Salticidae and Flowers: Are Alpine Jumping Spiders Accidental Pollen Vectors

Jada Brown, University of New Mexico

Mentor: Dr. Kaysee Arrowsmith, University of Texas at Austin

Rocky Mountain Biological Laboratory, 2026

Abstract

Pollinator predation can have widespread impacts on plant-pollinator interactions, particularly in terms of avoidance behaviors in flower-visiting insects and the fitness of predator hosting plants. Yet, few studies have taken into account the potential for these predators to accidentally vector pollen between plants while seeking prey items. In this study, we examined members of the family Salticidae for pollen presence on their external surface and how the variables of body length, floral abundance, and floral richness may impact the number of pollen grains detected on these arachnids. Additionally, we compared pollen loads of salticid and hemipteran specimens to determine whether the presence of pollen grains on Salticidae specimens were proportionate to other non-traditional pollinators. We found a statistically significant relationship between pollen load and body length, as well as significant differences when comparing pollen presence on the surface of salticid and hemipteran specimens, favoring hemipterans as the more likely transferrors of pollen. While the pollen load of salticid specimens was low when compared to hemipterans, the evidence that this pollen presence can still be predicted through variables in their environment has offered new insights into the deeper complexity pollinator predators may be adding to plant-pollinator interaction systems.

Introduction

A large proportion of studies performed on plant-pollinator interactions in zoophilous angiosperms are concerned primarily with taxa that forage for pollen and nectar resources, such as flower-visiting insects and occasionally birds or bats (Ulyshen et al., 2023). These interactions are typically driven by the pollinator's need for sustenance from the plant itself (Pellmyr et al., 2019). However, there are a multitude of insects and other arthropods that seek non-nutrient resources from flowering plants, such as shelter from predation (Vereecken et al., 2013), or warmer temperatures due to their ectothermic metabolisms (Whitney et al., 2008). This opens up the possibility for wandering arthropods to become accidental or incidental pollinators as they move from plant to plant (Yamazaki, 2025), either avoiding predators, seeking out potential mates, or searching for prey items. One example of this is hemipterans within the family Miridae which utilize the floral bracts of dioecious trees for shelter during reproduction (Ishida et al., 2008). While these insects also seek nectar from the same floral bracts (Ishida et al., 2008), their use of flowers as refuge can offer insights into how other taxa may become incidental pollinators by using floral resources for purposes other than food.

Alpine environments contain a diverse range of floral morphologies, but are often dominated by species with open flowers (Makrodimos et al., 2008). While this form of flower is typically an indicator of more generalist leaning pollination systems (Makrodimos et al., 2008), it may also indicate increased predation risk for visiting insects from visual or ambush hunters. Several clades within Araneae hunt upon and around flowers, including members of the family Thomisidae which frequent open flowers due to their sit-and-wait method of procuring prey (Dukas & Morse, 2003). Their presence on flowers has been observed influencing plant-pollinator interactions to the point where flower-visiting insects actively avoid foraging on thomisid occupied plants (Huey & Nieh, 2017). This can lead to changes in plant fitness, most notably from the consumption of visiting pollinators that reduce successful visitation rates, pollination events, and seed or fruit set (Letícia Menezes Camurça et al., 2023). Yet these same predators can also predate upon florivorous and herbivorous insects that would consume the gynoecium, androecium, and various other resource intensive segments of a flowering plant (Letícia Menezes Camurça et al., 2023) which can then open up the potential for increased reproduction and fitness in host plants (Romero & Vasconcellos-Neto, 2004).

While many studies regarding thomisid presence focus upon their predation of flower-visiting insects and associated cryptic traits such as inflorescence (Huey & Nieh, 2017) or floral scent preference (Knauer et al., 2018), few investigations appear to examine the thomisids themselves for pollen presence,

and even fewer studies look at possible pollen transfer in more mobile members of Araneae. For instance, members of the family Salticidae have a more active mode of hunting that involves stalking their prey until an opportune moment arises, such as when the prey item is distracted or grooming (Nelson, 2023). There is also the occurrence of mechanoreceptory hairs that aid in their precision jumping (Aguilar-Arguello et al., 2021) and acute vision for prey assessment and terrain navigation, particularly in the event where they are calculating jump trajectory (Aguilar-Arguello et al., 2021). This reliance on visual cues has led many salticids to inhabit brightly illuminated and open habitats (Nelson, 2023), including meadows within alpine ecosystems. Such habitats often provide a multitude of enrichment opportunities that may confer increased exploratory behaviors, as salticids that develop in diverse or complex environments are more likely to explore larger ranges (Liedtke et al., 2015). These expanded ranges of traverse may result in salticids coming into increased contact with the anthers and stigmas of open flowers, and potentially become unintentional vectors of the pollen for these flowers. The presence and abundance of hairs on the exoskeletons of salticids may further contribute to this accidental pollen acquisition, as similar phenomena have occurred in syrphids (Doyle et al., 2020) and bombyliids (Carneiro et al., 2024) wherein additional hairs on the external surface aids in pollen acquisition and transfer.

