

# Newsletter

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## Assessment of the pinned specimen digitization progress of the University of Alaska Museum Insect Collection

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### Abstract

During the spring semester of 2020, a project was launched to assess the current digitization progress of the pinned UAM Insect Collection. The goal was to discover how many specimens were undigitized within each order and rank orders by their digitization completeness to allow strategically targeted digitization efforts. Undigitized specimens represent “dark data,” and by assessing the collection, we hoped to help bring these data into the light so they can be used to answer scientific questions. We examined each drawer of the pinned Insect collection and counted any specimens not bearing a UAM barcode label. Upon completion of the initial count, UAM staff digitized some of the previously undigitized specimens. The pinned collection is now 90% digitized. All but four orders are now 100% digitized. The four orders that are not yet 100% digitized are Coleoptera (99%), Hymenoptera (90%), Diptera (83%), and Hemiptera (74%).

### Introduction

As anthropogenic climate change enlarges our planet’s sixth mass extinction crisis (Ceballos et al., 2015), there is an increasing urgency to museum science (Raven and Miller, 2020). Efforts have accelerated to digitize biodiversity data held by the world’s Natural History Collections with a goal of creating open access data according to the

FAIR Data Principles: findability, accessibility, interoperability, and reusability (Nelson and Ellis, 2019; Heberling et al., 2021). Many museums have a significant number of specimens whose data are not yet being shared online with the scientific community. Such unshared, undigitized data are often called “dark data” (Heidorn, 2008; Sikes et al., 2016). Dark data are more difficult to access and are consequently often ignored by biodiversity informaticians using

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so-called 'Big Data' to answer questions of conservation concern. For example, Kerr et al. (2015) analyzed open access, online bumble bee data covering 110 years of collection effort in North America and Europe and detected trends showing range losses and elevational shifts. Specimens with dark data that were relevant to this study were not included because their data were not shared according to FAIR data principles.

The University of Alaska Museum Insect Collection (UAM) is now over two decades old. UAM staff have been able to keep track of and summarize annual growth of the collection's digitized specimens but had lost track of its undigitized holdings. It is relatively easy to count museum specimen records in a database (Sikes, 2015; Whitmore et al., 2020), but specimens that are not yet digitized must be counted manually and doing so only provides a snapshot of the undigitized holdings. As work progresses and new specimens are added to the collection and old undigitized specimens are processed, the count of undigitized specimens becomes inaccurate.

In the spring of 2020, we assessed the digitization progress in the UAM pinned collection. The purpose of the project was to find out how many specimens were undigitized per insect order.

## Methods

We started at the first drawer of the pinned insect collection and visually counted any specimens not bearing a UAM barcode label using a hand-held tally counter. All digitized pinned specimens have a Data Matrix barcode label, which sticks out from under the data label and is visible from above (Figure 1). We proceeded through all the drawers in this manner, grouping counts within each order. We did not count parasites or phoretic specimens such as mites or nematomorphs (e.g., UAM:Ento:354713) on pinned insect specimens. A pin with multiple specimens of the same taxon on it (e.g., inside a gelatin capsule) was counted as a single undigitized specimen because once digitized it would be a single database record. Our total count is therefore a minimum, not actual, number of pinned specimens (Sikes, 2015).

After we finished a first pass at counting, UAM staff used those results to strategically target undigitized specimens for immediate digitization. We therefore present two undigitized counts: the first pass, and the later, most recent counts to show the effectiveness of this strategic approach. We used the most recent counts to calculate the percent digitized for each order and for the entire pinned collection.



Figure 1: Example of pinned specimens with UAM barcodes visible.

Table 1: List of pinned specimens in the UAM Insect Collection by order with initial (1) counts of undigitized specimens from Spring 2020, later current counts (2), current (8 Feb 2021) digital record totals, and percent digitization of each order.

Order	Undigitized (1)	Undigitized (2)	Digitized	% digitized
Archaeognatha	0	0	2	100
Blattodea	3	0	30	100
Coleoptera	747	614	75,098	99.2
Dermaptera	0	0	5	100
Diptera	14,720	14,689	72,054	83.1
Ephemeroptera	2	0	36	100
Hemiptera	3,693	3,693	10,632	74.2
Hymenoptera	7,642	7,480	69,508	90.3
Isoptera	0	0	1	100
Lepidoptera	16	0	14,882	100
Mantodea	0	0	1	100
Mecoptera	0	0	2	100
Neuroptera	45	0	246	100
Odonata	9	0	116	100
Orthoptera	1,334	0	2,709	100
Plecoptera	28	0	110	100
Psocodea	0	0	47	100
Thysanoptera	0	0	80	100
Trichoptera	371	0	854	100
Zygentoma	1	0	3	100
<b>Totals</b>	<b>28,611</b>	<b>26,476</b>	<b>246,416</b>	<b>97.4<sup>2</sup></b>

<sup>2</sup>Averaged.

## Results

The results in Table 1 show that the UAM Insect pinned collection holds a minimum total of 272,892 specimens of which a little over 26,000 are not digitized (90.3% digitized). All small orders, those with fewer than 3,000 specimens, are 100% digitized. Of the larger orders, Lepidoptera is the most thoroughly digitized (100%) and Hemiptera the least (74.22%).

## Discussion

The most thoroughly digitized large order, Lepidoptera, at 100% was recently the focus of a large NSF-funded "Advancing Digitization of Biological Collections" grant titled LepNet (Seltmann et al., 2017), which was intended to complete digitization on all the UAM pinned Lepidoptera specimens. Coleoptera, the second most thoroughly digitized order at 99%, is the taxonomic focus of the curator (second author), and therefore has received more attention than others. However, Coleoptera (75,712 specimens) is only the third largest order in the collection behind Diptera (86,743 specimens) and Hymenoptera (76,988 specimens). The third most thoroughly digitized order, Hymenoptera,

at 90% digitized, grew over the last 6 years from two separate unfunded donations. The first was a large collection of thousands of undigitized parasitoid wasps from the Dominique Collet collection; the second donation was of the Master's thesis voucher specimens from University of Alaska Fairbanks graduate student Alexandria Wenninger. Together, these donations account for most of the undigitized Hymenoptera specimens. The fourth most thoroughly digitized order, Diptera, at 83% digitized, has the largest total number of undigitized specimens (14,689), the bulk of which are from the USDA Palmer Agricultural Experiment Station and the Kathryn Sommerman biting fly collections of the mid 20<sup>th</sup> century. The least thoroughly digitized order, Hemiptera, at 74% digitized has many drawers of undigitized and unidentified Miridae and Cicadellidae (including many nymphs that are probably unidentifiable) from the USDA Palmer Agricultural Experiment Station collection. It is questionable whether these long series of old, unidentified and likely unidentifiable specimens are worth digitizing (or keeping for that matter). Their DNA might be of value, and probably the only way to identify most of them, but trying to obtain identifications in this manner would be very costly and a large percentage of specimens might fail to sequence due to de-

graded DNA (raising the cost per successful identification considerably).

The high rate of digitization in the UAM Insect Collection is due primarily to the use of the pro-active DBYL digitization protocol (Database Before You Label) as described in Sikes et al. (2017). This approach is typically an order of magnitude more efficient than retro-active digitization of already labeled and taxonomically sorted specimens. It ensures that specimens are 'born digital' with data captured at the collection event level, and have barcodes and database records before their labels are printed and before they are taxonomically sorted and identified. All the 26,000 undigitized pinned specimens were prepared using the far less efficient method of typing data into a computer to generate labels (for those prepared in modern times), placing the labels on specimens, sorting taxonomically, and if any digitization happens at all, it is done by reading the data on the labels and typing those data back into a computer one specimen at a time. Assuming that growth of museum collections continues indefinitely into the future, then most specimens have yet to be collected. The last 200+ years of specimen collections will eventually become less than 10% of the material held in museums. If entomologists wish to maximize the value of limited research funding, they should adopt the DBYL protocol, or something similar, to ensure their specimens are 'born digital' and do not become a ten-fold cost burden on future generations.

Prior to this project we did not know the size of the pinned insect collection nor what percent was undigitized. Having completed this assessment, the UAM Insect Collection is now able to strategically target future digitization efforts to bring these specimens' "dark data" into the light. We hope to conduct a similar assessment of the alcohol collection in the near future.

## Acknowledgments

This work was completed in fulfillment of the University of Alaska Fairbanks Museum Research Apprenticeship (MRAP 288) course taken by the first author. We thank Kyle Campbell for encouraging the first author to take an MRAP course.

