

**Course Name: I Think Biology**

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W9L47\_Mutualism - Figs (Case Study)

Hello, welcome to I Think Biology NPTEL course. My name is Divya and I am a faculty at Azim Premji University. Today you are going to be learning about figs. Figs, the queen of trees. I am sure you would have come across figs and eaten figs either in its raw form or in its dry form. In fact, this is dried figs sold in the, in the Delhi market. Figs were in fact one of the oldest plants to be cultivated, much earlier than you know wheat or pulses which we cultivated them.

So in fact, it's as old as cultivation is as old as 9400 BC. It's it's known that Aristotle mentions about fig and figs reproductive system. So people knew about figs, how to cultivate figs long time back.

We will learn more about figs, specifically about different kinds of fig trees around us, why fig trees are so important and fig-fig-wasp interaction. This is a mutualistic interaction and we will learn more about that, Okay. So you would have come across or seen fig trees. This is an example of a banyan tree here and this is an example of a peepal tree and this is known as cluster figs. I am talking about all these trees as fig trees.

Yes, they belong to the genus *Ficus* and they are popularly known as figs. Banyan tree, peepal tree are also fig trees basically, they are *Ficus*, right. So, and another tree which you may or may not have seen is known as strangler fig. This when it grows as a young tree, it takes support of another tree and then eventually that particular support tree dies, it strangles that and then this becomes a big, really big tree. This is a photograph of you know abandoned temple or you know broken down, some kind of a temple where fig tree, strangler fig has come out.

Alright, so figs are really diverse, fig trees. There are around 750 species of them around the world and India, Asia and basically Asia and Australia, that belt has around 500 species. And in India alone, there are around 90 species found, various *Ficus* trees, *Ficus* species are found. It is particularly diverse in the northeast and the Andamans and there are various forms, right? So

there are climbers, there can be vines, there can be stranglers. They are also found as Bonsai.

If you go to nursery, you will see a certain Ficus species made into bonsais. There are also ornamental, can be ornamental plants too. So they come in various, various forms. And why are fig tree, fig trees so important? They are considered as keystone species. Keystone species are species which you know, which have overarching or disproportionately large influence on their environment surrounding them.

So, fig trees are one of these keystone species because it influences lot of different plants as well as animals. These, these fig trees, they fruit asynchronously, that means that while one tree is fruiting, another tree doesn't. But overall, in a year, there is a continuous supply of food. For example, in a forest, there is one tree after another tree which keeps fruiting and animals there, for animals such as birds and mammals, there is a continuous supply of food.

Not only this, there are various interaction which happens in in, on the fig tree. There are mammals, there are different birds, there are insects which at various stages of fig development, these various interactions happen and we'll talk about this in detail later in this class. We already talked about diversity of fig trees in the world as well as in India. And fig trees are important to study fig fig, to understand fig and fig wasp mutualism. Mutualism is where both parties are benefited, both fig as well as wasp are benefited by this interaction and we'll talk about this in detail.

Figs also influence, has influenced various cultures. Gautam Buddha attained moksha or enlightenment sitting under a fig or a ficus tree. Its figs are also have a mention in Bible. Figs also are part of various tribal practices. So figs are really, really important to study.

Before going into figs, we need to understand a little bit about the flower anatomy. So forget about various words here, but what you need to understand is flower has male and female reproductive parts. The male part is anthers where basically there are various, basically there are pollens which are held in this reproductive, male reproductive part and that can fall on of the same flower or a different flower basically on a female reproductive part. So the female reproductive part has stigma, style and ovary. Stigma is a sticky part where it kind of deposits the pollen grains and then they travel through the style and reaches the ovary where there are various ovules.

So that's about flower anatomy and flowers are arranged either single, it's known as flower, but multiple flowers. A collection of flowers is known as inflorescence and there can be various types. I am just showing you pictures or schematic representation of some of these. It can be raceme or spike, spadix, Catkin, a combination of this. This is Racemose corymb or umbel.

So these are various arrangements of flowers on a stalk. Why I am telling you is I am coming to fig inflorescence. One more thing before we get to fig inflorescence. Flowers can be of monoecious, it can have a monoecious arrangement or a dioecious. It can be in a dioecious plant or hermaphrodites.

