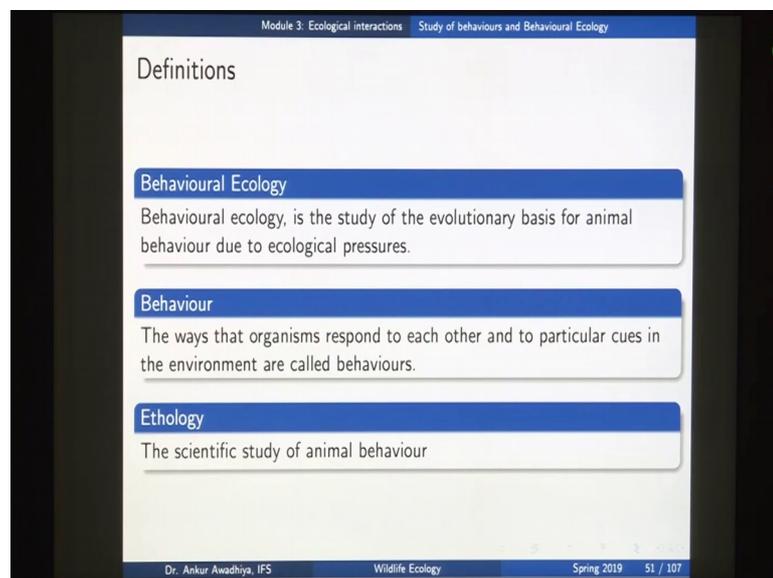


**Wildlife Ecology**  
**Dr. Ankur Awadhiya**  
**Department of Biotechnology**  
**Indian Institute of Technology, Kanpur**

**Lecture - 09**  
**Study of Behaviour and Behavioral Ecology**

[FL] Today we begin our next lecture which is the Study of Behaviours and Behavioural Ecology.

(Refer Slide Time: 00:17)



The slide is titled "Definitions" and is part of a presentation on "Study of behaviours and Behavioural Ecology" from "Module 3: Ecological interactions". It contains three definitions:

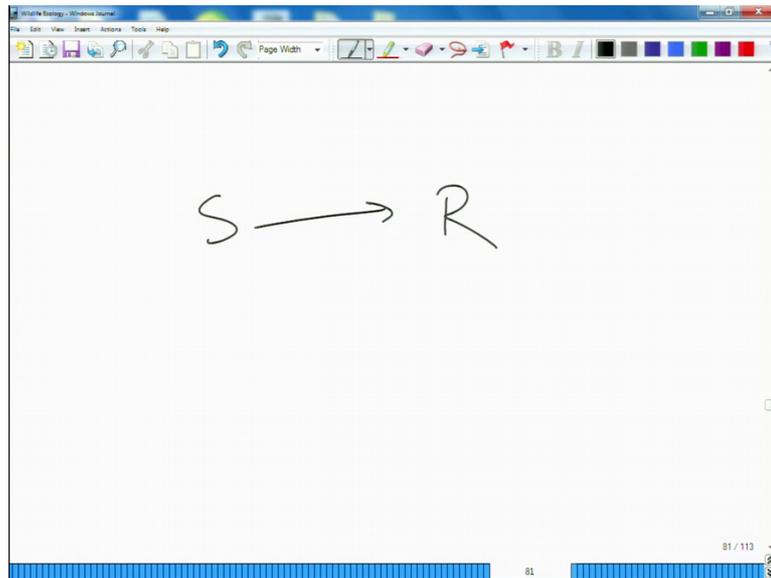
- Behavioural Ecology**: Behavioural ecology, is the study of the evolutionary basis for animal behaviour due to ecological pressures.
- Behaviour**: The ways that organisms respond to each other and to particular cues in the environment are called behaviours.
- Ethology**: The scientific study of animal behaviour

The slide footer includes: Dr. Ankur Awadhiya, IFS; Wildlife Ecology; Spring 2019; 51 / 107.

So, before we begin let us look at the definitions what is behavioural ecology? Behavioural ecology is the study of the evolutionary basis for animal behaviour due to ecological pressures. So, essentially what we are saying when we say behavioural ecology is that we say that there is an ecological pressure which is governing the behaviour of animals and we are trying to understand what is the relationship between both of these and how that also plays a role in the evolutionary process.

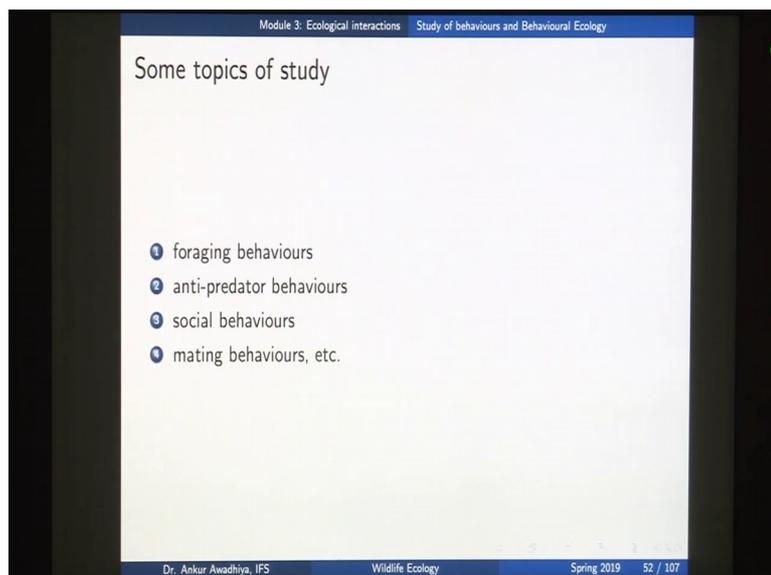
Behaviour refers to the ways that organisms respond to each other and to particular cues in the environment.

(Refer Slide Time: 00:58)



So, essentially so, if you have a stimulus and that stimulus is resulting in a response. So, the way in which the organism is utilizing or sensing this is stimulus making all the computations about what to do and giving out this response all this is known as behavior. And the study of behaviours the scientific study of animal behaviour goes by the name of ethology.

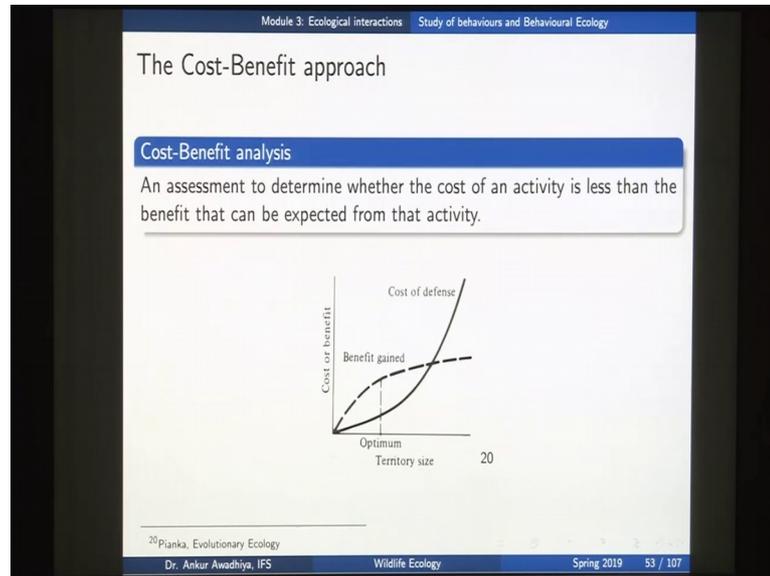
(Refer Slide Time: 01:25)



And there are a number of topics that we study in the case of behavioural ecology. We study foraging behaviours which means how do animals eat, how do they decide, which

thing to eat, what not to eat and so on. Anti predator behaviours: so, how do animals try to avoid their own predators, how do they try to save themselves. Social behaviours: how do animals behave in a group and also the meeting behaviours and so on.

(Refer Slide Time: 01:54)



And one fundamental approach through which we understand behaviours goes by the name of the cost benefit approach. Now the cost benefit analysis is an assessment to determine whether the cost of an activity is less than the benefit that can be expected from the activity.

So, to give a simple example, suppose I consider that the cost of this pen is say 10 rupees and the benefit that I will derive by using this pen or by getting this pen is say 15 rupees. So, in that case I will go and do and get this pen so that will be a behavior. On the other hand, if I think that the cost of this pen is again 10 rupees, but the benefit that I will get out of getting this pen is say 5 rupees. So, in that case why should I go for this pen? Maybe I will I will not get to go for this pen.

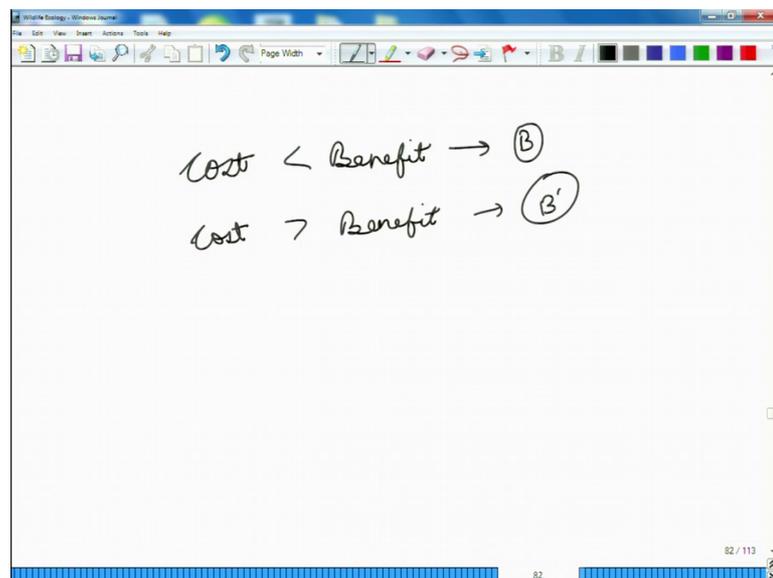
Now, similarly an animal also has to make a number of choices. So, for instance there is a tiger and that tiger sees a sambar in front of it. Now this tiger has to make some calculations, how far is that sambar, what is the terrain that is between the tiger and the sambar if that terrain is extremely rugged if this tiger has to say climb up a mound and then get back. Probably it will not go for hunting this sambar because the activity by which it will go in hunt the sambar will also entail quite a lot of cost in terms of

energetics. So, the tiger will be expending its energy to get to that sambar to chase that sambar and to kill that sambar. Now the benefit that the tiger will get if it goes for this attempt is the energy or the nutrition that will it will get by eating that sambar

Now, if the cost is more than the benefit. If the if the terrain is extremely rugged and there is a very low probability that this tiger will be able to eat the sambar. So, in that case when the cost is more than the benefit the tiger will probably not go for this for chasing this sambar. On the other hand if the benefit is much greater than the cost.

So, for instance this tiger sees that it was resting somewhere and this sambar came near itself. So, it does not have to run a very great distance. At the same time this tiger is hungry. So, essentially it requires these nutrients it puts a very high price or a very high value on nutrition. So, in that case this tiger will go and attack the sambar and maybe kill it and eat it.

(Refer Slide Time: 04:32)



So, essentially we perform something when the cost less than the benefit so, in that case you have the behaviour that will happen. And if the cost is greater than the benefit, then you will probably have some other behaviour which will refer to as by B prime. So, in this case the second behaviour in the case of our tiger would be to do nothing or maybe to take some bit more of rest. Now in this context this curve becomes important, now here we are trying to put. So, in this case we are trying to understand what is the territory

size that will be used by an organism? By putting this territory size here and the cost or benefit as the territory size changes on the y axis.

So, the y axis is cost of benefit the x axis is the territory size. Now for instance if there is a tiger that has a small territory. So, if you have a small territory, you have a small amount of benefit because you can only hunt n number of animals that are present in your territory and at the same time the cost of defending that territory is also less because there is a very small area that needs to be defended. Now if the territory size increases so, the cost increases.