## Author Contributions

The first author laid eyes on every pinned specimen while counting those that were undigitized, and drafted a report. The second author designed the project and helped with writing and analysis. The remaining authors worked on strategically digitizing specimens after the first pass had been completed and helped review the manuscript.

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## Bugs in winter

by John Hudson and Bob Armstrong

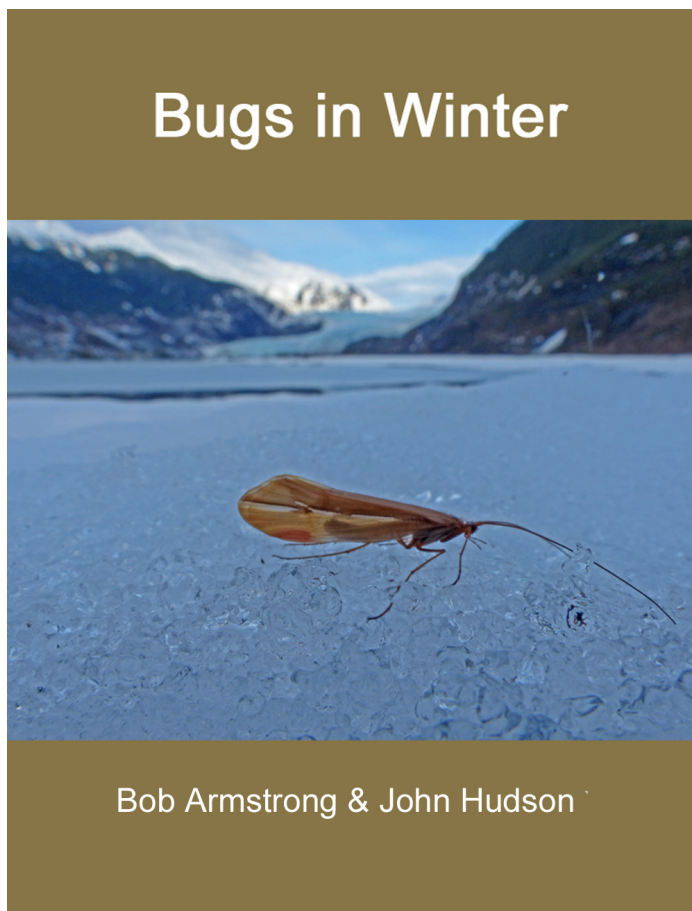


Figure 1: Cover of the *Bugs in Winter* guide.

We got started on “*Bugs in Winter*” (Figure 1), a small guide to some of the invertebrates seen around Juneau in winter, when we noticed tiny springtails moving about on the surface of the snow (Figure 2). And then we saw and photographed a beetle larva (Figure 3) and adult dance fly (Figure 4) eating a springtail on the snow in mid-winter. These events stimulated our interest and desire to learn

and understand why some bugs are out and about in winter. For example, one study indicated that some springtails are able to move fairly long distances, about a mile, on the snow by orientating on the sun or the dark horizon (something they can’t do living down in and on the ground in summer).



Figure 2: A springtail in the Genus *Ptenothrix* identified by Frans Janssens.

The good news is there are a broad range of invertebrates that are active in winter, but not too many. So, it was possible to put together photos and information that covers the ones you are most likely to see. Our little *Bugs in Winter* guide contains interesting facts about the creatures and their behavior. You can see what we have learned so far in this evolving pdf: <https://www.naturebob.com/sites/default/files/Bugs%20in%20Winter%20optimized%20March%201%2C%202021.pdf>. Our main reason for creating *Bugs in Winter* is to provide information to educators to inform and stimulate their students about the variety of invertebrates that can be easily seen on snow in winter.



Figure 3: A soldier beetle larva (Family Cantharidae) feeds on a springtail.



Figure 4: An adult dance fly feeds on a springtail.



Figure 5: A frozen hammock spider (Genus *Pityohyphantes*, identified by Joey Slowik).





Figure 6: A male Bruce spanworm mates with the wingless female.

In winter we often see spiders crawling about on the snow (Figure 5). Some of the spiders appeared to be frozen. Spiders are freeze resistant but not freeze tolerant. Several spiders that appeared to be frozen were warmed gradually but did not “come back to life.” According to Joey Slowik, spiders that are on the snow during a warm period may be prevented from accessing refuges in leaf litter when the temperature suddenly falls below freezing. This may be the main reason that some become frozen on the snow surface.

The Bruce spanworm moth is well known for outbreaks that can defoliate leaves of deciduous trees and shrubs throughout much of Alaska. In Juneau we see the males mating at night with the wingless females on blueberry plants in late fall and early winter (Figure 6). Eggs are laid near the plants and the caterpillars emerge in spring and feed on the blueberry leaves. One study indicated that the defoliation by Bruce spanworms on blueberries may, over the long run, actually benefit the plants. It appears that the caterpillars’ frass provides more nutrients than the

autumn-shed leaves.

At Nugget Falls near the Mendenhall Glacier we often see adult midges (Family Chironomidae) mating on snow and ice in mid-winter. Some of these midges are commonly called snow midges (genus *Diamesa*, Figure 8). Snow midges are one of the first insects to colonize streams exposed by retreating glaciers. Some adults can survive temperatures down to 3 °F, but quickly die if held in a warm hand.

The vast majority of caddisflies (order Trichoptera) overwinter in the egg or larval stage. A few caddisflies overwinter as adults and are referred to as snow sedges. The snow sedge *Psychoglypha subborealis* is often seen flying on pleasant days in late fall and early spring, even when there is snow on the ground in Juneau (Figure 7). The larvae of this caddisfly are often found in water bodies that shrink in size or dry up in winter. Safe inside the overwintering adult, the eggs avoid exposure to harsh winter conditions.



Figure 7: The snow sedge *Psychoglypha subborealis* near the Mendenhall Glacier in Juneau.

One of the most common and easily observed winter-active insects are the snowflies. Snowflies belong to a few families in the order Plecoptera (stoneflies). Adults emerge in late winter and crawl about on the snow in search of mates (Figure 9). Many have full-sized wings like other stoneflies, but are rarely seen in flight in the winter months. In some the wings are reduced or absent. Bridges, poles, and fences near streams are great places to find adult snowflies.

Acknowledgement: We would like to thank Derek Sikes for identifying the soldier beetle, Joey Slowik for identifying the hammock spider, Frans Janssens for identifying the springtail, and Patrick Hudson for identification of the non-biting midges.





Figure 8: A mating pair of non-biting midges in the Genus *Diamesa*.



Figure 9: An adult snowfly (Family Capniidae).



# Notes on a collection of spiders from agricultural by-catch from the Matanuska-Susitna area of Alaska

by Jozef Slowik<sup>1</sup>

Spiders are an important natural predator in many ecosystems, though their contribution to pest control in agroecosystems does seem unclear (Nyffeler and Birkhofer, 2017). This is largely due to the limited habitat and spider diversity found in agricultural plots (Nyffeler and Sunderland, 2003). However, spiders are often specialists and recognizing which species may assist with a pest problem, and enhancing the field to encourage that species may be beneficial (Rypstra et al., 1999). There have been no studies on arachnids from agriculture in Alaska. This study looked at by-catch from several other pest related studies around Palmer, Alaska and identified the species associated with those agriculture systems.

## Methods

Spider specimens were removed from by-catch vials collected as part of several USDA projects examining pests of crops grown in the Matanuska-Susitna valley. Fields sampled were at the Matanuska Experiment Farm and Extension Center (N 61.5686° W 149.2495°), The Point Mackenzie Correctional Farm (N 61.4186° W 150.0924°). Additionally, fields at Pyrah's (N 61.5319° W 149.0823°), Cambell's (N 61.5153° W 149.0800°), and VanderWheel's (N 61.5634° W 149.1495°) commercial farms were sampled.

Specimens were collected using either Aphid pan traps (APT) (Pantoja et al., 2010b) or click beetle traps (CBT) (Pan-

toja et al., 2010a). Specimens were collected off rhubarb (*Rheum* spp.), potato (*Solanum tuberosum* (L.)), or lettuce (*Lactuca sativa* L.). Collections occurred over the years 2006–2008.

A total of 1812 by-catch vials were examined. Spiders were identified to species if mature, and family if juvenile using Ubick et al. (2005). Family guild organization follows Uetz et al. (1999). Not all by-catch samples included crop information (24%). All specimens have been deposited at the University of Alaska Museum of the North.

