Course Name: I Think Biology

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W9L48_Seed Dispersal (Case study)

Hi, my name is Divya. I am a faculty at Azim Premji University teaching Biology in the undergrad program. Do you know what these are? These colorful and varied structures are seeds from various plants and these are microscopic images of them. In today's class, we will look at seed dispersal. We will first look at what are seeds, why are they important and why are they important to be dispersed. We will also look at these two scientists, Janzen and Connel who proposed the hypothesis about seed dispersal.

We will then specifically go into figs as a case study and who eats figs and how are they, are they effectively dispersing the seeds of figs and then finally we will look at a scientific study about seed dispersal and how it is carried out. Seeds, as you know are embryos of plants packed with nutrition and they have an outer covering. If you look at the nutrition of seeds, they have a lot of fats, fiber various micronutrients, and proteins. They carry around 150 calories per ounce of a seed, so it is extremely nutritious.

So you will see that doctors often advise you to have at least a few seeds like almonds cashews or groundnuts per day. So angiosperms and gymnosperms produce these seeds and these are, there are examples or there are records of the earliest seeds that could be traced back to 420 to 350 million years from gymnosperms. So these are fossil seeds that are found dating back to around 400 million years ago. And things like ferns which are shown here, plants like ferns, mosses, this must be familiar to you, you know a wall, outside compound wall filled with moss or liverwort, they do not produce seeds but they use water as a means to propagate themselves. So only angiosperms and gymnosperms produce seeds and this you would have learned in your school.

Okay, so seeds come in all kinds of shapes and sizes. You would have seen this, these are mustard seeds, they are tiny right and you put them for seasoning. Here is, this is what is known as a coco de mer seed and these are around 25 kilos, and each of them is that heavy. So you can see that their shapes and sizes are varied and depending on that their dispersal mechanism is also very, very different. Seeds need to be carried away from the mother plant elsewhere for it to

disperse and then they will germinate there, right?

So seed dispersal can happen by wind if the seeds are very light. So here is a seed with almost like a parachute kind of a structure which helps, you know, the wind is, wind can carry the seed away from the parent plant. Here is a seed again, a bunch of seeds, this is in milkweed plant which is like at the, when the seeds are ready to disperse they are carried again through the wind. This is again a familiar tree for you, these are coconut trees, these are dispersed by water so if coconut trees are present near the coast then the seed falls and they are carried by water. Of course, not all coconut trees are present near water bodies but this is one common method of dispersal.

A lot of seeds are also dispersed through animal agents including us, right? So we eat say a mango or a grape or something else and then we throw away the seeds. If we happen to throw it on the road or on the roadside where there is mud it has a potential to germinate. Here is a dog that has roamed around in the grass and its coat has a lot of tiny seeds so when the dog goes somewhere else it is dispersing these seeds. So various ways, and mechanisms of seed dispersal, right?

So the question is where should the seeds disperse so that most of them germinate, right? The whole purpose of seed dispersal is for it to germinate. Should it disperse, should it fall very close to the parent tree or should it fall away or should it be taken away from the parent tree? What is, what is the, what would be better? I will give a few seconds for you to think about it. So in fact, if the seed falls slightly away from the parent tree the chances of its germination are a lot higher. So in fact these two scientists known as Jansen and Connel proposed this hypothesis about seed dispersal.

So this is a busy graph. I will tell you what the axes have first and then we will talk about the graph. So on the x-axis is the distance from the parent tree. So how far is the seed from the parent tree? So let us say that the parent tree is here and the seed is, you know, this distance gives how far it has gone from the parent tree. On this side of the y-axis are several seeds per unit area, how many seeds are present per unit area, and here is the probability that seeds and all seedlings will mature.

Not all seeds that have fallen will germinate, right? So this is the probability of that happening. So what you see here is if the, if the seed falls directly below the parent tree then yes there are a lot of seeds which fall directly below the parent tree and that this is, this particular line, this curve says that there are a lot of seeds which fall right below the parent tree and as the distance from the parent tree increases the number of seeds found decreases. But they, all of them do not survive. So here, what you see here is lots of seedling mortality. That means that if they fall right below the parent tree they do not survive.

So chances of them surviving if they are right below the parent tree are very, very low. We will talk about why that is so in a minute. But say for example if they fall far away from the parent tree, that is, you know, say 50 meters or 100 meters from the parent tree then the probability of them surviving is very high but there are not that many seeds which have, you know, gone so far away. So there is a seedling survival sweet spot which is, you know, where these two lines cross this area is optimal for seed survival which is where it can germinate and become a mature plant. Okay, so this is what these two scientists proposed and why is it that seeds cannot survive under their mother tree? Can you think about some reasons?

