**Basic Course in Ornithology**
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**Lecture -17**
**Vocal Behaviour Ecology and Evolution (Part2)**

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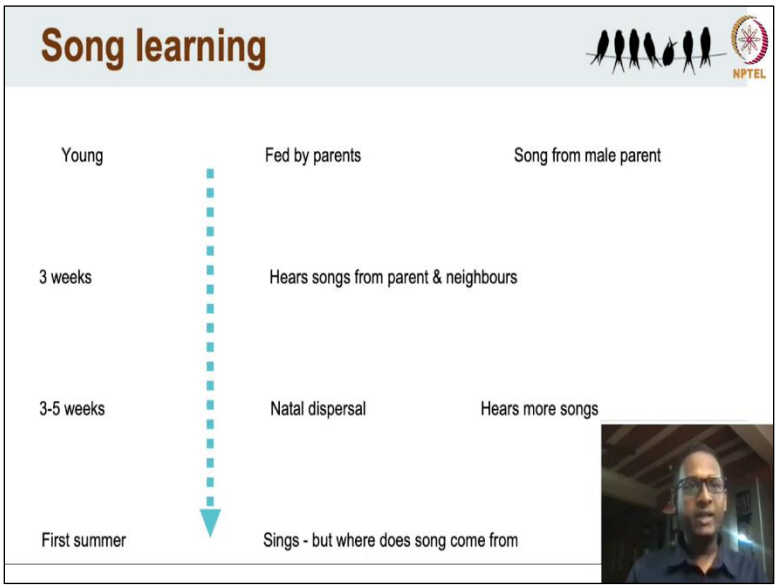


Song variation, here we are going to discuss what kind of variation exists in songs and what function they serve. But before we get to describing variation itself, we should understand how the variation forms and for that you have to understand a little bit of the process of song learning. So here, what I have done is describe the stages of a young bird – hatchling. And you can imagine that there is a very young bird that is being fed by its parents and at this time it listens to the song of the male parent.

And as you must have heard and if you haven't , young birds have, a sensitive window where they learn bird song and this is where the imprinting happens and male birds are thought to the parent are thought to sing more during this time. So, of course, birds sing just before the young I mean to attract the females and then later there is a smaller window as the young are out where the male is singing as well.

And you can imagine that this goes on till about three weeks where the bird is actually hearing the songs from the parent but also from the neighbours because obviously the neighboring territories

the male is again singing to its young and so on. So, the bird is hearing the parent… but also hears the neighbours. And at about three to five weeks is natal dispersal where they actually move out of the territory of the parent.

And all through this time the bird is still hearing more songs and at some point - at the first year, the first summer, the bird is singing its own breeding song. But the question is where does the song come from? Because as we have seen now, it hears a lot of the male parent but it also hears neighbours and as it disperses it hears a whole lot of other birds as well.

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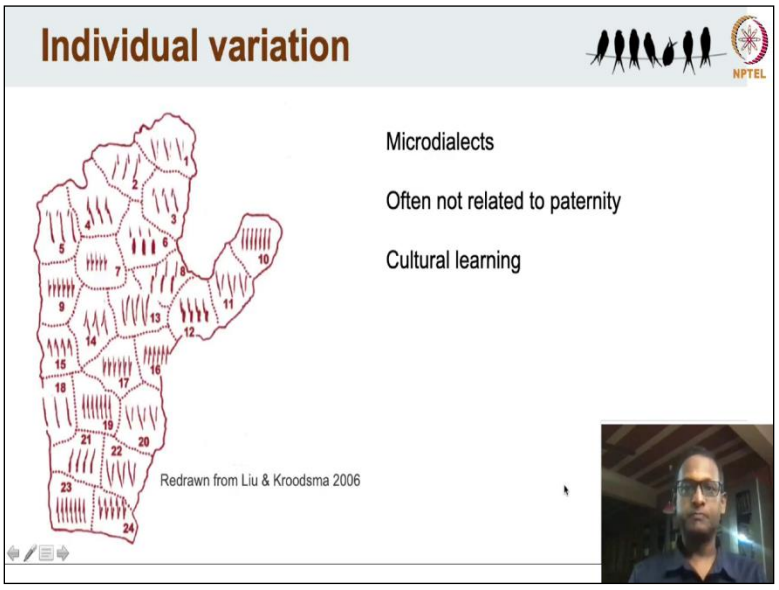


So, where do these songs come from, and that is the basis of individual variation in songs. And if you remember we discussed microdialects which are the small similarities in songs in a particular area. This is one of these very rare, very detailed studies which shows bird territories. So, they are numbered here as 1, 2, 3, 4 and what is shown here are spectrograms. So, you can see very quickly that there are some birds with songs that actually do resemble each other and they are next to each other.

