CHAPTER 7: *DROSOPHILA* SPECIES MANAGEMENT

7.1 BACKGROUND

Fourteen species of Hawaiian picture wing *Drosophila* flies are currently listed as threatened or endangered, and many more are equally rare. Six listed species are endemic to Oahu, and three – *D. montgomeryi*, *D. obatai*, and *D. substenoptera* – are currently known to occur on Army lands. OANRP work on *Drosophila* began in March 2013, focusing on monitoring known populations, surveying for new ones, and restoring habitat.

This year's surveys were significantly reduced compared to previous years due to unforeseen personnel issues, and were mostly limited to monitoring of existing sites. In addition, the El Nino weather pattern beginning in the summer of 2015, with a wet summer in leeward areas followed by a dry winter, has resulted in severely reduced *Drosophila* populations among both common and rare species.

7.2 SURVEY METHODS

Many species of Hawaiian *Drosophila*, including the picture wing group to which all of the endangered species belong, are readily attracted to baits of fermented banana and mushrooms. Both baits are spread on a cellulose sponge which is hung from a tree in a cool, shaded, sheltered site, and checked for flies after about one hour. Depending on the quality of the site (number and size of host plants, and microclimate) and the density of baiting spots, surveys typically consist of setting out 16-24 sponges, in groups of 4 or 8 with groups separated by 20-100 m. Baits are checked at least every hour, as flies do not necessarily stay at baits for long periods; number and species of all picture wings on each sponge are recorded at each check. The greatest activity is typically during the cooler hours before 10 AM and after 2 PM, but flies may appear at any time. Direct quantification of *Drosophila* populations is difficult, since populations may fluctuate not only seasonally but from day to day. However, repeated surveys can yield useful data on long-term trends. Abundance numbers are reported as the maximum number of individuals observed on a survey day (compiled by adding the maximum observed at each discrete group of bait sponges at any one time, assuming that the same individual flies may move between sponges within a group but are unlikely to be seen at two different groups), since numbers fluctuate through the day.

Known, significant populations of *D. montgomeryi* at Kaluaa MU and *D. substenoptera* at Palikea MU, where flies occur relatively consistently, are monitored monthly in order to determine approximate population trends through the year. For *D. montgomeryi*, Pualii (designated as a management site for *D. montgomeryi*) and Waianae Kai (not a managed population, but the largest known population) are monitored quarterly. Other known populations (Kaala and Lower Opaeula for *D. substenoptera*, Lihue and Manuwai for *D. obatai*) are visited periodically through the year, typically quarterly or less. New populations of endangered *Drosophila* were searched for by looking in similar habitat both in areas suggested by other staff as having host plants, at historic collecting localities, and in new sites where surveys have been minimal. Numbers of *Vespula pensylvanica* (western yellowjacket), a potentially serious invasive predator, are monitored at Palikea and Puu Hapapa with 10 heptyl butyrate baited traps at each site checked monthly.

7.3 RESULTS

7.3.1 *Drosophila montgomeryi*

Drosophila montgomeryi is a small yellow-brown species which breeds in rotting bark of *Urera kaalae* (endangered, very few wild trees left) and *Urera glabra* (opuhe, uncommon but found at many sites). It

Figure 1: Distribution of *Drosophila montgomeryi* observations in the 2015-16 reporting year and earlier records from 2009-15, with known *Urera* spp. sites and all survey points in the Waianae range.

is currently known from ten sites that are regarded as five population units (PUs), effectively covering nearly its entire historic range in the Waianae mountains (Figure 1). Field work this year has focused on monitoring known populations rather than searching for new sites (Table 1). The Lihue PU was not surveyed due to access issues. While *Urera glabra* occurs widely across the Waianae range, it often occurs as scattered clumps of a few or only one individual, unsuited for survival of *D. montgomeryi* and probably not viable for long-term survival of this dioecious, wind-pollinated tree.

