Feeding Preferences and Potential Competition between *Ariolimax columbianus* and *Arion rufus*

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Abstract

Within the last 100 years, the arrival in the Pacific Northwest of the invasive European slug *Arion rufus* has introduced a potential competitor for the iconic banana slug *Ariolimax columbianus*, the second largest terrestrial slug in the world. We conducted transect studies in three habitats (cedar forest, Doug fir forest, and grasslands) on San Juan Island, WA, to examine the relative demographics of these slugs and note possible food sources. Utilizing those data, we conducted feeding preference studies across leaves from 16 local plant species, incorporating slugs from the two species from different source habitats, different size classes, and both the black and brown morphs of *Arion rufus*, which tend to specialize in different habitats. We used ImageJ to measure the area eaten from each leaf and calculated feeding rates. The feeding preferences of *Ariolimax columbianus* were consistent across size classes and source populations, and the two color morphs and various source populations of *Arion rufus* were also largely consistent within this species. While both species are generalists, they demonstrated feeding preferences that frequently overlapped, indicating that *Ariolimax columbianus* may compete with *Arion rufus* for food resources.

Introduction

Invasive species have become an increasing problem throughout the world due in large part to human-facilitated dispersal across oceans and land. An invasive species can have a negative impact in many ways, including decimating local plant or animal populations through consuming or competing with native species. For example, the garlic snail *Oxychilus alliarius* was native to northwest Europe but introduced to Hawaii in 1937 (Curry and Yeung, 2013). Originally, scientists thought that *O. alliarius* only ate snails with shells less than 3 mm, indicating that the large native snails, *Achatinella mustelina*, were safe from predation, but recent research demonstrated that the invader can consumes

snails larger than 3 mm, posing a more serious threat than previously thought to the endangered native snails (Curry and Yeung, 2013). One non-native species of slug in Hawaii, *Veronicella cubensis*, was found to prefer two native and two non-native, but widely established, plants when tested on six native and four non-native plant species and so may change the plant community structure through its preference (Shiels et al., 2014). In another study, four different invasive slug species in Hawaii all preferred two endangered native plant species over other invasive and non-endangered plant species and thus decreased seedling survival of these threatened species (Joe and Daehler, 2007).

The largest native slug species within the United States, *Ariolimax columbianus*, is found within the Pacific Northwest of the United States from California up to Washington State and into Canada (Richter, 1976). In general, slugs are an integral part of the forest ecosystem, helping recycle nutrients and decompose forest litter (Osman, 2013) and *Ariolimax columbianus* serves this role in the coniferous forests. Historically, no native slug species attains adult sizes even close to that of *Ariolimax columbianus*, so similar-sized competitors are not in the evolutionary history of *Ariolimax columbianus*. But within the past 100 years, a large invasive slug species has been spreading through the Pacific Northwest.

Invasive slugs in the *Arion* genus are usually transported to the USA on shipments of plants and other resources, such as mushrooms, flower bulbs and potting soil (Wittwer, 2004; Barr et al., 2009). In Alaska, slugs in the *Arion* genus invaded from Europe and invaded the Pacific Northwest by moving South from Alaska and also being directly transported from Europe (Gotthardt, 2010). While genetic sequencing of individuals established determined that the species is most likely *Arion rufus* (Barr et al., 2009), there appears to be a species complex produced by hybridization among *Arion rufus*, *Arion ater* and *Arion vulgaris*, so some scientists refer to the invasive slugs as the Arion ARVC complex (personal communication with D. Robinson). Thus, literature concerning invasive *Arion* species within the Pacific Northwest, Canada, and Alaska denoted as any of these three species (*rufus*, *ater* or *vulgaris*)

likely refer to the same species or species complex. As of 2009 *Arion rufus* the invasive *Arion* species found on San Juan Island, Washington State, USA was identified as only that species (personal communication with D. Robinson), so within this paper I will refer to the invasive species as *Arion rufus* regardless of what the cited papers called their study animal.

A large slug that can grow up to fifteen centimeters, *Arion rufus* has two major color variants along a continuum from jet black to brown. Generally, the black color morph is found within forests while the brown color morph is found within fields, grasslands and disturbed areas (Cates and Orians, 1975). Slugs in general are able to cause massive damage to forests by eating favored plants and seedlings (Gotthardt, 2010). When given 78 plant species from wildflower strips, slugs of the species *Arion lusitanicus* preferred four of the plant species that were all annuals (Briner and Frank, 1998). Over time, such preference can negatively change the succession and make up of a local ecosystem. Gotthardt (2010) determined that *Arion rufus* in Alaska was moderately invasive and a known garden nuisance that spread easily. But no studies have comprehensively evaluated the extent of the negative impact of *Arion rufus* on natural plants (Gotthardt, 2010).

