

# Newsletter

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| In this issue:  |    |
|---|----|
| Two biocontrol insects of invasive yellow toadflax self-established in Anchorage, Alaska: the toadflax flower-feeding beetle and the toadflax seed capsule weevil | 2  |
| Work on a spider list for Alaska  | 9  |
| New pollinators and insect visitors to orchids in Southeast Alaska and the Aleutian Islands,  |    |
| and components of the orchid pollinator network in Southeast Alaska   | 12 |
| An Alaska review of The Social Wasps of North America   | 30 |
| Review of the sixteenth annual meeting  | 32 |
| Metabarcoding pollinators on Kenai National Wildlife Refuge, Kenai Peninsula, Alaska  | 35 |
| Defoliation of haskap shoots by the honeysuckle moth in Southcentral Alaska   | 50 |
| The beehive honey moth as a pest of stored honey bee comb in Alaska   | 56 |

# Two biocontrol insects of invasive yellow toadflax self-established in Anchorage, Alaska: the toadflax flower-feeding beetle and the toadflax seed capsule weevil

#### by Alexandria Wenninger<sup>1</sup>

Two biological control agents of the invasive plant yellow toadflax (*Linaria vulgaris* Miller, 1768) have established in Anchorage, Alaska without intentional introduction: the toadflax flower-feeding beetle (*Brachypterolus pulicarius* (Linnaeus, 1758)) and the toadflax seed capsule weevil (*Rhinusa antirrhini* (Paykull, 1800)). Both of these species were accidentally introduced to eastern North America in the early 1900s and are now found throughout much of the continent where yellow toadflax infestations occur; some states have intentionally redistributed these species, however no formal biocontrol introductions of these species both occur in Anchorage, Alaska. Feeding by these two species reduces seed production, which may slow the spread and establishment of new populations of invasive toadflax in Alaska.

# The toadflax flower-feeding beetle, *Brachypterolus pulicarius* (Linnaeus) (Coleoptera: Kateretidae)

The toadflax flower-feeding beetle emerges as an adult in spring and feeds on emerging toadflax shoot tips before laying eggs into unopened flower buds (Wilson et al. 2005). Adults are brown to black in color and ~2–3 mm in length (Figure 1). The larvae feed on flowers (ovaries, pollen, and anthers) and developing seeds before dropping to the ground to overwinter as pupae (McClay 1992). Larvae are yellow in color with a brown to black head and darkened band on the pronotum, reaching a length of ~7 mm (Figure 2). Larval feeding can reduce a flower's seed production by as much as ~75%–90% (Harris 1961, McClay 1992, Winston et al. 2014). Pupae are yellow in color, ~2–3 mm in length, and feature a row of paired spines along the dorsum extending from the head to the end of the abdomen (Figure 2); the spines on the thorax project forward toward the head whereas the spines on the abdomen project back toward the rear. The adults have been reported feeding on flowers of other plant species, including strawberry and dandelion, however, the species is only known to be able to complete development on species in the genus *Linaria* (Hervey 1927). Only one generation is known per year in Canada, with the species overwintering as pupae, however, in Europe and some states in the US, some may eclose late in the season and overwinter as an adult (Government of British Columbia 2018).

The toadflax flower-feeding beetle is thought to have been accidentally introduced to North America in New York, USA in 1919, after which it was intentionally redistributed to various localities within the lower 48 states, however I found no evidence of intentional introductions in Alaska. The toadflax flower-feeding beetle has been released in and is established in British Columbia (Government of British Columbia 2018) though it has not yet been recorded in Yukon, Canada<sup>2</sup>. This beetle was first recorded from Alaska in 2016 when one individual was caught in a vane trap in Anchorage<sup>3</sup>. This species was found on toadflax as early in the season as 2 June 2022, and some adults were still present on flowers on 13 September. I

<sup>&</sup>lt;sup>1</sup>University of Alaska Fairbanks Cooperative Extension Service Integrated Pest Management Program, akwenninger@alaska.edu

<sup>&</sup>lt;sup>2</sup>There is conflicting information in the literature about the presence of this species in western Canada. Harris (1961) states that the species had been found in all Canadian provinces by 1953, however, this species has not been recognized as being present in British Columbia nor Yukon in the first (Bousquet 1991) nor second (Bousquet et al. 2013) editions of the *Checklist of the Beetles of Canada and Alaska*. A publication titled '*Brachypterolus pulicarius* L.' found on the Government of British Columbia website states that intentional releases of this organism as a biocontrol on Dalmatian toadflax (*Linaria dalmatica* L.) occurred in 1989 and 2004 and describes the species as established in British Columbia. I was unable to find any further records of this species in Yukon.

<sup>&</sup>lt;sup>3</sup>https://arctos.database.museum/guid/UAM:Ento:351434



Figure 1: Left: Adult *Brachypterolus pulicarius*, a.k.a. toadflax flower-feeding beetle on yellow toadflax shoot. Right: Adult *Rhinusa antirrhini*, a.k.a. toadflax seed capsule weevil on yellow toadflax flower. Photographed June 2022 in Anchorage, Alaska by A. Wenninger.

wild-collected larvae between 18–23 August to rear indoors; the beetles were able to be reared from larva to adult at room temperature (~70 °F) and the first adults emerged 12 September.

# The toadflax seed capsule weevil, *Rhinusa antirrhini* (Paykull) (Coleoptera: Curculionidae)

The toadflax seed capsule weevil emerges as an overwintered adult in late spring and feeds on emerging toadflax shoot tips and flowers before laying eggs into the flower's ovaries (Wilson et al. 2005). Adults are grey to black in color, setose, and ~2.5–3mm in length (Figures 1 and 3). Egg deposition into the host plant tissue triggers gall formation; the seeds near the egg expand beyond their typical size resulting in seed inviability (Sing et al. 2016). The developing larvae then feed on both the galled tissue as well as on other developing seeds within the capsule (Sing et al. 2016). The legless larvae are creamy white with a black head capsule, ~4mm in length, and feed on galled seed tissue before pupating inside the seed capsule (Figure 2). Adults emerge in late summer to early fall and will often overwinter inside the seed capsule or in plant debris (Nowierski 2004).

*Rhinusa antirrhini* is thought to have been accidentally introduced to the eastern United States, first recorded around 1909, and to British Columbia, Canada, first recorded in 1917, after which intentional introductions were made in various localities of both Canada and the lower 48 states (Winston et al. 2014), however I found no evidence of intentional introductions in Alaska. This beetle was previously recorded from Alaska in both Fairbanks in October 2006<sup>4</sup> and Anchorage in July 2008<sup>5</sup> on yellow toadflax. In 2022 this species was collected as early as 2 June and as late as 13 September.

<sup>&</sup>lt;sup>4</sup>https://arctos.database.museum/guid/UAM:Ento:25891, https://arctos.database.museum/guid/UAM:Ento:25892, https://arctos.database.museum/guid/UAM:Ento:25974, https://arctos.database.museum/guid/UAM:Ento:25974, https://arctos.database.museum/guid/UAM:Ento:25976

<sup>&</sup>lt;sup>5</sup>https://arctos.database.museum/guid/UAM:Ento:97224, https://arctos.database.museum/guid/UAM:Ento:97225, https://arctos.database.museum/guid/UAM:Ento:97227, https://arctos.database.museum/guid/UAM:Ento:97227, https://arctos.database.museum/guid/UAM:Ento:97227, https://arctos.database.museum/guid/UAM:Ento:97229, https://arctos.database.museum/guid/UAM:Ento:97229, https://arctos.database.museum/guid/UAM:Ento:97230, https://arctos.database.museum/guid/UAM:Ento:97231, https://arctos.database.museum/guid/UAM:Ento:97232, https://arctos.database.museum/guid/UAM:Ento:97230, https://arctos.database.museum/guid/UAM:Ento:97231, https://arctos.database.museum/guid/UAM:Ento:97233, https://arctos.database.museum/guid/UAM:Ento:97234, https://arctos.database.museum/guid/UAM:Ento:97234, https://arctos.database.museum/guid/UAM:Ento:97234, https://arctos.database.museum/guid/UAM:Ento:97234, https://arctos.database.museum/guid/UAM:Ento:97234, https://arctos.database.museum/guid/UAM:Ento:97234, https://arctos.database.museum/guid/UAM:Ento:97234, https://arctos.database.museum/guid/UAM:Ento:97234, https://arctos.database.museum/guid/UAM:Ento:97234, https://arctos.



Figure 2: Larval, pupal, and adult stages of the two species of biocontrol beetles (not to scale). Top left: *Brachypterolus pulicarius* larva at base of *L. vulgaris* flower (flower petals have been removed to expose the larva at the base). Top middle: *B. pulicarius* larva, ventral and dorsal habita. Top right: Adult *B. pulicarius*, lateral habitus. Bottom left: *Rhinusa antirrhini* larva feeding inside *L. vulgaris* seed capsule. Bottom middle: *R. antirrhini* pupa inside *L. vulgaris* seed capsule. Bottom right: Adult *R. antirrhini* lateral habitus. Immatures photographed August 2022 and adults photographed June 2022 in Anchorage, Alaska by A. Wenninger.

The toadflax seed capsule weevil was previously recognized for its potential to decrease seed production of invasive toadflax in Anchorage (Lamb et al. 2009, = Gymnetron antirrhini), however, I have been unable to find any report of further surveys of the distribution of this species in Alaska since those initial discoveries. Seed reductions due to feeding by this species have been reported as high as 90% in Washington (Nowierski 2004), however most reported attack rates are lower than this (Winston et al. 2014). Previous observations in Alaska have reported ~20% attack rate on yellow toadflax by an unknown weevil (Alaska Natural Heritage Program 2011), which is consistent with the 20–25% typical seed reduction observed in Canada (Nowierski 2004). Predators and parasitoids of this species may contribute to the variation seen in seed attack rates among localities. A study in Ottawa, Canada found anywhere from 4% to 85% of collected *R. antirrhini* larvae were parasitized (Allison 2009). Alaska is also home to the solitary predatory wasp Cerceris nigrescens, which is known to collect adult R. antirrhini as prey for nest provisioning (Krombien 1938, Scullen 1965). It is worth noting that *R. antirrhini* may delay oviposition in areas where it is in competition with *B. pulicarius* (Turner 2008), and furthermore *B. pulicarius* larvae have been observed predating upon *R. antirrhini* eggs (Jacobs and Sing 2006). Many authors report that these competitive and antagonistic interactions between B. pulicarius and R. antirrhini prevent their impact on toadflax from being additive (Harris 1961, Winston et al. 2014, Sing et al. 2016).

#### Host

Yellow toadflax (*Linaria vulgaris* Miller) was introduced to North America in the 1600s for ornamental and medicinal purposes. By 1849 the species had spread across the eastern and mid-western United States where it became a significant agricultural weed (Saner et al. 1995, Sing et al. 2022). The species is now



Figure 3: Lateral habitus of adult *R. antirrhini* collected 2 June 2022 in Anchorage, Alaska. Photo by Derek S. Sikes, University of Alaska Museum of the North, Arctos record: https://arctos.database.museum/guid/UAM:Ento:476269.

found throughout much of North America, having spread as a contaminant in crop seed and baled hay, through railway corridors and ship ballasts, and from intentional ornamental plantings (Saner et al. 1995, Sing et al. 2022). The plant produces yellow, spurred flowers with orange throats, borne in terminal clusters (Figure 4); leaves are pale green and arranged alternately on the stem (Alaska Natural Heritage Program 2011). Yellow toadflax can spread by seed or root fragments and its invasion is facilitated by disturbance. Once established, yellow toadflax can form dense colonies that suppress native grasses and perennials (Alaska Natural Heritage Program 2011). Toadflax seeds often remain viable after ingestion by wildlife and livestock (primarily ungulates and birds) which is thought to facilitate long-range dispersal as well as dispersal into wilderness areas (Sing et al. 2016, 2022).



Figure 4: Left: Closeup of the toadflax flower. Note the tiny beetle posterior hanging out of the flower, belonging to *Rhinusa antirrhini*. Photographed 26 June 2022. Right: Invasive toadflax flowers peppering an Anchorage roadside, photographed 29 August 2022. Photos from Anchorage, Alaska by A. Wenninger.

# 2022 Survey Results

Midtown and Northeast Anchorage were surveyed opportunistically in 2022 for existing yellow toadflax populations and for the presence of the two biocontrol beetles on toadflax (Figure 5). The locations where I surveyed toadflax in 2022 can largely be simplified into 11 distinct locations (Figure 5a); *B. pulicarius* was detected at all 11 of these locations (Figure 5b) and *R. antirrhini* was detected at 8 of the 11 locations (Figure 5c).



Figure 5: Anchorage 2022 toadflax and biocontrol beetle survey locations. a) Locations where *Linaria vulgaris* (yellow toadflax) occurs and was checked for biocontrol beetles in Anchorage in 2022. b) Locations where *Brachypterolus pulicarius* was detected on toadflax and c) locations where *Rhinusa antirrhini* was detected on toadflax. Maps generated using ArcGIS Online, Oceans Basemap; Basemap credits: Esri, De-Lorme, NaturalVue | Kenai Peninsula Borough, Matanuska-Susitna Borough GIS, Municipality of Anchorage, State of Alaska, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA.