Like probably you could say nine and seven are kind of similar but if you notice something that that is far like 10 and 23 are also similar. So, it is possible often and some of these studies show that the song sharing the similarity in song is not necessarily related to paternity. So, the birds can

sing songs of their neighbours or some songs that they learn from around them. So, there is an aspect of cultural learning that is there in birdsong.

So, this is one of these fascinating reasons why people like to study bird song, because yes there is some effect of genetics (of paternity) but there are there is a kind of transmission that happens culturally as well. So, birds that are isolated from one another, birds that live in some part even for short periods of time can have these microdialects. And so, you can, as people who study these birds, use these to understand some of these broader patterns.

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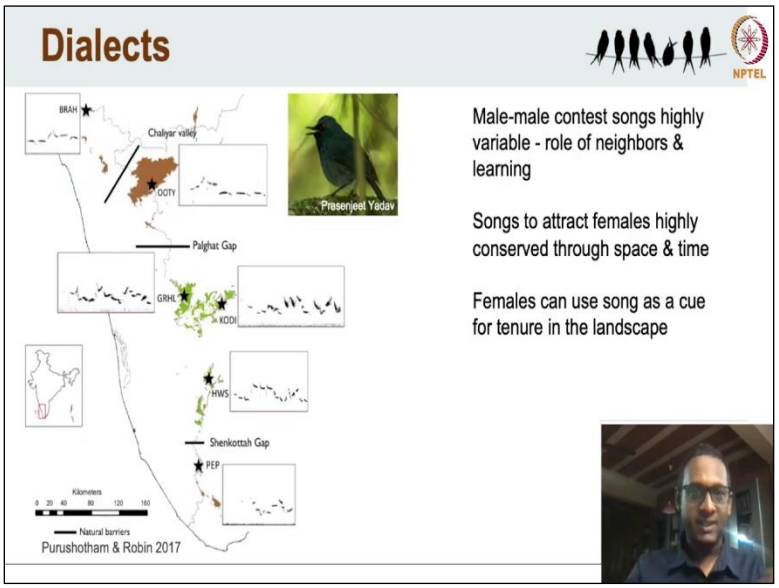


So yeah, that kind of follows to these dialects that are formed. For example, this bird in the Western Ghats - the White-bellied sholakilli (this is work from my lab) where you have this bird which is found only on mountain tops. And as you can see with the spectrograms, the songs are actually very different on each mountain. So, that is expected from the previous slides when you have some kind of isolation birds learn from each other and the songs are different.

So, it is expected that bird songs on different mountains are going to be different. But what is also interesting is that birds just isolated by deforestation or fragmentation can also have different songs like for example these two have slightly different songs they have slightly different dialects. So, how this forms is essentially from a lot of variability in bird song? Male- male contests encourage a lot of variability.

And there is a role of neighbours and other birds for these birds to learn these songs. And sometimes the songs that are that are used to attract females are highly conserved through space and time. So, I know these sounds like it is counter to what we have been discussing so far which is to increase variability. But so, the idea is to be variable but not so much that the female does not recognize the male from the same area. So, in some species measures that birds that are very different are not actually recognized.

So, females then use these songs as a cue for tenure in the landscape. So, which means that if it is a bird which is not from the same landscape, the females can quickly understand that just by listening to the sound of the bird. So, remember that a lot of this is communication and the idea is driven by all kinds of forces which is sexual selection, male-male interaction and now we are talking about isolation that results in dialects.

And this is happening because birds are trying to communicate essentially various signals in through these vocalizations. And at this point, I want to kind of bring in another idea which is of phylogeny and here by phylogeny I mean genetic relatedness and then we will talk about performance limits which is that why do some.. I mean why cannot birds just keep making all sorts of permutations of sounds why is that limiting. So, what limits these variations, what limits the sounds that these animals make that is this next section that we are going to talk about.