When studying interactions between *Ariolimax columbianus*, *Arion rufus* and *Limax maximus* slug species, *Limax maximus* was found to be more aggressive for food, and disrupted the mating and feeding activity of *Ariolimax columbianus* (Rollo, 1983). But when *Ariolimax columbianus* was with *Arion rufus*, its behavior did not change but individuals of *Arion rufus* consumed more food than those of *Ariolimax columbianus* (Rollo, 1983). This indicates that *Arion rufus* and *Ariolimax columbianus* may not directly compete, but the possibility remains that they may indirectly compete.

Slugs are generalist eaters, but can be more selective as to which plants they eat (Pallant, 1969). Feeding preferences can be due to a wide variety of characteristics, including taste, nutrition content, and texture. Snails and slugs in Hawaii preferred both native and non-native seedling that had thick leaves (Shiels et al., 2014). Pallant (1969) found that *Agriolimax reticulatus* mainly ate *Urtica dioica*

and *Ranunculus repens* in the woods when given the choice of ten different palatable plant species. If a species of slug has a favored food source, then that source may quickly become rare or extirpated by a large slug population (Gotthardt, 2010).

While *Ariolimax columbianus* and *Arion rufus* attain approximately the same maximum size, and both are frequently found near each other in the forest, *Ariolimax columbianus* only lays up to 30 eggs a year in a 7 year life span (Morrow, 2000), while *Arion rufus* lays over 150 eggs a year in a 2 year life span (Gotthardt, 2010). *Arion rufus* therefore potentially produces a third more eggs within a much shorter life span and could easily increase its population size much more quickly than *Ariolimax columbianus*. Both species are reported to have generalist diets (Strauss et al., 2009), but they may also specialize within different micro-niches and prefer certain species of food to reduce competition.

We examined the feeding preferences of *Ariolimax columbianus* and *Arion rufus*, using slugs from three microhabitats found on the island: Douglas fir forests, Cedar forests, and grasslands. Transect studies were completed within the three microhabitats to observe what the slugs were on and eating, what their population densities were, and to compare population densities between species. Feeding preference trials were completed in the laboratory using leaves from 15 species of plants and using slugs from *Arion rufus* and *Ariolimax columbianus* from various habitats using various size classes, and both the black and brown morph of *Arion rufus*.

Methods

To determine how abundant both the *Arion rufus* and *Ariolimax columbianus* are in forests and meadows on San Juan Island, we conducted belt transects in various microhabitats (Fig. 1). Forest sites were within Friday Harbor Labs forested preserve. The Friday Harbor Laboratories contains a forest preserve that was germinated between1860 and 1900 (Schroeder, 2007). Within the forest preserve the areas studied were a Douglas fir (*Pseudotsuga menziesii*) forest with lots of bald hip rose (*Rosa*