## Results

Of the 1812 by-catch vials examined 165 (9.1%) contained spiders. A total of 262 spiders were found, of those 176 were adult and could be identified to species. Forty-two species were identified representing 10 families (Table 1). One additional family, Theridiidae, was only represented by juveniles. The highest number of specimens and species was exhibited by the family Linyphiidae (Table 2). Rhubarb samples dominated the crop type sampled ( $n = 133$ ) compared to potato ( $n = 10$ ) and lettuce ( $n = 7$ ). The Wandering Sheet guild dominated species and samples because of the inclusion of Linyphiidae. Second was the Ambusher (Thomisidae and Philodromidae) and Orbweaver (Araneidae and Tetragnathidae) guilds (Table 3).

Specimen data are available at [https://arctos.database.museum/viewAccn.cfm?transaction\\_id=21127085](https://arctos.database.museum/viewAccn.cfm?transaction_id=21127085).

Table 1: Species list, trap type species collected with, and crop species collected off of, for a collection of spiders from agricultural fields in the Matanuska-Susitna Valley, Alaska.

Family	Species	Trap type	Crop
Araneidae	<i>Araniella proxima</i> (Kulczyński, 1885)	APT	rhubarb
	<i>Larinioides cornutus</i> (Clerck, 1757)	APT	rhubarb
	<i>Larinioides patagiatus</i> (Clerck, 1757)	APT, CBT	rhubarb
Clubionidae	<i>Clubiona furcata</i> Emerton, 1919	CBT	rhubarb
	<i>Clubiona riparia</i> L. Koch, 1866	APT, CBT	rhubarb
Dictynidae	<i>Dictyna brevitarsa</i> Emerton, 1915	APT	rhubarb
	<i>Dictyna major</i> Menge, 1869	APT, CBT	rhubarb
	<i>Emblyna annulipes</i> (Blackwall, 1846)	APT, CBT	lettuce, rhubarb
	<i>Emblyna manitoba</i> (Ivie, 1947)	APT	rhubarb
Gnaphosidae	<i>Zelotes fratris</i> Chamberlin, 1920	CBT	
Linyphiidae	<i>Agyneta lophophor</i> (Chamberlin & Ivie, 1933)	CBT	

Continued on next page...

<sup>1</sup>University of Alaska Cooperative Extension Service

Family	Species	Trap type	Crop
Linyphiidae	<i>Allomengea dentisetis</i> (Grube, 1861)	CBT	rhubarb
	<i>Bathypantes brevipes</i> (Emerton, 1917)	APT	rhubarb
	<i>Bathypantes latescens</i> (Chamberlin, 1919)	APT, CBT	rhubarb
	<i>Bathypantes pallidus</i> (Banks, 1892)	CBT	rhubarb
	<i>Centromerus sylvaticus</i> (Blackwall, 1841)	APT, CBT	rhubarb
	<i>Diplocephalus subrostratus</i> (O. Pickard-Cambridge, 1873)		potato
	<i>Erigone arctica</i> (White, 1852)	CBT	lettuce
	<i>Erigone atra</i> Blackwall, 1833	APT, CBT	lettuce, rhubarb
	<i>Erigone blaesa</i> Crosby & Bishop, 1928	CBT	lettuce, potato
	<i>Erigone dentigera</i> O. Pickard-Cambridge, 1874	APT	rhubarb
	<i>Erigone tanana</i> Chamberlin & Ivie, 1947	APT	
	<i>Gnathonarium taczanowskii</i> (O. Pickard-Cambridge, 1873)	APT, CBT	lettuce, rhubarb
	<i>Mecynargus paetulus</i> (O. Pickard-Cambridge, 1875)	APT, CBT	rhubarb
	<i>Microlinyphia pusilla</i> (Sundevall, 1830)	APT, CBT	rhubarb
	<i>Microneta viaria</i> (Blackwall, 1841)	CBT	lettuce, rhubarb
	Misc #3	APT, CBT	rhubarb
	<i>Phlattothrata parva</i> (Kulczyński, 1926)	APT, CBT	rhubarb
	<i>Praestigia kulczynskii</i> Eskov, 1979	CBT	rhubarb
	<i>Walckenaeria atrotibialis</i> (O. Pickard-Cambridge, 1878)	CBT	rhubarb
	Lycosidae	<i>Pardosa palustris</i> (Linnaeus, 1758)	CBT
Philodromidae	<i>Rhysodromus alascensis</i> (Keyserling, 1884)	CBT	rhubarb
	<i>Philodromus cespitum</i> (Walckenaer, 1802)	APT, CBT	rhubarb
	<i>Philodromus placidus</i> Banks, 1892	APT	potato
Salticidae	<i>Thanatus striatus</i> C. L. Koch, 1845	CBT	rhubarb
	<i>Attulus striatus</i> (Emerton, 1911)	APT	rhubarb
	<i>Pelegrina montana</i> (Emerton, 1891)	APT	rhubarb
Tetragnathidae	<i>Tetragnatha dearmata</i> Thorell, 1873	APT	rhubarb
	<i>Tetragnatha laboriosa</i> Hentz, 1850	APT	rhubarb
Thomisidae	<i>Misumena vatia</i> (Clerck, 1757)	APT	rhubarb
	<i>Ozyptila gertschi</i> Kurata, 1944	CBT	rhubarb
	<i>Ozyptila sincera canadensis</i> Dondale & Redner, 1975	CBT	rhubarb

Table 2: Spider families, number of specimens, and number of representative species for a collection of spiders from agricultural fields in the Matanuska-Susitna Valley, Alaska.

Family	Number of specimens	Percent of specimens	Number of species	Percent of species
Araneidae	16	6.1	3	7.1
Clubionidae	9	3.4	2	4.8
Dictynidae	11	4.2	4	9.5
Gnaphosidae	1	0.4	1	2.4
Linyphiidae	169	64.5	20	47.6
Lycosidae	5	1.9	1	2.4
Philodromidae	14	5.3	4	9.5
Salticidae	4	1.5	2	4.8
Tetragnathidae	13	5.0	2	4.8
Theridiidae	5	1.9	0	0
Thomisidae	15	5.7	3	7.1

Table 3: Guild, number of specimens, and number of representative species for a collection of spiders from agricultural fields in the Matanuska-Susitna Valley, Alaska.

Guild	Number of specimens	Number of species
Guild	Number of specimens	Number of species
Foliage Runners	9	2
Ground Runner	6	2
Stalker	4	2
Ambusher	29	7
Wandering Sheet	169	20
Orb Weaver	29	5
Space Web Builder	16	4

## Discussion

These data represent the first sampling of spider species occurring in association with agriculture in Alaska. It is also the first data on species occurrences in Southcentral Alaska since Chamberlin and Ivie's work in 1947. Although these data are from agricultural settings, the data are representative of other diversity surveys in Alaska (Slowik, 2006; Slowik and Blagojev, 2012; Sikes et al., 2013). These data do differ from agricultural data from the contiguous United States in which Linyphiidae do make up the most diverse group found, but they are not the most commonly collected family (Young and Edwards, 1990), but they agree with agricultural data from Europe (Nyffeler and Birkhofer, 2017).

Generally wandering guilds including the families Salticidae and Lycosidae will make up a larger proportion of specimens and species (Young and Edwards, 1990; Kerzicnik et al., 2013). However, this is likely an artifact of the collection methods as both traps are above ground level requiring the spider to climb up the vegetation to become victim of the trap. Given that only 9.1% of samples had spiders in the samples, this implies that the trapping methods were not very efficient at trapping spiders. For an IPM application these traps were effective at collecting their intended pest and spared natural predators like spiders, though the true abundance of spiders is not known for comparison. Unfortunately, crop comparison could not be conducted due to the low number of samples from potato and lettuce, but these data are an initial baseline to build on.

## Acknowledgements

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## Pollination, pilfering, and predation in an orchid pollinator network in the Juneau area of Southeast Alaska

by Marlin Bowles<sup>1</sup> and Robert Armstrong<sup>2</sup>

### Summary

We studied insect pollinators and other visitors to 14 native orchids of the Juneau area of Southeast Alaska. At least 15 insect pollinators, a pollen consumer, and 4 spiders were found among ten orchid species. New North American records included pollination of *Coeloglossum viride* by march flies (Bibionidae), visitation and possible pollination of *Listera cordata* by *Dryomyza* flies, pollen transfer on *Corallorhiza trifida* by dance flies (Empididae) and pollination of *Corallorhiza mertensiana* by a *Bombus* species. New pollinators of *Platanthera dilatata* included the hawkmoth *Hyles gallii*, the butterfly *Pieris marginalis* and several new Noctuidae species. We observed for the first time the bee mimic *Eristalis anthophorina* foraging on *Spiranthes romanzoffiana*. A complex network occurred among these orchids and insects. Some orchids had multiple pollinators, while some insects pollinated multiple orchids. Several insects were nectar thieves, including one pollinator. Noctuidae moths pollinate *Platanthera dilatata*, but they appear to be nocturnal nectar thieves of two other orchid species (*Goodyera oblongifolia* and *S. romanzoffiana*) that are diurnally pollinated by *Bombus* species. Plume moths (*Amblyptilia* sp.) are nectar thieves on *G. oblongifolia* and *P. dilatata* but do not pollinate other orchids. More work is needed to understand interactions among these orchids and their pollinators and nectar thieves.

