APPENDIX G

Survey of Native Invertebrate Resources in proposed expansion of Hawaiian Memorial Park – July 2017

Prepared by: Steven Lee Montgomery, Ph. D.

Survey of Native Invertebrate Resources in proposed expansion of Hawaiian Memorial Park, Kāne'ohe, O'ahu

July 20, 2017

Prepared by:
Steven Lee Montgomery, Ph. D., Waipahu, Hawai'i

Submitted to:
HHF Planners

For:
Hawaiian Memorial Life Plan Ltd.

Table of Contents

Figures

SUMMARY
The Hawaiian Memorial Park Expansion, Kāne'ohe, O'ahu, project site sampled in 2008 and 2017 surveys yielded predominantly adventive insect species, and ten native arthropods. One invertebrate listed under federal endangered species statutes was located within the survey area. No native mollusks were observed.

INTRODUCTION

This report summarizes the findings of an invertebrate[1] survey conducted within Hawaiian Memorial Park property, Kāne'ohe, O'ahu (Figure 1, 2). The area to be used for burial purposes within the Hawaiian Memorial Park (HMP) expansion site is 28.2 acres (ac.). The overall Petition Area is a 53.45 ac. portion of a 164.4 ac. parcel within TMK 4-5-33:001. The balance of the 53.45 acres will be for a Cultural Preserve, other open space and roadways (HHF 2017). This survey was conducted by Steven Lee Montgomery, Ph.D., for HHF Planners, Honolulu, Hawai'i.

The primary purpose of this survey was to determine the presence or absence on the property of any endemic or indigenous terrestrial invertebrates, especially any species with legal status under federal or state threatened and endangered species statutes (DLNR 1998, USFWS, 2008, 2017). Invertebrates are often the dominant fauna in natural Hawaiian environments. Native Hawaiian plant, vertebrate, and invertebrate populations are interdependent. Invertebrates are the food of some birds and the pollinators of plants. Certain insects are obligatorily attached to specific host plants and are able to use only that plant as their food. Those insect - host relationships are ancient and intertwined. Native invertebrates have proven inventive in adapting to opportunities in changed ecosystems. A surprising number of native arthropod species survive even in degraded habitats. Nevertheless, the overall health of native Hawaiian invertebrate populations depends upon habitat quality and absence or low levels of predators introduced from the continents. Sufficient food sources, host plant availability, and the absence or low levels of introduced, continental predators and parasites comprise a classic native, healthy ecosystem. Consequently, where appropriate in the survey discussion, host plants, and some introduced arthropods are also noted.

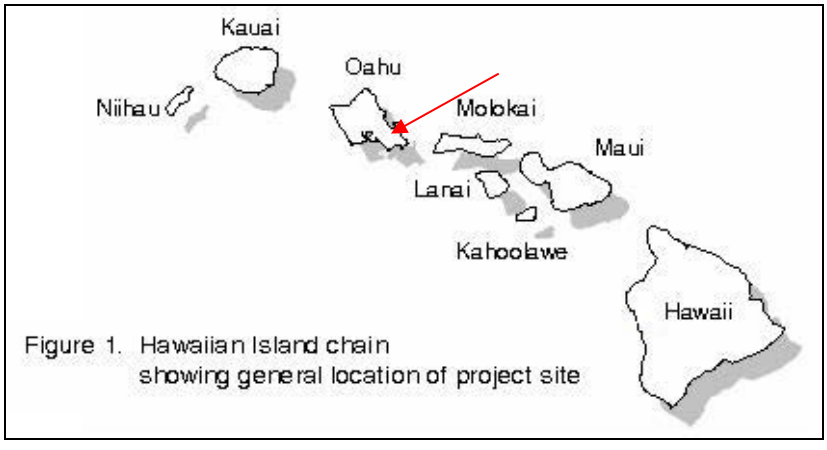

Figure 1. Hawaiian Island chain showing general location of project site

[1] Animals without backbones: insects, spiders, snails, shrimp, etc.

Figure 2: Map of Hawaiian Memorial Park expansion area showing general area of survey (white outline)

GENERAL SITE DESCRIPTION

The Hawaiian Memorial Park (HMP) expansion site at Kāne'ohe, O'ahu, surveyed is 53 acres. The larger parcel is bound on the west by residential housing and a natural ridgeline on the east. Oneawa Hills separates the parcel from Kapa'a Quarry and the H-3 Freeway. Pohai Nani Retirement Community is near the northern section of the proposed expansion. The south-southeastern boundary of the larger parcel is a steeply sloped, vegetated portion of the Hawaii State Veterans Cemetery.

Figure 3: Typical sparse understory with alien canopy.

The general area where the site is found has been through a variety of changes as first Polynesians, then Europeans adapted the area vegetation to their own needs. From early Hawaiian cultivation of crops and housing to rice cultivation and pineapple growing, feral grazing animals and formal cattle ranching (McCurdy and Hammatt 2008), the native vegetation - and native invertebrate population - was displaced by a succession of introduced plants or chewed and grubbed out by introduced mammals (Figure 3) (Devaney 1976).

The parcel has been described by botanical consultants as a Lowland Alien Wet Forest "with very few of the natural plant elements remaining. Feral pigs (*Sus scrofa*) continue to degrade the vegetation and understory plants by rooting, resulting in soil disturbance." (LeGrande 2006, 2017). In 2017 pigs continue to be a factor in disturbance of aquatic habitats of the native damselfly on the property.

Figure 4

Although open, grassy areas (Figure 4) and large fields of fern (Figure 5) may seem pleasant to view, they are devoid of native Hawaiian plants serving as hosts for native invertebrates.

Figure 5

Two native Hawaiian plants encountered were a small patch of ʻuhaloa (*Waltheria indica*) (Figure 6) and some ʻākia (*Wikstroemia* spp.) (Figure 7). Both species are unpalatable to livestock, commonly surviving in pastures and being rejected by feral goats.

ʻ

Figure 6: ʻUhaloa (*Waltheria indica*) may be protected from grazers by fuzzy leaves.

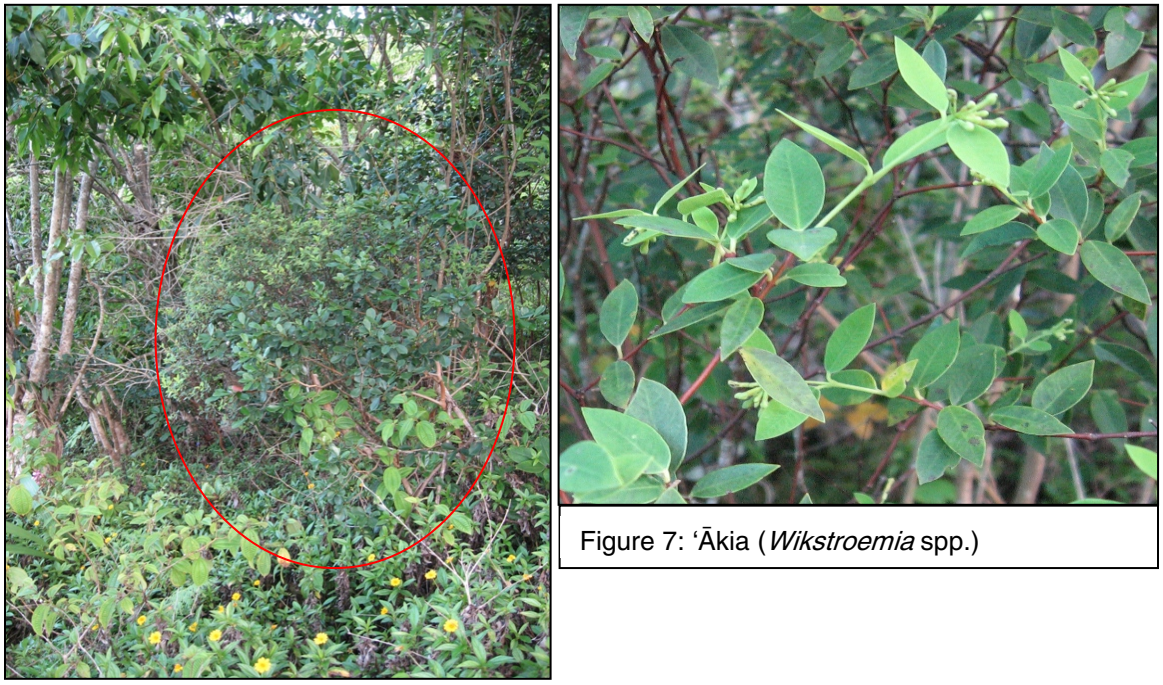

Figure 7: ʻĀkia (*Wikstroemia* spp.)

