



Terrestrial Invertebrates

Hawaiian tree snails

Subfamily Achatinellinae

SPECIES STATUS:

99 species 44 Federally Listed as
Endangered 44 State Listed as Endangered State

Recognized as Endemic

SPECIES INFORMATION: Achatinellinae is an endemic subfamily of snails which includes around 100 described species in the genera *Achatinella*, *Partulina*, *Perdicella*, and *Newcombia*. Unfortunately, about half of these species are thought to be extinct, and what remains are facing imminent extinction (Hadfield 1986, Yeung and Hayes 2018). These large arboreal snails range in size from approximately 10 to 20 millimeters and give live birth to three to seven offspring per year. Members of the genus typically live upwards of ten years and are nocturnal, feeding on algae, bacteria, and fungus that grow on the surface of leaves, branches, and trunks of host trees (Hadfield and Miller 1989, Hadfield et al. 1993). Having beautiful shells, Hawai‘i’s tree snails have been described as the “jewels of the forest” and are well known in the islands. In Hawaiian tradition snails sing and many are referenced in mele, hula, and mo‘ōlelo (Sato et al. 2018).

DISTRIBUTION: Members of this subfamily are all single-island endemics occurring on O‘ahu, M‘aui, Moloka‘i, Lana‘i, and Hawai‘i Island.

ABUNDANCE: The entire subfamily is experiencing drastic range reductions and extinctions across their range.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this subfamily is native wet and mesic forests.

THREATS: The entire subfamily is in imminent danger of going extinct. They are considered critically imperiled wherever they occur. The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.), *Euglandina* spp., and Jackson’s chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland et al. 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be

impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity.

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term

- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

References:

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Terrestrial Invertebrates

Hawaiian Land snails

Family Amastridae



Photo: D. R. Sischo; *Amastra cylindrica*

SPECIES STATUS:

325 species

State Recognized as Endemic

SPECIES INFORMATION: The family Amastridae is the most speciose snail family in the islands with 325 described species. Even more special is the fact that the entire family is endemic to the Hawaiian Islands. In general, Amastrids are considered to be ground dwelling or semi arboreal, and they are detritivores, feeding on dead and decaying leaves of a variety of native plants, with many having a preference and close association to plants in the Urticaceae (nettle family). Of all the Hawaiian land snails, no group has seen more extinction than those in the family Amastridae (Régner et al. 2015). This family's existence is confined entirely to the main Hawaiian Islands, with no closely related members anywhere else in the world (Cowie et al. 1995). Of the 325 described species, only 15 were thought to remain in 2014 (Régner et al. 2015). However, since 2014 extensive surveys have documented more than a half dozen additional species just barely hanging on— bringing the total alive today to only 23 species of the 325. Nearly half of these owe their continued existence to rediscoveries made only possible through continued surveys, followed by emergency captive rearing and reintroduction efforts by researchers at the Bishop Museum, the Honolulu Zoo, and the Division of Forestry and Wildlife's Snail Extinction Prevention Program. All this is to say, without conservation intervention in the form of captive propagation, and reintroduction into protected areas, the outlook of the few remaining species in the Amastridae family is bleak, and Hawaii will lose one of the only endemic animal families left in the islands.

DISTRIBUTION: Members of this family are all single-island endemics with species historically occurring on all main Hawaiian Islands.

ABUNDANCE: The entire family is experiencing drastic range reductions and extinctions across their range.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this subfamily is native wet and mesic forests. Some species such as those in the genus *Leptachatina* occur mostly on rocky talus. Snails are often associated with plants in the Urticaceae (nettle family).

THREATS: The entire subfamily is in imminent danger of going extinct. They are considered critically imperiled wherever they occur. The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.), *Euglandina* spp., and Jackson's chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al.

1984, Hadfield 1986, Cowie 2001, Holland *et al.* 2008, Meyer *et al.* 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach *et al.* 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity.

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
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- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants, particularly in the Urticaceae.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
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RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.

- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
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Terrestrial Invertebrates

Hawaiian tree snails

Subfamily Auriculellinae

SPECIES STATUS:

32 species State Recognized as Endemic

SPECIES INFORMATION: Auriculellinae is an endemic subfamily of snails which includes 32 described species in the genus *Auriculella* (Yeung et al. 2020). These small arboreal snails range in size from approximately 6 millimeters or less and lay eggs. Species are mostly nocturnal, feeding on algae, bacteria, and fungus that grow on the surface of leaves, branches, and trunks of host trees. Having beautiful shells, Hawai'i's tree snails have been described as the “jewels of the forest” and are well known in the islands. In Hawaiian tradition snails sing and many are referenced in mele, hula, and mo'ōlelo (Sato et al. 2018).

DISTRIBUTION: Members of this subfamily are all single-island endemics occurring on O'ahu, Māui, Moloka'i, Lana'i, and Hawai'i Island.

ABUNDANCE: The entire subfamily is experiencing drastic range reductions and extinctions across their range.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this subfamily is native wet and mesic forests.

THREATS: The entire subfamily is in imminent danger of going extinct. They are considered critically imperiled wherever they occur. The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.), *Euglandina* spp., and Jackson's chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al.* 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication

with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity.

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
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MONITORING:

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RESEARCH PRIORITIES:

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Terrestrial Invertebrates

Hawaiian Land snails

Family Endodontidae

SPECIES STATUS:

33 species

State Recognized as Endemic



Cookeconcha hystricella Photo to N. Yeung

SPECIES INFORMATION: The Endodontid family is endemic to Oceania with 33 described species from the Hawaiian Islands (Pilsbry 1905). Little is known regarding habitats or life history of this group as almost the entire family has gone extinct from the Hawaiian Islands. Today only three species are known to occur, two species in the genus *Cookeconcha* from O‘ahu, and one species in the genus *Endodonta* from the Northwestern Hawaiian Island of Nihoa. This group is extremely imperiled.

DISTRIBUTION: Members of this family are all single-island endemics with species historically occurring on all main Hawaiian Islands and on Northwestern Hawaiian Islands, where *Endodonta christenseni*, an extant species on the island of Nihoa is believed to be the last *Endodonta* on Earth (Hayes et al. 2020).

ABUNDANCE: The entire family is experiencing drastic range reductions and extinctions across their range.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this subfamily is native dry and mesic forests, as well as coastal strand. On Nihoa, *Endodonta christenseni* is found in extremely dry exposed habitat in clumps of the native grass *Eragrostis variabilis*.

THREATS: All remaining Hawaiian species in the family are in imminent danger of going extinct. They are considered critically imperiled wherever they occur. The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.), *Euglandina* spp., and Jackson’s chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al.* 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sisco). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity.

CONSERVATION ACTIONS:

Hawai‘i’s State Wildlife Action Plan
October 1, 2025

- Survey across their range for undiscovered populations.
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- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
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- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found be to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.

- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

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Kala subrutula, Photo by David Sischo

Terrestrial Invertebrates

Hawaiian Land Snails

Family Euconulidae and Oxychilidae

SPECIES STATUS:

66 species

State Recognized as Endemic

SPECIES INFORMATION: Hawai'i has 60 species of Euconulids and six species of Oxychilids (Yeung and Hayes 2018). These flat round snails with a shell diameter of 3-10 mm resemble cinnamon buns, and can be found on the ground and in the vegetation. Interestingly, the shells of the euconulids and oxychilids are translucent, so the colors you see on the shell are actually the snails organs and body showing through.

DISTRIBUTION: All Hawaiian species are endemic with species historically occurring on all main Hawaiian Islands.

ABUNDANCE: Both families are experiencing range reductions and extinctions.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for these families include wet and mesic native forests.

THREATS: The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.), *Euglandina* spp., and Jackson's chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al.* 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity. .

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce

- offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

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Terrestrial Invertebrates

Vitrinid sp. N. Yeung



Hawaiian Land snails

Families Gastrodontidae and Vitrinidae

SPECIES STATUS:

4 species

State Recognized as Endemic

SPECIES INFORMATION: Hawai'i has one known species of vitrinid and three species of gastrodontids (Yeung and Hayes 2018). Both families are globally distributed with Hawaiian endemic species. Little is known about their life histories or conservation status.

DISTRIBUTION: Members of this family are endemic to the main Hawaiian Islands.

ABUNDANCE: Little is known of their abundance and distribution.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this family is native wet and mesic forests.

THREATS: The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.), *Euglandina* spp., and Jackson's chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al.* 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo).

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.

- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found to be depredating Hawaiian snails.
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- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

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Plueropoma sp.

Terrestrial Invertebrates

Hawaiian Land snails

Family Helicinidae

SPECIES STATUS:

14 species

State Recognized as Endemic

SPECIES INFORMATION: 14 species of Helicinidae are endemic to the Hawaiian Islands, although the family is distributed globally. Only eight species are known to persist (Yueng and Hayes 2018). Interestingly, this family is operculate, having a small “door” or hard piece on its foot that allows the animal to seal up tight, A common feature of inter-tidal and marine snails. The operculum protects the snails from predators and from drying out. Species can be both arboreal and ground dwelling.

DISTRIBUTION: Members of this family are all single-island endemics with species historically occurring on all main Hawaiian Islands.

ABUNDANCE: The entire family is experiencing drastic range reductions and extinctions across their range. They are critically imperiled wherever they occur.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this subfamily is native wet and mesic forests.

THREATS: All remaining Hawaiian species in the family are in imminent danger of going extinct. They are considered critically imperiled wherever they occur. The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.), *Euglandina* spp., and Jackson’s chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al.* 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sisco). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity.

CONSERVATION ACTIONS:

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- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.

- Conduct investigations on the impacts of herbicide on snail populations.
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Elasmias sp., Photo by David Sischo

Terrestrial Invertebrates

Hawaiian land snails

Subfamilies Pacificellinae and

Tornatellidinae

SPECIES STATUS:

77 species State Recognized as
Native or Endemic

SPECIES INFORMATION: Snails in the subfamilies Pacificellinae and Tornatellidinae are small micro snails occurring throughout the Pacific. Most species are single island endemics however several species have multi-island distributions. These micro snails range in size from approximately 2 to 4.5 millimeters (Cowie 1995, Goulding et al. 2023). Little is known about their life history or conservation status but they are likely experiencing similar declines to other more well-studied groups.

DISTRIBUTION: Members of this subfamily occur throughout the Hawaiian Archipelago

ABUNDANCE: These entire subfamilies are likely experiencing range reductions and extinctions across their ranges.

LOCATION AND CONDITION OF KEY HABITAT: Occurs in a variety of habitat types from coastal strand to mountain summits.

THREATS: The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.), *Euglandina* spp., and Jackson's chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland et al. 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity.

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and

Jackson's chameleons.

- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best

distribution of individuals between cages and between facilities to hedge against extinction.

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Succinea sp. David Sishco

Terrestrial Invertebrates

Hawaiian Land snails

Family Succineidae

SPECIES STATUS:

42 species

State Recognized as Endemic

SPECIES INFORMATION: Hawai‘i has 42 endemic species in the globally distributed family Succineidae. Only 29 species are known to be extant (Yeung and Hayes 2018). These snails range in size from approximately 5-12 mm and are both arboreal and ground dwelling and lay large gelatinous egg masses. Locally, these snails are known as “Snot in a Hat,” because their large body often does not fit inside their small-flat shells. These are some of the most commonly observed snails along upper elevation hiking trails.

DISTRIBUTION: Members of this family are all single-island endemics with species historically occurring on all main Hawaiian Islands.

ABUNDANCE: The entire family is experiencing range reductions and extinctions across their range.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for this family is native wet and mesic forests, with some species occurring in coastal strand.

THREATS: The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.), *Euglandina* spp., and Jackson’s chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al.* 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sishco).

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and

Jackson's chameleons.

- Establish captive populations to temporarily hold individuals for safe keeping or produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of

individuals between cages and between facilities to hedge against extinction.

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Vertiginid sp. Photo by N. Yeung

Terrestrial Invertebrates

Hawaiian Land Snails Family Vertiginidae And Pupillidae

SPECIES STATUS:

66 species

State Recognized as Endemic

SPECIES INFORMATION: Hawai'i has 55 species of vertiginids and one species of pupillid, both families have unidentified cryptic diversity (Yeung and Hayes 2018). All species are considered micro-mollusks with adult shell sizes being less than 3 mm. These tiny snails often go unnoticed as without a microscope they look like a grain of sand. However, under the microscope you will see that these snails have very textured, domed shells with whorls often stacking on top of one another resembling a bee hive.

DISTRIBUTION: All Hawaiian species are endemic with species historically occurring on all main Hawaiian Islands.

ABUNDANCE: Both families are experiencing range reductions and extinctions.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat for these families include both low and high elevation forests.

THREATS: The most urgent threats come from climate change impacts such as fire and drier conditions, loss of habitat due to habitat-altering weeds and ungulates, and most devastatingly direct predation by introduced predators such as rats (*Rattus* spp.), *Euglandina* spp., and Jackson's chameleons (*Chamaeleo jacksonii*) (Schalie 1969, Clarke et al. 1984, Hadfield 1986, Cowie 2001, Holland *et al.* 2008, Meyer et al 2017). Although it has not been observed in Achatinelline habitat, the New Guinea flatworm *platydemus manokwari*, has been introduced to the islands and has been documented in lower elevation habitats. This flatworm is a molluscivore and has caused devastating declines of native snail populations in other areas of the Pacific (Gerlach et al. 2020). Additionally, pathogens and parasites are thought to be impacting some populations, but more research is needed to confirm (Personal Communication with David Sischo). Low reproductive rates and limited dispersal abilities all increase the vulnerability to demographic and environmental stochasticity. .

CONSERVATION ACTIONS:

- Survey across their range for undiscovered populations.
- Conduct phylogenetic assessments to confirm species identify and the phylogenetic relationships to other populations and species. As well as to assess the potential maintenance of genetic diversity and the reduction of inbreeding impacts.
- Conduct stop-gap predator control where possible to reduce impacts from introduced predators. Actions include rat trapping and the manual removal of *Euglandina* spp. and Jackson's chameleons.
- Establish captive populations to temporarily hold individuals for safe keeping or

- produce offspring for reintroduction or augmentation of wild populations.
- Increase capacity and redundancy for captive rearing by establishing populations at multiple facilities.
- Construct predator-proof fences to protect wild populations and to reintroduce populations from captivity.
- Establish populations within multiple predator-proof fences to create redundancy.
- Conduct direct translocations of populations to protected habitat when necessary.
- Conduct translocations of species outside of their historical ranges when recovery potential within their range is reduced due to, but limited to, climate change, predator load, or degradation of habitat, etc.
- Improve habitat at reintroduction sites by growing and planting host plants.
- Develop capacity for detection dogs to improve efficiency of predator-removal efforts from inside new predator-proof fences and during incursions at existing fence sites.

MONITORING:

- Implement scientifically robust monitoring of populations to assess trends and threats
- Cross reference population monitoring data with a detection probability index to more accurately measure population sizes.
- Continue predator detection surveys at regular intervals, adjusting predator exclusion and/or control accordingly.
- Continue population distribution surveys in known and potential habitats.

RESEARCH PRIORITIES:

- Develop and refine survey protocols to facilitate the collection of useful population data. Including research and development of improved capture-mark-recapture techniques, as well as improvement of relative abundance indices.
- Conduct investigations to assess the impacts of disease and parasites on wild and captive snail populations.
- Develop cryo-storage techniques for tissues lines or other genetic material for long-term storage.
- Conduct investigations on effective predator control strategies, particularly for Jackson's Chameleons, *Euglandina* spp., *platydemus manokwari*, and other predators found to be depredating Hawaiian snails.
- Improve predator-proof fencing with research and development of more effective barriers and materials.
- Conduct investigations to improve the diet of captive snail populations by working towards development of a completely cultured or manufactured diet.
- Conduct investigations to determine life-history characteristics, such as growth rate, age at first reproduction, fecundity, longevity, etc.
- Conduct investigations on the impacts of herbicide on snail populations.
- Use a modeling approach to refine captive rearing methodology in terms of the size captive populations need to be, to be resistant to stochastic declines, the numbers and size classes that can be released into the wild, and at what intervals, as well as the best distribution of individuals between cages and between facilities to hedge against extinction.

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Terrestrial Invertebrates

Mites (and Ticks) Order Acari

ORDER INCLUDES:
39 Native Families
79 Native Genera
9 Indigenous Species
107 Endemic Species

GENERAL INFORMATION: Mites are the most diverse and abundant arachnid, and except for ticks, many mites are barely visible to the naked eye. The order is ubiquitous and is one of the oldest terrestrial animal taxa. Feeding habits of mites vary greatly; some species are predators of other mites, some species are parasites of animals, while others feed on plants, fungus, decaying organic matter, excrement, or carrion. Many non-native mites are considered to be pests, while some are considered useful for biocontrol of other pests. All ticks, except one species of *Ixodes* described from sea and shore birds on Laysan Island (Kauō) are non-native to Hawai‘i. Ticks are external parasites of vertebrates, feeding on blood, and can transmit the widest variety of pathogens of any blood-sucking arthropod, including bacteria, rickettsiae, protozoa, and viruses. The order Acari is poorly known in Hawai‘i and the group is in desperate need of taxonomic scrutiny. While approximate native families, genera, and species numbers are listed, the status of some species is questionable. These numbers are not exact and will vary with additional research.

DISTRIBUTION: Mites and ticks are known from all the MHI as well as some of the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Mites and ticks inhabit a wide range of terrestrial and aquatic habitats. Key habitats are unknown but are mostly host-dependent.

THREATS:

- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward mites should include:

- Conduct surveys to determine the distribution and abundance of known mites and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Support specialized taxonomic work to identify and describe new species to science.

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Theridion grallator. Photo: Ryan Chang

Terrestrial Invertebrates

Spiders

Order Araneae

ORDER INCLUDES:

Kaua'i cave wolf spider, Federally Endangered
 16 Native Families
 44 Native Genera
 184+ Endemic Species

GENERAL INFORMATION: Spiders have four pairs of legs, no antennae, and are predaceous. Worldwide, there are over 75,000 species. Hawai'i is home to at least 184 endemic species believed to have originated from 34 founder species. The original spider colonizers are thought to have reached Hawai'i by ballooning, a method of travel where a spider is carried by the wind on a strand of web. Eighty percent of the known Hawaiian native spider species belong to ten genera in seven families: *Cyclosa* (Araneidae), *Orsonwelles* (Linyphiidae), *Pagiopalus* and *Pedinopistha* (Philodromidae), *Havaika* (Salticidae), *Tetragnatha* (Tetragnathidae), *Argyrodes*, *Ariamnes*, and *Theridion* (Theridiidae), and *Mecaphesa* (Thomisidae). However, many more species remain to be described, particularly in the genera *Argyrodes*, *Tetragnatha*, and *Theridion* and perhaps also in *Cyclosa* and *Havaika*. Widespread endemic species include *Tetragnatha quasimodo*, *Mecaphesa anguliventris*, *M. facunda*, and *Pagiopalus* spp. The happy-face spider (pictured above) is a well-known species that comes in a variety of color morphs. This variation may have evolved to reduce predation by preventing birds from establishing a reliable search image. Like many invertebrates found in Hawai'i, some taxa of spiders have undergone extensive adaptive radiations. For example, the genus *Tetragnatha* (long-jawed spiders) contains about 37 described and around 13–23 additional undescribed endemic species that occur throughout the MHI and are found in various native habitats. The constituent species encompass a spectrum of colors, shapes, sizes, ecological affinities, and behaviors. They reach their highest diversity in montane wet and mesic forests, dry forests, high and low shrublands, and scrub. There are likely many species yet to be discovered in this genus. In the NWHI, the small islands of Nihoa and Mokumanamana (Necker) have a unique pair of endemic trapdoor spiders (*Nihoa mahina* and *N. hawaiiensis*), with no representatives on the MHI. Due to the lack of taxonomic specialists and the fact that most species are nocturnal, many Hawaiian native spiders remain poorly known or undescribed.

DISTRIBUTION: Spiders are known from all the MHI in addition to a few of the NWHI.

ABUNDANCE: As a group, unknown. A lack of systematic surveys hampers population estimates. However, the loss of native habitats likely means species within the order are declining. Of the known species, *Adelocosa anops* (limited to a single cave on Kaua'i) and *Doryonychus raptor* (restricted to high elevation habitats on Kaua'i) appear to be the most threatened on the MHI, while populations of single island endemics from the NWHI such as *Nihoa mahina* and *Nihoa hawaiiensis* remain mostly unknown.

LOCATION AND CONDITION OF KEY HABITAT: Spiders occur in all habitats in Hawai‘i including caves, lava flows, forests, and shrublands. Key habitat requirements are poorly known but mostly consist of mixed native to mostly native forests and ecosystems.

THREATS:

- Predation by invasive, non-native species, especially social insects such as ants and wasps, and perhaps also other spiders.
- Loss or degradation of habitat. *Adelocosa anops* (Lycosidae) is known from a single cave on Kaua‘i which is threatened by development.
- Insufficient information for species assessments.
- Lack of expertise to describe the large number of undescribed new species and review groups with taxonomic uncertainty.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward spiders should include:

- Forest restoration. Spider populations have responded positively to reforestation efforts at Auwahi Dry Forest in East Maui.
- Conduct surveys and document non-native predators and parasitoids of spiders.
- Control of invasive non-native invertebrate predators like ants and vertebrate predators such as coqui frogs.
- Conduct surveys to determine the distribution and abundance of known spiders and to document new species to science.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Monitor known populations to assess trends in abundance.

RESEARCH PRIORITIES:

- Conduct systematic and taxonomic assessments of poorly known taxa, including radiations from the following families and genera: Lycosidae, Theridiidae (*Argyroides*, *Ariamnes*, and *Theridion*), Araneidae (*Cyclosa*, *Araneus*), Linyphiidae, Philodromidae (*Pagiopalus* and *Pedinopistha*), Oonopidae, Salticidae (*Havaika*), Thomisidae (*Mecaphesa*), and Tetragnathidae (*Doryonychus* and *Tetragnatha*).
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.
- Conduct studies to document the biology, habitat requirements, and life history of native species.

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Nihoa mahina. Photo: Sheldon Plentovich/USFWS

Terrestrial Invertebrates

Brushed Trapdoor Spiders

Order Araneae

Family Barychelidae

Genus *Nihoa*

GENUS INCLUDES:

2 Endemic Species

GENERAL INFORMATION: Barychelidae are known as brushed trapdoor spiders. Two species are found in Hawai‘i, both being endemic: *Nihoa hawaiiensis* (Raven, 1988) and *Nihoa mahina* Churchill & Raven, 1992. Not much is known about these species as there have not been any official surveys or biological studies to date.

DISTRIBUTION: Mokumanamana (Necker, *N. hawaiiensis*) and Nihoa (*N. mahina*) (NWHI).

ABUNDANCE: As a group unknown. A lack of systematic surveys hampers population estimates. However, anecdotal evidence suggests mature adults are less frequently seen during service trips. Invasive ants have been seen attacking immature spiders that researchers come across (S. Plentovich, personal communication, October 1, 2024).

LOCATION AND CONDITION OF KEY HABITAT: *Nihoa mahina* and *N. hawaiiensis* are only found on the rocky intertidal zones of these small Leeward islands.

THREATS:

- Predation by invasive ants.
- Loss or degradation of habitat by invasive weeds.
- Climate change and sea level rise.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward brushed trapdoor spiders should include:

- Control of invasive ants and other non-native invertebrates.
- Control of invasive weeds.
- Conduct surveys to determine the distribution and abundance of these species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Monitor known populations to assess trends in abundance.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of the two species of *Mahina*.

References:

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Hogna hawaiiensis. Photo: W. Haines.

Terrestrial Invertebrates

Wolf Spiders

Order Araneae

Family Lycosidae

FAMILY INCLUDES:

Kaua'i cave wolf spider, Federally Endangered

7 Native Genera

11 Endemic Species

GENERAL INFORMATION: Wolf spiders are agile hunters, mostly living on the ground. These spiders are known for having two of their eight eyes very large, giving them excellent eyesight for hunting their prey. The endemic Hawaiian Lycosidae are an amazing example of adaptive shifts. They have colonized and adapted to the harsh terrains of lava flows, high elevations, and dark cave systems where the Kaua'i cave wolf spider, *Adelocosa anops*, evolved to have no eyes. Each of the seven genera has only one or two species, indicating multiple independent colonizations of the islands.

DISTRIBUTION: Wolf spiders are recorded from the MHI except Ni'ihau, Kaho'olawe, and Lāna'i. One species is found on Laysan (NWHI).

ABUNDANCE: As a group, unknown. A lack of systematic surveys hampers population estimates. However, the loss of native habitats likely means species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Wolf spiders occur in a wide range of extreme habitats in Hawai'i including lava tubes, lava flows, subalpine, alpine, and aeolian ecosystems.

THREATS:

- Predation by invasive, non-native arthropod species such as ants, other non-native spiders, lesser brown scorpions, and vertebrates such as cane toads.
- Loss or degradation of habitat. *Adelocosa anops* (Lycosidae) is known from a single cave on Kaua'i that is threatened by development.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward wolf spiders should include:

- Conduct surveys and document non-native predators and parasitoids of spiders.
- Control of invasive non-native invertebrate predators like ants.
- Conduct surveys to determine the distribution and abundance of known spiders and to document new species to science.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Monitor known populations to assess trends in abundance.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaii Press.

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Eumecochernes sp. Photo: Michael Slay.

Terrestrial Invertebrates

Pseudoscorpions

Order Pseudoscorpionida

ORDER INCLUDES:

7 Native Families

8 Native Genera

15 Native & Endemic Species

GENERAL INFORMATION: Pseudoscorpions are small predatory arachnids that prey on other arthropods. Unlike true scorpions, Pseudoscorpions do not have a stinging tail. Fertilization is either external or internal. Most females construct a brood nest. The order is poorly known in Hawai‘i.

DISTRIBUTION: Pseudoscorpions are known from Kaua‘i, Maui, O‘ahu, the island of Hawai‘i and on Midway Atoll and Laysan Island in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Pseudoscorpions prefer habitats that provide cracks, nooks, or crevices in which they can retreat. In Hawai‘i, caves are an important habitat; however, the importance of other habitats is unknown.

THREATS:

- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward pseudoscorpions should include:

- Conduct surveys to determine the distribution and abundance of known pseudoscorpions and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.

- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaii Press.

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Terrestrial Invertebrates

Springtails

Order Collembola

ORDER INCLUDES:

5 Native Families

32 Native Genera

95 Native Species

95 Endemic Species

GENERAL INFORMATION: Springtails are primitive, wingless hexapods related to insects. They are typically scavengers or fungivores; some also feed on living plant material. They go through a slight metamorphosis and usually grow to less than five millimeters (0.2 inches), and are often much smaller. Long-legged flies (Dolichopodidae), ants, and spiders are known to prey on springtails. The order is poorly known in Hawai‘i.

DISTRIBUTION: Springtails are known from all MHI except Kaho‘olawe and Ni‘ihau, and a few are found in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Because they are often sensitive to desiccation, springtails are most often found in damp habitats. However, they occur in a wide range of habitats, primarily in soil and leaf litter. Species also can be found in trees, lava tubes, and in the desert-like habitat at the summit of Mauna Kea and on coral atolls.

THREATS:

- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward springtails should include:

- Conduct surveys to determine the distribution and abundance of known springtails and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.

- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

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Neomachilis heteropus

Terrestrial Invertebrates

Jumping bristletails
Order Archaeognatha

ORDER INCLUDES:

1 Native Family
1 Native Genus
5 Native Species
5 Endemic Species and Subspecies

GENERAL INFORMATION: Jumping bristletails are primitive insects. They feed on algae, lichen, plant material, and possibly dead arthropods. Fertilization is external and may involve courtship. The order is poorly known in Hawai‘i. Compared to other invertebrate orders found in Hawai‘i, Archaeognatha is represented by very few taxa. Within the single-represented family, Machilidae, two endemic species and three subspecies of *Neomachilis* are described.

DISTRIBUTION: Bristletails are known from all MHI except Kaho‘olawe and Ni‘ihau.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means species within the order are declining. One species, *N. insularis*, is common and widely distributed while the other two, *N. heteropus* and *N. perkinsi*, are very rare.

LOCATION AND CONDITION OF KEY HABITAT: Bristletails occupy a variety of habitats including leaf litter on forest floors, rotting logs and stumps, dead tree fern fronds, bunch grass, caves, and lava tubes.

THREATS:

- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward bristletails should include:

- Conduct surveys to determine the distribution and abundance of known bristletails and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.

- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaii Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Sturm H. 1993. A new *Neomachilis* species from the Hawaiian Islands (Insecta: Archaeognatha: Machilidae). Bishop Museum Occasional Papers 36: 1-16.

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Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawaii Press.



Terrestrial Invertebrates

Beetles

Order Coleoptera

ORDER INCLUDES:

26 Native families

87 Native genera

1,348 Native Species

1,337 Endemic Species

GENERAL INFORMATION: The order Coleoptera is the largest order of animals in the world, containing well over a million species. Beetles can be found in all habitats and fill a huge variety of ecological niches. In Hawai‘i, beetles have undergone extensive adaptive radiations and are the dominant insects in most habitats. Carabid beetles are the dominant predatory insects in native wet forests, and species in the family Curculionidae (weevils) are the dominant herbivorous insects in all habitats. Different species of beetles also feed on fungi, some specialize on particular plant parts and others are detritivores. Diversity within most families is generally highest on Maui, O‘ahu, and Kaua‘i. The most speciose families include: Carabidae (5 genera/239 spp.), Curculionidae (10 genera/169 spp.), Belidae (*Proterhinus*/158 spp.), Ptinidae (3 genera/138 spp.), Cerambycidae (3 genera/128 spp.), Nitidulidae (7 genera/93 spp.), and Staphylinidae (12 genera/92 spp.). Many species are little known, especially in the families Belidae and Staphylinidae; substantial research has not been conducted on either family in over 100 years. As an example of the diversity of Hawai‘i’s beetles, two genera are briefly outlined below. *Blackburnia* (Family: Carabidae) are nocturnal, occupy a variety of ecological niches, and nearly all species are flightless and restricted to single islands or volcanoes. Endangered or threatened species in this genus are mostly known from shrublands and mesic koa forests. Recent research has discovered 38 new species (29% of the species in the genus), and non-native ants are a particular threat to this genus. *Rhyncogonus* (Family: Curculionidae weevils) are flightless, nocturnal weevils; most adults are herbivorous. Nearly all are endemic to single islands and are known from all the MHI and the NWHI. Members of the genus are the dominant leaf-chewing beetle group in Hawai‘i, and many species are specific to particular plant communities where they feed on a narrow range of host plants. Threats to this genera include habitat degradation by pigs (*Sus scrofa*), habitat-modifying non-native invasive plants, predation by ants, and human disturbance. All species in this genus are considered to be of concern. Recent research has discovered 15 new species (31% of the species in the genus).