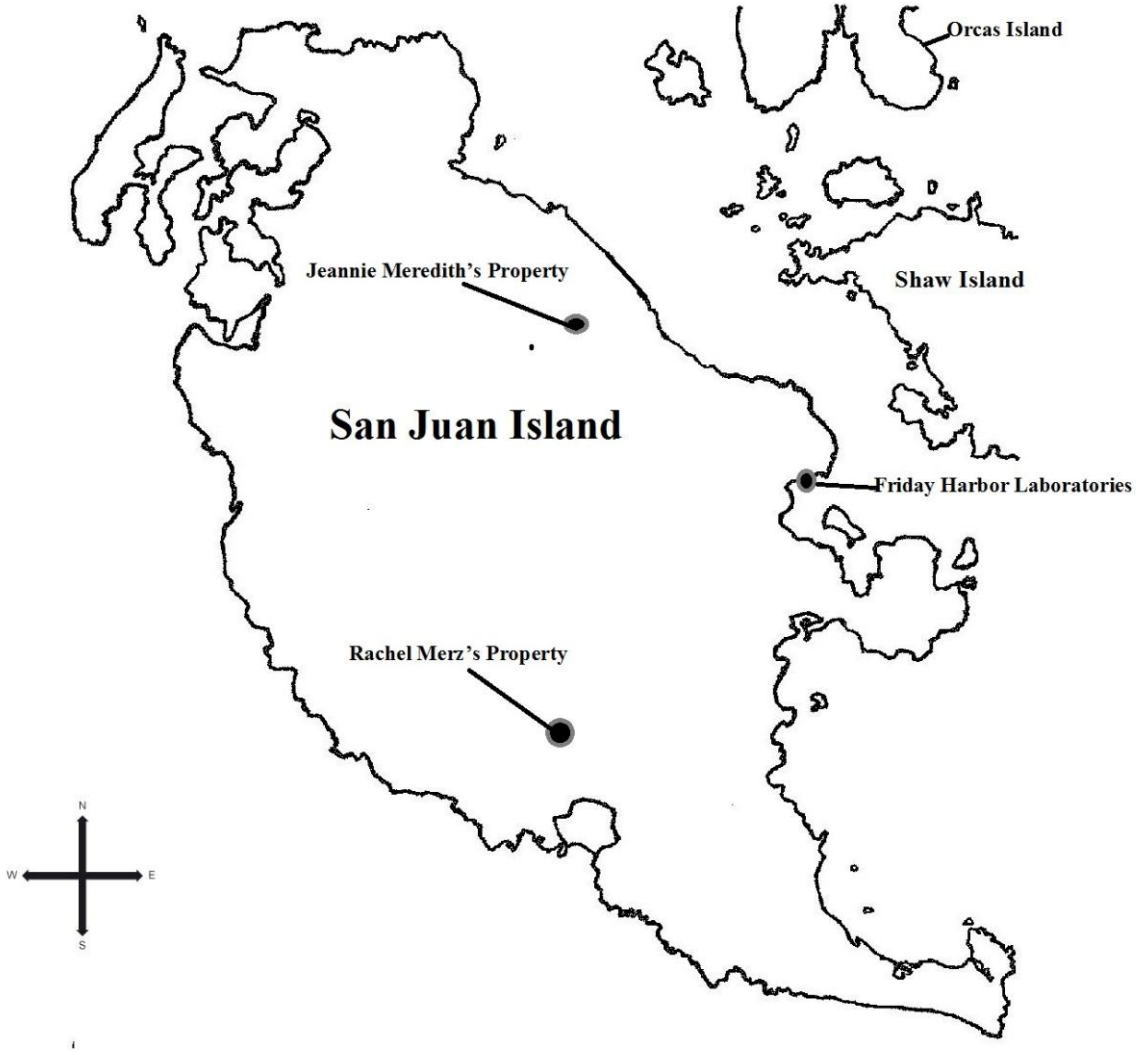

Figure 1: Map of the San Juan Island and surrounding islands, with the transect and collection sites marked. Map traced from a guide map.

gymnocarpa) and snowberry (*Symphoricarpos albus*), and a cedar (*Cedrus deodora*) forest with sword ferns (*Polystichum munitum*), lady ferns (*Athyrium filix-femina*) and salal (*Gaultheria shallon*). Grassland sites were a meadow on Jeannie Meredith's land (48° 34.302’ N, 123° 04.154’ W) and grassland on Rachel Merz's property adjacent to hay fields (48° 30.100’ N, 123° 04.497’ W). Transect lines were fifteen meters long and were broken into continuous three meter by two meter long quadrats, with at least three meters between each line. Within each quadrat any slug was identified to species (and color morph if *Arion rufus*) and each slug’s length and width (at the widest part of the mantle) was measured. The plant species each individual slug was on and the slugs’ behavior (cruising, sitting or eating) were recorded. These data were used to examine the population densities in the various habitats and to examine the range of sizes of the slugs in the areas.

We conducted trials with *Ariolimax columbianus* and the black and brown morphs of *Arion rufus*, using a variety of plant species to examine what preferences each slug species and color morph had, and whether those preferences differed based on the source habitat of the slugs. Plant species used were chosen based on those utilized by slugs in the transect studies, and dominant plant species in the various habitats. Fifteen plant species were used: stinging nettle (*Urtica dioica*), salmonberry (*Rubus spectabilis*), pathfinder (*Adenocaulon bicolor*), salal (*Gaultheria shallon*), velvet grass (*Holcus lanatus*), common vetch (*Vicia sativa*), Canada thistle (*Cirsium arvense*), hairy cat’s ear (*Hypochaeris radicata*), snowberry (*Symphoricarpos albus)*, white clover (*Trifolium repens*), plantain (*Plantago major*), woodland strawberry (*Fragaria vesca*), red lettuce (*Lactuca sativa*), basil (*Ocimum basilicum*), and English daisy (*Bellis perennis*). Each plant species had leaves of various toughness, which could be a factor in which species the slugs prefer. Table 1 shows the ranking of plant species leaf toughness within each grouping of plants tested.