A few `ōhi'a lehua (*Metrosideros*) were found. Ant invaders have removed insect fauna and nectar. The taller introduced plants dominate, take more sunlight, so providing very scant habitat for native invertebrates.

Figure 8: `Õhi'a lehua

INVERTEBRATE SURVEY METHODS

Previous Surveys

Surveys for avian and mammalian (Bruner 2006) and botanical resources (LeGrande 2006) at the project area were very helpful in preparing for the prior 2008 study, but had no reference to other invertebrate surveys or sightings. My own July 2008 survey on the property was used as background and a cross check to these 2017 surveys. A review of the online collection databases of the Bishop Museum and University of Hawaii collections and a search of the index of the Proceedings of the Hawaiian Entomological Society using place names from the archaeology reports did not reveal any prior studies. Also reviewed was the Office of Environmental Quality Control documents database.

Searches in the Bishop Museum online entomological data base did yield useful O'ahu damselfly records referred to below.

Fieldwork

Since 1968, I have taken part in field projects in environments similar to the project site, at other locations on the island of O'ahu, and throughout the island chain. Those experiences and the results of those surveys provided the basis for my study design and my analysis of results. This survey builds on my previous survey in 2008 at this site. Also, a field study of damselfly behavior in Oklahoma was assigned to me for 8 weeks by Dr. George and Juanda Bick to aid them in 1964 (Bick 1965).

Field surveys in 2017 were conducted at the project site over a period of several months. I conducted a general assessment of terrain and habitats after reviewing maps and prior reports (above). Survey efforts were conducted by day and night, a technique which is vital for a thorough survey. The property was traversed across all habitat types, alternately following pathways to search for any springs or native botanical resources and substitute host plant options for native invertebrates.

FIELD SCHEDULE: 2017

July 27	day field survey
August 18	day field survey / night survey, moonrise 3:05am[2]
September 12	day field survey part with Botanist LeGrande
September 20	day field survey / night survey, Waxing Crescent with 1% of the Moon's visible disk illuminated; Moonset 7:13 p.m.
September 22	day field survey / night survey; Waxing Crescent with 8% of the Moon's visible disk illuminated; Moonset 8:31 p.m.
October 5	day field survey, part of time with Dr. Polhemus
November 19	day field survey / night survey; Waxing Crescent with 2% of the Moon's visible disk illuminated; Moonset 7:09 p.m.
December 4	day field survey
December 8, 9	day field survey
December 12	day field survey
December 14	day field survey

COLLECTING METHODS

The following collecting methods for terrestrial invertebrates were used as appropriate to the terrain, botanical resources, and target species.

Host plant searches: Host plants, both native and introduced, were sampled for arthropods that feed or rest on plants. Searches included visual inspection of resting sites and searching known feeding or breeding sites such as under dead bark.

Sweep nets: This is a general method of censusing most flying and perching insects. A fine mesh net was swept across plants, leaf litter, etc. to sample any flying or perching insects. Transfer from the net was either by aspiration, or by placing the net contents into a holding container.

Visual observation: At all times, I was vigilant for any visual evidence of arthropod presence or activity. Visual observations provide valuable evidence and are a cross check that extends the reach of sampling techniques. Visual observation also included turning over rocks, dead wood, and other debris.

[2] all moon data from U.S. Naval Observatory [USNO]

Light sampling: A survey of insects active at night is vital to a complete record of the fauna. Many insects are active only at night to evade birds, avoid desiccation and high temperatures, or to use night food sources, such as night opening flowers. Light sampling uses a bright light in front of a white cloth sheet. (Figure 9) Night active insects seem to mistake the collecting light for the light of the moon, which they use to orient themselves. In attempting to navigate by the entomologist's light, confused insects are drawn to circle the light and land on the cloth in confusion. This type of collecting is most successful during the dark phase of the moon, or under clouds blocking starlight. On level sites vegetation usually blocks the light from being seen over long distances, and moths and other night fliers are not drawn from distant locations outside the survey area.

The locations for my light were chosen based on experience, potential native host plant proximity, and to obtain a variety of terrain types (Figure 10). Screening vegetation meant that the nearby housing areas contributed little competing light. The primary light source was a Mercury Vapor bulb. A secondary source was an ultra violet (UV) or black light bulb. At the more remote location a mantel propane lantern was used. Light wave lengths from all three are known to be attractive to night active insects. The sheet was monitored and visiting species observed. Light surveying was conducted for roughly 3.5 - 4 hours in each location.

Figure 9: Light assists in surveying arthropods

Survey Limitations / Conditions

My ability to form advisory opinions is limited or influenced in the following ways:

Collecting conditions

Weather was favorable for surveying during the fieldwork with patchy clouds and light breezes during night light monitoring. Night monitoring was done during the dark of the moon. Sunny parts of the day were chosen for monitoring damselfly habitat.

The moon presented no competition to the collecting light as it was "dark" on most of the nights or the moon set early in the evening. (USNO)

Seasons: Monitoring at a different time of the year might produce a different arthropod list. Weather and seasonal vegetation changes play an especially important role in any survey of invertebrates. Many arthropods time their emergence and breeding to overlap or follow seasonal weather or to coincide with growth spurts of an important plant food. Host plant presence/absence, and seasonal changes, especially plant growth after heavy rains, affect the species collected. Summer 2017 saw a few short rain events but vegetation was in a normal summer condition. However, the low level of native plants found at the site is the strongest factor in determining the invertebrates encountered. Given the short inventory of native plants at this site, seasonal factors are not as important in this instance. Nevertheless, a decision was made to conduct additional field days on site after rains began in October / November 2017.

Limited duration: Surveying for a longer period of time might change the list of species; however, given the size of the property, I believe the survey provides an adequate review of the property's resident native invertebrates. (See below: INVERTEBRATES NOT PRESENT, for exceptions)

Physical limitations: The size of the property allowed the survey to cover the area adequately. The overall study strategy and light survey site selections were designed to achieve this aim. The resulting survey was representative and targeted in favor of locating and examining the few native host plants.

Selectivity: My survey was focused on finding endemic and indigenous Hawaiian species. No attempt was made to collect or completely document the many common alien arthropod species present in the area. Several invertebrates of human health concern are noted later in this report. See MEDICALLY IMPORTANT SPECIES.

Figure 10: Map of project site showing light survey locations 2008 and 2017

D = general location of damselflies

X = site of night light monitoring 2008
X = site of night light monitoring 2017

INVERTEBRATE SURVEY RESULTS:

This discussion[3] focuses on native species encountered, on species that affect native invertebrate survival, and on adventive species of concern in human health or commonly feared. Included are species seen in 2008 and 2017.

MOLLUSCA: PULMONATA
Cannibal or Rosy Wolf snail
Euglandina rosea (Férussac)

Giant African Snail
Lissachatina fulica (Bowdich)
Dry bleached shells of the Rosy Wolf snail were often found, indicating the snails are present and likely preying on aliens like the common pest Giant African Snail. Rosy Wolf snail also has done great damage to populations of native land snails, and there no longer are native snails here. (CABI)

Figure 11: Rosy Wolf snail (R) approaching Giant African Snail (L)

Red-rimmed Melania *Melanoides tuberculata* (Mueller)
These freshwater snails were within spaces being used by native damselflies but do not compete for food resources as they eat algae and debris. They are believed to have been in the islands since the early 1800s and perhaps for longer and are often associated with kalo roots. (Yamamoto 2000)

Figure 12: Melania snails in puddles.