## Reporting

In 2023 I plan to develop protocols for involving citizen scientists in surveying for beetles on toadflax to help expand our understanding of the distribution of these beetles beyond Anchorage. Currently, infestations of yellow toadflax on public land can be reported via the mobile app 'Alaska Invasives ID' or at https://alaskainvasivesreporter.org. I am especially interested in reports of the biocontrol beetles on yellow toadflax observed outside of Anchorage. Photos and location can be submitted directly to Statewide IPM Technician Alex Wenninger via email at akwenninger@alaska.edu or via our monitoring portal at https://alaskapestreporter.org.

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<sup>&</sup>lt;sup>6</sup>https://arctos.database.museum/guid/UAM:Ento:476269, https://arctos.database.museum/guid/UAM:Ento:476271, https://arctos.database.museum/guid/UAM:Ento:476273, https://arctos.database.museum/guid/UAM:Ento:476275, h

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# Work on a spider list for Alaska

#### by Jozef Slowik<sup>7</sup>

Last fall Yuri Marusik reached out to Derek Sikes and I about putting together a spider species list for the state of Alaska. As hard as it is for some people to believe, a really good species list of spiders has never been done. Sure, there have been reports with new species, like Chamberlin and Ivie's 1947 Spiders of Alaska (Chamberlin and Ivie 1947). Another one, Paquin et al.'s (2010) Canada species list included Alaska, but the Alaska part was more so of a courtesy and very incomplete just based on Canadian National Collection (CNC) collection records. But there has not been one that really looked over the species and all the records.

I had put together species lists of museum records similar to what Paquin's list was, but not the nitty gritty leg work of asking if this was a valid record, a good ID, or if that species made sense to be found here. Derek's former student Brandi Fleshman started the project back for her never completed Master's. And Derek has done an amazing job of cataloging spider list publications in Arctos. So, I do have a really good foundation to get rolling on.

I began with the odd balls. I pulled data off the World Spider Catalog<sup>8</sup>, Arctos<sup>9</sup>, GBIF<sup>10</sup> and iNaturalist<sup>11</sup> and started looking through species which shouldn't be here and if I could verify those IDs. I quickly ran into issues with iNaturalist data. I love iNaturalist. I use it all the time. But with spiders where you need to see some fine feature of the genitalia for a good ID, a picture of the spider on a leaf often is not going to work. This quickly became a large issue for validating those iNaturalist IDs and I ended up having for the most part to toss that data. I want this list to be a conservative list of species which, if there is any question about one, could be verified with a specimen. But removing iNaturalist data actually dropped only a few species.

Next was the GBIF data. The University of Alaska Museum (UAM) as well as many other museums all make their specimen records open source and GBIF is the clearing house for that. The problem is most institutions have not had the money to database their spider collections and get that data out. But even knowing this, there were a number of odd species to be found in the GBIF data. One set was collected and identified by Herb Levi from his trips to Alaska in the early 2000s. Many of his IDs are appropriate, but others are common Eastern US species which I wouldn't think to find in Alaska. Thankfully, his specimens are deposited in the Museum of Comparative Zoology (MCZ) collection. So, should a researcher need to validate that record for that Eastern species this far west they could. And I did have them verify the ID labels. Herb was an amazing arachnologist and I have to assume those are good IDs. But we all make mistakes. Perhaps if I find time I will have them loaned and verify them, if I have time.

This GBIF search also turned up a few erroneous IDs. Working with other arachnologists I was able to validate they were bad IDs and remove those species from the list. Through networking over GBIF data I was also able to validate other odd species I would not have thought to be found here, or are the only records for the state. This included a number of species collected by Bea Vogel and Ake Holm from the North Slope on a trip they took in the 1970s. These include a number of holarctic species and their collections are the only North American records. I think we need more geographically diverse North Slope collecting in the future. Is anyone else interested?

As I've worked this chunky species list, I continually find issues with species. I had to take a step back and remember that for much of this last century Alaska was considered remote, and much of the state still is. Trips to the state were a true expedition. So, specimens collected were often happenstance and almost always considered new to science. This is also because the spider fauna at the time for most of the world was poorly known. Alaska has a bunch of species which are described from single specimens, from remote

<sup>&</sup>lt;sup>7</sup>UAF Cooperative Extension Service

<sup>&</sup>lt;sup>8</sup>https://wsc.nmbe.ch/

<sup>&</sup>lt;sup>9</sup>https://arctos.database.museum

<sup>&</sup>lt;sup>10</sup>https://www.gbif.org/

<sup>&</sup>lt;sup>11</sup>https://www.inaturalist.org/

places, long, long ago. Chasing down the information on the collection event, finding the types, and then comparing them to described species all takes time. I remember a great comment by Jon Coddington, an arachnologist with the Smithsonian and an expert on diversity, to a young student presenting diversity data at a spider meeting, "there is no such thing as a singleton," he said. And he's right. It takes two (usually) to make a population. So, these single spiders are an error. There has to be more if they are a natural population, or if an accidental occurrence, like a stowaway, then they should be removed. But what do you do when the singleton is a new species and the only known specimen is the type?

One interesting set I'm working with were collected by George Marx and described by Eugen von Keyserling, both 19<sup>th</sup> century arachnologists. Keyserling published a collection about the spiders of the Americas in the 1890s and Marx finished editing it after Keyserling died. The catch with these species is Marx had poor organization skills. Arachnologist working with these spiders have often lamented about the wrong labels being in the vials because the spider clearly could not be found where the label says. For example, Marx collected *Xeropigo tridentiger* (O. Pickard-Cambridge) from Sitka and the Aleutians. He identified those specimens as *Cybaeus algidus*, a species which he never formally described. Willis Gertsch came across the specimens in his Corrinidae work and noted that this is a tropical species, found from the Caribbean into South America. This is clearly a labeling problem of Marx's, but thankfully the specimens are in the MCZ and that information can be verified. Another problem of Marx's and Keyserling's species descriptions is that what we thought we needed to know to differentiate species at the turn of the 20<sup>th</sup> century turned out not to be very useful. So, yes there are descriptions and illustrations, but they don't help much. Several of these species have been declared *nomen dubium* because of this.

Thankfully, when Marx died much of his collection of spiders ended up going to the Smithsonian. So, I've obtained many of the types and so far they are species which are now described as other species. So not true one offs. But others are probably hopeless. One is *Lepthyphantes arcticus* (Keyserling). Keyserling's (1886) description is pretty general for a large portion of Linyphiinae spiders. He does provide an illustration, but it's pretty vague and he neglects to even mention the epigynum in his description. Banks (1899) does refer to finding another specimen of Keyserling's species which he moves into the genus *Bathyphantes*. I have seen Banks' specimen and would guess it's a *Bathyphantes brevipes* (Emerton), which makes much more sense. Unfortunately for this mystery, Keyserling's type is lost. So, what can you do?

But this is not the only set of singleton types from Alaska. A much more troublesome set are spiders included in Chamberlin and Ivie's Spiders of Alaska (Chamberlin and Ivie 1947). These include a number of Linyphiidae species, of the Erigoninae subfamily. These are tiny spiders, most about 2 mm in length. The other catch is that they are all females. Females in this group do not always have good characters for identification. Often the genus is defined using male palp characters. So, how do you place a female who lacks those characters? For Chamberlin and Ivie, they placed them into the *Erigone* genus with uncertainty. This was not an uncommon thing at the time. All of these small dwarf spiders were placed into the genus *Erigone* originally before arachnologists knew the diversity. Now we know better, but at the time without good characters and having no real idea of species which might occur in Alaska, Chamberlin and Ivie dumped them there. A few have been picked out and correctly placed into other genera but many reside where they were described questionably in *Erigone*.

Many of Chamberlin's types have ended up in the American Museum of Natural History (AMNH), which is good. But it doesn't always help. Many of the new species described were actually collected by Chamberlin's nephew J. C. Chamberlin while he worked for the USDA based where I'm at now, the Matanuska Experiment Farm. But in Chamberlin and Ivie's haste or perhaps because they didn't get good info from his nephew the collection data on the specimens is vague. For example, *Erigone bodenburgi* Chambelin and Ivie which he describes from a single female carries the location of Bodenburg Butte, which is near Palmer, but the geocode of 61N 149W, just degrees, is nowhere close. And again, we're talking about a single 2 mm Erigoninae female. Pretty cryptic if you knew where to look, but the Butte is pretty big. The area has changed since the 1940s. So, where to even start looking? The female alone doesn't have any defining characters which could define its generic placement, so a male is needed. And unfortunately, there are a bunch more species just like this.

At this point I'm chasing dreams of finding J. C. Chamberlin's field notes, or even R. V. Chamberlin's identification notes, but have been unable to turn up anything. Oh well. It doesn't remove the species

from the list, just adds a little more flavor to some of the species.

For now, it's the slow grind of literature searches for species records and chasing distributions for the 450 or so species I've left to research. I hope to finish in 2023, but summer is ramping up quickly and spider time is short.

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by Marlin Bowles<sup>12</sup> and Bob Armstrong<sup>13</sup>

# Abstract

We provide new records for insects pollinating or foraging on orchids in Southeast Alaska as well as the Aleutian Islands. Bumble bees (Bombus spp.) were observed foraging on the ordinarily self-pollinating Platanthera aquilonis and on the food-deceptive Calypso bulbosa var. occidentalis. The latter species is thought to be pollinated by queen *Bombus* species, however we observed *B. melanopygus* workers due to a late spring. We also found *B. melanopygus* pollinating *Goodyera oblongifolia*, and significant variation in pod production between two populations. A Noctuidae moth, apparently *Mniotype tenera* was observed pollinating *Pla*tanthera convallariifolia in the Aleutian Islands. Other Lepidoptera records include the Nocutuidae Plusia spp. on Platanthera dilatata and the Geometridae Antepirrhoe fasciata and Rheumaptera subhastata on P. stricta. New Diptera records include mosquito (Aedes) species foraging and bearing pollinia on P. obtusata as well as the phorid fly Megaselia sp. and the dryomyza fly Dryomyza anilis foraging on Neottia banksiana. We suggest that this orchid may omit a fetid odor that attracts these carrion-feeding insects. These records bring the number of insects pollinating or foraging on Southeast Alaska orchids to at least 20 species among 13 families in the Diptera, Hymenoptera, and Lepidoptera. They also increase the number of orchids with verified pollinators in Southeast Alaska to 17 species. Most of these insects pollinate only 1 or 2 orchid species, indicating the importance of the entire insect community to the orchid population. In contrast, Bombus species pollinate at least 5 orchids across the entire flowering season. The spring-flowering Calypso bulbosa could be vulnerable to climate warming that causes this species to flower before emergence of queen bumblebees.

# Introduction

Given the threat of climate warming to disrupt plant-pollinator synchrony, especially spring flowering plants with specialized pollinators (Kudo and Ida 2013), it is critical to understand these relationships within pollinator networks (Schatz et al. 2020). The Southeast Alaska archipelago and adjacent coastal area support at least 28 native orchid species and varieties (Bowles and Armstrong 2019); at least eight additional species occur in the remaining regions of Alaska. The network of insects that pollinate these orchids is most well known for Southeast Alaska, where 15 pollinating insects have been identified for 14 orchid species, leaving half of the orchid flora with unknown pollinators (Bowles and Armstrong 2021). This paper reports new information on pollinators and other insect visitors to orchids in Southeast Alaska, and one species from the Aleutian Islands. We also examine the relationships between known pollinator families and orchid genera, including several that may be vulnerable to climate warming.

## Methods

With two exceptions, this work occurred within the City and Borough of Juneau, Alaska or on adjacent Tongass National Forest land. We used field observations and digital images for insect identification.

<sup>&</sup>lt;sup>12</sup>Juneau, Alaska, mbowles@mortonarb.org

<sup>&</sup>lt;sup>13</sup>Juneau, Alaska, bob@discoverysoutheast.org

Confirmation was also accessed through online resources such as **BugGuide.net**, or specimen identification by an authority. We recorded video and time-lapse images to determine presence of insect visitors to several species. We also used bait to attract potential pollinators to one species, and an enclosed terrarium to observe potential pollinators of a second species. All photos are by the authors except as indicated.

# Results

Pollinators and visitors to eight orchid species are reported (Table 1).

