



Alien invaders

A tale of two crayfish



The introduction of non-native species to new habitats is usually seen as a threat to native biodiversity. What are the impacts of these alien invasions? Are they always bad? Ecologist Zara Gladman explores the stories of two very different non-native crayfish in Scotland

We must make no mistake. We are seeing one of the great historical convulsions of the world's fauna and flora.

Charles Elton (1958) *The Ecology of Invasions*

It is 60 years since pioneering ecologist Charles Elton published his book *The Ecology of Invasions*. Elton highlighted the dangers to our ecosystems of **non-native, invasive species** — organisms introduced by humans into areas outside their natural **range**. In today's interconnected world, invasive alien species are widely regarded as the second biggest threat to **biodiversity** after habitat loss.

In Britain, the aliens have most definitely landed. Grey squirrels, giant hogweed and American mink are among a plethora of non-native animals and plants that have become well-established, often thousands of kilometres from their natural range.

Impacts of invaders

Competition, predation and disease spread by incoming invaders can spell bad news for native species. Non-native species have contributed to the extinction of about 68% of North American fish taxa and threaten over half the world's critically endangered bird species.

The economic costs are eye-watering, with invasions in the UK, USA, Australia, South Africa, India and Brazil costing hundreds of billions of pounds every year. These costs include reduced crop yields, lower income from tourism and negative impacts on ecosystem services including pollination, flood control and water purification. The alien problem has led to the formation of dedicated management groups and steering committees, from the Non-Native Species Secretariat in Great Britain, to the Global Invasive Species Programme worldwide.

Given the huge efforts made by conservationists to understand and tackle the impacts of alien invasions, it is difficult to envisage a situation in which such species might be considered beneficial, or be deliberately introduced into a new ecosystem. In recent years, however, the notion that all non-native species are 'bad' has been challenged.

This *Impact* column tells the stories of two very different non-native species in Scotland: the North American signal crayfish (*Pacifastacus*

leniusculus) and the white-clawed crayfish (*Austropotamobius pallipes*), which is native to England and Wales but not Scotland.

The ecology of crayfish

Crayfish are decapod ('ten-footed') crustaceans, of which there are over 600 described species. These omnivorous, lobster-like creatures have a broad diet, feeding on plants, detritus, invertebrates, amphibians and fish. Their relatively large size (around 17.5 cm long on average) and the high densities that populations may reach, mean that crayfish have a significant impact on aquatic environments, and are often considered **keystone species**.

Crayfish have been of interest to humans for centuries, largely as a food source. Thomas Henry Huxley — nicknamed Darwin's 'bulldog', because of his passionate support of Darwin's evolution theory — used crayfish as a model organism for the study of zoology (see Box 1). They have also been used as agents to control disease-carrying snails, bait for predatory fish and **bioindicators** for heavy-metal pollution. Not least, they've inspired art, literature and music (see Further reading).

This wide range of benefits probably explains why there have been so many introductions of non-native crayfish to new habitats across the world.

Signal crayfish

The signal crayfish is **native** to western North America, between the Rocky Mountains and the Pacific Ocean. Distinguished by white patches or 'signals' on its **chelae**, the species is found in rivers, lakes and other freshwater habitats.

Signal crayfish first arrived in Europe in 1959, when they were imported to Sweden for **aquaculture**. The species was later exported to several other European localities, including Britain.

Aquaculture entrepreneurs set up crayfish farms across Britain, hoping to make the same profits enjoyed by farmers in Scandinavia. Crayfish were introduced to a variety of

Key words

- Ex-situ conservation
- Invasive
- Keystone species
- Non-native/alien species
- Range



Alien species in Britain: grey squirrel, mink and giant hogweed (and see front cover)



habitats with varying levels of security and, inevitably, breeding populations became established in the wild. The first wild signal crayfish in Scotland was recorded in Galloway in 1995.

The impact in Scotland

Scotland, unlike the rest of Britain, has no native crayfish. The consequences of introducing a large, omnivorous crustacean to naïve Scottish ecosystems were unknown. The signal crayfish in Scotland became the focus of much research (including my own), and the bane of many anglers

Box | Huxley, crayfish and cannibalism

In his book *The Crayfish* Huxley describes the unfussy eating habits of crayfish: 'few things in the way of food are amiss to the crayfish; living or dead, fresh or carrion, animal or vegetable, it is all one.'

He goes on:

'under certain circumstances, the males...not content with mutilating or killing their spouses, after the fashion of animals of higher moral pretensions, they descend to the lowest depths of utilitarian turpitude, and finish by eating them.'



A North American signal crayfish displaying white signals on its claws

fishing in crayfish-infested waters. See Figure 1 for the location of the sites mentioned here.

