THE INVASIVE NEW ZeALAND MUd Snail (PortamoPyrgus antiPodARUm) FOUND IN Streams oF THE LAKE OntARio WaTersHED1

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ABSTRACT

The invasive New Zealand mud snail (Potamopyrgus antipodarum) has been established in the Laurentian Great Lakes since at least 1991 and in the western United States since the late 1980s. In the western U.S. this snail has spread rapidly in rivers and streams where it dominates biomass in some locations. In Lake Ontario this species has been, until now, confined to water deeper than 4m. Here we report the first finding of the New Zealand mud snail in streams in the Great Lakes region. The snail was found in one of five sites examined in northwest New York. This finding demonstrates the continued spread of this species. The presence of the snail in lotic waters in the Great Lakes region may lead to substantial ecosystem changes similar to those observed in the western U.S. and elsewhere. It is advised that streams emptying into the Great Lakes be monitored for the presence of this species. [J PA Acad Sci 82(1): 7–11, 2008]

INTRODUCTION

The New Zealand mud snail, Potamopyrgus antipodarum (Gray 1843), is a global invasive species with well-established populations in the British Isles (Wallace 1985), mainland Europe (e.g., Stadler et al. 2005), Australia (Ponder 1983), Japan (e.g., Shimada and Urabe 2003), and North America (Bowler 1991; Zaranko et al. 1997). In North America there are two main populations, one centered in the rivers and streams of the western United States (Bowler 1991; Richards et al. 2001; Kerans et al. 2005), and one centered in the Laurentian Great Lakes (Zaranko et al. 1997; Grigorovich et al. 2003; Levi et al. 2007). Invasive populations, including those in North America, appear to be clonal, the result of parthenogenetic reproduction (Proctor et al. 2007). The snail in New Zealand exists in mixed populations of clonal and sexual individuals (Lively 1987). There are at least three different clones established in North America.

Two different clones have been discovered in the western U.S. The dominant western clone appears to be identical to a clone found in Australia (Embridge Fromme and Dybdahl 2006; Proctor et al. 2007), and it was probably introduced by stocking fish (Bowler 1991; Bowler and Frest, 1992). In the western U.S. the snail is a nuisance species in rivers and streams. It was first found in the late 1980s in the Snake River in Idaho (Bowler 1991) and has since spread to every western U.S. state west of the Rocky Mountains except for New Mexico (Proctor et al. 2007). Densities of the snail in some locations have been found to be 500,000 per m2 (Hall et al. 2003).

Based on molecular data (Embridge-Fromme and Dybdahl 2006) from one site (Wilson, NY–Lake Ontario), it appears that one genotype exists in the Great Lakes. This clone is identical to one of the two clones found in mainland Europe (Embridge-Fromme and Dybdahl 2006; Proctor et al. 2007) where it is found in a wide range of freshwater habitats including lakes and streams (Dybdahl pers. comm.; Jokela pers. comm.). It is likely that it was introduced via international shipping and may have been the result of ballast water introduction. In the Great Lakes, the snail was first discovered in 1991 in the northeast and southwest portions of Lake Ontario and in parts of the St. Lawrence River (Zaranko et al. 1997). The geographic range of the snail has since expanded within Lake Ontario (Levi et al. in press) and now includes Lake Superior (Grigorovich et al. 2003), and Lake Erie (Levi et al. 2007). Population densities of the snail in the Great Lakes vary substantially within and between years with densities ranging from <10 per m2 to about 5000 per m2 (Zaranko et al. 1997; Levi et al. in press). The distribution within the lakes ranges from 4 m to at least 40 m in depth (Zaranko et al. 1997; Levi et al. in press). The fact that the snail has not been found in shallow water (< 4 m) may be a reason why, until now, they have not been found in rivers or streams emptying into the Great Lakes.

Relatively little is known about the ecological impacts of the snail. What is known has been discovered by studying populations in streams and rivers in the western U.S. and in Australia. In streams and rivers, P. antipodarum has been shown to compete with native invertebrates, such as mayflies (Cada 2004), possibly by inhibiting colonization (Kerans et al. 2005) and/or consuming a substantial proportion of primary production (Hall et al. 2003; Cada 2004; Hall et al. 2006). The snail dominates secondary productivity in several locations (Hall et al. 2006) and negatively impacts higher trophic levels (Cada 2004; Hall et al. 2006). Trout have been shown to feed upon Potamopyrgus (Vinson et al. 2007), and the diets of trout and sculpin have been shown to change in

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response to increased densities of the mud snail in nature (Cada 2004). This effect was probably due to the change in community composition associated with the snail. Consumption of the snails by fish in streams may decrease growth rates and result in weight loss because the snail is a poor food source compared to native prey (Vinson et al. 2007). The snails have also been found to alter the carbon and nitrogen cycling in lotic habitats (Hall et al. 2003). Specific effects in the Great Lakes have yet to be determined. One reason for the lack of knowledge about the effects of the snails in the Great Lakes is due to the relatively simultaneous introduction of zebra mussels to the region, which makes attributing ecological changes to Potamogeton diffusus difficult. One of the primary concerns about the Great Lakes population is the potential for the species to spread from the lakes into lotic waters where substantial ecological effects have been noted (Hall et al. 2003; Cada 2004; Kerans et al. 2005).

