



Behavioral Differences among Three Species of Weevil in the Genus *Larinus*

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Larinus minutus



Larinus obtusus



Larinus planus

Introduction

Invasive species cause billions of dollars in economic damages annually worldwide¹. Biocontrol tactics can be a useful and effective tool for land managers to combat these invasions and many species of weevil act as biocontrol agents in this endeavor². This is done with the introduction of a predator or pathogen from the native range of the invading species². *Larinus obtusus* and *Larinus minutus* are two weevil species that are native to Europe, and are commonly used in North America for biocontrol of the invasive plant *Centaurea stoebe* (syn. *Centaurea maculosa*)². They utilize *C. stoebe*, through herbivory and also by ovipositing in the flowering heads. *Larinus planus* is also native to Europe, but was introduced accidentally to North America and, while also historically used as biocontrol, it has been shown to be a threat to native *Cirsium* species, including the threatened *Cirsium pitcheri*, which is native to the dunes of Lake Michigan³. All three *Larinus* species have been studied for their connections to host plants, but many aspects of their behavior have not been thoroughly explored^{2,4}. For instance, time budgets and activity levels have not been quantified, and could have important impacts on the field efficacy of these species in control of their target plants. In this study, behavioral data was gathered for the weevil species through 66 observational sessions.



Fig 1. *Larinus obtusus* rests inside the flowering head of *C. stoebe*.

Study Questions

- What is the full range of behavior for each weevil species?
- How much time is spent on each activity?
- How does each species vary in its placement and detectability within the enclosures?
- What is similar and unique among the species?

Methods



Fig 2. Enclosures used for *L. minutus* and *L. obtusus*.

- Ad lib observations were conducted for several days prior to observational sessions on focus individuals
- *Larinus minutus* and *L. obtusus* were placed in tulle enclosures with a metal frame (60x67x26cm)
- *Larinus planus* was placed in a glass aquarium (53x33x28cm)
- Vials were used to hold four cuttings from host plants in each enclosure
- *Centaurea stoebe* was used for *L. minutus* and *L. obtusus*, while *Cirsium arvense* was used for *L. planus*
- Ten individual weevils were placed in each enclosure
- Observations were conducted in five minute sessions, two times an hour on each species for two days
- One individual was observed per session
- Each observed behavior was noted for its type and duration
- The individual to be observed was randomized for each session
- Before each session, the placement of all detected individuals was recorded
- The number of *L. minutus* fell to nine on the second day due to the death of one individual
- The *L. planus* did not display many of the behaviors noted earlier in the season (Brackley and Warneke, pers. obs.)
- Behavioral data for *L. planus* were discarded for this reason
- Because *L. planus* did not change its perching habits, placement and detectability data were still used for *L. planus*
- All data were analyzed in R, with the additional packages *rgl*, *FactoMineR* and *vegan*

Results

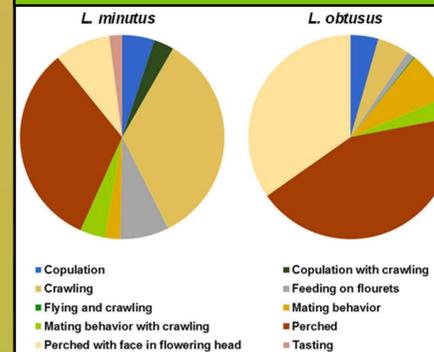


Fig 3. Proportion of time used for each activity for *L. minutus* and *L. obtusus*.

Detectability

Larinus minutus had the lowest rate of detectability (71%), while *L. planus* had the highest (81%) and *L. obtusus* fell in the middle of these two extremes (75%). Only the difference between *L. minutus* and *L. planus* was statistically significant, however (*L. planus/L. minutus* $p=0.0036$; *L. obtusus/L. minutus* $p=0.2670$; *L. obtusus/L. planus* $p=0.0925$)⁵.

Placement

The three species utilized their enclosures differently from one another. *Larinus obtusus* spent the majority of its time on the flowering heads, while *L. minutus* and *L. planus* were more varied in their placement throughout the cage. A PERMANOVA was used to test the variance between the species, and the results were statistically significant ($p<0.001$)^{6,8}. This is visualized in Figure 5, which shows the null, or expected values, compared with the observed value in red^{6,9}.

Behavior

Most of the observed behaviors were performed by both *L. minutus* and *L. obtusus*, but at different frequencies and duration (Fig. 3). When considering activity level only, *L. minutus* was more active, while *L. obtusus* was far more sedentary ($p=0.0017$). To take the entire behavioral data set into account, principal components analysis was used to compare the time spent on each activity. *Larinus minutus* and *L. obtusus* were significantly different in the way they spent their time ($p<0.001$). The image on the right is a way of visualizing the variance between *L. minutus* and *L. obtusus* (Fig. 4). In this analysis, the closer the spheres, the more similar the groups being compared. To create the image, data was resampled 10000 times and analyzed using the *rgl* package in R according to the methods described in previous work^{5,6,7}.

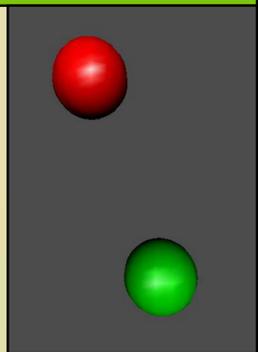
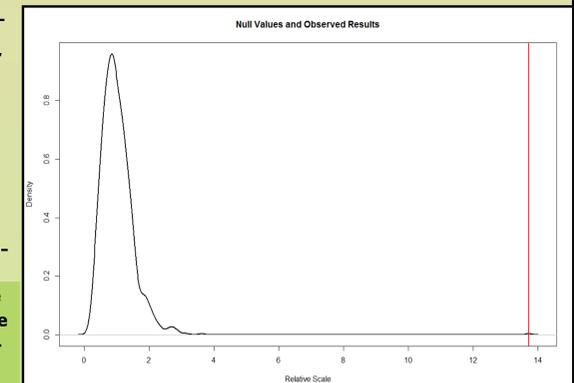


Fig 4. Differences in behavior between *L. minutus* and *L. obtusus*, as visualized in 3D space.

Fig 5. Graphed results of the PERMANOVA used to analyze differences in placement between all three species.



Conclusions

- *Larinus minutus* and *L. obtusus* performed similar behaviors, but the duration and frequency of the behaviors varied.
- All three species utilized their enclosures in a way that was unique from the other species.
- Detectability varied, but was only significantly different between *L. minutus* and *L. planus*.

This study examined three species of the genus *Larinus* for their behavior and utilization of a man-made enclosure. The placement of individuals of the three species, the behavior and activity levels of *L. minutus* and *L. obtusus*, as well as the detectability rates between *L. minutus* and *L. planus* all differed significantly. Despite the superficial similarities between these three weevil species, they are unique in many ways. These differences, recorded in the absence of any competing species, may indicate differences in fundamental niche for each species¹⁰. Variance in the shape of the fundamental niche suggest that the species will utilize resources differently when placed in the same environment for biocontrol. However, this is not easy to predict, particularly when associated competitor and predatory species are not known. Knowledge about these differences sheds light on a genus that is not often studied in regards to behavior. Opportunities for future research include similar studies in a natural setting, with a focus on the interactions between the weevils and other species in the same community.

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