The killer shrimp is not as bad as its reputation

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At the same time as the invasion of the killer shrimp began in the early 1990s, the populations of many native invertebrates in the large waterways of Central Europe started to decline. Credit: J. Brandner/ TUM

Researchers at the Technical University of Munich (TUM) have discovered that the amphipod crustacean, which is native to the Ponto-Caspian region, is not a true predator and only plays an indirect role in the massive species extinction of small crustaceans in native waters. According to experimental results, the invasive killer shrimp actually only drove native amphipods out of their hiding places, making them easy prey for the round goby, a species which also originates from the Black Sea region.

Their paper, which was published in the scientific journal *BMC Ecology*, is the first behavioral study worldwide showing the interaction of two invasive species in the context of the decline of native species. At the same time as the invasion of the killer shrimp (*Dikerogammarus villosus*) began in the early 1990s, the populations of many native invertebratesin the large waterways of Central Europe, such as *Gammarus pulex*, started to decline.

A former field study conducted by the Chair of Aquatic Systems Biology at the TUM demonstrates how serious the situation currently is for the native relatives of the invasive newcomer from the Black Sea region. In this study, researchers investigated the species diversity along the banks of the entire Upper Danube from Kelheim to the Austrian border. *G. pulex*, the native crustacean, is practically extinct in those regions.

Instead, the researchers caught a large quantity of killer shrimp and round gobies (*Neogobius melanostomus*) in their nets. Both species originate in the Black Sea region and probably entered the watercourse systems of Central Europe as 'stowaways' on ships. For a long time, the invasive killer shrimp with its two prominent humps was the prime suspect for the disappearance of species among its native relatives. It was seen as a predatory glutton, which earned it the infamous nickname 'killer shrimp' among English speakers.

Favorite meal: amphipods?

In order to find out if this was really the case, the systems biologist Dr Sebastian Beggel, who has worked extensively on the biology of amphipods for a long time, carried out a standardized laboratory test together with his working group in Weihenstephan. For this purpose, the team set up aquaria both with and without hiding places where both crustaceans were placed—either alone or together with round gobies.

The idea for this came from findings obtained as a result of research on invasive gobies in the Danube, on which two doctoral theses had already been written at the Chair of Aquatic Systems Biology. Hence, the researchers in Munich knew that although these predatory fish have a highly flexible diet, they have a preference for a certain type of amphipods, so-called gammarids. Furthermore, they were also able to demonstrate that the round gobies switched to consuming these gammarids once they reached a certain size.

"They always pick whatever provides them with the most energy, making them highly effective users of resources. This gives them an edge over specialized species", said Sebastian Beggel. Along the banks of certain rivers, the round gobies already account for more than 70 percent of the entire fish population in some places.

Researchers also knew that once they reach a certain size, their preferred diet consists of mollusks and river amphipods. As the interdisciplinary team at the Chair of Aquatic Systems Biology discovered in their experiments, when faced with a choice between native amphipods and the killer shrimp they knew from their old homeland, they showed a clear preference for the 'new flavor'.

Behavioral, not only dietary experiments

In the experiment, the research team ensured that the population density corresponded to that of the original occurrence of the animals in the wild. "That was important in order to be able to apply our findings to natural conditions", Sebastian Beggel explained. They also carried out series of experiments with crustaceans of various sizes in order to rule out the possibility that the fish preferred a certain size. "The interesting thing here was that we did not simply carry out a dietary experiment, but instead considered the behavior of the animals", he commented on the approach.

In order to obtain representative findings, they carried out various experimental runs over a period of several weeks with up to 20 repetitions. In each run, they noted down exactly how long the crustaceans swam about and how quickly they disappeared between the large rocks provided in some of the aquariums as a possible hiding place.

One particularly interesting question was if and how this behavior would change in the presence of the predatory fish. "We found that three hours was a good observation period for each run", the biologist reported. In this time frame, the animals exhibited all of their behavioral characteristics. "Furthermore, in subsequent examinations of the stomach contents of the fish, we were still able to find something, as the digestive process had not progressed much during this relatively short period of time."

Not a killer, just an aggressive squatter

The first few test runs already demonstrated that the killer shrimp did not see its local relatives as a welcome addition to its menu, nor did it exhibit a noticeable proclivity for hunting them, which to date were the reasons cited for the decline in the amphipod population. Strictly speaking, the 'killer shrimp' did not act like a greedy predator during the behavioral experiments, but rather took on the role of an aggressive

squatter.

"The killer shrimp uses hiding places more intensively, ousting the native species", said Beggel, summarizing his observations. For example, in aquariums with hiding places containing only native crustaceans and gobies, a mere nine percent of the amphipods fell prey to the fish. However, if killer shrimp were also present in the aquarium, this number rose to up to 60 percent. "The disappearance of native amphipods in waterways is likely due to the interaction between the two invasive species", the researchers confirmed.

"In the Bavarian Danube, there are large numbers of killer shrimp and round gobies, which leads to an entirely new food web with modified species communities", said Beggel. He also sees the study as further proof that the 'invasive meltdown', as has been postulated in the theory of invasion biology for quite some time, has already long been taking place in a number of large watercourses such as the Danube. For scientists such as Sebastian Beggel, who are interested in basic ecological mechanisms, this is a highly fascinating process. "The entire system is restructuring itself—and we are there to observe it."

More information: S. Beggel et al, Synergistic impacts by an invasive amphipod and an invasive fish explain native gammarid extinction, *BMC Ecology* (2016). DOI: 10.1186/s12898-016-0088-6

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