Disruptive interactions
predator-prey relationships in invasions

Mhairi E Alexander explains the way that normal predator-prey relationships can be affected by the arrival of alien species.

All organisms must eat in order to survive, and for predators this involves killing and eating prey. For the individuals that are involved there are obvious consequences, such as survival or death. However, these relationships also scale up and play a critical role in how populations and communities are structured. Predator-prey relationships are therefore critically important ecological interactions.

The arrival of a new, alien species into a system can have the potential to disrupt these interactions, and much research is focused on understanding why this might happen. Natural systems in South Africa are not immune to the impacts of biological invasions. Current research on the role of invasive species in predator-prey interactions shows them to be of key importance across a range of different environments. But how do invasive species affect these predator-prey relationships? And, importantly, what are the consequences?

Redfin minnows, Pseudobarbus afer, in their natural habitat. Image: Dr Darragh Woodfod

The European paper wasp Polistes dominula on its nest (left) and the German wasp Vespula germanica (right). Image: Wikimedia Commons

Native predator good – alien predator bad?

In any predator-prey interaction, the prey either 'live' or 'die' and this outcome doesn't depend on whether the predator is native or alien. What is often important in the alien-native interactions, however, is the rate at which predation occurs. Invasive species are often 'better' predators, consuming more prey than native counterparts at a much faster rate – and this can of course have serious consequences for the prey species and their long-term survival.

South Africa has experienced a number of fish introductions and many of them are large predatory species that have become established in headwater streams. Where they are found, native aquatic invertebrates and small fishes, like the endemic redfin minnow (*Pseudobarbus afer*), are often absent. Laboratory feeding trials have shown that invasive fish, such as largemouth bass (*Micropterus salmoides*) and sharptooth catfish (*Clarias gariepinus*), consume a greater number of prey at a faster rate in comparison to native fish across a range of prey densities. Researchers therefore suggest that the negative impact, which is consistently observed across invaded river systems in South Africa, is driven considerably by this increased predatory ability of the invasive fishes.

But why are these invasive fish better predators than the natives? In general, predators are adapted for catching and consuming prey, while prey are adapted for escaping from such threats. And in fact in South Africa's headwater streams, many of the small fish move into central channels at night, where they remain suspended in midwater. This is known to be an effective strategy against predation by native eels that move along the sides of the streams, searching in crevices and vegetation for food. These small fish however then become vulnerable to predation by the invasive predators that swim through these channels searching for a meal.

This is an example of an evolved antipredatory response towards a native threat that isn't appropriate in the face of an invasive predator. It also highlights clearly a type of impact invasive species can have on predator-prey interactions. However, these documented effects came from studies on existing invasions where impact had already occurred. But what about those species with the potential to invade where impact hasn't been documented? Ideally environmental managers have to predict the impact of a

damaging invasive predator before the impact happens and often knowledge can be gained through studying invasion history of a species from other parts of the world where there has already been a negative effect. An example is that of the European shore crab which has a serious impact on prey communities globally, and work is being done now to prevent the same occurring in South Africa (see box).

The domino effect

When alien predators are introduced to a new area they can have more than just direct impacts on focal prey species. Invaders can also create a domino effect by causing an indirect increase or decrease of an associated species (which can be an animal or a plant, or both). These processes, called trophic cascades, can have significant impacts on a range of species. They also occur among native species. However, the effects of an invader on such phenomena are often hard to predict and can have serious, negative consequences.

Feral cats, for example, are considered to be among the global Top 100 Worst Invasive Species (http://www.issg.org/worst100_species.html) and in South Africa they have effects on small indigenous vertebrates such as birds, reptiles and mammals. This often results in the decline of indigenous species with impacts tending to be greatest on endemic birds on islands.

