Picture-wing fly
(Drosophila musaphilia)

5-Year Review
Summary and Evaluation

U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
Honolulu, Hawaii

5-YEAR REVIEW

Species reviewed: Picture-wing fly (*Drosophila musaphilia*)

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5-YEAR REVIEW
Picture-wing fly/*Drosophila musaphilia*

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office:
Region 1, Endangered Species Program, Division of Recovery Jesse D'Elia, (503) 231-2349

Lead Field Office:
Pacific Islands Fish and Wildlife Office, Loyal Mehrhoff, Field Supervisor, (808) 792-9400

Cooperating Field Office(s):
N/A

Cooperating Regional Office(s):
N/A

1.2 Methodology used to complete the review:

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office of the U.S. Fish and Wildlife Service (USFWS), beginning on April 8, 2010. The review was based on the final rule to list 12 Hawaiian picture-wing flies, designation of critical habitat for 12 species of picture-wing flies from the Hawaiian Islands Final Rule, the Recovery Outline for 12 Hawaiian picture-wing flies, current published and unpublished materials and expert opinions and knowledge on the *Drosophila musaphilia* species. The draft five-year review was then reviewed by the Endangered Species Recovery Program Leader and the Assistant Field Supervisor for Endangered Species before signature by the Pacific Islands Fish and Wildlife Office Field Supervisor and transmittal to the Regional Office.

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; initiation of 5-year status reviews of 69 species in Idaho, Washington, Hawaii, Guam, and the Commonwealth of the Northern Mariana Islands. Federal Register 75(67):17947-17950.

1.3.2 Listing history

Original Listing
FR notice: [USFWS] 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(89):26835-26852.
Date listed: May 9, 2006
Entity listed: Species
Classification: Endangered

Revised Listing, if applicable
FR notice: N/A
Date listed: N/A
Entity listed: N/A
Classification: N/A

1.3.3 Associated rulemakings:

[USFWS] 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. Final Rule. 73(234):73794-73888.

Critical habitat totaling 794 acres (321 ha) was designated for *Drosophila musaphilia* in the Kokee region of northwestern Kauai island.

1.3.4 Review History: N/A

1.3.5 Species' Recovery Priority Number at start of this 5-year review: 5

1.3.6 Current Recovery Plan or Outline

Name of plan or outline: Recovery Outline for 12 Hawaiian Picture-wing Flies
Date issued: August 2006
Dates of previous revisions, if applicable: N/A

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

_____ ***Yes***
__X__ ***No***

2.1.2 Is the species under review listed as a DPS?

____ ***Yes***
_X__ ***No***

2.1.3 Was the DPS listed prior to 1996?

____ ***Yes***
____ ***No***

2.1.3.1 Prior to this 5-year review, was the DPS classification reviewed to ensure it meets the 1996 policy standards?

____ ***Yes***
____ ***No***

2.1.3.2 Does the DPS listing meet the discreteness and significance elements of the 1996 DPS policy?

____ ***Yes***
____ ***No***

2.1.4 Is there relevant new information for this species regarding the application of the DPS policy?

____ ***Yes***
__X__ ***No***

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

____ ***Yes***
__X__ ***No***

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

____ ***Yes***
____ ***No***

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery?

____***Yes***
____***No***

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:
A draft recovery plan for *Drosophila musaphilia* is being developed but was not published at the time of completing this 5-year review.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:
The general life cycle of Hawaiian *Drosophila* is typical of most flies: after mating, females lay eggs from which larvae (immature stage) hatch; as larvae grow they molt (shed their skin) through three successive stages (instars); when fully grown, the larvae change into pupae (a transitional form) in which they metamorphose and emerge as adults. Montgomery (1975) determined that the host plant for *Drosophila musaphilia* is koa, *Acacia koa*. The females lay their eggs upon, and the larvae develop in, the moldy slime flux (seep) that occasionally appears on certain trees with injured plant tissue and seeping sap. Defining the full range of *D. musaphilia* is difficult because its host plant, koa, is fairly common and stable within, and surrounding, the known range of *D. musaphilia* on Kauai; however, the frequency of suitable slime fluxes occurring on the host plant appears to be much more restricted and temporally unpredictable (Science Panel 2005). The koa slime fluxes are believed to have a short life of suitability for the adult *D. musaphilia* as a food source though suitability for larval development may be considerably longer (K. Kaneshiro *in litt* 2006). This is thought to be the result of slime flux environment changing due to the larval feeding activity within the slime flux.