[3] Organization of this section and Table 1 follow that of "Hawaiian Terrestrial Arthropod Checklist"

ARTHROPODA: ARANEAE (spiders)

Heteropodidae
Heteropoda venatoria
Large Brown Spider or Cane Spider

This spider was prolific at the November 19 night survey site, coming quickly to the light to gather 'free food' as the insects responded to the light.

Although this fast running spider is often startling to people, they are not known to bite or harm humans. Conversely, they are helpful in controlling pests such as cockroaches. They hunt mostly at night and do not pose a risk to the day flying damselflies. They may be encountered by work crews in broken pipes, piles of dry brush or under discarded wood or cardboard. They should be allowed to run away.

Figure 13: Adult cane spiders are common on site.

COLEOPTERA: beetles

Hydrophilidae: **water scavenger beetle** *Enochrus sayi*
One example was found of this 4mm long general predator, an adventive water scavenger beetle, but not a threat to native damselflies.

DIPTERA (Flies and Mosquitoes)

Ceratopogonidae **midges**

Dasyhelea hawaiiensis

Larvae of *Dasyhelea* may be very numerous among algae covered by flowing water at all elevations. F. X. Williams suspected they were much preyed upon by the nymphs of native damselflies (*Megalagrion* sp.) (Williams1944). Swarms of these harmless, very tiny midges, mostly males, often draw attention while dancing beside bushes.

Culicidae Mosquitoes
Aedes albopictus Skuse **Forest Day Mosquito**
Culex quinquefasciatus Say, 1823 **Southern House Mosquito**, Day Biter
Toxorhynchites amboinensis (Doleschall, 1857) **Cannibal Mosquito**

Figure 14**:** Young of *Toxorhynchites* [approx. half inch in length] are controlling the biting mosquitoes on site

Aedes and *Culex* mosquitoes are present on site, however they are breeding in rather small numbers in the flowing stream and undetected in cement bounded spring source waters. The control factor is the natural presence of the much larger young of the *Toxorhynchites* mosquito (Figure 14), which feeds frequently in water receptacles. The *Toxorhynchites* were imported into the islands in 1950s from Java as a biocontrol agent. *Toxorhynchites* young voraciously capture and eat the young of many other mosquito and moth fly species (Steffan 1969, 1982; Funasaki 1988). The larvae of very few other mosquito species are cannibalistic, feeding as predators on the larvae of other mosquitoes sharing their habitats. Their females don't rely on a blood meal and are restricted to a nectar diet. Night biting *Culex* larvae were found only in a few 1 to 2 inch deep pools and serve as one food used by the damselfly young in these very shallow stream waters.

ARTHROPODA: INSECTA

HEMIPTERA: HETEROPTERA (True bugs)
Miridae (**Leaf bugs**): *Trigonotylus hawaiiensis*

This endemic bug, *Trigonotylus hawaiiensis* (Kirkaldy), 1902, is known from all the major islands, Laysan, and Nihoa. It is known from sea level to 5000 ft. and is widespread on O'ahu. It feeds on both native and alien grasses. (Zimmerman 1948b)

HYMENOPTERA (wasps, bees, ants) Formicidae (**ants**):
Alien ants are known to prey on other insects (Zimmerman 1948-80) and are well documented as a cause of low levels of native arthropods, especially in elevations up to 2000 ft. (Perkins 1913). Ants are cited as a "primary threat" factor for the Blackline Hawaiian Damselfly in the 2011 Listing of Endangered Species (*Federal Register* 2011).

Figure 15: In 2008 Long-legged ants were seen on the property, but not in 2017.

Long-legged Ant
The long-legged ant (*Anoplolepis gracilipes*) was seen on the property in great numbers in 2008. Nearly every tree had a column of these ants marching up and down the trunk (Figure 15). Many areas on the ground were heavily patrolled. None were seen in 2017 survey visits. The likely cause is the renewed dominance of the big-headed ant.

Big-headed ant
Pheidole megacephala, a strong predator ant, has moved into the property since 2008. They are known to displace other ants. Long-legged and African big-headed ants (*Pheidole megacephala*) do not seem to overlap in distribution. Rather they maintain separate territories, effectively apportioning the hunting grounds between themselves, offering few ant-free zones to native arthropods. They are a threat to emergent damselflies.

Hymenoptera continued

Glaber ant

Ochetellus glaber, the small black adventive glaber ant, was seen on the property in 2008 and 2017, but in small numbers. *It* seemed to occupy a different distribution from that of the big-headed ant. It exhibited a tree trail forming behavior. It may be nesting in dry wood and in old termite holes and should be naturally controlled by site clearing activity. It is known from all major islands (HBS 2002a). Both sweet and protein (i.e., native insects) are attractive foods. One authority states the ant "bites fiercely" (Tenorio and Nishida 1995). Use caution around nests in hollow stems and when near active ant trails.

Figure 16: Glaber ants were seen running trails on tree trunks

LEPIDOPTERA (butterflies and moths)

Cosmopterigidae: ***Hyposmocoma*** sp.

Figure 17: *Hyposmocoma* sp.
Photo# starr-030724-0089
credit: "Forest & Kim Starr" (HEAR)

Adult *Hyposmocoma* or case bearer moths responded to the light. *Hyposmocoma* are called "case bearers" because after an early beginning inside a leaf curl or similar hiding place, caterpillars create protection in intricately constructed portable shells of silk. For camouflage, they add bits of their surroundings to the case: snips of dry grass / leaves, flakes of bark, maybe a little dirt. The case is then easily mistaken by a predator as another part of the inedible landscape. These bunkers are fitted with a hinged lid (operculum), pulled shut by mandibles to defend them from enemies. They are dependent on their case, and die if removed – even if protected from predators and given food. They don't move far, feed while partly emerged from the case, dragging along the protective armor by six true legs. Cases are sometimes attached to rocks or tree trunks and foliage. (Manning/Montgomery in Liittschwager & Middleton 2001) With over 500 kinds, *Hyposmocoma* micromoths are the greatest assemblage of Hawaiian Island moths, showing astonishing diversity. After writing 630 pages on them, Dr. Zimmerman lamented the inadequacy of his study. He noted an enormous cluster of species with explosive speciation and diverging radiation (Zimmerman 1978). Much remains to be learned about them by University of Hawaii's Daniel Rubinoff and his graduate students (Rubinoff & Haines 2006).

Lepidoptera continued

Crambidae: ***Eudonia*** sp. (Moss moths)

There are 15 *Eudonia* species known from O'ahu, all Hawaiian endemics. Several O'ahu species are also known from other islands. None are considered rare, endangered, or threatened. Some species have been reared from moss where they build silken tunnels of protection in which to feed (Swezey 1910), but for many species the host plant is not recorded yet. (HBS 2002a, HOSTS, Zimmerman 1958)

Figure 18: *Mestolobes* sp.
Photo# starr-030825-0008
credit: "Forest & Kim Starr" (HEAR)

Crambidae: ***Mestolobes*** species (likely *minuscula*)

The commonest of the small moths or micro-moths, *Mestolobes* (Figure 18), responded to our light survey. It is known from every major island. Although a large genus of over 30 species, 10 known from O'ahu, it has not been studied in depth despite a 1906 plea to study its habits by R. C. L. Perkins (1907). It has been collected while visiting flowers for nectar diurnally and when responding to light. *Mestolobes* was reported to "often fly actively in cane fields" (Williams 1931). In the 1800s it was reported to fly in small groups and was seen at lower elevations (Perkins 1913). The host plant of this endemic is not certain. There is one record of one larvae reared from a host - the roots of sugar cane on O'ahu in 1930, yet it was never considered even a minor pest (Swezey 1931.) (HBS 2002a, HOSTS, Zimmerman 1958)

Figure 19: koa haole moth

Geometridae: ***Semiothisa infusata***

The **koa haole moth** (Figure 19) responded to the light survey. It is a common species dependent on the host plant *Leucaena leucocephala* for the caterpillar.

