Wildlife Ecology
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Lecture – 15
Population studies and applications

[FL] We carry on with our discussions on population in ecology, and today we look at some case studies of how the population studies are actually done in the field.

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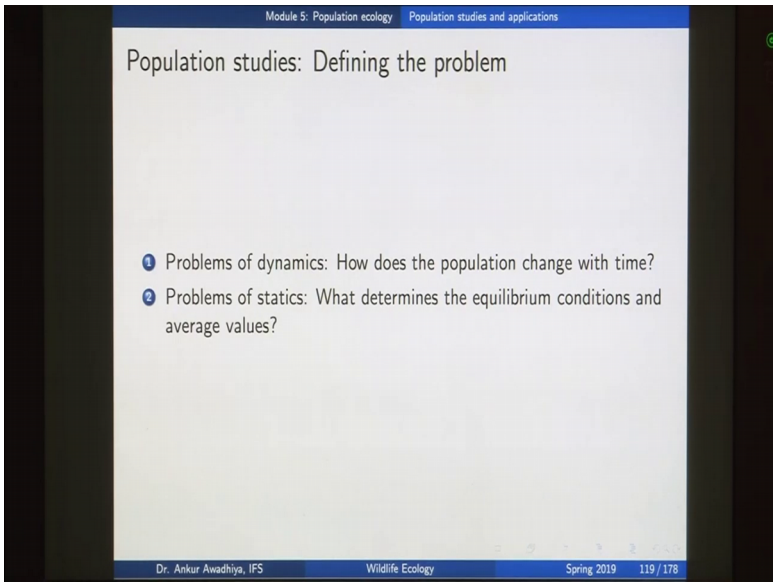

So, if you have any population study it begins with defining the problem, because if you have any population there are n number of things that you can learn about the population. Your problem could be say why is this population growing, or not growing, or if you have two different populations what are the factors that are leading to different growth rates in different populations. Or for instance if you have a population, why does it grow in a particular season, why does it not grow in other seasons? So, there can be a n number of problems. So, the first thing that we need to do is to define the problem. What are we trying to study in this case?

And secondly, to define the population because if you have a very large population then maybe you could take a small subset or maybe you could look at some sub populations or meta populations. So, you have to be very clear about what is the areal extent, what are the animals that you are, or organisms that you are considering as part of your

population? And what are those organisms that are not a part of your population. Now once you have done that there can be two kinds of studies: one is known as the problems of dynamics. Now, problems of dynamics ask the question how is a population changing with time.

So, for instance if we have a population of whales in an ocean and these whales are reproducing, but at the same time there are poachers who are killing these whales for meat and probably the population is reducing with time. So, if you are looking at anything that is changing with time such as the population size in the case of these whales which is reducing with time, we will call it a population of dynamics. Because it is dynamically changing, it is changing with time. The second kinds of studies are known as problems of statics.

So, in the case of statics you are looking at a static population, there is no change happening with time. So, it asks the question what determines the equilibrium conditions and the average values. So, for instance if you see that in your forest you have say 40 tigers, and this year you have 40 tigers, 5 years ago you also had 40 tigers, even 10 years back you had 40 tigers. So, there is nothing changing in this population. So, we are having some births, we are having some deaths, but more or less everything is getting cancelled out and the population is remaining static at 40 tigers.

Now the problem of statics in this case could be why is this population stuck at 40, why does it not become 41, why does it not become 39? Or, you could ask the question what is determining the carrying capacity of this habitat, why is this habitat only able to support 40 tigers why not more? Or, you could ask the question, what are the interactions that these organisms have, when they have this fixed size of 40 tigers, what are their home range sizes, how much amount of territory are they defending?

So, these kinds of questions will be known as the problems of statics. So, we have problems of dynamics in which things are changing with time. And we have problems of statics in which things are constrained with time and we are asking the question what is determining the equilibrium conditions and the average values.

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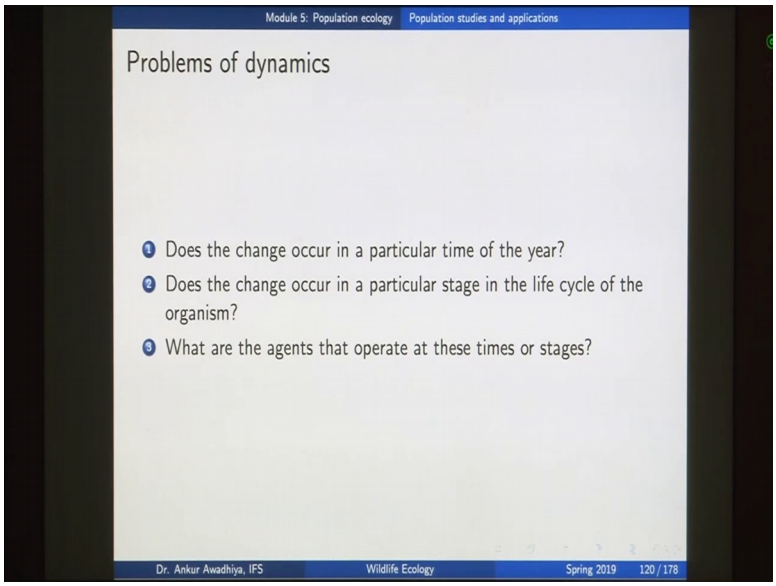

Now, if you have a problem of dynamics. So, there is something that is changing with time. Now to study such a change you can follow these 3 steps; the first one is you will ask the question does the change occur in a particular time of the year? So, for instance if we are talking about the whales, that are there in the ocean we can ask the question when do these animals breed? When do they have the young ones, and when is the time, when they are getting poached? So, are these things having some amount of temporal distribution? So, you have births only in a fix season probably you have poaching only in a fixed season.

So, this is the first question that you will ask. The second question is does the change occur in a particular stage in the lifecycle of the organism? So, for instance when we are talking about poaching, are people poaching mostly the adult organisms or are they poaching the calves, is there any change between are they poaching the male organisms or are the female are they poaching the female organisms. So, is there any particular thing that is related to the lifecycle that is causing the change and the third one is what are the agents that operate at these times or at these stages?

Now let us take another example, let us talk about some insect population. So, we are going to look at the locust problem in detail in this lecture. So, in the case of locust these are organisms, these are small insects and these insects are very harmful for the crops. So, they are very prominent agricultural pests. So, these organisms they will come in

huge sized swarms. So, there will be a swam that can have, as many as say millions of creatures. So, there are millions of insects that are coming together. If you combine their weights together, it can be as high as 50000 tons of weight. Now each of these insect it eats in a day leaves that are roughly equal to its own weight. So, if you have a swarm that has a weight of 50000 tons.

So, it requires 50000 tons of vegetation every day just to sustain itself. Now if you have a major pests, such as a locust you would want to know; when are the times when you are getting such a huge swarm? Because you do not get these swarms every year, if you are having these swarm every year then probably most of the ecosystems would have been decimated by these organisms. So, you will have a swarm say once in every 15 years or once in every 20 years. If that happens, you will ask the question what is suddenly leading to an increase in the size of this population.

Because the population was roughly constant, because of which we were not seeing any swarm for past 15 years and this year we are seeing a big swarm. So, there is something that is changed with time. So, here you will ask these questions does this change occur in a particular time of the year. So, if you are looking at a swarm of these insects are they coming in a particular time of the year? So, that would give you an indication of what are the reproductive periods for this particular insect. The second is the changes that we are seeing.

So, we did not see a change in the last 15 years, and this year we are seeing a change. So, probably that had to do something with the rainfall that happened, or probably a draught that happened. So, it could be related to some climatic conditions, or it could be related to say an external condition such as a predator probably it is possible, that the predators of locust they have gone down. Now if the predators of locusts have gone down in numbers, then it is also possible that the locusts will increase in their population.

So, the population will blast. Now in such a scenario we can ask this question that, we are seeing this locust in this particular season, but what was the stage that the predator was preferentially feeding upon? Was it feeding upon the adult insects, was it feeding upon the nephew stages, or was it feeding upon the eggs of this insect. If you asked that question that is the second question, the change that we are occurring is that related to

some particular stage in the lifecycle of the organism, or for instance we are seeing that these and these organisms are coming with the onset of rains.

So, in that case we can say that yes; then it should be related to the adult organisms, because they are probably laying more number of eggs in this particular season. So, one is the time of the year, second is the stage of the animal, and the third one is what are the agents that are operating at these times or at these stages, and there can be a number of such agents.

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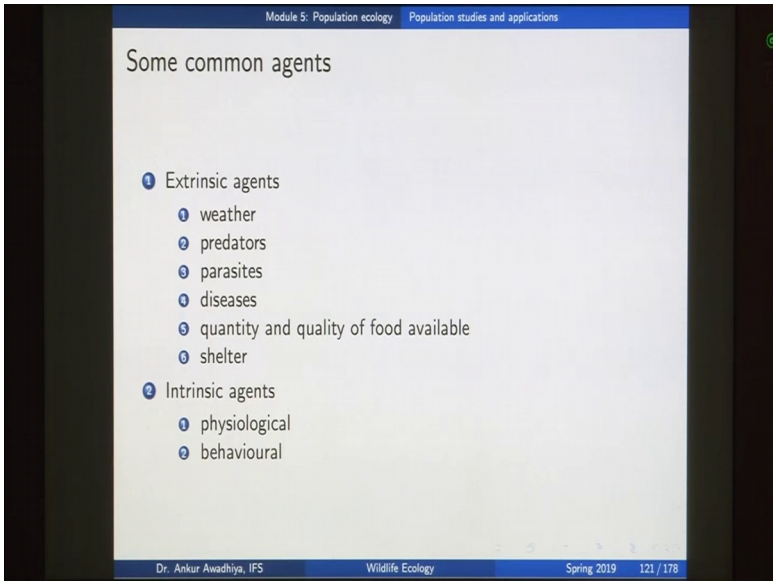

You can have extrinsic agents, or you can have intrinsic agents; extrinsic agents are those agents that are acting outside of the organism. So, things such as weather probably it was very hot, with probably it was very cold, very dry, very wet. So, weather can be an extrinsic agent. So, probably rained much better this year so, that is why we are seeing more number of locust.