Now our tiger will have to expend much more amount of energy to defend that territory. So, the cost of defense increases like this. So, earlier it was very less and then it is increasing exponentially and then when you have a very large size territory any small bit of increase in the size will entail quite a lot of cost to defend that territory. On the other hand if you look at the benefits that are gained; if you have a very small territory, you have a very little amount of benefit. Now as territory size increases your benefits increase, but then they start getting saturated after a while because one instance if a tiger is able to kill only 1 prey every week. So, it is killing somewhere around 50 preys in a year. Now if it is able to get 50 preys in this much size of territory that is good enough for it.

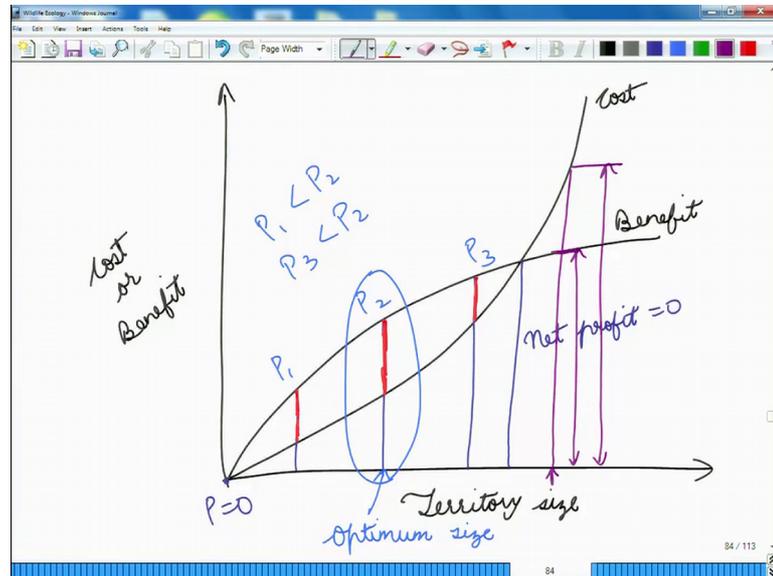
Now, if that size increases so, at this size you have like 100 animals that are available to be killed at this size we have around 200 animals that are available to be killed, but then a tiger is only going to eat somewhere around 50 animals. So, what is it going to do? By having 200 animals in its territory that does not make any sense. So, in that case will say that the benefit increases, but after a while it starts saturating. So, which is why we are saying that this curve is becoming more and more parallel to the x axis.

Now as territory size increases so, in this area will say that the benefit is greater than the cost in this area. So, all of these areas are or all of these territory sizes are those that the tiger will go for if we look at this area. So, at this particular size of territory we have the cost of defense is greater than the benefit that is being provided by that size of territory.

So, our tiger may not go for that size of a territory. So, all of these the area which is or the curve that is from here to herem now this is the area in which the tiger is going to operate. Now amongst all of these different sizes there would be one size that is the most

optimum size. So, if the tiger goes for this size. So, the benefit minus the cost which is the profit is with very large if for instance the territory size is this much. So, let us draw this curve.

(Refer Slide Time: 08:27)



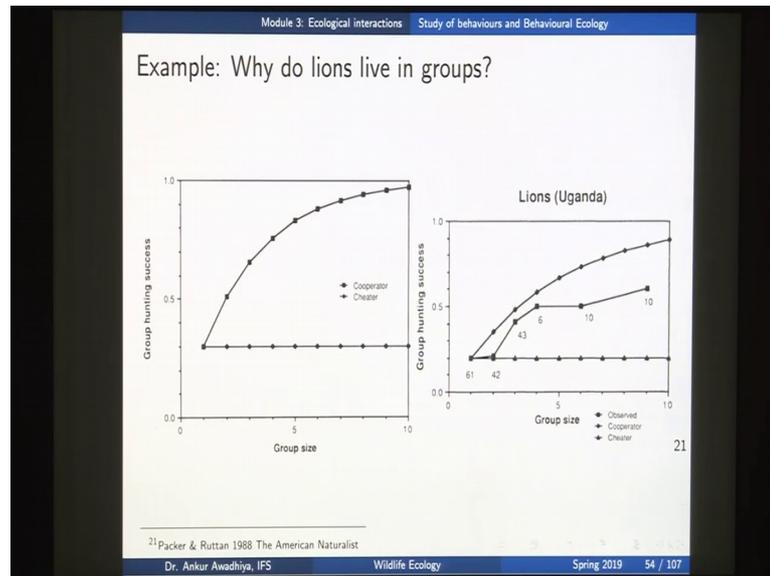
So, here we have the territory size and here we have the cost or benefit. Now in this case the cost increases like this and the benefit goes like this. Now this is the benefit; now if we are considering a territory size of this much. So, at this territory size the cost and benefit are equal. So, the profit net profit is 0 and similarly at this particular point you have the net profit is equal to 0. Now at this size of the territory we have a profit that is given by this much which is the benefit minus the cost. And at this size you have a profit that is given by this much size which is the benefit minus cost and if we take another area to the left, again the profit reduces.

So, if we say that we have these profits of  $P_1$   $P_2$   $P_3$ . So, in that case we have  $P_1$  is less than  $P_2$  and  $P_3$  is also less than  $P_2$  so,  $P_2$  is the maximum. So, in this case this territory size will be called as the most optimum size of the territory because here your benefits are much greater than the cost. Now if we consider a territory size like this. So, at this particular size we have the benefit that is given by this much. So, this is the benefit and the cost is given by this much. So, the benefit is less than the cost. So, actually your tiger will be expending much more amount of energy and is getting very little in return. So, probably it will not go for that particular size. So, by doing such an analysis we can

compute or try to understand why certain behaviours are preferred by animals and why certain behaviours are not preferred by the animals.

Now, will look at another example will look at another example.

(Refer Slide Time: 10:44)



Now this example is about why do carnivores live in groups? Now here we are considering a theoretical case in which you have lions and the x axis is showing you the group size of the lions and the y axis is showing you the group hunting success. So, essentially group hunting success means that if the group of a particular size is going for a kill.

So, it has spotted a prey animal and it is going for a kill so, what is the probability that it will that this group will be able to kill the prey and get the food? Now if there is only 1 lion in the group. So, if you have the point here. So, the group hunting success is only about 0.3 which means that only three out of 10 animals or roughly 1 out of 3 animals that is being hunted gets hunted.

Now, if you have more number of lions in the group. So, suppose you have 2 number of lions so, the hunting efficiency increases point from 0.3 to 0.5. So, in the first case you had a situation that the line was able to get food only one in three cases and the second case it gets food [rough/roughly] roughly 50 percent of the time. And as the size of the group increases and if they are able to cooperate fully, so will have a situation in which

the group hunting success will become closer and closer to 1. So, essentially if you have like 10 lions in the group and these 10 lions are cooperatively trying to hunt an animal so, there is a very good chance that they will actually be able to hunt that animal, but that only happens if the lions are cooperating fully.

Whereas, if the lions are trying to cheat or if the lions are trying to hunt by themselves and they are not cooperating. So, one lion is not cooperating with the next line; so the hunting efficiency will not increase. So, this is what our theoretical model states. Now if you look at actual field situations of the lions and if we see these lions of Uganda so, we will observe that the actual situation is somewhere in between. So, actually you have lions that cooperate for some time and they also try to cheat for some. So, this is a way in which we can understand why the lions are living in groups.

(Refer Slide Time: 13:13)

Sex	Costs of grouping	Benefits of grouping
Male	Sharing of paternity	1. Increased access to mates 2. Protection of offspring against infanticide
Female	Lower rate of food intake	1. Help from kin 2. Territorial defense

We can even detect it further by looking at the cost and benefits of group living for lions. Now we consider the cases of males and females separately, now if you are living in a group and if you are a male lion. So, there will be a sharing of paternity which means that if there is only 1 lion and or say if in the group you only have 1 male lion. So, all the cubs that are born in this particular pride will be fathered by only that particular lion, but if that lion is allowing another male lion to live inside that group so that male lion may also give rise to the progeny.

So, in that case the paternity of the cubs is being shared by both of these lions. If you have say 3 or 4 male lions that are living together so, all 4 of them will be sharing the paternity or in other words the lion in the 1 male lion that was earlier having an exclusive access to all the females. Now has to share the females between both other lions says.

So, that is a cost of grouping for the male lion the benefit of grouping for the main lion is that it has an increased access to mates. So, for instance if you had only a single lion so, it would not be able to compete with the already existing prides. So, it will not be able to make a space for itself, but then if it combines with another male lion and if they work cooperatively. So, in that case they will be able to topple the other prides and take their females. So, it also the benefit of grouping is that it increases the access to mates and also it provides a protection to the offspring against infanticide.

What is that mean? If you have a pride in which you have male lions and female lionesses and if that pride is toppled over so, essentially the male lions have been defeated by an incoming group. So, what this incoming group will do is that it will kill off all the cubs that are there in this pride, why? Because the male lions that are coming from outside they also want to mate and the females will not get into heat; if they are having cubs with them.

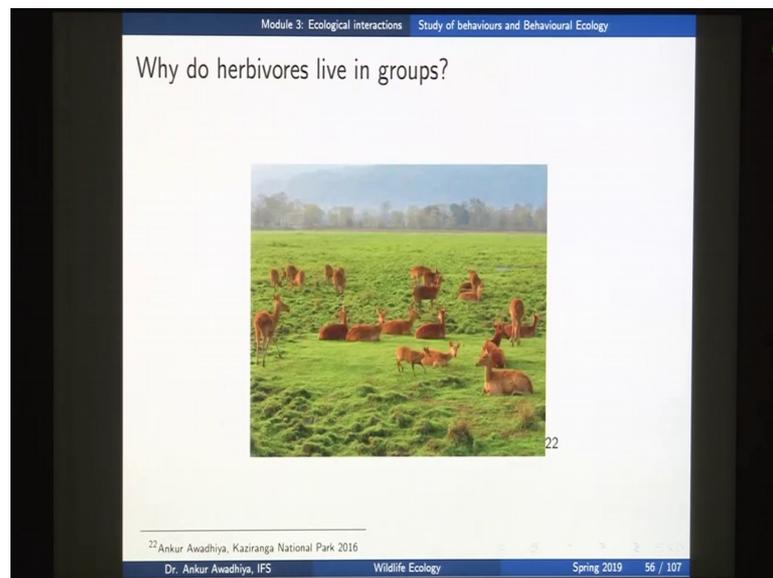
So, the incoming lions will try to kill off the of the existing offsprings to make way for their own offsprings. Now as we saw in one of the earlier lectures we always talk about fitness. Now fitness does not mean that you give rise to more number of progeny it means that you give rise to more number of progeny and more and more of them are able to survive and able to reproduce to the next generation as well.

So, if the lions are able to produce cubs, but if those cubs get eaten up or are killed by incoming lions. So, that does not make much sense evolutionarily. So, which is why we have this behaviour that the lions even though they have this cost of sharing the paternity even then they will try to remain in group they will also allow other lions to come and cooperate with themselves. So, that they have an increased access to mates and by providing a united front, it is much more plausible that the pride in which this cooperating lions are there will not be toppled and so their offsprings will have protection against infanticide.

Now that is for the main lions what is the benefit for the female lions or the lionesses, why do lionesses also live in the group? Now lionesses live in the group because so again here we have the cost and benefits the cost of living in the group is a lower rate of food intake because the larger the size of the group, the more the lesser the amount of food that you will have from every hunt whereas, it also has some benefits there is help from the kin and there is territorial defense.