Figure 20: Blackline Hawaiian Damselfly

ODONATA (Dragonflies, Damselflies)

Coenagrionidae
Megalagrion nigrohamatum nigrolineatum (Perkins), 1899

Blackline Hawaiian Damselfly or Rainbow-eye Damselfly
Hawaiian: pinao ānuenue (adult) lohelohe (naiad / immature)
(Liittschwager and Middleton 2001)[4]

Ancient damselflies are known from fossils aged at 140 million years. Native Hawaiian damselflies are a very remarkable cluster of 25 species descended from a single, wind carried waif that arrived at Hawai'i fresh waters from a very remote time and place in the Asia region. They have diversified to occupy many aquatic niches and, amazingly, even shifted by natural selection from water to occupy moist leaf litter under ferns in rain forests. The Blackline or Rainbow-eye Damselfly of O'ahu was formally named by R. C. L. Perkins in 1899, aptly noting:" The bright yellow face and the colour of the eyes, which are bright green or turquoise blue on the lower half, and red on the upper, give this species a most remarkable appearance when flying around streams." (Williams 1936)

Francis X. Williams wrote 80 years ago this was a common species from sea level to 2400', but by 1996 it appeared to be extirpated from the Waianae Mountains and present in the Ko'olau only as scattered colonies, breeding in pools along upland streams and in seepage fed pools along overflow channels (Williams 1936, p 318; Polhemus and Asquith 1996).

[4] The writer conferred with Professor Larry Kimura of University of Hawai'i, Hilo, about Hawaiian names while assisting on the captions for insects in "Remains of a Rainbow" by Liittschwager and Middleton. 2001

Figure 21: Blackline Hawaiian Damselfly resting on site

The brown, inch-long nymphs (Figure 22) favor a concealed existence clinging under stones or hiding in algae masses both in moving and quiet waters for long intervals. They use 3 long, hairy, sac-like caudal gills as swimming flippers. Their diet includes bloodworms, which are larvae of *Chironomus hawaiiensis*, *Forcipomyia* midge, *Tanytarsus*, *Culex*, *Limonia* and Scatella shore flies, and even sowbugs (*Philoscia angusticauda*), and oribatid mites. (Williams 1936).

Males are territorial, guarding patches along the water from other males by short repelling sorties as they feed and await the approach of receptive females. After mating in a heart-shaped loop, couples often fly in tandem (Figure 23), alighting on plants emerging from the water to insert eggs into plant tissue, usually under the water level. Kalo is one of the few emergent water plants available in their waters now, but some were seen with broken, pig – chewed petioles, so management by a hog wire fence exclosure can improve the number of plants emerging from water available for ant- free perches during egg insertions.

At the HMP site, on sunny days, up to 8 males were sighted spaced out along the waters, but with thick cloud cover and much decreased sunlight, only two, one or none were present, at mid-day, probably with damselflies having risen into trees to roost. Polhemus and Magnacca both noted in personal communications that far fewer females than males spend time concentrated beside waters, the females having dispersed into other higher vegetation for security.

Today there is much growing scientific interest about these insects. For example, December 2017, the Pacific Entomology Conference of the Hawaiian Entomological Society included two presentations on damselflies. Karl Magnacca of RCUH reported that adults in the related Orangeblack Hawaiian Damselfly, *M. xanthomelas*, are easily seen flying, feeding on day-flying insects, and live only about one month, but the cryptic, aquatic larva grows by predatory foraging for 3 months. He reviewed Bishop Museum's Hawai'i Biological Survey work from 1994 on the Tripler Army Medical Center population, where it was necessary to conduct a detailed investigation of the biology. (Polhemus 1995)

At the same Pacific Entomology Conference Robert Peck reported on persistence of the related *M. xanthomelas* in a coastal Big Island federal historical park's managed brackish ponds at Kaloko, North Kona and nearby a'a lava depressions dated at 3000 years. A small damselfly population in Kiholo, North Kona, also inhabits anchialine pools that fortunately still lack introduced *Gambusia* fish.

The primary threats are predation on naiads (immatures) by alien fish, especially *Gambusia affinis, Poecilia latipinna,* and *P. reticulata*, the guppy. (Polhemus 1993)

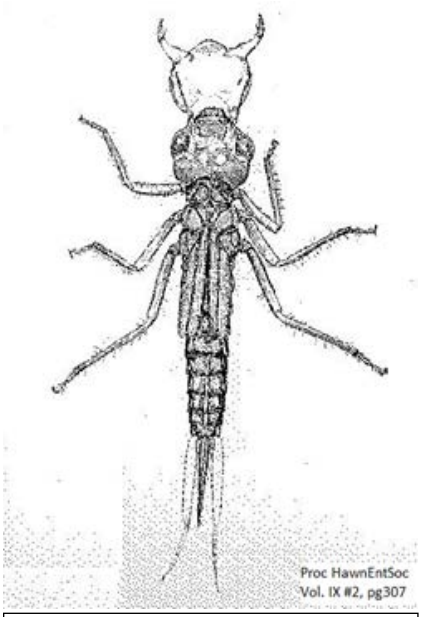

Figure 22 Last Stage nymph with lower jaw extended 18mm (Williams 1936)

Most remarkable for luminous eyes compounded of thousands of tiny lens facets arrayed in a spectrum from lime to turquoise to red, this rainbow-eye damselfly is a beauty to observe. Their large wrap-around eyes give panoramic vision for easy detection of flying prey movements. Graceful acrobats, they may fly backwards, race prey, hover or fly in tandem while copulating in air. They are deadly aerial predators with beautiful black, spiny legs forming into a basket to capture prey. They pounce, or take prey on the wing, then begin to feed on their still-living lunch. Damselflies will catch and eat any insect smaller than they are, even moths, leafhoppers, and crane flies. The larger damsels devour the smaller species and are, in turn, prey for the even larger dragonflies.

The more vibrant hues of male eyes may attract females and threaten rival males. Males aggressively patrol aerial corridors near breeding pools where females lay eggs after mating. Males are fearless in protection of genetic posterity, undeterred by approaching humans, making them easy to observe.

Figure 23: Pair of damselflies in tandem; male in front guards female in rear placing eggs in plant with bent abdomen.

The cellophane-like intricately veined wings are exquisite. In 1874, the world's damselfly expert determined the Hawaiian group was allied to South Pacific-Asian species. Calling them "the most magnificent species of the Legion", he erected a new group to account for their unique wing vein patterns. (McLachlan in Zimmerman 1948a). Rapid snapshots of wings in flight reveal the front and back wings stroke independently creating a smooth ride as air currents balance.