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Table 1: Pollinators and insect visitors observed on orchids of the Juneau area.

Common name	Scientific name	Pollinators (literature)	Observed pollinators and insect visitors
Northern bracted orchid	<i>Coeloglossum viride</i>	Europe: Coleoptera, Hymenoptera, <i>Formica</i> (Claessens and Seiffert, 2017)	Bibionidae ( <i>Bibio vestitus?</i> ) bearing pollinia
Western fairy slipper	<i>Calypso bulbosa</i> var. <i>occidentalis</i>	<i>Bombus</i> sp. (Ackerman, 1981)	none
Western coralroot	<i>Corallorhiza mertensiana</i>	none	<i>Bombus</i> sp.
Early coralroot	<i>Corallorhiza trifida</i>	self-pollinating (Catling, 1983)	Empididae sp.
Giant rattlesnake plantain	<i>Goodyera oblongifolia</i>	<i>Bombus</i> sp. (Ackerman, 1975)	<i>Bombus</i> sp., Noctuidae (nectar thief), <i>Amblyptilia pica</i> (nectar thief)
Northwestern twayblade	<i>Listera banksiana</i>	none	Dryomyzidae (non-pollinating)
Heart-leaved twayblade	<i>Listera cordata</i>	Mycetophilidae, Sciaridae (Ackerman and Mesler, 1979)	Sciaridae, rove beetle <i>Eusphalerum pothos</i> (consuming pollinia)
Blunt-leaved orchid	<i>Platanthera obtusata</i>	Culicidae (Gorham, 1976)	Empididae (probing for nectar)
Bog adder's mouth	<i>Malaxis paludosa</i>	Mycetophilidae (Reeves and Reeves, 1984)	none
Chamisso's orchid	<i>Platanthera chorisiana</i>	self-pollinating (Catling, 1984), Coleoptera (Inoue, 1981)	none
Slender bog orchid	<i>Platanthera stricta</i>	Geometridae, Empididae, <i>Bombus</i> sp. (Patt et al., 1989)	Geometridae, Empididae (bearing pollinia)
Two-leaved (Aleutian) adder's mouth	<i>Malaxis diphyllis</i>	none	none
White bog orchid	<i>Platanthera dilatata</i>	Noctuidae (Larson, 1992)	Noctuidae spp., <i>Hyles gallii</i> , <i>Pieris marginalis</i> , <i>Bombus</i> sp., <i>Amblyptilia</i> sp.
Hooded ladies' tresses	<i>Spiranthes romanzoffiana</i>	<i>Bombus</i> sp. (Larson and Larson., 1987; Larson and Larson, 1990)	<i>Bombus melanogypus</i> , <i>Eristalis anthophorina</i> , Noctuidae (nectar thief)

## Introduction

Orchid species are well known for their specialized adaptations to insect pollinators (e.g., Darwin, 1862; Argue, 2012a,b). Their floral structures include a showy modified petal (lip) that attracts insects and directs them toward a food reward as well as pollen masses (pollinia) and the stigma. Nectar is usually located in recessed spurs, at the base of the lip, or in floral tubes, where the ability of an insect to access nectar is often determined by the length of its proboscis (we use tongue interchangeably), or their body structure. This is particularly evident in the rein orchids (*Platanthera* spp.), which use flower color and nectar spur

length to partition moth and butterfly pollinator species by their color preferences and tongue lengths (Hapeman and Inoue, 1997). A few species, such as *Calypso bulbosa* are pollinated by deceit, as they falsely advertise a food reward, and attach pollinia to insects as they exit the flower. Self-pollination (autogamy) has evolved independently among different orchid groups, though they may maintain flower structure that allows pollinia removal and outcrossing (Catling, 1983). Some orchid species may be pollinator generalists, or insect species may be versatile pollinators among different orchids. Given the array of adaptations to different pollinators among different types of orchids, these assemblages may display structure or

modularity similar to other plant-pollinator networks (e.g., Olesen et al., 2007).

## Objectives

Despite the wealth of investigations into orchid pollination biology, pollinators have not been determined for many North American species (Argue, 2012a,b), which represents a major gap in knowledge about their reproductive requirements. Southeast Alaska has at least 27 native orchid species or varieties (e.g., Hultén, 1968; Brown, 2006). For more information and orchid nomenclature see Bowles and Armstrong (2019). The Juneau area of Southeast Alaska has 14 native orchids with populations accessible for field study. Only eight of these species have pollinators reported in the North American literature (Table 1). In this paper we report on the results of a multi-year effort to catalog pollinators of these species. We sought to determine if orchids in this region are pollinated by insects known from the literature, and whether new pollinators could be identified. We also asked whether other insects may function as nectar thieves or flower consumers, and whether insect predators, such as spiders, use these orchids and impact pollinating insects. Finally, we asked whether pollinators and orchid species groups could be identified that suggested structure

in the network of orchids and their insect pollinators in our study area.

## Study area, and orchid species and known pollinators

Juneau is located in the Central Panhandle Climate Zone of Southeast Alaska, which has warmer winters, cooler summers and greater precipitation than interior Alaska (Bieniek et al., 2012). Vegetation is predominantly coastal rainforest of Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*), as well as open fen and muskeg bog with scattered shore pine (*Pinus contorta* var. *contorta*) and mountain hemlock (*Tsuga mertensiana*). Early successional uplift meadows may occupy coastal areas, while alpine vegetation also occurs on coastal mountains.

A single orchid species, the bracted orchid or frog orchid (*Coeloglossum viride* var. *viride*), occurs in alpine meadows. Its short inflorescence of green flowers appears in early summer. It produces nectar in short spurs as well as at the lip base. No North American pollinators have been reported. In Europe it is pollinated by many alpine insects, including five beetle (Coleoptera) species and four Hymenoptera species as well as the ant *Formica exsecta* (Claessens and Seiffert, 2017).



Figure 1: Motion-sensitive trail cam positioned to record visitors to *Platanthera dilatata*.





Figure 2: A dark-winged fungus gnat (Sciaridae) on flowers of the twayblade *Listera cordata*.

Seven species occupy rainforest habitat. Calypso (*Calypso bulbosa* var. *occidentalis*) is restricted to small forested islands. In early spring it produces small showy pink slipper-like flowers that lack a food reward. This orchid is pollinated by queen bumble-bees (*Bombus* spp.) that switch foraging to other nectar-producing plant species, resulting in low seed pod production.

Three forest species flower in late spring and early summer, producing short inflorescences of small green flowers. The heart-leaved twayblade (*Listera cordata*) and western twayblade (*L. banksiana*) are frequent in old-growth forests, while the blunt-leaved orchid (*Platanthera obtusata*) is rare in coastal forests. *Listera cordata* produces nectar at the lip base, and is pollinated by fungus gnats (Mycetophilidae and Sciaridae) (Ackerman and Mesler, 1979). However, no pollinators are reported for *L. banksiana*. *Platanthera obtusata* has a nectar spur and is pollinated primarily by mosquitoes (Cuclidae) (Gorham, 1976).



Figure 3: A geometrid moth (left) and a dance fly (Empididae, right) visiting flowers of *Platanthera stricta*. Note settling behavior of geometrid and pollinia on proboscis of dance fly.



Figure 4: *Autographa corusca* (left) and *Actebia fennica* (right) foraging on *Platanthera dilatata*. Note settling behavior, length of proboscis and presence of pollinia. Right photo by Gwen Baluss

The early coralroot (*Corallorhiza trifida*) and the western coralroot (*C. mertensiana*) often occur with twayblades in near-coastal forests. They are less common and tend to flower later, producing leafless stalks bearing small green and white flowers in *C. trifida* or larger purple and white flowers in *C. mertensiana*. *Corallorhiza trifida* has a reduced nectar spur and has been shown to be autogamous, forming seed pods in enclosures (Catling, 1983). The open structure and longer nectar spur of *C. mertensiana* flowers suggest insect pollination (Freudenstein, 1997); however, no pollinators are reported. The giant rattlesnake plantain (*Goodyera oblongifolia*) is restricted to near-coastal forest. It flowers in late summer, producing a tall spike of white flowers from an evergreen basal rosette of dark green leaves. Nectar is produced at the base of a short floral tube, and it is bumble bee (*Bombus*)-pollinated (Ackerman, 1975).