Because there is a lot of shade under a tree, right? So seeds need a lot of sunlight to grow, that is one reason and more importantly, there are a lot of predators and parasites which are very specific to that particular host tree, that particular species. So they will also eat the seeds, parasites, and predators. These are seed predators I am talking about which can take away the seed and eat them up or damage the seed. And if there are a lot of seeds in a place together then there is also competition among seeds for the same resources, sunlight, water, nutrients, everything, right? So because of this chances of them surviving close to the parent tree is less. So we will look at whether this is true by looking at case studies.

Okay, now let us look at this particular study conducted by Asmita Sengupta. She is in a place called ATREE in Bangalore. She and her colleagues conducted a study on rhesus macaques. These are, you will be familiar with these monkeys. So, she studied seed dispersal by rhesus macaques in the Buxa Tiger Reserve in West Bengal and she published, they published this in the American Journal of Primatology. Okay, see they asked are fig eaters effective seed dispersals. They asked a lot of questions, but we are going to look at this particular question.

So they were interested in knowing how many plant species are dispersed by macaques, okay, because this study was conducted in a forest, right? So there are a lot of trees, there are a lot of plant species and these macaques eat a lot of fruits and disperse those seeds. So they wanted to know how many plant species are dispersed by macaques, and how are seeds handled. What do I mean by handle? Seeds if they are small can be swallowed, if they are large like mango or something then they are thrown, right? So how are seeds handled how far from the parent tree are seeds deposited and what is the effect of seed handling on germination? These are various questions that they were interested in knowing. We will only focus on certain key questions, but before going into that imagine how you even find out what these monkeys are eating and if are they good seed dispersals. So here is a sketch of how these studies, how the study can be conducted. Here monkeys what do you have to do? You have to just sit and watch. You have to sit and watch what these monkeys are eating and of course, this sketch illustrates that monkeys are nicely sitting and there is a, you know, a human is sitting slightly far observing them, but often monkeys are far away up in the, near the canopy of the tree and eating various fruits or leaves and what not, right? Or jumping from one branch to another branch.

So you have to be very vigilant and careful and very silent so that and you perhaps have to use a binocular to see what they are eating. And you have to wait patiently so that if the monkeys drop these fruits or seeds then you can look at it and say okay these are the seeds, these are the fruits eaten by monkeys and these are the seeds that they are dispersing, right? So you have to do what is known as scan sampling meaning you scan all the monkeys present on a tree or in an area and then look at what they are doing, right? So this is one kind of field observation technique, a sampling technique that you can use to look at whether monkeys are the kinds of seeds that these monkeys are dispersing. So scan sampling requires observing monkeys closely, right?

So would researchers' presence alter the behavior of monkeys? That's the question for you to think about. This is an important point because say suppose we are you know jumping up and down, we are very happy seeing a monkey and we are you know making a noise and saying you know messaging to each other, we are talking to our neighbors, and then seeing the monkey and also recording data that doesn't work, right? So we should be careful that our behavior doesn't affect monkey's behavior and that doesn't affect data collection. So this is an important point because often when we are collecting data, our presence should not alter another animal's behavior whether it's done in the lab or the field.

Alright, getting back to the results. So what Sengupta and her colleagues found was that monkeys ate fruits from close to 80 different species of plants in that forest. That's amazing, right? And monkeys ate fruits of three different fig species and they swallowed the seeds of the figs. As you know from the earlier class fig seeds are tiny, right? So that can be swallowed. So monkeys did that and they ate three species of you know figs.

And on average the monkeys disperse seeds more than 70 meters from the fig tree. So monkeys did not sit on the fig tree and ate it and dropped the you know fruit. You know they were traveling, they were plucking fig fruit and they were traveling a little bit further and they were dispersing these seeds. How do they disperse the seeds if they are swallowing the seeds? They go through the monkey's gut and the poop has a lot of seeds, right? So the dispersed seeds germinated faster and more seeds germinated than the control seeds. So the dispersed seeds are nothing but the seeds which have you know gone through the monkey's gut and the monkey would have gone and pooped in some other place and the seeds would have come down to the ground and they will germinate, right? So what they are saying is the dispersed fig seeds germinated faster and more seeds were germinated than the control.

Does that mean that what is control here? Control is seeds that have not gone through the monkey's gut. So what Sengupta did was they took fig fruits that had fallen from the tree and germinated them. So that acted as a control. So let us look at one more study. This is a graph from a neotropical study.