Table 1: Toughness scores for the sixteen plants tested in trials based on personal observations.

Toughness Score	**First Forest Plant Set**	**Second Forest Plant Set**	**Garden Plant Set**	**Grassland Plant Set**
1 (Toughest)	Salal (*Gaultheria shallon*)	Snowberry (*Symphoricarpos albus*)	English Daisy (*Bellis perennis*)	Canada Thistle (*Cirsium arvense*)
2	Salmonberry (*Rubus spectabilis*)	Plantain (*Plantago major*)	Hairy Cat's Ear (*Hypochaeris radicata*)	Common Vetch (*Vicia sativa*)
3	Pathfinder (*Adenocaulon bicolor*)	Woodland Strawberry (*Fragaria vesca*)	Basil (*Ocimum basilicum*)	Hairy Cat's Ear (*Hypochaeris radicata*)
4 (Least Tough)	Stinging Nettle (*Urtica dioica*)	White Clover (*Trifolium repens*)	Red Lettuce (*Lactuca sativa*)	Velvet Grass (*Holcus lanatus*)

Slugs were collected in the morning between 6am and 8am, since the slugs are nocturnal but were still active at that time and easily visible for collection. They were kept in the lab without food until the trial containers and leaves were set up each late afternoon to evening. The slugs were kept in the shade before use in trials, with a room temperature of 21-24^{O}C. Leaves were collected the same day of the trial set-up, stored in the refrigerator until use, and used within 48 hours of collection. Sometime between 4pm and 11pm, each container (dimensions: 27.94 cm x 17.78 cm x 8.89 cm) was set up with a 1cm thick layer of moist dirt (20 mL of reverse osmosis water added to the dirt and four sponges wetted and placed in the corners) from the forest on the bottom and leaves from four different plant species, one in each quadrat of the container, with the approximate leaf surface area the same across all four species. For each trial, one slug was placed in the center of the container and was always oriented in the same direction. While the order of leaf species in each of the corners rotated clockwise one position each trial. A digital picture was taken of each leaf before the trial, using a WG-1 Adventure Series Waterproof 14 MP Digital Camera with 5x Wide-Angle Optical Zoom. The slugs were left undisturbed with the plant material in a shaded, humid area for twenty-four hours. After the trial was over, pictures were taken of each leaf that had any consumption. Typically trials were checked ten to twelve hours after commencement; if 50% or more of a leaf was consumed, a new leaf of that species was photographed and replaced the old leaf. We have not yet had time to measure areas of consumption of each leaf, those data will be forthcoming. Instead, for this paper, after each trial leaf preference was scored based on the amount of herbivory, with the most herbivory of a trial receiving one. We then tallied the number of trials choosing each species as the first choice, and compared across species using a chi-square analysis to determine whether a single species or two was significantly preferred to the others.

Each slug used in a trial was weighed and its length and width (at the mantle) were measured before being placed in the container. More biomass likely results in more metabolic demand to sustain oneself, so slug size will be used as a blocking variable when looking at area consumption. The slug lengths and wet weights were plotted onto a graph to compare the lengths versus wet weights between the three slug species/color morphs. A portion of each slug species and color morph from the trials were killed in a -80^{O}C freezer and dried out for 48 hours in a drying oven at 79^{O}C. The dry weights of the slugs were then measured and plotted against the lengths.

Results

The relationship between slug length and its wet weight resulted in a linear line for Ariolimax columbianus (y=2.0874x – 4.2291, N=130), brown morph Arion rufus (y=1.3868x + 2.8802, N=206) and black morph Arion rufus (y=1.5251x + 3.3343, N=68) (Fig. 2). The relationship between slug length and dry weight resulted in a linear line for Ariolimax columbianus (y=0.1984x – 0.2463, N=73), brown morph Arion rufus (y=0.106x + 0.5039, N=81), and black morph Arion rufus (y=0.2074x – 0.1746, N=35) (Fig. 3). The slopes for all three species/color morphs and between wet versus dry weight are not drastically different and all are linear lines. Because of this correlation, we can feel confident that our various slug lengths represent affiliated masses- both of wet and dry weights.