DISTRIBUTION: Beetles are known from all the MHI and the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss and degradation of native habitats likely means species within the order are declining. Based on extensive collecting efforts in suitable habitats abundance of common species is estimated minimally at 5,000 adult individuals per hectare. In contrast, the rarest species are collected or observed once per decade. Comparing modern collections with those from the 1890s indicates that abundance in mesic koa (*Acacia koa*) forests, *Sophora-Deschampsia* shrublands, and low elevation mesic ‘ōhi‘a (*Metrosideros polymorpha*)

forests has declined precipitously. These habitats are often most heavily impacted by alien, social Hymenoptera (e.g., ants and vespid wasps) predators, other alien arthropods such as non-native Isopoda (sowbugs), and invasive weeds.

LOCATION AND CONDITION OF KEY HABITAT: Beetles are among the most ecologically diverse groups and occur in most terrestrial and aquatic habitats. Key habitat requirements of individual species are poorly known.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Non-native predators like ants (Formicidae) and wasps (Vespidae), non-native parasitoids (Hymenoptera), as well as non-native competitors such as non-native sowbugs (Isopoda) are negatively affecting native beetle populations.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Collecting certain showy or large beetles for sale may affect populations, especially in the genus *Plagithmysus* (Cerambycidae).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward beetles should include:

- Baiting and control of Argentine ant (*Linepithema humile*) in Haleakalā shrublands.
- Baiting and control of other invasive non-native ant species in native habitats.
- Rehabilitation of mesic forests on O‘ahu, Maui, Moloka‘i, and the island of Hawai‘i.
- Control of weeds in wet and mesic forests, especially species of *Miconia*, *Tibouchina*, *Alsophila*, and *Passiflora*.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine distribution and abundance of known coleopterans and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species’ distributions to determine areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

- Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.
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Proterhinus sp.

Terrestrial Invertebrates

Primitive weevils

Order Coleoptera

Family Belidae

Genus *Proterhinus*

GENUS INCLUDES:

161 Endemic Species

19 Subspecies

GENERAL INFORMATION: *Proterhinus* is the only representative of the primitive weevil family Belidae in Hawai‘i and has evolved into the most diverse species radiation of the Hawaiian weevils (Curculionoidea). *Proterhinus* species are twig, stem, woodborers, and few are known to be leafminers. Larvae are thought to be host-specific, but hosts are known for only a few species, and adult host-specificity remains unclear. While 180 species and subspecies are described, the number of endemic species is estimated to be much higher. Known species are difficult to identify based on current keys and available resources. This group is in need of revision and taxonomic scrutiny.

DISTRIBUTION: *Proterhinus* are recorded from all the MHI except Ni‘ihau and Kaho‘olawe.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss and degradation of native habitats likely means species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Key habitat requirements of individual species are poorly known but associated with endemic forest plants.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Loss of host-specific plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Predation by non-native predators.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward primitive weevils should include:

- Baiting and control of invasive non-native ants and other predators.
- Rehabilitation of mesic koa forests on O‘ahu, Maui, Moloka‘i, and the island of Hawai‘i.
- Control of weeds in wet and mesic forests, especially species of *Miconia*, *Tibouchina*, *Alsophila*, and *Passiflora*.

- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine distribution and abundance of known species and to document new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to determine areas supporting large numbers of endemic species.
- Initiate efforts to locate and identify new species.
- Conduct studies to document biology, habitat requirements, and life history of endemic species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

- Chamorro ML, Atkinson, T, Matsunaga JN, Engasser, EL, Franz, N. In prep. A Catalog of the Curculionoidea of the Hawaiian Archipelago, Johnston and Wake Atolls, and the Phoenix Islands (Kiribati). Bishop Museum Occasional Papers.
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Blackburnia pavidula

Terrestrial Invertebrates

Ground Beetles
Order Coleoptera
Family Carabidae

FAMILY INCLUDES:

5 Native Genera
400 Native Species
400 Endemic Species

GENERAL INFORMATION: The ground beetles (Carabidae) are one of the largest families of animals with over 40,000 species worldwide. The entire group is predatory, sometimes with special adaptations to particular prey. Despite the common name of the family, many of the Hawaiian endemic species are arboreal, hiding during the day in crevices or moss mats and emerging at night to hunt on tree trunks. Others are riparian, specializing in stream bank habitats. The endemic fauna is dominated by two large genera: *Blackburnia* with 133 species (Liebherr and Zimmerman, 2000), and *Mecyclothorax* with 241 (Will and Liebherr, 2022). The remaining genera are much smaller. *Bembidion*, a worldwide genus, is represented by 23 endemic species found in a variety of habitats; *Paratachys* by five species of minute wingless beetles, mostly riparian with one cave dweller; and *Tachys oahuensis*, a lowland species also found on some of the Northwest Hawaiian Islands. *Blackburnia* are generally larger, and are widely distributed on all islands; many species have reduced hind wings and are flightless. *Mecyclothorax* are smaller and all are flightless; they are especially diverse on East Maui, with nearly half the total restricted to there, but absent from Kaua‘i. Many of both have very restricted ranges, making them highly vulnerable to local habitat disturbance; *Mecyclothorax* in particular are almost all limited to a single volcano and often a particular section of forest. Wing reduction is also found in the *Bembidion*; the flighted ones are often found on multiple islands, while the flightless species are island or mountain endemics. Subfossil cave sediments indicate that a robust lowland fauna was formerly present, including both extinct species and those now restricted to montane areas (Liebherr and Porch, 2015).

DISTRIBUTION: Ground beetles are known from all the MHI and several of the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. Many species are cryptic, inhabiting leaf litter and moss mats, requiring labor-intensive survey methods to find. However, the loss and degradation of native habitats likely means that species within the family are declining.

LOCATION AND CONDITION OF KEY HABITAT: Ground beetles are found in a wide variety of terrestrial habitats, primarily mesic and wet forests, leaf litter, and stream margins. Key habitat requirements of most individual species are poorly known.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Non-native predaceous ants (Formicidae) and parasitoid wasps (Scelionidae: *Trimorus* spp.) as well as non-native carabids such as *Metacarpodes buehneri* are negatively affecting native beetle populations.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Biocontrol agents or organisms may affect some native species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward beetles should include:

- Baiting and control of Argentine ant (*Linepithema humile*) in Haleakalā shrublands.
- Rehabilitation of mesic forests.
- Control of weeds in wet and mesic forests, especially species of *Miconia*, *Clidemia*, *Tibouchina*, *Alsophila*, and *Passiflora*.
- Improve commercial shipment inspections to prevent further introduction of alien invertebrates harmful to native species.
- Conduct surveys to determine distribution and abundance of known taxa and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to determine areas supporting large numbers of native species.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Initiate studies to determine the effects of non-native organisms on beetle populations.

References:

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Terrestrial Invertebrates



Nesotocus kauaiensis. Photo: W. Haines.

**True Weevils and
Bark Beetles**
Order Coleoptera
Family Curculionidae

FAMILY INCLUDES:
15 Native genera
>356 Native Species
>353 Endemic Species
>7 Endemic Subspecies

Native genera and number of described native species

Acalles 22 species
Anotheorus 3 species
Chaenosternum 1 species
Deinocoissonus 1 species, 3 subspecies
Dryophthorus 19 species
Dryotribodes 1 species
Dryotribus 2 species
Heteramphus 12 species
Nesotocus 4 species
Oodemus 61 species, 4 subspecies
Orothreptes 1 species
Rhyncogonus 47 species
Seenomma 1 species
Stenotrupis 2 species
Xyleborus 22 species

The Hawaiian true weevils are diverse plant-feeding insects with several lineages of adaptive radiations, many of which need updated taxonomic assessment. Like many other groups, the weevils lack basic information on their status and biology. Some feed on living leaves, others bore in dead wood, others are found in leaf litter and their exact feeding habits are unknown. The scolytine genus *Xyleborus* are ambrosia beetles, boring tunnels in wood and feeding on fungi that they cultivate there rather than directly on the wood itself.

DISTRIBUTION: Recorded from all MHI (except Kaho‘olawe) and the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss and degradation of native habitats and host plants, and the increase in non-native invasive predators and parasitoids likely indicate that species populations are declining. At least 125 species are known from five or fewer individuals ever collected. Many species have not been collected since their original descriptions.

LOCATION AND CONDITION OF KEY HABITAT: Coastal/lowland, mesic, and montane.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Loss of host plants.
- Non-native predators such as ants, rats, and coqui frogs.
- Non-native parasites and parasitoids.
- Displacement by non-native competitors.
- Insufficient information on life histories of species, especially rare species, hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward weevils should include:

- Control of non-native predatory invasive ants, rats, and coqui frogs.
- Control of weeds in key habitats.
- Restoration of key habitats; planting host plants.
- Conduct surveys to determine distribution and abundance of known species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate efforts to locate and identify new species.
- Conduct studies to document the biology, habitat requirements, and life histories of rare and understudied species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

- Chamorro ML, Atkinson, T, Matsunaga JN, Engasser, EL, Franz, N. In prep. A Catalog of the Curculionoidea of the Hawaiian Archipelago, Johnston and Wake Atolls, and the Phoenix Islands (Kiribati). Bishop Museum Occasional Papers.
- Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawaii Press.
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- Samuelson GA. 2003. Review of *Rhyncogonus* of the Hawaiian Islands (Coleoptera: Curculionidae). Bishop Museum Bulletin in Entomology vol 11.



Rhyncogonus blackburni

Terrestrial Invertebrates

Broad-nosed weevils

Order Coleoptera

Family Curculionidae

Genus *Rhyncogonus*

GENUS INCLUDES:

47 Endemic Species

GENERAL INFORMATION: Species in the genus *Rhyncogonus* are flightless, nocturnal weevils. The *Rhyncogonus* genus is an exemplary example of beetles that have radiated in Hawai‘i into at least 47 described species. Adults are herbivorous leaf chewers and larvae are associated with roots or plant parts in the soil. Many species are specific to particular plant communities where they feed on a narrow range of host plants, but host-specificity of adult weevils and larvae is poorly understood. Nearly all species are endemic to single islands and are known from all the MHI and two of the NWHI. Threats to this genus include habitat degradation by pigs (*Sus scrofa*), habitat-modifying non-native invasive plants, predation by ants and rats, and human disturbance. All species in this genus are considered to be of concern.

DISTRIBUTION: Recorded from the MHI (except Ni‘ihau and Kaho‘olawe) and the NWHI (Laysan, Nihoa, and Mokumanamana).

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss and degradation of native habitats and the increase in non-native invasive predators likely mean species within the genus are declining.

Samuelson 2003’s species status assessments indicate that at least 18 of 47 species of *Rhyncogonus* may possibly be extinct, with at least one definitely extinct. Surveys targeting *R. welchii* were conducted by the Bishop Museum between 2015 and 2020 in Halona Valley, O‘ahu. While possible feeding damage was noticed on *Sapindus oahuensis* foliage, no individuals were recovered (Evenhuis et al. 2021).

LOCATION AND CONDITION OF KEY HABITAT: Coastal/lowland and Montane.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Loss of host plants.
- Non-native predaceous ants (Hymenoptera: Formicidae) and predaceous rats.
- Non-native parasites and parasitoids.
- Non-native competitors.

- Insufficient information on life histories of almost all species hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Rhyncogonus* species should include:

- Control of non-native predatory invasive ant species, rats, and coqui frogs.
- Control of weeds in key habitats.
- Restoration of key habitats; planting host plants.
- Conduct surveys to determine distribution and abundance of known species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Initiate efforts to locate and identify new species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

- Chamorro ML, Atkinson, T, Matsunaga JN, Engasser, EL, Franz, N. In review. A Catalog of the Curculionoidea of the Hawaiian Archipelago, Johnston and Wake Atolls, and the Phoenix Islands (Kiribati). Bishop Museum Occasional Papers.
- Evenhuis NL, Arakaki KT, Imada CT. 2021. Terrestrial arthropod survey of Halona Valley, Joint Base Pearl Harbor-Hickam, Naval Magazine Lualualei Annex, August–November 2020. Final report prepared for the U.S. Navy. Hawaii Biological Survey Contribution No. 2021-003. 37 pp.
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Eopenthes sp.

Terrestrial Invertebrates

Click beetles

Order Coleoptera

Superfamily Elateroidea

Family Elateridae

47 Endemic species

Family Eucnemidae

54 Endemic species

GENERAL INFORMATION:

Family Elateridae

Dacnitus: 1 sp.

Eopenthes: 34 spp.

Itodacnus: 12 spp.

Family Eucnemidae

Dromaeolus: 49 spp.

Epiphanis: 1 sp.

Fornax: 4 sp. The superfamily Elateroidea includes click beetles, fireflies, and their relatives. In Hawai‘i it is represented by two families, Elateridae (true click beetles) and Eucnemidae (false click beetles). Both groups are capable of engaging a mechanism at the junction of the pro- and mesosterna to snap the body with an audible click, as a defense and to flip themselves over. The larvae of all species are found in dead rotting wood, where they may be detritivores or predators. All three elaterid genera (*Dacnitus*, *Eopenthes*, and *Itodacnus*) are strictly endemic to Hawai‘i. *Eopenthes* is the largest and most common, with 34 species. The 11 known species of *Itodacnus* are rarer, except for one species frequently found on Kaua‘i. *Dacnitus* is represented by a single species that has apparently not been seen since the 1800s. Among the eucnemids, *Dromaeolus* are by far the most diverse and abundant, though still rare; typically one or two individuals are found per Malaise trap sample. Forty-nine species are known, but most from only one or two specimens, and there are probably more undescribed. The four native *Fornax* species are all extremely rare, last collected in 1965, and the monotypic *Epiphanis* is only known from the original collections in 1895.

DISTRIBUTION: Click beetles are known from all the MHI except Kaho‘olawe and Ni‘ihau, and two *Itodacnus* are found on Necker and Nihoa.

ABUNDANCE: Unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss and degradation of native habitats likely means species within the superfamily are declining. Larvae are cryptic in dead wood and adults are active for a relatively brief period in the summer, so they may be underrepresented by traditional survey methods. *Eopenthes* may be collected by sweeping and *Dromaeolus* in Malaise traps, but both are still rare.

LOCATION AND CONDITION OF KEY HABITAT: Click beetle larvae live in dead wood or other decaying matter, but the precise ecological role of the native species is unknown. All are reliant on native plants, primarily in upper-elevation forests.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Predation by invasive, non-native species, especially social insects such as ants (Formicidae) and wasps (Vespidae)
- Insufficient information, especially for rare species, hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward click beetles should include:

- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine distribution and abundance of known click beetles and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to determine areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
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Apterocyclus waterhousei. Photo: W. Haines

Terrestrial Invertebrates

Stag beetles

Order Coleoptera

Family Lucanidae

Genus *Apterocyclus*

GENUS INCLUDES:

5 Endemic Species

GENERAL INFORMATION: Stag beetles (Lucanidae) are a family containing about 1,200 described species worldwide. In Hawai‘i, stag beetles are represented by a single endemic genus, *Apterocyclus*, which includes five species known only from the island of Kaua‘i (Paulsen and Hawks 2014). Adult *Apterocyclus* beetles are flightless and completely lack hind wings. Adult beetles are nocturnal and rarely encountered. Anecdotal observations suggest that adults may emerge synchronously when seeking mates, as there are historical reports of large congregations of beetles crawling in leaf litter at night (Osborn 1920, R. Rice personal communication). For the species whose larvae are known (*A. honoluluensis* and *A. waterhousei*), the grublike larvae live in the soil in koa forests where they feed on decaying organic matter (Swezey 1915). Little is known about the biology of the other three species, whose larvae are not documented. Nonnative rodents appear to be a major threat to *Apterocyclus* species, and scooped-out fragments of adult beetles are often found piled in hollows under logs in the same areas where larvae are found (W. Haines personal observation). Ants are also a likely threat to *Apterocyclus* larvae.

DISTRIBUTION: Kaua‘i; found in the montane plateau area from Kōke‘e to Makaweli.

ABUNDANCE: The status of stag beetle populations is unknown and difficult to assess, as adults are rarely encountered, and larvae live in the soil. Larvae of one species, *A. honoluluensis* can be relatively common under logs in koa forests of northwest Kaua‘i. A second species, *A. waterhousei*, has been recently collected in similar habitats but is less widespread than *A. honoluluensis*. A third species, *A. kawaii*, is known from only two specimens collected from private land as recently as 1996, and populations, if extant, are likely highly localized and rare. The other two species, *A. palmatus* and *A. munroi*, have not been recently seen and may be extinct, but because original collection data is vague, it is possible that populations still exist in remote locations that have not been surveyed (Paulsen and Hawks 2014).

LOCATION AND CONDITION OF KEY HABITAT:

Key habitat for *A. honoluluensis* and *A. waterhousei* includes mesic forests of Kaua‘i, especially koa-dominated forests, in Kōke‘e State Park, Nā Pali-Kona Forest Reserve, and Pu‘u Ka Pele Forest Reserve, which are largely intact and under active conservation management. Key habitat for *A. kawaii* and *A. munroi* may primarily be located on private land in the Makaweli region, though it is possible these species occur in other areas but have not been detected. Key habitat for *A. palmatus* is unknown, as the original collection locality is listed only as 4,000 ft elevation on Kaua‘i.

THREATS:

- Loss and degradation of habitat due to habitat-modifying invasive plants, browsing and grazing by non-native ungulates, and logging.
- Non-native predaceous ants (Formicidae) as well as non-native competitors such as the coconut rhinoceros beetle (CRB).
- Rodents, including rats and mice, which prey on adult beetles and possibly larvae.
- Insufficient information hampers conservation efforts for rare species.
- Collecting beetles for sale or trade may affect populations.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Apterocyclus* stag beetles should include the following:

- Conduct surveys to assess status of the three species that have not been recently collected and whose status is unknown.
- Control non-native rodents in upland koa forests through the use of traps or other methods.
- Establish rodent-proof exclosures on Kaua‘i into which *Apterocyclus* and other vulnerable species can be translocated and monitored.
- Rehabilitate mesic koa forests on the island of Kaua‘i.
- Preserve, maintain, and restore habitats that support existing populations.

MONITORING:

- Establish new monitoring protocols for *Apterocyclus* larvae to detect population trends, especially in areas with different degrees of rodent control.

RESEARCH PRIORITIES:

- Initiate targeted searches for *Apterocyclus* species not recently collected or observed.
- Initiate studies to determine distributions of extant *Apterocyclus* species.
- Initiate studies to determine the effects of biocontrol organisms (including potential biocontrol agents for coconut rhinoceros beetle) on beetle populations.
- Initiate studies on *Apterocyclus* life history and rearing methods.

References:

- Osborn, H.T. 1920. A note on *Apterocyclus* (Coleoptera, Lucanidae). *Proceedings of the Hawaiian Entomological Society*. 4(2): 375-376.
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Anisolabis howarthi. Photo: Mike Slay

Terrestrial Invertebrates

Earwigs

Order Dermaptera

ORDER INCLUDES:

- 1 Native Family
- 3 Native Genera
- 10 Native Species
- 9 Endemic Species

GENERAL INFORMATION: Earwigs have slender, flattened bodies and are easily recognized by the pair of large pincers at the tip of their abdomens. Earwigs are nocturnal and most are carnivorous, although some species are omnivorous. Females lay eggs in the soil, under objects, or in other protected places, and guard eggs and care for young until they can find food for themselves. Earwigs hatch from eggs and molt as they grow, obtaining more antennal segments and progressively more developed wings with each molt. Earwigs are considered harmless to people, although some species emit a foul-smelling substance when disturbed. All native earwigs are members of the family Carcinophoridae. Six endemic species in the genus *Anisolabis* represent an adaptive radiation from a marine littoral ancestor, probably *A. maritima*, which is indigenous to Hawai‘i. *A. maritima* and *Euborellia eteronoma* are widespread and populations appear stable. *A. perkinsi*, known only from Kaua‘i, has apparently declined. *A. howarthi* is restricted to caves on Hawai‘i Island. It is rarely seen and each cave may harbor a distinct population. The other four *Anisolabis* species have not been recollected for at least 75 years and may be extinct. Two species were known from O‘ahu, one was endemic to Maui, and one was known from the island of Hawai‘i. One recently described species from Hawai‘i, *Paraflexolabis ornata*, is only known from three specimens and may not be native. Earwigs are not considered pests in Hawai‘i, although they are elsewhere in the world.

DISTRIBUTION: Earwigs are known from all the MHI and the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Earwigs occur in a variety of habitats including caves, coastal and marine littoral areas, mesic and sometimes wet forests, and possibly recent lava flows.

THREATS:

- Invasive predators and parasites.
- Possibly alien diseases.
- Loss or degradation of habitat.
- Possible disease.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward earwigs should include:

- Conduct surveys to determine the distribution and abundance of known earwigs and to document and identify new species.
- Conserve areas supporting native species, especially cave habitats.
- Conduct surveys searching for populations of species thought to be extinct.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Determine the status and population trends of *A. perkinsi* and initiate studies designed to determine the causes of its decline.
- Conduct studies to document the biology, habitat requirements, and life history of native species.
- *A. maritima* and *A. howarthi* populations possess geographic variation. Initiate studies to determine whether populations are distinct species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

- Brindle A. 1980. The cavernicolous fauna of Hawaiian lava tubes. 12. A new species of blind troglobitic earwig (Dermaptera: Carcinophoridae), with a revision of the surface living earwigs of the Hawaiian Islands. Pacific Insects 21:261-274.
- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
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Campsicnemus penicillatus. Photo: Karl Magnacca.

Terrestrial Invertebrates

True flies Order Diptera

ORDER INCLUDES:

26 Native Families
77 Native Genera
1,500+ Native Species
1,500+ Endemic Species

GENERAL INFORMATION: All flies, except wingless species, have two pairs of wings; one pair is functional, the other (known as halteres) is highly modified. Because of their importance in genetic research, Dipterans are well-studied. The initial founders of Hawaiian populations are believed to have reached the islands on birds or by being caught in wind currents. Numerous adaptive shifts and unusual evolutionary developments characterize the species found in Hawai‘i, making the Hawaiian fauna globally significant. These include the freshwater canacids *Procanace* and the enigmatic coastal asteiid *Bryania bipunctata*. The most speciose genera include *Campsicnemus*, *Drosophila*, *Scaptomyza*, *Tylparua*, and *Lispocephala*. Species in the genus *Drosophila* are perhaps the best-known native dipterans because of the scientific interest in the group’s genetics and adaptive radiations. About a quarter of the world’s known species of Drosophilidae are endemic to Hawai‘i.

DISTRIBUTION: Native flies are known from all the Main Hawaiian Islands and many of the Northwestern Hawaiian Islands.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Flies occur in a variety of freshwater and terrestrial habitats.

THREATS:

- Habitat loss and degradation. Habitat is lost to conversion for agriculture, logging, and grazing, and is disturbed by a suite of non-native ungulates and the introduction of invasive plants.
- Predation. Non-native species, including ants, wasps, crustaceans, and fish prey on flies.
- Lack of data. Insufficient information, especially for rare species, hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward flies should include the following:

- Conduct surveys to determine the distribution and abundance of known fly species and to document and identify new species.

- Preserve, maintain, and restore habitats supporting existing populations.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.

MONITORING: Continue surveys to monitor the status of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional, new populations.
- Survey to determine the status of species believed to be extinct.
- Conduct studies to document the biology, habitat requirements, and life history of poorly known native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

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Foote D, Carson H. *Drosophila* as monitors of change in Hawaiian ecosystems. Available at: <http://biology.usgs.gov/s+t/noframe/t233.htm> (last accessed 3 December 2004).

Hardy DE. 1960. Insects of Hawaii: Volume 10 Diptera: Nematocera–Brachycera. Honolulu: University of Hawai'i Press.

Nishida GM, editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawaii Press.



Procanace acuminata.

Photo: Hawaii Biological Survey.

Terrestrial Invertebrates

Beach flies

Order Diptera

Family Canacidae

Genus *Procanace*

Genus Includes:

9 Endemic Species

GENERAL INFORMATION: Canacidae, or beach flies, is a relatively small family of acalyptrate Diptera found throughout coastal regions of the World. The genus *Procanace* contains nine endemic species in Hawai‘i. The endemic Hawaiian *Procanace* are notable within the genus and the family for their adaptation to freshwater habitats, rather than seashores like almost all others. They live along streams where the larvae feed on algae growing on rocks in fast-flowing sections and can be found from high elevations almost to sea level. A group of highly specialized endemic parasitoid wasps, *Aspidogyrus* (Hymenoptera: Figitidae) attacks them in the pupal stage.

DISTRIBUTION: Species are found on all the Main Hawaiian Islands except Ni‘ihau and Kaho‘olawe. Three species are endemic to Kaua‘i, while the rest are found on multiple islands.

ABUNDANCE: Largely unknown for individual species. Some taxa are locally abundant and can be observed in the hundreds of individuals while others are infrequently observed and known from only a few museum specimens. Seasonal abundance may vary with flow rate and water availability.

LOCATION AND CONDITION OF KEY HABITAT: Species in this genus are found in association with freshwater stream habitats throughout the MHI. They require fast stream flow, high oxygenation, and relatively high stream volume, so reduction in flow by human diversions and reduced rainfall has probably impacted habitat quality.

THREATS:

- Water scarcity. Extended periods of drought or human-made water diversions can threaten critical habitat by eliminating native stream ecosystems.
- Invasive species. These can have a negative impact either as predators or habitat competitors (Englund 2002; Englund and Polhemus 2002).

CONSERVATION ACTIONS: Specific management directed toward beach flies should include the following:

- Protect existing habitats in freshwater stream systems.
- Conduct surveys to determine distribution and abundance of known species and to document and identify new species.

MONITORING: Aquatic insects have been extensively used as indicators of water quality in freshwater streams and lakes (Rosenberg et al. 2008). The fauna of the Hawaiian islands has a reduced number of these indicator species because of the remote location of the archipelago and the difficulty of colonization for many freshwater aquatic groups. Native Hawaiian damselflies (*Megalagrion* spp.) have been used as bioindicators (Englund 2001; Englund et al. 2007) but populations of these species are small, difficult to monitor, and are subject to conservation action. Developing native Diptera (Canacidae, Ephydriidae, and Chironomidae) as bioindicators will provide a new management tool for native Hawaiian aquatic ecosystems and will lead to more secure sources of fresh water. Monitoring actions should thus include the following: establish new monitoring for species that are not currently monitored.

RESEARCH PRIORITIES:

- Link distribution and abundance data for *Procanace* with measures of water quality to create a model for aquatic ecosystem monitoring in Hawai‘i.

References:

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Terrestrial Invertebrates

Long-legged flies

Order Diptera

Family Dolichopodidae

FAMILY INCLUDES:

17 Native Genera

282 Native Species

>280 Endemic Species

GENERAL INFORMATION: Genera with endemic species

Adachia: 6 spp.

Campsicnemus: >200 spp.

Conchopus: 6 spp.

Elmoia: 8 spp.

Eurynogaster: 24 spp.

Sigmatineurum: 11 spp.

Swezeyella: 7 spp.

Uropachys: 9 spp.

Arciellia, *Asyndetus*, *Diaphorus*, *Hydrophorus*, *Major*, *Medetera*, *Paraliancalus*: 1–3 spp. each

The long-legged flies are a highly diverse group in Hawai‘i. The largest genus is *Campsicnemus*, with over 200 species described to date. It is the second largest radiation of endemic flies in Hawai‘i, and the sixth largest overall. They are particularly notable for the modification and ornamentation of the male legs (usually the middle one), which is used in courtship. They are generalist predators of small arthropods such as springtails and mites and inhabit a variety of forest habitats. Color is correlated to general habitat preference: species found on leaf litter are typically dull brown, water skaters are shiny brown to black, and those that prefer live leaves are metallic green to blue. A complex of genera formerly lumped under *Eurynogaster*, including *Adachia*, *Arciellia*, *Elmoia*, *Major*, *Sigmatineurum*, *Swezeyella*, and *Uropachys* contains similar but larger species with less elaborate male ornamentation. Most are distributed generally in forests, but *Sigmatineurum* and *Major* are specialists in aquatic habitats, found at seeps, waterfalls, and cascades. In contrast, the species of *Conchopus* are found only at the coast, on wave-washed rocks, and *Hydrophorus* are found around brackish coastal and lowland ponds.

DISTRIBUTION: Long-legged flies are known from all the Main Hawaiian Islands except Ni‘ihau and Kaho‘olawe. The coastal *Hydrophorus* and *Conchopus* are also found in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. Some species are common and abundant, while others are rarely seen and known from only a handful of specimens. Some of latter may be infrequently collected due specialized habitats rather than inherent rarity. Little is known about the habitat requirements of specific species, particularly for immature stages, and the loss of native habitats likely means that some species are declining.

LOCATION AND CONDITION OF KEY HABITAT: *Campsicnemus*, *Eurynogaster*, and related genera occur in a variety of terrestrial habitats, depending on the species. Some are typically found on leaf litter, others arboreally on leaves, and still others are specialized water skaters on puddles and still pools. *Sigmatineurum* and *Major* are specialists in aquatic habitats, found at seeps, waterfalls, and cascades. The species of *Conchopus* are found only at the coast on wave-washed rocks, and *Hydrophorus* are found around brackish coastal and lowland ponds.

THREATS:

- Habitat loss and degradation. Habitat is lost to conversion for agriculture, logging, and grazing, and is disturbed by a suite of non-native ungulates and the introduction of invasive plants.
- Predation. Non-native species, including ants and wasps, prey on these flies.
- Competition. Non-native long-legged flies, water treaders, and other insects may compete for resources.
- Lack of data. Insufficient information, especially for rare species, hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward long-legged flies should include the following:

- Conduct surveys to determine the distribution and abundance of known species and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.

MONITORING: Continue surveys to monitor the status of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional, new populations.
- Survey to determine the status of species believed to be extinct.
- Conduct studies to document the biology, habitat requirements, and life history of poorly known native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Hardy DE, Kohn MA. 1964 Insects of Hawaii Volume 11: Diptera, Brachycera. Honolulu: University of Hawaii Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.



Terrestrial Invertebrates

Pomace flies
Order Diptera
Family Drosophilidae

Genera with endemic species
Drosophila: >500 spp.
Scaptomyza: >150 spp.

GENERAL INFORMATION: The Hawaiian Drosophilidae are perhaps the best-known native flies because of the scientific interest in the group's genetics and adaptive radiations. About a quarter of the world's known species of Drosophilidae are endemic to Hawai'i. Although well-separated in the rest of the world, *Scaptomyza* is the sister group to the Hawaiian *Drosophila* clade and the Hawaiian endemic subgenera are often difficult to unambiguously separate from *Drosophila*. Thus they are often treated as a single group, although it is unclear if they are derived from one or two introductions to Hawai'i. Unusually among Hawaiian taxa, *Scaptomyza* dispersed out of Hawai'i multiple times, and all non-Hawaiian groups are derived from Hawaiian ancestors. About 500 species of *Drosophila* and 150 species of *Scaptomyza* are described, hundreds more are known but not yet described, and many more await discovery. The total estimate of this group of flies is likely to be 800–1,000 species, the largest radiation of endemic species in Hawai'i. The large, conspicuous members of the Hawaiian *picture wing* species group are the most famous but represent only about 120 species.