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:
Bait can be used to survey for Hawaiian *Drosophila* but only to indicate the presence or absence of taxa. There is no technique currently available to uniquely mark individual flies and thereby quantify *Drosophila musaphilia* numbers (K. Magnacca *in litt*. 2010). In addition, Hawaiian *Drosophila* life cycles, are influenced by rainfall patterns and other environmental variables, making survey results difficult to compare over time and across sites.

Until surveys conducted in 2010, *Drosophila musaphilia* had not been observed during bait surveys since 1988. A total of 17 *D. musaphilia* observations have been recorded from 1968 to 2010. The number of surveys conducted, the number of surveys that had *D. musaphilia* observations, and the total number of individuals observed for each historical survey location and time period are summarized for surveys conducted from 1965 to 2011 (Table). The summary has been compiled from K. Kaneshiro, *in litt*. (2005), C. Campora, *in litt*. (2012) and K. Magnacca, *in litt*. (2012). The surveys were conducted with baits

comprised of fermented baby food and mushrooms that were infused with yeast and applied to a sponge left out overnight. In January 2010, two females and one male were observed, and in July 2010, one male was observed, on bait along the Nualoa trail in Kokee State Park (Magnacca *in litt.* 2012). One *D. musaphilia* was also observed March 25, 2010 in the Kokee region during surveys conducted on State lands and land under stewardship by the U.S. Navy (C. Campora *in litt*. 2012). This fly was observed on State lands at Site B, one of four U.S. Navy survey locations along Kokee Road. In this case, an *Acacia koa* slime flux was approximately 50 feet away from where the fly was observed in 2010. *Drosophila musaphilia* was not observed during subsequent surveys conducted at the same locations in Kokee in 2011. In 2011, the slime flux was dry (C. Campora *in litt*. 2012). The rarity in detection of *D. musaphilia* and the wide variability in detection of *Drosophila* species in general, complicate estimation of population abundance, structure, and demographics.

TABLE. Total number of surveys (first number), number of surveys with *Drosophilia musaphilia* fly observations (second number), and total number of *D. musaphilia* observed (third number) between 1965-2011 at in the Kokee and Halemanu, Alexander Reservoir and Waimea Canyon Road region of Kauai.

	Total No. surveys/No. of surveys with *D. musaphilia*/Total number of *D. musaphilia* observed		
Years	**Kokee/Halemanu**	**Alexander Reservoir**	**Waimea Canyon Road**
1965-1969	18/1/1	1/1/2	
1970-1974	9/2/6		
1975-1979	4/0/0		
1980-1984	4/0/0		
1985-1989	7/1/2		
1990-1994	2/0/0		1/1/1
1995-1999	7/0/0		
2009-2010	3/3/5		
2011	1/0/0		

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):
No new information is available.

2.3.1.4 Taxonomic classification or changes in nomenclature:
No changes in taxonomic classification have occurred. Hardy (1965) formally described *Drosophila musaphilia* from specimens collected at

Kokee, Kauai, in 1952. Although Hardy (1965) originally indicated that *D. musaphilia* is very similar to *Drosophila villosipedis*, more recent work indicates *D. musaphilia* is most closely related to *D. hawaiiensis* (Kaneshiro *et al*. 1995). *Drosophila musaphilia* is characterized by a predominantly black thorax with gray fuzz and a very narrow gray stripe extending down the top. The legs are dark brown to yellow, with the front tibia devoid of ornamentation, and the tips of the legs have abundant long, black hairs on top. The wings are three times longer than wide with characteristic markings of the *Drosophila hawaiiensis* group. The abdomen is dark brown to black and densely covered with brown fuzz. The body length is about 5.0 millimeters (0.2 inches) and the wings 5.25 millimeters (0.21 inches) long. A key to the characterized Hawaiian Drosophila species was developed by Magnacca & Price (2012) that clearly distinguishes *D. musaphilia* from other *Drosophila* species.