Table 1: List of Invertebrates: Hawaiian Memorial Park, Kāne'ohe, O'ahu

Species	Common Name	Status	Comments	2008	2017
MOLLUSCA					
GASTROPODA					
PULMONATA	Snails / Slugs				
Achatinidae					
Lissachatina fulica (Bowdich) *[previously Achatina fulica* (Bowdich *1822)]*	Giant African Snail	Pur			X
Spiraxidae					
Euglandina rosea (Férussac)	Rosy Wolf Snail	Adv			X
Thiaridae	Malaysian live bearing snails				
Melanoides tuberculate (Mueller)	Melania	Adv			X
ARTHROPODA					
ARACHNIDA					
ARANEAE	Spiders				
Heteropodidae					
Heteropoda venatoria (Linnaeus), 1767	Large Brown Spider / Cane Spider	Adv			X
Pholcidae					
Pholcus phalangioides (Fuesslins, 1775)	Longbodied Cellar Spider	Adv			X
SCORPIONIDA					
Scorpiones	Scorpions				
Isometrus maculatus (De Geer)	Lesser Brown Scorpion	Adv		X	X
INSECTA					
COLEOPTERA	Beetles				
Oedemeridae					
Ananca bicolor (Fairmaire), 1849	Red-Black False Blister Beetle	Adv		X	
DERMAPTERA	Earwigs				
Chelisochidae					
Chelisoches morio (Fabricius), 1775	Black Earwig	Adv			X
DIPTERA	Flies and Mosquitoes				
Culicidae	Mosquito				
Aedes albopictus Skuse	Forest day mosquito	Adv	Prey of damselfly		X
Culex quinquefasciatus Say, 1823	Southern house mosquito	Adv			X
Toxorhynchites amboinensis (Doleschall, 1857)	Cannibal mosquito	Pur	Preys on pest mosquitoes; does not bite humans		X
Chironomidae	Midges				
Chironomus hawaiiensis Grimshaw, 1901		End	Prey of damselfly		X
Ceratopogonidae	Biting Midges				
Dasyhelea hawaiiensis					
Forcipomyia howarthi Wirth & Howarth, 1982		End	Prey of damselfly		X
Ephydridae	Shore flies				
Brachydeutera hebes Cresson, 1926	Shore fly	End	Feeds on algae, fresh water		X
Tipulidae					
Limonia perkinsi Grimshaw, 1901	Crane fly	Adv			X
HEMIPTERA: HETEROPTERA	True Bugs				
Miridae	Leaf Bugs				
Trigonotylus hawaiiensis(Kirkaldy), 1902		End		X	
Lygaeidae					
Nysius terrestris Usinger, 1942	Seed bug	End	On Portulaca		X
Veliidae					
Microvelia vagans White	Velvet Water bug	Adv	On surface of water		X

Species	Common Name	Status	Comments	2008	2017
INSECTA					
HYMENOPTERA	Wasps, Bees, Ants				
Anthophoridae					
Xylocopa sonorina F. Smith, 1874	Sonoran Carpenter Bee	Adv			X
Apidae					
Apis mellifera Linnaeus, 1758	Honey Bee	Pur			X
Formicidae	Ants				
Anoplolepis gracilipes	Long-legged Ant	Adv		X	
Camponotus variegatus (F. Smith, 1858)	Carpenter Ant	Adv		X	X
Ochetellus glaber (Mayr), 1862	Glaber Ant	Adv		X	
Pheidole megacephala (Fabricius), 1793	Big-headed Ant	Adv			X
Vespidae	Wasps				
Polistes exclamans Viereck, 1906	Common Paper Wasp	Adv			X
LEPIDOPTERA					
Cosmopterigidae	Case Bearers				
Hyposmocoma sp.		End	At light	X	X
Crambidae	Micro-Moths				
Eudonia sp.	Moss Moth	End		X	X
Mestolobes sp. (likely minuscula)			No common name	X	X
Geometridae					
Semiothisa infusata	Koa Haole Moth	Adv		X	X
Noctuidae	Miller Moths				
Achaea janata (Linnaeus), 1758	Croton Caterpillar	Adv			X
Nymphalidae					
Agraulis vanillae (Linnaeus, 1758)	Passion Vine Butterfly	Adv			X
Danaus plexippus (Linnaeus, 1758)	Monarch Butterfly	Adv			X
ODONATA	Dragonflies Damselflies				
Coenagrionidae					
Megalagrion nigrohamatum nigrolineatum (Perkins), 1899	Blackline Hawaiian Damselfly Rainbow-eye Damselfly pinao ānuenue	End	Endangered		X
ORTHOPTERA	Grasshoppers, Crickets				
Tettigoniidae					
Euconocephalus nasutus (Thunberg), 1815	Aggravating Grasshopper	Adv	In tall grass		X
CHILOPODA					
Scolopendromorpha	Centipedes				
Scolopendridae					
Scolopendra subspinipes Leach 1815	Large Centipede	Adv		X	X
DIPLOPODA	Millipedes				
Paradoxosomatidae					
Oxidus gracilis (C.L. Koch), 1847	Garden Millipede	Adv		X	X

Status:

End	endemic to Hawaiian Islands	Ind	indigenous to Hawaiian Islands
Adv	adventive	Pur	purposefully introduced

Names authority: Hawaii Biological Survey 2002a, b; Nishida 2002; Zimmerman 1948-80; Zimmerman 2001

INVERTEBRATES NOT PRESENT

Plant and invertebrate populations are interdependent; consequently, host plant availability is one way to review invertebrate health. As discussed in the botanical survey (LeGrande 2006, 2017) and archaeology reports (McCurdy and Hammatt 2008), the area has a long history of human use: Hawaiian agriculture, rice and pineapple production, cattle ranching and coffee cultivation, with feral pigs currently present, all destructive to native plants. The resulting extremely low level of native plants serving as arthropod hosts leads to the low level of Hawaiian arthropods.

SPECIES NOT FOUND

Any survey for federally protected species should include consideration of all native invertebrates (snails, spiders, and insects). A review of the archaeological survey of the area (McCurdy and Hammatt 2008) indicated no lava tubes at the project site which could support cave-adapted native invertebrate species. Nor did this survey give any indication of lava tubes.

MOLLUSCA

No native mollusks were observed during this survey.

GASTROPODA Pulmonata

Achatinellidae: **Achatinella**

O'ahu does have protected snail species, the O'ahu tree snails, but the flora, rats (Bruner 2006; dead individual found on site September 12, 2017), Rosy Wolf snail (*Euglandina rosea*) [see above] and other factors now make this property unsuitable habitat for the native Hawaiian endemic snails listed as endangered.

DIPTERA

Drosophilidae: *Drosophila*

No native *Drosophila* were observed on the property. The property is now unsuitable habitat for any of the endemic *Drosophila* some being listed as endangered or threatened. These native Hawaiian picture wing flies require a much more native environment with host flora not offered at this property. (*Federal Register* 2006a, b). Nevertheless, a large Monkeypod tree sap exudate or flux was examined as a possible breeding site of *Drosophila* in 2008. Smaller fluxes were examined September 20 and November 19, 2017. (Figure 24) None yielded any native invertebrates. Some native *Drosophila* flies are known to lay eggs only in sap fluxes where sweet, fermenting plant sap slowly leaks from a wound. Fermented by yeasts, the sap is made into a rich food for larval flies. Some introduced tree sap "tastes" enough like the native sap to entice some native flies to lay eggs at this resource when populations of the fly remain. This flux appeared devoid of larvae, even of *D. carbonaria*, which is known from Kailua since the 1990s.

Species Not Found: continued

Figure 24: Monkeypod tree fluxes examined for *Drosophila* 2017 (L) and 2008 (R)

.

LEPIDOPTERA

Sphingidae: *Manduca blackburni*

The Blackburn's sphinx moth[5] (*Manduca blackburni*), an endangered species (Fed Reg 1999-2000) was not found in this survey. Historically, the moth is known from drier locations and the critical habitat established for the moth on O'ahu is many miles distant from this property. Neither the moth's solanaceous native host plant, 'aiea (*Nothocestrum* sp.), nor the best alien host, tree tobacco (*Nicotiana glauca*), were observed on the property or found by the botanical survey (LeGrande 2006, 2017).

[5] Blackburn hawk moth is the official common name recognized by the HES Committee on Common Names of Insects (1990). Blackburn's sphinx moth has come into popular usage.

MEDICALLY IMPORTANT SPECIES

Centipedes, scorpions, black or brown widow spiders:

The piles of dead brush and leaves common throughout the property are classic habitat for centipedes, scorpions, black or brown widow spiders. Although few of these medically important species were seen in this survey, they are likely hiding in dry leaves & under dead wood, plants, inside discarded pipes present in the area. Surveyors, crews clearing debris, etc. should be alert for all these species which may pose a serious risk to some individuals. When moving stones or piled brush, wearing gloves, covered shoes, long sleeves, and long pants will greatly reduce the risk of accidental contact and bites [for example: pull socks up over pant cuffs to deter disturbed critters from crawling up pants; use cut off socks to slide over connect between gloves and long sleeve shirt cuff]. Supervisors should be aware of any allergy by employees. Some individuals can experience anaphylactic reactions to venom of any of the mentioned arthropods, not just bees. Please see *What Bit Me?* (Nishida and Tenorio 1993) for additional information.

