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Technical Report 148

INVENTORY OF ARTHROPODS OF THE WEST SLOPE SHRUBLAND AND ALPINE ECOSYSTEMS OF HALEAKALA NATIONAL PARK

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INTRODUCTION

Subalpine shrubland and alpine aeolian ecosystems occur in Hawaii on the upper portions of Mauna Kea, Mauna Loa, Hualalai and Haleakala volcanoes on the islands of Hawaii and Maui. These high elevation ecosystems make up a relatively small percentage of the total land area in the state, but because most of them remain fairly intact, they represent important habitats for native species. In particular, they serve as home to a number of unique and highly adapted arthropod species that occur nowhere else (Loope and Medeiros 1994).

On Maui, shrubland and alpine ecosystems occur in and around Haleakala National Park (HALE) on the mountain's upper west slope, upper south slope, and within the crater (actually a large erosional depression). They form core protected habitats for the park, being not only the most visible and identifiable components for HALE visitors, but also serving as central foci for the park's mission to preserve native biodiversity. A critical prerequisite of effective resource management in these areas is knowledge of their biological diversity, both native and introduced. The arthropod fauna of these areas has been studied on numerous occasions, beginning with collections by Blackburn and Perkins in the late 18^{th} century (Blackburn and Sharp 1885, Liebherr and Polhemus 1997), and including a relatively exhaustive inventory in the mid- 1970's (Beardsley 1980). These and other collections have ensured that the endemic arthropod fauna in HALE's subalpine shrubland and alpine aeolian zones is relatively well known. While new endemic species continue to be found, the fauna in well-studied taxonomic groups is probably relatively complete (but poorly-studied groups are likely to yield considerable numbers of new species when specialists finally address them). In contrast, the introduced fauna continues to grow by virtue of continual new introductions, and repeated inventories (i.e. monitoring) are the only way to measure the rate of this growth and to make early detections of particularly destructive species.

The shrublands and alpine habitats on Haleakala's upper west slope and summit are the most accessible, both to study by researchers and to anthropogenic source pools of introduced species. This portion of the mountain houses the park headquarters, service area and park road – which provides vehicular access to visitor centers, overlooks and the scientific observatories at the summit. Thousands of visitors, staff and others use this road each day, making it a likely route of entry into the park for many introduced arthropod species. Compared to other flanks of the mountain, the upper west slope is also the most directly exposed to major areas of development below. We conducted an inventory of arthropods in this area using three systematic sampling techniques in two elevational zones, supplemented by limited opportunistic hand collecting. This report catalogues all arthropod species collected in the course of the inventory, and when possible, provides additional information relevant to the species listed. We assess inventory completeness and the relative effectiveness of the different sampling techniques. We also make limited comparisons between our inventory, which took place between 2001 and 2004, and the most recent similar effort, conducted in 1975 to 1977 (Beardsley 1980).

METHODS

Study area

The west slope of Haleakala, from the park entrance at 2050 m to the summit at 3055 m, includes strong gradients in both elevation and rainfall. Mean annual rainfall ranges from less than 1000 mm near the summit to approximately 1750 mm in the vicinity of Hosmer Grove campground near the park entrance (Giambelluca et al. 1986). Mean annual air temperature at park headquarters, at 2120 m elevation, is 12.4º C, and drops to 8.7º C at the summit (Halenet 2003). These gradients combine to form a variety of microhabitats and transition zones.

Elevations from 2050 m to approximately 2300 m often sit within the clouds of the inversion layer, and consequently enjoy higher precipitation in the form of rainfall and fog. These areas support subalpine shrubland of varying density; more windward shrublands near Hosmer Grove and Waikamoi Preserve have denser shrub cover, with nearly complete vegetative groundcover; as one progresses leeward toward the southern flank of the mountain, precipitation decreases, the shrubland becomes less dense and vegetative groundcover thins dramatically. The dominant shrub species in this elevational zone are *Styphelia tameiameiae* (Cham. & Schlechtend.), *Sophora chrysophylla* (Salisb.), *Vaccinium reticulatum* (Sm.), *Dubautia menziesii* (A. Gray), *Dodonea viscosa* Jacq. and *Coprosma montana* Hillebr. Additional overstory plants include *Santalum haleakalae* Hillebr. and the occasional *Metrosiderus polymorpha* Gaud. Common groundcover plants include the introduced grasses *Holcus lanatus* L. and *Anthoxanthum odoratum* L., native grasses *Deschampsia nubigena* Hillebr. and *Agrostis sandwicensis* Hillebr., native sedges *Carex wahuensis* C.A. Mey and *Carex macloviana* Dum. d'Urv., the indigenous bracken fern *Pteridium aquilinum* (L.) Kuhn, plus numerous additional native and introduced herbs.

Above the inversion layer, from roughly 2300 m elevation to the summit, clearer and drier air tends to predominate. As a result of the decreasing moisture and temperature, the shrubland thins and transitions to alpine habitat. Shrubs become stunted and increasingly sparse, and groundcover thins from regular clumps of bunchgrass and herbs to mostly bare expanses of cinder and rock with the occasional grass, sedge, rush, fern or other small herb. Dominant shrub species in these areas are *S. tameiameiae*, *D. menziesii*, *V. reticulatum*, and less commonly as elevation increases, *S. chrysophylla*. Groundcover plants include *D. nubigena*, the endemic rush *Luzula hawaiiensis* Buchenau, the endemic aster *Tetramalopium humile* (A. Gray) Hillebr., and other native and introduced ferns and herbs.

Sampling

We conducted standardized arthropod sampling in two elevational zones on the west slope and crater rim of Haleakala volcano, within Haleakala National Park. These zones roughly spanned elevations of 2250 to 2450 m and 2675 to 2875 m (Fig. 1). The lower elevation zone was situated entirely within subalpine shrubland, but included a range of wetter and drier areas that varied in their degree of vegetative cover, while the upper zone was situated on or near the crater rim in an area of transition from open shrubland with some grass cover to largely bare cinder and rock terrain with sparse shrubs and herbs. These two areas are referred to as the lower and upper zones in this report.

Most sampling occurred within 5 m by 5 m plots (Fig. 1). Twenty four plots were initially established in each elevational zone, in an approximately random fashion. Sixteen of these plots in each zone were situated within Argentine ant (*Linepithema humile* [Mayr]) infested habitat, whereas eight plots were in nearby habitat uninvaded by Argentine ants. To maintain an equal number of plots outside of Argentine ant infested habitat in each year, some of these plots had to be moved between years as the ant population boundaries advanced, and Figure 1 therefore shows more than 24 total plot locations in each zone. In each plot, we conducted pitfall sampling, litter extraction and shrub beating. We installed three pitfall traps in each plot (300 ml [10 oz], 80 mm diameter cups; 50:50 propylene glycol:water solution as preservative), spaced at least 2 m apart, and left open for two weeks. One pitfall in each plot was baited around the rim with blended fish (monamon) while the other two were unbaited. We also collected leaf litter from three areas in each plot, mixed it together and removed one liter; this was placed in a Berlese funnel for 24 hours (we previously determined that 99% of the leaf litter catch exited the litter within the first 24 hours). Finally, shrub vegetation within each plot was beaten between 1000 and 1600 h. Each focal shrub species received five beats (spread among multiple individuals of each species within each plot, if possible) onto a 1 m^2 nylon beating sheet, from which we aspirated all arthropods. Focal shrub species were *S. chrysophylla, D. menziesii, V. reticulatum* and *S. tameiameiae* in the lower zone, and *S. tameiameiae* and *D. menziesii* in the upper zone.

Sampling periods for these 5 m by 5 m plots were as follows: 17 September-1 October 2002 for lower zone plots, 18 September-2 October 2002 for upper zone plots; 6-20 July 2003 for lower zone plots, 14-28 June 2003 for upper zone plots; 10-24 July 2004 for lower zone plots, 13-27 June 2004 for upper zone plots.

Samples from a total of 48 plots were collected during 2002, 48 plots during 2003, and 24 plots during 2004. These samples were sorted to varying degrees in different years. Samples in 2003 were completely sorted and all arthropods were identified (according to limitations described below); however the number of plots for which samples were sorted varied among sampling techniques – all 48 plots for vegetation beating samples, 40 plots for pitfall trap samples and 24 plots for litter extraction samples. Samples in 2002 and 2004 were sorted with an emphasis on finding new or rare species, and the remaining arthropods were not counted.

In addition, we made 29 opportunistic hand collections from 2001 to 2004, spanning the area from the park service area to the summit (Fig. 1). These collections targeted apparently new or interesting species.

Identification

Arthropods in most taxonomic groups were identified to the level of species. We did not identify several groups beyond the level of family or order, however, either because the groups were difficult and had previously been treated by a specialist (parasitic Hymenoptera and Pseudococcidae; addressed in Beardsley [1980]), or because individuals were too numerous and taxonomically intractable (Acari). These unidentified arthropods were preserved and catalogued for future researchers.

All generic and species determinations were either made by a specialist, or by P. Krushelnycky (PDK). For all determinations made by PDK, original species descriptions and keys were consulted, or comparisons were made with reference material at the Bernice P. Bishop Museum, the University of Hawaii Insect Museum, the Hawaii Department of Agriculture collection, or the Haleakala National Park insect collection. Whenever possible, both original literature and reference material were consulted. Voucher specimens are deposited in the Bernice P. Bishop Museum, the Haleakala National Park Insect Collection, the Essig Museum of Entomology, and the University of Hawaii Insect Museum. Species presence and distribution data from this inventory will be entered into NPSpecies, the National Park Service Biodiversity database.