Six species occur in muskeg bogs and uplift meadows. The bog adder's mouth (*Malaxis paludosa*) occupies muskeg, while the Aleutian adder's mouth (*M. diphyllus*) occurs in bogs and meadows. They produce short spikes of minute green flowers from basal leaves in mid-summer, and are rare and inconspicuous. Both *Malaxis* species produce small amounts of nectar at the base of the lip, and are probably pollinated by fungus gnats (Reeves and Reeves, 1984), though they have not been confirmed for *M. diphyllus*. They can co-occur with the equally rare Chamisso's orchid (*Platanthera chorisiana*), which produces short inflorescences bearing small green flowers. This species is reported as autogamous in Canada (Catling, 1984); but, in Japan it produces nectar in a short spur and is pollinated by the beetle *Oedemeronia lucidicollis* (Inoue, 1981).



Figure 5: The bumble bee *Bombus melanogynus* foraging on *Spiranthes romanzoffiana*.

The slender bog orchid (*Platanthera stricta*) occurs in muskeg, muskeg-forest borders and roadsides. It begins flowering in early summer, producing tall leafy stalks with spikes of small green flowers with short nectar spurs. This orchid appears to be a pollinator generalist, as it is pollinated by moths (Geometridae), dance flies (Empididae spp.), and *Bombus* species (Patt et al., 1989). The white bog orchid (*Platanthera dilatata* var. *dilatata*) grows in open muskeg, meadows, and along roadsides. It begins flowering in mid-summer, producing tall leafy stalks with spikes of fragrant white flowers with long nectar spurs. Only

Noctuidae moths are reported as pollinating this species (Larson, 1992). Noctuidae are termed settling moths with respect to *Platanthera* pollination, as they may alight or partially hover while grasping flowers and do not hover in the same manner as Sphingidae (Hapeman and Inoue, 1997). These longer-tongued hawk moths have been suggested as pollinators as well, especially of *P. dilatata* var. *leucostachys*, which has longer nectar spurs than the typical variety (Sheviak C., 2002). The ladies' tresses orchid (*Spiranthes romanzoffiana*) flowers in late summer in muskeg and along lakeshores. Although less common, it often occurs with *P. dilatata*; its inflorescences reach maturity as those of the latter species are senescing. It produces a short spike of fragrant white flowers with nectar at the base of the floral tube, and is pollinated by *Bombus* spp. (Larson and Larson., 1987).



Figure 6: A March fly (Bibionidae) pollinating *Coeloglossum viride*. Note pollinia at the front of the head and partly opened flowers.

## Methods

Much of this work was conducted using motion-sensitive or time-lapse trail cams with flash and close focus capabilities. They could be left unattended to determine, and sometimes quantify, diurnal and nocturnal visitation by insects that were sensitive to human presence (Figure 1). We also recorded video, time-lapse and other photographic images on still cameras with macro capabilities. A black-light was used to capture moths foraging on *Goodyera oblongifolia*. Links to videos and slides from this work are provided in the videos and slide shows section (page 24). The working conditions for this project were not conducive for collecting voucher insect specimens. Often only a single individual was observed carrying pollinia, and its collection would have disrupted pollination. Many other visitors were observed only in video camera outputs, and could not be accessed for precise identification. As a result, we relied upon field observation or identification from pho-



tographs for species identities, and many pollinators could not be identified below the family level. For several orchid species, we used insect enclosures to determine whether they were autogamous, and we also quantified seed pod production to assess the effectiveness of pollinators. All photos are by the authors except as noted.



Figure 7: A *Dryomyza* fly (Dryomyzidae) on flower of *Listera banksiana*.



Figure 8: Sequence showing a dance fly (Empididae) entering and leaving a flower of *Corallorhiza trifida* while bearing pollinia on its thorax.

## Results and Discussion

We observed 15 or more insect taxa visiting ten orchid species that were either pollinators or appeared likely to be pollinators (Table 1). They represented the Hymenoptera, Lepidoptera, and Diptera. These insects represented five of the seven taxa reported in the North America literature as pollinators and about eight newly recorded pollinators for the study orchids. The Noctuidae were particularly dif-

ficult to identify as species. Other insects included one pollen consumer and two nectar thieves (Inouye, 1980), which consistently visited some orchid species. At least four spider taxa occurred on the orchids, including three web-spinning species and one ambushing species, as well as several predatory wasp species.

### Confirmation of reported pollinators

Among forest species, fungus gnats were observed repeatedly on *Listera cordata*; however, none were bearing pollinia. One species (Figure 2) appears to be a dusky-winged fungus gnat (Sciaridae). We made a single observation of a *Bombus* species visiting *Goodyera oblongifolia*.



Figure 9: *Bombus* species pollinating *Corallorhiza mertensiana*. Note pollinia positioned below eyes.

In fen, meadow and muskeg habitats, we recorded pollinators on three orchid species. On *Platanthera stricta* we observed a dance fly (Empididae sp.) bearing pollen on its proboscis as well as a moth species (Geometridae) foraging for nectar (Figure 3). On *Platanthera dilatata*, several Noctuidae moth species (probably *Autographa corusca* and *Actebia fennica*) were found bearing pollinia on their tongues while foraging for nectar (Figure 4). On *Spiranthes romanzoffiana*, we recorded visits by the black-tailed bumble bee (*Bombus melanogynus*) (Figure 5). As this orchid flowers in late summer, they were probably male drones. *Goodyera oblongifolia* is also late-flowering, and may have been visited by this *Bombus* species as well.

### Newly reported pollinators or visitors

In alpine, *Coeloglossum viride* was pollinated by march flies (Bibionidae, possibly *Biblio vestitus*). These flies entered and exited flowers while bearing multiple pollinia at the base of their heads below the eyes (Figure 6). They often force into newly opening flowers, apparently to access nectar. This insect appears to be an important pollinator of this orchid

in the alpine zone of our study area. More work is needed to determine whether additional insects, such as those in European alpine, pollinate this species in North America.



Figure 10: The hawkmoth *Hyles gallii* pollinating *Platanthera dilatata*. Note hovering behavior and pollinia on the proboscis.



Figure 11: The butterfly *Pieris marginalis* nectaring on *Platanthera dilatata*. Note pollinia on proboscis.

In forest habitats we recorded new pollinators (or apparent pollinators), for three orchid species. Although no pollinators or other insect visitors have been reported for *Listera banksiana*, we observed *Dryomyza* flies (*Dryomyza* sp.) visiting this orchid (Figure 7). They appeared to be

foraging for a food reward on the orchid lip; however, none of the insects were observed carrying pollinia. The *Dryomyza* fly oviposits on bear scat and salmon carcasses, and might be attracted to this orchid if it emits a similar odor. Most individuals of *L. banksiana* produced seed pods, and those we excluded from pollinators did not produce seed pods. This suggests that *L. banksiana* is obligately insect-pollinated; but, more work is needed to confirm pollinating species. Although *Corallorhiza trifida* may be autogamous, we observed dance flies (Empididae sp.) entering their flowers and exiting bearing pollinia on their upper thorax (Figure 8). These visits could provide occasional outcrossing in this apparently self-pollinating orchid. Dance flies were also observed probing flowers of *Platanthera obtusata* but did not extract pollinia and may not pollinate this species. Nevertheless, they appear to be versatile pollinators as one was observed bearing pollinia from *Platanthera stricta* on its proboscis. We recorded pollination of *Corallorhiza mertensiana* by a *Bombus* species. Multiple pollinia were deposited at the base of the head below the eyes of this bee while it foraged for nectar (Figure 9). Our data suggest that bees may be efficient pollinators of this coralroot. Open-pollinated plants at two sites averaged 50–80% of flowers forming seed pods, while inflorescences that were bagged to exclude pollinators did not produce seed pods. This suggests that *C. mertensiana* is an obligate insect-pollinated species.



Figure 12: The bee-mimic *Eristalis anthophorina* foraging on *Spiranthes romanzoffiana*.

