Basic Course in Ornithology
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Lecture -22
Bird Communities Concepts - Part 2

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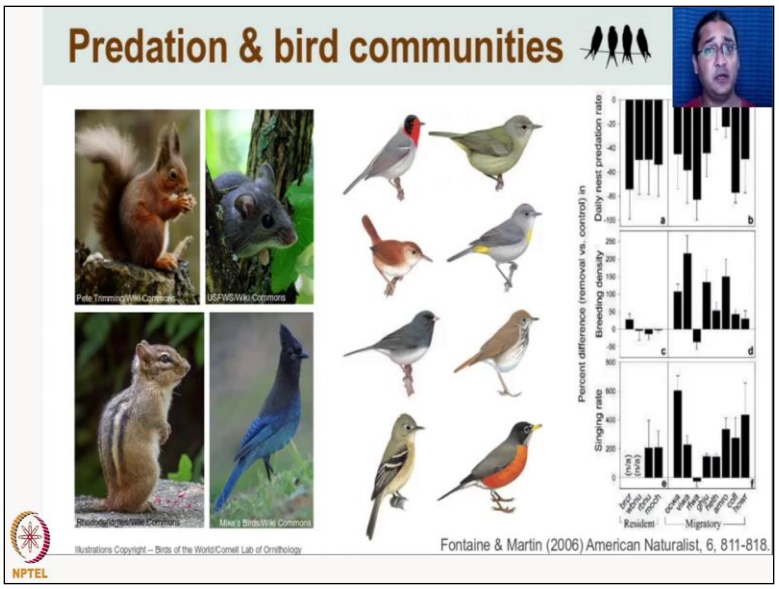

Here's an example of predation structuring bird communities. What you see on the left are nest predators of birds in the middle. So, you have a variety of rodents and other birds that are actually nest predators of the nest of this community of birds that that is represented by these uh paintings in the middle and what the authors did was very interesting they actually went to various patches of forest where these birds would nest.

And they removed these predators, they tracked these predators and they removed them from the habitat. And then they compared various things.. various measures between the habitats that had the predators and habitats that did not have the predators. And what did they compare they compared from bottom to top. In that graph on the right, they compared singing rates of birds, they compared the breeding densities of birds and they compared the nest predation rates of birds in the habitats that did not have the predators versus the habitats that had the predators.

The habitats that did not have the predators actually had many more birds, the singing rates of these birds for almost all of these species. The species on the x-axis represented by those species codes the singing rates of these birds were much higher in the habitats that did not have the predators. The breeding densities of these birds were much higher in the habitats that did not have the predators and the nest predation rate also declined for all species was lower in the habitats that did not have the predators.

So, the very presence of the predators influence whether a bird would come and nest in the habitat to begin with and that affects bird communities. Right. So, if a bird decides not to nest in a particular habitat because it contains these predators that the predator is having a negative effect on the abundance of the bird species without even eating it. And therefore, it had then has an impact on the abundances of all of these various bird species and therefore an impact on the community structure as a whole.

And so, predation can be a very very important factor that determines how many individuals or how many species are found in a particular habitat.

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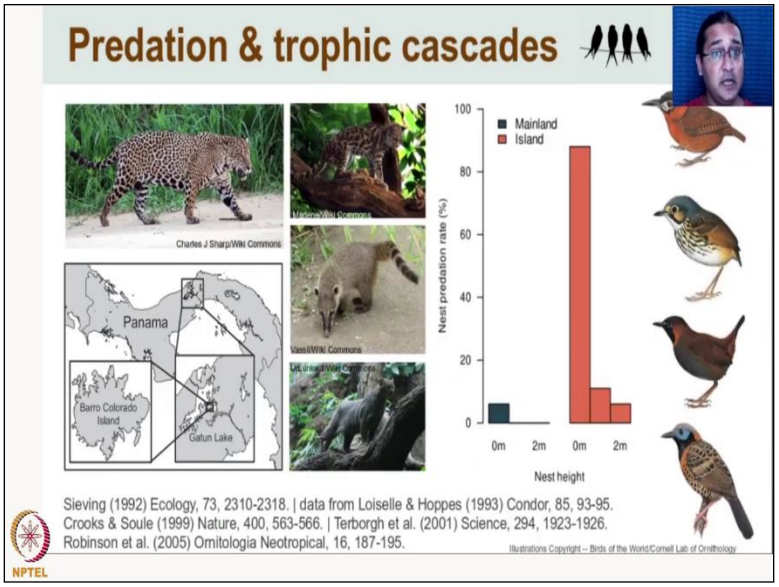

Predation also has very interesting indirect impacts on bird species this is a fascinating example from Central America. When the Panama canal was built in the early 1900s, this was a canal connecting the pacific and the Atlantic oceans built through the center of Panama. It created a lake

in the middle of Panama and the lake caused the isolation of an island… and it created an island called Barro Colorado island which was in the middle of this lake because it was a part of the forest that was higher than the surrounding parts of the forest.

And so, when this area got inundated and the lake was formed, the top high elevation forest became an island in the middle of the lake that is called Barro Colorado island and a lot of community ecology work comes from Barro Colorado island. Barro Colorado island is so small that it cannot support predators, predators like jaguars large predators like jaguars. And so, jaguars disappeared from Barro Colorado island, there are no jaguars Barro Colorado island.

But there are jaguars on the mainland adjacent mainland. Now the disappearance of the jaguars allowed what are called mesopredators or intermediate level predators to increase intensity. So, the removal of the jaguar or the disappearance of the jaguar led to an increase in the abundances of mesopredators like the Ocelot, the Quati and the Jaguarundi, these three species that you see in the center there.

And the increase in the abundance of these mesopredators caused greater nest predation. These are all predators that feed on the nests of ground nesting birds. And if you look at predation rates of birds on the mainland in green and the island in red and these are nests at different heights zero meters means these are nests on the ground one meter nest one meter above the ground at two meters nest two meters above the ground, you can see that there is hardly any predation on the mainland.

There is some predation on the ground nesting birds in the mainland maybe you know 5 to 6% of the nests that are on the ground are eaten or destroyed. But on the island, almost 90% of the nests on the ground are destroyed which is because of the absence of the jaguar. So, the removal of the jaguar which is not actually interacting directly with any of these ground nesting birds through this intermediate mesopredator release has led to high nest predation on Barro Colorado island and the high nest predation is actually led to the extinction of multiple bird species on the island itself.