Table 1: New pollinators and insect visitors to orchid species in Southeast (SE) Alaska and the Aleutian Islands. Insect species are listed by order.

| Species                         | Location and<br>flowering<br>season      | Pollination<br>system                                   | Lepidoptera  | Hymenoptera                                 | Diptera   |
|---------------------------------|--|---|--|---|---|
| Calypso<br>bulbosa<br>Goodyera  | SE Alaska,<br>early spring<br>SE Alaska, | pollinator<br>required, food<br>deception<br>pollinator |  | Bombus<br>melanopygus<br>(Apidae)<br>Bombus |   |
| oblongifolia                    | late summer                              | required,<br>nectariferous                              |  | <i>melanopygus</i><br>(Apidae)              |   |
| Neottia<br>banksiana            | SE Alaska,<br>early summer               | pollinator<br>required,<br>nectariferous                |  |   | <i>Megaselia</i> sp.<br>(Phoridae),<br><i>Dryomyza</i><br>anilis (Dry-<br>omyzidae) |
| Platanthera<br>aquilonis        | SE Alaska,<br>mid-summer                 | self-<br>pollinating,<br>nectariferous                  |  | <i>Bombus</i> sp.<br>(Apidae)               |   |
| Platanthera<br>convallariifolia | Aleutian<br>Islands,<br>mid-summer       | pollinator<br>required,<br>nectariferous                | <i>Mniotype<br/>tenera</i><br>(Noctuidae)                              |   |   |
| Platanthera<br>dilatata         | SE Alaska,<br>mid-summer                 | pollinator<br>required,<br>nectariferous                | Plusia putnam,<br>Plusia nichollae<br>(Noctuidae)                      |   |   |
| Platanthera<br>obtusata         | SE Alaska,<br>early summer               | pollinator<br>required,<br>nectariferous                |  |   | Aedes<br>communis,<br>Aedes<br>excrucians<br>(Cucilidae)                            |
| Platanthera<br>stricta          | SE Alaska,<br>early summer               | pollinator<br>required,<br>nectariferous                | Rheumaptera<br>subhastata,<br>Antepirrhoe<br>fasciata<br>(Geometridae) |   |   |

#### Calypso bulbosa var. occidentalis (Linnaeus) Oakes (western fairy slipper)

This western variety reaches its northern range limit on forested islands in Southeast Alaska. It is the first native orchid to flower and uses food deception to attract naive queen bumblebees (*Bombus* spp.), which soon switch to spring flowers that provide food resources (Ackerman 1981). The lip of the single flower

is a long-lasting showy slipper, and unpollinated plants may remain in flower for a month. Unlike lady's slipper orchids (*Cypripedium*), which retain pollinia and release pollen grains, entire pollinia are removed from *Calypso* by attachment to the scutellum, a smooth segment on the dorsal surface of the bee (Ackerman 1981). The width of the gap between the orchid column (which holds pollinia) and the lip opening may range from 5 to 10 mm. This variability, in combination with variability in bee species sizes and switching to flowers with food rewards, results in low seed pod production (Ackerman 1981). *Salix* and *Vaccinium* species provided an alternative food source in Finland, where 7% of queen *Bombus* species in our study area (Figure 1).



Figure 1: Queen Bombus foraging on Salix sp. in Southeast Alaska.

In 2023, a late spring in our study area delayed flowering of *C. bulbosa*, allowing overlap with emergence of *Bombus melanopygus* Nylander workers. They were determined to be workers based on their small size and late emergence. *Calypso bulbosa* plants translocated to the Jensen Arboretum, Juneau, were visited by these bumblebees (Figure 2), one of which entered a *C. bulbosa* flower (Figure 3). Though we did not observe pollinia transfer, this is the first report of *Bombus* workers visiting *C. bulbosa* var. *occidentalis*, and demonstrates that a weather-caused shift in flowering may result in asynchrony with foraging queen bumblebees. This orchid could be vulnerable to climate warming that would disrupt this synchrony, thereby reducing pollination and seed production.

#### Goodyera oblongifolia Rafinesque (large rattlesnake plantain orchid)

This western orchid reaches its northern range limit in near-coastal forests of Southeast Alaska. Extensive populations of plants averaging > 100 rosettes of vegetative and flowering plants per 10 m<sup>2</sup> area occur where disturbance has reduced shrub cover. Flowering occurs in late summer and extends into early fall. The inflorescence comprises a spike of small white flowers that contain nectar and are reportedly pollinated by *Bombus* species that cause low (< 50%) seed pod production (Ackerman 1975). Our previous monitoring of this species revealed nocturnal visitation by Noctuidae moths, which are apparently nectar thieves that do not contribute to reproduction (Bowles and Armstrong 2021). However, we were unable to document pollination by *Bombus* species.



Figure 2: A Bombus melanopygus worker approaching a Calypso bulbosa flower.

In 2022, we documented flower visitation by bumblebees resembling *Bombus melanopygus* with time-lapse images and with direct observation. Individuals bearing pollinia approached (Figure 4) and briefly visited (Figure 5) multiple flowers on an inflorescence before moving to neighboring plants. They also appeared to forage especially on higher density patches, quickly moving through orchid populations. We compared percent and total seed capsule production per inflorescence between two sites with different inflorescence densities and sizes, Rainforest and Tee Harbor (Figure 6). Data are from n = 26 random 10 m<sup>2</sup> plots, and from n = 109 random inflorescence samples. Tee Harbor had 38% greater average percent seed capsule production, greater flowering plant density, and smaller inflorescences than did the Rainforest population. Average total capsule production was also greater, by 33%, in the Tee Harbor population (p = 0.013, Mann-Whitney *t*-Test). This supports findings that greater flowering plant density enhances bee visitation and pollination at the local scale (Hegland 2014). However, other factors, such as bee population size and nest proximity, as well as orchid population size, could affect visitation rates. Nocturnal foraging by Noctuidae moths might also cause bumble bees to reject inflorescences that have been subject to high levels of nectar thievery (Bowles and Armstrong 2021). More work is needed to test this hypothesis.

#### Neottia (Listera) banksiana (Lindley) Reichenbach (Northwest twayblade)

This western species reaches its northern range limit in coastal Southeast Alaska forests. Pollination is required for seed pod production, which ranged from 10 to 80% in our study areas. Flowering occurs in late spring, with an inflorescence of up to 20 small green flowers. Most members of the genus are reported to provide small amounts of nectar at the base of the lip, and to attach pollinia to insects as they feed on the nectar. The smaller heart-leaved twayblade *Neottia cordata* (Linnaeus) Richards flowers earlier in similar habitat and is pollinated by fungus gnats, which are attracted to a strong fetid odor (Ackerman and Mesler 1979). *Dryomyza* sp. flies visited *N. banksiana* in previous years, but none were observed accessing nectar nor carrying pollinia (Bowles and Armstrong 2021). *Dryomyza anilis* Fallen feeds on salmon carcasses (Hocking et al. 2009) as well as bear scat. This leads us to hypothesize that *N. banksiana* produces a fetid smell to attract pollinators; however, it does not have a strong odor detectable to humans.



Figure 3: A Bombus melanopygus worker foraging in the lip of a Calypso bulbosa flower.

In 2023, following van der Niet et al. (2011), we placed pieces of salmon carcass as bait at the base of flowering *N. banksiana* plants to enhance attraction of potential pollinators. This procedure attracted large numbers of *Dryomyza anilis* flies as well as the Phorid fly *Megaselia* sp. Phorid flies also feed on salmon carcasses (Hocking et al. 2009) and pollinate other plants (Rupp et al. 2021). Both insects were observed feeding on the lips of *N. banksiana*, but neither carried pollinia. The *Megaselia* appears to be too small to contact the orchid column (Figure 7), but *Dryomyza* flies appear to be large enough to remove pollinia (Figure 8). Additional work is needed to assess whether this orchid produces a fetid odor detectable by insects, and whether *Dryomyza* flies function as pollinators.

#### Platanthera aquilonis Sheviak (northern green rein orchid)

This rein orchid was formerly treated with the tetraploid *P. hyperborea*, but was segregated as *P. aquilonis* (Sheviak 2001) as it is diploid and has a more western distribution in northern North America including southeast and south central Alaska. These species self-pollinate or have rain-assisted pollination, but appear to provide nectar in short spurs and may have outcrossing races (Sheviak 2001, Kropf 2015). *Platanthera aquilonis* is also considered one of the diploid progenitors (x *P. dilatata*) of the polyploid *P. huronensis*; however, pollen vectors that would facilitate this cross are not well-known (Wallace 2003). Though classified as a nocturnal moth-pollinated species (Hapeman and Inoue 1997), Kropf (2015) observed *Bombus jonellus* Kirby visiting *P. hyperborea* in Iceland, which suggests that *Bombus* species might facilitate outcrossing in *P. aquilonis* as well.

In 2019 we observed a *Bombus* species foraging on *Platanthera aquilonis* (Figure 9) in a mixed population of this species with *P. dilatata* and *P. huronensis* in an uplift meadow in the Haines area of Southeast Alaska. This observation complements the finding of Kropf (2015). Moreover, as bumble bees also appear to pollinate *P. dilatata* (van der Voort et al. 2022), our observation provides further evidence that *Bombus* species may be pollen vectors between *P. aquilonis* and *P. dilatata*, allowing spontaneous populations of their hybrid *P. huronensis*. More work on potential for pollinia transfer in *P. aquilonis* is needed to verify this process.



Figure 4: *Bombus melanopygus* bearing pollinia on its tongue approaching a *Goodyera oblongifolia* inflores-cence.

#### Platanthera convallariifolia Fischer ex Lindley (lily-leaved rein orchid)

This orchid is native to the Aleutian Islands, eastern Russia (Kamchatka) and northern Japan. Its range extends east through southwest Alaska to Kodiak and the Kenai peninsula, with outposts in coastal Alaska about 150 km west of the western border of Southeast Alaska. It is a polyploid derived from crossing between *P. dilatata* x *P. stricta* (Wettewa et al. 2020).

The flower and inflorescence structure of *Platanthera convallariifolia* suggests a nocturnal settling moth syndrome (as opposed to a hovering moth), where primary pollinators would be members of the Noctuidae or Pyrilidae (Hapeman and Inoue 1997). Noctuidae might serve as pollen vectors between *P. dilatata* and *P. stricta*. However, no pollinators had been reported for *P. convallariifolia*. In 2021, we received images from Abi Woodbridge showing a Noctuidae moth pollinating *P. convallariifolia* (Figure 10) at Unalaska, Aleutian Islands. This moth appears to be in the genus *Mniotype*, and resembles *M. tenera* Smith (Figure 11). The type locality of *M. tenera* is Kukak Bay, in the Western Peninsula of Alaska (Dyar 1900).

#### Platanthera dilatata (Pursh) Lindley (white bog orchid)

This wide-spread orchid ranges from the Aleutian Islands east to Southeast Alaska, north to central Alaska, and east across North America. The flower and inflorescence structure of *Platanthera dilatata* suggests a settling-moth syndrome, and primary pollinators are members of the Noctuidae, including at least 11 such species across North America, as well as several butterflies, bumblebees and a hawkmoth (Wallace and Bowles 2023). In 2022, we observed a day-flying *Plusia* (Noctuidae) species pollinating this orchid, which had not been reported in Bowles and Armstrong (2021). Individuals appear to represent both *P. putnami* Grote (Figure 12) and *P. nichollae* Hampson (Figure 13). In *P. putnami* the basal spot of the stigma extends above the cubital vein in most specimens, giving it a triangular appearance; in *P. nichaol*-



Figure 5: Bombus melanopygus bearing pollinia on its tongue while foraging on Goodyera oblongifolia flowers.

*lae*, the more oval basal spot rarely extends above the cubital vien, and in the West the two species are frequently confused (Lafontaine and Poole 1991).



Figure 6: Relationship between flowering plant density per 10 m<sup>2</sup> plot, seed capsule production, and inflorescence size in *Goodyera oblongifolia*. p values are Mann-Whitney *t*-Test probabilities.



Figure 7: *Megaselia* sp. fly foraging on the lip of *Neottia banksiana*. Note relatively small size relative to column height and lack of contact with column.



Figure 8: *Dryomyza anilis* fly foraging on the lip of *Neottia banksiana*. Note relatively large size and head in contact with column.



Figure 9: Bombus sp. foraging on an inflorescence of Platanthera aquilonis.



Figure 10: Noctuidae resembling *Mniotype tenera* bearing pollinia on its tongue while foraging on the inflorescence of *Platanthera convallariifolia*. Photo by Abi Woodbridge.



Figure 11: Wing pattern of Noctuidae resembling Mniotype tenera. Photo by Abi Woodbridge.



Figure 12: Noctuidae resembling *Plusia putnami* bearing pollinia on its tongue while foraging on *Platanthera dilatata*.