So let's get to what is that? Monoecious plant where it has both male and reproductive, male and female reproductive flowers or parts in the same plant. Those are known as monoecious plants. Dioecious plants is basically two separate plants. So the female reproductive or the female flowers are present on one plant and the male flowers are present on another plant. So dioecious plants help basically out, it helps mixing genetic, it helps in genetic diversity where you know genetic material from one plant has to mix with another plant where there is a male male flower totally. In hermaphrodite flowers basically both, again both male and female flowers are found in the same, actually male and female parts are found on the same flowers.

So with this background we will now go into studying fig inflorescence. This is known as Syconium. The inflorescence itself is known as Syconium. That is basically it has a fleshy receptacle. This whole thing is fleshy. This is of course a raw cut open you know a fruit which is raw but this whole thing becomes fleshy and it has tiny male and female flowers inside and this is known as ostiole or basically a hole through which fig wasps enter. So this is a raw fig fruit cut open and this is a ripe fig fruit. The whole thing is actually an inflorescence so these are bunch of flowers sitting inside a receptacle but we even call the fruit as fig fruit but it's actually an inflorescence. Okay so let's look at it more schematically.

Here is a picture. So this is monoecious fig inflorescence where both male and female flowers are present together. So this is the ostiole which I'm, which I was talking about. This is a tiny hole in which fig wasps enter and male flowers with anthers are represented like this, right. So these are all male flowers. And female flowers there are two kinds. One is a long style flower. This is a long style flower. So this is a style and this is a stigma. These are the ovaries, Okay. So females flowers are of two kinds. One is a long style flower and another is a short style flower, Okay.

So you can see both female flowers, long style and short style and male flowers are present in a monoecious syconium. This is an Immature Syconium that means it's still raw. Mature Syconium are represented in a different colour, Okay. All these pictures are taken from this book iThink Biology. Okay so now let's look at the life cycle of a fig and how fig wasp influences the life cycle of a fig, okay.

So let's go from here. This is a female wasp. A female wasp already, its coming from a different fig fruit, fig inflorescence and it is laden with pollen. Right? So it has come laden with pollen and a female wasp enters the syconium through that ostiole. Right? So female wasp has travelled

and it has entered the syconium through the ostiole and then what it does is it lays eggs in some of the flowers and it pollinates some other flowers and then it dies. So that is the, that's what the female wasp does, okay?

So where does it lay egg and which flower does it pollinate? Basically remember I told you about these long styled and gall flowers, short styled flowers. Basically the long style flowers here it can't basically put eggs. When I mean eggs, it's eggs of these wasps. Okay? So the female wasps can't reach the ovary here. It can't reach the ovary because there is a long style. So this is the ovary, this is the long style. The female wasps ovipositor. Ovipositor is a structure through which eggs are laid. Okay? So female's wasps ovipositors are short, so it can't reach the ovary to lay an egg when it encounters long style flowers.

So the long style flowers, it just pollinates. That means that the pollen grains which has come from another tree is used to pollinate these long style flowers. So long style flowers are pollinated whereas these short style flowers also known as gall flowers that basically the ovaries are kind of up. Right? So the female wasps can actually pierce into these ovaries and lay an egg and this in turn will turn into gall flowers. That means that it the flower, flower basically the ovaries are helping the wasp larvae develop and these are known as gall flowers. Right?

So I know there is a lot to remember but we will go over it again. We will summarize it again but please be with me when I am describing the life cycle of fig and fig wasps. So the female wasp lays eggs in some flowers. Those are the long style flowers and then, sorry. Those are the gall flowers and it pollinates other flowers. Right? So you will get some fig seeds and some gall harboring wasp larvae.

Both of them are parallelly developing. Right? Fig seeds are also developing, the wasp larvae is also developing and that is what happens. And then male wasps, the larvae basically becomes males and females but males are the first to come out. Males are like this. They have very tiny antenna. Look at the antenna of the female. Antenna are like nose for insects. Right? So, antenna is through which it smells, it detects smell. So female wasps have long antennae whereas males have very, very tiny antennae and they have very rudimentary eyes. See eyes are very small here whereas here female wasps have big eyes.

We will come to why why that is in a minute. And male wasps basically all function of a male wasp is to fertilize the females. They go mate with the, once the females come out they mate with the females and basically they dig a tunnel through this, this is probably the tunnel. They dig a hole on the mature syconium and then they die. Basically they are making a hole so that the female, the mated females can get out of this syconium and then they fly towards another fig inflorescence. So that is the life cycle of this fig wasp and also the fig.