Richness estimation

The observed number of species in inventories of highly diverse taxonomic groups, such as arthropods, is almost always a serious underestimation of true species richness (Colwell and Coddington 1994, Chazdon et al. 1998, Brose et al. 2003, Walther and Moore 2005). Diverse communities typically contain many rare species, and some of these will inevitably be missed. As a consequence, a variety of statistical techniques have been developed or adapted to produce less biased estimators of true species richness. These estimators include parametric, non-parametric and species accumulation curve-fitting techniques, all of which extrapolate richness estimates from species incidences or abundances in the inventory (Colwell and Coddington 1994).

Using the 2003 dataset only, for which samples were completely sorted and counted, we created species by sample abundance matrices for analysis. For estimation of total species richness as well as richness within subsets of species defined by native status, we pooled all samples collected in each plot, including all sampling techniques. Here we used only the 40 plots for which both vegetation beating and pitfall samples were sorted; 16 of these plots lacked litter extraction data, but this technique yielded the fewest species and the absence of these data is not likely to have overly distorted our results. For estimation of richness yielded by the different sampling techniques, we pooled all samples that used the same technique within each plot. Here we used all plots for which samples were sorted: 48 for vegetation beating, 40 for pitfall traps and 24 for litter extraction. For all analyses, we excluded taxa that were not identified to species or morphospecies (Acari, parasitic Hymenoptera and Pseudococcidae). We used the program EstimateS (Colwell 2005) to calculate species richness estimates. This program provides richness estimates using seven non-parametric methods as well as a curve-fitting method. To calculate the richness estimates and to produce smoothed taxon sampling curves, we set EstimateS to randomize sampling order 100 times and to sample without replacement.

RESULTS AND DISCUSSION

We collected a total of 60,146 individual arthropods in the course of this inventory. Of these, 11,086 (18.4%) were mites (Acari), mealybugs (Hemiptera: Pseudococcidae), or parasitic wasps (Hymenoptera), and were not further identified. The remaining arthropods represented a total of 257 taxa in 17 orders (Table 1, Appendix). For most of these taxa (203) it was possible to make species-level determinations; nearly all of the remainder were identified to the level of genus, but for a few taxa the genus and species remain undetermined. All taxa that were not identified to species (exclusive of the groups listed above) were separated into morphospecies. A database of all arthropods collected is retained by the Pacific Island Network of the National Park Service Inventory and Monitoring Program.

We believe that 81 of our taxa (31.5%) are new records for HALE, the majority representing introduced species (Table 1). Many of these are new records for Maui, and some are new state records (to be reported elsewhere). A minority of the new records are native species. Most new native species records represent range extensions, some represent new species that have arisen through taxonomic revision (or upcoming revision; these are all in the Hemiptera), and two are new species discovered during this inventory. The newly discovered native species are *Orthocladius* n. sp. (order Diptera, family Chironomidae) and *Campsicnemus* n. sp. (order Diptera, family Dolichopodidae). The endemic status of two additional new species discovered during this inventory, *Corynoptera* n. sp. (order Diptera, family Sciaridae) and *Liposcelis* n. sp. "kipukae" (order Psocoptera, family Liposcelidae), currently remains unclear.

The inventory benefitted substantially from sampling in the two different elevational zones. While the lower zone clearly supported more species, and samples collected in the lower zone yielded 80% of the total number of species captured, the remaining 20% of species were unique to the upper zone (Table 2). Sampling in the upper zone was more important for capturing additional endemic species as compared to introduced species: 27% of all endemic species captured occurred exclusively in the upper zone, while only 16% of all introduced species captured occurred exclusively in the upper zone (Table 2).

Species accumulation curves produced from the 2003 dataset indicate that this inventory was not complete – observed richness did not reach an asymptote for native species, introduced species, or species of unknown native status (Fig 2a). Nor did species accumulation plateau with any of the three sampling techniques employed (Fig. 2b). All of the richness estimators that were calculated showed sensitivity to sample size in at least half of all data subsets, and usually in all subsets. This characteristic makes it difficult to evaluate the accuracy of the different richness estimators (Fisher 1999, O'Hara 2005, Walther and Moore 2005). However, several of the non-parametric estimators have been found to most consistently produce the least biased estimates in other inventories (Brose et al. 2003, Walther and Moore 2005, but see O'Hara 2005), and are almost certainly more accurate than the observed richness totals. We therefore followed the guidelines of Brose et al. (2003), and used the second-order jackknife estimator of species richness (Table 3). These estimates suggest that the 2003 standardized sampling only captured about 62-66% of the species that are present in the study area and that are likely to be trapped with our chosen sampling methods.

Pitfall trapping was the most effective technique used (Fig. 2b). Baited pitfall traps accumulated species more quickly than unbaited traps (not shown), and each type of pitfall trap captured a number of species that were not caught with the other type. But because species accumulation had not yet begun to plateau, it is not clear how many of these unique captures were due to the presence or absence of bait, as opposed to simply resulting from the increase in trapping effort when both types of pitfall traps were considered. After pitfall trapping, vegetation beating was the second most effective collecting technique (Fig 2b). Importantly, these two techniques captured largely non-overlapping sets of species: 60.4% of species captured by pitfall traps were unique to this sampling technique, while 54.2% of species captured through vegetation beating were caught exclusively with this technique. In comparison, litter extraction was least effective at capturing many different species (Fig. 2b), and only 19.1% of leaf litter species were caught exclusively with this technique.

The species list for the upper west slope and summit areas of HALE would be substantially expanded by employing other sampling techniques, such as Malaise trapping and light trapping that target strong flying groups like Lepidoptera, and by employing vegetation sampling techniques on additional host plants, including additional shrub and tree species and herbaceous vegetation. A relatively low level of hand collecting during the study period, for example, added 15 species. Naturally, identification of the remaining groups that we were not able to address, particularly the mites, would also dramatically expand the species list. By way of comparison, an inventory of HALE's crater district conducted in the 1970's (Beardsley 1980) reported a total of 389 species. This earlier survey, while excluding non-insect arthropods, sampled at many sites throughout the crater and Kaupo Gap that represent habitat types different from the west slope and summit areas, used different sampling techniques (including light traps and malaise traps), sampled on different host plants, and included some historical records for the crater district that were not collected in the course of the survey.

It is clear that introduced species continue to arrive and establish in the west slope shrubland and alpine zone of HALE, but the rate at which this is occurring is currently difficult to estimate. For well studied groups such as the beetles (Coleoptera), bugs (Hemiptera) and flies (Diptera), our new species records probably mostly represent relatively recent arrivals to the park. In contrast, other groups that had many new introduced species records in our inventory, such as spiders (Araneae), springtails (Collembola), barklice (Psocoptera) and thrips (Thysanoptera), have previously been treated much less thoroughly. New records in these groups probably include many species that had been present at the time of earlier surveys but were simply not targeted or identified.

Taken at face value, the chosen richness estimates for the 2003 dataset imply that the west slope shrubland and aeolian zone arthropod community is composed of about 53% introduced species and 40% native species (plus about 6% species of unknown status). In the 1970's, Beardsley (1980) found an insect fauna represented by only 40% introduced species and 60% native species. A comparison of these two statistics could provide a rough quantification of the changes in the park's arthropod fauna during the intervening years, but this is likely to be fairly inaccurate for several reasons. First, because there were many more individuals of introduced species captured than individuals of native species in the present inventory, the native species sampling curve rose much more steeply than the introduced species curve when plotted as a function of individuals captured instead of samples collected (not shown). It is therefore possible that additional sampling would have resulted in a higher native to introduced species ratio. Second, the large differences between our inventory and that of Beardsley's make quantitative comparisons regarding species composition and change inappropriate. If we had sampled on more kinds of native plants, for instance, we would likely have increased the number of host-specific native species to a much greater degree than introduced species, which tend to be generalists. Similarly, if we had sampled in wetter and more remote habitats, as Beardsley did, we may have obtained a higher native to introduced species ratio. Also, the use of different sampling techniques, as well as differences in the availability of taxonomists and systematists, means that the two surveys were able to focus to some degree on different arthropod groups. Discrepancies in the proportion of native to introduced species in these different groups would also affect the overall makeup of the surveyed fauna. A final difference between the two inventories was the relative influence of the Argentine ant. By excluding many endemic species and benefiting a number of introduced species, Argentine ant invasion results in a higher proportion of introduced species in the overall arthropod community (Krushelnycky 2007). Because our inventory had many sampling points located within Argentine ant invaded habitat, while Beardsley only had a few collections within habitat invaded by Argentine ants (which were much more localized at the time), our inventory inevitably produced a community composition more biased towards introduced species. As the Argentine ant continues to spread in the west slope shrubland, towards the summit and into the crater (Krushelnycky et al. 2005b), native richness will likely decline and community dominance by introduced species will likely increase in these areas of the park.

A strength of our inventory lies in its inclusion of a standardized and quantitative component (i.e. all of the non-hand collected samples). While species lists can often be efficiently lengthened with haphazard or general collecting techniques, and these techniques should therefore also be included, it is difficult to construct robust species accumulation curves from haphazard methods alone. Without species accumulation curves, or the underlying standardized sampling data, it is difficult to estimate true species richness, estimate inventory completeness, or make comparisons between inventories (Gotelli and Colwell 2001). In addition, our analysis of the standardized sampling techniques used in the present inventory should provide useful information for managers wishing to develop monitoring protocols for arthropod communities in Hawaiian shrubland and alpine habitats.