Whether members of Salticidae become accidental pollen vectors as they roam around open flowers searching for prey items and prospective mates, or when using these plants as a vantage point for surveying their surroundings, remains unknown. Thus, we performed a study to determine if pollen grains could be detected on the external surface of salticid specimens collected from alpine meadows. Any detected quantity of pollen will be examined in combination with flower abundance and richness to account for any correlations between pollen load, floral density, and floral diversity. If pollen loads are found to occur in significant quantities when compared to other non-traditional pollinators, such as members of the order Hemiptera which are regarded as pollinators (Garcia et al., 2023) despite their less numerous and shorter hairs, it could implicate the potential for pollinator predators to have beneficial impacts on the fitness of host plants.

Methods

- *Field sites*

Salticidae specimens were collected from a subalpine wildflower meadow located near the Rocky Mountain Biological Laboratory (R.M.B.L.) in Gothic, CO, USA (38°57.50′ N, 106°59.30′ W, 2900-m above sea level), within the Gunnison National Forest. This site contains a high abundance of Salticidae and hosts four transects, each covering an area of 1x20-meters that were utilized for both plant diversity and abundance assessments.

- *Specimen Capture*

Salticidae specimens were hand-captured from occupied plants using either a falcon tube or glass jar. Once captured, the location of capture (i.e., transect section or closest approximation), plant species the specimen was found on, location on the plant the specimen was found on (e.g., stem, leaf), and date of capture were recorded. Captured salticids were then placed into a freezer at the end of the field day to euthanize them for future analysis. Hemipteran specimens were captured from flowers using glass vials containing ethyl acetate to euthanize them. Salticid specimens were labeled and transferred to a glass specimen vial containing 70% ethanol for curation in the Gothic Natural History Museum.

- *Lab Work*

A Leica dissecting microscope was used at 4.0x magnification to locate pollen grains on the hairs and exoskeleton of salticid and hemipteran specimens. For hemipteran specimens, pollen counts were divided into three categories: head + thorax, abdomen, and legs including the antennae. For salticid specimens, pollen counts were divided into three categories: cephalothorax, abdomen, and legs including the pedipalps. Species and sex identification of Salticidae specimens also occurred during this time. For some specimens, the sex is not applicable due to the death position limiting the view of the anterior ventral portion of the abdomen and of the pedipalp tips. Body length measurements occurred via General™ Ultra Tech™ digital calipers to the nearest +/- 0.5 millimeters.

- *Statistical Analysis*

Data analysis occurred in R Studio, where the *lme4* package was used to perform generalized linear models between salticid pollen load and three possible predictors: body size, floral abundance, and floral richness. T-tests were performed to test for significance between pollen occurrence in hemipterans and salticids.

Results

20 Salticidae and 10 Hemiptera specimens were collected between June 23 and July 29, 2026. The average pollen grain count for salticids across all body segments was 31.8 with a standard deviation of 22.8, while the average pollen grain count for hemipterans was 142 with a standard deviation of 162 for all body segments. Welch two sample t-tests were performed to examine the relationship between pollen loads for salticids and hemipterans (Table 1), with the main comparisons occurring among total pollen load, legs and antennae or chelicerates and legs pollen load, abdomen pollen load, and pollen load on the cephalothorax for salticids or head plus thorax for hemipterans. No significant differences were observed amongst head and thorax pollen load ($p = 0.1368$; Figure 1), marginal significance was observed in legs pollen load ($p = 0.06879$; Figure 1) and total pollen load ($p = 0.06115$; Figure 1), and a statistically significant difference was observed in abdomen pollen loads ($p = 0.04396$; Figure 1) between salticids and hemipterans.

A negative binomial generalized linear model was performed to examine the relation between total pollen load and three predicting variables: body length, floral abundance, and floral richness (Table 2). The negative binomial family was utilized instead of the poisson family, as was originally intended, due to overdispersion of data. Body length ($p = 0.00832$; Figure 2) was found to have a significant positive correlation with pollen load, such that as body length increased the total pollen load of salticid specimens also increased. Floral richness ($p = 0.33464$; Figure 3) and floral abundance ($p = 0.28959$; Figure 4) were found to have a non-significant effect on the pollen load of salticid specimens. However, both models were observed to exhibit positive correlations between floral richness, floral abundance, and pollen load to the extent that as the richness or abundance of flowers increased, the total pollen load found on salticids also increased.

Discussion

Of the 20 *Platycryptus californicus* specimens captured at the field site, all 20 of them were found to have some amount of pollen on their exoskeletons. We had initially planned on sampling from three distinct locations, each containing transects, however due to the scarcity of Salticidae at one of the field sites (AP; Figure 5) and the late site setup of the third (VB; Figure 5), our sampling efforts were focused to the locale with the highest abundance of salticids (GT; Figure 5). The environment of the main field site (GT; Figure 5) consisted of open wildflower meadows surrounded by willows, with aspen groves further uphill. The meadow itself was bordered by a dirt road to the east. *Platycryptus californicus* was found to be the most abundant species, as over 30 individuals were at least sighted in the field, whereas

individuals of *Phidippus audax* were only sighted twice and therefore removed from analysis. During surveys, no salticids were directly removed from their nests. Instead, specimens were opportunistically found wandering across plants within transect sections. The species of plant and the structure from which salticid specimens were initially collected was recorded, with 18 specimens collected from leaves and 2 specimens from the stems of plants. As for plant species, 11 specimens were collected from *Helianthella quinquenervis*, 4 from *Pyrrocoma crocea*, 2 from *Delphinium barbeyi*, 2 from *Valeriana edulis*, and 1 from *Frasera speciosa*. No members of Salticidae were collected from the reproductive structures of plants as opposed to members of Hemiptera, which were only collected from the flowers of angiosperms due to their frequent presence on this portion of the plant.