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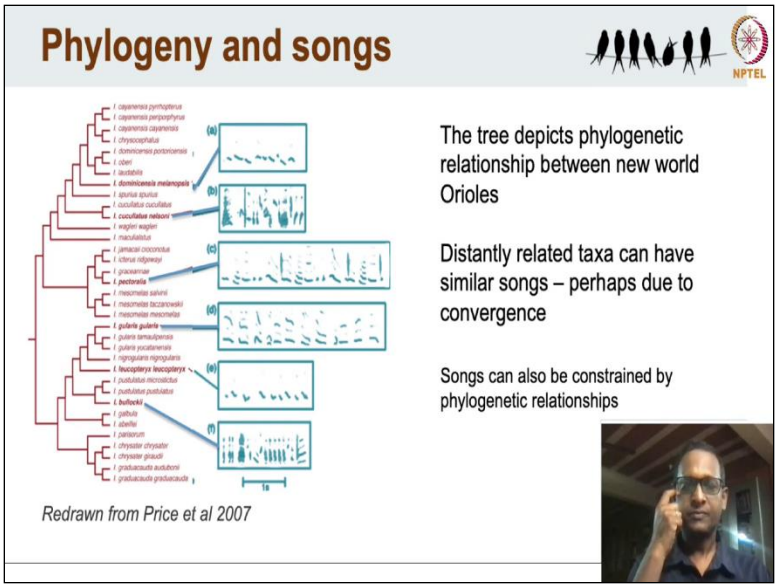


So, phylogeny is very simple, essentially it is a tree of different organisms usually of different species and the more closely linked you are. So, think of it as a dendrogram, the closer your links are in these how the bars are joined the more related you are. And more different you are if you are on a completely different branch then you are more distantly related.

So, as you can see this phylogenetic tree has one big group here and another big group here and within that there is one group here and another group here and so on. Now what I wanted you to see from this is that there are some birds that have very similar songs like this one and this one here or even this one and this one and they are these are Orioles - New World Orioles and the tree shows the relationship between these Orioles.

And what these authors show is that despite being very distantly related sometimes the birds tend to sound like one another and this is thought to be convergence. So, convergence of songs can also happen. You must have read about examples of other kinds of evolutionary convergence for example traits like flight. So, birds and some mammals like bats can fly and that is again a convergent evolution.

Similarly, it is possible to have convergence in bird song as well, as you can see with these spectrograms. So, this one I am showing you is an example of convergence in song types but it is also possible to have songs that are constrained by phylogeny. Which means that organisms that

are more closely related tend to sound like one other and they have more similar sound songs or calls. For example, let us say Doves tend to sound like each other.

So, one Dove and another Dove they are slightly different but I mean one species of Dove and another species of Dove and but they have somewhat similar characteristics in songs. So, if you go out - that is a Dove or a Pigeon and this is a Flycatcher, that is because of these phylogenetic constraints or phylogenetic relationships. Let's say how songs tend to sound similar within a phylogenetic group (within a related group of birds).

So, what I have shown here is that in some cases birds can tend to sound similar because of their genetic relationships and sometimes there is convergence as well. So, that does not mean that there is no pattern, it means that one has to examine this with respect to the species in question because evolution can act differently depending on the circumstance.

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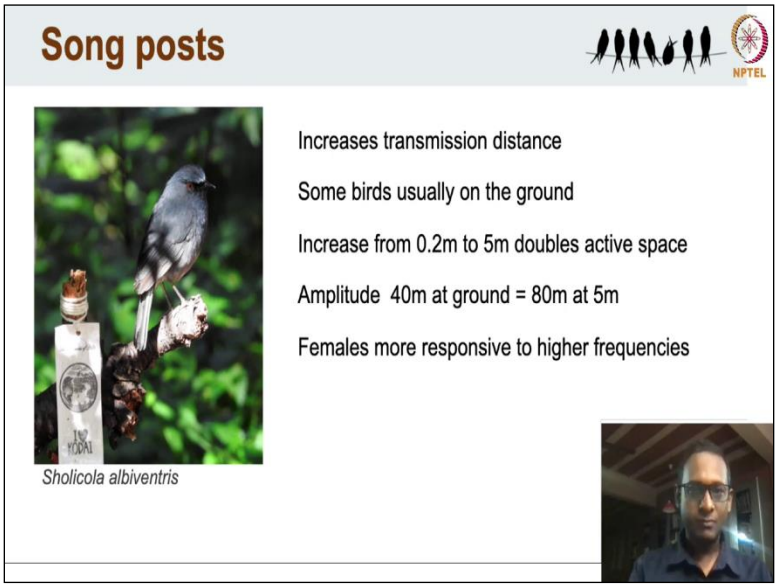


