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Astacology

Observations of claw differences in an invasive crayfish *Orconectes virilis*

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Abstract

The Northern Crayfish *Orconectes virilis* is a relatively new invasive species to Calgary, Alberta Canada. We observed unique morphological characteristics concerning the claws (cheliped) of four (3 males and 1 female) out of 31 crayfish captured using a sweep sampling method from a creek in Calgary, Canada. These specimens exhibited a notable difference in claw size between the right and left claws. Differences in claw sizes can be attributed to an ongoing process of regeneration due to loss of the crayfish's cheliped.

Introduction

Invasive species consist of organisms that are not native to an area and are typically successful and abundant when compared to native species (Hellmann et al. 2008). Many invasive species are observed to have negative impacts on the native ecosystems and are currently a major topic of research in the field of ecology (Barney & Tekiela 2020). The Northern Crayfish species *Orconectes virilis* have shown great potential for invasion with negative consequences, especially in Europe and North America (Holdich et al. 2009). Recently *O. virilis* has also been recorded in the Columbia River basin within Washington State (Larson et al. 2010). These introductions and/or range expansions have unknown consequences for the ecosystem and can have big impacts on management and conservation (Bergstrom et al. 2009). The Northern Crayfish is a new invasive species to Alberta waterways and is expanding westward into previously uninhabited bodies of water (Phillips et al. 2009).

Crayfish species have become of increasing interest to conservation ecologists in recent years (Glon et al. 2018). The Northern Crayfish is known for significant ecosystem alterations due to their modification of habitat and processes of leaf breakdown (Phillips et al. 2009, Schofield et al. 2001). As the known range of Northern Crayfish extends further in the Alberta watersheds, there has been an influx in study efforts to protect freshwater ecosystems from the implications of their invasion as a non-native species (Phillips et al. 2009). While conducting research on the Northern Crayfish, individuals in our sample displayed unusual morphological traits concerning their claws.

Methods and Materials

Site description

Field sampling was conducted from October through November 2021 in Nose Creek (51°10'14.4"N 114°01'29.9"W) in northeastern Calgary, Alberta, Canada (Figure 1). The creek is a steady, slow-flowing waterbody with a pH around 8.4-8.5 at an elevation of 1045 m above sea level. The riparian vegetation surrounding the study area primarily consisted of tall grasses (Figure 2).

Figure 1: Location of the Nose Creek sample site in Nose Creek, Canada (51°10'14.4"N 114°01'29.9"W). Alberta, Canada is depicted in the blue shading. Map credit: Amanda C. Luzardo. Source: Esri, CGIAR, USGS | Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/ NASA, USGS, EPA, USDA, NRCan, Parks Canada.

Figure 2: Location of the Nose Creek, Canada (51°10'14.4"N 114° 01'29.9"W). Picture credit: Sophie Prevost.

Study organism

The Northern Crayfish species *Orconectes virilis* is Canadas most widespread species and are common in streams, rivers and lakes with rocky bottoms that provide protection from predators (Phillips et al. 2009). *O. virilis* are primarily carnivorous (Momot 1995); they can tolerate temperature extremes, anywhere from near 0 °C to 39 °C (Mundahl & Benton 1990); egg laying starts once the water has reached a temperature of 11 °C (Weagle & Ozburn 1972, Berrill & Arsenault 1982); *O. virilis* requires an average pH of about 5.8 for long-term survival (France 1987).

Study system

Crayfish were captured with a sweep net that was run through the water. The measurements of morphological characteristics of the claws, body, and tail were taken in mm using a ruler.

Results

Of the 31 crayfish captured, 27 (87%) displayed symmetrical claws (Fig. 3A) and four (13%) displayed asymmetrical claws (Fig. 3B), of which 3 were males and one female. We observed one male with a missing left claw; one female with a broken claw; and two male crayfish (Table 1, Crayfish 1 and 2) that exhibited a notable difference in claw size between the right and left claws (Figure 3B).