In muskeg and meadow habitats, we recorded new pollinators for two species. In addition to expected visits by Noctuidae moth species, we recorded diurnal and nocturnal visits by the hawkmoth *Hyles gallii* to *Platanthera di-*



*latata* (Figure 10). In contrast to the low number of pollinia carried by Noctuidae, *H. gallii* carried large numbers of pollinia on its proboscis. It appeared to be a very efficient pollinator even though its proboscis length greatly exceeded nectar spur length. We also observed occasional visits by the margined white butterfly (*Peris marginalis*) to this orchid, during which it extracted pollinia on its proboscis (Figure 11). This butterfly may be a rare and inefficient pollinator of *P. dilatata* in our region. *Bombus* species also occasionally visited this orchid, but it is unlikely that they were able to access nectar held in its comparatively long nectar spurs. We suggest that as with *P. stricta*, *P. dilatata* is a generalist with regard to pollinators, but that they vary in pollination efficiency. Although *Spiranthes romanzoffiana* is reported as bee-pollinated, we also observed a bee-mimic Syrphidae (*Eristalis anthophorina*) on this orchid. It foraged in the same manner as *Bombus* species by moving upward on the inflorescence while probing flowers with its proboscis (Figure 12). Although we could not detect presence of pollinia on its proboscis, it may function as a pollinator.



Figure 13: The plume moth *Amblyptilia pica* foraging on *Goodyera oblongifolia*. Note slender proboscis relative to size of floral tube.

## Nectar thieves

Species belonging to two different families appeared to function as nectar thieves on *Goodyera oblongifolia*. In early fall, numerous geranium plume moths (*Amblyptilia pica*) were observed visiting late-flowering plants of *G. oblongifolia* (Figure 13). These insects easily inserted their long slender proboscis into the comparatively short floral tube of the orchids. None were observed bearing pollinia, and the plants they visited did not produce seed pods. This species overwinters as an adult, and the nectar from *G. oblongifolia* may be quite beneficial to these insects, as no other flowering plant species occurred in the area occupied by the orchids. We have observed such visitation at multiple sites over multiple years. We also observed a plume moth (*Amblyptilia* sp.) nectaring on *P. dilatata* without removing pollinia. Likewise, *A. pica* has been recorded as a probable nectar thief on *P. orbiculata* in New Hampshire (Bergum et al., 2018).



Figure 14: Nocturnally foraging *Autographa corusca* on *Goodyera oblongifolia*. Note proboscis inserted into floral tube.

*Goodyera oblongifolia* was also visited by a second apparent nectar thief, Noctuidae moths that may be *Autographa corusca* (Figure 14). Over a fifteen day period, 24 hour time-lapse videos (at one minute intervals) revealed an average of 8.7 visits per night among 15 plants. However, no diurnal visitors were recorded, and no seed pods were formed on these plants. In an area 0.15 km away where plants were not video monitored, 62% of 178 flowers produced seed pods among 17 plants. Although we do not know if Noctuidae visited the adjacent area, they did not pollinate



plants at the first site, and their repeated visits suggest that they were removing nectar from these plants. Their proboscis length is greater than the floral tube, which may have facilitated nectar thievery. Several of these moths that were captured by blacklight also did not bear pollinia. *Goodyera oblongifolia* is reported to have naturally low levels of seed pod production, and spreads by rhizomes (Ackerman, 1975). Nectar thieves can influence reproductive fitness by influencing behavior of pollinators (Zhang et al., 2014). If the high visitation rate we observed for Noctuidae species reduced nectar availability, it might have contributed to reduced visitation by *Bombus* and the low reproduction that we observed. If widespread, this process could provide selective pressure for the development of vegetative spread as an alternate use of reproductive resources by *G. oblongifolia*. More work is needed to test this hypothesis.



Figure 15: Nocturnally foraging Noctuidae on *Spiranthes romanzoffiana*.

We also video-recorded nocturnal visits by Noctuidae moths to a second *Bombus*-pollinated orchid, *Spiranthes romanzoffiana* (Figure 15). This orchid is closely related to *Goodyera*, and Noctuidae species may function as nectar thieves on this species as well. However, it differs from *G. oblongifolia* by having relatively high levels of *Bombus*

visitation and seed pod production (Larson and Larson, 1987). The greater level of reproduction for *S. romanzoffiana* could be related to habitat conditions, as this orchid occurs in open vegetation where its inflorescences may be highly visible (Larson and Larson, 1990), while coastal *G. oblongifolia* populations occupy dense shaded spruce forests (Ackerman, 1975).

Although not reported in the literature, our results indicate that Noctuidae species that pollinate *Platanthera dilatata* may function as nocturnal nectar thieves on two *Bombus*-pollinated orchid species with overlapping flowering periods. *Platanthera dilatata* flowers from late June through late July in our region, while *Spiranthes romanzoffiana* and *Goodyera oblongifolia* usually flower from mid-July through August. More work is needed to determine the number of Noctuidae species involved in visitation to these orchids and whether individual Noctuidae species overlap in their visits. The Noctuidae species we have observed appear to have proboscis lengths that exceed the nectar spur length of *P. dilatata* as well as the floral tube lengths of *S. romanzoffiana* and *G. oblongifolia*. However, these species differ in their manner of pollinia placement (Argue, 2012a,b). *Platanthera dilatata* positions its pollinia on either side of the nectar spur entrance, which facilitates pollinia deposition on the proboscis. The latter species position their pollinia within the floral tube on its dorsal side, which are attached to the proboscis of nectar-seeking species. The pollinia may be less likely to contact the slender proboscis of Noctuidae moths (Figure 14). Also, as their flowers mature, the pollinia are moved upward to expose the stigma (Argue, 2012a,b). In *G. oblongifolia*, the pollinia lose their adhesive ability as the flower matures, making them less likely to adhere to an insect proboscis.

## Pollinator network

The orchids and insect visitors in our study area comprise a complex network in which orchids may have multiple pollinators or may share pollinators and nectar thieves (Figure 19). To some extent, pollinator types appear to be structured among different orchid groups. For example, orchids with smaller flowers and more easily accessible nectar resources display adaptation to Diptera species that have comparatively small bodies and short tongues. In contrast, orchids with more showy larger flowers that maintain nectar in recessed spurs show adaptation to Lepidoptera species. Moreover, proboscis lengths of *Platanthera* pollinators in this network correspond to orchid nectar spur lengths, supporting the idea that orchids partition pollinator resources by adapting their spur lengths to proboscis lengths (Hapeman and Inoue, 1997). *Bombus* species, which have intermediate proboscis lengths, visit orchids with intermediate flower sizes and nectar resources maintained in shorter floral tubes or nectar spurs. One species, *Calypso*



*bulbosa*, attracts *Bombus* species by advertising a false reward. Longer-tongued *Bombus* species that would access greater floral diversity may occur in our area, but we have no information on this group. The additional pollinator-nectar thief relationship among the Lepidoptera-pollinated *Platanthera dilatata* and the *Bombus*-pollinated *Goodyera oblongifolia* and *Spiranthes romanzoffiana* suggests that interactions become more complex in association with larger orchids with greater nectar resources. However, we may lack comparative information on interactions among the smaller orchids and pollinators.



Figure 16: The rove beetle *Eusphalerum pothos* consuming pollen of *Listera cordata*.

### Pollen consumers

A rove beetle species (*Eusphalerum pothos*) was recorded consuming pollen on the twayblade orchid *Listera cordata* (Figure 16). Rove beetles are well known pollenophagous feeders (Sayers et al., 2019). Although we have limited data, we found no difference in seed pod production between plants attacked by rove beetles and those that did not have rove beetles. While foraging for pollen, these beetles occasionally had pollinia attached to their heads, but they did not appear to pollinate plants.

### Insect predation

We observed insect predation by four different spider taxa. However, predation of pollinators appeared to be rare. Two web-spinning spiders, the silver long-jawed orb weaver (*Tetragnatha laboriosa*) and the six-spotted orb weaver (*Araniella displicata*) were observed on the slender

bog orchid (*Platanthera stricta*). The former species had captured a biting midge (Ceratopogonidae), while the latter species appears to have captured a wasp (Hymenoptera) as prey (Figure 17). As this orchid can occupy muskeg borders where shrubs are present, this may have facilitated web building by these spiders. A cobweb spider (Theridiidae) was observed with a captured fungus gnat on the western twayblade (*Listera cordata*) (Figure 18). This orchid routinely produces a large number of seed pods in our area, and it is unlikely that pollinator predation affects its levels of seed production.



Figure 17: The orb weaver *Araniella displicata* with captured wasp on *Platanthera stricta*.



Figure 18: A cobweb spider (Theridiidae) with fungus gnat prey item on *Listera cordata*.