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Table 1. Summary of captures organized by arthropod orders.

Order	# Native taxa	# Introduced taxa	# taxa unk. origin	**Total # taxa**	# Native new records	# Introduced new records	# New records unk. origin	**Total # new records**
Araneae	9	18	6	**33**	0	12	4	**16**
Collembola	4	9	1	**14**	2	5	0	**7**
Archaeognatha	1	0	0	**1**	0	0	0	**0**
Coleoptera	12	29	2	**43**	0	6	0	**6**
Dermaptera	0	1	0	**1**	0	0	0	**0**
Diptera	19	15	5	**39**	7	3	2	**12**
Hemiptera	25	23	0	**48**	6	4	0	**10**
Hymenoptera	4	8	0	**12**	0	1	0	**1**
Lepidoptera	12	3	0	**15**	0	0	0	**0**
Neuroptera	3	2	0	**5**	1	0	0	**1**
Psocoptera	7	10	0	**17**	0	9	0	**9**
Siphonaptera	0	1	0	**1**	0	0	0	**0**
Thysanoptera	4	17	1	**22**	3	12	0	**15**
Isopoda	0	1	0	**1**	0	1	0	**1**
Lithobiomorpha	0	2	0	**2**	0	2	0	**2**
Cambalida	1	0	0	**1**	0	0	0	**0**
Julida	0	2	0	**2**	0	1	0	**1**
TOTALS	**101**	**141**	**15**	**257**	**19**	**56**	**6**	**81**

Table 2. Number of species captured in each elevational zone, and number of species unique to each elevational zone. Species collected opportunistically are excluded.

a)	**Number of species captured**[1]		
zone	native	introduced	total
lower	71 (73%)	108 (84%)	192 (80%)
upper	57 (59%)	71 (55%)	133 (55%)
both	97	128	240

b)	**Number of unique species**[2]		
zone	native	introduced	total
lower	40 (41%)	57 (45%)	107 (45%)
upper	26 (27%)	20 (16%)	48 (20%)

[1]Percentages in parentheses indicate the degree to which species captured in each elevational zone contribute to the total number of species captured in both zones for each category.
[2]Percentages in parentheses indicate the degree to which unique species captured in each elevational zone contribute to the total number of species captured in both zones for each category.

Table 3. Observed and estimated richness of the 2003 standardized sampling dataset.

	Observed[1] richness	Estimated[2] richness
Native species	87	139.3
Introduced species	122	184.2
Species of unknown origin	12	22.6
All species	221	345.1
Pitfall traps	159	256.1
Vegetation beating	96	155.4
Litter extraction	47	70.0

[1]Total number of species collected in the 2003 sampling protocol
[2]Mean estimated true richness of the 2003 dataset using the second-order jackknife estimator in EstimateS (Colwell 2005)

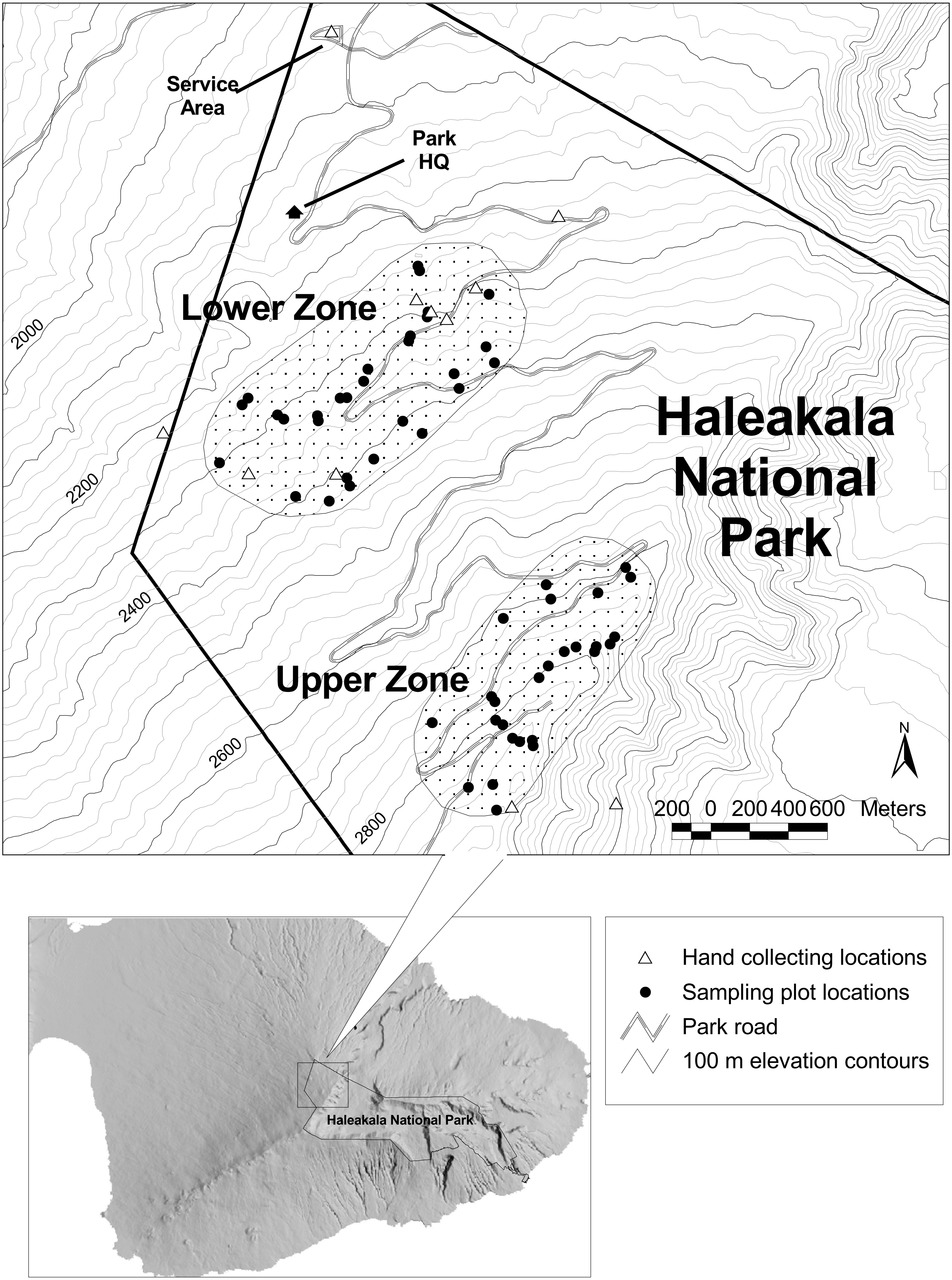

Figure 1. Sampling localities.

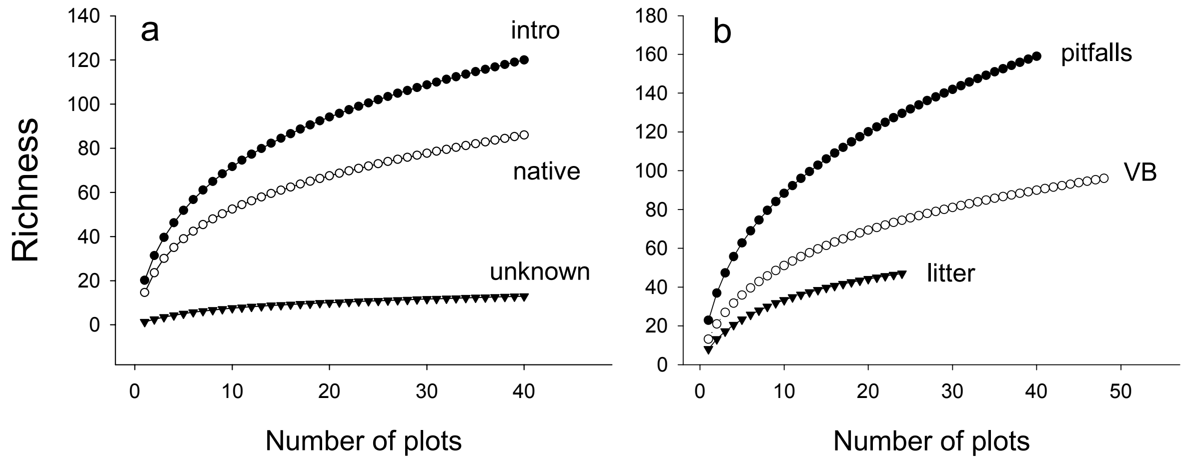

Figure 2. Species accumulation curves, scaled to number of plots sampled, for subsets of the 2003 dataset. a) sampling curves for all introduced species (intro), all native species (native) and all species of unknown origin (unknown). b) sampling curves for each of the three sampling techniques employed – pitfall sampling (pitfalls), vegetation beating (VB) and litter extraction (litter).

APPENDIX. Annotated list of all arthropod taxa collected.

The following list includes only taxa captured during the course of this inventory. We exclude species collected outside the study period or study area, as defined in the Methods. For each taxon record, we specify its native status (* before the genus name indicates an introduced species, + indicates a species of unknown origin, while no symbol indicates an endemic species; a ? indicates that the generic determination is uncertain); we list the authority that made the determination (e.g., det. PDK); and we indicate whether it represents a new record for the park. While we did not undertake an exhaustive literature search, we believe these new records are valid based on the collections consulted and the literature examined. In cases where we found specimens previously collected at HALE in museum collections, we do not list those species as new records here even if we could find no published record of its prior collection (including cases where the species was not recorded from Maui in Nishida [2002]).