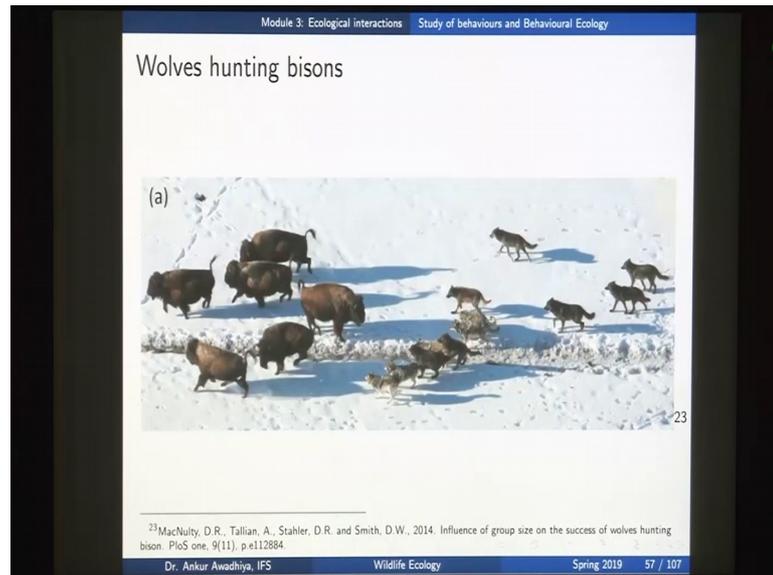
So, in protection of their cubs and in performing the grooming of the cubs they also get help from their siblings. And then it also helps in territorial defense because you have more number of lions and lionesses that are defending the same amount of territory. Now as we saw before, there is a cost there is a benefit both for males and females. So, the males and the females will normally go for the cost benefit approach and wherever the benefit minus the cost is the greatest that would be the optimal number of males and the optimum number of females that will come together to form the group.

(Refer Slide Time: 18:05)



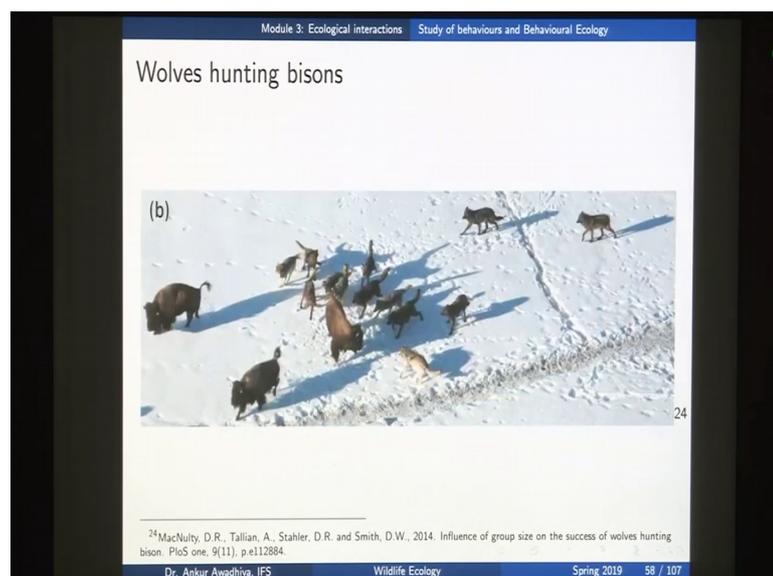
Now, similarly herbivores also live in groups again, why?

(Refer Slide Time: 18:09)



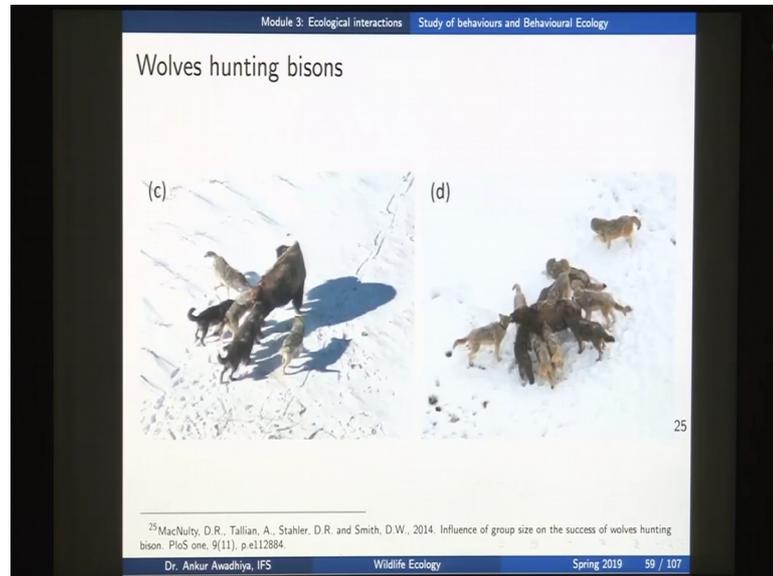
Because like this is a paper that demonstrated that when you have bison that are living together and there is this pack of wolves. Now if again if you have a big sized pack of wolves so, they will be able to hunt much more efficiently if there if they are able to cooperate with each other. Now similarly if the bison are there in the group in that case the wolves will find it extremely difficult to hunt the bison because they will put up a united front for defense.

(Refer Slide Time: 18:38)



But, if the bison becomes solitary if one of the bison lags behind, then that case that particular bison will be attacked by the wolves from all sides and then it will get eaten up.

(Refer Slide Time: 18:51)



(Refer Slide Time: 18:53)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

Potential benefits and costs of group living animals

Potential benefits	Potential costs
Increased foraging efficiency	1. Competition for food 2. Increased risk of diseases or parasites
Reduced predation	Attraction of predators
Increased access to mates	1. Loss of paternity 2. Brood parasitism
Help from kin	Loss of individual reproduction

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 60 / 107

So, we can see that in the case of group living animals if you look at the cost and benefits the benefits are increased foraging efficiency. So, essentially if you are hunting together, if you are living together, if you are hunting together so, there is a greater chance that you will be able to hunt somebody. So, in the case of these wolves they were able to hunt

because they are of a larger size. If there was a single wolf probably, it would not be able to hunt the bison. On the other hand, the cost is that there is competition for food and there is an increased risk of diseases or parasites.

Now because this bison was hunted by so many wolves so, all these wolves will have to share the flesh. So, in that case that is a cost that is associated with the group living and at the same time because they are living together. If one of these wolves gets sick so that will also spread diseases to the other wolves. So, by living together there is a greater propensity that you become prey to diseases.

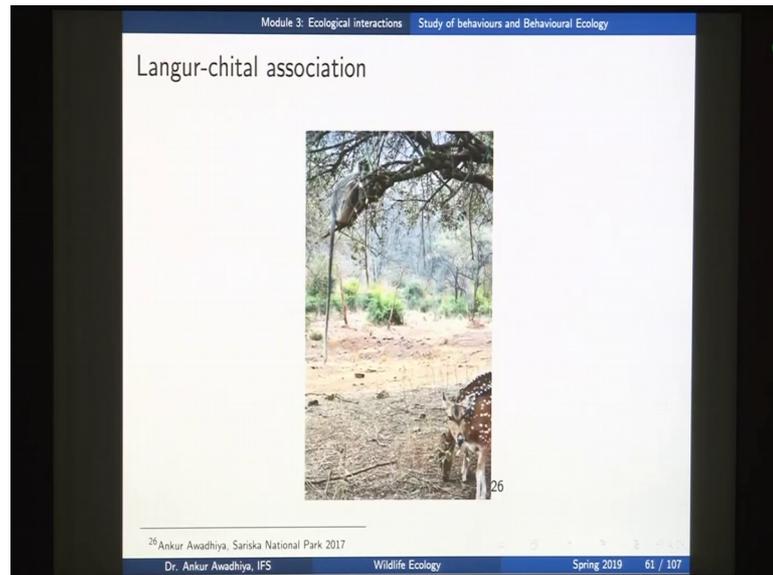
Now, the other potential benefit is that of reduced predation whereas, at the cost as the attraction of predators. What do we mean by this? If you are living together so, for instance; if this bison was not a part of this group, but was living alone. So, in that case this bison would normally have been hunted long back, but because you have all of these bison that are putting together a united front so, only one of them will get hunted and the others will be able to survive.

So, that is a benefit the cost is that if you have a larger sized group. So, more number of predators might get attracted to hunt this particular group. So, again you have cost and benefits. Other potential benefits are increased access to mates whereas, the potential cost are loss of paternity and brood parasitism. Now what does that mean? If you are living together in a big group so, the animal has got a greater access to the mates because you have more number of males and females that are living together; so, it is much more likely that you have an access to a mate.

The potential cost is loss of paternity as we saw before because the mates are not exclusively available to any particular organism and also there is a chance of brood parasitism in which you can have a situation where an outsider can come into your group mate with the females and then move out.

Similarly, you have the potential benefit of help from the kin if you are trying to raise your kids and the potential cost is loss of individual reproduction.

(Refer Slide Time: 21:49)



Now by looking at different cost and benefit analysis, we can also understand various ecological behaviours like this community interactions that we saw before. You have this langur, here, you have the chitals here and they are interacting because the chitals are getting access to the leaves and the fruits from these trees. When the langur is dropping them the chital is also having an a benefit of having these eyes that are the eyes of the langurs that are on top of the tree and are able to see the predators.

On the other hand, the langurs are also getting some amount of benefit from the chitals because the chitals are able to sense the predators from a lower height So, these cost and benefit analysis can help us understand different community interactions in ecology.

(Refer Slide Time: 22:37)

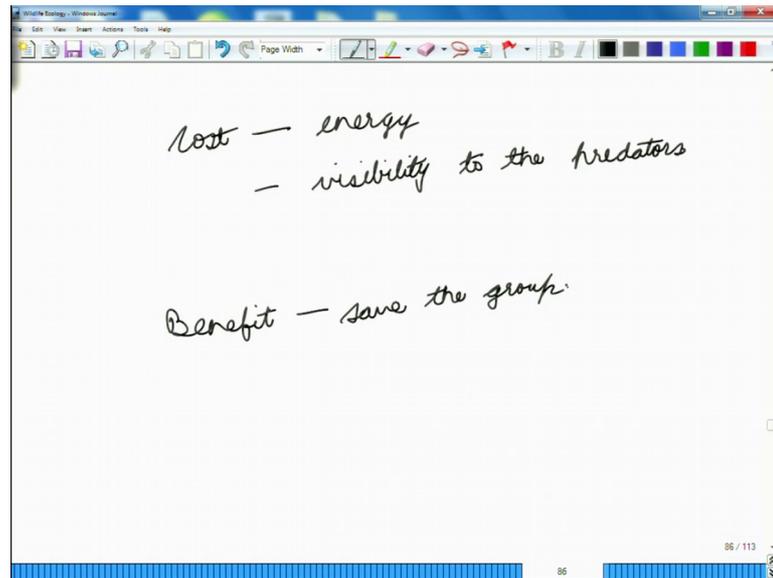


Now, another example is if you are living in a group, then there is a chance that you will find a predator nearby and you have to make a decision whether or not you should give out an alarm call.

Now what is an alarm call? Now this is a ground wailing squirrel. So, this is a species of squirrels that lives on the ground, it lives as part of a group and whenever it sees a predator it gives out this alarm call. Now if you give out an alarm call, you are alerting everybody in the group that there is a predator nearby, but then the predator will also hear you alarm call. So, in that case you are making yourself much more visible to the predator. So, there is a chance that the predator in place of hunting anybody else will go after you because you have made your position extremely clear to the predator by giving out this alarm call

So, again you have the cost and benefits of giving out an alarm call.

(Refer Slide Time: 23:57)

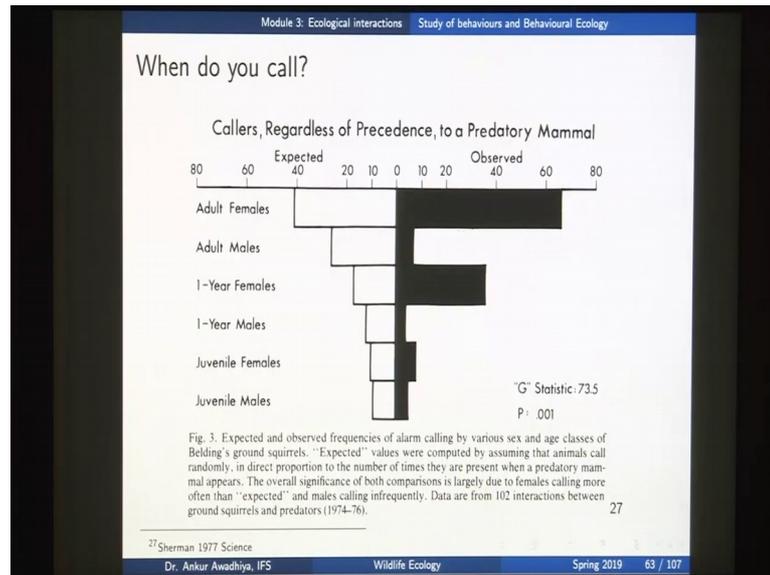


You have the cost and you have to benefit. The cost is that you are using up your energy to make the alarm call and the other cost is that you are making yourself visible to the predators. The benefit is that you are able to save the group. So, is this behaviour now the question here is the cost is something that you are entailing to yourself. So, you can get killed if you make the alarm call. The benefit is something that you are making to the group because you are saving not yourself, but the other organisms that are there in the group.

