

5-YEAR REVIEW

Short Form Summary

Species Reviewed: *Drosophila heteroneura*
(picture-wing fly)

Current Classification: Endangered

Federal Register Notice announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2018. Endangered and threatened wildlife and plants; initiation of 5-year status reviews for 156 species in Oregon, Washington, Hawaii, Palau, Guam, and the Northern Mariana Islands. Federal Register 83(88): 20088–20092, May 7, 2018.

Lead Region/Field Office:

Region 12, Portland Regional Office/Pacific Islands Fish and Wildlife Office (PIFWO), Honolulu, Hawai'i

Name of Reviewer:

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John Vetter, Animal Recovery Coordinator, PIFWO
Megan Laut, Conservation & Restoration Team Manager, PIFWO

Methodology used to complete this 5-year review:

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office (PIFWO) of the U.S. Fish and Wildlife Service (Service) beginning in October 2019. The review was based on a review of current, available information since the last 5-year review for *Drosophila heteroneura* (USFWS 2012). The evaluation by Diane Sether, Invertebrate and Wildlife Biologist, was reviewed by John Vetter, Animal Recovery Coordinator, and Megan Laut, Conservation and Restoration Team Manager.

Background:

For information regarding the species' listing history and other facts, please refer to the Fish and Wildlife Service's Environmental Conservation On-line System (ECOS) database for threatened and endangered species at <http://ecos.fws.gov/ecp/>.

Review Analysis:

Please refer to the previous 5-year review for *Drosophila heteroneura* published in the Federal Register on August 28, 2012 (available at https://ecos.fws.gov/docs/five_year_review/doc4100.pdf for a complete review of the species' status, threats, management efforts, and references cited. We are not aware of any significant new information regarding the species' biological status since listing to warrant a change in the Federal listing status of *D. heteroneura*. The Recovery Outline for Hawaiian Multi-Island Species was published July 30, 2020 (available at https://ecos.fws.gov/docs/recovery_plan/SIGNED_Multi-Island_recovery_outline_07-30-2020_1.pdf). The Multi-Island Recovery Plan that includes *D. heteroneura* is scheduled to be developed and completed in 2021.

Drosophila heteroneura, in the family Drosophilidae, is a picture-wing fly endemic mesic and wet montane habitats on the island of Hawai‘i. Historically, the species was known from 24 sites on four of the island’s five volcanoes (Hualālai, Kīlauea, Mauna Kea, Mauna Loa). Currently the species is known from the mesic montane habitat in the Kukuioipa‘e and Ka‘ohe area of the South Kona Forest Reserve.

New Status Information:

- No new information on the distribution of *Drosophila heteroneura* has been received since the last 5-year review. Based on relatively extensive survey data from 1965 to 1999, the population of *D. heteroneura* has clearly declined (Kaneshiro 2005 in litt., entire). The species was recorded 760 times during surveys between 1975 and 1979. In the early 1980s, the first disappearance of a *D. heteroneura* population was recorded from the ‘Ōla‘a Forest in Hawaii Volcanoes National Park (Carson 1986, entire; Foote and Carson 1995, entire). Subsequently, the absence of the species was noted at several other locations in southern and western parts of the island where *D. heteroneura* had previously been relatively common. By the late 1980s, *D. heteroneura* was believed to be extinct until an extremely small population was discovered on private land at Hualālai Volcano in 1993. The species was not observed again until 1998 when eight individuals were observed (Kaneshiro 2005 in litt., entire). In 1999, a *D. heteroneura* population was recorded at the National Wildlife Refuge South Kona Hakalau Forest unit. At this South Kona site, over 134 individuals were observed from 1999-2001 (Foote 2005 in litt., entire). The most recent observations of the species were on the South Kona Forest Reserve at Kukuioipa‘e and Ka‘ohe area (Magnacca 2012 in litt., entire). In 2009, at an elevation of about 4,600 feet (ft) (1,400 meters [m]), five *D. heteroneura* females and five males were observed on a bait sponge. In 2010, at the same location, five females and four males were observed. The last observation of this population was made in 2011, when three females were observed at the 4,900 ft (1,495 m) elevation (Magnacca 2012 in litt., entire). Currently, the species appears to be limited to the South Kona area (Magnacca 2019 in litt., entire).
- The current population size or distribution of *Drosophila heteroneura* throughout its historic range is unknown. The species is believed to be extant in South Kona (Magnacca 2019 in litt., entire). It is possible the species survives in undocumented, isolated populations at other locations that have mesic to wet, montane habitats with suitable host plants (*Clermontia* spp., *Cheirondendron* sp., or *Delissea* sp.). Most of the historic areas have not been surveyed in the last 20 years.
- The complete genome of *Drosophila heteroneura* is now sequenced (Kang et al., 2016).

