



**RESULTS OF THE 2009 ALIEN SPECIES  
AND WĒKIU BUG (NYSIUS WEKIUICOLA)  
SURVEYS ON THE SUMMIT OF  
MAUNA KEA, HAWAI'I ISLAND**

**Hawaii  
Biological  
Survey**

**Final Report**

**July 2010**

**RESULTS OF THE 2009 ALIEN SPECIES AND WĒKIU BUG (*NYSIUS WEKIUCOLA*) SURVEYS ON  
THE SUMMIT OF MAUNA KEA, HAWAI'I ISLAND**

**FINAL REPORT**

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## **EXECUTIVE SUMMARY**

As part of a continuing long-term study, the Hawaii Biological Survey of the Bishop Museum was contracted by the Office of Mauna Kea Management (OMKM) to monitor for alien arthropod species and to continue monitoring populations of the wēkiu bug (*Nysius wekiuicola* Ashlock and Gagné), which is endemic to the Mauna Kea summit area of Hawai'i Island. A nine-day field trip was conducted in July 2009 to continue the monitoring of introduced arthropod species found at the Mauna Kea summit, and to continue monitoring wēkiu bug populations within critical core habitats. The objective of the alien arthropod baseline and monitoring surveys was to provide information to managers on any potential threats to endemic Mauna Kea arthropod species such as the wēkiu bug. Intensive surveys for ants were conducted to assess if any populations are currently found within any areas in close proximity to wēkiu bugs. Ants are already well-established at the summit regions of Haleakalā National Park on Maui, and this elevational range is well-within that of lowest elevation that wēkiu bugs have been found. Because of the predatory and social nature of ants, and because ants have caused the extinction and decline of native arthropods throughout Hawai'i, it was imperative to search high risk areas around the Mauna Kea summit region.

During the course of the 2009 field study we collected 118 wēkiu bugs at different cinder cones throughout the Mauna Kea summit region, and also set out 89 traps for alien species monitoring. In 2009, No new resident alien species were found during intensive alien arthropod species monitoring around the summit region, and species of particular concern such as ants were not found from Hale Pohaku (2,755 m) to the highest point in the Hawaiian Islands of Pu'u Wēkiu (4,205 m). Aeolian arthropod drift capture density and species diversity in the arthropod traps set out around the summit was quite high in 2009, likely a result of moist conditions in the lower elevation regions of Mauna Kea during the preceding winter.

## **INTRODUCTION**

As part of a continuing long-term study, the Hawaii Biological Survey of the Bishop Museum was contracted for the 2009 field season by the Office of Mauna Kea Management (OMKM) to assess and document alien arthropod species found at the Mauna Kea summit area. The purpose of these field studies was to establish a baseline for possible alien arthropod species currently inhabiting the Mauna Kea summit area having the potential to negatively affect wēkiu bugs (*Nysius wekiuicola* Ashlock and Gagné) or other native arthropod species. Additionally, to provide long-term capture data in areas of known critical wēkiu bug habitat, wēkiu bug population monitoring also occurred during the 2009 field season at the Mauna Kea summit area.

This study continues Bishop Museum's wēkiu bug research that originated in the early 1980s (Howarth and Stone 1982), and resumed again in the late 1990s to the present (Howarth *et al.* 1999, Englund *et al.* 2002, 2005, 2007, 2009, Porter and Englund 2006). OMKM was interested in obtaining baseline data for alien arthropod species having the potential to threaten wēkiu bugs and other native arthropods. The objectives for the 2009 field seasons were to 1) conduct surveys for alien arthropod species in areas of known wēkiu bug core habitat at the Mauna Kea summit area, and adjacent but less favored habitats, 2) assess alien arthropod species composition at the summit areas on Mauna Kea with high tourist and worker activities, including observatory areas, the Hale Pohaku visitor center, and roadways, 3) conduct a baseline survey for alien arthropod species in areas around the proposed Thirty Meter Telescope (TMT), and the batch plant staging area that will be used if the TMT is built, and 4) monitor wēkiu bug populations in selected known high quality habitats to provide comparisons to previous Bishop Museum surveys.

## **STUDY AREA**

The overall study area for the 2009 field season has been thoroughly described in previous Bishop Museum reports and this can be found in Howarth *et al.* (1982), Howarth *et al.* (1999), Englund *et al.* (2002, 2005, 2007, 2009) and Porter and Englund (2006), and was similar to the 2007-2008 study area (Englund *et al.* 2009). The study area started at the Hale Pohaku visitor center and staff quarters at 2,850 m (9,300 ft) elevation, and encompassed portions of the alpine zone of the Mauna Kea volcano (Figure 1), including both the Mauna Kea Science Reserve (MKSR) and the Mauna Kea Ice Age Natural Area Reserve (NAR). For the purposes of this study, we defined cinder cones as non-vegetated, dormant volcanic cones in the alpine zone above 2,925 m, (9,600 ft). Elevations sampled for alien arthropods during 2007–2008 fieldwork ranged from a maximum of 4,205 m (13,796 ft) at the summit of Pu'u Wēkiu to a low of 2,850 m (9,300 ft) around Hale Pohaku. Visual observations were also made throughout the study area while hiking between sampling points. Tables 1–4 contain GPS coordinates, elevations, and date traps were set for all sample points within the study area. Because the present study was for both wēkiu bugs and alien arthropod species, all species (except wēkiu bugs) collected in traps during these studies were kept for further analysis. This is also why some of the sample locations are

duplicated for the alien species and wēkiu bug data tables (i.e., Tables 1 and 2). Sample locations were duplicated in Tables 1-4 when non-wēkiu bug taxa were collected in wēkiu bug pitfall traps.

Unless otherwise stated, pu'u names were derived from USGS topographic quad maps. WGS 84 datum was used for recording GPS locations. Many pu'u have not yet been given official names, and when possible these cinder cones are identified by their altitude as stated on USGS topo maps. However, when no altitudes are given names of nearby landmarks or distinctive features were used. These names should not be viewed as official, but rather allow us to more easily identify specific areas of the vast summit region of Mauna Kea. Altitudes were determined using a combination of USGS 7.5 minute topographic quad maps, a handheld altimeter, and a barometric altimeter on the GPS unit, calibrated daily at Hale Pohaku and at the elevation markers on the road up to the observatories.

## **METHODS**

### Alien Arthropod Species

The objectives for the 2009 fieldwork emphasized documenting alien species found within the Mauna Kea summit area. An analysis of all arthropod species collected during the 2009 field trip was conducted for this report. Species were identified to the lowest possible taxonomic unit possible, which was dependent upon expertise available for each taxonomic group.

The main purpose of fieldwork of the present study was to establish the continuing baseline for alien species and identify species on Mauna Kea having a potential to negatively affect wēkiu bugs and other native arthropods. In this regard we sampled a broad range of habitats at the summit, focusing on various pathways whereby alien arthropods might first become introduced. We also sampled a wide variety of undisturbed habitat types where wēkiu bugs are historically known to have high concentrations, and nearby disturbed habitats that are associated with past or present human activities.

A broad array of traps together with general collecting were used to collect alien arthropod species. Yellow pan traps and yellow sticky traps were used to collect flying insect species while glycol pitfall traps were used to collect non-flying arthropods. Yellow pan traps were ballasted with rocks to ensure they did not blow away in the windy summit area, and a small amount of ethylene glycol (antifreeze) was added to the water in each pan trap to prevent the water from freezing, reduce evaporation during the daytime, and act as a preservative. Yellow sticky traps were tied to large rocks that allowed both ground dwelling and flying arthropods access to these traps. Glycol pitfall traps were constructed similar to previous years wēkiu bug traps (Englund *et al.* 2002), baited with shrimp paste around the caprock, and filled with a mixture of water and glycol. Glycol pitfall traps were not placed in habitats likely to contain wēkiu bugs.



Because alien ant species are believed to rank as one of the highest threats to wēkiu bugs and other native arthropods, particular effort was focused on determining the presence or absence of ant species within the Mauna Kea summit area. We heavily sampled for ants at visitor center picnic and garbage can areas, around Hale Pohaku staff areas, the summit lunch room building, and around several of the larger telescope facilities such as the Gemini and Keck observatories. Ant traps consisted of wooden tongue depressor sticks dipped in generous amounts of peanut butter. All ant bait peanut butter traps were checked at regular intervals of 2-3 days during the duration of the fieldwork. Numerous baited (with shrimp paste) glycol pitfall traps throughout the study area also served as potential ant traps.

In summary, alien arthropod trapping at each collection locality consisted of four different trap types: 1) peanut butter sticks for ants, 2) yellow sticky traps, 3) yellow pan traps, and 4) one ethylene glycol pitfall trap. These four different traps were all placed within about 4-5 m of each other, and a gps point was taken for that locality. These four traps in proximity ran for at least 3 days, and if needed were checked on a more regular basis to ensure liquid levels were adequate to continue capture arthropods. Table 1 in Appendix B contains the collection localities (including gps points) for the 2009 alien arthropod trapping.

#### Wēkiu Bug Sampling

In 2009, glycol pitfall traps were not used in areas known or suspected to contain wēkiu bugs. During the 2009 fieldwork, wēkiu bug sampling consisted of using baited shrimp pitfall traps (which generally do not harm the insects) in areas of previously known wēkiu bug populations. Limited visual surveys for wēkiu bugs were also conducted, but this met with limited success because there was little snowpack (with the exception of one small patch at Pu‘u Pohaku) during the 2009 field season, which tends to concentrate the bugs along the edges of the snow. A detailed explanation of techniques used for shrimp pitfall traps in this study can be found in Englund *et al.* (2002). Individual wēkiu bug pitfall trap locations were recorded with GPS (WGS 84 datum), as were locations where wēkiu bugs were visually observed while hiking. Locations, elevations, cinder cone area, and length of time sampled can be found in Appendix B, Table 2 for the 2009 sampling.

## **RESULTS AND DISCUSSION**

The winter of 2008–2009 had large amounts of snowfall, with some snowfall events exceeding 0.6 m (<http://www.hawaii247.com/2008/12/12/mauna-kea-summit-road-remains-closed/>), and some snow patches remaining until mid-July 2009 at Pu‘u Pohaku. The abundant moisture during the 2008–2009 winter led to high densities of aeolian drift being collected from the various traps used during the study.

The study period at the Mauna Kea summit for alien arthropod and wēkiu bug sampling ran from July 1–10, 2009. Tables 2 and 3 (Appendix B) summarize trap locations by cinder cone, elevation, date set, trap type, and GPS coordinates. Overall the 2009 wēkiu bug sample effort consisted of 45 pitfall traps and 89 alien arthropod

species traps. Sample effort for wēkiu bugs was defined by total trap days, which are the number of nights each baited shrimp pitfall trap was operating. Shrimp pitfall trap effort for wēkiu bugs during the 2009 field season was 285 trap days. All non-native arthropods collected in wēkiu bug pitfall traps were considered bycatch and also included in our species analysis.

### **Wēkiu Bug Trap Placements in Study Area**

A total of 45 shrimp pitfall traps, were set in various cinder cone areas at selected elevations during the 2009 fieldwork season (Figure 1, Table 2). Sampled areas from 2009 included the main summit region, with permanent monitoring stations at Pu‘u Hau Kea, Pu‘u Wēkiu, Pu‘u Hau Oki, and the Pu‘u’s north and south of the VLBA, and Poi Bowl (Figures 1–3). No wēkiu bugs were collected in any alien arthropod traps during the 2009 field season.

### **Wēkiu Bug Collections**

A total 118 wēkiu bugs were collected in early July 2009 during a total of 285 trap days, for an average catch of 0.4 wēkiu bugs/trap day (Table 4). Sampling occurred slightly later in July during the summer of 2008, when only 70 bugs were captured during an effort of 120 trap days. Pu‘u Hau Kea has been intensively sampled nearly every year since 2001 because of its unaltered habitat and often times high wēkiu bug captures. Wēkiu bug collection data from the Pu‘u Hau Kea monitoring station in 2009 is summarized in Table 5.

### **Alien Arthropod Species Surveys**

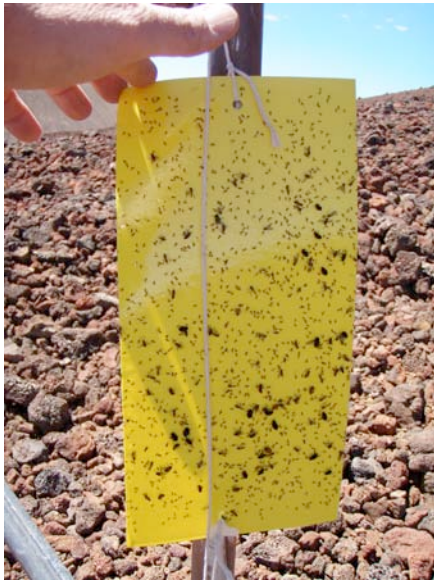
A wide range of native and non-native arthropod species were collected during the 2009 field seasons, and a list of these species and sampling sites they were collected from is found in Tables 1 and 6, and in the text after each sample site. Although many of the same taxa were found repeatedly at a large number of sample sites, we have also listed taxa found by collection area, as shown in the next section of the report.

Many of the arthropod species collected were classified as aeolian (taxa that were carried with the wind or flew up from lower elevations). Because night-time temperatures go below freezing throughout most of the year, virtually all of the aeolian species have a short life span at the summit and are not considered residents. Resident species are either native species adapted to the harsh life conditions at the summit, or are non-native species from temperate regions that are able to withstand the daily freeze–thaw cycle and live and reproduce within the summit region. In general there should be less concern about aeolian, non-resident arthropod species that get blown up to the summit because they soon die and become a potential food source for wēkiu bugs.

For the alien arthropod species, the majority of the aeolian drift was represented by the species that were the stronger fliers, for example muscid and calliphorid flies, and lady beetles (*Hippodamia convergens* and *Coccinella septempunctata*). Although this was a presence/absence survey for alien arthropods and not a

quantitative drift study, it was obvious from looking at the snowpack drift and our trap results that Diptera (primarily calliphorids and muscids) and lady beetles constituted the primary biomass of aeolian drift. Diet preference studies for wēkiu bugs have not yet been published, but field observations from prior studies indicated that wēkiu bugs were commonly observed adjacent to snowpacks feeding primarily on freshly thawed Diptera.

Hymenoptera were represented mostly by weaker flying taxa, with the exception of *Apanteles* spp. (a parasitoid) that were consistently present in large numbers at the summit and common at all sites. The high numbers of *Apanteles* spp. may be due to a large population of lepidopterous larvae associated with extensive pasturelands adjacent to the summit region that provides them with the caterpillars they typically parasitize. The European earwig (*Forficula forficularia*) was found in high numbers only around the Onizuka Visitor Center at Hale Pohaku, and is a pest and predatory, but has not become established above the visitor center. Psyllids were also extremely abundant (100 or more in most samples) in all areas up to the summit, but are aeolian drift from lower elevations. In a qualitative sense, aeolian drift species composition around the higher summit areas appears to be fairly consistent since the late 1990s, and especially high during the current 2009 fieldwork.



High densities of aeolian drift collected in alien traps at the Pu'u Pohaku summit during the 2009 fieldwork.

**Summary of Alien Arthropod Species Collected in 2009**

The following is a summary of arthropods collected in discrete sampling areas during the 2009 field season, including a brief description of sample location along with any arthropod by-catch found during wēkiu bug collections. Detailed gps locations and additional information for these sampling sites can be found in Tables 1-4 in the appendices section. Aeolian species found during these surveys are likely not a major threat to native species at this time, and it is likely that resident alien arthropod species have greater potential impacts.

To allow more information to be displayed, we have abbreviated standard entomological terms in the tables. Often it was difficult to determine the status of a particular species, that is why many have question marks next to their habitat and their end/adv (native/introduced) status. The following abbreviations in the 2009 species tables are based upon Nishida (2002):

end = endemic: native to the Hawaiian islands, and found only in Hawai‘i

adv = adventive: introduced into Hawai‘i, most likely accidentally introduced

pur = purposeful introduction: introduced into Hawai‘i usually for biological control of insect and plant pests

unc = unknown

Aeolian = species is not a resident of the area where it was collected, but blown up from lower elevations

Resident = lives and reproduces in the area where the species was collected

Below is a list of species found at specific sampling sites for the 2009 sampling field season, and a brief description of the sample area. Areas or sample sites with no insect collections are not included in the list below.