Here we report the first occurrence of Potamogeton diffusus in shallow lotic waters in the Great Lakes region.

METHODS

Five streams emptying into Lake Ontario in Niagara County, NY were sampled on 5 June 2007 along roadways. Rocks and other debris ranging in size from 8 cm$^3$ to 1000 cm$^3$ were picked up out of riffle and pool habitats and examined for the presence of P. antipodarum. If no mud snails were discovered after twenty minutes at a location the search was concluded. The presence or absence of New Zealand mud snails was noted and a sample was collected where they were found; however, no density estimates were made. Snails collected were identified using The Freshwater Snails (Mollusca: Gastropoda) of New York State by Jokinen (1992) and compared to a personal reference collection of P. antipodarum. All sites examined were characterized by relatively shallow water (<1 m) and easy access to the streams from the road. Locations of each site are listed in Table 1.

RESULTS

P. antipodarum (Figure 1) was found in one of the five sites examined (Figure 2; Table 1). At site 1, they were easily found and collected from large rocks by the tunnel on the north side of the road (Rt. 18F). Approximately 75 snails were collected from all sides of five large rocks examined. Although populations in the Great Lakes exhibit smooth and keeled morphs, no shell armature was found on the snails collected in the streams. The majority of the snails from site 1 possessed a dark encrusting material on the shells, however (Figure 1).

![Figure 1. Two individual P. antipodarum snails collected from site 1. The snail on the right is encrusted with a hard granular material.](image)

<table>
<thead>
<tr>
<th>Site #</th>
<th>Stream</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Potamogeton found?</th>
<th>Site distance (by way of stream) from Lake Ontario (km)</th>
<th>Stream width; depth sampled</th>
<th>Substrate</th>
<th>Watershed characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unnamed stream near Youngstown, NY</td>
<td>43° 16.215'</td>
<td>79° 01.256'</td>
<td>Yes</td>
<td>0.5</td>
<td>2.5 m; &lt;0.5 m</td>
<td>Large Cobble</td>
<td>Mixed agricultural and forest</td>
</tr>
<tr>
<td>2</td>
<td>Fourmile creek</td>
<td>43° 16.089'</td>
<td>79° 00.229'</td>
<td>No</td>
<td>1.4</td>
<td>7 m; &lt;0.5 m</td>
<td>Cobble and silt</td>
<td>Mixed agricultural and residential</td>
</tr>
<tr>
<td>3</td>
<td>Twelvemile creek</td>
<td>43° 16.725'</td>
<td>78° 53.406'</td>
<td>No</td>
<td>7.6</td>
<td>~5 m; &lt;0.5 m</td>
<td>Mostly silt, some cobble</td>
<td>Mostly agricultural</td>
</tr>
<tr>
<td>4</td>
<td>East Branch</td>
<td>43° 18.434'</td>
<td>78° 49.880'</td>
<td>No</td>
<td>2.4</td>
<td>~6 m; &lt;0.5 m</td>
<td>Cobble</td>
<td>Mostly agricultural</td>
</tr>
<tr>
<td>5</td>
<td>East Branch of Eighteen mile creek</td>
<td>43° 13.150'</td>
<td>78° 41.734'</td>
<td>No</td>
<td>16</td>
<td>9 m; &lt;0.5 m</td>
<td>Cobble</td>
<td>Mixed agricultural and forest</td>
</tr>
</tbody>
</table>
DISCUSSION

To our knowledge, this is the first finding of the New Zealand mud snail in streams in the eastern United States. The snail has not been found in other large collections from streams in this region based upon word from several other researchers and organizations (Jackson pers. comm.; Suprenant pers. comm.; Strayer pers. comm.). This species can be rather inconspicuous at low densities, however. Thus we suggest that researchers re-examine archived collections from the Lake Ontario watershed.

