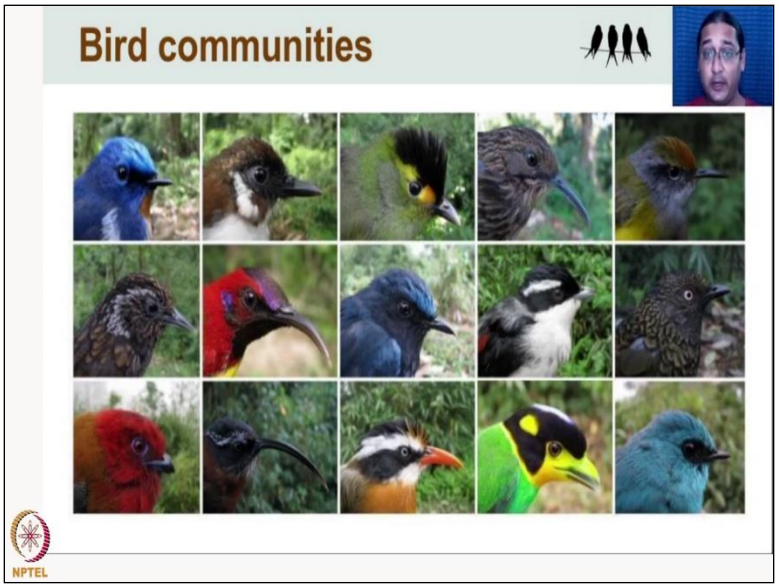
Basic Course in Ornithology
Dr. Umesh Srinivasan
Indian Institute of Science, Bangalore

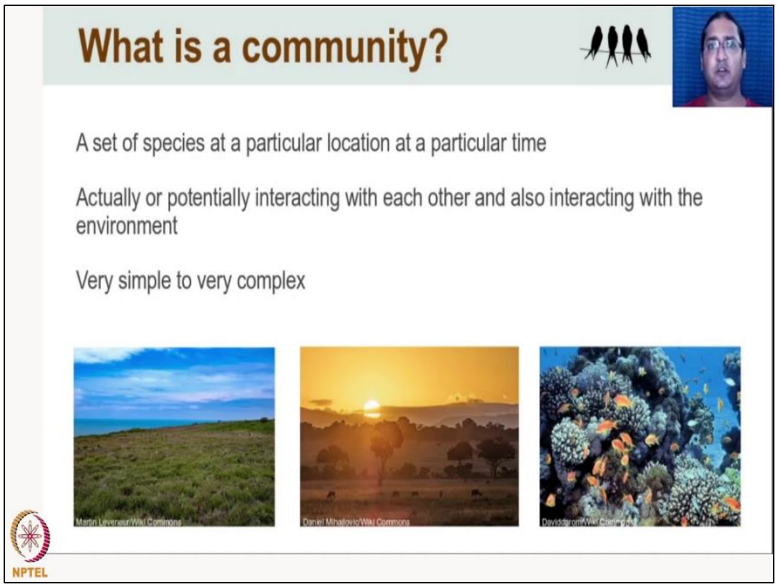
Lecture -21
Bird Communities Concepts - Part 1

(Refer Slide Time: 00:26)



Welcome back to basic ornithology where today we will be talking about bird communities and you would have often heard the term community or ecological community or community ecology. What does that actually mean what is a community? There are many definitions of what the community is what an ecological community is.

(Refer Slide Time: 00:40)



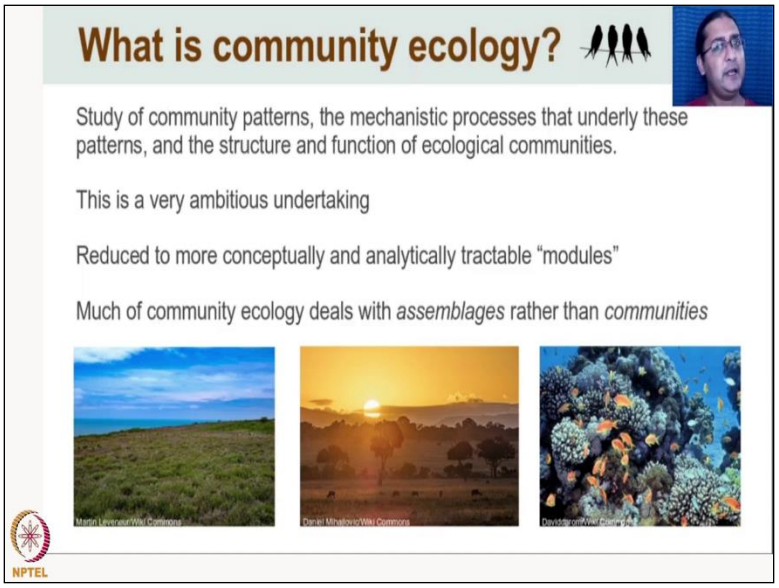
But, the most broad definition of an ecological community is 'it is the set of species that are present at a particular location and at a particular time and this set of species could actually be interacting with each other or could potentially interact with each other'. So, one species could be eating another species another species could be competing with the fourth species. So, they could be species that are actually interacting with each other or they could potentially interact with each other.