During comparison analysis between hemipterans and salticids, hemipterans were found to carry more pollen grains on their body and therefore be the more likely transferrors of pollen between plants (Table 1; Figure 1). However, there is the potential for this vectoring of pollen to be behaviorally linked. One leaf-caught hemipteran was examined beneath the dissection microscope, and was found to have lower pollen counts when compared to leaf-caught salticid specimens. Where salticids are encountering pollen, or how, may be strongly linked to their behavior. Most salticids found on leaves were able to quickly drop down further into nodes of the plant to avoid capture, which may convey why they were never found on open flowers due to exposure to predators. Whether they receive the discarded pollen from other pollinator taxa, such as *Bombus* that are known to shake the pollen from flowers (De Luca et al., 2012), or gain it directly from the flowers themselves was not observed in this study but is a possible direction for future research.

Despite the small pollen loads detected on *Platycryptus californicus* specimens, larger salticids were still found to carry greater pollen loads than smaller specimens (Figure 2). This aligns with past investigations into the correlation between body size and pollen load (Cullen et al., 2021; Kendall et al., 2019) in more traditional pollinator taxa. While not statistically significant, there was a positive trend between floral abundance and pollen load (Figure 3), as well as between floral richness and pollen load (Figure 4). While floral morphology has been observed to impact pollinator preference (Timberlake et al., 2024), it is unknown as to how members of Salticidae may be responding to the variations in floral compositions. For instance, different floral richness may confer altered prey item types or availability, and an increase in floral density could mean more crowded yet diverse regions of topography for saltids to traverse. These differences may correlate to predictable behaviors that lead to larger pollen loads in Salticidae, such as an increased preference for flower-visiting insects or increased interactions with flowers hidden beneath the leaves of other plants due to the exposure of taller flowers.

Conclusion

It is important to consider the potential for pollinator predators to become pollinators themselves, especially in the current climate of rapidly changing phenology wherein plant-pollinator interactions may become mismatched due to earlier snowmelts (Kudo, 2013) and drought conditions (Brunet et al., 2024). Many aspects of Salticidae ecology, particularly natural habitat and plant interaction behaviors, remain undescribed in alpine and subalpine environments. While pollen was successfully detected on the exoskeletons of all 20 specimens, it remains unknown if pollen presence would continue to be detected in other species of Salticidae, or other specimens collected from different wildflower meadows outside and within the East River Valley. Future directions for this study primarily involve observational studies into the wandering behaviors of salticids and prey preference in areas of differing floral density. As, this may offer insights into how members of Salticidae are acquiring pollen, and if they are vectoring this pollen to the reproductive regions of angiosperm plants.

Works Cited

Aguilar-Arguello, S., Taylor, A. H., & Nelson, X. J. (2021). Jumping spiders attend to information from multiple modalities when preparing to jump. *Animal Behaviour*, *171*, 99–109. https://doi.org/10.1016/j.anbehav.2020.11.013

Brunet, J., Inouye, D. W., Wilson Rankin, E. E., & Giannini, T. C. (2024). Global change aggravates drought, with consequences for plant reproduction. *Annals of Botany*. https://doi.org/10.1093/aob/mcae186

Carneiro, L. T., Williams, J. N., Barker, D. A., & Arceo‐Gomez, G. (2024). Individual‐Based Networks Reveal the Importance of Bee Fly (Bombyliidae) Pollination in a Diverse Co‐Flowering Community. *Journal of Applied Entomology*, *149*(6), 845–854. https://doi.org/10.1111/jen.13373

Cullen, N., Xia, J., Wei, N., Kaczorowski, R., Arceo-Gómez, G., O'Neill, E., Hayes, R., & Ashman, T.-L. (2021). Diversity and composition of pollen loads carried by pollinators are primarily driven by insect traits, not floral community characteristics. *Oecologia*, *196*(1), 131–143. https://doi.org/10.1007/s00442-021-04911-0

De Luca, P. A., Bussière, L. F., Souto-Vilaros, D., Goulson, D., Mason, A. C., & Vallejo-Marín, M. (2012). Variability in bumblebee pollination buzzes affects the quantity of pollen released from flowers. *Oecologia*, *172*(3), 805–816. https://doi.org/10.1007/s00442-012-2535-1

Doyle, T., Hawkes, W. L., Massy, R., Powney, G. D., Menz, M. H., & Wotton, K. R. (2020). Pollination by hoverflies in the Anthropocene. *Proceedings of the Royal Society B: Biological Sciences*, *287*(1927), 20200508. https://doi.org/10.1098/rspb.2020.0508

