

**Arthropod Survey of 'Ōpae 'ula and Adjacent
Summit Areas of the Ko'olau Mountains, O'ahu, Hawai'i**

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INTRODUCTION

The insects and related arthropods (jointed legged animals such as spiders, mites, and isopods) are the dominant animals in most terrestrial ecosystems both in terms of numbers of species and numbers of individuals (Preston *et al.*, 1995). There are 8963 arthropod species recorded from the Hawaiian Islands (Nishida, 1997). The Bishop Museum was contracted to conduct an arthropod survey in the vicinity of 'Ōpae 'ula in the northern Ko'olau Mountains. This area contains some of the most pristine native forest left on the island of O'ahu, Hawai'i. This study will be used to help determine whether or not 'Ōpae 'ula warrants Natural Area Reserve status since many important and rare species of plants and animals occur there. While access is limited, human activity and pig damage is evident and as the area holds some of the last remaining native forest on O'ahu, it becomes imperative that steps be taken in order to protect it. This study serves to provide information useful to that purpose.

METHODS

This report provides a list of arthropods and related fauna collected from 'Ōpae 'ula, upper Kaluanui and Kaipapau areas of the Ko'olau Mountains, O'ahu, Hawai'i. Specimens were collected using primarily pyrethrum fogging together with sweep nets, hand aspirators, and host searching. As collecting time was limited to 1.5 days, the technique of using a water-based parathyroid to disturb and dislodge arthropods from selected substrates was very effective. This fogging technique utilizes a white plastic sheet, which is spread out under a mossy log or other habitat, and the selected area is fogged with the parathyroid. The arthropods become irritated, dazed, and finally dislodged from the substrate. The arthropods fall or jump down onto the sheet where they are either aspirated into a vial or picked up individually with forceps. The specimens are then stored in vials containing 95% ethyl alcohol with appropriate locality and host/substrate information. The material was brought back to Bishop Museum for processing and identification by specialists.