New Threats:

- Most of the mesic and wet montane habitats of *Drosophila heteroneura* have experienced prolonged periods of abnormally dry to extreme drought conditions for the past 20 to 30 years (NIDIS 2020). This has resulted in overall habitat degradation and appears to alter decay processes of the picture-wing fly host

plants' bark. Drought also alters the entire plant community on which the fly depends. 'Ōhi'a is an important tree in the mesic montane and wet montane habitats of *D. heteroneura*. Almost the entire 'ōhi'a canopy has died in the mesic montane habitats in the southern part of the Ka'u District, South Kona and on Hualālai over the past 20 to 30 years, due to the prolonged drought. This area of the island previously received most of its water input from fog interception by the tall 'ōhi'a trees, rather than rainfall (Magnacca 2012 in litt., entire).

- The plant disease, rapid 'ōhi'a death (ROD) is an ongoing threat to 'ōhi'a, an important canopy tree in the mesic and wet montane habitats of *Drosophila heteroneura*. This lethal disease of 'ōhi'a is caused by two fungal pathogens, *Ceratocystis lukuohia* and *Ceratocystis huliiohia* (Barnes et al., 2018, entire). *Ceratocystis huliiohia* is less aggressive and has been found on the islands of Kaua'i, O'ahu, Maui, and Hawai'i; *C. lukuohia* is highly aggressive and has been identified on the islands of Hawai'i and Kaua'i (Friday et al. 2020, entire; Heller et al. 2019, entire). Hundreds of thousands of 'ōhi'a have died from this fungus infection on the island of Hawai'i and ROD is present throughout the range and current habitat of *D. heteroneura*. (Friday et al. 2020, entire). Like drought, the loss of canopy allows more sunlight to reach the forest floor increasing the temperature and lowering the humidity, and subsequently, adversely affecting the picture wing fly and its habitat.
- Nonnative feral ungulates pose a threat to *Drosophila heteroneura* through destruction and degradation of the species' habitat and herbivory of its host plants. Regulatory mechanisms are inadequate to address this threat (USFWS 2006, p. 26842–26844). The State of Hawai'i provides game mammal (feral pigs and goats, axis deer, and mouflon sheep) hunting opportunities on State-designated public hunting areas on the island of Hawai'i (HDLNR 2015, pp. 19–21 and 66–77). The State's management objectives for game animals range from maximizing public hunting opportunities to support sustained yield in some areas to completely removing game animals by State staff, or their designees, in other areas (HDLNR 2015, entire).
- Picture-wing flies are adversely impacted by competition with several species of nonnative tipulid flies (large crane flies) in the family Tipulidae for larval host substrates. The larvae of nonnative tipulid flies feed within the decomposing bark of the host plants utilized by *Drosophila heteroneura* (Science Panel 2005, pp. 1–23; Magnacca 2005 in litt., entire). The nonnative crane fly, *Libnotes* sp. has become extremely abundant in *Cheirodendron* bark (Magnacca et al. 2008, p. 32). According to Magnacca et al. (2008), "It is not uncommon to bring a *Cheirodendron* branch into the lab to rear drosophilids, only to find that three weeks later all that remains between the outer bark and wood is limoniid frass." Though the impacts of this new *Libnotes* sp. has not yet been studied, the effect of tipulid competition, in general, is a reduction of available host plant material for the larvae of the picture-wing fly. In laboratory studies, Grimaldi and Jaenike (1984, pp. 1113–1120) demonstrated that competition between *Drosophila* spp.

larvae and other fly larvae can exhaust food resources, which affects both the probability of larval survival and the body size of adults, resulting in reduced adult fitness, fecundity, and lifespan.

