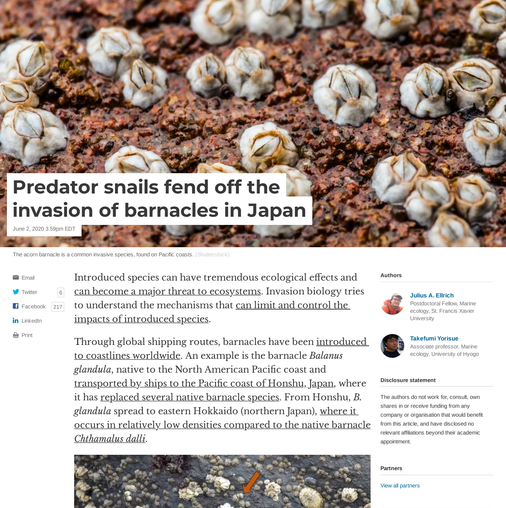

Predator snails fend off the invasion of barnacles in Japan

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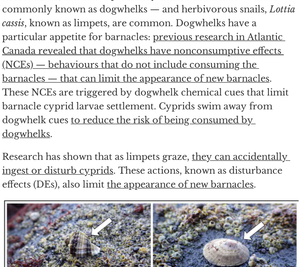
The acorn barnacle is a common invasive species, found on Pacific coasts. (Shutterstock)

Introduced species can have tremendous ecological effects and can become a major threat to ecosystems. Invasion biology tries to understand the mechanisms that can limit and control the impacts of introduced species.

Through global shipping routes, barnacles have been introduced to coastlines worldwide. An example is the barnacle *Balanus glandula*, native to the North American Pacific coast and transported by ships to the Pacific coast of Honshu, Japan, where it has replaced several native barnacle species. From Honshu, *B. glandula* spread to eastern Hokkaido (northern Japan), where it occurs in relatively low densities compared to the native barnacle *Chthamalus dalli*.



Introduced barnacles (*Balanus glandula*, white arrow) and native barnacles (*Chthamalus dalli*, brown arrow). (Takefumi Yorisue)

Furthermore, *B. glandula* has reached as far as the Atlantic coasts of Argentina and South Africa, with negative effects on native barnacle populations and other seafloor dwellers.

Biotic resistance is the ability of native species to limit the spread of invasive species. Working as marine ecologists at Akkeshi Marine Station, on the Pacific coast of Hokkaido (Takefumi Yorisue, Kyosuke Momota), and the Marine Ecology Lab, Saint Francis Xavier University in Nova Scotia (Julius A. Ellrich), we established an international collaboration to investigate the low B. glandula densities in Hokkaido rocky intertidal habitats.

Predatory and herbivorous snails

In Hokkaido, the native predatory snails *Nucella lima* — more commonly known as dogwhelks — and herbivorous snails, *Lottia cassis*, known as limpets, are common. Dogwhelks have a particular appetite for barnacles: previous research in Atlantic Canada revealed that dogwhelks have nonconsumptive effects (NCEs) — behaviours that do not include consuming the barnacles — that can limit the appearance of new barnacles. These NCEs are triggered by dogwhelk chemical cues that limit barnacle cyprid larvae settlement. Cyprids swim away from dogwhelk cues to reduce the risk of being consumed by dogwhelks.

Research has shown that as limpets graze, they can accidentally ingest or disturb cyprids. These actions, known as disturbance effects (DEs), also limit the appearance of new barnacles.

The native dogwhelk *Nucella lima* (left) and the native limpet *Lottia cassis* (right). (Takefumi Yorisue); Author provided

We hypothesised that the native dogwhelks and limpets would contribute to biotic resistance against *B. glandula*. To test our hypothesis, we conducted a series of experiments in Akkeshi Bay, in Hokkaido. We examined dogwhelk feeding preferences for barnacles in the laboratory and dogwhelk NCEs and limpet DEs on barnacle population growth in the field.

Native dogwhelks and limpets

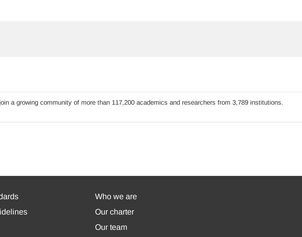
First, we compared dogwhelk feeding preferences for introduced and native barnacles by providing dogwhelks with similar-sized *B. glandula* and *C. dalli* individuals. We found that the dogwhelks preferred the introduced *B. glandula* over the local *C. dalli*. Next, we compared dogwhelk feeding preferences for large and small *B. glandula* individuals. We found that dogwhelks preferred large *B. glandula* individuals.

These preferences are likely driven by prey profitability: previous research with dogwhelks on the North American Pacific coast indicated that dogwhelks that fed on *B. glandula* grew faster than those who fed on *C. dalli*, and dogwhelks fed with large *B. glandula* individuals grow the fastest.

Our findings suggest that dogwhelk predation limits the *B. glandula* spread in Hokkaido, especially as large *B. glandula* individuals produce more offspring than small *B. glandula* individuals.

Population control measures

We examined the effect of dogwhelk NCEs on *B. glandula* settlement and population growth. For that, we installed cages with mesh compartments in the harbour of Akkeshi Marine Station. The cages prevented the dogwhelks from feeding on the barnacles, and we found that the presence of dogwhelks limited the growth of *B. glandula* populations by 56 per cent.



An illustration showing the effects of the presence of local dogwhelk on introduced barnacle populations. (Julius A. Ellrich, Takefumi Yorisue and Kyosuke Momota)

We conducted a similar experiment using limpets in a cage with the barnacles. We found that feeding limpets limited the growth of *B. glandula* populations by 81 per cent.

Employing native dogwhelks and limpets

Our results highlight that in the case of barnacles in Japan, predation and disturbance by native species are important ecological processes that can contribute to biotic resistance against introduced species. It is essential to understand such complex processes in order to protect native species that help to maintain biotic resistance. Without biotic resistance, it is more likely that introduced species — such as *B. glandula* — can spread and have negative effects on native species and communities.

Understanding biotic resistance can support local organisms in protecting their ecosystems against biological invasions, eliminating the need for more extreme measures.

Invasive species | Snails

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The authors do not work for, consult, own shares in or receive funding from any company or organisation that would benefit from this article, and have disclosed no relevant affiliations beyond their academic appointment.

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