Dukas, R., & Morse, D. H. (2003). Crab spiders affect flower visitation by bees. *Oikos*, *101*(1), 157–163. https://doi.org/10.1034/j.1600-0706.2003.12143.x

Garcia, L., Gould, J., & Eubanks, M. (2023). Bugs carry pollen too: Pollination efficiency of Plant bug pseudatomoscelis seriatus (hemiptera: Miridae) visiting cotton flowers. *Florida Entomologist*, *106*(2). https://doi.org/10.1653/024.106.0209

Huey, S., & Nieh, J. C. (2017). Foraging at a safe distance: crab spider effects on pollinators. *Ecological Entomology*, *42*(4), 469–476. https://doi.org/10.1111/een.12406

Ishida, C., Kono, M., & Sakai, S. (2008). A new pollination system: brood-site pollination by flower bugs in Macaranga (Euphorbiaceae). *Annals of Botany*, *103*(1), 39–44. https://doi.org/10.1093/aob/mcn212

Kendall, L. K., Rader, R., Gagic, V., Cariveau, D. P., Albrecht, M., Baldock, K. C. R., Freitas, B. M., Hall, M., Holzschuh, A., Molina, F. P., Morten, J. M., Pereira, J. S., Portman, Z. M., Roberts, S. P. M., Rodriguez, J., Russo, L., Sutter, L., Vereecken, N. J., & Bartomeus, I. (2019). Pollinator size and its consequences: Robust estimates of body size in pollinating insects. *Ecology and Evolution*, *9*(4), 1702–1714. https://doi.org/10.1002/ece3.4835

Knauer, A. C., Bakhtiari, M., & Schiestl, F. P. (2018). Crab spiders impact floral-signal evolution indirectly through removal of florivores. *Nature Communications*, *9*(1). https://doi.org/10.1038/s41467-018-03792-x

Kudo, G. (2013). Vulnerability of phenological synchrony between plants and pollinators in an alpine ecosystem. *Ecological Research*, *29*(4), 571–581. https://doi.org/10.1007/s11284-013-1108-z

Letícia Menezes Camurça, Melo, M., Cibele Cardoso Castro, & Ana Virgínia Leite. (2023). Trophic interactions between plants, pollinators, florivores and predators: a global systematic review. *Biological Journal of the Linnean Society*, *141*(2), 214–222. https://doi.org/10.1093/biolinnean/blad079

Liedtke, J., Redekop, D., Schneider, J. M., & Schuett, W. (2015). Early Environmental Conditions Shape Personality Types in a Jumping Spider. *Frontiers in Ecology and Evolution*, *3*. https://doi.org/10.3389/fevo.2015.00134

Makrodimos, N., Blionis, G. J., Krigas, N., & Vokou, D. (2008). Flower morphology, phenology and visitor patterns in an alpine community on Mt Olympos, Greece. *Flora - Morphology, Distribution, Functional Ecology of Plants*, *203*(6), 449–468. https://doi.org/10.1016/j.flora.2007.07.003

Nelson, X. J. (2023). A road map of jumping spider behavior. *Journal of Arachnology*, *51*(2). https://doi.org/10.1636/joa-s-22-011

Pellmyr, O., Kjellberg, F., Herre, E. A., Kawakita, A., Hembry, D. H., Holland, J. N., Terrazas, T., Clement, W., Segraves, K. A., & Althoff, D. M. (2019). Active pollination drives selection for reduced pollen‐ovule ratios. *American Journal of Botany*, *107*(1), 164–170. https://doi.org/10.1002/ajb2.1412

Romero, G. Q., & Vasconcellos-NetoJ. (2004). BENEFICIAL EFFECTS OF FLOWER-DWELLING PREDATORS ON THEIR HOST PLANT. *Ecology*, *85*(2), 446–457. https://doi.org/10.1890/02-0327

Timberlake, T. P., Vere, N. de, Jones, L. E., Vaughan, I. P., Baude, M., & Memmott, J. (2024). Ten‐a‐day: Bumblebee pollen loads reveal high consistency in foraging breadth among species, sites and seasons. *Ecological Solutions and Evidence*, *5*(3). https://doi.org/10.1002/2688-8319.12360

Ulyshen, M., Urban-Mead, K. R., Dorey, J. B., & Rivers, J. W. (2023). Forests are critically important to global pollinator diversity and enhance pollination in adjacent crops. *Biological Reviews of the Cambridge Philosophical Society*, *98*(4), 1118–1141. https://doi.org/10.1111/brv.12947

Vereecken, N. J., Dorchin, A., Dafni, A., Hötling, S., Schulz, S., & Watts, S. (2013). A pollinators' eye view of a shelter mimicry system. *Annals of Botany*, *111*(6), 1155–1165. https://doi.org/10.1093/aob/mct081

Whitney, H. M., Dyer, A., Chittka, L., Rands, S. A., & Glover, B. J. (2008). The interaction of temperature and sucrose concentration on foraging preferences in bumblebees. *Naturwissenschaften*, *95*(9), 845–850. https://doi.org/10.1007/s00114-008-0393-9

Yamazaki, K. (2025). Incidental pollination by passing animals: An overlooked mechanism? *PLANTS, PEOPLE, PLANET*. https://doi.org/10.1002/ppp3.70015

Table 1:

Welch two sample t-test results comparing pollen grain counts between Salticidae and Hemiptera specimens at the $\alpha = 0.05$ significance level.

data	t	df	p-value
pollen_total	2.1329	9.178	0.06115
pollen_legs	2.0474	9.6588	0.06879
pollen_abdomen	2.3368	9.0976	0.04396
pollen_head	1.6292	9.2562	0.1368

Table 2:

Negative Binomial Generalized Linear Model results for salticid pollen load predictor variables, significance is determined at the $\alpha = 0.05$ level.

