AGRICULTURAL RESEARCH FOUNDATION
PROGRESS REPORT
FUNDING CYCLE 2019 – 2021

TITLE:

Host preference of the pest slug *Deroceras reticulatum* among key pasture grasses, legumes and herbs.

RESEARCH LEADER:

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EXECUTIVE SUMMARY:

The gray field slug, *Deroceras reticulatum*, is a key pest of arable crops (e.g. ryegrass and white clover) in the Willamette Valley. Large investments in control methods (e.g. chemical molluscicides and mechanical tillage) often fail to keep this pest below damaging levels (Anderson et al. 2013). The problem of slugs as crop pests has been widely studied (Barker 2002), but less information exists on the impact of slugs to pastoral systems. Research from New Zealand tends to indicate that slugs are only a pasture pest under certain conditions (e.g. ample summer rain, inadequate grazing management that allows for extra cover and refuge sites) (Barker 1989). In some instances, high levels of slug herbivory have been shown to diminish forage quality and in turn cause economic losses to dairy output (Ferguson et al. 2018). In the present study we are conducting several pilot studies on slug presence in Oregon's pastoral systems, the effect of grazing on slug populations, as well as conducting laboratory and field bioassays on *D. reticulatum* feeding preference among common grasses, legumes, and herbs.

OBJECTIVES:

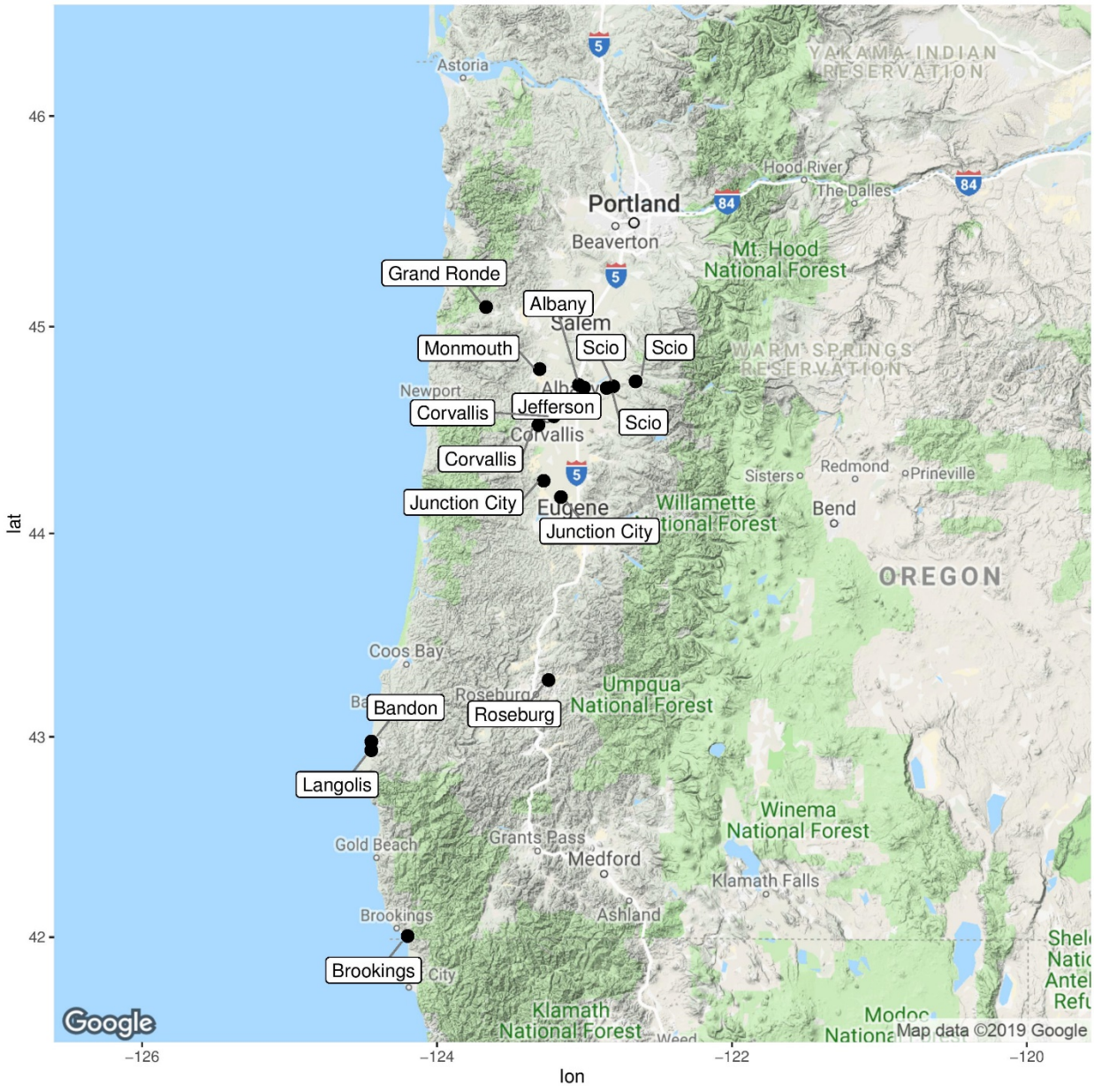
The primary objectives of this study are to document *D. reticulatum* and overall slug presence in Oregon's pastoral systems and to determine *D. reticulatum* feeding preferences between common grasses, legumes, and herbs. The supporting objectives are: 1) Record slug species diversity and survey for presence of *D. reticulatum* in local pastures; 2) Determine whether *D. reticulatum* exhibits feeding preferences in laboratory choice, no-choice bioassays and; 3) Assess the extent of *D. reticulatum* herbivory in a controlled field cage bioassay.

