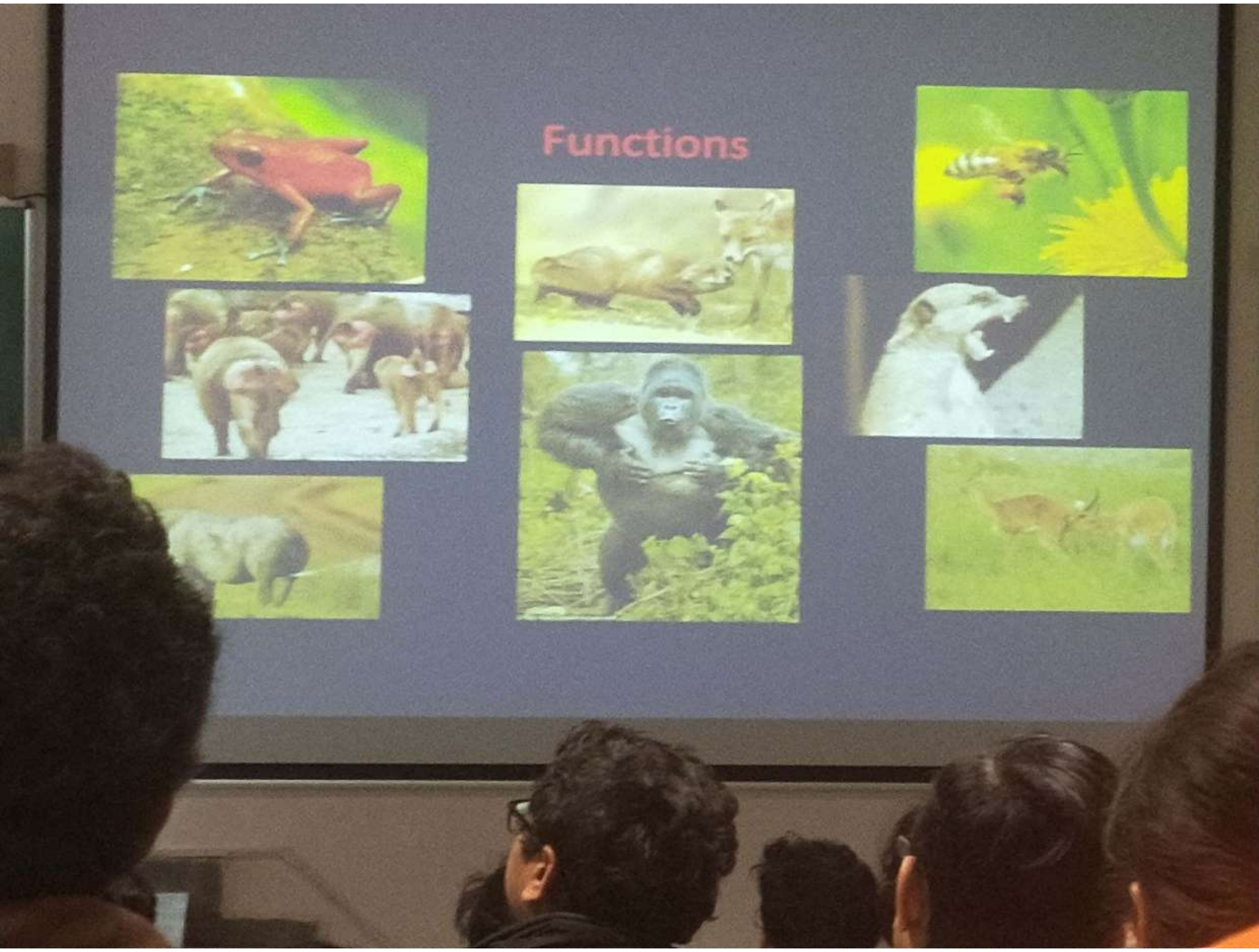

Aposematism
• Aposematism: Apo (away) sema (sign): Warning colouration
Is the phenomena by virtue of which prey species use a warning signal to indicate their noxious or toxic form (or unpalatability) to potential predators.
This kind of signalling is beneficial to both prey and predator

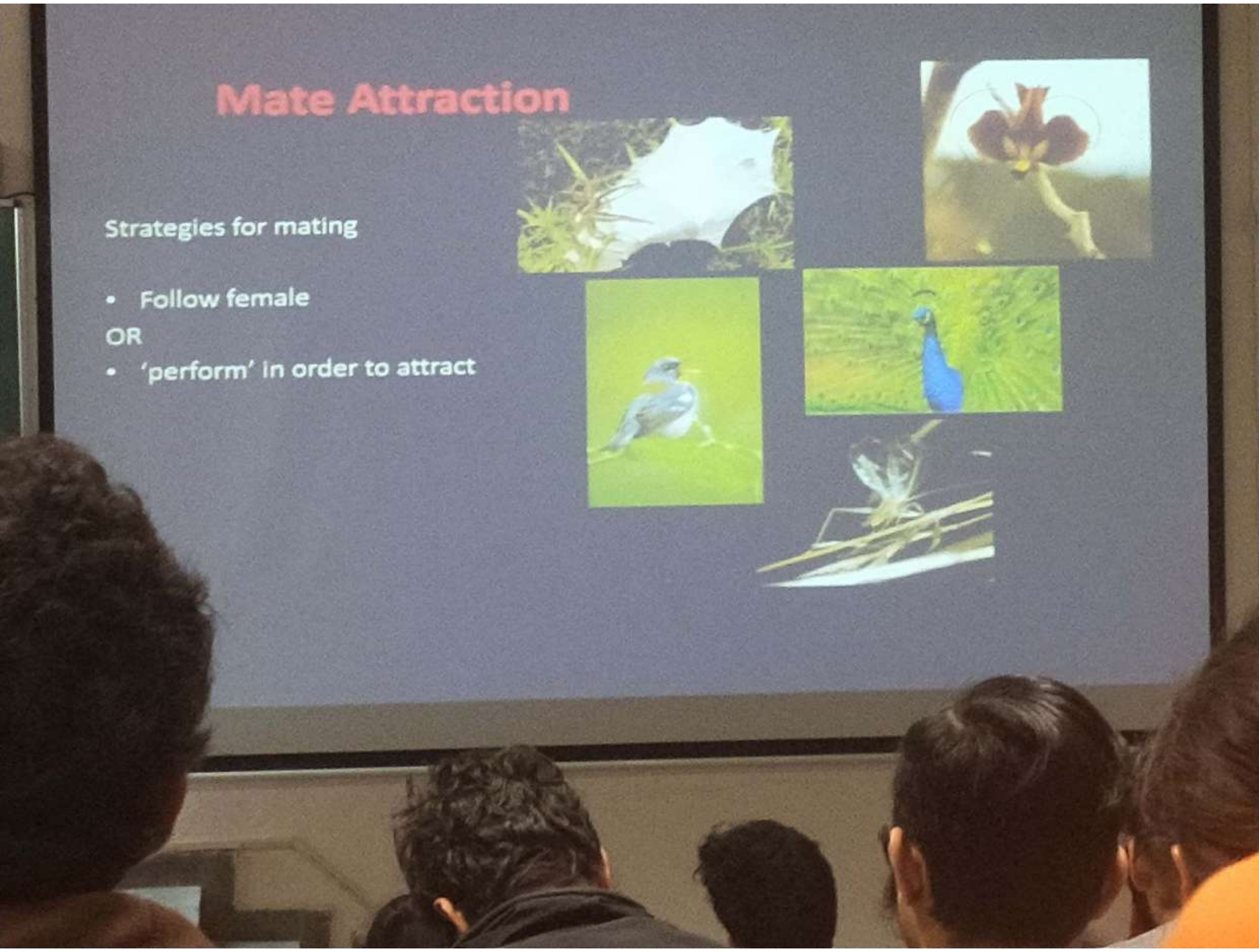


Bats as predators of katydids
Who is at higher risk? Singing males or silent females?
Katydid Males produce loud and conspicuous calls for mate attraction putting them at high risk of predation from eavesdropping predators.
Silent females approach signalling males; their higher motility may also place them at risk.

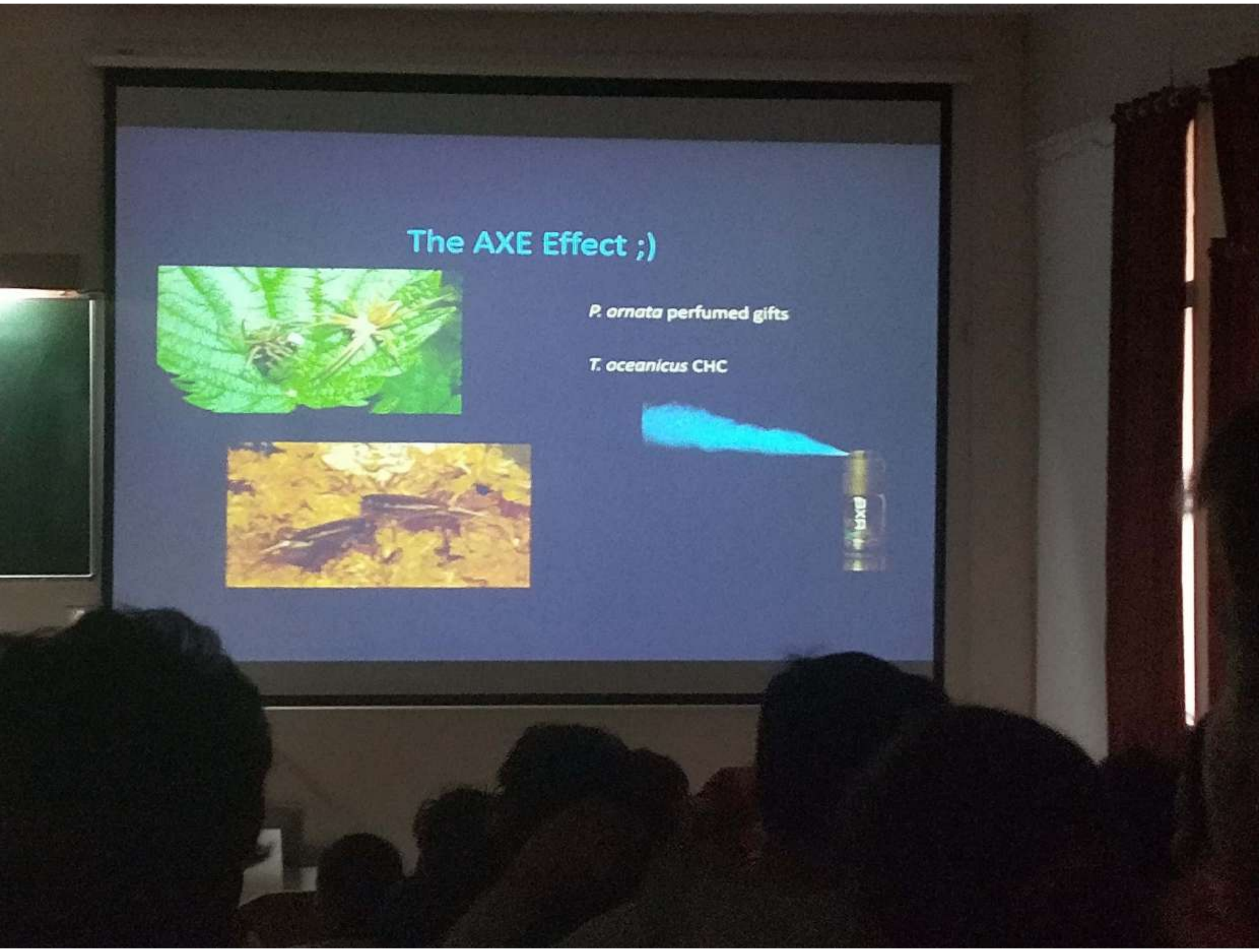

Adaptations and counter-adaptations
Predator Activity
Predator Adaptation
Prey Adaptation
Search for Prey
a) Improved sensory acuity to find prey*
b) Search in prey-abundant area
a) Crypsis
b) Spacing
Prey Recognition
Learning
Pattern Recognition
Mimicry*
Polymorphism*
Catching Prey
Motor Skills Speed, Agility; Hunting Tactics *
Weapons of offence
Escape flights, 'startle' response
Weapons of defence
Aposematism
Handling Prey
Subduing Skills
Detoxification
Active defence, spines, shell, toxin
Adapted from Krebs and Davies


Evolutionary Arms Race
• Initially, even slight and very crude adaptations could confer a selective advantage
• Improvements in one of the two parties (predator/prey) then selected for improvement in the other
• This results in improved counter-adaptations
• Can they serve as a starting point for an evolutionary arms race?
• How does the race end? Does it ever? Can predators become such efficient hunters such as to drive prey to extinction? And vice-versa
• Red-Queen Hypothesis (keep running to stay at the same place); coevolution of competing species


Functions

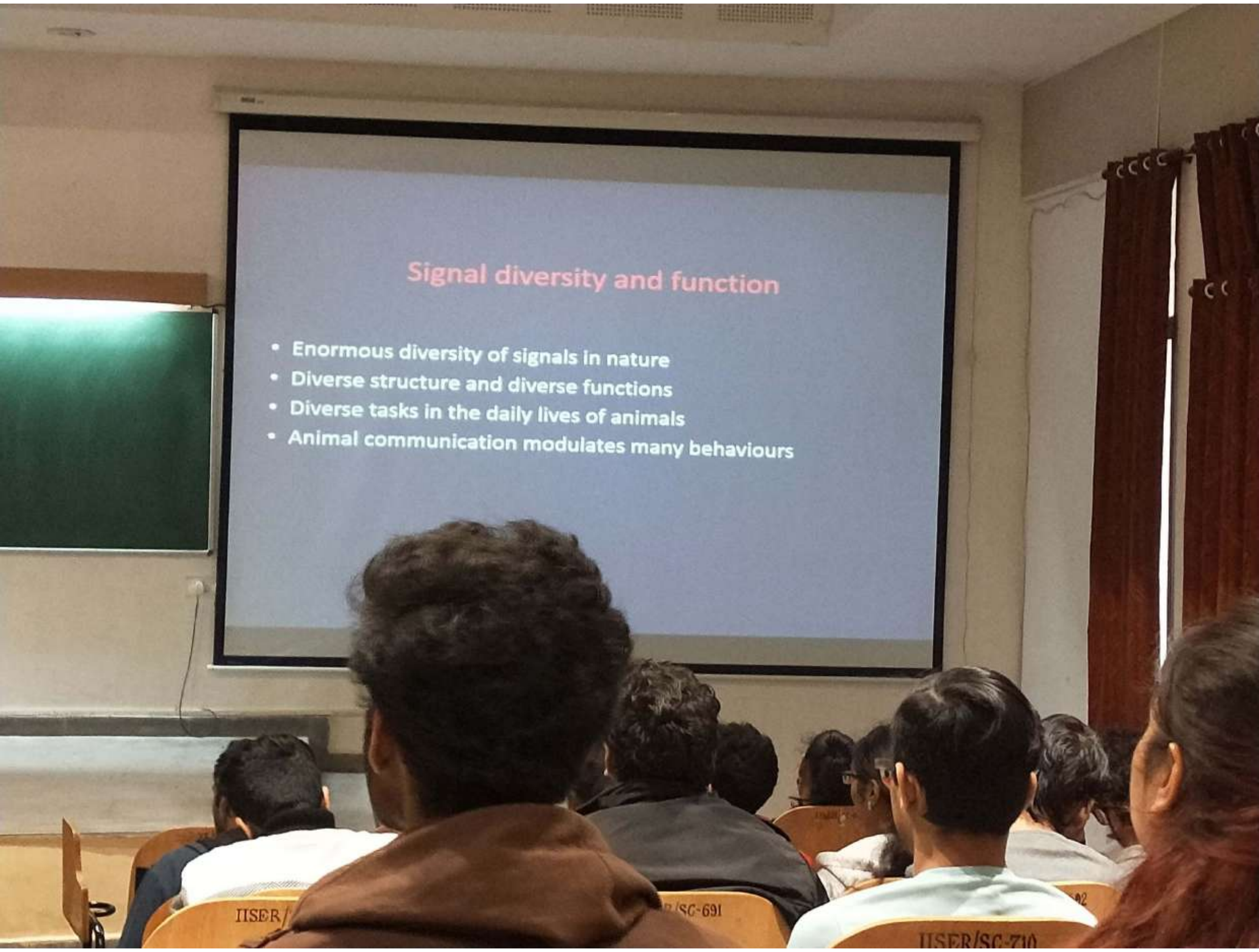

Mate Attraction
Strategies for mating
• Follow female
OR
• 'perform' in order to attract

