Course Name: I Think Biology

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W9L45_Ecological Interactions - Part 2

Hi, welcome back to the I Think Biology NPTEL course. My name is Jayanti Mukherjee and today we are going to continue our discussions on ecological interactions. Let us get started. If you remember in our last lecture, we talked about the various ecological interactions that occur in nature or is commonly recognized by us. Some of them are positive, some of them are negative, among the negative were competition, predation, herbivory, parasitism, ammensalism, and some of the positives are mutualism, facilitation and commensalism. So, we in today's lecture going to focus on some of them and emphasize or broaden on some of them, while others we will just mention because there are less examples known in these areas.

So, let us get started. We will start with the first interaction, competition. So, in competition as we know this is interspecific competition, two species or separate species competition and that is an interaction where both the individuals or both species compete for one resource that are limited and they are competing for a resource which can limit their growth, survival or fitness or reproduction. But this competition of a resource can depend on what kind of resource it is.

It can be food, it can be space or it could also be a mate depending on the species we are talking about. Generally, it is seen in animals, however, in plants this kind of things are not seen, but depends on what we are looking at it could be competition for any of these things. So, now let us see what this can be. Let us take an example of this grass. okay So, when it is a grass what could compete for this particular resource? Let us see, it could be a grasshopper or it could be a bison.

So, when you actually think about it, it might come to your mind, oh this might not be a competition, they are just existing together and you are right, they are actually existing or it is called the coexistence, they are coexisting together, but still they are competing for the same resource. If you think about it that grasshoppers may compete more with

grasshoppers like other grasshoppers or their same individuals which is also correct, intraspecific competition which is within a species and within a species between different individuals, intraspecific competition is generally seen to be a stronger competition than interspecific competition. But in this context we are going to only talk about interspecific competition which is two species competition and in this case grasshopper is competing for grasses with the bison. So, what could be another example? A deer and what are competing for this? A jackal could be competing for a deer with a leopard and there could be also tiger and other predators that we look at. So, interspecific competition first was actually Gause 1934 explained this as competitive exclusion principle where Gause did it with an example or an experiment with two paramecium species.

Paramecium as you can see unicellular organism and there are he took two paramecium species one is paramecium aurelia, one was paramaecium caudatum and he put them in one single petri dish. He grew both of them separately also and he took the same amount of resource and then grew both of them together to see what would be the outcome of that group. So, in the beginning he found that paramecium aurelia was going down in abundance and paramecium caudatum was flourishing, but after time passed or after some hours he found that caudatum actually reduced much in growth and discarded or discarded from that petri dish and the whole petri dish was full of paramecium aurelia. So, only one species survived. Caudatum was excluded from that setup and he that's how he came up with this competitive exclusion principle stating that when two species are competing for the same resource they there could be the competition could be very strong and one could be excluded from that environment or area because the other one is a good competitor.

So, a lot of scientists actually try to explain this as an ecological niche. So, you might have heard of this term right niche. Ecological niche is generally defined as the sum of species use of biotic and abiotic resources in its environment and it's called this name was given by several different scientists including Grinnell, Elton and Hutchinson. So, Joseph Grinnell and Charles Elton actually defined niche in terms of the habitat. So, they said that it is the sum of species' abiotic resources that in the environment that one species uses.

Whereas when it came to Hutchinson he took it a step forward saying that it is actually a character or an attribute of the species itself stating that it is an N-dimensional hyper volume or here where dimensions are conditions or resources. So, hyper volume mean he meant something like this. So, let's take an example according to Hutchinson N-dimensional hyper volume where hyper volume are conditions or resources. So, you are fighting for certain conditions or resources. Here let's take there are two resources sunlight and moisture.

So, you are competing for two resources, and in this abstract space of these two resources you can see one is species A in this light brown color and this is the that hyper volume. So, it is actually don't confuse this with an area, it is not an area it's an abstract area of that resource a combination of sunlight and moisture. So, species A could exist in conditions where there are high sunlight and low moisture. okay Similarly, if you see species B, now species B is actually existing in higher sunlight as well as higher moisture. So, in both the axis it is high x and y.

Let me take out the pointer here. In moisture also it is high, where and in sunlight also it is high. Compared to that let's take a look at species C. Species C on the other hand it can exist in moisture higher moisture but its sunlight requirement is low. So, now when we talk about this term that I used requirement.

It is very arbitrary for example, is this species will the species be happy with less sunlight? Essentially not. That is the reason the species C has now been restricted to that particular area of resource use because it has another competitor species B which is using the higher sunlight area. Now, let's take an example of, normal life example of this. If you think about species A, a plant species A which can use higher sunlight and less moisture it could be a desert plant. It could grow in arid region where it is very bright sunlight and less moisture.

Whereas when we come to species B it has very high sunlight but also higher moisture. So, it could be a plant in a forest area, a tree in a forest area because it has high sunlight, it has big canopy. So, it's a tree in its forested area whereas species C is also could be in forested area but now it is not the tree but it is a sub canopy species or a shrub which grows under the tree, right. Let's take an example. Now, what have I written as realized niche or fundamental niche, right.