Hale Pohaku parking lot area: Located near the Hale Pohaku living quarters and cafeteria, this area was located at an elevation of approximately 2850 m. In 2009, there were no alien species of concern found around this area, although the parking lot and adjacent living area around Hale Pohaku has greater potential for new alien invertebrates than any other area with the exception of the Onizuka Visitor center. Native species of note were a healthy population of native *Hyaleus* sp. bees, along with a native seed bug (Lygaeidae). Alien ant species were not collected in this area (or anywhere at the Mauna Kea summit area at or above Hale Pohaku) in 2009.

**HP Parking Lot (lower) (Sites 1, 2, 3, 4)**

| order      | family        | genus-species-author                          | end/ind/adv/pur/unk | Resident/Aeolian |
|------------|---------------|---|---------------------|------------------|
| ARANEAE    | Gnaphosidae   | <i>Urozelotes rusticus</i> (L. Koch, 1872)    | adv                 | Resident         |
| COLEOPTERA | Carabidae     | <i>Laemostenus complanatus</i> (Dejean, 1828) | adv                 | Resident         |
| COLEOPTERA | Tenebrionidae | <i>Tribolium</i> sp.                          | adv                 | Aeolian          |
| DERMAPTERA | Forficulidae  | <i>Forficula auricularia</i> Linnaeus, 1758   | adv                 | Resident         |
| DIPTERA    | Agromyzidae   | <i>Liriomyza</i> sp.                          | adv                 | Aeolian          |

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|              |               |  |      |          |
|--------------|---------------|--|------|----------|
| DIPTERA      | Calliphoridae | <i>Chrysomya megacephala</i> (Fabricius, 1794)       | adv  | Aeolian  |
| DIPTERA      | Calliphoridae | ?Genus ?species                                      | adv  | Aeolian  |
| DIPTERA      | Muscidae      | <i>Atherigona orientalis</i> Schiner, 1868           | adv  | Aeolian  |
| DIPTERA      | Muscidae      | ?Genus ?species                                      | adv  | Resident |
| DIPTERA      | Sciaridae     | several species                                      | adv  | Aeolian  |
| DIPTERA      | Syrphidae     | <i>Toxomerus marginatus</i> (Say, 1823)              | adv  | Resident |
| HETEROPTERA  | Lygaeidae     | <i>Nysius</i> sp.                                    | end? | Resident |
| HOMOPTERA    | Aphididae     | ? <i>Aphis</i> sp.                                   | adv  | Aeolian  |
| HYMENOPTERA  | Braconidae    | <i>Apanteles</i> several spp.                        | adv  | Resident |
| HYMENOPTERA  | Chalcidoidea  | several species                                      | adv  | Resident |
| HYMENOPTERA  | Colletidae    | <i>Hylaeus</i> sp.                                   | end  | Resident |
| HYMENOPTERA  | Ichneumonidae | <i>Diadegma blackburni</i> (Cameron, 1883)           | adv  | Resident |
| HYMENOPTERA  | Braconidae    | <i>Apanteles</i> sp.                                 | adv  | Aeolian  |
| LEPIDOPTERA  | Oecophoridae  | <i>Thyrocopa</i> sp.                                 | end  | Resident |
| LEPIDOPTERA  | Pterophoridae | nr. <i>Anstenoptilia marmorodactyla</i> (Dyar, 1902) | adv  | Aeolian  |
| PSOCOPTERA   | Ectopsocidae  | Indet sp. wingless immature                          | adv  | Resident |
| THYSANOPTERA | Thripidae     | <i>Frankliniella</i> sp.                             | adv  | Aeolian  |

Onizuka Visitor Center (Sites 5, 44, 45, 46)

Although intensively sampled in 2009 with four series of four different kinds of insect traps, no potentially threatening aeolian or alien species were collected here. Sampling took place around the parking lot and around the trash cans at the visitor center, with negative results for ants in 2009. Of interest, the native *Hylaeus* sp. bees were still common at this site, as they have been in previous years. Of particular interest, the rare flightless native moth *Thyrocopa kikaiekea* recently described by Medeiros (2008) was found at this site. This alpine moth species has similar behavior and ecological requirements to a closely related species on Haleakalā, Maui that is now found only in areas lacking introduced ants (Medeiros 2008). The lack of any major problematic alien species such as ants is reflected in the abundance of endemic and rare native arthropod species at this site and around Hale Pohaku.

| order      | family       | genus-species-author                        | end/ind/adv/pur/unk | Resident/Aeolian |
|------------|--------------|---|---------------------|------------------|
| ARANEAE    | Corinnidae   | <i>Meriola arcifera</i> (Simon, 1886)       | adv                 | Resident         |
| ARANEAE    | Salticidae   | ?Genus ?species (immature)                  | adv                 | Resident         |
| DERMAPTERA | Forficulidae | <i>Forficula auricularia</i> Linnaeus, 1758 | adv                 | Resident         |
| DIPTERA    | Agromyzidae  | <i>Liriomyza</i> sp.                        | adv                 | Aeolian          |
| DIPTERA    | Ephydriidae  | <i>Hydrellia tritici</i> Coquillett, 1903   | adv                 | Aeolian          |
| DIPTERA    | Muscidae     | <i>Haematobia irritans</i> (Linnaeus, 1758) | adv                 | Aeolian          |
| DIPTERA    | Muscidae     | several species                             | unk                 | Aeolian          |
| DIPTERA    | Muscidae     | ?Genus?species                              | unk                 | Aeolian          |
| DIPTERA    | Oestridae    | <i>Hypoderma bovis</i> (Linnaeus, 1758)     | adv                 | Aeolian          |

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|              |                |   |      |          |
|--------------|----------------|---|------|----------|
| DIPTERA      | Phoridae       | several species                             | unk  | Aeolian  |
| DIPTERA      | Sciaridae      | several species                             | unk  | Aeolian  |
| DIPTERA      | Sphaeroceridae | <i>Leptocera</i> sp.                        | adv  | Aeolian  |
| HETEROPTERA  | Lygaeidae      | <i>Nysius</i> sp.                           | end? | Resident |
| HOMOPTERA    | Psyllidae      | ? <i>Trioza</i> sp.                         | end  | Aeolian  |
| HYMENOPTERA  | Apidae         | <i>Apis mellifera</i> Linnaeus, 1758        | pur  | Aeolian  |
| HYMENOPTERA  | Braconidae     | <i>Apanteles</i> several spp.               | adv  | Aeolian  |
| HYMENOPTERA  | Chalcididae    | <i>Brachymeria obscurata</i> (Walker, 1874) | pur  | Aeolian  |
| HYMENOPTERA  | Chalcidoidea   | unknown                                     | unk  | Aeolian  |
| HYMENOPTERA  | Colletidae     | <i>Hylaeus</i> sp.                          | end  | Resident |
| HYMENOPTERA  | Ichneumonidae  | <i>Ichneumon cupitus</i> Cresson, 1877      | adv  | Aeolian  |
| HYMENOPTERA  | Ichneumonidae  | <i>Diadegma blackburni</i> (Cameron, 1883)  | adv  | Aeolian  |
| HYMENOPTERA  | Ichneumonidae  | <i>Ichneumon laetus</i> Brulle, 1846        | pur  | Aeolian  |
| HYMENOPTERA  | Sphecidae      | <i>Pison hospes</i> R. Smith, 1879          | adv  | Aeolian  |
| HYMEOPTERA   | Pompillidae    | <i>Anoplius toluca</i> (Cameron, 1893)      | adv  | Aeolian  |
| LEPIDOPTERA  | Noctuidae      | <i>Agrotis</i> sp.                          | end  | Resident |
| LEPIDOPTERA  | Oecophoridae   | <i>Thyrocopa</i> sp.                        | end  | Resident |
| THYSANOPTERA | Thripidae      | <i>Frankliniella</i> sp.                    | adv  | Aeolian  |

**VLBA Parking Lot and Wēkiu trap bycatch (Sites 024, 100, 101, 102, 103, 104, 105)**

Only three species were found in the region around the VLBA parking lot (3725 m elevation), and in the bycatch of the wēkiu traps from the Pu‘u’s north and south of the VLBA. All species collected here were aeolian, and none were resident species capable of causing harm to native arthropod species.

| order       | family        | genus-species-author                                | end/ind/adv/pur/unk | Resident/Aeolian |
|-------------|---------------|---|---------------------|------------------|
| COLEOPTERA  | Coccinellidae | <i>Hippodamia convergens</i> Guerin-Meneville, 1844 | pur                 | Aeolian          |
| HYMENOPTERA | Ichneumonidae | <i>Ichneumon cupitus</i> Cresson, 1877              | adv                 | Aeolian          |
| HYMENOPTERA | Scelionidae   | <i>Scelio pembertoni</i> Timberlake, 1932           | pur                 | Aeolian          |

**Burns Cone Parking Lot (Site 43)**

This area was located at a parking lot at 3667 m elevation and was near an unnamed cinder cone at the John Burns Highway sign. Sampling at this location consisted of peanut butter traps, glycol pitfall, sticky, and yellow pan traps. Ant traps were negative, and only two widespread aeolian species were collected here.

| order   | family    | genus-species-author                        | end/ind/adv/pur/unk | Resident/Aeolian |
|---------|-----------|---|---------------------|------------------|
| DIPTERA | Muscidae  | <i>Haematobia irritans</i> (Linnaeus, 1758) | adv                 | Aeolian          |
| DIPTERA | Sciaridae | several species                             | unk                 | Aeolian          |



Batch Plant Parking Lot (trailhead area to Lake Waiau) (Sites 047, 048, 049, 050)

The batch plant parking lot is a large, flat, graded area at approximately 4040–4070 m elevation, adjacent to the base of Pu‘u Hau Kea. This area is also the parking lot for visitor day hikes to Lake Waiau. The only resident species found here was the large endemic wolf spider (*Lycosa hawaiiensis*). A native aeolian psyllid (*Trioza* sp.) was extremely abundant here and elsewhere on the summit, often thickly covering the yellow sticky traps. No potentially harmful introduced species were found in the batch plant parking lot area during the 2009 sampling.

| order       | family         | genus-species-author                                | end/ind/adv/pur/unk | Resident/Aeolian |
|-------------|----------------|---|---------------------|------------------|
| ARANEAE     | Lycosidae      | <i>Lycosa hawaiiensis</i> Simon, 1899               | end                 | Resident         |
| COLEOPTERA  | Coccinellidae  | <i>Hippodamia convergens</i> Guerin-Meneville, 1844 | pur                 | Aeolian          |
| DIPTERA     | Calliphoridae  | <i>Calliphora vomitoria</i> (Linnaeus, 1758)        | adv                 | Aeolian          |
| DIPTERA     | Calliphoridae  | <i>Chrysomya megacephala</i> (Fabricius, 1794)      | adv                 | Aeolian          |
| DIPTERA     | Calliphoridae  | <i>Lucilia sericata</i> (Meigen, 1826)              | adv                 | Aeolian          |
| DIPTERA     | Calliphoridae  | several species                                     | adv                 | Aeolian          |
| DIPTERA     | Ephydriidae    | <i>Hydrellia tritici</i> Coquillett, 1903           | adv                 | Aeolian          |
| DIPTERA     | Muscidae       | ?Genus ?species                                     | unk                 | Aeolian          |
| DIPTERA     | Phoridae       | several species                                     | unk                 | Aeolian          |
| DIPTERA     | Sarcophagidae  | several species                                     | adv                 | Aeolian          |
| DIPTERA     | Sphaeroceridae | several species                                     | adv                 | Aeolian          |
| DIPTERA     | Syrphidae      | <i>Toxomerus marginatus</i> (Say, 1823)             | adv                 | Aeolian          |
| DIPTERA     | Tachinidae     | several species                                     | adv                 | Aeolian          |
| HETEROPTERA | Lygaeidae      | <i>Geocoris pallens</i> Stål, 1854                  | adv                 | Aeolian          |
| HOMOPTERA   | Psyllidae      | ? <i>Trioza</i> sp.                                 | end                 | Aeolian          |
| HYMENOPTERA | Braconidae     | <i>Apanteles</i> (several spp.)                     | adv                 | Aeolian          |
| HYMENOPTERA | Pompilidae     | <i>Anoplius toluca</i> (Cameron, 1893)              | adv                 | Aeolian          |
| LEPIDOPTERA | ?Oecophoridae  | ?Genus ?species (larva)                             | unk                 | Aeolian          |

Pu‘u Hau Kea (Sites 009, 010, 011, 012, 013)

This cinder cone was part of our annual wēkiu bug monitoring during the 2009 field season, and collections of alien arthropod species here were found in wēkiu bug shrimp traps. No potentially harmful alien arthropod species were collected here in 2009. Of interest was finding the native aquatic ephydrid *Brachydeutera hebes* in wēkiu traps; these individuals were probably breeding in nearby Lake Waiau and attracted to the rotting shrimp paste.

| order      | family      | genus-species-author                     | end/ind/adv/pur/unk | Resident/Aeolian |
|------------|-------------|--|---------------------|------------------|
| COLEOPTERA | Cleridae    | <i>Necrobia rufipes</i> (De Geer, 1775)  | adv                 | Aeolian          |
| COLEOPTERA | Dermestidae | <i>Dermestes maculatus</i> De Geer, 1774 | ind                 | Aeolian          |

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|             |                |   |     |         |
|-------------|----------------|---|-----|---------|
| DIPTERA     | Ephydridae     | <i>Brachydeutera hebes</i> Cresson, 1926  | end | Aeolian |
| DIPTERA     | Ephydridae     | <i>Hydrellia tritici</i> Coquillett, 1903 | adv | Aeolian |
| DIPTERA     | Phoridae       | ?Genus ?species                           | unk | Aeolian |
| DIPTERA     | Sciaridae      | several species                           | unk | Aeolian |
| DIPTERA     | Sphaeroceridae | several species                           | unk | Aeolian |
| HYMENOPTERA | Braconidae     | <i>Apanteles</i> sp.                      | adv | Aeolian |
| HYMENOPTERA | Ichneumonidae  | <i>Ichneumon cupitus</i> Cresson, 1877    | adv | Aeolian |
| HYMENOPTERA | Ichneumonidae  | ?Genus ?species                           | unk | Aeolian |

**Lake Waiau (Site 007)**

Although part of the Natural Area Reserve and not in the Science Reserve, Lake Waiau was monitored in 2009 because the moisture provided in an otherwise desert environment is a major attractant to potentially harmful alien species. Harmful arthropods potentially becoming established in the slightly more mild and moist microclimate around the lake's shores could then expand their range to the rest of the summit area, especially ants. The area we monitored included the Lake Waiau shoreline, grassy areas, muddy areas near shore, the intermittent stream outflow of Lake Waiau, and the nearshore waters. The waters of Lake Waiau serve as a deadly attraction to aeolian insects as none of the alien (adv/pur) species shown below likely will withstand the near-daily freezing temperatures at the 4000 m elevation. As in 2008, an alien predatory carabid beetle species (*Agonum muelleri*) was found around the Lake Waiau shoreline. This species is of potential concern as its dietary habits overlap with that of the wēkiu bug.

| order       | family        | genus-species-author                                | end/ind/adv/pur/unk | Resident/Aeolian |
|-------------|---------------|---|---------------------|------------------|
| COLEOPTERA  | Carabidae     | <i>Agonum muelleri</i> (Herbst)                     | adv                 | unknown          |
| COLEOPTERA  | Coccinellidae | <i>Hippodamia convergens</i> Guérin-Meneville, 1844 | pur                 | Aeolian          |
| DIPTERA     | Ephydridae    | ?Genus ?species                                     | unk                 | Aeolian          |
| HETEROPTERA | Lygaeidae     | <i>Geocoris pallens</i> Stål, 1854                  | adv                 | Aeolian          |
| HYMENOPTERA | Braconidae    | <i>Apanteles</i> sp.                                | adv                 | Aeolian          |
| LEPIDOPTERA | Unknown       | specimen badly damaged                              | unk                 | Aeolian          |

**Pu'u Wēkiu (Sites 029-038, 042)**

In 2009 we set traps for alien arthropod species around the weather station area that was operating in the bottom of Pu'u Wēkiu crater. Any arthropod bycatch in the wēkiu shrimp pitfall traps was also analyzed and recorded. The highest elevation in the Hawaiian archipelago is found at the Pu'u Wēkiu cinder cone, and besides the wēkiu bug the only other native arthropod collected here in 2009 was the native wolf spider (*L. hawaiiensis*). All other taxa collected were aeolian species and thus not considered a threat to native arthropods.