DISTRIBUTION: Native drosophilids are known from all the Main Hawaiian Islands except Kaho'olawe and Ni'ihau.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate for most species. However, the loss of native habitats likely means that many species within the family are declining. Many of the *picture wing* species can be surveyed non-lethally with fermented baits and because they can be identified by wing pattern, but most other species either are not attracted to baits, can only be identified with a microscope, or both. Members of the *modified mouthparts* species group and most *Scaptomyza* tend to be cryptic and are rarely collected except by rearing from their host material. Fourteen species of picture-wing *Drosophila* are listed as endangered, and many more are equally rare.

LOCATION AND CONDITION OF KEY HABITAT: Pomace flies occur mainly in wet to mesic forest, and breed in rotting plant material. A few species reach into subalpine areas or dry forest. Nearly all species are highly specific to one or a few host plants. The species groups of *Drosophila* are mainly divided based on host plant substrate: bark, leaves, and fungus. *Scaptomyza* often use more ephemeral substrates such as rotting flowers, and some utilize unusual breeding habitats such as decaying silversword seeds and the sticky resin of *Pisonia* seed pods. One group, subgenus *Titanochaeta*, are predators on spider eggs. The hosts of many species are unknown.

THREATS:

- Habitat loss and degradation. Habitat is lost to conversion for agriculture, logging, and grazing, and is disturbed by a suite of non-native ungulates and the introduction of invasive plants.
- Predators and parasitoids. Non-native species, including ants and wasps, prey on these flies.
- Competition. Non-native detritivores and herbivores, such as ambrosia beetles, crane flies, and isopods, use the same host substrates and can alter the environment making it unsuitable for breeding.
- Lack of data. Insufficient information, especially for rare species, hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward pomace flies should include the following:

- Conduct surveys to determine the distribution and abundance of known species and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.

MONITORING: Continue surveys to monitor the status of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional, new populations.
- Survey to determine the status of species believed to be extinct.
- Conduct studies to document the biology, habitat requirements, and life history of poorly known native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

- Hardy DE. 1965. Insects of Hawaii: Volume 12 Diptera: Drosophilidae. Honolulu: University of Hawaii Press.
- Magnacca KM, Foote D, O'Grady PM. 2008. A review of the endemic Hawaiian Drosophilidae and their host plants. *Zootaxa* 1728: 1–58.
- Magnacca KM, Price DK. 2015. Rapid adaptive radiation and host plant conservation in the Hawaiian picture wing *Drosophila* (Diptera: Drosophilidae). *Molecular Phylogenetics and Evolution* 92: 226–242.
- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.



Drosophila kikiko, Kaua'i sister species of *D. aglaia*, nearly identical in appearance.
Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing *Drosophila* *Drosophila aglaia*

SPECIES STATUS:

Federally Listed as Endangered
State Listed as Endangered

Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila aglaia* Hardy, 1965 is one of the most striking members of the *picture wing* species group of Hawaiian *Drosophila* pomace flies. The species is endemic to the Wai'anae range of O'ahu, occurring in diverse mesic forest gulches. Although it was never common, it was historically found widely throughout the range on the eastern and northern slopes. *D. aglaia* is the namesake of the *aglaia* species subgroup, which consists of six extremely rare species. It is nearly identical to the recently discovered *D. kikiko* of Kaua'i (pictured above), differing only in minor characters like the coloration of the side of the thorax and the front leg hairs of the male. Notably, the host plants are unknown for *D. aglaia* and all but one member of the *aglaia* subgroup. This uncertainty regarding their precise habitat makes surveys specifically targeting *D. aglaia* difficult.

DISTRIBUTION: Known only from the Wai'anae range of O'ahu, where it has historically been found at six sites from Mokulē'ia, west of Ka'ala, to Pu'u Palikea at the southern end. The most recent record was in 1997 at Pu'u Palikea, but intensive surveys from 2013–2022 have failed to recover it there. This species has not been seen since 1971 at other historically known sites. There are no records from the leeward side, including Wai'anae and Makaha valleys, but these areas were not intensively sampled during the early collecting period (1966–1975).

ABUNDANCE: Unknown. The lack of any records for the past 18 years means it is possible the species is extinct. However, several other *Drosophila* species have been rediscovered after longer absences. Even at heavily sampled sites, they may persist at low levels that are not detectable with standard survey methods or move in only when there is suitable breeding material. Given that the most recent record was less than 20 years ago, it is presumed to be still extant.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. The host of *D. aglaia* is unknown. It was reported as *Touchardia sandwicensis* (as *Urera sandwicensis*) in earlier reports (Montgomery 1975, Kaneshiro and Kaneshiro 1995), but this was based on an erroneous identification of *D. kinoole*. Therefore, the precise habitat requirements of *D. aglaia* are unknown. However, at five of the six historic sites, native vegetation is declining in general (Pu'u Palikea being the exception).

THREATS:

- Habitat loss and degradation due to invasive plants and invertebrates, disturbance by non-native ungulates, and fire from nearby agriculture, residential, and military activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila aglaia* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Use these results to create a management plan for species recovery.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for extant populations, in both historic and novel sites.
- Conduct studies to document the biology, habitat requirements, and life history.

References:

- Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.
- Magnacca, KN, Price, DK. 2015. Rapid adaptive radiation and host plant conservation in the Hawaiian picture wing *Drosophila* (Diptera: Drosophilidae). *Molecular Phylogenetics and Evolution* 92: 226–242.
- Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.
- U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 71: 26835–26852.
- U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 73: 73734–73895.



Terrestrial Invertebrates

Picture wing *Drosophila* *Drosophila differens*

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

Designation of Critical Habitat for 12 Species of
Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila differens* Hardy & Kaneshiro, 1975 is a member of the *planitibia* species group, which includes the largest, most charismatic, and most beautiful species of native pomace flies. This group is distinctive due to the extra crossvein in the wings of all species except the Kaua‘i representatives. Within the group, *D. differens* closely resembles the other species of the *planitibia* subgroup, *D. planitibia* of Maui, and *D. heteroneura* and *D. silvestris* of Hawai‘i. It differs from *D. planitibia* only in having the face yellow rather than black, but laboratory experiments have shown that hybrid male offspring are sterile. The species is endemic to Moloka‘i, occurring in montane wet forest. Like other members of the *planitibia* subgroup, it breeds in rotting bark of lobeliads.

DISTRIBUTION: *Drosophila differens* was historically known from several upper elevation sites on Moloka‘i, all within the Nature Conservancy’s current Kamakou Preserve. Its true range is probably greater, but much of the area to the east is extremely difficult to access. There have been only two collections since 1977, one in 1983 and one in 1999. Surveys in 2005, 2007, and 2010 failed to recover it. However, it was rediscovered in Pu‘u ‘Ali‘i Natural Area Reserve in 2024.

ABUNDANCE: Unknown. The lack of recent records at historic sites suggests it has strongly declined. Native host plant lobeliads now occur at low abundance in these areas and other sites where *D. differens* was recently rediscovered. Other sites near the summit of Kamakou Peak where lobeliads are more common have not been surveyed.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae and are generally host-specific. *Drosophila differens* is reported to breed in *Clermontia*, which continues to occur in the area it had been found, though it is relatively uncommon. *Cyanea* and *Trematolobelia* (also lobeliads) occur in the area, *Trematolobelia* is even abundant in some places. It is likely that these two genera of plants also serve as hosts for *D. differens*.

THREATS:

- Habitat loss and degradation due to invasive plants and rats, disturbance by non-native ungulates.
- Non-native predators, including wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila differens* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for extant populations, in both historic and novel sites.
- Conduct studies to document the biology, habitat requirements, and life history.

References:

- Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.
- Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.
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- U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 73: 73734–73895.



Drosophila digressa. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing *Drosophila*
Drosophila digressa

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Drosophila digressa* Hardy & Kaneshiro, 1968 is a medium-sized picture wing fly endemic to Hawai‘i Island. It is a member of the *lanaiensis* species subgroup, which consists of five species, all being rare. All members of this subgroup breed primarily in decaying branches and trunks of *Charpentiera* spp. (pāpala), and usually secondarily in *Pisonia* spp. (pāpala kēpau). Both of these have highly restricted distributions on Hawai‘i. The species occurs in mesic to wet forests where its host plants are found. Although always uncommon and sporadic, it was historically found at sites across the southern and western portions of the island.

DISTRIBUTION: *Drosophila digressa* is historically known from six sites: Moanuahea on Hualālai, Pāpā and Manukā in South Kona, Kīpuka 9 along the Saddle Road, and Kīpuka Puaulu and ‘Ōla‘a in Hawai‘i Volcanoes National Park. Recent collections and observations have come only from Manukā, the nearby site of Honomalino, and ‘Ōla‘a; there are no host plants remaining at Moanuahea or Kīpuka 9, and all picture wing flies disappeared from Kīpuka Puaulu several years ago (Pāpā has not been accessible for several years).

ABUNDANCE: Unknown. Based on repeated visits to the two known populations, numbers at the ‘Ōla‘a site appear to be low but consistent while rarely detectable at Manukā but may experience large booms. Both conditions are vulnerable to stochastic events, especially at Manukā where the forest is drying out and many canopy trees are dying.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae and are generally host-specific. The known host of *D. digressa* is *Charpentiera* (Montgomery 1975, Kaneshiro and Kaneshiro 1995). Many species that typically use this tree can also utilize the more abundant *Pisonia* (Magnacca et al., 2008), and *D. digressa* has been found in areas of Manukā where only *Pisonia* is present. However, the long-term survival of the flies is unclear when *Charpentiera* is almost completely absent. ‘Ōla‘a and other wet forest areas formerly had very large *Charpentiera* trees that served as important hosts for *D. digressa* and other species, but most of these were dead by the late 1990s. The population at Honomalino occurs in a rare forest type with only a very small number of host plants and may not be viable.

THREATS:

- Habitat loss and degradation due to invasive plants, disturbance by non-native ungulates, and fire from nearby agricultural and residential activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila digressa* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining habitat requirements such as microclimate.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historic and novel sites.
- Determine major threats and limiting factors.
- Conduct studies to determine if restoration of *Charpentiera* is possible or feasible.

References:

- Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.
- Magnacca, KN, Foote, D, O'Grady, PM. 2008. A review of the endemic Hawaiian Drosophilidae and their host plants. *Zootaxa* 1728: 1–58
- Magnacca, KN, Price, DK. In press. Rapid adaptive radiation and host plant conservation in the Hawaiian picture wing *Drosophila* (Diptera: Drosophilidae). *Molecular Phylogenetics and Evolution*.
- Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.
- U.S. Fish and Wildlife Service. 2013. Endangered and threatened wildlife and plants; determination of endangered species status for 15 species on Hawaii Island. *Federal Register* 78: 64638–64690.



Drosophila hemipeza. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing *Drosophila* *Drosophila hemipeza*

SPECIES STATUS:

Federally Listed as Endangered
State Listed as Endangered

Designation of Critical Habitat for 12 Species of
Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila hemipeza* (Hardy, 1965) is a member of the *planitibia* species group, which includes the largest, most charismatic, and most beautiful species of native pomace flies. This group is distinctive due to the extra crossvein in the wings of all species except the Kaua‘i representatives. The unusual wing pattern is similar to the related *D. substenoptera* and the unrelated *D. pilipa*, but is otherwise distinctive. It can be distinguished from the partially sympatric *D. substenoptera* (also endangered) by having the two crossveins nearly in line rather than widely staggered, with the marks over them creating a single dark band across the wing. Both species have an unusual habit of both sexes frequently walking with the wings spread and facing forward, even when not displaying to another fly, possibly making them more vulnerable to predators. *D. hemipeza* is endemic to O‘ahu, occurring from diverse mesic to wet forest. Historically, *D. hemipeza* was found widely throughout both of O‘ahu’s mountain ranges, but its distribution has dramatically contracted. Like other members of the *planitibia* subgroup, it breeds in rotting bark of lobeliads, including *Cyanea* and *Lobelia*, but has also been reared from *Urera kaalae* (‘ōpuhe), an unusual host for this group.

DISTRIBUTION: *Drosophila hemipeza* was historically known from both the Ko‘olau and Wai‘anae ranges of O‘ahu, but primarily the latter. However, the only two Ko‘olau sites are at the opposite ends of the island (Pūpūkea and Pauoa Flats), suggesting it had a wide distribution there. In the Wai‘anae it was found widely, from Makaleha Valley, Mākaha Valley, ‘Ēkahanui, Kalua‘ā Gulch, and several sites in the vicinity of Pu‘u Palikea. Though always uncommon, the great majority of records are from Palikea, where it can still be regularly found. The only other known site today is Pu‘u Hāpapa, above Kalua‘ā Gulch, where it is very rare and has not been seen since 2015. Lab-reared flies have been released into the wild at ‘Ēkahanui in the Wai‘anae range and Mānoa Cliff in the Ko‘olau range, but it is not yet clear if they have established self-sustaining populations.

ABUNDANCE: Unknown. During nine years of ongoing monthly monitoring from 2013–2022, the O‘ahu Army Natural Resources Program (OANRP) found a low but relatively consistent population of this species at Palikea, and only rare individual observations at Hāpapa (OANRP, 2014). While this indicates at least one stable population, it is probably also small enough to be vulnerable to stochastic events like droughts.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae and are generally host-specific. *Drosophila hemipeza* is reported to breed in *Cyanea*, *Lobelia*, and *Urera*, which all occur at both present

sites. Since there is only one rearing record from each plant, it is unknown whether there is a preferred host; however, if there is it is likely to be for the lobeliads, which related species use exclusively. Both Palikea and Hāpapa are fenced to exclude feral ungulates and intensively managed for rare plants and snails, and habitat is generally improving at both sites.

THREATS:

- Habitat loss and degradation due to invasive plants and invertebrates, disturbance by non-native ungulates, and fire from nearby agriculture, residential, and military activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila hemipeza* specifically, management needs include:

- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining the primary host plant and other habitat requirements.
- Establish laboratory breeding colonies for reintroduction to sites where the species has been extirpated.

MONITORING:

- Continue monitoring populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

- Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.
- Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.
- Oahu Army Natural Resources Program. 2014. Status Report for the Makua and Oahu Implementation Plans. Pacific Cooperative Studies Unit, Honolulu.
- U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 71: 26835–26852.
- U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 73: 73734–73895.



Drosophila heteroneura.

Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing *Drosophila*

Drosophila heteroneura

SPECIES STATUS:

Federally listed as Endangered

State listed as Endangered

Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila heteroneura* (Perkins, 1910) is a member of the *planitibia* species group, which includes the largest, most charismatic, and most beautiful species of native pomace flies. This group is distinctive due to the extra crossvein in the wings of all species except the Kaua‘i representatives. The species is endemic to Hawai‘i, occurring in montane mesic to wet forest, where it cooccurs with *D. silvestris*, except in Kohala. Like other members of the *planitibia* subgroup, it breeds in rotting bark of lobeliads. *Drosophila heteroneura* closely resembles other members of the subgroup including *D. differens* of Moloka‘i, *D. planitibia* of Maui, and *D. silvestris* of Hawai‘i. However, *D. heteroneura* differs strikingly from all of these in having a broad head, particularly in the males which possess a distinct “hammerhead”. Laboratory experiments have shown that they can produce viable hybrids with *D. silvestris*, and hybrid individuals have been detected in the wild. Combined with the relative ease of laboratory rearing, this has led to *D. heteroneura* being used extensively in genetics research.

DISTRIBUTION: *Drosophila heteroneura* is historically known from many collections at twelve sites across the island of Hawai‘i except for Kohala. However, sometime after 1980, it underwent a serious decline, disappearing from sites in east Hawai‘i where it had formerly been common. Since 1998, it has only been known from a small area in South Kona.

ABUNDANCE: Unknown. *Drosophila heteroneura* has been extirpated throughout nearly all of its historic range, including many sites where it was formerly regularly collected, indicating a population decline of over 95%. At the sites where it remains, it was sometimes moderately abundant during surveys conducted from 1998–2011. However, access is extremely limited, and much of the area has not been surveyed in many years. Some sites were resurveyed in 2022–2023 and found to have undergone a catastrophic decline in host plants compared to 2011, with no flies found.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. The primary host of *D. heteroneura* is the bark of lobeliads, particularly larger trees of *Clermontia*. These are especially vulnerable to disturbance by feral ungulates and direct herbivory by rats and slugs. Most of the current range of *D. heteroneura* is not fenced from ungulates. The disappearance of *D. heteroneura* coincided with both the decline of an important host species, *Clermontia*

hawaiiensis, and the arrival of the western yellowjacket (*Vespula pensylvanica*), a major predator of native insects.

THREATS:

- Habitat loss and degradation due to invasive plants, invertebrates, and rats, disturbance by non-native ungulates.
- Non-native predators, including wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila heteroneura* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining habitat requirements such as microclimate.
- Establish laboratory breeding colonies for reintroduction to sites where the species has been extirpated.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

- Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.
- Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.
- U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 71: 26835–26852.
- U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 73: 73734–73895.



Drosophila montgomeryi, courtship dance.

Terrestrial Invertebrates

Picture wing *Drosophila* *Drosophila montgomeryi*

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

Designation of Critical Habitat for 12 Species of
Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila montgomeryi* Hardy & Kaneshiro, 1971 is a member of the *vesciseta* species subgroup, which contains seven species of relatively uniform appearance – mostly yellow-brown, with few dark markings, and a similar pattern on the wings. They are among the smallest of the picture wings, and some individuals may even be smaller than non-picture wings. Each island has one species that breeds on *Pisonia* spp. (pāpala kēpau) and one on *Urera* spp. (‘ōpuhe), except that there is no *Pisonia* breeder known from Kaua‘i. The two groups appear similar, but the *Urera* breeding species can all be readily distinguished by having the median anterior mark on the wing longer than wide, rather than square. Other details of the coloration and male leg hairs, involved in courtship, serve to separate the species, all of which are rare. *Drosophila montgomeryi* is endemic to O‘ahu, occurring in diverse mesic forest where it breeds in *Urera*.

DISTRIBUTION: *Drosophila montgomeryi* was historically known mainly from the Wai‘anae range of O‘ahu, where it was recorded from three sites: Alaiheihe, Kalua‘ā, and ‘Ēkahanui, with the majority coming from the last. There is a single historic record from the southeastern Ko‘olau range, but it has not been adequately surveyed there. Since 2009, it has been found at a total of 10 sites in five populations, from Wai‘anae Valley, Schofield Barracks, Kalua‘ā and Hāpapa, Puali‘i, and Pu‘u Palikea. Lab-reared flies have been released into the wild at ‘Ēkahanui in the Wai‘anae range and Mānoa Cliff in the Ko‘olau range, but it is not yet clear if they have established self-sustaining populations.

ABUNDANCE: This species is still found in nearly its full historic range and some additional sites. However, it apparently can no longer be found at ‘Ēkahanui, where it was historically most abundant. While the Kalua‘ā/Hāpapa and Wai‘anae populations consist of multiple sites with moderate numbers of flies and host plants, the other three sites have only small and ephemeral populations, with relatively few host plants available. In addition, the Wai‘anae sites have drastically declined in quality and abundance over the past 10 years. Nine years of ongoing monthly monitoring from 2013–2022 by the O‘ahu Army Natural Resources Program (OANRP) found a strong seasonal pattern to *D. montgomeryi* abundance at Kalua‘ā and Hāpapa, with high numbers from February through June and dropping to near zero between August and November (OANRP 2014). These observations, and the restricted distribution of *Urera*, suggest that it is primarily limited by the abundance of host plants.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. *Drosophila*

montgomeryi is documented as breeding in *Urera kaalae*, and is presumed to also breed in *U. glabra* since it occurs at sites where only the latter species is present. *Urera glabra* is still found at many sites and is long-lived and resilient, but suffers from low recruitment and few young plants are seen outside of heavily managed areas. Because broken branches root easily, many apparent individuals in a patch may be clones; since it is dioecious, this may result in all plants in the area being one sex. However, in recent years the invasive ambrosia beetle *Euwallacea* cf. *fornicatus* has been attacking damaged but living trees, causing their death rather than allowing them to regrow. On the other hand, *U. kaalae* is a relatively short-lived tree and has undergone a catastrophic decline over the past 40 years, with only a handful of wild plants remaining. Seedlings are especially vulnerable to slug predation. The loss of *U. kaalae* as a significant breeding host is probably responsible for the absence of *D. montgomeryi* from 'Ēkahanui, where both were formerly abundant. Palikea and Kalua'ā/Hāpapa are fenced to exclude feral ungulates and intensively managed for rare plants and snails, and habitat is generally improving at both sites. The Wai'anae sites cannot be fenced due to the likelihood of damage from falling rocks, which can also directly damage the host plants.

THREATS:

- Habitat loss and degradation due to invasive plants and invertebrates, disturbance by non-native ungulates, and fire from nearby agriculture, residential, and military activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila montgomeryi* specifically, management needs include:

- Continue and expand fencing to protect habitat from ungulate disturbance.
- Outplant *Urera* spp. in protected areas to increase available breeding habitat, with the goal of creating self-sustaining populations of plants.
- Establish laboratory breeding colonies for reintroduction to sites where the species has been extirpated.

MONITORING:

- Continue monitoring populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historic and novel sites.
- Determine major threats and limiting factors, particularly limits on *Urera* reproduction.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

- Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.
- Oahu Army Natural Resources Program. 2014. Status Report for the Makua and Oahu Implementation Plans. Pacific Cooperative Studies Unit, Honolulu.
- U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 71: 26835–26852.
- U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 73: 73734–73895.



Drosophila mulli. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing *Drosophila* *Drosophila mulli*

SPECIES STATUS:

Federally Listed as Threatened

State Listed as Threatened

Designation of Critical Habitat for 12 Species of
Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila mulli* Perreira & Kaneshiro, 1990 is an unusual fly with no clear affinity to other picture wing species groups. It can be immediately distinguished from all others by the small size of the wing spots, nearly all yellow-brown color, and long hairs covering both the front tibia and tarsus of the male. It is endemic to Hawai‘i, occurring in lowland to montane wet forest. The breeding host of *D. mulli* is unclear. It is closely associated with native *Pritchardia* palms – adults have been found almost exclusively by collecting them from the undersides of *P. beccariana* leaves. However, it has never been reared and the breeding location is unknown. No other *Drosophila* are known to be associated with palms.

DISTRIBUTION: *Drosophila mulli* is known from three sites between 2500 and 3200 feet elevation: ‘Ōla‘a Forest Reserve (1985–86), Stainback Highway (1998), and Saddle Road (2013–14). It is probably more widely distributed than these records suggest; since it is apparently not attracted to baits, flies can only be collected from very short palm trees, which are rare.

ABUNDANCE: Unknown. *Drosophila mulli* is difficult to collect and may occur more abundantly than is recognized if taller palms could be searched.

LOCATION AND CONDITION OF KEY HABITAT: All known picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. The uncertainty about the breeding host of *D. mulli* makes it difficult to ascertain the habitat quality. However, it is clear that it has a strong association with *Pritchardia* palms. Although *P. beccariana*, the only species on which *D. mulli* has been found, is surviving better than the other species on Hawai‘i, it still suffers from poor reproduction due to rat and beetle predation on the seeds, and the extinction of birds that formerly dispersed the fruit. The fungal disease Rapid ‘Ōhi‘a Death (ROD) has had a greater impact on the lower elevation forests where *D. mulli* occurs than the higher sites where most other picture wing flies are typically found. The Saddle Road site where it was last collected in 2013–2014 is now much more open and dry, and may not support *D. mulli* anymore despite the continued presence of *Pritchardia*.

THREATS:

- Habitat loss and degradation due to invasive plants, invertebrates, fungal pathogens, and rats, disturbance by non-native ungulates.
- Non-native predators, including wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila mulli* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining habitat requirements such as microclimate.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 73: 73734–73895.



Drosophila musaphilia. Photo: Glenn Uemura.

Terrestrial Invertebrates

Picture wing *Drosophila* *Drosophila musaphilia*

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

Designation of Critical Habitat for 12 Species of
Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila musaphilia* Hardy, 1965 is a member of the *hawaiiensis* species subgroup, the second largest within the *grimshawi* group. As far as known, all members of the group breed in fermenting sap fluxes of native trees rather than bark as is typical for picture wing *Drosophila*. It is dark gray with a continuous band across the middle of the wing, generally similar in appearance to related species and the unrelated, sympatric *D. villosipedis*. It can be readily distinguished from all other species by the wing pattern, with the median band sinuate rather than straight and the mark on the dm-cu crossvein L-shaped, as well as by the details of the male front leg setation. *Drosophila musaphilia* is endemic to Kaua‘i, occurring in mesic to wet forest where it breeds in fermenting sap fluxes of *Acacia koa* (koa).

DISTRIBUTION: *Drosophila musaphilia* was historically known three sites: Mt. Kāhili (Alexander Reservoir) and two sites in Kōke‘e State Park. It has been recently collected along the Nu‘alolo Trail and elsewhere along Kaunuohua Ridge in Kōke‘e.

ABUNDANCE: Unknown. This species appears to have always been rare within historical collecting, compared to others that have undergone clear declines between the early collecting period (1966–1975) and today. While it can be found occasionally at certain locations, typically no more than one or two individuals are seen at a time; it does not appear to experience population booms as some other endangered *Drosophila* species do.

LOCATION AND CONDITION OF KEY HABITAT: The breeding host of *Drosophila musaphilia* is *Acacia koa*, where larvae feed in fermenting sap fluxes. *Acacia koa* is abundant and reproducing at all sites where *D. musaphilia* is found, suggesting that unlike other rare *Drosophila*, its numbers may not be strictly host-limited at the sites where it occurs. It appears to be extremely limited in range compared to the broad distribution of *Acacia koa*, suggesting limiting due to either non-host factors or in the extent of suitable conditions for sap fluxes. Introduced saprophagous invertebrates may also affect breeding habitat quality.

THREATS:

- Habitat loss and degradation due to invasive plants and insects, disturbance by non-native ungulates, and fire from nearby agriculture and recreational activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila musaphilia* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Use these results to create a management plan for species recovery.

MONITORING:

- Continue monitoring populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 73: 73734–73895.



Terrestrial Invertebrates

Picture wing *Drosophila* *Drosophila neoclavisetae*

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

Designation of Critical Habitat for 12 Species of Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila neoclavisetae* Perreira & Kaneshiro, 1990 is a member of the *adiastola* species group. The species is endemic to West Maui, occurring in montane wet forest. It is part of a closely related complex of species including *D. clavisetae* of East Maui and *D. neogrimshawi* of O‘ahu which all have an extra crossvein in the wing, a convergent character with the *planitibia* species group. Among these, *D. neoclavisetae* is distinguished by its wing pattern and details of the setation. The breeding host of *D. neoclavisetae* is not known for certain, but almost all other members of the *adiastola* group, including close relatives, breed in rotting bark of lobeliads, primarily *Clermontia* and *Cyanea*.

DISTRIBUTION: *Drosophila neoclavisetae* was historically known from only two collections, from 1969 and 1975, at upper elevation sites on West Maui along the Pu‘u Kukui Trail. Surveys in the same area in 2007 and 2009 failed to recover it there. Its true range is probably greater, but much of the West Maui mountain region is extremely difficult to access.

ABUNDANCE: Unknown. The lack of any records for the past 50 years means it is possible the species is extinct. However, several other *Drosophila* species have been rediscovered after longer absences. Even at heavily sampled sites, they may persist at low levels that are not detectable with standard survey methods or move in only when there is suitable breeding material. The sampling effort in the area has been relatively low for detecting rare species.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. Like its close relatives, *D. neoclavisetae* probably primarily breeds in *Clermontia*, which continues to occur in the area where these flies have been found in moderate abundance. The other lobeliad genera *Cyanea* and *Trematolobelia* also occur relatively frequently in the area, and it is likely that *D. neoclavisetae* breeds in these as well. Overall the habitat at Pu‘u Kukui is largely intact, and the reasons for the absence of *D. neoclavisetae* are not clear.

THREATS:

- Habitat loss and degradation due to invasive plants and rats, disturbance by non-native ungulates.
- Non-native predators, including wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila neoclavisetae* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and critical habitats to better direct conservation measures.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for extant populations, in both historic and novel sites.
- Conduct studies to document the biology, habitat requirements, and life history.

References:

Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.

Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.

U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 71: 26835–26852.

U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 73: 73734–73895.



Drosophila obatai. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing

Drosophila

Drosophila obatai

SPECIES STATUS:

Federally listed as Endangered

State listed as Endangered

Designation of Critical Habitat for 12 Species of

Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila obatai* Hardy & Kaneshiro, 1972 is a member of the *orphnopeza* species subgroup, the largest within the *grimshawi* group. It is readily distinguished from most other species by the dusty gray appearance of the body and the small size of the wing spots, characters it shares with the related *D. sodomae* of Maui Nui. *Drosophila obatai* is endemic to O‘ahu, occurring in diverse mesic forest where it breeds in *Dracaena* spp. (halapēpē).

DISTRIBUTION: *Drosophila obatai* was historically known mainly from the Wai‘anae range of O‘ahu, where it was collected once from Makaleha Valley and twice from a site near Pu‘u Pane, east of Ka‘ala in 1970–1971. There are also two records from that period from the southeastern Ko‘olau range (Wailupe and Wai‘alae Nui), but it has not been adequately surveyed for there. It was rediscovered at Manuwai Gulch in 2011 and has since been found at East Makaleha, near Pu‘u Pane, and two sites in Pūle‘e Gulch in Schofield Barracks.

ABUNDANCE: Unknown. This species is still found in nearly its full historic range as well as some additional sites, though the Ko‘olau sites have not been surveyed. However, repeated surveys from 2013–2022 by the O‘ahu Army Natural Resources Program (OANRP) have found that it is present regularly and in moderate numbers only at Manuwai; at all other sites it is rarely seen, and then only as single individuals. These observations, and the restricted distribution of *Dracaena*, suggest that it is primarily limited by the abundance of host plants.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. *Drosophila obatai* is reported to breed in *Dracaena* (=Pleomele). The species was not recorded in fly-rearing records, but it is known to breed in at least *Dracaena halapepe* since it occurs at sites where that host plant is the only species present. *Dracaena forbesii* is presumed to be a host since it is extremely morphologically similar to *Dracaena halapepe*, but *D. obatai* has not been definitively associated with it. Both plant species are widespread, long-lived, and resilient, but suffer from low recruitment and few young plants are seen outside of heavily managed areas. They typically occur as relictual patches of one to five trees, often separated from other patches by mostly non-native vegetation. Because broken branches root easily, many apparent individuals in a patch may be clones. Manuwai and Pūle‘e are fenced to exclude feral ungulates and Manuwai is

managed for rare plants, and habitat is generally improving at both sites. Other sites continue to degrade due to the presence of feral pigs and goats.

THREATS:

- Habitat loss and degradation due to invasive plants and rats, disturbance by non-native ungulates, and fire from nearby agriculture, residential, and military activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila obatai* specifically, management needs include:

- Continue and expand fencing to protect habitat from ungulate disturbance.
- Continue rat control to allow reproduction of *Dracaena*.
- Outplant *Dracaena* in protected areas to increase available breeding habitat, with the goal of creating self-sustaining populations of plants.
- Establish laboratory breeding colonies for reintroduction to sites where the species has been extirpated.