Figure 25: Leaf cover habitat – use care

Figure 26: When removing abandoned pipes [arrow] workers should be alert for centipedes and other dangerous species inside or under.

Medically Important Species: continued

COLEOPTERA: Oedemeridae

Figure 27: Red-black false blister beetle

Ananca bicolor (Fairmaire) 1849, or red-black false blister beetles responded to the light survey in 2008 and should be assumed still present although not seen in 2017. The species is known from several major islands, including Oahu and as far as Ni'ihau and Midway. The beetles are attracted to lights, but also feed on flower pollen by day. When irritated or pressed (between clothing and skin, for example) they ooze a defensive irritating chemical causing blistering of skin. The susceptibility to blistering is reported to vary as do healing rates. Although irritating, uncomfortable, and very unpleasant, the blisters are not life threatening. Seek medical attention if blistering is widespread or does not heal promptly.

See "*What's Bugging Me?*" (Tenorio and Nishida 1995) or for detailed discussion see University of Florida / Florida Dept. of Agriculture web site http://entomology.ifas.ufl.edu/creatures/urban/medical/blister_beetles.htm. (Arnett 2008)

Figure 28: Carpenter bee: black female, golden male; tunnel housing.

HYMENOPTERA: Anthophoridae

Carpenter bees (*Xylocopa sonorina*) were not observed but are likely present in the dry, dead wood on site. The black carpenter bee females and golden males are easily seen. Carpenter bees carve out a short tube tunnel in soft wood (fence post, dry branches) as their home (Figure 28). They do not form colonies, but live individually. Carpenter bees are not a danger to people under normal circumstances, but if cornered can sting.

Medically Important Species: continued

Apidae

As in many locations in the islands, it is probable there are hidden honey bee (*Apis mellifera)* colonies on the property. Dead trees with hollows are a favored location for a hive. If in clearing areas bees are encountered, a beekeeper should be contacted to remove the colony safely. Employees with an allergy to stings should inform their supervisor and carry their response kit at all times.

Vespidae

Common paper wasps (*Polistes* sp.) are on the property. This wasp favors dry, sheltered sites. These wasps are common throughout the lowlands and especially like to build their 'paper' nests under overhangs. (Figure 29). They are a danger to humans. They sting repeatedly, unlike honey bees. Nests are best destroyed at night when all wasps are on the paper nest. Destroying the nest during daylight hours will result in rebuilding when the wasps return later in the day.

SEE ALSO Glaber ant on page 18

Figure 29: Typical paper wasp nest

POTENTIAL IMPACTS

Potential Impacts on Native, Rare, Federally or State Listed Species

One federally and state listed endangered or threatened invertebrate species is known on this property. Recommendations are given below. The remaining native Hawaiian invertebrates observed are widespread in distribution.

RECOMMENDATIONS

Protections for Damselfly

Damselfly populations and human developments can co-exist. As far back as July 1925, a specimen of *Megalagrion nigrohamatum* was taken near Kalihi Stream in a neighborhood already well populated (Bishop Museum Checklist Query /HBS 2002a). A population of *M. xanthomelas* on O'ahu at a Tripler Army Hospital grounds stream course has been sustained by managing piped water for 20 years (Karl Magnacca, RCUH, personal communication 2017). On Lāna'i, *M. xanthomelas* was found breeding in a large, ornamental pond behind the Kō'ele Lodge (Polhemus & Asquith 1996).

The following are recommendations to maintain the HMP population:

A. Monitor water source

The source of the water appears to be steady. Regular inspections should be conducted to assure water is continuing to flow and a backup plan can be drawn up to supply water if levels are depleted. In the landscaping and in creating roadways upslope, to assure the continuing seepage of water that supplies the aquatic habitats used by the damselflies, monitoring of the water source is important.

Options:
During construction phase, include a monitoring plan of the seep as part of project's design phase and included with other BMP measures (e.g. erosion control, etc.).

Inspection should be conducted prior to the start of construction to establish and document baseline water flow conditions. Monitoring should occur during construction and for 6 months post-construction to ensure water continues to flow from the seep.

During construction phase, seep area should be checked on a weekly basis to inspect water flow in coordination with mandated weekly BMP erosion control measure checks.

After construction, inspections should be conducted weekly for the first 3 months, and every 2 weeks thereafter if conditions are satisfactory, up to a total of 6 months. After 6 months, HMP staff can conduct monthly inspections of the seep to monitor for continued water flow.

If water flow is significantly disrupted, piping of new water could be provided, or other measures implemented to supplement short-term water flow, during contractor consultations with design team or other specialists to evaluate conditions and determine appropriate measures. This has been successful at another site for a related endangered damselfly (Evenhuis et al. 1995).

RECOMMENDATIONS: Protections for Damselfly continued

B. Monitor for invasions of fish

Predation by non-native fish, especially mosquito fish (*Gambusia affinis*), is a "primary threat" factor in the 2011 Listing of Endangered Species (*Federal Register* 2011). "*G. affinis*...has been accused of disrupting native aquatic ecosystems and destroying native species ....such as the damselfly, Megala*grion*" (Howarth 1985). The regular presence of predatory *Toxorhynchites* mosquito larvae assuring these waters do not breed hordes of mosquitoes without any alien bio-control Gambusia fish are not needed. Well-meaning but uninformed persons disposing of their unwanted ornamental pet aquarium fishes into the site's waters create a high risk of native damselfly extirpation. Those doing water monitoring Inspections (A above) should be alert for the new presence of alien fishes and report to ensure prompt identification and removal by experienced biologists.

C. Fencing

A strong threat to damselflies are feral pigs present on site, attracted to wet areas to feed and loaf. Their hoof marks are often seen in wet mud. Wallowing and rooting for worms are a major alteration and disruption of damselfly breeding and resting places. The deeper, puddle-like areas created by pigs as wallows are risky mosquito and fish invasion and breeding sites.

Pig excluding fencing will protect the habitat from disturbance and improve damselfly habitat while reducing the area's attractiveness to swine. Damselflies often rest and molt on dead leaves or small sticks in stream margins or muddy areas. Their coloring is so cryptic, even a careful person could easily step on them. Fencing should be strong hogwire designed with a lower barbed strand to resist digging. Native sea bean vines (Ka'e'e) already on site can be used to mask the fence from view (*Mucuna gigantea* – see Botany report). Consultation with Federal environmental units (e.g. National Park Service), Hawaii Division of Forestry & Wildlife and The Nature Conservancy can aid design of a functional barrier, as all have positive experiences blocking this type of swine damage.

Figure 30: Individual damselflies, especially naiads, are hard to detect amid leaves and mud, meaning even well-intentioned people could step on them.

Potential Impacts: recommendations continued

Figure 31: Night camera caught wild pig invading damselfly habitat.

Figure 32: Wild pig hoof prints in damselfly habitat.

Potential Impacts: recommendations continued

Figure 33: Typical habitat patrolled by damselfly males.

Figure 34: Wet area deepened by pigs as wallow, not suitable for damselflies.

RECOMMENDATIONS: Protections for Damselfly continued

D. Provide ant evasion assistance

Adult damselflies can easily evade the Big-headed ants by flight. The naiads can become ant prey when they crawl out to molt skins into soft, teneral adults. Ants will not cross water barriers so the provision of small sticks placed upright, and well away from the edges of waterlogged areas and pools, can serve as safe zones for emerging naiads. This could be done during periodic monitoring of water levels and inspections for invasive fish. No special supplies are needed; any stick on site approximately a foot long will serve.

