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Terrestrial Molluscs of Kawartha Lakes Region, Canada: Land Snail and Slug Habitat Specifications and Invasive Species (A Review of the Literature)

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Abstract
Despite molluscs being one of the most diverse phyla that occupy a wide variety of environmental niches, there is surprisingly limited amounts of research done, especially regarding terrestrial Gastropods like snails and slugs. When considering the terrestrial molluscs of the Kawartha Lakes region, there are virtually no research articles available. Regardless of this, snails and slugs play an important role in ecosystems and their overall numbers are decreasing globally. This literature review aims at dissecting articles written about snail and slug species that are invasive to Ontario and what habitats terrestrial molluscs prefer, as well as their role within an ecosystem.

Keywords
Snails — Slugs — Invertebrates —Molluscs —Mollusks —Kawartha Lakes, Ontario Canada — Invasive Species — Native Species —Habitat

1. Invasive Species

Homogenization of the global mollusc species is slowly occurring due to the decline of native species and the increase of a select few tougher species that are able to occupy various environments (Cowie & Robinson, 2003). When invasive species are introduced, either intentionally or accidentally, the native species is often reduced or eliminated due to predation or competition (Cowie & Robinson, 2003). These introduced species may cause few, if any, problems, but other times they significantly reduce native flora and fauna, and can cause medical complications for humans and animals (Cowie & Robinson, 2003). Overall, snails have been mostly deliberately introduced and this usually means that the invasive species will have a better chance of survival (Cowie & Robinson, 2003). They have been introduced for various reasons, including the aquarium industry and for human consumption such as escargot (Cowie & Robinson, 2003). But like countless other invertebrates, snails and slugs are also introduced unintentionally when produce products and other goods are brought over via boat or airplane (Cowie & Robinson, 2003).

Invasive species are defined as a species whose introduction potentially poses a threat to the native diversity, and their effects are felt across ecosystems and economies (Kozłowski, 2012). The study done by Kozłowski (2012) investigated the invasive species of snails and slugs in Poland and their effects on local flora and native gastropod species. They found that, like in Ontario, slugs and snails have significant numbers of invasive species compared to their native species, and that the alien species are higher risk for damaging agriculture and preying on native species (Kozłowski, 2012). While most of the species in this particular study are in fact different than those found in the Kawartha Lakes region, the risks of damage to plants and the threats to native diversity are greatly the same. However, one species that was found in this study that also occurs in the Kawartha Lakes region is *Arion rufus*, an invasive slug species originally from Western Europe who colonizes in large groups (Kozłowski, 2012). One individual can lay 415 eggs in its lifetime and they are capable of overwintering at any stage in their life, making this slug a very tough species that is capable of outnumbering native slug species (Kozłowski, 2012). This omnivorous species originally inhabited forested areas, but is now found in almost all types of biotopes. Natural and developed areas are also biotopes in which *A. rufus* inhabits, which suggests that this slug is a real threat to the native diversity (Kozłowski, 2012). Because it does the greatest damage to vegetable crops (beets, potatoes, lettuce, carrots, cabbage, parsley, beans, etc.) and other herbs and flowers, *A. rufus* is also a threat to the farming industry and the economy (Kozłowski, 2012).

According to Cowie et al. (2009), the United States spends more than $120 billion per year (as of 2005) associated with damage to agriculture and the environment caused by invasive species. Furthermore, the study confirms that molluscs, with a few exceptions, receive very little attention compared to invasive plants, insects, and pathogens (Cowie et al., 2009). This study found that the snail families *Helicidae* and *Cochlicellidae* were significantly ranked pests in the United States, as well as other regions: in Australia's pastures, South Africa's grapevines, and California's citrus fields, to name a few (Cowie et al., 2009). These two families were included in the attached snail and slug collection, indicating that they

are present (and likely prevalent) in Southern Ontario. With slugs, the species *Deroceras reticulatum* was considered a serious "potential" invader, but its presence in the Kawartha Lakes region is already known as it was also included in the attached mollusc collection (Cowie et al., 2009). All of these results point to the common conclusion that invasive slugs and snails can have disastrous effects on ecosystems and species diversity.

2. Habitat Preferences

It may come as no surprise that even the native species of slug and snail can be considered pests because of what they choose to feed on, such as seeds and seedlings, and the stems and leaves of growing plants (Choi et al., 2004). This has resulted in the use of harmful molluscicides and other chemicals that aim to prevent damage to agriculture (Choi et al., 2004). One study focused on the slug species *Deroceras reticulatum*, a species that is invasive in Canada and the United States, originating from Western Europe (Choi et al., 2004). This slug has a very wide range of suitable habitats because it is highly adaptable to new environments and conditions, however there are a few key habitat features that the species prefers. *D. reticulatum* lays its eggs between cracks in the soil, with egg-laying peaking in the early autumn and late spring, thereby suggesting that temperature and soil-presence play a vital role in reproduction (Choi et al., 2004).

Other factors that are known to affect the activity of this species are wind speed, humidity, and soil moisture (Choi et al., 2004). According to their research, adult survival was more dependent on rain fall than temperature, which suggests that slugs are able to adapt to a variety of air and soil temperatures, but still require moisture in able to survive and move around (Choi et al., 2004). The time period for a juvenile to become an adult (33.5 days) remained unchanged in different conditions, however the likelihood of a juvenile surviving is lessened if conditions worsen (Choi et al., 2004). However, juvenile *D. reticulatum* are still resilient, as the study found that even under the worst conditions they were able to survive for up to eight days (Choi et al., 2004). While adult survival was dependent upon rainfall, juvenile survival was found to be mostly dependent on temperature (Choi et al., 2004). Therefore, it is safe to conclude that overall, the species is equally dependent on rainfall and temperature for survival.