MONITORING:

- Continue monitoring populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historic and novel sites.
- Determine major threats and limiting factors, particularly limits on *Dracaena* reproduction.

References:

- Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.
- Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawai'i. Proceedings of the Hawaiian Entomological Society 22(1): 65–103.
- Oahu Army Natural Resources Program. 2014. Status Report for the Makua and Oahu Implementation Plans. Pacific Cooperative Studies Unit, Honolulu, Hawaii.
- U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 71: 26835–26852.
- U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. Federal Register 73: 73734–73895.



Drosophila ochrobasis. Photo: Karl Magnacca.

Terrestrial Invertebrates

Picture wing *Drosophila*

Drosophila ochrobasis

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

Designation of Critical Habitat for 12 Species of
Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila ochrobasis* Hardy & Kaneshiro, 1968 is a member of the *adiastola* species group. The species is endemic to Hawai‘i, occurring in montane wet forest. It is part of the *adiastola* subgroup, which is characterized by having the wings largely dark with scattered clear spots. Among these, *D. ochrobasis* is distinguished by the males having the base of the wing mostly clear with only a few faint marks; females are almost indistinguishable from the sympatric *D. setosimentum*. The primary breeding host of *D. ochrobasis*, if it has one, is unclear. Nearly all members of the *adiastola* subgroup breed in *Clermontia* (with the exception of one small clade which has switched to *Touchardia*), including the sympatric sibling species *D. setosimentum*. The presence of two such closely related species may mean that *D. ochrobasis* has switched to a new host. It has been reared three times, each from a different host and part: *Clermontia* roots, *Marattia* (mulesfoot fern) rachis, and *Myrsine* leaves.

DISTRIBUTION: *Drosophila ochrobasis* is historically known from many collections at six sites between 1966 and 1975, from a Saddle Road kīpuka, Ka‘ū Forest Reserve, Hualālai, and Kohala. However, sometime after this period, it underwent a serious decline, with only a single collection from the Saddle Road in 1986 before it was rediscovered in Kohala in 2006. Since then it has been found consistently at a few sites in the Kohala area, but nowhere else.

ABUNDANCE: Unknown. *Drosophila ochrobasis* appears to be extirpated throughout nearly all of its historic range, including many sites where it was formerly regularly collected, indicating a population decline of over 95%.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. The uncertainty about the breeding hosts of *D. ochrobasis* makes it difficult to ascertain the habitat quality. It is clear that *Clermontia* is nearly gone from some of the sites where *D. ochrobasis* previously occurred, while it is still abundant at Kohala. However, *D. ochrobasis* does not live in some areas with abundant *Clermontia* that should be within its range, such as South Kona, where *D. setosimentum* is common.

THREATS:

- Habitat loss and degradation due to invasive plants and rats, disturbance by non-native ungulates.
- Non-native predators, including wasps (*Vespula pensylvanica*).

- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila ochrobasis* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining habitat requirements such as microclimate.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

- Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.
- Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.
- U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 71: 26835–26852.
- U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 73: 73734–73895.



Drosophila primaeva, externally identical sister species of *D. sharpi*. Photo: Karl Magnacca.

Terrestrial Invertebrates

Sharp's *Drosophila* *Drosophila sharpi*

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Drosophila sharpi* Hardy, 1965 is a basal member of the Hawaiian *Drosophila*. It and its sympatric sister species *D. primaeva* represent an ancient lineage that was one of the first to branch off during the evolution of the group and has few or no other living relatives. Although not a member of the picture wing clade, it is often treated with them due to its similar size and habits. It is a large, brown fly with only a few inconspicuous wing marks and generally lacking in ornamentation except for a sclerotized black rim on the labellum of the male, which is also found in the fungus-feeding *haleakalae* group and the similar but very poorly-known *rustica* group. Morphologically it can be separated from *D. primaeva* only by details of the genitalia, but they are significantly different in chromosomal banding pattern. It is endemic to Kaua'i, occurring in mesic to wet forest.

DISTRIBUTION: *Drosophila sharpi* was historically known from two sites, Mt. Kāhili in the south and Kōke'e in the northwest. The last record from Kōke'e is from 1991, but due to close similarity to the more common *D. primaeva* it is possible that some individuals have been sighted since then but not collected. The first and last record from Kāhili was in 1968, but access is limited and few surveys have been conducted there recently.

ABUNDANCE: Unknown. The lack of any recent records means it is possible the species is extinct. However, several other *Drosophila* species have been rediscovered after much longer absences. Even at heavily sampled sites, they may persist at low levels that are not detectable with standard survey methods. Given that the most recent record was less than 25 years ago, it is presumed to be still extant.

LOCATION AND CONDITION OF KEY HABITAT: The breeding host of *Drosophila sharpi* is unknown. Its sister species *D. primaeva* breeds in decaying bark of Araliaceae, *Cheiodendron* spp. and *Polyscias* (= *Tetraplasandra*) spp., and given their close similarity it is likely that *D. sharpi* does as well. *Cheiodendron* is abundant and reproducing at all sites where *D. sharpi* has been found, suggesting that unlike other rare *Drosophila*, its numbers may not be strictly host-limited at the sites where it occurs.

THREATS:

- Habitat loss and degradation due to invasive plants and disturbance by non-native ungulates.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).

- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila sharpi* specifically, management needs include:

- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining habitat requirements such as microclimate.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for extant populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

- Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.
- Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawai'i. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.
- U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; determination of endangered status for 48 species on Kauai and designation of critical habitat. *Federal Register* 75: 18960–19008.

Terrestrial Invertebrates



Drosophila substenoptera. Photo: Karl Magnacca.

Picture wing

Drosophila

Drosophila substenoptera

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

Designation of Critical Habitat for 12 Species of
Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila substenoptera* Hardy, 1969 is a member of the *planitibia* species group, which includes the largest, most charismatic, and most beautiful species of native pomace flies. This group is distinctive due to the extra crossvein in the wings of all species except the Kaua‘i representatives. The unusual wing pattern is similar to the related *D. hemipeza* and the unrelated *D. pilipa* but is otherwise distinctive. It can be distinguished from the partially sympatric *D. hemipeza* (which is also endangered) by having the two crossveins widely staggered rather than nearly in line, with the marks over them distinctly separate. Both species have an unusual habit of both sexes frequently walking with the wings spread and facing forward, even when not displaying to another fly, possibly making them more vulnerable to predators. The species is endemic to O‘ahu, occurring in wet forest. It was historically found widely throughout both mountain ranges of the island, but its range has dramatically contracted. Like other members of the *cyrtoloma* subgroup, it breeds in rotting bark of araliads, including *Cheirodendron* spp. (‘ōlapa and lapalapa) and *Polyscias* spp. (‘ohe mauka).

DISTRIBUTION: *Drosophila substenoptera* was historically known from five sites in the Ko‘olau range (from the Castle Trail to Ka‘au Crater) and four in the Wai‘anae range (Pu‘u Palikea and three sites around Ka‘ala) of O‘ahu. In the latter, it can still be found at most of its historic sites – just below the summit of Ka‘ala, along the crestline to Pu‘u Kalena, and at Palikea. However, at all sites but Palikea, it is only seen as single individuals. In the Ko‘olau range, it has declined more severely and only one site is known, from the middle Pe‘ahināi‘a Trail.

ABUNDANCE: During nine years of ongoing monthly monitoring from 2013–2022, the O‘ahu Army Natural Resources Program (OANRP) found a low but relatively consistent population of this species at Palikea, and only rare individual observations in the vicinity of Ka‘ala and at Pe‘ahināi‘a (OANRP, 2014). While this indicates at least one stable population, it is probably also small enough to be vulnerable to stochastic events like droughts.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae and are generally host-specific. *Drosophila substenoptera* breeds in Araliaceae, primarily *Cheirodendron* spp. and secondarily the rarer *Polyscias* (= *Tetraplasandra*) spp. *Cheirodendron* is abundant and reproducing at all sites where *D. substenoptera* is found, suggesting that, unlike other rare *Drosophila*, its numbers are not

strictly host-limited at the sites where it occurs. However, it appears to prefer the taller, slightly drier forest such as that at Palikea and Pe‘ahināi‘a rather than the stunted, boggy forest found at the summits of both Ka‘ala and the Koolau crest, where most *Cheirodendron* is now found.

THREATS:

- Habitat loss and degradation due to invasive plants, disturbance by non-native ungulates, and fire from nearby agriculture, residential, and military activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).
- Insufficient information hampers conservation efforts.

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila substenoptera* specifically, management needs include:

- Continue and expand fencing to protect habitat from ungulate disturbance.
- Conduct studies on life history and essential habitats to better direct conservation measures, including determining habitat requirements such as microclimate.
- Establish laboratory breeding colonies for reintroduction to sites where the species has been extirpated.

MONITORING:

- Continue monitoring populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historic and novel sites.
- Determine major threats and limiting factors.

References:

- Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.
- Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.
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- U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 73: 73734–73895.



Drosophila hexachaetae, sympatric sister species of *D. tarphytrichia*, nearly identical in appearance.

Terrestrial Invertebrates

Picture wing *Drosophila*

Drosophila tarphytrichia

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

Designation of Critical Habitat for 12 Species of
Picture-Wing Flies: Final Rule – USFWS 2008

GENERAL INFORMATION: *Drosophila tarphytrichia* Hardy, 1965 is one of the smallest members of the *picture wing* species group of Hawaiian *Drosophila* pomace flies. The species is endemic to O‘ahu, primarily in the Wai‘anae range (there is only a single record from the eastern Ko‘olau range, from 1949), occurring in diverse mesic forest gulches. Although always uncommon, it was historically widely found throughout the range on the eastern and northern slopes. It is a member of the *lanaiensis* species subgroup, which consists of five species, all of which are rare. Uniquely among *picture wing* species, it is nearly identical to a sympatric sibling species, *D. hexachaetae* (pictured above), differing only in the front leg morphology of the male. These two species are strikingly different from their relatives, and superficially most closely resemble members of the *vesciseta* subgroup, which are also small with an unmarked thorax. All members of the subgroup breed primarily in decaying branches and trunks of *Charpentiera* spp. (pāpala), and usually secondarily in *Pisonia* spp. (pāpala kēpau). While the latter is still abundant even in disturbed areas, the former has declined significantly since the early 1970s when most specimens were collected.

DISTRIBUTION: Known mainly from the Wai‘anae range of O‘ahu, where it has historically been found at four sites in Honouliuli Forest Reserve: Kalua‘ā, Pu‘u Kaua (‘Ēkahanui), Mauna Kāpū, and Pu‘u Palikea. The type specimen was from Mānoa Falls in the Ko‘olau range, but there have been no other records from that side of the islands since that one in 1949. The most recent record was in 1997 at Pu‘u Palikea, but intensive surveys 2013–2022 have failed to recover it there. At other historic sites, it has not been seen since 1975. It is possible that the close similarity to *D. hexachaetae*, which is also rare, has led it to be undercounted when specimens are not collected – males can only be separated by examining the front legs with a high-powered lens or microscope, and females cannot be distinguished at all. However, with increased conservation concern for this species they have been checked regularly during recent surveys (2013–2022), and all have been *D. hexachaetae*.

ABUNDANCE: Unknown. The lack of any records for the past 28 years means it is possible the species is extinct. However, several other *Drosophila* species have been rediscovered after longer absences. Even at heavily sampled sites, they may persist at low levels that are not detectable with standard survey methods or move in only when there is suitable breeding material. Given that the most recent record was less than 30 years ago, it is presumed to be still extant.

LOCATION AND CONDITION OF KEY HABITAT: All picture wing *Drosophila* live in rotting bark or sap fluxes of native trees as larvae, and are generally host-specific. The known host of *D. tarphytrichia* is *Charpentiera* (Montgomery 1975, Kaneshiro and Kaneshiro 1995). Many species that typically use this tree can also utilize the more abundant *Pisonia* (Magnacca et al., 2008), but the long-term survival of the flies is unclear when *Charpentiera* is almost completely absent. Until the early 1970s the major gulches of Honouliuli, ‘Ēkahanui and Kalua‘ā, were dominated by large trees of *Charpentiera tomentosa*. However, an unexplained outbreak of the native tip-boring moth *Mapsidius charpentierii* resulted in the death of most of the large trees, followed by invasion by alien canopy trees. While *Charpentiera* persists in the area, since that time the moths have kept all trees very small, reducing the amount of breeding material available.

THREATS:

- Habitat loss and degradation due to invasive plants, excessive damage by native insects, disturbance by non-native ungulates, and fire from nearby agriculture, residential, and military activity.
- Non-native predators, including ants and wasps (*Vespula pensylvanica*).

CONSERVATION ACTIONS: Conservation of *Drosophila* requires 1) knowledge of the current sites occupied by the species; 2) conservation of a steady supply of breeding hosts at multiple sites; and 3) mitigation of ongoing threats, such as habitat destruction by feral ungulates and the presence of destructive alien arthropod predators. A general understanding of life history and habitat requirements is a prerequisite for management actions, though not for determining endangered status. The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Drosophila tarphytrichia* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Conduct studies on life history and critical habitats to better direct conservation measures.
- Use these results to create a management plan for species recovery.

MONITORING:

- Continue surveys to identify populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for extant populations, in both historic and novel sites.
- Conduct studies to determine if restoration of *Charpentiera* is possible or feasible.

References:

- Kaneshiro, KY, Kaneshiro, K. 1995. Draft listing proposal for 18 species of Hawaiian picture-wing *Drosophila*. Document submitted to the Pacific Islands Office, U.S. Fish and Wildlife Service, Honolulu, Hawaii.
- Magnacca, KN, Foote, D, O’Grady, PM. 2008. A review of the endemic Hawaiian Drosophilidae and their host plants. *Zootaxa* 1728:1–58
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- Montgomery, SL 1975. Comparative breeding site ecology and the adaptive radiation of picture-winged *Drosophila* (Diptera: Drosophilidae) in Hawaii. *Proceedings of the Hawaiian Entomological Society* 22(1): 65–103.
- U.S. Fish and Wildlife Service. 2006. Endangered and threatened wildlife and plants; determination of status for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 71: 26835–26852.
- U.S. Fish and Wildlife Service. 2008. Endangered and threatened wildlife and plants; designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands. *Federal Register* 73: 73734–73895.



Terrestrial Invertebrates

Tiger flies
 Order Diptera
 Family Muscidae
 Genus *Lispocephala*

GENUS INCLUDES:
 >103 Endemic Species

GENERAL INFORMATION: *Lispocephala* is a genus of predatory tiger flies (subfamily Coenosiinae). They are large, bristly, and fast-flying, catching prey in flight and feeding with toothed mouthparts. The genus *Lispocephala* consists of about 180 species worldwide, but over 100 of these are endemic to Hawai‘i. Although they appear to be generalist predators, a high diversity of species often occurs in any given area, so they may specialize in particular prey or habitats. Many undescribed species are known as well. Some of their diversity may be due to variation in the larval stage, which is poorly known for most species. Some are known to prey on *Drosophila* larvae, while others live in streams feeding on the larvae of canaceids, chironomids, and other aquatic flies.

DISTRIBUTION: *Lispocephala* are known from all the Main Hawaiian Islands except Kaho‘olawe and Ni‘ihau.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the genus are declining. Many species are common and abundant within intact native forest, but others are very rare and many have not been collected in decades. Due to their rapid and active flight, they are not as easily collected as other native flies.

LOCATION AND CONDITION OF KEY HABITAT: *Lispocephala* mainly occur in mid to upper elevation mesic to wet forest. Larval habitat may be more important for their conservation, but is only known for a few species.

THREATS:

- Habitat loss and degradation. Habitat is lost to conversion for agriculture, logging, and grazing, and is disturbed by a suite of non-native ungulates and the introduction of invasive plants.
- Predation. Non-native species, including ants, wasps, crustaceans, and fish, prey on these flies.
- Lack of data. Insufficient information, especially for rare species, hampers conservation efforts.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations,

thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward tiger flies should include the following:

- Conduct surveys to determine the distribution and abundance of known species and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.

MONITORING: Continue surveys to monitor the status of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional, new populations.
- Survey to determine status of species believed to be extinct.
- Conduct studies to document the biology, habitat requirements, and life history of poorly known species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

- Hardy DE. 1981. Insects of Hawaii: Volume 14 Diptera: Cyclorrhapha IV, Series Schizophora Section Calyptratae. Honolulu: University of Hawai'i Press.
- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
- Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawai'i Press.



Coleotichus blackburniae. Photo: Will Haines.

Terrestrial Invertebrates

True bugs
Order Hemiptera
Suborder Heteroptera

SUBORDER INCLUDES:

14 Native Families
45 Native Genera
437 Native Species
>434 Endemic Species

GENERAL INFORMATION:

The Hawaiian Heteroptera consists of species found on the alpine summit of Mauna Kea to species that live in aquatic habitats. Their diets range from phytophagy to predatory to scavengers. Members of this suborder are known as true bugs, and the most familiar groups are assassin bugs (Reduviidae), stink bugs (Pentatomidae), and plant bugs (Miridae). The largest number of native species occurs in the families Lygaeidae (i.e., seed bugs) and Miridae (i.e., plant bugs), many of the latter of which are still poorly studied and understood.

As an example of the diversity of Hawai‘i’s true bugs, three genera of the family Miridae are briefly outlined here. Most species in the genus *Nesiomiris* are endemic to single islands. The 50 described native species are known from all the MHI and feed only on the host plants in the following genera: *Cheirodendron*, *Ilex*, and *Polyscias*. The 96 described species in the genus *Orthotylus* are endemic to single islands in the MHI chain. Most individual *Orthotylus* species depend on a single host plant or several closely related species, with plants in the Rubiaceae family being important hosts. All but one of the 40 described native species in the genus *Sarona* are also endemic to single main Hawaiian Islands, and most depend on a single host plant species, often in the genus *Melicope*.

DISTRIBUTION: True bugs are known from all the MHI and the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats and host plants likely means species within the suborder are declining. Populations occurring in dry and mesic forests are believed to be declining rapidly.

LOCATION AND CONDITION OF KEY HABITAT: True bugs occur in aquatic (both marine and freshwater) and terrestrial habitats, including high-elevation alpine areas.

THREATS:

- Loss or degradation of habitat, especially dry lowland habitats and coastal zones.
- Loss of host-specific plants.
- Insufficient information for species assessments.

- Predation by invasive non-native insects such as ants (Hymenoptera: Formicidae) and generalist egg predators.
- Predation by invasive vertebrates such as coqui frogs (*Eleutherodactylus coqui*)
- Parasitism of koa bugs (*Coleotichus blackburniae*) by *Trichopoda pennipes* (Diptera: Tachinidae) and *Trissolcus basalis* (Hymenoptera: Scelionidae).
- Parasitism by non-native invertebrates.
- Displacement by non-native congeners (e.g., invasive members of the family Lygaeidae, particularly *Nysius* spp.).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward true bugs should include:

- Control of fire in dry and mesic forest habitats.
- Outplant native plants, especially hosts of declining heteropteran species.
- Protect coastal strand habitats from off-road vehicles and excessive foot traffic in areas where native vegetation remains.
- Conduct surveys to document and determine the distribution and abundance of known true bugs.
- Conduct surveys and document non-native predators and parasitoids.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Initiate studies of the genera *Orthotylus*, *Koanoa*, *Sulamita*, *Kalania*, and *Pseudoclerada*, all of which appear to have many undescribed species. Document the biology, habitat requirements, and life histories.
- Conduct systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny.
- Support specialized taxonomic work to identify and describe new species to science.
- Initiate efforts to relocate species that have not been observed in at least 50 years.

References:

- Asquith A. 1994. Revision of the endemic Hawaiian genus *Sarona* Kirkaldy (Heteroptera: Miridae: Orthotylinae). Bishop Museum Occasional Papers 40:1–81.
- Gagne WC. 1997. Insular evolution, speciation, and revision of the Hawaiian genus *Nesiomiris*. Bishop Museum Bulletins in Entomology 7. Honolulu, (HI): Bishop Museum Press.
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Nysius wekiukola. Photo: G. Heaton.

Terrestrial Invertebrates

Maunakea Wēkiu Bug
Nysius wekiucola

“Maunaloa Wēkiu Bug”
Nysius aa

GENERAL INFORMATION:

The Maunakea wēkiu bug, *Nysius wekiucola*, and the “Maunaloa wēkiu bug”, *Nysius aa* (no accepted common name but some generally call both summit bugs “wēkiu bugs”), are micropterous seed bugs in the family Lygaeidae (Hemiptera: Heteroptera). *N. wekiucola* is only found on the summit of Maunakea while its apparent sister species, *N. aa*, can only be found on the upper slopes of Maunaloa. Both flightless species live under rocky ‘a‘ā and cinder. Unlike most members of the Lygaeidae, these two species do not feed on plant tissue but are scavenger-predators that feed on dead and dying insects blown up the mountain from lower elevations.

DISTRIBUTION: Hawai‘i Island

ABUNDANCE: Surveys and studies of *Nysius wekiucola* bug over 11 years showed populations are stable given current threats are minimized. Abundance of the *N. aa* bug remains unknown due to a lack of systematic surveys to determine population estimates.

LOCATION AND CONDITION OF KEY HABITAT: Cinder cones (pu‘u) on the summit of Maunakea (*N. wekiucola*) and the summit of Maunaloa (*N. aa*), at elevations between 3415 and 4205m.

THREATS:

- Loss or degradation of habitat via human traffic and development of astronomy observatory facilities

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. Specific management directed toward *Nysius wekiucola* and *N. aa* should include:

- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Initiate surveys to determine abundance of *N. aa*

References:

Ashlock PD, Gagné WC. 1983. A remarkable new micropterous *Nysius* species from the aeolian zone of Mauna Kea, Hawai'i Island (Hemiptera: Heteroptera: Lygaeidae). *International Journal of Entomology* 25(1): 47-55.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Polhemus, DA. 1998. *Nysius aa* (Heteroptera: Lygaeidae), a new species of micropterous wekiu bug from the summit of Mauna Loa Volcano, Hawaii. *Proceedings of the Entomological Society of Washington* 100(1): 25-31.

Endangered and Threatened Wildlife and Plants; Candidate Removal of Wekiu bug (*Nysius wekiuicola*); Proposed Rules, 76 Fed. Reg. 66377 (October 26, 2011), Docket No. FWS-R9-ES-2011-0061; MO-9221050083-B2.



Kamehameha lunalilo

Terrestrial Invertebrates

Plant bugs

Order Hemiptera

Family Miridae

FAMILY INCLUDES:

15 Native Genera

>222 Native & Endemic Species

GENERAL INFORMATION:

Genera with endemic species

Engytatus: 10 spp.

Nesiomiris: 50 spp.

Opuna: >5 spp.

Orthotylus: >95 spp.

Sarona: 40 spp.

Sulamita: >5 spp.

Astelianmiris, *Hyalopeplus*, *Kalania*, *Kamehameha*, *Koanoa*,

Loulucoris, *Nesidiorchestes*, *Pseudoclerada*, *Trigonotylus*: 1–3 spp. each

Miridae is a large and diverse family, with a correspondingly large number of endemic lineages. Most species feed on plants, hence the common name plant bugs; however, some are predaceous, and for many natives the life history is unknown. There are three large radiations: *Nesiomiris*, *Orthotylus*, and *Sarona*. All three are highly host-specific, with each species restricted to single islands. *Nesiomiris* is unusual in that all 50 species are found only on a few hosts in Araliaceae (*Cheirodendron* spp. and *Polyscias* spp.) and Aquifoliaceae (*Ilex anomala*), with multiple species often found sympatrically. *Orthotylus* are found on a wide variety of host plants in at least 18 families; a few are found on multiple plants and may be predaceous. *Sarona* occur on a few of the same hosts as *Orthotylus*, but most are on different plants, especially *Melicope*. The remaining genera are much smaller and have varied habits; *Engytatus*, *Loulucoris*, and *Sulamita* are host-specific plant feeders, while the others are found in a variety of situations and may be generalists or predaceous. *Hyalopeplus pellucidus* is remarkable for an endemic insect in being a generalist herbivore found in a wide range of habitats from dry coastal strands to montane wet forests. *H. pellucidus* seems to be able to survive in the presence of invasive predatory ants, but this cannot be said for other native plant bugs. *Nesidiorchestes* is a peculiar group of flightless jumping bugs found in leaf litter. Undescribed species are known at least for *Kamehameha*, *Koanoa*, *Nesidiorchestes*, and *Sulamita*, but comprehensive revisions are required to determine exactly how many there are.

DISTRIBUTION: Leaf bugs are known from all the MHI except Kaho‘olawe. *Hyalopeplus* and *Kamehameha* are also found on Nihoa.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. Most species are tightly associated with native plants, and their fate is tied to that of the plants. However, they may not be able to locate isolated populations of hosts such as in restoration areas.

LOCATION AND CONDITION OF KEY HABITAT: Mirids occur in a wide variety of terrestrial habitats, from the coast to high-elevation subalpine areas, but primarily in forests.

THREATS:

- Loss or degradation of habitat, especially lowland dry and mesic forests and coastal zones.
- Loss of host plants.
- Insufficient information for species assessments.
- Predation and parasitism by invasive non-native insects including ants (Formicidae), parasitoid wasps (Hymenoptera), and generalist egg predators.
- Displacement by non-native mirids.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward leaf bugs should include:

- Control of fire in dry and mesic forest habitats.
- Outplanting of native plants, especially those that are hosts to declining species.
- Protect coastal strand habitats from off-road vehicles and excessive foot traffic in areas where native vegetation remains.
- Conduct surveys to determine the distribution and abundance of known true bugs and to document and identify new species.
- Prevent introduction of invasive ants to areas they do not already occur.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Initiate studies of the genera *Kamehameha*, *Koanoa*, *Sulamita*, *Kalania*, *Opuna*, and *Pseudoclerada*, all of which appear to have many undescribed species. Work to identify and describe new species to science.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa.
- Initiate efforts to relocate species that have not been observed in at least 50 years.

References:

- Asquith A. 1994. Revision of the endemic Hawaiian genus *Sarona* Kirkaldy (Heteroptera: Miridae: Orthotylinae). Bishop Museum Occasional Papers 40: 1–81.
- Gagne WC. 1997. Insular evolution, speciation, and revision of the Hawaiian genus *Nesiomiris*. Bishop Museum Bulletins in Entomology 7. Honolulu, (HI): Bishop Museum Press.
- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
- Polhemus DA. 2002. An initial review of *Orthotylus* in the Hawaiian Islands, with descriptions of twenty-one new species (Heteroptera: Miridae). Journal of the New York Entomological Society 110(3–4): 270–340.
- Polhemus DA. 2004. Further studies on the genus *Orthotylus* (Heteroptera: Miridae) in the Hawaiian Islands, with descriptions of thirty-four new species. Journal of the New York Entomological Society 112(4): 227–333.



Nabis subrufus

Terrestrial Invertebrates

Damsel bugs
Order Hemiptera
Family Nabidae
Genus *Nabis*

GENUS INCLUDES:
>50 Native & Endemic Species

GENERAL INFORMATION: Damsel bugs are predaceous true bugs related to assassin bugs (Reduviidae). There are 25 described endemic species, with about as many documented but as yet undescribed species. Damsel bugs are generalist predators, but most species are microhabitat specialists. These are primarily the sites where they seek or ambush prey, such as moss mats, specific plants, or leaf litter. The majority of species have reduced wings and are flightless, with restricted geographic ranges.

DISTRIBUTION: Damsel bugs are known from all the Main Hawaiian Islands except Ni‘ihau and Kaho‘olawe.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the genus are declining. Many species have not been collected in years.

LOCATION AND CONDITION OF KEY HABITAT: Damsel bugs occur in mid to upper-elevation dry to wet forests, into subalpine shrubland. The small range of many species makes them vulnerable to disturbance and small-scale habitat destruction such as fire.

THREATS:

- Loss or degradation of habitat, especially for flightless species and in dry and mesic forests.
- Loss of host plants and microhabitats, such as drying leading to loss of moss mats.
- Insufficient information for species assessments.
- Predation by invasive non-native insects including ants (Formicidae).
- Displacement by non-native relatives (e.g., invasive members of the family Reduviidae and alien *Nabis*).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward damsel bugs should include:

- Control of fire in dry and mesic forest habitats.
- Conduct surveys to determine the distribution and abundance of known damsel bugs and to document and identify new species.

- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Initiate studies to document the biology, habitat requirements, and life history of understudied species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.
- Initiate efforts to relocate species that have not been observed in at least 50 years.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 1948. Insects of Hawaii: Volume 3 Heteroptera. Honolulu: University of Hawaii Press.



Oechalia prob. *suehiroae*

Terrestrial Invertebrates

Predatory stink bugs

Order Hemiptera

Suborder Heteroptera

Family Pentatomidae

Genus *Oechalia*

GENUS INCLUDES:

14 Endemic Species

GENERAL INFORMATION: *Oechalia* species are members of the stink bug family (Pentatomidae), of which most species are plant feeders. Unlike their phytophagous cousins, *Oechalia* belongs to the subfamily Asopinae, a subfamily known for its predatory behavior, feeding on soft-bodied insects like caterpillars. This group of endemic predatory stink bugs is very understudied and not much is known of their current status.

DISTRIBUTION: The *Oechalia* are known from six of the MHI: Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Maui, and Hawai‘i.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: The species of *Oechalia* occur mostly in the mid and upper-elevation forests.

THREATS:

- Loss or degradation of habitat
- Insufficient information for species assessments.
- Predation by invasive, non-native insects including ants (Formicidae) and generalist egg predators, and parasitism by non-native flies (Diptera) and wasps (Hymenoptera).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Oechalia* should include:

- Conduct surveys to determine the distribution and abundance of known true bugs and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.
- Control invasive non-native invertebrates.

MONITORING:

- Initiate monitoring the status of populations to detect declines in native species,
- Monitor impacts from non-native parasitoids and predators.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life histories of these species.
- Initiate studies to determine current distributions of known endemic species.
- Initiate efforts to locate and identify new species.
- Initiate studies to determine the effects of non-native predators and parasitoids on species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Usinger RL. 1941. The genus *Oechalia* (Pentatomidae, Hemiptera). Proceedings of the Hawaiian Entomological Society 11(1): 59-93.

Usinger RL. 1942. A new species of *Oechalia* from Oahu (Pentatomidae, Hemiptera). Proceedings of the Hawaiian Entomological Society 11(2): 217-218.



Nesodyne sp.

