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Preliminary Study of the Influence of Conductivity and Calcium Concentrations on the Density and Species Richness of Native and Invasive Gastropods in Grand Teton National Park, Wyoming

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PRELIMINARY STUDY OF THE INFLUENCE OF CONDUCTIVITY AND CALCIUM CONCENTRATIONS ON THE DENSITY AND SPECIES RICHNESS OF NATIVE AND INVASIVE GASTROPODS IN GRAND TETON NATIONAL PARK, WYOMING

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✦ INTRODUCTION

Freshwater gastropods are a diverse taxa that inhabit a wide variety of freshwater habitats (Lydeard et al. 2004, Strong et al. 2008). Freshwater gastropods often form narrow endemic ranges (Strong et al. 2008) with many species restricted to a single drainage or an isolated spring (Brown et al. 2008). In North America, over 60% of freshwater snails are listed as imperiled or presumed extinct (Lysne et al. 2008). The main factors for the reduction in snail biodiversity are habitat loss, water pollution, and the introduction of invasive species (Strong et al. 2008).

Invasive species can dramatically alter the native community by reducing biodiversity and changing ecological processes (Alonso and Castro-Diez 2008). The effects of invasive species on aquatic ecosystems are often permanent and lead to reductions in biodiversity due to predation and competition with native species (Alonso and Castro-Diez 2008, Lysne et al. 2008, Strayer 1999). Invasive gastropods impact native ecosystems by altering carbon and nitrogen levels (Hall et al. 2003, Arango et al. 2009), consuming large amounts of primary producer biomass (Hall et al. 2003, Riley et al. 2008, Strayer 2010), and changing native macroinvertebrate community composition (Kerans et al. 2005, Riley et al. 2008, Cross et al. 2010, Brenneis et al. 2011).

Some invasive gastropods tolerate a wide range of abiotic environmental conditions including temperature and salinity (Alonso and Castro-Diez 2008). However, other environmental factors have received less attention, but may be important in determining the range of invasive snails and their impact on native gastropod populations. Conductivity and environmental calcium levels are important for growth and reproduction in gastropods (Kefford and Nugegoda 2005, Zalizniak et al. 2009) because decreased levels of calcium and other ions results in decreased shell strength, reduced locomotion, and increased metabolic demands (Hunter et al. 1967, Dalesman and Lukowiak 2010). A few studies have shown a direct relationship between conductivity and growth and reproduction in invasive snails. Herbst and colleagues (2008) reported that the invasive New Zealand mud snail, *Potamopyrgus antipodarum,* is tolerant of medium and high levels of specific conductivity and only showed decreased survival when conductivity was below 100 µS/cm. In Australia, the invasive snail *Physa acuta* had lower growth and egg production in water with conductivity below 100 µS/cm (Kefford and Nugegoda 2005). However, few studies have examined the impact of conductivity on the distributions of native and invasive snail populations or the possible interactions between native and invasive snails for limited calcium ions.

Conductivity can also affect the species richness of gastropods. High conductivity is positively correlated with species richness of mollusks worldwide (Dillon 2000). In a study of 31 lakes in Northern Wisconsin, conductivity below 36µS/cm resulted in lower snail species richness while lakes with higher than 50µS/cm exhibited higher snail diversity (Hrabik et al. 2005). Yet, little research into the relationship between conductivity and gastropod species richness has been conducted in stream ecosystems.

Due to the impacts that invasive gastropods may have on native gastropod populations, it is important to identify the environmental factors that affect invasive gastropod populations. We conducted a preliminary field survey to test the hypothesis that conductivity is directly correlated with gastropod density and species richness.

✦ METHODS

We conducted a preliminary field survey along Polecat Creek in the John D. Rockefeller, Jr. Memorial Parkway. Sampling locations occurred above, at, and below the geothermal hot spring which corresponds to three conductivity levels (low, intermediate and high, respectively) in the stream. Geothermal springs increase the minerals available and conductivity of waters at and below their inputs (Herbst et al. 2008). To assess snail richness and abundance, we collected gastropods using a stovepipe sampler (20.4 cm diameter) from a single channel transect at each location. Gastropod samples were collected at five locations along each channel transect. We preserved samples in 70% ethanol immediately after collection and later counted and identified all snails to the lowest taxonomic level. We also counted the abundance of bivalves in each sample as bivalves may compete for calcium ions in areas where this mineral is limited. We also measured temperature, conductivity, total hardness, and salinity using an YSI probe and water quality test kits.

For our preliminary field study, we used a one-way ANOVA tests to determine whether abiotic factors (temperature, conductivity, etc.) and gastropod density (total snail density, the density of individual families, and snail richness) differed significantly among the three locations along Polecat Creek (Quinn and Keough 2002).

