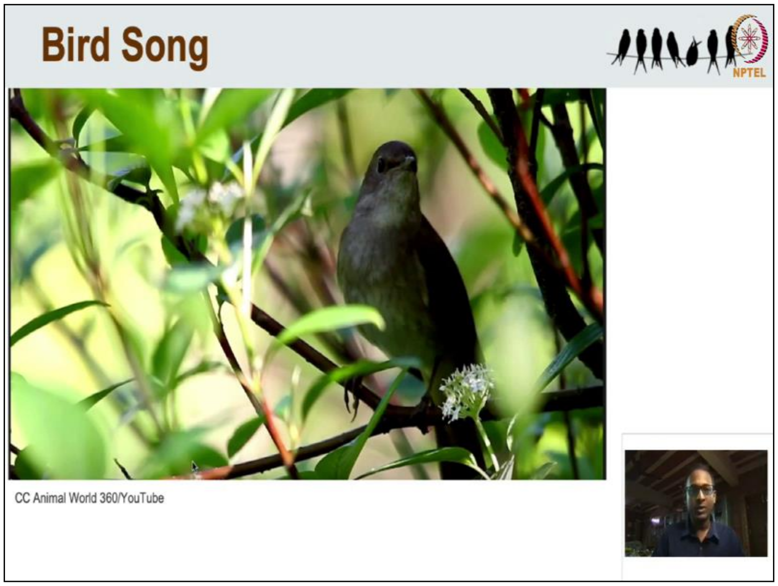
Basic Course in Ornithology
Dr. V. V. Robin
Indian Institute of Science Education and Research, Tirupati

Lecture -16
Vocal Behaviour Ecology and Evolution (Part1)

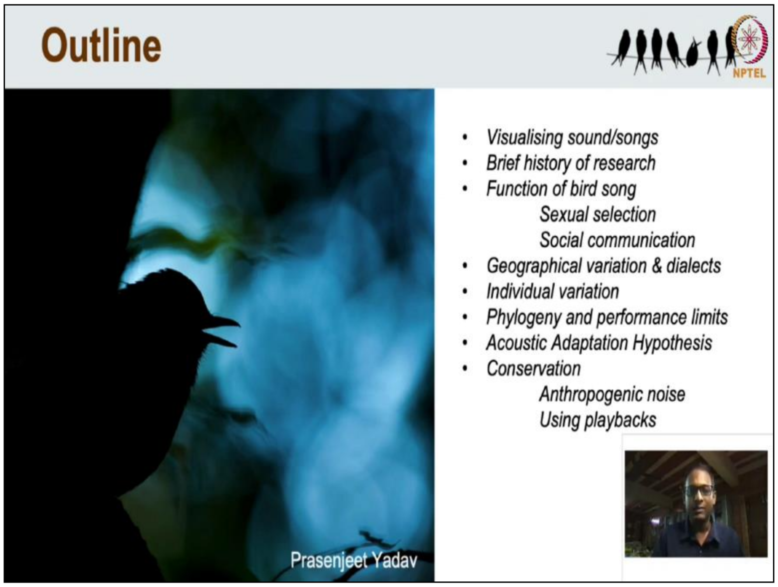
(Refer Slide Time: 00:39)



Hello everyone, hi! I am V. V. Robin or Robin Vijayan and I am going to talk to you today about vocal behaviour, ecology and evolution and I am based at IISER, Tirupati. So, we all know about bird song because it is a very prominent part of nature. So, wherever there is a natural surrounding around us, people hear birds and birds sing. So, this is a very important part of how people associate with nature as well.

But today, we are going to talk about how we study bird song, how we study acoustics of birds. And I will start the proceedings by playing the song of this Nightingale which has a very fascinating song. Well, let us just wait for it. So, as you can see, this bird has so many very interesting sounds that it is making and the questions that we can ask is why are these sounds being produced? How are they being produced? What may be the context of the song and how we can study them?