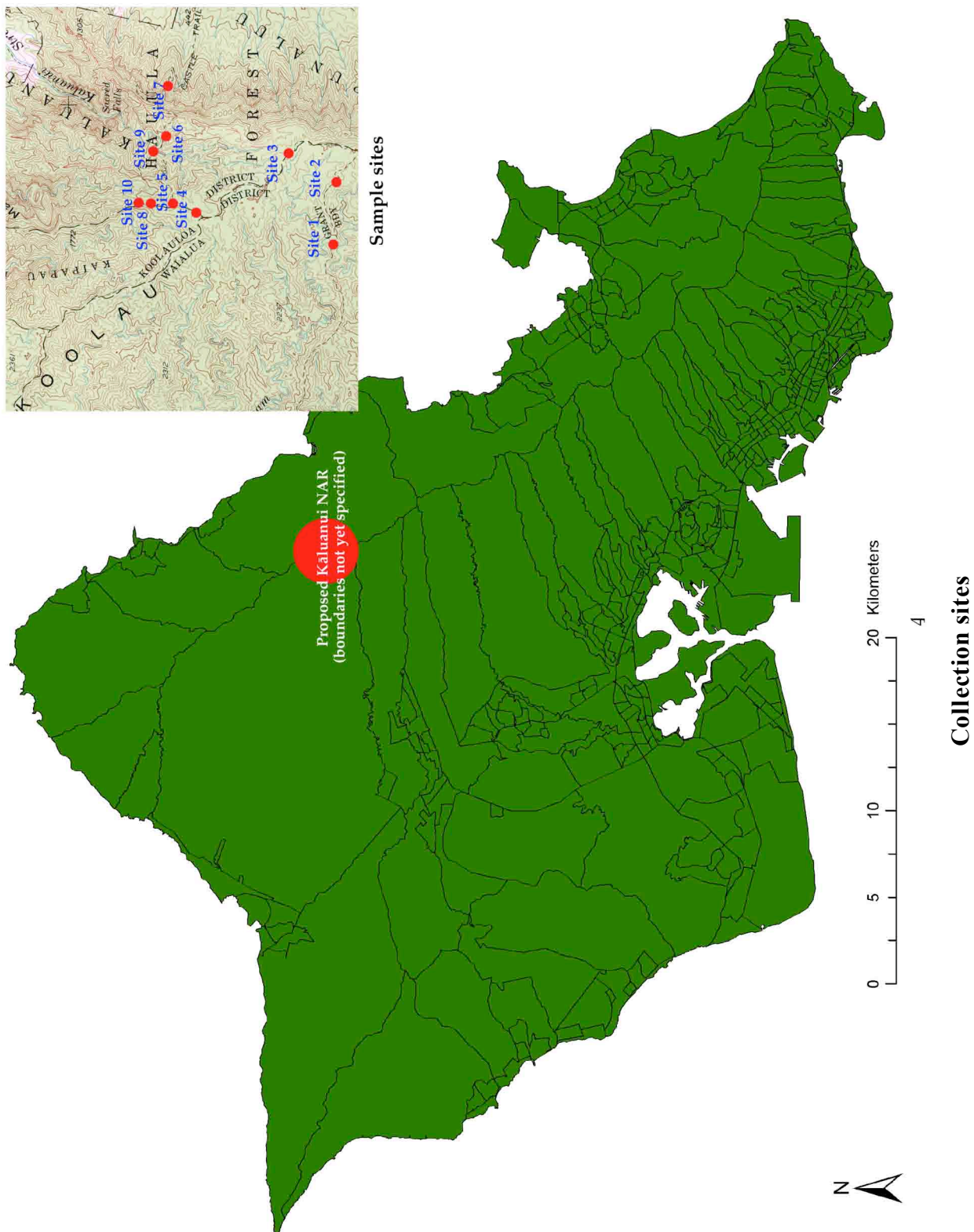
COLLECTION SITES

All collecting was done on summit trails in the 'Ōpae'ula, Castle Trail, Ko'olau Summit Trail and upper Kaluanui and Kaipapau drainages. The vegetation consisted primarily of 'ōhi'a wet forest with stands of *loulou* palms including several patches of *Wikstroemia oahuensis*, *Cheirodenndron trigynum*, and *Tetraplasandra oahuensis*. Fogging samples were done on mossy 'ōhi'a, and on several of the plant species mentioned above. A complete list of sites are listed in Table 1. The location of the study area is found in Figure 1.

Table 1: Collection Sites

Site 1.	HAWAIIAN IS: O'ahu I: Ko'olau Mts.; 'Ōpae 'Ula; 2500ft. elev. 21.X.2002 Fog Mossy <i>Pritchardia</i> palm
Site 2.	HAWAIIAN IS: O'ahu I: Ko'olau Mts.; 'Ōpae 'Ula; 2500ft. elev. 21.X. 2002 Fog mossy 'ōhia log
Site 3.	HAWAIIAN IS: O'ahu I: Ko'olau Mts.; 'Ōpae 'Ula; 2600ft. elev. 21.X.2002 Fog mossy 'ōhia log
Site 4.	HAWAIIAN IS: O'ahu I: Ko'olau Mts.; Castle Trail; N21°34'4.8" W157°59'36.4"; 2600ft. elev. 22.X.2002, Fog <i>Freycinetia arborea</i> leaf axils
Site 5.	HAWAIIAN IS: O'ahu I: Ko'olau Mts.; Castle Trail; 2600ft. elev. 22.X.2002 Fog mossy 'ōhia log
Site 6.	HAWAIIAN IS: O'ahu I: Ko'olau Mts.; Castle Trail; 2600ft. elev. 22.X.2002 Fog mossy 'ōhia trunk
Site 7.	HAWAIIAN IS: O'ahu I: Ko'olau Mts.; Headwaters of Kaipapau Stream; N21°33'15" W157°55'21.8"; 2800ft. elev.; 22.X.2002; Fog <i>Pritchardia</i> trunk
Site 8.	HAWAIIAN IS: O'ahu I: Ko'olau Mts.; Headwaters of Kaipapau Stream; N21°33'15" W157°55'21.8"; 2800ft. elev.; 22.X.2002; Fog mossy 'ōhia trunk
Site 9.	HAWAIIAN IS: O'ahu I: Ko'olau Mts.; Headwaters of Kaipapau Stream; N21°33'15" W157°55'26.8" 2800ft. elev.; 22.X.2002; Fog mossy 'ōlap'a trunk
Site 10.	HAWAIIAN IS: O'ahu I: Ko'olau Mts.; Headwaters of Kaipapau Stream; N21°33'15" W157°55'26.8" 2800ft. elev.; 22.X.2002; Fog mossy 'ōhia log

Figure 1.