When we are talking about the physical limitations to song, birds can also adapt in some ways. For example, a transmission distance - sometimes birds that that live on the ground they go up a little bit and sing from these, what are called the song posts. So, song posts are very specific locations in a bird's territory from where it sings.

So, again sorry for anthropomorphizing, but you can imagine these as watch towers from where you look out and these birds have these song post which are slightly higher and from there they sing and you can identify them very easily usually because they have very regular spots in a bird's territory. So, what happens is when a bird is singing there is something called the active space which is the space that the bird's song actually reaches.

So, for a specific amplitude what people have shown is that if you go from, let us say, ground to five meters it can double the active space. So, what that means is for a specific amplitude the bird is singing at a specific amplitude, it can reach let us say 40 meters from the ground but if the bird goes up to 5 meters and sings from there it can actually double that and the song can then reach 80 meters.

So, increasing the height on from a song post can actually double the active space for a bird and females are also receptive to more I mean they can hear these birds and they are also sometimes receptive to higher frequency songs. So, that is interesting as well but some of these are that depends on the species. So, this is not a broad generalization in that sense.

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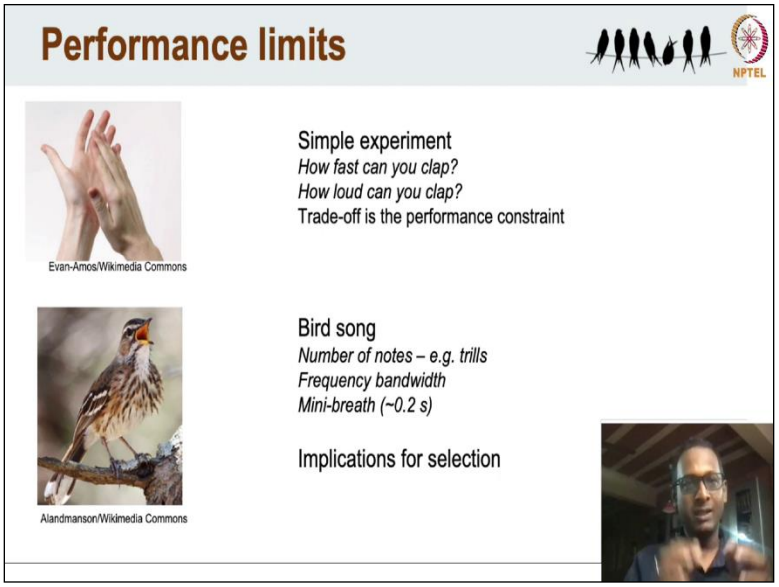


The part that I was talking to you about performance limits sometimes that is a little bit difficult to understand and I will try to explain the basic question is why do not if we know that the theory says that you have to have very high song rate, you have to have high frequency bandwidth

between minimum and maximum frequency. So, why cannot birds just do them all. And that is often because of different kinds of limits - the physical limits that are placed on the bird.

A simple experiment that you can perform right now is to find out, all you need is your hands and find out how fast you can clap. So, you can go like … right that is really fast I am sure many of you can clap faster but then I say how loud can you clap and suddenly you notice that you have to actually take your hands far apart and then clap. So, you cannot have really fast and loud.

So, there is a trade-off and that is the limit. This is some kind of a performance limit or trade-off that you experience yourself. So, birds experience this in various ways. This can be with behavioural parameters as in some birds cannot go high up, they cannot do something else because something else is limiting the bird. Other simple examples for bird song is the number of notes example trills.