And all of these species are also interacting with the environment right they are interacting with the temperatures in their environment they are interacting with the rainfall in the environment and so on. So, they are not only interacting biotically with each other but also with their abiotic environment things like temperature and rainfall and communities can be very very simple to very very complex. So, you have an example of a simple community on the bottom left there which is an alpine grassland very few species of plants, very few species of other organisms as well.

And so fewer interactions between these species in that community and you can have very very complex communities like tropical rainforests or coral reefs where you have a number of species that are all interacting with each other. And so, you have a large number of interactions in such hyper diverse communities. Now, remember that the community is not limited to a taxonomic group. So, it is the set of for example in the rain forest this set of trees, grasses, shrubs, plants, arthropods, birds, mammals and so on.

All of them form the community because their set of species present in that particular location and at a particular time and they are either actually interacting with each other or could potentially interact with each other.

(Refer Slide Time: 02:26)



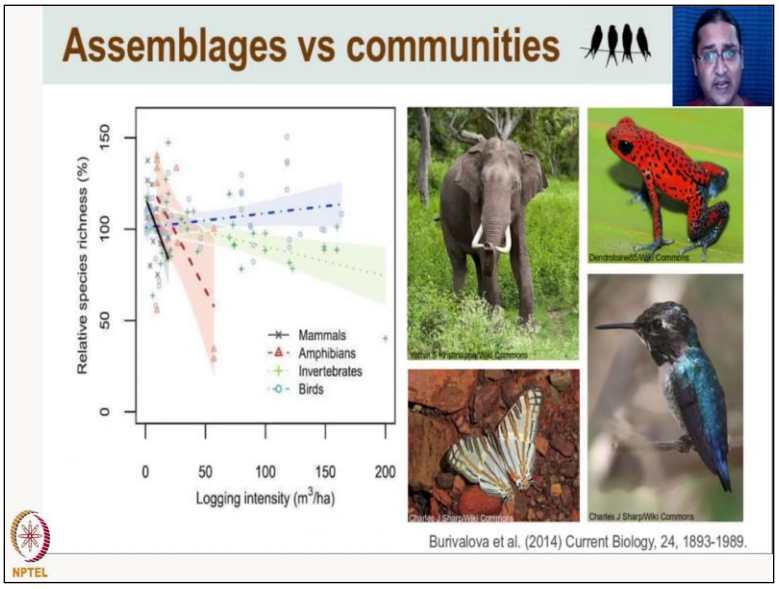
And what is community ecology then? If you define the community in this way, what is community ecology. As a community ecologist myself, I study community patterns. So, are there a lot of rare species in this community, are there a lot of common species in the community, how many species are there and why are there such patterns in rarity and commonness, why are there so and so species in this particular habitat, why are there only that number of species in this habitat.

And so, what are the mechanistic processes that underlie these community patterns. So, the study of the structure and the function of ecological communities that is what community ecology is. And of course, trying to understand all the mechanisms that create these community patterns is a very ambitious undertaking especially when we go to hyper diverse communities that have large numbers of species. And so, very often community ecologist reduce that complexity by focusing on a part of the community and studying the interactions between species in that part of the community.

So, very often community ecology deals with conceptually and analytically tractable smaller subsets of the community attractable modules of the community that being said much of community ecology actually does not deal with communities technically but deals with assemblages. What is an assemblage? An assemblage is a group of species present at a particular location and at a particular time but limited to a particular taxonomic group.

And this is a very very common approach in community ecology trying to understand. For example, how mammals or birds or arthropods or plants change in their structure of the assemblages in space and time.

(Refer Slide Time: 04:14)



Here is an example of that - what you see on the left is a graph showing you logging intensity, logging intensity being the number of trees being removed from the forest habitat. And so, the greater the number of trees removed the greater the volume of the wood that is extracted from the habitat and as you go from the left which is zero that is primary forest which has never been logged to the right you are going towards forest that has been had more and more of its trees extracted.