Terrestrial Invertebrates

Leafhoppers, Planthoppers

Order Hemiptera

Suborder Auchenorrhyncha

ORDER INCLUDES:

33 Native Families

20 Native Genera

>353 Native & Endemic Species

GENERAL INFORMATION: The Hawaiian Auchenorrhyncha suborder is particularly species-rich in Hawai‘i. All members of the suborder are phytophagous and feed on sap from plant tissue. The most speciose families in Hawai‘i include: Cicadellidae, Cixiidae, and Delphacidae; undescribed species likely occur in each family. Unfortunately, even in these diverse families, the constituent species are generally represented by few specimens, and their life history is poorly known. As an example of the diversity of Hawai‘i’s leafhoppers and planthoppers, three endemic genera are outlined. The endemic genus *Nesophrosyne* (Cicadellidae) is comprised of 72 described species and subspecies with many more remaining undescribed. Most species depend on a narrow range of host plants. Eighty-five described species and subspecies comprise the endemic genus *Nesosydne* (Delphacidae). Many species are endemic to individual islands, and most species depend on a narrow range of host plants. The endemic genus *Oliarus* (Cixiidae) is comprised of 87 described species and subspecies, most of which are endemic to a single island. Unlike the previous genera, members of this genus are not dependent on specific host plants.

DISTRIBUTION: Members of the suborder Auchenorrhyncha are found on all the MHI except Kaho‘olawe

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents any population estimate. However, the loss and degradation of native habitats, especially the loss of native host plants, likely means that species within the order are declining. Species that are dependent on plant species of dryland forests, as in the genus *Dictyophorodelphax*, are believed to be declining because of the almost total loss of native dry forests and their specific host plants (endemic *Euphorbia* spp.). The most abundant species appear to be found in the genus *Nesophrosyne* and their tolerance to invasive ants (Formicidae) likely explains their abundance.

LOCATION AND CONDITION OF KEY HABITAT: Auchenorrhyncha is a very ecologically diverse group and occurs in most terrestrial habitats including lava tubes. Key habitat requirements of individual species are poorly known.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.

- Loss of native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Predatory invasive ants.
- Natural enemies of invasive cicadellids including the two-spotted leafhopper (*Sophonia rufofascia*) and glassy-winged sharpshooter (*Homalodisca vitripennis*) may have the potential to adversely affect native cicadellid species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward Auchenorrhyncha should include:

- Conduct surveys to determine distribution and abundance of known Auchenorrhyncha and to document and identify new species.
- Outplant native host plants that support rare Auchenorrhyncha.
- Control of invasive non-native invertebrates.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations to detect declines in native species and to detect new non-native species.

RESEARCH PRIORITIES:

- Initiate studies of species' distributions to determine areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Initiate studies to determine the effects of natural enemies on species in the family Cicadelliade.
- The genus *Nesophrosyne* (Cicadellidae), comprised of many undescribed species that depend on rare native host plants, should be reviewed and revised as appropriate.
- Conduct systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny.
- Conduct studies to document the biology, habitat requirements, and life history of native species.

References:

- Bennett GM, O'Grady PM. 2013. Host-plants shape insect diversity: Phylogeny, origin, and species diversity of native Hawaiian leafhoppers (Cicadellidae: *Nesophrosyne*). *Molecular Phylogenetics and Evolution* 65:705–717.
- Giffard WM. 1925. A review of the Hawaiian *Cixiidae*, with descriptions of species. *Proceedings of the Hawaiian Entomological Society* 6: 51–171.
- Howarth FG, Mull WP. 1992. *Hawaiian insects and their Kin*. Honolulu: University of Hawai'i Press.
- Nishida GM editor. 2002. *Hawaiian terrestrial arthropod checklist*, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
- Osborn, H. 1935. Cicadellidae of Hawaii. Bernice P. Bishop Museum Bulletin 134: 1–62.
- Zimmerman EC. 1948. *Insects of Hawaii: Volume 4, Auchenorrhyncha*. Honolulu: University of Hawaii Press.



Nesophrosyne sp.

Terrestrial Invertebrates

Leafhoppers
Order Homoptera
Family Cicadellidae

FAMILY INCLUDES:
6 Native Genera
>266 Native & Endemic Species

GENERAL INFORMATION:

Genera with endemic species

Balclutha: 9 spp.

Nesophrosyne: >250 spp.

Balolina, *Kirkaldiella*, *Nesolina*, *Nesophryne*: 1–3 spp.

Leafhoppers are jumping insects that suck sap from the leaves of plants. The endemic genus *Nesophrosyne* is by far the largest group of native species. It currently contains 72 described species and subspecies, but the bulk of the diversity remains undescribed, with at least 150 undescribed species known in collections. All are endemic to individual islands, sometimes to one volcano, and are host-specific to one native plant genus. This enormous undescribed diversity presents challenges for identification and monitoring for conservation. However, many are already documented by DNA barcodes and associated photos. The other genera are much smaller, rarer, and more restricted in distribution. *Kirkaldiella* and *Nesophryne* are related to *Nesophrosyne* and have similar habits, feeding on dicots in mesic and dry forests. *Balclutha*, *Balolina*, and *Nesolina* belong to a different lineage and feed on grasses.

DISTRIBUTION: Leafhoppers are found on all the MHI except Ni‘ihau and Kaho‘olawe, from the coast to high-elevation forests.

ABUNDANCE: Some species may be seasonally abundant, especially those that feed on more common plants. They often become rare or completely disappear during the drier summer and fall months.

LOCATION AND CONDITION OF KEY HABITAT: Because these leafhoppers produce honeydew, an attractive food for ants, *Nesophrosyne* have been noted to be better able to survive in the presence of non-native ant (Formicidae) populations than most native insects which are not adapted to these non-native predators. However, these leafhoppers can only survive where their host plants do. It is unknown how well they are able to disperse naturally to find new populations of host plants, such as restoration sites. The grass-feeding groups are particularly affected by the loss of native host plants.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native predatory wasps (Crabronidae) and parasitoids (various Hymenoptera) may adversely affect some species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward leafhoppers should include:

- Conduct surveys to determine distribution and abundance of known leafhopper species and to document and identify new species.
- Outplanting of native host plants that support rare species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations to detect declines in native species and to detect new non-native species.

RESEARCH PRIORITIES:

- Initiate studies to determine species' distributions to determine areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Initiate studies to determine the effects of introduced arthropods on species in the family Cicadellidae.
- *Nesophrosyne* should be reviewed and revised as appropriate.

References:

- Bennett GM, O'Grady PM. 2013. Host-plants shape insect diversity: Phylogeny, origin, and species diversity of native Hawaiian leafhoppers (Cicadellidae: *Nesophrosyne*). *Molecular Phylogenetics and Evolution* 65:705–717.
- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
- Zimmerman EC. 1948. Insects of Hawaii: Volume 4 Homoptera: Auchenorrhyncha. Honolulu, HI: University of Hawaii Press.



Dictyophorodelphax mirabilis

Terrestrial Invertebrates

Planthoppers
Order Hemiptera
Family Delphacidae

FAMILY INCLUDES:
7 Native Genera
>144 Native & Endemic Species

GENERAL INFORMATION:

Genera with endemic species

Aloha: 9 spp.

Dictyophorodelphax: 5 spp.

Emoloana: 6 spp.

Leialoha: 12 spp.

Nesosydne: >83 spp.

Nesothoe: 23 spp.

Nesodryas, *Nesorestias*, *Nothorestias*: 2 spp. each

Planthoppers in the family Delphacidae are a large and diverse group worldwide. They are easily distinguished from other families by the large moveable spur at the apex of the hind tibia. The endemic genera have diverse habits; almost all are strongly host-plant specific. *Emoloana* belongs to a different subfamily from the other genera and feeds on native grasses.

Dictyophorodelphax is a striking endemic genus with a long horn on the head; all species feed on native 'akoko (Euphorbiaceae: *Euphorbia*). The two species of *Nesodryas* feed on monocots.

The remaining genera feed on a wide variety of wet to mesic forest trees and shrubs, with a high diversity of hosts within each. *Nesosydne* is by far the most diverse genus, with many undescribed species.

DISTRIBUTION: Delphacids are known from all the Main Hawaiian Islands except Ni'ihau and Kaho'olawe. Several species of *Emoloana* are also known from Laysan in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the family are declining with populations occurring in dry and mesic forests are believed to be declining rapidly. A large number of species of *Nesosydne* have not been collected in many years and may be very rare or extinct. *Emoloana* is especially vulnerable as it is restricted to native grasses which are increasingly rare.

LOCATION AND CONDITION OF KEY HABITAT: Delphacid planthoppers occur widely from lowland dry habitats to mesic and wet forests and subalpine areas. Lowland and drier habitats are particularly threatened.

THREATS:

- Loss or degradation of habitat, especially dry lowland habitats.
- Loss of host plants.
- Insufficient information for species assessments.
- Predation and parasitism by invasive non-native insects including ants (Formicidae), parasitoid wasps (Hymenoptera), and generalist egg predators.
- Displacement by non-native competitors (e.g., invasive members of the superfamily Fulgoroidea).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward planthoppers should include:

- Control of fire in dry and mesic forest habitats.
- Outplanting of native plants, especially those that are hosts to declining species.
- Conduct surveys to determine the distribution and abundance of planthoppers and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Initiate studies of the genera *Nesosydne* and *Nesothoe*, which appear to have many undescribed species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.
- Initiate efforts to relocate species that have not been observed in at least 50 years.

References:

- Asche, M. 2000. A review of the systematics of Hawaiian planthoppers (Hemiptera: Fulgoroidea). *Pacific Science* 51(4):366–376.
- Goodman KR. 2010. Emerging biodiversity: Diversification of the Hawaiian *Nesosydne* planthoppers. PhD dissertation, University of California, Berkeley.
- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
- Zimmerman EC. 1948. Insects of Hawaii: Volume 4 Homoptera: Auchenorrhyncha. Honolulu: University of Hawai'i Press.



Phyllococcus oahuensis galls on a *Urera glabra* leaf

Terrestrial Invertebrates

Psyllids, Mealybugs, and Scale Insects

Order Hemiptera
Suborder Sternorrhyncha

ORDER INCLUDES:

3 Native Families
23 Native Genera
>108 Native & Endemic Species

GENERAL INFORMATION: Ninety-seven percent of the described 108 endemic species of Sternorrhyncha are within the families Triozidae (Psylloidea) and Pseudococcidae (Coccoidea). Compared with the diverse and numerous invasive Sternorrhyncha recorded in Hawai'i, the endemic species are outnumbered by more than three to one. All members of the suborder are phytophagous feeders on the phloem of plant tissue. All endemic species are extremely host-specific, most having only a single host plant species. More than thirty-five species of *Pariaconus* (Triozidae) are specific to *Metrosideros polymorpha*. Endemic Hawaiian mealybugs and psyllids have evolved closely with their host plants and some exhibit remarkable gall-forming habits.

DISTRIBUTION: Members of the suborder Sternorrhyncha are found on all the MHI except Ni'ihau and Kaho'olawe.

ABUNDANCE: As a group unknown. Most species are rare and have not been recorded for decades. A lack of systematic surveys prevents any population estimate. However, the loss of these species' obligate host plants, often rare or threatened endemic plant species, means the inevitable decline of many endemic Sternorrhyncha.

LOCATION AND CONDITION OF KEY HABITAT: Sternorrhyncha are found in remnant native and mixed mesic forests where host plants still exist.

THREATS:

- Habitat loss and degradation due to urbanization, agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants and invertebrates.
- Loss of obligate endemic host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Insufficient taxonomic work on describing new species and reviewing groups with taxonomic uncertainty.
- Non-native parasitoids (Hymenoptera), and predators such as ladybeetles (Coleoptera: Coccinellidae).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby

reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward endemic Sternorrhyncha should include:

- Conduct surveys to determine distribution and abundance of known species and to document and identify new species.
- Conduct surveys to document and identify non-native predators and parasitoids.
- Outplant native host plants specific to rare taxa.
- Preserve, maintain, and restore habitats supporting existing populations.
- Control invasive non-native invertebrates.

MONITORING:

- Initiate monitoring the status of populations to detect declines in native species and new non-native species. Monitor impacts from non-native parasitoids and predators.
- Initiate monitoring of rare host plant species.

RESEARCH PRIORITIES:

- Initiate studies to determine species' current distributions of known endemic species.
- Initiate efforts to locate and identify new species.
- Initiate studies to determine the effects of non-native predators and parasitoids on species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.
- Conduct studies to document the biology, habitat requirements, and life history of native species.

References:

- Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.
- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
- Percy DM. 2017a. Making the most of your host: the *Metrosideros*-feeding psyllids (Hemiptera, Psylloidea) of the Hawaiian Islands. ZooKeys 649: 1-163.
- Zimmerman EC. 1948. Insects of Hawaii: Volume 5, Homoptera, Sternorrhyncha. Honolulu: University of Hawaii Press.



Swezeyana atra

Terrestrial Invertebrates

Psyllids

Order Hemiptera

Suborder Sternorrhyncha

Superfamily Psylloidea

Family Triozidae

FAMILY INCLUDES:

11 Native Genera

>73 Native & Endemic Species

GENERAL INFORMATION: The Hawaiian Triozidae are extremely specialized psyllids, most being single-island endemic species. All but one of the 9 genera are specialized to just one host plant species or host plant genus. Listed below are the known endemic genera, the number of described species, and their known host plants. Many species remain undescribed, and more are being collected every day.

Cerotrioza: 2 species (*Xylosma hawaiiensis*)

Crawforda: 1 species (*Polyscias hawaiiensis*)

Hemischizocranium: 2 species (*Zanthoxylum dipetalum*)

Hevaheva: 8 species (*Melicope*)

Kuwayama: 6 species (*Pisonia sandwicensis*, *Sideroxylon polynesicum*)

Megatrioza: 5 species (*Pritchardia*)

Pariaconus: 36 species (*Metrosideros*)

Paurotriozana: 1 species (*Cryptocarya oahuensis*)

Stevekenia: 2 species (*Nothocestrum longifolium*, *N. peltatum*)

Swezeyana: 9 species (*Planchonella sandwicensis*)

Trioza: 1 species (*Cryptocarya mannii*)

Several of these genera (*Hevaheva*, *Megatrioza*, *Pariaconus*, and *Swezeyana*) illustrate the amazing adaptive radiations between the endemic psyllids and their host plants in the Hawaiian Islands. The *Pariaconus* genus contains 36 described species, all specific to a single host plant, *Metrosideros polymorpha*. These species have extraordinary biological and morphological diversity, also shown in their diverse galling biology. There are likely additional species which have not yet been discovered.

DISTRIBUTION: Members of the family Triozidae are found on all the MHI except Kaho‘olawe and Ni‘ihau.

ABUNDANCE: A lack of systematic surveys prevents any population estimate. However, the loss and degradation of native habitats, especially the loss of rare endemic host plants, likely means species within the order are declining. The species-specific nature of the Triozidae highlights the dependence on host plant abundance and distribution. While *Metrosideros polymorpha* is the most widespread of the known hosts, there have been huge losses of *M.*

polymorpha trees due to the spread of *Ceratocystis lukuohia* and *C. huliohia* (causal agents of Rapid ‘Ōhi‘a Death) in forested areas where *Pariaconus* are known.

LOCATION AND CONDITION OF KEY HABITAT: Key habitats are host plant-dependent but range from wet bogs to lowland mesic forest.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of obligate endemic host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native parasitoid wasps (Hymenoptera)
- Predation by non-native lady beetles (Coleoptera: Coccinellidae)

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward Triozidae should include:

- Conduct surveys to determine distribution and abundance of known species and to document and identify new species.
- Conduct surveys to document and identify non-native predators and parasitoids.
- Outplant endemic host plants specific to rare taxa.
- Preserve, maintain, and restore habitats supporting existing populations.
- Control invasive non-native invertebrates.

MONITORING:

- Initiate monitoring the status of populations to detect declines in native species and new non-native species. Monitor impacts from non-native parasitoids and predators.
- Initiate monitoring of rare host plant species.

RESEARCH PRIORITIES:

- Initiate studies to determine species’ current distributions of known endemic species.
- Initiate efforts to locate and identify new species.
- Initiate and support taxonomic specialists to describe species new to science.
- Initiate studies to determine the effects of non-native predators and parasitoids on species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Percy DM. 2017a. Making the most of your host: the *Metrosideros*-feeding psyllids (Hemiptera, Psylloidea) of the Hawaiian Islands. ZooKeys 649: 1-163.

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- Percy DM. 2018. Revision of the Hawaiian psyllid genus *Swezeyana*, with descriptions of seven new species (Hemiptera, Psylloidea, Triozidae). *ZooKeys* 758: 75-113.
- Zimmerman EC. 1948. Insects of Hawaii: Volume V. Homoptera: Sternorhyncha. Honolulu, HI: University of Hawaii Press.



Nesodynerus scoriaceus. Photo: Karl Magnacca.

Terrestrial Invertebrates

Bees and wasps Order Hymenoptera

ORDER INCLUDES:

- 14 Native Families
- 42 Native Genera
- >800 Native Species
- >800 Endemic Species

GENERAL INFORMATION: The order Hymenoptera is large and diverse, and is best known because of the social behavior of ants, bees, and wasps. Hawai‘i’s native Hymenoptera fauna, however, is comprised of non-social bees and wasps and does not include any native ants. The most speciose genus is *Sierola* (Bethylidae) with 278 described and an estimated 400–500 total species. Several species in each of the genera *Hylaeus* (Colletidae), *Ectemnius* (Sphecidae), and *Nesodynerus* (Vespidae), including *H. difficilis*, *H. pubescens*, *E. nesiotes*, *E. polynesiensis*, *N. peles*, and *N. scoriaceus*, are common and relatively abundant. However, the status of many other species in these genera, as well as species in the genera *Enicospilus* (Ichneumonidae), *Sclerodermus* (Bethylidae), *Sierola* (Bethylidae), is unknown. As elsewhere, Hawaiian bees and wasps have important ecosystem functions including pollinating native plants and keeping other insects, particularly herbivorous species, in check. The native *Hylaeus*, or yellow-faced bees, are important pollinators for many native plants. Most of the native wasps are arthropod predators or parasites, often specific to particular taxa. For example, species in the family Mymaridae parasitize small insects and insect eggs; species in the family Encyrtidae are parasitoids of mealybugs (Hemiptera); species in the family Figitidae lay their eggs on fly (Diptera) pupae, and species in the families Vespidae and Bethylidae prey on Lepidoptera caterpillars. A large radiation in the family Pteromalidae is largely unstudied, but is believed to parasitize native beetle grubs.

As an example of the diversity of Hawai‘i’s hymenopterans, two genera are briefly outlined. The 64 species in the bee genus *Hylaeus* occur on all the Main Hawaiian Islands (MHI) and Nihoa. They nest in hollow stems, holes in trees, under bark, in crevices, or in burrows in soil. Potential threats include non-native bees (*Ceratina* spp.) found in the native coastal habitats used by *Hylaeus* species and competition with the European honeybee (*Apis mellifera*) for nectar and pollen. Confirmed threats include introduced ants (Formicidae) which compete with *Hylaeus* for nesting sites, and the big-headed ant (*Pheidole megacephala*) and Argentine ant (*Linepithema humile*) which prey on the native bees. Since *Hylaeus* bees pollinate native plants, their loss would be detrimental to the recovery of native plants.

Wasps in the genus *Sierola* are found throughout the Indo-Pacific region, but over 2/3 of the known species are endemic to Hawai‘i. They are small, black wasps found primarily in wet and mesic forests. At present 156 species are known from O‘ahu and 108 from the island of Hawai‘i, with the other islands almost totally unexplored. Hundreds of species remain to be described, and it is not uncommon to find more than ten morphospecies (i.e., species established solely on morphological characteristics) at a single site. These species are difficult to collect, and many

morphospecies are found in very low numbers; this may be an artifact of collection methods or due to their rarity. Similar to other wasps, females find a Lepidoptera larva, sting and paralyze it, and lay an egg on it. Once the egg hatches the larva feeds on the caterpillar.

DISTRIBUTION: Native Hymenoptera are found on all the MHI and Laysan and Nihoa in the Northwestern Hawaiian Islands.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Hymenopterans occur in most terrestrial habitats.

THREATS:

- Competition with non-native wasps and ants.
- Predation by non-native insects.
- Loss or degradation of habitat, especially the loss of native host plants for bees.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward hymenopterans should include the following:

- Conduct surveys to determine the distribution and abundance of known hymenopterans and to document and identify new species.
- Preserve, maintain, and restore habitat for existing populations.

MONITORING: Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct systematic and taxonomic assessments of poorly known taxa.
- Work to identify and describe new species to science.
- Conduct studies to document the biology, habitat requirements, and life history of endemic species.
- Refine methods for conducting quantitative surveys.

References:

Daly HV, and Magnacca KN. 2003. Insects of Hawai'i Vol 17: Hawaiian *Hylaeus* (Nesoprosopis) bees. University of Hawai'i Press, Honolulu.

Magnacca KN. 2020. Review of *Sierola* Cameron (Hymenoptera: Bethyridae) of the Hawaiian Islands. Part 1: O'ahu. Bishop Museum Bulletin in Entomology 14:1:311.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Takumi RL. 1999. A Systematic Review of the *Ectemnius* (Hymenoptera: Sphecidae) of Hawai'i, University of California Press, Berkeley.

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Flat wasps
 Order Hymenoptera
 Family Bethyridae
 Genus *Sierola*

GENUS INCLUDES:
 >400 Native and Endemic Species

GENERAL INFORMATION: *Sierola* is a group of small parasitoid wasps widely distributed in the Austro-Pacific region. They are very diverse in Australia and representatives are found on nearly all Pacific islands, but about half or more of the world's known species are endemic to Hawai'i. Over 400 species have been documented from the islands, with Maui Nui poorly collected. They attack caterpillars of microlepidoptera, particularly the families Cosmopterigidae, Gelechiidae, Gracilariidae, and Tortricidae. The hosts of most *Sierola* species are unknown, however, the species are differentiated mainly by characters used to access concealed hosts (such as head shape and mandible form), so it is presumed that most are relatively specialized on particular host taxa. Although they do not make nests, females sometimes guard paralyzed hosts on which their larvae are developing. A few species are common, but the large majority are very rare, often known from only one or a few specimens. Many are found primarily or exclusively in the forest canopy and are rarely collected even if they may not be rare in the environment. At least one O'ahu species apparently adapted to alien sugarcane-feeding moths; it was only ever collected in cane fields. Its native host is unknown, probably a native grass-feeding moth, and it has not been collected since the end of large-scale sugar cultivation.

DISTRIBUTION: *Sierola* are found on all the MHI except Ni'ihau and Kaho'olawe.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the genus are declining.

LOCATION AND CONDITION OF KEY HABITAT: *Sierola* occur in most terrestrial habitats. Most are found in lowland and montane forests, but a few are coastal.

THREATS:

- Competition with non-native wasps and ants.
- Predation by non-native insects (direct predation and predation of their hosts).
- Loss or degradation of habitat, especially the loss of native host plants for host caterpillars.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward hymenopterans should include the following:

- Conduct surveys to determine the distribution and abundance of known species and to document and identify new species.
- Preserve, maintain, and restore habitat for existing populations.

MONITORING: Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct systematic and taxonomic assessments for Kaua‘i, Maui, Moloka‘i, and Lāna‘i.
- Conduct studies to document the biology, habitat requirements, and life history.
- Refine methods for conducting quantitative surveys.

References:

Fullaway DT. New species of *Sierola* with explanatory notes. Bishop Museum Occasional Papers 7(7):57-159.

Magnacca KN. 2020. Review of *Sierola* Cameron (Hymenoptera: Bethyridae) of the Hawaiian Islands. Part 1: O‘ahu. Bishop Museum Bulletin in Entomology 14:1–311.

Magnacca KN. 2024. Review of *Sierola* Cameron (Hymenoptera: Bethyridae) of the Hawaiian Islands. Part 2: Hawai‘i. Bishop Museum Bulletin in Entomology 16:1–203.



Terrestrial Invertebrates

Yellow-faced bees
Order Hymenoptera
Family Colletidae
Genus *Hylaeus*

GENUS INCLUDES:
64 Native & Endemic Species

GENERAL INFORMATION: The yellow-faced bees (*Hylaeus*) are the only bees native to Hawai‘i. The 64 species evolved from a single ancestor in the subgenus *Nesoprosopis*, which is found throughout east and southeast Asia. They nest in hollow stems, holes in trees, under bark, crevices, cavities in rocks, or burrows in soil, and are important pollinators for many native plants. Aside from the coastal tree heliotrope, they rarely visit alien plants. Non-native bees including small carpenter bees (*Ceratina* spp.), sweat bees (*Lasioglossum* spp.), and the alien yellow-faced bee *Hylaeus strenuus* are competitors for both floral resources and nest sites. The European honeybee (*Apis mellifera*) and some ants such as the Argentine ant (*Linepithema humile*) also compete for nectar and pollen. Other introduced ants such as the big-headed ant (*Pheidole megacephala*) and yellow crazy ant (*Anoplolepis gracilipes*) are major predators and often exclude native bees entirely. Since *Hylaeus* bees pollinate native plants, their loss would be detrimental to the recovery of native plants. Five species have evolved to be cleptoparasites (cuckoo bees), laying their eggs in the nests of other species. While this habit is found in many groups of bees, these are the only cleptoparasitic species in the family Colletidae worldwide. Despite the apparent decline of many species, new undescribed species continue to be found.

DISTRIBUTION: Yellow-faced bees are found on all the MHI and Nihoa in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining. Numbers of many species appear to have declined significantly since the last large-scale surveys in 2002 and 2011. A few species, such as *H. difficilis* in dry shrubland and *H. unicus* in wet forest, are relatively common, but the majority are rare and some are only known from one or two specimens.

LOCATION AND CONDITION OF KEY HABITAT: Yellow-faced bees occur in most terrestrial habitats including coastal strands, dry shrublands, wet forests, and alpine stone deserts. Coastal and lowland habitats are highly limited due to the presence of ants. Some montane dry forests that have been invaded by ants and myoporum thrips have greatly reduced bee abundance and diversity, and some species that were restricted to that habitat may now be extinct.

THREATS:

- Competition with non-native bees (particularly honeybees), other non-native wasps such as yellowjackets, alien *Hylaeus*, and non-native ants.
- Predation by non-native insects, mainly ants.
- Loss or degradation of habitat, especially the loss of native host plants.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward yellow-faced bees should include the following:

- Conduct surveys to determine the distribution and abundance of known species and to document and identify new species.
- Preserve, maintain, and restore habitat for existing populations.

MONITORING: Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct systematic and taxonomic assessments of poorly known taxa.
- Conduct studies to document the biology, habitat requirements, and life history of endemic species.
- Refine methods for conducting quantitative surveys.

References:

Daly HV, and Magnacca KN. 2003. Insects of Hawai'i Vol 17: Hawaiian *Hylaeus* (Nesoprosopis) bees. University of Hawai'i Press, Honolulu.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.



Terrestrial Invertebrates

Yellow-faced bee
Hylaeus anthracinus

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Hylaeus anthracinus* (F. Smith, 1853) is a medium-sized bee found on all the main islands except Kaua‘i and Ni‘ihau, where the closely related *H. flavifrons* occurs. It lives primarily in coastal areas, sometimes extending up into lowland dry forest on Maui, with one record from montane dry forest on Hawai‘i. The island populations form three highly genetically distinct clusters which may be cryptic species: Hawai‘i, Maui + Kaho‘olawe, and Moloka‘i + O‘ahu (there are no recent records from Lāna‘i). Therefore, it is important to conserve all island populations. This and other coastal species are the only native bees that regularly visit flowers of an introduced plant, the tree heliotrope (*Heliotropium foertherianum*, formerly known as *Tournefortia argentea*). With the loss of most of the native coastal vegetation, tree heliotrope is now a critical floral resource. Other important plants visited for pollen and nectar include naupaka (*Scaevola taccada*), ‘ilima (*Sida fallax*), ‘ōhai (*Sesbania tomentosa*), naio (*Myoporum sandwicense*), and ‘akoko (*Euphorbia* spp.).

DISTRIBUTION: *Hylaeus anthracinus* is found from Hawai‘i to O‘ahu and was formerly one of the most widely distributed native bees. While it is still known to occur on all islands in that range except Lāna‘i, the loss of native coastal vegetation has caused the occupied area to contract dramatically. It can still be found along several long stretches of coastline on the northwest coast of Hawai‘i in South Kohala and North Kona, sometimes in extremely high densities. Elsewhere on the island, it is known only from a single, very small population near South Point, and from a reintroduced population at Pu‘uhonua O Hōnaunau National Historical Park in South Kona (there is one high-elevation record at Pōhakuloa from 2004, but it has not been found there since and it is unknown if there is a breeding population there). On Maui and Moloka‘i, it has been found at only two sites, though much of the coast is unexplored. Three sites are known for O‘ahu, where population numbers have seriously declined since 2011 with the spread of an alien yellow-faced bee from India, *Hylaeus strenuus*.

ABUNDANCE: Unknown. *Hylaeus anthracinus* may occur in extremely high densities in the south Kohala and north Kona areas, but elsewhere it is generally found in low numbers. At nearly all sites, it is restricted to narrow stretches of coastal strand less than 30 meters (98 feet) wide, and sometimes only a single row of trees or shrubs. The former largest population on O‘ahu, at Ka‘ena Point, has virtually disappeared since 2011 for unknown reasons and is currently small and highly fragmented.

LOCATION AND CONDITION OF KEY HABITAT: Native coastal vegetation has declined dramatically, and only a tiny fraction of its original extent currently exists. Much of what remains is invaded by alien ants, which dominate lowland areas. As a result, most coastal bees

are only found in marginal habitat that is too dry for ants to live in. Native *Hylaeus* do not visit introduced plants except for tree heliotrope, and observations suggest they cannot survive on naupaka (the most common coastal shrub) alone. Current populations of *Hylaeus anthracinus* are widely scattered so they are unlikely to disperse these large distances on their own to sites where vegetation restoration is carried out. The recently introduced alien bee *Hylaeus strenuus* appears to be a major competitor in coastal and lowland dry habitats, and has displaced native *Hylaeus* from several sites on O‘ahu. It has already been detected on Kaua‘i and will likely spread to the other islands as well.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants (primarily *Anoplolepis gracilipes*, *Linepithema humile*, and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.
- Stochastic events. Events such as droughts, tsunamis, and high tides are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus anthracinus* specifically, management needs include the following:

- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.
- Establish reintroduced populations where appropriate.
- Restoration of coastal habitat.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historical and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Determine if species status is warranted for the three genetic populations.
- Conduct studies on captive rearing for reintroduction to establish new populations.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

Daly, HV, and Magnacca, KN. 2003. Insects of Hawaii, Volume 17: Hawaiian *Hylaeus* (*Nesoprosopis*) Bees (Hymenoptera: Apoidea). Honolulu: University of Hawai‘i Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawai‘i, *Hylaeus* (*Nesoprosopis*) (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

- Magnacca, KN, and King, CBA. 2013. Assessing the presence and distribution of 23 Hawaiian yellow-faced bee species on lands adjacent to military installations on O‘ahu and Hawai‘i Island. Technical Report No. 185. Pacific Cooperative Studies Unit, University of Hawai‘i, Honolulu, Hawai‘i. 39 pp.
- U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76: 55170–55203.