Figure 13: Noctuidae resembling *Plusia nichollae* below an inflorescence of *Platanthera dilatata*. A rear leg of this specimen bears an orchid pollinia.

| Table 2: Summaries for orchid genera and and numbers of insect species known to pollinate orchid species in an orchid pollinator network in   |
|---|
| Southeast Alaska. Insects are categorized by order and family, orchids are categorized by genus. Orchid species with known pollinators are based  |
| on Bowles and Armstrong (2021), Argue (2012a), Argue (2012b), this paper and references therein. <i>n</i> <sub>orchid spp</sub> : Number of orchid species. <i>n</i> <sub>known</sub> : |
| Number of orchid species where pollinators are known. n <sub>unknown</sub> : Number of orchid species where pollinators are unknown. *: Based in part on                                |
| literature. **: Includes one or more self-pollinating species that may outcross as well. ***: Pollinia not observed on one or more species. See Table 3                                 |
| for column totals.  |

| Pollinators  | Calypso | Coeloglossum | Corallorhiza  | Cypripedium    | Goodyera | Malaxis      | Neottia      | Piperia      | Platanthera                  | Spiranthes |
|--|---------|--------------|---------------|----------------|----------|--------------|--------------|--------------|------------------------------|------------|
| n <sub>orchid spp.</sub><br>n <sub>known</sub><br>n <sub>unknown</sub><br>Diptera:<br>Bibionidae | 1<br>1  | 1<br>1<br>1  | 3<br>2<br>1** | 3<br>2*<br>1** | 1<br>1   | 2<br>1*<br>1 | 4<br>2*<br>2 | 2<br>1*<br>1 | 7<br>5*<br>2**               | 1<br>1     |
| Cucilidae<br>Dryomyzidae<br>Empididae<br>Scariadae<br>Syrphidae                                  |         |              | 1             |                |          | 1            | 1***<br>1*   |              | 2***<br>1                    | 1***       |
| <b>Hymenoptera:</b><br>Apidae<br>Halictidae<br>Andrenidae<br><b>Lepidoptera:</b>                 | :<br>1* |              | 1             | 1*<br>1*<br>1* | 1        |              |              |              | 1*                           | 1          |
| Geometridae<br>Pieridae<br>Noctuidae<br>Sphingidae<br><b>Totals</b>                              | 1       | 1            | 2             | 3              | 1        | 1            | 2            | 1*           | 2***<br>1<br>5***<br>1<br>13 | 2          |

| Pollinators  | Totals  | Totals                                 |
|--|---|--|
| $n_{ m orchid\ spp.}$<br>$n_{ m known}$<br>$n_{ m unknown}$<br><b>Diptera:</b><br>Bibionidae | 25<br>17<br>18<br><i>n</i> <sub>insect species</sub><br>1 | <i>n</i> orchid genera pollinated<br>1 |
| Cucilidae<br>Dryomyzidae<br>Empididae<br>Scariadae<br>Syrphidae                              | 2<br>1<br>1+<br>1+<br>1                                   | 1<br>1<br>2<br>2<br>1                  |
| <b>Hymenoptera:</b><br>Apidae<br>Halictidae<br>Andrenidae<br><b>Lepidoptera:</b>             | 1+<br>1+<br>1+  | 6*<br>1*<br>1*                         |
| Geometridae<br>Pieridae<br>Noctuidae<br>Sphingidae<br><b>Totals</b>                          | 3<br>1<br>5<br>1<br>20                                    | 2<br>1<br>1<br>1<br>21                 |

Table 3: Table 2 continued. *n*<sub>insect species</sub> : Number of insect species. *n*<sub>orchid genera pollinated</sub> : Number of orchid genera pollinated.

#### Platanthera obtusata (Banks ex Pursh) Lindley (blunt-leaved orchid)

The blunt-leaved orchid has a strongly boreal distribution, extending north of the Arctic Circle in Alaska and Canada, and east across North America. This species is known to be pollinated primarily by mosquitoes in the Genus *Aedes*, which are attracted by a specific odor produced by the orchid (Lahondère et al. 2020). Gorham (1976) reported 15 mosquito species and an additional unidentified mosquito as pollinators of *Platanthera obtusata*, including six from north-central Alaska. It is unknown whether these or other *Aedes* species pollinate this species in Southeast Alaska.

We observed and photographed *Aedes* mosquitoes visiting *Platanthera obtusata* in spruce forest near the Mendenhall Glacier, and in an enclosed terrarium to which mosquitoes and flowering stems of *P. obtusata* had been introduced. Mosquitoes were observed bearing pollinia only in the terrarium after a 12 hr overnight period (Figure 14). These mosquitoes belong to the non-band-legged group and appear to be *A. communis* DeGeer but their identity has not been confirmed. Mosquitoes in forest also foraged on flowers (Figure 15). They belong to the band-legged group and appear to be *A. excrucians* Walker but their identity has not been confirmed. A male mosquito was observed on *P. obtusata* in forest but its identity is unknown (Figure 16). *Aedes excrucians* was not reported as a pollinator in Alaska (Gorham 1976). If confirmed, this species may represent a new pollinator of *P. obtusata* in this state.

#### Platanthera stricta Lindley (slender bog orchid)

This northern rein orchid ranges from the Aleutians east across southern Alaska to western North America, where it may be frequent in open wetlands. Its inflorescence and flower structure suggest that it is pollinated by settling moths, and a wide range of pollinators have been recorded from Washington, including Geometridae moths, Empididae flies, and *Bombus* bumblebees (Patt et al. 1989). We previously reported an unkown Geometridae visiting flowers of *Platanthera stricta*, and an Epididae bearing pollinia



Figure 14: Mosquito resembling Aedes communis bearing pollinia on Platanthera obtusata.



Figure 15: Mosquito resembling Aedes excrucians foraging on Platanthera obtusata.

on this orchid (Bowles and Armstrong 2021). We have now found the Geometridae Antepirrhoe fasciata Barnes & McDunnough bearing pollinia (Figure 17) and the Geometridae Rheumaptera subhastata Nolcken visiting flowers of *P. stricta* (Figure 18). Patt et al. (1989) also recorded *A. fasciata* as a primary pollinator. Rheumaptera subhastata may be confused with *R. hastata* Linnaeus, but the former uses Alnus (alder) sp as a larval host, while the latter uses Betula (birch) (McGuffin 1973) and only Alnus occurs in the locality where *R. subhastata* was recorded. Though this moth was not observed bearing pollinia, the proboscis length and foraging behavior of the individual observed suggest that it could serve as a pollinator of *P. stricta*.



Figure 16: Male Aedes sp. foraging on Platanthera obtusata.



Figure 17: Antepirrhoe fasciata bearing pollinia at the base of its tongue while foraging on Platanthera stricta.

# Components of the pollinator network

This work expands our knowledge of the insect community that forms a pollinator network among Southeast Alaska's orchid species. Our observations and other published literature indicate that at least 20 insect species among 3 orders and 13 families may comprise this network (Table 2).

The Diptera order has the greatest number of families (6), with 7 species that appear to pollinate 6 orchid genera and 8 species. These flies are morphologically diverse, matching flower sizes and nectar resources. Minute Scariadae (fungus gnats) feed on nectar at the base of the lip in equally small *Neottia* and *Malaxis* 



Figure 18: Rheumaptera subhastata foraging on Platanthera stricta.

flowers. Larger Bibionidae (March flies) and Dryomyzidae flies feed on nectar in larger *Coeloglossum* and *Neottia* flowers. Empididae (dance flies) and Culicidae (mosquitoes) use longer tongues to feed on nectar in recessed spurs of *Platanthera*. A large Syrphidae (a bee-mimic hover fly) forages on bee-pollinated *Spiranthes*, though we have not seen it carrying pollinia. These insects carry pollinia from different orchid species on their eyes, heads, tongues and backs.

The Lepidoptera order includes 5 families representing 10 species that specialize on only two orchid genera, *Platanthera* and *Piperia* (some authors treat both as *Platanthera*) representing 5 species. These orchids have relatively large volumes of nectar held in recessed spurs adapted to the tongue lengths of their pollinators. Most appear to attach pollinia to the tongues of their pollinators, linking tongue and spur length to reproductive isolation. Noctuidae moths have the greatest number of species, but they may pollinate a single orchid species, *Platanthera dilatata*, in Southeast Alaska, and functionally represent a single pollinator that carries pollinia on its tongue. Noctuidae species also appear to be the only pollinators in this network that also function as a nectar thief on other orchids, feeding on the bee-pollinated *Goodyera oblongifolia* and *Spiranthes romanzoffiana*.

Hymenoptera pollinators contain only three families, the bumblebees (Apidae) and smaller bees in the Andrenidae and Halictidae. Despite low diversity, this group is responsible for pollinating as many orchid genera as the Diptera and at least 6 orchid species. It is the primary group that pollinates slipper orchids (*Calypso* and *Cypripedium*), which use food deception to attract pollinators. *Cypripedium* orchids appear to be pollinated by smaller Bombidae, Halictidae and Andrenidae bees (Bernhardt et al. 2014, Edens-Meier et al. 2018).

The bumblebee *Bombus melanopygus* may be the one of the single most important orchid pollinating insect species. It pollinates across the orchid flowering season, with queens pollinating the spring flowering *Calypso bulbosa* (carrying pollinia on their backs) and workers responsible for mid- to late-summer pollination of *Corallorhiza mertensiana* (carrying pollinia on their heads) and late summer pollination of *Spiranthes romanzoffiana* and *Goodyera oblongifolia* (carrying pollinia on their tongues). Newly emerged queens also forage and may pollinate in early fall.

The bee-pollinated orchids could be particularly vulnerable to climate warming if it causes phenological shifts that lead to asynchrony with foraging bumblebees that pollinate these species. For example, earlier spring flowering lead to asynchrony with bumblebee phenology in the Rocky Mountains (Pyke et al. 2016). Likewise, earlier spring flowering produced phenological asynchrony between *Bombus* queens and *Corydalis* in northern Japan (Kudo and Ida 2013). A similar effect might be expected to occur with the spring-flowering *Calypso bulbosa*.

Climate change effects on late summer or fall flowering plant-pollinator phenologies are poorly under-

27

stood (Gallinat et al. 2015). Though climate warming might lead to earlier flowering of other bee-pollinated orchids, such a shift would still encounter *Bombus* pollinators as they are active throughout the flowering season. The late-summer flowering *Goodyera oblongifolia* might be most vulnerable, as it currently has little competition for pollinators with other plants. Earlier flowering that encountered greater competition for pollinators, coupled with nectar thievery by Noctuidae and its typical low seed-pod production might lead to reduced reproduction in this species. The study of how climate warming affects plant-pollinator relationships should intensify with ongoing climate change, and should be expected to reveal many additional outcomes that threaten to decouple orchids from their pollinators and reduce their reproduction and survival.

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# An Alaska review of *The Social Wasps of North* America

#### by Alexandria Wenninger<sup>14</sup>

*The Social Wasps of North America*, written and illustrated by Chris Alice Kratzer, is a visual guide to all 208 species of social vespines, polistines, and crabronids known from North America, from Alaska east to Greenland and south to Panama. Alaska is home to 11 of these species belonging to the genera *Dolichovespula* (6 species) and *Vespula* (5 species), which we often call 'yellowjackets'. Yellowjackets provide important ecosystem services in Alaska through their roles in predation, pollination, and decomposition. Despite their importance, public perception of yellowjackets is often negative due to their propensity to sting in defense of their nest. It is refreshing to see these important insects receive some positive media attention through this guide, and to see it written in a way that is accessible to a general audience.



Figure 1: Cover of The Social Wasps of North America.

The first part of the guide focuses on the ecology and evolution of social wasps. This section is informative but also written in a conversational tone and peppered with small bits of humor, making it an enjoyable read. Also included is a chapter about why wasps sting and how to avoid it, which is written in a way that gives some context of a wasp's perspective of humans and how our own behavior can elicit a defensive reaction from social wasps. While this section is short, this may be one of the most helpful sections for a general audience, as having some understanding of the mechanisms behind why wasps sting can give folks a sense of agency over their interactions with social wasps.

For those who already have some familiarity with social wasps the highlight of the book is the illustrating. Each species includes a dorsal illustration, often one for each male and female wasp, as well as an

<sup>&</sup>lt;sup>14</sup>University of Alaska Fairbanks Cooperative Extension Service Integrated Pest Management Program, akwenninger@alaska.edu

illustration of the face. What is particularly impressive about the illustrations for the vespines is that each illustration is split down the middle with one side showing a melanic color form and the other side showing a xanthic, ferruginous, or leucistic color form as applicable. Our yellowjackets found in Alaska often tend to lean more melanic, so it was elating to find some of the intraspecific color variation represented in this guide, and cleverly shown in a way that doesn't take up extra space. The illustrations are truly a delight and future illustrators working with groups of insects that exhibit color variability should consider this style of illustration.

Overall this is an excellent visual introduction to the social wasps of North America that both wasp enthusiasts and entomologists can appreciate. As a visual guide, you won't find a depth of information about any individual species nor identification keys, but you will find careful attention to illustration detail and an impressive comprehensiveness of taxa for such a large geographic area of interest.

# Review of the sixteenth annual meeting

## by Dana Brennan<sup>15</sup>

The sixteenth annual Alaska Entomological Society meeting was held at the Department of Natural Resources building in Fairbanks and virtually via Zoom on February 17, 2023. We are grateful to the Fairbanks DNR group for offering us the space.



Figure 1: Members present at the meeting. Back row, from left: Robin Andrews, Curtis Knight, Jina Malone, Alex Wenninger, Sayde Ridling, Taylor Kane, Joey Slowik, Julie Riley, Dennis Fielding. Front row, from left: Thalles Pereira, Dana Brennan, Derek Sikes, Roger Burnside.

# Presentations

**Jason Grant**, a plant taxonomist based in Switzerland, regularly returns to Fairbanks and spends time documenting moths and other organisms he finds outside using iNaturalist. In his talk, "Notable observations and potential range extensions of moths in Alaska," Grant discussed methods for attracting and documenting moths, making identifications, and some exciting finds, including species not previously documented in Alaska. In the future, Grant plans to continue looking for moths, possibly starting a moth week sampling event, and depositing reference specimens for museum curation.