The voracious eating habits of signal crayfish have a major impact on the ecosystems they invade. In the upper reaches of the River Clyde, the density of invertebrates in areas of river inhabited by crayfish was 40% lower than at crayfish-free sites. The diversity of several groups of invertebrates was also reduced. Experiments have highlighted the potential for signal crayfish to harm globally endangered species such as the freshwater pearl mussel through disturbance and predation. The possible impact of crayfish on salmon — a commercially important fish in Scotland — remains a serious concern. Crayfish compete with juvenile salmon for shelter, leaving the young fish more exposed and at risk of predation.

Signal crayfish don't just affect the living parts of the ecosystem. They also modify their habitats physically. By digging burrows for refuge in rivers and lakes, crayfish destabilise the banks, causing erosion. In Loch Ken, where there are high densities of crayfish burrows, bank-side alder trees and other plants have suffered serious damage. Hungry crayfish also cause nuisance to anglers by taking bait intended for fish. Local businesses around Loch Ken have reported losses, as anglers choose to take their trade to crayfish-free waters.

Can we control them?

If signal crayfish are so bad, why don't we just encourage people to catch and eat them? This would certainly reduce the population. However, scientists are concerned that exploiting these crayfish for food — and thus highlighting their value — would lead to further illegal introductions of the species in new locations, adding to the problem.

Unfortunately, prospects for eradication or even control of signal crayfish are poor. There is increasing acceptance among scientists and local people that these aliens are here to stay, leaving Scottish ecosystems irreversibly changed.

- A White-clawed crayfish, Durness population
- B White-clawed crayfish, Renfrewshire population
- C Signal crayfish, upper River Clyde
- D Signal crayfish first discovered near this site
- E Signal crayfish, Loch Ken

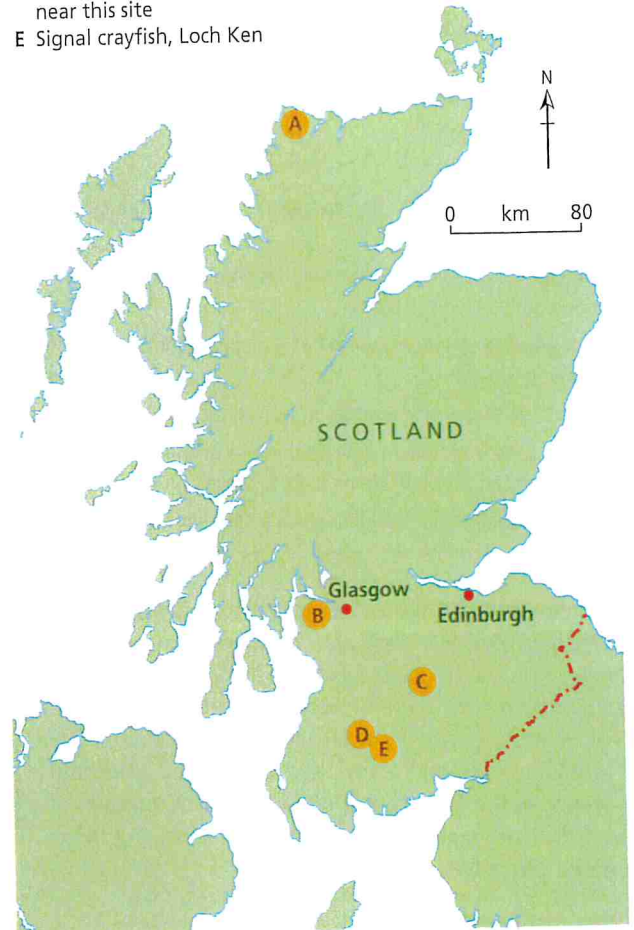


Figure 1 Crayfish study sites in Scotland

White-clawed crayfish

The white-clawed crayfish is native to England, Wales and other parts of Europe but historically absent in Scotland. There are, however, two introduced populations — one in a loch in Durness, north Scotland, the other in a reservoir in Renfrewshire. Both populations were introduced several decades ago and do not appear to have spread.

The white-clawed crayfish has suffered serious declines in its native range, largely due to the introduction of the

Further reading

Learn more about the UK's non-native species on the GB Non-Native Species Secretariat website. There are links to mobile phone apps you can use to identify and record invaders: www.nonnativespecies.org

For information on the white-clawed crayfish, including fact-sheets and local projects, visit Buglife's UK Crayfish Hub: www.buglife.org.uk/uk-crayfish-hub

Elvis Presley and Kitty White, 'Crawfish': www.youtube.com/watch?v=RnsfMYH0vNQ

Terms explained



Aquaculture The cultivation of aquatic animals and plants (especially fish, shellfish and seaweed) in natural or controlled marine or freshwater environments.

Biodiversity The variety of plant or animal life present in an area.

Bioindicator A species whose presence or absence indicates the health of an ecosystem.

Chelae Pincer-like claws.

Ex-situ conservation Protecting species outside their natural habitats.

Invasive species An alien species that has spread to cause damage to native biodiversity.

Keystone species A species which has a major role in the way an ecosystem functions.

Native species A species occurring in its natural range.