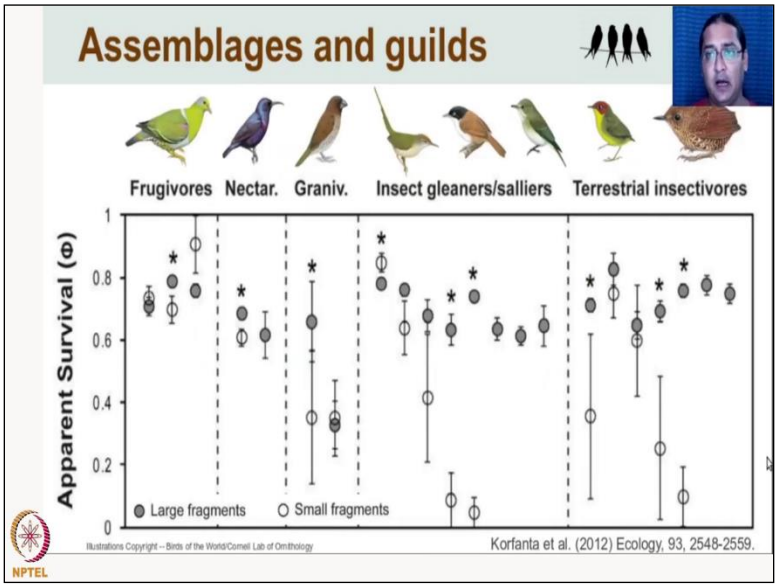
What you see in the y-axis is how the species richness of these assemblages changes with logging intensity and there are four assemblages here all of these are limited again remember to taxonomic groups. So, there is the mammal assemblage, there is the amphibian assemblage, there is the

invertebrate assemblage and there is the bird assemblage and you can see that the mammal and amphibian species richness.

So, the number of species declines very very strongly with even small increases in logging intensity whereas the assemblage of invertebrates and birds please show either minimal declines in species richness or actually slight increases in species richness with increases in logging intensity. So, this approach is very very common in community ecology where we look at a certain taxonomy group and ask how does the structure and the composition of that taxonomic group change over space and time.

So, very often in community ecology, we are dealing not necessarily with the entire set of species in that particular location in time but we are dealing with assemblages. Within assemblages we often divide species into what are called guilds or functional guilds.

(Refer Slide Time: 06:00)



In this case, you have a bird assemblage and we are asking the question how does the survival rate of different species of birds change with habitat fragmentation? So, habitat fragmentation is a process by which large tracts of forest become smaller and more isolated because they are cut down. The forest is cut down for human use and you are asking the question if you went to a large tract of forest what would the survival rates of these birds be and that is represented by the dark circles.

And if you went to a small forest - a small patch of forest habitat fragment what would the survival rates of the birds be and those are represented by the open circles. So, the y-axis is survival rates and the x-axis is actually different species. And what the authors here have done is divide this bird species into guilds based on their diet. Now this is one way to divide a bird assemblage into guilds based on the diet.

So, are these birds eating fruits (frugivores), nectar (nectarivores), grain or seeds granivores or insects and that is your different diet guilds. But you can also divide the bird assemblage into guilds based on other properties - do they nest in cavities, so you have the cavity nesting yet or do they nest elsewhere. So, you have a nesting guild and in this case the insect eaters and the insectivore birds have been divided based on the stratum that they use.

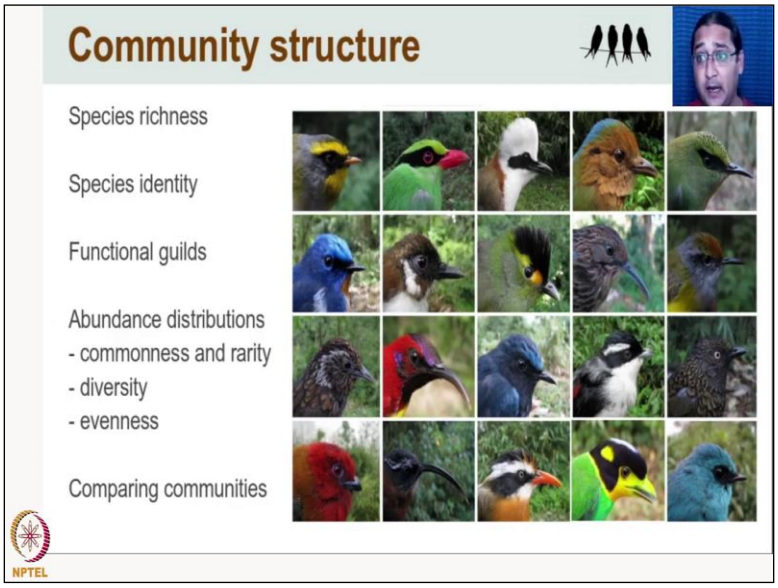
So, you have terrestrial insecticides which feed on the ground and you have the non-terrestrial insectivores which feed in vegetation above the ground. And dividing these birds into guilds is meaningful because the diet of the birds can have a very huge bearing on how their survival rates change because of fragmentation. So, for instance arthropod densities and insect densities might actually come down very much in small fragments.