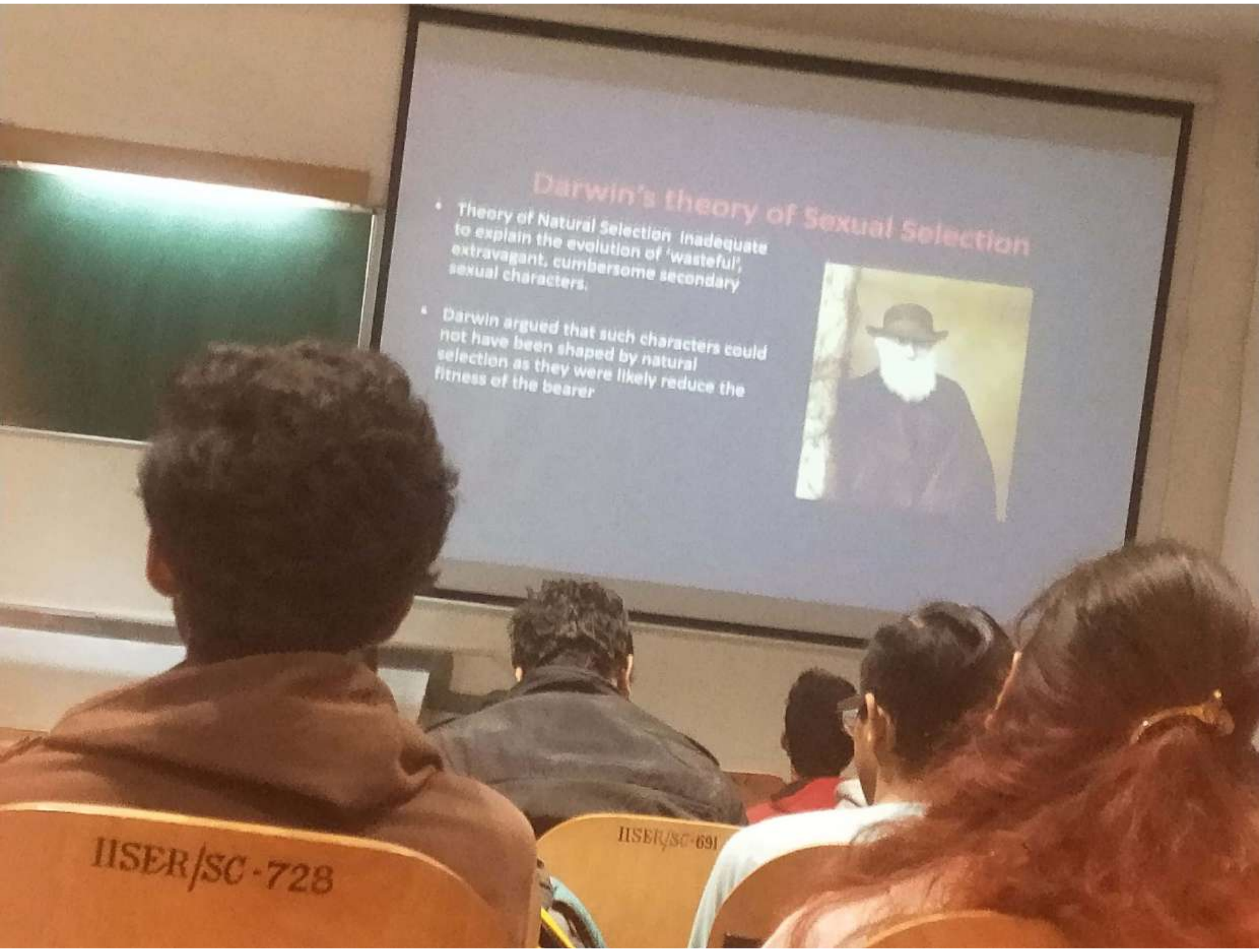

Nuptial gifts


The AXE Effect ;)
P. ornata perfumed gifts
T. oceanicus CHC
AXE

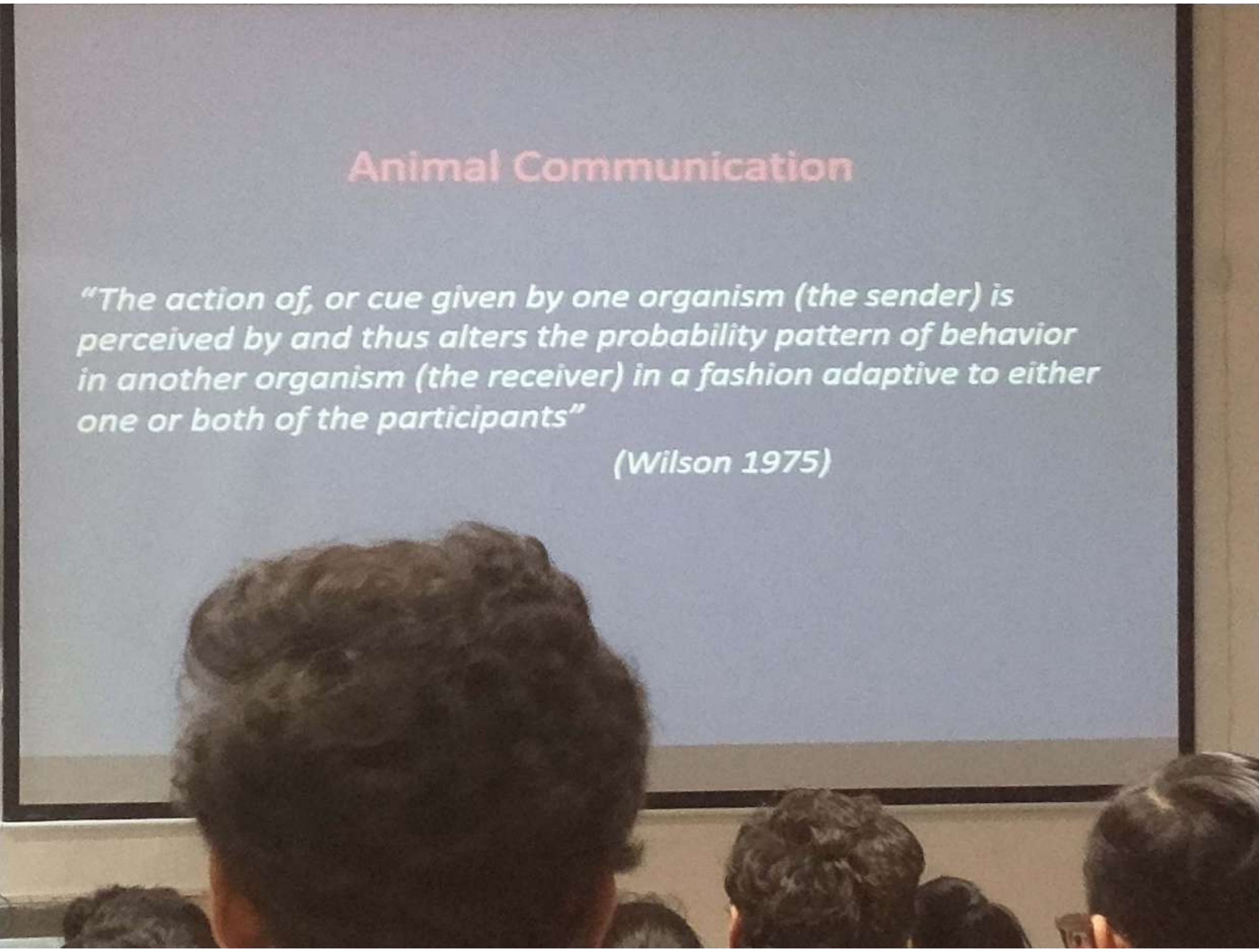

Singing and dancing for love:
Animal communication
for mate attraction
Manjari Jain
Special Lecture
14th Feb 2020
IISER/SC-691

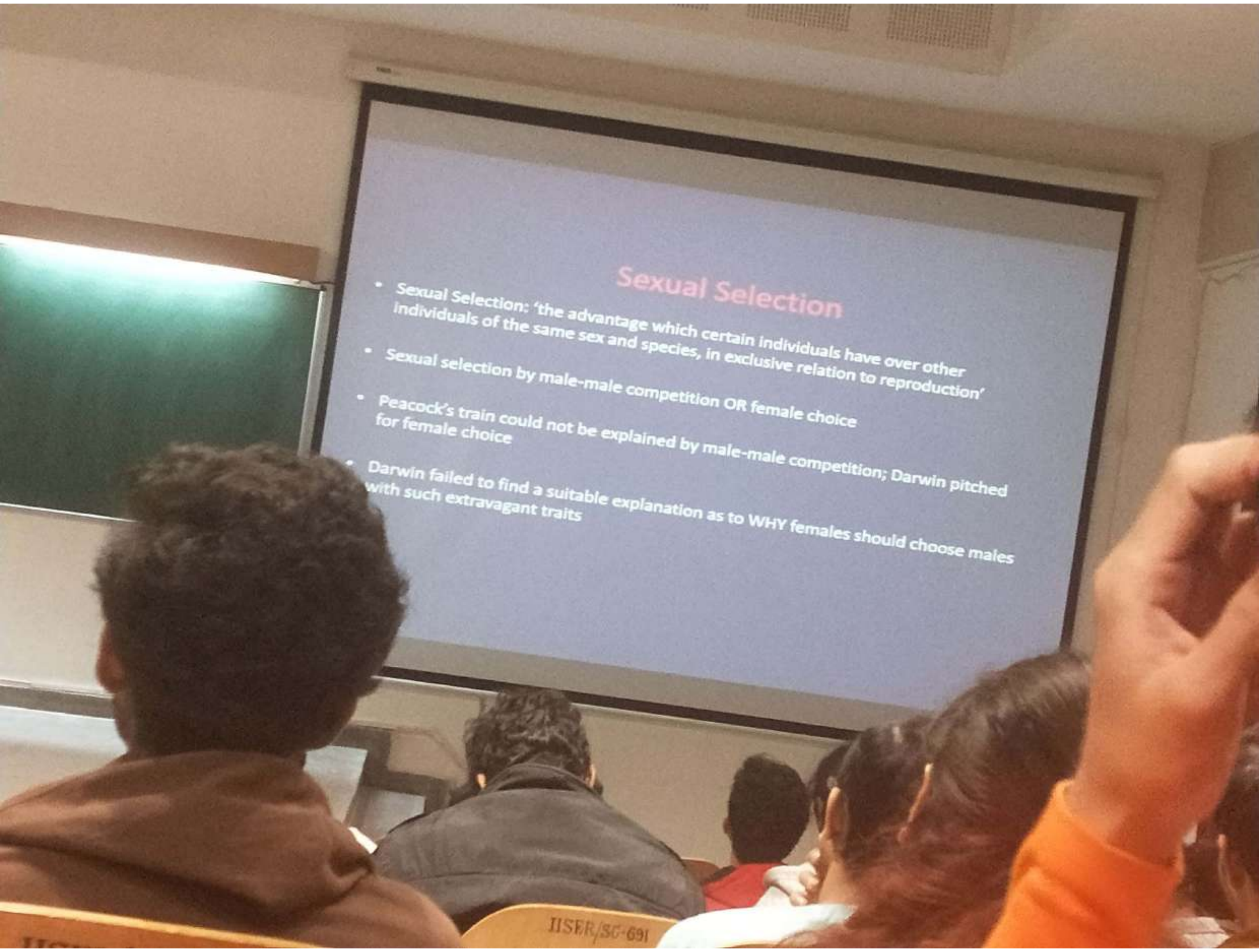

Singing and dancing for love

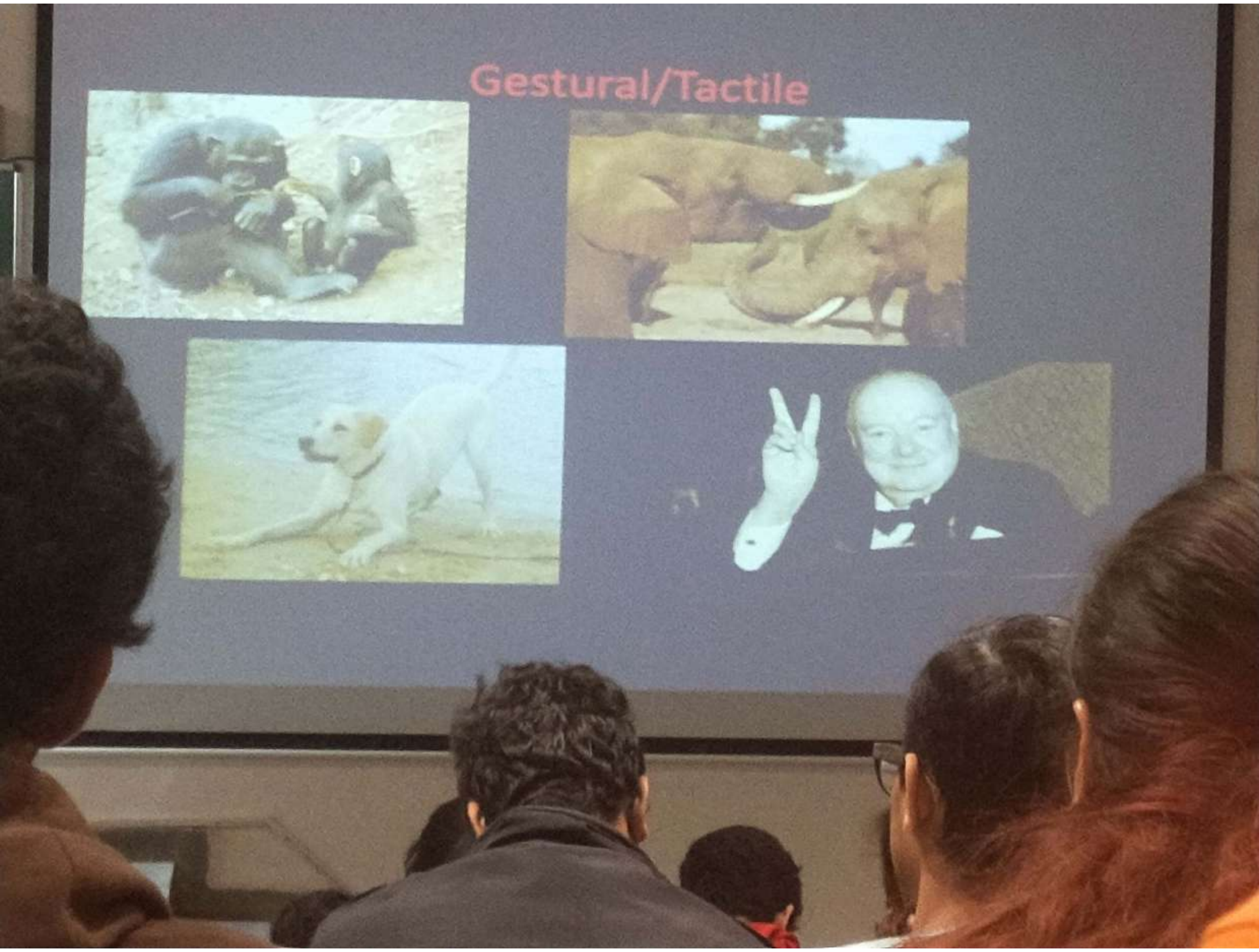

Signal diversity and function
• Enormous diversity of signals in nature
• Diverse structure and diverse functions
• Diverse tasks in the daily lives of animals
• Animal communication modulates many behaviours
IISER/SC-691
IISER/SC-710