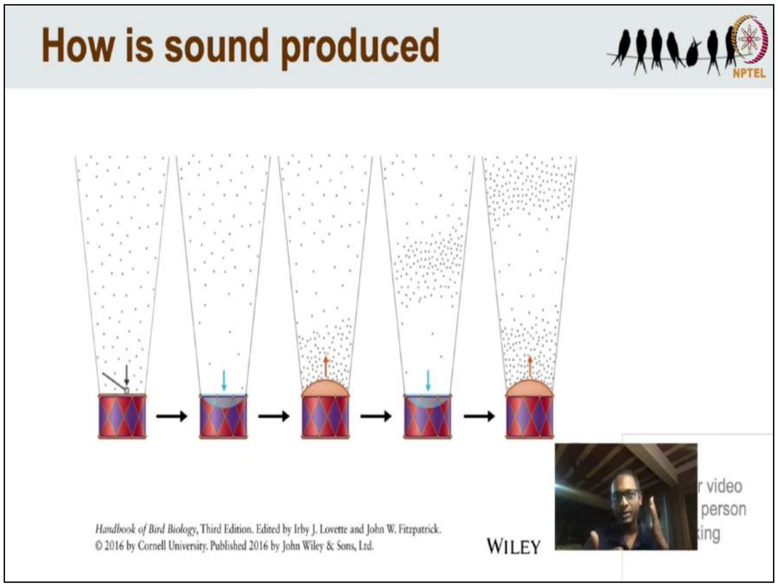
(Refer Slide Time: 02:14)



So, in this lecture, we will talk about a few we cover some aspects of acoustics/ bioacoustics and we start by talking about how to visualize sounds or songs and we will quickly take you through a brief history of the research in this field. And then we move on to - what do these bird songs mean? There are parts of sexual selection, parts of social communication. In what context do those make sense?

We will also talk about geographical variation and dialects, individual variation, phylogeny and performance limits, acoustic adaptation hypothesis and some aspects of conservation especially to do with anthropogenic noise and using playbacks.

(Refer Slide Time: 03:07)



So, we will start with talking about visualizing song or sounds. Before we discuss how to visualize song and sounds. I think one of the important things to do is to discuss how sound is produced first. So, this is a really nice illustration and what you see here are drums. So, this is a drum and this is the stick with which the drum is struck. So, when the drum is struck there is some these are molecules that are all around.

And you can see, essentially, what happens is that there is a compression of these molecules and expansion that happens and this is what kind of forms these waves and as these waves hit our ears that is then translated into the sounds that we hear. So, this is a very simple illustration of this fairly complex mechanism I suppose.

(Video Start: 04:10)

But for our purposes of visualizing songs and sounds for this study and for academic research, the way we represent it is using these two kinds of figures at the bottom. You see one with x-axis - this has time. So, this is in seconds. So, this song is about one second … one point three seconds. So, it is really short, right? And on the y-axis here is kilohertz. So, that is the frequency. So, this song is then about two kilohertz that is being produced. This panel above is also time, in fact it is the same sound.

So, these are two representations of exactly the same sounds and they are produced at the same time and this one has amplitude on it. So, what that means is that because sound travels as waves from zero you have a certain positive value and you have a negative value as well. So, these are actually lots of very very tiny waves which are kind of put together it looks like a beam - but we will we will go into that subsequently.

But what is important to understand is this representation the wave format is actually like an oscillogram and it is reflective of the amplitude and this one has frequency. So, let us listen to this. Right? Let us listen to it once more. So, that is just one frequency sound that is produced at two kilohertz and nothing else and it is at a constant volume - amplitude. Now I am going to change things a little bit it is the same exact thing that we were talking about in the set of figures one has amplitude the other has frequency.

Here I am producing with my phone one kilohertz sound and then I keep increasing the sound slowly and it will go up to 8 kilohertz and you can see how the spectrogram which is this representation of frequency and time how that is changing and how the amplitude is represented here. So, here I went up to 8 and then I came down to one and then went up again there is a Koel in the background if you can hear those little dots and that came down and here what I am doing is I am keeping the frequency constant at 4 kilohertz and I am reducing the sound from my phone which is making this frequency.