So, this is the term which I used as a requirement. So, species C will also flourish in higher sunlight, okay. So, that's the reason this light green color is total niche of species C say which is the fundamental niche. So, this is the area or the space or the hyper volume species C can use whereas now because of computation it is not able to use that, it has restricted itself to something which is currently it is using which is this dark green area that is called its realized niche. So, fundamental niche is which you can have or can use, realized niche is what you are actually using particularly when competition comes into play, this realized niche is the more realistic niche of a species, okay.

If two species niches overlap completely, those species cannot coexist. So, if you think about that example of the grasshopper and the bison, if the grasshopper is exactly using

same amount of grass as the and quality or species everything similar as the bison then it will be becoming a severe competitor of the bison, okay. But grasshopper is generally using that resource in a different way as than bison and that is the reason they both are able to coexist together in an environment, okay. Now, let's see a little bit more. This is the same example, these are different niches and similarly there could be multiple other small niches of different species here.

So, for example, these red ones use similar amount of sunlight but see how they have partitioned in terms of low moisture to very high moisture. Same for the orange dots, they are separated according to sunlight and the gray dots also have separated across sunlight as well as moisture. So, this is just a very, you know, hypothetical model and that will give you an idea of how these niche is actually distributed in nature, how this pattern occurs. Now, let's go further ahead. We are not going to this very complicated model here, but this is just for your information, just I am mentioning it here that two scientists, mathematicians, one was Russian mathematician Alfred James Lotka and Vito Volterra, another Italian mathematician, they both came up with this model called the Lotka-Volterra competition model and this is the equation for that which suggested that if two species, they mathematically proved that if two species niche overlap completely, then those two species will not be able to coexist and we are not going to the details of this model because it is beyond the scope of this course.

So, now we will take some examples from our i think biology book in the chapter feline fables, you can see some of the competition we talked about in terms of existing in the cats and its on specific species. So, two different research groups wanted to study this question and they were interested in understanding what is diet overlap or diet here is a resource overlap between these three some or three sympatric species. If you remember from our speciation lecture, sympatric mean species that are occurring in the same region. So, let us now take tiger, the top or apex predator, leopard, smaller than smaller in size than tiger and dhole, dhole are also the Indian wild dogs. So, these all these both these studies were conducted one was conducted in India and one in Nepal, we are going to go into a little bit detail of what they did. okay.

So, Andheria et al in 2007 and Kafle et al 2019, they both looked at a very similar question, but they approached this question a bit differently. So, one did it with diet analysis and the other did it with camera trap and analyzing the pictures, seeing the frequency of what they get in the camera traps. So, the first study Andheria et al, this came from a very famous wildlife biologist from India, Dr. Ullas karanth and he studied, they studied these three sympatric species in Bandipore, tiger reserve of Karnataka where they looked at tiger, diet overlap of tiger, leopard and wild dog, dhole. What they found was, they did the SCAT, SCAT is the fecal sample analysis.

What they found in this study was that tiger went for, tigers actually body size is more than 200 kilograms and it is a much bigger animal than leopard and tigers main diet comprised of gaur or the big bison that we saw, Indian bison. Some are deer which is a big deer compared to spotted deer or chital deer and larger animals. Larger animals in the sense, in this case not babies, right. They went for tiger, always went for bigger animals, larger sized animals compared to leopards and dhole which went for wild pigs, chital deer which are much smaller deer than sambhar deer and younger animals. And leopard and wild dogs body weight or size was very much comparable and they were below 100 kilos.

So, according to the body mass or the weight of the predator, there was a niche partitioning here going on, you know, a niche resource requirement where they separated in their diet in the same region. Okay and niche partitioning in prey size as a result of the body size of the predator. This is the first take home message from here and difference in hunting patterns also supported this niche partitioning. For example, tiger and tiger is a sneak predator, okay and how this niche partitioning was happening because you see when we say how you can always ask, think about it, you can always ask them, you are saying leopards and dholes, they are very similar animals. Aren't they very fierce competitors? Yes, they are fierce competitors.

They are competing for similar resources. They have similar body size, body weights and they are competing, but what they are, their difference in hunting strategies or patterns is leopards are very sneak predator. They sit and wait for prey to come, whereas wild dogs or Indian wild dogs actually chase their prey for long-long distances and then catch them, okay. So, this is how they are catching their prey, but they are going, still going for similar kind of prey in nature. So, but whichever, you know, niche partitioning is happening, whichever differences they are maintaining, these three species can still coexist without driving each other to extinction or local extinction for that matter.

So, competition is happening, but it is a more stabilized competition which has enabled these three symbiotic species to coexist in the same area, okay. Let's take the example two, Calfley et al. They also looked at predator species in Chitwan National Park in Nepal and this is the map of that area. What they did was the area of 932, 932 kilometers square. They divided this area into 2 by 2 kilometer grids.