So, you have these interesting what are called trophic cascades where the top predator and the presence of the top predator allows the existence or the presence of certain species in the bird community in this case but the predator itself is not interacting with any of these birds in the bird community but the removal of the predator and mesopredator release causes the local extinction of these ground nesting birds because of nest predation.

And then the community changes completely because you have all these ground nesting birds becoming completely extinct from the island. So, the island bird community is very different from the mainland bird community and that is thought to be because of the presence of the jaguar on the mainland versus the absence of the jaguar on the island. So, that is an example of top-down control of communities where predation is a very important factor leading to community properties like community structure.

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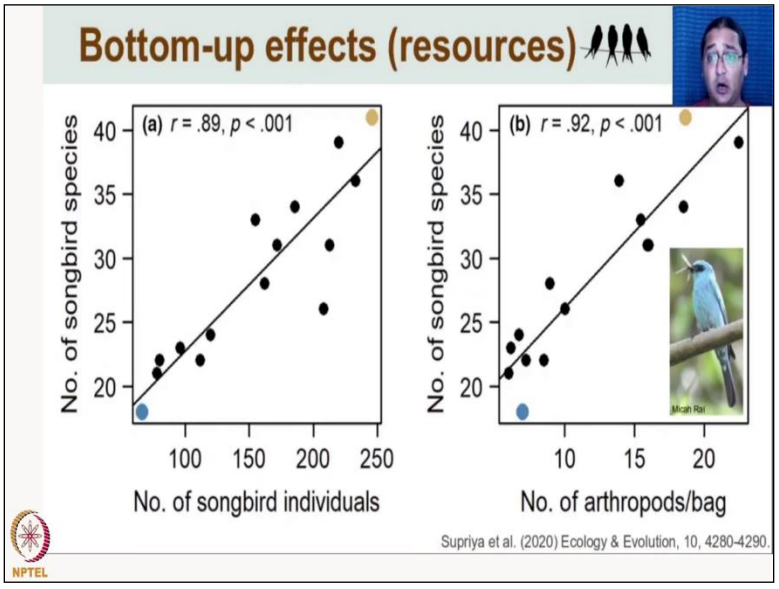

But bottom-up effects are also important. Here is an example from the eastern Himalayas where if you look on the left side graph the number of songbird individuals in a particular location and the number of songbird species are highly correlated. So, if you have more individuals of birds, you know instead of 100 individuals you have 250 individuals. The 100 individuals are represented by about 23 species whereas where you have 250 individuals who have 40 species.

So, the more individuals there are in a habitat, the more likely that there are more species also in the habitat and what determines how many individuals are there in the habitat? It is determined by the density or the availability of food in the habitat. So, if you look at the right side graph then the number of arthropods per bag which is a measure of the density or abundance of arthropods that these birds are eating is changing from very low density on the left side to very high density on the right side.

And the number of species of birds that is in the community is very very highly correlated with the density of arthropods in the bag. So, the higher the density of resources the greater the availability of resources the more number of individuals that that location can support. And the greater the number of individuals that the location can support the greater the number of species that that location can also support. So, here is an example of bottom-up impacts where the lower trophic level which is the availability of resources determines the community of species at any location.

So, you have these top-down effects and as well as bottom-up effects operating across trophic levels to determine community structure.

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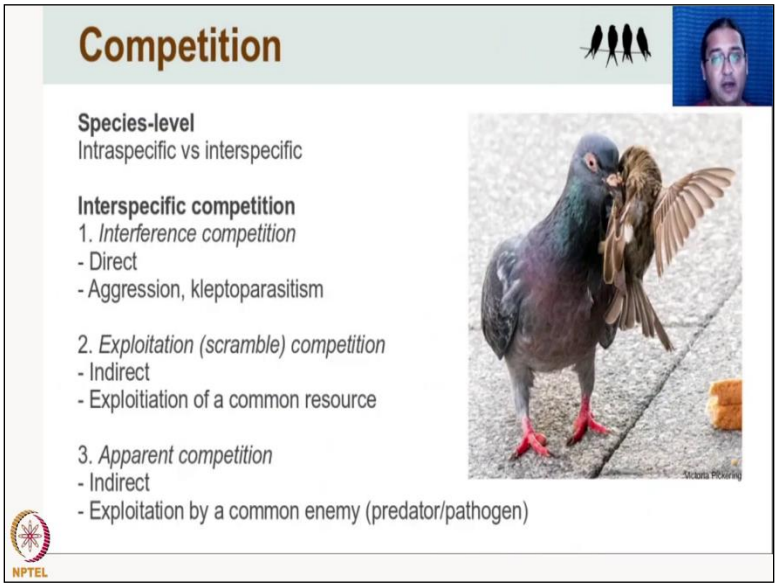

You also have lateral effects. One very important example of a lateral effect is competition and on the right what you are seeing is a competition between a pigeon and a sparrow for bread and

competition is a very very common interaction between species in nature. If it is within a species competition called intraspecific if it is between species it is called interspecific competition.

So, you can have competition between two individuals of the same species intra-specific competition or like you see on the right competition between two individuals of different species which is inter-specific competition. And inter-specific competition is of various kinds, you have interference competition which is direct. You actually have a bird coming and directly you know aggressively stealing food from another bird which is what is happening here on the right, it is direct it is involved with aggression it is more something called kleptoparasitism which is basically stealing.

And then you have indirect forms of inter-specific competition which are exploitation competition and what is called apparent competition. Exploitation competition occurs through the exploitation of a common resource but the birds are not directly interacting with each other but because they are sharing the same resource the presence of one bird will have an impact on the presence of the other bird because they are both feeding on the same resources or utilizing the same resource.

Then you have a fascinating example of a competition it is called apparent competition which is mediated through exploitation by a common enemy which could be a predator or a pathogen and we will take a look at a very very fascinating example of that as well.