The average left claw length for the population of crayfish that exhibited symmetrical claw lengths was 26 mm. No right claw measurements were taken since these crayfish exhibited symmetrical claw lengths between the right and left claws. Crayfish 1 had a left claw length of 13 mm, and a right claw length of 33 mm, there was a 20 mm difference between the two claws. Similarly, Crayfish 2 had a left claw length of 22 mm and a right claw length of 30 mm, there was an 8 mm difference between the claws (Table 1). We determined the ratio of body length to the left/right claw lengths for Crayfish 1 and 2, and then compared these ratios to the average left claw to body length ratios for remaining males in our sample population of a similar size range. The average ratio of left claw length to body length for these Remaining individuals was 0.76, which differs from that of Crayfish 1 (0.38) and Crayfish 2 (0.63) (Table 1).

Discussion

The differences in claw size could be explained because of claw regeneration. Freshwater crayfish are capable of claw regrowth after a limb is damaged or removed (Feleke et al. 2021). The left claws of Crayfish 1 & 2 clearly represent the early stages of claw regeneration. Limb removal may be by autotomy (i.e., removed by the individual

Figure 3: (A) Symmetrical claws of Northern Crayfish (both claws ~26 mm). (B) Crayfish 1 (right claw 33 mm, left claw 13 mm). Nose Creek, Canada (51°10'14.4"N 114°01'29.9"W). Photo credit: Julia Custelcean and Nicole M. Johnson.

Table 1: Analysed claw and body measurements for Northern Crayfish sample population of similar sized male individuals from Nose Creek, Canada.

Measurement	Symmetrical Claw Crayfish (Mean)	Crayfish 1	Crayfish 2
Body Length (mm)	34	34	35
Right Claw Length (mm)	---	33	30
Right Claw : Body Length Ratio	---	0.97	0.85
Left Claw Length (mm)	26	13	22
Left Claw : Body Length Ratio	0.76	0.38	0.63

intentionally), or by some aggressive interaction (Feleke et al. 2021). We can extend this observation of the smaller claw size and consider two additional individuals that illustrated the stage prior to regeneration. This would be when claws were either damaged as seen in one female or missing as seen in one male. Therefore, the four out of 31, crayfish that displayed abnormalities represent different stages of claw regeneration.

The finding that most of the anomalous crayfish were male might be due to higher levels of aggression in male crayfish. For example, reproductive males of *Orconectes quinebaugensis* spend more time in agonistic behaviour and had more fight than reproductive females (Warren et al. 2009). Therefore, male crayfish are more likely to have their claws removed during altercations with other crayfish. This intraspecific aggression might be driven by population density and increased competitive pressures (Hudina et al. 2015). This suggests that the population studied at the Nose Creek has a high enough population that aggression might be considered an issue. Competition with conspecifics can in turn express traits that might be useful in challenging environments and can help drive a successful range expansion into new environments (Hudina et al. 2015).

The difference in right and left claw size is important to consider due to the influence of claw size on mating and relative survival of *Orconectes virilis*. Large claw size seems to give crayfish a competitive advantage over conspecifics with smaller claws (Wilson et al. 2007). Therefore, Crayfish 1 and 2 would be at a disadvantage when compared to the remaining population. Additionally, as the claws are being regrown, less energy can be allocated to functions such as mating and reproduction. Furthermore, the regrown claws of crayfish are weaker than the original claws and would remain at a disadvantage even when the claw is fully regrown (Graham et al. 2021). The local environment can also be impacted by the process of claw regeneration as crayfish show an increased leaf litter processing on account of the increased energy requirements for claw regeneration (Carvalho et al. 2018). This could reduce the food resources availability for other species in the area. Furthermore, our finding of 13% claw regeneration is high but comparable to that reported in other studies (Graham et al. 2021). We must also acknowledge that our sample size is small, therefore, further research should be done on this topic to confirm the results of this pilot study.

Conclusion

In summary, our pilot study observed several unique morphologies in Northern Crayfish that are likely attributed to processes of claw regeneration because of aggressive behaviour. These aggressive behaviours can be seen more prominently in larger populations and result in a competitive advantage during range expansion. There seems to be a lack in data available regarding the ecology of Northern Crayfish, especially the invasive populations now occurring in Southern Alberta. Further investigation is recommended to help determine the cause of these morphological observations and potential impacts on native riparian communities.

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