That could be an extrinsic reason, or you can talk about predators; probably the predator numbers went down because of which more number of locusts are able to survive and because of which we are seeing more number of locust. Another extrinsic agent could be parasites or diseases probably for the past 15 years; there were some parasites, or some diseases, that were infecting these insects and probably this year those parasites died off. So, that is very similar to the effect of predation, or it could be related to the quantity and

quality of the food that is available, probably the locust had a very good amount of food because of the rains.

So, they had ample amount of fresh grasses to feed upon, and because they were having a plentiful amount of food and this food was also of a good quality. So, they were able to devote much more amount of resources into reproduction. So, this could also be an extrinsic agent or another one could be the shelter. So, for instance till now your locust eggs were being predated upon by say dragonflies, and this year after the eggs were laid there was some amount of leaf fall and all the; in all the eggs that were laid they were covered with leaves.

So, they got a shelter and the dragonflies were not able to find the eggs. So, this could also be an extrinsic reason, or there could be some intrinsic reasons. So, intrinsic reasons are things that have physiological or behavioral, now when we talk about physiological reason, probably there was something in the shape of hormones that was the; that key in the bodies of these organisms. Because of which they were able to lay much more number of eggs, or they can be a behavioral change. In which case we can say that something change because of which these organisms, they just came together.

And they were together they did not have to spend quite a lot of time, in finding out a mate. And in that case there was much more amount of mating and because of which we had a much larger number of eggs. So, this could also be another reason. So, we have seen, we can say that there are a number of extrinsic agents and intrinsic agents that are acting on every population at all times. Now, the reason for the change in your population, or the reason for your dynamic problems, could be one of these, it could be more of these, or it could be all of these, or probably something even otherwise.

So, you will have to locate each and every of these changes and we have an idea of which all changes are applying on your particular population. And that is about the dynamic problems.

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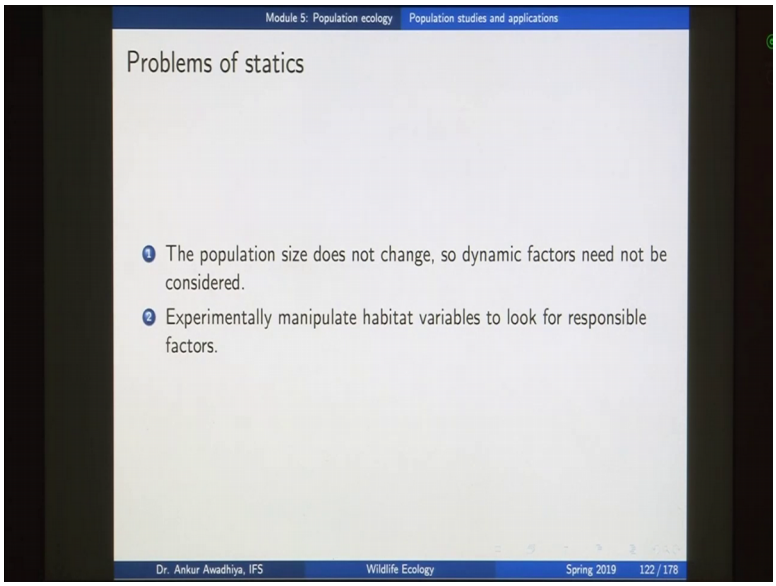

What about the static problems? Now if you population sizes say static. So, you can ask the question that the population size is not changing. So, dynamic factors will need not to be considered. And what are the habitat variables that are responsible for the size of the population? So, this is the question that you can ask. So, how do you solve this question? You can experimentally manipulate the habitat variables to look for the responsible factors.

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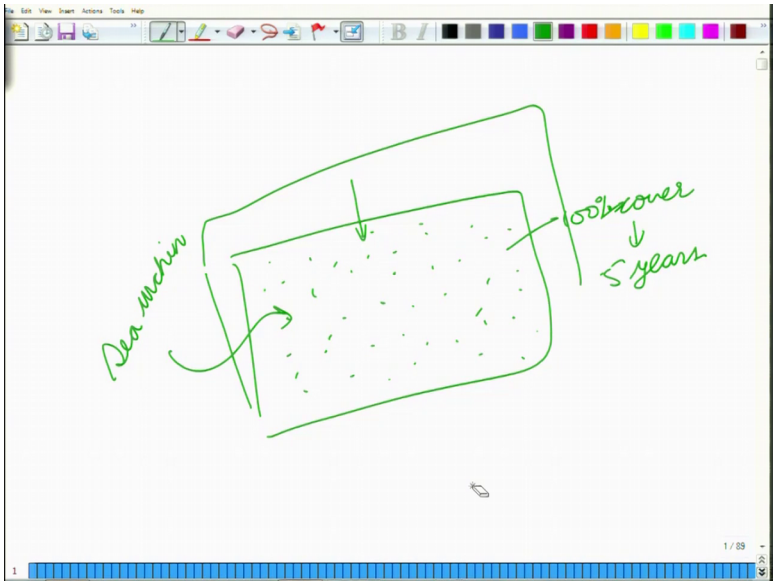

So, for instance; you have say a part in the seas that is having a very high growth of algae. So, in this case; you can ask the question that and you have this whole area that is covered with the algae. So, you have a 100 percentage cover. And we have this 100 percent cover say for the past 5 years. So, nothing is changing. Now you can ask the question why is nothing changing in this area, probably that is because you have ample amount of nutrients. So, if you try to reduce the amount of nutrients that you have in this area.

So, probably you will cordon off this area and give it your this salty water that has been filtered and the nutrients have been taken away. And then you will see that yes, the population is declining. So, probably it was constant because it was having ample amount of nutrients or probably it was constant because it was not having any predators here. So, in that case you can try to bring in some predators. So, for instance you can bring in a sea urchin into this area, and why were there no predators in this area.

Because probably there was a very huge amount of wave action so, in that case you can just create a containment in this area and then you can leave the sea urchins. So, in that case you will come to know that yes you are having 100 percentage cover in this area. Because the wave action is not permitting you the sea urchins to come into this area so, anything can be manipulated and we do such kinds of habitat manipulations in small scales if we have to look at a problem of statics. So, if there is a population that is maintained at a very low level.

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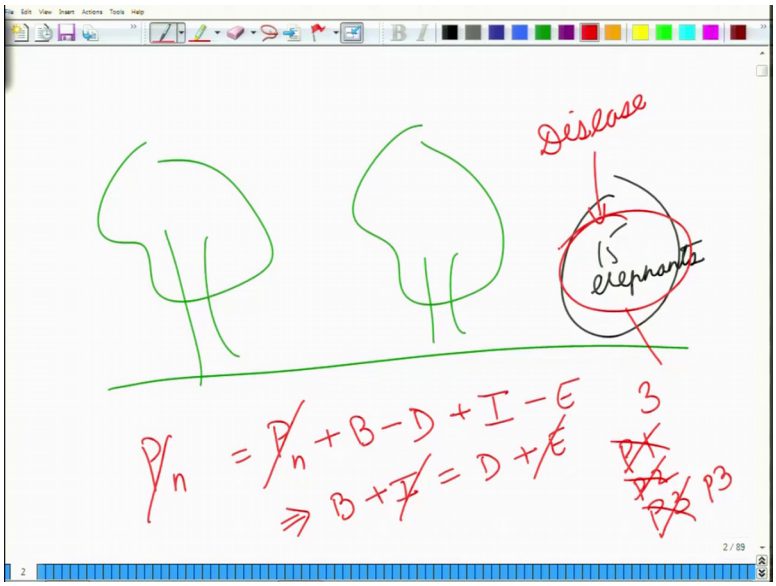

So, let us say you have a forest; in this forest you have say some elephants and the population size of the elephants is not increasing. So, let us say you have these 15 elephants. And the population size has remained constant at 15 for the past number of years. So now, you can ask this question why are these elephants not giving birth, or probably the question why are these animals when they are giving birth, why are the young ones not able to grow up?

So, whenever we are talking about a static population. So, we have seen earlier that if you talk about the population in the nth plus 1 generation, that will be equal to the population in the nth generation plus, the number of organisms that were born minus the number of animals that died, plus the number of animals that emigrated into the area, minus the number of animals that emigrated out of this area.

So, population at the n plus 1 generation is the population at the nth generation, plus number of births minus number of deaths, plus immigration minus emigration. Now if we are saying that P n plus 1 is equal to P n, because nothing is changing with time. So, we can say that P n plus 1 is equal to P n. In that case P n and P n get canceled away and you get this equation that the number of births, plus the number of immigrations is equal to the number of deaths plus the number of immigrations.