A German study showed very different environmental factors that were necessary for the survival of the land snail. Müller et al. (2005) found that terrestrial snails whose habitats were largely forested areas depended mostly on the soil parameters, specifically the calcium content and pH value. Calcium plays a very important role in shell formation, a factor which helps determine species density and richness (Müller et al., 2005). Calcium is also important for reproduction, for a permeable cell membrane, and other physiological processes (Müller et al., 2005). Therefore, high calcium content in soil is important, and in its absence snails are dependent on calcium in food, which is more difficult for them to obtain (Müller et al., 2005). Similarly to slug species, terrestrial snails also depend on soil moisture. However, there are other factors that influence their population density and richness as well such as the depth of the litter layer and dead wood, both of which demonstrate positive correlations (Müller et al., 2005). In their experiments, Müller et al. (2005) found that the number of individual snails significantly increased as the coverage of the herbaceous layer (dead wood, beech) increased. Interestingly, they found this to be consistent regardless of the dead wood's moisture content (Müller et al., 2005). Dead wood, as Müller et al. (2005) point out, is considered a microhabitat (or an environmental niche) and is likely a desired habitat for slugs and snails due to environmental and predator protection, and because dead wood causes the soil's pH levels to increase, which is considered an important factor for snails.

3. Molluscan Impacts on Ecosystems

As is the case with most invertebrates, terrestrial molluscs have an important role in ecosystems that is often overlooked and understudied. Often times, these small creatures are considered pests, and molluscicides are used to reduce their populations, also inadvertently eliminating their usefulness as well. One study by Hanley et al. (1995) looked directly at the effects of molluscan grazing in grasslands, particularly their effect on seedlings. Molluscs can help to maintain the growth of plants like fairy flax (*Linum catharticum*) which would otherwise overtake the growing area of other plants (Hanley et al., 1995). Molluscs prefer to feed on seedlings over mature plants, likely due to their size, so while they may only eat a small amount of vegetation overall, the effect on the plants' populations can be dramatic (Hanley, et al., 1995). For example, the slug species *Deroceras reticulatum* is known to have a significant effect on perennial ryegrass (Lolium perenne) because it eats the young shoots at the ground level, causing a large proportion to die off (Hanley et al., 1995). Their experiment showed that slugs preferred the grass plots over the bare one (and no slugs were found in the plots treated with molluscicide), and the *Deroceras* species were dominating the plots (Hanley et al., 1995). They found that the un-grazed plots (with no molluscs present) were represented by a combination of white clover (*Trifolium repens*), common dandelions (*Taraxacum officinale*), common starwort (*Stellaria graminea*), and the perennial grass *Stellaria graminea*; in contrast, the plots with molluscan grazing were dominated by stinking willies (*Senecio jacobaea*), thereby demonstrating the influence molluscs can have on an ecosystem including negative effects, such as reducing biodiversity (Hanley et al., 1995). Therefore, a mollusc's presence may be advantageous or disadvantageous for an ecosystem depending on a number of factors such as plant type, slug and snail population density and/or richness, and what other plants are present in that ecosystem.

A study by Lanta (2007) confirmed that slug and snail presence can indeed affect plant growth, particularly the competition between co-existing plant species. They completed a study similar to that by Hanley et al. (1995), but focused on the effects of molluscan grazing in species-rich plant communities versus species-poor communities (Lanta, 2007). The results showed that species-rich communities were much more resistant to slug grazing than species-poor were (Lanta, 2007). Similarly, Lanta (2007) also found that there was a dramatic shift in plant species represented in the plots with slugs present versus the control plots. This was because those that were grazed by slugs were typically overtaken by one dominant plant species, thereby greatly influencing species diversity and species richness (Lanta, 2007). This domination of one species is not directly caused by molluscan grazing, but rather a "change in interspecific competition" between plants caused by the disadvantage of select plants that the slugs are feeding on (Lanta, 2007). Overall, the results between Hanley et al. (1995) and Lanta (2007) were harmonious and led to the same conclusion of snails and slugs having the ability to greatly influence the plant representation of ecosystems.

4. Conclusion

Research on terrestrial molluscs may be scarce but it seems to be increasing slowly, as molluscs' importance for an ecosystem is becoming important. Besides their ability to alter plant communities and to control plant growth, they are vital for the survival of many predators such as birds, racoons, and fish. Research on these small creatures helps to promote protection of them and their habitats, and to educate those who may wish to use molluscicides or pesticides, while also reducing the purposeful introduction of new species. Introduced species are often reducing the amount of native species, both in molluscs and plants, leading to a gradual homogenizing of ecosystems.

Molluscan populations have been in decline and many important species are becoming threatened, endangered, and even extinct (Régnier et al., 2009). This is due to numerous factors such as habitat loss, invasive species and inter-specific competition, and even parasites such as *Cosmocercoides dukae*, a type of nematode (Anderson, 1960; Lydeard et al., 2004). Based on some of the studies reviewed in this paper, it can safely be concluded that the reduction or elimination of molluscs would greatly influence biodiversity.

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