This is a spiral monkey. You can see that it is hanging from its tail and I am just going to tell you about this because this is an interesting graph and you will also get an exercise about how to interpret graphs. So this is about what happens to seeds when they pass through a monkey's gut. So there are a lot of studies done like this, not just Sengupta and her colleagues but several other people have done this and asked similar questions in various parts of the world. So here what they are looking at is the germination time of seeds and germination percentage of seeds. That means what percentage of seeds actually germinated and how long did it take to germinate when they were dispersed by monkeys when they went through the monkey's gut?

So there are three different kinds of data which has been collected. One is Folivore- Frugivore. Folivores are monkeys that eat leaves and also fruit. Frugivores are species of monkeys that only eat fruits and Insectivore, Frugivore are those which eat insects as well as fruits. So this is the study conducted by various kinds of monkeys, not just Spider Monkey but different species and they asked this question.

I am going to just concentrate on the Frugivore part here. Rest of it you can read and interpret it later. So Frugivores are the monkeys that only feed on fruits. So let us look at what the data says. So here on the x axis proportional change from control means baseline is control.

From that what is the change relative to the control? So if you look at the blue line here, basically this is the median or the mean value of proportional change, and whatever is in parenthesis are the numbers, the actual number of data that these ancestors have obtained. So let us look at germination time. For this is actually in this study if you look at it, it is slightly less than zero. So when compared to control the seeds dispersed by Frugivore monkeys take slightly longer to germinate, that is what this means, than control.

You should look at this and see where it lies on the x-axis. But when you look at how many seeds germinated, they are far more than the control. So you look at it somewhere close to you know 80%, there is a variation. So this is the mean value and these are error bars, this is the variation of the data point or the spread of the data. So definitely around close to 75 to 80% of all the seeds that went through monkeys got germinated whereas germination time itself was lesser than control.

So this is how seed germination studies and seed dispersal studies are carried out in an actual when you do research. So now let us think about how, what happens, and what is the pattern of seed dispersal when wind disperses the seeds. So if wind disperses the seeds then what pattern of seed dispersal would you expect from each tree? Let us think about A, B, C, and D are different trees that are wind-dispersed. What do you expect, how do you expect the seed shadows to look when they are dispersed by the wind? You would see that it is a clump distribution around the same trees. So small letters are seeds dispersed and big capital letters are

the trees, mother trees around which they are dispersed.So you will see that most of A seeds are found closer to the mother tree, some are of course dispersed elsewhere and the pattern holds for other trees as well.

So let us look at one more example, if birds disperse these seeds what pattern do you expect? So we have talked about winds, we have talked about monkeys dispersed in seeds, what about birds? Knowing the biology of these, you know that birds fly so what do you expect? So this is something you can answer by yourself. Lastly, you should think about why is seed dispersal so important and how is related to conservation. So as you can see, so let us see that these are different habitats, these are patchy habitats which means that if you look at any forest, it is very very difficult to find a continuous forest where animals can move from one patch to another patch without any, you know without any disturbance. So often what we find is because of logging or because of you know one road is going in the middle or because of various reasons, forest or tree covers they are just found in patches, you can even think about urban landscape for that matter. There are some trees in clumped, distributed in a clumped pattern and then there are a lot of urban you know apartments or whatnot and then there will again be some clump of trees, right?

So what happens to seed dispersal if the habitat is fragmented? Let us take up one example, this is W is wind dispersed, you know seed, B is bird dispersed and M is monkey dispersed. What happens to these seeds? So suppose for example monkeys have, there are plants which are, where fruits are eaten by monkeys and they have to be dispersed here, is it possible or the chances of these seeds going to this patch of forested land, is it likely? There might, you know monkeys might be scared to walk from one habitat patch to another because there is say let us say, a lot of heavy traffic in this area. So that becomes difficult for the plant to survive elsewhere, right? So these are conservation issues where people are thinking okay how do we even connect these habitat patches? Can we connect so that it facilitates the movement of animals from one area to another area and hence helps in the dispersal of these seeds? So these are important points, I am not going into detail about this due to lack of time, but you should think about it. So in summary, we know that seeds and fruits come in different shapes and sizes.

These traits which are shaped, traits are shaped by natural selection for specific dispersal mechanisms. That means that if it is, if it is wind dispersed, it has to be carried through wind, so right, so it is adapted for wind dispersal or if it is water dispersal, it is adapted for water dispersal. So natural selection has shaped them for various means of dispersal. Wind dispersal results in seeds, in more seeds clumped near the parental tree whereas animal dispersal results in clump distribution away from parental trees. And finally, fragmented habitats hinder animal movement and thus hinder seed dispersal. So one has to be careful to kind of thinking about how to conserve these habitats.