Now in the case of a closed system you can even have a situation where there is no emigration no immigration and so, you can have a very simple scenario that the births

are equal to the number of deaths. Now if the population is constant you can ask this question why is the birth equal to the number of deaths, what is there in this population that is keeping it at a low level. Probably there are some predators, probably there are some diseases, probably there are some parasites, probably the habitat is not good enough.

So, the animals are not getting nutritious feed, and in that case you can tinker each and every of these variables. So, if you think that the cause is a disease that is there in the animals you can go and check if they have these diseases. So, you can take say blood samples, you can take fetal samples, and you can look for what all pathogens are present in them. You look for parasites that are there, now every organism in the wild will have some diseases it will have some parasites. So, probably you saw that there were 3 parasites that were there in this particular in most of the elephants.

So, you have your parasite 1 parasite 2, and parasite 3. Now the next question could be which of these is responsible for keeping the population at a low level. So, there could be one parasite because of which the calves are dying at a very young age. So, that is keeping the birth the death rates in the population at a very high level. So, in that case you can start treating these calves. So, you care off all the parasites once and probably these calves are still dying off.

Then so, you can say that parasite one was not responsible for the high juvenile mortality that we had that we were seeing here, probably you remove the second parasite again nothing happens. Then you treat for the third parasite and then suddenly you see that the calves are not dying. So, in that you can say that this parasite P 3 was responsible for keeping this population static at this number of 15 elephants.

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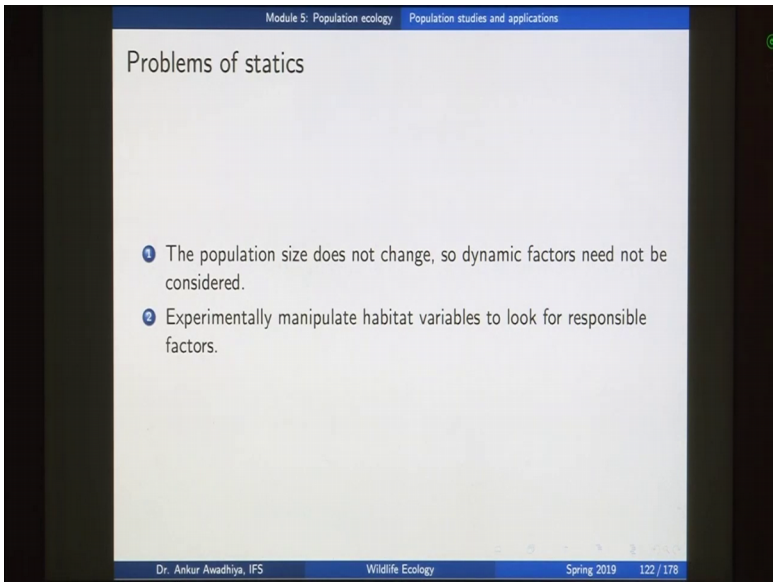

So, again in the case of a static problem, the problem is not the population size is not changing. So, dynamic factors do not have to be considered. So, you are saying that P n plus 1 is equal to P n or essentially births minus deaths plus immigration minus emigration is equal to 0. So, that simplifies our calculations to quite a high degree. And then you look for how many animals are immigrating, how many animals are emigrating?

And in a number of cases will find that these numbers are also very small or probably 0. And in that case we will ask the question what is keeping the birthrate at the current level, what is keeping the death rate at the current level? And then we can manipulate different habitat variables to look for the responsible factors that are keeping this population at this at a particular size.

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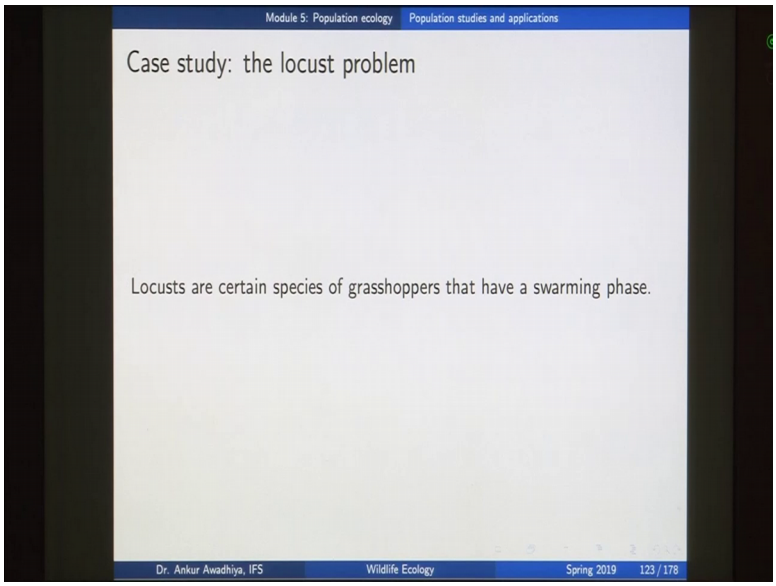

So, now we will look at one such population study which is the problem of the locust, now locust are certain species of grasshoppers that have a swarming phase. So, there is still very less amount of certainty when do you cause call an organism a grasshopper, when do you call it a locust. They are both very closely related organisms, but mostly grasshoppers will be seen solitary, but then locusts will be seen in large sized swarms. So, they have we can say that they are grasshoppers with a swarming phase.

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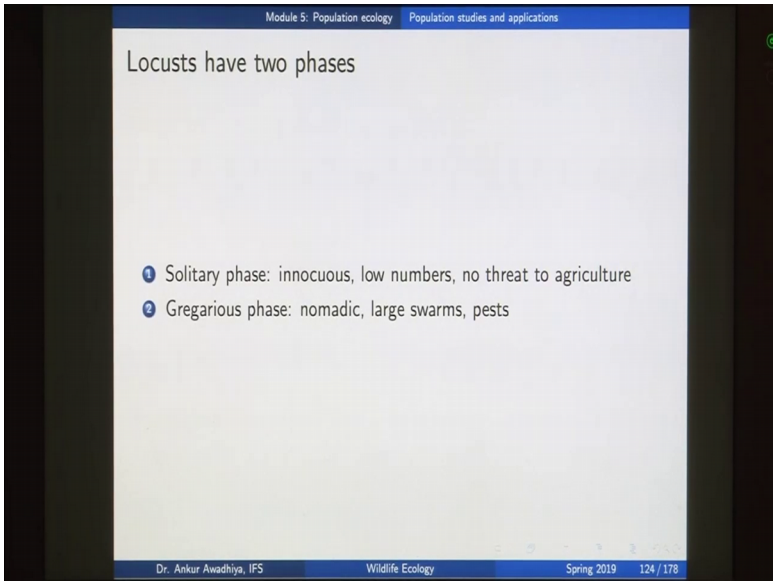

Now, locusts are known to have these two phases. So, the first phase is a solitary phase and in the case of a solitary phase they will behave more like grasshoppers, in which here is they are innocuous. They have low numbers, and they do not pose a threat to either agriculture or to the habitats. And then there is the second phase which is a gregarious phase, which is a nomadic phase. So, these locusts they make last forms. So, it is a swarming phase.

So, they make last sized forms then they move to other areas and once they start moving to other areas they will have a huge requirement of leaves and because of which will become very important pest for agriculture and also for conservation. Now this is something that we know today that these locusts are having these two phases. Now how do you get to this understanding that this is the same organism that is having these two phases.

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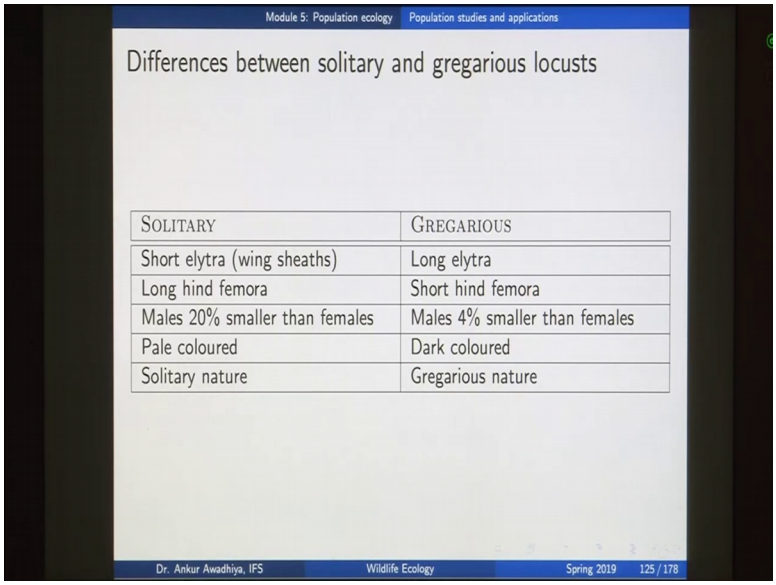

So, this is what we are going to look at in this case study. So, let us begin with looking at these two phases. So, in the case of the solitary phase there are morphological differences between the solitary and the gregarious phases. In the case of the solitary phase you have short size elytras which are the wing sheaths, which are covering the wings, and in the case of gregarious phases you have long sized elytras. In the solitary phase you have long hind femora and you have a short hind femora in the case of gregarious phase. You

have males that are 20 percentage smaller than females and solitary you have males that are 4 percent smaller than females in gregarious.

So, essentially in this case you can say that the males are very small. So, there is a huge amount of sexual dimorphism that you will see. Now in the solitary phase the animals are pale colored mostly light green in color and in the case of gregarious phase they are dark in color. And solitary as the name implies they have a solitary nature, they do not form groups; in the case of gregarious they form last sized groups. Now this was known for quite some time that you are seeing these grasshoppers, you are seeing this locust that come in sized forms and when they come they decimate the whole of the crops.