Kaluaa & Waieli MU

Three sites in this MU – Puu Hapapa, North Kaluaa, and Central Kaluaa gulch 1 – have been monitored monthly since June 2013 (though not every site was visited each month) over a total of 54 survey days. In past years abundance of *D. montgomeryi* has followed a distinct seasonal pattern, increasing dramatically over the winter months to a peak between January and May (Figure 2), more or less in synchrony with several common *Drosophila* species. This is most likely due to increased rain and treefalls from storms that cause death or branch breakage of *Urera* near monitoring sites. During the 2015-16 sampling season, there was no such winter pulse in *D. montgomeryi*, with only relatively few scattered individuals. More appeared in the late spring and early summer before dropping out again. The common species *D. inedita* and *D. ambochila* did both have similar winter seasons as in previous years, although they did not reach as high abundance as usual.

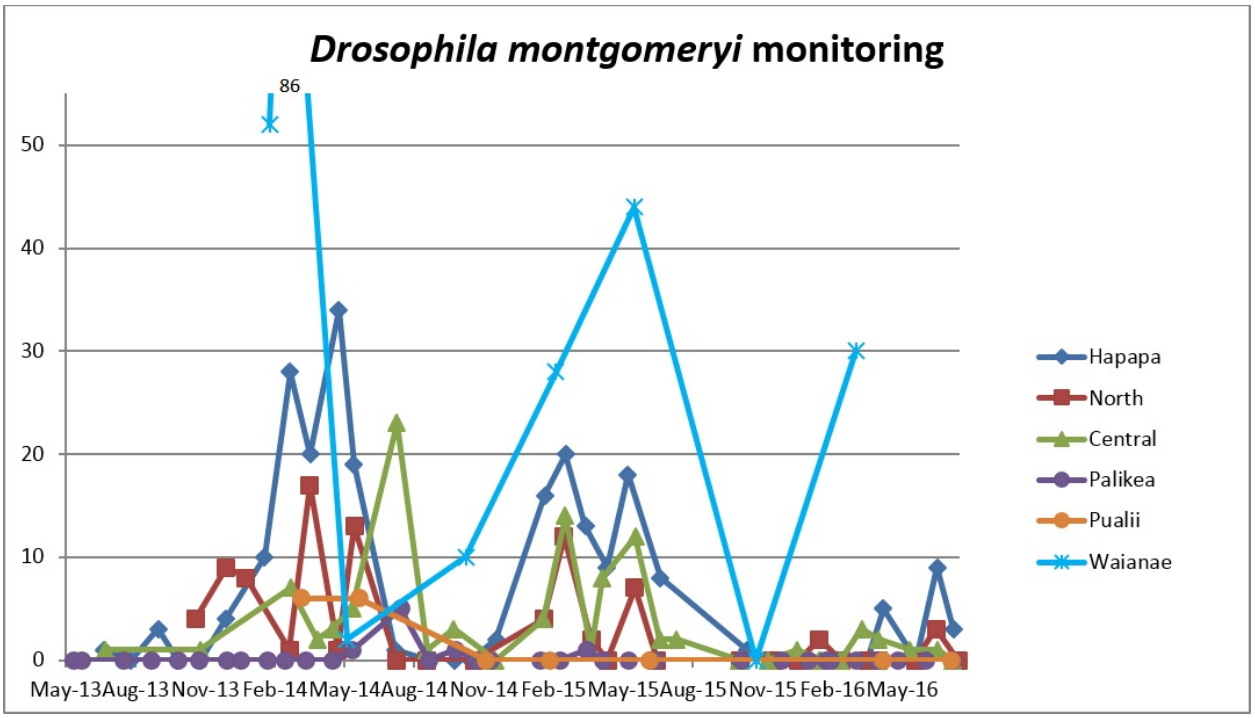

Figure 2: *Drosophila montgomeryi* numbers during monthly monitoring at three sites in Kaluaa PU (Puu Hapapa, North Kaluaa, and Central Kaluaa) and Palikea, and quarterly monitoring at Waianae and Pualii. Y axis is the maximum number observed across the entire site on the survey day (see Survey Methods, section 5.2).