General Recommendations for promotion and protection of native invertebrates

Landscape with native plants:

The earlier and 2017 botanical surveys recommended landscaping with native plants during the project (LeGrande 2006, 2017). In addition to their beauty and the positive cultural and social values communicated by the use of native plants, these plants would provide habitat and refuge for native arthropods while creating a more interesting area for people walking and contemplation. Native plants will remain green and thus more fire resistant throughout the summer. Native plantings may have lower maintenance costs when chosen to match area needs. As native plants tend to reach a predictable height and foliage spread, well-chosen plantings usually mean less hedge trimming and weed whacking. In the areas to be left undeveloped or used to screen the HMP expansion from housing, native plants in a mixture of ground cover, shrub, and tree heights will slow run off, retain moisture and recharge aquifers while holding soil at low cost. The plantings can provide educational, visual, and aesthetic benefits to HMP visitors. Native insects and other creatures may use this refuge over time.

Native plants can be as convenient for mass plantings as the introduced plants commonly used to re-vegetate after new construction. A list of suppliers of native plants is available at http://nativeplants.hawaii.edu/nursery/

ACKNOWLEDGMENTS

Steven Lee Montgomery conducted all surveying and is responsible for all conclusions. Anita Manning assisted with database searches, in the field, and contributed to preparation of this report. Thanks goes to Maya LeGrande for field collaboration Sept. 12, to Justin Soriano and night security staff of Hawaiian Memorial Park, and Dr. Daniel Polhemus, US Fish & Wildlife Service, for time in the field.

Photos are by Anita Manning or Steven Montgomery unless otherwise attributed.

STANDARD NOMENCLATURE

Invertebrate names follow

Freshwater & Terrestrial Mollusk Checklist (HBS 2002b)
Common Names of Insects & Related Organisms (HES 1990)
Hawaiian Terrestrial Arthropod Checklist (HBS2002a; Nishida 2002)

Plant names follow

Manual of the Flowering Plants of Hawai'i (Wagner et al. 1999)
A Tropical Garden Flora (Staples and Herbst 2005)

Mammal names follow *Mammals in Hawai'i* (Tomich 1986).

Place name spelling follows *Place Names of Hawaii* (Pukui et al. 1976).

ABBREVIATIONS

DLNR	Department of Land and Natural Resources, State of Hawai'i
DOFAW	Division of Forestry and Wildlife
ESA	Endangered Species Act of 1973, as amended.
HBS	Hawai'i Biological Survey
HMP	Hawaiian Memorial Park
n.	new
RCUH	Research Corporation of the University of Hawai'i
sp.	species
spp.	more than one species
TMK	Tax Map Key
USFWS	United States Fish and Wildlife Service

GLOSSARY[6]

Adventive: organisms introduced to an area but not purposefully.

Alien: occurring in the locality it occupies ONLY with human assistance, accidental or purposeful; not native. Both Polynesian introductions (e.g., coconut) and post-1778 introductions (e.g., guava, goats, and sheep) are aliens.

Arthropod: insects and related invertebrates (e.g., spiders) having an external skeleton and jointed legs.

Diurnal: active in the daylight hours

Endangered: A species listed and protected under the Endangered Species Act of 1973, as amended.

Endemic: naturally occurring, without human transport, ONLY in the locality occupied. Hawaii has a high percentage of endemic plants and animals, some in very small microenvironments.

Indigenous: naturally occurring without human assistance in the locality it occupies; may also occur elsewhere, including outside the Hawaiian Islands. (e.g., Naupaka kahakai (*Scaevola sericea*) is the same plant in Hawai'i and throughout the Pacific).

Insects: arthropods with six legs, and bodies in 3 sections

Invertebrates: animals without backbones (insects, spiders, snails / slugs, shrimp)

Larva/larval: an immature stage of development in offspring of many types of animals.

Mollusk: invertebrates in the phylum Mollusca. Common representatives are snails, slugs, mussels, clams, oysters, squids, and octopuses.

Native: organism that originated in area where it lives without human assistance. May be indigenous or endemic.

Naturalized: an alien organism that, with time, yet without further human assisted releases or plantings, has become established in an area to which it is not native.

Nocturnal: active or most apparent at night.

Pupa: the stage between larva and adult in insects with complete metamorphosis, a non-feeding and inactive stage often inside a case

Purposefully introduced: an organism brought into an area for a specific purpose, for example, as a biological control agent.

Polyphagous: eating many different types of food

Rare: threatened by extinction and low numbers.

Species: all individuals and populations of a particular type of organism, maintained by biological mechanisms that result in their breeding mostly with their kind.

Teneral: newly emerged and soft bodied, vulnerable

6 Glossary based largely on definitions in *Biological Science: An Ecological Approach*, 7th ed., Kendall/Hunt Publishing Co., Dubuque, a high school text; on the glossary in *Manual of Flowering Plants of Hawai'i*, Vol.2, Wagner, et al., 1999, Bishop Museum Press, and other sources.

LITERATURE CITED

Arnett, Jr., Ross H. "False blister beetles." Originally published as Division of Plant Industry Entomology Circular 259. On web site of University of Florida / Florida Dept. of Agriculture http://creatures.ifas.ufl.edu/urban/medical/blister_beetles.htm Accessed July 28, 2008

Bick, G. H. and J. C. Bick. 1965. "Demography and Behavior of the Damselfly, Argia Apicalis (Say), (Odonata: Coenagriidae)," *Ecology*, 46: 461–472.

Bruner, P. L. 2006. "Avifaunal and Feral Mammal Field Survey for the Hawaiian Memorial Park Expansion Area, Kaneohe, Oahu, Hawaii." Prepared for: Clark and Green Associates. 11 pp.

CABI. Invasive Species Compendium. *Lissachatina fulica*. CAB International. [Accessed Feb 19, 2015]. USDA National Agricultural Library, National Invasive Species Information Center. Accessed December 11, 2017

Department of Land and Natural Resources (DLNR). 1998. Indigenous Wildlife, Endangered and Threatened Wildlife and Plants, and Introduced Wild Birds. Department of Land and Natural Resources. State of Hawaii. Administrative Rule §13-134-1 -§13-134-10, March 2, 1998; Exhibit 1, 13-124, 11/1/2014.

Devaney, D., M. Kelly, P. J. Lee, and L. S. Motteler. 1976. *Kāne'ohe: A History of Change (1778-1950)*. Bernice. P. Bishop Museum. The Bess Press, Honolulu. 271 pp.

Division of Forestry and Wildlife. Native Ecosystems Protection & Management. *Damselflies of Kaluanui.* Accessed Nov 2017. http://dlnr.hawaii.gov/ecosystems/damselflies-of-kaluanui/ Photo by Dan Polhemus.

Evenhuis, N, D. A. Polhemus, S. Swift, K. Arakaki, D. J. Preston. 1995. "A study of the biology of the Orangeblack Hawaiian Damselfly (*Megalagrion xanthomelas*), with special reference to conservation of the population at Tripler Army Medical Center, Oahu," *Bishop Museum Technical Report 8*. Bishop Museum Press, Honolulu, Hawaii.

Federal Register. 1999-2000. Title 50, Vol. 1, Parts 1 to 199. [Revised as of October 1, 2000] U.S. Government Printing Office via GPO Access [CITE: 50CFR17.11, Page 102-143].

_____. 2006a. Title 50, Vol. 71, No. 89, May 9. *Endangered and Threatened Wildlife and Plants; Determination of Status for 12 Species of Picture-Wing Flies From the Hawaiian Islands*. [CITE: 50 CFR 17, Page 26835 -26852].

_____. 2006b. Vol. 71, No. 157, August 15. *Proposed Designation of Critical Habitat for 11 Species of Picture-Wing Flies From the Hawaiian Islands*. [CITE: 50 CFR Part 17, Page 46994 – 47054].

LITERATURE CITED: cont.

Federal Register. 2011. Vol. 76, No. 148, August 2. Endangered and Threatened Wildlife and Plants; Listing 23 Species on Oahu as Endangered and Designating Critical Habitat for 124 Species; Proposed Rule. [CITE: 50 CFR 17, Page 46362-46594]

Funasaki, G.Y., P.-Y. Lai, L. M. Nakahara, J. W. Beardsley, and A.K. Ota. 1988. "A review of biological control introductions in Hawaii: 1890 to 1985," *Proceedings of the Hawaiian Entomological Society*, 28:105-160.