So, here we are looking at one question of population dynamics. So, we have this population of ground squirrels and every squirrel has to make this decision whether or not to give an alarm call. If there is an alarm call, it is putting itself a risk it is using of its own energy and the benefits are not coming to itself, but are coming to the other members that are there in the group.

So, in the first instance it might look like any squirrel that is giving out an alarm call is sacrificing itself for the group. So, is it a case of altruism or are we observing some other points that are working here or are at play here to give up this behaviours.

(Refer Slide Time: 25:31)



So, this phenomena was studied. So, scientists tried to understand when do you make a call. So, here we have a graph of the callers regardless of residence to a predatory mammal.

So, here we see that if you have these adult females and here we have an expected rate of calling and here we have the observed rate of calling. Now expected rate of calling is given by computing; so, expected values are computed by assuming that animals call randomly in direct proportion to the number of times they are present when a predatory mammal appears. So, essentially if you have more number of females or if you have situations in which the females were there when there was this predatory animal that had come there. So, we put a random chance that every animal is going to make a call every n number of times.

So, from that we get this expected rate of calling and here you observe the observed rate of calling. This is what actually happens in the ground. Now you can see here that the females were expected to call say 41 percent of time, but they actually called around 65 percent of time. So, they are the calling was much greater than what we had expected.

In the case of adult males we had expected them to call around 25 percent of times, but they actually called just around 8 percent of time. Now in the case of 1 year females we had expected them to call say around 15 percent of times, but they also called somewhere around 38 percent of times. So, in the case of 1 year females as well as in the

case of the adult females, we observe that they are observed rates of calling are much greater than the expected rates of calling.

Now, in the case of 1 year males we had expected them to call around 10 percent of time and they actually call say around 5 percent of 9. So, here also the observed rate was much less than what was expected. And in the case of juveniles it was very much less than what was expected.

(Refer Slide Time: 27:51)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

### Concept of kin selection

**Kin selection**  
The evolution of traits that increase the survival, and ultimately the reproductive success, of one's relatives.

**Group selection**  
Natural selection for traits that favour groups rather than individuals. Because group selection operates much more slowly than individual selection, it is a much weaker selective force in most circumstances.

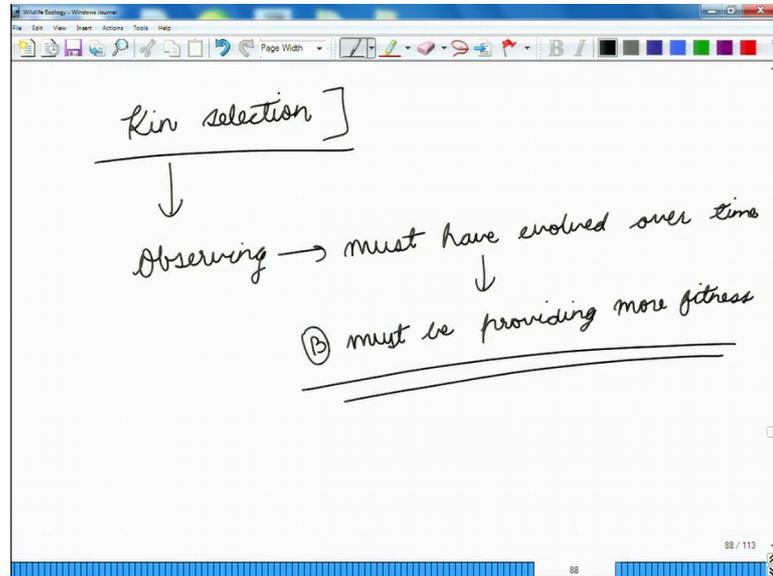
Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 65 / 107

Now the question is so why do females call more than expected and why do males called less than expected? So, what is there that is making the females put themselves more at risk to alert their group. So, this question brings us to the concept of kin selection. In the case of these ground dwelling squirrels it is observed that the females in generally live together and the males after they have reached some stage of maturity they move out.

So, essentially if a female is calling up is giving out this alarm call it is alerting most of its own relatives whereas, the male does not have much to lose in terms of genes if one of the members or more of the members of the group gets killed. Because the male wants to protect its own genes because it is in any case going to move somewhere else. So, the male puts much more price on saving itself than saving the group whereas, the female puts a much greater price on saving the group than on saving itself because it has more number of genes that are common with that of the group. So, here we have the concept of

kin selection and kin selection see is the evolution of traits that increase the survival and ultimately the reproductive success of ones relatives.

(Refer Slide Time: 29:18)



Now, in the case of kin selection if we are observing this behaviour that you have organisms that are trying to that are even willing to sacrifice themselves to save somebody else from their own kin that is which are relatives. If this behaviour is being observed, it means that this behaviour must have evolved over time.

Now if there is a behaviour that has evolved over time, then this behaviour must be providing more fitness. Because if you have a situation in which there is a behaviour that gives you more amount of fitness only then that behaviour will be selected through the process of natural selection and only then such a behaviour will be evolved and which is why we are observing this behavior. Now the question is how is it possible that by sacrificing yourself you are getting a fitness and by you; I mean not just you, but your genes how are your genes getting to a situation that they are more fit to survival if they are sacrificing.

Now, here we also have another corollary which is known as group selection. Natural selection for traits that favor groups rather than individuals because group selection operates much more slowly than the individual selection so, it is a much weaker selective force in most circumstances. Now in this case what we are seeing that when we have the kin selection, we are also observing the group selection kin selection is only working.

When you are working in a large size group and in this group your own fitness is not that important as is the fitness of the whole of the group. Now why is that so?

(Refer Slide Time: 31:18)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

### Hamilton's rule

Genes increase in frequency when

$$rB > C$$

where

- $r$  = the genetic relatedness of the recipient to the actor, often defined as the probability that a gene picked randomly from each at the same locus is identical by descent.
- $B$  = the additional reproductive benefit gained by the recipient of the altruistic act,
- $C$  = the reproductive cost to the individual performing the act.

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 66 / 107

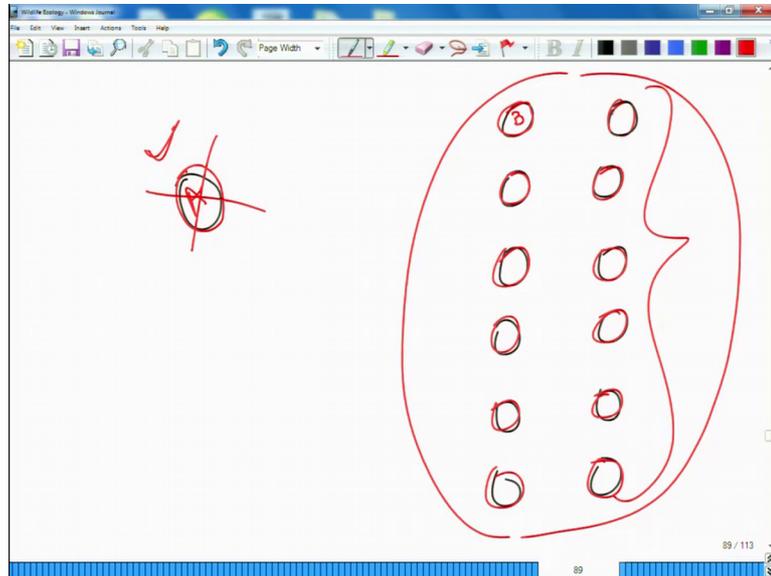
So, Hamilton gave us this rule which says that genes increase in frequency when we have this formula it works. So, we have  $r$  into  $B$  is greater than  $C$  where  $r$  is the genetic relatedness of the recipient to the actor; often defined as the probability that a gene picked randomly from each at the same locus is identical by descent. So,  $r$  is the genetic relatedness between the recipient and the actor. In this case the actor is the ground squirrel that is giving out the alarm call and the recipients are the other members of the group. Now capital  $B$  is a additional reproductive benefit that is gained by the recipient of the altruistic act.

Now, reproductive benefit that is gained by the recipient by this we mean that when the ground squirrel made out the alarm call the other members of the group, they were saved and they were able to reproduce and their progeny were was able to survive. So, that is the additional reproductive benefit that it got because there was one squirrel that sacrificed itself.

If that squirrel had not sacrificed itself or had not given out the alarm call which increases the chances of it getting sacrificed so in that case more and more members of the group would have been killed and so their progeny would also be less. And  $C$  is the

reproductive cost to the individual performing the act which is the reproductive cost of the squirrel that gave out the alarm call.

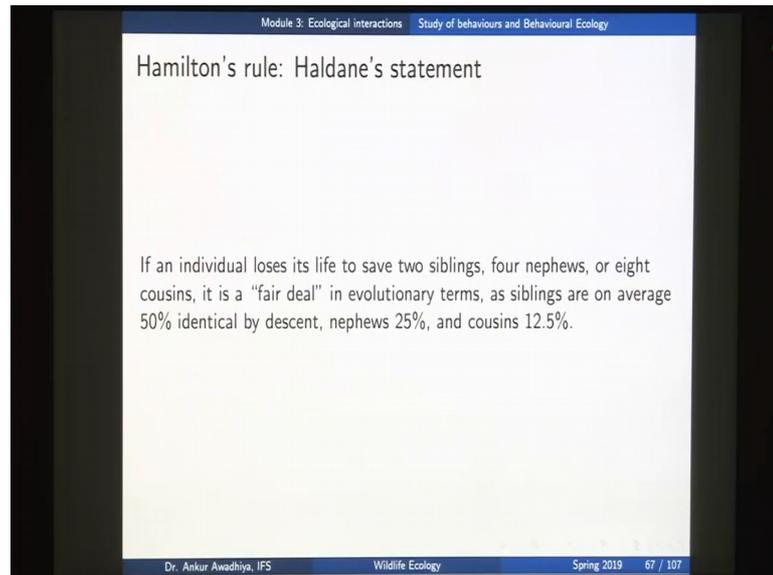
(Refer Slide Time: 32:58)



So, basically what we are saying here is that if you have an individual and this individual has a number of other relatives. Now, if you have to make a choice whether you should kill yourself or whether you should have the whole of this group killed; so how do you make that choice? It will depend on one how much are you related to the big group. So, for instance if the level of relatedness is very less. So, basically this individual is related to this individual and all the other members are not related to the actor individual or A.

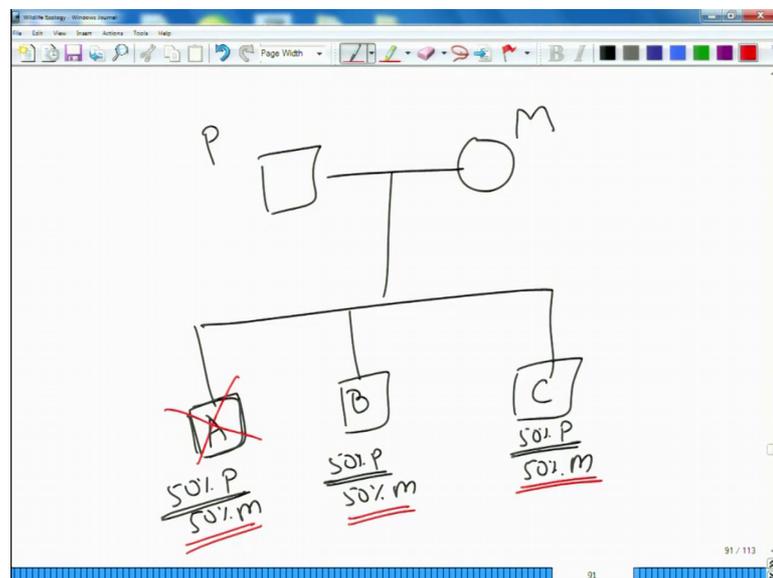
So, the other members are not related to A only B is related to A. So, in that case because A and B have different have different genes. So, A would try to protect itself even at the cost of the whole of the group because it does not have much to lose if the group dies off. On the other hand if A has a relative here, here, here so, if all of these are related to A. So, in that case if a sacrifices itself and is able to save so many members of the group. So, more and more of the genes that were present in a are getting or survival because the group gets the survival or to put it in the words of Haldane. So, Halden give up this statement.