Terrestrial Invertebrates

Yellow-faced bee
Hylaeus assimulans

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Hylaeus assimulans* (Perkins, 1899) lives primarily in coastal areas, often extending up into lowland dry forests. Each island population is genetically distinct, but they do not form divergent clusters of potential cryptic species. It is much larger than related species, and its size may be an adaptation to eating the large pollen of ‘ilima (*Sida fallax*), with which it is closely associated and visits more often than other species. Other important plants visited for pollen and nectar include naupaka (*Scaevola taccada*), pā‘ū o Hi‘iaka (*Jacquemontia ovalifolia*), and nehe (*Lipochaeta* spp.).

DISTRIBUTION: *Hylaeus assimulans* was historically found from Maui to O‘ahu. The loss of native coastal vegetation has caused its range to contract dramatically. It has not been collected from O‘ahu since at least the 1930s, and surprisingly there are no recent records for Moloka‘i where there is extensive coastal habitat. It is currently known from only one to three sites on each island. On Maui, it is found at scattered localities on West Maui and in the Makena area. On Lāna‘i, it has been found on both the east and northwest slopes in mostly alien vegetation, and there is a single record from Kaho‘olawe.

ABUNDANCE: Unknown. *Hylaeus assimulans* is generally found in very low numbers where it occurs. It is subject to extreme population fluctuations due to the dry conditions of its habitat and episodic blooming of its preferred flowers, particularly on Lāna‘i. The Maui population is the most widely distributed, and the difficulty of accessing sites on West Maui may be preventing a better assessment of its range.

LOCATION AND CONDITION OF KEY HABITAT: Native coastal vegetation and dry forest have declined dramatically, and only a tiny fraction of its original extent currently exists. Much of what remains is invaded by alien ants, which dominate lowland areas. Current populations of *Hylaeus assimulans* are widely scattered so they are unlikely to disperse these long distances on their own to sites where vegetation restoration is carried out. ‘Ilima is one of relatively few native plants that can regrow vigorously after fire, but repeated fires will convert a shrubby ‘ilima understory into grass.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants

(primarily *Anoplolepis gracilipes*, *Linepithema humile*, and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.

- Stochastic events. Events such as droughts, tsunamis, and high tides are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus assimulans* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.
- Establish reintroduced populations where appropriate.
- Restoration of coastal and dry forest habitat.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations in both historic and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

Daly, HV, and Magnacca, KN. 2003. Insects of Hawaii, Volume 17: Hawaiian *Hylaeus* (*Nesoprosopis*) Bees (Hymenoptera: Apoidea). Honolulu: University of Hawai'i Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawai'i, *Hylaeus* (*Nesoprosopis*) (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76: 55170–55203.

Terrestrial Invertebrates

Yellow-faced bee

Hylaeus facilis

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

GENERAL INFORMATION: *Hylaeus facilis* (F. Smith, 1879) is a medium-sized bee found on O‘ahu and Maui Nui. It has a broad habitat range, from the coast through lowland and montane dry to mesic shrubland and open forest. Once the most abundant and widely collected of Hawaiian bee species, it is now exceedingly rare. The reasons for its decline all across its range are unclear, as other related species continue to thrive in the same habitats on at least some islands. Its floral hosts probably include the same ones used by related species in the same habitat, including naupaka (*Scaevola taccada*), ‘ilima (*Sida fallax*), and the introduced tree heliotrope (*Heliotropium foertherianum*, formerly known as *Tournefortia argentea*) at the coast, and ‘a‘ali‘i (*Dodonaea viscosa*), pūkiawe (*Leptecophylla tameiameia*), and ‘ōhi‘a lehua (*Metrosideros polymorpha*) in upland areas.

DISTRIBUTION: *Hylaeus facilis* was historically found from Maui to O‘ahu, though there are no records from Kaho‘olawe. It prefers the drier leeward areas, from the coast to about 1,524 meters (5,000 feet) elevation.

ABUNDANCE: Unknown. While it was common on all islands through the 1930s, sometime between then and when intensive collecting resumed in 1998 it experienced a severe collapse in numbers. There are only four records from the past 50 years, each of single individuals: two from O‘ahu in 1969 and 1975, one from Maui in 1993, and one from Moloka‘i in 2005.

LOCATION AND CONDITION OF KEY HABITAT: Native coastal vegetation has declined dramatically, and only a tiny fraction of its original extent currently exists. Dry shrubland is also highly degraded and rare on O‘ahu and Maui Nui, except for subalpine areas of East Maui above 2000 m where *H. facilis* was never found. Much of what remains is invaded by alien ants, which dominate lowland areas. As a result, native bees are often found in marginal habitat. Some suitable areas appear to exist, but *H. facilis* has not been found in them. In some of these areas, other native *Hylaeus* that were historically collected in company with *H. facilis* are still present. Thus, *H. facilis* may have specialized habitat requirements that are currently unknown. The closely related *H. simplex* of Hawai‘i was also formerly abundant but has completely disappeared and is probably extinct.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants

(primarily *Anoplolepis gracilipes*, *Linepithema humile*, and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.

- Stochastic events. Events such as droughts, tsunamis, and high tides are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus facilis* specifically, management needs include the following:

- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historical and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

Daly HV, and Magnacca KN. 2003. Insects of Hawaii, Volume 17: Hawaiian *Hylaeus* (*Nesoprosopis*) Bees (Hymenoptera: Apoidea). University of Hawai‘i Press, Honolulu.

Magnacca KN. 2007. Conservation status of the endemic bees of Hawai‘i, *Hylaeus* (*Nesoprosopis*) (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

Magnacca KN, and King CBA. 2013. Assessing the Presence and Distribution of 23 Hawaiian Yellow-faced Bee Species on Lands Adjacent to Military Installations on O‘ahu and Hawai‘i Island. Technical Report No. 185. Pacific Cooperative Studies Unit, University of Hawai‘i, Honolulu.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76: 55170–55203.



Hylaeus hilaris. Photo: Karl Magnacca.

Terrestrial Invertebrates

Yellow-faced bee

Hylaeus hilaris

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

GENERAL INFORMATION: *Hylaeus hilaris* (F. Smith, 1879) is a medium-sized bee found on Maui Nui. It is one of the most beautiful native bees, as well as one of the rarest known to be recently extant, and lives exclusively in coastal areas. Unlike most other native bees, it is a cleptoparasite or cuckoo bee; rather than constructing a nest, the female enters the nest of another species and lays an egg inside the cell. The cleptoparasite larva then hatches and consumes the provisions, either killing the host larva directly or leaving it to starve. Adults visit flowers occasionally to feed themselves, but females do not collect pollen for a nest. While this strategy is common in general (about a quarter of all bees are cleptoparasites), *H. hilaris* and its four relatives among the Hawaiian *Hylaeus* are the only members of the family Colletidae to have evolved this trait.

DISTRIBUTION: *Hylaeus hilaris* was historically found on Maui, Molokaʻi, and Lānaʻi. The loss of native coastal vegetation has caused the occupied area to contract dramatically, as its host species have declined. Since the 1930s, it is known from only two collections (1990 and 1999) from Moʻomomi Preserve on Molokaʻi, each of a single individual.

ABUNDANCE: Unknown, but the population is undoubtedly very low. *Hylaeus hilaris* is exceedingly rare and its long-term survival is unlikely unless there are more populations or the abundance of hosts is significantly increased. The hosts of *H. hilaris* are *H. anthracinus* and *H. longiceps*, which are themselves listed endangered species.

LOCATION AND CONDITION OF KEY HABITAT: Native coastal vegetation has declined dramatically, and only a tiny fraction of its original extent currently exists. Much of what remains is invaded by alien ants, which dominate lowland areas. As a result, most coastal bees are only found in marginal habitat that is too dry for ants to live in. The single current population of *H. hilaris* is widely separated from other suitable areas so they are unlikely to disperse these long distances on their own to new sites. The recently introduced alien bee *H. strenuus* appears to be a major competitor in coastal and lowland dry habitats and has displaced native *Hylaeus* from several sites on Oʻahu. However, it could potentially serve as a host for the native cleptoparasitic species.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.

- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants (primarily *Anoplolepis gracilipes*, *Linepithema humile*, and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly or indirectly (via the host bees) compete with or prey on this species.
- Stochastic events. Events such as droughts, tsunamis, and high tides are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus hiliaris* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.
- Establish reintroduced populations where appropriate.
- Restoration of coastal habitat.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historic and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

- Daly, HV, and Magnacca, KN. 2003. Insects of Hawaii, Volume 17: Hawaiian *Hylaeus* (*Nesoprosopis*) Bees (Hymenoptera: Apoidea). Honolulu: University of Hawai‘i Press.
- Magnacca, KN. 2007. Conservation status of the endemic bees of Hawai‘i, *Hylaeus* (*Nesoprosopis*) (Hymenoptera: Colletidae). *Pacific Science* 61(2): 173-190.
- U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. *Federal Register* 76: 55170–55203.

Terrestrial Invertebrates

No photo available

Yellow-faced bee

Hylaeus kuakea

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

GENERAL INFORMATION: *Hylaeus kuakea* is a medium-sized bee endemic to O‘ahu. Unlike most of the native *Hylaeus*, the face mark of the male is ivory-colored rather than yellow. It lives in lowland dry to mesic forest, in association with various understory shrubs. It was only discovered in 1997, and little is known of its habits.

DISTRIBUTION: *Hylaeus kuakea* is restricted to the Wai‘anae range of O‘ahu. There are only three records of the species, each of a single individual: one from Schofield Barracks South Range in 1997, one from Mākaha Valley in 2009, and one from Wai‘anae Valley in 2014.

ABUNDANCE: Unknown. *Hylaeus kuakea* is apparently extremely rare, as more than one has never been found at any given site. Like many *Hylaeus*, it may prefer spending time in the canopy, which could make it more difficult to observe.

LOCATION AND CONDITION OF KEY HABITAT: Mid-elevation dry and mesic forests have declined dramatically, and only a tiny fraction of their original extent currently exists. Much of what remains is invaded by alien ants, which dominate lowland areas. While upper elevation wet habitat remains relatively intact, alien plants invading from below in the aftermath of ungulate disturbance have seriously impacted the habitat favored by *H. kuakea*.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants (primarily *Anoplolepis gracilipes* and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.
- Stochastic events. Events such as droughts are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus kuakea* specifically, management needs include the following:

- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.
- Establish reintroduced populations where appropriate.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations in both historical and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

Daly, HV, and Magnacca, KN. 2003. Insects of Hawaii, Volume 17: Hawaiian *Hylaeus* (*Nesoprosopis*) Bees (Hymenoptera: Apoidea). Honolulu: University of Hawai‘i Press.

Magnacca, KN. 2007. Conservation status of the endemic bees of Hawai‘i, *Hylaeus* (*Nesoprosopis*) (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.

Magnacca, KN, and King, CBA. 2013. Assessing the presence and distribution of 23 Hawaiian yellow-faced bee species on lands adjacent to military installations on O‘ahu and Hawai‘i Island. Technical Report No. 185. Pacific Cooperative Studies Unit, University of Hawai‘i, Honolulu, Hawai‘i. 39 pp.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76: 55170–55203.



Terrestrial Invertebrates

Yellow-faced bee

Hylaeus longiceps

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

Hylaeus longiceps. Photo: Karl Magnacca.

GENERAL INFORMATION: *Hylaeus longiceps* (Perkins, 1899) is a medium-sized bee found on O‘ahu and Maui Nui. It lives primarily in coastal areas, sometimes extending up into lowland dry forest on Lāna‘i. The island populations form two genetic clusters, with O‘ahu individuals distinct from those on Maui, Moloka‘i, and Lāna‘i. Therefore, it is important to conserve all island populations. This and other coastal species are the only native bees that regularly visit flowers of an introduced plant, the tree heliotrope (*Heliotropium foertherianum*, formerly known as *Tournefortia argentea*). With the loss of most of the native coastal vegetation, tree heliotrope is now a critical floral resource. Other important plants visited for pollen and nectar include naupaka (*Scaevola taccada*), ‘ilima (*Sida fallax*), ‘ōhai (*Sesbania tomentosa*), naio (*Myoporum sandwicense*), and ‘akoko (*Euphorbia* spp.).

DISTRIBUTION: *Hylaeus longiceps* is found from Maui to O‘ahu. While it still occurs on all islands in that range except Kaho‘olawe, the loss of native coastal vegetation has caused the occupied area to contract dramatically. It is currently known from only two or three sites on each island. On Maui, it is found at relictual dune sites east and west of Kahului on the north shore. On Moloka‘i, it is known only from the Nature Conservancy’s Mo‘omomi Preserve and Moloka‘i Land Trust’s Anapuka Preserve, but much of the coast is unexplored. Two sites were known O‘ahu. *Hylaeus* have all but disappeared from Ka‘ena Point after 2011 but a small population is currently being monitored in the Kahuku area.

ABUNDANCE: Unknown. *Hylaeus longiceps* is generally found in very low numbers where it occurs. At most sites, it is restricted to narrow stretches of coastal strand less than 30 m wide, and sometimes only a single row of trees or shrubs. One site on Maui is a small dune with a patch of native vegetation at the top, surrounded by a golf course, and is probably unsustainable in the long term. The former largest population on O‘ahu, at Ka‘ena Point, has virtually disappeared since 2011 for unknown reasons. The Lāna‘i population is the most widely distributed, but the island is often subject to drought conditions and no surveys have been conducted for *Hylaeus* there since 1999.

LOCATION AND CONDITION OF KEY HABITAT: Native coastal vegetation has declined dramatically, and only a tiny fraction of its original extent currently exists. Much of what remains is invaded by alien ants, which dominate lowland areas. As a result, most coastal bees are only found in marginal habitat that is too dry for ants to live in. Native *Hylaeus* do not visit introduced plants except for tree heliotrope, and observations suggest they cannot survive on naupaka (the most common coastal shrub) alone. Current populations of *Hylaeus longiceps* are

widely scattered making it difficult for them to disperse these long distances on their own to sites with suitable coastal vegetation and areas where restoration has occurred. In 2023, private landowners near the single O‘ahu population site cleared a vast stretch of key habitat with native coastal vegetation this species is dependent on. The recently introduced alien bee *Hylaeus strenuus* appears to be a major competitor in coastal and lowland dry habitats, and has displaced native *Hylaeus* from several sites on O‘ahu. It has already been detected on Kaua‘i and will likely spread to the other islands as well.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants (primarily *Anoplolepis gracilipes*, *Linepithema humile*, and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.
- Stochastic events. Events such as droughts, tsunamis, and high tides are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus longiceps* specifically, management needs include the following:

- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.
- Establish reintroduced populations where appropriate.
- Restoration of coastal habitat.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historic and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Conduct studies on captive rearing for reintroduction to establish new populations.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

- Daly, HV, and Magnacca, KN. 2003. Insects of Hawaii, Volume 17: Hawaiian Hylaeus (Nesoprosopis) Bees (Hymenoptera: Apoidea). Honolulu: University of Hawai‘i Press.
- Magnacca, KN. 2007. Conservation status of the endemic bees of Hawai‘i, Hylaeus (Nesoprosopis) (Hymenoptera: Colletidae). Pacific Science 61(2): 173-190.
- Magnacca, KN, and King, CBA. 2013. Assessing the presence and distribution of 23 Hawaiian yellow-faced bee species on lands adjacent to military installations on O‘ahu and Hawai‘i Island. Technical Report No. 185. Pacific Cooperative Studies Unit, University of Hawai‘i, Honolulu, Hawai‘i. 39 pp.

U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. Federal Register 76: 55170–55203.



Hylaeus mana. Photo: Karl Magnacca.

Terrestrial Invertebrates

Yellow-faced bee

Hylaeus mana

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

GENERAL INFORMATION: *Hylaeus mana* is one of the smallest native bees. It is endemic to O‘ahu, where it lives in lowland mesic forest and is mainly found in association with sandalwood or ‘iliahi (*Santalum freycinetianum*). This makes it one of the few native *Hylaeus* to show signs of ecological specialization. It was only discovered in 2002, and little else is known of its habits. It has an unusual amount of coloration in the female, which makes both sexes immediately identifiable in the field.

DISTRIBUTION: *Hylaeus mana* is restricted to the Ko‘olau range of O‘ahu. While it occurs relatively widely on leeward ridges from Mau‘umae (Olympus) in the southeast to Mānana in the north, it is restricted to the narrow zone around 450–520 m (1500–1700 feet) elevation where ‘iliahi is found. Below this elevation, the vegetation is either predominantly alien or shrubland, and above it becomes wetter.

ABUNDANCE: Unknown. *Hylaeus mana* is generally found in low numbers where it occurs. The highest number of individuals that have been observed or collected at a site at once is three.

LOCATION AND CONDITION OF KEY HABITAT: Mid-elevation dry and mesic forests have declined dramatically, and only a tiny fraction of their original extent currently exists. Much of what remains is invaded by alien ants, which dominate lowland areas. While upper elevation wet habitat remains relatively intact, alien plants invading from below in the aftermath of ungulate disturbance have seriously impacted the habitat favored by *H. mana*. In addition, ‘iliahi was heavily logged in the early 19th century for the sandalwood trade, greatly reducing its abundance. As a result, *H. mana* is restricted to small ridgetop patches, often isolated by broad and deep gulches dominated by alien plants. This habitat is also seasonally dry and highly susceptible to fire; several large remnant stands of ‘iliahi have been destroyed by fires in recent years.

THREATS:

- Habitat loss and degradation. Habitat is threatened by invasive plants, non-native ungulates, development, and fire.
- Competition and predation. Non-native Hymenoptera, including bees (particularly *Apis mellifera*, *Ceratina smaragdula*, *Lasioglossum* spp., and *Hylaeus strenuus*), ants (primarily *Anoplolepis gracilipes* and *Pheidole megacephala*), and wasps (*Vespula pensylvanica*), can directly compete with or prey on this species.

- Stochastic events. Events such as droughts are threats to the species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations and maintain sustainable populations of host plants, thereby reducing the risk of extinction. For *Hylaeus mana* specifically, management needs include:

- Conduct surveys to determine distribution and abundance.
- Protect remaining habitat from development and ant invasion.
- Establish reintroduced populations where appropriate.
- Restoration of key habitats and associated plants.

MONITORING: Continue surveys of known populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for new populations, in both historical and novel sites.
- Develop and refine methods for conducting quantitative surveys.
- Evaluate life history and essential habitats to better direct conservation measures, such as determining habitat requirements for nest sites.

References:

- Daly, HV, and Magnacca, KN. 2003. Insects of Hawaii, Volume 17: Hawaiian *Hylaeus* (*Nesoprosopis*) Bees (Hymenoptera: Apoidea). Honolulu: University of Hawai‘i Press.
- Magnacca, KN. 2007. Conservation status of the endemic bees of Hawai‘i, *Hylaeus* (*Nesoprosopis*) (Hymenoptera: Colletidae). *Pacific Science* 61(2): 173-190.
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- U.S. Fish and Wildlife Service. 2011. Endangered and threatened wildlife and plants; 12-month finding on five petitions to list seven species of Hawaiian yellow-faced bees as endangered. *Federal Register* 76: 55170–55203.



Photo: Bow Tyler

Terrestrial Invertebrates

Square-headed wasps

Order Hymenoptera

Family Crabronidae

Genus *Ectemnius*

GENUS INCLUDES:

21 Native & Endemic Species

GENERAL INFORMATION: Square-headed wasps (*Ectemnius*) are generalist predators of flies (Diptera). They particularly attack large calyptates such as blow flies and flesh flies, and often appear at a carcass before the flies themselves do. However, they will take any suitably sized fly, and Hawaiian species are known to use fruit flies (Tephritidae), big-headed flies (Pipunculidae), and others, including non-native species. The genus is cosmopolitan; the 21 endemic species occur on all the Main Hawaiian Islands (MHI) except Ni‘ihau and Kaho‘olawe, where lowland or coastal species may have occurred in the past. Unlike most native insects, many of the species are found on more than one island; only 12 are single-island endemics. They are well-studied taxonomically and it is unlikely more new species will be discovered. They nest in hollow stems, holes in trees, under bark, in crevices, or in burrows in soil.

DISTRIBUTION: Native *Ectemnius* are found on all the MHI except Ni‘ihau and Kaho‘olawe.

ABUNDANCE: Unknown. Anecdotal data from general observations suggests most species have declined over the past 30 years, but evidence is lacking. It is difficult to conduct systematic surveys for them due to their sporadic occurrence, and none have been attempted which prevents any population estimate.

LOCATION AND CONDITION OF KEY HABITAT: *Ectemnius* occur in most terrestrial habitats, from coastal strand to montane dry shrubland and wet forest.

THREATS:

- Competition with non-native wasps and ants.
- Predation by non-native insects, particularly ants (Formicidae) which directly predate nests.
- Loss or degradation of habitat, especially the loss of native land snails which are hosts for endemic blow flies.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward hymenopterans should include the following:

- Conduct surveys to determine the distribution and abundance of known hymenopterans and to document and identify new species.

- Preserve, maintain, and restore habitat for existing populations.

MONITORING: Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of endemic species.
- Determine threats and causes of decline.
- Refine methods for conducting quantitative surveys.

References:

Takumi RL. 1999. A Systematic Review of the *Ectemnius* (Hymenoptera: Sphecidae) of Hawai'i, University of California Press, Berkeley.



Terrestrial Invertebrates

Potter wasps

Order Hymenoptera

Family Vespidae

Subfamily Eumeninae

SUFAMILY INCLUDES:

113 Native & Endemic Species

GENERAL INFORMATION:

Euodynerus: 4 spp.

Nesodynerus: 109 spp.

Nesodynerus is an endemic genus of potter wasps restricted to the Hawaiian Islands. With 109 species, it is the second largest radiation of native Hymenoptera. They are predators, provisioning their nests with caterpillars. The nesting habits are varied; some dig holes, others make free-standing mud nests (from which the common name of the larger group is derived), but the majority use pre-existing cavities, such as beetle tunnels, human-made holes, and old nests of other wasps. A few species are relatively common and can sometimes be abundant, but the majority are very rare and many have not been collected in over 100 years. The genus as a whole is poorly studied, and some species may be restricted to particular niches rather than rare per se. Little is known about the drivers of diversity or how the various species may be adapted to particular prey species or habitats.

The four species of *Euodynerus* are derived from a separate colonization event. Unlike *Nesodynerus*, they did not diversify much; two species are endemic to Kauaʻi, one to Oʻahu, and the fourth, *E. nigripennis*, is widespread across all the larger islands. A generalist species found from the coast up to 1200 m elevation, it was widespread and abundant, even in cane fields and urban areas, up until the 1960s. Since then it and its relatives have disappeared even from higher elevation, intact forests where *Nesodynerus* are found.

DISTRIBUTION: *Nesodynerus* and *Euodynerus* are found on all the MHI except Kahoʻolawe.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats and abundance of alien competitors likely means that species in the group are declining. All of the *Euodynerus* species have apparently not been seen for decades.

LOCATION AND CONDITION OF KEY HABITAT: *Nesodynerus* and *Euodynerus* occur in most terrestrial habitats, from the coast to montane wet forest. They are now mostly restricted to higher-elevation forests.

THREATS:

- Competition with non-native wasps and ants, particularly the keyhole wasp *Pachodynerus nasidens*.
- Predation by non-native insects, both direct on nests and indirect, reducing the population of hosts.
- Loss or degradation of habitat, especially the loss of native plants for host caterpillars.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Nesodynerus* and *Euodynerus* should include the following:

- Conduct surveys to determine distribution and abundance and to document and identify new species.
- Preserve, maintain, and restore habitat for existing populations.

MONITORING: Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct systematic and taxonomic assessments of poorly known taxa.
- Conduct studies to document the biology, habitat requirements, and life history of endemic species.
- Refine methods for conducting quantitative surveys.

References:

Carpenter JM. 2008. Review of Hawaiian Vespidae (Hymenoptera). Bishop Museum Occasional Papers 99:1–18.

Perkins RCL. 1899. Hymenoptera Aculeata: Eumenidae. Fauna Hawaiiensis 1(1):30–75.



Eupithecia sp. Photo: W. Haines.

Terrestrial Invertebrates

Moths and Butterflies Order Lepidoptera

ORDER INCLUDES:
 23 Native Families
 66 Native Genera
 >1013 Native Species
 >1010 Endemic Species

GENERAL INFORMATION: The beauty and popularity of many species of butterflies and moths makes Lepidoptera perhaps the best known insect order. Hawai‘i supports over 1013 described native species of moths, but only two native butterfly species: Blackburn’s blue (*Udara blackburni*; Lycaenidae), and Kamehameha butterfly (*Vanessa tameamea*; Nymphalidae). The latter is Hawai‘i’s state insect. This disparity in numbers is likely the result of the fact that many moths are generalists, while most butterflies are dependent on specific host plants, making it unlikely that they would establish in the islands unless their host plant was already here. Most native moths are very small, with most only having a wingspan of one centimeter (0.4 inches) or less, and most are poorly known. Approximately 363 species of native moths are in the genus *Hypsmocoma*, and many more are likely undescribed. *Hypsmocoma* is the second most diverse animal lineage in Hawai‘i (after flies in the family Drosophilidae). These moths inhabit a wide range of habitats, although some species are restricted to single stream or river drainages. As a genus they are mostly herbivorous, feeding on plant debris and lichens, though some species are carnivorous, feeding on snails. Less than one percent of the world’s known moths and butterflies are predaceous, but in Hawai‘i, predaceous behavior has evolved independently in two lineages (*Hypsmocoma* and *Eupithecia*).

DISTRIBUTION: Lepidopterans are known from all the MHI and the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss of native habitats likely means that species within the order are declining. Recent surveys and reviews of museum specimens estimated that about a third of native Lepidopterans have not been collected in over 50 years and are likely extinct.

LOCATION AND CONDITION OF KEY HABITAT: Butterflies and moths occur in all native habitats from sea level to alpine deserts. Host material is widely varied and includes native plants, lichens, algae, and fungi. Some species feed only in the decaying wood of particular plant species.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.

- Loss of obligate native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Predation by non-native species, such as ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and social wasps (Vespidae), especially *Vespula* spp.
- Parasitism by non-native flies (Diptera) and wasps (Hymenoptera).

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward moths and butterflies should include:

- Improve commercial shipment inspections to prevent further introduction of alien invertebrates harmful to native species.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine the distribution and abundance of known moths and butterflies and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to locate areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species to science.
- Systematic review of the order.
- Conduct studies to document the biology, habitat requirements, and life history of native species.

References:

- Austin K., Rubinoff D. 2024. Towards a conservation assessment of the endemic Hawaiian moths and butterflies. Hawaii Conservation Conference. Oral presentation.
- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
- Rubinoff D, Haines W. 2005. Web-spinning caterpillar stalks snails. Science 309:575.
- Zimmerman EC. 2001. Insects of Hawai'i: Volume 1 Introduction. Honolulu: University of Hawai'i Press.



Hyposmocoma kahamanao

Terrestrial Invertebrates

Cosmet Moths

Order Lepidoptera

Family Cosmopterigidae

Genus *Hyposmocoma*

GENUS INCLUDES:

>500 Native & Endemic Species

GENERAL INFORMATION: *Hyposmocoma* is a Hawaiian endemic genus of small to minute moths, also known as Hawaiian fancy-cased caterpillars. Approximately 360 species are described (Nishida, 2002), and hundreds more remain undescribed, making them the second largest endemic radiation in Hawai'i (flies in the family Drosophilidae being the largest). The group is divided into two subgenera, *Hyposmocoma sensu stricto*, where the caterpillars make cases (205 species), and *Euperissus*, where the caterpillars live freely (158 species; Zimmerman, 1978). As caterpillars they are mostly herbivorous, feeding on leaves, ferns, plant debris, and lichens. However, some species are predatory on insects and even snails, which is extremely rare among Lepidoptera (Rubinoff and Haines, 2005). They inhabit a wide range of habitats, from the coast to montane wet forests and barren lava flows. Some are aquatic or semi-aquatic, grazing on moss and algae on rocks of permanent or intermittent streams. Due to the large size of the group, small size of individual specimens, and many cryptic species, identification is often difficult, especially without both the larval case and the adult.

DISTRIBUTION: *Hyposmocoma* are known from all the MHI and the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates, and their small size, large number of undescribed species, and lack of literature resources make the species difficult to identify. The loss of native habitats likely means that species within the genus are declining, particularly those that inhabit specialized niches. However, at least some of the case-making species are able to persist at disturbed lowland sites with few other native species.

LOCATION AND CONDITION OF KEY HABITAT: *Hyposmocoma* occur in all native habitats from sea level to alpine deserts. Host material is widely varied and includes native plants, lichens, algae, and mosses. Some species are predatory on insects or snails.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.

- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*) and Argentine ant (*Linepithema humile*), and parasitic wasps (Hymenoptera) attack both larvae and adult moths.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward moths and butterflies should include:

- Conduct surveys to determine the distribution and abundance of known *Hypocyma* species and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to locate areas supporting large numbers of native species.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Initiate efforts to locate and identify new species.
- Systematic review of the genus to create an identification framework.

References:

- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
- Rubinoff D, Haines W. 2005. Web-spinning caterpillar stalks snails. Science 309:575.
- Zimmerman EC. 1978. Insects of Hawai'i: Volume 9 Microlepidoptera Part II. Honolulu: University of Hawai'i Press.



Omiodes monogramma. Photo: W. Haines.

Terrestrial Invertebrates

Crambid snout moths and grass moths

Order Lepidoptera

Family Crambidae

FAMILY INCLUDES:

11 Native Genera

137 Native Species

136 Endemic Species

GENERAL INFORMATION: The family Crambidae includes 137 described native species which feed on a variety of native plants. The most species-rich crambid genus is *Eudonia*, containing more than 60 described species, and likely many more undescribed species. Caterpillars of many *Eudonia* species feed on mosses and lichens and can be common, even in relatively disturbed areas. Other large lineages in this family include *Udea* (44 spp.), *Mestolobes* (34 spp.), and *Omiodes* (23 spp.). Caterpillars of *Udea* and *Mestolobes* feed on a variety of native plants, while most *Omiodes* feed on monocots, including grasses, sedges, palms, and lilies. Most crambid moths are nocturnal, but many *Mestolobes* are active during the day, and are frequently seen visiting flowers. Crambid moths, like other native lepidoptera, are likely important pollinators for native plants.

DISTRIBUTION: Crambid moths are known from all the MHI and the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss of native habitats likely means that species within the order are declining. Several species of *Omiodes* have not been seen in over 100 years and are likely extinct.

LOCATION AND CONDITION OF KEY HABITAT: Crambid moths occur in all native habitats from sea level to alpine deserts. Host material is widely varied and includes native flowering plants, mosses, and lichens.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and several species of parasitic flies (Diptera) and wasps (Hymenoptera) attack both larvae and adult moths.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward crambid moths and butterflies should include:

- Improve commercial shipment inspections to prevent further introduction of alien invertebrates harmful to native species.
- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine the distribution and abundance of known crambid moths and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to locate areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Systematic review of genera within the family.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 1958. Insects of Hawaii: Volume 8 Lepidoptera: Pyraloidea. Honolulu: University of Hawaii Press.



Scotorythra sp. Photo: W. Haines.