Alex Wenninger looped us in on the goings on at Cooperative Extension Service in Anchorage in her IPM highlight reel. Her presentation showed exciting, new, and unusual finds, including: honeysuckle moth, a well-documented pest of haskaps; pale green weevil; California horntail; pear slug; raspberry leafminer—though only a eulophid parasitoid was reared; black-beaked green weevil; apple seed Chalcid, which causes dimpling in crab apples; and biological control agents for yellow toadflax: a flower feeding beetle and a seed capsule feeding weevil.

In another talk on the citizen science application, iNaturalist, **Sayde Ridling** presented "Using iNaturalist as a Bioblitz Tool." Ridling discussed the benefits and costs of using iNaturalist for bioblitz events and some of the cool things found during these events. For instance, the Beaver Creek iNaturalist-based bioblitz had more taxa recorded than all area efforts from 1912 to present combined! While using the application makes for easy open access data and community involvement, iNaturalist bioblitz events can lack the networking opportunities and physical collections important for novel area species. It is likely that more

<sup>&</sup>lt;sup>15</sup>Alaska Department of Natural Resource, Anchorage, Alaska, danambrenn@gmail.com

bioblitz events will use iNaturalist, so it is important to account for the weaknesses of an application-based bioblitz when planning.

**Derek Sikes** gave us a call to action in his talk, "How many species? A comparison of Alaska's to Sweden's entomofauna." When comparing Alaska entomofauna to Sweden's, Sweden has four times the documented species, even though Alaska is substantially larger in size! Sikes gave several reasons that could explain this difference. When comparing species richness, Hymenoptera are most specious in Sweden while Diptera are most specious in Alaska. Looking forward, if we want to better document the species diversity in Alaska, Sikes emphasizes we need to substantially increase our documenting efforts now, as many of our species will be impacted by the changing climate.

**Liz Graham** filled us in on recent hemlock sawfly and western blackheaded budworm activity in Southeast Alaska. Since first being reported from the public in 2018, the hemlock sawfly outbreak peaked in 2019 before the population crashed in 2020. At this time, western blackheaded budworm populations began to increase, leading to detectable hemlock mortality and topkill in 2021. In 2022, western blackheaded budworm feeding shifted more to Sitka spruce. Diseased caterpillars have been found on the landscape, suggesting natural population controls are taking course to bring an end to the outbreak. For now, surveying will continue and various projects related to these outbreaks are in the works.

In "2022 Southcentral Forest Health Roundup," **Jason Moan** updated participants on the goings on in his office. The rusty tussock moth outbreak is now over, and egg masses sent for study returned with heavy parasitism from a new Alaska record, *Telenomus dalmani*. Whether this parasitoid has always been here and or is a new arrival into Alaska is unclear. The spruce beetle outbreak continues, with 48,800 acres of new mortality mapped, mostly in Chugach National Forest and the Cantwell area. Damage in black spruce is being observed, where failed spruce beetle galleries and Ips galleries have been found, suggesting they may be working synergistically in smaller diameter spruce trees.

**Jackson Audley** gave us an update on continued spruce beetle tree protection research in his presentation, "Development of a semiochemcial repellent to protect spruce trees from spruce beetle in Alaska." For the last few years, the USFS Pacific Southwest Research Station has been testing various semiochemical treatments applied to trees in many western states to determine what is most effective at protecting spruce from spruce beetle mass attacks. Various formulations have been tested, and there's promising results that could provide single tree protection from attacks. Research is ongoing and more trials will be conducted in 2023; look for papers from this group to learn more!

In, "Discovery of gnat snakeworms in Alaska: a new species of *Sciara* Meigen (Diptera: Sciaridae) based on morphological, molecular, and citizen science data," **Thalles Pereira** gave us a look into some exciting research he is in the process of publishing regarding these flies and their unusual behaviors. Since the paper is in progress to describe this new species, we will save the details of the talk for now, so be on the lookout for Pereira's paper coming soon!

Thanks to our sole student presenter, **Robin Andrews**, who returned to the AKES meeting to present her recent work, "Chasing <sup>13</sup>C labeled recent photosynthate through belowground soil fauna food webs and finding it almost everywhere." After collecting soil cores at various times after dosing trees with <sup>13</sup>C and comparing those values to baseline data, trophic levels can be determined and grouped. Future work will focus on validating those groupings and separating fungivores from faunivores. We are happy to learn more about her work and congratulate her on winning the student presentation award.

# **Business items – highlights**

The society discussed the idea of having the meeting over two days, which would allow for a shorter time commitment for each day to accommodate for those who must take time off work to attend. Ideas for a split day meeting included having a keynote or social event or student presentations the evening before and the main meeting the following day.

• Replacement for Bioquip gift awards for science fair winners was discussed. It was agreed to give recipients \$25 cash.

- Creating AKES t-shirts was discussed again, a committee was formed to finalize a design, and an amount was agreed upon for the commission of a new design.
- AKES newsletters will be databased with the UAF library so they are available in perpetuity.
- In the future, there may be funding available for travel for society members that would like financial assistance to attend meetings.
- Current officers were retained: Dana Brennan (president), Robin Andrews (vice president), Taylor Kane (secretary), and Roger Burnside (treasurer).

Minutes from our business meeting are available on the website.

# Metabarcoding pollinators on Kenai National Wildlife Refuge, Kenai Peninsula, Alaska

by Matt Bowser<sup>16</sup>, Anya Bronowski, and Dom Watts<sup>17</sup>

# Introduction

Pollinating insects provide important ecosystem services in Alaska (Fulkerson et al. 2021) and the pollinators themselves are wildlife that the Kenai National Wildlife Refuge (KNWR) was established in part to conserve (Kenai National Wildlife Refuge and US Fish & Wildlife Service, Alaska Regional Office, Division of Conservation Planning & Policy 2010). Because many pollinators appear to be generally declining (Potts et al. 2010, Cameron et al. 2011, Koh et al. 2016), our objective was to begin documenting pollinator diversity on KNWR and surrounding lands.

The Alaska Bee Atlas (Fulkerson et al. 2021, https://accs.uaa.alaska.edu/wildlife/ak-bee-atlas) is a sampling program designed to provide information on the biodiveristy of pollinators throughout Alaska. In 2022, KNWR biologists participated in the Alaska Bee Atlas effort.

# Methods

#### Sampling Design

We followed the sampling plan guidance of Fulkerson et al. (2021). Most of KNWR lies within lowest priority areas mapped in Fulkerson et al. (2021), but the southernmost part of the Refuge lies within a medium priority area. We prioritized sampling in this area, but access in this area is difficult. We surveyed only at Emerald Lake in this medium priority area.

We surveyed for insect pollinators at a variety of other sites on the Refuge, trying to sample in diverse habitats (Figure 1). We sampled dry, rocky slopes off of Skilak Lake Road following the advice of Justin Fulkerson (Alaska Center for Conservation Science, Anchorage, Alaska).

We accessed sites by road and floatplane.

#### **Field Methods**

We sampled pollinators using bee bowl traps (Figure 2), blue vane traps (Figure 3), and aerial nets (Figure 4), generally following the field methods of Fulkerson et al. (2021) with the exception that we collected specimens into SK picglobal 99.9% pure propylene glycol. Field notes are available from Bowser (2022c) and Bronowski (2022).

#### **Specimen Processing**

Samples were stored in a -23°C freezer except when samples were being processed. Invertebrates were separated from debris by hand under a dissecting microscope. Care was taken to reduce possible cross-contamination of DNA among samples.

<sup>&</sup>lt;sup>16</sup>USFWS Kenai National Wildlife Refuge, Soldotna, Alaska, matt\_bowser@fws.gov

<sup>&</sup>lt;sup>17</sup>USFWS Kenai National Wildlife Refuge, Soldotna, Alaska



Figure 1: Map of Alaska Bee Atlas sampling priority hexagons as of May 11, 2022 and sites we surveyed for pollinators in 2022. KNWR: Kenai National Wildlife Refuge boundary. The map was generated with R, version 4.2.2 (R Core Team 2022) using the R packages sf, version 1.0-9 (Pebesma 2018) and pdftools, version 3.3.3 (Ooms 2023c).



Figure 2: A bee bowl trap, part of a set bee bowls off of Skilak Lake Road, June 27, 2022 (credit: Matt Bowser/USFWS).

We separated samples that were all or mostly bees from samples that were mostly flies and other invertebrates. We shipped 12 samples of bees to the Alaska Center for Conservation Science<sup>18</sup>, University of Alaska Anchorage, Anchorage, Alaska to be processed by methods described by Fulkerson et al. (2021).

We homogenized the remaining 19 samples plus one legacy bulk pollinator sample from a previous project (Bowser 2012) using a blender and cleaning between samples with DIY-DS cleaning solution as described by Buchner et al. (2021). Our sample homogenization protocol is included below.

We homogenized samples using a Nutri Ninja QB3000SS blender.

<sup>&</sup>lt;sup>18</sup>https://accs.uaa.alaska.edu/



Figure 3: Two blue vane traps near Hidden Lake Campground, June 17, 2022 (credit: Matt Bowser/US-FWS).



Figure 4: Dominique Watts collecting pollinators using an aerial net above Twin Lakes, August 3, 2022 (credit: Matt Bowser/USFWS).

#### **DIY-DS** recipe

- 20 g NaOH
- 20 g Alconox
- 15.1 g NaHCO<sub>3</sub>
- 267 ml 4.5% bleach
- deionized water to fill to 21

#### Preparation

1. 120 ml plastic cups should be washed with DIY-DS and rinsed before sampling. Finish by rinsing inside the 120 ml cup with deionized water. Hand dry 120 ml cup with paper towel.

Homogenize samples

- 1. Before running samples, rinse blender by running 100 ml of deionized water for 20 s.
- 2. Pre-label a 10 ml plastic vial with the specimen GUID and add a barcode vial label. Also pre-label and add a barcode label to a 120 ml specimen cup.
- 3. Clean forceps with DIY-DS.
- 4. Take the label out of the original container with the cleaned forceps and place into the new 120 ml sample container.
- 5. Add the contents of the sample vial to the blender.
- 6. Rinse original sample vial with cold, clean propylene glycol and pour rinsate in the blender with the rest of the sample.

- 7. Fill blender to 100 ml with cold, clean propylene glycol.
- 8. Blend for 90 s.
- 9. Using a new disposable pipette, fill the pre-labelled 10 ml plastic vial with about 9.5 ml of homogenate.
- 10. Pour the rest of the sample into the pre-labeled 120 ml specimen cup.
- 11. Rinse blender by running 100 ml tap water for 10 s.
- 12. Wash blender by running 100 ml of DIY-DS for 10 s.
- 13. Rinse this out in the lab sink with tap water.
- 14. Rinse blender by running 100 ml deionized water for 10 s.

We shipped 9 ml of homogenate from each of the 20 homogenized samples to Molecular Research Laboratory<sup>19</sup>, Shallowater, Texas for metabarcoding.

#### **Molecular Methods**

We chose to use the *mlCOlintF/jgHCO2198* (GGWACWGGWT GAACWGTWTA YCCYCC / TAIACYT-CIG GRTGICCRAA RAAYCA) primer set of Leray et al. (2013) for PCR, targeting a 313 bp region of the COI DNA barcoding region.

The *mlCOlintF/jgHCO2198* primer pair was used with barcodes on the forward primer in 30–35 PCR cycles using the HotStarTaq Plus Master Mix Kit (Qiagen, USA) under the following conditions: 94°C for 3 minutes, followed by 30–35 cycles of 94°C for 30s, 53°C for 40 seconds and 72°C for 1 minute, after which a final elongation step at 72°C for 5minutes was performed. After amplification, PCR products were checked in 2% agarose gel to determine the success of amplification and the relative intensity of bands. Multiple samples were pooled together in equal proportions based on their molecular weight and DNA concentrations. Pooled samples were purified using calibrated Ampure XP beads. The pooled and purified PCR product was used to prepare an illumina DNA library. Sequencing was performed at MR DNA on a MiSeq following the manufacturer's guidelines.

#### **Bioinformatics**

The bioinformatics pipeline was run on the Yeti supercomputer (USGS Advanced Research Computing 2021). We used the MetaWorks pipeline, version 1.11.3 (Porter and Hajibabaei 2022) with the RDP classifier (Wang et al. 2007) and the Eukaryote CO1 reference set for the RDP Classifier, version 4.0.1 (Porter and Hajibabaei 2018). We processed data in R, version 4.2.2 and 4.2.3 (R Core Team 2022, 2023) using the R packages ape, version 5.7-1 (Paradis and Schliep 2019); Biostrings, version 2.66.0 (Pagès et al. 2022); bold, version 1.2.0 (Chamberlain 2021a); curl, version 5.0.0 (Ooms 2023a); ips, version 0.0.11 (Heibl 2008); msa, version 1.30.1 (Bodenhofer et al. 2015); openssl, version 2.0.6 (Ooms 2023b); reshape2, version 1.4.4 (Wickham 2007); ritis, version 1.0.0 (Chamberlain 2021b); and uuid, version 1.1-0 (Urbanek and Ts'o 2022).