- Changes in environmental conditions that may result from global climate change include increasing temperatures, decreasing precipitation, and increasing storm intensities. The habitats of *Drosophila heteroneura* are likely to be affected by changes in temperature, humidity, precipitation and the frequency and severity of storms (Clark et al. 2019, p. 11; Lowe et al. 2019, p. 13). These stressors may change the habitats on Hawai‘i and exacerbate other threats making the habitats unsuitable for the *D. heteroneura*, its host plants, or both. Climate change vulnerability is defined as the relative inability of a species to display the possible responses necessary for persistence under climate change (changes in rainfall and temperatures). Based on Fortini et al. (2013, pp. 69, 73) an assessment of the host plants at the species level concluded that the *Drosophilla heteroneura* larval host species vary in vulnerability to the impacts of climate change. On a scale of 0 being not vulnerable to 1 being extremely vulnerable to climate change, *Cheirodendron trigynum* ssp. *trigynum* has a vulnerability score of 0.126, *Clermontia* spp. had vulnerability scores between 0.0727 to 0.617, and *Delissea undulata* (now *Delissea argutidentata*) has a vulnerability of 0.593. Additionally, changes in temperature and humidity may alter the decay cycle of the host plant substrates the picture-wing flies require in order to breed.
- Parasitic wasps are a threat to *Drosophila heteroneura*. In 2014, an ichneumonid wasp, *Gelis tellenae*, emerged from what was believed to be a healthy, intact *Drosophila mulli* pupa (Magnacca 2014 in litt., entire). The parasitized pupa was collected from the Upper Waiākea Forest Reserve. The distribution of the parasitoid and the extent of the parasitization of other species of picture-wing fly, such as *D. heteroneura*, is not known. This wasp species is a previously undocumented threat. Several other species of small parasitic wasps (Family Braconidae), including *Diachasmimorpha tryoni*, *Diachasmimorpha longicaudata*, *Opius vandenboschi*, and *Biosteres arisanus*, were purposefully introduced into Hawai‘i to control nonnative pest tephritid fruit flies (Funasaki et al. 1988, pp. 105-160). These parasitic wasps are also known to attack other species of flies, including native flies in the family Tephritidae. While these parasitic wasps have not been recorded parasitizing Hawaiian picture-wing flies and, in fact, may not successfully develop in Drosophilidae, females will indiscriminately sting any fly larvae in their attempts to oviposit, resulting in mortality of the larvae (USFWS 2013, p. 64676). Because of this indiscriminate predatory behavior, nonnative parasitoid wasps represent a threat to *D. heteroneura*.

New Management Actions:

- In 2008, five units totaling 4,582 acres (ac) (855 hectares [ha]), of critical habitat was designated for *Drosophila heteroneura* (USFWS 2008, entire). Critical habitat Unit 1, located in the Ka‘u Forest, consists of 125 ac (51 ha) of wet montane ‘ōhi‘a forest, and is located on the southern slope of Mauna Loa.

Ranging in elevation between 5,215–5,510 ft (1,590–1,680 m), this unit is owned by the State of Hawai‘i, and is largely managed as part of a State Forest Reserve. General actions to manage rapid ‘ōhi‘a death and prevent ungulate damage to host plants have benefitted *Clermontia* spp. and subsequently, *D. heteroneura* if present.

- Critical habitat Unit 2, located on the National Wildlife Refuge, South Kona Section, consists of 3,604 ac (1,459 ha) of montane, mesic, closed koa and ‘ōhi‘a forest, and is located on the western slope of Mauna Loa on the island of Hawai‘i. Ranging in elevation between 2,980–5,755 ft (910–1,755 m), this unit is owned by the Service, and is managed as part of the Kona Unit of the Hakalau Forest National Wildlife Refuge. General actions to manage rapid ‘ōhi‘a death and prevent ungulate damage benefit *Drosophila heteroneura*, if present, and its *Clermontia* spp. hosts.
- Critical habitat Unit 3, located within the lower Kahuku section of Hawai‘i Volcanoes National Park, consists of 687 ac (278 ha) of montane, mesic to wet, ‘ōhi‘a forest, and is located on the southern slope of Mauna Loa. Ranging in elevation between 3,705–4,685 ft (1,130–1,430 m). Hawai‘i Volcanoes National Park is completing an environmental assessment for restoration work planned in the Kahuku section of the park. The restoration efforts include constructing boundary fences and removing feral ungulates, invasive plant control, and reforestation with native plants. *Clermontia lindseyana*, *Clermontia clermontoides*, *Clermonita hawaiiensis*, and *Clermontia montis-loa*, hosts of *Drosophila heteroneura*, are present in this section and are expected to benefit from the restoration actions. *Drosophila heteroneura* is historically known from these park lands, but no recent (in the last ≈20 years) surveys have been conducted specifically for the picture-wing fly species. The planned restoration actions in the lowland mesic Kahuku section are expected to improve the condition of the mesic forest that may house undocumented, isolated populations or future reestablishment of *D. heteroneura* populations.
- Large populations of *Clermontia* sp. a host of *Drosophila heteroneura*, have reestablished on the northeastern slopes of Mauna Loa near Pu‘u Maka‘ala and Kulani in the wet montane ‘ōhi‘a forest since ungulate fencing was installed (Magnacca 2019 in litt., entire). The host plants occur as understory vegetation beneath the canopy of ‘ōhi‘a and koa trees. Historically, *D. heteroneura* is known from the the northeastern slopes of Mauna Loa, though no recent surveys for the picture-wing fly have been conducted in this area. The presence of large populations of host plants provides an important resource for reestablishment of *D. heteroneura*.