For all taxa collected through standardized methods, we also list the area(s) in which it was collected (lower or upper zone), its relative abundance, and the technique(s) with which it was captured (PF = pitfall traps, LE = litter extraction with Berlese funnel, VB = vegetation beating of focal shrub species [stytam = *Styphelia tameiameiae*, sopchr = *Sophora chrysophylla*, vacret = *Vaccinium reticulatum*, dubmen = *Dubautia menziesii*]). For taxa captured through hand collecting only, we report the location of capture.

Relative abundance categories are rare (individuals captured < 5), uncommon (5 < individuals captured < 15), common (15 < individuals captured < 100), and abundant (100 < individuals captured). In addition, we list the collection methods in order of decreasing number of individuals captured for each species. Where multiple plant species are listed for vegetation beating, these are also listed in order of decreasing captures. When greater than approximately 90% of individuals were caught on a single plant species, suggesting host status, this plant (or in some cases combination of plants) is underlined. *It is important to note that these abundance designations are based exclusively on our captures in this study*; while our collection methods were quantitative, they may be biased against certain species. For example, species for which we did not sample the correct host plant, or which are more abundant at other times of year, or which are not efficiently captured with our sampling methods may all be more common than indicated from our results.

Current validity of taxonomic names and their authors follows those listed in the Integrated Taxonomic Information System (http://www.itis.usda.gov/index.html), Platnick (2006) or Nishida (2002). We provide synonyms only where names have changed recently, for example since Nishida (2002). Finally, authorities who made determinations are as follows: JB = J. Beatty, KC = K. Christiansen, GE = G. Edgecombe, NE = N. Evenhuis, CPE = C.P. Ewing, VF = V. Framenau, JG = J. Garb, RG = R. Gillespie, JH = J. Heinze, PDK = P. Krushelnycky, BK = B. Kumashiro, JKL = J.K. Liebherr, KM = K. Magnacca, SM = S. Marshall, JM = J. Miller, EM = E. Mockford, SN = S. Nakahara, DAP = D.A. Polhemus, DP = D. Pollock, ASR = A.S. Ramsdale, GAS = G.A. Samuelson, BS = B. Seifert, RS = R. Shelley, CT = C. Tauber, MT = M. Tremblay, PV = P. Vilkamaa and MZ = M. Zapparoli.

PHYLUM ARTHROPODA

CLASS ARACHNIDA

Order Acari (mites)

We collected over 10,200 individual Acari, belonging to many morphospecies. It was beyond the scope of our inventory to tackle this difficult taxonomic group, which probably contains many new species.

Order Araneae (spiders)

Family Agelenidae

*Tegenaria domestica (Clerck, 1757) det. PDK
hand collecting; park service area, in laundry room and other buildings
This species has also been collected at Paliku cabin (Roth and Nishida 1997).

Family Araneidae

*Gasteracantha mammosa L. Koch, 1844 det. PDK
hand collecting; park service area, from web on outside of building

Family Corinnidae

*Meriola arcifera (Simon, 1886) det: JB
lower and upper zones; uncommon; PF
NEW HALE RECORD

Family Desidae

*Badumna longinqua (L. Koch, 1867) det. PDK
hand collecting; west slope shrubland, on *Coprosma montana*; park service area, in laundry room
NEW HALE RECORD

Family Dysderidae

*Dysdera crocata C.L. Koch, 1838 det: PDK

lower and upper zones; common; PF

Family Gnaphosidae

*Urozelotes rusticus (L. Koch, 1872) det. PDK

lower zone; rare; PF

This is the first record of this species for the west slope or crater district. The only prior HALE record is from lower Kipahulu Valley, near the coast. This spider is extremely abundant on Mauna Kea, and in the future could become an important introduced predator in HALE shrubland ecosystems.

Family Linyphiidae

+Centromerus sp. 1 det. JM

lower zone; rare; PF

NEW HALE RECORD

This and the following two *Centromerus* species may be new endemic species.

+Centromerus sp. 2 det. JM

lower zone; rare; PF

NEW HALE RECORD

This species also occurs in the Kipuka Puu Huluhulu area of Hawaii Island. In addition, Bishop Museum holdings include unidentified specimens of this species from Poli Poli State Park, Maui, and from Hawaii Volcanoes National Park at Kipuka Ki, Mauna Loa.

+Centromerus sp. 3 det. PDK

upper zone; rare; PF

Although not previously identified or reported in the state, Bishop Museum holdings include two specimens that appear to be this species, collected from HALE, “ridge E. of Kipahulu Valley, 6100 ft, sifting moss on tree trunks” by W.C. Gagne on June 24, 1981; and from Poamoho Trail, Koolau Mtns., Oahu.

*Eperigone fradeorum (Berland, 1932) det. JM

upper zone; rare; PF

NEW HALE RECORD

*Erigone autumnalis Emerton, 1882 det: JM

lower and upper zones; uncommon; PF, LE

NEW HALE RECORD

*Erigone dentosa O.P.-Cambridge, 1894 det. JM

upper zone; rare; PF

NEW HALE RECORD

+?Meioneta sp. det. JM

lower zone; common; VB stytam

NEW HALE RECORD

The identity of this species is still unknown, and it differs from the *Meioneta* sp. of Gertsch (1973). It is possible that it is a new species related to the endemic cave species, *Meioneta gagnei* Gertsch. It is strongly impacted by the invasive Argentine ant, with no specimens collected within the boundaries of ant populations.

*Nesioneta lepida Millidge, 1991 det. PDK

upper zone; rare; PF

NEW HALE RECORD

*Ostearius melanopygius (Cambridge, 1880) det: JB

lower and upper zones; common; PF

NEW HALE RECORD

This cosmopolitan species (Platnick 2006) is incorrectly listed as endemic in the Hawaiian Terrestrial Arthropod Checklist (Nishida 2002).

*Tenuiphantes tenuis (Blackwall, 1852) det: JB

lower and upper zones; abundant; PF, VB stytam sopchr

NEW HALE RECORD

+Linyphiidae sp. det. JM

lower and upper zones; uncommon; PF

Genus and species undetermined; this is probably a new state record. It appears to occur only where ants are absent.

Family Lycosidae

Lycosa sp. det: VF

lower and upper zones; abundant; PF

This endemic species has typically been refered to as *Lycosa hawaiiensis*, but is apparently extremely similar to or the same as *Lycosa oahuensis* Keyserling. The entire group, however, is in need of revision and the taxonomy is likely to change (V. Framenau pers. comm.).

Family Miturgidae

*Cheiracanthium mordax L. Koch, 1866 det: PDK

lower zone; common; VB dubmen sopchr stytam vacret

This species is extremely abundant on certain parts of Mauna Kea at similar elevations, and could become an important introduced predator at HALE in the future.

Family Oxyopidae

+Oxyopes sp. det: PDK
Lower zone; rare; VB stytam
NEW HALE RECORD

Family Philodromidae

Pagiopalus atomarius Simon, 1900 det: PDK
lower and upper zones; common; VB stytam dubmen vacret sopchr, PF, LE

Family Salticidae

*Habronattus tarsalis (Banks, 1904) det: JB
lower and upper zones; common; PF
NEW HALE RECORD
This common species may be an important introduced predator.

Havaika sp. det. PDK
(= Sandalodes)
hand collecting; west slope shrubland, foraging on ground

Family Tetragnathidae

Tetragnatha quasimodo Gillespie, 1991 det. RG
hand collecting; park service area, on outside of building

Tetragnatha sp. det. RG
hand collecting; west slope shrubland, adjacent to standing pool in gulch

Family Theridiidae

*Achaearanea acoreensis (Berland) det: JB
lower and upper zones; uncommon; PF
NEW HALE RECORD

*Achaearanea cf. riparia (Blackwall, 1834) det: JB
(= Achaearanea cf. saxatilis [C.L. Koch, 1834])
lower zone; abundant; VB stytam sopchr vacret dubmen, PF
NEW HALE RECORD
This species is common on Haleakala and extremely abundant on parts of Mauna Kea at similar elevations, and has been considered an invasive species (Gruner 2005). On the

other hand, its morphology suggests a Pacific faunal affinity, perhaps indicating that it could be native in Hawaii (M. Arnedo pers. comm.). Because it is a conspicuous species yet was not collected by Perkins (Simon 1900) or Suman (Suman 1964), was not reported in the state until 1999 (Beatty et al. 2000), and has no known related endemic species, we believe it is not native to Hawaii.

*<u>Steatoda</u> <u>grossa</u> (C.L. Koch, 1838) det. JB
lower and upper zones; abundant; PF
This large spider builds tangle webs beneath medium to large rocks, and may be an important introduced predator. It has been commonly collected in the park, but we could find no prior report of its presence in the literature.

<u>Theridion</u> <u>mauiense</u> Simon, 1900 det. PDK
lower zone; abundant; VB stytam, vacret, dubmen

*<u>Theridion</u> <u>melanostictum</u> Cambridge, 1876 det. PDK
lower zone; uncommon; VB stytam vacret, PF
NEW HALE RECORD

Family Thomisidae

<u>Misumenops</u> <u>kanakanus</u> (Karsch, 1880) det. JG
lower zone; abundant; VB stytam sopchr dubmen vacret, PF, LE

<u>Misumenops</u> sp. 1 det: JG
lower zone; rare; VB stytam
Only one immature specimen collected, but this species is likely to be *Misumenops anguliventris* (J. Garb pers. comm.).