RESULTS

There were 80 species of insects and related arthropods collected in the areas of 'Ōpae 'ula, Castle Trail, and upper Kaluanui drainage, Ko'olau Mountains, Oahu. These taxa are listed in Table 2, along with an indication of which are endemic, adventive, purposefully introduced or of unknown origin. Of the 80 species identified, 84% were endemic. There were 3 species new to science collected during this survey. Several species were determined to genus only and several of these may be undescribed species. The high percentage of endemic species collected at 'Ōpae 'ula reflects the pristine nature of much of the vegetation in the area. The high preponderance of native plant species is also reflective of the difficulty in accessing this area. Collecting was confined to areas at or near the crests of traversable trails and this limited us in time and sample site selection. With the help of Department of Fish & Wildlife biologist, Talbert Takahama, sites were chosen based on finding rare and unusual plants. Sites were also chosen by substrate type in order to include as wide a range of habitat types as possible.

Table 2: Insects and related arthropods collected from the upper Kaluanui drainage, Ko'olau Mountains

Taxa	Status ¹
ARACHNIDA	
ACARI (Mites)	
Oribatulidae	
<i>Lucoppia burrowsii</i> (Michael)	Adv
ARANEAE (Spiders)	
Araneidae (Orb weavers)	
<i>Cyclosa</i> sp.	End
Linyphiidae	
<i>Labulla</i> sp.	End
<i>Neoscona</i> sp.	Adv
Tetragnathidae (Long-jawed spiders)	
<i>Tetragnatha hawaiiensis</i> Simon	End
<i>Tetragnatha limu</i> Gillespie	End
<i>Tetragnatha</i> sp.	End
Theridiidae (Widows, Comb-footed spiders)	
<i>Argyrodes argyrodes</i> (Walckenaer)	Adv
Thomisidae (Crab spiders)	
Genus species	Unk
BLATTARIA (Cockroaches)	
Blattellidae	
<i>Balta similis</i> (Saussure)	Adv
COLEOPTERA (Beetles)	
Aglycyderidae (=Proterhinidae, short-nosed weevils)	
<i>Proterhinus</i> sp. A	End
<i>Proterhinus</i> sp. B	End
<i>Proterhinus</i> sp. C	End
<i>Proterhinus</i> sp. D	End
<i>Proterhinus</i> sp. E	End
<i>Proterhinus</i> sp. F	End
<i>Proterhinus</i> sp. G	End
<i>Proterhinus</i> sp. H	End
Carabidae (predatory ground beetles)	
<i>Blackburnia calignosa</i> (Blackburn)	End
<i>Blackburnia fordi</i> Liebherr	End
<i>Blackburnia fossipennis</i> (Blackburn)	End
<i>Blackburnia mutabilis</i> (Blackburn)	End
<i>Blackburnia palmae</i> (Blackburn)	End
<i>Blackburnia optata</i> (Sharp)	End

Table 2: Insects and related arthropods collected from the upper Kaluanui drainage, Ko'olau Mountains (continued)

Taxa	Status ¹
COLEOPTERA (Beetles) continued	
Carabidae (predatory ground beetles) continued	
<i>Blackburnia</i> sp.	End
Curculionidae	
<i>Acalles</i> sp. D1, Samuelson	End
<i>Acalles</i> sp. – no cells, cup glabr.	End
<i>Syagrius fulvitaris</i> Pascoe	Adv