Table 1. Known populations of *Drosophila heteroneura* from listing to this 5-year review.

Date	Populations	Individuals	Recovery Criteria¹
2006 listing	≤24 (based on surveys from 1965 to 1999)	unknown	N/A
2006 recovery outline	≤5	unknown	N/A
2008 critical habitat	≤5	unknown	N/A
2012 5-year review	≤5	unknown	N/A
2020 recovery outline	≥1	unknown	N/A
2020 species report	≥1	unknown	N/A
2020 5-year review	≥1	unknown	N/A

¹N/A=not available; the recovery plan and species-specific recovery criteria is currently under development and is expected to publish in 2021.

Table 2. Status of threats to *Drosophila heteroneura* and ongoing conservation efforts.

Threat	Listing Factor	Current Status	Conservation/Management Efforts
Ungulates	A	Ongoing	Partial—some strategic fencing is in place at the ‘Ōla‘a Small Tract of Hawaii Volcanoes National Park and Pu‘u Maka‘ala and Kulani in the ‘Ōla‘a Forest
Invasive nonnative plants	A	Ongoing	None
Fire	A	Ongoing	Partial—general fire management plans are in place for ‘Ōla‘a Small Tract, Forest Reserves, and the South Kona Wildlife Refuge, but fire load is an ongoing issue
Stochastic events (drought, hurricane)	A	Ongoing	None
Altered decay cycle of host plants	A	Ongoing	None
Predation by wasps	C	Ongoing	None
Predation by ants	C	Ongoing	None
Inadequate existing regulatory mechanisms	D	Ongoing	Partial—restrictions on transport of invasive species to the island are insufficient to prevent introduction of invasive species and diseases; regulatory mechanisms are inadequate to address the threat of ungulate destruction of <i>Drosophila heteroneura</i> habitat
Habitat altering plant disease	E	Ongoing	None
Loss of plant hosts	E	Ongoing	Partial; Large populations of <i>Clermontia</i> spp. have reestablished at Pu‘u Maka‘ala

Threat	Listing Factor	Current Status	Conservation/Management Efforts
			and Kulani due to fencing and ungulate removal;
Rats	E	Ongoing	None; rats prey on <i>Drosophila heteroneura</i> and the seeds, bark, and flowers of the picture-wing flies <i>Clermontia</i> spp. and <i>Delissea</i> spp. hosts
Limited numbers	E	Ongoing	None
Competition from flies	E	Ongoing	None
Climate change	E	Ongoing	None

Synthesis:

Drosophila heteroneura, a species of picture-wing fly, is a member of the family Drosophilidae. The species is endemic to the island of Hawai‘i where, historically, it was known to be relatively widely distributed from 24 locations, ranging in elevation from approximately 2,980 to 5,755 feet (ft) (908 to 1,754 meters [m]). The species has been recorded in the mesic to wet, montane habitats on four of the island’s five volcanoes (Hualālai, Kīlauea, Mauna Kea, Mauna Loa). The species now appears to be limited to the Kukuioipa‘e and Ka‘ohe section of the South Kona Forest Reserve where it was last observed in 2011, though this does not preclude the possibility that isolated, undocumented populations occur in suitable habitat with low threat levels. Though adult *D. heteroneura* are generalist microbivores feeding off decaying plant material, the species depends on decaying stems of *Cheirodendron* sp., *Clermontia* spp., and *Delissea* sp. as a host for oviposition and larval development. The loss or decrease in host plant resources and the degradation of habitat that meets the humidity needs of the fly and supports the decay cycle of the plant host threaten the existence of *D. heteroneura*. The limited populations of *D. heteroneura* make it vulnerable to catastrophic events such as fire, hurricanes, and volcanic activity. In addition, this picture-wing fly is threatened by predation from wasps and ants, parasitization from wasps, and competition for resources from crane flies. The lengthy and conspicuous lekking and courtship behaviors of the picture-wing fly and its relatively large size, leave the species vulnerable to predation by western yellow-jacket wasps. These wasps are also believed to feed upon picture-wing fly larvae within their host substrates. It is postulated *D. heteroneura* larva may be particularly vulnerable to predation because of the thin bark of *Clermontia* spp. Other nonnative wasps may indiscriminately sting the larvae of *D. heteroneura* resulting in its mortality. Because *D. heteroneura* larvae feed on decaying stems and bark and pupate in the soil, the larvae and pupae are vulnerable to predation by ants. In addition, competition for limited larval substrate with crane flies can exhaust food resources, which affects both the probability of *D. heteroneura* larval survival and the body size of adults. This can result in reduced adult fitness, fecundity, and lifespan of *D. heteroneura*. The plant hosts of *D. heteroneura* are particularly vulnerable to ungulate damage from grazing and trampling. Rats are known to feed on seeds, stems, and flowers of *Clermontia* spp. and may also predate picture-wing fly larva in the streams.

In summary, the primary factors that pose serious and ongoing threats to the species, its plant hosts, and its habitat range include the following: habitat degradation and destruction, nonnative ungulates and plants, drought, fire, predation, parasitization, competition for breeding resources, inadequate regulatory mechanisms to address nonnative species, natural disasters, limited numbers of populations and individuals, potential environmental changes, and the interaction of these threats. Due to the limited number of known populations and large number of unmanaged threats, this species best meets the definition of endangered. A recovery plan is expected to be completed in 2021.

Recommendations for Future Actions:

- Develop measurable downlisting and delisting criteria for the recovery of *Drosophila heteroneura*.
- Conduct surveys for extant populations throughout the range of *Drosophila heteroneura*.
- Monitor and assess abundance of individuals and growth trend of populations.
- Establish a captive rearing program for *Drosophila heteroneura*.
- Identify and prepare suitable habitats for translocation of picture-wing flies.
- Outplant populations of *Drosophila heteroneura* host plants in suitable habitats that can support the plant host and picture-wing fly.
- Protect existing host plants of *Drosophila heteroneura* from rats.
- Increase numbers of populations and individuals in suitable habitat through translocation to build resilient populations with redundancy and representation.
- Develop and implement fire management plans for all populations of *Drosophila heteroneura* and its habitat.
- Construct and maintain fenced exclosures to protect host plants of *Drosophila heteroneura* from the negative impacts of feral ungulates.
- Control feral ungulates that threaten *Drosophila heteroneura* and its hosts throughout the picture-wing flies' habitat.
- Control invasive, nonnative plant species that compete with the host plants in *Drosophila heteroneura* habitats.
- Identify new and emerging threats, such as *Gelis tellenae*, and determine their range and impact on *Drosophila heteroneura*.
- Develop and implement effective control methods for nonnative wasps at all *Drosophila heteroneura* and host plant populations.
- Develop and implement effective control methods for ants at all *Drosophila heteroneura* and host plant populations.
- Develop and implement effective control methods for crane flies at all *Drosophila heteroneura* and host plant populations.
- Develop and implement effective control methods for rats in the habitats of *Drosophila mulli* and its host plants.
- Intercept and control any new threats to *Drosophila heteroneura* before they become widespread.

- Develop fine-scale climate models to identify future suitable habitat based on existing and historical distributions and determine potential future climate conditions.
- Identify, develop, and support alliances and partnerships to plan and implement *Drosophila heteroneura* habitat restoration and management to benefit and recover the species.

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See previous 5-year review for a full list of references (USFWS 2012)

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**U.S. FISH AND WILDLIFE SERVICE
SIGNATURE PAGE for 5-YEAR REVIEW of
Drosophila heteroneura (picture-wing fly)**

Pre-1996 DPS listing still considered a listable entity? N/A

Recommendation resulting from the 5-year review:

- Delisting
- Reclassify from Endangered to Threatened status
- Reclassify from Threatened to Endangered status
- X No Change in listing status

Name of Reviewer:

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For Field Supervisor, Pacific Islands Fish and Wildlife Office

_____ Date _____