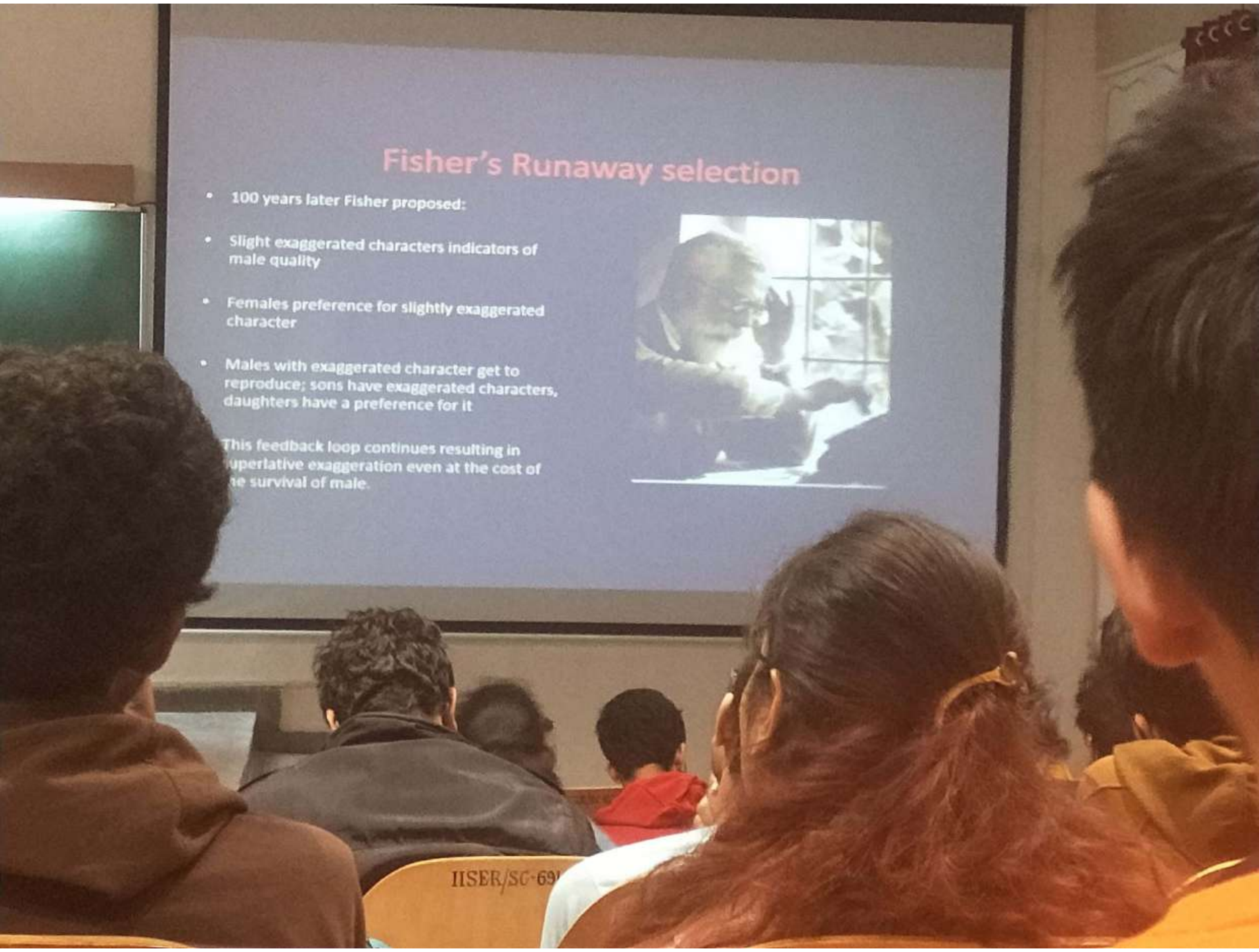


Darwin's theory of Sexual Selection
Theory of Natural Selection inadequate to explain the evolution of 'wasteful', extravagant, cumbersome secondary sexual characters.
Darwin argued that such characters could not have been shaped by natural selection as they were likely reduce the fitness of the bearer
IISER/SC-728
IISER/SC-691

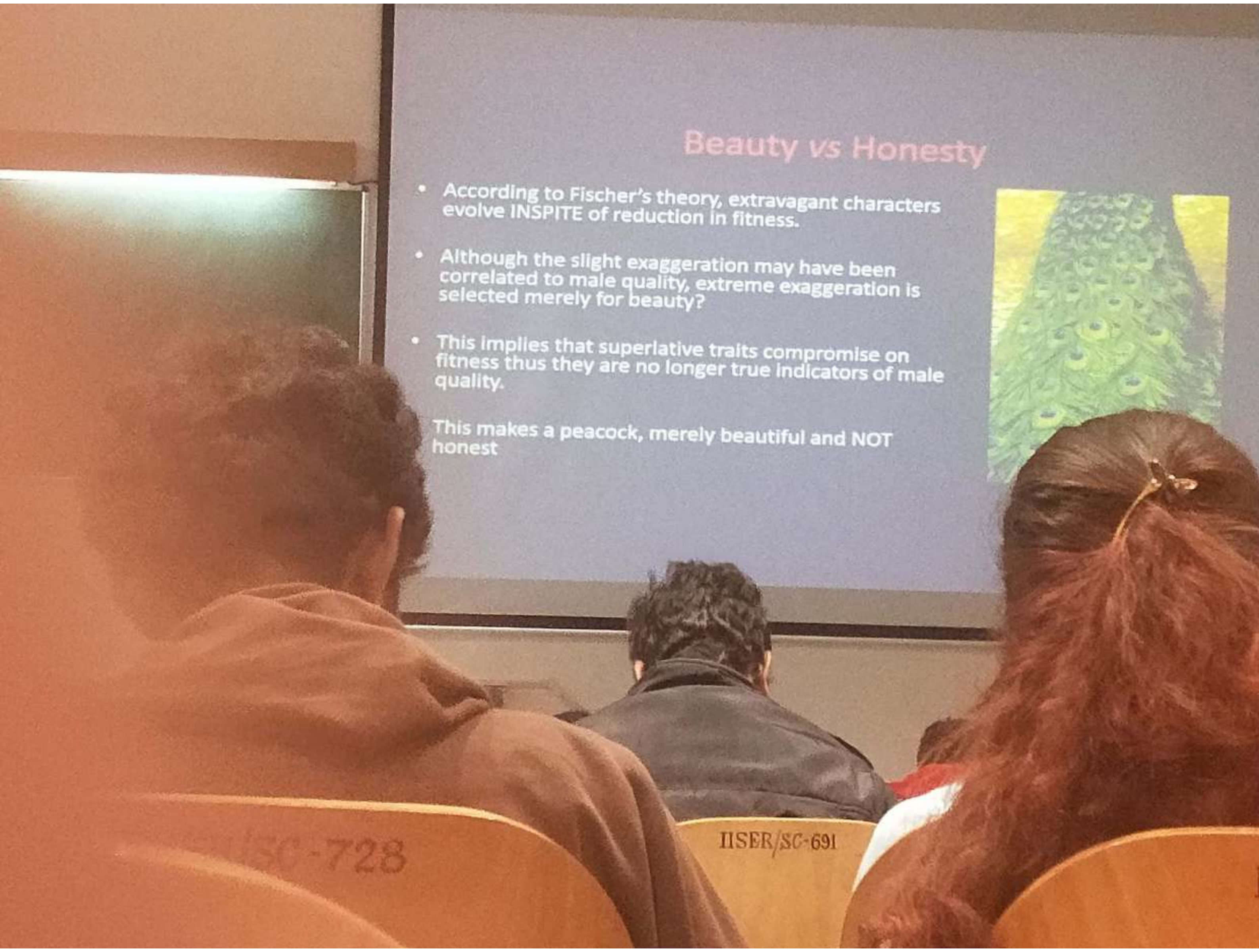

Animal Communication
"The action of, or cue given by one organism (the sender) is perceived by and thus alters the probability pattern of behavior in another organism (the receiver) in a fashion adaptive to either one or both of the participants"
(Wilson 1975)

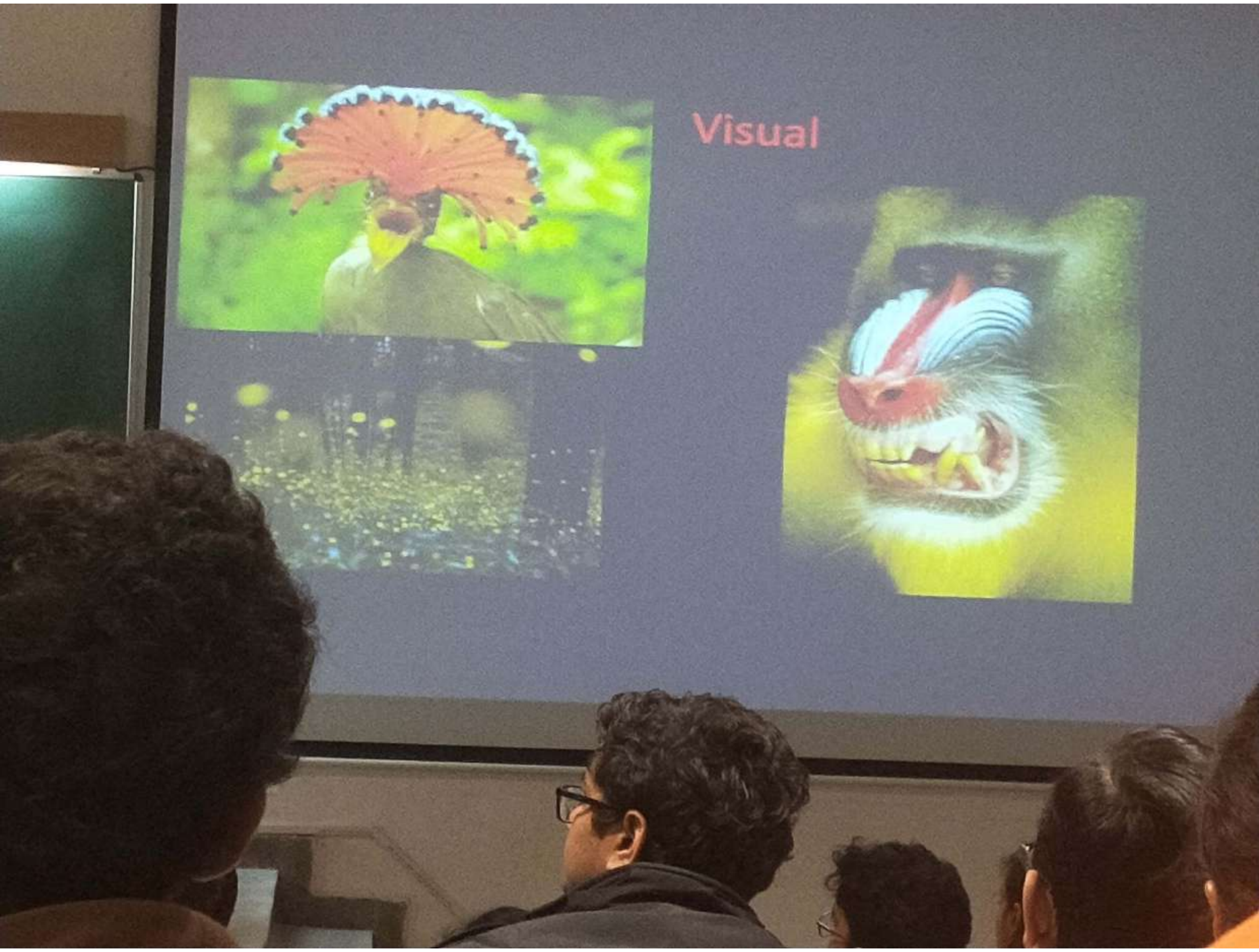

Sexual Selection
Sexual Selection: 'the advantage which certain individuals have over other individuals of the same sex and species, in exclusive relation to reproduction'
Sexual selection by male-male competition OR female choice
Peacock's train could not be explained by male-male competition; Darwin pitched for female choice
Darwin failed to find a suitable explanation as to WHY females should choose males with such extravagant traits
IISER/SC-691

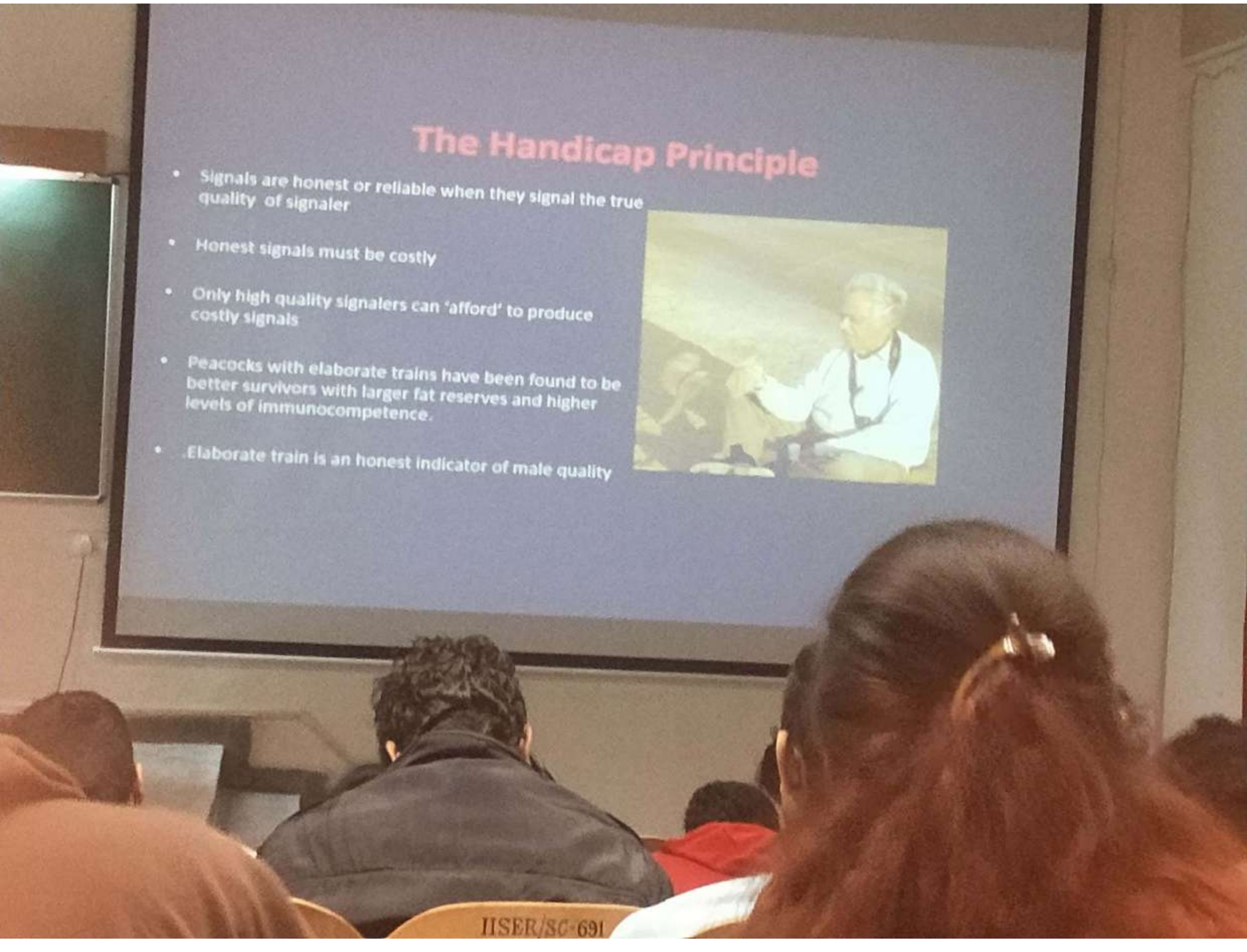

Gestural/Tactile


Fisher's Runaway selection
100 years later Fisher proposed:
Slight exaggerated characters indicators of male quality
Females preference for slightly exaggerated character
Males with exaggerated character get to reproduce; sons have exaggerated characters, daughters have a preference for it
This feedback loop continues resulting in
uperlative exaggeration even at the cost of
e survival of male.
IISER/SC-69

