Lecture 16 Transcript

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In this session we are talking about invasive species.

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So the learning outcomes for this session:

We should be able to describe what makes a species invasive, we should be able to list some characteristics of invasive species.

We should be familiar with the ways invasive affect local species and ecosystems.

And we should know some basic techniques to reduce the spread of invasive species.

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An invasive species is one that has introduced to a new area and is harmful to the local organisms.

It could be any organism type. It is important to understand that not all species that are introduced are harmful and most do not remain long in the new environment.

They usually have characteristics that make them particularly good invaders, which we will talk about in this session. Most invasive species are introduced by humans either deliberately or by accident.

It is thought that nearly half of species that's 42% are at risk of extinction or severe harm by invasive species.

Some famous examples that we will be coming back to include the cane toad in Australia, the zebra mussel in the USA and Japanese knotweed across Europe.

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A rule of thumb for numbers of species that become invasive is the 10s rule. Williamson came up with this to describe the invasion success of plants in England, but the rule is quite robust and can be applied to many different invasive organisms, with a few exceptions.

If a set of non-native species are introduced to an area only 10% will actually appear in the wild. Then 10% of these will establish and 10% of those will become invasive.

For example, if somebody ordered 1000 beautiful plant species from South Africa and put them in their garden in Myanmar. Only 100 of the species would escape the garden. Out of these 100 only 10%, so 10 species will establish in the environment and reproduce and spread. Finally, only one of these species will become invasive so of the initial 1000 species, only one will become invasive. And has 0.1% chance.

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Very few species invade a new ecosystem. This is not coincidence or chance. There are certain characteristics that might help the species to become invasive and it is useful to know because then we may be able to predict which species become invasive, monitor them, control them or prevent them from invading at all.

It is important that a species can be very adaptable to different conditions and to have a very rapid life cycle. They must grow and reproduce rapidly, and they must have many offspring and a high dispersal. This means if we look at the population ecology survivorship paradigm from week three, so that's this figure here. We can see that invasive species tend to be r-selected or type three. What is interesting is that if we look at the survivorship curve in this figure. We see the Type three species do not expect to live to adulthood. So they have many, many offspring to increase the chances of some of them getting to grow to adulthood and reproduce. But in the case of invasive species they have moved to a new place. Conditions might be different. The reasons for the lower survival at home in our home range like predators or parasites might not be here in the new area. So numbers increase rapidly and they become invasive. Their ability to grow very rapidly might mean they compete for space and resources and so other native species might not be able to compete.

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Invasive seem to actually perform better in their new location compared to their home location or home range. There are three main reasons for this.

The first is that because of niche theory, they will have less competition with others of the same species or individuals of a different species. It is unlikely that many individuals of the same species will be relocated to an area. And even if they are they disperse very rapidly, so they may not be in very high competition, and the local species may have different requirements, which means that they can partition resources. This is called niche partitioning. Or the local species may just be poor competitors.

Alternatively, the new place maybe might actually be better or as good as the home range for the species. In the UK, we have many invasive Asian species such as rhododendron, Himalayan balsam and Japanese knotweed. The climate is similar so that these species can rapidly invade without suffering stress.

The third point is that many species will relocate will move without the predators or parasites. This is known as the enemy release hypothesis.

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The enemy release hypothesis states that in new environments the invader will experience less pressure from grazers, predators or parasites, and so should increase in abundance and distribution.

When it arrives in the new place, it may have left behind enemies that reduce their growth and fitness.

The hypothesis suggests that natural enemies are the main reason that the invader is not usually the most dominant species in its home range but becomes enormously dominant and numerous in the new range.

It also suggests that the defences it may have needed at home are not so important here, so it can redirect its resources into competition.

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The enemy release hypothesis is just a hypothesis and there are many conditions and criticisms of it.

The enemies in the new area are very important to the success of the invader. If you weren't assessing how likely it was for a species to become invasive in a new area, you would need to look at the new potential enemies. For example, if there are mainly specialized species in the area, such as plant herbivores and insects. Let's say we want to put a new plant in an area, but all the local insects are specialists, which means they will only eat a very limited number of plant species. Our new species is likely to become invasive because none of the insects will eat it. Then we need to knock out the population size of the enemies. Are there lots around to keep our plant species under control?

It is not very useful if we have lots of species of generalist feeders, that will eat anything, but there were only a few of them.

Finally, we could consider if they eat the leaves, seeds, flowers or roots. This would have a big impact on the success of the invader. If there are a lot of seed predators, this would reduce reproductive success, while a herbivore that ate the leaves would reduce growth and potentially the ability of the plant to photosynthesize and gather resources to make seed later on.