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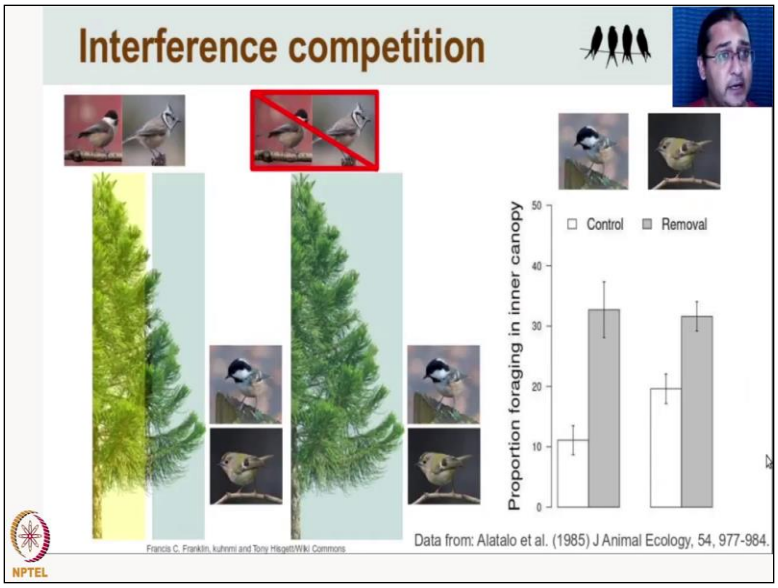

So, let us look at exploitation competition or interference competition sorry. Here is an example of multiple species of birds in the coniferous forests of Europe. And you have these let us look at the graph on the this little schematic on the left you have two species of tits which feed on the inner part of the coniferous trees. So, they are feeding these two species of tits on top are feeding only on the inner part of the coniferous trees.

And you have these other two species the goldcrest and the coal tit which are feeding on the outer parts of the coniferous trees. Now what the authors in this very interesting paper did was to conduct this experiment where they removed these two tit species that feed on the inner part of the coniferous trees near the trunk. And what they found was the removal of these two tit species allowed the other species to then extend their feeding areas or extend their niche into the areas where these two tits species would ordinarily forage.

The absence of these tit species allowed these the coal tit and the goldcrest to actually start feeding closer to the trunk. So, the presence meant that they would prevent the coal tit and the goldcrest from feeding in the inner part of the tree. The removal of these species now allows these two species to expand their niche and now start feeding on the inner part of the coniferous trees as well.

And you can see the graph on the right over there where the proportion of foraging in the inner canopy for both these species the coal tit and the goldcrest is much higher when these other tit

species are removed compared to when those two species are present. So, the control is where the species are present and you can see that the foraging in the inner canopy they only spend about 10% of the time forging in the inner canopy whereas when you remove these species of tits from the inner canopy then the other species start foraging much more in the removal in the canopy about 30%.

So, they increase their forging in the canopy by about threefold in the absence of these species. So, this is an example of interference competition where the two tits the willow tit and the crested tit actually prevent the foraging of the coal tit and the goldcrest in the inner part of the canopy of coniferous trees in Europe.

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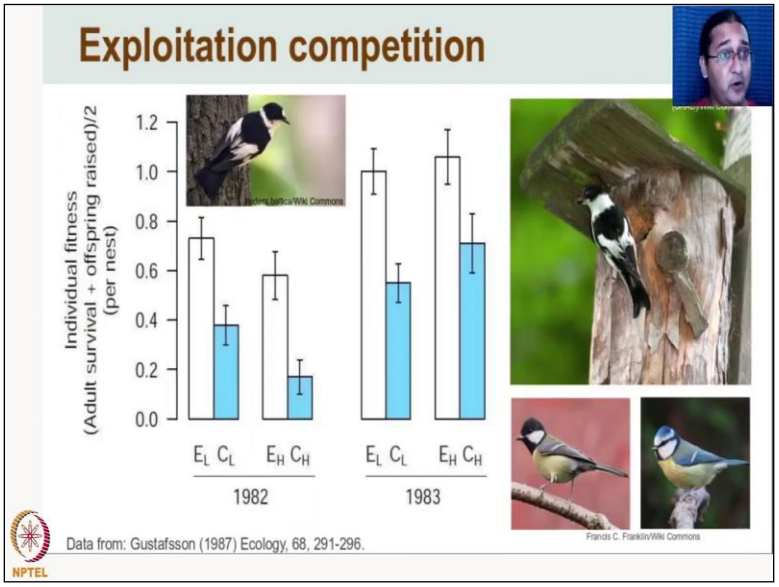

Let us look at an example of exploitation competition. This is exploitation competition between the Collared flycatcher which is the bird that you see on the top left there and two species of tits the Great tit and the Blue tit again from Europe. Both of these species exploit a common resource what is that common resource the common resource is nest boxes. So, both of these are all three of these species are cavity nesting species the Great tit and the Blue tit also nest in cavities, the Collared flycatcher also nest in three cavities.

And what the researchers here did again was an experimentally excluded the tits from these nest boxes. So, remember this is a common resource used by both of these species the Collared

flycatcher and the tits. They are both using nest boxes and the researchers experimentally excluded the tits from using these nest boxes. And what happened then was that the Collared flycatcher had access to all of these nest boxes that the tits were prevented from using.

We have two graphs here for two these are results from two different years. Let's look at the patterns - are the same for both those years. But let's look at here 1982, which is on the left and you have the fitness of the Collared flycatcher on the y-axis. If it is measured in some way number of offspring raised per nest. And you are seeing the low density on the left and high density areas on the right. So, low density of birds on the left and high density of birds on the right, two different kinds of communities.

And where the tits are experimentally removed 'E' versus where the tits are allowed to remain 'C', which is the control in either the low density case or the high density case. The fitness of the Collared flycatcher is always higher when experimentally these tits have been removed. And it is always lower in the control plots where the tits are allowed to nest in these nest boxes. And this is a pattern you see whether the bird community is high density or low density is a pattern you see across years.

Where the exclusion of the tits from these nest boxes allows the Collared flycatcher to utilize these common resource nest boxes and increase its fitness very very much compared to when the tits are present. So, these Collared flycatchers and these tit are not necessarily directly interacting with each other but because they are utilizing a common resource the absence of one of these competitors then allows the other competitor to increase its fitness in this case.

So, that was an example of exploitation competition where two species are utilizing a common resource and therefore having reciprocally negative impacts on each other. So, the presence of one species reduces the fitness of the other, presence of the second species reduces the fitness of the first.