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):
Drosophila musaphilia is found only on the island of Kauai. The species is considered to be very rare, and in the absence of *Acacia koa* slime fluxes, is not likely found (Science Panel, 2005). The periodicity of the slime fluxes complicates monitoring the distribution pattern of the picture-wing fly.

Since *Drosophila musaphilia* was first identified in 1952, the species has only been observed 17 times from 1966-2011 during 57 different survey dates (C. Campora, *in litt*. 2012; K. Kaneshiro, *in litt*. 2005; K. Magnacca, *in litt*. 2012). Historically, *D. musaphilia* was known from only four sites, one at 579 meters (1900 feet) above sea level, and three sites between 790-1,130 meters (2,600-37,00 feet) above sea level. The best available information concerning the status of the species at these sites is as follows: (1) a single observation of *D. musaphilia* was recorded from one lowland, wet Ohia, *Metrosideros polymorpha*, forest site at Wahiawa (Alexander Reservoir) in 1968 (this population is believed to be extirpated); (2) at the Halemanu site, the species was observed in 1970 and last observed in 1972 but not in subsequent surveys as recent as 1996; (3) one individual was observed in 1968 at the Kokee (Nualolo Trail) site and not again during numerous surveys through 1999; then in 2010, a total of five individuals were observed in three surveys; and (4) one individual was observed in 1992 along the Waimea Canyon Road at an elevation of 790 meters (2,600 feet) (K. Kaneshiro, *in litt*. 2005).

The survey results from 2010 show *Drosophila musaphilia* presence in the historic Kokee range. Surveys in the other historical ranges have not been

conducted since 1968 (Alexander Reservoir), 1992 (Waimea Canyon Road), and 1996 (Halemanu).

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):
In accordance with section 3(5)(A)(i) of the Endangered Species Act and the regulations at 50 CFR 424.12, in determining which areas occupied at the time of listing to propose as critical habitat, we consider the Primary Constituent Elements (PCE) to be those physical and biological features that are essential to conserving the species and that may require special management or protection. The PCE for *Drosophila musaphilia* are: (1) mesic, montane, *Metrosideros polymorpha* (ohia) and *Acacia koa* (koa) forest between the elevations of 790–1,130 meters (2,600–3,700 feet); and (2) the larval stage host plant *A. koa*, which exhibits one or more life stages, from seedlings to senescent plants (USFWS, 2008).

A Final Rule establishing critical habitat for *Drosophila musaphilia*, went into effect January 5, 2009 (USFWS, 2008). Critical habitat designated *Drosophila musaphilia*-Unit 1-Kokee consists of 321 hectares (794 acres) of montane, mesic, *Acacia koa* and *Metrosideros polymorpha* forest, and is located in the Kokee region of northwestern Kauai. Ranging in elevation from 1,010–1,140 meters (3,310–3,740 feet), this unit is owned by the State of Hawaii and occurs on lands managed as part of a State park, forest reserve, and natural area reserve. According to the most recent survey data (K. Kaneshiro, *in litt*. 2005), this unit was occupied by *D. musaphilia* at the time of listing. This unit includes the known elevation range, moisture regime, and native forest components used by foraging adults that have been identified as the PCEs for this species. This unit also includes populations of *A. koa*, the larval stage host plant associated with this species.

One *Drosophila musaphilia*, was observed during surveys conducted by the U.S. Navy on state lands and lands under U.S. Navy stewardship in the Kokee region of Kauai, in March 2010 (C. Campora, *in litt*. 2012). The Pacific Missile Range Facility Integrated Natural Resources Management Plan includes measures to benefit *D. musaphilia* on the lands managed by the U.S. Navy that are adjacent to the designated critical habitat.

