

Range expansion and parasitism in the nonnative snail *Radix auricularia*

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ABSTRACT.—The nonnative snail *Radix auricularia* was found at 4 previously unknown locations in Wyoming. At Two Ocean Lake in Grand Teton National Park, *R. auricularia* was found with trematode infections that were the same cercarial type found in native snails during the same sampling period. Although finding parasitic infections in a nonnative species challenges the enemy release hypothesis, the presence of trematodes in *R. auricularia* may act to suppress population growth of this snail, thereby emolliating the negative impact this snail may have on native populations. Further research assessing the prevalence of trematode parasites in *R. auricularia* would aid in understanding whether this nonnative snail harbors parasites across its invasive range, which could have ramifications for parasitism of local waterfowl and wildlife in these habitats.

RESUMEN.—Encontramos al caracol no nativo *Radix auricularia*, en cuatro sitios no reportados anteriormente en Wyoming. En el Lago Two Ocean del Parque Nacional Grand Teton, *R. auricularia* presentó infecciones causadas por trematodos, iguales a las infecciones encontradas en los caracoles nativos durante el mismo período de muestreo. A pesar de que, encontrar infecciones parasitarias en especies no nativas desafía la hipótesis de la liberación del enemigo (ERH, por sus siglas en inglés), la presencia de trematodos en *R. auricularia* puede actuar para disminuir su crecimiento poblacional, reduciendo el posible impacto negativo que tiene en poblaciones nativas. Investigación futura, que evalúe la prevalencia de los parásitos trematodos en *R. auricularia* podría ayudar a comprender si este caracol no nativo alberga parásitos a lo largo de su rango invasivo que promueva el parasitismo de aves acuáticas locales y vida silvestre de estos hábitats.

In freshwater ecosystems, invasive gastropods threaten the diversity of native gastropods (Lydeard et al. 2004). Invasive gastropods can outcompete native gastropods for food resources (Strayer 1999, Brown et al. 2008, Riley et al. 2008, Hendrickx et al. 2015, Larson and Black 2016); bring parasites to new ecosystems or act as alternative hosts for native parasites, which may increase parasitic infections in native gastropods (Torchin and Mitchell 2004, Mastitsky et al. 2010, Karatayev et al. 2012, Gérard et al. 2017); and alter nutrient cycling, which may influence the amount and type of food resources available to native gastropods (Hall et al. 2003, Arango et al. 2009). Yet, for many nonnative gastropods, little is known about their current distributions or impacts on native gastropods.

The European ear snail, *Radix auricularia*, is a nonnative gastropod in North America with limited research in invaded ecosystems,

unknown and possibly expanding distributions, and little quantitative data on habitat requirements and possible impacts on other organisms including native gastropods. In the snail's native range (most of Europe and temperate Asia), multiple freshwater gastropod surveys indicate that *R. auricularia* can reside in a wide range of temperatures (4 to 32 °C), specific electrical conductivities (200–1200 µS/cm), and habitat types (slow-moving rivers and streams, ponds, reservoirs, and wetlands; Spyra 2010, Vinarski and Serbina 2012, von Oheimb et al. 2016). In some locations in its native range, *R. auricularia* can reach high population densities (accounting for 16% to 54.4% of snails based on abundance) forming monocultures and constituting a large snail biomass (19%–23%; Vinarski and Serbina 2012). Additionally, in Eastern Europe, *R. auricularia* is primarily studied as the host for avian schistosomes (*Trichobilharzia szidati*, *T. ocellata*, and