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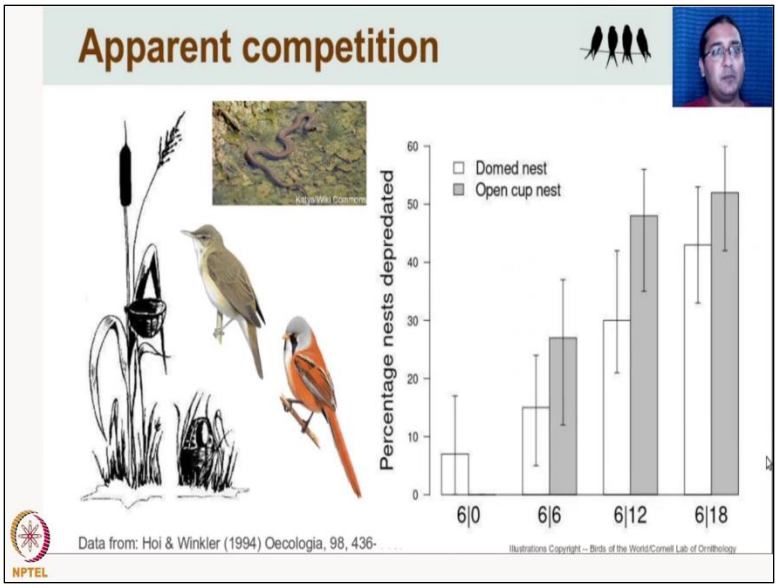

Let us look at an example of a apparent competition, apparent competition is fascinating uh where competition between two species is actually mediated by the presence of a common enemy or… or in this case a predator. So, you have the Reed warbler which is the bird in the center there below the snake and you have the Bearded tit and both these species nest in marshland. And the Reed warbler nests in this open cup nest higher above the ground whereas the bearded tit ne sta domed nest on the ground

And you have the water snake that is a predator that eats the eggs in the nestlings of both of these species. So, it is a predator that is shared by both of these species the Reed warbler as well as the Bearded tit. Now, what happens here this is fascinating. So, these researchers what they did was that they in a particular habitat, they kept the density of the domed nests used by the Reed warbler identical six.

So, you see the graph of that the density of the domed nests are represented by the number before the line on the x-axis. So, the number of domed nests was kept constant at six in the habitat (the density of the dome nest). Whereas, they artificially increased the density of the open cup nest in the habitat. So, they had a situation where the density of the open cup nest was zero, a situation where the density of the open cup nest was six in the habitat, a situation or treatment where the density of the open cup nest was 12 and then 18.

So, you have on the x axis - the density of the domed nest on the left side and the density of the open cup nest on the right side. So, density of the domed nest remains six in all the treatments but the density of the open cup increases. What you have on the right on the y-axis is the percentage of the nests that are depredated by this common enemy (this common predator the water snake). And you can see that even though the number of domed nests remains identical in all treatments as you increase the density of the open cup nests.

The predation rate on the dome nests increases. So, what is happening here is that when there are higher number of open cup nests in the habitat, the snake activity there to predate on these open cup nests is higher but they are also finding the domed nest to eat. And so, if you increase the abundance of the species that nests in the open cup nests, you are also having a negative impact on the species that lessen the dome nest because they have a common predator.

So, the snake is not only eating the open cup nests but it is also predating on the domed nests. And so, what is happening here is that the increase in the abundance of one species is having a negative impact on the second species. Now, they are not sharing the same kind of nests or the stratum for the nest one is nesting on the ground, one is nesting higher above the ground. So, they are not in direct competition for nesting space.

But if you increase the abundance of one of those species because it attracts predators, it also increases predation rate on the second species. And so, this is an example of an indirect form of competition called apparent competition where a common enemy like a predator in this case is actually leading to an increase in the predation rates of one species because of the higher density of a second species even though both of those species are not interacting directly with each other. So, that was three types of competition.

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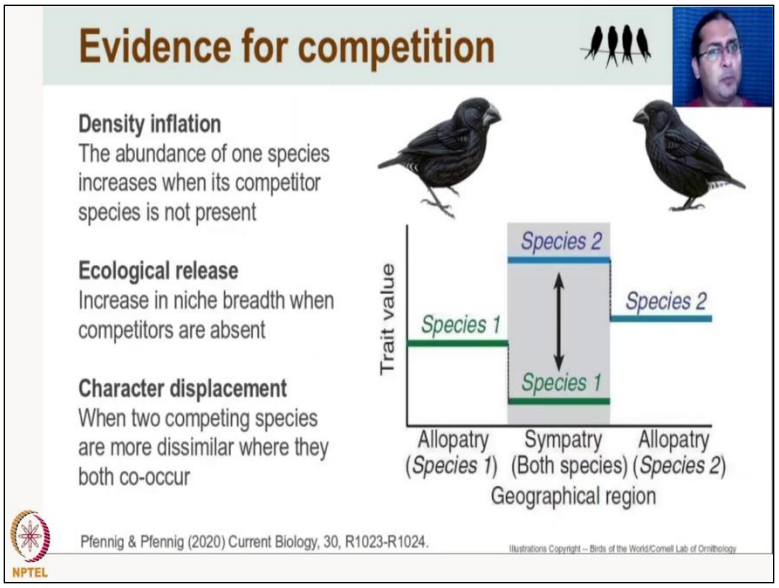

How do we know that competition exists in nature what is the evidence we have for competition? There are various forms of evidence that we have for competition; one of them is density inflation which is that when a competitor is absent the abundance of one of the other competitive species increases. So, if you have two species that are competing with each other and one of the species is removed then the abundance of the second species will increase you often see this on mainland and islands.

So, in islands for example, where you have two species that are competing with each other, the densities of both those species will be low on an adjacent island where one of those species is absent the density of its competitor becomes higher than it is on the mainland. So, we see this density inflation where the absence of the competitor actually allows the population size of its competitor species to increase.

We also see something called ecological release, we saw that with the example with the tits and the Goldcrest where when competitors are absent these species (if there are two species) that are competing species one and species two then if species one is removed or this one of the competitors is absent then species two is able to expand its niche and is able to utilize more of the resources present in the habitat than when the competitor is present.

And one of the interesting ways in which we infer competition is through something called character displacement where which is a phenomenon there when you have two competing species. If they are found together, they are more dissimilar in the habitat or the location where they are both found together compared to where they are found separately. You can see this with the Galapagos finches or Darwin's finches and their beak sizes.

So, you have beak size which is a trait and you can see that trait value on the y-axis. Let's say that is the thickness of the bill and you have the trait value which is the thickness of the bill on the y-axis when species one and species two are found separately. In Allopatry, which is called Allopatry where species one and species two are found separately they are not coexisting in the same location.

Then species two the bill depth of species two and the bill depth of species one are very very similar whereas when species one and species two are found together in the same habitat then the trait value becomes very very different. What this means is that because these two species, species one and species two are competing with each other when they are found together, they diverge they become different from each other. So, that they minimize their resource use.

So, the depth of the bill or the size of the bill determines what the species can eat. And if two species come together in the same habitat and they are both eating the same thing over time what will happen is that these two species will become dissimilar in beak size. So, that they are able to exploit different resources, reduce competition and therefore coexist in the same location. So, this is called character displacement.