Hawai'i Biological Survey (HBS). 2002a. Hawaiian *Arthropod Checklist*, online authority file of terrestrial arthropod names for the Hawaiian Islands. B. P. Bishop Museum, Honolulu. www2.bishopmuseum.org/HBS/checklist/

_____. 2002b. Bishop Museum *Hawaiian Freshwater & Terrestrial Mollusk Checklist*. Accessed April 2008.

Hawaiian Entomological Society (HES). 1990. *Common Names of Insects & Related Organisms*. Committee on Common Names of Insects. 87 pp.

Hawaiian Ecosystems at Risk project (HEAR). Accessed July 2008. www.hear.org/starr/hiinsects/images

HHF Planners. 2017. *Hawaiian Memorial Park Expansion Project Environmental Impact Statement Preparation Notice*. For Hawaiian Memorial Life Plan Ltd. 77 pp.

HOSTS - a Database of the World's Lepidopteran Hostplants, Natural History Museum London. Accessed July 2008. www.nhm.ac.uk/research-curation/projects/hostplants/

Howarth, F. G. 1985. quoted p.155 in Funasaki, G. Y., P.-Y. Lai, L. M. Nakahara, J.W. Beardsley, and A.K. Ota. 1988. "A review of biological control introductions in Hawaii: 1890 to 1985," *Proceedings of the Hawaiian Entomological Society,* 28:121-160.

LeGrande, M. 2006. "Botanical Resources Assessment for the Hawaii Memorial Park Expansion, Kaneohe, Oahu." Prepared for: Clark & Green Associates. 12 pp.

_____. 2017. "Hawaiian Memorial Park Expansion Plan Kaneohe, Oahu." Prepared for Helber, Hastert, & Fee Planners. 13 pp.

Liittschwager, D. and S. Middleton, photographers. 2001. *Remains of a Rainbow*, National Geographic / Environmental Defense Fund. Accompanying zoological captions by Manning, Montgomery, *et al*.

McCurdy, T. D. and Hammatt, H. H. 2008. "Archaeological Inventory Survey for the Hawaiian Memorial Park Expansion, Kāne'ohe Ahupua'a, Ko'olaupoko District, Island of O'ahu." Prepared for Helber, Hastert & Fee Planners. 124 pp.

McLachlan, R. 1874. "Note on some Odonata from the Sandwich Islands...," *Entomologist's Monthly Magazine*, 11:29.

LITERATURE CITED: cont.

Magnacca, K. 2017. Personal Communication. RCUH

Nishida, G. M. (ed.). 2002. *Hawaiian Terrestrial Arthropod Checklist*. Fourth edition. *Bishop Museum Technical Report* 22, 313 pp

Nishida, G. M. and J. M. Tenorio. 1993. *What Bit Me?* Univ. of Hawaii Press. 72 p.

Perkins, R. C. L. 1907. "The insects of Tantalus," *Proceedings of the Hawaiian Entomological Society,* 1(2):42.

_____. 1913. "Introduction. Being a review of the land-fauna of Hawaiia," and "Vertebrates." *In*: Sharp, D., ed., *Fauna Hawaiiensis. Vol. 1*. Cambridge University Press, Cambridge, and Bishop Museum Special Pub. 6. pp ix-ccxxviii.

Polhemus, D. 1993. "Damsels in distress: a review of the conservation status of Hawaiian *Megalagrion* damselflies (Odonata: Coenagrionidae)," *Aquatic Conservation: Marine and. Freshwater. Ecosys*tems 3: 343–49.

_____ 1995. "The Orangeblack Hawaiian Damselfly, Megalagrion xanthomelas (Odonata: Coenagrionidae): Clarifying the Current Range of a Threatened Species," *Contribution No. 1996-003 to the Hawaii Biological Survey*
http://hbs.bishopmuseum.org/pdf/op45-30-53.pdf

Polhemus, D., and A. Asquith. 1996. *Hawaiian Damselflies: A Field Identification Guide.* Bishop Museum Press, Honolulu, Hawai'i. 122pp.

Pukui, M. K., S. H. Elbert, and E. T. Mookini. 1976. *Place Names of Hawaii*. University of Hawaii Press, Honolulu, Hawai'i. 289 pp.

Rubinoff, D. and W. P. Haines. 2006. "*Hyposmocoma molluscivora* Description," *Science,* 311:1377

Staples, G. W. and D. R. Herbst. 2005. *A tropical garden flora.* Honolulu, Bishop Museum Press, 908 p.

Steffan, W. A. 1969. "Hawaiian Toxorhynchites (Diptera: Culicidae)," *Proceedings of the Hawaiian Entomological Society*, 20(1): 141-155.

_____. 1982."Notes and Exhibitions," *Proceedings of the Hawaiian Entomological Society*, 24(1):14.

Swezey, O. H. 1910. "Feeding Habits of Hawaiian Lepidoptera," *Proceedings of the Hawaiian Entomological Society*, 2(3):484.

LITERATURE CITED: cont.

Swezey, O. H. 1931. "Miscellaneous notes," *Proceedings of the Hawaiian Entomological Society*, 7(3):484.

Tenorio, J. M. and Nishida, G. M. 1995. *What's Bugging Me?* University of Hawaii Press. 184 p.

Tomich, P. Q. 1986. Mammals in Hawaii. Bishop Museum Press, Honolulu, Hawaii. 375 p.

U.S. Fish & Wildlife Service (USFWS). 2008; 2017. USFWS Threatened and Endangered Species System (TESS), online at http://ecos.fws.gov/tess_public/StartTESS.do

U.S. Naval Observatory (USNO), Astronomical Applications Department. *Sun and Moon Data for One Day*. http://aa.usno.navy.mil/

University of Florida/Florida Dept. of Agriculture. *Featured Creatures: blister beetles*. Accessed Nov 2017. http://entomology.ifas.ufl.edu/creatures/urban/medical/blister_beetles.htm.

Wagner, W. L., D. R. Herbst, and S. H. Sohmer. 1999. *Manual of the flowering plants of Hawaii*, Rev. ed. University of Hawaii Press and Bishop Museum Press, Honolulu, 1919 pp.

Williams, F. X. 1931. *Handbook of the Insects and Other Invertebrates of Hawaiian Sugar Cane Fields.* Experiment Station of the Hawaiian Sugar Planters' Association, Honolulu, Hawaii. 400 pp.

_____ 1936. "Biological Studies in Hawaiian Water-Loving Insects. Part II Odonata or Dragonflies," *Proceedings of the Hawaiian Entomological Society*, 9(2):273-348.

_____ 1944. "Biological Studies in Hawaiian Water-Loving Insects. Part III, IV, V" *Proceedings of the Hawaiian Entomological Society*, 12(1):149-197.

Yamamoto, M. N. and Tagawa, A. W. 2000. *Hawaii's native & exotic freshwater animals*. Mutual Pub., Honolulu, Hawaii. 200 pp.

Zimmerman, E. C. 1948- 80. *Insects of Hawaii*. University of Hawaii Press, Honolulu.

_____. 1948a. *Insects of Hawaii. Volume 2: Apterygota to Thysanoptera*. University of Hawai'i Press, Honolulu. 475 pp.

_____. 1948b. *Insects of Hawaii. Volume 3: Heteroptera*. University of Hawai'i Press, Honolulu. 255 pp.

_____. 1958. *Insects of Hawaii. Volume 8: Lepidoptera: Pyraloidea*. University of Hawai'i Press, Honolulu. ix + 456 pp

LITERATURE CITED: cont.

Zimmerman, E. C. 1978. *Insects of Hawaii*. *Volume 9: Microlepidoptera Part II*, University of Hawaii Press, Honolulu. pp. 1029-1699.

_____. 2001. *Insects of Hawaii. Volume 1: Introduction*. University of Hawai'i Press, Honolulu. xx + 206 pp.