<u>Misumenops</u> sp. 2 det: JG
lower and upper zones; uncommon; PF, LE
Unlike the other *Misumenops* species, this undetermined species was captured exclusively on the ground.

CLASS ENTOGNATHA

Order Collembola (springtails)

Family Entomobryidae

*Entomobrya atrocincta Schott, 1896 det: PDK
lower and upper zones; abundant; PF, LE
This very abundant introduced species is extremely difficult to differentiate from the endemic *Entomobrya nyhusae*. Some of our specimens may therefore represent *E. nyhusae*, however the latter species has not yet been reported from Maui.

Entomobrya kea Christiansen & Bellinger, 1992 det: KC
lower and upper zones; uncommon; PF
In addition to this species, our specimens may include the endemic *Entomobrya mauna*, which co-occurs with *E. kea* at high elevations and has been previously collected from upper Haleakala (Christiansen and Bellinger 1992).

*Entomobrya multifasciata (Tullberg, 1871) det. PDK
lower and upper zones; abundant; PF, LE
This distinctive species is the most ubiquitous and abundant springtail in the study area.

+Entomobrya sp. det. KC
lower zone; uncommon; PF, LE
Only immature specimens collected, however this species is probably the introduced *Entomobrya guthriei* (K. Christiansen pers. comm.), which has been previously collected from HALE (Christiansen and Bellinger 1992).

*Pseudosinella octopunctata Borner, 1901 det. PDK
lower and upper zones; common; PF, LE
NEW HALE RECORD

Family Hypogastruridae

Anurida anini Christiansen & Bellinger, 1992 det. KC
lower zone; rare; LE
NEW HALE RECORD

*Hypogastrura boletivora (Packard, 1873) det. PDK
lower zone; uncommon; PF
NEW HALE RECORD

*Neanura muscorum (Templeton, 1835) det. PDK
lower zone; uncommon; LE, PF
NEW HALE RECORD

Xenylla auka Christiansen & Bellinger, 1992 det. PDK
lower and upper zones; abundant; LE, PF
NEW HALE RECORD
One of the most ubiquitous and abundant endemic springtails in the study area.

Family Isotomidae

Anurophorus lohi Christiansen & Bellinger, 1992 det. PDK
lower and upper zones; abundant; LE, PF
One of the most ubiquitous and abundant endemic springtails in the study area.

*Cryptopygus benhami Christiansen & Bellinger, 1980 det. KC
lower zone; common; LE
NEW HALE RECORD

*Cryptopygus thermophilus (Axelson, 1900) det. PDK
lower zone; uncommon; LE

*Isotoma notabilis Schaffer, 1896 det. KC
lower zone; common; LE, PF
NEW HALE RECORD

Family Onychiuridae

*Tullbergia macrochaeta (Rusek, 1976) det. PDK
lower zone; abundant; LE

CLASS INSECTA

Order Archaeognatha

Family Machilidae

Neomachilis ?heteropus (Silvestri, 1904) det. PDK
upper zone; rare; PF
We captured only one female specimen from this rare group, making definitive species determination impossible (H. Sturm pers. comm.). *Neomachilis heteropus*, however, is

the only species currently known from Maui; Perkins reportedly collected this species at 5000 ft on Haleakala in 1896 (Sturm 1993).

Order Coleoptera (beetles)

Family Aglycyderidae

Proterhinus sp. det. PDK

upper zone; uncommon; VB dubmen

This endemic group is extremely speciose and difficult to identify. Our specimens may represent more than one species.

Family Apionidae

*Exapion ulicis (Forster, 1771) det. BK

lower zone; rare; VB sopchr, dubmen

We collected only two specimens of this intentionally introduced biocontrol agent, however it is presumably more abundant on its host plant, gorse (*Ulex europaeus*).

Family Carabidae

Blackburnia frigida (Blackburn, 1878) det. JKL

upper zone; uncommon; PF

Blackburnia lenta (Sharp, 1903) det. JKL

lower and upper zones; common; PF

Prior to our survey, this species was collected only once in 1975 at Halemau'u trailhead in addition to the original 5 specimens collected by Perkins in 1894. While this species is now relatively common on the west slope and crater rim area of HALE, its distribution in this locality is quite restricted, placing it at direct risk from expanding populations of Argentine ants (Krushelnycky et al. 2005a). It has recently been found by PDK on Kalapawili ridge on the north rim of the crater, however, revealing another population that is beyond the immediate reach of Argentine ants.

Blackburnia rupicola (Blackburn, 1878) det. JKL

upper zone; uncommon; PF

Mecyclothorax apicalis Sharp, 1903 det. JKL

lower zone; rare; PF

This species has been collected only rarely in recent years.

Mecyclothorax cordithorax Liebherr, 2005 det. JKL
lower and upper zones; common; PF, LE
Apparently rare in the study area in the late 19th and early 20th centuries (J. Liebherr pers.comm.), this species is now the most common native carabid on HALE's west slope.

Mecyclothorax micans (Blackburn, 1878) det. JKL
upper zone; rare; PF
Although we captured only 1 individual, this species has been collected more commonly in recent decades.

Mecyclothorax montivagus (Blackburn, 1878) det. JKL
lower and upper zones; rare; PF

Mecyclothorax rusticus Sharp, 1903 det. JKL
upper zone; rare, PF
Prior to our single collection here, this species had not been seen since 1896 (Krushelnycky et al. 2005a).

*Trechus obtusus Erichson det. JKL
lower and upper zones; abundant; PF, LE
This recently introduced beetle was first detected in 1998 at Hosmer Grove and has since been spreading across the mountain to at least Poli Poli State Park (Leibherr and Takumi 2002). It has also recently been detected in Koolau Gap and on Hanakauhi Peak. It is already the most abundant carabid species in HALE's west slope shrubland, appears to be increasing in abundance in some areas, is not negatively affected by Argentine ants at this time, and consequently may place significant competitive pressure on native *Mecyclothorax* species (Liebherr and Krushelnycky 2007).

Family Cerambycidae

Plagithmysus funebris Sharp, 1896 det. PDK
lower and upper zones; rare; PF
While we collected few specimens in our pitfall traps, this species is occasionally more common on its host plant, mamane (*Sophora chrysophylla*).

Plagithmysus ?swezeyanus Gressitt & Davis, 1971 det. PDK
upper zone; rare; VB dubmen

Family Chrysomelidae

*Altica carinata (Germar, 1824) det. PDK
upper zone; rare; VB stytam
NEW HALE RECORD
This species appears to be a recent introduction to the state. One specimen in the Bishop

Museum was collected from fresh strawberries in an Oahu grocery. It is possible that this species feeds on Kula strawberries and was carried up to HALE on the winds.

*Lema trilineata Olivier det. PDK
hand collecting; near summit, on *Dubautia menziesii*
NEW HALE RECORD

Family Coccinellidae

*Coccinella septempunctata Linnaeus, 1758 det. PDK
lower zone; rare; VB sopchr

*Diomus notescens (Blackburn, 1889) det. PDK
lower and upper zones; uncommon; VB vacret, dubmen

*Diomus sp. det. PDK
upper zone; uncommon; VB stytam
NEW HALE RECORD
The specific designation of this beetle remains undetermined in all state holdings examined.

*Hippodamia convergens Guerin-Meneville, 1844 det. PDK
lower and upper zones; common; VB stytam sopchr vacret, PF

*Hyperaspis fimbriolata Melsheimer, 1847 det. PDK
hand collecting; just inside crater rim, in leaf litter

*Olla v-nigrum Mulsant, 1866 det. PDK
lower and upper zones; uncommon; VB dubmen sopchr

*Rhyzobius forestieri (Mulsant, 1853) det. PDK
lower zone; rare; VB dubmen

*Rhyzobius lophanthae (Blaisdell, 1892) det. PDK
lower zone; common; VB vacret stytam dubmen

*Scymnus loewii Mulsant, 1850 det. PDK
lower zone; uncommon; VB stytam

Family Corylophidae

+Sericoderus ?pubipennis Sharp, 1885 det. PDK
lower zone; uncommon; PF

Family Cryptophagidae

*?Cryptophagus sp. det. ASR
lower and upper zones; rare; PF
NEW HALE RECORD

Family Curculionidae

*Listroderes costirostris Schonherr, 1826 det. PDK
(= Listroderes difficilis Germain, 1895)
lower zone; rare; PF
NEW HALE RECORD

Oodemas sp. det. PDK
lower and upper zones; uncommon; PF, LE
This endemic genus contains many species, and differentiating them is difficult. Our specimens may represent several species.

*Pantomorus cervinus (Boheman, 1840) det. PDK
(= Asynonychus godmanni Crotch, 1867)
lower zone; uncommon; VB sopchr dubmen
This phytophagous species can become much more abundant in similar habitats, for example on Mauna Kea. It feeds on a wide variety of species, especially *Sophora chrysophylla* and *Chenopodium oahuense*.