Genus species	Unk
Nitidulidae	
<i>Eupetinus subaper</i> Scott	End
<i>Eupetinus striatus</i> (Sharp)	End
COLLEMBOLA (Springtails)	
Entomobryidae	
<i>Entomobrya</i> sp.	End
<i>Salina celebensis</i> (Schaeffer)	Adv
<i>Seira</i> sp. A	End?
<i>Seira</i> sp. B	End?
DERMAPTERA (Earwigs)	
Chelisochidae	
<i>Chelisoches morio</i> (Fabricius)	Adv
DIPTERA (Flies)	
Dolichopodidae	
<i>Campsicnemus</i> sp.	End
Tipulidae	
<i>Limonia gloria</i> Byers, 1994 – 1 male (genitalia matches illustration in Byers: this specimen is fully winged.)	End
<i>Limonia jacobae</i> (Alexander)	End
<i>Limonia hardyana</i> Byers	End
<i>Limonia</i> sp. 1 male	End
HETEROPTERA (True bugs)	
Nabidae (Damsel bugs)	
<i>Nabis lusciosus</i> White	End
<i>Nabis kaohinani</i> (Kirkaldy)	End
<i>Nabis</i> n. sp. (= " <i>ulanui</i> " in manuscript)	End
<i>Nabis</i> n. sp. (= " <i>lilinoe</i> " in manuscript)	End

Table 2: Insects and related arthropods collected from the upper Kaluanui drainage, Ko'olau Mountains (continued)

Taxa	Status ¹
HETEROPTERA (True bugs continued)	
Lygaeidae (Seed bugs)	
<i>Nesocryptias oahuensis</i> Usinger & Ashlock	End
<i>Oceanides picturatus</i> Usinger	End
genus and species (= " <i>Akua oahuensis</i> ") in manuscript	End
Miridae (Plant bugs)	
<i>Hyalopeplus pellucidus</i> (Stål)	End
<i>Nesomiris beardsleyi</i> Gagné	End
<i>Nesiomiris trifurcates</i> Gagné	End
Saldidae (Shore bugs)	
<i>Saldula kauaiensis</i> Cobben	End
Veliidae (Water striders)	
<i>Microvelia vagans</i> White	End
HOMOPTERA (Leafhoppers & planthoppers)	
Cicadellidae (leafhoppers)	
<i>Nesophrosyne oreadis</i> Kirkaldy	End
<i>Nesophrosyne</i> n. sp	End
HYMENOPTERA (Bees, wasps, and ants)	
Apidae (bees)	
<i>Apis mellifera</i> Linnaeus	Pur
NEUROPTERA (Lacewings)	
Hemerobiidae (Brown lace wings)	
<i>Micromus vagus</i> (Perkins)	End
ODONATA (Dragonflies, damselflies)	
Aeshnidae (Darners)	
<i>Anax strenuous</i> Hagen	End
Coenagrionidae (Damselflies)	
<i>Megalagrion hawaiiense</i> (McLachlan)	End
<i>Megalagrion koelense</i> (Blackburn)	End
<i>Megalagrion oahuense</i> (Blackburn)	End
Libellulidae (Skimmers)	
<i>Nesogonia blackburni</i> (McLachlan)	End
ORTHOPTERA (Grasshoppers, katydids, and crickets)	
Gryllidae (Crickets)	
<i>Laupala</i> sp. A	End

Table 2: Insects and related arthropods collected from the upper Kaluanui drainage, Ko'olau Mountains (continued)

Taxa	Status ¹
ORTHOPTERA (Grasshoppers, katydids, and crickets) continued	
Gryllidae (Crickets)	
<i>Laupala</i> sp. B	End
<i>Leptogryllus</i> sp. A	End
<i>Prognathogryllus</i> sp. nr. <i>oahuensis</i> Perkins	End
<i>Trigonidium</i> sp. A	End
<i>Trigonidium</i> sp. B	End

<i>Trigonidium</i> sp. C	End
PSOCOPTERA (Bark lice)	
Elipsocidae	
<i>Palistreptus</i> sp.	End
THYSANURA (Silverfish and fishmoths)	
Nicoletidae (Fishmoths)	
<i>Nicoletia</i> sp.	Adv
AMPHIPODA (Scuds and sandhoppers)	
Talitridae	
<i>Floresorchestia pickeringi</i> (Dana)	End
<i>Talitroides topitotum</i> Burt	Adv
ISOPODA (Pill bugs, slaters)	
Armadillidae	
<i>Spherillo</i> sp.	End
Porcellionidae (Sow bugs)	
<i>Porcellio laevis</i> Latreille	Adv
CHILOPODA (Centipedes)	
Geophilomorpha (Soil centipedes)	
Lithobiidae	
<i>Lithobius</i> sp. A	End
<i>Lithobius</i> sp. B	End
DIPLOPODA (Millipedes)	
Polydesmida	
Paradoxosomatidae	
<i>Oxidus gracilis</i> (C.L. Koch)	Adv