So, I reduced it and then I increased it. Right? So, we will stop somewhere here. So, as you can see here the frequency went up to about 11 kilohertz came down and then I set it to 4 kilohertz at the frequency but then I toggled my output and made it really low and then I increased it slowly. So, you can see that the sound is staying at 4 kilohertz but the volume is changing and as the volume changes the amplitude that is reflected here changes.

So, this pretty much gives you an idea of what happens with the songs. Now let us play a real song of a Black capped chickadee. So, first we will play I will play this entire sound. Now you get an idea of what the spectrogram and the waveform - what they look like. So, let us play this and then I will zoom in and play one bit of that and then I will further zoom in and show you some more.

Now, let us zoom in and we listen to this bit so you can make out that how each note little units sound and with practice actually you should be able to kind of listen to a song and then imagine what the spectrogram would be like and conversely when you listen. When you're watching the spectrogram you should be able to imagine what the sound is like and that is great if you can get there.

So now we will do a little bit more practice so that you can look at these spectrograms and you can understand that because further down this talk we are only going to use spectrograms. So, you will have to keep imagining the sounds. So, this is one tiny bit of song. So, this is 70 milliseconds it is not even one second and this is only the waveform and remember I told you there are these tiny waves inside.

So, these are those tiny waves. Let's play this that is it just one beep. You can see how that is made of. So, many of these waves and it has some modulation within it. I hope you have understood a little bit about how songs are represented how you can visualize songs and sounds. Now, let us do a little bit more and if you look at. So, this is this is the song of the White throated sparrow, a know well studied bird in North America. You might remember in your bird books when you look at a reference for what a bird sounds like there would be some words that describe a sound and often it is like this, this one is supposed to sound like 'poor old sam peabody peabody peabody'. So, let us see. Now that we know what a spectrogram is this is again the same spectrogram it is just the colors are different.

So, on x axis is time. So, you can see that the time is about three and a half a second song and this is frequency same as before. So, let me play this. So, that is when the bird is actually using its mouth and lungs and everything to make the sounds but in case this is not the case for several birds as Woodpeckers they are really unique and they have this drum.. this drumming sound and some of these species are known to have very characteristic drumming sounds. Let's listen to some that are that are known this is the Downy woodpecker.

So, this is supposed to call at about 16 drums per second and let us listen to another one and this one is the Hairy woodpecker, this is actually Hairy woodpecker. So, as you can see this is much faster than the first one that we heard the names are not that important. But the point is that some birds have very fast drum. The drumming sound and some others have very short and you can distinguish species by that.

And here is a third one and you can see that this is a more variable drumming sound it can be slow or it can be fast. This is a Sapsucker - Yellow bellied Sapsucker. So, the point here is that there are species specific drumming sounds as well. So, I mean throughout this talk I keep talking about songs because that is what the passerines perform but the analysis the analytical approaches can be used for any kind of bio-acoustics as well.

That is just for you to listen to all of these again but let us move on. This is the Common yellowthroat and this is supposed to have 'witch-i-ty witch-i-ty' call and this is how it would be described in words but now we know what the spectrogram looks like. And I wanted you to see a bird which has this frequency modulation like it has it goes the notes go from a very low frequency to a much higher frequency and then it drops down because a lot of fly catchers and several other species that you will come across do that.

So, let us let us listen to this. And like I was saying it is not in birds sounds are produced with various parts of their body. There was a Hummingbird, I do not have the song here which produces very nice very interesting sounds with feathers. And but this one is a Common Snipe and it has some adaptation on its on its feathers with which it makes a very interesting sound. Let's listen to this.