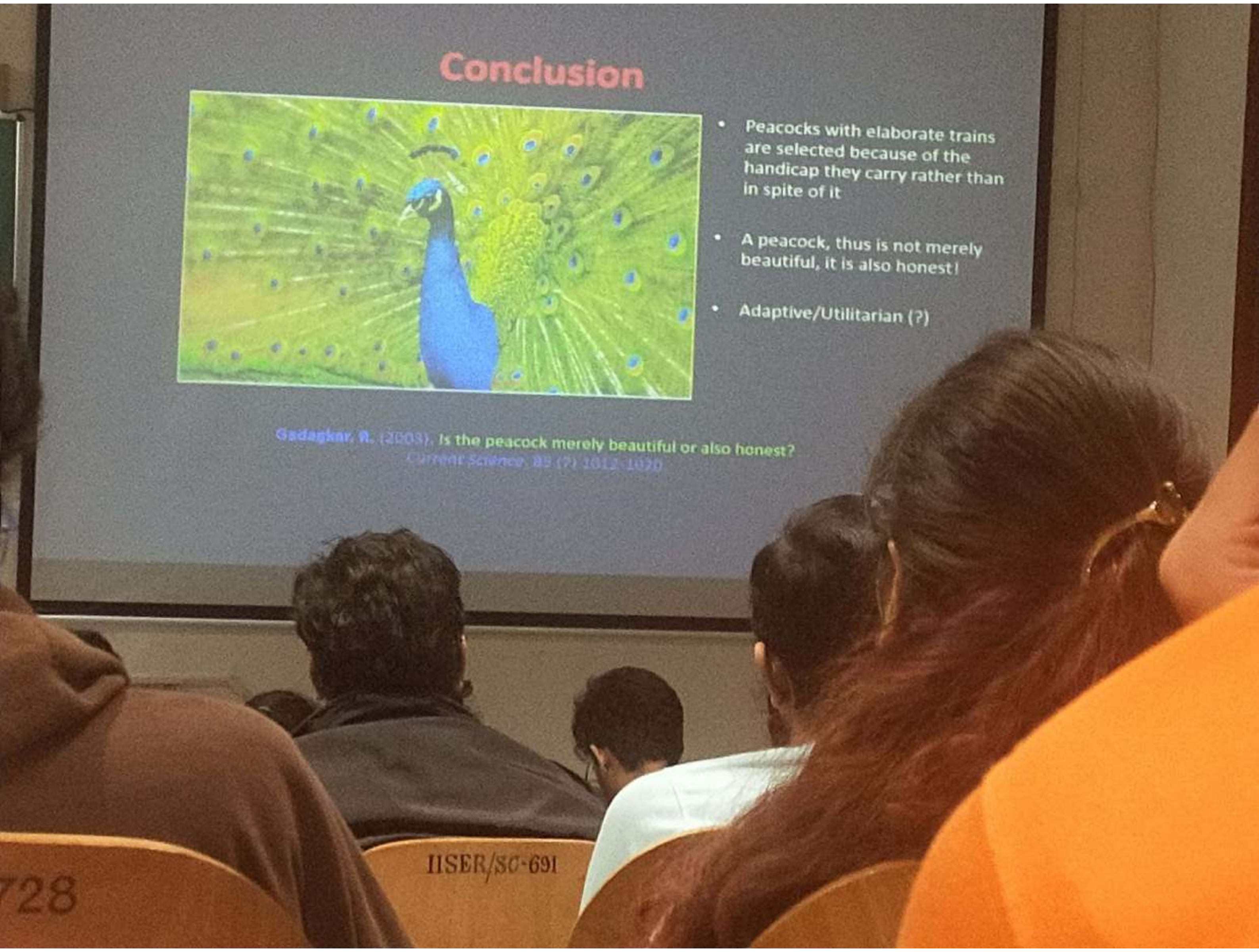

Acoustic

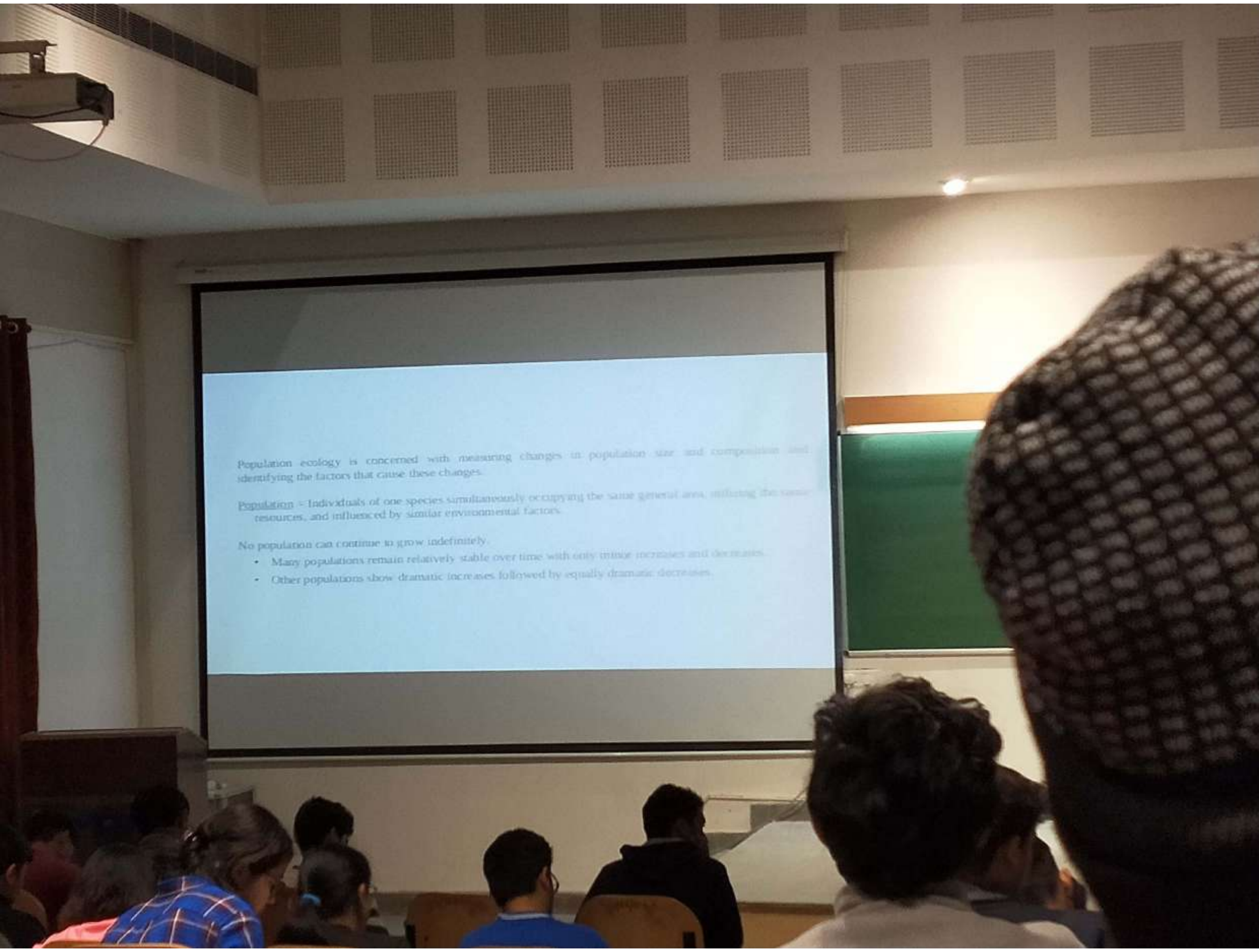

Beauty vs Honesty
According to Fischer's theory, extravagant characters evolve INSPITE of reduction in fitness.
Although the slight exaggeration may have been correlated to male quality, extreme exaggeration is selected merely for beauty?
This implies that superlative traits compromise on fitness thus they are no longer true indicators of male quality.
This makes a peacock, merely beautiful and NOT honest
SC-728
IISER/SC-691

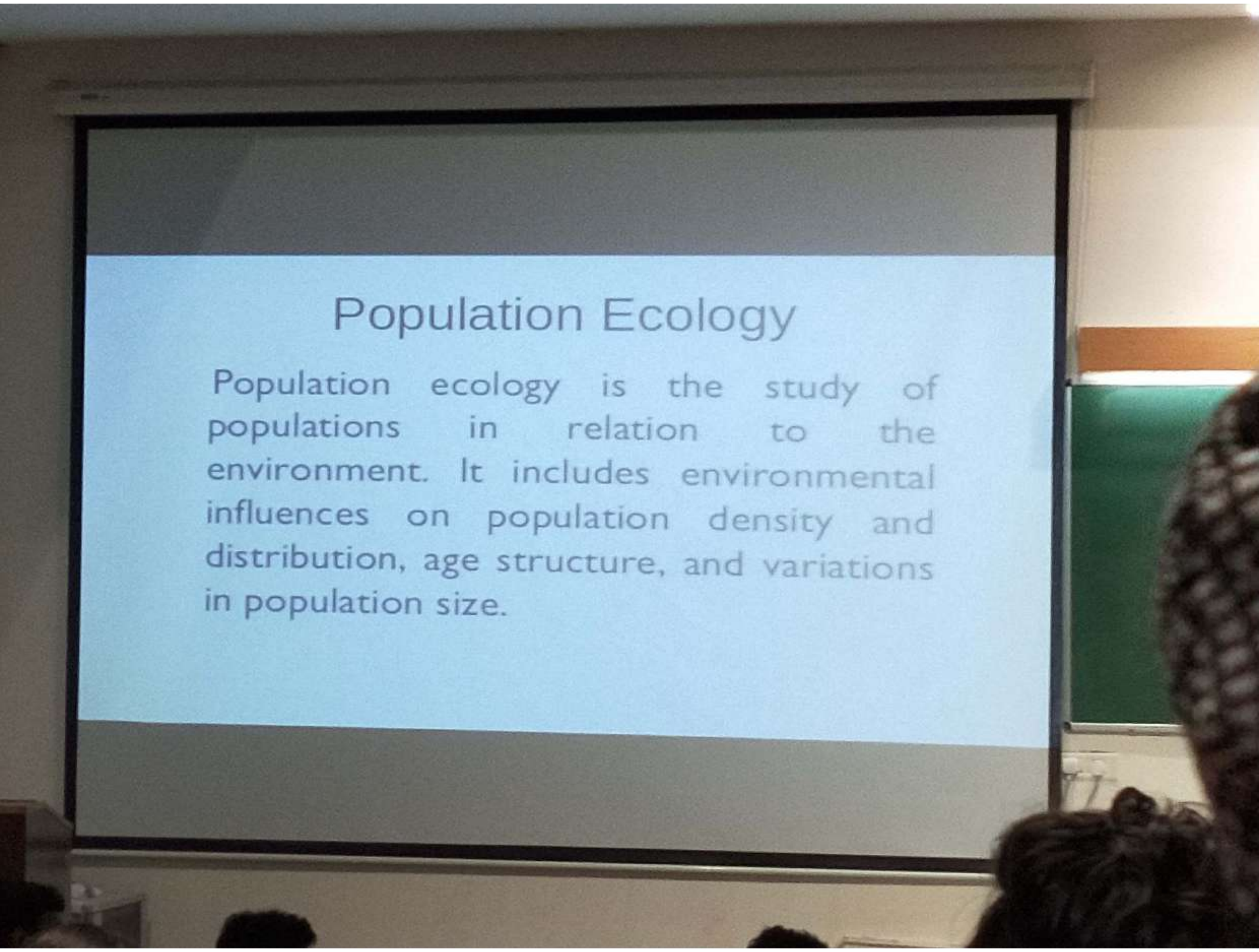

Visual


The Handicap Principle
Signals are honest or reliable 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
IISER/SC-691


Olfactory


Conclusion
Peacocks with elaborate trains are selected because of the handicap they carry rather than in spite of it
A peacock, thus is not merely beautiful, it is also honest!
Adaptive/Utilitarian (?)
Is the peacock merely beautiful or also honest?
IISER/SC-691
728


Population ecology is concerned with measuring changes in population size and composition and identifying the factors that cause these changes.
Population = Individuals of one species simultaneously occupying the same general area, utilizing the same resources, and influenced by similar environmental factors.
No population can continue to grow indefinitely.
Many populations remain relatively stable over time with only minor increases and decreases.
Other populations show dramatic increases followed by equally dramatic decreases.


Population Ecology
Population ecology is the study of populations in relation to the environment. It includes environmental influences on population density and distribution, age structure, and variations in population size.

B. Patterns of Dispersion

A population's geographical range is the geographic limits within which a population lives.

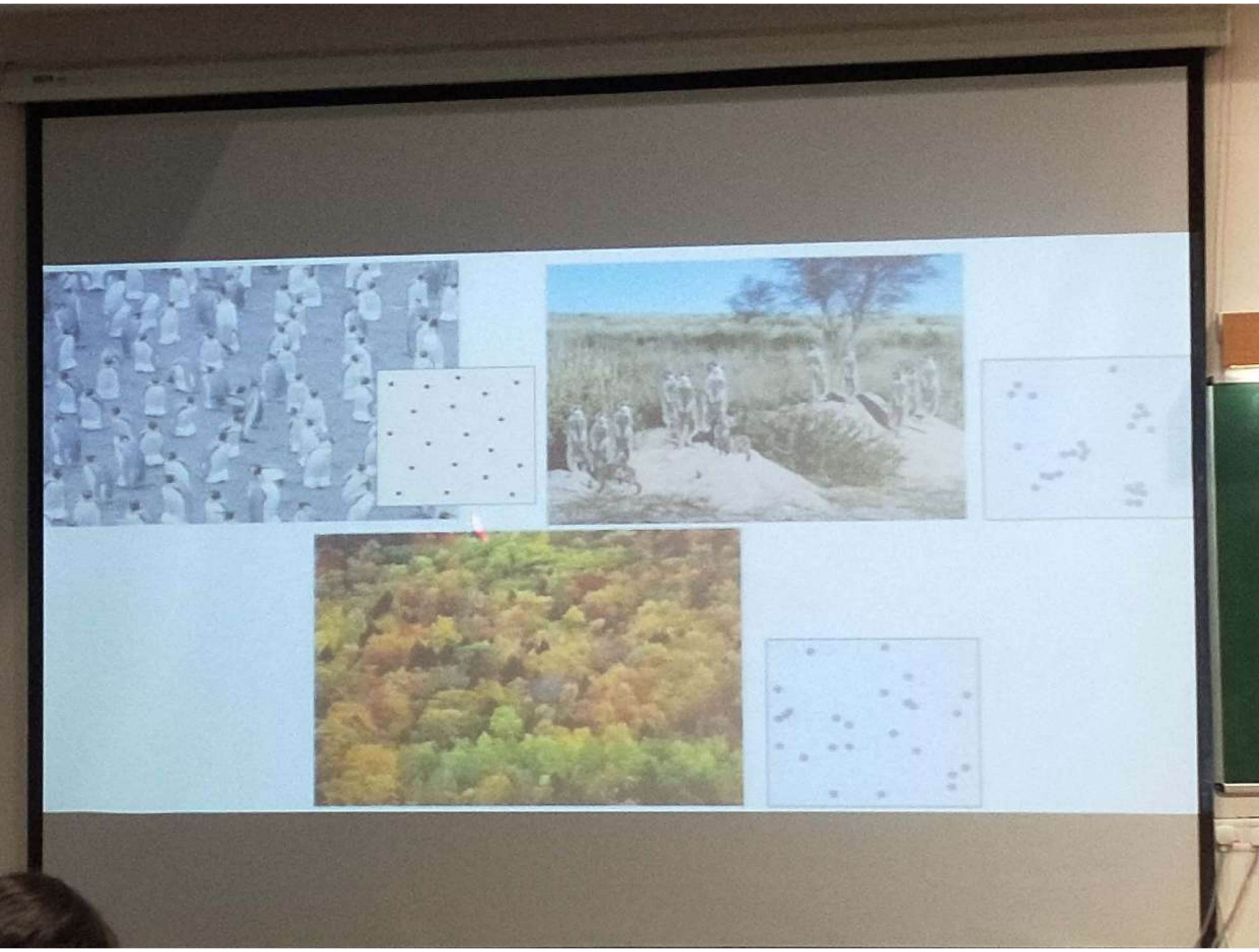
- Local densities may vary substantially because not all areas of a range provide equally suitable habitat.