Trills are these single notes that are repeated but there is a big trade-off with frequency bandwidth. So, if you have to have a song that goes from low to high bandwidth and repeat them multiple times that is sometimes not physically possible for birds and birds also have something called the mini-breath. So, essentially you cannot just continuously sing, you have to breathe. So, a lot of the notes have between them something called the mini-breath and this is very small 0.2 seconds.

And birds have a way of kind of making a trade-off sometimes by switching syrinx and things like that more detailed than is necessary but you can look it up. But essentially a lot of these limits the performance limits have implications for selection - natural selection and sexual selection.

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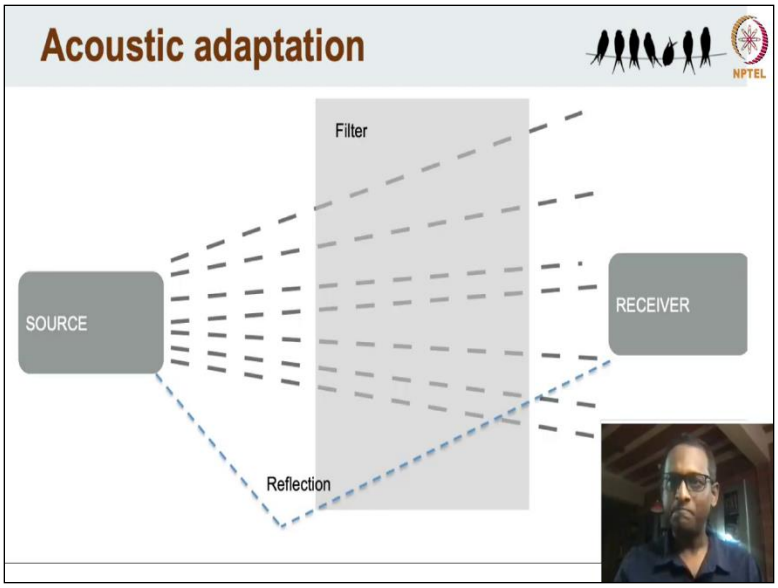


Acoustic adaptation hypothesis: So, before we understand acoustic adaptation hypothesis, let us come back a little bit more and wind back to our idea of how sound is produced and how it travels. So, we discussed a number of ways that birds sing to attract males or to repel competitors and so on. But in reality, sound undergoes lots of things that are happening in the environment. So, you have a source and you have a receiver but in the middle often there is some kind of a filter.

This filter can be the habitat, the trees, the tree trunks, the leaves and sometimes even you could consider humidity and so on that affects the source - the sound that comes from the source to when it reaches the receiver. So, there can be different things that happen. Similarly, there is also reflection that can happen - the sounds can reflect off surfaces like water or sheet rock and so on. So, one has to kind of think about how the sounds are your spectrograms sometimes can show up echoes or some kinds of distortions because of some of these effects reflections and so on.

So, one needs to account for that but more importantly the question is - birds when they are singing, they want the receiver which is the other male or the female to get the signal. So, how do the birds adapt to the environment that is around them.

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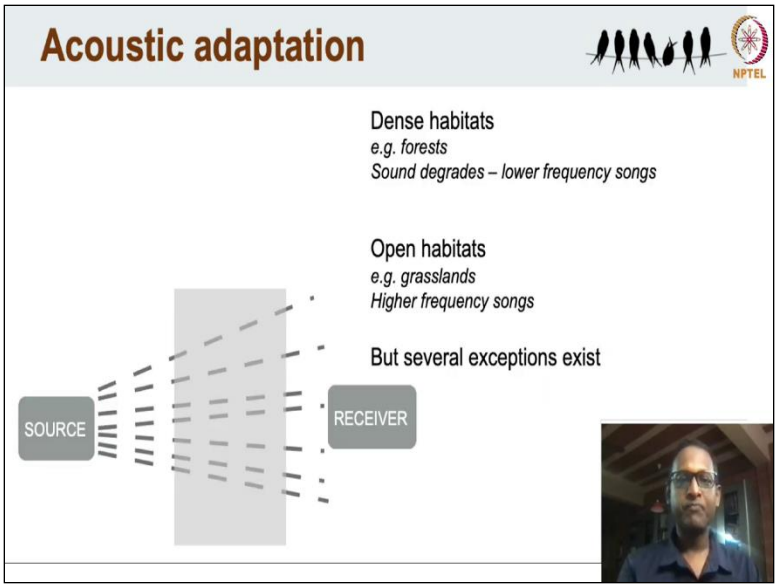