And therefore, you see that insect gleaners and the insect eaters are actually showing much lower survival rates in small fragments than in large patches of forest. You can see that the dark circles are often higher than the open circles which means the survival rates of these insectivores is higher in large fragments than in small fragments. Whereas if you look at the frugivores, there is hardly any difference between the survival rates of frugivores in small and large fragments.

So, different diet guilds respond differently to habitat fragmentation. In fact, the insect eating birds or the insectivores are so affected by fragmentation that very often entire species disappear from the forest fragments and that is why you do not see the survival rates for these species in small fragments at all because they are just not present in small fragments, they have got locally extinct in the small fragments.

So, these functional guilds in these assemblages very often determine the response that species have to changes in habitat in space and time and that is why assemblages are often divided into various kinds of functional guilds.

(Refer Slide Time: 09:13)



Now, if you recall, we were talking about community structure and the study of community structure and the mechanisms that lead to particular kinds of community structures and what does that mean? What does community structure mean? Structure is a way in which multiple ways in which we measure the properties of a community. So, if I met the eastern Himalayan bird community at 2000 meters and these are all bird species from eastern Himalayas at 2000 meters, I can ask how many species there are in this community.

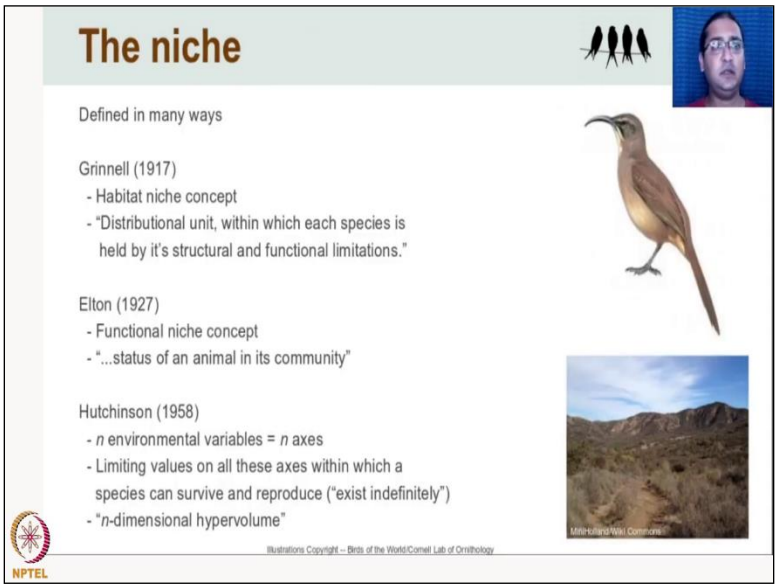
So, what is the species richness of this community? I can ask what are the different kinds of species that are found here and therefore what is the composition of this community? I can ask, are there certain functional guilds like insectivorous birds that are more common in this community than there are in other communities? And then I can look at the abundances or the population sizes of different species in the community.

And I can ask questions like is does this community is it dominated by one species that is extremely common and the other species are very very rare which means that this community is less even in its abundance distribution compared to any other community. So, I can look at the abundances of

different species and ask how equal or unequal are these abundances and why might that be. And all these various measures of the community then allow us to compare communities with each other.

Is this community more species rich than that one, is the rainforest community made up of birds that have more even abundances more equal population sizes than a community of birds in the grassland? And so, quantifying community structure then allows us to compare communities.

(Refer Slide Time: 10:49)



One of the fundamental concepts in community ecology is that the niche and I am sure you have heard this word very very often 'this species occupies a particular niche that species occupies a different niche' what does the niche mean? Like many things in community ecology the niche has been defined in many ways. The earliest definition of the niche was by Grinnell in 1917 which is the habitat niche concept.

So, he described the niche of the California Thrasher which is the bird on the top right there as being the habitat of the California Thrasher which is chaparral habitat that you see at the bottom right there. And he said the California Thresher is held within the chaparral habitat as in it cannot leave the chaparral habitat and occupy other habitats. So, it is the he called it the distributional unit within each species is held because it is adapted to that particular habitat or that distributional unit.