We compared our sequences to sequences from a local reference library (Bowser 2022a) using the vsearch --usearch\_global command of vsearch, version 2.21.1 (Rognes et al. 2016).

In order to exclude potential false positive detections as defined by MacKenzie et al. (2006) due to demultiplexing errors (see Deiner et al. 2017), we conservatively removed from the Exact Sequence Variant (ESV) table all occurrences that represented less than 0.4% of the total number of reads for any ESV, based the experience of (Bowser 2023b), where an apparent rate of mis-assignment of up to 0.36% was found. We also removed all occurrences represented by only one or two reads.

Complete methods including all configurations, commands, and scripts used for processing data are available from Bowser (2023a).

Identifications of *Bombus* species were conformed to the names provided by Sikes and Rykken (2020).

http://www.akentsoc.org/newsletter.php

<sup>&</sup>lt;sup>19</sup>https://www.mrdnalab.com/

#### Data Availability

Project data and project photos are available on Arctos via an Arctos project record (https://arctos. database.museum/project/10003917) and specimen records can be viewed via an Arctos search<sup>20</sup>. Project information is also available from a project record on ServCat (https://ecos.fws.gov/ServCat/Reference/ Profile/148742). Raw sequence data from this project are available from Bowser (2022b). Resulting occurrence data have been published as an occurrence dataset (Bowser et al. 2023). Results from specimens sent to the Alaska Center for Conservation Science are available from the 2018 to 2022 Results Map at https://arcg.is/1myveP.

#### **Results Summary**

The single legacy sample from 2011 yielded 71 species and 18 BINs (Table 4). The 17 samples collected in 2022 yielded 206 species and 85 BINs (Table 5).

| Phylum     | Class           | Order       | Species | BINs |
|------------|-----------------|-------------|---------|------|
| Arthropoda | Arachnida       | Araneae     | 1       | 0    |
| Arthropoda | Insecta         | Coleoptera  | 1       | 0    |
| Arthropoda | Insecta         | Diptera     | 61      | 14   |
| Arthropoda | Insecta         | Hemiptera   | 1       | 2    |
| Arthropoda | Insecta         | Hymenoptera | 2       | 2    |
| Arthropoda | Insecta         | Lepidoptera | 3       | 0    |
| Arthropoda | Insecta         | Odonata     | 1       | 0    |
| Ascomycota | Dothideomycetes | Capnodiales | 1       | 0    |

Table 4: Numbers of species and BINs observed in the sample from 2011 by orders.

Table 5: Numbers of species and BINs observed in the sample from 2022 by orders.

| Phylum     | Class      | Order            | Species | BINs |
|------------|------------|------------------|---------|------|
| Annelida   | Clitellata | Crassiclitellata | 1       | 0    |
| Arthropoda | Arachnida  | Araneae          | 11      | 0    |
| Arthropoda | Arachnida  | Sarcoptiformes   | 2       | 0    |
| Arthropoda | Arachnida  | Trombidiformes   | 0       | 1    |
| Arthropoda | Collembola | Collembola       | 3       | 0    |
| Arthropoda | Collembola | Entomobryomorpha | 1       | 1    |
| Arthropoda | Collembola | Symphypleona     | 0       | 1    |
| Arthropoda | Insecta    | Coleoptera       | 22      | 3    |
| Arthropoda | Insecta    | Diptera          | 99      | 60   |
| Arthropoda | Insecta    | Ephemeroptera    | 1       | 0    |
| Arthropoda | Insecta    | Hemiptera        | 16      | 9    |
| Arthropoda | Insecta    | Hymenoptera      | 28      | 10   |
| Arthropoda | Insecta    | Lepidoptera      | 9       | 0    |
| Arthropoda | Insecta    | Orthoptera       | 1       | 0    |
| Arthropoda | Insecta    | Psocodea         | 1       | 0    |
| Arthropoda | Insecta    | Thysanoptera     | 2       | 0    |
| Arthropoda | Insecta    | Trichoptera      | 1       | 0    |
| -          |            | -                |         |      |

<sup>20</sup>https://arctos.database.museum/search.cfm?project\_id=10003917

39

| Phylum     | Class           | Order           | Species | BINs |
|------------|-----------------|-----------------|---------|------|
| Chordata   | Aves            | Galliformes     | 1       | 0    |
| Chordata   | Mammalia        | Rodentia        | 1       | 0    |
| Mollusca   | Gastropoda      | Stylommatophora | 3       | 0    |
| Ascomycota | Dothideomycetes | Capnodiales     | 1       | 0    |
| Ascomycota | Sordariomycetes | Hypocreales     | 2       | 0    |

In the single sample from 2011, the most abundant species in terms of read abundances was 16,848 reads of *Ctenicera angusticollis* (Figure 5). Other abundant identifications were flies in the families Muscidae, Anthomyiidae, and Fanniidae. In 2022, the highest read abundance was for *Speyeria mormonia* (Boisduval, 1869) (Lepidoptera: Nymphalidae), which we detected in three samples (Figure 6). Reads of *Helina* species (Diptera: Muscidae), *Rhadiurgus variabilis* (Zetterstedt, 1838) (Diptera: Asilidae), and *Xylota subfasciata* Loew, 1866 were also abundant.



Figure 5: Top 16 most abundant identifications in terms of DNA read abundances from the single 2011 pollinator sample. BOLD:AAZ5940: *Hiatomyia* sp. BOLD:AAZ5940 (Diptera: Syrphidae). BOLD:AAB2863: *Dasysyrphus* sp. BOLD:AAB2863 (Diptera: Syrphidae). BOLD:ACI3668: *Delia* sp. BOLD:ACI3668 (Diptera: Anthomyiidae).

The most frequently observed identifications were four *Helina* species that were detected in 5–10 out of the 17 samples (Figure 7). The fungus *Cladosporium allicinum* (Fr.) Bensch, U.Braun & Crous (Capnodiales: Cladosporiaceae) was detected in 6 samples. The bee parasite *Apocephalus borealis* Brues, 1924 (Diptera: Phoridae) was detected in four samples.

#### Bees

We detected no bees in the sample from 2011 and 12 species of bees in 2022 (Table 6). All of these bee species are widespread in Alaska based on occurrence records available through the Global Biodiversity Information Facility (GBIF, https://www.gbif.org/), but we are not aware of other records of *Andrena* 



Figure 6: Top 16 most abundant identifications in terms of DNA read abundances from the 2022 pollinator samples. BOLD:AAE0058: *Mydaea* sp. BOLD:AAE0058 (Diptera: Muscidae). BOLD:AAG9634: *Dolichopus* sp. BOLD:AAG9634 (Diptera: Dolichopodidae). BOLD:ACC7057: *Phaonia* sp. BOLD:AAC9637 (Diptera: Muscidae). BOLD:AAG0459: *Suillia* sp. BOLD:AAG0459 (Diptera: Heleomyzidae). BOLD:AAL8103: Anthomyiidae sp. BOLD:AAL8103.

*milwaukeensis* or *Halictus rubicundus* from the Kenai Peninsula. All of the *Bombus* species we found are known to be abundant or common in our area (Rykken 2022).

| Family       | Species                                 |
|--------------|---|
| Andrenidae   | Andrena milwaukeensis Graenicher, 1903  |
| Apidae       | <i>Apis mellifera</i> Linnaeus, 1758    |
| Apidae       | Bombus flavifrons Cresson, 1863         |
| Apidae       | Bombus frigidus Smith, 1854             |
| Apidae       | Bombus insularis (Smith, 1861)          |
| Apidae       | Bombus lapponicus sylvicola Kirby, 1837 |
| Apidae       | Bombus melanopygus Nylander, 1848       |
| Apidae       | Bombus mixtus Cresson, 1879             |
| Apidae       | Bombus sitkensis Nylander, 1848         |
| Halictidae   | Halictus rubicundus (Christ, 1791)      |
| Megachilidae | Megachile melanophaea Smith, 1853       |
| Megachilidae | Megachile relativa Cresson, 1878        |

Table 6: Bee species observed in 2022.

## Flies

Flies were by far the most speciose group collected by our sampling effort. In the single sample from 2011 we documented 61 species and 14 BINs representing 24 families (Table 7). In 2022 we found 99 species and



Figure 7: Top 16 most frequently observed identifications. BOLD:AAF9792: Empididae sp. BOLD:AAF9792. BOLD:AAG2875: *Ceratagallia* sp. BOLD:AAG2875 (Hemiptera: Cicadellidae). BOLD:AAG9634: *Dolichopus* sp. BOLD:AAG9634 (Diptera: Dolichopodidae). BOLD:AAM8925: *Lygus* sp. BOLD:AAM8925 (Hemiptera: Miridae).

60 BINs of flies in 32 families (Table 8). In both years the most diverse families observed were Muscidae and Anthomyiidae.

Table 7: Numbers of species and BINs of flies observed in the sample from 2011 by families.

| Family         | Species | BINs |
|----------------|---------|------|
| Anisopodidae   | 1       | 0    |
| Anthomyiidae   | 12      | 1    |
| Bibionidae     | 1       | 0    |
| Calliphoridae  | 2       | 0    |
| Chloropidae    | 0       | 1    |
| Empididae      | 1       | 2    |
| Fanniidae      | 1       | 0    |
| Lauxaniidae    | 1       | 0    |
| Limoniidae     | 1       | 1    |
| Lonchaeidae    | 0       | 2    |
| Muscidae       | 20      | 1    |
| Mycetophilidae | 0       | 1    |
| Phoridae       | 1       | 0    |
| Pipunculidae   | 2       | 0    |
| Psilidae       | 1       | 0    |
| Sarcophagidae  | 1       | 0    |
| Scathophagidae | 3       | 1    |
| Sciaridae      | 2       | 0    |
| Sciomyzidae    | 1       | 0    |

| Family        | Species | BINs |
|---------------|---------|------|
| Sepsidae      | 1       | 0    |
| Stratiomyidae | 1       | 0    |
| Syrphidae     | 6       | 3    |
| Therevidae    | 0       | 1    |
| Tipulidae     | 2       | 0    |

| Table 8: Numbers of species a | and BINs of flies | observed in t | the sample from | ι 2022 by familie | es. |
|-------------------------------|-------------------|---------------|-----------------|-------------------|-----|
|-------------------------------|-------------------|---------------|-----------------|-------------------|-----|

| Family          | Species | BINs |
|-----------------|---------|------|
| Agromyzidae     | 1       | 1    |
| Anthomyiidae    | 10      | 6    |
| Anthomyzidae    | 1       | 0    |
| Asilidae        | 1       | 0    |
| Bibionidae      | 1       | 0    |
| Calliphoridae   | 2       | 0    |
| Ceratopogonidae | 0       | 1    |
| Chironomidae    | 4       | 4    |
| Chloropidae     | 4       | 3    |
| Culicidae       | 1       | 1    |
| Dolichopodidae  | 6       | 5    |
| Empididae       | 2       | 2    |
| Ephydridae      | 2       | 0    |
| Fanniidae       | 2       | 2    |
| Heleomyzidae    | 2       | 1    |
| Hybotidae       | 2       | 4    |
| Lauxaniidae     | 1       | 0    |
| Muscidae        | 27      | 6    |
| Mycetophilidae  | 6       | 3    |
| Phoridae        | 8       | 8    |
| Pipunculidae    | 1       | 0    |
| Rhagionidae     | 0       | 1    |
| Sarcophagidae   | 2       | 1    |
| Scathophagidae  | 1       | 0    |
| Scatopsidae     | 1       | 0    |
| Sciaridae       | 2       | 3    |
| Sepsidae        | 1       | 0    |
| Simuliidae      | 1       | 4    |
| Sphaeroceridae  | 1       | 1    |
| Stratiomyidae   | 2       | 0    |
| Syrphidae       | 3       | 2    |
| Tachinidae      | 1       | 1    |

#### **Pollinator Associates**

*Apocephalus borealis*, a parasitoid of bees and vespine wasps (Tihelka et al. 2021) was both frequently observed in our samples from 2022 and abundant in terms of read counts. Adult *A. borealis* might have been collected, but it is more likely that these internal parasites were within their hosts at the time they were collected.

The fungus *Cladosporium allicinum* is common from environmental samples worldwide, collected from living and dead plants, air, water, and humans (Schubert et al. 2007, Bensch et al. 2012). We found no

literature records of *Cladosporium allicinum* taken from insects, but *Cladosporium* species can function as symbionts or pathogens of insects (Liu et al. 2022).

We detected *Wolbachia* (Rickettsiales: Anaplasmataceae) sequences in the 2011 sample and in 15 out of the 17 samples from 2022. *Wolbachia* bacteria infect many insect species and alter their hosts' reproductive systems (Werren 1997). *Wolbachia* can be present in high proportions of pollinator populations (Evison et al. 2012).

We also detected *Steinernema* (Rhabditida: Steinernematidae) in one sample<sup>21</sup>, a sample where most reads were of *Bombus* species. The *Steinernema* sequence was 97.34% identical to a sequence identified as *Steinernema kraussei* (Steiner, 1923) Travassos, 1927, a species known to be pathogenic to *Bombus terrestris* (Linnaeus, 1758) (Dutka et al. 2015).