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| <b>order</b> | <b>family</b> | <b>genus-species-author</b>                         | <b>end/ind/adv/pur/unk</b> | <b>Resident/Aeolian</b> |
|--------------|---------------|---|----------------------------|-------------------------|
| ARANEAE      | Lycosidae     | <i>Lycosa hawaiiensis</i> Simon, 1899               | end                        | Resident                |
| COLEOPTERA   | Cleridae      | <i>Necrobia rufipes</i> (De Geer, 1775)             | adv                        | Aeolian                 |
| COLEOPTERA   | Coccinellidae | <i>Hippodamia convergens</i> Guerin-Meneville, 1844 | pur                        | Aeolian                 |
| DIPTERA      | Agromyzidae   | <i>Liriomyza</i> sp.                                | adv                        | Aeolian                 |
| DIPTERA      | Calliphoridae | <i>Lucilia sericata</i> (Meigen, 1826)              | adv                        | Aeolian                 |
| DIPTERA      | Calliphoridae | several species                                     | unk                        | Aeolian                 |
| DIPTERA      | Ephydriidae   | <i>Hydrellia tritici</i> Coquillett, 1903           | adv                        | Aeolian                 |
| DIPTERA      | Muscidae      | <i>Haematobia irritans</i> (Linnaeus, 1758)         | adv                        | Aeolian                 |
| DIPTERA      | Muscidae      | several species                                     | unk                        | Aeolian                 |
| DIPTERA      | Oestridae     | <i>Hypoderma bovis</i> (Linnaeus, 1758)             | adv                        | Aeolian                 |
| DIPTERA      | Phoridae      | ?Genus ?species                                     | adv                        | Aeolian                 |
| DIPTERA      | Sarcophagidae | several species                                     | adv                        | Aeolian                 |
| DIPTERA      | Sciaridae     | several species                                     | unk                        | Aeolian                 |
| DIPTERA      | Syrphidae     | <i>Toxomerus marginatus</i> (Say, 1823)             | adv                        | Aeolian                 |
| DIPTERA      | Sepsidae      | <i>Sepsis biflexuosa biflexuosa</i> Strobl, 1883    | adv                        | Aeolian                 |
| DIPTERA      | Unknown       | early instar larvae                                 | unk                        | Aeolian                 |
| HETEROPTERA  | Lygaeidae     | <i>Geocoris pallens</i> Stål, 1854                  | adv                        | Aeolian                 |
| HOMOPTERA    | Psyllidae     | ?Trioza sp.   | end                        | Aeolian                 |
| HYMENOPTERA  | Braconidae    | <i>Apanteles</i> several spp.                       | adv                        | Aeolian                 |
| HYMENOPTERA  | Ichneumonidae | ?Genus ?species                                     | unk                        | Aeolian                 |
| THYSANOPTERA | Thripidae     | <i>Frankliniella</i> sp.                            | adv                        | Aeolian                 |

**Pu'u Poliahu (Sites 019–023)**

This cinder cone was not sampled with the four alien insect trap types, but five wēkiu bug pitfall traps were placed here, and we did have a large amount of alien arthropod species bycatch during the 2009 field season. All data below come from wēkiu shrimp pitfall traps and no alien species of concern were found in this known wēkiu bug habitat.

| <b>order</b> | <b>family</b> | <b>genus-species-author</b>                         | <b>end/ind/adv/pur/unk</b> | <b>Resident/Aeolian</b> |
|--------------|---------------|---|----------------------------|-------------------------|
| ARANEAE      | Lycosidae     | <i>Lycosa hawaiiensis</i> Simon, 1899               | end                        | Resident                |
| COLEOPTERA   | Coccinellidae | <i>Hippodamia convergens</i> Guerin-Meneville, 1844 | pur                        | Aeolian                 |
| COLEOPTERA   | Cleridae      | <i>Necrobia rufipes</i> (De Geer, 1775)             | adv                        | Aeolian                 |
| DIPTERA      | Calliphoridae | several species                                     | unk                        | Aeolian                 |
| DIPTERA      | Ephydriidae   | <i>Hydrellia tritici</i> Coquillett, 1903           | adv                        | Aeolian                 |
| DIPTERA      | Muscidae      | several species                                     | unk                        | Aeolian                 |
| DIPTERA      | Sarcophagidae | several species                                     | adv                        | Aeolian                 |
| DIPTERA      | Sciaridae     | several species                                     | unk                        | Aeolian                 |
| DIPTERA      | Sepsidae      | <i>Sepsis biflexuosa biflexuosa</i> Strobl, 1883    | adv                        | Aeolian                 |

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|             |                |   |     |         |
|-------------|----------------|---|-----|---------|
| DIPTERA     | Sphaeroceridae | several species                         | unk | Aeolian |
| DIPTERA     | Syrphidae      | <i>Toxomerus marginatus</i> (Say, 1823) | adv | Aeolian |
| HETEROPTERA | Lygaeidae      | <i>Geocoris pallens</i> Stål, 1854      | adv | Aeolian |
| HOMOPTERA   | Psyllidae      | ? <i>Trioza</i> sp.                     | end | Aeolian |
| HYMENOPTERA | Braconidae     | <i>Apanteles</i> sp.                    | adv | Aeolian |

**Poi Bowl (Sites 121-125)**

Poi Bowl is the locally named bowl-shaped ski slope area behind the Subaru and Keck telescopes, and is a known area of high wēkiu bug concentration. This area was sampled with five wēkiu bug pitfall traps. Below are the alien arthropods that were found as bycatch inside the wēkiu bug traps. Because of the relatively moist conditions in the lowlands adjacent to the Mauna Kea summit, a fairly diverse selection of aeolian species were collected here. No alien species of concern were found at Poi Bowl.

| order       | family         | genus-species-author                                 | end/ind/adv/pur/unk | Resident/Aeolian |
|-------------|----------------|--|---------------------|------------------|
| COLEOPTERA  | Cleridae       | <i>Necrobia rufipes</i> (De Geer, 1775)              | adv                 | Aeolian          |
| COLEOPTERA  | Coccinellidae  | <i>Coccinella septempunctata</i><br>(Linnaeus, 1758) | pur                 | Aeolian          |
| COLEOPTERA  | Staphylinidae  | ?Genus ?species                                      | unk                 | Aeolian          |
| DIPTERA     | Calliphoridae  | <i>Lucilia sericata</i> (Meigen, 1826)               | adv                 | Aeolian          |
| DIPTERA     | Chironomidae   | <i>Chironomis</i> sp.                                | unk                 | Aeolian          |
| DIPTERA     | Muscidae       | ?Genus ?species                                      | unk                 | Aeolian          |
| DIPTERA     | Phoridae       | several species                                      | unk                 | Aeolian          |
| DIPTERA     | Sarcophagidae  | several species                                      | adv                 | Aeolian          |
| DIPTERA     | Sciaridae      | ? <i>Bradysia</i> sp.                                | unk                 | Aeolian          |
| DIPTERA     | Sepsidae       | <i>Sepsis biflexuosa biflexuosa</i><br>Strobl, 1883  | adv                 | Aeolian          |
| DIPTERA     | Sphaeroceridae | several species                                      | unk                 | Aeolian          |
| DIPTERA     | Tachinidae     | several species                                      | adv                 | Aeolian          |
| HETEROPTERA | Lygaeidae      | <i>Geocoris pallens</i> Stål, 1854                   | adv                 | Aeolian          |
| HYMENOPTERA | Braconidae     | <i>Apanteles</i> sp.                                 | adv                 | Aeolian          |
| HYMENOPTERA | Ichneumonidae  | <i>Diagegma blackburni</i> (Cameron,<br>1883)        | adv                 | Aeolian          |
| HYMEOPTERA  | Pompillidae    | <i>Anoplus toluca</i> (Cameron, 1893)                | adv                 | Aeolian          |

Pu'u Hau Oki and around Keck Observatory (Sites 008, 025–028, 112)

The uppermost slopes of this cinder cone contain the Keck and Subaru Observatories, and the area sampled here includes alien arthropod insect traps around the Keck Observatory, and the list below also includes bycatch from wēkiu bug traps placed throughout the cinder cone. The only native arthropod species collected here (other than wēkiu bugs) was the indigenous dermestid beetle (*Dermestes maculates*). All other arthropod taxa collected here in 2009 were alien aeolian species unlikely to survive overnight freezing temperatures.

| order        | family         | genus-species-author                                | end/ind/adv/pur/unk | Resident/Aeolian |
|--------------|----------------|---|---------------------|------------------|
| COLEOPTERA   | Dermestidae    | <i>Dermestes maculates</i> De Geer, 1774            | ind                 | Aeolian          |
| COLEOPTERA   | Coccinellidae  | <i>Hippodamia convergens</i> Guerin-Meneville, 1844 | pur                 | Aeolian          |
| COLEOPTERA   | Staphylinidae  | ?Genus ?species                                     | unk                 | Aeolian          |
| DIPTERA      | Phoridae       | ?Genus ?species                                     | unk                 | Aeolian          |
| DIPTERA      | Sciaridae      | ? <i>Bradysia</i> sp.                               | unk                 | Aeolian          |
| DIPTERA      | Sepsidae       | <i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893    | adv                 | Aeolian          |
| DIPTERA      | Sphaeroceridae | several species                                     | unk                 | Aeolian          |
| DIPTERA      | Syrphidae      | <i>Toxomerus marginatus</i> (Say, 1823)             | adv                 | Aeolian          |
| HETEROPTERA  | Lygaeidae      | <i>Geocoris pallens</i> Stål, 1854                  | adv                 | Aeolian          |
| HOMOPTERA    | Psyllidae      | ? <i>Trioza</i> sp.                                 | end                 | Aeolian          |
| HYMENOPTERA  | Braconidae     | <i>Apanteles</i> sp.                                | adv                 | Aeolian          |
| HYMENOPTERA  | Eurytomidae    | <i>Eurytoma</i> sp.                                 | adv                 | Aeolian          |
| HYMENOPTERA  | Ichneumonidae  | <i>Ichneumon cupitus</i> Cresson, 1877              | adv                 | Aeolian          |
| HYMENOPTERA  | Pompilidae     | <i>Anoplius toluca</i> (Cameron, 1893)              | adv                 | Aeolian          |
| THYSANOPTERA | Thripidae      | <i>Frankliniella</i> sp.                            | adv                 | Aeolian          |

Summit Lunchroom (Site 110)

The area sampled here included inside and around the summit lunchroom building at 4226 m elevation. Insect traps were placed around the building, inside the building on trash cans, and in the long underground hallway area. Even though this area has food and high traffic, no alien arthropod species of concerns were found here, and the summit lunchroom building is apparently too cold for even cockroaches or other insect pests to survive. No resident arthropod species were found around the lunchroom building, and all ant traps were negative as they were at other summit areas. Large muscid flies are occasionally a nuisance to the summit lunchroom cook staff, but these flies are alien aeolian species not capable of surviving the cold nighttime summit temperatures.

| order      | family        | genus-species-author                                | end/ind/adv/pur/unk | Resident/Aeolian |
|------------|---------------|---|---------------------|------------------|
| COLEOPTERA | Coccinellidae | <i>Hippodamia convergens</i> Guerin-Meneville, 1844 | pur                 | Aeolian          |
| COLEOPTERA | Staphylinidae | ?Genus ?species                                     | unk                 | Aeolian          |
| DIPTERA    | Agromyzidae   | <i>Liriomyza</i> sp.                                | adv                 | Aeolian          |
| DIPTERA    | Ephydriidae   | <i>Hydrellia tritici</i> Coquillett, 1903           | adv                 | Aeolian          |

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|              |                |  |      |         |
|--------------|----------------|--|------|---------|
| DIPTERA      | Muscidae       | several species                                  | unk  | Aeolian |
| DIPTERA      | Muscidae       | <i>Haematobia irritans</i> (Linnaeus, 1758)      | adv  | Aeolian |
| DIPTERA      | Phoridae       | <i>Genus ?species?</i>                           | adv  | Aeolian |
| DIPTERA      | Sarcophagidae  | several species                                  | adv  | Aeolian |
| DIPTERA      | Sciaridae      | several species                                  | unk  | Aeolian |
| DIPTERA      | Sepsidae       | <i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893 | adv  | Aeolian |
| DIPTERA      | Sphaeroceridae | <i>Copromyza equina</i> Fallen, 1820             | adv  | Aeolian |
| DIPTERA      | Syrphidae      | <i>Toxomerus marginatus</i> (Say, 1823)          | adv  | Aeolian |
| DIPTERA      | Tachinidae     | <i>several species</i>                           | adv  | Aeolian |
| HOMOPTERA    | Cicadellidae   | ?Genus ?species                                  | end? | Aeolian |
| HOMOPTERA    | Psyllidae      | ? <i>Trioza</i> sp.                              | end  | Aeolian |
| HYMENOPTERA  | Braconidae     | <i>Apanteles</i> several spp.                    | adv  | Aeolian |
| HYMENOPTERA  | Ichneumonidae  | <i>Ichneumon cupitus</i> Cresson, 1877           | adv  | Aeolian |
| THYSANOPTERA | Thripidae      | <i>Frankliniella</i> sp.                         | adv  | Aeolian |

Gemini Telescope (Site 111)

The Gemini telescope observatory building area was sampled with a variety of insect traps within a 0–5 m distance of the observatory buildings. Arthropod species collected here in 2009 were entirely aeolian and not considered residents or species that would reproduce in this area. No native or resident arthropod species were collected in our traps, although the traps were set a short distance from known wēkiu bug habitat.

| order       | family        | genus-species-author                                | end/ind/adv/pur/unk | Resident/Aeolian |
|-------------|---------------|---|---------------------|------------------|
| COLEOPTERA  | Coccinellidae | <i>Coccinella septempunctata</i><br>Linnaeus, 1758  | pur                 | Aeolian          |
| COLEOPTERA  | Coccinellidae | <i>Hippodamia convergens</i> Guerin-Meneville, 1844 | pur                 | Aeolian          |
| DIPTERA     | Agromyzidae   | ?Genus ?species                                     | adv                 | Aeolian          |
| DIPTERA     | Calliphoridae | <i>Lucilia sericata</i> (Meigen, 1826)              | adv                 | Aeolian          |
| DIPTERA     | Calliphoridae | several species                                     | unk                 | Aeolian          |
| DIPTERA     | Ephydriidae   | <i>Hydrellia tritici</i> Coquillett, 1903           | adv                 | Aeolian          |
| DIPTERA     | Phoridae      | ?Genus ?species                                     | unk                 | Aeolian          |
| DIPTERA     | Sarcophagidae | several species                                     | adv                 | Aeolian          |
| DIPTERA     | Sciaridae     | several species                                     | unk                 | Aeolian          |
| DIPTERA     | Sepsidae      | <i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893    | adv                 | Aeolian          |
| DIPTERA     | Syrphidae     | <i>Toxomerus marginatus</i> (Say, 1823)             | adv                 | Aeolian          |
| HOMOPTERA   | Cicadellidae  | ?Genus ? species                                    | end?                | Aeolian          |
| HOMOPTERA   | Psyllidae     | ? <i>Trioza</i> sp.                                 | end                 | Aeolian          |
| HYMENOPTERA | Braconidae    | <i>Apanteles</i> several spp.                       | adv                 | Aeolian          |
| LEPIDOPTERA | Unknown       | unknown, damaged specimen                           | unk                 | Aeolian          |