The three microhabitats were broken down into five categories and slug population densities were then graphed for both species and both *Arion rufus* color morphs (Fig. 4). *Ariolimax columbianus* was found in the Douglas fir forest, the short grass areas of the Douglas fir forest, and the cedar forest. The brown morph of *Arion rufus* was found within tall and short grasslands the most, but was also found in all three forest categories, especially the cedar forest. The black morph *Arion rufus* was found only within the Douglas fir forest and the short grass areas of the Douglas fir forest.

The population densities were also calculated into percentages so that they could be compared across species and color morphs (Table 2). The brown morph *Arion rufus* was the only one found in the grasslands. *Ariolimax columbianus* made up 91.20% of the population within the Douglas fir forest, while the brown morph *Arion rufus* only made up 2.20% and the black morph *Arion rufus* made up 6.60% of the population. In the cedar forest, *Ariolimax columbianus* was still the highest percentage of the population with 52.60%. The brown morph *Arion rufus* made up 47.40% of the population, and there were no black morph *Arion rufus* slugs.

A chi-square goodness of fit test was used to find the top significantly preferred choice, and then omitting that highest choice the test was run again to see if any other choices were preferred significantly more. Looking at the forest leaf group with salal, stinging nettles, pathfinder and salmonberry, *Ariolimax columbianus* from the cedar forest and from the Douglas fir forest significantly preferred stinging nettles first (X^2=11.34, df=3, p<0.01; X^2=16.27, df=3, p<0.001) and preferred pathfinder second. Brown morph *Arion rufus* from the grasslands and from the forest meadow also significantly preferred stinging nettles first (X^2=16.27, df=3, p<0.001; X^2=7.81, df=3, p<0.05) and pathfinder second. Black and brown morph *Arion rufus* slugs from the Douglas fir forest significantly preferred stinging nettles first (X^2=16.27, df=3, p<0.001; X^2=16.27, df=3, p<0.001) and preferred pathfinder second. Black and brown morph *Arion rufus* slugs from the cedar forest significantly preferred pathfinder first (X^2=7.81, df=3, p<0.05; X^2=16.27, df=3, p<0.001) and preferred stinging nettle second.

The other forest leaf group included four different forest plant species: snowberry, woodland strawberry, clover and plantain. *Ariolimax columbianus* from the Douglas fir forest significantly preferred clover (X^2=16.27, df=3, p<0.001). Black morph *Arion rufus* from the Douglas fir forest did not significantly prefer any leaf species over another (X^2=7.81, df=3, p>0.05). Brown morph *Arion rufus* from both the Douglas fir forest and the grasslands preferred plantain (X^2=7.91, df=3, p<0.05;

X^2=16.27, df=3, p<0.001).

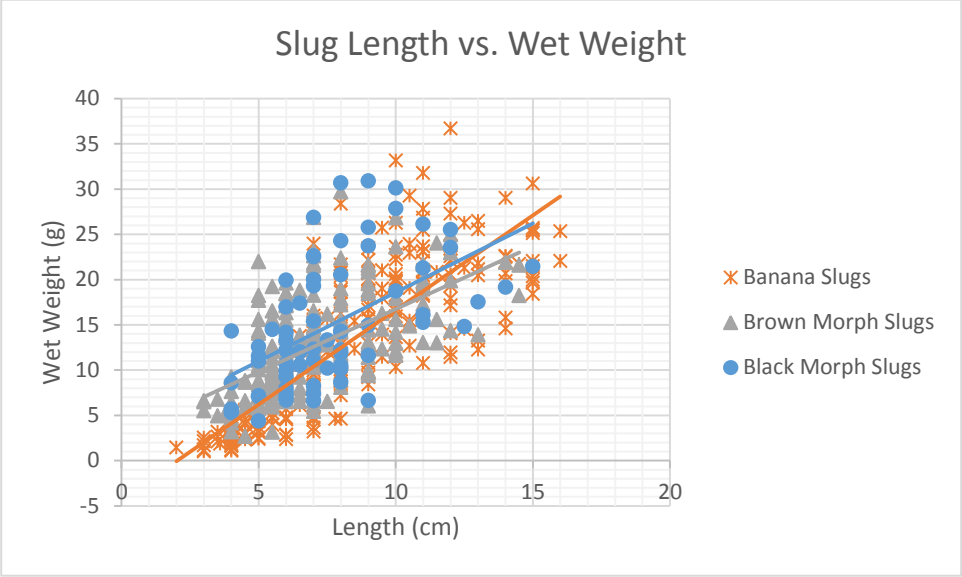

Figure 2: Individual slug length compared to individual slug wet weights. Best fit lines shown for each slug species.