(Refer Slide Time: 34:35)



If an individual loses, its life to save two siblings. Now you have a situation.

(Refer Slide Time: 34:41)

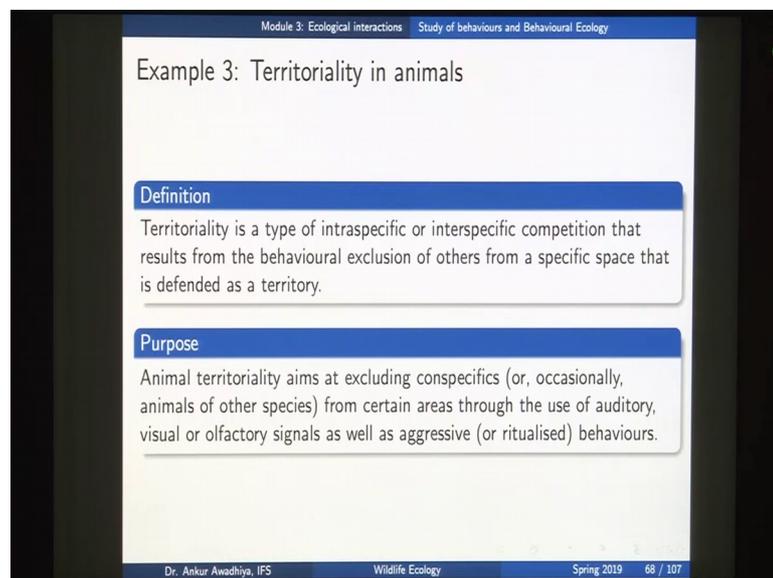


You have a mom and a dad and then you have say 3 siblings. Now these are the paternal chromosomes. So, if this is paternal this is maternal, now this individual has 50 percent genes from P and 50 percent genes from M and similarly this individual has 50 percent from P 50 percent from M and similarly this individual has 50 percent from P and 50 percent from M.

Now, if this individual if individual A sacrifices itself to save B and C together. So, in that case by losing 50 percent of genes of P, it is saving more than 50 percent genes of P. So, by losing 50 percent of genes of P by sacrificing itself, it is able to save more than 50 percent of genes of P and by losing these 50 percent of genes of M it is able to save more than 50 percent genes of M.

So, essentially in genetic terms it is a benefit. So, if an individual loses its life to save 2 siblings or 4 nephews or 8 cousins it is termed to be a fair deal in evolutionary terms as siblings are on average 50 percent identical by descent nephews are 25 percent identical by descent and cousins are 12.5 percent identical by descent.

(Refer Slide Time: 36:20)



The slide is titled "Example 3: Territoriality in animals" and is part of a presentation on "Module 3: Ecological interactions" and "Study of behaviours and Behavioural Ecology". It contains two main sections: "Definition" and "Purpose".

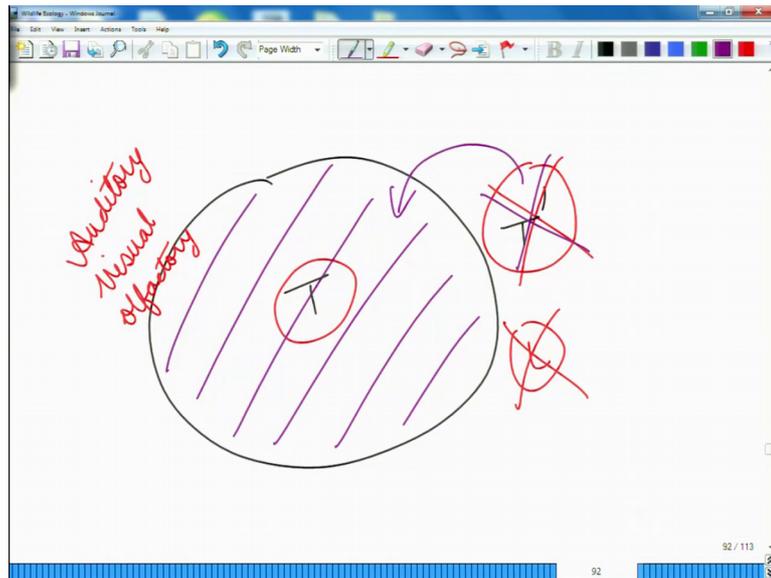
**Definition**  
Territoriality is a type of intraspecific or interspecific competition that results from the behavioural exclusion of others from a specific space that is defended as a territory.

**Purpose**  
Animal territoriality aims at excluding conspecifics (or, occasionally, animals of other species) from certain areas through the use of auditory, visual or olfactory signals as well as aggressive (or ritualised) behaviours.

At the bottom of the slide, the text reads: "Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 68 / 107".

Now, another example of how behaviour plays a role in ecology is the case of territoriality. Now territoriality is a type of intraspecific or interspecific competition. So, intraspecific is within the same species, interspecific is between two or more species that results from the behavioural exclusion of others from a specific space that is defended as a territory. So, what do we mean by that?

(Refer Slide Time: 36:52)



If you have this much space and there is a tiger that is defending this area. So, it will not allow any other tiger to come to this area. So, this is a territorial behavior. Now the purpose is animal territoriality aims at excluding conspecifics. So, conspecifics are individuals of the same species; so, like another tiger. So, animal territoriality is aims at excluding conspecifics.

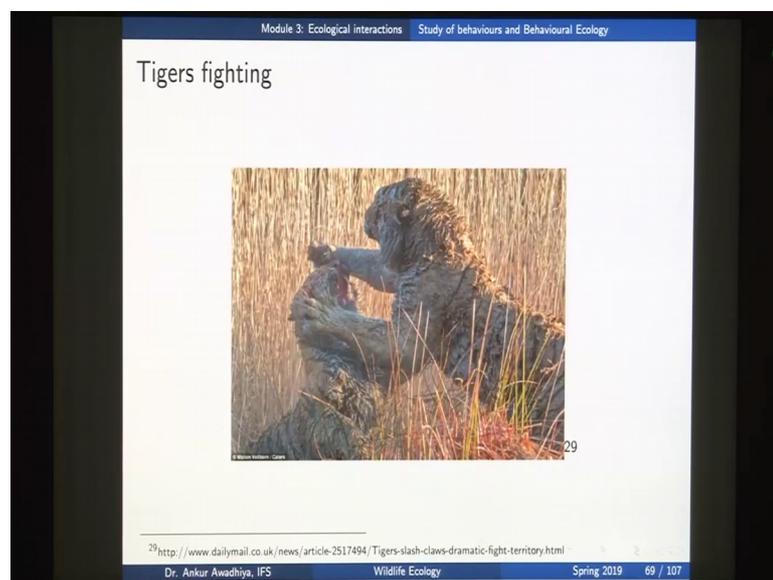
So, if you have this tiger here, it will not allow this tiger to come into this territory. So, it is excluding another member of the same species or occasionally animals of other species. So, for instance if this tiger is not allowing a leopard to get into this territory, then it is then we will say that it is excluding an animal of another species from certain areas through the use of auditory visual or all factory signals as well as aggressive or ritualized behaviours.

So, what would this tiger do to exclude others? It would give out some amount of auditory signals. So, essentially it will start growling for instance or it will give out some or some sort of visual signals by say scratching on different trees so that it makes a mark. So, if there is a bark of a tree this tiger will go and scratch on the bark. So, that it makes it known to everybody that I am here. So, this is my calling card or it might say scratch on the ground or it might give out some olfactory signals olfactory signals means that this tiger will go close to a tree and then it will give out us a spray of urine on that particular tree.

So, that it is giving out its smell that this is my area. So, by doing all of these different behaviours, it is excluding others from its own territory and this might also involve aggressive behaviour say aggressive behaviour is when one tiger attacks another.

So, here we are looking at one problem of population ecology. So, population ecology will try to understand how these individuals in a population are members of the same species that are living together, how are they interacting with each other. So, territoriality is one way and which they are interacting. So, what source of behaviours do we see?

(Refer Slide Time: 39:20)



Well we can find tigers that are hunting which are not hunting, but actually attacking each other.

(Refer Slide Time: 39:28)



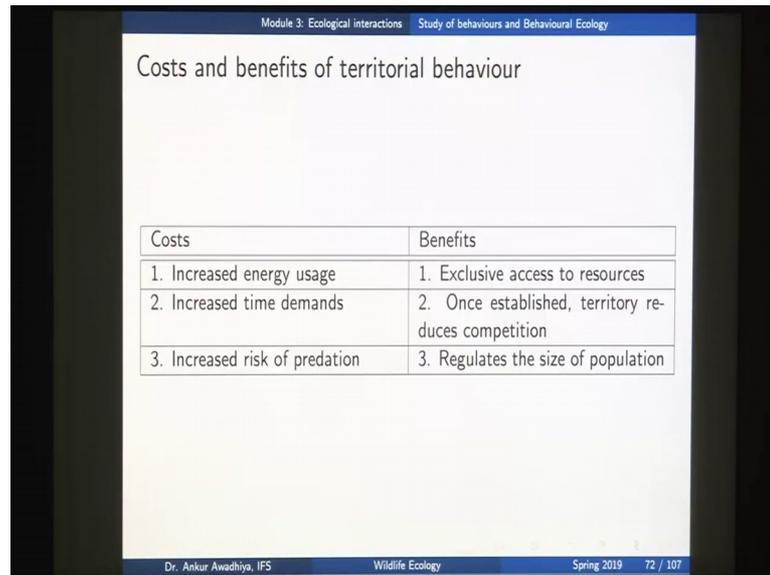
We have seen this example of penguins that were showing out this ritualized behaviour. So, they pegged it another and also they gave out this.

(Refer Slide Time: 39:37)



Sound or we saw these black bucks that were also showing this aggressive behaviour. So, in this case also they are excluding others from their own areas.

(Refer Slide Time: 39:46)



Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

### Costs and benefits of territorial behaviour

Costs	Benefits
1. Increased energy usage	1. Exclusive access to resources
2. Increased time demands	2. Once established, territory reduces competition
3. Increased risk of predation	3. Regulates the size of population

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 72 / 107

Now, if we have territoriality why do we have territoriality is the question, why did this territorial behaviour evolve, what are the costs and benefits of having this territorial behavior? Now the cost is increased energy usage because if you have to defend a territory, you will have to go around, we will have to make multiple rounds, you will have to patrol that territory which requires energy.

If you have to show a ritualized behaviour or aggression that also requires energy that also requires time. So, increased time demands and also in an increased risk of predation, why? Because when you are targeting or when you are using all of your time and energy against a member of your own species so, it is much more likely or very easy for a predator to hunt you.

So for instance if there is an animal that is engaged in a ritualized behavior if you have a sambar that is doing a preaching behavior; now what is a preaching behavior? A sambar will go to a very tall tree or a tree that is situated at a height and there this sambar will stand up on two of its legs and then it will give out some visual displays or it will give out some olfactory signals at that particular location. So, that so that it is known to everybody that this is the biggest size sambar in this area.