#### **New Distribution Records**

*Ero canionis* Chamberlin & Ivie, 1935 (Araneae: Mimetidae); *Atomaria testacea* Stephens, 1830 (Coleoptera: Cryptophagidae); *Liriomyza baptisiae* (Frost, 1931) (Diptera: Agromyzidae); *Fannia neopolychaeta* Chillcott, 1961 (Diptera: Fanniidae); *Tachypeza fenestrata* (Say, 1823) (Diptera: Hybotidae); *Phaonia protuberans* Malloch, 1923 (Diptera: Muscidae); *Phaonia serva* (Meigen, 1826); *Megaselia hirticrus* (Schmitz, 1918) (Diptera: Phoridae); *Megaselia lucifrons* (Schmitz, 1918); *Agria housei* Shewell, 1971 (Diptera: Sarcophagidae); *Boettcheria litorosa* (Reinhard, 1947) (Diptera: Sarcophagidae); *Olethreutes bipunctana* (Fabricius, 1794) (Lepidoptera: Tortricidae); *Coleophora quadruplex* McDunnough, 1940 (Lepidoptera: Coleophoridae); *Peristenus howardi* Shaw, 1999 (Hymenoptera: Braconidae) and *Cubocephalus anatorius* (Gravenhorst, 1829) (Hymenoptera: Ichneumonidae) appear to be new records for Alaska. The the non-native species *Odontothrips loti* (Haliday, 1852) and *Uroleucon taraxaci* (Kaltenbach, 1843) also appear to be new for the state.

*Coleophora quadruplex* was known from multiple Canadian provinces (Pohl et al. 2018, GBIF.Org 2023e), but we found no previous records from Alaska. *Olethreutes bipunctana* had also been reported from Canada (Pohl et al. 2018, GBIF.Org 2023f), but apparently not from Alaska.

*Fannia neopolychaeta* had been known from as close to Alaska as British Columbia (Chillcott 1960) and Yukon Territory (GBIF.Org 2023a), but our record appears to be new for Alaska. *Eudasyphora canadiana* Cuny, 1980 had been reported from Alaska by Cuny (1980), but there were no georeferenced Aslakan records in GBIF. *Phaonia protuberans* was known from the Northwest Territories and Yukon Territory (Huckett 1965, GBIF.Org 2023b), but it had not been reported from Alaska. *Phaonia serva* (Meigen, 1826) occurs in the Northwest Territories (Huckett 1965), but ours appears to be the first record from Alaska. *Tachypeza fenestrata* appears to be a new record for Alaska, but this species is present nearby in Yukon Territory. *Aspistes spathis* had been reported from Alaska by Cook (1965), but we found no georeferenced Alaskan occurrences (GBIF.Org 2023d). We found no Alaska records of *Megaselia lucifrons*, but this species is known from Yukon Territory. *Agria housei* and *Boettcheria litorosa* appear to be new records for Alaska, but there are records of these species from Yukon Territory.

*Peristenus howardi* (Hymenoptera: Braconidae) had been reported from Idaho and Washington by Day et al. (1999) and it has since been found in Alberta (Zhang 2018, GBIF.Org 2023c), but this species had not been reported from Alaska.

#### **Non-native Species**

We documented occurrences of seven non-native species. The European honey bee, *Apis mellifera* Linnaeus, 1758, was detected in bee bowls set out at Headquarters lake wetland near Soldotna<sup>22</sup>. The thrips *Odon-tothrips loti* (Haliday, 1852) (Thysanoptera: Thripidae) was detected in bee bowls deployed in a meadow off of Skilak Lake Road<sup>23</sup>. We found *Uroleucon taraxaci* in a disturbed clearing off of Ski Hill Road<sup>24</sup>. *Pol-*

<sup>&</sup>lt;sup>21</sup>https://www.gbif.org/dataset/86875091-d166-4986-802a-343b341424c6/event/12127687

<sup>&</sup>lt;sup>22</sup>https://www.gbif.org/occurrence/4093719140

<sup>&</sup>lt;sup>23</sup>https://www.gbif.org/occurrence/4093715897

<sup>&</sup>lt;sup>24</sup>https://www.gbif.org/occurrence/4093719079

*lenia vagabunda* (Meigen, 1826) (Diptera: Polleniidae) was collected in bee bowls at Kenai National Wildlife Refuge headquarters in Soldotna<sup>25</sup>, where this species had been found previously by Bowser (2015). We detected the earthworm *Dendrobaena octaedra* (Savigny, 1826) (Crassiclitellata: Lumbricidae) in bee bowls set at Picnic Lake<sup>26</sup>. Sequences we obtained of the slug *Deroceras agreste* (Linnaeus, 1758) (Stylommatophora: Agriolimacidae) from bee bowls set at multiple locations<sup>27</sup> were 99.35–99.68% identical to sequences identified by Zając and Stec (2020) as *Deroceras agreste*. We found the slug *Arion fuscus* (O.F.Müller, 1774) (Stylommatophora: Arionidae) off of the Vista Trail<sup>28</sup>.

*Pollenia vagabunda* had been found at the Kenai National Wildlife Refuge headquarters area previously (Bowser 2015). *Uroleucon taraxaci* (Kaltenbach, 1843) is believed to be introduced in North America (Foottit et al. 2006) and has been recorded from as close to Alaska as Yukon Territory (Maw et al. 2000). We detected this aphid in in bee bowls set in the back lawn of KNWR headquarters, where its host, *Taraxacum officinale* Weber ex Wiggins, is abundant. The epigeic earthworm *Dendrobaena octaedra* is almost ubiquitous near roads on KNWR (Saltmarsh et al. 2016) and this worm does climb (Römbke et al. 2017), so its presence in a bee bowl was not surprising. *Deroceras agreste* had previously been found in the Ski Hill Road area by Bowser et al. (2020); its occurrence at Picnic Lake in the Mystery Creek area was new. Our finding of *Arion fuscus* was the first record of an arionid slug on KNWR. *Arion fuscus* had previously been identified in Alaska from Sitka (Schade 2018).

#### **Intersting Non-insect Records**

We detected two vertebrate species: a single record of Willow Ptarmigan (*Lagopus lagopus* (Linnaeus, 1758)) at an alpine meadow above Twin Lakes<sup>29</sup> and three records of northern red-backed voles (*Myodes rutilus* (Pallas, 1779)) in the vicinity of the Kenai National Wildlife Refuge's headquarters in Soldotna<sup>30</sup>. At Twin Lakes we had seen and heard a family of Willow Ptarmigan within about 100 m of the area where we had sampled pollinators using aerial nets. In the sample from which the Willow Ptarmigan DNA was detected, no biting flies were detected, so the ptarmagin record was not from a blood meal of a fly. There might have been ptarmigan DNA in or on muscid or phorid flies in the sample. There were also no biting flies detected in any of the three bee bowl samples where vole DNA was found. Voles may have tasted the propylene glycol or otherwise explored the bee bowls.

#### **Identification Notes**

Some of our reads were 100% similar to sequences both identified as *Spilogona alticola* (Malloch, 1920) (Diptera: Muscidae) and *Spilogona contractifrons* (Zetterstedt, 1837) in BOLD BIN BOLD:AAB5278<sup>31</sup>. Huckett (1965) expressed his doubt that these two species were distinct. We assigned these to *Spilogona contractifrons* as we have done in previous work (Bowser et al. 2020). Other reads were 100% similar to sequences of *Spilogona* sp. 12AKR *sensu* Renaud (2012), which had also been documented locally by Bowser et al. (2020).

#### Conclusions

Complementing morphological identifications by metabarcoding enabled us to efficiently identify many more non-bee species than we would have been able to process and identify in a timely way and it also

https://www.gbif.org/occurrence/4093716136,

https://www.gbif.org/

<sup>&</sup>lt;sup>25</sup>https://www.gbif.org/occurrence/4093716650

<sup>&</sup>lt;sup>26</sup>https://www.gbif.org/occurrence/4093717859

<sup>&</sup>lt;sup>27</sup>https://www.gbif.org/occurrence/4093716677,

occurrence/4093717282

<sup>&</sup>lt;sup>28</sup>https://www.gbif.org/occurrence/4093715392

<sup>&</sup>lt;sup>29</sup>https://www.gbif.org/occurrence/4093716617

https://www.gbif.org/occurrence/4093718205, https://www.gbif.org/

<sup>&</sup>lt;sup>30</sup>https://www.gbif.org/occurrence/4093718979, occurrence/4093716762

<sup>&</sup>lt;sup>31</sup>https://doi.org/10.5883/BOLD:AAB5278

provided detections of some bee parasites. We believe that using multiple methods is an expedient way to improve our understanding of insect pollinators in Alaska.

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48

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# Defoliation of haskap shoots by the honeysuckle moth in Southcentral Alaska

# by Alexandria Wenninger<sup>32</sup>

The honeysuckle moth (*Ypsolopha dentella* (Fabricius, 1775)) has been identified as a defoliator of developing shoots on haskap (aka 'honeyberry' or 'blue honeysuckle', *Lonicera caerulea* Linnaeus) in Southcentral Alaska. Haskap is a cold-hardy ornamental shrub that is grown for its edible berries in Alaska, however little information is available regarding insect pests of haskap in North America. Several instances of shoot defoliation on haskaps and ornamental honeysuckles were reported from Anchorage and the Matanuska-Susitna Valley in late May and early June of 2022 leading to an investigation into the identity and life history of this non-native defoliator (Figure 1).



Figure 1: Left and Middle: Late instar larvae blending in with stems on ornamental Tatarian honeysuckle. Photographed 8 June 2022 in Anchorage, AK by A. Wenninger. Right: Late instar larva on a haskap shoot, note the two-toned color pattern of the reddish stripe up the green haskap stem. Photographed 14 June 2022 by A. Wenninger.

# Honeysuckle Moth Life History

Honeysuckle moth caterpillars were found feeding on host plants late May through mid-June in both Anchorage and the Matanuska-Susitna Valley. Early instar caterpillars feed within developing leaf shoots, producing silk which keeps the developing leaves loosely clasped together into a retreat, protecting the feeding caterpillars (Figure 2). The early instar caterpillars are pale yellowish in color with green lon-gitudinal stripes down the dorsum and many long, dark setae speckling their abdomens. Later instar caterpillars develop a wide, reddish stripe down the dorsum, which appears to mimic the two-toned coloration of haskap and ornamental honeysuckle stems (Figure 1). The caterpillars display notable quick and erratic "wiggling" movements when disturbed, and upon reaching the edge of the leaf may leap from the host plant by a silken thread affixed to their retreat in a process other authors have named "bungee-jumping" (Eisner et al. 2005); soon after making the leap they return to the retreat by pulling themselves up by their mouthparts, folding the silken thread as they go. Pupation occurs within a spindle-shaped

<sup>&</sup>lt;sup>32</sup>University of Alaska Fairbanks Cooperative Extension Service Integrated Pest Management Program, akwenninger@alaska.edu

silken covering on or near the host plant. Adults at rest are ~12 mm long and appear reddish brown laterally with a pale dorsal band that makes a ventral turn posteriorly; when viewed laterally the posterior end appears upturned ("apically falcate") and the face features a brush of setae projected forward (Figure 3). Adults have been observed in Anchorage from early July through August (University of Alaska Museum records accessed 6 June 2022 via Arctos and iNaturalist records accessed 15 July 2022). Information about the overwintering of this species is scarce, but it is thought that eggs are laid on the host plant in late summer and the species overwinters as an egg (Wall 2005, Montgomeryshire Moth Group 2009).



Figure 2: Early instar larvae feeding within a silk-tied haskap shoot; the outer leaves have been removed to reveal the larvae within. Photographed 23 May 2022 by A. Wenninger.



Figure 3: Adult honeysuckle moth. Reared from a caterpillar, photographed 23 June 2022 by A. Wenninger.

# Hosts

The honeysuckle moth is known to feed on members of the honeysuckle genus (*Lonicera* spp.). This defoliator is of particular interest due to its impact on haskap (*Lonicera caerulea*), a cold-hardy ornamental shrub grown in Alaska for its early-ripening edible berries. Wild-types of *L. caerulea* are circumpolar in distribution, native to forests of Asia, Europe, and North America<sup>33</sup>, however, Alaska is not within the native range of this species. The University of Saskatchewan (Saskatchewan, Canada) began a haskap breeding

<sup>&</sup>lt;sup>33</sup>The taxonomic status of *L. caerulea* is still under debate. Some taxonomists have proposed splitting the North American species apart from *L. caerulea* and into two distinct species—*L. villosa* in central/eastern North America and *L. cauriana* in western North America (Fernald 1925). However, genetic and morphological study is yet to produce a widely-accepted global taxonomy (Peterson et al. 2018, Hayes and Peterson 2020)

program in 2000, creating cultivars of haskap with improved taste and berry size, and is now home to a diverse collection of haskap cultivars including 35 Russian cultivars, over 70 Japanese types, and wild collections from Canada, in addition to thousands of seedlings planted from controlled crosses among their collection (Bors 2008). Despite the extensive study of haskap through the University of Saskatchewan Fruit Program and production of haskap by the Haskap Canada Association, this plant is largely considered to have few pests in Canada, with reported pests including birds and powdery mildew without mention of defoliating caterpillars (Bors 2008, Haskap Canada Association 2018). Ferris (2017) mentions leafrollers with a vigorous wiggle found in production haskaps in Yukon, Canada, however, no identification or photo is given to determine whether this may be the honeysuckle moth. Honeysuckle moth larvae were also collected from ornamental Tatarian honeysuckles (*Lonicera tatarica* Linnaeus) in Anchorage in 2022.