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Wolfe carried out a very neat experiment, looking at the ability of White Campion or White Cockle *Silene latifolia* to spread. *Silene* is native in Europe, where it is a small pretty flower that has a scent and flowers at night. It grows along roadsides and field margins. In North America, it was introduced accidentally and has spread all over the continent. It is termed a noxious weed, which means it is so harmful and invasive, that if you see it, you must remove it. In America it invades fodder grass fields and it is recommended that farmers remove it at the seedling stage. This is very different to Europe, where it is a very popular flower.

Wolfe asked the question if enemy release is the reason *Silene* is so invasive in America. When it moves across the Atlantic, does it leave its enemies behind? This seems a good explanation for the success of the species. Wolfe hypothesized that enemy attack would be greater in Europe than in America. *Silene* has a wide range of herbivore grazers and pathogens in Europe. So it was a very interesting test species.

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Wolfe found very strong results. Overall *Silene* was 17 times more likely to be attacked by some kind of enemy in Europe, compared with North America. In North America 60% of the *Silene* populations had no enemies at all, while in Europe only 16% had no enemies. In Europe 50% that's half of the populations had damage for more than one organism type.

The aphids and the flower herbivores are both generalist feeders, meaning they fed on a wide range of hosts. The fungal diseases and the fruit predators were specialists, they attacked only a small number of plant species. But if you look at the difference in the bars between Europe on the left and North America on the right in each graph, we see that the percentage of individuals affected does not seem to be very different between generalists and specialists.

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There could be three outcomes of the parasites that live on an invasive species. They could continue to affect the invader by riding with them to the new place. For example, animals bought as pets and released could have fleas, ticks that continue to affect them. Or there might be local parasites that could move on to them. Finally, they might stay free of parasites in the new place.

So this paper by Torchin and colleagues looked at the green shore crab *Carcinus maenas*, to see if it was released from this parasite when it was in a new place. It is native in Europe and has a parasite that will effectively castrate it. That is, it will remove its ability to reproduce. Torchin and colleagues looked at crabs in the whole native range of Europe, and also the areas at invaded including Australia, South Africa and the USA. In these two graphs, we see that for the black dots which is the home or native range. There is a negative relationship between the percentage of parasites and the size of the crab in the top graph. And the weight of the crab in the bottom. So as you get more parasites, the crabs get smaller.

And areas where 75% of the crabs have been parasitized, they are very small and have low body weight. So the parasite is taking resources from the crab and preventing them from growing large.

Now look at the white dots here. You see that all the dots are on the y axis. This means that the percentage of parasitic infection is zero. So there's none through this distribution. So it's zero parasitic infection. And look at where they are on the Y axis. They are higher than the black dots. So they have no parasites in Australia, South Africa and Australia and they are bigger than the crabs in Europe, where they are at home.

If you look at the bottom graph, it is not quite so obvious for weight. So you have some of the Europe ones that are heavier. This could be for a number of reasons such as quality of food. But the general message here is that the green shore crab has escaped its parasites when it invades other areas, and it gets bigger as a result. Therefore, there is support here for the enemy release hypothesis.

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Now, there is strong support for the enemy release hypothesis, I would like to highlight some problems or assumptions that the hypothesis makes.

It is not always true of every invader.

And it is a very simple idea. Natural ecosystems, do not often work so simply.

There are four key assumptions.

The first is that the native specialist enemies are not present in the new range. So when the invader moves from his home range to its new range, the specialist enemies are not in the new range.

It also assume that the enemies cannot switch to the new invader.

We also have to assume with this hypothesis that if there are generalist enemies, those that will attack a wide range of hosts that they will avoid the invader.

And we may have to assume that they cannot take advantage of the loss of enemies because there may be new stressors like climate or some kind of food resource problem and so on.

We also need to bear in mind that the timeframe for invasion means that after a while the natural enemies in the new range would adapt to start feeding on the invader. But by this point, the damage to the ecosystem, or to the native species might already be extensive

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There are four main ways that invaders can have negative impacts on the new area.

They can reduce native diversity. In the case of Japanese knotweed in Europe this highly competitive species can displace many local plant species.

So the second point is that they could predate local species. One example is rats. Rats have been living on ships for centuries and there are countless small islands across the world that have seen a ship arrive, and rats swim onto the island and make it their home. In many cases, there were no rats before and they easily destroy entire populations of ground nesting seabirds by eating the eggs.