On Dassen Island, 10 km off the West Coast of South Africa, feral cats were found to severely alter the numbers of nestling seabird chicks through predation, resulting in decreases in adult populations. Research has shown that seabirds can drastically alter the composition of flora on breeding islands by providing nutrients for plant growth with their excrement. Once these colonies are decimated, interruption to this nutrient cycling can dramatically change plant communities. As a result of this trophically cascading threat, a feral cat eradication programme was started in the 1980s and had successfully exterminated the invasive species by 2008.

Such indirect impacts of introduced species can also affect society, and invasive predators can cause serious problems for the economy. For instance, there are a number of industries in South Africa that are dependent on pollination by bees and other insects, e.g. the wine trade. However, this is under threat with the arrival of two voracious predators, the European paper wasp (*Polistes dominula*) and the German wasp (*Vespula germanica*). Through predation on bees and insect larvae, these wasps are placing serious pressure on the native pollinators. Their invasion is showing no signs of slowing down. There is therefore great concern that with an increase in predation by wasps, and a decrease in pollinator prey, there may be a serious impact on the wine industry that requires the services of these native pollinators as part of the crop cycle. As such, in South Africa's Western Cape, there is a concerted effort to contain the spread of these invasive predatory insects (http://www.capetowninvasives.org.za/project/animals).

It's not all about invasive *predators*

Although there tends to be a greater emphasis on invasive predators, alien species can also arrive in a new region as prey. The majority of scientific studies tend to focus more on predatory invasive species as they generally have a greater, more conspicuous impact. However, what this neglects is that an invader may also become an important food source to native predators. An interesting question is therefore what happens when native predators are faced with a new type of invasive prey?

Well, firstly, there may be a number of challenges to overcome for a native predator if it is to effectively consume an invasive prey species. However, an invader might not fall within the feeding capabilities of a native predator and it might continue to focus its feeding on native species. This reduces predation pressure of the invasive species and can allow it to spread. In marine systems in South Africa the invasive barnacle (*Balanus glandula*) is continuing its spread along the coast, and studies on predation by native whelks have shown them to actively avoid eating this invasive prey, preferring to consume the native barnacle. It is suggested that this is because the native has thinner shells and more easily accessed flesh.

The European shore crab: an incoming predatory threat?

A young European shore crab showing the characteristic green colour.

Image: Wikimedia Commons

The rocky intertidal shore of South Africa's West Coast is home to a great diversity of species owing to the cool, productive upwelled waters. However, one important group of taxa that is poorly represented in this zone are predators. This is in contrast to many global rocky shore regions and is often related to an unsuitable and harsh environment. There is therefore an 'empty niche' that is not filled by any native predator and we are potentially playing a waiting game where an invasive species may arrive and cause devastation.

This may have already occurred through the introduction of the European shore crab (*Carcinus maenas*) to South Africa via ballast water transfers from large ocean-going vessels. Owing to these introductions, the shore crab has now established populations in Table Bay and Hout Bay harbours. This species is another top global invader with a devastating impact history whereby it alters community make-up and structure through heavy predation on species such as mussels and whelks in regions of invasion. There is therefore great concern that this species might have similar effcts on the already marginalised native species if it were to make its way out of these harbours.

The worry is so great that an eradication programme is underway to investigate the feasibility of removing this species from Hout Bay. Only time will tell if this programme will be successful. In the meantime this preatory niche remains unfilled and much focus of marine invasive screening is on identifying those species that might be voracious predators with the capacity to cause serious impacts on South African intertidal rocky shores.

The native predatory whelk, Trochia cingulata, *feeding on an invasive mussel.* Image: Dr Tammy Robinson

However, invasive prey may even become the preferred resource and a native predator that is able to consume a new dominant prey type will be at an advantage to those that cannot.

The mussel invasions that have occurred in South Africa (detailed in Dr Tammy Robinson's article on the patterns and trends of marine invasions) are an example of a case where there have been significant changes to prey availability. Historically, native predatory whelks have preferentially consumed the once abundant native ribbed mussel (*Aulacomya atra*). However, these whelks are now presented with a very different foraging landscape owing to the Mediterranean mussel invasion. The whelks have subsequently adapted to the new dominant invasive prey and consume them in greater numbers in lab feeding experiments, even when they are offered in combination with their previous favourite, the native ribbed mussel.