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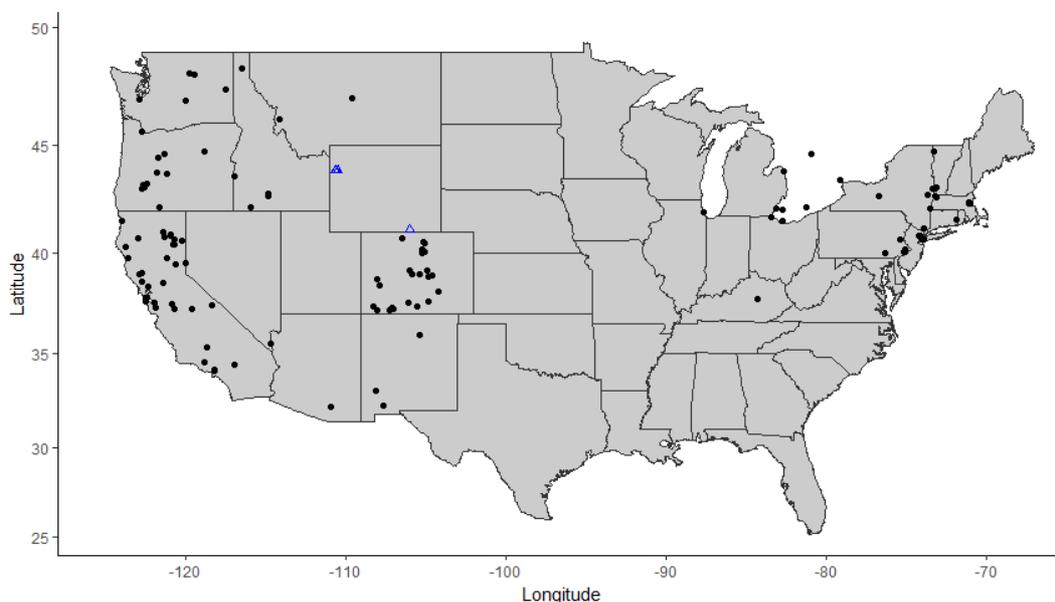


Fig. 1. Current range of the invasive snail *Radix auricularia* in the United States. Range data obtained from the USGS Invasive Species Database (Kipp et al. 2017) are shown as solid black circles, while new locations in Wyoming are shown as open blue triangles.

T. franki) which can negatively influence native waterfowl populations (Kolarova et al. 1997, Zbikowska 2004).

In North America, *R. auricularia* has been introduced across the United States to areas including the Hudson River area, the Great Lakes region, and at least 8 states (Colorado, Arizona, California, Idaho, Montana, New Mexico, Oregon, and Washington) in the western United States (Kipp et al. 2017). Yet, little research has been conducted on the distribution, habitat requirements, or possible negative impacts this nonnative snail may be having on native species. Here, I report the first occurrence of *R. auricularia* in Wyoming, as well as the first record of trematode parasites using this snail as a host in invaded ecosystems.

I conducted aquatic gastropod sampling at locations in the Greater Yellowstone Ecosystem (Grand Teton National Park, Yellowstone National Park, and Teton County, WY; 43.8°N, 110.7°W) in the summers of 2014 and 2015. At each survey location, I collected native and invasive snails by hand or by using hand sieves (for a total of 2 h of sampling effort at each location). Using the same methods, I also collected snails from the Laramie River

watershed (41.1°N, 106.0°W) in Albany County, Wyoming, in September 2015.

All snails were identified to genus and examined for trematode infections. I conducted parasitological examinations of the snails by shedding and dissecting snails for trematode infections. To assay trematode prevalence (infection rate) in all snails, I placed individual snails in 30-mL cups containing 20 mL of filtered water under a 60-W lightbulb for 2 h. This method forces the release of the trematode larval stage (cercariae). Next, I dissected all infected snails under a dissecting microscope to confirm infection status and to assess the cercarial type of the trematodes. Trematodes were identified to cercarial type (the lowest possible taxonomic level for larval trematodes) using Schell (1970).

I found 4 previously unrecorded (based on USGS introduced species map; Kipp et al. 2017) locations with populations of *R. auricularia* in Wyoming (Fig. 1). Three locations occurred in Grand Teton National Park (Two Ocean Lake, Oxbow Lake, and Third Creek), while the fourth population was found in the Big Laramie River near Jelm, Wyoming. At all 4 locations, *R. auricularia* was found at low population densities (about 1 snail/m²) in

TABLE 1. Trematode prevalence and cercarial larval type found in different species of native snails and *Radix auricularia* at 4 locations in Wyoming. Cercarial larval type is the lowest taxonomic distinction for larval trematodes released from snails (Schell 1970).