Predictors	Estimate Std.	Error	z value	Pr(>| z |)	Significance
(Intercept)	1.066762	0.849648	1.256	0.20928	
body_length	0.373569	0.141571	2.639	0.00832	**
flower_count	0.004090	0.003862	1.059	0.28959	
flower_species	0.116135	0.120371	0.965	0.33464	

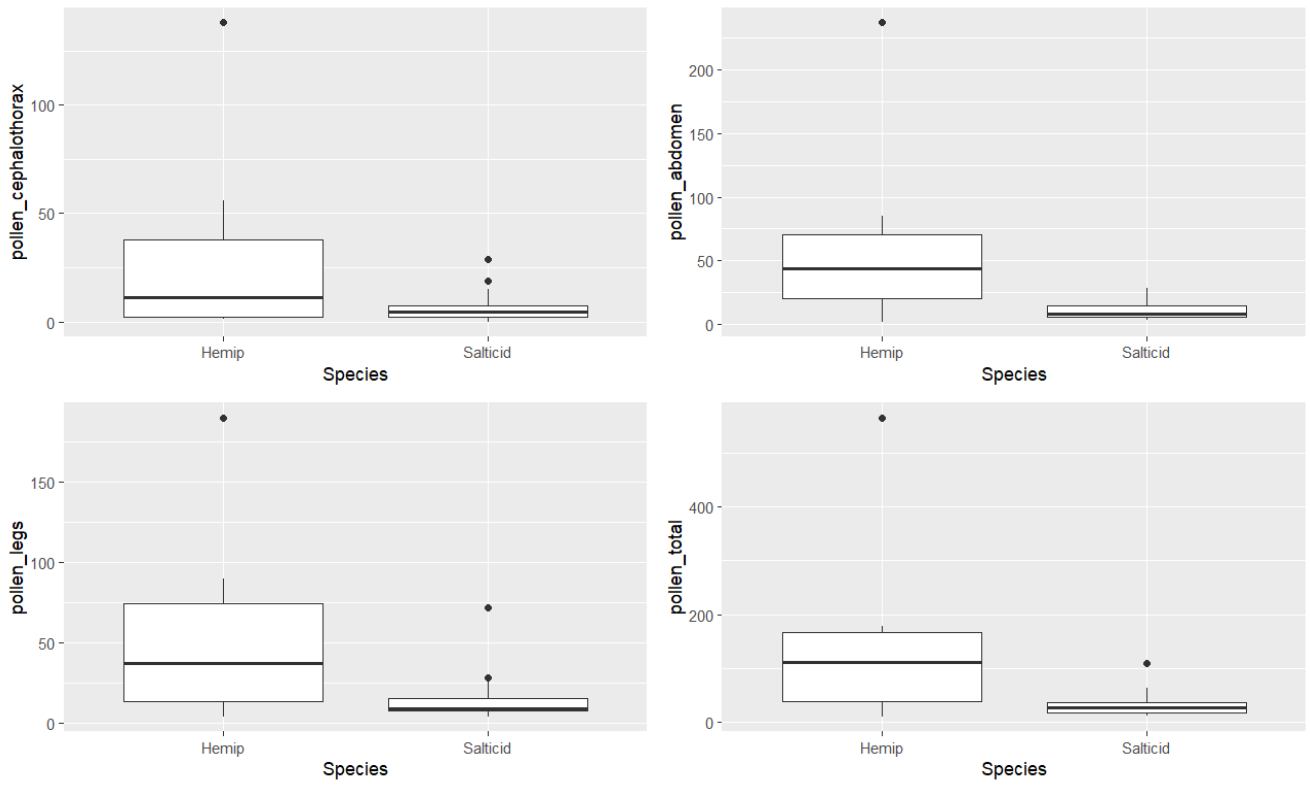

Figure 1. Depicts the relationship between Salticidae and Hemiptera pollen loads.