2.3.1.7 Other:

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

Lands with suitable habitat and the designated critical habitat units need management and control for feral ungulates, nonnative weeds, and fire. Additionally, suitable lands need management and enhancement of *Acacia koa* seeps and slime fluxes that will improve the *Drosophila musaphilia* flies habitat.

Drosophila musaphilia require a mix aged stand of *Acacia koa* and the presence of slime flux to complete their life cycle. Adult *A. koa* plants are fairly common and stable within, and surrounding, the known picture-wing fly-range on Kauai. However, the frequency of suitable slime fluxes occurring on the host plant appears to be much more restricted and temporally unpredictable (Science Panel 2005). Ungulate populations of pig, goat and black-tailed deer, inflict significant damage or mortality to *A. koa* through browsing, trampling, and uprooting. All three ungulate groups will feed upon *A. koa* seedlings, reducing regeneration of *A. koa* and number of available seedlings. Of the three feral ungulates, pigs are the most serious threat, followed by goats, and then black-tailed deer. Ungulate populations have not been eliminated or managed through fencing or lethal control. Additional knowledge on *A. koa* seep and slime flux distribution, occurrence, and relationship with *D. musaphilia* life cycle is also needed so that suitable habitat enhancement and ungulate management decisions can be made.

The invasion of several nonnative plants, particularly *Psidium cattleianum*, *Lantana camara*, *Melinis minutiflora*, *Rubus argutus* (prickly Florida blackberry), *Clidemia hirta*, and *Passiflora mollissima*, further contribute to the degradation of native forests and replacement of *Drosophila musaphilia* host plants. *Melinis minutiflora* is a grass that burns readily, often grows at the border of forests, and tends to carry fire into areas with woody native plants (Smith 1985; Cuddihy and Stone 1990). This invasive grass is able to spread prolifically after a fire and effectively out-compete less fire-adapted native plant species, ultimately creating a stand of nonnative grass where forest once stood. Invasive nonnative weeds have not been eliminated or effectively managed through hand removal, selective herbicide application, or other control methods to alleviate competition and reduce fire risk. Invasion by nonnative plants and the resultant increase in fire risk remains a significant threat to the mesic forests that *D. musaphilia* inhabits on Kauai.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Overutilization is not known to be a threat to this species.

2.3.2.3 Disease or predation:
Disease is not known to be a threat to any of the Hawaiian picture-wing

flies. However, predation by nonnative insects and other arthropods poses a grave threat to Hawaii's native *Drosophila*, through direct predation or possibly parasitism as well as competition for food or space (Howarth and Medeiros 1989; Howarth and Ramsay 1991; Howarth et al. 2001). Western yellowjacket wasps (*Vespula pennsylvanica*) and other nonnative insect predators and competitors, such as Argentine ant (*Iridomyrmex humilis*), pose direct threats to picture-wing flies. Management plans suitable for these predators in *D. musaphilia* habitats have not been developed.

2.3.2.4 Inadequacy of existing regulatory mechanisms:
Regulatory mechanisms remain inadequate for thorough protection of the species, particularly quarantine regulations pertaining to the prevention of accidentally introduced arthropods, and augmentation and introduction of biological control agents in Hawaii.

2.3.2.5 Other natural or manmade factors affecting its continued existence:
The lack of knowledge on seep and slime flux distribution and occurrence and the complex life cycle of *Drosophila musaphilia* impede quantification and analysis of population structure.

The effects of climate change on picture-wing flies and host-plant range will likely be significant. Life cycle characteristics such as length of larval period and adult longevity are highly dependent on temperature and other environmental factors affected by climate change. In general, stage length and longevity decrease with temperature increase. Fecundity and sex ratio can also be influenced by temperature. However, current climate change analyses in the Pacific Islands lack sufficient spatial resolution to make predictions on impacts to this species. The Pacific Islands Climate Change Cooperative has currently funded climate modeling that will help resolve these spatial limitations. We anticipate high spatial resolution climate outputs by 2013.