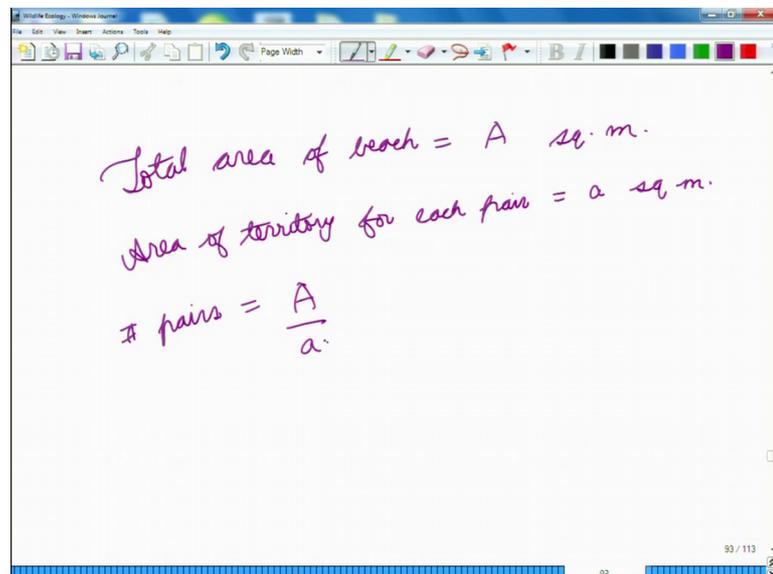
Now, when a sambar is doing this when it is engaged in this particular behavior, a tiger might very easily come and hand this tiger this sambar because the because the sambar is not putting any attention on the tigers; it is only putting its attention to the other members

of its own species. So, this also increases a risk of predation, but even with all of these costs we see territorial behaviour because it provides certain benefits. If you have a territory you have an exclusive access to resources.

So, you if a tiger has defended this territory so all the animals that are inside this territory are now food for this particular tiger. It does not have to share these animals or these prey species with the other tigers. If there are any tigresses in this territory, it does not have to share it its mates with the other tigers. So, it provides an exclusive access to resources and once it has been established territory reduces competition, why? Because in the earliest situation if you are allowing this tiger to enter into this area. So, both of these animals would have been using the same area.

So, there would have been much greater competition, but once you have defended this territory once you have excluded this tiger outside. So, then the amount of competition is much less and one more benefit is that it regulates the size of the population because for instance here we observed that you have these penguins and each of these is maintaining a territory and each of these will require this territory and will not permit anybody else or any other penguin to enter into its own territory.

(Refer Slide Time: 43:06)



The image shows a whiteboard with handwritten text in purple ink. The text is as follows:

$$\begin{aligned} \text{Total area of beach} &= A \text{ sq. m.} \\ \text{Area of territory for each pair} &= a \text{ sq. m.} \\ \# \text{ pairs} &= \frac{A}{a} \end{aligned}$$

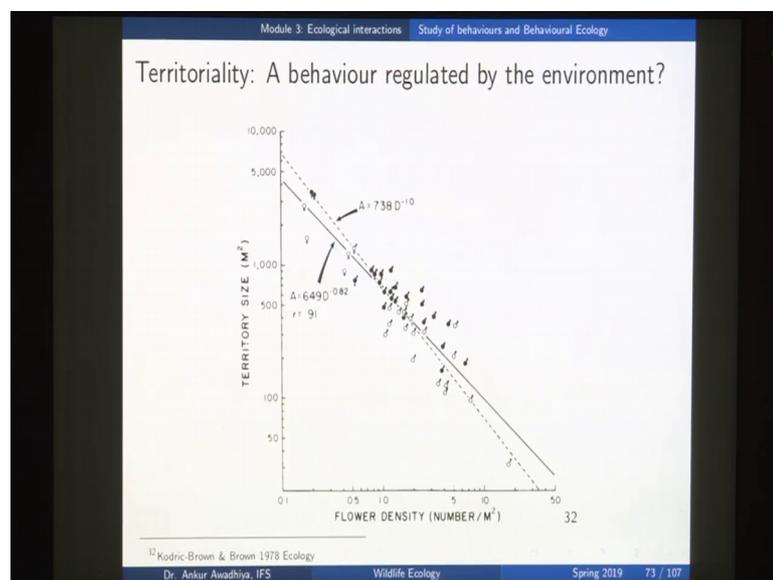
The whiteboard also shows a software interface at the top with a menu bar (File, Edit, View, Draw, Actions, Tools, Help) and a toolbar with various drawing tools. At the bottom right, there is a page number '93 / 113'.

So, for instance if the total area of beach is say A square meters and area of territory for each pair is a square meters. So, then the number of pairs that can be found in this beach will be given by capital A divided by small a. And if the number of pairs so, the number

of penguin pairs; if it is greater than this value of capital A divided by small a so, in that case they will not find any space for breeding. So, they will not find any amount of sand nearby to have their own nest.

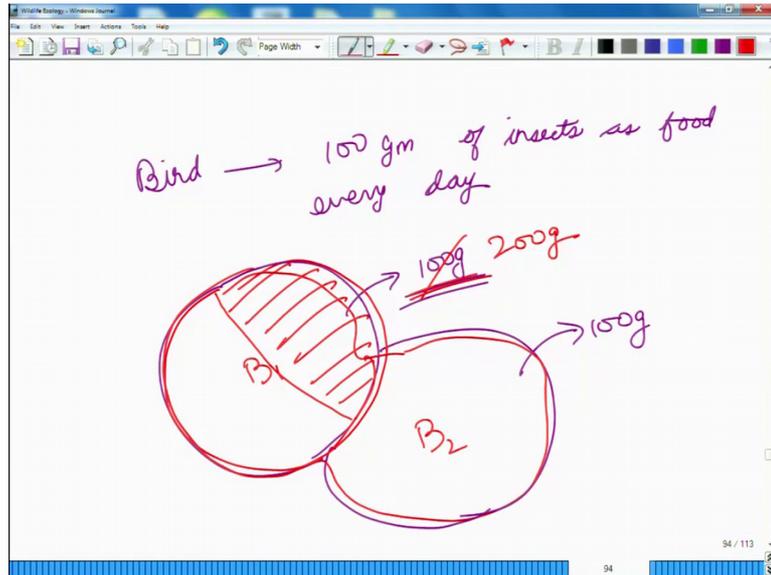
So, it automatically this behaviour of territoriality it automatically puts a check on the size of the population. So, this is also another benefit that we get from the territorial behaviour. So, this is why we see territorial behaviours even though we have so many costs that are involved with having a territory.

(Refer Slide Time: 44:21)



And this territorial behaviour is also regulated by the environment because an animal wants to have a territory. So, the benefits that an animal is getting out of a territory is that it gets an exclusive access to the resources.

(Refer Slide Time: 44:41)



Now, for instance there is a bird and this bird say it requires 100 grams of insects as food every day. Now this bird is not going to defend a territory that can provide it with say 200 grams of insects every day. Because if it has this much amount of territory and this much amount of territory gives it 100 grams of insects every day and if it wanted a larger territory say this much excess territory.

So, this state you also gives it more amount of insects ability, but it only requires this much. So, in that case why should it use its energy to defend a much greater area than is required right. So, in that case it will not defend this area and it will allow some other bird to take this area as a second territory. So, this is bird 1 and it will allow a second bird to take this area as its own territory. So, you will have these two territories.

Now what happens if we increase the number of insects that are available to this bird in this area itself? So, in place of this area providing it with 100 grams of insects suppose we added more number of insects into this territory so, that this area in place of providing 100 grams starts providing 200 grams of insects. In that case would this bird reduce its area? So, it turns out that if you do that the bird will reduce its area by half. So, the amount of insects that is being provided in this particular patch of land is an environmental phenomenon.

So, it is something that is being regulated by the environment. So, for instance if you have more amount of winds that bring in more insect into this territory so, this territory will have more number of insects. Or for instance if there is a bloom of flowers and

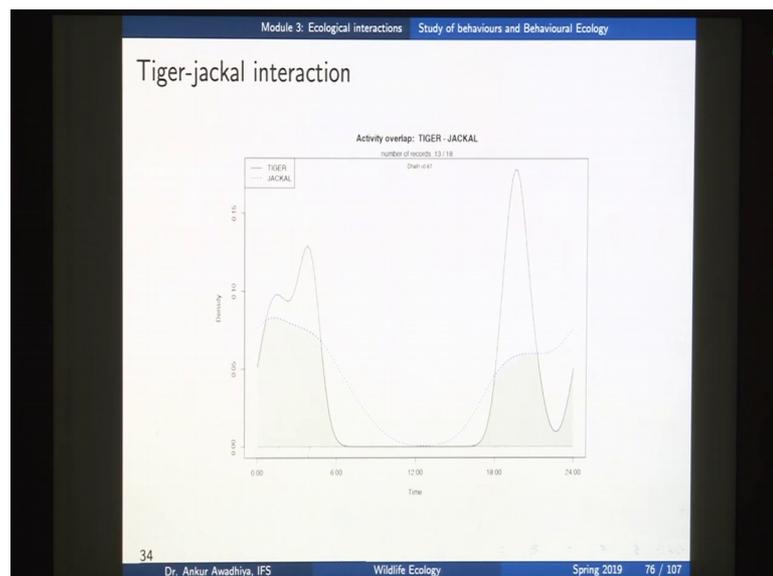
so, insects are having more flowers to feed on so, the number of insects would grow up. So, that is an environmental phenomenon and that is regulating a behaviour which is territoriality the size of the territory.

So, in this study what was done is here we have flower density. So, flower density was increased experimentally and here we have the size of the territory. And as we can see if you have a less flower density, you go for a larger size territory. If you have more number of flowers so, you have more amount of food you go for a lesser size of a territory. So, we can say that there are a number of behaviours that get regulated by the environment and territorialities.

So, in a sense the study of behaviours or behavioural ecology provides us answers or provides us explanations to a number of phenomena that we observe in nature, be it population interactions, be it community interactions or ecosystem interactions and so on. And so, study of behaviours or behavioural ecology is an extremely integral part of the study of ecology.

Now, that the next question is how do we study the behaviours. So, there are a number of methods through which we study behaviours; one behaviour is to design information from the activity patterns.

(Refer Slide Time: 48:16)



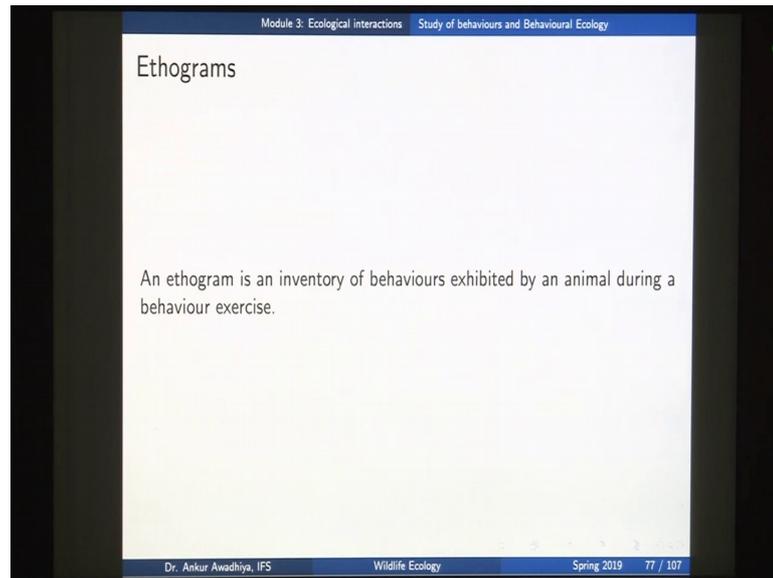
So, this is one example. So, in this case, we have plotted time on the x axis. So, it goes from 12 O clock in the midnight which is 0000 and then till 24 0 0. So, this is 6 0 clock in the morning, this is 12'O clock in the afternoon, this is 6'O clock in the evening and on the y axis we have density of animals and we have plotted this black line shows the tiger density and the this dashed line shows the chital density or the chital activity that is seen at that particular point of time.

Now here we observe that both of these curves do not match each other. So, the amount of concordance between both of these or the amount of overlap between both of these is just about 24 percent. Now why is that? So, now, if we see this is the time where chitals are most active. So, they are most active during early day and during late in the evening, they rest for some time in the afternoon, but they are active at these two points.