So, this has been known since antiquity even if you look at the old testament you will have references of these locust that are coming and that are acting as a plague for the society.

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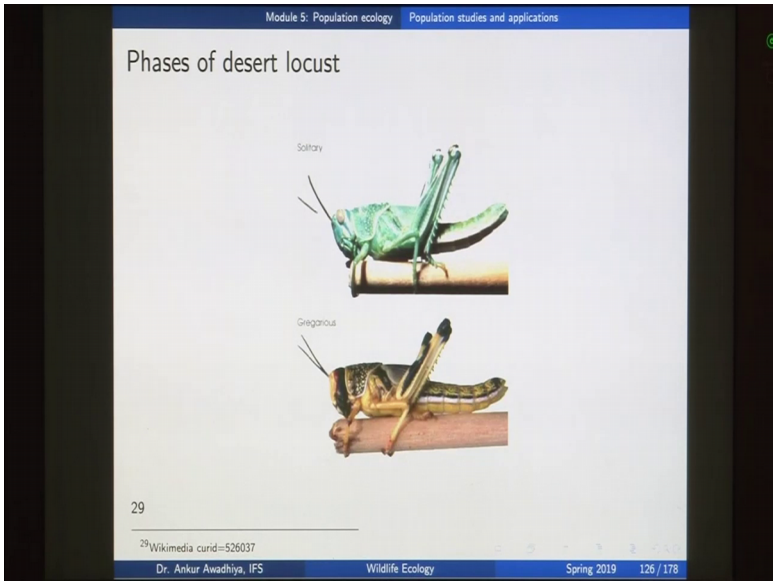

But then when people try to look at these locust yhey found these two kinds of organisms. So, you have this lighter colored version, and you have this dark colored version. And, both of these look so different that for a very long period people used to think that these are the grasshoppers that live in our in the grassland, and these are the locusts that come into our agricultural fields. And they were actually considered two different species.

So, now the question was that this species you see this is this particular species, once in every 15 years, or once in every 20 years, whenever it comes there is a huge amount of decimation to the crops. There is a huge amount of decimation to the grasslands, which also affects a number of other animals especially the dairy animals, and then once these locust are vanishing they completely vanish off. So, you have no trace of them for the next 15, 20 years and then suddenly they come up again and you do not see them in the intervening period.

So, in the intervening period you only see these green organisms. So for a very long time people used to think that these are two different species altogether.

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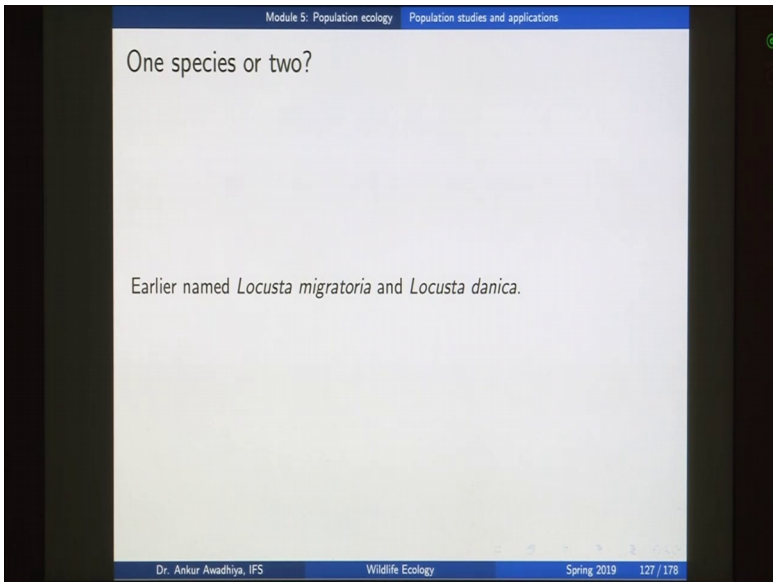

And the first one was named so, these names are locusta migratoria. So, that is the migrating species or the dark colored species the one that we have downwards. The second one was known as locusta danica which is the light colored species. So, we will used to think that these are two different species. So, if you start at with such a foundation and you perform any number of operation studies you are going to be wrong. Why? So, we will come to that.

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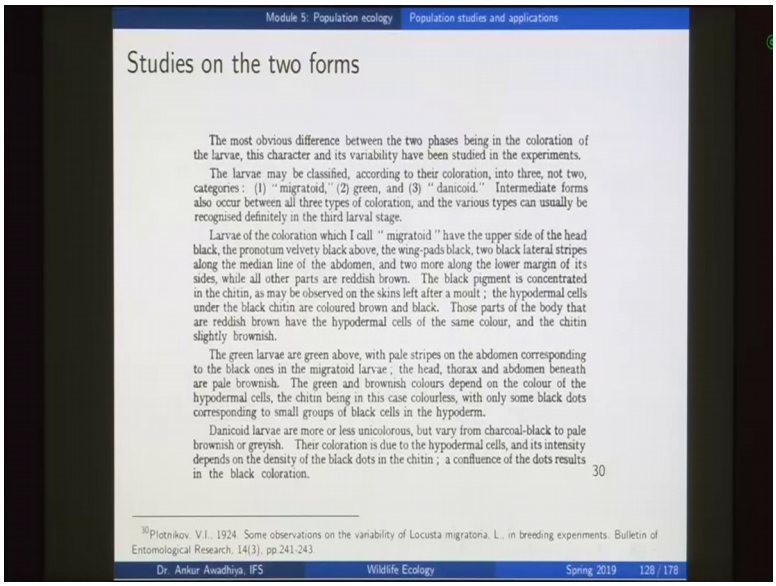

So, people started looking at these differences and for a very long period the scientists were completely perplexed what is happening, we do not see these dark colored animals for 15 to 20 years, and then they come up again in a jefe. But, then when people started doing the population studies; so, we have this person by the name of Plotnikov, and he started taking looking at the different these two different forms. And we started looking at the larvae of these. So, this is an extract from his paper and he writes the most obvious difference between the two phases being in the coloration of the larvae, this character and its variability have been studied in the experiments. The larvae may be classified according to their coloration into 3 and not 2 categories. First is the migratoid category, the second is green, and third is danicoid.

So, migratoid is something that is related to the migratory form, danicoid is something that is related to the dynamic form and there is the third variety which is green. Intermediate forms also occur between all three types of coloration and the various types can usually be recognized definitely in the third larval stage. Now as in a number of insects this particular insect also has a number of larval stages, and the differences can typically be seen in the third level stage larvae of the coloration which I call migratoid have the upper side of the head black the crow to numb velvety black below.

So, he is essentially describing all these three different varieties. So, you have this migratoid variety you have the green variety and you have the nanny coat variety now it

is important to note here that when you are looking at the larvae you can see these three different varieties we are not going to get into details of all these three, but then there are three different varieties that you can very easily see based on their appearances based on their morphology as well as based on the colors now just as we had seen that you have these two varieties and you can very easily make it make them out using their colors.

So, similarly you can look at the larvae also using their colors. So, that is the first level of understanding that we get. So, this is how you proceed in doing any of the population study the first thing is to look at the population and to describe things.

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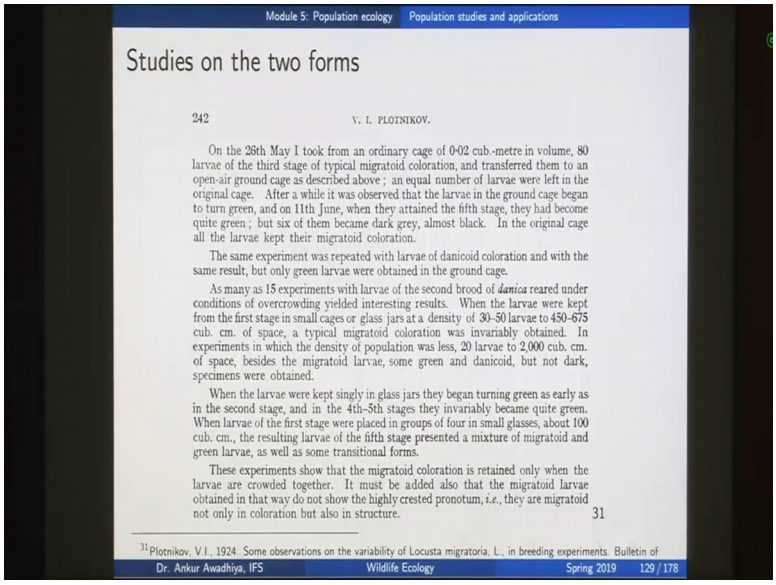

So, he further writes on the 29 th of May I took from an ordinary case. So, he is describing in an experiment in this case now, what was the experiment the experiment was that the scientist took out these larvae and he put these larvae into containers in different numbers.