Year/location	Snail species	No. of snails collected	No. of snails infected	Prevalence of trematode infections	Cercarial type present ^a
2014					
Oxbow Lake	<i>Lymnaea</i> sp.	67	6	9.0%	ECH
	<i>Physa</i> sp.	21	3	14.2%	FUR
	<i>R. auricularia</i>	1	0	0.0%	—
Third Creek	<i>Physa</i> sp.	12	1	8.3%	ECH
	<i>R. auricularia</i>	6	0	0.0%	—
Big Laramie River	<i>R. auricularia</i>	18	0	0.0%	—
2015					
Two Ocean Lake	<i>Physa</i> sp.	29	2	6.9%	MONO; XIPH
	<i>Planorbella</i> sp.	5	2	40.0%	ECH
	<i>R. auricularia</i>	10	4	40.0%	MONO; ECH

^aFour cercarial types were found in different snails at different locations and include echinostome cercaria (ECH), furcocercaria (FUR), monostome cercaria (MONO), and xiphidocercaria (XIPH). A dash indicates that no infected snails were found for that snail species at that location.

slow-moving or stagnant water and in association with mud substrate and macrophytes.

I shed all *R. auricularia* specimens for parasites and found infections in 4 of 10 snails at Two Ocean Lake (Table 1). Infected snails harbored single infections of either echinostome or monostome cercaria. These 2 cercarial types were also found in the native snails, *Planorbella* sp. and *Physa* sp., during the same sampling period in Two Ocean Lake (Table 1). I did not find trematode infections in the 3 other populations of *R. auricularia* in Wyoming; however, the low sample sizes of *R. auricularia* (Table 1) at these locations makes determination of infection status unlikely unless the overall infection rate for the location is very high.

I identified 4 previously unknown locations for *R. auricularia* which are the first reported occurrences of this nonnative snail in Wyoming. The continued spread of *R. auricularia* is troublesome due to the lack of research on this species in North America and the possible negative impacts this snail may have on native species. *Radix auricularia* has been shown to compete with native pond snails (*Lymnaea* sp.) in permanent lentic environments (Adam and Lewis 1992). Therefore, *R. auricularia* may reduce resources for native snails and other grazing macroinvertebrates if this nonnative snail reaches high population sizes (as occurs in its native range; Vinarski and Serbina 2012) in invaded ecosystems.

My study also found the first recorded trematode infections in *R. auricularia* in North America. The prevalence of 40% in Two Ocean Lake is substantially higher than prevalence

values reported in the snail's native range (<5%; Kolarova et al. 1997, Zbikowska 2004). This may be due in part to the small sample size ($n = 10$) but may also indicate that trematodes are selectively infecting *R. auricularia*. I found that *R. auricularia* was infected with 2 cercarial types that were also found in native snails (Table 1). This may suggest that *R. auricularia* is acting as a host for native trematodes; however, determining the origins of these parasites as native to Wyoming and using *R. auricularia* as a host, or native to Europe and brought to the United States inside *R. auricularia*, was not possible and would require genetic analysis of the trematodes to definitively state their origins. In either situation, the presence of an additional host for trematodes may have negative impacts for local waterfowl and wildlife because trematodes complete their life cycle in vertebrate hosts.

The presence of trematodes in the Two Ocean Lake populations of *R. auricularia* is unexpected but may explain the low population densities of *R. auricularia* found in many locations. Finding introduced snails with trematode infections is rare (Adema et al. 2009, Ladd and Rogowski 2012, Harried et al. 2015) and this lack of parasites (which often castrate snail hosts thereby significantly reducing the snail's fitness; Baudoin 1975) is often stated as a reason for the invasion success of nonnative snails (via the enemy release hypothesis; Vilà et al. 2005, Davies 2009, Roy and Lawson-Handley 2012). My observations of infected *R. auricularia* in Two Ocean Lake does not negate the enemy release hypothesis

for other invasive snail species but may explain why *R. auricularia* is often considered a nonnative species instead of an invasive species. If trematode infections in *R. auricularia* are common across the introduced range of this snail, the parasites may be suppressing *R. auricularia* populations to low enough levels to reduce or eliminate any negative impacts associated with this nonnative snail.

The presence of *R. auricularia* in Wyoming shows an expansion of this nonnative snail's range, and the presence of trematode parasites in these snails may indicate a natural control method occurring in this nonnative species that may be reducing the impacts of this snail on native species. Additional research into the prevalence of trematode infections across the invasion range of this species will aid in assessing the importance of parasitism in controlling populations of *R. auricularia*.

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