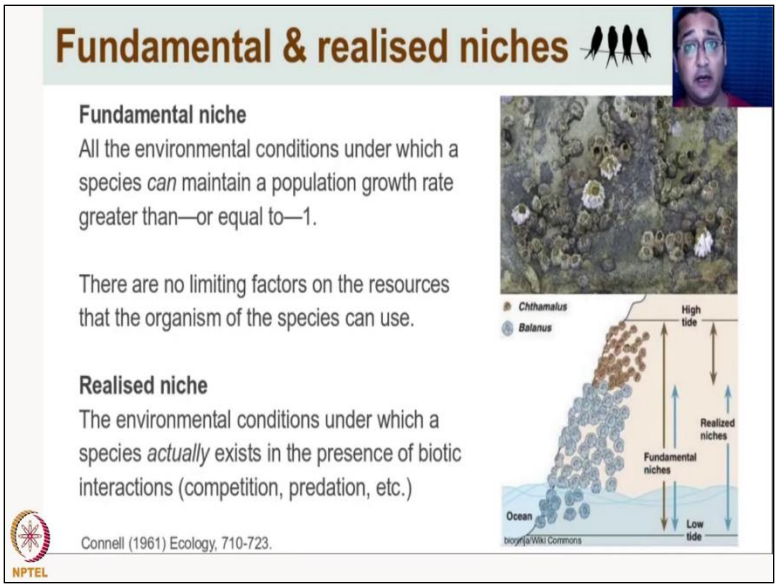
So, Grinnell's concept of the niche is the habitat niche concept that this species occupies this habitat. Elton 10 years later described the niche of a species as its role in the community. So, not really which habitat is this species found in but is it a primary consumer, is it a secondary consumer, is it a predator, is it a producer. And so, he called the status of an animal in his community which is the role that it plays - which is the functional niche concept.

The most commonly used concept which is slightly more complicated is the concept proposed by Hutchinson and he called this an n-dimensional hyper volume. What that means is that let's look at a tropical rainforest bird like what does a tropical rainforest bird need it needs relatively warm temperatures. So, high temperatures but not too high not like desert like temperatures and it needs a certain minimum amount of rainfall to exist in that region right.

So, it is only going to be found in a particular part of the temperature axis and a particular part of the rainfall axis. And so, if you have multiple axes of resources that species are using then the combination of where a species is found on all of these axes then defines the niche of the species. So, for just very simply for a tropical rainforest bird species on two axis the rainforest bird occupies the part of temperature that is warm and part of the rainfall that is high and that determines its niche in those two along those two axis - the temperature in the rainfall axis.

And you can add more and more axes like this and then that determines where the species is found that determines its niche. This is obviously practically very very difficult to do. You cannot go out and measure all the axes along which apparent for example is using resources. So, very often community ecologist will talk about the temperature niche or the you know rainfall in each of the species making it slightly more easy to study the Hutchinsonian niche.

(Refer Slide Time: 14:09)



A further concept within the niche is that of the fundamental and realized niche. Many of you must have heard these terms - the fundamental niche, the realized niche. The fundamental niche is all the environmental conditions under which a species can maintain a population growth rate equal to greater than one. So, a population that has a growth rate of either one or more is a population that can exist indefinitely. A population with a growth rate of one means it is a stable population neither increasing nor decreasing.

Population with a growth rate greater than one means it is increasing. A population that has a growth rate less than one and consistently has a population growth with less than one will decline and become extinct. So, the fundamental niche is all the environmental conditions under which a species can maintain its population size. Population can exist in that location. So, again coming back to our tropical rainforest birds, it is warm wet conditions under which it can maintain its population.

Whereas, if the conditions change - if the temperature goes beyond a certain threshold, if the rainfall comes down then it is not going to be able to survive in those conditions. The fundamental niche of a tropical rainforest bird would be warm wet conditions. The fundamental niche assumes something very very important which is that there are no limiting factors on the resources that can be used by the organism. What does that mean?

So, if you have a species found in a particular habitat and that species uses a particular resource then there are no limiting factors on the use of that resource by the species. For example, there is no other species that is competing with it to monopolize those resources. So, the fundamental niche often assumes that there are no biotic interactions, there is no competition, there is no predation etc happening and the species is free to use whatever resources are there in the environment.

But that is not the case in nature. Right. Biotic interactions exist species interact with each other. So, the realized niche is what happens when these competitive predate predation etc interactions come into play. So, the realized niche is the environmental conditions under which a species actually exists in the presence of these biotic interactions. So, here is a classical study by Cornell looking at two species of barnacles Chthamalus and Balanus which are found in these rocky intertidal pools along the coastline of the United States.

And you can see that Chthamalus which is the darker barnacle represented in red and balance which is the lighter barnacle represented in the graphic in blue occupy two very different parts of the intertidal pool. So, Chthamalus is found higher up and Balanus is found lowered down. Now why does this happen? Why is the realized niche of Chthamalus the upper part of the intertidal zone and why is the realized niche of Balanus where they are actually found in the environment the lower part of the intertidal zone and so on?