What is also interesting is that this experience with one invasive mussel has seemed to make them even more capable of feeding on a second newly-invasive mussel species, *Semimytilus algosus* that, introduced from Chile, has only recently become established.

The importance of invasions in predatory interactions

It is clear that invasive species play an important role in community dynamics and the functioning of ecological systems. This is not lost in the context of predator-prey interactions and invasive species can pose a threat to not only native prey populations but can play an important role as a basal prey resource with far-reaching effects on the associated species.

In South Africa, invasive species also play an important role in predator-prey relationships, with research showing them to be drivers of species loss when they occur as predators, as well as having an important role as a prey resource. Ultimately, all predator-prey interactions are about life and death but it really does appear that what is doing the killing and what is being eaten have important consequences for the county's natural systems. **Q**

Originally from Scotland, Mhairi Alexander completed her PhD in 2012 at Queen's University Belfast in Northern Ireland. Her thesis investigated the predatory strength of a native amphipod species that is ubiquitous on intertidal rocky shores around the UK and Europe. She moved to South Africa at the beginning of 2013 to work at the C•I•B at Stellenbosch University on predicting impacts of invasive species through resource use quantification. Although a lot of her work to date has been in marine systems, she now also studies freshwater invasions in South Africa in collaboration with researchers at the South African Institute for Aquatic Biodiversity in Grahamstown.

Grasslands of Lesotho helped to inspire a career in invasion science

Growing up in the grasslands of the mountain Kingdom of Lesotho, Dr Sebataolo Rahlao has travelled a long road to academic and personal success in invasion science. *Quest* asked him a few questions about his career in invasion science.

What is your current position?

I am the Director of Invasives Monitoring and Reporting at the South African National Biodiversity Institute (SANBI).

What did you study?

I started my academic career at the National University of Lesotho, where I successfully completed a BSc with my majors in biology and physical geography. I then decided to trade the mountains for the sea, and enrolled for an honours degree at the University of Cape Town (UCT). I continued with my studies at UCT and graduated with an MSc in Conservation Ecology. From there I moved to the Stellenbosch winelands to pursue a PhD at the DST-NRF Centre of Excellence for Invasion Biology (C·I·B), where the focus of my thesis was on the vulnerability of ecosystems to grass invasions (using *Pennisetum setaceum* as a model) under different scenarios of global change.

Why did you choose to follow a career in invasion science?

Initially, I wanted to specialise in environmental science and enrolled for a BSc Hons at UCT. It was during this year that I became familiar with the Centre of Excellence at the Percy Fitzpatrick Institute at UCT. I met with Prof. Morne du Plessis, the then Director, and told him about my interest in their MSc Conservation Biology course. I was told the course was very intensive and that I would need to work ten times harder than in my Honours course. This was the motivation I needed, and decided to give it my best shot. During the course of that year, I was introduced to invasion science by Prof. David Richardson, Director of the C·I·B, and Dr Guy Preston, Director of the Working for Water programme. I found invasion science fascinating and decided to specialise in it. The following year I enrolled for a PhD with Prof. Karen Esler at the C·I·B.

Sebataolo Rahlao. Image: Sebataolo Rahlao

What does your position as Director of Invasives Monitoring and Reporting involve?

In my position, I have to provide leadership in the development of a programme that monitors and reports on invasive alien species in South Africa. I regularly report to the Minister of Environmental Affairs on the status of invasive alien species in South Africa. A large part of my work also involves maintaining strategic partnerships to strengthen the use of scientific evidence for the management of invasive alien species.

What are the most important lessons you've learnt during your career?

It is of utmost importance to understand the people you work with and treat them with respect. Confidence and competence will get you far in life – spend time and any resources you have to develop that combination! In some instances one needs to work ten times harder to be successful in your career.

What do you do to unwind?

I am up for a good hike and love to travel.