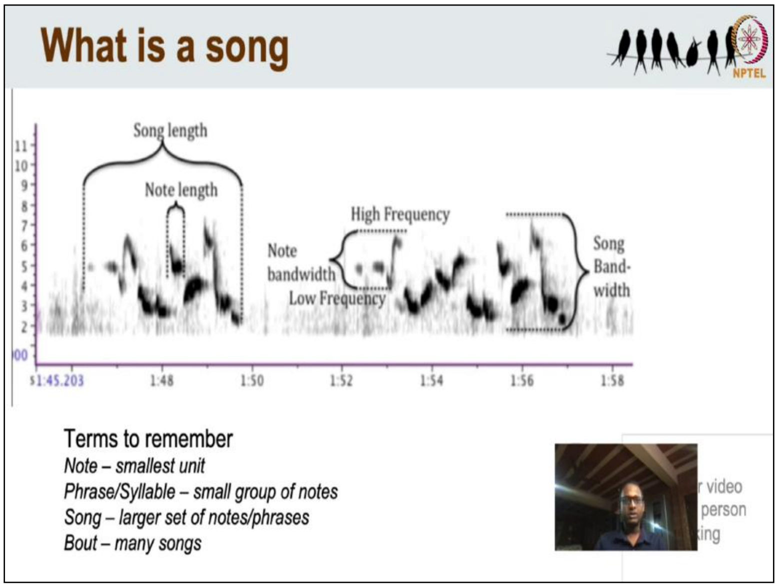
I hope you could hear that. So, this sound is just produced by with the feathers and you will see some kind of a harmonic stack - this is called harmonics and usually you try and find the fundamental frequency which is the one major frequency that that it produces. So, anyway that is more technical than we need for this, for the purpose of this lecture.

But I suppose you can see the variety that is there in these bird vocalizations /acoustics. This is a call of the Black capped Chickadee and this one has these repeated ‘dee’ notes. So, it goes ‘dee’ and it also has a gargle call. Let us listen to the first one, the interesting part about this call - let me explain that before I played is that the call actually it has these different notes but depending on which flock the bird is in it can actually it jumbles up the order of the of the notes accordingly.

So, it is actually used for the group identity this particular set of notes and let us listen to that. And then we have the gargle call which is made by the same species but this is used in aggressive interactions as a as a signal for of aggression with other males. So, what I was trying to kind of show here that there are different contexts that different birds use different kinds of vocalizations /acoustics, but it is sometimes very species specific. So, that is the ‘dee’ call again and you can see how much that those sounds vary between context.

(Video End: 18:38)

(Refer Slide Time: 18:40)



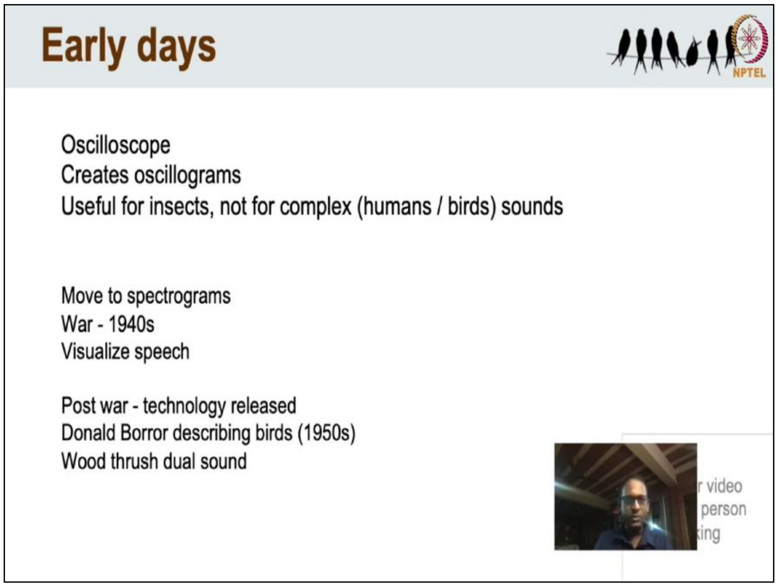
So, that is enough. So, now let us also talk about what actually constitutes a song I keep talking about different characters of song. So, what exactly do we measure from a spectrogram and this is again if you remember time and this is frequency the most important thing to remember is that the smallest let us go from the smallest unit. The smallest unit is the ‘note’ and a note is just this it is like any undivided sound the smallest undivided sound that is a simple way that I kind of used to understand this and it helps because it is very simple.

And you can find these notes, these are undivided little sounds that ,you can actually make out on the spectrogram and a set of notes a small set of notes is a ‘phrase’ and then you have a ‘song’ which is a larger set of notes. So, phrases can be something within a song you can have small syllable types or phrases different publications different authors use this interchangeably phrase and syllable but this is it both of them mean exactly the same thing it is a small group of notes.