Proposed Thirty Meter Telescope area (Sites 39, 40, 41)

This area is in the flats region within the proposed Thirty Meter Telescope (TMT) site. Wēkiu bugs have never been collected in or around the TMT site because it lies in a heavily glaciated region (Englund *et al.* 2007). In 2009 a comprehensive arthropod survey was again conducted here, including glycol pitfall and other various insect traps. Only three resident species were collected here, the large native *Lycosa* spider, a native springtail (Collembola), and a potentially native species of fly. Threats from nonindigenous species to native taxa were not observed at this site. Baited ant traps were also negative at the proposed TMT site, as they were elsewhere around the summit.

| order        | family        | genus-species-author                                | end/ind/adv/pur/unk | Resident/Aeolian |
|--------------|---------------|---|---------------------|------------------|
| COLEOPTERA   | Coccinellidae | <i>Hippodamia convergens</i> Guerin-Meneville, 1844 | pur                 | Aeolian          |
| DIPTERA      | Calliphoridae | <i>Chrysomya megacephala</i> (Fabricius, 1794)      | adv                 | Aeolian          |
| DIPTERA      | Muscidae      | <i>Haematobia irritans</i> (Linnaeus, 1758)         | adv                 | Aeolian          |
| DIPTERA      | Muscidae      | several species                                     | unk                 | Aeolian          |
| DIPTERA      | Muscoidea     | ?Genus ?species                                     | unk                 | Aeolian          |
| DIPTERA      | Nematocera    | indet Fam.  | unk                 | Aeolian          |
| DIPTERA      | Phoridae      | ?Genus ?species                                     | unk                 | Aeolian          |
| DIPTERA      | Sarcophagidae | several species                                     | adv                 | Aeolian          |
| DIPTERA      | Sciaridae     | several species                                     | adv                 | Aeolian          |
| DIPTERA      | Sepsidae      | <i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893    | adv                 | Aeolian          |
| DIPTERA      | Syrphidae     | <i>Toxomerus marginatus</i> (Say, 1823)             | adv                 | Aeolian          |
| HETEROPTERA  | Lygaeidae     | <i>Nysius</i> sp.                                   | end?                | Aeolian          |
| HETEROPTERA  | Lygaeidae     | <i>Geocoris pallens</i> Stål, 1854                  | adv                 | Aeolian          |
| HOMOPTERA    | Aphididae     | ? <i>Aphis</i> sp.                                  | adv                 | Aeolian          |
| HOMOPTERA    | Psyllidae     | ? <i>Trioza</i> sp.                                 | end                 | Aeolian          |
| PSOCOPTERA   | Ectopsocidae  | <i>Ectopsocus</i> sp.                               | adv                 | Aeolian          |
| HYMENOPTERA  | Braconidae    | <i>Apanteles</i> several spp.                       | adv                 | Aeolian          |
| HYMENOPTERA  | Braconidae    | <i>Bracon</i> sp.                                   | adv                 | Aeolian          |
| HYMENOPTERA  | Chalcidoidea  | several species                                     | unk                 | Aeolian          |
| HYMENOPTERA  | Ichneumonidae | <i>Ichneumon cupitus</i> Cresson, 1877              | adv                 | Aeolian          |
| HYMENOPTERA  | Megachilidae  | <i>Megachile timberlakei</i> Cockerell, 1920        | adv                 | Aeolian          |
| HYMENOPTERA  | Scelionidae   | ?Genus ?species                                     | pur?                | Aeolian          |
| THYSANOPTERA | Thripidae     | <i>Frankliniella</i> sp.                            | adv                 | Aeolian          |
| THYSANOPTERA | unknown       | ?Genus ?species                                     | unk                 | Aeolian          |

**Pu'u Pohaku (Sites 113–120)**

This sample area was located in the Natural Area Reserve and contains a small but consistent outlying wēkiu bug population. Two sets of alien arthropod traps were used at this cinder cone, with one set at the base of the cinder cone near the weather station operating during the 2009 study, and the other set of traps near the summit around the intermittent Henderson Lake. Bycatch from five wēkiu bug traps set at Pu'u Pohaku was also included in the species list below. In July 2009 the lake contained some surface and subsurface water, at least 20 cm in depth, but mostly the water was below the surface of the rocks near the summit. The large number of arthropod taxa collected at this station may be partially explained by the water in the intermittent lake, but it is unclear why so many more taxa were collected here as compared to Lake Waiau. The large number of alien arthropod species collected at this cinder cone demonstrates the need for comprehensive sampling throughout the Mauna Kea summit area, as these water bodies outside the Science Reserve and the surrounding riparian regions may provide habitats for initial establishment of alien species. As with other stations around the summit area all ant baits were negative. Of interest, two species of aquatic beetles were collected by hand from the intermittent standing waters of Henderson Lake. No resident alien species of concern were collected here in 2009. A small patch of snow was also located in the ravine draining the summit Pu'u Pohaku, with this snow patch much reduced in size but remaining until July 10, 2009. This was the only visible snow at the summit during the 2009 field work.

| order      | family         | genus-species-author                                | end/ind/adv/pur/unk | Resident/Aeolian |
|------------|----------------|---|---------------------|------------------|
| ARANEAE    | Lycosidae      | <i>Lycosa hawaiiensis</i> Simon, 1899               | end                 | Resident         |
| COLEOPTERA | Chrysomellidae | <i>Altica torquata</i> Le Conte, 1858               | adv                 | Aeolian          |
| COLEOPTERA | Cleridae       | <i>Necrobia rufipes</i> (De Geer, 1775)             | adv                 | Aeolian          |
| COLEOPTERA | Coccinellidae  | <i>Hippodamia convergens</i> Guerin-Meneville, 1844 | pur                 | Aeolian          |
| COLEOPTERA | Dytiscidae     | <i>Rhantus pacificus</i> (Boisduval, 1835)          | end                 | Resident         |
| COLEOPTERA | Hydrophilidae  | <i>Hygrotus</i> sp.                                 | adv                 | Resident         |
| DIPTERA    | Agromyzidae    | ?Genus ?species                                     | adv                 | Aeolian          |
| DIPTERA    | Ephydriidae    | <i>Hydrellia tritici</i> Coquillett, 1903           | adv                 | Aeolian          |
| DIPTERA    | Lonchopteridae | <i>Lonchoptera furcata</i> (Fallen, 1823)           | adv                 | Aeolian          |
| DIPTERA    | Muscidae       | ?Genus ? species                                    | unk                 | Aeolian          |
| DIPTERA    | Muscidae       | <i>Haematobia irritans</i> (Linnaeus, 1758)         | adv                 | Aeolian          |
| DIPTERA    | Phoridae       | ?Genus ?species                                     | unk                 | Aeolian          |
| DIPTERA    | Phoridae       | several species                                     | unk                 | Aeolian          |
| DIPTERA    | Sarcophagidae  | several species                                     | adv                 | Aeolian          |
| DIPTERA    | Sciaridae      | several species                                     | unk                 | Aeolian          |
| DIPTERA    | Sciaridae      | ? <i>Bradysia</i> sp.                               | unk                 | Aeolian          |
| DIPTERA    | Sepsidae       | <i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893    | adv                 | Aeolian          |
| DIPTERA    | Sepsidae       | <i>Sepsis thoracica</i> (Robineau-Desvoidy, 1830)   | adv                 | Aeolian          |
| DIPTERA    | Sphaeroceridae | several species                                     | unk                 | Aeolian          |

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|              |                  |  |     |   |
|--------------|------------------|--|-----|---|
| DIPTERA      | Syrphidae        | <i>Toxomerus marginatus</i> (Say, 1823)              | adv | Aeolian                                     |
| DIPTERA      | Tephritidae      | <i>Ensina sonchi</i> Linnaeus, 1767)                 | adv | Aeolian                                     |
| HETEROPTERA  | Lygaeidae        | <i>Geocoris pallens</i> Stål, 1854                   | adv | Aeolian                                     |
| HETEROPTERA  | Miridae          | <i>Coridromius variegates</i><br>(Montrouzier, 1861) | adv | Resident on 'aweoweo<br>in lower elevations |
| HETEROPTERA  | Miridae          | <i>Spanagonicus albofasciatus</i> (Reuter,<br>1907)  | adv | Aeolian                                     |
| HETEROPTERA  | Nabidae          | <i>Nabis capsiformis</i> Germar, 1837                | adv | Aeolian                                     |
| HOMOPTERA    | Aphididae        | <i>Aphis gossypii</i> Glover, 1877                   | adv | Aeolian                                     |
| HOMOPTERA    | Psyllidae        | ? <i>Trioza</i> sp.                                  | end | Aeolian                                     |
| HYMENOPTERA  | Braconidae       | <i>Apanteles</i> sp.                                 | adv | Aeolian                                     |
| HYMENOPTERA  | Braconidae       | <i>Ontsira pallaiatus</i> (Cameron, 1881)            | adv | Aeolian                                     |
| HYMENOPTERA  | Chalcidoidea     | ?Genus ?species                                      | unk | Aeolian                                     |
| HYMENOPTERA  | Chalcidoidea     | several species                                      | unk | Aeolian                                     |
| HYMENOPTERA  | Ichneumonidae    | <i>Diadegma blackburni</i> (Cameron,<br>1883)        | adv | Aeolian                                     |
| HYMENOPTERA  | Proctotrupeoidea | ?Genus ?species                                      | adv | Aeolian                                     |
| LEPIDOPTERA  | Tortricidae      | <i>Amorbia emigratella</i> Busck, 1910               | adv | Aeolian                                     |
| PSOCOPTERA   | Ectopsocidae     | <i>Ectopsocus</i> sp.                                | adv | Aeolian                                     |
| PSOCOPTERA   | Ectopsocidae     | <i>Ectopsocus perkinsi</i> Banks, 1931               | adv | Aeolian                                     |
| THYSANOPTERA | Phlaeothripidae  | ?Genus ?species                                      | adv | Aeolian                                     |

**Introduced Species of Concern: Coleoptera**

Since 2005 several new alien predatory beetle species that could adversely impact the wēkiu bug have been found, including other beetles such as dermestids (1 new Hawai‘i Island record) and staphylinids (2 new state records) (see Englund *et al.* 2005). The pathway for introduction for these alien beetle species is unknown.

In 2009 no new species of carabid beetles were found around the Mauna Kea summit region, but in 2008 a new state record for an introduced species of predatory carabid beetle (*Agonum muelleri*) was collected around Lake Waiau (Englund *et al.* 2009, Liebherr *et al.* 2009), and was captured in the same location in 2009. Although this species has been collected several times in recent years, no published or unpublished records were available to determine how long it has been in Hawaii. The first specimen of *A. muelleri* was collected by Steven L. Montgomery in 2006 in a Berlese trap set near a snowbank at the UH 2.2 meter telescope at the Mauna Kea summit (Liebherr *et al.* 2009), but all other specimens since that time have been collected around the Lake Waiau shoreline. Of the 89 alien traps used during the present 2009 monitoring we found *A. muelleri* only at Lake Waiau.

Carabid beetles are predaceous both as larvae and adults. The rather recent collections of this beetle, underscores the need for regular monitoring of the Mauna Kea alpine environment for alien predatory insects.

### **Other Potential Threats to Wēkiu Bugs**

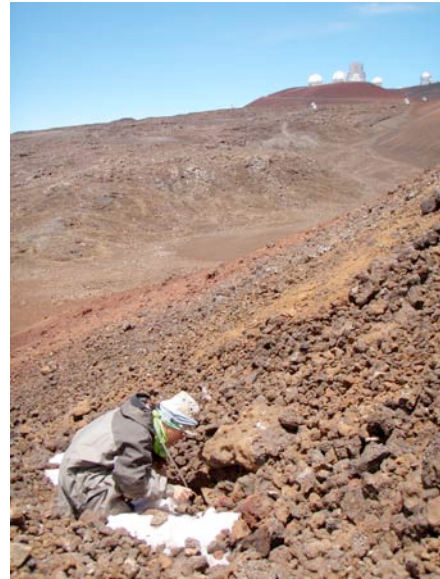
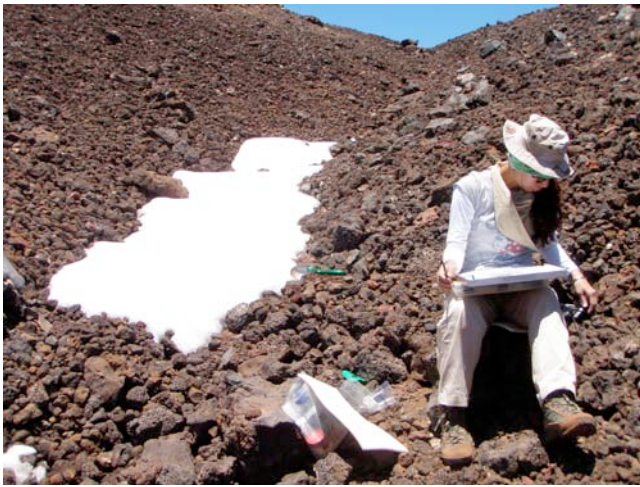
Alien ant species are the greatest potential threat to wēkiu bugs at the Mauna Kea summit area. Argentine ants (*Linepithema humile*) are currently found at Haleakalā National Park, Maui in elevational ranges close to overlapping with that of the lower distribution of wēkiu bugs (Krushelnycky *et al.* 2005). At Haleakalā National Park ant invasions have been documented to decrease native arthropod species diversity, with native predators such as the large endemic wolf spider (*Lycosa* sp.) rapidly declining in the face of ant invasions (Krushelnycky and Gillespie 2008). Ants are also implicated in the decline of the rare flightless *Thyrocopa apatela* moth found around the summit area of Haleakalā crater, and a closely related flightless species (*Thyrocopa kikaeleka*) was recently described from the Mauna Kea summit region in 2008 (Medeiros 2008). The potential for ant invasion to the Mauna Kea summit region is high, as ants are abundant along the Saddle Road area around the Pu‘u Huluhulu turnoff (Evenhuis *et al.* 1996)

An endemic wolf spider (*Lycosa* sp.) is also found at Mauna Kea and is one of the top predators of the summit region, and along with the wēkiu bug would be expected to precipitously decline if ants ever become established. Because wēkiu bugs are much more restricted in their habitat choice than the wide ranging native wolf spiders (generally the bugs are found in the upper portion of non-glaciated cinder cones), it is expected that wēkiu bugs would be even more vulnerable to ant invasions than the spiders. No new species of alien spiders were found during the 2009 fieldwork that could potentially cause impacts to wēkiu bugs or other sensitive native biota.

Regular monitoring and a rapid response to any ant introduction in the summit area, or along roadways going to the summit will be necessary to ensure the continued survival of the wēkiu bug. The European earwig mentioned above is predatory and a scavenger, and thus also has the potential to interact negatively with wēkiu bugs. Earwigs have never been found above the Hale Pohaku area and apparently are unable to handle the harsher summit conditions.

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Pu'u Pohaku snowpatch on July 4, 2009, and July 10, 2009

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*wekiuicola*), a rare insect species unique to Mauna Kea, Hawai`i Island. Final report. Prepared for Office of Mauna Kea Management, University of Hawaii, Hilo. 49 pp.