*Tychius picirostris (Fabricius, 1787) clover seed weevil det. GAS
lower zone; rare; VB stytam
NEW HALE RECORD

Family Dermestidae

*Dermestes frischi Kugelann, 1792 det. GAS
upper zone; rare; PF

Family Latridiidae

*Aridius nodifer (Westwood, 1839) det. GAS
lower and upper zones; uncommon; PF

Family Mycetophagidae

*Litargus balteatus Le Conte, 1856 det. PDK
lower and upper zones; rare; PF, VB stytam

*Typhaea stercorea (Linnaeus, 1758) det. PDK
lower and upper zones; rare; PF

Family Nitidulidae

*Carpophilus hemipterus (Linnaeus, 1758) driedfruit beetle det. CPE
lower zone; uncommon; PF

*Carpophilus humeralis (Fabricius, 1798) det. CPE
lower zone; uncommon; PF

Family Scarabaeidae

*Onthophagus nigriventris D'Orbigny, 1905 det. PDK
lower zone; rare; PF

Family Staphylinidae

*?Atheta sp. 1 det. PDK
lower zone; rare; PF

*?Atheta sp. 2 det. PDK
lower zone; uncommon; PF

+?Diestota sp. det. PDK
lower zone; rare; PF

*Philonthus sp. nr. discoideus (Gravenhorst, 1802) det. ASR
lower and upper zones; common; PF

*Tachyporus sp. det. ASR
upper zone; rare; PF
NEW HALE RECORD

*Hypocyphtini sp. det. PDK
upper zone; rare; PF
Genus and species undetermined.

Order Dermaptera (earwigs)

Family Forficulidae

*Forficula auricularia Linnaeus, 1758 det. PDK
lower and upper zones; common; PF

Order Diptera (flies)

Family Agromyzidae

+Phytoliriomyza montana Frick, 1953 det. PDK
upper zone; rare; VB stytam
Listed as endemic? in Nishida (2002).

Family Anthomyiidae

*Delia platura (Meigen, 1826) seedcorn maggot det. PDK
lower and upper zones; abundant; PF

Family Calliphoridae

Dyscritomyia grimshawi James, 1981 det. PDK
upper zone; rare; PF

*Eucalliphora latifrons (Hough, 1899) det. PDK
lower and upper zones; abundant; PF

*Pollenia rudis (Fabricius, 1794) det. PDK
lower zone; rare; PF

Family Cecidomyiidae

Lestremia sp. det. PDK
upper zone; rare; PF
Only a single female collected.

+Cecidomyiidae sp. det. PDK
upper zone; uncommon; PF
Genus and species undetermined. Only females collected.

Family Chamaemyiidae

*<u>Leucopis</u> <u>albipuncta</u> Zetterstedt, 1855 det. PDK
lower and upper zones; rare; VB dubmen, PF

Family Chironomidae

<u>Orthocladius</u> n. sp. det. KM
upper zone; rare; PF
NEW SPECIES
This species keys to *O. grimshawi* Hardy in Hardy (1960), but recent examination of the genus *Orthocladius* indicates that many undescribed species exist, including this one (K. Magnacca pers. comm.).

Family Dolichopodidae

<u>Campsicnemus</u> <u>macula</u> Parent, 1940 det. PDK
lower zone; rare; PF
NEW HALE RECORD

<u>Campsicnemus</u> <u>mediofloccus</u> Hardy & Kohn, 1964 det. PDK
lower zone; uncommon; PF

<u>Campsicnemus</u> n. sp. det. NE
lower and upper zones; common; PF
NEW SPECIES
This new endemic species awaits description.

Family Drosophilidae

*<u>Drosophila</u> sp. det. PDK
lower zone; rare; PF
A single female captured.

<u>Scaptomyza</u> <u>bryanti</u> Hackman, 1959 det. PDK
lower zone; rare; PF

<u>Scaptomyza</u> <u>cuspidata</u> Hardy, 1965 det. PDK
lower zone; rare; PF

Scaptomyza intricata Hardy, 1965 det. PDK
lower zone; rare; PF
NEW HALE RECORD

Family Heleomyzidae

*Tephrochlamys sp. det. PDK
lower zone; rare; PF
NEW HALE RECORD

Family Mycetophilidae

+Leia sp. det. NE
lower zone; rare; PF
NEW HALE RECORD

Family Phoridae

Megaselia sp. det. PDK
lower and upper zones; common; PF

Family Sarcophagidae

*Blaesoxipha plinthopyga (Wiedemann, 1830) det. PDK
lower and upper zones; common; PF

*Helicobia morionella (Aldrich, 1930) det. PDK
lower zone; rare; PF

*Ravinia anxia (Walker, 1849) det. PDK
lower and upper zones; uncommon; PF

Family Scatopsidae

*Coboldia fuscipes (Meigen, 1830) det. PDK
upper zone; rare; PF
NEW HALE RECORD

Family Sciaridae

*Bradysia sp. nr. impatiens (Johannsen, 1912) det. PV
lower and upper zones; uncommon; PF, VB stytam
NEW HALE RECORD

Bradysia molokaiensis (Grimshaw, 1901) det. PV
upper zone; uncommon; PF
NEW HALE RECORD

Bradysia setigera (Hardy, 1960) det. PV
upper zone; rare; PF

*Bradysia tritici (Coquillet, 1895) det. PDK
upper zone; rare; PF

+Corynoptera n. sp. det. PV
lower and upper zones; common; PF
NEW SPECIES
According to P. Vilkamaa, this represents a new species.

Ctenosciara hawaiiensis (Hardy, 1956) det. PV
upper zone; rare; PF

Hyperlasion magnisensoria (Hardy, 1956) det. PDK
lower zone; rare; PF
NEW HALE RECORD

+Sciaridae sp. det. PDK
lower zone; rare; PF
One wingless female specimen of undetermined genus and species was collected.

Family Sepsidae

*Sepsis thoracica (Robineau-Desvoidy, 1830) det. PDK
upper zone; rare; PF, VB stytam

Family Sphaeroceridae

Trachyopella hardyi (Tenorio, 1968) det. SM
lower zone; rare; PF
NEW HALE RECORD

Family Syrphidae

We captured only immature syrphids, which are common introduced predators of Hemiptera on various shrubs.

Family Tachinidae

*Chaetogaedia monticola (Bigot, 1887) det. PDK
lower zone; rare; PF

*Gonia longipulvilli Tothill, 1924 det. PDK
upper zone; rare; PF

Family Tephritidae

Trupanea cratericola (Grimshaw, 1901) det. PDK
upper zone; rare; PF

Trupanea limpidapex (Grimshaw, 1901) det. PDK
upper zone; rare; PF

Family Tipulidae

Limonia hawaiiensis (Grimshaw, 1901) det. PDK
upper zone; rare; PF

Limonia stygipennis (Alexander, 1919) det. PDK
lower zone; rare; PF

Order Hemiptera

Family Alydidae

*Alydus pilosus Herrich-Schaeffer, 1848 det. DAP
hand collecting; west slope shrubland, park service area; adult on *Sophora chrysophylla*, immature in grass
NEW HALE RECORD
Immatures of this species are ant mimics.

Family Anthocoridae

*Alofa sodalis (White, 1878) det. PDK
lower zone; rare; PF

Family Aphididae

*Aulacorthum solani (Kaltenbach, 1843) det. MT
lower zone; rare; VB dubmen

*Brachycaudus helichrysi (Kaltenbach, 1843) det. MT
lower and upper zones; common; PF, VB dubmen

*Ericaphis fimbriata (Richards) blueberry aphid det. MT
lower and upper zones; abundant; VB vacret stytam dubmen sopchr, PF
Although this aphid has not been previously reported for the state, it has been previously collected on Maui (M. Tremblay pers. comm.). It is now very abundant on *Vaccinium reticulatum*, especially in areas invaded by the Argentine ant.

*Illinoia azaleae (Mason, 1925) det. MT
lower and upper zones; abundant; VB vacret stytam dubmen sopchr, PF
This aphid is the second most abundant species on *Vaccinium reticulatum*, and is also more abundant in ant-invaded areas. It has been present for at least 30 years.

*Macrosiphum euphorbiae (Thomas, 1878) det. MT
lower zone; common; PF, VB dubmen sopchr stytam

*Sitobion fragariae (Walker, 1848) det. MT
lower and upper zones; common; PF, VB dubmen sopchr vacret stytam
Although this aphid has not been previously reported for the state, it has been previously collected on Maui (M. Tremblay pers. comm.).

Family Cercopidae

*Clastoptera xanthocephala Germar, 1839 det. PDK
lower and upper zones; uncommon; VB dubmen sopchr

Family Cicadellidae

*Graminella sonora (Ball, 1900) det. PDK
lower zone; rare; PF

Nesophrosyne haleakala Kirkaldy, 1910 det. PDK
lower and upper zones; uncommon; VB sopchr dubmen, PF

*Planiocephalus flavicosta (Stal, 1862) det. PDK
upper zone; rare; PF
NEW HALE RECORD

*Cicadellidae sp. det. DAP
lower zone; rare; PF
Genus and species undetermined.

Family Delphacidae

Emoloana sporobolicola (Kirkaldy, 1910) det. PDK
lower zone; rare; PF
As this species is a grass feeder, it was not targeted by our sampling methods and is likely more common than our results indicate.

Nesosydne osborni (Muir, 1916) det. PDK
lower and upper zones; abundant; VB dubmen sopchr, PF, LE
This species is extremely similar to *Nesosydne bridwelli* Muir 1919, and differs only in the shape of the aedegius. Zimmerman (1948) stated that the two forms may represent variation within a single species. We collected both forms, as well as individuals with intermediate morphology. Because of this non-discrete variation, we refer to them only as *N. osborni* here, the species with priority.