Where if you have the character in this case the beak, size of the beak or the size of the bill where these two species, species one species two are found separately the size of the beak is very very similar because they are not competing with each other they do not co-exist and therefore there is no competition. Whereas, when in the condition or location where two species actually do coexist actually found with each other then the beak size becomes very different over time between the two species allowing them to coexist by eating different things. So, there are many ways in which we can infer whether competition is happening or not.

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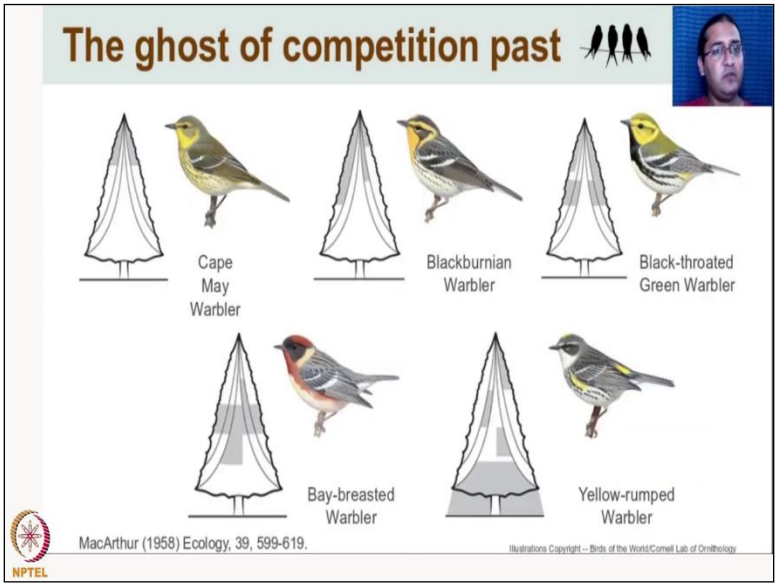

One of the fundamental concepts in competition is what is called competitive exclusion. Competitive exclusion says that two species that occupy exactly the same niche cannot coexist one of them will drive the other extinct. And one of the ways in which people have inferred competitive exclusion is based on what is called the ghost of competition past which is that we see patterns in the way in which species behave or in species morphology and anatomy that tells us that it is likely that there was competition between these species in the past.

But now they have become sufficiently different from each other to avoid competition. Example of this classic example of this is Macarthur's warblers. Five species of very very similar warblers that eat very very similar things, all of which coexist in the same coniferous forest habitat, they all breed in the same coniferous forest habitat in the in North America. But even though they are all found they could be found on the same tree they are feeding in very different parts of the tree.

So, the Cape May Warbler for example is feeding on the tops of the trees of the apex of the coniferous trees and on the outer side of the canopy. The Blackburnian is feeding on the outer side of the canopy as but further lower down in the canopy as well and you can see that these different species are feeding a Yellow-rumped Warbler for example is feeding in the bottom part of the canopy.

And the inference from these patterns is that these species would have competed in the past but they have changed their behaviors to minimize competition with each other and therefore allow them to coexist. So, they are not competitively excluding each other because they no longer have the same niche and this is what is called 'the ghost of competition past' which is inferring from current patterns from present patterns of behaviour or morphology or physiology the fact that it is likely that two very very similar species (closely related species) did actually compete in the past.

And that has led to character displacement that has led to them changing their morphologies or behaviours to allow them to coexist by minimizing competition between each other, in this case minimizing competition by foraging in different parts of the canopy of these coniferous trees in the same location.

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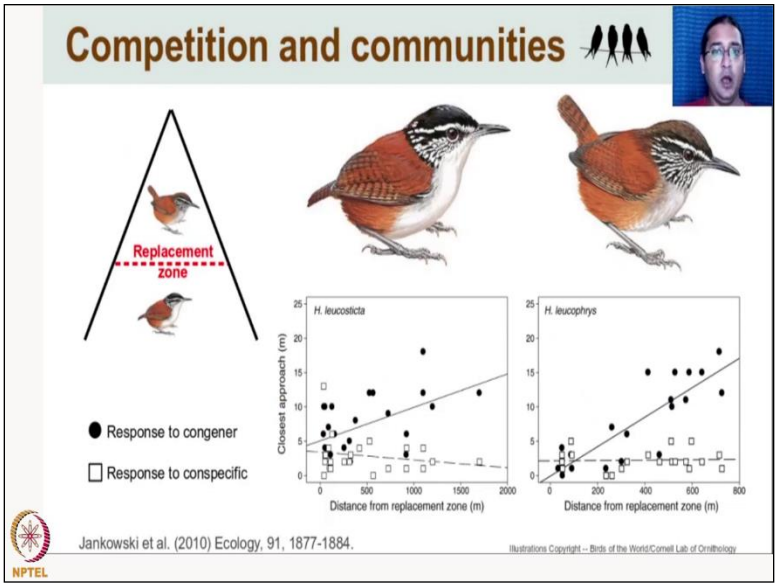

How does competition structure communities, a competition actually we have very clear evidence that competition does in fact structure bird communities. This is an example from South America where you have two very very closely related species of wrens. One of which is found in at the lower elevations of this mountain (that triangle represents a mountain) one species found at a lower elevation the other species is found at a higher elevation.

And there is some elevation at which this one species replaces the other and that is called the replacement zone. Now, one good example for evidence for competition between bird species is

whether they respond to playback. What does that mean? If I went to the territory of a bird and I played a call on a little speaker if I played the song of the same species then that species would approach the speaker in an aggressive manner.

Because the species is territorial and it will not tolerate the presence of another individual of the same species. So, there is intraspecific competition between these two individuals of the same species and one way to measure that intra-specific competition is if you play the song of a species in the territory of an individual of the species does it approach the speaker or not. So, what the researchers did in this case was very very interesting.

They went to the replacement zone and they played the song of both the conspecific which is the species which is the song of the same species and that of the heterospecific or the song of the other species. And what they found is very interesting, just look at the dots the squares what they mean the closed dark circles is the response to the congener which is the other species and the open square is the response to the conspecific, so, the song of the same species.

So, the y-axis shows you the closest approach to the speaker in meters. So, the closer a bird comes to the speaker the more, the inference is that the greater competitive interaction is happening between these two individuals because a bird would approach the speaker very very close (to a very very close distance), if it is competing with the other individual. And you can see that at the replacement zone which is the x axis is distance from the replacement zone.