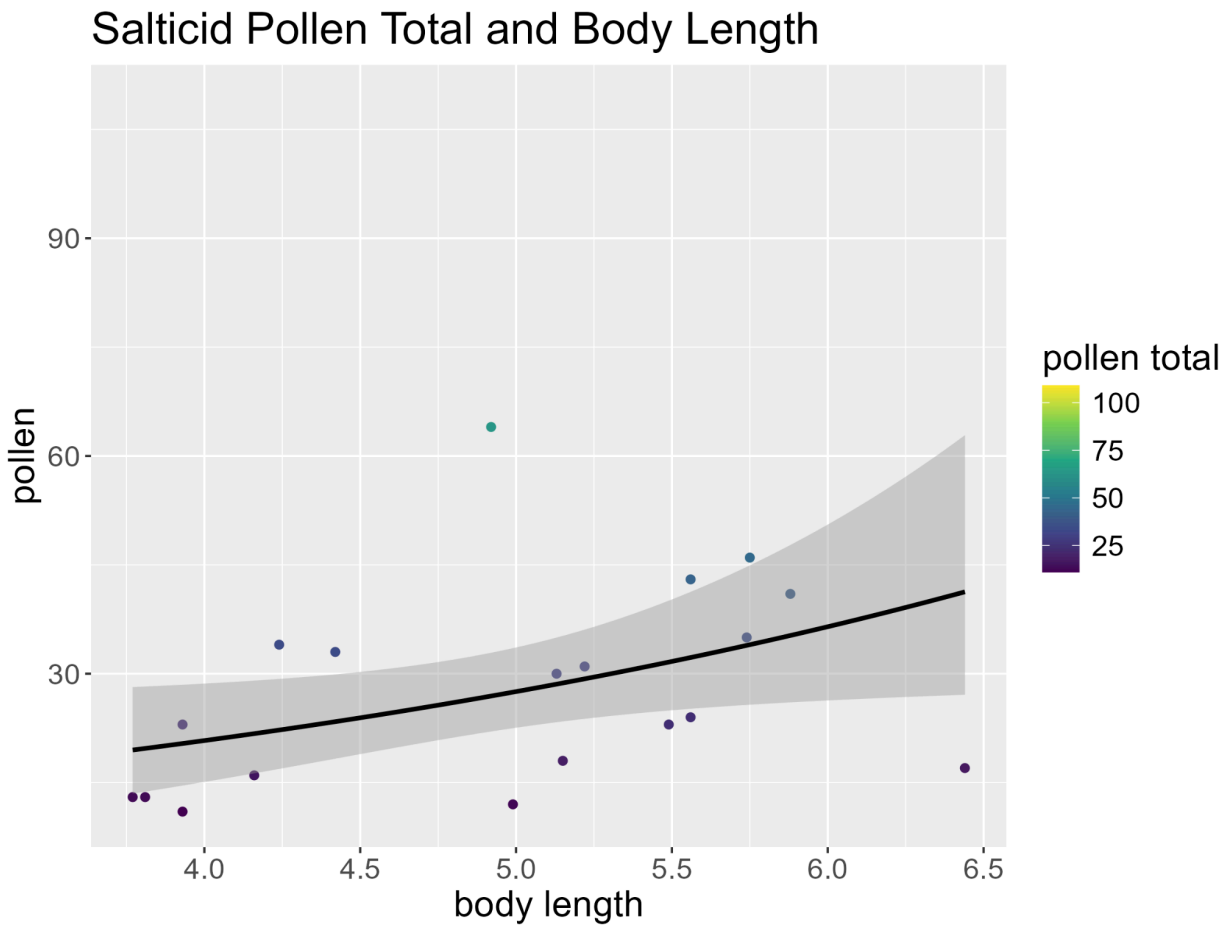

Figure 2. Depicts the predicted relationship between salticid pollen load and body length based on a negative binomial generalized linear model. Raw data points are shown alongside a predicted pollen total curve with the 95% confidence interval shaded in.