And one hypothesis that is proposed is the acoustic adaptation hypothesis and in which essentially what that means is you have some dense habitats like forests. So, which has a lot of foliage and trees and so on and sounds can degrade very rapidly because of that. So, the idea is that or the hypothesis is that birds that have or have adapted to this by switching to lower frequency songs.

So, birds in dense habitats are supposed to have lower frequency sounds and contrastingly, in the open habitats for example grasslands where sounds attenuation is not that much sounds can travel better. There birds tend to use higher frequency songs. So, this is a general hypothesis about how sound is supposed to travel and how birds have adapted to it. But there are several exceptions and if you are going to look it up you will find you know several studies that show that there is a that some birds follow the acoustic adaptation hypothesis and some that do not show that.

And this is true, various people have examined this in various kinds of habitat. But this is something to be considered, to remember when you are studying forest birds and open habitat birds. For example if you are comparing birds in different habitats - this is something to always keep in mind. And in fact, when people study birds even within forests, you try and keep in mind that the level of openness or dense habitats that has / may also have, some effect on on the frequencies that the birds there produce.

So, this is another part of the variability that can come in from all these other ideas that we have talked about. So, remember that the birds song needs to travel through a specific environment and they may have adapted to that.

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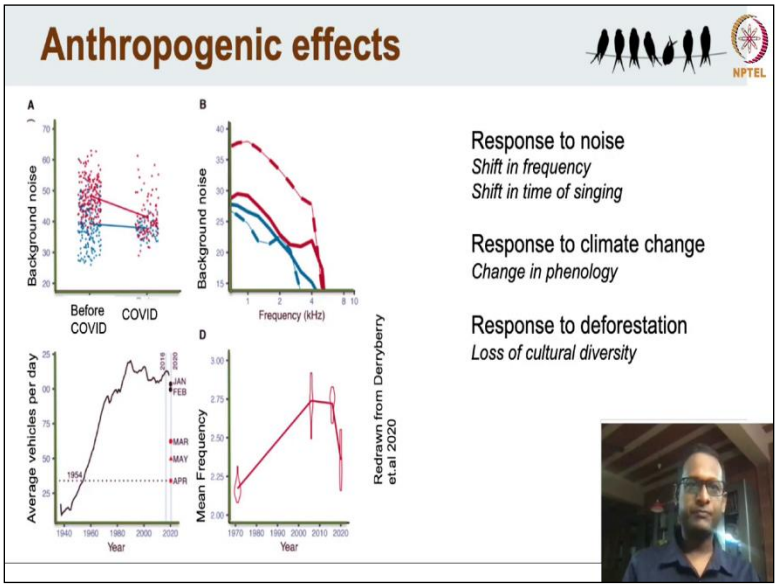


The last part of the talk is about conservation, which is in trying to understand the impacts of anthropogenic activities on bird song and also on how you can use bird song for aiding conservation and I will deal with these two separately. So, first anthropogenic effects. So, this is essentially how bird songs are affected by human activities. One of the most common ways that birds can be affected is by noise.

So, the background noise that can affect how birds communicate with each other. A common response that people have found based on various studies is that there is a shift in the frequency of the songs. So, they are trying to avoid a certain frequency of background noise. So, usually there is an increase in frequency of the bird song. There are studies that also show a shift in the time of singing.

So, if birds are usually singing at a particular time and if that matches with the rush hour traffic. (traffic noise is a big source of noise pollution). So, then they are known to shift that their peak singing window to offset this noise the background noise that is there. An excellent study recently showed the effect of what is known as anthropause because of the COVID lockdowns.

So, I will walk you through this study. So, this panel here on the left has on the y-axis background noise and you have before COVID and during the COVID lockdown. The red and the blue dots are the red are from urban habitats and blue dots are from rural habitats and this study was conducted the Golden Gate Park in the US. And so, the traffic is pretty high during rush hour and so on.