At the replacement zone, the one species responds as strongly to its own song (responds as aggressively to its own song) as it does to the song of the other species. And that is true in both cases where at the replacement zone one species is as aggressive towards the song of its own species as it is to the other species. But as you go further and further away from the replacement zone the degree of aggression is much lower.

So, the closest approach to the speaker becomes is much higher (the distance that a species uh that an individual approached the speaker it does not approach the speaker as closely) and that is you can see with the black dots that is what the pattern is, where the response to the other species

becomes less and less aggressive as you move away from the replacement zone. So, at the replacement zone what is happening is very very strong competition between two species very very strong inter specific competition preventing both those species from occupying the same territory or occupying the same habitat.

And therefore, at the replacement zone you have strong interspecific aggression strong into specific competition which is preventing the high elevation species from moving down preventing the low elevation species from moving up and therefore along the elevational gradient what you have is two species excluding each other and if you sum that across multiple species basically influencing the structure of the communities at low elevations and high elevations.

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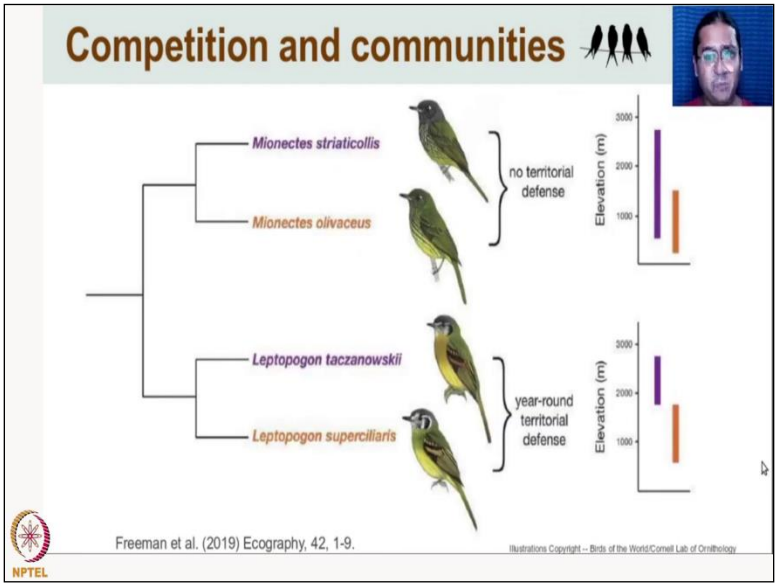

Another fascinating example of this is again from Latin America from the Andes where you have two sister species pairs. So, you have two species of *Mionectes* two species of *Leptopogon*, the *Mionectes* are not territorial whereas the *Leptopogon* are both territorial. And you see the map of the elevational ranges of these species on the right the sister species that have no elevational or no territorial defense actually overlap a lot in their elevational ranges.

Whereas the two species sister species of *Leptopogon* that are very very territorially, defensive do not coexist one is a low elevation species and the other is a high elevation species. So, competition is actually the lack of competition is allowing the lack of territorial defense is allowing the

Mionectes to coexist along this elevational gradient. Whereas, the territorial difference between the *Leptopogons* is preventing their coexistence in that particular along that particular elevation gradient.

So, if you look at competition, then across multiple sister species pairs whether there is territorial defense or no territorial defense, these species… the behavior of the species causes them to occupy certain parts of the elevational range or not occupy other parts of the elevation. And therefore, competition then structures how bird communities are found across an elevational gradient.

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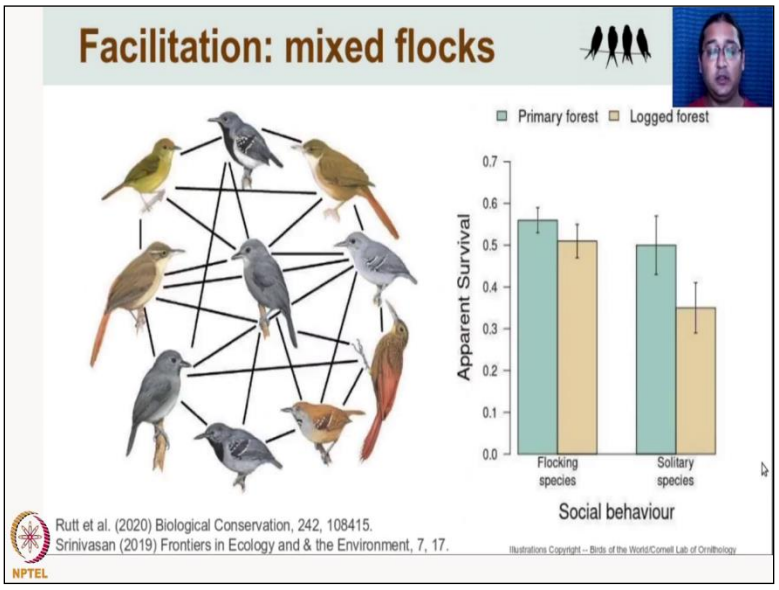

The flip side to competition is facilitation and one of the fascinating phenomena in birds across the world in forest habitat. In forest habitats across the world is what are called mixed species bird flocks, mixed species bird flocks are these interactive networks of multiple species. You know flocks of single species, flocks of Rosy pastors or flocks of you know mynas, these are very very tight cohesive flocks of multiple species that feed together and move together.

Especially in forests across the world, those of you who are bird watchers and have gone into forest you would have found these groups of multiple species you know 15 species 20 species all feeding and moving together as a single group, why do they do that? That is because of two reasons the presence of some species allows the others to increase their foraging rates. So, some species for

example when they are moving through the vegetation that disturbing insects which then become accessible to other species in the flock.

So, they are actually increasing the amount of food that participants in the flock can eat and the other reason is that some species are very very good sentinels or very very good warning systems against predators. So, some species will warn the other species in the flock of the presence of a predator allowing them to take cover very very quickly. And so, you have this mutualistic relationship between species in the flock where there is enhanced access to resources as well as reduced predation risk.

Both of these things enhanced access to resources and reduced predation risk are directly important for survival and some of our own work from the eastern Himalayas has shown that when primary forest or forest that has never been disturbed and you compare the survival rates of species that form mixed species flocks and joint mixed species flocks in primary forest and in a logged forest, primary forest in green and the log forest in brown.

The survival rates of the flocking species are very very similar in primary and logged forest. Whereas, if you look at the species that do not join (never join) mixed flocks, they just do not join but evolutionary not hardwired to join mixed flocks, actually have about a 30 reduction in survival in logged forest than in primary forest. So, just flocking allows these species to adapt to changes in predation pressure, changes in the availability of resources.