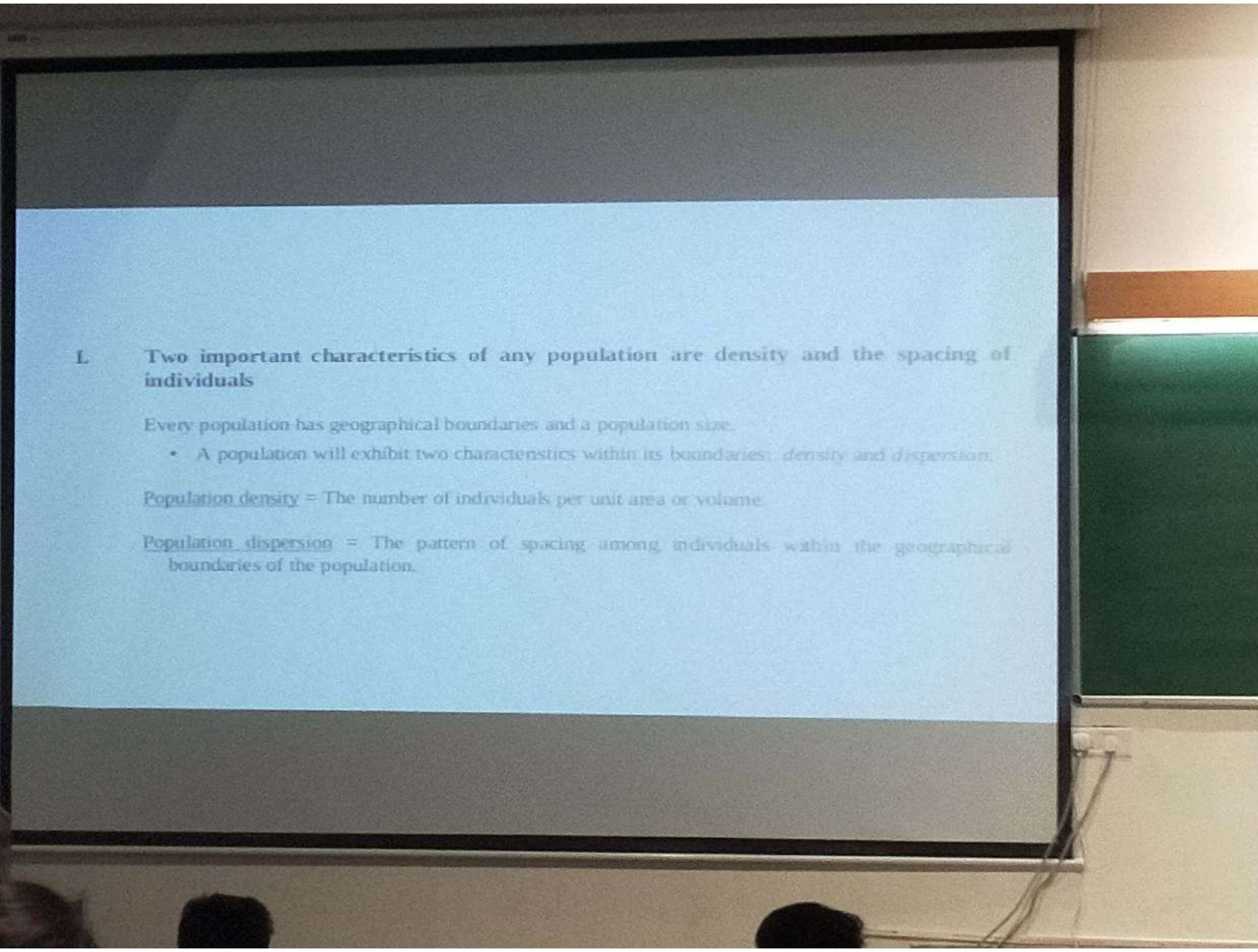
Individuals exhibit a continuum of three general patterns of spacing in relation to other individuals: *clumped*, *uniform*, and *random*.

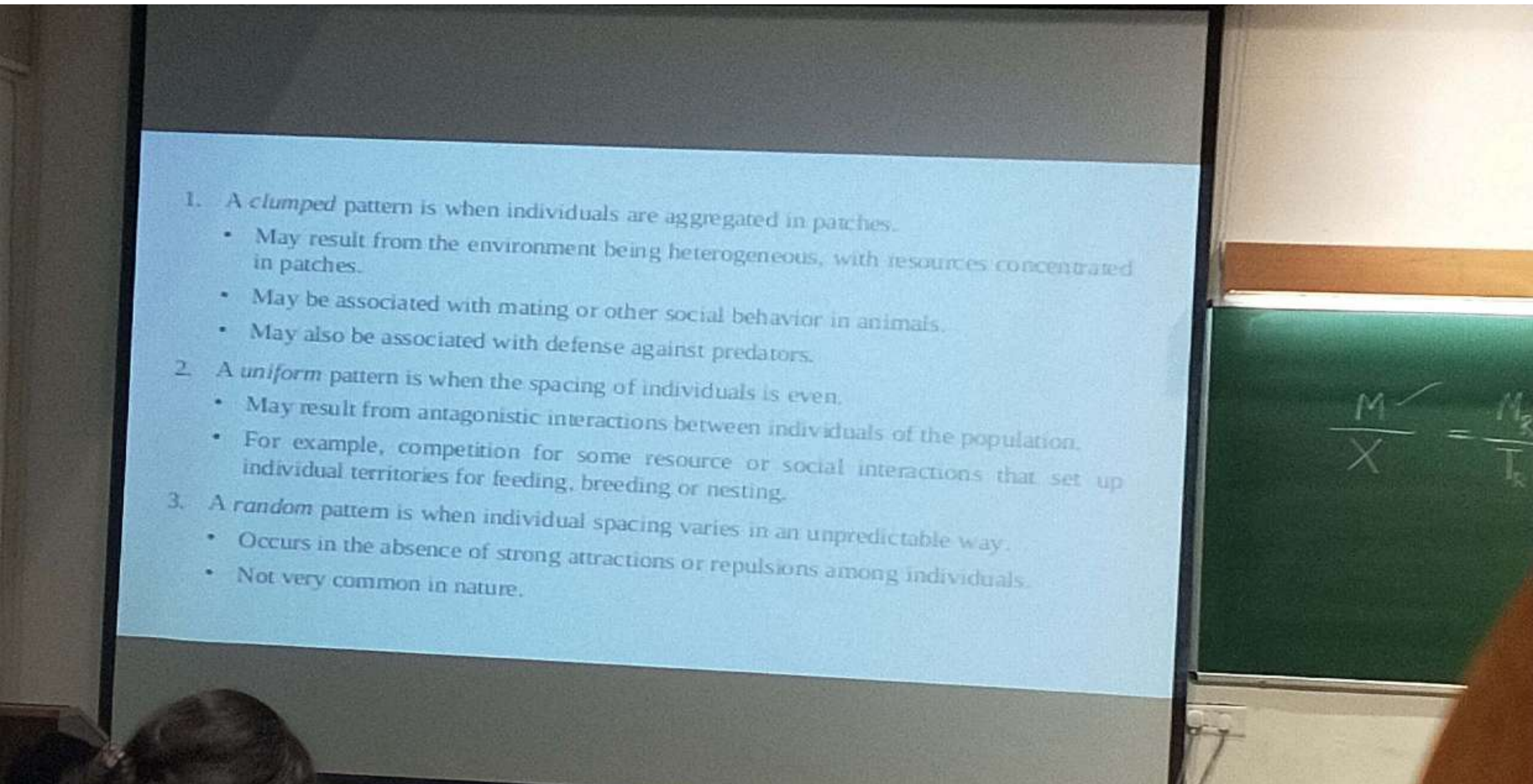
A. **Measuring Density**

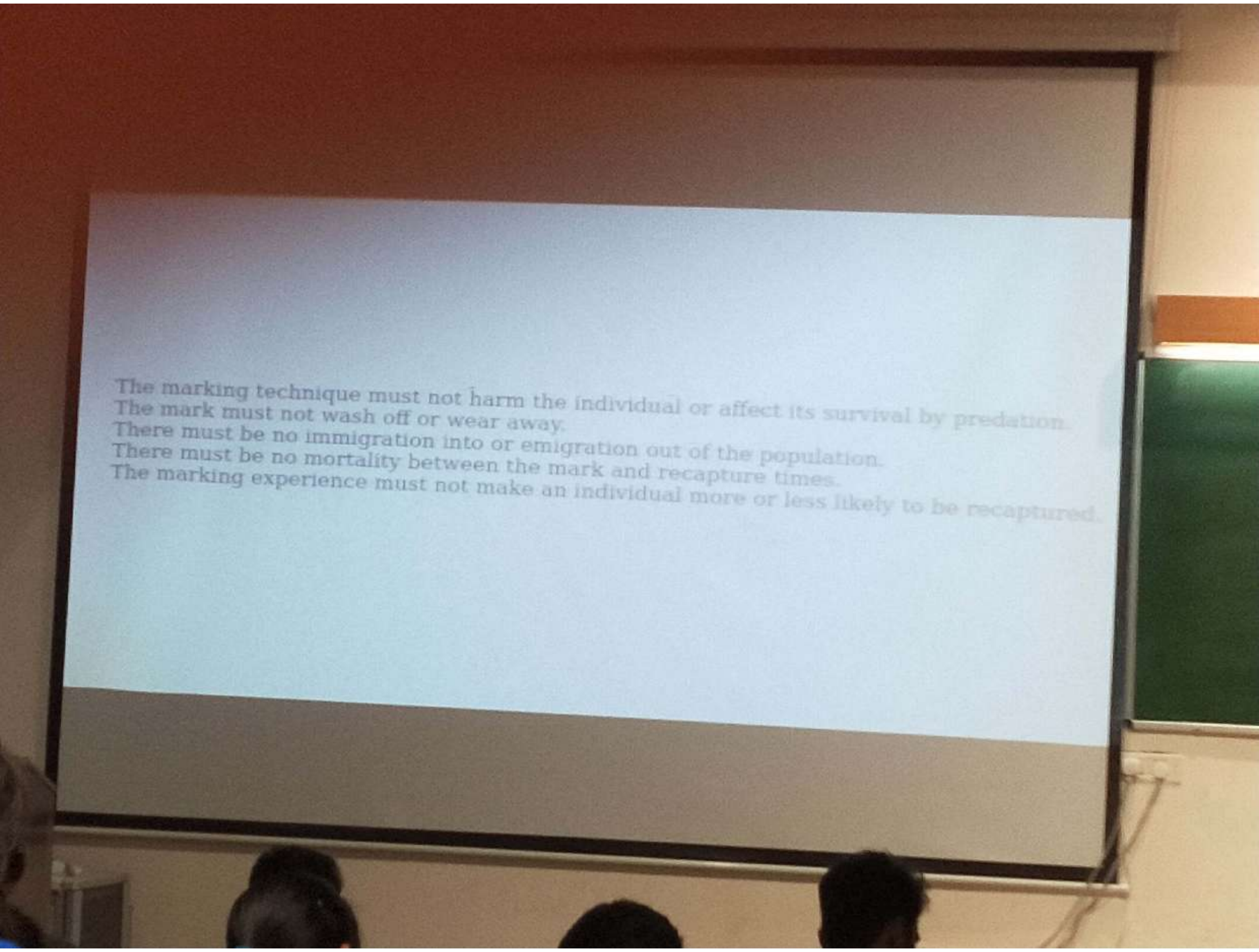
It is usually impractical or impossible to count all individuals in a population, so ecologists use a variety of sampling techniques to estimate densities and total population size.

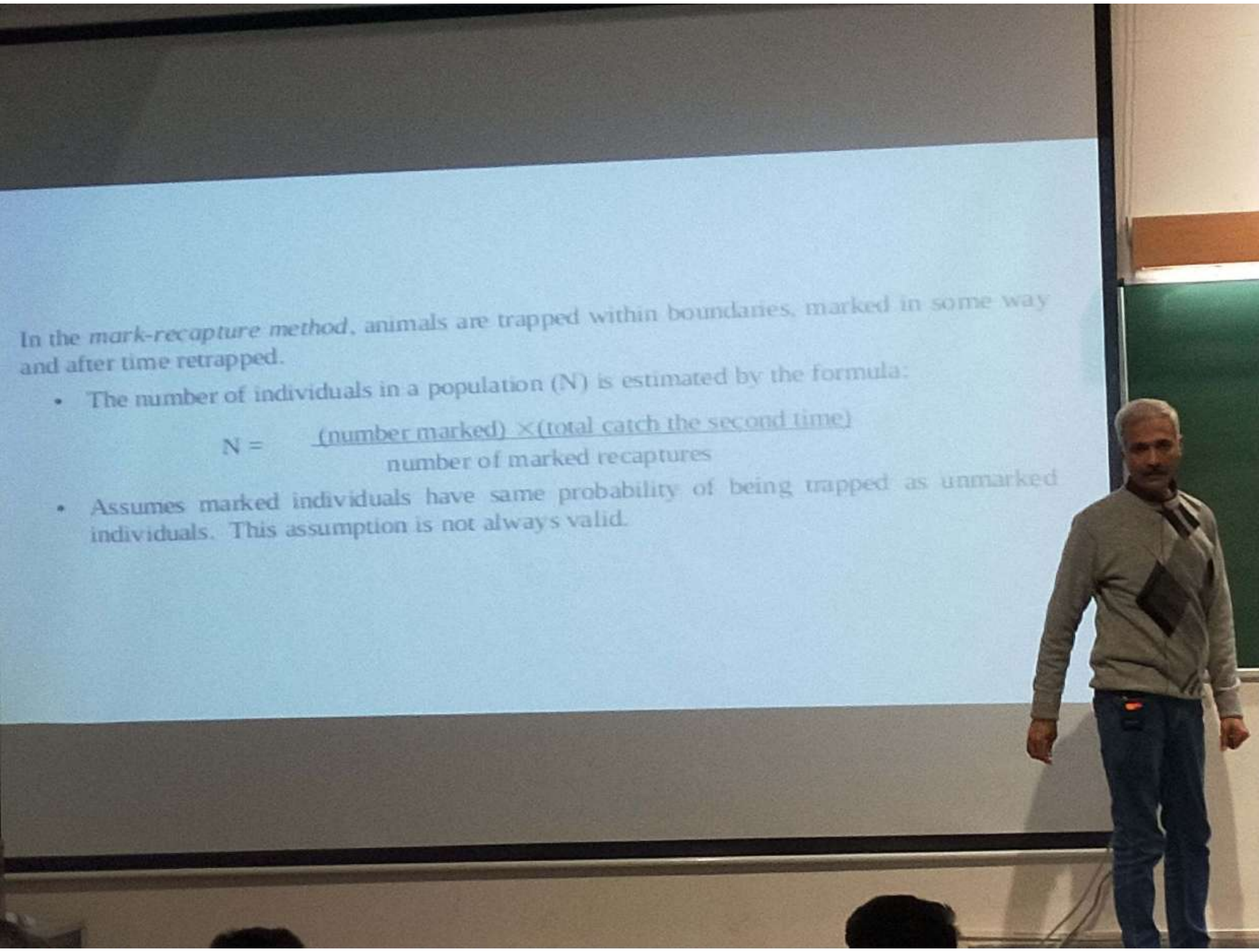
- May count all individuals in a sample of representative plots. Estimates become more accurate as sample plots increase in size or number.
- May estimate by indirect indicators such as number of nests or burrows, or by droppings or tracks.
- May use the *mark-recapture method*.




I. Two important characteristics of any population are density and the spacing of individuals
Every population has geographical boundaries and a population size.
• A population will exhibit two characteristics within its boundaries: density and dispersion.
Population density = The number of individuals per unit area or volume.
Population dispersion = The pattern of spacing among individuals within the geographical boundaries of the population.