PROCEDURES:

1. Survey of slug species diversity in pastures

Field scouting for gray field slugs started in March 2019. A network of local producers interested in participating in scouting for slugs was assembled through email contact (Figure 1). Fifteen producers agreed to place five slug traps (2 ft x 2 ft plywood boards) on their pastures and to check the traps weekly for slugs. The producers were instructed to send pictures to us of the trap locations, forage composition, and of each collected slug for species determination. With this setup, slugs were surveyed weekly from March 15 to July 5 and correlations could be drawn between slug numbers and forage composition.

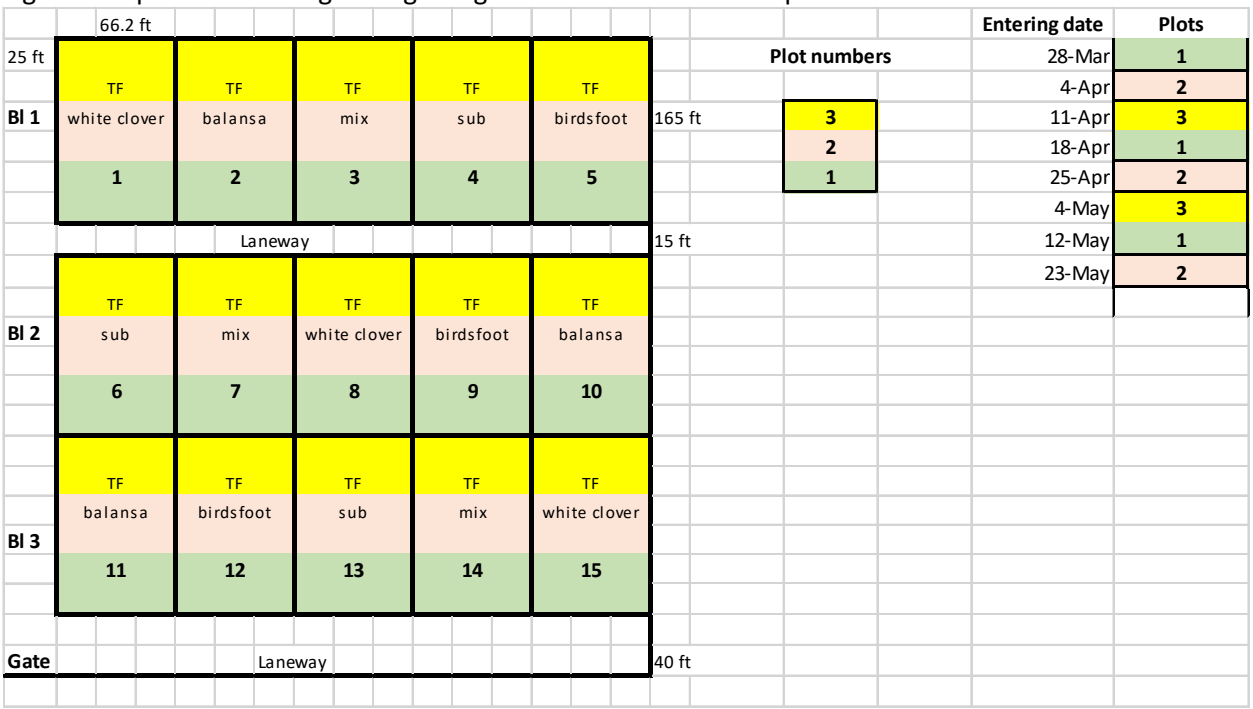
Figure 1. Locations of producer collaborators for slug sampling