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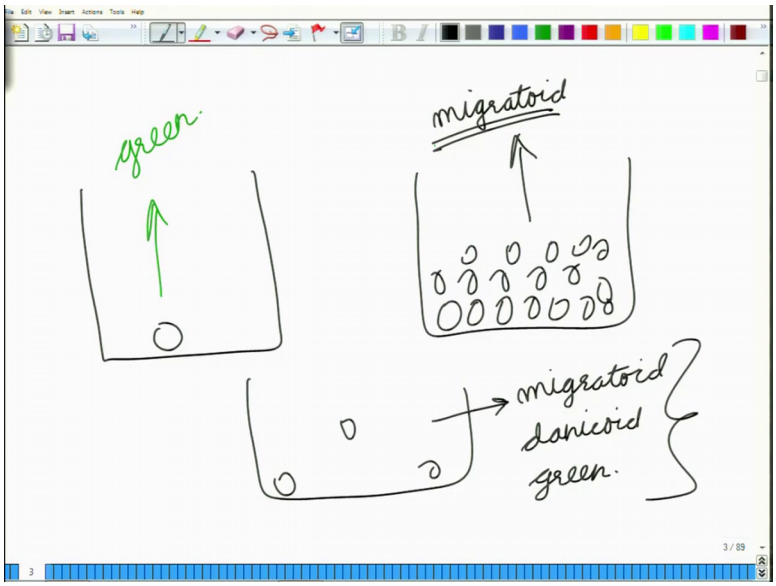

So, you can keep these larvae either solitary. So, in that case you have a container or a cage in which you have only one larvae or you can keep them out in a very dense format. So, you have a number of larvae that I kept together or you can keep them at some medium densities. So, this is the experiment that he did. So, he took out these larvae and kept them at different densities. So, he describes the case. So, that is not very important, but then he says that after a while it was observed that the larvae in the ground cage began to turn green and on the 11th of June they attained the 5th stage they had become quite green, but 6 of them became dark grey almost black in the original cage all the larvae kept their migratory coloration.

So, essentially when you are keeping these larvae in different densities then you are seeing that there are some larvae that are changing their colors then the same experiment was repeated with larvae of danicoid coloration and with the same result. But, only green larvae were obtained in the ground cage as many as 15 experiments with larvae of the second brood of danica reared under conditions of overcrowding yielded interesting results. When the larvae were kept from the first stage in small cages in jars a density of 30 to 50 larvae to 450 to 675 cubic centimeter of space a typical migratoid coloration was invariably obtained in experiments in which the density of the population was less 20 larvae to 2000 cubic centimeter of space besides the migratoid larvae some green and danicoid, but not dark specimens were obtained.

So, essentially if you are keeping these larvae at a very high concentration. So, in this case you are typically getting the migratoid variety and in these cases you are getting some that are migratoid some that are dinicoid and some that are green colored larvae. So, essentially through this experiment what he proved was that both of these varieties were actually one species they are not two different species even though they look very different from each other, but they are one species. So, that was the first level of understanding.

So, remember when we started we said that whenever you are doing a population study you have to define the problem and you have to define the population. Now, suppose earlier I mean before that before this paper whenever we had a study on the locust they only focused on the green locust or the only focus on the dark colored locust. Now, whenever you are talking about only the dark colored locust that is leading to the harm to your crops you are not defining your population correctly.

Because you are missing out all the lighter color versions that are actually also a part of the same population they are the same species they are living together in the same area they are capable of interbreeding together and probably they are interpreting together. And in that case it has to be defined as one population if you are wrong with your fundamentals if you are wrong with defining of your population then the rest of the results are not going to proceed correctly.

So, this was the experiment and he showed that both of these are the same species now when the larvae were kept singly in glass jars they began turning green as early as in the second stage and in the four to fifth stages they invariably became quite green when larvae in the first stage were placed in groups of four in small glasses about hundred cubic centimeters the resulting larvae of the fifth stage presented a mixture of migratoid and green larvae as well as some transitional forms.

So, not only do you have these two varieties here you get a third one if you keep this larvae singly you get only get the green larvae now what are we getting to here if you keep these organisms at a very low density. So, that is just one organism that is having a plenty of space to itself it becomes a green colored variety if it is kept in a very high density it invariably becomes a migratoid variety and if it is kept in between condition then you get all these three different varieties.

So, just by looking at the morphological and the color characteristics of the organisms you should not rush to say that these are different species it is also possible that what you are observing is a trait that is coming out of some extrinsic factors. Now, remember we talked about the extrinsic factors right before and this is one extrinsic factor how much space do you have per animal.

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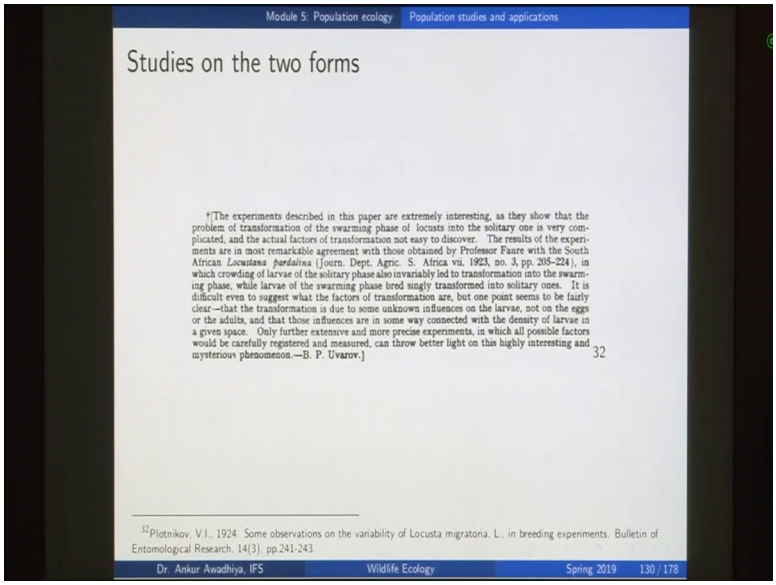

Now, this particular work was made used by another Russian, British scientist by the name of Uvarov and he used these results to say that actually these locusts are coming in two different phases. So, he said that these dark varieties and these light varieties are two different phases and they can change from one to another.

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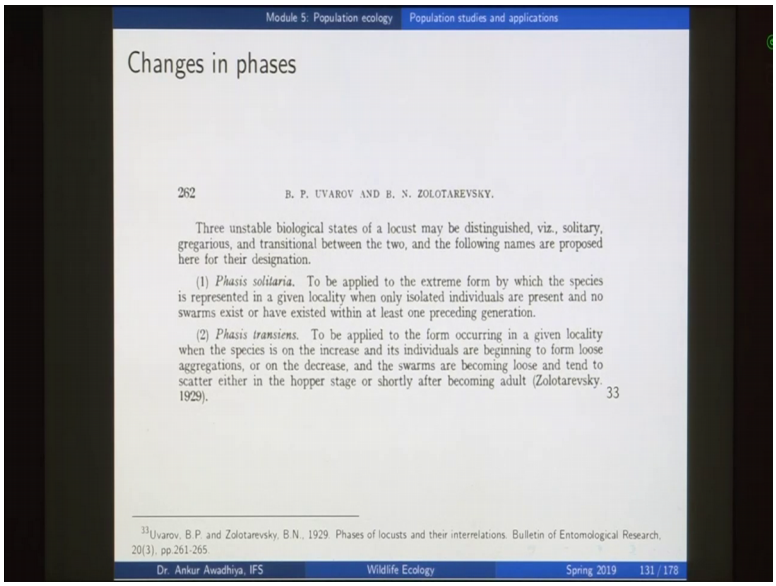

So, if you look at this seminal the seminal paper that was written by uvarov he said that there are these two phases and he named it as phasis solitaria that is the solitary phase and the phasis transiens which is the transient phase and then there is also a third piece. So, phasis solitaria is a term to be applied to the extreme form by which the species is represented in a green in a given locality when only isolated individuals are present and no swarms exist or have existed within the last one preceding generation now not only are these larvae different.

But also the adults that are coming out of them they are also different and uvarov looked at the behaviors of these two these two different forms and he said that we call them as phasis solitaria and physically gregarious and the transitional phase, now in the solitary phase when you have these green colored organisms they will live in that particular place they will have a large space for themselves. And, they have not formed in this generation or the previous generation then we call it a solitary phase then is done with the second phase or the transient fields to be applied to the form occurring in a given locality when the species is on the increase.

And its individuals are beginning to form loose segregation or on the decrease and thus swarms are becoming loose and tend to scatter either in the hopper stage or shortly after becoming adult and then he termed a third phase which was the gregarious phase.

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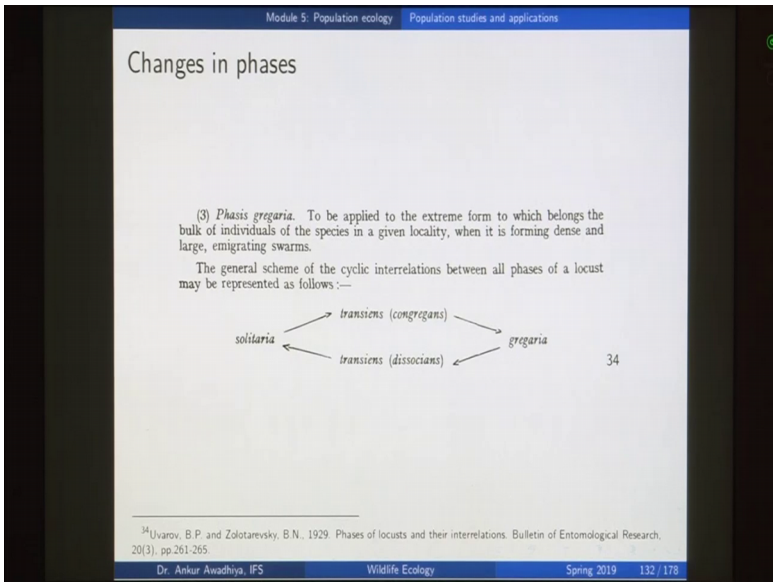

Now, in the gregarious phase it is to be applied to the extreme form to which belongs the bulk of individuals of the species in a given locality when it is forming dense and large immigrating swarms now whatever of said was that these larvae are different similarly the adults are also different and the as we had seen in this case that we have these three different varieties the migratoid that any code and the green variety similarly even in the case of the adults you have these three phases.