**APPENDIX A: FIGURES**

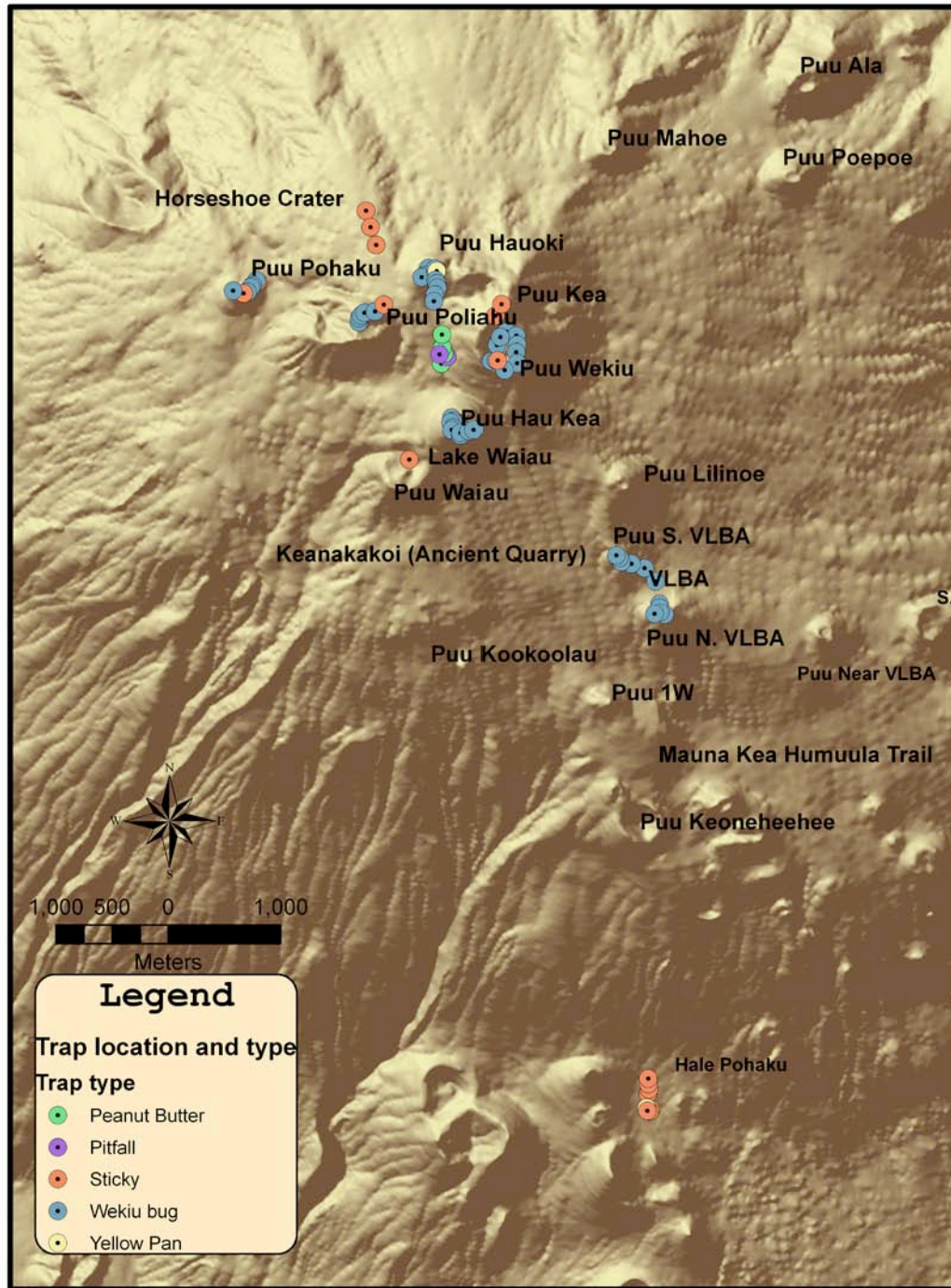


Figure 1. Overall study area for 2009 fieldwork for the alien arthropod species and wēkiu bug sampling.

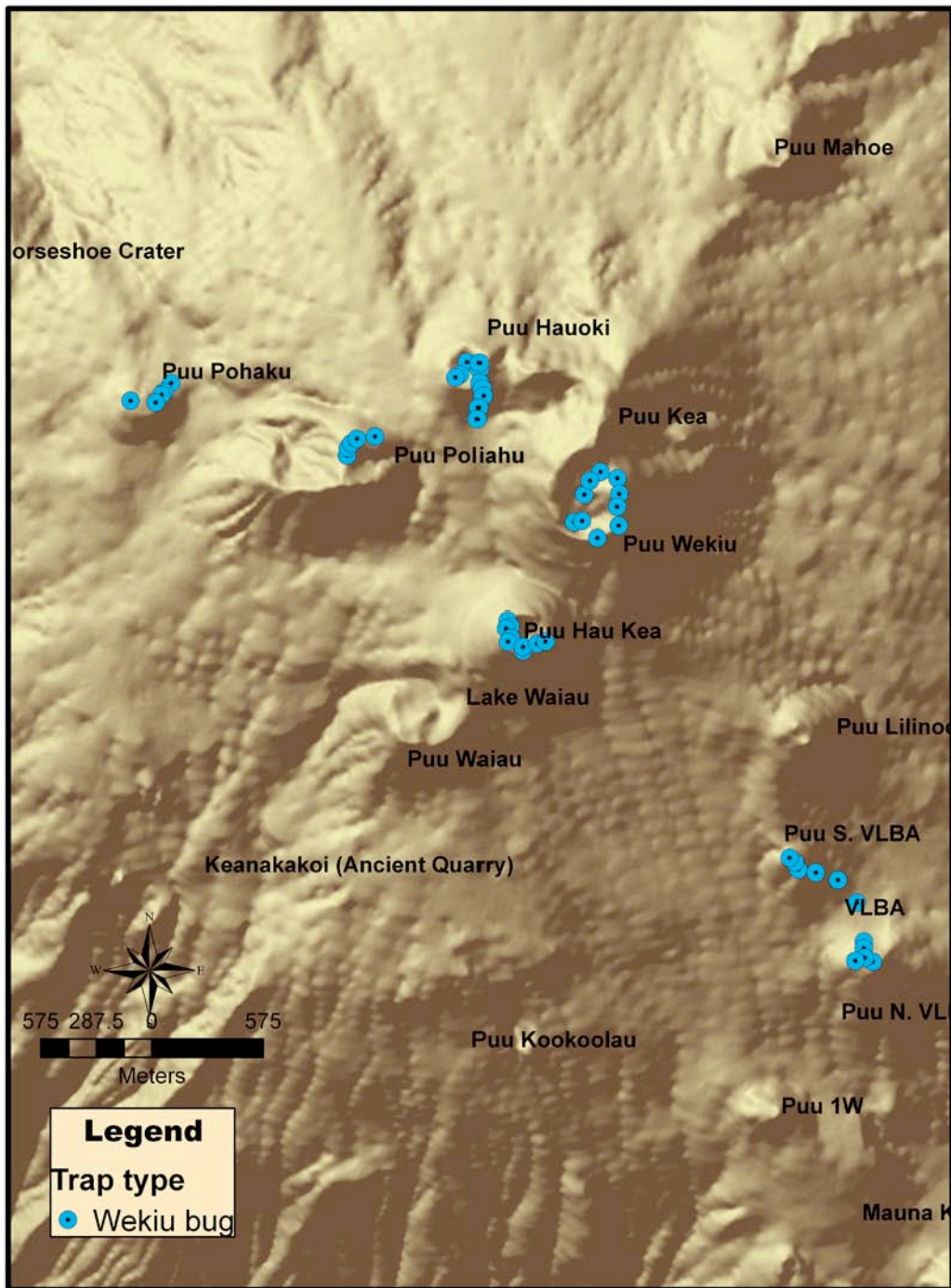


Figure 2. Overall study area for wēkiu bug sampling sites during the 2009 field season.



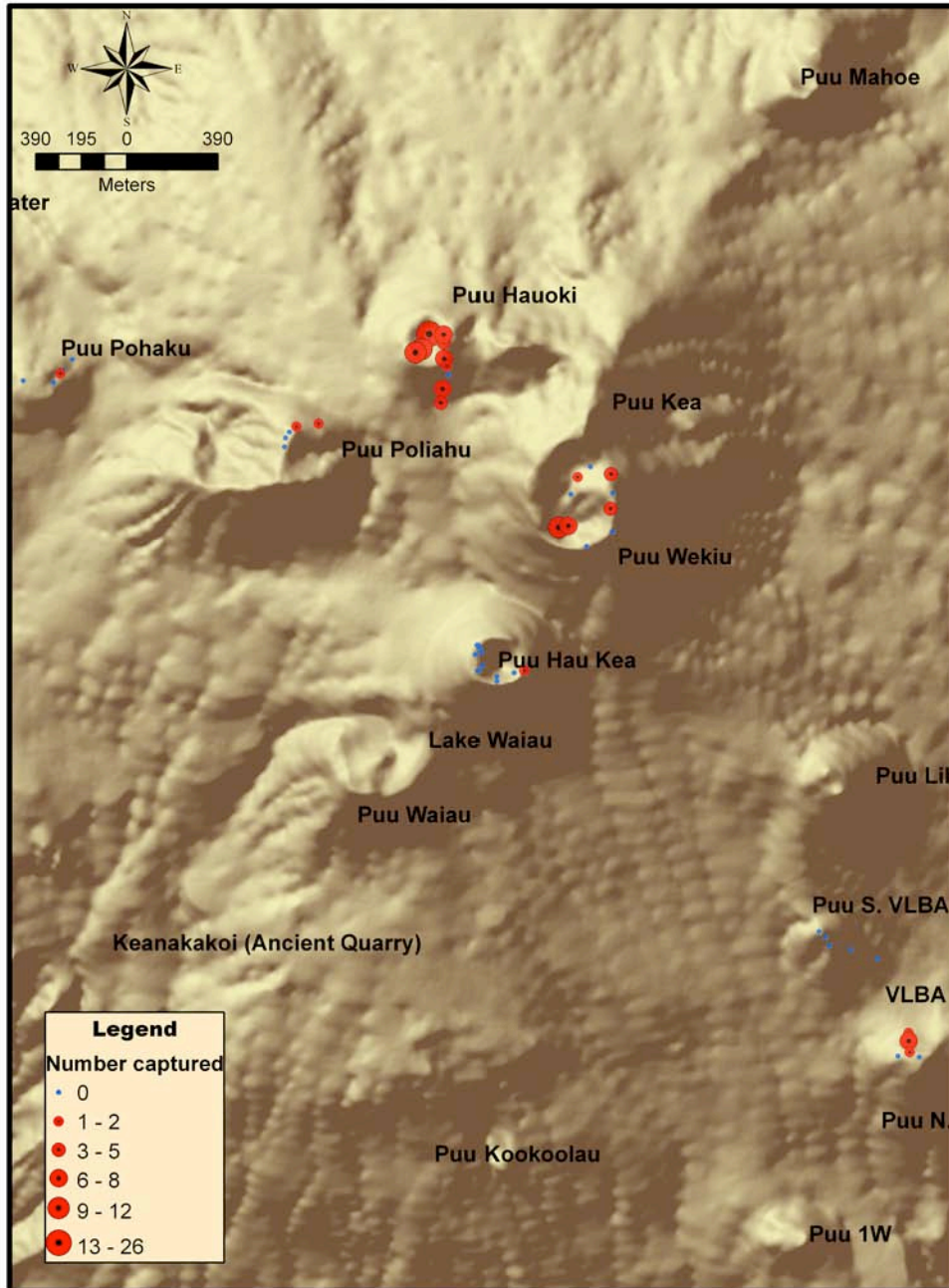


Figure 3. Wēkiu bug concentrations during the 2009 field season.

**APPENDIX B: TABLES**

*Hawaii Biological Survey Report on the 2009 Mauna Kea Alien Arthropod Sampling*

Table 1. Sample locations for alien arthropod and wēkiu bug sampling for the 2009 field season.

| Site No. | Cinder Cone   | 2009 Date Set | 2009 Dates to check/service | Trap Elevation | GPS Coordinates (WGS 84) | Trap Type       |
|----------|---|---------------|-----------------------------|----------------|--------------------------|-----------------|
| 001      | Hale Pohaku Parking (Lower)                         | July 1 2009   | July 4, 7, 10, 2009         | 2755 m         | 19.76058°N 155.45601°W   | Peanut Butter   |
| 001      | Hale Pohaku Parking (Lower)                         | July 1 2009   | July 4, 7, 10, 2009         | 2755 m         | 19.76058°N 155.45601°W   | Pitfall         |
| 001      | Hale Pohaku Parking (Lower)                         | July 1 2009   | July 4, 7, 10, 2009         | 2755 m         | 19.76058°N 155.45601°W   | Yellow Pan Trap |
| 001      | Hale Pohaku Parking (Lower)                         | July 1 2009   | July 4, 7, 10, 2009         | 2755 m         | 19.76058°N 155.45601°W   | Sticky          |
| 002      | Hale Pohaku Parking- By Old Water Tank              | July 1 2009   | July 4, 7, 10, 2009         | 2794 m         | 19.76091°N 155.45593°W   | Peanut Butter   |
| 002      | Hale Pohaku Parking- By Old Water Tank              | July 1 2009   | July 4, 7, 10, 2009         | 2794 m         | 19.76091°N 155.45593°W   | Pitfall         |
| 002      | Hale Pohaku Parking- By Old Water Tank              | July 1 2009   | July 4, 7, 10, 2009         | 2794 m         | 19.76091°N 155.45593°W   | Yellow Pan Trap |
| 002      | Hale Pohaku Parking- By Old Water Tank              | July 1 2009   | July 4, 7, 10, 2009         | 2794 m         | 19.76091°N 155.45593°W   | Sticky          |
| 003      | Hale Pohaku Lower Parking- By Kitchen               | July 1 2009   | July 4, 7, 10, 2009         | 2822 m         | 19.76134°N 155.45598°W   | Peanut Butter   |
| 003      | Hale Pohaku Lower Parking- By Kitchen               | July 1 2009   | July 4, 7, 10, 2009         | 2822 m         | 19.76134°N 155.45598°W   | Pitfall         |
| 003      | Hale Pohaku Lower Parking- By Kitchen               | July 1 2009   | July 4, 7, 10, 2009         | 2822 m         | 19.76134°N 155.45598°W   | Yellow Pan Trap |
| 003      | Hale Pohaku Lower Parking- By Kitchen               | July 1 2009   | July 4, 7, 10, 2009         | 2822 m         | 19.76134°N 155.45598°W   | Sticky          |
| 004      | Hale Pohaku—Near the staircase to the Machine shop. | July 1 2009   | July 4, 7, 10, 2009         | 2845 m         | 19.76176°N 155.45602°W   | Peanut Butter   |
| 004      | Hale Pohaku—Near the staircase to the Machine shop. | July 1 2009   | July 4, 7, 10, 2009         | 2845 m         | 19.76176°N 155.45602°W   | Pitfall         |
| 004      | Hale Pohaku—Near the staircase to the Machine shop. | July 1 2009   | July 4, 7, 10, 2009         | 2845 m         | 19.76176°N 155.45602°W   | Yellow Pan Trap |
| 004      | Hale Pohaku—Near the staircase to the Machine shop. | July 1 2009   | July 4, 7, 10, 2009         | 2845 m         | 19.76176°N 155.45602°W   | Sticky          |
| 005      | Onizuka Visitor Center                              | July 1 2009   | July 4, 7, 10, 2009         | 2828 m         | 19.75931°N 155.45576°W   | Peanut Butter   |
| 005      | Onizuka Visitor Center                              | July 1 2009   | July 4, 7, 10, 2009         | 2828 m         | 19.75931°N 155.45576°W   | Pitfall         |
| 005      | Onizuka Visitor Center                              | July 1 2009   | July 4, 7, 10, 2009         | 2828 m         | 19.75931°N 155.45576°W   | Yellow Pan      |



*Hawaii Biological Survey Report on the 2009 Mauna Kea Alien Arthropod Sampling*

Table 1 (cont.). Sample locations for alien arthropod sampling for the 2009 field season.