2. Sampling at OSU Sheep Center

An additional field sampling pilot study was set up at the OSU Sheep Center (Figure 2). In this study, three blocks of five plots were delineated and randomly planted with pasture mixes of tall fescue and one of the following: Balansa clover, Birdsfoot trefoil, sub-clover, white clover, or multispecies mix (all aforementioned plants). Each plot was further divided into three sub plots for grazing rotation. Sheep were kept on one sub plot for four to thirteen days depending on conditions. Two slug traps were placed in each plot for 30 total traps. The traps were all located in the same grazing zone (sub plot), meaning six grazing sheep were added at the same time in each plot. Slugs were sampled weekly.

Figure 2. Experimental design and grazing rotation at the OSU Sheep Center



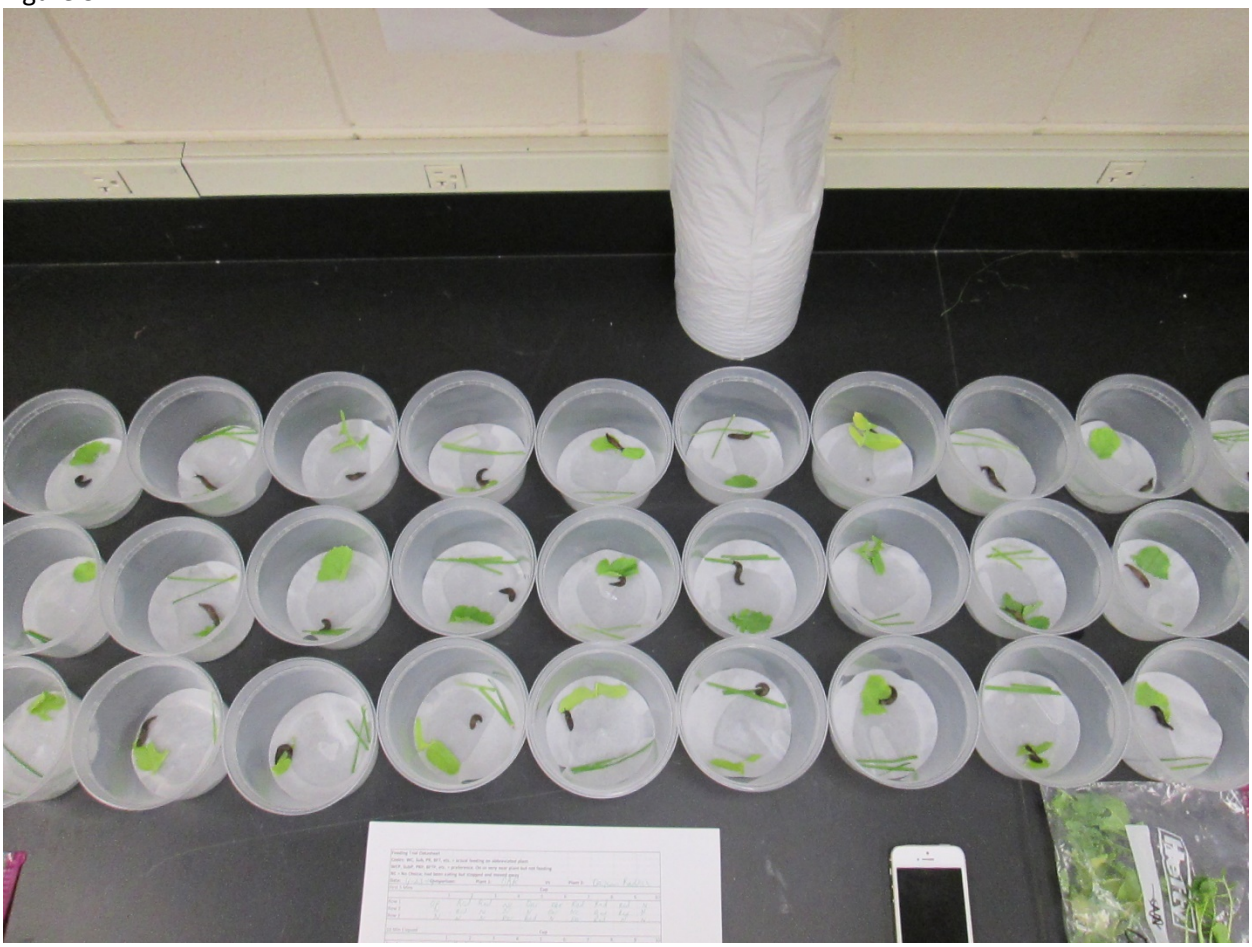
3. Laboratory feeding preference bioassay