And songs are a larger set of notes like this one. So, this is a song, this is another song, this is song number two. And a bout can actually have several such songs. So, this is an important aspect in various bird biology components which is the song rate, how many songs per minute does a bird sing? Because it is obviously linked to energetics and fitness. Therefore, one can measure different aspects of the song from a spectrogram.

The length components - you can measure the note length, the song length, you can also measure the frequency - the low frequency, the high frequency, you can look at the bandwidth which is nothing but the high frequency minus the low frequency and this is again a biological component because what this means is females are thought to prefer birds with high frequency bandwidth that that go from low to high frequency. So, you will find a lot of songbirds that have this these kinds of syllables and notes.

(Refer Slide Time: 21:16)

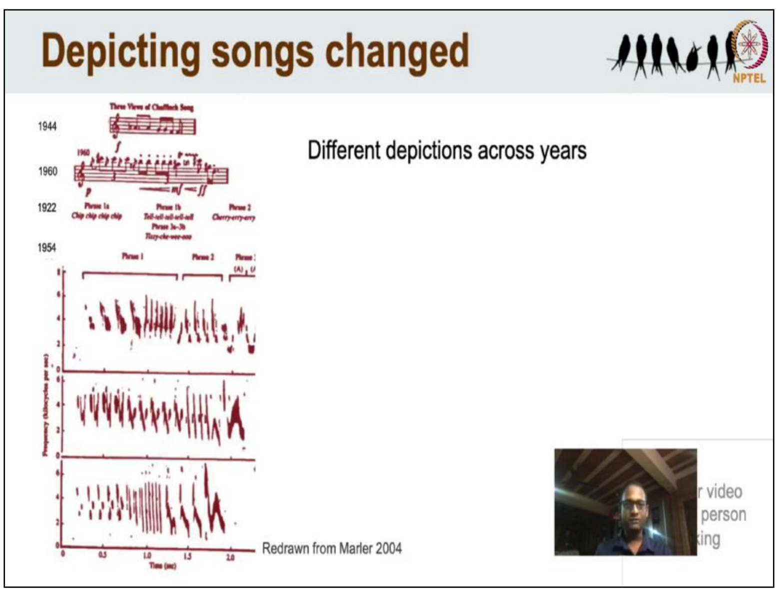


So, we move on to a brief history of song research just to provide some perspective on this field. One has to acknowledge that this is not a very old field of research and it is very driven by the technology that is used to describe these sounds. In the early days, it was an oscilloscope that creates oscillograms. And if you remember those are the ones with the waveform with the line that goes up and down.

And those are useful for organisms like the insects which have a very specific frequency not too much modulation and a lot of the variation is in how these sounds are distributed in time. So, you can have short pulses, fast pulses and so on but it is not for complex sounds like humans and birds. And the move to spectrograms actually happened only in the 1940s and this was driven by the world war where people wanted to analyze and visualize speech- human speech for the purposes of the war.

Postwar, the technology was released and one of the early people who used this technology was Donald Burror and he in the 1950s described a whole lot of birds with spectrograms the bird sounds with the spectrograms. And I suppose in India we're still doing this for several species. The Wood thrush dual sound, I have not shown it here but do look it up this is one of the early descriptions of the Wood thrush song.

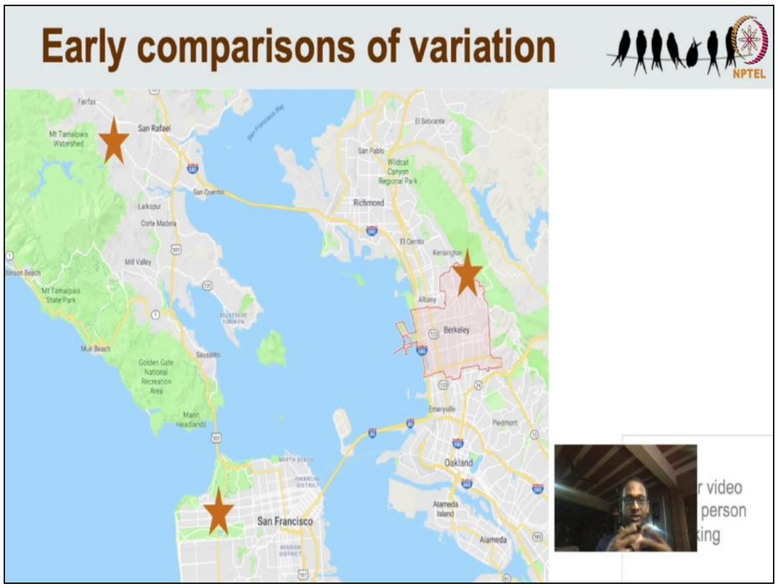
(Refer Slide Time: 23:02)