So, what you can see here is that the urban areas have higher background noise before COVID and what happens during COVID is that that urban noise just goes down almost to rural levels and this is also you can you can see in the frequency how this kind of drops. And the panel here on the left shows the average number of vehicles per day on the y-axis and this is the year and you can see that the number of vehicles per day kind of drop down to 1950s levels the average number of vehicles per day.

And what was really fascinating was that these authors found because they had populations that they were studying for a long time they were able to understand how the frequency has shifted and it has come down to some of these 1950s sort of levels because, they argue, of the reduction in background noise. So, this is a fascinating study very rarely are people able to kind of show such as time series data that shows a shift in frequency.

So, this is really fascinating. But in addition to this, you can imagine and people have found that birds respond to climate change. And in the in this case, main effect of climate change is on the phenology of the bird which is that birds start and stop breeding at different times in response to climate that is changing. Of course, birds are known to track climatic patterns very strongly and any kind of changes in the climate will affect the breeding the timing of breeding of these birds which then in turns in turn kind of affects the singing behaviour.

So, birds would then sing later or earlier depending on what is happening to the climate. You can use bird song to study effects of climate change, effect of anthropogenic noise. People have also shown that with deforestation there is an effect on birdsong. This can happen with a slight it can

happen in two ways - it can happen with isolation that there are some slightly different song types that are generated those microdialects. We talked about that can happen because of deforestation.

But you can also have loss of cultural diversity. So, this is almost like a loss of an allele in genetic diversity except that because you have a very small population. Researchers in Spain have shown that Larks that live there in small isolated population have a lower cultural diversity which is they have lower song diversity possibly because of deforestation - let us call it landscape change.

So, these are some of the broad impacts of anthropogenic change but you can imagine that there are other ways that you can use bioacoustics and song to actually for conservation. You can use songs to detect these birds because especially for rare birds using songs or calls to detect them has become a very big part of conservation biology.

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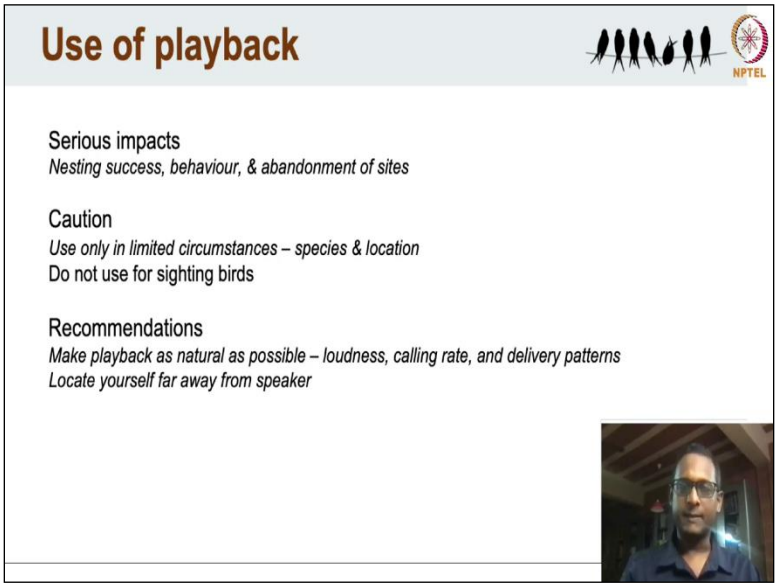


Use of playback: So, birds especially in rare birds often there is a problem with detecting them and bioacoustics is a good way of detecting them and it can therefore be used in conservation biology. But using playbacks to detect birds has a very serious impact as well and this can affect the nesting success, it can affect the behaviour and can even lead to a abandonment of sites. So, let me put this in context. We have seen how song rates affects birds. So, if there is a lot of playback, essentially what the competing male the territory holding male thinks is that there is this super fit male that is there and it can abandon the territory. In some cases, there is some habituation that can happen.

So, in some bird they found that it is not that negative, they sometimes get so used to this playback that they stop responding to it.