The feeding preference bioassays were conducted on relevant comparisons between common species of grasses, legumes, and herbs that were categorized into several functional groups (Table 1). All plants were grown from seed and planted with Sunshine Mix no. 4 in 1 gal pots in the greenhouse and *D. reticulatum* were collected each week that tests were set up. Thirty replicates of each comparison were run at a time, a replicate consisted of a 16 oz plastic deli container (Figure 3) lined with a wetted filter paper (VWR 9.0 cm dia.) and small clippings of each plant being compared (approx. 0.02 g), placed on opposite ends of the container. Slugs were placed in the center and were monitored at 5 min, 10 min, 20 min, and 30 min upon which the trial was terminated. A choice was recorded when a slug actively fed on either clipping. If a slug fed on both species, the first choice was considered its primary feeding option. A preference was recorded if slugs traveled towards one plant, but did not feed, and a no choice was recorded if slugs remained in the container's center.

Table 1. Common grasses, legumes, and herbs

Functional Group	**Common Varieties**	
Perennial clovers (most commonly grown)	White clover	Red clover
Annual legumes (self regenerating)	Balansa clover	Sub clover
Herbs	Chicory	Plantain
Perennial legumes	Alfalfa	Birdsfoot trefoil
Grasses	Diploid perennial ryegrass	Tetraploid perennial ryegrass
Grasses cont.	Perennial ryegrass	Tall fescue

Figure 3.



4. Field Cage Bioassays

Deroceras reticulatum were experimentally added to four field emergence cages (no bottom) that were dug into the soil in a multispecies mix plot at the OSU Rangeland Science forage test plots (Figure 4; located Behind Oldfield Hall on 35th street). Fifteen slugs were added to each cage with the goal of directly estimating slug feeding preferences by observing slug location and plant damage after 24 hours. Temperature, humidity, and dew point were recorded with a HOBO (Onset Computer Corporation) Tiny Tag recorder.

Figure 4. Field cage bioassay deployed at the OSU forage test plots

SIGNIFICANT ACCOMPLISHMENTS:

1. Survey of slug species diversity in pastures

We had a good response rate from producers, with eleven consistently sending weekly data. Based off pictures sent to us by producers, we were able to successfully identify all collected slugs to the species level. Producers overwhelmingly collected *D. reticulatum* in their field traps, but several other species were collected as well, including a single species of air breathing land snail at one location. In total, 297 *Deroceras reticulatum*, 4 *Vespericola columbianus* (land snail), 1 *Milax gagates*, 1 *Deroceras laeve*, 2 *Arion intermedius*, and 2 *Arion subfuscus* were collected across all eleven producer sites. *Deroceras reticulatum* was found at all sites, and the other species were all found between only three sites. Example trap placement can be seen in Figure 5.

Figure 5. Cow investigating newly placed slug trap on a producer's field.

2. OSU Sheep Center Sampling

Weekly sampling from March 15 to May 31 was conducted at the OSU Sheep Center. The highest numbers of slugs were seen in the two weeks prior to sheep grazing. In total 56 slugs in week one, 33 slugs in week two, followed by 17 the day after grazing commenced (grazing April 4, sampling April 5). However, it is difficult to separate this trend from that of growing season progression (fewer slugs are seen as precipitation decreases and temperature increases). The second grazing interval began on April 25 and we collected five slugs preceding grazing (April 18) and 12 on May 3, following grazing. Slug numbers decreased significantly in May and sampling was ceased when grazing ended on May 31. The layout of this study can be appreciated in Figures 6 and 7.

Figure 6. OSU Sheep Center experimental plots

Figure 7. Slug trap at OSU Sheep Center

3. Laboratory Feeding Preference Bioassay

Thirty replicates were run for each combination listed in Table 1. There were some differences in slug preference albeit not necessarily statistically significant (Table 2). Between groups, it seems like there is a slight trend towards *D. reticulatum* being more likely to make any choice when two legumes are presented, and less likely to make a choice when presented with grasses. Within groups, the largest differences were seen between alfalfa (15 first choice) and Birdsfoot trefoil (6 first choice) and between red clover (13 first choice) and white clover (4 first choice).