| Site No. | Cinder Cone                      | 2009 Date Set | 2009 Dates to check/service | Trap Elevation | GPS Coordinates (WGS 84) | Trap Type       |
|----------|----------------------------------|---------------|-----------------------------|----------------|--------------------------|-----------------|
| 005      | Onizuka Visitor Center           | July 1 2009   | July 4, 7, 10, 2009         | 2828 m         | 19.75931°N 155.45576°W   | Sticky          |
| 007      | Lake Waiau                       | July 2, 2009  | July 5, 8, 2009             | 3990 m         | 19.81122°N 155.47691°W   | Peanut Butter   |
| 007      | Lake Waiau                       | July 2, 2009  | July 5, 8, 2009             | 3990 m         | 19.81122°N 155.47691°W   | Pitfall         |
| 007      | Lake Waiau                       | July 5, 2009  | July 8, 2009                | 3990 m         | 19.81122°N 155.47691°W   | Yellow Pan Trap |
| 007      | Lake Waiau                       | July 2, 2009  | July 5, 8, 2009             | 3990 m         | 19.81122°N 155.47691°W   | Sticky          |
| 039      | 30 m proposed scope- lowest end  | July 4, 2009  | July 7, 10, 2009            | 4044 m         | 19.83112°N 155.48088°W   | Peanut Butter   |
| 039      | 30 m proposed scope- lowest end  | July 4, 2009  | July 7, 10, 2009            | 4044 m         | 19.83112°N 155.48088°W   | Pitfall         |
| 039      | 30 m proposed scope- lowest end  | July 4, 2009  | July 7, 10, 2009            | 4044 m         | 19.83112°N 155.48088°W   | Yellow pan      |
| 039      | 30 m proposed scope- lowest end  | July 4, 2009  | July 7, 10, 2009            | 4044 m         | 19.83112°N 155.48088°W   | Sticky          |
| 040      | 30 m proposed scope- middle site | July 4, 2009  | July 7, 10, 2009            | 4058 m         | 19.82981°N 155.48047°W   | Peanut Butter   |
| 040      | 30 m proposed scope- middle site | July 4, 2009  | July 7, 10, 2009            | 4058 m         | 19.82981°N 155.48047°W   | Pitfall         |
| 040      | 30 m proposed scope- middle site | July 4, 2009  | July 7, 10, 2009            | 4058 m         | 19.82981°N 155.48047°W   | Yellow Pan      |
| 040      | 30 m proposed scope- middle site | July 4, 2009  | July 7, 10, 2009            | 4058 m         | 19.82981°N 155.48047°W   | Sticky          |
| 041      | 30 m proposed scope- upper site  | July 4, 2009  | July 7, 10, 2009            | 4068 m         | 19.82838°N 155.47997°W   | Peanut Butter   |
| 041      | 30 m proposed scope- upper site  | July 4, 2009  | July 7, 10, 2009            | 4068 m         | 19.82838°N 155.47997°W   | Pitfall         |
| 041      | 30 m proposed scope- upper site  | July 4, 2009  | July 7, 10, 2009            | 4068 m         | 19.82838°N 155.47997°W   | Yellow Pan      |
| 041      | 30 m proposed scope- upper site  | July 4, 2009  | July 7, 10, 2009            | 4068 m         | 19.82838°N 155.47997°W   | Sticky          |
| 042      | Puu Wekiu- By Weather Station    | July 4, 2009  | July 7, 10, 2009            | 4149 m         | 19.81926°N 155.46964°W   | Peanut Butter   |
| 042      | Puu Wekiu- By Weather Station    | July 4, 2009  | July 7, 10, 2009            | 4149 m         | 19.81926°N 155.46964°W   | Yellow Pan      |
| 042      | Puu Wekiu- By Weather Station    | July 4, 2009  | July 7, 10, 2009            | 4149 m         | 19.81926°N 155.46964°W   | Sticky          |
| 043      | Burns Cone Parking               | July 4, 2009  | July 7, 10, 2009            | 3677 m         | 19.79345°N 155.45845°W   | Peanut Butter   |
| 043      | Burns Cone Parking               | July 4, 2009  | July 7, 10, 2009            | 3677 m         | 19.79345°N 155.45845°W   | Pitfall         |
| 043      | Burns Cone Parking               | July 4, 2009  | July 7, 10, 2009            | 3677 m         | 19.79345°N 155.45845°W   | Yellow Pan      |
| 043      | Burns Cone Parking               | July 4, 2009  | July 7, 10, 2009            | 3677 m         | 19.79345°N 155.45845°W   | Sticky          |

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Table 1 (cont.). Sample locations for alien arthropod sampling for the 2009 field season.

| Site No. | Cinder Cone   | 2009 Date Set | 2009 Dates to check/service | Trap Elevation | GPS Coordinates (WGS 84) | Trap Type     |
|----------|---|---------------|-----------------------------|----------------|--------------------------|---------------|
| 024      | VLBA Parking Lot  | July 3, 2009  | July 6, 9, 2009             | 3757 m         | 19.80174°N 155.45601°W   | Pitfall       |
| 044      | Onizuka Visitor Center- Ajacent to restroom               | July 1 2009   | July 4, 7, 10, 2009         | 2879 m         | 19.75916°N 155.45586°W   | Peanut Butter |
| 044      | Onizuka Visitor Center- Ajacent to restroom               | July 1 2009   | July 4, 7, 10, 2009         | 2879 m         | 19.75916°N 155.45586°W   | Pitfall       |
| 044      | Onizuka Visitor Center- Ajacent to restroom               | July 1 2009   | July 4, 7, 10, 2009         | 2879 m         | 19.75916°N 155.45586°W   | Yellow Pan    |
| 044      | Onizuka Visitor Center- Ajacent to restroom               | July 1 2009   | July 4, 7, 10, 2009         | 2879 m         | 19.75916°N 155.45586°W   | Sticky        |
| 045      | Onizuka Visitor Center- Above parking lot by mamane trees | July 1 2009   | July 4, 7, 10, 2009         | 2876 m         | 19.75942°N 155.45610°W   | Pitfall       |
| 045      | Onizuka Visitor Center- Above parking lot by mamane trees | July 1 2009   | July 4, 7, 10, 2009         | 2876 m         | 19.75942°N 155.45610°W   | Yellow Pan    |
| 046      | Onizuka Visitor Center                                    | July 1 2009   | July 4, 7, 10, 2009         | 2865 m         | 19.75919°N 155.45604°W   | Peanut Butter |
| 046      | Onizuka Visitor Center                                    | July 1 2009   | July 4, 7, 10, 2009         | 2865 m         | 19.75919°N 155.45604°W   | Sticky        |
| 047      | Batch Plant Area- Lowest point Parking area               | July 2, 2009  | July 5, 8, 2009             | 4047 m         | 19.81895°N 155.47432°W   | Pitfall       |
| 047      | Batch Plant Area- Lowest point Parking area               | July 2, 2009  | July 5, 8, 2009             | 4047 m         | 19.81895°N 155.47432°W   | Sticky        |
| 047      | Batch Plant Area- Lowest point Parking area               | July 2, 2009  | July 5, 8, 2009             | 4047 m         | 19.81895°N 155.47432°W   | Yellow Pan    |
| 047      | Batch Plant Area- Lowest point Parking area               | July 2, 2009  | July 5, 8, 2009             | 4047 m         | 19.81895°N 155.47432°W   | Yellow Pan    |
| 047      | Batch Plant Area- Lowest point Parking area               | July 2, 2009  | July 5, 8, 2009             | 4047 m         | 19.81895°N 155.47432°W   | Peanut Butter |
| 048      | Batch Plant Area- by the porta potti                      | July 2, 2009  | July 5, 8, 2009             | 4053 m         | 19.81949°N 155.47383°W   | Sticky        |
| 048      | Batch Plant Area- by the porta potti                      | July 2, 2009  | July 5, 8, 2009             | 4053 m         | 19.81949°N 155.47383°W   | Peanut Butter |
| 048      | Batch Plant Area- by the porta potti                      | July 2, 2009  | July 5, 8, 2009             | 4053 m         | 19.81949°N 155.47383°W   | Pitfall       |
| 049      | Batch Plant Area- Park way up road                        | July 2, 2009  | July 5, 8, 2009             | 4056 m         | 19.81976°N 155.47408°W   | Pitfall       |
| 049      | Batch Plant Area- Park way up road                        | July 2, 2009  | July 5, 8, 2009             | 4056 m         | 19.81976°N 155.47408°W   | Sticky        |

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Table 1 (cont.). Sample locations for alien arthropod sampling for the 2009 field season.

| <b>Site No.</b> | <b>Cinder Cone</b>                                  | <b>2009 Date Set</b> | <b>2009 Dates to check/service</b> | <b>Trap Elevation</b> | <b>GPS Coordinates (WGS 84)</b> | <b>Trap Type</b>    |
|-----------------|---|----------------------|------------------------------------|-----------------------|---------------------------------|---------------------|
| 049             | Batch Plant Area- Park way up road                  | July 5, 2009         | July 8, 2009                       | 4056 m                | 19.81976°N 155.47408°W          | Peanut Butter       |
| 050             | Batch Plant Area- halfway up by the large rock pile | July 2, 2009         | July 5, 8, 2009                    | 4059 m                | 19.82023°N 155.47424°W          | Yellow Pan          |
| 050             | Batch Plant Area- halfway up by the large rock pile | July 2, 2009         | July 5, 8, 2009                    | 4059 m                | 19.82023°N 155.47424°W          | Yellow Pan          |
| 050             | Batch Plant Area- halfway up by the large rock pile | July 2, 2009         | July 5, 8, 2009                    | 4059 m                | 19.82023°N 155.47424°W          | Sticky              |
| 050             | Batch Plant Area- halfway up by the large rock pile | July 2, 2009         | July 5, 8, 2009                    | 4059 m                | 19.82023 N 155.47424°W          | Peanut Butter       |
| 051             | Batch Plant Area- highest point                     | July 5, 2009         | July 8, 2009                       | 4079 m                | 19.82128°N 155.47429°W          | Yellow Pan          |
| 051             | Batch Plant Area- highest point                     | July 5, 2009         | July 8, 2009                       | 4079 m                | 19.82128°N 155.47429°W          | Sticky              |
| 051             | Batch Plant Area- highest point                     | July 5, 2009         | July 8, 2009                       | 4079 m                | 19.82128°N 155.47429°W          | Pitfall             |
| 051             | Batch Plant Area- highest point                     | July 5, 2009         | July 8, 2009                       | 4079 m                | 19.82128°N 155.47429°W          | Peanut Butter       |
| 052             | Batch Plant Area- middle of Plant area              | July 2, 2009         | July 5, 8, 2009                    | 4060 m                | 19.81969°N 155.47447°W          | Pitfall             |
| 110             | Lunchroom/Summit                                    | July 3, 2009         | July 7, 9, 2009                    | 4209 m                | 19.82285°N 155.46989°W          | Peanut Butter       |
| 110             | Lunchroom/Summit                                    | July 3, 2009         | July 7, 9, 2009                    | 4209 m                | 19.82285°N 155.46989°W          | Pitfall             |
| 110             | Lunchroom/Summit                                    | July 3, 2009         | July 7, 9, 2009                    | 4209 m                | 19.82285°N 155.46989°W          | Yellow Pan trap     |
| 110             | Lunchroom/Summit                                    | July 3, 2009         | July 7, 9, 2009                    | 4209 m                | 19.82285°N 155.46989°W          | Sticky              |
| 111             | Gemini Scope  | July 3, 2009         | July 7, 9, 2009                    | 4225 m                | 19.82379°N 155.46938°W          | Peanut Butter       |
| 111             | Gemini Scope  | July 3, 2009         | July 7, 9, 2009                    | 4225 m                | 19.82379°N 155.46938°W          | Yellow Pan trap (2) |
| 111             | Gemini Scope  | July 3, 2009         | July 7, 9, 2009                    | 4225 m                | 19.82379°N 155.46938°W          | Sticky              |
| 112             | Keck- Behind by office area (outside)               | July 3, 2009         | July 7, 9, 2009                    | 4182 m                | 19.82637°N 155.47481°W          | Peanut Butter       |
| 112             | Keck- Behind by office area (outside)               | July 3, 2009         | July 7, 9, 2009                    | 4182 m                | 19.82637°N 155.47481°W          | Sticky              |
| 112             | Keck- Behind by office area (outside)               | July 3, 2009         | July 7, 9, 2009                    | 4182 m                | 19.82637°N 155.47481°W          | Yellow Pan trap     |
| 113             | Puu Poliahu Base                                    | July 2, 2009         | July 3, 2009                       | 4115 m                | 19.82361°N 155.47925°W          | Sticky              |
| 114             | Puu Pohaku- Base by Weather Station                 | July 4, 2009         | July 7, 10, 2009                   | 4014 m                | 19.82532°N 155.48997°W          | Peanut Butter       |

*Hawaii Biological Survey Report on the 2009 Mauna Kea Alien Arthropod Sampling*

Table 1 (cont.). Sample locations for alien arthropod sampling for the 2009 field season.

| <b>Site No.</b> | <b>Cinder Cone</b>                  | <b>2009 Date Set</b> | <b>2009 Dates to check/service</b> | <b>Trap Elevation</b> | <b>GPS Coordinates (WGS 84)</b> | <b>Trap Type</b> |
|-----------------|-------------------------------------|----------------------|------------------------------------|-----------------------|---------------------------------|------------------|
| 114             | Puu Pohaku- Base by Weather Station | July 4, 2009         | July 7, 10, 2009                   | 4014 m                | 19.82532°N 155.48997°W          | Yellow Pan       |
| 114             | Puu Pohaku- Base by Weather Station | July 4, 2009         | July 7, 10, 2009                   | 4014 m                | 19.82532°N 155.48997°W          | Sticky           |
| 119             | Puu Pohaku                          | July 4, 2009         | July 7, 10, 2009                   | 4036 m                | 19.82434°N 155.49113°W          | Peanut Butter    |
| 119             | Puu Pohaku                          | July 4, 2009         | July 7, 10, 2009                   | 4036 m                | 19.82434°N 155.49113°W          | Yellow Pan       |
| 119             | Puu Pohaku                          | July 4, 2009         | July 7, 10, 2009                   | 4036 m                | 19.82434°N 155.49113°W          | Sticky           |

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Table 2. Shrimp pitfall trap GPS locations (WGS 84) for wēkiu bug surveys conducted in June 2009.

| Site No. | Cinder Cone  | 2009 Date Set | 2009 Dates to check/service | Trap Elevation | GPS Coordinates (WGS 84) | Trap Type |
|----------|--|---------------|-----------------------------|----------------|--------------------------|-----------|
| 009      | Puu Hau Kea  | July 2, 2009  | July 5, 8, 2009             | 4124 m         | 19.81455°N 155.47333°W   | Wekiu bug |
| 010      | Puu Hau Kea- Keck Side                             | July 2, 2009  | July 5, 8, 2009             | 4120 m         | 19.81463°N 155.47339°W   | Wekiu bug |
| 011      | Puu Hau Kea- Inside Crater                         | July 2, 2009  | July 5, 8, 2009             | 4116 m         | 19.81436°N 155.47325°W   | Wekiu bug |
| 012      | Puu Hau Kea- Keck Side                             | July 2, 2009  | July 5, 8, 2009             | 4125 m         | 19.81426°N 155.47346°W   | Wekiu bug |
| 013      | Puu Hau Kea-                                       | July 2, 2009  | July 5, 8, 2009             | 4118 m         | 19.81383°N 155.47322°W   | Wekiu bug |
| 014      | Puu Hau Kea  | July 2, 2009  | July 5, 8, 2009             | 4128 m         | 19.81365°N 155.47336°W   | Wekiu bug |
| 015      | Puu Hau Kea  | July 2, 2009  | July 5, 8, 2009             | 4124 m         | 19.81323°N 155.47261°W   | Wekiu bug |
| 016      | Puu Hau Kea  | July 2, 2009  | July 5, 8, 2009             | 4115 m         | 19.81342°N 155.47261°W   | Wekiu bug |
| 017      | Puu Hau Kea  | July 2, 2009  | July 5, 8, 2009             | 4116 m         | 19.81358°N 155.47192°W   | Wekiu bug |
| 018      | Puu Hau Kea  | July 2, 2009  | July 5, 8, 2009             | 4126 m         | 19.81368°N 155.47151°W   | Wekiu bug |
| 019      | Puu Poliahu  | July 2, 2009  | July 5, 8, 2009             | 4155 m         | 19.82215°N 155.48135°W   | Wekiu bug |
| 020      | Puu Poliahu  | July 2, 2009  | July 5, 8, 2009             | 4154 m         | 19.82250°N 155.48131°W   | Wekiu bug |
| 021      | Puu Poliahu  | July 2, 2009  | July 5, 8, 2009             | 4158 m         | 19.82272°N 155.48116°W   | Wekiu bug |
| 022      | Puu Poliahu  | July 2, 2009  | July 5, 8, 2009             | 4159 m         | 19.82294°N 155.48088°W   | Wekiu bug |
| 008      | Puu Hau Oki- Near the Weather Station crater floor | July 3, 2009  | July 6, 9, 2009             | 4118 m         | 19.82658°N 155.47552°W   | Wekiu bug |
| 025      | Puu Hau Oki- on slope near Subaru Scope            | July 3, 2009  | July 6, 9, 2009             | 4135 m         | 19.82600°N 155.47583°W   | Wekiu bug |
| 026      | Puu Hau Oki- Slope Westside of Subaru Scope        | July 3, 2009  | July 6, 9, 2009             | 4151 m         | 19.82586°N 155.47607°W   | Wekiu bug |
| 027      | Puu Hau Oki- On rim next to Keck Scope             | July 3, 2009  | July 6, 9, 2009             | 4174 m         | 19.82626°N 155.47493°W   | Wekiu bug |