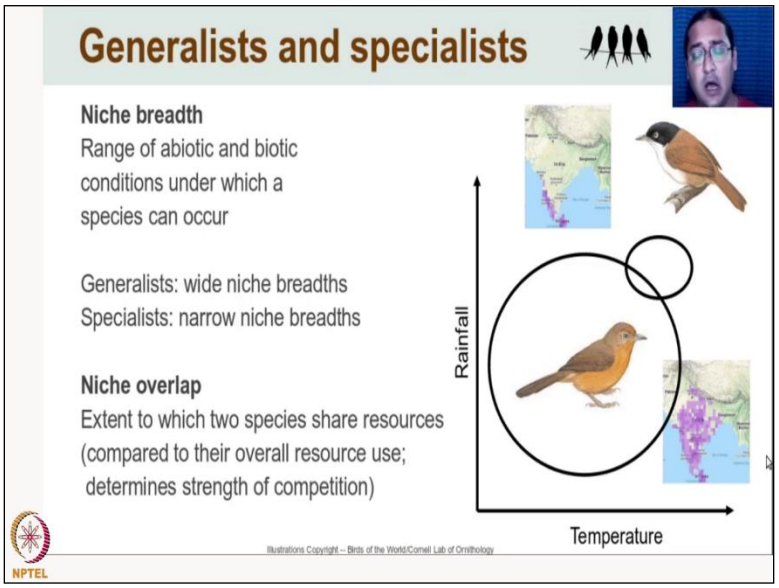
What Cornell did was he removed Balanus from these rocky intertidal pools and what he found was Chthamalus in the absence of Balanus able to colonize even the lower depths of the intertidal pool. So, if you remove Balanus which is the lighter barnacle or the blue barnacle from the lower parts of these rocky intertidal pools, Chthamalus is actually able to colonize the entire depth of the intertidal pool.

And so, the fundamental niche of Chthamalus, the red barnacle is the entire rocky intertidal pool depth which means in the absence of Balanus, absence of competition with Balanus, Chthamalus can potentially occupy the entire part of the rocky intertidal pool. But competition with Balanus is limiting it to the upper part of these intertidal pools. And so, the fundamental niche where

Chthamalus can potentially exist in the absence of competition is the entire depth of the intertidal pool but the realized niche of a Chthamalus is the upper part of the intertidal pool.

So, the fundamental niche again is the potential areas where the species can potentially exist. The realized niche is where it actually exists because it might be excluded from certain areas or certain habitats because of the presence of other species and competition with species for instance.

(Refer Slide Time: 19:01)



When it comes to niches, we often talk about what is called niche breadth and these breadth of course, like the fundamental niches the range of abiotic and biotic conditions under which the species can occur. And species can either be generalists have wide niche breadth or specialists which have narrow niche breadth. So, here is an example of two related babbler species the Tawny-bellied Babbler and the Dark-fronted Babbler and you are seeing the space of temperature and rainfall in which these species can occur.

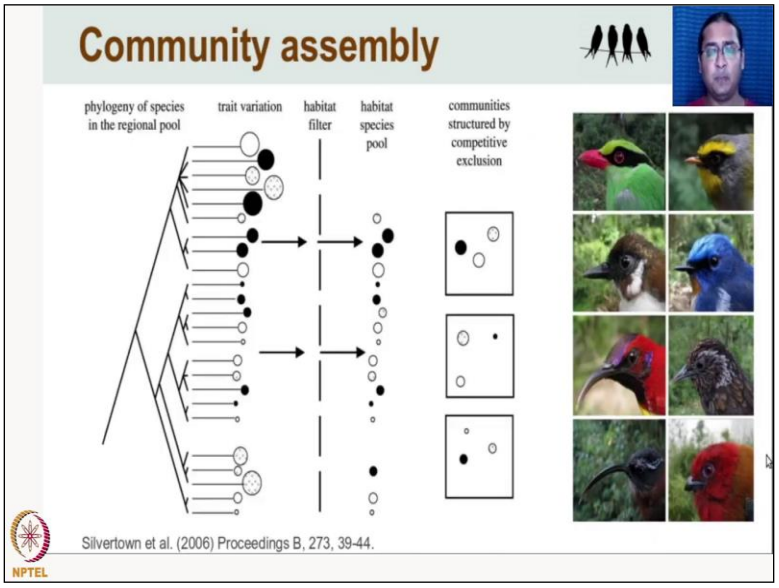
So, you have temperature on the x-axis going from cooler temperatures to warmer temperatures, your rainfall on the y-axis going from low rainfall areas to high rainfall areas. You can see that the Tawny-bellied Babbler (this is just a cartoon graphic) occupies very large areas of temperature and rainfall. It is more of a habitat generalist. It has a large niche breadth in both temperature and in rainfall.

So, it occupies a large niche and therefore because it occupies a large niche it also has a larger geographical range. So, it is found pretty much across all of India and Sri Lanka because it is able to survive and maintain populations in a wide range of temperatures, in a wide range of rain fall. The Dark-fronted Babbler on the other hand is a specialist, it has a narrow niche breadth, it is found in areas that have generally high temperatures and high degree of rainfall and that also limits where it is found.