Spreading disease is a common problem of invasive species. In the 19th century, grey squirrels were introduced to the UK from North America. They were pets and escaped and invaded the whole of the UK. Unfortunately, they carried a disease called squirrelpox, which almost drove the native red squirrels to extinction. For many years, there was a cash reward for killing grey squirrels and they are still considered a pest. Red squirrels are reduced to a few very small populations.

Finally, they can alter the balance of natural ecosystems. This is most easily seen in American beavers who will change the dynamics of forests by cutting down trees and making dams in rivers.

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There are many ways of introducing species, as I'm sure you realized through this lecture. I'll just list some of the most common ones.

Ships take on water to maintain a certain weight. This is called ballast and it gives stability to the ship on rough seas. Unfortunately, they take in water at the start of their journey and let it go at the end. It is thought to be the way that the highly invasive zebra mussels were moved from the Black Sea in Russia to the great lakes in the USA. The ships would suck up the water in the Black Sea, and with it the larvae of the mussels and then later would release the water and the larvae into the Great Lakes. Separate mussels can cause millions of dollars worth of damage to boat engines, power plants and public water pipes, because they grow in such high density is that they can clog up all sorts of different structures.

We talked about shipping and the pet trade.

Tourism is another way invasives spread. There are high reported densities of invasives in tourist hotspots. So, for example, Macchu Pichu or various temples. And people bring them in or sow seeds from the treads of their shoes or the treads of their car tyres and you find very high densities of invasive species at these tourist hotspots.

Finally, it might be deliberate but poorly advised. In 1935 cane toads were brought to Australia from South America to eat the beetles that were destroying sugar cane. So the Cane Toad was intended to reduce the numbers of these beetles, because the beetles were a problem. But toads have an enormous appetite and they will eat almost anything or small animals and some plants. So this creates huge changes in the local ecosystem.

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Invasive Species cost billions of dollars of damage every year. The main economy that is affected is agriculture. It's very expensive to eradicate them or remove invasive species. And there are huge worldwide initiatives that are attempting to remove them. Agriculture is one of our largest industries worldwide and invasive species that either feed on the crops or plants that become part of the crop can cost nations enormous amounts of money. And also it is quite difficult and expensive to try and eradicate them or control them, and it is not guaranteed to be successful.

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So there are three main ways we can remove invasive species.

First is physical control. And this is simply removing them wherever we see them. Pulling out plants or cutting them down, culling or trapping animals are always to exert physical control.

This would not be possible for invasive pathogens or a lot of parasites, unfortunately.

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The second way is chemical control. There are a lot of these that are aimed at insects, rodents and plants. There is a danger of contaminating the area and killing the wrong species. So, these must be used very carefully. There is also a chance of it contaminating the environment and leading to bioaccumulation. So there needs to be a thorough risk assessment before using chemicals.

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The third way is biological control. This is why you actually use an invaders natural enemy against them in their new range. The enemy may eat the organism or give it a disease. It will control the population of the invader. Biological control or bio control usually would need an active management role by humans. One example used across the world is ladybirds. Ladybirds control aphids that eat and destroy food crops in greenhouses and they cost an enormous amount of money every year. Ladybirds have been very effective at controlling aphid populations, especially the seven spot. However, there is a risk to biocontrol, and that is that it may become invasive itself and destroy populations of species that were not the problem. While ladybirds have been extremely effective in controlling aphids, mistakes have been made. A commercial pest company bought in the wrong kind of ladybird from Asia to Europe and this became invasive. It is called the Harlequin ladybird and it is bigger, better defended and more competitive for food than the European natives. So biocontrol can be extremely successful and cost effective, that it needs careful research before any organism is released.

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I thought I'd just give some general advice that official organizations give out to help reduce the spread of invasive species and these are things that you yourself can do so it's things like, be careful about buying native plants for your garden. Make sure that your boat is thoroughly cleaned if you're moving it between lakes or water bodies. Keep your boots clean when you go walking. Don't take anything home from different ecosystems.

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Finally, we need to make sure that invasive species, we understand that they are not the same as introduced species. Many introduced species cause no problems at all.

An invasive species can be anything. It can be a plant, it can be an animal. It can be a microbe.

The enemy release hypothesis could be one reason invasives are so successful, but they have a huge economic cost.

But there is hope. There are lots of ways that we could possibly reduce their spread.

Reading

Begon page 190-197

Williamson 10s rule

Torchin shore crab

Wolfe Silene

Discussion topics

Are there any species in Myanmar that are invasive?

Why are invasive species important in ecology?

What would be some ways of removing an invasive fish from a river?