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Table 2 (cont.). Sample locations for wēkiu bug sampling for the 2009 field season.

| Site No. | Cinder Cone   | 2009 Date Set | 2009 Dates to check/service | Trap Elevation | GPS Coordinates (WGS 84) | Trap Type |
|----------|---|---------------|-----------------------------|----------------|--------------------------|-----------|
| 028      | Puu Hau Oki -1/4 down slope from Keck on East slope | July 3, 2009  | July 6, 9, 2009             | 4161 m         | 19.82656°N 155.47494°W   | Wekiu bug |
| 029      | Puu Wekiu   | July 3, 2009  | July 6, 9, 2009             | 4191 m         | 19.82156°N 155.46893°W   | Wekiu bug |
| 030      | Puu Wekiu- Outer slope                              | July 3, 2009  | July 6, 9, 2009             | 4213 m         | 19.82128°N 155.46809°W   | Wekiu bug |
| 031      | Puu Wekiu- Rim near Ahu Tower                       | July 3, 2009  | July 6, 9, 2009             | 4227 m         | 19.82055°N 155.46800°W   | Wekiu bug |
| 032      | Puu Wekiu- Inside slope on Ahu side                 | July 3, 2009  | July 6, 9, 2009             | 4216 m         | 19.81995°N 155.46809°W   | Wekiu bug |
| 033      | Puu Wekiu- Outer Slope                              | July 3, 2009  | July 6, 9, 2009             | 4215 m         | 19.81907°N 155.46799°W   | Wekiu bug |
| 034      | Puu Wekiu- Outer Slope                              | July 3, 2009  | July 6, 9, 2009             | 4196 m         | 19.81849°N 155.46904°W   | Wekiu bug |
| 035      | Puu Wekiu- Inner Crater 2/3 down                    | July 3, 2009  | July 6, 9, 2009             | 4167 m         | 19.81920°N 155.47018°W   | Wekiu bug |
| 036      | Puu Wekiu-  | July 3, 2009  | July 6, 9, 2009             | 4153 m         | 19.81927°N 155.46980°W   | Wekiu bug |
| 037      | Puu Wekiu   | July 3, 2009  | July 6, 9, 2009             | 4180-m         | 19.82049°N 155.46971°W   | Wekiu bug |
| 038      | Puu Wekiu   | July 3, 2009  | July 6, 9, 2009             | 4185 m         | 19.82115°N 155.46944°W   | Wekiu bug |
| 100      | Puu North VLBA                                      | July 3, 2009  | July 6, 9, 2009             | 3776 m         | 19.80279°N 155.45695°W   | Wekiu bug |
| 101      | Puu North VLBA                                      | July 3, 2009  | July 6, 9, 2009             | 3819 m         | 19.80312°N 155.45805°W   | Wekiu bug |
| 102      | Puu North VLBA                                      | July 3, 2009  | July 6, 9, 2009             | 3860 m         | 19.80325°N 155.45892°W   | Wekiu bug |
| 103      | Puu North VLBA                                      | July 3, 2009  | July 6, 9, 2009             | 3858 m         | 19.80358°N 155.45909°W   | Wekiu bug |
| 104      | Puu North VLBA                                      | July 3, 2009  | July 6, 9, 2009             | 3864 m         | 19.80379°N 155.45935°W   | Wekiu bug |
| 105      | Puu South VLBA                                      | July 3, 2009  | July 6, 9, 2009             | 3770 m         | 19.79994°N 155.45564°W   | Wekiu bug |
| 106      | Puu South VLBA                                      | July 3, 2009  | July 6, 9, 2009             | 3786 m         | 19.79963°N 155.45563°W   | Wekiu bug |
| 107      | Puu South VLBA                                      | July 3, 2009  | July 6, 9, 2009             | 3811 m         | 19.79901°N 155.45518°W   | Wekiu bug |
| 108      | Puu South VLBA                                      | July 3, 2009  | July 6, 9, 2009             | 3809 m         | 19.79919°N 155.45558°W   | Wekiu bug |
| 109      | Puu South VLBA                                      | July 3, 2009  | July 6, 9, 2009             | 3806 m         | 19.79904°N 155.45605°W   | Wekiu bug |
| 115      | Puu Pohaku- Base near Weather Station               | July 4, 2009  | July 7, 10, 2009            | 4010 m         | 19.82540°N 155.49005°W   | Wekiu bug |

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Table 2 (cont.). Sample locations for wēkiu bug sampling for the 2009 field season.

| <b>Site No.</b> | <b>Cinder Cone</b>              | <b>2009 Date Set</b> | <b>2009 Dates to check/service</b> | <b>Trap Elevation</b> | <b>GPS Coordinates (WGS 84)</b> | <b>Trap Type</b> |
|-----------------|---------------------------------|----------------------|------------------------------------|-----------------------|---------------------------------|------------------|
| 116             | Puu Pohaku                      | July 4, 2009         | July 7, 10, 2009                   | 4024 m                | 19.82498°N 155.49040°W          | Wekiu bug        |
| 117             | Puu Pohaku                      | July 4, 2009         | July 7, 10, 2009                   | 4029 m                | 19.82485°N 155.49052°W          | Wekiu bug        |
| 118             | Puu Pohaku                      | July 4, 2009         | July 7, 10, 2009                   | 4034 m                | 19.82448°N 155.49080°W          | Wekiu bug        |
| 120             | Puu Pohaku                      | July 4, 2009         | July 7, 10, 2009                   | 4046 m                | 19.82455°N 155.49203°W          | Wekiu bug        |
| 121             | Poi Bowl- Behind Keck           | July 6, 2009         | July 9, 2009                       | 4168 m                | 19.82563°N 155.47490°W          | Wekiu bug        |
| 122             | Poi Bowl- Side of Keck          | July 6, 2009         | July 9, 2009                       | 4153 m                | 19.82536°N 155.47479°W          | Wekiu bug        |
| 123             | Poi Bowl- Keck side midway down | July 6, 2009         | July 9, 2009                       | 4144 m                | 19.82502°N 155.47472°W          | Wekiu bug        |
| 124             | Poi Bowl- lower 2/3             | July 6, 2009         | July 9, 2009                       | 4123 m                | 19.82447°N 155.47495°W          | Wekiu bug        |
| 125             | Poi Bowl- base                  | July 6, 2009         | July 9, 2009                       | 4105 m                | 19.82393°N 155.47501°W          | Wekiu bug        |

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Table 3. Wēkiu bug capture data from the 2009 field sampling season.

| <b>SAMPLE NUMBER</b> | <b>Cinder Cone</b>                                   | <b>2009 Date Set</b> | <b>2009 Dates checked</b> | <b>Elevation</b> | <b>GPS Coordinates (WGS 84)</b> | <b>Wēkiu #'s</b> | <b>Trap Type</b> |
|----------------------|--|----------------------|---------------------------|------------------|---------------------------------|------------------|------------------|
| 009                  | Puu Hau Kea  | July 2, 2009         | July 5, 8, 2009           | 4124 m           | 19.81455°N 155.47333°W          | 0                | Shrimp           |
| 010                  | Puu Hau Kea-Keck Side                                | July 2, 2009         | July 5, 8, 2009           | 4120 m           | 19.81463°N 155.47339°W          | 0                | Shrimp           |
| 011                  | Puu Hau Kea-Inside Crater                            | July 2, 2009         | July 5, 8, 2009           | 4116 m           | 19.81436°N 155.47325°W          | 0                | Shrimp           |
| 012                  | Puu Hau Kea-Keck Side                                | July 2, 2009         | July 5, 8, 2009           | 4125 m           | 19.81426°N 155.47346°W          | 0                | Shrimp           |
| 013                  | Puu Hau Kea-   | July 2, 2009         | July 5, 8, 2009           | 4118 m           | 19.81383°N 155.47322°W          | 0                | Shrimp           |
| 014                  | Puu Hau Kea  | July 2, 2009         | July 5, 8, 2009           | 4128 m           | 19.81365°N 155.47336°W          | 0                | Shrimp           |
| 015                  | Puu Hau Kea  | July 2, 2009         | July 5, 8, 2009           | 4124 m           | 19.81323°N 155.47261°W          | 0                | Shrimp           |
| 016                  | Puu Hau Kea  | July 2, 2009         | July 5, 8, 2009           | 4115 m           | 19.81342°N 155.47261°W          | 0                | Shrimp           |
| 017                  | Puu Hau Kea  | July 2, 2009         | July 5, 8, 2009           | 4116 m           | 19.81358°N 155.47192°W          | 0                | Shrimp           |
| 018                  | Puu Hau Kea  | July 2, 2009         | July 5, 8, 2009           | 4126 m           | 19.81368°N 155.47151°W          | 1                | Shrimp           |
| 019                  | Puu Poliahu  | July 2, 2009         | July 5, 8, 2009           | 4155 m           | 19.82215°N 155.48135°W          | 0                | Shrimp           |
| 020                  | Puu Poliahu  | July 2, 2009         | July 5, 8, 2009           | 4154 m           | 19.82250°N 155.48131°W          | 0                | Shrimp           |
| 021                  | Puu Poliahu  | July 2, 2009         | July 5, 8, 2009           | 4158 m           | 19.82272°N 155.48116°W          | 0                | Shrimp           |
| 022                  | Puu Poliahu  | July 2, 2009         | July 5, 8, 2009           | 4159 m           | 19.82294°N 155.48088°W          | 1                | Shrimp           |
| 023                  | Puu Poliahu  | July 2, 2009         | July 5, 8, 2009           | 4144 m           | 19.82306°N 155.47998°W          | 2                | Shrimp           |
| 008                  | Puu Hau Oki-Near the Weather Station crater floor    | July 3, 2009         | July 6, 9, 2009           | 4118 m           | 19.82658°N 155.47552°W          | 26               | Shrimp           |
| 025                  | Puu Hau Oki- on slope near Subaru Scope              | July 3, 2009         | July 6, 9, 2009           | 4135 m           | 19.82600°N 155.47583°W          | 9                | Shrimp           |
| 026                  | Puu Hau Oki-Slope Westside of Subaru Scope           | July 3, 2009         | July 6, 9, 2009           | 4151 m           | 19.82586°N 155.47607°W          | 10               | Shrimp           |
| 027                  | Puu Hau Oki-On rim next to Keck Scope                | July 3, 2009         | July 6, 9, 2009           | 4174 m           | 19.82626°N 155.47493°W          | 3                | Shrimp           |
| 028                  | Puu Hau Oki - 1/4 down slope from Keck on East slope | July 3, 2009         | July 6, 9, 2009           | 4161 m           | 19.82656°N 155.47494°W          | 7                | Shrimp           |
| 029                  | Puu Wekiu  | July 3, 2009         | July 6, 9, 2009           | 4191 m           | 19.82156 N 155.46893 W          | 0                | Shrimp           |
| 030                  | Puu Wekiu-Outer slope                                | July 3, 2009         | July 6, 9, 2009           | 4213 m           | 19.82128°N 155.46809°W          | 4                | Shrimp           |
| 031                  | Puu Wekiu- Rim near Ahu Tower                        | July 3, 2009         | July 6, 9, 2009           | 4227 m           | 19.82055°N 155.46800°W          | 0                | Shrimp           |



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| <b>SAMPLE NUMBER</b> | <b>Cinder Cone</b>                          | <b>2009 Date Set</b> | <b>2009 Dates checked</b> | <b>Elevation</b> | <b>GPS Coordinates (WGS 84)</b> | <b>Wēkiu #'s</b> | <b>Trap Type</b> |
|----------------------|---|----------------------|---------------------------|------------------|---------------------------------|------------------|------------------|
| 032                  | Puu Wekiu-<br>Inside slope on<br>Ahu side   | July 3, 2009         | July 6, 9,<br>2009        | 4216 m           | 19.81995°N 155.46809°W          | 5                | Shrimp           |
| 033                  | Puu Wekiu-<br>Outer Slope                   | July 3, 2009         | July 6, 9,<br>2009        | 4215 m           | 19.81907°N 155.46799°W          | 0                | Shrimp           |
| 034                  | Puu Wekiu-<br>Outer Slope                   | July 3, 2009         | July 6, 9,<br>2009        | 4196 m           | 19.81849°N 155.46904°W          | 0                | Shrimp           |
| 035                  | Puu Wekiu-<br>Inner Crater 2/3<br>down      | July 3, 2009         | July 6, 9,<br>2009        | 4167 m           | 19.81920°N 155.47018°W          | 12               | Shrimp           |
| 036                  | Puu Wekiu-                                  | July 3, 2009         | July 6, 9,<br>2009        | 4153 m           | 19.81927°N 155.46980°W          | 8                | Shrimp           |
| 037                  | Puu Wekiu                                   | July 3, 2009         | July 6, 9,<br>2009        | 4180-m           | 19.82049°N 155.46971°W          | 0                | Shrimp           |
| 038                  | Puu Wekiu                                   | July 3, 2009         | July 6, 9,<br>2009        | 4185 m           | 19.82115°N 155.46944°W          | 2                | Shrimp           |
| 100                  | Puu North<br>VLBA                           | July 3, 2009         | July 6, 9,<br>2009        | 3776 m           | 19.80279°N 155.45695°W          | 0                | Shrimp           |
| 101                  | Puu North<br>VLBA                           | July 3, 2009         | July 6, 9,<br>2009        | 3819 m           | 19.80312°N 155.45805°W          | 0                | Shrimp           |
| 102                  | Puu North<br>VLBA                           | July 3, 2009         | July 6, 9,<br>2009        | 3860 m           | 19.80325°N 155.45892°W          | 0                | Shrimp           |
| 103                  | Puu North<br>VLBA                           | July 3, 2009         | July 6, 9,<br>2009        | 3858 m           | 19.80358°N 155.45909°W          | 0                | Shrimp           |
| 104                  | Puu North<br>VLBA                           | July 3, 2009         | July 6, 9,<br>2009        | 3864 m           | 19.80379°N 155.45935°W          | 0                | Shrimp           |
| 105                  | Puu South<br>VLBA                           | July 3, 2009         | July 6, 9,<br>2009        | 3770 m           | 19.79994°N 155.45564°W          | 1                | Shrimp           |
| 106                  | Puu South<br>VLBA                           | July 3, 2009         | July 6, 9,<br>2009        | 3786 m           | 19.79963°N 155.45563°W          | 7                | Shrimp           |
| 107                  | Puu South<br>VLBA                           | July 3, 2009         | July 6, 9,<br>2009        | 3811 m           | 19.79901°N 155.45518°W          | 0                | Shrimp           |
| 108                  | Puu South<br>VLBA                           | July 3, 2009         | July 6, 9,<br>2009        | 3809 m           | 19.79919°N 155.45558°W          | 1                | Shrimp           |
| 109                  | Puu South<br>VLBA                           | July 3, 2009         | July 6, 9,<br>2009        | 3806 m           | 19.79904°N 155.45605°W          | 0                | Shrimp           |
| 115                  | Puu Pohaku-<br>Base near<br>Weather Station | July 4, 2009         | July 7,<br>10, 2009       | 4010 m           | 19.82540°N 155.49005°W          | 0                | Shrimp           |
| 116                  | Puu Pohaku                                  | July 4, 2009         | July 7,<br>10, 2009       | 4024 m           | 19.82498°N 155.49040°W          | 0                | Shrimp           |
| 117                  | Puu Pohaku                                  | July 4, 2009         | July 7,<br>10, 2009       | 4029 m           | 19.82485°N 155.49052°W          | 1                | Shrimp           |
| 118                  | Puu Pohaku                                  | July 4, 2009         | July 7,<br>10, 2009       | 4034 m           | 19.82448°N 155.49080°W          | 0                | Shrimp           |
| 120                  | Puu Pohaku                                  | July 4, 2009         | July 7,<br>10, 2009       | 4046 m           | 19.82455°N 155.49203°W          | 0                | Shrimp           |
| 121                  | Poi Bowl                                    | July 6, 2009         | July 9,<br>2009           | 4,168 m          | 19.82563°N 155.47490°W          | 6                | Shrimp           |
| 122                  | Poi Bowl                                    | July 6, 2009         | July 9,<br>2009           | 4,153 m          | 19.82536°N 155.47479°W          | 1                | Shrimp           |
| 123                  | Poi Bowl                                    | July 6, 2009         | July 9,<br>2009           | 4,144 m          | 19.82502°N 155.47472°W          | 0                | Shrimp           |
| 124                  | Poi Bowl                                    | July 6, 2009         | July 9,<br>2009           | 4,123 m          | 19.82447°N 155.47495°W          | 6                | Shrimp           |
| 125                  | Poi Bowl                                    | July 6, 2009         | July 9,<br>2009           | 4,105 m          | 19.82393°N 155.47501°W          | 5                | Shrimp           |
| <b>2009 Totals</b>   |   |                      |                           |                  |                                 | 118              |                  |