Now, one of the things that has also changed, we kind of touched upon this in a previous section here is how songs are depicted. We talked about one way of depicting songs which is in words that describe the sounds - the way you say the sound, sounds like how the bird sings. But people have also tried to use musical notations to describe songs and you can see that in at different time points this has changed significantly.

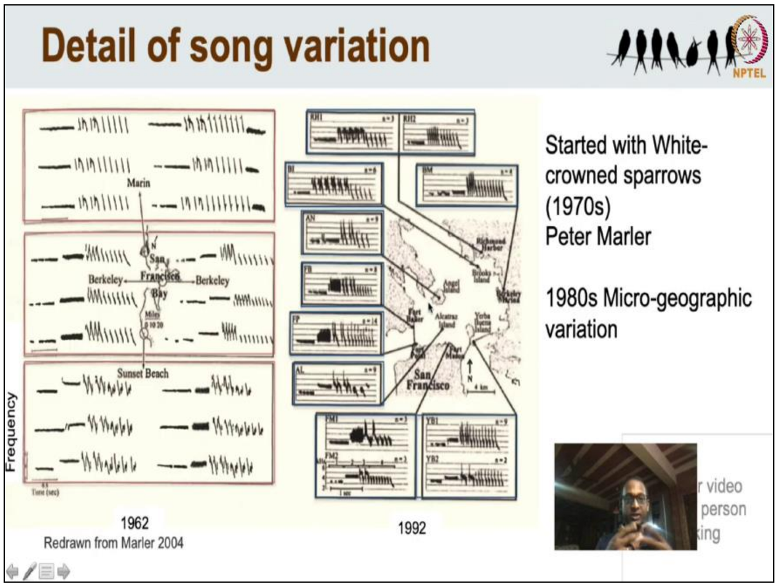
You have gone from musical notations, complex new musical notations to words and now of course from the 1950s you can see spectrograms that describe these sounds. So, depictions have changed over the years.

(Refer Slide Time: 24:00)



And the early research often used comparison of variation and this is a fascinating study that is done in the San Francisco Bay Area between three different locations there were illustrations studies that came up in the 1960s

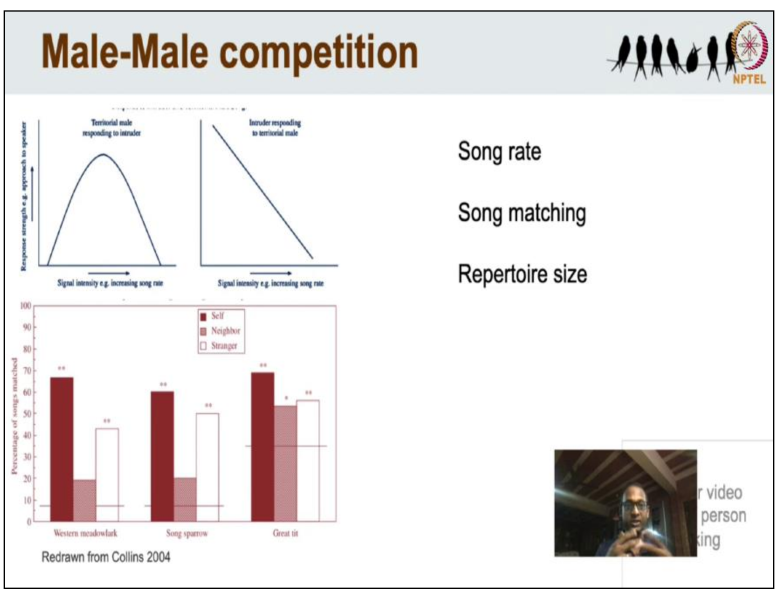
(Refer Slide Time: 24:14)