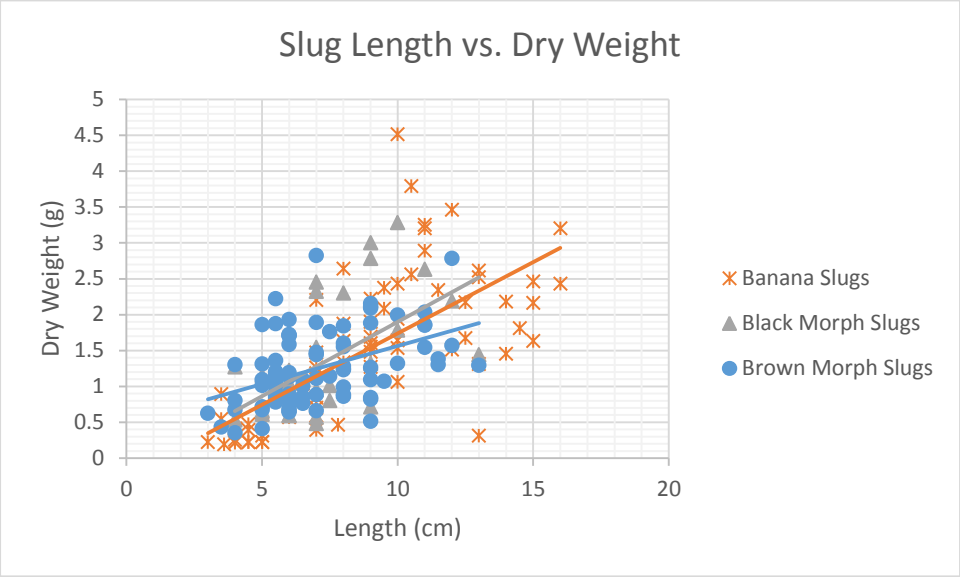

Figure 3: Individual slug lengths compared to individual dry weights. All three species/color morphs are present.

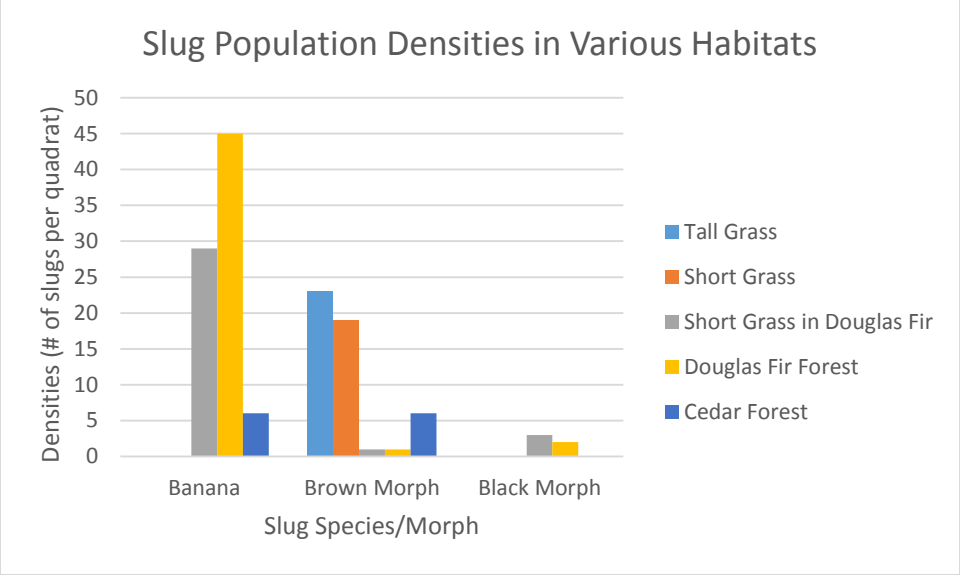

Figure 4: Slug population densities within the three microhabitats and their subcategories: tall grass, short grass, short grass in Douglas fir forest, Douglas fir forest and cedar forest.

Table 2: Slug population densities of both species and color morphs in the three microhabitats.