Terrestrial Invertebrates

Geometer moths
Order Lepidoptera
Family Geometridae

FAMILY INCLUDES:
7 Native Genera
82 Native & Endemic Species

GENERAL INFORMATION: The family Geometridae, or geometer moths, is fairly well represented in the Hawaiian fauna, including 82 recognized species within seven genera. Caterpillars of geometrid moths are often referred to as inchworms, due to the way they move in a stepwise fashion, reaching forward with their front legs, grasping the substrate, then bringing the back half of their body up to meet the front. Geometrid caterpillars lack prolegs (leg-like abdominal appendages) along most of their abdomen, possessing them only on the last segments. The largest genera of native geometrid moths are *Scotorythra* (44 spp.) and *Eupithecia* (22 spp.). Caterpillars of *Scotorythra* moths feed on the vegetation of native plants. Some species are specialists, feeding on only one genus or species of native plant; others, such as *S. rara*, are generalists, able to feed on many different types of plants. The koa looper, *S. paludicola*, sometimes has population explosions, defoliating koa forests on Maui and Hawai‘i. The genus *Eupithecia* includes some of the most unique native animals; most of the Hawaiian species have evolved a predatory lifestyle. Their caterpillars situate themselves along the edge of a leaf and wait for unsuspecting insects to stumble upon them. They have backward-pointing trigger hairs at the tip of their abdomen, allowing them to sense when small insects come into contact with them. They then snap backward and grab prey with their well-developed, grasping forelegs. These are among the only ambush predator caterpillars in the entire world.

DISTRIBUTION: Geometer moths are known from all the main Hawaiian Islands except Ni‘ihau and Kaho‘olawe.

ABUNDANCE: As a group, unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Geometer moths occur in all types of native habitats from sea level to alpine deserts. Host material includes a wide variety of native plants, though many *Eupithecia* species are entirely carnivorous.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.

- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and several species of parasitic flies (Diptera) and wasps (Hymenoptera) attack both larvae and adult moths.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward geometrids should include:

- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine the distribution and abundance of known species and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to locate areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Systematic review of genera in the family, including description of undescribed species.
- Characterization of pheromones of *Scotorythra* spp. to facilitate monitoring of outbreaking species such as the koa looper.

References:

- Haines WP, Heddle ML, Welton P, Rubinoff D. 2009. A recent outbreak of the Hawaiian koa moth, *Scotorythra paludicola* (Lepidoptera: Geometridae), and a review of outbreaks between 1892 and 2003. *Pacific Science* 63(3): 349-369.
- Heddle AL. 2003. Systematics and phylogenetics of the endemic genus *Scotorythra* (Lepidoptera: Geometridae) in the Hawaiian Islands. Dissertation, University of California at Berkeley. 310 pp.
- Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.
- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
- Zimmerman EC. 2001. Insects of Hawai'i: Volume 1 Introduction. Honolulu: University of Hawai'i Press.



Philodoria splendida. Photo: K. Magnacca.

Terrestrial Invertebrates

Painted leaf miners

Order Lepidoptera

Family Gracillariidae

Genus *Philodoria*

GENUS INCLUDES:

52 Endemic Species

GENERAL INFORMATION: *Philodoria* is an endemic genus in the leaf-mining moth family Gracillariidae. Aside from the questionably-native *Caloptilia mabaella*, *Philodoria* species are the only native representatives of the large and widespread Gracillariidae family, which includes a number of agricultural pests. The flattened caterpillars feed in between the top and bottom surface of leaves, forming mines that may be serpentine or contiguous (blotch) depending on the species. All are host plant specific at least to family, often to species. Adults are minute, often with bright or metallic patterns.

DISTRIBUTION: *Philodoria* are known from all the MHI except Ni‘ihau and Kaho‘olawe, and one widespread species is also found on Nihoa in the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss of native habitats likely means that species within the genus are declining, and some may be extinct. Mines of some species that have not been recovered recently have been found in herbarium specimens of their host plants.

LOCATION AND CONDITION OF KEY HABITAT: *Philodoria* occur in all native habitats from sea level to alpine deserts. They feed in a wide variety of plants, from common species such as *Metrosideros polymorpha* (‘ōhi‘a lehua) and *Pipturus albidus* (māmaki) to endangered ones such as *Argyroxiphium grayanum* and *Hesperomannia* spp.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and several species of parasitic flies (Diptera) and wasps (Hymenoptera) prey on both larvae and adult moths.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations,

thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Philodoria* should include:

- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine the distribution and abundance of known leaf miners and to document and identify new species.
- Conduct outplanting of native host plants within or near existing moth populations.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to locate areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Systematic review of the genus.

References:

Kobayashi S, Johns CA, and Kawahara AY. 2021. Revision of the Hawaiian endemic leaf-mining moth genus *Philodoria* Walsingham (Lepidoptera: Gracillariidae): its conservation status, host plants and descriptions of thirteen new species. *Zootaxa* 4944(1): 1–175.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Zimmerman EC. 1978. Insects of Hawaii: Volume 9 Microlepidoptera. Honolulu: The University Press of Hawaii.



Udara blackburni (left) and *Vanessa tameamea* (right).

Photos: W. Haines.

Terrestrial Invertebrates

Butterflies

Order Lepidoptera

Superfamily

Papilionoidea

SUPERFAMILY

INCLUDES:

2 Native Families

2 Native Genera

2 Native & Endemic Species

GENERAL INFORMATION: Hawai‘i supports about a thousand native moth species, but only two native butterflies: Blackburn’s blue (*Udara blackburni*; Lycaenidae), and the Kamehameha butterfly (*Vanessa tameamea*; Nymphalidae). The latter is Hawai‘i’s state insect. Both are larval food specialists. Caterpillars of the Kamehameha butterfly feed on native plants in the nettle family (Urticaceae), primarily māmakī (*Pipturus* spp.) but also ‘akolea (*Boehmeria grandis*), ‘olonā (*Touchardia latifolia*) and ‘ōpuhe (*T. sandwicensis*), while those of Blackburn’s blue feed on koa (*Acacia koa*) and ‘a‘ali‘i (*Dodonaea viscosa*). Using only koa and ‘a‘ali‘i as host plants is somewhat unusual for insects since these plants are unrelated. Interestingly, though, koa and ‘a‘ali‘i are also the two host plants of the koa bug (*Coleotichus blackburniae*).

DISTRIBUTION: The Kamehameha butterfly is known from all of the Main Hawaiian Islands except Kaho‘olawe. Blackburn’s blue is known from all of the Main Hawaiian Islands.

ABUNDANCE: Unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss of native habitats likely means that the species are declining. The Kamehameha butterfly has been increasingly less abundant over the past 30 years, particularly on O‘ahu where it is rarely seen in the Ko‘olau range. Captive rearing and reintroductions of the Kamehameha butterfly were attempted by DLNR-DOFAW from 2016 to 2020 in the southern Ko‘olau Range of O‘ahu but were not successful due to high predation rates on caterpillars. Blackburn’s blue appears to be fairly common but has not been studied as much.

LOCATION AND CONDITION OF KEY HABITAT: Both butterflies occur in native dry to wet forests.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Predation by non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and parasitism by several species of parasitic flies (Diptera)

and wasps (Hymenoptera) that attack eggs and larvae. Introduced birds, particularly red-vented bulbuls and Japanese white-eyes, also prey on caterpillars.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward butterflies should include:

- Conduct surveys to determine the distribution and abundance of both species to assess current conservation status.
- Preserve, maintain, and restore habitats supporting existing populations.
- Encourage planting of host plants in natural areas and in nearby residential areas.

MONITORING:

- Support and expand existing monitoring efforts.
- Determine if declines are occurring and target affected areas for conservation actions.

RESEARCH PRIORITIES:

- Conduct studies on life history, distribution, and critical habitats to better direct conservation measures.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.



Terrestrial Invertebrates

Blackburn's Sphinx Moth

Manduca blackburni

SPECIES STATUS:

Federally listed as Endangered

State listed as Endangered

State recognized as Endemic

NatureServe Heritage Rank G1 -

Critically imperiled

Recovery Plan for the Blackburn's Sphinx Moth (*Manduca blackburni*) - USFWS 2005
Designation of Critical Habitat for the Blackburn's Sphinx Moth: Final Rule – USFWS 2003

SPECIES INFORMATION: Blackburn's sphinx moth is one of Hawai'i's largest native insects (Family: Sphingidae) with a wing span of up to 12 centimeters (5 inches). Adults are overall gray with black bands across the top of their wings and five orange spots on each side of their abdomen. Caterpillars are large and populations contain two distinct color morphs, bright green or purple/gray. Both morphs have scattered white speckles across their back and a horizontal white stripe on the side of each segment. Caterpillars feed on plants in the nightshade family (Solanaceae), especially native trees in the genus *Nothocestrum*, but also on non-native solanaceous plants such as tree tobacco (*Nicotiana glauca*), commercial tobacco (*N. tabacum*), eggplant (*Pseudomonas solanacearum*), tomato (*Lycopersicon esculentum*), and Jimson weed (*Datura stramonium*). Adults have been observed feeding on the nectar of koaliawa (*Ipomea indica*). Additional likely adult nectar sources include other species of *Ipomea*, maiapilo (*Capparis sandwichiana*), and 'ilie'e (*Plumbago zeylancia*); it is believed that the moth pollinates these species, but further study is necessary. Development from egg to adult may be as short as 56 days, but pupae may aestivate (i.e., remain dormant during hot or dry conditions) in the ground for as long as a year. Moths are found year-round but may be most active between January and April and, again, between September and November, especially after rains.

DISTRIBUTION: Originally distributed across all the Main Hawaiian Islands (MHI), the species was believed to be extinct in the late 1970s. In 1984, it was rediscovered on East Maui. Additional populations have recently been found on Kaho'olawe and the island of Hawai'i. Blackburn's sphinx moth can be found across a broad elevational gradient from sea level to 1,540 meters (5,000 feet), though it does not breed in all locations where the adults might be found.

ABUNDANCE: Unknown. The species' short life span as an adult, rarity, and mobility makes estimating population sizes difficult. Despite this, it is believed that populations have declined over the past 100 years since the moth no longer occurs on several islands on which it had been recorded. Currently, the largest populations reside on Maui and Hawai'i. Historical accounts and museum specimens suggest the species was widespread and common on most of the MHI.

LOCATION AND CONDITION OF KEY HABITAT: Historical records indicate that Blackburn’s sphinx moth mostly occurred in coastal, lowland, and dry forests in areas receiving less than 127 centimeters (50 inches) of rain per year. Human modification of Hawaiian landscapes has greatly reduced these communities; for example, more than 90 percent of Hawai‘i’s dry forests have been destroyed. Depending on the location and elevation, the composition of the plant species in moth habitat varies considerably. However, some common native plants found in areas where the species occurs include lama (*Diospyros sandwicensis*), ‘ohe (*Polyscias sandwicensis*), hao (*Raovolfia sandwicensis*), ‘āla‘a (*Planchonella sandwicensis*), āulu (*Pisonia sandwicensis*), ‘a‘ali‘i (*Dodonaea viscosa*), naio (*Myoporum sandwicense*), and wiliwili (*Erythrina sandwicensis*). The populations on Maui and Hawai‘i are primarily associated with non-native tree tobacco and native ‘aiea (*Nothocestrum* spp.) trees. Perhaps the largest stand of ‘aiea trees in the State is located on Maui in the Kanaio Natural Area Reserve. On Moloka‘i, potential moth habitat consists of mixed-species mesic and dry forests with both native and non-native plants (see below). On Kaho‘olawe, caterpillars currently feed on the non-native tree tobacco. Although the species will feed on non-native plants, primary constituent elements of critical habitat as designated by the USFWS (see below; critical habitat) include the endemic larval host plant species *N. latifolium* and *N. breviflorum*, and native nectar sources for adults including koaliawa, other species of *Ipomoea*, maiapilo, and ‘ilie‘e. These species are likely superior to non-natives in that they are more persistent, especially during drought conditions.

THREATS: Historically, habitat loss and degradation due to ranching, introduced plants and animals, human development, and wildfire reduced the quantity and quality of native habitats. In 2003, 40,420 hectares (99,433 acres) of critical habitat was designated by the USFWS on the islands of Hawai‘i, Maui, Moloka‘i, and Kaho‘olawe. Current threats include non-native ants, especially the big-headed ant (*Pheidole megacephala*), and several species of parasitic flies and wasps. Although little documentation exists of direct predation, in areas where big-headed ants occur, native insects have been eliminated. Several alien wasp species have been documented parasitizing the Blackburn’s sphinx moth. All species of host *Nothocestrum* are declining. Because of development, competition from non-native species, browsing by cattle and feral goats, and wildfire, the larval host plant, *N. breviflorum* on the island of Hawai‘i, and the potential host plant, *N. peltatum* on Kaua‘i, are federally listed as endangered. Given that the species inhabits dry habitats, natural variation in rainfall can result in reduced food availability and negatively affect moth populations.

CONSERVATION ACTIONS: The Kanahā Pond Sanctuary dune restoration project on Maui is planting native host plants in response to observations of caterpillars on plants in the restoration area. In addition to common statewide and island conservation actions, specific management directed toward Blackburn’s sphinx moth should include:

- Restoration of habitat (e.g. dry and mesic shrubland and forests) and increased protection of currently occupied habitats, especially those supporting host plants.
- Support cultivation and restoration of *Nothocestrum* species.
- Restore *Nothocestrum* on Kaho‘olawe to support moth populations.
- Re-establish moth populations throughout their historic range.
- Prevent introduction of non-native invertebrates that may pose a risk to existing moth populations.

MONITORING:

- Continue surveys of populations in known and potential habitats.
- Continue monitoring of *Nothocestrum* species.
- Monitor non-native plant and animal populations in known as well as potential moth habitat.

RESEARCH PRIORITIES:

- Evaluate the species' habitat needs, population status, and life history.
- Evaluate limiting factors on the species, possibly through controlled release trials. This should be geared towards establishing additional populations across the former range of the species.

References:

- U.S. Fish and Wildlife Service. 2003. Designation of Critical Habitat for the Blackburn's Sphinx Moth: final rule. Federal Register 68: 34710-34766.
- U.S. Fish and Wildlife Service. 2005. Recovery plan for the Blackburn's Sphinx Moth (*Manduca blackburni*). Portland, Oregon.
- U.S. Fish and Wildlife Service. 2009. Blackburn's Sphinx Moth (*Manduca blackburni*) 5-Year Review: Summary and Evaluation. Pacific Islands Fish and Wildlife Office. Honolulu, Hawaii.



Terrestrial Invertebrates

Fabulous Green Sphinx

Order Lepidoptera

Family Sphingidae

Tinostoma smaragditis

GENERAL INFORMATION: *Tinostoma smaragditis*, known as the “fabulous green sphinx of Kaua‘i,” is one of the largest and most enigmatic Hawaiian native insects. It was long known from a single specimen collected in the 1890s by a member of the Gay family (owners of Makaweli), and failure to obtain any more specimens combined with the lack of any other relatives led some to believe that it was not actually a Hawaiian species, either having been mislabelled or a one-off accidental import. However, it was rediscovered in 1961, and since then a series of specimens have been found in diverse mesic forest in the Kōke‘e and Kalalau areas. The most recent sighting was in 2000, and further searches in the Kōke‘e and Wailua River areas have not found any more. The host plant is unknown; one female caught in 1992 laid several eggs before dying, but the caterpillars that hatched did not feed on any of the plants offered.

DISTRIBUTION: *Tinostoma smaragditis* is known only from Kaua‘i, primarily in the northwest corner of the island.

ABUNDANCE: Extremely rare; known only from about 15 specimens total, and not seen for 25 years.

LOCATION AND CONDITION OF KEY HABITAT: Based on the location of collections, *Tinostoma smaragditis* appears to inhabit diverse mesic forest. There are still some significant stands of this habitat type remaining, but since its specific host plant is unknown, the primary factor in assessing habitat status is missing.

THREATS:

- Habitat loss and degradation due to disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.
- Insufficient information hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and several species of parasitic flies (Diptera) and wasps (Hymenoptera) probably attack eggs and larvae.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Tinostoma smaragditis* should include:

- Conduct surveys to determine its distribution and abundance.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.

RESEARCH PRIORITIES:

- Conduct studies to determine the host plant and other key life history traits.

References:

Heddle MR, Wood KR, Asquith A, Gillespie RG. 2000. Conservation status and research on the fabulous green sphinx of Kaua‘i, *Tinostoma smaragditis* (Lepidoptera: Sphingidae), including checklists of the vascular plants of the diverse mesic forests of Kaua‘i, Hawai‘i. *Pacific Science* 54(1): 1–9.

Zimmerman EC. 1958. *Insects of Hawaii: Volume 7 Macrolepidoptera*. Honolulu: University of Hawaii Press.



Mantua fulvossericea. Photo: K. Magnacca.

Terrestrial Invertebrates

Leaf-roller moths

Order Lepidoptera

Family Tortricidae

FAMILY INCLUDES:

13 Native Genera

>90 Native & Endemic Species

GENERAL INFORMATION: The family Tortricidae is a large, diverse group worldwide. The family is commonly known as leaf-roller moths, although some have other habits such as feeding in seeds or fruit. The native Hawaiian fauna is notable for the high number of colonists, with each genus derived from a separate introduction event. As a result, while there are several moderately large radiations, many groups have only a few species. The most diverse genera are *Pararrhaptica* and *Spheterista*, each with over 20 species, and *Cydia* and *Eccoptocera* each with at least 15. Some, such as *Bactra straminea* and *Cryptophlebia illepida*, appear to be highly variable and widespread species but are probably actually cryptic species complexes in the process of rapid evolution.

DISTRIBUTION: Tortricids are known from all the MHI and the genus *Crociosema* is also found on many of the NWHI.

ABUNDANCE: As a group unknown. A lack of systematic surveys prevents accurate population estimates. However, the loss of native habitats likely means that species within the family are declining. Recent surveys have found fewer of many species than in the past; many others have not been collected in 50 years or more and are likely extinct.

LOCATION AND CONDITION OF KEY HABITAT: Tortricids occur in all native habitats from sea level to alpine deserts. Most feed on the leaves or seeds of native plants. Some species have adapted to feed on alien grasses.

THREATS:

- Habitat loss and degradation due to conversion for agriculture, logging, grazing, and soil disturbance by a suite of non-native ungulates, and the introduction of invasive plants.
- Loss of native host plants.
- Insufficient information, especially for rare species, hampers conservation efforts.
- Non-native species, including ants (Formicidae), especially the big-headed ant (*Pheidole megacephala*), and wasps (Hymenoptera) parasitize and prey on larvae and adult moths.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward leaf-roller moths should include:

- Initiate studies on life history, distribution, and critical habitats to better direct conservation measures.
- Conduct surveys to determine the distribution and abundance of known tortricids and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Support and expand existing monitoring efforts.
- Establish new monitoring for priority species that are not currently monitored.

RESEARCH PRIORITIES:

- Initiate targeted searches for species not recently collected or observed.
- Initiate studies to determine species' distributions to locate areas supporting large numbers of native species.
- Initiate efforts to locate and identify new species.
- Systematic review of the family.

References:

Austin KA, and Rubinoff D. 2024. Nine new species of Hawaiian leaf-roller moths (Lepidoptera: Tortricidae), including one probably extinct species. *Proceedings of the Hawaiian Entomological Society* 56: 29–59

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 1978. *Insects of Hawaii: Volume 9 Microlepidoptera*. Honolulu: University of Hawaii Press.



Micromus swezeyi. Photo: Brendan Wang.

Terrestrial Invertebrates

Lacewings and Antlions Neuroptera

ORDER INCLUDES:

3 Native Families

5 Native Genera

50 Endemic Species and subspecies

GENERAL INFORMATION:

Family Chrysopidae- 22 species and subspecies

Family Coniopterygidae- 1 species

Family Hemerobiidae- 25 species and subspecies

Family Myrmeleonidae- 2 species and subspecies

Lacewings and antlions are predators, feeding on other insects in both their immature and adult stages. Most adult species in the genus have four large, net-veined, wings. Species in the Chrysopidae are bright green and colorful, while species in the Hemerobiidae are mostly brown. A few species are flightless (e.g., *Micromus lobipennis* and *M. haleakalae*). The largest number of Hawaiian endemic species are found in the genera *Anomalochrysa* (Chrysopidae) and *Micromus* (Hemerobiidae). Many native species of brown lacewings (Hemerobiidae: *Micromus*) are relatively common, but others – particularly those with highly modified or reduced wings – are rare. The native antlions (Myrmeleontidae: *Distoleon*) are rare and very poorly known; it is unclear if there are multiple endemic species present, or if they are indigenous variants of the widespread *D. bistrigatus*.

DISTRIBUTION: Neuropterans are known from all the MHI except for Kaho‘olawe and Ni‘ihau. Members of this order also are known from the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Mostly unknown. However, lacewings and antlions appear to occur in a wide range of habitats.

THREATS:

- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations,

thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward lacewings and antlions should include:

- Conduct surveys to determine the distribution and abundance of known lacewings and antlions and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 1957. Insects of Hawaii: Volume 6, Ephemeroptera-Neuroptera-Trichoptera and Supplement to Volumes 1 to 5. Honolulu: University of Hawaii Press.



Anax strenuus. Photo: Karl Magnacca.

Terrestrial Invertebrates

Damselflies and dragonflies Odonata

ORDER INCLUDES:

- 3 Native Families
- 4 Native Genera
- 29 Native Species
- 27 Endemic Species

GENERAL INFORMATION: Dragonflies and damselflies are among the most common and easily recognized aquatic insects. All members of the order are predaceous, both as immatures and adults. All dragonflies and damselflies have an aquatic immature form (naiad). Adults have large compound eyes, two pairs of large membranous wings, and a long, thin abdomen. The order consists of two suborders, one (Anisoptera) containing the dragonflies and the other (Zygoptera) the damselflies. Dragonflies are very strong fliers, soaring for long distances, and at rest holding their wings spread. Damselflies generally do not fly long distances, and at rest hold their wings together above the body. Because of the diversity and extensive adaptive radiation, the native damselfly genus *Megalagrion* is particularly well-studied. Many *Megalagrion* species are endemic to single islands or ridges, and at least ten of the 23 species in the genus are considered at risk. *Megalagrion oahuense* is one of the few truly terrestrial damselflies in the world. Several other species are semi-terrestrial, the naiads living in tiny amounts of water held by the rosette-forming native plants *Astelia* and *Freycinetia*. The endemic green darner dragonfly, *Anax strenuus*, is one of our largest native insects with a wingspan of up to 14 cm (5.5 inches). Six endemic damselflies (*Megalagrion leptodemas*, *M. nesiotes*, *M. nigrohamatum nigrolineatum*, *M. oceanicum*, *M. pacificum*, and *M. xanthomelas*) are federally listed as endangered.

DISTRIBUTION: Dragonflies and damselflies are known from all the Main Hawaiian Islands except for Kaho‘olawe. The widespread indigenous globe skimmer dragonfly (*Pantala flavescens*) is also found in the NWHI.

ABUNDANCE: Most of the native dragonflies remain relatively common, although the endemic clubtail *Nesogonia blackburni* is somewhat rare. However, many species of *Megalagrion* are rare, and their abundance and distribution has declined dramatically over the past 100 years.

LOCATION AND CONDITION OF KEY HABITAT: Larvae and adults occur in or near a wide range of aquatic habitats (e.g., streams, plunge pools, reservoirs, anchialine pools, lowland swamps and marshes), montane forests and bogs, and lowland habitats, many of which are threatened by habitat change and loss. In particular, the introduction of mosquitofish and topminnows (Poeciliidae) for control of mosquitoes has eliminated *Megalagrion* damselflies from many streams. Bullfrogs (*Rana catesbeiana*) also prey on naiads and can spread from stream to stream across land.

THREATS:

- Habitat loss or degradation caused by water diversions, pollution, and disturbance by feral ungulates.
- Predation of naiads by non-native invasive invertebrates, fish, and frogs.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward dragonflies and damselflies should include the following:

- Identify and protect streams currently free of non-native species and human alterations, particularly in lowland areas.
- Conduct surveys to determine distribution and abundance of known dragonfly and damselfly populations and to document and identify new species.
- Enhance protection of key watersheds.
- Support captive breeding and relocation/translocation of endangered *Megalagrion* species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring of known populations to assess population trends.
- Survey for additional, new populations.
- Conduct surveys for species believed to be extinct.

RESEARCH PRIORITIES:

- Determine the cause(s) of decline of stream-breeding species, particularly on O‘ahu.
- Conduct studies to determine life history factors for conservation.
- Assess potential haplotype differences among island populations of widespread species to determine the importance of protecting populations on individual islands.

References:

- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
- Polhemus DA. 1993. Damsels in distress: a review of the conservation status of Hawaiian *Megalagrion* damselflies. Aquatic Conservation: Marine and Freshwater Ecosystems 3:343-49.
- Polhemus DA. 2004. Critical species of Odonata in the Hawaiian Islands. International Journal of Odonatology 7(2):133-138.
- Polhemus DA, Asquith A. 1996. Hawaiian damselflies: a field identification guide. Honolulu, (HI): Bishop Museum Press.
- U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; endangered status for 23 species on Oahu and designation of critical habitat for 124 species; final rule. Federal Register 77:57648–57862.



Megalagrion leptodemas.

Terrestrial Invertebrates

Crimson Hawaiian damselfly

Megalagrion leptodemas

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

GENERAL INFORMATION: *Megalagrion leptodemas* (Perkins, 1899) is a small, relatively slender damselfly. Males are predominantly bright red except on the posterior half of the abdomen, and females are greenish. Despite the coloration of the males, their small size and shy habits make them inconspicuous when flying about. Adults are found along stream corridors near standing pools or slow-moving stream sections that serve as breeding sites, usually not straying far from the stream. Along with *M. oceanicum*, it is among the rarest O‘ahu species known to be extant.

DISTRIBUTION: Endemic to O‘ahu, it formerly occurred on both sides of the island but is now apparently extirpated from the Wai‘anae range. In the Ko‘olau range, it occurs in only three isolated locations in the upper reaches of streams: Moanalua, North Halawa, and Ma‘akua.

ABUNDANCE: Unknown. The total population is extremely small due to the highly constrained habitat available and few remaining populations.

LOCATION AND CONDITION OF KEY HABITAT: The naiads inhabit still pools and slow-flowing sections of streams. Like most native damselflies, this species cannot survive where introduced fish and frogs are present. As a result, it is now restricted to upper elevations in streams where barriers such as waterfalls prevent upstream movement of aquatic predators.

THREATS:

- Habitat loss and degradation. Habitat is lost or degraded by erosion, the presence of feral ungulates, stream diversion and alteration, and alien aquatic plants.
- Predation. Non-native predators, including invasive fish, frogs, ants, birds, and reptiles, consume this species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. This species has not been reared in captivity. For *Megalagrion leptodemas* specifically, management needs include the following:

- Conduct surveys around known populations to determine threat levels and control needs.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Develop captive rearing methods for the species.
- Use these results to create a management plan for species recovery.

MONITORING: Periodically census populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historical and novel sites.
- Conduct studies to determine if reintroduction to additional sites is feasible.
- Develop captive rearing methods for the species.

References:

Polhemus DA, and Asquith AA. 1996. Hawaiian Damselflies: A Field Identification Guide. Bishop Museum Press, Honolulu, Hawaii.

U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; endangered status for 23 species on Oahu and designation of critical habitat for 124 species; final rule. Federal Register 77: 57648–57862.



Megalagrion nesiotes. Photo: Dan Polhemus, USFWS.

Terrestrial Invertebrates

**Flying earwig
Hawaiian damselfly**
Megalagrion nesiotes

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Megalagrion nesiotes* (Perkins, 1899) is a large damselfly, distinguished from other Hawaiian species by the blue and black color pattern and enlarged terminal appendages of the male. Females are brown with black stripes on the thorax. As a dark-colored, weak-flying species that occurs in forests, it is relatively inconspicuous and difficult to observe. Never very common, this species had not been seen since the 1930s before it was rediscovered along a stream on Maui in the early 1990s.

DISTRIBUTION: Historically this species was known from windward East Maui and Hawai‘i, mostly below 914 meters (3,000 feet) elevation. The last collections from Hawai‘i were made in the 1930s, and intensive surveys at historical sites in Puna and Volcano have not recovered it. However, its coloration and habits may mean it has been overlooked. The only known population site is on the north slope of Haleakalā, where the species was rediscovered in the 1990s after a gap of 75 years.

ABUNDANCE: Unknown. The sole known population is small and vulnerable to stochastic events, and no individuals have been observed during recent visits. The species was last sighted in 2005, and several damselfly surveys of the area between 2009 and 2022 failed to detect the species.

LOCATION AND CONDITION OF KEY HABITAT: The breeding habitat is unknown. Based on its behavior and relationships, it is thought to breed in terrestrial or semiterrestrial habitat, such as uluhe mats, damp leaf litter, or wet banks. Because these are not associated with the introduced aquatic predators that have caused the decline of most *Megalagrion* species, the main driver of this species’ decline is unclear.

THREATS:

- Habitat loss and degradation. Habitat is lost or degraded by erosion, the presence of feral ungulates, and alien aquatic plants.
- Predation. Non-native predators, including invasive invertebrates, frogs, ants, birds, and reptiles, consume this species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations,

thereby reducing the risk of extinction. For *Megalagrion nesiotes* specifically, management needs include the following:

- Conduct surveys around the known population to determine threat levels and control needs.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Use these results to create a management plan for species recovery.

MONITORING: Periodically census the population in order to assess stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historical and novel sites.
- Conduct studies to determine if reintroduction to additional sites is feasible.

References:

Polhemus DA, and Asquith, AA. 1996. Hawaiian Damselflies: A Field Identification Guide. Bishop Museum Press, Honolulu, Hawaii.

U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; listing the flying earwig Hawaiian damselfly and Pacific Hawaiian damselfly as endangered throughout their ranges. Federal Register 75: 35990–36012.

U.S. Fish and Wildlife Service. 2023. Flying earwig Hawaiian damselfly (*Megalagrion nesiotes*) 5-year Review 2023. Available at https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/4698.pdf (accessed 17 Dec 2024).



Photo: W. Haines

Terrestrial Invertebrates

Blackline Hawaiian damselfly

Megalagrion

nigrohamatum nigrolineatum

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

GENERAL INFORMATION: *Megalagrion nigrohamatum nigrolineatum* (Perkins 1899) is a moderate-sized damselfly, immediately distinguishable from all other Hawaiian species by the greenish to blue color of the lower half of the face and eyes. Males and females are sexually dimorphic in color pattern, with males reddish on the side of the thorax and females yellow to light blue. Adults are found along stream corridors in the vicinity of the pools and slow-moving stream sections that serve as breeding sites.

DISTRIBUTION: Endemic to O‘ahu, it formerly occurred on both sides of the island but is now apparently extirpated from the Wai‘anae range. In the Ko‘olau range, it occurs in scattered locations along streams of the central and northern regions, on both the windward and leeward sides. Approximately 20 populations are currently known.