Table 4. Summary of 2009 sample effort and wēkiu bug captures from surveyed Mauna Kea cinder cones using shrimp pitfall traps in July 2009.

| Cinder Cone  | Highest Elevation | Total Traps | Wēkiu bugs in traps | Wēkiu bugs visual observation only | Trap Dates | Total Trap Days <sup>1</sup> |
|--------------|-------------------|-------------|---------------------|------------------------------------|------------|------------------------------|
| Pu'u Hau Kea | 4,131 m           | 10          | 1                   | 0                                  | 2–8 July   | 60                           |
| Pu'u Hau Oki | 4,174 m           | 5           | 55                  | 0                                  | 3–9 July   | 30                           |
| Pu'u Wēkiu   | 4,205 m           | 10          | 31                  | 0                                  | 3–9 July   | 60                           |
| Pu'u N. VLBA | 3,852 m           | 5           | 0                   | 0                                  | 3–9 July   | 30                           |
| Pu'u S. VLBA | 3,809 m           | 5           | 9                   | 0                                  | 3–9 July   | 30                           |
| Pu'u Pohaku  | 4,046 m           | 5           | 1                   | 0                                  | 4–10 July  | 30                           |
| Pu'u Poliahu | 4,159 m           | 5           | 3                   | 0                                  | 2–8 July   | 30                           |
| Poi Bowl     | 4,168 m           | 5           | 18                  | 0                                  | 6–9 July   | 15                           |
| Totals       |                   | 45          | 118                 | 0                                  |            | 285                          |

<sup>1</sup>Trap days = total nights x total traps per cinder cone.

Table 5. Summary of wēkiu bugs captured at the Pu'u Hau Kea (within the Natural Area Reserve) cinder cone in Bishop Museum related studies since 2001. Data includes using a combination of glycol and shrimp pitfall data for all years except 2007, 2008, and 2009 when only shrimp traps were used.

| Year and Month when Trapping Occurred | Total Wēkiu bugs | Trap Days | Catch Corrected for Effort (Bugs/Trap Day) |
|---------------------------------------|------------------|-----------|--|
| 2001 (Polhemus 2001) <sup>1</sup>     | 473              | 40        | 11.8                                       |
| 2002 (Sept)                           | 13               | 48        | 0.27                                       |
| 2004 (July)                           | 0                | 90        | 0  |
| 2005 (April/May)                      | 20               | 144       | 0.14                                       |
| 2006 (April/May)                      | 56               | 80        | 0.7  |
| 2007 (June)                           | 217              | 78        | 2.8  |
| 2008 (July)                           | 43               | 60        | 0.7  |
| 2009 (July)                           | 1                | 60        | 0.02                                       |
|                                       |                  |           | <b>Avg = 2.1</b>                           |

<sup>1</sup>Data from Polhemus (2001) was from glycol traps only and results may not be directly comparable to our shrimp traps.

**APPENDIX C: ALIEN AND NATIVE ARTHROPOD TABLES 2009**

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Table 6. Overall species list of native and alien arthropods found during the 2009 field study, specific sites where each taxa were found is listed in main text.

| Taxa | Order      | Family         | Genus-Species-Author                                | Biogeographic Status: (end/ind adv/pur/unk) | Resident/Aeolian |
|------|------------|----------------|---|---|------------------|
| 1    | ARANEAE    | Corinnidae     | <i>Meriola arcifera</i> (Simon, 1886)               | adv   | Resident         |
| 2    | ARANEAE    | Gnaphosidae    | <i>Urozelotes rusticus</i> (L. Koch, 1872)          | adv   | Resident         |
| 3    | ARANEAE    | Lycosidae      | <i>Lycosa hawaiiensis</i> Simon, 1899               | end   | Resident         |
| 4    | COLEOPTERA | Carabidae      | <i>Agonum muelleri</i> (Herbst, 1784)               | adv   | Resident         |
| 5    | COLEOPTERA | Carabidae      | <i>Laemostenus complanatus</i> (Dejean, 1828)       | adv   | Resident         |
| 6    | COLEOPTERA | Cleridae       | <i>Necrobia rufipes</i> (De Geer, 1775)             | adv   | Aeolian          |
| 7    | COLEOPTERA | Coccinellidae  | <i>Coccinella septempunctata</i> Linnaeus, 1758     | pur   | Aeolian          |
| 8    | COLEOPTERA | Coccinellidae  | <i>Hippodamia convergens</i> Guerin-Meneville, 1844 | pur   | Aeolian          |
| 9    | COLEOPTERA | Dermestidae    | <i>Dermestes maculatus</i> De Geer, 1774            | ind   | Aeolian          |
| 10   | COLEOPTERA | Dytiscidae     | <i>Rhantus pacificus</i> (Boisduval, 1835)          | end   | Resident         |
| 11   | COLEOPTERA | Hydrophilidae  | <i>Hygrotus</i> sp.                                 | adv   | Resident         |
| 12   | COLEOPTERA | Chrysomellidae | <i>Altica torquata</i> Le Conte, 1858               | adv   | Aeolian          |
| 13   | COLEOPTERA | Tenebrionidae  | <i>Tribolium</i> sp.                                | adv   | Aeolian          |
| 14   | COLEOPTERA | Staphylinidae  | ?Genus ?species                                     | unk   | Aeolian          |
| 15   | DERMAPTERA | Forficulidae   | <i>Forficula auricularia</i> Linnaeus, 1758         | adv   | Resident         |
| 16   | DIPTERA    | Agromyzidae    | <i>Liriomyza</i> sp.                                | adv   | Aeolian          |
| 17   | DIPTERA    | Agromyzidae    | ?Genus ?species                                     | adv   | Aeolian          |
| 18   | DIPTERA    | Calliphoridae  | <i>Calliphora vomitoria</i> (Linnaeus, 1758)        | adv   | Aeolian          |
| 19   | DIPTERA    | Calliphoridae  | <i>Chrysomya megacephala</i> (Fabricius, 1794)      | adv   | Aeolian          |
| 20   | DIPTERA    | Calliphoridae  | <i>Lucilia sericata</i> (Meigen, 1826)              | adv   | Aeolian          |
| 21   | DIPTERA    | Calliphoridae  | ?Genus ?species                                     | adv   | Aeolian          |
| 22   | DIPTERA    | Chironomidae   | <i>Chironomus</i> sp.                               | unk   | Aeolian          |
| 23   | DIPTERA    | Ephydriidae    | <i>Brachydeutera hebes</i> Cresson, 1926            | end   | Aeolian          |
| 24   | DIPTERA    | Ephydriidae    | <i>Hydrellia tritici</i> Coquillett, 1903           | adv   | Aeolian          |
| 25   | DIPTERA    | Ephydriidae    | ?Genus ?species                                     | unk   | Aeolian          |
| 26   | DIPTERA    | Lonchopteridae | <i>Lonchoptera furcata</i> (Fallen, 1823)           | adv   | Aeolian          |
| 27   | DIPTERA    | Muscidae       | <i>Atherigona orientalis</i> Schiner, 1868          | adv   | Aeolian          |
| 28   | DIPTERA    | Muscidae       | <i>Haematobia irritans</i> (Linnaeus, 1758)         | adv   | Aeolian          |
| 29   | DIPTERA    | Muscidae       | several species                                     | unk   | Aeolian          |
| 30   | DIPTERA    | Oestridae      | <i>Hypoderma bovis</i> (Linnaeus, 1758)             | adv   | Aeolian          |
| 31   | DIPTERA    | Phoridae       | several species                                     | unk   | Aeolian          |
| 32   | DIPTERA    | Sphaeroceridae | <i>Leptocera</i> sp.                                | adv   | Aeolian          |
| 33   | DIPTERA    | Sarcophagidae  | several species                                     | unk   | Aeolian          |
| 34   | DIPTERA    | Sciaridae      | ? <i>Bradysia</i> sp.                               | unk   | Aeolian          |
| 35   | DIPTERA    | Sciaridae      | several species                                     | unk   | Aeolian          |
| 36   | DIPTERA    | Sepsidae       | <i>Sepsis biflexuosa biflexuosa</i> Strobl, 1893    | adv   | Aeolian          |
| 37   | DIPTERA    | Sepsidae       | <i>Sepsis thoracica</i> (Robineau-Desvoidy, 1830)   | adv   | Aeolian          |
| 38   | DIPTERA    | Sphaeroceridae | several species                                     | unk   | Aeolian          |

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| Taxa | Order        | Family           | Genus-Species-Author                                 | Biogeographic Status: (end/ind adv/pur/unk) | Resident/Aeolian     |
|------|--------------|------------------|--|---|----------------------|
| 39   | DIPTERA      | Syrphidae        | <i>Toxomerus marginatus</i> (Say, 1823)              | adv   | Aeolian              |
| 40   | DIPTERA      | Tachinidae       | several species                                      | adv   | Aeolian              |
| 41   | DIPTERA      | Tephritidae      | <i>Ensina sonchi</i> Linnaeus, 1767)                 | adv   | Aeolian              |
| 42   | DIPTERA      | Nematocera       | indet Fam.   | unk   | Aeolian              |
| 43   | DIPTERA      | Unknown          | early instar larvae                                  | unk   | Aeolian              |
| 44   | HETEROPTERA  | Lygaeidae        | <i>Geocoris pallens</i> Stål, 1854                   | adv   | Aeolian              |
| 45   | HETEROPTERA  | Lygaeidae        | <i>Nysius</i> sp.                                    | end?  | Resident             |
| 46   | HETEROPTERA  | Miridae          | <i>Coridromius variegates</i> (Montrouzier, 1861)    | adv   | Resident on 'aweoweo |
| 47   | HETEROPTERA  | Miridae          | <i>Spanagonicus albofasciatus</i> (Reuter, 1907)     | adv   | Aeolian              |
| 48   | HETEROPTERA  | Nabidae          | <i>Nabis capsiformis</i> Germar, 1837                | adv   | Aeolian              |
| 49   | HOMOPTERA    | Aphididae        | <i>Aphis gossypii</i> Glover, 1877                   | adv   | Aeolian              |
| 50   | HOMOPTERA    | Aphididae        | ? <i>Aphis</i> sp.                                   | adv   | Aeolian              |
| 51   | HOMOPTERA    | Psyllidae        | ? <i>Triozia</i> sp.                                 | end   | Aeolian              |
| 52   | HYMENOPTERA  | Braconidae       | <i>Apanteles</i> sp.                                 | adv   | Aeolian              |
| 53   | HYMENOPTERA  | Braconidae       | <i>Ontsira pallaiatus</i> (Cameron, 1881)            | adv   | Aeolian              |
| 54   | HYMENOPTERA  | Chalcididae      | <i>Brachymeria obscurata</i> (Walker, 1874)          | pur   | Aeolian              |
| 55   | HYMENOPTERA  | Chalcidoidea     | several species                                      | unk   | Aeolian              |
| 56   | HYMENOPTERA  | Colletidae       | <i>Hylaeus</i> sp.                                   | end   | Resident             |
| 57   | HYMENOPTERA  | Eurytomidae      | <i>Eurytoma</i> sp.                                  | adv   | Aeolian              |
| 58   | HYMENOPTERA  | Ichneumonidae    | <i>Diadegma blackburni</i> (Cameron, 1883)           | adv   | Aeolian              |
| 59   | HYMENOPTERA  | Ichneumonidae    | <i>Ichneumon cupitus</i> Cresson, 1877               | adv   | Aeolian              |
| 60   | HYMENOPTERA  | Ichneumonidae    | <i>Ichneumon laetus</i> Brulle, 1846                 | pur   | Aeolian              |
| 61   | HYMENOPTERA  | Ichneumonidae    | ?Genus ?species                                      | unk   | Aeolian              |
| 62   | HYMENOPTERA  | Megachilidae     | <i>Megachile timberlakei</i> Cockerell, 1920         | adv   | Aeolian              |
| 63   | HYMEOPTERA   | Pompillidae      | <i>Anoplius toluca</i> (Cameron, 1893)               | adv   | Aeolian              |
| 64   | HYMENOPTERA  | Proctotrupeoidea | ?Genus ?species                                      | adv   | Aeolian              |
| 65   | HYMENOPTERA  | Scelionidae      | <i>Scelio pembedtoni</i> Timberlake, 1932            | pur   | Aeolian              |
| 66   | HYMENOPTERA  | Scelionidae      | ?Genus ?species                                      | pur?  | Aeolian              |
| 67   | HYMENOPTERA  | Sphecidae        | <i>Pison hospes</i> R. Smith, 1879                   | adv   | Aeolian              |
| 68   | LEPIDOPTERA  | Oecophoridae     | <i>Thyrocopa kikaelekea</i> Medeiros, 2008           | end   | Resident             |
| 69   | LEPIDOPTERA  | Pterophoridae    | nr. <i>Anstenoptilia marmorodactyla</i> (Dyar, 1902) | adv   | Aeolian              |
| 70   | LEPIDOPTERA  | Noctuidae        | <i>Agrotis</i> sp.                                   | end   | Resident             |
| 71   | LEPIDOPTERA  | Tortricidae      | <i>Amorbia emigratella</i> Busck, 1910               | adv   | Aeolian              |
| 72   | PSOCOPTERA   | Ectopsocidae     | <i>Ectopsocus perkinsi</i> Banks, 1931               | adv   | Aeolian              |
| 73   | PSOCOPTERA   | Ectopsocidae     | <i>Ectopsocus</i> sp.                                | adv   | Aeolian              |
| 74   | PSOCOPTERA   | Ectopsocidae     | Indet sp. wingless immature                          | adv   | Resident             |
| 75   | THYSANOPTERA | Phlaeothripidae  | ?Genus ?species                                      | adv   | Aeolian              |
| 76   | THYSANOPTERA | Thripidae        | <i>Frankliniella</i> sp.                             | adv   | Aeolian              |
| 77   | THYSANOPTERA | unknown          | ?Genus ?species                                      | unk   | Aeolian              |