So, it has a smaller geographic range size. So, it is found only in the western parts of India and in Sri Lanka where rainfall is high and temperatures are also high. And you can see there is a small amount of overlap in the niches of the generalist Tawny-bellied Babbler and the specialist Dark-fronted Babbler and that's what is called niche overlap. It is the extent to which species share resources and that determines the strength of competition between these species.

So, if two species have exactly the same niches then niche overlap is 100% it is perfect niche overlap and they are likely to be very highly competitive highly high competitors with each other whereas if species have a very minimal niche overlap, then they are likely to not be competing with each other as strongly.

(Refer Slide Time: 21:11)



What is it, what are the mechanisms that structure community, how is a community assembled at a particular location? This is sort of a schematic that gives you a sort of starting point to try and

understand what is it that determines why a certain set of species is found where it is found. Let's think of it this way, let us go from the left to the right, you have a certain number of species in the regional species pool.

So, let's say all the species in India form the regional species pool and these species vary in their traits some species are adapted to a warm condition, some species are adapted to cool conditions and each of those traits is represented by a different size of the circle. So, each of these circles is a species. Let's say the trait that we are interested in is adaptation to rainfall and the larger species require more rainfall.

The smaller species are adapted to areas that have less rainfall. And so, these species obviously cannot exist across the length and breadth of India because rainfall varies very much across India. So, at any part of the country, the habitat conditions at that particular location impose a filter. So, you have all these species in the regional species pool but if you go to a particular location the habitat will only allow those species to exist that are capable of adapting to those conditions in the habitat.

And that gives rise to the habitat species pool. So, in the habitat as a whole, you have these species that are adapted to the conditions that the habitat provides in terms of temperature rainfall and so on. Once you have a habitat species pool, what determines whether two species coexist or not. Now, if you look at the habitat filter what it is done is that it is excluded all the large species, it excluded all the species that require high rainfall.

So, it is only allowed, let us say this is a desert habitat, it only allowed species that are adapted to lower rainfall areas or the small species represented by the small species to exist in the habitat forming the habitat species pool. And within the habitat species pool, what determines whether two species will exist at coexist at a particular location or not, let's say that is competition. Then once these species have been filtered by the habitat some other trait between these species now needs to be different for them to coexist.

So, for example, now you have colour as the trait that needs to be different. Let's say that is diet, let us say two species that have very very similar diet are competing so strongly with each other that they cannot coexist. And so, now at a particular location within the habitat, the bird community if it is structured by competitive exclusion which means that two species that have very very similar diets cannot coexist.

Then what you are seeing is that species of different diets represented by the different coloured circles now coexist at a particular location. So, these are species that are these are communities that are structured by competitive exclusion. So, you have a larger regional species pool, you have a habitat that filters out abiotic conditions or environmental conditions that filter out certain species that are not adapted to that particular habitat allowing only the adapted species into the habitat species pool.

And then within that habitat at a particular location whether two species can coexist or cannot coexist depends on let's say how strong competitively they are, how strongly they compete with each other and that means that species that have very very similar diets (represented by the colour here) cannot coexist. And therefore, each community has a dark species a white species and a species pattern species.

Here is an example of that let us say you are looking at the Thar desert and you have the regional species pool which is all the Indian birds. They are all adapted to various degrees of rainfall. The species that are represented by large circles are adapted to high rainfall areas, the species that are represented by small circles are adapted to low rainfall areas, Thar desert is the habitat. The rainfall is less than 250 millimeters annually in the Thar desert.

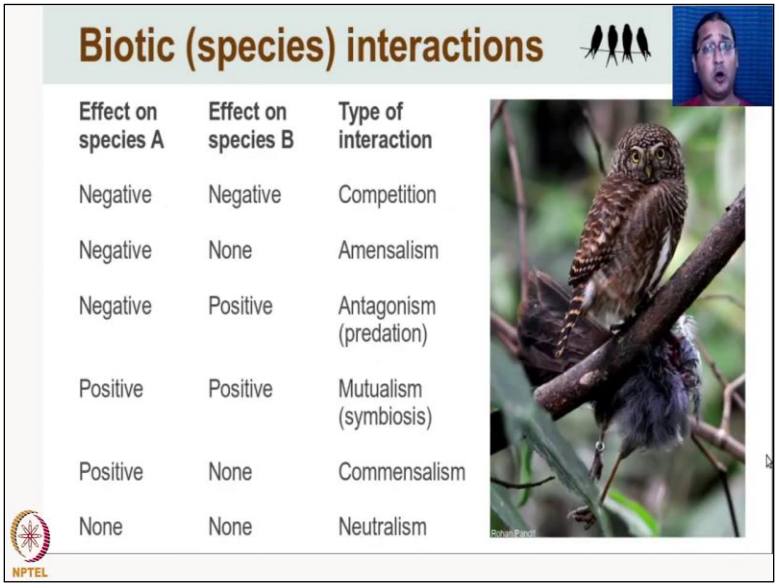
So, it is filtering out all the species that require rainfall more than 250 millimeters annually allowing species to pass through the habitat filter only those species that are adapted or can survive in an area that receives less than 250 millimeters of rainfall. So, you can see that in the habitat species pool all of these species are more similarly sized than the species in the regional species pool and that is because the size is representative of how much rainfall they can tolerate.