1. A *clumped* pattern is when individuals are aggregated in patches.
• May result from the environment being heterogeneous, with resources concentrated in patches.
• May be associated with mating or other social behavior in animals.
• May also be associated with defense against predators.
2. A *uniform* pattern is when the spacing of individuals is even.
• May result from antagonistic interactions between individuals of the population.
• For example, competition for some resource or social interactions that set up individual territories for feeding, breeding or nesting.
3. A *random* pattern is when individual spacing varies in an unpredictable way.
• Occurs in the absence of strong attractions or repulsions among individuals.
• Not very common in nature.


The marking technique must not harm the individual or affect its survival by predation.
The mark must not wash off or wear away.
There must be no immigration into or emigration out of the population.
There must be no mortality between the mark and recapture times.
The marking experience must not make an individual more or less likely to be recaptured.


In the mark-recapture method, animals are trapped within boundaries, marked in some way and after time retrapped.
The number of individuals in a population (N) is estimated by the formula:
N = (number marked) ×(total catch the second time) / number of marked recaptures
Assumes marked individuals have same probability of being trapped as unmarked individuals. This assumption is not always valid.

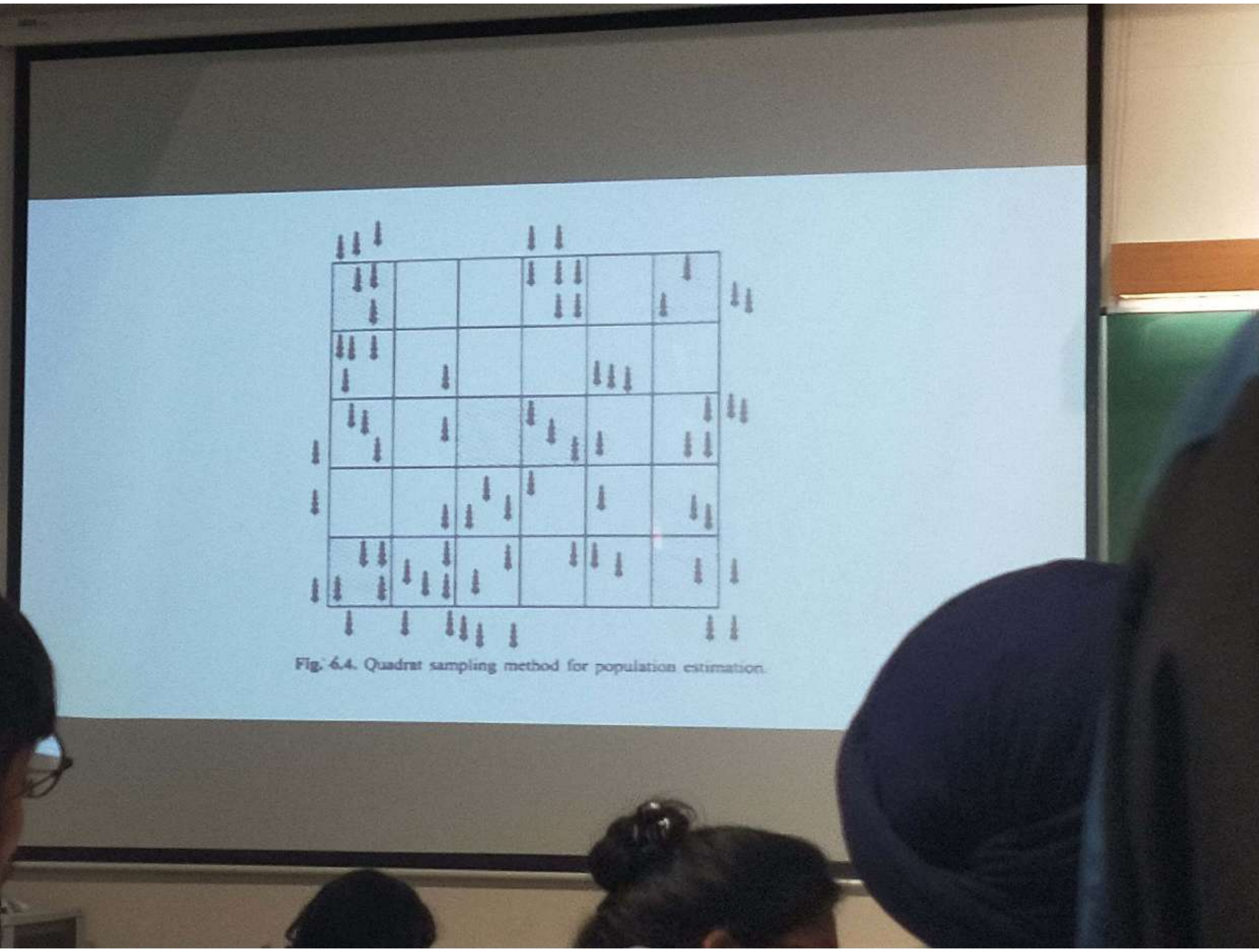
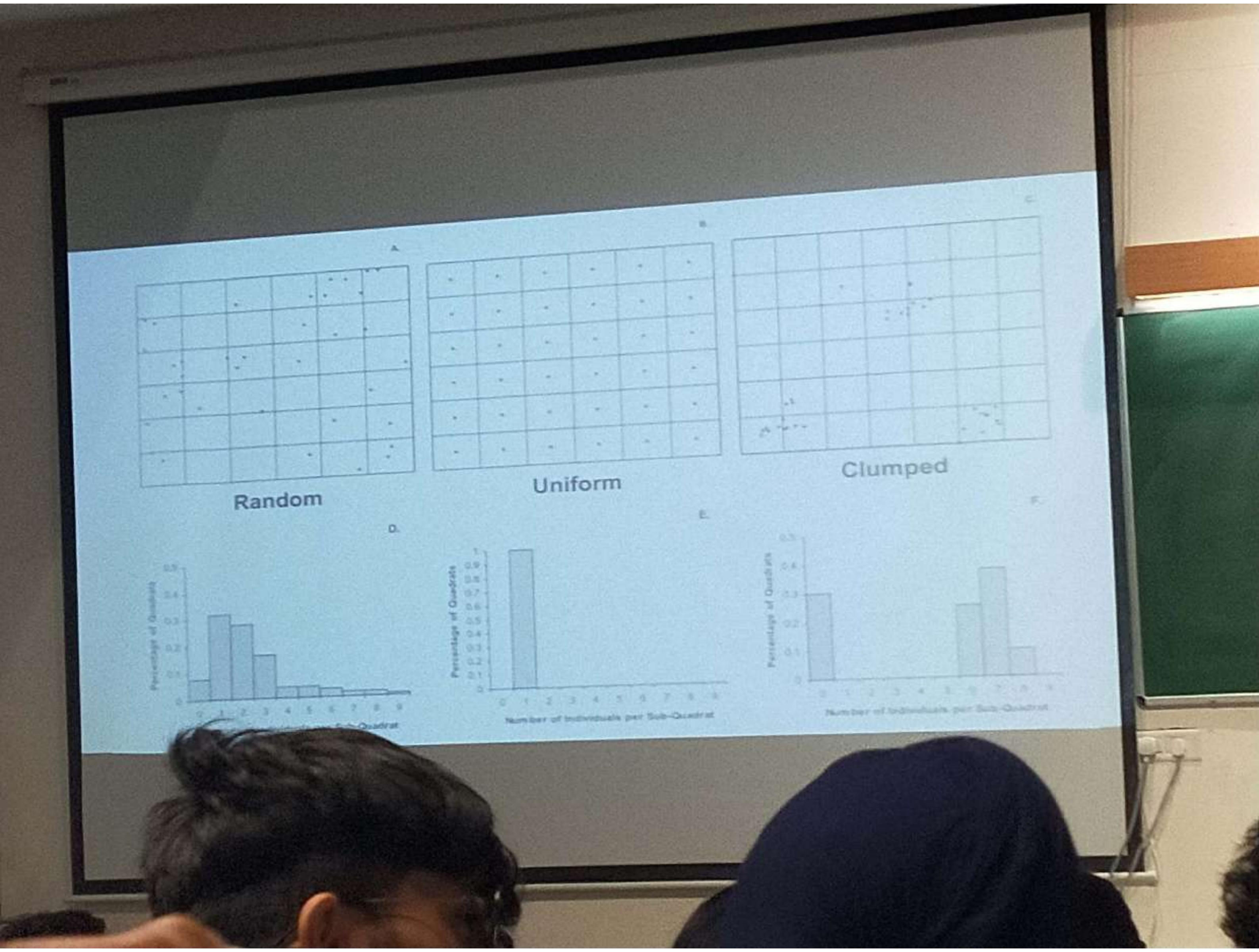
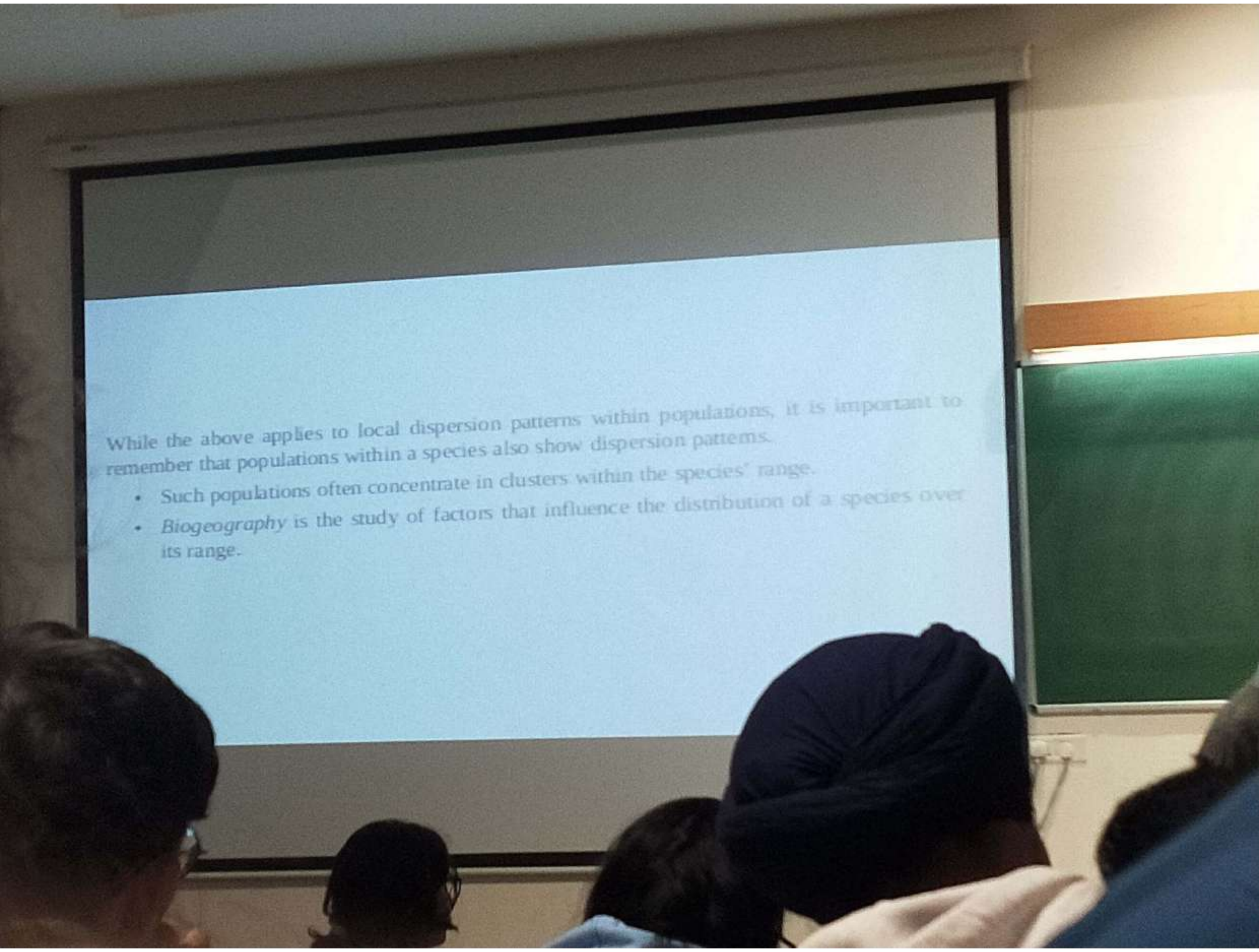
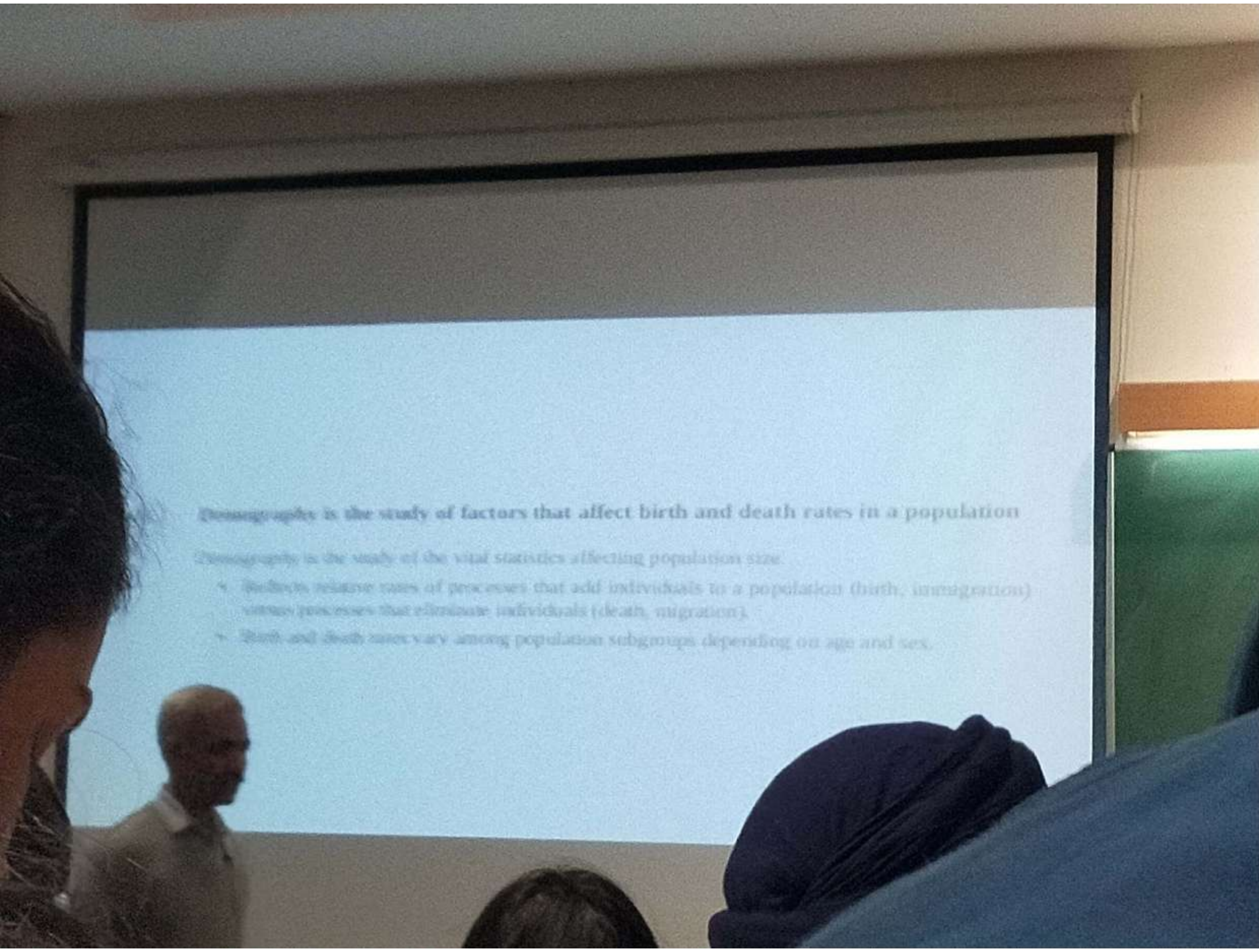