So basically to go over it again, a wasp, a female wasp enters and a syconium and it lays eggs in some and pollinates another and basically both fig trees and gall flowers, fig seeds and gall

flowers are simultaneously being produced. And then once the wasp is mated, female basically gets out of the syconium. Right? So the males never see the you know day, right. So they never get out of a fig fruit. So that's why they do not have to have a you know big eyes, they do not have to have a big antenna.

So their whole life is spent inside you know inside the syconium. Now if you happen to cut open some of the ficus or fig fruits, you will see several of these wasps. In fact, we do this as a practical in our own university and you see if it's in the right season you will see larvae as well as wasps. Actually if you cut open a fig you will see see that. Now what you get in the market, those figs are very different and those don't have these wasps.

Alright, so moving on. Now the system becomes slightly more complicated. Till now I talked about monoecious figs and now I am going to be talking about dioecious figs, right. So let's recap monoecious figs. This is an immature fig. Remember immature are depicted in green color and mature ciconium are depicted in pink color.

Right, it is an immature fig of a monoecious plant and this is a mature syconium of a monoecious plant where there is both male and female wasps developing and there is, this is represented as this little thing is represented as, is basically wasp egg and this pink thing is a fig seed. So both seeds and wasps are produced in monoecious plants, monoecious figs. Whereas in dioecious there are of two kinds. One is basically a hermaphrodite fig, another is a female where only you know all the seeds, all the flowers inside a mature syconium will turn into seeds.

We will come to that. Basically what happens here is, so in dioecious figs, so let us look at this. Here there are only you know long styled, long styled flowers. right? So here when a male or when a female comes in, it cannot reach these long style flowers to oviposit them. So all of these flowers turn into seeds, okay? So in dioecious plants, so there are two kinds. One is a where all of these have long style flowers and all of them become seeds. Whereas in the other kind, that's the hermaphrodite kind, it has both male and female flowers. This is the male flower. You see here, there are some of these are anthers represented as a male flowers and there are mostly short styled, short styled ovaries.

These are, with these will turn into gall flowers, gall fruits. That means they turn into wasps. So there are, there will be some long style flowers, but mostly there are short styled female flowers. So all of them will turn into wasps and of course there are some male flowers here. So the question is how do these you know, how do fig, may female wasp even enter you know, it's of no use for a wasp to enter these female only, female syconiums. Right, so the the point here is that these these female only, long style only you know, the syconium which has only long styled flowers, these actually have to attract a wasp in order for it to pollinate and pollinate this inflorescence and turn into actual fig fruits with lot of seeds. Right?

So how does it do that? I'll let you think about it. I'll come to this at the very end or this will be given as a question. One hint is that these these syconium, they produce a chemical volatile cocktail, basically a combination of chemicals which are, which are mimicking a hermaphrodite flower. That means that wasps are fooled to think that oh this flower, this syconium or inflorescence also, it smells exactly like this. So they are fooled to enter, they are deceived to make to enter this syconium and once they enter, of course they cannot lay egg, but they they end up pollinating most of these flowers and that is how the plant manages to keep the system going.

It's fascinating, right? Okay, to summarize everything, there are various reproductive strategies in figs, monoecious, dioecious which is hermaphrodite and dioecious female flowers. So in the monoecious both male and female flowers are in the same syconium and male and female flowers are dispersed throughout the syconium and both long styled and short styled female flowers are produced and because of this they have produced both seeds as well as wasps. Okay, that's got to do with monoecious reproductive strategy. In dioecious, in the hermaphrodite system both male and female flowers are in the same syconium, male flowers are present near that ostiole and female flowers are concentrated at the base. You saw that in the figure in the previous slide and there are short styled female flowers.

So all of them or most of them get turned into basically wasps and very few are produced as seeds. And in the dioecious or the female you know plant or reproductive strategies only female flowers are present and basically they have long styled female flowers and all of them will become seeds and very, very few wasps are present. And these are the ones which employ deception or they deceive wasps because they mimic a volatile or a chemical blend which are basically volatile compounds of that of a hermaphrodite syconium. So wasps think that they smells you know they, their smells are similar so wasps are deceived and they come inside this dioecious syconium only to basically pollinate the entire long style female flowers and they produce seeds instead of wasps.