Table 2: Insects and related arthropods collected from the upper Kaluanui drainage, Ko'olau Mountains (continued)

Taxa	Status ¹
DIPLOPODA (Millipedes) continued	
Spirostreptida	
Cambalidae	
<i>Nannolene</i> sp. A	End
<i>Nannolene</i> sp. B	End

¹Status: End= Endemic, Adv= Adventive, Pur= purposely introduced, Unk=unknown.

Notable Species Found in the upper Kaluanui drainage and Adjacent Areas

A complete annotation on the biology and status of each species listed in Table 2 is beyond the scope of this report. Several species records for the upper Kaluanui and adjacent areas, however, are notable either because of their rarity or significance to science. These records are briefly elaborated below. The arrangement follows the same order as in Table 2. Other records deserve mention here, but these species are too poorly known to warrant inclusion.

COLEOPTERA

Aglycyderidae (Proterinid weevils): These tiny (less than 3 mm long) primitive weevils are remarkably diverse in Hawai'i. About 175 species are known only from the Hawaiian Islands; these constitute more than 90% of the world's fauna in the family. The larvae are woodborers, mostly in twigs and stems of native plants, and most species are host specific. There were 8 unidentified species collected during this study.

Carabidae (Ground beetles): Although this family contains many endemic species, we only collected 7 species during this survey. Additional surveys may produce more species.

HETEROPTERA

Miridae (Plant bugs): Hawaiian plant bugs remain under studied. About 50 species have been named, but at least another 100 species are in collections. Most species are plant feeders, but many are predaceous or omnivorous. Many species are found only in a small geographical area and feed on a single species of plant. There were three species collected; *Hyalopeplus pellucidus* - on *Wikstroemia oahuensis*, *Nesomiris beardleyi* - on *Cheirodendron trigynum*, and *Nesomiris trifurcates* - on *Tetraplasandra oahuensis*

Nabidae (Damsel bugs): The damsel bugs are all predatory on other insects. There are 30 Hawaiian species, but new species continue to be discovered. *Nabis lusciosus* and *Nabis kaohinani* both flightless species were taken from mossy logs and trunks. Two flightless species new to science, *Nabis* n. sp. (= "ulanui" in manuscript) and *Nabis* n. sp. (= "lilinoe" in manuscript) - were also taken from mossy logs and trunks. All four species are O'ahu endemics.

Lygaeidae (Seed bugs): *Nesocryptias oahuensis*, a flightless species was taken from mossy logs and trunks. *Oceanides picturatus*, an O'ahu endemic was taken on *Wikstroemia oahuensis*, and a new genus and species (= "*Akua oahuensis*") in manuscript a very rare taxon was taken from mossy tree trunks along the Castle Trail. It is the only native member of the Rhyparochromidae known from Hawaii,

Pentatomidae (Stink bugs and shield Bugs): *Coleotichus blackburniae*, the koa bug, is the largest and most conspicuous native true bug. It is nearly an inch long and iridescent blue, green, maroon, and yellow. Once common on koa and a'ali'i on all of the main islands, it has become rare following the introduction, beginning in the 1960s, of several parasites for biological control of the pestiferous southern green stink bug, *Nezara viridula*. Historically *C. blackburniae* was known from the Ko'olau Mts., but none were seen during this survey.

HOMOPTERA

Cicadellidae (Leafhoppers): Two species in the native genus *Nesophrosyne* (Cicadellidae) were collected. *Nesophrosyne oreadis* found on *Wikstroemia oahuensis* and *Nesophrosyne* n. sp. collected on *Broussaisia arguta*. Better results with this group might be obtained at a different times of year, since they are sensitive to host plant phenology. Many species of Delphacidae were collected; Dr. Manfred Asche in Berlin will analyze them.