Nesosydne nigrinervis (Muir, 1919) det. PDK
lower and upper zones; abundant; VB stytam vacret dubmen, PF, LE

Nesosydne raillardiicola (Muir, 1919) det. PDK
lower and upper zones; abundant; VB dubmen sopchr vacret stytam

Family Lygaeidae

*Geocoris pallens Stal, 1854 det. PDK
upper zone; common; PF, VB stytam

*Graptostethus manillensis (Stal, 1859) det. PDK
upper zone; rare; PF

Nesius ochriasis baldwini Usinger, 1945 det. PDK
lower zone; uncommon; VB sopchr

Nysius abnormis Usinger, 1942 det. DAP
lower zone; uncommon; LE, VB stytam

Nysius beardsleyi Ashlock, 1966 det. DAP
lower zone; rare; VB sopchr vacret, PF, LE

Nysius coenosulus Stal, 1859 det. DAP
upper zone; rare; VB stytam

Nysius communis Usinger, 1942 det. DAP
lower and upper zones; common; VB dubmen sopchr stytam vacret

Nysius kinbergi Usinger, 1959 det. DAP
lower and upper zones; uncommon; VB stytam sopchr vacret dubmen

Nysius lichenicola Kirkaldy, 1910 det. DAP
lower and upper zones; common; PF, VB stytam dubmen

*Nysius palor Ashlock, 1963 det. DAP
upper zone; rare; VB stytam, PF
This introduced *Nysius* was first seen in the Northwest Hawaiian Islands and has recently spread to the main islands (D. Polhemus pers. comm.). Although it currently appears to be rare at HALE, it is extremely abundant in similar habitats and elevations on Mauna Kea. It may become more common at HALE in the future, competing with native *Nysius*.

Nysius rubescens White, 1881 det. DAP
lower; uncommon; VB vacret, PF

Nysius terrestris Usinger, 1942 det. DAP
lower and upper zones; uncommon; VB stytam vacret, LE

Family Margarodidae

*Icerya purchasi Maskell, 1878 cottony cushion scale det. PDK
hand collecting; west slope shrubland, on *Sophora chrysophylla*

Family Miridae

Engytatus hawaiiensis (Kirkaldy, 1902) det. PDK
lower and upper zones; abundant; VB dubmen, vacret

*Hyalopeplus pellucidus (Stal, 1859) det. PDK
hand collecting; west slope shrubland, on ground

Opuna n. sp. 1 det. DAP
lower and upper zones; abundant; VB stytam, sopchr, PF
NEW SPECIES
Many species of endemic *Opuna* remain to be described from dryland habitats, including this and the following three from HALE (D. Polhemus pers. comm.).

Opuna n. sp. 2 det. DAP
lower zone; uncommon; VB sopchr
NEW SPECIES

Opuna n. sp. 3 det. DAP
lower zone; rare; VB sopchr
NEW SPECIES
The host for this undescribed species is *Santalum haleakalae* (D. Polhemus pers. comm.).

Opuna n. sp. 4 det. DAP
lower zone; rare; VB sopchr
NEW SPECIES

Orthotylus coprosmophila Polhemus, 2005 det. DAP
hand collecting; west slope shrubland, on *Sophora chrysophylla*

Orthotylus sophoroides Polhemus, 2005 det. DAP
lower and upper zones; abundant; VB sopchr vacret dubmen

Sarona haleakala Asquith, 1994 det. PDK
lower zone; uncommon; VB dubmen

Family Nabidae

*Nabis capsiformis Germar, 1837 det. DAP
hand collecting; just inside crater rim, on ground

Nabis n. sp. (= "haleakala" Polhemus in manuscript) det. DAP
upper zone; rare; VB stytam, PF
NEW SPECIES

Nabis n. sp. (= "siban" Polhemus in manuscript) det. DAP
lower zone; rare; VB stytam
NEW SPECIES

Family Pentatomidae

Oechalia pacifica (Stal, 1859) det. PDK
hand collecting; west slope shrubland, on *Dubautia menziesii*

Family Pseudococcidae

Numerous pseudococcids were collected, especially on *Styphelia tameiameiae*, in pitfalls and from litter samples, but these were not identified beyond the level of family.

Family Psyllidae

*Acizzia uncatoides (Ferris & Kylver, 1932) koa psyllid det. PDK
lower and upper zones; common; VB stytam dubmen sopchr, PF

*Glycaspis brimblecombei Moore det. PDK
lower zone; rare; VB sopchr
NEW HALE RECORD
This Australian psyllid feeds on Eucalyptus and was first recorded in the state in 2001.

Family Reduviidae

*Empicoris rubromaculatus (Blackburn, 1888) det. PDK
lower zone; rare; PF

Family Rhyparochromidae

*Brentiscerus australis (Bergroth, 1916) det. DAP
lower and upper zones; uncommon; PF

Family Tingidae

*Corythuca morrilli Osborn & Drake, 1917 det. PDK
lower zone; rare; VB sopchr
NEW HALE RECORD

Order Hymenoptera (ants, wasps, bees)

Family Apidae

*Apis mellifera Linnaeus, 1758 honey bee det. PDK
upper zone; rare; PF
Although we captured only one individual, honey bees are relatively common in HALE.

Family Colletidae

Hylaeus nivicola Meade-Waldo, 1923 det. KM
upper zone; uncommon; PF
Our sampling techniques did not target this and other *Hylaeus* species; this species is relatively common.

Hylaeus volatilis (F. Smith, 1879) det. KM
upper zone; rare; PF

Family Formicidae

*Cardiocondyla kagutsuchi Terayama, 1999 det. BS & JH
hand collecting; west slope shrubland, various locations, from nests under rocks
This species was previously misidentified as the very similar *Cardiocondyla venustula* Wheeler. Both species occur in Hawaii, but so far all specimens from HALE have been identified as *C. kagutsuchi* (B. Seifert pers. comm. and P. Krushelnycky unpubl. data).

*Hypoponera opaciceps (Mayr, 1887) det. PDK
lower and upper zones; uncommon; PF
This species is widespread in the park, but forms small colonies and occurs in low numbers.

*Linepithema humile (Mayr, 1868) Argentine ant det. PDK
lower and upper zones; abundant; PF, VB vacret dubmen stytam sopchr, LE
Without question, the single greatest current threat to a variety of endemic arthropod species on upper Haleakala. This species was first reported from HALE in 1967, and has since spread to occupy over 600 ha of the park and adjacent Haleakala ranch. Its history of expansion strongly suggests that it will spread to the majority of the west slope and crater areas of the park, potentially infesting the entire ranges of some highly localized endemic species (Krushelnycky et al. 2005b).

*Strumigenys rogeri Emery, 1890 det. PDK
lower zone; rare; PF
NEW HALE RECORD?

Only a single specimen of this distinctive species was collected during this survey, and it has not been detected before or since during much extensive fieldwork related to the Argentine ant on the west slope of HALE. This species typically lives at lower elevations. It is possible (but fairly unlikely) that the specimen in question arrived via sample contamination, or (more likely) that a small colony existed ephemerally. The collection locality should be searched more exhaustively for more individuals.

Family Ichneumonidae

*Spilichneumon superbus (Provancher, 1886) det. PDK
upper zone; uncommon; PF

Family Pompilidae

*Anoplius toluca (Cameron, 1893) det. PDK
lower and upper zones; common; PF
This predator of spiders may be exerting substantial pressure on *Lycosa* and other native spiders.

Family Vespidae

Odynerus nubicola Perkins, 1899 det. PDK
upper zone; rare; PF
Our sampling techniques did not target this and other *Odynerus* species; this species is relatively common.

Odynerus sociabilis Perkins, 1899 det. PDK
upper zone; uncommon; PF
This species very similar to *O. molokaiensis*; our specimens may be *O. molokaiensis*.

*Vespula pensylvanica (Saussure, 1857) western yellowjacket det. PDK
lower zone; rare; PF
Although less abundant than in the past, this species is not rare – our sampling techniques did not target yellowjackets. *Vespula* are predators of a wide variety of arthropods (Gambino 1992), and are likely exerting substantial impacts on native species.

Parasitic Hymenoptera

We collected many additional species of micro-Hymenoptera, most of which are probably parasitoids, but these were not sorted below the level of order.

Order Lepidoptera (moths, butterflies and skimmers)

As we did not employ light traps as a sampling technique, all Lepidoptera in our survey were captured through ineffective methods (except for immatures of some species, as well as the ground active *Thyrocopa apatela*). Our abundance designations are therefore likely to be inaccurate. Moreover, since most were captured in pitfall traps, the specimens were badly damaged and difficult to identify to species.

Family Carposinidae

Carposina sp. det. DP
lower zone; uncommon; PF

Family Cosmopterigidae

Hyposmocoma sp. 1 det. PDK
lower zone; uncommon; PF, LE
This taxon identified from the immature, case-making caterpillars. It may correspond to one of the adult taxa listed below.

Hyposmocoma sp. 2 det. DP
lower and upper zones; common; PF, VB stytam

Hyposmocoma sp. 3 det. DP
lower zone; rare; PF

Hyposmocoma sp. 4 det. DP
lower and upper zones; rare; PF

Family Crambidae

Eudonia sp. det. DP
upper zone; common; PF

?Mestolobes sp. det. DP
lower zone; common; PF, VB stytam

?Orthomecyna sp. det. DP
lower and upper zones; common; PF

Uresiphita polygonalis virescens (Butler, 1881) det. PDK
lower zone; rare; VB sopchr
We collected only 2 caterpillars of this species, however it can be much more common on

Sophora chrysophylla at the peak of its season.

Family Lycaenidae

*Lampides boeticus (Linnaeus,1767) bean butterfly det. PDK
upper zone; rare; PF

Family Noctuidae

Agrotis sp. det. DP
lower zone; rare; PF
Although only one adult *Agrotis* was captured, immature noctuids were more common in pitfall traps, particularly in the upper zone. These caterpillars are most likely endemic *Agrotis* species.