Non-native (alien) species A species that has been introduced by humans into an area outside its natural range.

Range The area(s) of the world in which a species is found.

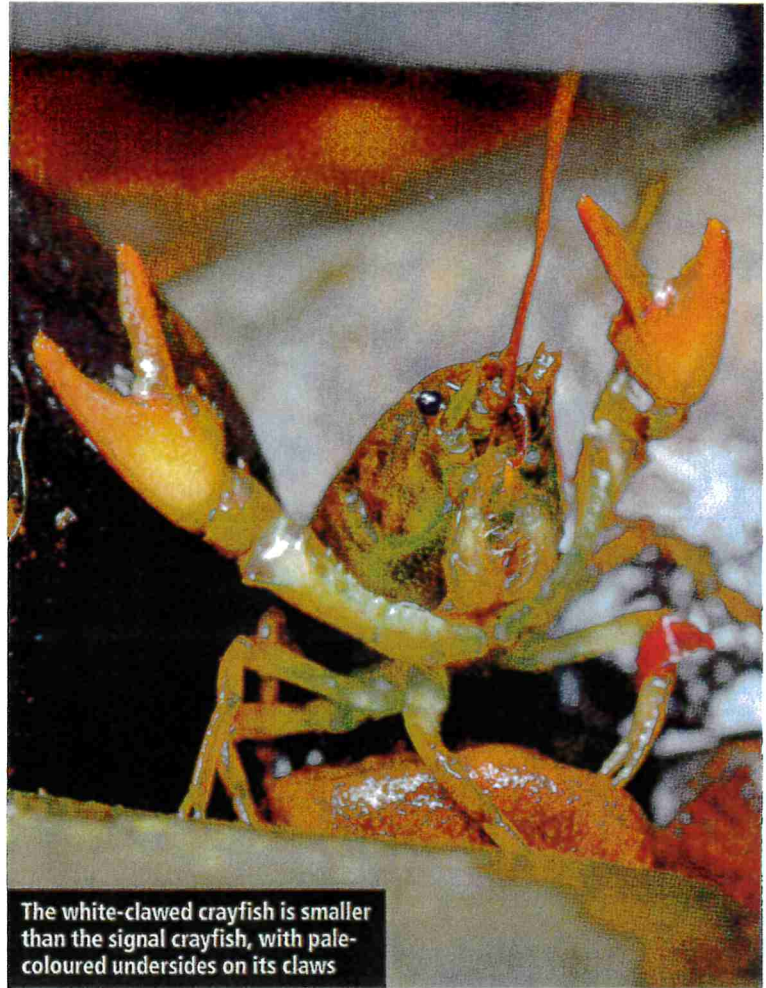
larger, more competitive signal crayfish and the spread of crayfish plague (see Box 2). The species is classed as endangered on the IUCN Red List of Threatened Species.

Despite being an alien in Scotland, the white-clawed crayfish is protected by both UK (Wildlife & Countryside Act 1981) and European law because of the potential importance of the Scottish populations for the survival of the species. This means it has the unusual position of being non-native but valued.

Ex-situ conservation

As keystone species, crayfish are expected to have a major influence on the ecosystems they inhabit. However, a lack of information about what the two Scottish sites were like before the white-clawed crayfish introductions has made it difficult to assess their impact. The Renfrewshire population exists in a man-made reservoir, stocked with other non-native species including rainbow trout, so threats to native biodiversity are not an issue. Because white-clawed crayfish do not appear to cause unwanted ecological impacts like the signal crayfish, conservationists have argued that the value of these endangered populations in Scotland is likely to outweigh any negative impacts resulting from their introduction.

As long as the white-clawed crayfish continues to decline in its native range, it has been suggested that



The white-clawed crayfish is smaller than the signal crayfish, with pale-coloured undersides on its claws

the Scottish populations might serve as important refuge sites for the species. The success of these populations, and the failure of traditional conservation methods (e.g. habitat protection, captive breeding) to prevent the extinction crisis elsewhere may encourage conservationists to consider **ex-situ conservation** as a viable strategy. Although it would be controversial, this could involve the deliberate introduction of white-clawed crayfish to other sites where it is not native.

The future?

The ethics of non-native species introductions may become even more blurred in the future. Climate change is expected to lead to extinction of many species in their natural ranges. Translocation of endangered species to higher, cooler latitudes could help them escape extinction. At the same time, global warming might enable some native species to expand their range and increase in their numbers to nuisance levels, causing damage reminiscent of invasive species. This could prompt a redefinition of the term 'invasive' to include some native species.

Point for discussion

- What are the potential ethical issues surrounding ex-situ conservation?

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Box 2 Crayfish plague

Crayfish plague is a fungal disease, to which white-clawed crayfish are susceptible. Signal crayfish are unaffected by plague but carry the disease. This means that signal crayfish have a negative impact on white-clawed crayfish not only because of competition, but also due to transmission of plague.