And then once you get to the habitat species pool, what determines whether these two species, three specie,s four species can coexist in a location in the habitat. Let's say that is diet and so you have communities (just this is just a schematic example). So, you might have a community that has a Great Indian bastard, Lark, Falcon and Sandgrouse that can potentially coexist in this location because they all eat very very different things.

So, you have these communities being assembled at different scales. You have the regional species pool, you have the habitat species pool - the species are much more similar to each other in some important trait in this case adaptation to dry conditions. And then after the habitat species pool when you zoom into a local scale and you look at birds that are coexisting with each other then they have to now be different in some way to avoid competition.

And so, you have these multiple processes operating in the assembly of ecological communities. So, that is sort of a conceptual understanding of how communities are assembled at a particular location.

(Refer Slide Time: 27:27)



We have talked a lot about competition and how competitive exclusion can structure communities. Let's look at all the various kinds of interactions that species have with each other. So, if you have two species, species A and species B, then species A can either have a negative effect on species

B or a positive effect on species B or no effect on species B and vice versa. So, species B can have a negative, positive or no effect on species A.

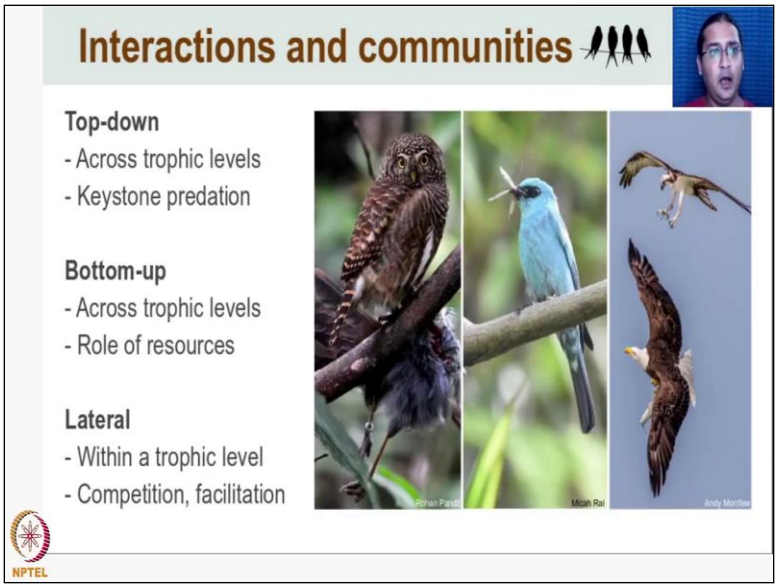
So, when two species both have negative effects on each other, this is called competition. So, the presence of one species reduces the fitness of the other species and vice versa. So, both have negative effects on each other that is called competition. When a species A has a negative effect on B and B has no effect on A then that is what is called Amensalism. Where one species has a negative effect on the other but the other has a positive effect on the first species that is called antagonism and a good example of that is predation.

So, a raptor, falcon let's say eating another bird, the falcon is getting a positive effect from the prey species whereas the prey species is losing in fitness. And therefore, there have one species has negative effect on the other and the other has a positive impact on the first and that is and what is called antagonism. Where two species both have positive effects on each other this is called mutualism or symbiosis.

Take a look at an example of that with mixed species bird flocks where one species has a positive effect on the other but the second species has no effect on the first that is what is called commensalism. For example, humans have a positive impact on several bird species that nest in buildings. Let's say humans have a positive impact on pigeons but the pigeons might not have any effect on the humans themselves and that is an example of commensalism.

And where two species have no effect on each other and there are lots of such examples where the presence of one species has no effect on the presence of the other and vice versa that is what is called a neutralism species are actually not having an impact on each other.

(Refer Slide Time: 29:39)



Now, interactions and communities these various kinds of species interactions are very very important in structuring communities. And we will take a look at these and what are these kinds of interactions, what are these kinds of processes that structure communities. These processes could be top down, bottom up or lateral. So, top down is an example of.. in community structuring which operates across trophic levels.

And an example of that is keystone predation, we will take a look at that bottom up again is across trophic levels and it is the role of the resources in supporting certain communities and lateral of course is where it is not across trophic levels but within a trophic level. So, it is like competition and facilitation between bird species at the same trophic level. Let's look at top down community structuring.