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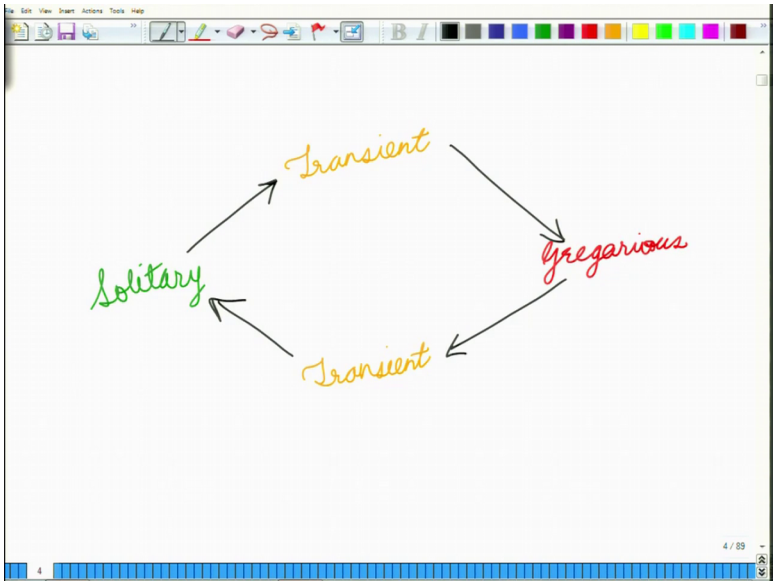

The first one is a solitary phase now if you have organisms in the solitary phase. So, they will have a large space for themselves and they are going to remain in that place for a very long period of time. So, they have been solitary and even in the previous generation they were solitary there is the second phase which she termed as the gregarious phase now the gregarious phase is the phase in which most of the animals are having this gregarious nature most of them are the dark color locust that we saw. So, if you look at this image. So, if you have the solitary phase you will have most of the organisms that are of this color in the gregarious phase most of that organisms will be of this color in the gregarious phase most of these animals are moving or they have and they are forming those forms or there they are starting to move and then in between we have the transient phase.

Now what happens is that if you have a solitary phase and the population is increasing. So, the population will tend to go towards transient if it increases further it will tend to become gregarious if the population is gregarious and you have ample space the number of animals have now come down maybe because of change in the environmental conditions. So, this gregarious will slowly turn into the transient phase and from the transient it moves to the solitary phase. So, at all times we can say that these animals or these insects they remain in these three phases.

So, you have the solitary phase you have the gregarious phase and the transient phase now when the solitary phasis is turning into the transient phase we are we call it the congregants phase because these are congregating and when these gregaria are turning towards solitary then the transient phase is known as a dissocians phase because they are now dissociating they are now coming out of this swarms.

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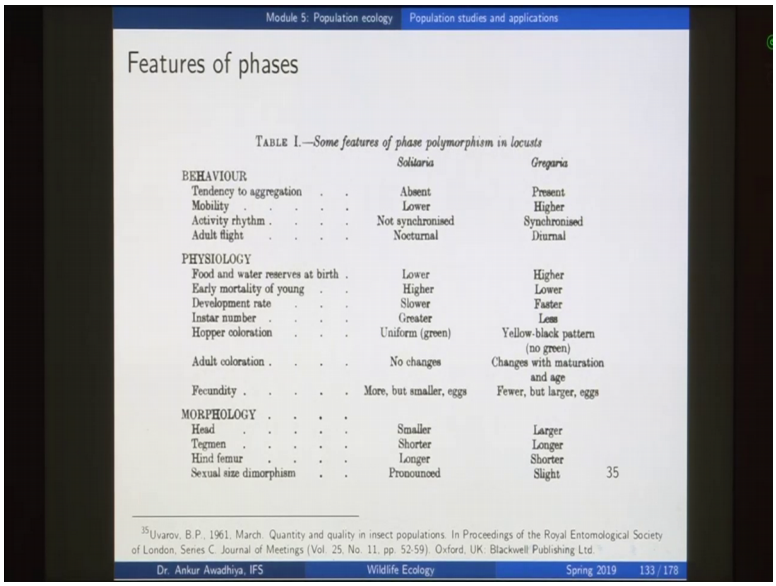

And next once you had this understanding that all of these organisms are belonging to the same species they are the same population then people started looking at the features of these phases. So, for instance if you look at the behavior the solitary do not tend to aggregate the gregarious tend to aggregate there is very little mobility in the solitary phase. So, the solitary phase just remains at one place the gregarious has a very high mobility it makes a swarm it moves away then the activity rhythm it is not synchronized. And solitary in the gregarious phase it is synchronized because, of which they are able to form a swarm, because all their activities are synchronized they all move at the same time.

Then, if we look at the adult flight the solitary phase flies in the nighttime the gregarious phases flies in the daytime. So, you can see that there are huge differences between the solitary and the gregarious phases of the same species. Then if you look at the physiology the food and water reserves in the case of solitary they are lower they are higher in gregarious early mortality of the young is higher in the solitary phase and lower in with the gregarious phase the development rate is faster in the case of gregarious it is. So, in the case of gregarious you will have less mortality of the young ones and a very fast conversion into the adults the number of instarts is also less.

So, instar refers to the number of larval stages that you have. So, you can see that the gregarious phase has been evolved in a manner that it does everything very fast. So, it

lays. So, when it lays the eggs then the eggs have a very less amount of mortality they very quickly convert into adults they have lesser number of in between hinges which are stages that are known as instars then if you look at the hopper coloration it is green in the solitary phase and yellow and black in the case of gregarious phase as we have already seen in the pictures then the adult coloration does not show any changes in the solitary phase whereas, in the case of the gregarious phase it changes with maturation and age.

So, the solitary one will always look green in the case of the gregarious phase it will become dark of it time then the fecundity is more in the case of solitary wave, but they have smaller number of smaller size takes in the gregarious phase they have fewer number of eggs, but they have larger size takes. So, because you have larger sized eggs; so, there is more amount of food that is available because of which the mortality is less because of which also the development is fast and you have lesser instars. And, you very quickly convert the eggs into the adults now the morphology is also very different in both of these phases.

So, whenever you are looking at a population study whenever we are talking about the dynamics we first began with describing the problem. So, we are studying the problem of where these are coming from how does the population change then we. Secondly, we define the population when we were defining the population we describe all different stages we looked at different life forms then the next stages to look at the timings when do they change what is causing this change.

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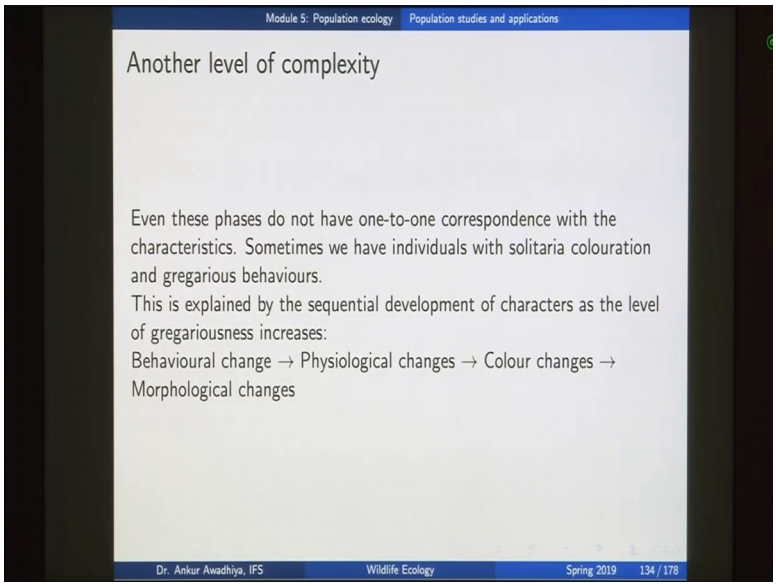

So, another level of complexity is that even in the case of these phases there is not a one to one correspondence between the characteristics. So, even though we are on the very blunt kelly earlier we said that these are two different species then we said that these are the same species, but then there are these two phases and they have very different characteristics, but then there is a level of complexity the complexity is that the solitary phase will not always show the solitary characteristics it may at times show. So, some gregarious characteristics similarly a gregarious phase will not always show all the gregarious characteristics it might at times show some solitary characteristics.

So, essentially when we looked at our computations when we said that we have this formula that is applying to all the cases this is a very this is a this is an extremely theoretical way of explaining things if you look at the field situations in a number of cases you will find things that change in the fields. So, in this case you have you have individuals with solitary acceleration and gregarious behavior now this was explained later on because we saw that there is a sequential development of characters.

So, first of all there is a change in the behavior after there is a change in the behavior we have physiological changes in terms of some hormones that are produced once you have these hormonal changes then the color changes and then there will be morphological changes.