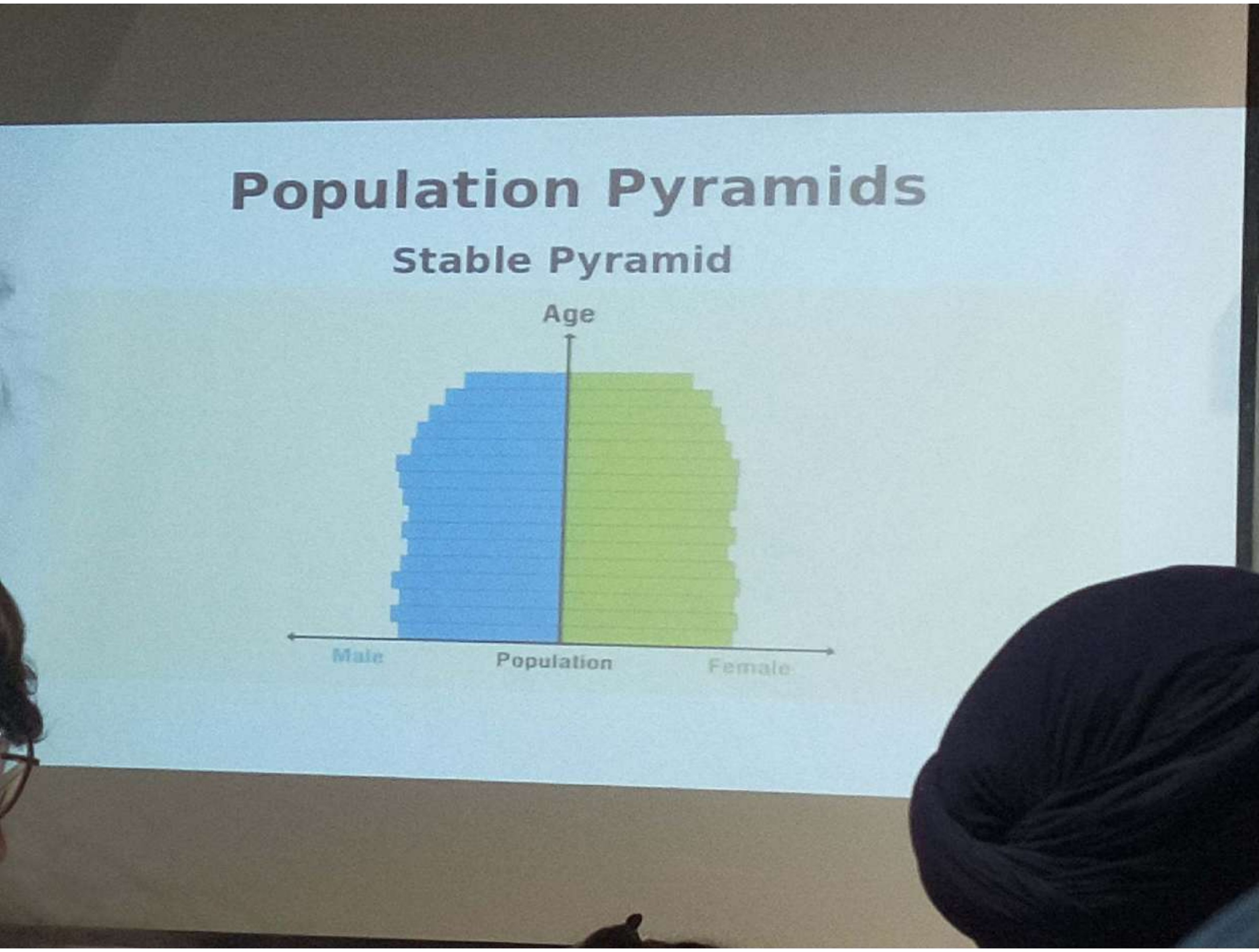
Fig. 6.4. Quadrat sampling method for population estimation.

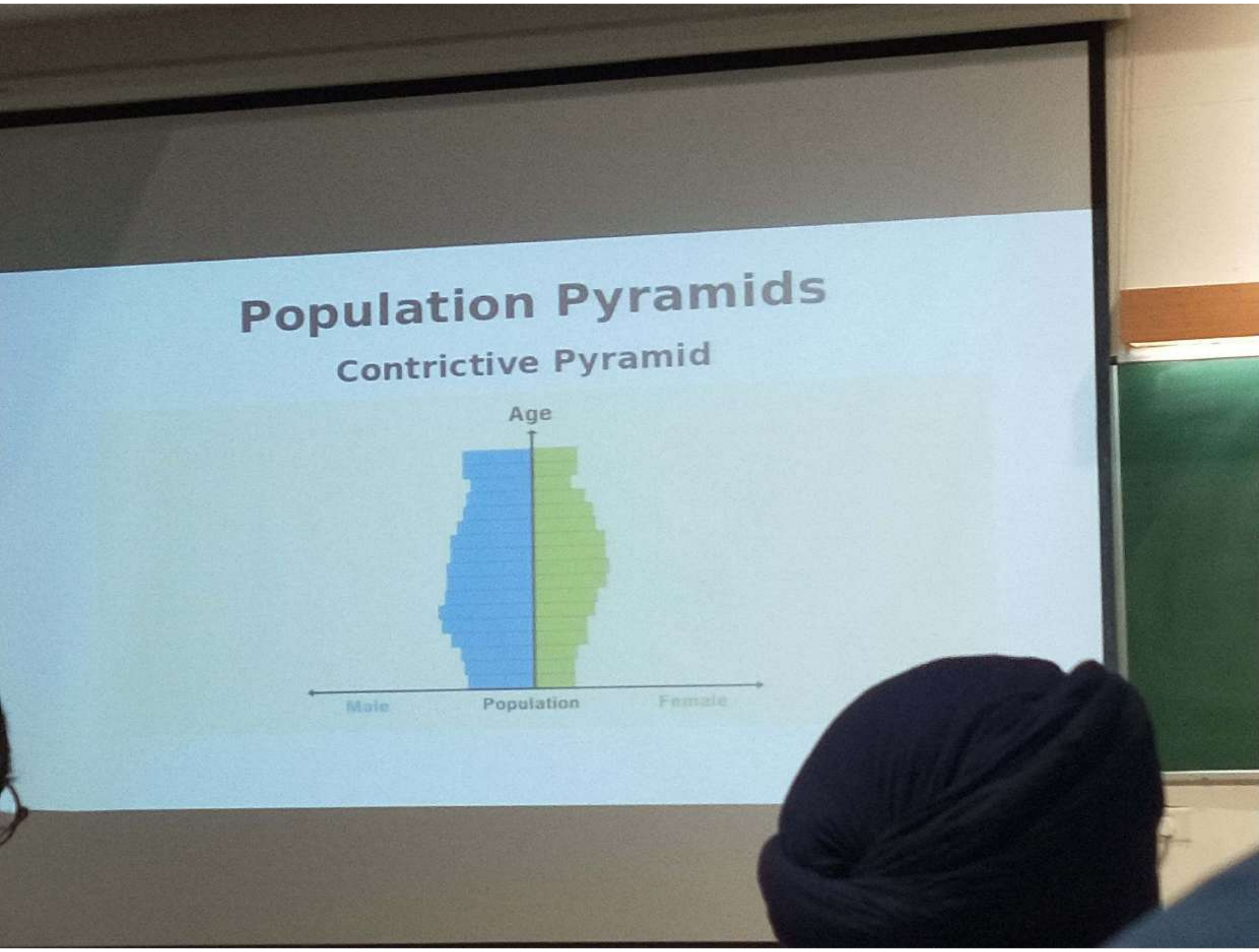


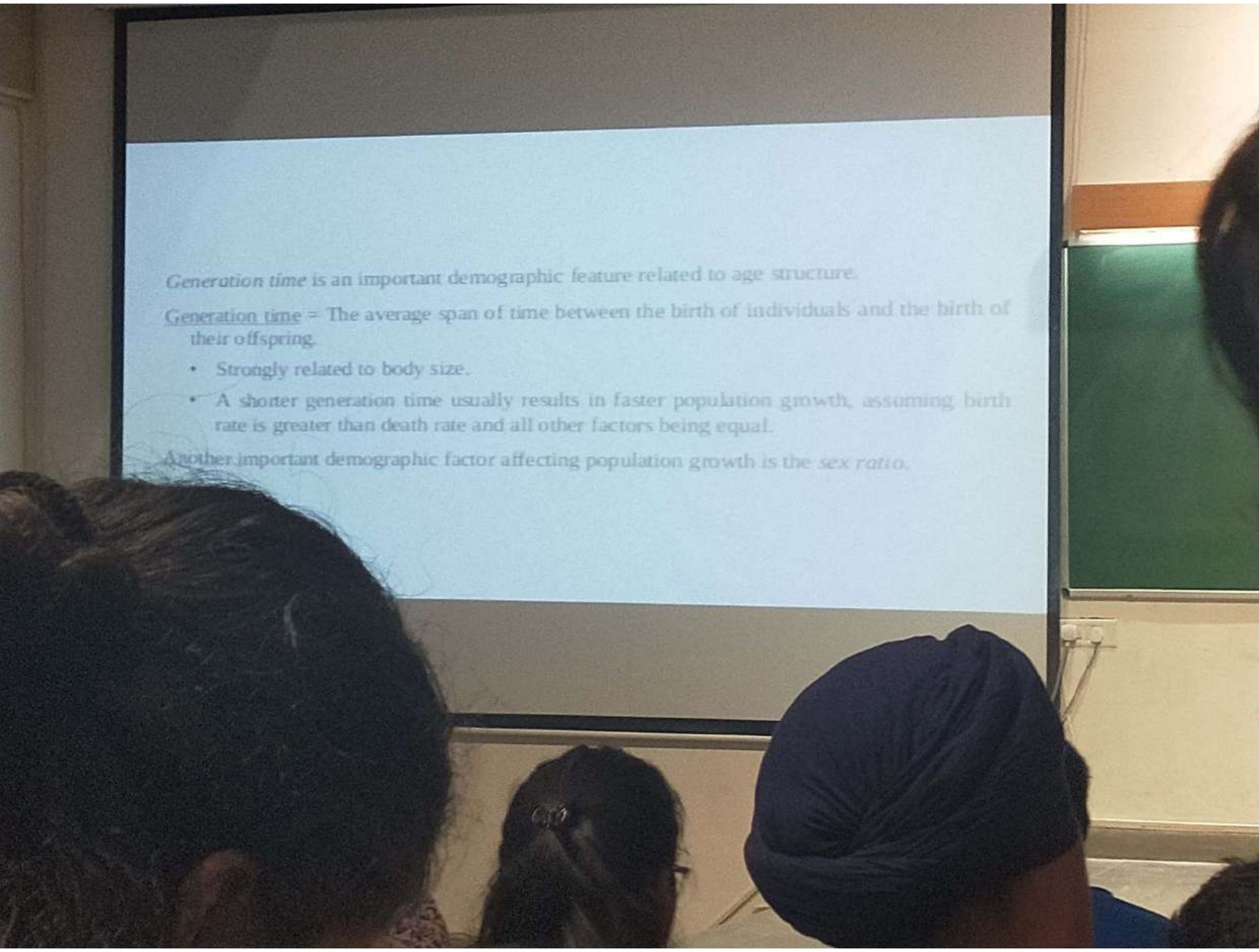
Random
Uniform
Clumped
Percentage of Quadrats
Number of Individuals per Sub-Quadrat

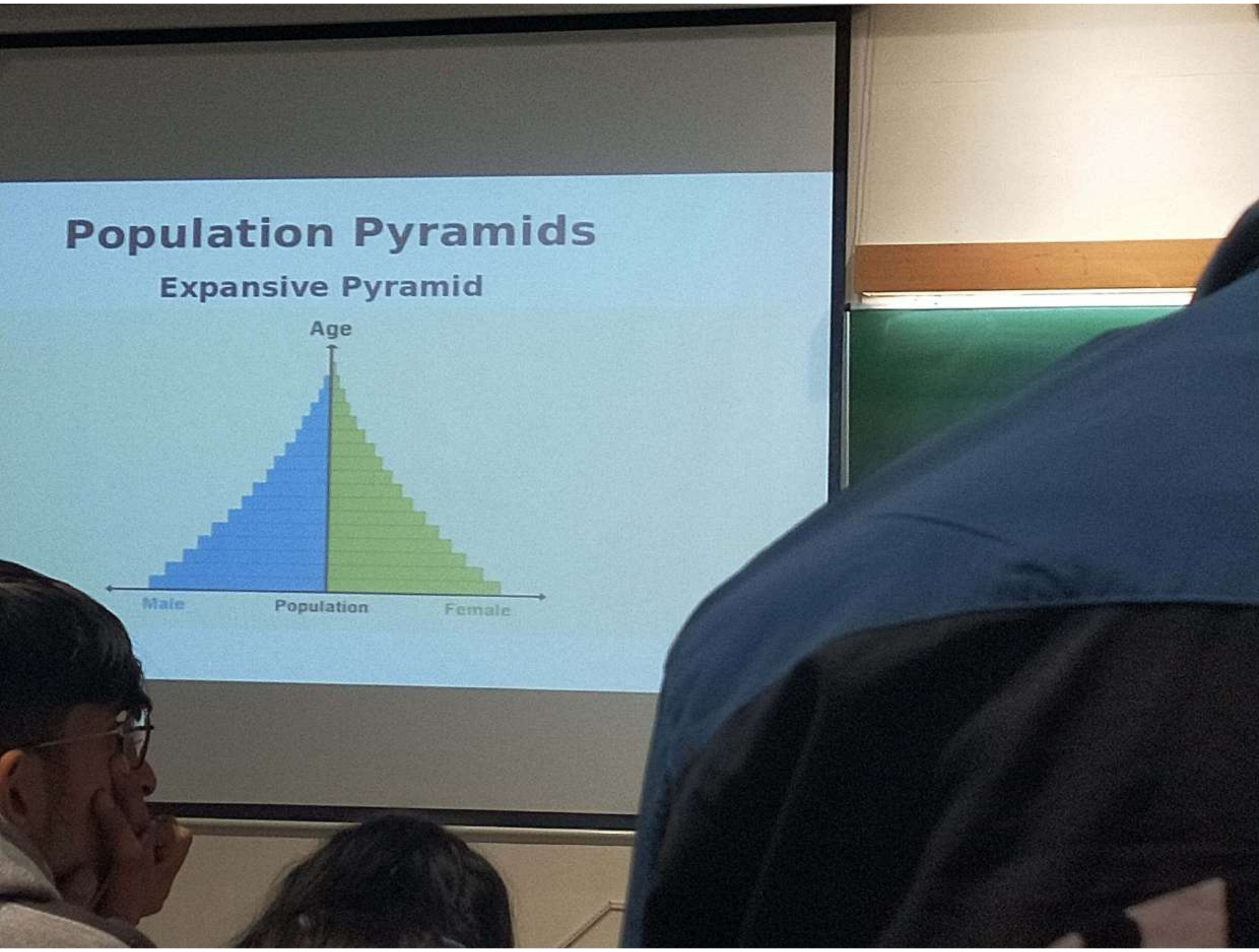

While the above applies to local dispersion patterns within populations, it is important to remember that populations within a species also show dispersion patterns.
Such populations often concentrate in clusters within the species' range.
Biogeography is the study of factors that influence the distribution of a species over its range.


is the study of factors that affect birth and death rates in a population
is the study of the vital statistics affecting population size.
rates of processes that add individuals to a population (birth, immigration)
individuals (death, migration).
vary among population subgroups depending on age and sex.


Population Pyramids
Stable Pyramid
Age
Male
Population
Female


Population Pyramids
Contrictive Pyramid
Age
Male
Population
Female


Generation time is an important demographic feature related to age structure.
Generation time = The average span of time between the birth of individuals and the birth of their offspring.
• Strongly related to body size.
• A shorter generation time usually results in faster population growth, assuming birth rate is greater than death rate and all other factors being equal.
Another important demographic factor affecting population growth is the *sex ratio*.


Population Pyramids
Expansive Pyramid
Age
Male
Population
Female

A. Age Structure and Sex Ratio

Many populations have overlapping generations where individuals of more than one generation coexist.

- Exceptions include species in which all of the adults reproduce at the same time, then die (annual plants, many insects).

The coexistence of generations produces an age structure in most populations.