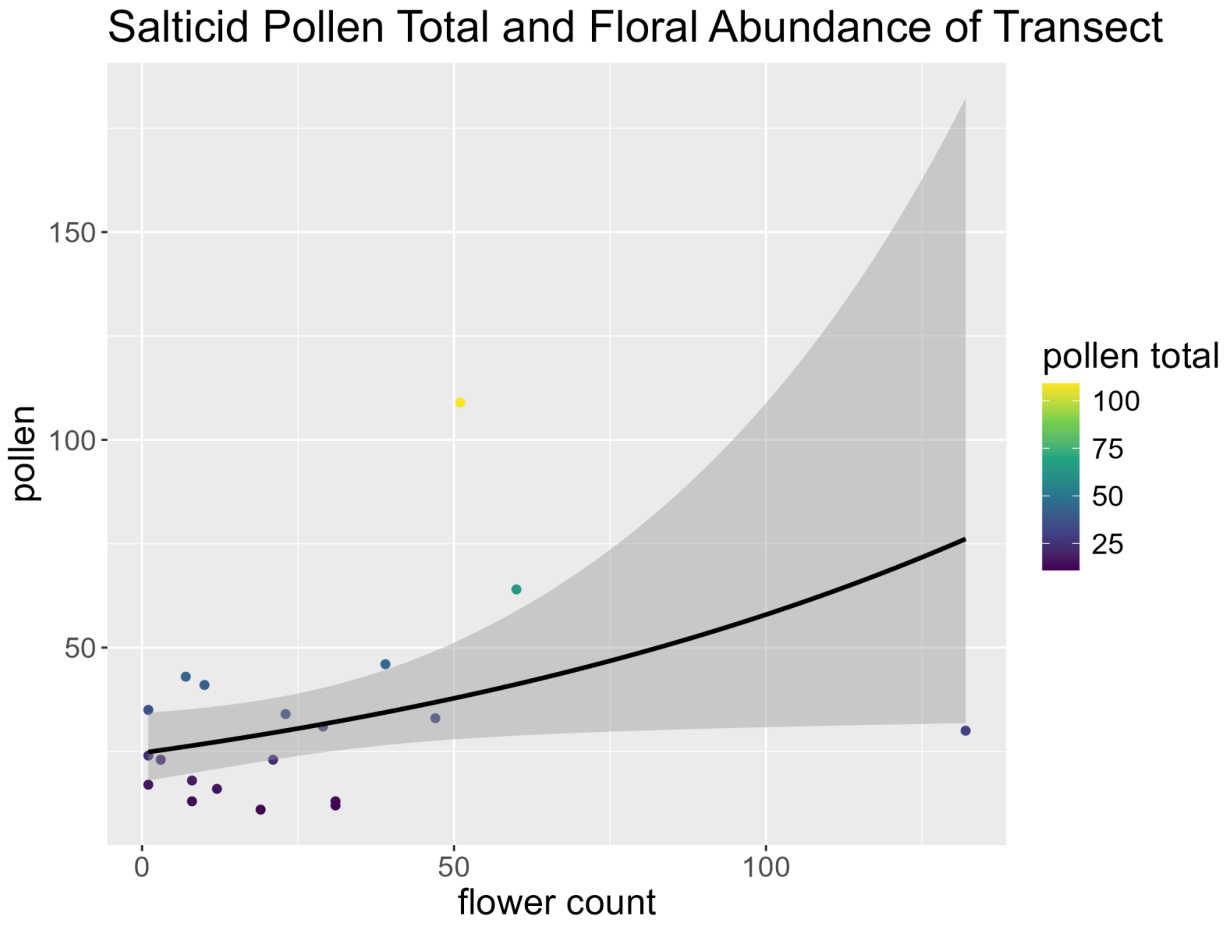

Figure 3. Depicts the predicted relationship between salticid pollen load and floral richness based on a negative binomial generalized linear model. Raw data points are shown alongside a predicted pollen total curve with the 95% confidence interval shaded in.