Table 2. Choice Results from laboratory feeding bioassay

Comparison	**Feeding**	**Preference**	**Second Choice**
Sub-Clover	14	0	1
Balansa	13	0	0
No Choice	3	NA	NA
Comparison	**Feeding**	**Preference**	**Second Choice**
Birdsfoot Trefoil	6	1	2
Alfalfa	15	1	3
No choice	2	NA	NA

Comparison	Feeding	Preference	Second Choice
White Clover	4	4	3
Red Clover	13	1	0
No Choice	5	NA	NA
Comparison	**Feeding**	**Preference**	**Second Choice**
Plantain	6	0	1
Chicory	10	0	0
No Choice	13	NA	NA
Comparison	**Feeding**	**Preference**	**Second Choice**
Tall Fescue	7	0	0
Tetraploid Perennial Rye	9	0	0
No Choice	14	NA	NA
Comparison	**Feeding**	**Preference**	**Second Choice**
Diploid Perennial Rye	9	0	2
Tetraploid Perennial Rye	12	0	0
No Choice	7	NA	NA

4. Field Cage Bioassay

The field cage bioassay was conducted between May 21, 2019 and May 22, 2019. *Deroceras reticulatum* were experimentally added to four field emergence cages (no bottom) that were dug into the soil in a multispecies mix plot at the OSU Rangeland Science test plots (Behind Oldfield Hall). Fifteen slugs were added to each cage with the goal of directly estimating slug feeding preferences by observing slug location and plant damage after 24 hours.

Out of sixty slugs, two were recovered in cage 1 and one slug was recovered in cage 2. However, observation of plant damage indicated that white clover and Balansa clover had been preferentially damaged over grasses and herbs. Visual estimation put the number of damaged plants at 10 % for white clovers in cages 1 and 2; 7 % for cages 3 and 4, and 10 % for Balansa clover in cages 3 and 4.

BENEFITS & IMPACT:

This series of pilot studies has provided a framework upon which further research into both the ecological role and pest status of slugs in Oregon's pastoral lands can be assessed. In our producer collaboration sampling, we found *D. reticulatum* at every location, indicating the widespread distribution of this pest. However, based off the low weekly numbers (infested fields would contain approx. 10 to 20 slugs per trap per week), we can allay most concerns about the pest status of *D. reticulatum* in pastoral situations.

In designing the sampling project at the OSU Sheep Center, we were informed by reports from several growers that slug numbers in ryegrass and clover grown for seed can be successfully reduced with heavy grazing. The rationale behind this is that during grazing sheep will inadvertently eat slugs on blades of grass and will trod repeatedly over the same ground, killing slugs and/or destroying their soil refugia. These possibilities remain speculative for now, but we plan to use our Sheep Center data as a

justification for further research into the effect of grazing on slug populations as well as livestock populations (e.g. does slug presence affect sheep behavior, nutritional impact of slug consumption, parasite transmission).

Our laboratory feeding bioassay confirmed the polyphagous nature of *D. reticulatum*, and has shown that *D. reticulatum* can potentially cause feeding damage to a wide range of pasture species. However, slug infestations in established pastures are quite rare, indicating that other factors are likely at play besides host availability. Despite that, slug damage can be a problem during pasture establishment when slugs are in high numbers and feeding on seedling plants, which are highly susceptible to damage (Ferguson et al. 1988; Barker 1989). It remains to be seen what key factors account for the differences in slug presence in seed crops versus pastures, some possibilities include: predator populations (e.g. carabids) in pastures, increased exposure to plant secondary metabolites, and grazing. Our data highlights the need to study slug presence not only in permanent pastures, but during pasture establishment where the risks of slug infestation can be considerable.

We plan to disseminate our findings to stakeholders and researchers alike, as well as pursue new avenues exposed by the present studies. The fact that *D. reticulatum*, native to Western Europe, has been found at remote locations in Oregon hundreds of miles apart, should at least be slightly astonishing. While the pest status of *D. reticulatum* in pastoral systems does not seem to warrant alarm, the unsettled details around grazing, pasture establishment, and parasite transmission (mollusks are common intermediate hosts for many mammalian parasites) pertinent areas for future research.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM: None

FUTURE FUNDING POSSIBILITIES:
Funding may be pursued through Western SARE Professional + Producer grants.