Age structure = Relative numbers of individuals of each age in a population.

- Generations overlap when average life span is greater than the time it takes to mature and reproduce.
- Every age group has a characteristic birth and death rate.
  - ⇒ Birth rate greatest for those of intermediate age.
  - ⇒ Death rate often greatest for the very young and very old.
- In general, a population with more older, nonreproductive individuals will grow more slowly, than a population with a larger percentage of young, reproductive age individuals.

TABLE 55.1

Life Table for the 1978 Cohort of Cactus Ground Finch (*G. scandens*) on Isla Daphne

AGE CLASS (YEARS)	NUMBER ALIVE	SURVIVORSHIP[a] (l_x)	MORTALITY[b]
0–1	210	—	0.57
1–2	91	0.43	0.14
2–3	78	0.37	0.10
3–4	70	0.33	0.07
4–5	65	0.31	0.05
5–6	62	0.30	0.32
6–7	42	0.20	0.45
7–8	23	0.11	0.35
8–9	15	0.07	0.07
9–10	14	0.07	0.21
10–11	11	0.05	0.09
11–12	10	0.05	0.60
12–13	4	0.02	0.25
13	3	0.01	—

[a]Survivorship = the proportion of the original cohort (here, of 210 individuals) who survive to age x.

[b]Mortality ("death rate") = the proportion of individuals of age x who die before reaching age x + 1.

TABLE 55.2

Fecundity Schedule for the 90 Females of the 1978 Cohort of Cactus Ground Finch (Table 55.1)

AGE CLASS (YEARS)	FECUNDITY[a] (m_x)	
0–1	0.00	
1–2	0.05	
2–3	0.67	
3–4	1.50	El Niño event, increased rainfall
4–5	0.66	
5–6	5.50	
6–7	0.69	Drought
7–8	0.00	
8–9	0.00	
9–10	2.20	
10–11	0.00	
11–12	0.00	

[a]Fecundity = number of fledglings per female per breeding season.

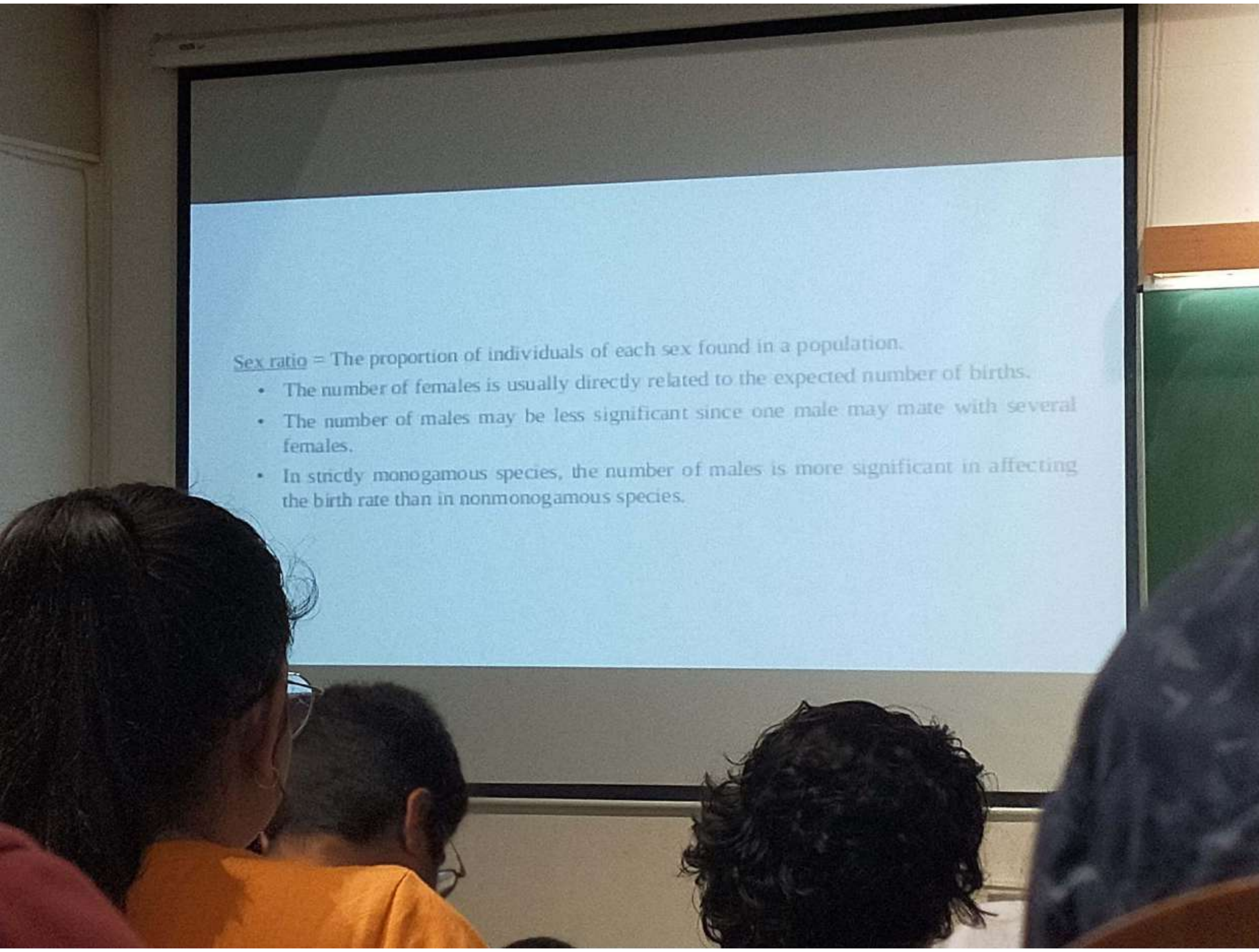
Survivorship curves plot the numbers in a cohort still alive at each age. Organisms may exhibit one of three general types of survivorship curves:

1. Type I curves are flat during early and middle life and drops suddenly as death rates increase among the older individuals.
   - Associated with species such as humans and other large mammals that produce few offspring that are well cared for.
2. Type II curves are intermediate with mortality being more constant over the life span.
   - Seen in *Hydra*, gray squirrels, and some lizards.
3. Type III curves show very high death rates for the young followed by lower death rates after individuals have survived to a certain critical age.
   - Associated with organisms, such as oysters, that produce very large numbers of offspring but provide little or no care.

B. Life Tables and Survivorship Curves

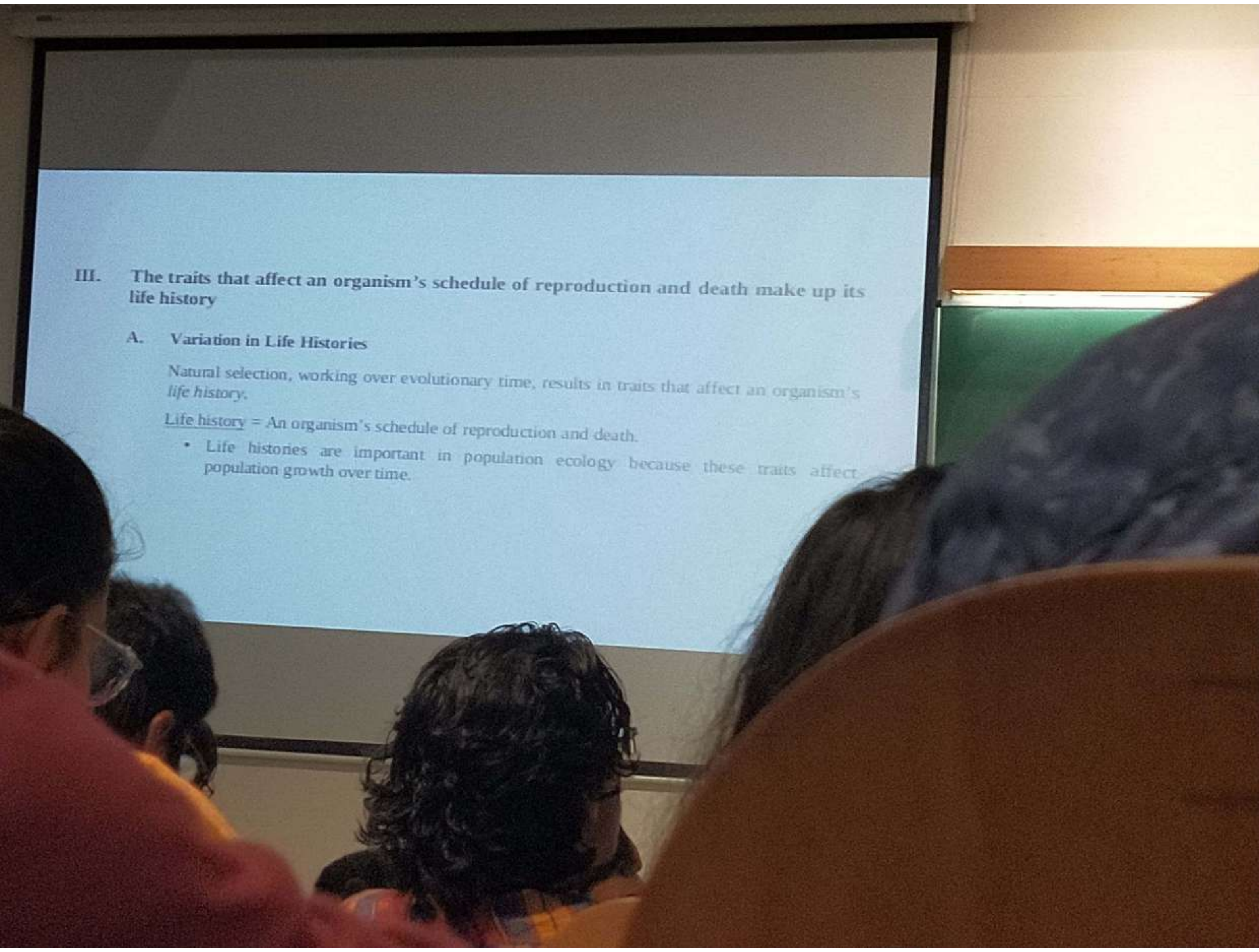
Life tables describe how birth rates and death rates vary with age over a time period corresponding to maximum life span.

- Constructed by following the fate of a *cohort*, a group of individuals of the same age, from birth until all are dead or by using the age specific birth and death rates in a population during a specified time.


Sex ratio = The proportion of individuals of each sex found in a population.
The number of females is usually directly related to the expected number of births.
The number of males may be less significant since one male may mate with several females.
In strictly monogamous species, the number of males is more significant in affecting the birth rate than in nonmonogamous species.

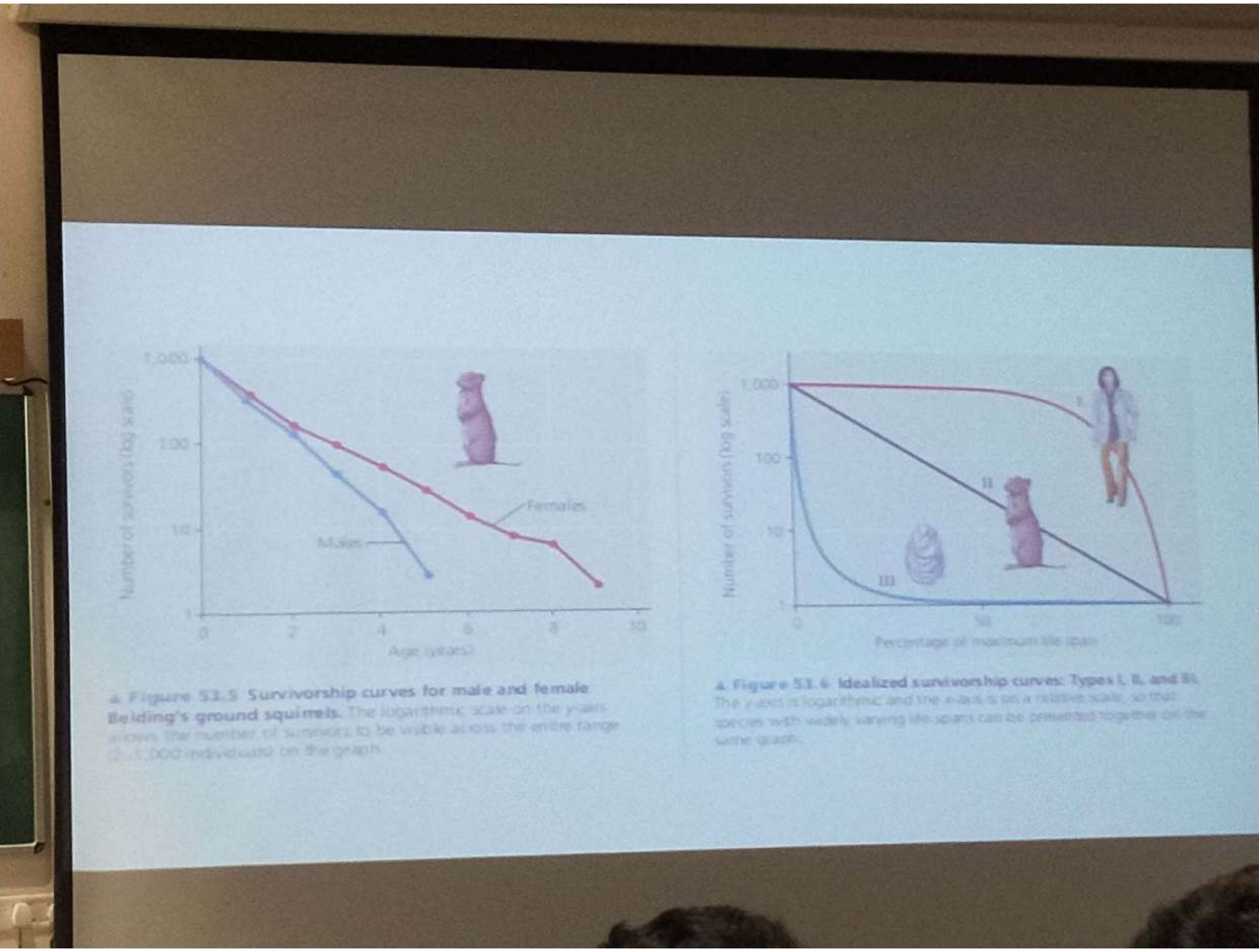
Even though life history traits vary widely, there are some basic patterns:

- Life histories often vary in parallel with environmental factors. For example, clutch sizes increase with latitude.
  - ⇒ Tropical birds lay fewer eggs than those in higher latitudes which reflects the number of offspring that can be successfully fed.
  - ⇒ Since daylengths are longer at higher latitudes than the tropics during offspring-rearing season, parent birds can gather more food and feed more offspring.
  - ⇒ The clutch size-latitude variation is also found in many mammals, lizards, and insects.


III. The traits that affect an organism's schedule of reproduction and death make up its life history
A. Variation in Life Histories
Natural selection, working over evolutionary time, results in traits that affect an organism's life history.
Life history = An organism's schedule of reproduction and death.
• Life histories are important in population ecology because these traits affect population growth over time.

There is a diversity in life histories due to the varying pressures of natural selection.

- Some animal species hatch in one type of biome, migrate to another where they mature for several years, then return to the initial biome for a single massive reproductive effort, then die (i.e. salmon).
- Other animal species hatch and mature rapidly in a single habitat, then have small reproductive efforts each year for several years (i.e. lizards).
- Life history characteristics may vary significantly among populations of the same species or even among individuals within a population.


1,000
100
10
1
Number of survivors (log scale)
0
2
4
6
8
10
Age (years)
Females
Males
Figure 53.5 Survivorship curves for male and female Belding's ground squirrels.
1,000
100
10
1
Number of survivors (log scale)
I
II
III
0
50
100
Percentage of maximum life span
Figure 53.6 Idealized survivorship curves: Types I, II,

Many species exhibit curves between the basic types of survivorship curves and some have more complex curves.

- Great tits show a high mortality rate in young birds (Type III) but a fairly constant mortality (Type II) in adults.
- Some invertebrates show a "stair-stepped" curve with brief periods of high mortality during molts, followed by periods of lower mortality when the exoskeleton is hard (i.e. crabs).