ABUNDANCE: Numbers are drastically reduced due to the highly constrained area of habitat available. The population is estimated to be about 800 to 1,000 individuals in total, with approximately 50 individuals at each site.

LOCATION AND CONDITION OF KEY HABITAT: The naiads live in pools and slow sections of perennial montane streams. Like most native damselflies, this species is impacted by nonnative fish, though it does overlap in range with mosquito fish and smallmouth bass in some streams and appears to be somewhat more resilient to predation than other *Megalagrion* species. Although it historically occurred close to sea level, it is now restricted to upper elevations where barriers such as waterfalls prevent upstream movement of aquatic predators.

THREATS:

- Habitat loss and degradation. Habitat is lost or degraded by erosion, the presence of feral ungulates, stream diversion and alteration, and alien aquatic plants.
- Predation. Non-native predators, including invasive fish, frogs, ants, birds, and reptiles, consume this species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations, thereby reducing the risk of extinction. Captive rearing of this species began in 2021 and reintroductions have been attempted to a limited degree, but methods are in need of refinement.

For *Megalagrion nigrohamatum nigrolineatum* specifically, management needs include the following:

- Conduct surveys around known populations to determine threat levels and control needs.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Develop and refine captive rearing methods.
- Use these results to create a management plan for species recovery.

MONITORING: Periodically census populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historical and novel sites.
- Conduct studies to determine if reintroduction to additional sites is feasible.

References:

- Polhemus DA, and Asquith AA. 1996. Hawaiian Damselflies: A Field Identification Guide. Bishop Museum Press, Honolulu, Hawaii.
- U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; endangered status for 23 species on Oahu and designation of critical habitat for 124 species; final rule. Federal Register 77: 57648–57862.



Megalagrion oceanicum.

Photo: Dan Polhemus, USFWS.

Terrestrial Invertebrates

Oceanic Hawaiian damselfly

Megalagrion oceanicum

SPECIES STATUS:

Federally Listed as Endangered

State Listed as Endangered

GENERAL INFORMATION: *Megalagrion oceanicum* (McLachlan, 1883) is a large, relatively robust damselfly. Like its relatives *M. heterogamias* of Kaua‘i and *M. blackburni* of Hawai‘i, males are predominantly red except near the tip of the abdomen, while females have a dull greenish thorax and a dark abdomen. The size and the predominantly red coloration of the males make them conspicuous when flying about. Adults are found along stream corridors around fast-moving stream sections that serve as breeding sites; they are strong fliers and may also be found in adjacent forests.

DISTRIBUTION: Endemic to O‘ahu, it formerly occurred on both sides of the island but is now apparently extirpated from the Wai‘anae range. In the Ko‘olau range, it occurs in scattered locations along streams on the windward side of the central and northern regions. Twelve populations were known when the species was listed as endangered, but recent surveys failed to detect the species in many of these locations, and its range is likely quite restricted, making it among the rarest damselflies endemic to O‘ahu.

ABUNDANCE: Unknown. The population is thought to be relatively small due to the highly constrained habitat available.

LOCATION AND CONDITION OF KEY HABITAT: The naiads live in fast-flowing sections of perennial montane streams, but may come out of the water to forage on mossy banks and rocks. Like most native damselflies, this species cannot survive where introduced fish and frogs are present. Although it historically occurred close to sea level and in all habitable streams, it is now restricted to upper elevations in streams where barriers such as waterfalls prevent upstream movement of aquatic predators.

THREATS:

- Habitat loss and degradation. Habitat is lost or degraded by erosion, the presence of feral ungulates, stream diversion and alteration, and alien aquatic plants.
- Predation. Non-native predators, including invasive fish, frogs, ants, birds, and reptiles, consume this species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations,

thereby reducing the risk of extinction. For *Megalagrion oceanicum* specifically, management needs include the following:

- Conduct surveys around known populations to determine threat levels and control needs.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Use these results to create a management plan for species recovery.

MONITORING: Periodically census populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historical and novel sites.
- Conduct studies to determine if reintroduction to additional sites is feasible.

References:

Polhemus DA, and Asquith AA. 1996. Hawaiian Damselflies: A Field Identification Guide. Bishop Museum Press, Honolulu, Hawaii.

U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; endangered status for 23 species on Oahu and designation of critical habitat for 124 species; final rule. Federal Register 77: 57648–57862.



Terrestrial Invertebrates

**Pacific Hawaiian
damselfly**
Megalagrion pacificum

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

Megalagrion pacificum. Photo: Hank Oppenheimer.

GENERAL INFORMATION: *Megalagrion pacificum* (McLachlan, 1883) is a moderate-sized damselfly, readily distinguished from all other Hawaiian species by the red and black color pattern of the male. Females are similar, with the abdomen predominantly black and the thorax marked with light green instead of red. Males can also be recognized by having the lower pair of terminal appendages much longer than the upper; in most species, the upper pair is longer. Once considered one of the most common and widespread species of Hawaiian damselfly, it is now extirpated from most of its range and restricted to a handful of sites. Adults are found around the seepage-fed side pools of stream corridors that serve as breeding sites.

DISTRIBUTION: Historically this species was found in the lowlands of all the main islands except Ni‘ihau and Kaho‘olawe. It apparently disappeared from O‘ahu first, around 1910, and later from Kaua‘i and Lāna‘i. Recent surveys have found it at seven streams on Moloka‘i (with possibly more that are unsurveyed), fourteen on Maui, and only one on Hawai‘i.

ABUNDANCE: Unknown. Numbers are drastically reduced due to the highly constrained area of habitat available.

LOCATION AND CONDITION OF KEY HABITAT: The naiads live in seepage-fed side pools off of main streams. Like most native damselflies, this species cannot survive where introduced fish and frogs are present. Formerly, *M. pacificum* was found in other lentic habitats such as marshes and taro ponds, but these are now almost all invaded by alien fish. It is now restricted to sites where barriers such as waterfalls prevent upstream movement of aquatic predators.

THREATS:

- Habitat loss and degradation. Habitat is lost or degraded by erosion, the presence of feral ungulates, stream diversion and alteration, and alien aquatic plants.
- Predation. Non-native predators, including invasive fish, frogs, ants, birds, and reptiles, consume this species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations,

thereby reducing the risk of extinction. For *Megalagrion pacificum* specifically, management needs include the following:

- Conduct surveys around known populations to determine threat levels and control needs.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Use these results to create a management plan for species recovery.

MONITORING: Periodically census populations in order to assess their stability and trends.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historical and novel sites.
- Conduct studies to determine if reintroduction to additional sites is feasible.

References:

- Polhemus DA, and Asquith, AA. 1996. Hawaiian Damselflies: A Field Identification Guide. Bishop Museum Press, Honolulu, Hawaii.
- U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; listing the flying earwig Hawaiian damselfly and Pacific Hawaiian damselfly as endangered throughout their ranges. Federal Register 75 :35990–36012.



Megalagrion xanthomelas

Terrestrial Invertebrates

**Orangeblack
Hawaiian damselfly**
Megalagrion xanthomelas

SPECIES STATUS:
Federally Listed as Endangered
State Listed as Endangered

GENERAL INFORMATION: *Megalagrion xanthomelas* (Selys-Longchamps, 1876) is a small, relatively slender damselfly. Males are red on the head, thorax, and tip of the abdomen, and black across most of the abdomen; females are patterned similarly but with pale brown instead of red. Adults are found around standing pools or slow-moving stream sections that serve as breeding sites, usually not straying far from the breeding habitat. It occurs primarily in lowland areas and is one of the most adaptable native damselflies, capable of breeding in brackish anchialine ponds, basal spring wetlands, pools in slow-moving streams, and artificial water bodies.

DISTRIBUTION: The most widely distributed species of native damselfly, *M. xanthomelas* has been documented from all the main islands except Kaho‘olawe. However, it has apparently been extirpated from Kaua‘i and Lāna‘i (the Ni‘ihau population is unknown). On O‘ahu it was formerly widespread, including in basal spring wetlands around Pearl Harbor and the vicinity of Honolulu, but the alteration of wetlands and near-ubiquitous presence of alien fish and frogs reduced them to a single small population on the grounds of Tripler Army Medical Center. This population appears to have been extirpated, with the last sighting in April 2023, and the O‘ahu population currently exists only in captivity and at reintroduction sites. There are a few small, widely scattered populations on West and East Maui. Moloka‘i and Hawai‘i have several significant populations, dwelling in both streams and anchialine ponds near the coast. In November 2019, surveys of previously known populations on Lāna‘i failed to locate any extant populations. Most of the locations had been infested with mosquito fish. As of 2024, plans are underway to attempt reintroduction of the species to Lāna‘i.

ABUNDANCE: Unknown. The Moloka‘i and Hawai‘i populations are thought to be relatively large, though the anchialine ponds on the Kona coast of Hawai‘i are under threat from development, pollution, and introduction of fish. Maui populations are relatively small and fragmented. The O‘ahu wild population is extremely small and vulnerable to extirpation.

LOCATION AND CONDITION OF KEY HABITAT: The naiads inhabit still pools and slow-flowing sections of streams. Unlike most other species that occur in similar habitat, *M. xanthomelas* can live in many types of this form of water body, provided introduced fish and frogs are absent. As a result, they have persisted in what would be considered degraded sites, including drainage ditches, leaking pipes, and golf course water hazards.

THREATS:

- Habitat loss and degradation. Habitat is lost or degraded by development, stream diversion and alteration, and alien aquatic plants.
- Predation. Non-native predators, including invasive fish, frogs, ants, birds, and reptiles, consume this species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. For *Megalagrion xanthomelas* specifically, management needs include the following:

- Conduct surveys around known populations to determine threat levels and control needs.
- Conduct studies on life history and essential habitats to better direct conservation measures.
- Continue captive rearing to maintain rare populations.
- Continue reintroduction efforts to expand its range.
- Use these results to create a management plan for species recovery.

MONITORING: Periodically census populations in order to assess their stability and trends. Regularly monitor any reintroduction sites.

RESEARCH PRIORITIES:

- Survey for additional populations, in both historical and novel sites.
- Conduct studies to determine if reintroduction to additional sites is feasible.

References:

Polhemus DA, and Asquith AA. 1996. Hawaiian Damselflies: A Field Identification Guide. Bishop Museum Press, Honolulu, Hawaii.

Polhemus, D.A., W. Haines, and K. Bustamente. 2020. Field survey report: Lanai inland waters assessment, native damselfly baseline survey- Endangered Species Act. 36 pp.

U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; endangered status for 23 species on Oahu and designation of critical habitat for 124 species; final rule. Federal Register 77: 57648–57862.

U.S. Fish and Wildlife Service. 2021. Orangeblack Hawaiian Damselfly (*Megalagrion xanthomelas*) 5-Year Review Summary and Evaluation https://ecos.fws.gov/docs/tess/species_nonpublish/3400.pdf (accessed 17 Dec 2024).



Prognathogryllus sp.

Terrestrial Invertebrates

Crickets and Katydid Order Orthoptera

ORDER INCLUDES:
3 Native Families
10 Native Genera
269 Native Species

268 Endemic Species

GENERAL INFORMATION: Crickets and katydids are well-known because of their jumping and singing abilities. In general, members of the order are herbivores, but many species are omnivores. Some of the best examples of cryptic coloration and mimicry are found in this group, with some species being shaped like leaves or colored to match their background. The number of endemic Hawaiian cricket species is twice the number known from the entire continental United States, yet only four of the major Orthopteran groups (tree crickets, sword-tail crickets, katydids, and grasshoppers) are represented. The largest number of endemic species by far is found in the sword-tail crickets, Trigonidiidae, primarily the genera *Nudilla* (formerly *Laupala*, 37 species) and *Zudella* (formerly *Paratrigonidium*, 133 species). They are often abundant in forests, sometimes even in disturbed areas, and species are difficult to distinguish. Unlike most crickets, many species sing during the day. Another genus, *Caconemobius* (~13 species) consists of species found in rocky areas including shorelines, cliffs, lava flows, and caves. The cave species are very variable and probably in the process of speciating.

The tree crickets (Oecanthidae) are divided into two major groups: *Prognathogryllus* (37 species) are large, robust, and sing, while *Leptogryllus* (28 species) and *Thaumtogryllus* (5 species) are more slender with tiny wings, courting via scent instead of singing. Because they live higher in trees, they are much more often heard than seen. Katydids (Tettigoniidae) are represented by a single small radiation, the endemic flightless genus *Banza* (11 species), as well as the enigmatic long-winged *Conocephaloides remotus*. The latter is known from only six specimens, the last from 1941, and is likely extinct.

DISTRIBUTION: Crickets and katydids are known from all the MHI except for Ni‘ihau. There are also two species endemic to Nihoa in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. Tree crickets are difficult to survey due to their habit of staying close to the canopy, and others tend to be cryptic and difficult to catch despite their songs. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Crickets and katydids occur in a wide range of habitats including mesic and wet forests, rocky shores and lava flows, and caves. Cave habitats are highly sensitive to disturbance and changes in temperature and humidity, and are

dependent on tree roots growing through the roof of the cave. A number of introduced crickets inhabiting forests, lava flows, and shorelines have arrived in recent decades.

THREATS:

- Loss or degradation of habitat.
- Non-native invasive predators, parasitoids, and competing cricket species.
- Habitat-modifying non-native plants.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward crickets and katydids should include:

- Conduct surveys to determine distribution of known crickets and katydids and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Determine monitoring methods for assessing taxa not amenable to standard methods.
- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to determine the effects of non-native predators and parasitoids on species.
- Conduct systematic and taxonomic assessments of poorly known taxa.
- Work to identify and describe new species to science.
- Conduct studies to document the biology, habitat requirements, and life history of native species.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Otte D. 1994. The Crickets of Hawaii. Philadelphia: Orthopterists' Society.

Zimmerman EC. 1948. Insects of Hawaii: Volume 2, Apterygota to Thysanoptera Inclusive. Honolulu: University of Hawaii Press.

Terrestrial Invertebrates



Harrisoniella densa. Photo: Liliana Tobar.

Lice

Order Phthiraptera

ORDER INCLUDES:

2 Native Families
25 Native Genera
57 Native Species
5 Endemic Species

GENERAL INFORMATION: Lice are wingless external parasites of birds or mammals. Unlike other parasites, lice cannot live long if removed from their host. Eggs or nits are glued directly to the feathers or hair of hosts. Most lice rely on a single species to serve as a host. Lice are poorly known in Hawai‘i.

DISTRIBUTION: Lice are known from the islands of Hawai‘i, Maui, and O‘ahu, as well as the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Poorly understood. However, since Hawaiian lice are typically bird parasites, those habitats that support healthy populations of various bird species should support lice populations.

THREATS:

- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward lice should include:

- Conduct surveys to determine the distribution and abundance of known lice and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawaii Press.



Kilaueella sp. Photo: Brendan Wang.

Terrestrial Invertebrates

Bark lice

Order Psocoptera

ORDER INCLUDES:

6 Native Families

7 Native Genera

>93 Native Species

>90 Endemic Species

GENERAL INFORMATION: Most bark lice are scavengers or feed on lichen found on woody vegetation. Bark lice are an important food source for native birds and other insectivores. The largest number of endemic species occurs within the genera *Ptycta*, *Palistreptus*, and *Kilaueella*. The first two genera have been revised and contain 60 and 20 taxa respectively; however *Kilaueella* is still largely unknown, and a large number of undescribed species are present.

DISTRIBUTION: Bark lice are known from all the MHI except for Ni‘ihau and Kaho‘olawe. One unusual species is only known from Laysan in the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Unknown. Found mostly on woody vegetation. They are more abundant in some locations than others, but the habitat requirements of the native taxa are poorly studied.

THREATS:

- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward bark lice and psocids should include:

- Conduct surveys to determine the distribution and abundance of known bark lice and psocids and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Thornton IWB. 1981. The Psocoptera of the Hawaiian Islands. Parts I and II, Introduction and the nonendemic fauna. *Pacific Insects* 23(1–2):1–49.

Thornton IWB. 1985. The Psocoptera of the Hawaiian Islands. Part III The endemic *Ptycta* complex (Psocidae): Systematics, distribution, and evolution. *International Journal of Entomology* 26(1–2):1–128.

Thornton IWB. 1990. The Psocoptera of the Hawaiian Islands. Part IV. The endemic genus *Palistreptus* (Elipsocidae): systematics, distribution, and evolution. *Bishop Museum Bulletins in Entomology* 4:1–57.

Zimmerman EC. 2001. *Insects of Hawaii: Volume 1 Introduction*. Honolulu: University of Hawaii Press.

Photo not available

Terrestrial Invertebrates

Fleas

Order Siphonaptera

ORDER INCLUDES:

- 1 Native Family
- 1 Native Genus
- 1 Native Species
- 1 Endemic Species

GENERAL INFORMATION: Fleas are typically parasites feeding on the blood of their vertebrate hosts. Larvae are free-living and feed on organic matter. One native species is known in the Hawaiian Islands. *Parapsyllus laysanensis*, a seabird parasite, was described from Laysan albatross nest material and has also been found in wedge-tailed shearwater nests. This order is poorly known in Hawai‘i.

DISTRIBUTION: Hawai‘i’s single native species of flea is known only from Laysan Island in NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate.

LOCATION AND CONDITION OF KEY HABITAT: Unknown. However, habitats supporting breeding colonies of seabirds are likely key to this species’ survival.

THREATS:

- Loss of hosts and degradation of habitat for host species.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward *Parapsyllus laysanensis* should include:

- Conduct surveys to determine distribution of known *P. laysanensis* populations and to document and identify new species of Siphonaptera.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of this endemic species.

References:

Davies RG. 1988. Outlines of entomology. New York, (NY): Chapman and Hall. 408 pp.

Haas GE, Wilson N, Tomich PQ. 1972. Ectoparasites of the Hawaiian Islands, I. Siphonaptera. Contributions of the American Entomological Institute 8(5): 1-76.

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Zimmerman EC. 2001. Insects of Hawaii: Volume 1 Introduction. Honolulu: University of Hawaii Press.



Neurisothis saki. Photo: S. Chun.

Terrestrial Invertebrates

Thrips

Order Thysanoptera

ORDER INCLUDES:

- 2 Native Families
- ~7 Native Genera
- 3 Endemic Genera
- ~26 Native Species
- ~21 Endemic Species

GENERAL INFORMATION: Thrips are herbivorous, fungivorous, or predaceous, preying on insects and mites. Most species in Hawai‘i are herbivores, feeding on the tissues of living plants, however, understanding true reproductive host plants of species is very difficult. Some species are parthenogenic, capable of producing young without mating. Metamorphosis is intermediate and thrips rarely exceed four millimeters (0.2 inches). Some thrips are gregarious and found in large colonies. This order is poorly known and understudied in Hawai‘i. The genus *Neurisothis*, with 14 species, is the only endemic thrips genus in Hawai‘i that has significantly radiated. Seven other genera in the family Phlaeothripidae have between one and five species considered to be native, but their true status is unclear and they may be introduced species that are unrecognized in their native range.

DISTRIBUTION: Thrips are recorded from all the MHI except for Ni‘ihau and Kaho‘olawe.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the order are declining. Several native species have not been collected since their original description decades ago.

LOCATION AND CONDITION OF KEY HABITAT: Thrips occur in a variety of habitats ranging from dry, lowland areas to wet, high-elevation forests. Fungivores are more likely to occur in wetter habitats. Individuals are often found in flowers, on branches, on leaves, under bark, in leaf litter, and in other well-protected locations.

THREATS:

- Loss or degradation of habitat.
- Loss of host-specific plants.
- Predation or parasitism.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward thrips should include:

- Conduct surveys to determine the distribution and abundance of known thrips and to document and identify new species.

- Control of invasive predators, such as ants.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct systematic and taxonomic assessments of poor known and understudied taxa; review and revise taxa in need of scrutiny.
- Initiate efforts to locate and identify new species.
- Initiate studies to determine the effects of natural enemies on native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

- Mound L, Nakahara S, Tsuda DM. 2017. Thysanoptera-Terebrantia of the Hawaiian Islands: an identification manual. *ZooKeys* 549:71-126.
- Mound LA. 2020. Diversity in the Hawaiian endemic genus *Neurisoithrips* (Thysanoptera, Thripidae). *Zootaxa* 4779(2):215-229.
- Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.
- Zimmerman EC. 1948. *Insects of Hawaii: Volume 2*. Honolulu: University of Hawaii Press. 475 pp.
- Zimmerman EC. 2001. *Insects of Hawaii: Volume 1 Introduction*. Honolulu: University of Hawaii Press.



Photo: Gordon Smith, USFWS

Terrestrial Invertebrates

Kaua'i Cave Arthropods
Adelocosa anops
 (Kaua'i Cave Wolf Spider)

Spelaeorchestia koloana
 (Kaua'i Cave Amphipod)

SPECIES STATUS:

Federally listed as Endangered

State listed as Endangered

NatureServe Heritage Rank G1 - Critically imperiled

Draft Recovery Plan for the Kaua'i Cave Arthropods: the Kaua'i Cave Wolf Spider (*Adelocosa anops*) and the Kaua'i Cave Amphipod (*Spelaeorchestia koloana*) – USFWS 2004

Final Rule: Designation of Critical Habitat for the Kaua'i Cave Wolf Spider and Kaua'i Cave Amphipod Critical Habitat – USFWS 2003

SPECIES INFORMATION: Both the Kaua'i cave wolf spider and the Kaua'i cave amphipod were discovered in 1971, and both are known from less than a dozen caves on the island of Kaua'i. Although a few wolf spider species (order Araneae, family Lycosidae) have reduced eyes, the Kaua'i cave wolf spider has completely lost all vestiges of eyes; this trait justifies the species placement in the monotypic genus *Adelocosa*. Adult spiders are between 12 and 19 millimeters (0.5 to 0.75 inches) in length and are overall reddish brown in color. The species' life history is poorly known. Like all spiders, the Kaua'i cave wolf spider is a predator and actively stalks its prey using its sense of touch or chemoreceptors. The species likely feeds on the Kaua'i cave amphipod and non-native arthropods. Unlike other wolf spiders, the fecundity of the Kaua'i cave wolf spider is low.

Compared to other terrestrial amphipods (order Amphipoda, family Talitridae), the Kaua'i cave amphipod has unusual morphological attributes which justifies its placement in the monotypic genus *Spelaeorchestia*. Like the Kaua'i cave wolf spider, the Kaua'i cave amphipod is blind, although it does possess eyes. Adults are seven to ten millimeters (0.25 to 0.4 inches) in length and have a translucent appearance. The species is a detritivore and has been observed feeding on rotting roots, plant material washed into the caves, and frass (i.e., arthropod fecal material). Little is definitively known about the species' life history.

DISTRIBUTION: Found only on Kaua'i. Both are restricted to caves found in a 10.5 square kilometer (four square mile) lava flow. The Kaua'i cave wolf spider has been documented in six caves, but only regularly observed in one. The Kaua'i cave amphipod has been documented in nine caves, but only regularly observed in two. The amphipod also occurs in a limestone cave formed on top of the lava flow.

ABUNDANCE: Unknown. Currently, no survey methods exist to accurately estimate the population of either species. However, counts have never documented more than 30 spiders or 80 amphipods.

LOCATION AND CONDITION OF KEY HABITAT: Caves in a single exposed lava flow in the Koloa Basin with very rocky to extremely rocky soils, and free from erosional sediments. Both species are restricted to dark, moist areas of larger caverns and smaller subterranean spaces. The latter may be the primary habitat for both the spider and amphipod. Both species appear to require very high humidity.

THREATS:

- All the land supporting these species is privately owned. Activities associated with development and agriculture (e.g., removal of native vegetation, filling, and grading) degrade the delicate environments supporting the Kaua‘i cave wolf spider and Kaua‘i cave amphipod. Removal of vegetation results in a reduction of organic material that the amphipod feeds on and affects the humidity levels in the caves. Filling and grading increase the rate at which sediments fill the caves.
- Non-native competitors and predators.
- Droughts could alter the high-humidity environment that is required by the species and that also limits the establishment of non-native cave fauna.
- Human disturbance or visitation to the caves and the use of pesticides are serious threats to both species.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. Both species were listed as endangered in 2000. In 2003, the USFWS designated 106 hectares (272 acres) as critical habitat for both species. In addition to common statewide and island conservation actions, specific management directed toward Kaua‘i cave arthropods should include:

- Protect habitat from further loss or degradation, including above-cave habitats.
- Habitat enhancement or restoration including outplanting with native species to stabilize cave environments and increase food resources for cave fauna.
- Prevent the establishment of additional non-native invertebrate species and control existing non-native species that potentially limit cave arthropod populations.
- Conduct public outreach to increase public understanding of and support for both species.

MONITORING:

- Continue monitoring the status of known populations to better understand the abundance and distribution of both species.

RESEARCH PRIORITIES:

- Develop methods to survey populations that are accurate and minimize damage to fragile cave environments.
- Conduct surveys or initiate studies to determine local population sizes and movements of individuals.
- Identify additional populations of both species.

- Conduct studies to determine the most appropriate plants to restore above-cave habitats.
- Conduct studies to determine the factors that regulate cave humidity levels and how variation in humidity affects both species.
- Assess the feasibility of translocating individuals to suitable, but unoccupied caves.

References:

- U.S. Fish and Wildlife Service. 2003. Final Rule: designation of Critical Habitat for the Kauai cave wolf spider and Kauai cave amphipod. Federal Register 68(68): 17430–17470.
- U.S. Fish and Wildlife Service. 2004. Draft recovery plan for the Kaua‘i cave arthropods: the Kaua‘i cave wolf spider (*Adelocosa anops*) and the Kaua‘i cave amphipod (*Spelaeorchestia koloana*). Portland, (OR): U.S. Fish and Wildlife Service. 55 pp.



Ligia hawaiiensis

Terrestrial Invertebrates

**Pillbugs, Sowbugs,
Woodlice, Isopods**
Order Isopoda

ORDER INCLUDES:
5 Native Families
10 Native Genera
25 Native Species
24 Endemic Species

GENERAL INFORMATION: Pillbugs, sowbugs, woodlice, and isopods have a variety of feeding habits. They can be carnivores, herbivores, or scavengers. Females carry eggs until they hatch, and larvae are not pelagic. This order is poorly understood in Hawai‘i.

DISTRIBUTION: Pillbugs, sowbugs, woodlice, and isopods occur on all the MHI with the exception of Ni‘ihau, and on all the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means species within the order are declining.

LOCATION AND CONDITION OF KEY HABITAT: Terrestrial members of this order occupy a wide range of habitats including marine littoral zones, rain forests, and caves.

THREATS:

- Competition from non-native species.
- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward pillbugs, sowbugs, woodlice, and isopods should include:

- Conduct surveys to determine the distribution and abundance of known isopods and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny. Work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Brusca R. 1997. Tree of life project [Internet]. Available at:
<http://tolweb.org/tree?group=Isopoda&contgroup=Peracarida>.



Cave Lithobiomorpha (undetermined species).
Photo: Mike Slay/TNC

Terrestrial Invertebrates

Centipedes

Order Geophilomorpha

Order Lithobiomorpha

ORDERS INCLUDE:

5 Native Families

10 Native Genera

~9 Native Species

~8 Endemic Species

GENERAL INFORMATION: Centipedes (Class Chilopoda) have elongated and segmented bodies. Worldwide, there are five divergent orders of centipedes; only two occur in Hawai‘i (Geophilomorpha and Lithobiomorpha). Species in the order Geophilomorpha hatch with the full complement of adult legs and segments (i.e., epimorphic growth), females care for eggs and young, and individuals move very slowly. In contrast, species in the order Lithobiomorpha obtain additional segments and legs with each molt (i.e., anamorphic growth), females do not care for eggs or young, and individuals move very rapidly. Both orders are poorly understood in Hawai‘i. While around eight species considered possibly endemic to Hawai‘i, at least four have questionable origins and may be indigenous or possibly even adventive.

DISTRIBUTION: Centipedes are known from Kaua‘i, O‘ahu, Moloka‘i, Maui, and the island of Hawai‘i as well as the NWHI.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the orders are declining.

LOCATION AND CONDITION OF KEY HABITAT: Unknown. However, centipedes occur in diverse Hawaiian habitats from lava tubes to the summit of Maunakea.

THREATS:

- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward centipedes should include:

- Conduct surveys to determine the distribution and abundance of known centipedes and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Bonato L, Foddai D, Minelli JA. 2004. The centipede order Geophilomorpha in the Hawaiian Islands (Chilopoda). Bishop Museum Occasional Papers 78: 13-32.

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Bishop Museum Technical Report No. 22: iv + 310 pp.

Shelley RM. 1999. Centipedes and millipedes with emphasis on North America fauna. The Kansas School Naturalist 45(3). Available at: <http://www.emporia.edu/ksn/v45n3-march1999/intro.htm>.



Nannolene sp. (undescribed). Photo: Mike Slay

Terrestrial Invertebrates

Millipedes

Orders Polyxenida, Spirostreptida

ORDER INCLUDES:

- 2 Native Families
- 2 Native Genera
- >16 Native Species
- >16 Endemic Species

GENERAL INFORMATION: Most millipedes (Class Diplopoda) are detritivores (i.e., feeding on decaying organic material) and play a role in breaking down decaying plant material. A few species are carnivorous, and a few others eat moist, living plant material. Millipedes hatch from eggs and molt as they grow, obtaining more segments and legs with each molt (i.e., anamorphic growth). Millipedes do not bite, but many will emit poisonous or foul-smelling substances to deter predators. Of the 15 orders of millipedes found worldwide, only two are found in Hawai‘i, and both are poorly known.

DISTRIBUTION: Millipedes are known from all the MHI except for Ni‘ihau. An undescribed cave-adapted species has been found in lava tubes on Hawai‘i.

ABUNDANCE: Unknown. A lack of systematic surveys prevents any population estimate. However, the loss of native habitats likely means that species within the orders are declining.

LOCATION AND CONDITION OF KEY HABITAT: Mostly unknown. Several blind species inhabit caves. Other species occur along shorelines.

THREATS:

- Loss or degradation of habitat.
- Insufficient information for species assessments.

CONSERVATION ACTIONS: The goals of conservation actions are not only to protect current populations and key breeding habitats, but also to establish additional populations, thereby reducing the risk of extinction. In addition to common statewide and island conservation actions, specific management directed toward millipedes should include:

- Conduct surveys to determine distribution of known millipedes and to document and identify new species.
- Preserve, maintain, and restore habitats supporting existing populations.

MONITORING:

- Continue monitoring the status of known populations.

RESEARCH PRIORITIES:

- Conduct studies to document the biology, habitat requirements, and life history of native species.
- Conduct and support systematic and taxonomic assessments of poorly known and understudied taxa. Review and revise genera in need of taxonomic scrutiny; work to identify and describe new species to science.

References:

Howarth FG, Mull WP. 1992. Hawaiian insects and their Kin. Honolulu: University of Hawai'i Press.

Nishida GM editor. 2002. Hawaiian terrestrial arthropod checklist, 4th edition. Honolulu (HI): Biological Survey, Bishop Museum.

Shelley RM. 1999. Centipedes and millipedes with emphasis on North America fauna. The Kansas School Naturalist 45(3).