2.4 Synthesis

Hawaii picture-wing fly, *Drosophila musaphilia*, is an endangered endemic species found only on the island of Kauai. The females of the species lay eggs upon *Acacia koa* (koa), and the larvae develop in a slime flux that occasionally appears on certain trees with injured plant tissue and seeping sap. The frequency of suitable slime fluxes is temporally unpredictable and in the absence of slime fluxes, *D. musaphilia* is rare, making quantitative surveys challenging. Surveys rely on baiting which provides only presence or absence taxa data. Distribution of *D. musaphilia* is limited to the Kokee region of northwestern Kauai. Primary Constituent Elements (PCE) are the physical and biological features essential for the conservation of a species. PCE for *D. musaphilia* habitat are mesic, montane,

Metrosideros polymorpha and *A. koa* forest between the elevations of 790–1,130 meters (2,600–3,700 feet), presence of the host plant, *A. koa*, from seedling to senescent stage, and presence of suitable slime flux for larval development.

A Final Rule designating critical habitat for *Drosophila musaphilia*, went into effect January 5, 2009. The critical habitat designated *Drosophila musaphilia*- Unit 1- Kokee consists of 794 ac (321 ha) of montane, mesic, ohia and koa forest, and is located in the Kokee region of northwestern Kauai. Ranging in elevation from 3,310–3,740 ft (1,010–1,140 m), this unit is owned by the State of Hawaii and occurs on lands managed as part of a State park, forest reserve, and natural area reserve. This unit includes the known elevation range, moisture regime, and native forest components used by foraging adults that have been identified as the PCEs for this species. This unit also includes populations of *A. koa*, the larval stage host plant associated with this species.

According to the most recent survey data, this unit was occupied by *Drosophila musaphilia* at the time of listing. In 2010, four *D. musaphilia* individuals were observed in two surveys on the Nualolo Trail and one individual was observed during surveys on State land along Kokee Road. A slime flux was located approximately 15 meters (50 feet) away. In 2011, the same slime flux was dry and *D. musaphilia* was not observed in similar baiting surveys conducted in 2011. The general rarity of this species and dependence on the presence of slime fluxes which are highly variable and poorly understood, makes estimations of population demographics, abundance, and distribution difficult.

Current threats to *Drosophila musaphilia* are feral pigs, goats, and black-tailed deer which feed on seedling koa, reducing regeneration and impacting host plant age distribution. Invasive, non-native weeds compete with koa and increase risk of fire. *Drosophila musaphilia* is also threatened by invasive yellowjacket wasps and ants which prey on *Drosophila*. Climate change may significantly impact the life cycle characteristics of *D. musaphilia* and the range of its host plants. A draft recovery plan for this species is being developed.

Only 5 observations of *Drosophila musaphilia* have been reported since the species was listed as endangered under the Endangered Species Act. Threats are not being managed. Therefore, *D. musaphilia* meets the definition of endangered, as it remains in danger of extinction throughout its range.

3.0 RESULTS

3.1 Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
____ *Extinction*
____ *Recovery*

____ *Original data for classification in error*
__X__ **No change is needed**

3.2 New Recovery Priority Number:

Brief Rationale:

3.3 Listing and Reclassification Priority Number:
N/A
Reclassification (from Threatened to Endangered) Priority Number: ____
Reclassification (from Endangered to Threatened) Priority Number: ____
Delisting (regardless of current classification) Priority Number: ____

Brief Rationale:

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

1. Develop and implement a Recovery Plan.

2. Protect habitat and control fire, invasive weed, and ungulate threats.

3. Conduct additional research on *Acacia koa* slime flux periodicity and D*rosophila musaphilia* association.

4. Continue coordination efforts with the military on the development and implementation of Integrated Natural Resource Management Plans.

5. Survey and document predatory threats.

6. Develop and implement a systematic survey and monitoring plan.

7. Evaluate the need to re-establish wild picture-wing fly populations within their historical range.

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Signature Page
U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Picture-wing fly
(*Drosophila musaphilia*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: _____

Review Conducted By:
Diane Sether, Invertebrate Biologist
Jess Newton, Endangered Species Recovery Program Leader
Assistant Field Supervisor for Endangered Species

Approved Jess Newton for **Field Supervisor, Pacific Islands Fish and Wildlife Office** Date 8/28/2012