comparing these three locations and looking at geographical variation in song this was done by Marler. And later others followed up with a more detailed micro-geographic variation and you can see that in the same area. Now, people have described how there are even in minor locations, small areas isolated from each other, there are slightly different versions of songs that these birds sing. This is all White crowned sparrow by the way.

So, there is considerable song variation that has been in from 1970s to 80s started getting described in this field.

(Refer Slide Time: 25:08)



Now we move on to understanding why do these birds sing, what are the functions of birdsong. As we discussed in the introduction earlier, one of them is male-male interaction. So, let me explain that. So, now what happens with birds that are singing is that the main function of the song is to maintain territories - that is to retain its territory. Apart from that they are also trying to attract mates and when they are doing this guarding of the territories, they are trying to chase away intruders, neighbors and so on.

So, I will explain this figure to you. At the top is two lines graph which show the signal intensity or in this case like song rate. So, we discussed song rate earlier which is the number of songs per minute and on the y-axis is the response strength. On this left panel, what you have is a territorial male that is responding to an intruder. So, there is an intruder that is coming in and the territorial male is actually responding to it.

Now if the signal intensity. So, the sound here is from the intruder. So, if the song rate keeps increasing the territorial male actually responds more and more but after a point it kind of drops off. And this in this case as a signal intensity increases in here, the signal is from the territorial male. So, the territorial male as its signal is increasing the song rate increases the intruder actually does not the intruder's response declines.

So, there is a strong effect of song rate whether it is from the intruder or from the territory holder. So, song rate is very important. Now if you have listened to bird singing outside you will notice that there is something interesting that happens. There is a bird that sings from one song post and then there is another bird that kind of responds to it. So, this is called song matching very often.

So, it is almost like a '*jugalbandi*' that you hear of in classical Indian music. So, what is happening here is that a bird is singing a song and this other bird is trying to match the songs of this bird that it is kind of competing with. And the more closer the match is the more signal of aggression that this is. And here the bottom graph here actually shows you how close this is. So, the filled bar is - so these are three different species these three sets of bar graphs and the filled one is the song of the of the individual itself.

So, individual A is singing and if you playback the song of the individual itself. This is the proportion of the songs that are matched by that. This is the greatest amount of aggression match it exactly and then you have neighbour and then you have stranger and there are small differences in how different species do song matching. And of course, if you have to match the song with a stranger that means you need to have a slightly broad repertoire size.

Repertoire size is nothing but different kinds of songs that you have, different notes that you have. So, it is like if that to anthropomorphize if an intruder comes in with a knife you have a knife to fight back with, if it comes with a gun you have a gun to fight back with. I am sorry it is just a very broad generalization but I hope you understand the idea of song matching and the importance of repertoire size.

The repertoire size will come up in the very next slide because it is also something that is important for mate attraction. So, this is male-male competition essentially to maintain territory that the male is guarding.

(Refer Slide Time: 29:50)

And then we have sexual selection where obviously the males are trying to attract females and females are selecting based on the best song that it hears. And in this graph, what we have is repertoire size of Great tit and the x-axis goes from low repertoire size to high and the y-axis is the mean number of displays from females. So, these are females actually soliciting copulations based on the repertoire size of the male.