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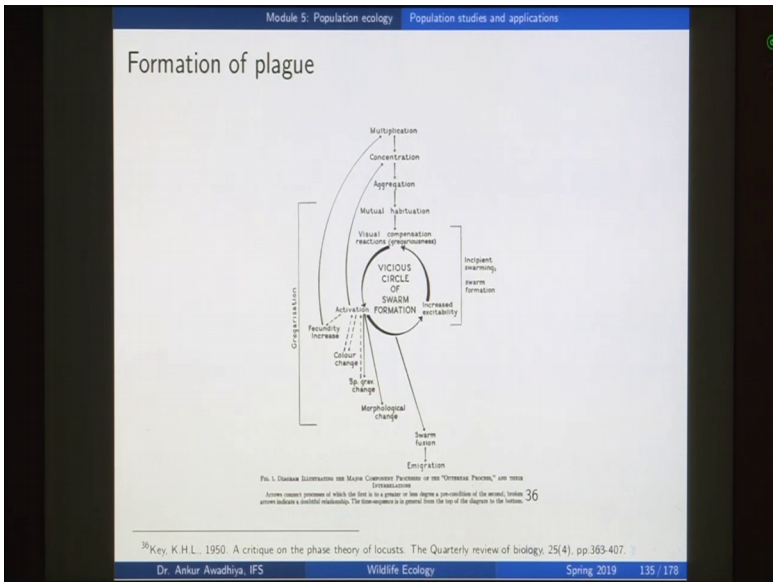

So, with this level of understanding we came to such a figure where we say that when there is a very high level of multiplication. So, when the numbers are increasing now these numbers could be increased and could be increasing of n number of factors now if for. Because, of any factor if they are having more amount of food or maybe a better climate then in that case the numbers increase whenever there is an increase in the numbers. Then the concentration of these organisms increases in the area now, when you have a higher concentration. So, most of the larvae tend to go towards the gregarious style and once that happens you have more amount of aggregation there is a mutual habituation and a visual compensation.

So, essentially what is happening is that when you have all these larvae that are together they are seeing each other at a very close proximity they are smelling each other at a very close proximity and because of which it leads to certain reactions which makes it into a swarm. So, the adults that form in these areas they are also getting mutually habituated they are also getting visual compensations they are also touching each other which then changes the behavior. So, once that happens you enter into this vicious cycle of the swarm formation.

So, you will have activation once there is activation there will be a change in the color then there will be a change in the specific gravity there will be morphological changes there will be an increase in the fecundity. So, they will lay eggs more often even though

they are laying less number of eggs, but then they lay eggs much more rapidly once that happens, because you are having more number of eggs then that will also lead to multiplication. So, it tends to give a positive feedback to itself.

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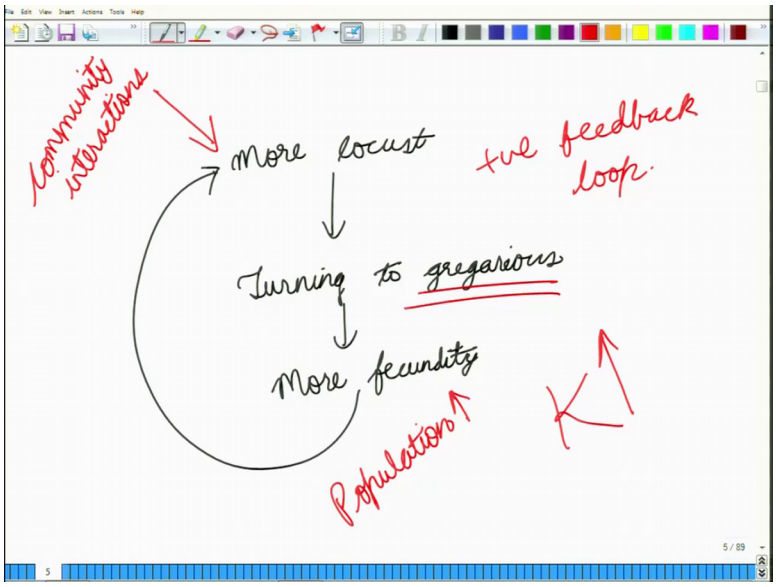

So, if you have more locust. So, more locust will lead to turning to gregarious phase now if you have a locust or if you have a group of locust that have turned into gregarious phase then they will lay more number of or they will have more fecundity, because they lay eggs very quickly and these eggs will also have very high amount of nutrients. Now, if you have more fecundity that will again lead to more number of locust which will again lead to this formation of gregarious characteristics which will further increase fecundity.

So, basically once this phenomenon has started it gives it a positive feedback and. So, this the size of the population goes on increasing. So, you trigger this population month and then it will start to explode now once that happens. So, there is this one phase because of which it is growing the positive feedback then at the same time it leads to the formation of a swarm now because you have a large number of individuals that are here in this place. So, after a while the resources will start becoming less and when the resources are becoming less.

So, in that case these organisms will form large size forms and they will start to move from one place to another place now we have seen this in the case of migration now in

the case of migration there was a seasonal movement of organisms from one place to another place say in search of food in search of better conditions or to get rid of a climate that was extremely harsh. So, we saw it in the case of birds now in this case this is not a migration, but this is actually a nomadic behavior.

So, these locusts they will move out they are not going to come back to that same place, but they will move out in search of more and more amount of food. So, there will be emigration from this area now if you have this activation once you have this activation there will be animals that will be going out there will be more number of animals that are getting into the system. And, at the same time there is an increase excitability of these particular animals.

So, if you have these insects that are extremely excited. So, in that case you will have other behavioral changes more amount of swarm formation and then because they are more excited they will again move into this field and they will lay even more number of eggs because they are completely excited animals now the point is till this point we are looking at the changes in the population. So, we are looking at only the biotic level changes what about the abiotic level changes now remember whenever we are talking about this population this population is a part of some community this community is a part of some ecosystem.

So obviously, the community is also playing some role in this population it is also influencing it positively or negatively the ecosystem is also influencing it positively or negatively. So, to understand this matter even fully did people started to look at.

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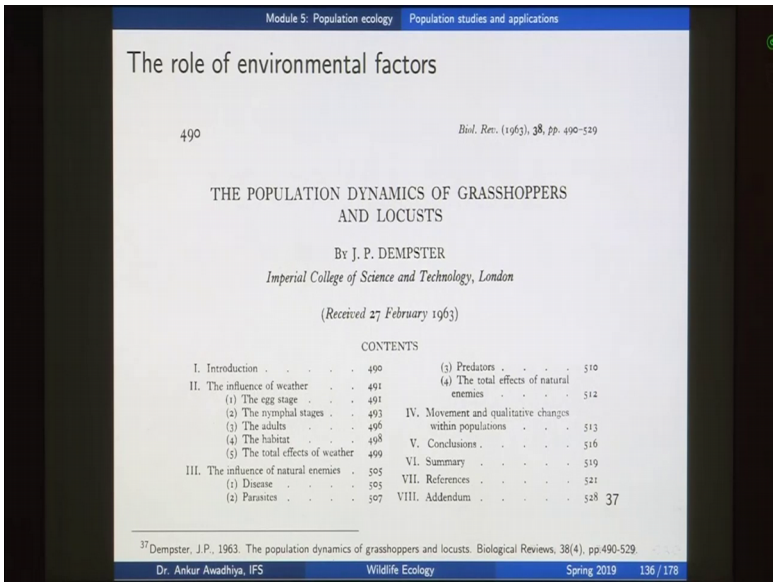

The community level interactions and the ecosystem level interactions. Now, what are these interactions? If you look at the community level interactions there are certain diseases, there are certain parasites there is some predation and which is leading to some amount of changes now. Because, if this phenomenon if it went on going again and again because you have a positive feedback loop. So, if you have these more number of locusts you will always have locusts that are gregarious locust.

So, then what is there that will again convert it from a gregarious nature to a solitary nature there has to be something now that something will act at this stage. So, you have some community interactions now these community interactions could be in the form of predation of the eggs it could be in the form of parasitism of the eggs it could be in the form of some diseases at the same time there are some ecosystem level interactions in the form of the abiotic components.

So, you have the influence of the weather now of course, there has to be some cue that is asking these locusts to turn into a gregarious phase at some particular point of time now what are those kinds of cues now the first thing is if you ask this question why should this locust convert itself into a gregarious phase now every organism needs to live more and more number of off springs, but then we had talked about the canning capacity the carrying capacity or key that is there in every environment now if there is a situation in which the population size is increasing.

So, there has to be a larger carrying capacity of the environment to cater to the needs of the large size population. So, if you have a larger population if you if there has to be a population increase there has to be an increase in the carrying capacity of the environment. Now, in this case the environment consists of say food, now if you have if you think like a locust if you want to have more number of eggs they should also be a be more amount of food that is available for the office springs to get. Because remember in the case of evolution we only talk about fitness.