*Pseudaletia unipuncta (Haworth, 1809) det. DP
lower zone; rare; PF

Family Oecophoridae

Thyrocopa apatela (Walsingham, 1907) det. PDK
lower and upper zones; common; PF
This flightless species has a distribution limited to the top of Haleakala. It has reduced wings and hops around the cinders and shrubland of the alpine and subalpine zones. It is very sensitive to Argentine ants, with nearly all individuals captured outside the boundaries of the ant populations.

Thyrocopa sp. det. DP
lower zone; rare; PF

Family Pterophoridae

*Pterophoridae sp. det. DP
lower and upper zones; rare; PF
Members of this group of introduced species are common in the shrubland and are active by day.

Order Neuroptera (lacewings, antlions)

Family Hemerobiidae

*Hemerobius pacificus Banks, 1897 det. CT
lower and upper zones; common; PF, VB stytam vacret dubmen

Micromus haleakalae (Perkins, 1899) det. CT
lower zone; rare; VB stytam

Micromus minimus (Perkins, 1899) det. CT
lower zone; rare; VB stytam dubmen
NEW HALE RECORD

Micromus vagus (Perkins, 1899) det. CT
lower zone; rare; VB vacret
Despite our few captures, this is one of the more commonly collected endemic *Micromus* species.

*Sympherobius barberi (Banks, 1903) det. CT
lower and upper zones; uncommon; VB stytam, PF

Order Psocoptera (psocids, barklice and booklice)

Family Ectopsocidae

*Ectopsocus californicus (Banks, 1903) det. EM
lower and upper zones; abundant; VB stytam vacret sopchr dubmen, PF, LE
NEW HALE RECORD

*Ectopsocus vachoni Badonnel, 1945 det. EM
lower and upper zones; abundant; LE, PF, VB stytam
NEW HALE RECORD
Extremely abundant in leaf litter.

Family Elipsocidae

*Elipsocus hyalinus (Stephens, 1836) det. EM
lower zone; uncommon; VB sopchr dubmen vacret
NEW HALE RECORD

Kilauella spp. det. EM

lower zone; abundant; VB stytam vacret dubmen sopchr

Four morphospecies were recognized and designated from our collections by E. Mockford, one of which is particularly abundant on *Styphelia tameiameiae*. Until this diverse and nearly untouched endemic genus is further studied, we refrain from referring to these taxa as new species. There can be little doubt, however, that many new species of *Kilauella* await description (Thornton 1990), including forms from HALE.

*Propsocus pulchripennis (Perkins, 1899) det. EM

lower and upper zones; uncommon; PF, VB stytam

Family Lachesillidae

*Lachesilla tectorum Badonnel, 1931 det. EM

lower and upper zones; uncommon; VB sopchr dubmen stytam

NEW HALE RECORD

Family Liposcelidae

*Liposcelis bostrychophila Badonnel, 1931 det. EM

lower and upper zones; common; LE, PF

NEW HALE RECORD

This cosmopolitan species also occurs near Ahumoa crater and Mauna Kea State Park on Hawaii Island.

+Liposcelis n. sp. (=”kipukae” Mockford and Krushelnycky in prep) det. EM

lower zone; uncommon; LE, PF

NEW SPECIES

This species appears likely to be endemic, but further study of the Hawaiian fauna in this genus is desirable. This species also occurs near Mauna Kea State Park and in the Kipuka Puu Huluhulu area on Hawaii Island.

Family Philotarsidae

*Haplophallus talilus? Thornton & New det. EM

lower zone; rare; VB dubmen

NEW HALE RECORD

This is the first record of this family and genus in the state.

Family Psocidae

Ptycta distinguenda (Perkins, 1899) det. EM
lower zone; rare; VB sopchr stytam

Ptycta haleakalae haleakalae (Perkins, 1899) det. EM
lower zone; common; VB stytam vacret sopchr dubmen

Ptycta microctena Thornton, 1984 det. EM
upper zone; rare; VB stytam

Family Trogiidae

*Cerobasis guestfalica (Kolbe, 1880) det. EM
lower zone; abundant; VB stytam vacret dubmen sopchr, PF, LE
NEW HALE RECORD
The most common and abundant psocopteran in the lower zone, particularly on *Styphelia tameiameiae*.

*Lepinotus reticulatus Enderlein, 1905 det. EM
lower zone; rare; LE
NEW HALE RECORD
While this species is currently rare at HALE, it is very abundant in leaf litter in similar habitats on Mauna Kea. It could become more abundant in the future.

Order Siphonaptera (fleas)

Family Ceratophyllidae

*Nosopsyllus fasciatus (Bosc, 1800) northern rat flea det. PDK
lower zone; rare; PF

Order Thysanoptera (thrips)

Family Aeolothripidae

*Aeolothrips bicolor Hinds, 1902 det. SN
lower zone; rare; VB stytam

Family Phlaeothripidae

Apterygothrips remotus (Bianchi, 1947) det. SN
upper zone; rare; PF, VB stytam

Haplothrips davisi Bianchi, 1946 det. SN
lower and upper zones; common; LE, PF
NEW HALE RECORD

*Haplothrips gowdeyi (Franklin, 1908) det. SN
lower zone; rare; VB stytam
NEW HALE RECORD

*Haplothrips leucanthemi (Schrank, 1781) det. SN
upper zone; rare; VB stytam, PF

*Hoplandrothrips sp. det. SN
lower and upper zones; rare; PF
NEW HALE RECORD

+Phlaeothripidae sp. det. PDK
lower zone; rare; LE
Genus and species undetermined.

Family Thripidae

*Aptinothrips rufus (Goeze, 1778) det. SN
lower zone; uncommon; LE, PF
NEW HALE RECORD

*Chirothrips manicatus Haliday, 1836 det. SN
lower and upper zones; uncommon; PF, VB stytam dubmen
NEW HALE RECORD

*Frankliniella crotolariae Mound & Marullo det. SN
lower zone; uncommon; VB vacret sopchr stytam
NEW HALE RECORD

*Frankliniella occidentalis (Pergande, 1895) det. SN
lower zone; rare; VB vacret stytam
NEW HALE RECORD

Neurisothrips carteri (Moulton, 1937) det. SN
lower and upper zones; common; VB stytam, PF, LE
NEW HALE RECORD

Neurisothrips multispinus (Bagnall, 1910) det. SN
lower and upper zones; abundant; VB stytam vacret sopchr dubmen, PF, LE
NEW HALE RECORD
The most abundant thrips in the study area; extremely abundant on *Styphelia tameiameiae*.

*Pezothrips kellyanus (Bagnall) det. SN
lower zone; common; PF, VB stytam vacret
NEW HALE RECORD

*Scirtothrips inermis Priesner, 1933 det. PDK
lower zone; rare; PF
NEW HALE RECORD

*Sericothrips staphylinus Haliday, 1836 det. SN
lower zone; rare; PF
NEW HALE RECORD
This species was introduced to Hawaii Island as a biocontrol agent for gorse, *Ulex europaeus*; presumably it is more abundant on its host plant.

*Tenothrips frici (Uzel, 1895) det. SN
lower zone; uncommon; VB sopchr stytam, PF

*Thrips florum Schmutz, 1913 banana flower thrips det. SN
lower zone; rare; VB dubmen
NEW HALE RECORD

*Thrips hawaiiensis (Morgan, 1913) det. SN
lower zone; uncommon; VB stytam vacret sopchr dubmen

*Thrips imaginis Bagnall, 1926 apple blossom thrips det. SN
lower zone; uncommon; PF, LE, VB stytam
NEW HALE RECORD
This Australian species is a pest of apples; it attacks the flowers (S. Nakahara, D. Tsuda pers. comm.).

*Thrips nigropilosus Uzel, 1895 det. SN
lower zone; rare; PF
NEW HALE RECORD

*Thrips tabaci Lindeman, 1889 onion thrips det. SN
lower zone; rare; PF, LE

CLASS MALACOSTRACA (Subphylum Crustacea)

Order Isopoda (isopods)

Family Porcellionidae

*Porcellio scaber Latreille, 1804 det. PDK
lower and upper zones; abundant; PF, LE
NEW HALE RECORD
Prior reports of the widespread occurrence of *Porcellio laevis* on the west slope of HALE (e.g. Cole et al. 1992) are probably misidentifications of *P. scaber*.

CLASS CHILOPODA (centipedes)

Order Lithobiomorpha

Family Henicopidae

*Lamyctes africana (Porat, 1871) det. GE & MZ
lower zone; rare; PF
NEW HALE RECORD

*Lamyctes emarginatus (Newport, 1844) det. GE & MZ
lower and upper zones; common; PF
NEW HALE RECORD

CLASS DIPLOPODA (millipedes)

Order Cambalida

Family Cambalidae

Nannolene sp. det. RS
upper zone; uncommon; PF
It is currently impossible to state whether the endemic Hawaiian species truly belong to the genus *Nannolene* due to the unsatisfactory taxonomic state of the group as a whole (R. Shelley pers. comm.), but we leave this species here until the situation is resolved.

Order Julida

Family Blaniulidae

*Proteroiulus fuscus (Am Stein, 1857) det. PDK
lower and upper zones; abundant; LE, PF

Family Julidae

*Cylindroiulus sp. det. RS
lower and upper zones; abundant; LE, PF
NEW HALE RECORD
Cylindroiulus latestriatus is the only *Cylindroiulus* species collected from Maui so far; our specimens likely belong to this species.