ODONATA

Aeshnidae (Darners): The Endemic species, *Anax strenuus* was not collected but quite common at several sites along the Ko'olau Crest Trail and the headwaters of the Kaluanui. This is the largest species in the genus and the largest dragonfly in the United States. Because of its large size it is named the Giant Hawaii Dragonfly. This is a mountain species and although it can occur at lower elevations it is now rarely seen at elevations below 700ft. on O'ahu.

Coenagrionidae (Damselflies): There are 22 species and 3 subspecies, all confined to the Hawaiian Islands. Nine species and subspecies of *Megalagrion* were historically recorded from Oahu, with 5 of these being endemic to the island. Three species were taken in the upper Kaluanui and Castle Trail areas during this survey: *Megalagrion hawaiiense* - breeding in pig wallows and other wet places; adults commonly encountered along the Koolau Crest Trail. *Megalagrion koelense* - breeding in water pockets at the bases of *Freycinetia arborea* leaves, and *Megalagrion oahuense* - breeding in damp fern litter, with adults abundant and regularly encountered along the Castle Trail.

Two other species of stream-breeding damselflies, both discussed in the past for Endangered Species listing, are also known from upper Kaluanui Stream (but not collected on the current survey, which had a terrestrial focus): *Megalagrion oceanicum* - breeds in rapids and small cascades and *Megalagrion nigrohamatum nigrolineatum* - breeds in stream pools. *Megalagrion oahuense*, *M. oceanicum*, and *M. nigrohamatum nigrolineatum* are O'ahu Endemics.

ORTHOPTERA

Gryllidae (Crickets): There are 243 native species of crickets known from Hawaii (Otte, 1994), which is more than twice as many as the total number known from the rest of the United States. Most native species have restricted ranges; some are known from only small

areas within single islands. Their great diversity makes them ideal for evolutionary studies (Otte, 1994). Hawaiian crickets live mostly in trees and shrubs, but a few forage in leaf litter. Most are omnivores, feeding on both plant and animal material. There were 7 species of endemic crickets collected in the upper Kaluanui drainage along the Ko'olau Summit Trail. A list of these species is contained in Table 2.

CONCLUSIONS

Although our collecting time was limited to just 1.5 days, at least 3 species new to science were discovered. This is one of the richest areas for arthropod endemism left on the island of O'ahu. Many large examples of *Pritchardia* palms dot the slopes on both the windward and leeward drainages. Patches of *Tetraplasandra oahuensis* and *Wikstroemia oahuensis* still thrive. There was minimal pig damage and little human activity at the upper elevations. Many non-native species are prevalent on trails and in shallow stream beds. Selected areas should be considered for fencing, especially in areas where rare and endangered plant species occur. Non-native plants should be controlled and/or removed. Fencing would prevent ungulate damage and spread of non-native weeds. A more intensive survey and long-term monitoring of rare species of invertebrates and plants should be considered in order to better understand and manage these areas. We must protect what may be the last pristine native forests left in the Ko'olau Mountains. Most native arthropods have very special habitat requirements. Many plant feeding species are host specific while others require special breeding and egg laying sites. Several species are rare by their very nature and precariously hang on. The discovery of new species is not unusual however, the very fact that new species still remain to be found make places like 'Ōpae 'ula a treasure to be preserved. 'Ōpae 'ula should be given the highest priority for Natural Area Reserve status. Not only will we be protecting many rare and endangered species but we will also be protecting those species we have yet to discover.

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GLOSSARY

Adventive: An inadvertently introduced non-native species.

Alien: A non-native species introduced to a region either purposefully or inadvertently through the actions of humans.

Aerial Sweep Net: A hand net used for general collecting. Modified versions may be used in aquatic situations or for beating and sifting.

Endemic: Native to and restricted to a geographical region.

Indigenous: Native to but not restricted to a geographical region.

Native species: A species naturally occurring in a region, i.e., having colonized the region without the aid of humans (See Endemic).

Pan Trap: A shallow pan filled with a fluid preservative and surfactant.

Pitfall Trap: A cup-like container having the top of the cup buried flush with the soil or leaf litter surface.