	Grassland	Doug Fir Forest	Cedar Forest
Banana	0%	91.20%	52.60%
Brown	100%	2.20%	47.40%
Black	0%	6.60%	0%

The garden plant group includes red lettuce, basil, hairy cat's ear and English daisy. *Ariolimax*

columbianus from the Douglas fir forest significantly preferred lettuce first (X^2=7.81, df=3, p<0.05) and preferred basil second. The black morph *Arion rufus* from the Douglas fir forest significantly preferred red lettuce first (X^2=7.81, df=3, p<0.05) and preferred basil second. The brown morph *Arion rufus* from both the Douglas fir forest and from the grasslands significantly preferred red lettuce first (X^2=7.81, df=3, p<0.05) and preferred basil second.

The leaf group containing grassland plants included common vetch, velvet grass, hairy cat's ear and Canada thistle. Only brown morph *Arion rufus* from the grasslands were tested, and they

Location	**Slug Morphology Type**	**Most Preferred**	**Most Preferred**	**Most Preferred**	**Most Preferred**
		Salal	Snowberry	Basil	Velvet Grass
		Salmonberry	Woodland Strawberry	Red Lettuce	Canada Thistle
		Stinging Nettles	Plantain	English Daisy	Hairy Cat's Ear
		Pathfinder	White Clover	Cat's Ear	Common Vetch

significantly preferred hairy cat's ear first (X^2=16.27, df=2, p<0.001) and preferred Canada Thistle second (X^2=16.27, df=2, p<0.001).

Cedar Forest	Banana	Stinging Nettle** Then Pathfinder (13)			
	Brown	Pathfinder*** Then Stinging Nettle (35)			
	Black	Pathfinder* Then Stinging Nettle (8)			
Douglas Fir	Banana	Stinging Nettle*** (43)	Clover*** (35) Small:11, Med: 9, Large: 15	Lettuce* then Basil (56)	
	Brown	Stinging Nettle*** Then Pathfinder (39)	Plantain* (35)	Lettuce* then Basil (23)	
	Black	Stinging Nettle*** Then Pathfinder (22)	No Preference (13)	Lettuce* then Basil (9)	
Forest Meadow	Brown	Stinging Nettle* Then Pathfinder (9)			
Grassland Field	Brown	Stinging Nettle*** Then Pathfinder (44)	Plantain*** (28)	Lettuce* then Basil (19)	Hairy Cat's Ear*** then Canada Thistle (20)

Table 3: Top two significant results of the feeding preference trials. Broken into slug species/morph, where the slugs were from, and the four sets of plant species used. Sample size for each set is in the parentheses. *=.05; **=.01; ***=.001

Discussion

Examining slug length versus wet weight (Fig. 1) and slug length versus dry weight (Fig. 2), all species and morphs showed the same trends in the best-fit lines. Therefore, overall all three species/morphs have approximately the same percentage of body water: body mass and this scales similarly across ontogeny. Therefore, as we compare feeding rates, it is likely that larger individuals of all species will likely need to consume more to sustain their larger biomass. However, whether the rate of assimilation across species is similar is unknown. Future data analysis using areas of leaves consumed will use body size as a blocking variable and will hopefully answer whether assimilation coefficients are similar across species.

Overall, *Ariolimax columbianus* and the black morph *Arion rufus* were only found within the forest microhabitats (Fig. 3), but the brown morph of *Arion rufus* was found more in the grasslands even though it was also in the forest microhabitats. This supports the observations in previous literature (Cates and Orians, 1975) that the brown morph *Arion rufus* is found in fields and disturbed areas more often, while the black morph *Arion rufus* is found mainly within forests. Comparing the population densities, *Ariolimax columbianus* was much more prevalent than either *Arion* morph in the Douglas fir forest, and was slightly more prevalent than the brown morph of *Arion rufus* in the cedar forest. This may indicate that currently the *Ariolimax columbianus* population is not drastically suffering from competition with the invasive *Arion rufus* because they use different microhabitats to different extents.

In the first set of forest plants, *Ariolimax columbianus* from both forest habitats preferred the stinging nettles, even though stinging nettles are most prevalent in the Douglas fir forest and not the cedar forest. Brown morph *Arion rufus* from the meadow also preferred stinging nettles even though there were no stinging nettles in the meadow. Brown morph *Arion rufus* from the grasslands also preferred nettles, even though stinging nettles are not found in the grasslands at all. Both the brown morph and black morph of *Arion rufus* from the cedar forest preferred pathfinder instead of stinging nettles, while the brown morph *Arion rufus* from the Douglas fir forest barely preferred stinging nettles

over pathfinder. This could indicate that black and brown morph *Arion rufus* slugs found in the cedar forest encounter pathfinder more often than stinging nettles, preferring the pathfinder more.