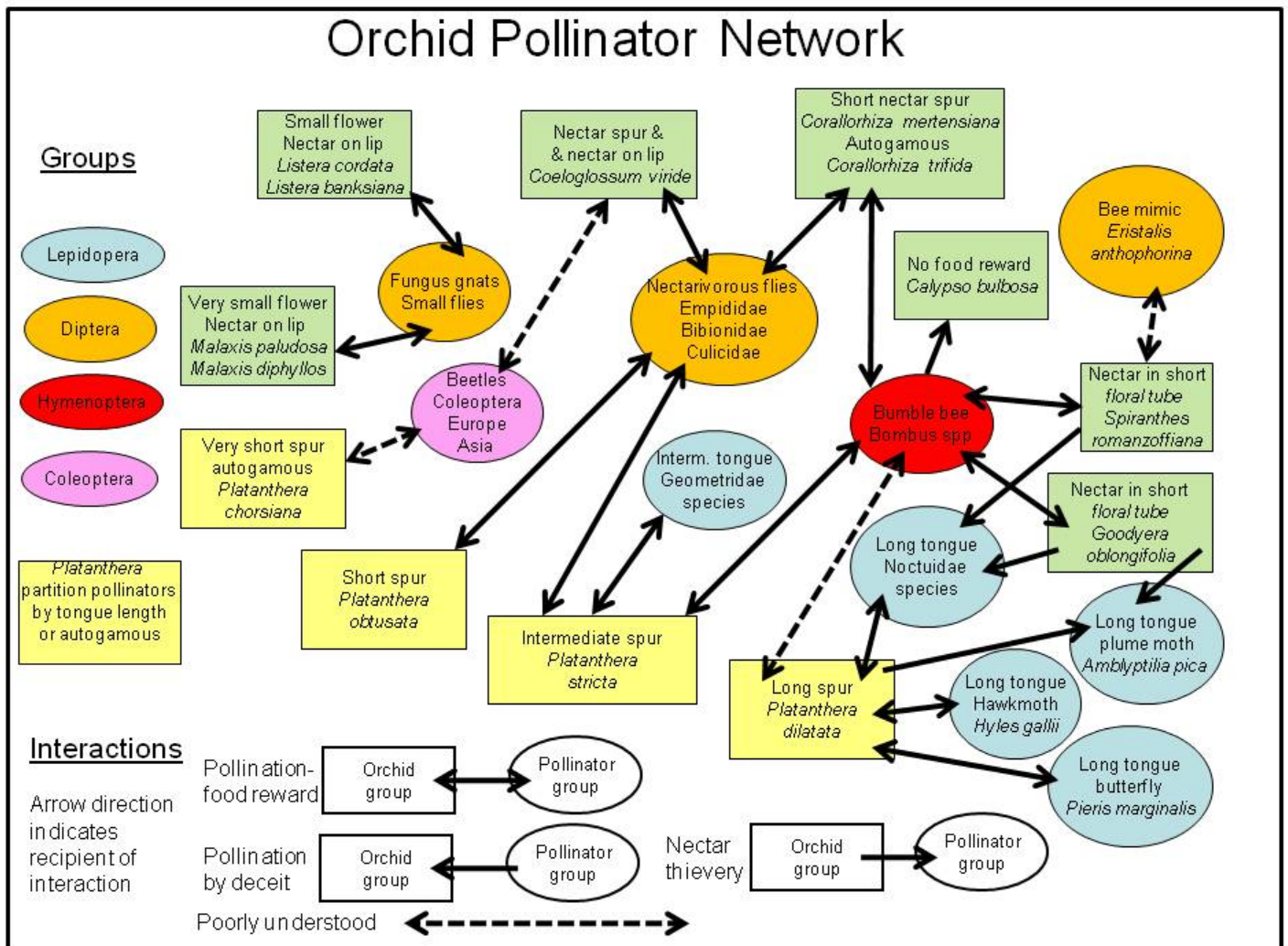


Figure 19: Relationships in an orchid pollinator network in the Juneau area of Southeast Alaska. Squares represent orchid species or species groups with similar morphological features. The *Platanthera* group is color-coded. Circles represent insect pollinators, or pollinator groups with similar morphological features, which are color coded by order. Arrow directions represent recipients of plant-pollinator interactions. Double-headed arrows indicate both pollination and food reward, single headed arrows indicate either pollination or food reward by nectar thievery. Dashed arrows indicate poorly understood relationships due to lack of information. Tongue is used interchangeably for proboscis in labeling modules.

Crab Spiders (Thomisidae) which hunt by ambushing prey on flowers, were observed on *Platanthera dilatata*. Their prey included a biting midge, crane fly (Tipulidae), and horse fly (Tabanidae) (Figure 20). None of these insects are known pollinators of *Platanthera* species and it is unknown whether crab spiders impact true pollinators of these orchids.

Yellow jackets (Vespiniae) are occasional visitors to *Platanthera dilatata*. We do not know whether they are foraging for insect prey, or perhaps seeking nectar. An Ichneumonid wasp (Ichneumonidae) was also observed on *Listera cordata*, but its activity could not be determined.

### Conclusions

This work confirmed published pollination (or flower visitation) of at least five different insect taxa to seven orchid species in the Juneau area of Southeast Alaska. We also recorded eight new North America pollinators or visitors for six orchid species. This included pollination of *Coeloglossum viride* by march flies (Bibionidae), visitation and possible pollination of *Listera cordata* by *Dryomyza* flies, pollen transfer on *Corallorhiza trifida* (which is thought to be autogamous) by dance flies (Empididae) and pollination of *Corallorhiza mertensiana* by *Bombus* species. We



also recorded new pollination of *Platanthera dilatata* by the hawkmoth *Hyles gallii*, the butterfly *Pieris marginalis* and several new Noctuidae species. The *H. gallii* would be expected to pollinate orchids with much longer nectar spurs. However *P. dilatata* appears to be adapted to multiple species with a wide range of proboscis lengths. We also observed for the first time the bee-mimic syrphid fly *Eristalis anthophorina* foraging on *Spiranthes romanzoffiana* in the same manner as its identified *Bombus* pollinator.



Figure 20: A female goldenrod crab spider (*Misumena vatia*) with a horse fly (Tabanidae) on *Platanthera dilatata*.

Nectar thievery is well known among flowers and insects, but a complex relationship among multiple orchid and insect species has not been reported from North America. We established that while Noctuidae moths function as adapted pollinators of *Platanthera dilatata*, they appear to be nocturnal nectar thieves of two other orchid species (*Goodyera oblongifolia* and *S. romanzoffiana*) that are diurnally pollinated by *Bombus* species. Further, *G. oblongifolia* is also visited by a second nectar thief, the geranium plume moth (*Amblyptilia pica*), which overwinters as an adult and may rely on this local nectar resource. We also observed a plume moth acting as a nectar thief on *P. dilatata*.

## Acknowledgments

We are grateful to the many people who contributed to this study. Derek Sikes and Joey Slowik (University of Alaska Museum of the North), identified difficult insects and spiders, respectively. Bob Biagi, Robbin McLeod and Bill Dean (BugGuide.net), also identified Bibionidae, Noctuidae and Syrphidae species, respectively. John Hudson assisted with additional insect identification and a provided blacklight capture of Noctuidae moths, and Gwen Baluss contributed

an additional Noctuidae. Rita Hassert (The Morton Arboretum), provided essential library assistance. We are also grateful to Don Kurz and Mary Willson for reviewing the manuscript, and to Lisa Wallace for comments on the pollinator network model.

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## Videos and slide shows

Below are links to videos and slide shows of insects visiting orchids in the Juneau area. Feel free to download and use however you wish.