Now, why are they active most during these two points? Well because the tigers are not that much active at that particular time the tigers are more active during the night time. So, between 12'O clock in the midnight and 6'O clock in the morning the tigers are more active and from 6'O clock in the evening to 12'O clock in the midnight, they are more active. So, in that case that the chitals are trying to avoid their predators; so, this is a behaviour of avoidance, but at the same time there has to be some amount of overlap between both of these, why? Because the tiger wants to have some amount of overlap because if there is absolutely no overlap so, in that case it will not be able to prey upon or predate upon the chitals.

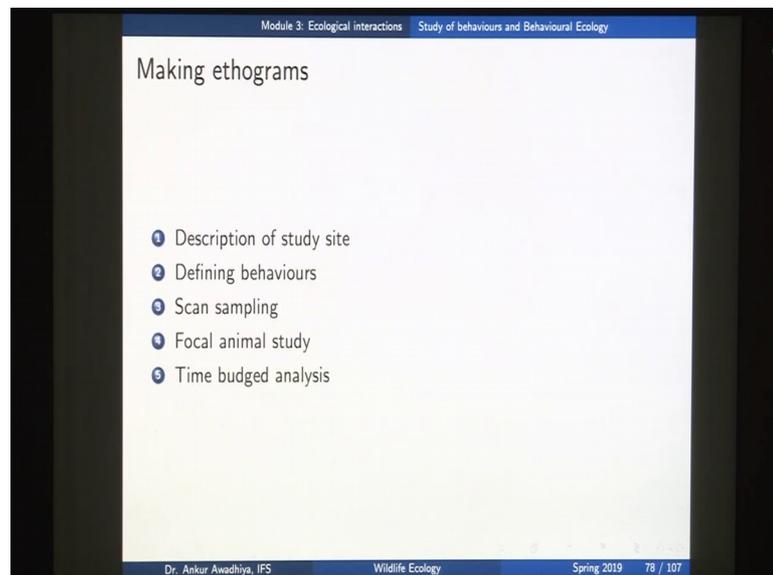
Now on the other hand if we look at the overlaps between two carnivores. So, tiger and jackal will observe that there is a much greater overlap between both of these. So, here again the black line is the tiger and the dashed blue line is the jackal and here we observe that the amount of overlap is as greater its 67 percent. So, this is one example through which we can discern different behaviours and why they are happening by looking at the activity patterns.

(Refer Slide Time: 50:41)



The second way is by making of ethograms. Now an ethogram is an inventory of behaviours that is exhibited by an animal during a behaviour exercise. So, how do we make an ethogram? So, it tells an inventory of behaviour. So, we are observing the animals and we are making an inventory of what this animal is doing.

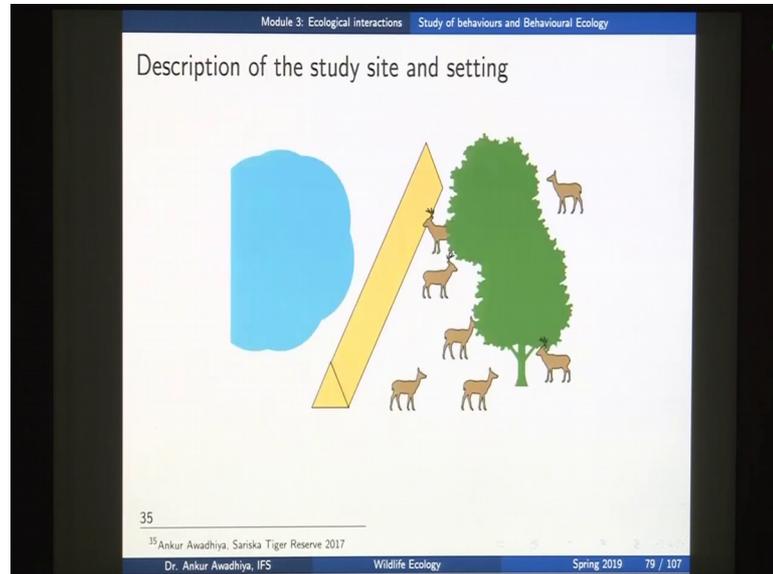
(Refer Slide Time: 51:01)



So, we begin by a description of the study site define the behaviours. So, we need to exactly define what do we mean by walking, what do we mean by standing and so on.

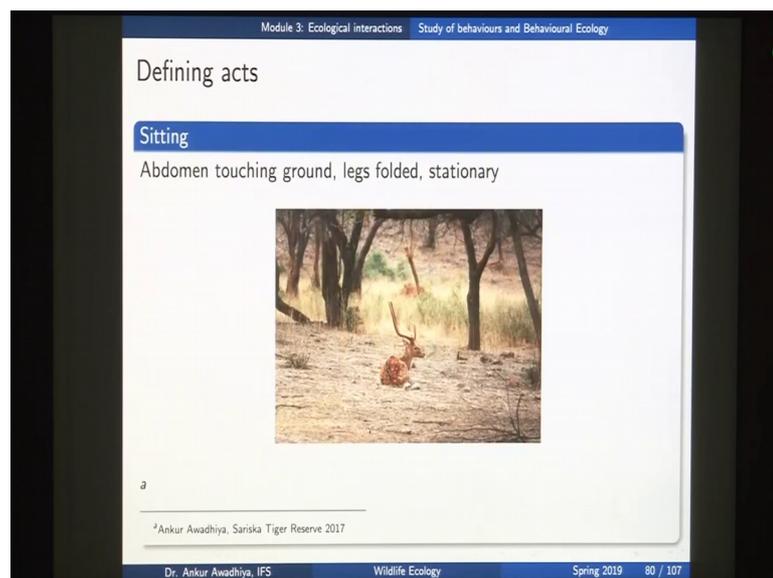
And then we do a scan sampling and a focal animal study and then we go for time budget analysis.

(Refer Slide Time: 51:16)



So, for instance this is when exercise that we did in (Refer Time: 51:20). So, there was a water body, there was this elevated road and on this side we had some chitals and there were some trees here.

(Refer Slide Time: 51:32)



So, this is the description of the study site and then we define different acts like sitting as abdomen touching, the ground legs folded and stationary.

(Refer Slide Time: 51:38)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

## Defining acts

### Standing

All hooves touching ground, legs straight, animal stationary, a sub-dominant interval during walking or feeding



a

<sup>a</sup>Ankur Awadhya, Sariska Tiger Reserve 2017

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 81 / 107

Standing is all whose stretching the ground leg straight animal stationary and this is a sub dominant interval during walking or feeding and so on. So, we define sitting, standing, walking, looking.

(Refer Slide Time: 51:48)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

## Defining acts

### Walking

Animal moving at slow pace with at least one hoof touching ground at all times



a

<sup>a</sup>Ankur Awadhya, Sariska Tiger Reserve 2017

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 82 / 107

(Refer Slide Time: 51:49)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

## Defining acts

### Looking

Animal stationary, ears raised in alert position, actively looking around



a

<sup>a</sup>Ankur Awadhya, Sariska Tiger Reserve 2017

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 83 / 107

(Refer Slide Time: 51:50)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

## Defining acts

### Feeding

Mouth towards ground, eating grass



a

<sup>a</sup>Ankur Awadhya, Sariska Tiger Reserve 2017

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 84 / 107

Feeding.

(Refer Slide Time: 51:51)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

### Defining acts

#### Running

Animal moving at fast pace with at least some times where all hooves are above ground



a

<sup>a</sup>Ankur Awadhya, Sariska Tiger Reserve 2017

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 85 / 107

Running.

(Refer Slide Time: 51:52)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

### Defining acts

#### Auto-grooming

Scratching or licking some part of own body



a

<sup>a</sup>Ankur Awadhya, Sariska Tiger Reserve 2017

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 86 / 107

Auto grooming auto grooming is when an animal is cleaning itself or scratching or licking some part of it its own body.

(Refer Slide Time: 51:58)

Module 3: Ecological Interactions Study of behaviours and Behavioural Ecology

## Defining acts

### Allo-grooming

Scratching or licking some part of other's body



a

<sup>a</sup> Ankur Awadhya, Sariska Tiger Reserve 2017

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 87 / 107

Allo grooming is when the animal is cleaning or scratching or licking some part of somebody else's body. So, we have defined all of these acts once we have defined these behaviours, we next want to know what each and every animal is doing during the period of our analysis.

(Refer Slide Time: 52:13)

Module 3: Ecological Interactions Study of behaviours and Behavioural Ecology

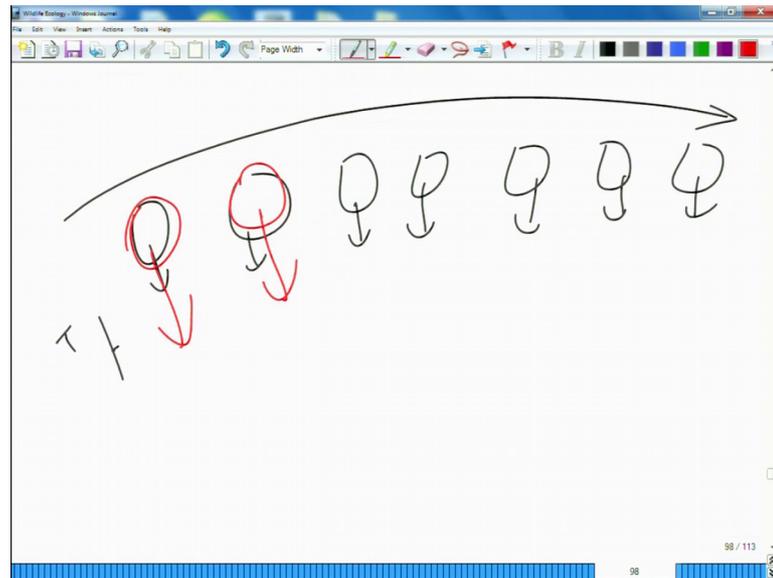
## Scan sampling

In the scan sampling method, we noted the beginning time of observation, and then scanned the complete group, noting the activities that different individuals were displaying.

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 88 / 107

So, for that we go for two kinds of studies: one goes by the name of scan sampling and the second is the focal animal sampling. Now in the case of scan sampling if we have n number of individuals.

(Refer Slide Time: 52:26)



So, we start with the first individual and we make a note of the time and what this animal is doing, then next what this animal is doing, next what this is doing and so on till we go to the last animal. So, in this way we are performing a scan of their behaviours from one end to the next end and then will repeat these behaviours to get a table something like this.

(Refer Slide Time: 52:49)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

### Scan sampling

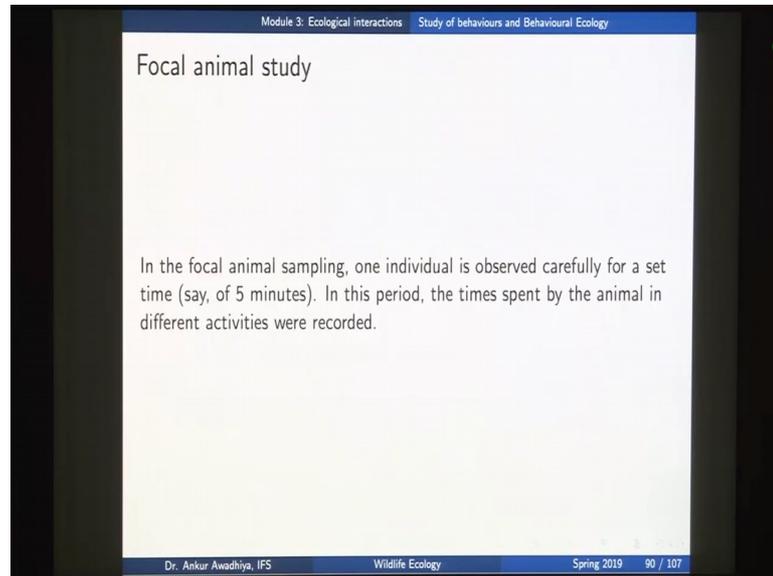
Obs: Ankur Awadhya		Date: 06/12/2017		Weather: Cloudy			
TR: Sariska		Range: Sariska		Beat: Karmikavas			
Location: Water hole		Start: 15:14 hours		End: 15:47 hours			
Species: Chital		Terrain: Flat					
Time in	Adult Male	Adult Male	Adult Male	Sub-adult Female	Juvenile Female	Juvenile Female	Time out
14:55	Walking	Feeding	Feeding	Feeding	Feeding	Looking	Walking 14:56
14:57	Feeding	Feeding	Walking	Feeding	Walking	Feeding	Feeding 14:57
14:58	Feeding	Looking	Running	Running	Feeding	Looking	Alert 14:59
15:00	Feeding	Feeding	Running	Feeding	Feeding	Walking	Feeding 15:00
15:00	Walking	Looking	Walking	Walking	Walking	Feeding	Feeding 15:01
15:02	-	Standing	Standing	Feeding	Looking	Feeding	Running 15:03
15:04	-	Walking	Feeding	Walking	Walking	Feeding	Feeding 15:05
15:06	-	Walking	Walking	Standing	Walking	Feeding	Feeding 15:06
15:07	-	Looking	Running	Feeding	Walking	Feeding	Feeding 15:08

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 89 / 107

So, in this table here we have the starting time and the ending time and at this time. So, we started at 14:55 and we ended at 14:56.