So, you might, question might come to your mind, how did they divide it? You know, did they physically go and divide this area into 2 by 2?. No, they actually took a map of it and a digital map. So, and they, on that map, they actually divided this area into 2 by 2 square kilometer grids and in this virtual grid, they took all the GPS point or the GPS

coordinate of this grid and went and set up a pair of camera tracks in each of these grids. Most, most of them, not all of them, but most of them to keep a very uniform distribution of cameras which can catch the pictures of prey species available as well as the sighting of the predator. So, based on these frequencies, they will analyze what they are finding. So, they did it in 362 locations and in each location continuously they kept it for 17 days and they got those monitoring data and then analyzed it, using these images, where both they found.

So, in this camera track, they mostly analyzed the images that they found from tigers, leopards as well as humans. Why humans? Because humans all the, most, lot of times actually come into conflicts with these predators. That's the reason they also wanted to see which are the areas where this conflict is more. Now, we will talk about why this conflict ? and you can see this is one of the maps they generated. If you look at, go back and take a look at this paper. you will see all the maps they generated and you can get into the detail of each and every results they found.

Actually, it was quite interesting. These each squares are called pixels and you see that there is a difference in abundance or abundance class. The blue ones are low in abundance, whereas red ones are higher in abundance. This is just one particular map and we are not, I am not going to show all the results what they found, but in summary what they found was, although there was significant overlap in prey of tiger and leopard, they found leopards were much more occurring in higher densities where they were closer to humans. Why? Because they were actually also preying on more on livestock and not native prey. So, livestock are actually easy prey, easy prey than wild animals and tigers were going for more larger animals and wild animals. whereas leopards were more relying on these livestock and easy prey and that is the reason they were also coming in contact or conflict with the humans around which you might have heard human wildlife conflict was happening in this region.

And I have given this paper, you can actually go and look it up in this journal to see what they found in more detail. So, I hope some of the concepts of competition is clarified from here. However, in our live online sessions, I will be available to address your questions and please feel free to think about these questions, come and ask the doubts that you have there. Our next interaction is predation. So, predation as you know is another negative interaction, but here one species is actually in competition both the species were negatively impacted in the sense they were, they had an energetic loss and both the species' fitness or survival or anything else was compromised.

But in predation one is benefited and one is either in the negative side or they are being eaten completely and they fall prey, so they actually it's fatal for the other organism. In

animals which is predation interaction, it is a fatal interaction. So, let's see what this says. Here you can see a lion attacking a zebra and here a cheetah which is another lion is of course a very big predator, cheetah are much smaller and they as you saw in the Indian example, this is a South African example in the South African landscape and you can see similar type of sympatric species where cheetah go for smaller prey size and lion actually also goes for larger animals. But we are not going to go into the competition of predation or competition of prey here, we are talking more remember about predation.

So, predation in nature has given rise to multiple ways of variation or speciation and multiple strategies to avoid predation. So, let's take an example, here you can see different butterflies, lot of these butterflies have developed mimicries. So, for example, if I am a butterfly and I am very tasty, I don't want to be eaten by a predator. Some of them have evolved a strategy where they have developed toxins in them, okay which is very bitter tasting and the predator will avoid that butterfly. However, those building or making of those toxins becomes very costly for your physiology.

So mimicry, in mimicry you have seen some butterflies actually mimic the poisonous butterfly and they are avoided by the predator just because they look like them, okay. So, in nature you will find very many examples of this kind of mimicry where the poisonous butterfly mimic is actually also avoided because they look like, look alike like the poisonous organism. Another example, is this, I hope you can spot this insect here, it's called a stick insect, it's also mimicry a dry stick, right, to avoid predation so that predators cannot spot it. This fish has evolved this nice big eye here at the back end so that the predator thinks that the fish is also seeing its eye, it's able to see and it's avoiding catching it from the mouth side. So it is confused that which side is the mouth of the fish, okay, so that it can avoid being eaten.

Similarly, here you can see this is poison dart frog. It is so poisonous and has toxins that it can be even fatal to human beings, okay. And this is an anti-predation strategy. Similar porcupines have developed these quills as you know to avoid predation, it's very difficult to hunt a porcupine for leopards or tigers and there is a term ecologists use risk of injury. So they will often leave this kind of prey because they risk, their injury risk they are going to avoid. So they don't mess with porcupines, they would rather have something else and if they are very hungry and no predator, sorry, no other prey are available they will eat porcupine, they will go for porcupines, okay.

This beautiful butterfly which has again evolved to big eyes at the rear end so that predators are confused and thinks it is some eyes that are seeing them. So, they will also avoid these kind of work answers, okay. So, predation is a negative interaction but it has given rise to various different strategies which has led to different speciation how it has

evolved over a time period of many many years. It is very unique. So, I hope you got an idea of predation as an interaction and we will end our lecture here for today and in the next lecture we will continue with other interactions like Herbivory, amensalism and commensalism. So, see you next class. Thank you. Bye-bye.