And so, flocking is very very important for the survival of a number of bird species in forest habitats throughout the world.

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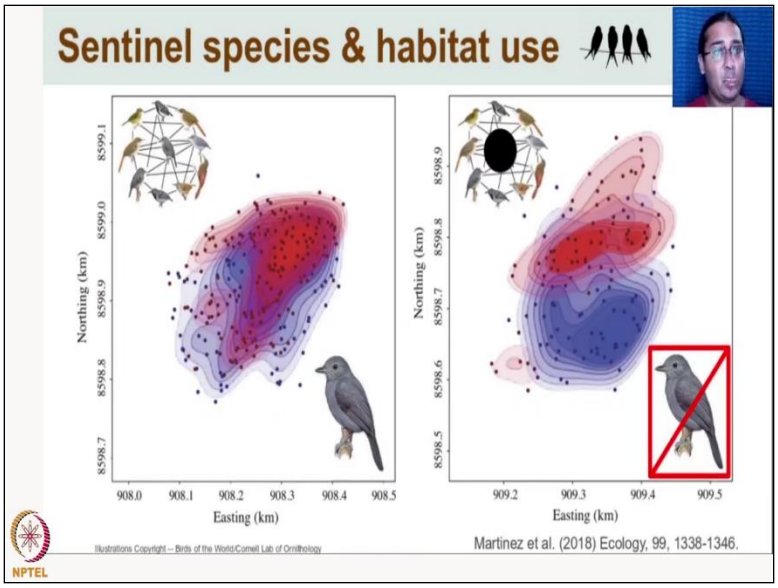

This is an interesting example of how important flocking is, this these are flocks from the Amazon, at the center of the flock you see this sentinel species which is the Antshrike here and the sentinel species warns the other species of predators in the flock. So, the authors who did something very very interesting, what they did was that from these flocks they took out the Antshrikes for a few days kept them in a cage fed them.

And they looked at how the foraging behaviour of the flocks changed. So, on the left you have the control where the Antshrike was not taken out and you have when the Antshrike was present the flocks are foraging pretty much in the same habitit same location throughout the experimental period. So, the Antshrike have not been removed each dot represents the location of the flock.

And you can see that the dots are pretty much in the same location or the same set of locations pretty much throughout the study period, that is the control. In the experimental, what the authors did was they recorded where these flocks are foraging in the presence of the Antshrike which is the red colored areas and after removing the Antshrike or the sentinel (the early warning species) where are these flocks foraging and you can see that in the presence of the Antshrike they are foraging in a very very different area compared to when the Antshrike has been removed with the blue which is in a very very different part of the habitat.

You can see the flock locations are very different in the presence of the Antshrike and the absence of the Antshrike.

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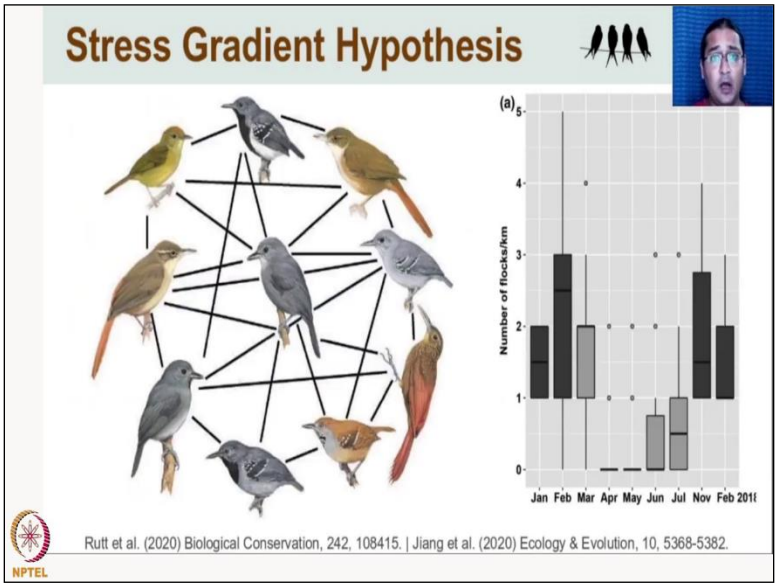

There the flocks are actually shifting to foraging from open forest in the presence of the Antshrike to much more closed forest in the absence of the Antshrike. Why is that that is because the Antshrike are very very good sentinels, they allow these birds to forage in the open habitat, where it is easy for predators to to attack the other members of the flock but they are able to forage in this habitat because the Antshrike warns the rest of the species in the flock from predators.

Whereas when the Antshrike is absent, the birds are moving from open forest to forests that is much more dense where predation is much more difficult. And so, you can see this change in the heights at which these birds are foraging between the control and the removal (the control represented by the dark circles) and the removal where the Antshrike is absent (by the open circle)s. And you have heights on the y axis the heights and vegetation in which these birds are foraging.

In the presence of the Antshrike, they are not foraging much in the low level (lower parts of the forest), right, they are foraging more in the canopy. So, you see a lot more canopy foraging in the presence of Antshrike (a lot more dark circles higher up towards the right) when the Antshrike is

present forging high up in the canopy, when you remove the Antshrike these birds are shifting towards foraging in lower elevations,

the grey bars are showing that there is a much higher proportion of foraging at the lower street lower parts of the forest than in the higher parts of the forest. So, the presence of these sentinel species and this facilitative interaction does change how the community is structured, where it is found and so on. So, these competitive and facilitative interactions also do have a very strong bearing on community structure in the community conversation.

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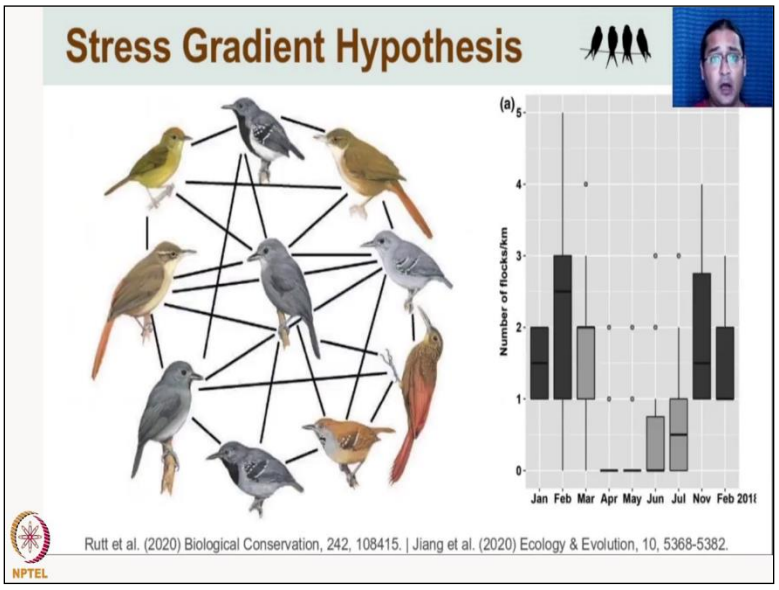

An interesting thing is what is called the stress gradient hypothesis in… in communities across the world. And this especially interesting evidence from plants for the stress gradient hypothesis is that when situations are very stressful let's say resources are very low, the predominant interaction between species in a community will be facilitation. Whereas, when resources are high and resources are available then the interactions between these species switches to competition.