✦ PRELIMINARY RESULTS

Of the abiotic factors measured between the three locations in Polecat Creek, temperature differed significantly among locations (df = 2, F = 35.014, p < 0.001) while conductivity was nearly significant (df = 2, Kruskal-Wallis = 5.132, p = 0.077; Table 1). The highest temperatures occurred at the site below the hot spring which was significantly different from the temperatures at the hot spring and above the hot spring. Conductivity was higher at the hot spring and below the hot spring than at the location above the hot spring (Table 1). Although water hardness did not differ significantly among locations (df = 2, F = 1.465, p =0.303), the overall trend was a reduction in total water hardness as locations moved downstream. Salinity was constant at all locations and therefore we did not assess statistically.

Table 1. Average abiotic factors for Polecat Creek, Wyoming at three sampling location. Standard deviation is shown in the parentheses.

Location	Temperature (°C)	Salinity (ppt)	Conductivity (µS)	Total Hardness (mg/L)
Above Spring	22.567 (0.321)	0.10 (0.00)	172.767 (0.666)	2.566 (0.192)
At Hot Spring	23.233 (0.153)	0.10 (0.00)	192.167 (30.277)	2.334 (0.667)
Below Spring	24.433 (0.321)	0.10 (0.00)	195.267 (6.503)	2.000 (0.000)

Table 2. Analysis of Variance results for snail abundance for Polecat Creek, Wyoming. The degrees of freedom (df), sum of squares (SS), mean squares (MS), f-ratio (F) and p-value (P) are given for each statistical test. Bold numbers indicate significant p-values.

Abiotic Factor	df	SS	MS	F	P
P. antipodarum	2	14,418.53	7,209.26	1.351	0.296
Native Snails	2	115.73	57.87	2.52	0.122
Clams	2	136.13	68.07	4.932	**0.027**
Snail Family Richness	2	1.73	0.87	1.3	0.308

Table 3. Mean abundance of mollusks as well as mean snail family richness for each location on Polecat Creek, Wyoming. Standard deviation is shown in the parentheses.

Location	Mean Mollusk Abundance			Mean Snail
	P. antipodarum	Native snails	Clams	Family Richness
Above Spring	36.2 (29.2)	0.8 (0.4)	0.4 (0.5)	2.0 (0.7)
At Hot Spring	19.2 (17.7)	7.2 (8.1)	7.6 (5.8)	1.8 (0.4)
Below Spring	91.8 (121.9)	2.0 (1.9)	2.6 (2.7)	2.6 (1.1)

There were no significant results among locations for snail abundance and family richness (Table 2). Although the abundance of *P. antipodarum* was not significantly different among locations ($p = 0.296$) the overall trend was for higher abundance of this invasive snail below the hot springs (Table 3). Alternatively, the native snails showed a slight, but non-significant ($p = 0.122$) increase in abundance at the hot spring location. Family richness ranged from one to four families of snails with the highest richness at the below hot spring location (Table 2), however these results were not statistically significant ($p = 0.308$). Additionally, we collected data on native clam abundance at each location as bivalves may compete with snails for calcium resources. We found that clam abundance were significantly higher at the hot spring location than above the hot spring ($p < 0.03$).

✦ DISCUSSION

Because we only sampled one stream on one occasion and found high variance in conductivity and *P. antipodarum* density within locations, interpretation of our data is difficult. However, based on these preliminary data, we found that temperature and to a lesser extent conductivity follow the expected pattern of increased levels at and below the hot spring. The presence of a gradient in both temperature and conductivity is consistent with other research (Herbst et al. 2008) and validates the use of these locations (above, at, and below the hydrothermal spring) for our different conductivity levels in future studies. We will use more detailed water testing procedures in future studies to have more definitive results for different ions (Ca, Mg, Cl, etc.).

Both native snail abundance and *P. antipodarum* abundance were not significantly different among locations, however, we found higher abundance of the invasive snail below the hydrothermal spring which is consistence with prior research (Herbst et al. 2008). Mean snail family richness was also found to be higher at the below hot springs location, however, these results were not significant, but may indicate that higher conductivity, temperature, or other factors may increase the richness of snails below hot springs. In our preliminary study, we found that both native snails and clams had higher abundances at the hot spring location while *P. antipodarum* abundance was lowest at this location (Table 3). These results may indicate that the hot spring provides a refuge for native mollusks by excluding *P. antipodarum* from the area. The underlying mechanism(s) for the low abundance of *P. antipodarum* cannot be determined based on our preliminary study; however, a wider range of water quality testing in future studies may provide insights into the underlying cause for the low abundance of *P. antipodarum* at hot spring locations.

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