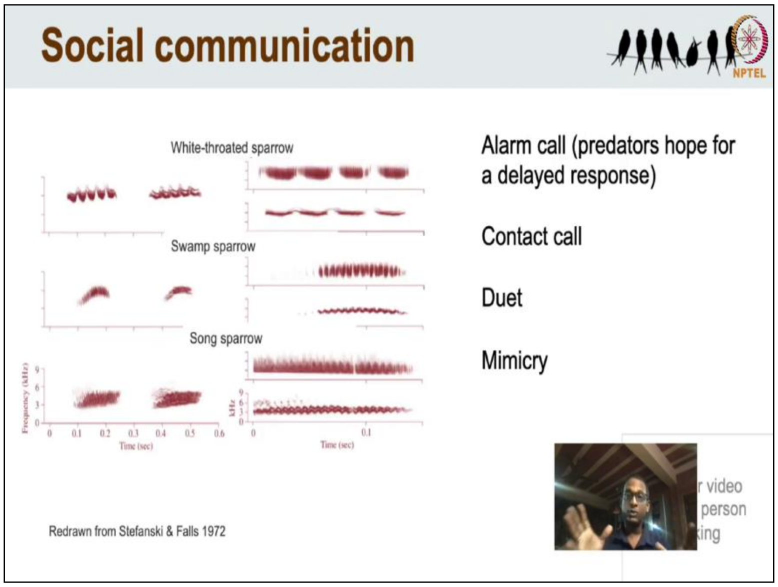
So, a quick note here, the previous slide if you should remember and a lot of these studies are done with playback experiments also. In some cases, they are actually looking at the bird and looking at the impact it has on the female for example and then they quantify it. But in some cases, they do playback experiments and these have to be done very carefully.

I have a slide on that towards the end but if you are wondering how some of these data are arrived at, that is how that happens. Anyway, getting back to the story. So, the large larger the repertoire size, the females seem to be more attracted to it and because this is supposed to be a signal of fitness and that is essentially what females are looking for. There are other things that females look for and this depends from species to species.

Depends on the kinds of songs that a species has, there are some things called the sexy-phrase or the sexy-syllable where there are some parts of a song which just have these unique notes. Often, these notes are the ones with high frequency modulation and those are supposed to be one of those win-or-lose kind of phrases that the birds use. The third thing that birds use is singing rate which is something that we talked about earlier as well - the number of songs per minute and that is again linked to energetics and to individual fitness.

So, the main functions of songs have been described to be male-male competition and then of course sexual selection.

(Refer Slide Time: 32:30)



There is also a whole world of social communication - the role of vocalizations and this is largely around interactions which are towards conspecifics sometimes heterospecifics. Alarm calls are the famous ones. Of course, alarm calls are meant to warn others of predators, the presence of predators and they are usually very narrow bandwidth and they are short. So, these are characteristics of alarm calls.

They do not have very elaborate frequency modulation and so on. Because you just want to send a signal which is just short and crisp. And what predators are kind of hoping for is a delayed response by the birds to an alarm call and then they kind of go hone in on those birds. There are contact calls - these are calls in for largely in group living birds but it can also be for two birds that are socially bonded birds and so this is just to kind of indicate for one bird to other that where the location is.

So, you feed, and as you forage and you move through your territory. You are trying to keep in touch with the other birds, the partner, or the group member. So, those are contact calls. You also have duets and duets can be fairly complicated. There is a whole categories - there are categories of kinds of duets which we will not go into but this very simply put is where there is something that sounds like a single vocalization but it is actually made by two birds.

So, one part is made by one and another part is made by another and there are studies that show that in some cases pair bonded birds, the male makes one part of the song and the female kind of quickly kind of adds that on to that. This is also thought to have made a role in maintaining territories and social contact. Mimicry is a very important aspect of bird song. So, birds this is essentially where a bird can mimic the sound of another bird.

If you have watched Drongos - very common in all across India. They are good mimics and they are known to use mimicry both to attract other members of other species. So, they are known to get birds together to form a flock using mimicry. So, they can pretend just by being one bird make lots of different kinds of bird sounds and then someone other birds think that oh there are a lot of birds here. So, they go there.

So, it is used to kind of build cohesiveness in flocks but it is also thought to mimic the sounds of predators and this is used for something called Kleptoparasitism which is to steal food to put it simply from a bird. So, let us say there is there is a bird with a nice juicy caterpillar or something like that and the mimicry bird can actually mimic the sound of a predator.

And of course, the bird with the caterpillar would then drop the caterpillar and fly away and this bird can swoop in and catch the caterpillar. So, that is another use of mimicry and it is also thought to be used to attract females.