And that might be what is happening with mixed species bird flocks this is from southeast Asia. Southeast Asia of course being a very very monsoonal area (you know April May June July when rainfall is high and arthropod abundances are also high), you tend to see that the number of flocks in the habitat which is on the y-axis reduces in April May June and July. Now remember the flocking is a facilitative process it is a set of facilitative interactions.

And when do you see these facilitative interactions, when do you see these flocks forming January February March November and November in the dry season in the cold season when resources are likely to be low is when these specifications interactions emerge. And when the resources are high then these facilitative interactions stop being important in allowing these species to survive.

And so, there is this hypothesis the stress gradient hypothesis which hypothesizes that in times of stress in terms of resources although the dominant interaction between species will be facilitation and when resources high that set of interactions switches to becoming competitive.

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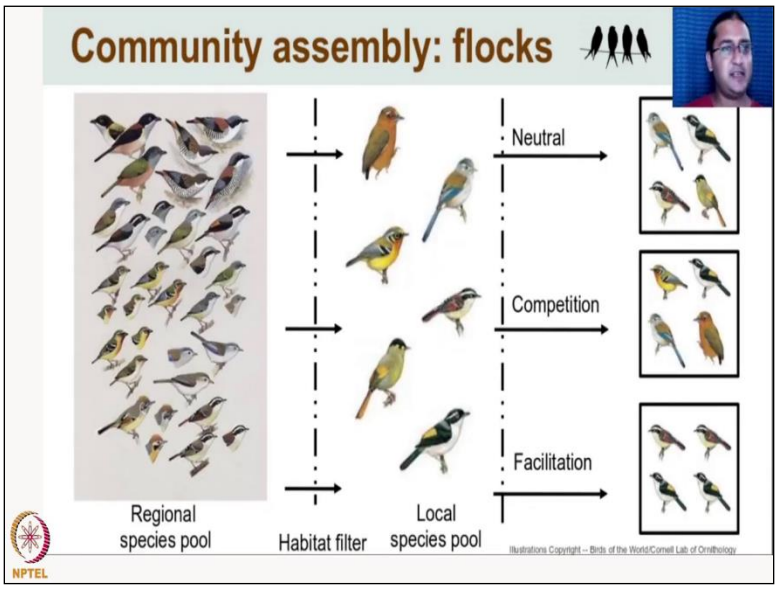

I will just end here with an interesting…approach that one could take to studying community ecology using mixed species bird flocks as an example. And you know you have a regional species pool of all the species that is found in a particular habitat, found in the region through that regional species pool there is a habitat filter that allows certain species to exist and that is the local species pool.

And so, if you have a set of species that can that do join mixed species flocks. So, you have for example, the regional species pool which is all the species in a habitat and then you have the local species pool with all the species that can potentially join mixed species flocks. So, do join mixed

species bird flocks and then you can ask why do certain species associate with each other more than they would associate with other species in mixed flocks.

So, why are mixed flocks formed of certain types of species and not of other types of species. So, if there was no real interaction between these species and mixed flocks were formed by random, then you should see that you know mixed flocks being of various kinds of compositions and so on. If it was competition that is creating these mixed flocks then all these species should be very very dissimilar from each other.

Whereas if it is facilitation and similar species are able to facilitate the foraging of other species then you should have more similar species forming these mixed flocks. So, mixed flocks can be thought of these mini-communities where you have species that are interacting with each other, coexisting within the flock and moving together and of all the species that can potentially join the flock you see certain kinds of flocks certain compositions of flocks.

And you can ask for instance why is it is it a competition that is forming these flocks that is causing these mini-communities to be structured in a certain way is it facilitation that is causing many communities to be structured in a certain way or is there actually no real process that is structured in these communities. So, mixed flocks are an interesting model system in which to study community assembly, biotic interactions between species in these mini-communities.

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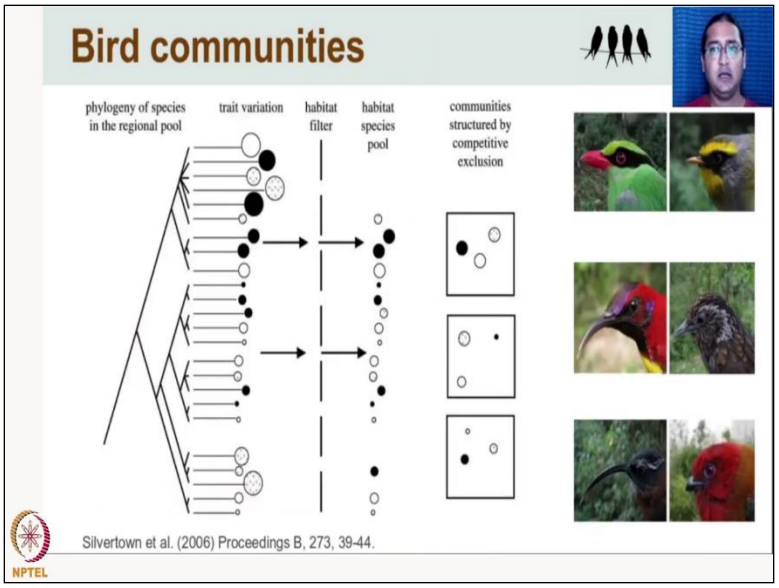

So, again just to recap how a community structured you have an abiotic or an environmental filter that filters out certain species that are not adapted to that environment that forms the habitat species pool. And then the habitat interactions - biotic interactions between the habitat species between species in the habitat, species pool, competition facilitation and so on. Predation bottom-up effects like resources then determine whether two species coexist in that part of the habitat or not. And so, that is our session about bird communities and I will end here. Thank you.