Okay, so you see that figs fig is really dependent on fig wasps in order for pollination so that seeds can be produced and fig wasps is also very much dependent on fig syconium in order to raise its own babies. Those are the larvae which turn into male and female wasps. So this is a fig fig wasp mutualism. In fact, there are specific you know each fig species has its own specific fig wasp. So it's species specific fig wasp. Right? So there are as many fig wasps or more fig wasps as there are fig, fig species around the world. So Sravanthi Upaluri would have talked about you know a specific paper, this specific paper where she would have talked about how to understand and read a scientific paper.

This is just a example of that paper where basically you see wasps here. This is a female wasp which is inside syconium. So you can see it has a short ovipositor. This is a pollinator wasp. What you see here with the long ovipositor, remember ovipositors are those which are basically a reproductive part of a wasp where through which it lays an egg. So only female wasps have these

ovipositors. Right, so these are basically parasitoid wasps which sit outside a syconium. This is a fig fruit, fig syconium. This is a fig syconium. It's sitting outside and it's putting its long needle-like ovipositor into the syconium.

Here you can see the schematic here. It's putting its ovipositor into the syconium and it's depositing an egg. So what happens here is it's called a parasitoid because it lays its own egg on top or if its larvae starts feeding on the pollinators or the, sorry, pollinator wasp larvae. So parasitoides are those which feed on other organisms. So here the fig parasitoid depends on the wasp, the pollinator wasp. Its wasp larvae it depends on and it feeds on. So this fig-fig wasp thing, it's not just fig and fig wasp. There are parasitoid wasp larvae which are developing in this fig syconium.

So you'll study in detail about this paper elsewhere. But what I wanted to show you is this scanning electron microscope pictures of these ovipositors. These are all pictures of ovipositors. Of course, it's a blown up image here. Don't think that they are this big. There the fig wasp itself is a few millimeter, you know, long and the ovipositors are tiny of course. But what is important here is I've written as structure mirrors function. That means that for different function, if it's a, you know, if it needs a long ovipositor, the structure is designed like that. If it needs to drill into the syconium, then it will have some kind of a small drill bit kind of a thing where it's strong enough to drill the syconium.

So basically the wasp has evolved in such a way that the wasp ovipositor, the female wasp's ovipositor structure mirrors what it needs to function, what the the the task it needs to perform. You will see more about this in in class which Sravanthi talks about. Alright. So all these examples are to tell you that really the fig and fig wasp mutualism is really co-evolved where structures are very, very, have evolved to perform a function and both the systems can't live without each other.

Right. So now I'm moving away from the wasp, but I'm looking at a big picture and this is basically we are saying that the syconium is like a microcosm. Right. That means that it's like an ecosystem inside it. There are pollinator wasps. Of course, there are there is male and female syconia and there are pollinator wasps which pollinate these flowers. But, and also produce its own babies. But there are predators waiting outside as soon as these wasps come out from one syconium to go into another syconium. There are predators like ants, spiders, dragonflies which are waiting to grab these pollinator wasps and feed on them. And there are non-pollinator fig wasps that such as gallers and parasitoides. We talked about parasitoides earlier which also depend on these pollinator wasps and they're inside the syconium.

Right. And there are nematodes. Nematodes are worms which are found, you know, which are found to hitchhike on these, using these wasps to get to another fruit. Then there are birds and monkeys which feed on these figs. Right. And and also they help in dispersing the fig fruits and

fig seeds elsewhere. Right. So there are predation, there is parasitism, there is mutualism, there is, you know, cheating with these. So that is there is mimicry which is going on with respect to those chemicals. So there is all kinds of interactions which are going on in this fig syconium. That's why it's known as fig microcosm. Right. And this is how you draw a mind map of all these interactions.

And finally, I, I would like to end by reiterating that figs are considered as keystone species. There are close to 1000 bird species and close to, you know, 300 mammals which are in around the world which are which feed on figs. These are examples of some of the Indian species. There are giant squirrel, Indian giant squirrel, lion tail macaques and great hornbills all found in western ghats which are, which feed on fig fig fruits.

There are of course fig wasps which we talked about it in detail. Right. So to summarize, fig trees are considered as keystone species because of its disproportionate effect on the ecosystem. And a syconium is an inflorescence found specifically in figs. And each ficus species has its own specific pollinator wasp and both fig and fig wasp life cycles are closely, intricately intertwined and co-evolved. And fig syconium can be considered as a microcosm-close to a 1000 bird species and 300 mammal species feed and depend on figs. So that's the end of this class. Thanks a lot.