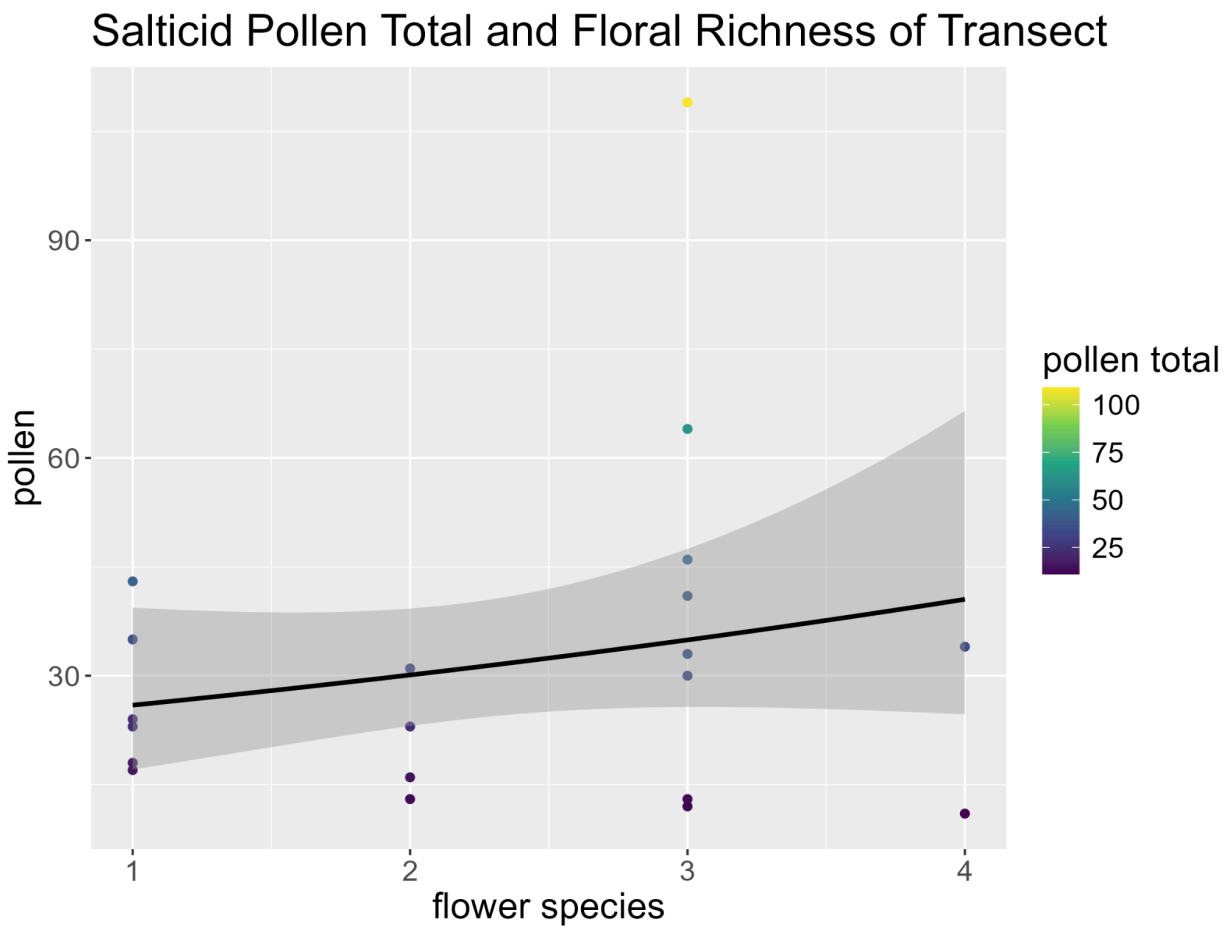

Figure 4. Depicts the predicted relationship between salticid pollen load and floral abundance based on a negative binomial generalized linear model. Raw data points are shown alongside a predicted pollen total curve with the 95% confidence interval shaded in.

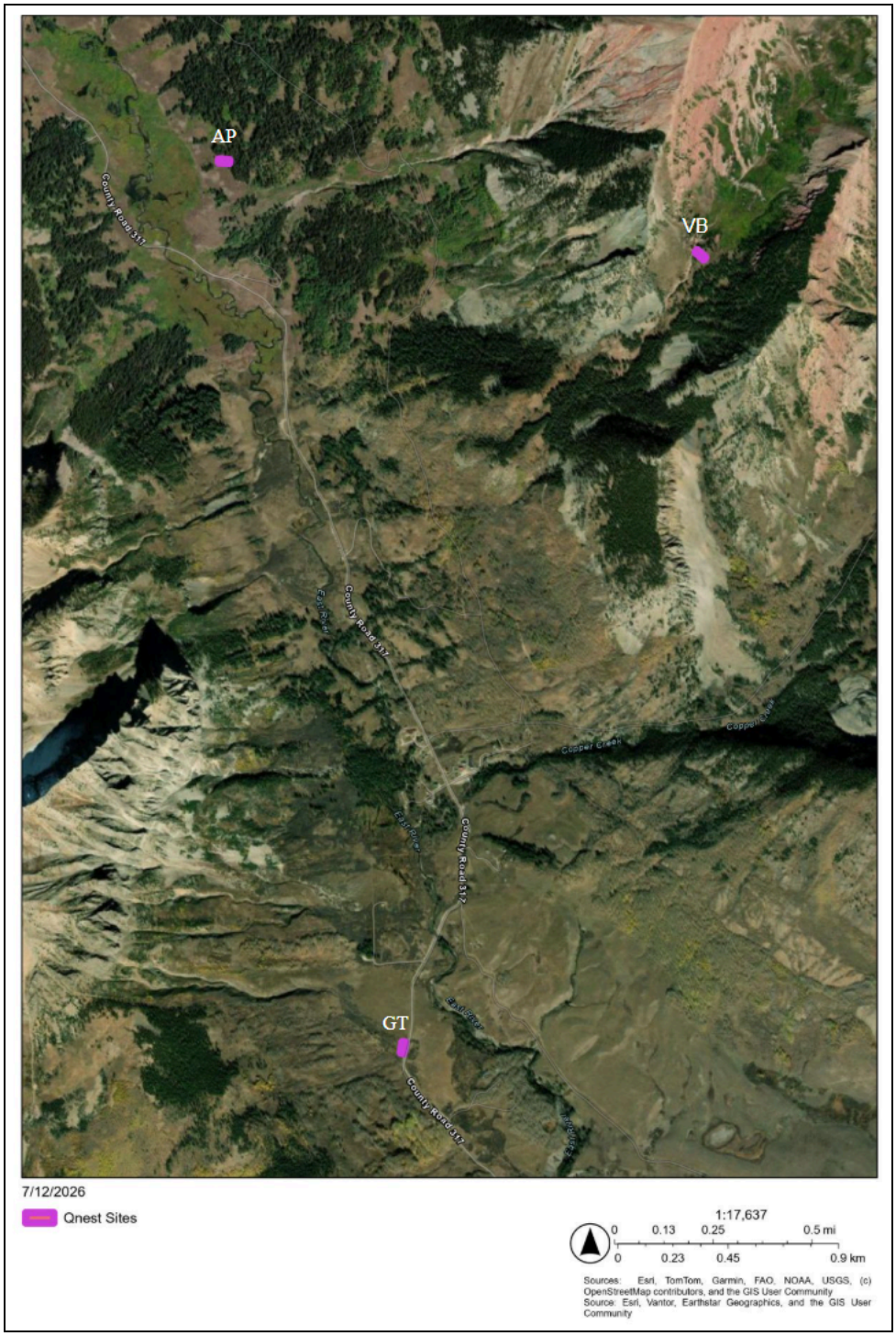

Figure 5. Depicts a map of Qnest field sites that were considered for specimen sampling and floral density measurements due to the transects established within each respective wildflower meadow.