So, during this time the adult male in this scene was walking the second adult male was feeding the third adult male was feeding and so on. So, in this case we are making a scan of what every animal is doing in that particular time.

(Refer Slide Time: 53:18)



The second way is a focal animal study now in the focal animal study, we focus on one particular individual. So, in this case coming back to the drawing board we will see that suppose we are focusing on this animal. So, will observe the behaviours of this particular animal for our designated period of time. Once that is done, then will move to another animal and witness its behaviour or observe or make a note of the behaviours of this animal for a particular designated time.

(Refer Slide Time: 53:45)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

### Focal animal study

Obs: Ankur Awadhya	Date: 06/12/2017	Weather: Cloudy
TR: Sarsika	Range: Sarsika	Beat: Karnikavas
Location: Water hole	Start: 15:14 hours	End: 15:47 hours
Species: Chital	Terrain: Flat	

Individual 1: Adult male				
S. No	Behaviour	Start	End	Time spent
1	Feeding	15:14:40	15:15:05	25s
2	Walking	15:15:05	15:15:27	22s
19	Walking	15:19:30	15:20:00	30s
20	Running	15:20:00		

Individual 2: Adult male				
S. No	Behaviour	Start	End	Time spent
1	Looking	15:24:43	15:25:59	1m 16s
2	Walking	15:25:59	15:26:09	10s
19	Walking	15:31:01	15:31:20	19s
20	Feeding	15:31:20		

Individual 6: Juvenile female				
S. No	Behaviour	Start	End	Time spent
1	Feeding	15:41:59	15:43:20	1m 21s
2	Walking	15:43:20	15:43:45	25s
19	Feeding	15:46:45	15:46:47	2s
20	Walking	15:46:47		

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 91 / 107

So, in that case we will come up with this table. So, in this table it says that for the first individual that is the adult male it showed all these different behaviours from these two these times. So, it did feeding from 15: 14: 40 to 15:15:05 and it spent 25 seconds here from after that it shifted from feeding to walking. So, 15 here we had ended at 15:15:05. So, from 15:15:05 till 15:15:27 for 22 seconds it did walking and so on. So, by this method, we can understand what each and every animal is doing for the designated periods of time.

(Refer Slide Time: 54:25)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

### Time budget table

Table: Summary of times spent by individuals on different activities

Activity	Individual 1: Adult male	Individual 2: Adult male	Individual 3: Sub-adult female
Feeding	135s	151s	71s
Walking	135s	43s	35s
Looking	20s	3m 21s	39s
Running	0	0	0
Auto-grooming	0	2s	0
Standing	30s	0	0
Time spent	5m 20s	6m 37s	2m 25s

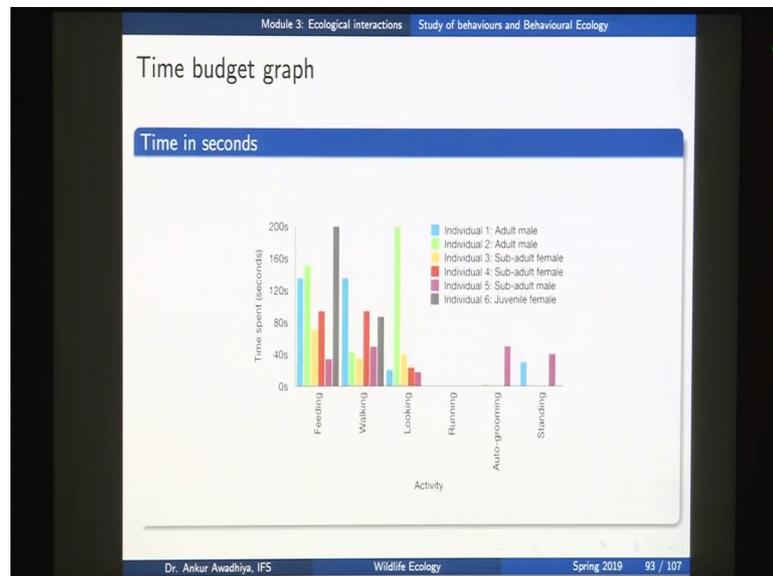
  

Activity	Individual 4: Sub-adult female	Individual 5: Sub-adult male	Individual 6: Juvenile female
Feeding	94s	34s	3m 21s
Walking	94s	49s	87s
Looking	23s	17s	0
Running	0	0	0
Auto-grooming	0	50s	0
Standing	0	40s	0
Time spent	3m 31s	3m 10s	4m 48s

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 92 / 107

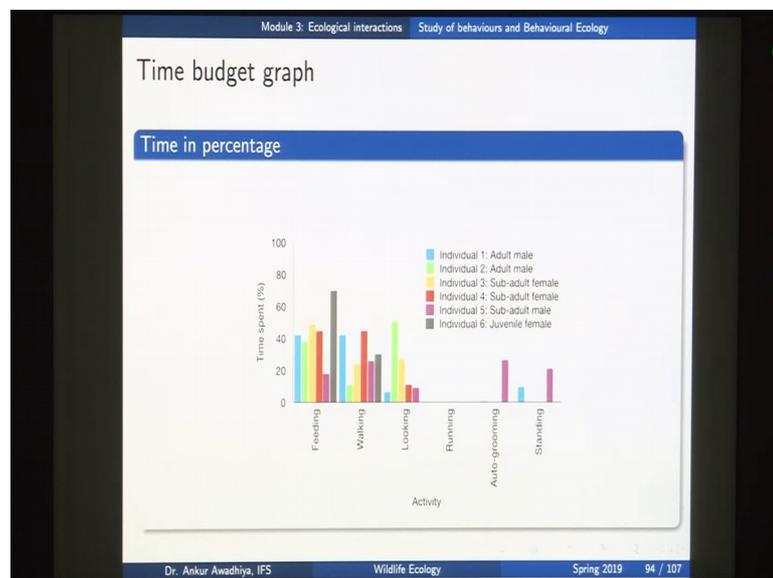
And from that we can come up with a time budget table or a time budget graph.

(Refer Slide Time: 54:28)

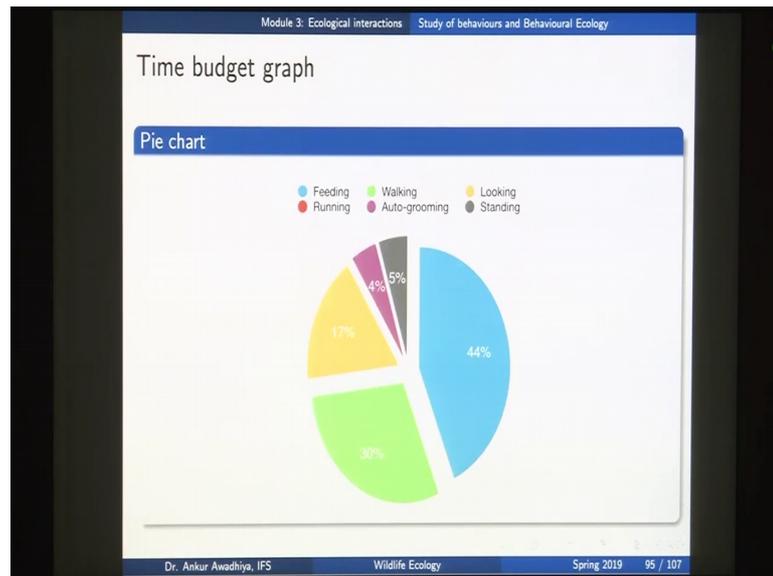


So, this graph can be in terms of seconds or in terms of percentages or in terms of a pie chart.

(Refer Slide Time: 54:34)



(Refer Slide Time: 54:36)



So, here what we are observing is that feeding is the most dominant behaviour that was shown in this particular group. So, as much as 44 percent of time was being spent on feeding. And 30 percent time was spent on walking which might be a behaviour that is correlated with feeding because the animal has fed on grasses somewhere and then it moves on then feeds again then moves on and so on. And then it spend as much as 17 percent of thing looking around.

Now this looking is mainly looking for the predators. Now if we have a situation in which there is a tiger nearby. So, in that case these two values will probably go down and looking will increase. So, this is a way in which we understand the behaviours. We make a note of behaviours to understand how that is playing a role in the ecology.

(Refer Slide Time: 55:24)

Module 3: Ecological interactions Study of behaviours and Behavioural Ecology

### Some observations

- 1 Dominant behaviours: feeding, walking, looking
- 2 Juveniles spend less time looking than adults and sub-adults, possibly because of parental protection
- 3 Sub-adult male spent considerable time in auto-grooming

In this way, ethograms and time-budget analyses can help us record and understand the behaviours of animals, with important implications for Ecology.

Dr. Ankur Awadhya, IFS Wildlife Ecology Spring 2019 96 / 107

So, for instance in our observations, we saw that the dominant behaviours were feeding, walking and looking as we saw in the pie chart. Juveniles spend less time looking than adults and sub adults possibly because of parental protection. So, just by looking at their behaviours, we can make this inference that because juveniles are spending less amount of time looking around, but their parents are spending much more time looking around.

So, there is a sense of parental protection that is also being provided. So, here we are looking at population level interactions where the parents are looking out for the children. And then sub adult males spend considerable time in auto grooming, so sub adult males are now getting into the stage of adulthood in which case they will also be able to mate. So, at this particular stage, they spend a considerable amount of time in auto grooming.

So, then we can make a correlation between different ages and different kinds of behaviours. So, in this way ethograms and time budget analysis can help us record and understand the behaviours of animals with important implications for ecology. So, in this lecture what we saw is that different behaviours are there because they have been evolutionarily selected. So, these behaviours have been selected because they are providing some amount of fitness to the individual or to the group.

Now what is that fitness why are some behaviours shown by certain organisms and not by others can be inferred by looking at the cost and benefits of any particular behaviour.

So, a behaviour like territoriality or a behaviour like avoiding of predators can be understood by looking at the cost and benefits and an animal will perform a behaviour only when the benefits are greater than the cost.

So, it is in a net profit and then by looking at the cost and benefits we can even come to a conclusion about what is the most optimum level of behaviour that an animal should depict. So, the most optimal behaviour will be where the benefit is much more greater than the cost; so the profit is maximized. So, that is the behaviour that will be shown we also looked at the concepts of kin selection and group selection.

So, even if there is a behaviour that is not favoring yourself, but you are able to save a number of individuals that are related to yourself. So, in that case evolution will select this behaviour because by this way the genes that are responsible for such a behaviour get selected and they are able to propagate themselves. So, the fitness increases and with that those particular genes that are responsible for the altruistic behaviours also increase.

And finally, we looked at different methods through which we understand these behaviours we through which be we go to the field and observe these animals and note down their different behaviours to make correlations that are important for population ecology, community ecology and so on. So, that is all for today.

Thank you for your attention [FL].