As the forest transitions into the Douglas fir forest area, the brown morph *Arion rufus* slugs have a change in preference to prefer stinging nettles first instead. This indicates that the brown morph *Arion rufus* has a feeding preference based on its habitat and which plants it regularly comes into contact with. The brown morph *Arion rufus* from the cedar forest prefers pathfinder first because pathfinder is more dominate in the microhabitat than stinging nettles. But the brown morph *Arion rufus* from the Douglas fir forest preferred stinging nettles first, since stinging nettles are more dominating in the microhabitat than pathfinder. Stinging nettles and pathfinder are the two least tough leaves in this grouping, so they are probably the easiest leaves for the slugs to eat. Tuberville et al. (1996) found that slugs and snails were not deterred by any number of stinging cells on stinging nettles, and they hypothesized that stinging nettles evolved their stinging cells as a defense for mammals specifically.

The second grouping of forest plants was snowberry, woodland strawberry, plantain and white clover. *Ariolimax columbianus* were found to prefer clover while brown morph *Arion rufus* from both the Douglas fir forest and the grasslands preferred plantain. Clover is a fairly thin and is the least tough leaf within this grouping, which could be why *Ariolimax columbianus* prefers it. Since it is very palatable and easy to eat, it is not surprising that it is the slugs' first choice. Plantain is found in both the Douglas fir forest and the grasslands, which would explain why the brown morph *Arion rufus* from both the forest and grassland prefer plantain. In this grouping plantain is the third toughest plant, though overall is still quite flexible and not too tough so there is still an easy plant for the slugs to eat. The black morph *Arion rufus* had no significant preference, though plantain did have the largest number with herbivory.

The garden plant set was red lettuce, basil, English daisy and hairy cat's ear. All species and color morphs preferred lettuce as their first choice and basil as their second choice. Lettuce and basil

are both flexible, flimsy and very easy to tear apart, making them very easy leaves for slugs to eat. Both are nutritious to humans, and therefore could be just as nutritious to slugs. This is bad news for gardeners, as *Arion rufus* is a known garden pest. Even though *Ariolimax columbianus* does prefer lettuce and basil, this species only resides within the forest and generally is not found in gardens.

The grassland plant group included hairy cat's ear, common vetch, velvet grass, and Canada thistle, with only brown morph *Arion rufus* from the grasslands tested on this grouping. The brown morph *Arion rufus* preferred hairy cat's ear first and Canada thistle second. This may be because hairy cat's ear is less tough than most of the other plant species. Brown morph of *Arion rufus* was the only slug species or morph ever found in the grasslands. Gardens are more similar to the grassland habitat, which indicates that the brown morph of *Arion rufus* is more likely to be a garden pest than *Ariolimax columbianus*. When combating slugs as a garden pest, gardeners should be safe to eradicate the invasive slugs, as long as they are surrounded more by grasslands or developed areas. If forests are near the garden, then *Ariolimax columbianus* may accidently be affected by the pest control methods.

While plant toughness can be an important part of how palatable a plant is to an organism, there could be many other factors. Previous research has found that *Ariolimax columbianus* preferred early successional plants over later successional plants for the higher levels of certain nutrients in the budding shoots (Cates and Orians, 1975). But Cates and Orians (1975) also acknowledge that other factors such as nutrition, amount of energy needed from the food source, and the season of growth also are complex factors that can affect feeding preference. We did not have the chance to examine the nutritional or chemical make-up of the plants, but future research could be done to see how those factors correlate with our feeding preference results.

Based on our results, while slugs are generalists they can still have very clear preferences when given a choice. For many of the plant groupings, both the black and brown *Arion rufus* morphs preferred the same 1-2 plant species, indicating no major differences between the two color morphs.

When comparing *Arion rufus* to *Ariolimax columbianus*, both species tend to prefer the same 1-2 plants species as their first choices. Therefore, they most likely compete for food to some extent. However, their wide range of acceptable foods, their similar population densities and their range of habitats and subdivision of the microhabitats (*Ariolimax columbianus* in forests while *Arion rufus* in grasslands) may diminish this impact. Future research needs to be done to explore what kind of competition may be occurring.

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