The genotype of Potamopyrgus antipodarum from this stream location was found to be identical to snails from Lake Ontario (Dybdahl unpublished data) indicating that the snail in the Great Lakes has invaded lotic habitats. In a limited survey of 14 streams emptying into Lake Ontario in upstate New York in 2003, Potamopyrgus was not found (Levri unpublished data). However, the sites sampled in the present study were not included in the 2003 survey. Site 1 is approximately 0.5 stream kilometers from Lake Ontario. It should be noted here that the sampling that revealed the presence of Potamopyrgus in streams was very limited.

Thus it is likely that the snail is established in other streams and rivers in the region. More detailed surveys are planned. Potamopyrgus antipodarum is a successful invader largely due to its reproductive capabilities and broad environmental tolerances (Proctor et al. 2007). Since invasive populations of this species reproduce parthenogenetically, only one snail is required to establish a new population. Snails can produce broods as large as 70 individuals (Levri unpublished data). Females can produce offspring during the entire growing season (Schreiber et al. 1998), and reproductive maturity can be reached in as little as 3 months (Jokela pers. comm.). In New Zealand and in invaded areas, the snail is found in a wide variety of aquatic environments, including rivers, streams, lakes, and springs, and can be found in a wide variety of habitats within each type of environment including fine and course substrates (Cunha and Moreira 1995; Kerans et al. 2005), vegetation (Dorgelo 1987; Quinn et al. 1996), littoral shorelines (Quinn et al. 1996), and deep benthos (Zaranko et al. 1997; Levri et al. 2007). Potamopyrgus can withstand a wide range of temperatures ranging from 0°C (Hylleberg and Siegismund 1987) to 32°C (Quinn et al. 1994). Cold winter temperatures
have been observed to result in high mortality (Zaranko et al. 1997). The snail also tolerates a wide range of salinities, as one population in the Columbia River estuary exists in an environment that fluctuates between completely fresh (0 ppt) to seawater (32 ppt) (Dybdahl and Kane 2005). It can also tolerate periodic scouring flows in lotic systems (Holomuzki and Biggs 2000).

In New Zealand, densities in streams are highly dependent on flood frequency with decreasing densities with increasing flood frequency, and densities rarely exceed 1000 per m² (Holomuzki and Biggs 1999). The densities of invasive populations in streams show substantially more variation. Densities of 30,000 per m² in the western U.S. are common (Richards et al. 2001; Dybdahl pers. comm.) and some locations have densities an order of magnitude larger (Kerans et al. 2005). In Australia, Potamopyrgus densities are positively correlated with human disturbance (Schreiber et al. 2003). Some studies have found that moderately eutrophic waters favor Potamopyrgus productivity (Dorgelo 1987, Scott et al. 1994). In one experiment, P. antipodarum was shown to prefer gravel compared to sand, fine sediment, and pebbles, but some snails were found on all substrates tested (Lysne and Koetsier 2006). In lotic systems, it appears that densities are highest in streams with relatively constant flow and temperatures and relatively high primary productivity (Hall et al. 2003; Richards 2004; Kerans et al. 2005).

Now that the snail is established in streams, dispersal can occur both naturally and by hitchhiking on recreational stream users. This type of dispersal is likely the primary method of dispersal in the western U.S. (Proctor et al. 2007). The snail can easily be caught in fishing equipment, clothing, footware, etc. It also is capable of surviving periods of at least 24 hours of complete drying (Levri unpublished data) and, if kept moist, can be viable for 50 days or more (Winterbourn 1970). To reduce the possibility of spreading, it has been suggested that water users:

1. clean all mud and debris from clothing and gear after using a water body containing the snail.
2. put gear in a freezer for 6–8 hours, hot water (>120°C) for a few minutes, or in a dry environment of at least 84°C for at least 24 hours before using gear in a new water body (Richards et al. 2004; Proctor et al. 2007).

Since some of the above methods may not always be practical, gear and footware can be treated with some common household cleaning solutions such as Formula 409®, Pinesol®, and ammonia (see Proctor et al. 2007 for more details).

Because of the rapid spread of the snail in the western U.S. and the snail’s ability to tolerate a wide range of habitats, we expect that a similarly rapid increase in range will occur in the eastern U.S. and southern Canada. Using GARP models, Loo et al. (2007) predicted that Potamopyrgus has a potential range of most of the continental United States, southern Canada, and much of inland Mexico.

We suggest that efforts begin immediately in the Great Lakes region and across eastern North America to educate recreational users, scientists, educators, and other water users about the potential harm that this species could cause and about measures to reduce their spread. Aside from streams emptying into Lake Ontario, it is advised that streams be monitored for the presence of this species in watersheds of Lake Erie and Superior. It is likely that this species will spread rapidly in rivers and streams of the Northeast United States and Canada.

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LITERATURE CITED