Alaska does have a native honeysuckle, the twin honeysuckle (*Lonicera involucrata* (Richardson) Banks ex Spreng.), which could potentially serve as host to the honeysuckle moth if the moth were to spread outside Southcentral Alaska. This native honeysuckle occurs in parts of Southeast Alaska but is not naturally occurring in Anchorage nor the Matanuska-Susitna Valley where the honeysuckle moth has been found (Bressette 2017).

#### **Records & Distribution**

The early records of the honeysuckle moth indicate this species was introduced to North America from Europe in the early 1900s. The earliest records I can find of this species in North America are reported by William T. M. Forbes under the name *Cerostoma xylostella*<sup>34</sup> Linnaeus (subgenus *Harpipteryx*) which he calls the "honeysuckle leaf-roller"; his reports include adults collected by Frank Haimbach in July 1910 flying near honeysuckle in Massachusetts (Forbes 1923, Johnson 1927) and adults collected in 1924 by Forbes himself in Ithaca, New York, from a trap light (Forbes 1924). Forbes (1924) refers to this species as a minor pest from Europe. Charles W. Johnson (1927) was interested in the dispersal of this newly introduced species; he reports this species under the name *Harpipteryx xylostella* L. as identified by lepidopterist August Busck and finds additional records of this species from 1919 in both Rhode Island and New Hampshire. Busck describes the honeysuckle moth as "a European species introduced within recent years" (Johnson 1927). Busck had previously published descriptions and keys to the North American *Cerostoma*-group yponomeutids in 1903, in which *H. xylostella* is mentioned as a European member of the genus but was not known to occur in North America at that time (Busck 1903). Additional names synonymous with this species include *Alucita dentella* Fabricius, *Tinea harpella* Dennis & Schiffermuller, and *Cerostoma affinitella* Staudinger.

There are two records of the honeysuckle moth in the University of Alaska Museum of the North Arctos database prior to 2022: an adult observed 10 July 1989 (UAMObs:Ento:97862) and an observation of unspecified life stage from 20 July 1992 (UAMObs:Ento:35257), both from Anchorage and both listing *"Lonicera* sp." as the habitat.

In 2022, caterpillars of the honeysuckle moth were reported late May through mid-June in Southcentral Alaska. The majority of reports indicated haskap (*L. caerulea*) as host; less commonly host was indicated to be ornamental Tatarian honeysuckle (*L. tatarica*). Joey Slowik (University of Alaska Fairbanks, Cooperative Extension Service, Integrated Pest Management Technician) and I verified six reports of the honeysuckle moth in Anchorage and three reports in the Matanuska-Susitna Valley (all near Palmer, AK) (Figure 4).

<sup>&</sup>lt;sup>34</sup>A note of caution when searching the earlier literature, there is a bit of taxonomic confusion involving the name *Cerostoma xylostella* (L.) as this name is also considered a synonym of the diamondback moth, *Plutella xylostella* (L.) (Alford 1971, Lim 1982). The host plants help to clarify which species a reference pertains to, as *P. xylostella* larvae feed on plants in the family Brassicaceae whereas Forbes' "honeysuckle leaf-roller" caterpillars were collected from *Lonicera* (Family Caprifoliaceae) (Forbes 1923). Forbes published several articles using the name *Cerostoma xylostella* to refer to the honeysuckle moth, however know that he uses the name *Plutella maculipennis* Curtis when referring to the diamondback moth (Forbes 1923). An interesting tidbit about the name is that in 1858, Van Voorst (1858) published a species list of British moths in which he includes name derivations for each species. He attributes the name *Cerostoma xylostella* to refer to the honeysuckle moth, interpreting "*xylostella*" to mean "feeds on honeysuckle" derived from the plant *Lonicera xylostelua*. It is thought that Linnaeus himself got the two species confused at some point in their descriptions (Harcourt 1963) but due to naming priority "*xylostella*" is currently considered to be the valid species name for the diamondback moth (Lim 1982).



Figure 4: Locations of verified honeysuckle moth reports received in 2022 from Anchorage, AK (left) and Matanuska-Susitna Valley, AK (right). Maps generated using ArcGIS Online, basemap 'Imagery' by Earthstar Geographics.

# **Rearing Methods**

I use the general methods outlined by Eiseman (2016) for rearing caterpillars. For this species I used 5 dram plastic vials with 1 sheet of toilet paper crumpled and pressed into the bottom of the vial and moistened with a couple drops of water (Figure 5). Each larva is placed singly in a prepared vial with a sprig of host material. Once the host material is exhausted, or once frass begins to accumulate, I move the larva to fresh host material in a clean, newly prepared vial to prevent mold. Once the larva pupates I move the pupa to clean vial with moistened toilet paper only, no host material. (To prevent data loss through the vial changing process I find it easiest to put the collection data on the lid, keeping the same lid with the specimen through each vial change.) Vials are kept at ambient room temperature, about 70 °F. I wild-collected several late-instar caterpillars on 8 June 2022 and reared them in this manner, the adults of which emerged 20–28 June 2022.



Figure 5: Container setup used for rearing the honeysuckle moth. The vial on the left contains a pupa, the middle and right vials each contain a single larva with a sprig of host material (*Lonicera tatarica*). Photographed 9 June 2022 by A. Wenninger.

## Reporting

Based on the timing we have seen in 2022, host plants should be monitored from late May through mid-June for feeding activity by caterpillars of the honeysuckle moth. Observations of the honeysuckle moth can be submitted via the UAF CES monitoring portal at https://alaskapestreporter.org.

#### Acknowledgements

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# The beehive honey moth as a pest of stored honey bee comb in Alaska

by Alexandria Wenninger<sup>35</sup>



Figure 1: Larvae, webbing, and frass on stored honey bee comb photographed by beekeeper Tim Huffman. Anchorage, AK, April 2021.

# Background

The beehive honey moth, *Vitula serratilineella* Ragonot, 1887, has been found to be a pest of stored comb of managed honey bees (*Apis mellifera* Linnaeus, 1758) in Alaska. In spring of 2021, an Anchorage beekeeper reached out regarding suspected wax moth activity in stored frames of drawn honeycomb. Lepidopteran larvae were found tunneling through masses of silk webbing and frass built on top of the comb (Figure 1). There are two well-known species of wax moths that infest domestic bee hives in North America: the greater wax moth *Galleria mellonella* (Linnaeus, 1758) and the lesser wax moth *Achroia grisella* (Fabricius, 1794), neither of which are known from Alaska. Wax moths are destructive pests of stored comb, however, they are not known for being particularly cold-hardy which makes most regions of Alaska unsuitable for their establishment; temperatures below 20 °F kill all life stages within a few hours (Gulati and Kaushik 2004). Interestingly, several beekeepers have found similar damage on stored comb in both Anchorage and Fairbanks, Alaska, both areas that regularly see winter temperatures well below 20 °F for extended periods of time, leading to suspicion that the apiculture pest seen by Alaska beekeepers was neither of the well-known wax moth species. Upon rearing and examination, the specimens collected by the Anchorage beekeeper in 2021 were identified as a common but lesser-known native pest of bee nests, the beehive honey moth, *Vitula serratilineella*<sup>36</sup>.

# Beehive honey moth, Vitula serratilineella

The beehive honey moth is native to Western North America where it is known to feed on pollen, honey, and/or larval remains in nests of bumble bees (*Bombus* spp.), leafcutter bees (*Megachile* spp.), domestic

56

<sup>&</sup>lt;sup>35</sup>University of Alaska Fairbanks Cooperative Extension Service Integrated Pest Management Program, akwenninger@alaska.edu
<sup>36</sup>Rearing and morphological identification were done by A. Wenninger. Molecular identification was conducted by Jozef Slowik,

IPM Technician, University of Alaska Fairbanks Cooperative Extension Service, following the methods of Hebert et al. (2003)

honey bees (*Apis mellifera*), and occasionally in association with nests of other Hymenoptera such as yellowjackets (subfamily Vespinae) (Spencer 1960, Williams 1978, Winston et al. 1981, Neunzig 1990). The beehive honey moth is also a minor pest of dried fruit, including apples, prunes, raisins, etc., and is referred to as the 'driedfruit moth' in some literature (Neunzig 1990).

*Vitula serratilineella* was first described in 1887 but the species description did not include any information about ecology or known feeding habits (Ragonot 1887). In 1920, a beekeeper from British Columbia discovered larvae feeding on honey in stored frames that were only partially capped before harvest; after rearing the larvae the beekeeper was able to identify the pest as *V. serratilineella* which he referred to as "a honey-feeding larva" (Cockle 1920). The beehive honey moth is recognized as a substantial pest of honeycomb in British Columbia (Winston et al. 1981, Government of British Columbia 2020), however this moth seems to be somewhat of a forgotten beekeeping pest in recent American literature, despite being regarded during the 1960's and 70's as a common and economically important pest of beekeeping in the Western United States (Okumura 1966, Williams 1978). While the greater wax moth (*G. mellonella*) is considered to be the most important lepidopteran pest of stored honey bee comb globally (Williams 1978), its inability to tolerate prolonged subfreezing temperatures precludes it from being a significant pest for Southcentral and Interior Alaska beekeepers. The beehive honey moth is likely to be the most significant lepidopteran pest of stored comb in Alaska.

# Identification

The larvae of the beehive honey moth (subfamily Phycitinae) (Figure 2) can be distinguished from the larvae of both the greater and lesser wax moths (subfamily Galleriinae) by the presence of a sclerotized ring surrounding the seta above the spiracle (SD1) on the second thoracic segment (T2) (Byrne and Moyle 2019). See Weisman (1991) for distinguishing among lepidopteran larvae as pests of stored products.



Figure 2: A close-up of a larva collected from stored comb, 22 April 2022.

The adult beehive honey moth forewings are greyish brown in color with distinct dentate transverse lines (Figure 3) (Ferguson 1991). The adult is ~1.3 cm in length. Vitula edmandsii is similar in appearance but is native to Eastern North America and has brown hindwings as opposed to the white hindwings of V. serratilineella. See Neunzig (1990) for distinguishing among genera of Phycitinae; see Ferguson (1991) for distinguishing among adult moths found as stored product pests.

The Mediterranean flour moth (*Ephestia kuehniella* Zeller, 1879) also looks similar to the beehive honey moth and there is one record of this species collected from beehive components in Alaska (December 2009, Arctos record UAMObs:Ento:113244). The Mediterranean flour moth is a cosmopolitan pest of cereal products that is known to occasionally infest stored comb containing pollen however it is unable to develop on brood comb or dead insects and is not considered to be a serious pest of beehives (Williams 1978). The keys provided by Weisman (1991) and Ferguson (1991) can be used to distinguish between larvae and adults (respectively) of the Mediterranean flour moth and the beehive honey moth, as well as several other lepidopteran pests of various stored products. (Note that the aforementioned keys reference the

Mediterranean meal moth using the synonym *Anagasta kuehniella* and the beehive honey moth using the synonym *Vitula edmandsii serratilineella*.) Okumura (1966) also provides an abbreviated key specifically to distinguish between larvae of these two species.



Figure 3: An adult beehive honey moth, reared from a larva infesting stored comb (larva collected 22 April 2022, adult emerged 12 May 2021).

## **Integrated Pest Management**

In apiculture, the beehive honey moth is primarily a pest of unoccupied combs, often in boxes of stored comb or in hives where the bees have perished (Okumura 1966). Comb that was only used for honey storage, not brood rearing, may be less attractive to lepidopteran pests of beehives due to the absence of stored pollen and larval debris in the cells (Hood 2010). This idea is supported by a study by Richards (1984) which found that *V. serratilineella* larvae raised on diets containing pollen from leafcutter bee nests had significantly higher survival rates than larvae raised on diets of only honey. Beekeepers may consider placing a queen-excluder in between the upper brood box and lower honey super of the hive to prevent bees from using the honey supers to rear brood.

Strong honey bee hives typically will not tolerate the beehive honey moth but be sure to only give a colony as much space as it can defend; adding too many supers too quickly can make it difficult for the bees to adequately defend the hive (Hood 2010). In weak colonies, the beehive honey moth larvae feed upon hive resources and can damage developing bee brood through their feeding activities (Winston et al. 1981). Weak colonies should be reduced down to an appropriate, defensible space for their size to prevent infestation by the beehive honey moth.

Lightly damaged comb can be gently brushed free of debris and will be cleaned, repaired, and reused by the bees. Heavily damaged comb on foundation can be scraped off and returned to the bees to be rebuilt, though it should be noted that the beehive honey moth typically does not cause substantial damage to the structure of the comb.

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