So, both are possibilities you can either have a very strong response and the bird can abandon the site or get acclimatized and then they stop responding to the playback. Now the risk here, when birds stop responding to playback is that they may also stop responding to the real bird because if you are very closely matched with the song of the bird from that area that is possibly a bad thing that can happen.

So, the negative implications of playback are actually fairly serious and this must be taken with very strong you know strong ethics at an individual level. So, the caution that must be borne with this is that one should use playback only in limited circumstances with specific species and specific locations only. Which is that you do not do broad spectrum playback, you do not play back one bird song and then another bird and then another bird and you keep doing it from multiple locations.

If you need to do playback, do it for special specific species and only from specific areas and I would suggest that do not use it for just for sighting birds. Because this is a very, what you are mimicking, is a very expensive process for the birds to make these sounds. So, I would suggest that make a playback as natural as possible and this is not just me there are other researchers who have kind of done thorough reviews. Some of this is posted in the additional reading material along with this lecture.

The simple instructions or suggestions are make playback if you have to use it as natural as possible which means - number one adjust the loudness to mimic as closely as possible to the natural sound which means that do not have a huge speaker that makes a much louder sound. Of course, if you make a louder sound what that means is you can reach farther but if your target bird is very close by that can have a serious impact on it.

So, before you do a playback you can even use a small decibel meter something on your phone. There are lots of apps that can show you sound level meters - I mean they show you in decibels

there are different degrees of accuracy but something is better than nothing. So, look - check for what loudness you are doing the playback at and fix it at that particular volume stop and do not exceed that.

Do not modify the call in any way, do not increase the calling rate which means that if a bird has let us say 10 song bouts - I mean 10 songs in a bout. So, it goes usually it is stop singing do not playback this section in multiple units. So, do not play back the same thing. So, long or do not compress it. So, that the calling rate changes which makes it faster. Do not change the delivery patterns, do not I mean try and play back with as natural setting as possible that is if at all you must do playback.

And the final suggestion would be that birds when they are actually listening for another bird when the signal comes to them, they are also looking for the source, which is the speaker. So, try not to be around the speaker. So, you could use a Bluetooth speaker in these days where you have the speaker located somewhere and you have your recording which is made as natural as possible with a specific volume stop and then you play that back while you are hidden away or something like that.

Now we described we talked in this lecture about how you can understand the ecology of a lot of these birds using playback. So, the use of playback is very valuable in understanding the biology of the birds but to use it for only sighting is using a big hammer to crack a really small nut. So, I would recommend that if you are interested in acoustics want to understand the biology of birds design your study very carefully and only then use playback.

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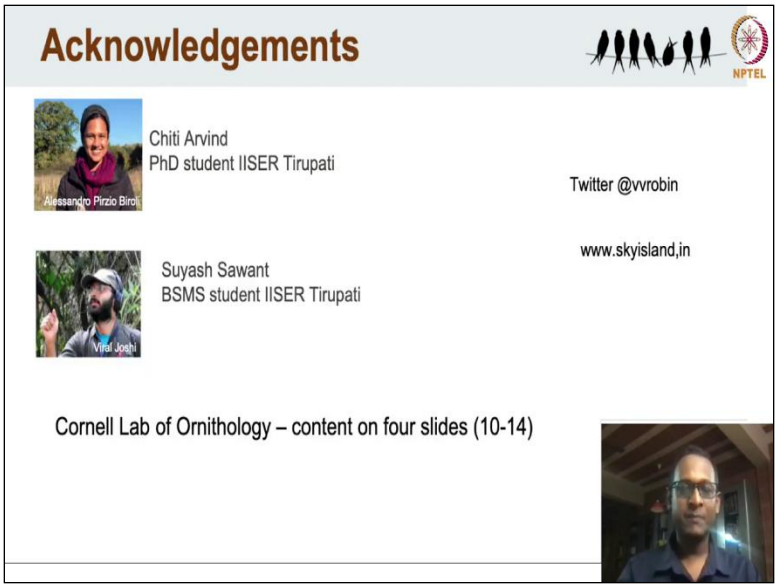


And I would like to end by thanking two students who helped put a lot of the content together Chiti Arvind - PhD student at IISER, Tirupati and Suyash. I also thank Cornell Lab of Ornithology for content on four slides and you can reach out to me and find me on my twitter handle as well as on our website.