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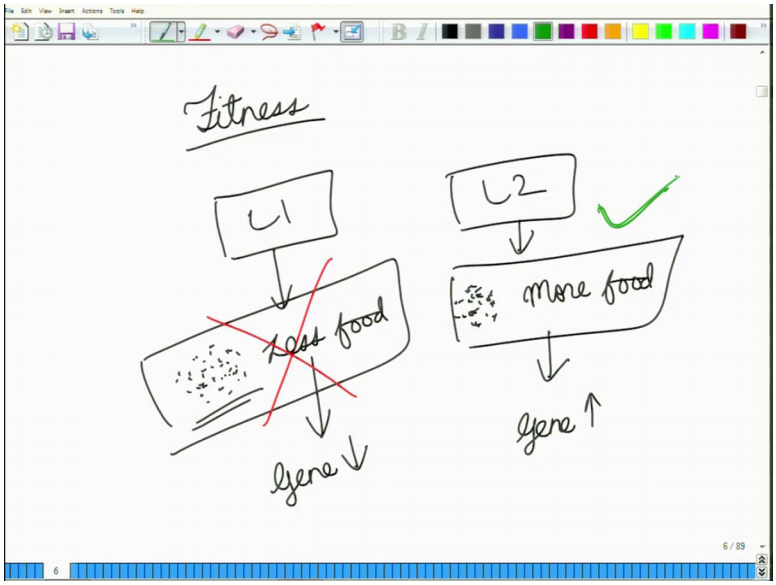

Now, fitness is not just an organism that is living that is producing more number of office springs, but then more and more of those office springs should also survive to the next generation. So now, you consider two locust let us call them l one and let us call them l two now, the l one locust has some genes because of which it lays a very large number of eggs in a season that does not have large amount of food. So, you have more number of eggs and you have less food. So, in that case most of these office springs die out. So, at then what will happen you will have that this particular gene that was leading to this behavior this beam will reduce in its frequency.

Because it is not able to leave enough number of bible off springs for the next generation; now let us consider a two that has some genes. Because, of which it only leaves more number of eggs when there is more food. Now, in that case these off springs are able to survive better because of which this particular gene increase in frequency.

Now, through generations well find a situation in which more and more of these genes the l one kind of genes they will be removed from generation to generation and more and more l two tech kinds of genes will increase in the gene pool.

So, there has to be some correspondence between the amount of food and the amount of and the number of x that a particular organism is laying or this particular population is laying. So, evolution can occur at the level of individuals or region it can even occur at the level of the populations. So, if you want to have more and more of these characteristics there has to be some cue especially in the form of weather. Because, if you have weather in which you have more amount of moisture you have more number of plants that are growing. So, in that case the population will get this cue that it should have more and more number of eggs.

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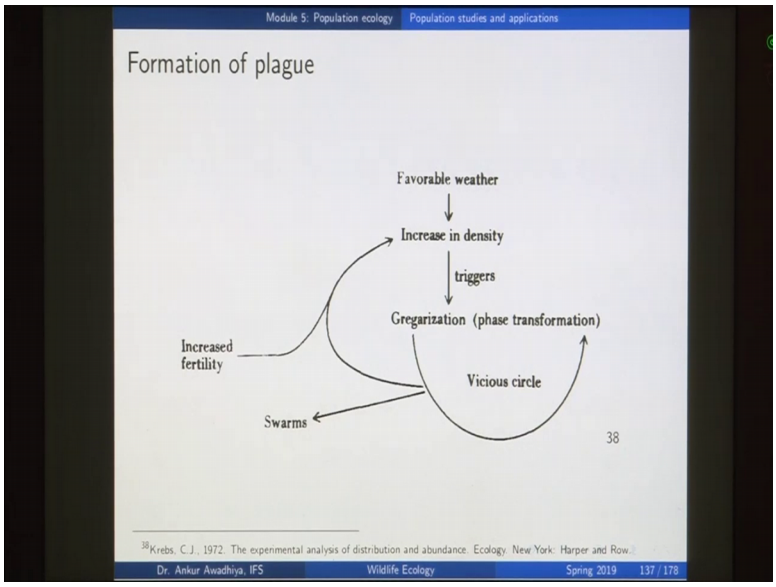

So, then we come to this particular model. So, you have a favorable weather which increases the density which further triggers the gregarization phase. So, the solitary locust are converting into a gregarious locust once that happens you have the vicious cycle in which this gregariousness increases gregariousness even further it leads to an increased fertility. You have in even more increase in density it is forming swarms and it is going out and then you have the impact of radiation you have impacts of parasitism or probably you have a weather condition that is not that good in that case the density would reduce if the density reduces in that case this gregarization is then reversed.

So, from the gregarious phase the locust converts into the solitary phase and this whole phenomenon stops and it will keep at in this solitary phase today again gets a favorable weather. So, probably it gets a favorable weather once on 15 or 20 years. So, this is when the population increases in size; now once you have come to that level of understanding then the next question would be how is this organism in able to know that the weather is favorable or not what are the kinds of cues that it is getting from the environment.

So, now we are talking about behavioral ecology the second thing would be if you have an increase in density then how does this organism convert from solitary behavior to the gregarious behavior. So, in that case now we are getting into the biochemical aspects of this ecology and this work is still continuing.

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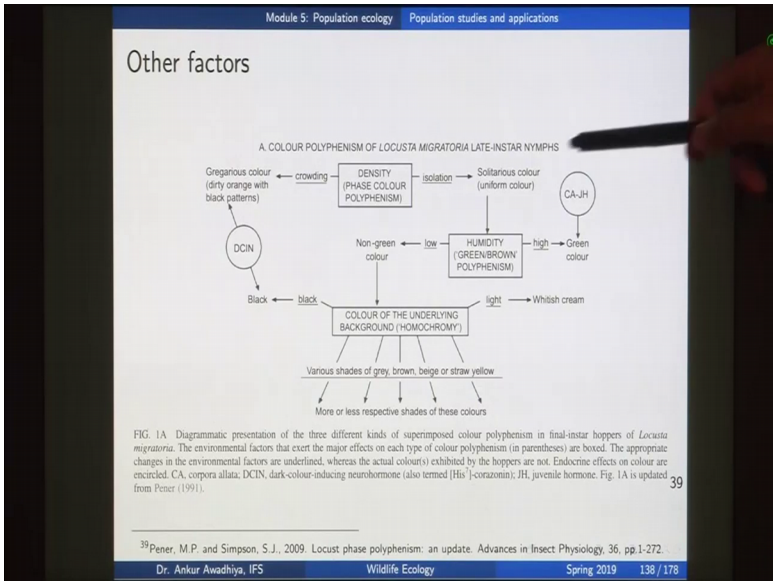

And so now, we know that there are certain juvenile hormones that are leading to this change in the color and there are some neuro chrome molecules that are also leading to this change in color and we are now working on these aspects. So, whenever we talk about a population study it can be studied in different aspects. So, you can study the static characteristics you can study the dynamic characteristics; now whatever you are studying you will first start with defining the problem what is the particular parameter that you want to study we will start with defining the population. You will start by defining the area in which you are going to perform this study then well when we are when we are defining the population will characterize the population. Once we have

characterized the population next we will ask: what are the particular times of here in which there are these changes.

Because of which we got to know about the weather changes. So, if it is the size of the population is increasing because, we are having more number of x. Then probably it is just before the rainy season next you will ask at what particular stage are we seeing the changes. So, in this case we are seeing the changes in the level of larvae and also in the level of adults. So, these are the two stages at which we are seeing the changes and then you try to join all of these dots together and once you have an understanding next you move on to the biochemical aspects.

So, what are the specific factors that are that are making this organism capable of sensing changes in the weather or sensing changes in the density. So, when we said that we are keeping these larvae together and they become a migratory larvae how are they able to know this is it because of touch is that because of smell. So, people have even done experiments in which case you have.

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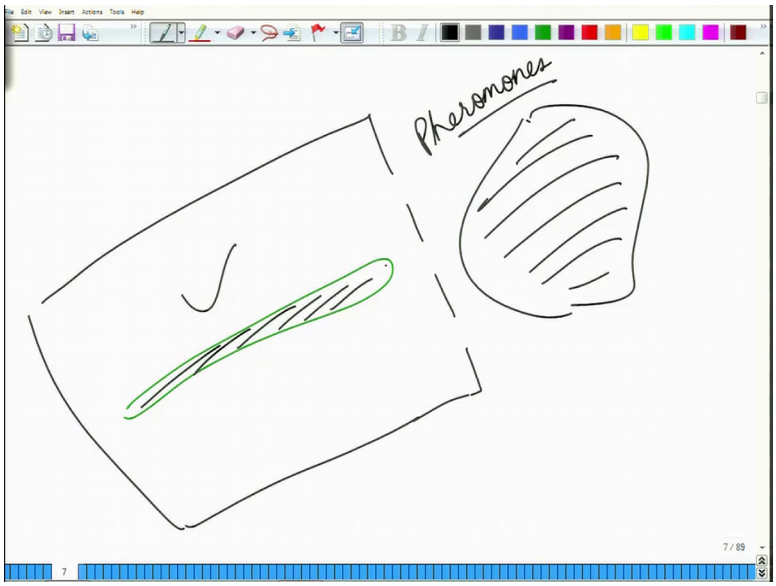

So, you have this green colored lobby in you keep it close to a dark colored organism and then if you allow this larvae to see the this dark colored organism, but it is not able to sense or smell this dark colored organism it continues to remain in a green color.

So, probably because you are separating them away using some piece of glass. So, probably these particular larvae it is kept in a glass bottle and in this case even though it is able to see these dark colored individuals in the surrounding it is not able to change itself, but then if you provide some holes in this compartment. So, that it is able to smell the your darker colored organisms in the surrounding then it is able to change its color into a darker form which will also tell us that there are some pheromones that are involved.

So, when we are looking at these population level studies we can get into as much detail as we want to, but whenever we are starting you need to remember that you have to look at static versus dynamic problems and the three stages at which you will work with your problem defining the problem in the population defining or understanding the time of the year in which you have the changes and understanding the stage in the life cycle in which you are seeing the changes. So, that is all for today.

Thank you for your attention [FL].