### Bumblebees

**Video:** Bumblebees on western coralroot orchids <https://vimeo.com/343560365>

**Video:** Bumblebee on white bog orchid <https://vimeo.com/342178916>

**Video:** Bumblebee on bog orchid <https://vimeo.com/280660265>

**Video:** Bee mimic and bumblebee on ladies-tresses orchid <https://vimeo.com/285643040>

### Butterflies

**Video:** Margined white butterfly on white bog orchid <https://vimeo.com/343845001>

## Dance flies

**Video:** Early coral root orchid with dance fly <https://vimeo.com/337668892>

**Video:** Dance fly on blunt-leaved orchid (*Platanthera obtusata*) <https://vimeo.com/276573344>

## Dryomyza fly

**Video:** *Dryomyza* fly on northwestern twayblade orchid <https://vimeo.com/430921806>

**Video:** *Dryomyza* fly on northwestern twayblade orchid on June 17, 2020 <https://vimeo.com/430250286>

**Video:** *Dryomyza* flies on a northwestern twayblade orchid in the rain <https://vimeo.com/429783758>

## Insects

**Slides:** What comes to a white bog orchid <https://vimeo.com/435323087>

**Video:** Insect on heart-leaved twayblade orchid flower <https://vimeo.com/421550015>

**Video:** Insect on a heart-leaved twayblade orchid <https://vimeo.com/420923156>

**Video:** Insects coming to a heart-leaved twayblade orchid <https://vimeo.com/419786193>

**Video:** Beetle and flies visit white bog orchid <https://vimeo.com/280590762>

**Video:** Insects on white bog orchid <https://vimeo.com/343935517> March Fly:

**Video:** March flies on frog orchids <https://vimeo.com/340916436>

## Moths

**Slides:** Noctuidae moth visits rattlesnake plantain orchid <https://vimeo.com/443394534>

**Slides:** Owlet moths visit rattlesnake orchids July 28, 2020 <https://vimeo.com/442730723>

**Slides:** Owlet moth visits to rattlesnake orchids <https://vimeo.com/442134257>

**Video:** Owlet moth on a white bog orchid <https://vimeo.com/348093863>

**Video:** Plume moth on white bog orchid at Buckbean Pond <https://vimeo.com/431302940>

**Video:** Plume moths on rattlesnake plantain orchid <https://vimeo.com/288474762>

**Video:** Hawkmoth on white bog-orchid <https://vimeo.com/281908716>

**Video:** Hawkmoth on bog orchid July 17 <https://vimeo.com/280467246>

**Video:** Noctuidae moth on orchid <https://vimeo.com/279993651>

**Video:** Noctuidae moth on bog orchid <https://vimeo.com/279969805>

**Video:** Hawkmoth & Noctuidae moths on white bog-orchid July 20 <https://vimeo.com/281101155>

## Rove beetles

**Slides & video:** Rove beetles on twayblade orchids <https://vimeo.com/422039321>

## Spiders

**Video:** The silver longjawed orbweaver hunting on a slender bog orchid <https://vimeo.com/436958381>

## Photography

**Slides:** Timelapse on white bog orchids <https://vimeo.com/440357095>

**Slides:** Timelapse on white bog orchid <https://vimeo.com/433273359>

**Slides & video:** Filming orchids with the Panasonic DMC FZ200 and FZ300 cameras <https://vimeo.com/421616175>

# Review of the fourteenth annual meeting

by Alexandria Wenninger<sup>1</sup> and Dana Brennan<sup>2</sup>



Figure 1: Zoom gallery view of the faces of 19 society members that were able to stay for the Society Business Meeting after the 14<sup>th</sup> annual meeting. From left to right, top row: Taylor Kane, Alex Wenninger, Susan Wise-Eagle, Derek Sikes, Roger Burnside. Second row: Mike Baldwin, Kyle Callegari, Matt Bowser, Liz Graham, Steve Swenson. Third row: Isaac Davis, Robin Andrews, Sydney Brannoch, Jessie Moan, Dana Brennan. Fourth row: Sayde Ridling, Renee Nowicki, Garret Dubois, Isaac Dell. Photo by Alex Wenninger.

Due to the risks posed by the ongoing SARS-CoV-2/Covid-19 pandemic, the Alaska Entomological Society Meeting held its first ever virtual annual meeting via the platform 'Zoom' on 30 January 2021.

## Presentations

In her talk titled "Hemlock sawfly in Southeast Alaska: using an interdisciplinary approach to monitor a large-scale defoliation event", **Liz Graham** walked us through several ways that she and Karen Hutton of the US Forest Service's Forest Health Protection unit have modified their monitoring protocols during the pandemic. One of their most notable methods was to use high resolution satellite imagery to monitor a hemlock sawfly outbreak. Liz stresses

the importance of using multiple methods to monitor insect outbreaks.

**Todd Sformo** gave an insightful talk about his thesis work which he had conducted in Fairbanks, Alaska on the overwintering physiology of insects, and their strategies for freeze tolerance and avoidance. After, he read aloud a literary piece he originally published in the journal *Catamaran* titled "So much depends upon..." which gave a heartfelt view of the frustrations and triumphs of studying insects in Alaska. His literary piece can be found in the Fall 2020, Volume 8, Issue 3 publication of the journal *Catamaran*. Todd currently works for the Department of Wildlife Management in the North Slope Borough.

**Jessica Rykken** shared insights from her state-wide survey tracking plant phenology and pollinator diversity across Alaskan National Parks in her talk titled "Flies rule! Exploring the full diversity of arthropod flower-visitors on

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common Alaskan plants". Jessica works as an entomologist in Denali National Park and is an expert in pollinators, and through this work sought to not only get a broader understanding of the range of floral-visiting arthropods across eight National Parks in the state, but also to get a baseline for the timing of floral availability and their arthropod visitors to compare to in the future as the climate warms.

Through his talk titled "Life history of Alaska's only Mygalomorph spider", **Joey Slowik** gave a fantastic overview of the spider *Antrodiaetus pacificus* including its habits and life cycle, as well as his efforts to survey its distribution in Southeast Alaska. Working with this spider is challenging because they have very isolated populations and they are cryptic in nature. Molecular work done by Joey suggests the Southeast Alaskan island populations of this spider are genetically distinct from the species on the mainland, and additionally due to their rarity and specific needs they may be a species of conservation concern. Joey currently works for the UAF Cooperative Extension Service out of Palmer.

**Jackson Audley** joined us this year to update us on the ongoing semiochemical work with Spruce Beetle in Alaska. Jackson and his colleague Chris Fettig with the Pacific Southwest Research Station of the USDA Forest Service have had ongoing experiments throughout the most recent spruce beetle outbreak to try to find methods that work to deter spruce beetle here in Alaska. His talk titled "An update on spruce beetle research efforts in Alaska and the Rocky Mountains" gave an overview of his experiments with deterring spruce beetle attack through use of semiochemicals, how Alaskan and Rocky Mountain populations of spruce beetle compare in their response to the same semiochemicals, and plans for new research avenues to explore.

**Derek Sikes** presented work he and Logan Mullen conducted in his talk titled, "Phylogeny and evolution of large body size in the rove beetle genus *Phlaeopterus* Motschulsky, 1853 (Coleoptera: Staphylinidae: Omaliinae: Anthophagini). Derek presents evidence that large body size evolved twice in this genus: this work was accepted for publication and will be available soon. Derek also notes that many of these species are associated with alpine snowfields, so the loss of these snowfields as the climate warms poses a conservation risk for these species; two of the newly described species of *Phlaeopterus* haven't been collected in the last 36 years despite some effort to do so. Derek Sikes is both a professor and researcher at the University of Alaska Fairbanks as well as the Curator of Insects at the University of Alaska Museum of the North.

**Curtis Knight** and **Ben Diehl** followed with a joint presentation of the USDA TASC (Technical Assistance for Specialty Crops) program in Alaska. Curtis Knight with

the Alaska Department of Natural Resources Division of Agriculture covered the "TASC overview: Eliminating pest-related trade barriers for the Alaskan peony industry with focus on thrips". **Ben Diehl**, agricultural researcher with Washington State University Mount Vernon Northwestern Washington Research & Extension Center, covered the "Alaska USDA FAS TASC: Morphological studies of thrips associated with peonies." The goals of this project are to establish thrips identification tools, conduct both field and post-harvest trials to determine control options against thrips, and to increase outreach with growers through training and workshops. By reaching these goals, the TASC project managers hope to reduce the economic impact of thrips for peony growers.

We had one student presentation and one student poster shared at the meeting this year. We congratulate **Taylor Kane** (UAF), recipient of the 2021 Student Presentation Award, for her talk, "The diversity and distribution of Alaskan *Boreus*". Taylor's research project will address a current gap in knowledge and we are excited to hear more about her findings in the coming years. Congratulations, Taylor! We also congratulate **Robin Andrews** (UAF), recipient of the 2021 Student Poster Award, for her poster titled, "Soil microarthropods tell tales that vegetation hides." Robin has been working with an understudied and challenging group of organisms and we commend her on her persistence. Congratulations, Robin! We also thank this year's student presentation award judges: Garret Dubois, Roger Burnside, and Alex Wenninger.

## Business items—highlights

- A suggestion was made to consider having the annual meeting occur on a week day next year rather than a Saturday. Next year officers will poll the AKEntoNet ListServe with a few preferred dates to choose from before scheduling the meeting.
- When we are able to return to in-person meetings, the society will consider having separate meeting rooms in each Anchorage, Fairbanks, and Juneau that are all then connected via Zoom. This way travel is reduced but there is still the in-person experience in each of the three main locations.
- Election results: Dana Brennan (president), Robin Andrews (vice president), Taylor Kane (secretary), and Roger Burnside (treasurer).

The minutes from our business meeting are available on the website.