Pualii

This site was visited for the first time in 2014, and quarterly monitoring began in 2015. At the time of the first visit, the last wild *Urera kaalae* tree in North Pualii Gulch had recently fallen and the decaying trunk was supporting a large number of *D. montgomeryi*. Unfortunately, the species has not been seen since the second visit there, and the survival of this population is uncertain. Only one of the original *U. kaalae* outplants remains, but at least 10 natural offspring of these plants have grown up, and several have now reached substantial height. This appears to be the only site where outplanted trees of this species are successfully reproducing. There are no *U. glabra* aside from recent outplants, which have not grown as much as those at other sites. Nevertheless, it is an area of high-quality native habitat, both in the immediate vicinity and further downslope in the gulch. It may be a potential reintroduction site after additional host plant restoration.

Palikea

Despite continuous monitoring here since May 2013 (targeting *D. substenoptera*, which is consistently found in the area), *D. montgomeryi* was not detected until May 2014. Three of the four records of *D. montgomeryi* here have been of single individuals, indicating that the population remains low. After a year of occasional sightings, it has not been seen here since March 2015. However, there are other patches of *Urera* around the Palikea MU that may also harbor populations of *D. montgomeryi*. The area where they were found is already a target for weed management and restoration, and has high potential for management to benefit *D. montgomeryi*. *Urera kaalae* was absent (many have been planted in the past year), but *U. glabra*

Site	Days	Max No.
Kaluaa - Central	10	3
Kaluaa - North	9	3
Puu Hapapa	9	9
Pualii	3	0
Palikea	9	0
Waianae	2	30
Ekahanui	1	0

Table 1: Survey effort for *D. montgomeryi* across all potential sites in 2015-16 reporting period, in survey days. "Max No." is the highest number of flies observed in a single day.

had already begun to increase naturally as weed control reduced alien cover, and outplanting has significantly boosted the population. Outplanted *U. glabra* here has done exceptionally well – many of them are 6–8 feet tall after only 18 months.

Waianae Kai

The largest known population of *D. montgomeryi* occurs in the northeastern subgulches of Kumaipo stream, Waianae Valley. Three sites have been discovered so far, all at the base of Mt. Kaala and consisting of small patches (~0.5 ha) of diverse native forest constrained by alien-dominated vegetation above and below. All are located on or just below steep slopes that are vulnerable to landslides, which may preclude fencing as a matter of practicality. A fourth was discovered this year, but it has been surveyed only once under unfavorable conditions and it is uncertain whether *D. montgomeryi* occurs there. However, being on a ridge it may be more amenable to fencing and protection of the habitat from pig damage which is severely impacting the other sites. Gulches to the west of the known sites were surveyed and found to contain no *Urera*; however, the area to the east in Hiu Gulch has yet to be checked, and there may be additional sites in the area.

Habitat restoration

This was the second year of active habitat management for *Drosophila montgomeryi*. Last year, approximately 50 *U. glabra* grown from cuttings were planted at each of North Kaluaa, Pualii, and

Figure 3: Habitat restoration for *D. montgomeryi* at Palikea. The photos in each column were taken from the same viewpoint on opposite ends of a clearing where invasive plants had been removed (October 2014) and *Urera glabra* and other natives planted in February 2015.

Palikea, and 35 at Central Kaluaa, between November 2014 and April 2015. In December 2015, an additional 35 *U. glabra* were planted at Central Kaluaa, and 25 *U. glabra* and 50 *U. kaalae* at North Kaluaa (see Restoration section for details). Approximately 50 *U. kaalae* each were also planted at Palikea, Central Kaluaa, and Pualii by the OPEPP program. All sites are exhibiting high survivorship (87–100%) and good growth, especially Kaluaa and Palikea (Figure 3). Observations of some individuals suggests that pruning of tip shoots of *U. glabra* may promote extremely vigorous growth of side branches and ultimately larger, more robust trees that will be better habitat for flies in a few years.

In May 2016, the alien fungal pathogen mamaki rust (*Pucciniastrum boehmeriae*) was first noticed and on *Urera kaalae* (Figure 4), and positively identified by HDOA. Although it manifests differently than in mamaki (*Pipturus albidus*), without any scorching or wilting of the leaves, the leaves are much more heavily covered in fungal spores and may fall off easily. The full effect of the rust is as yet unknown. Although present at all sites, the burden as determined by visible spores is highly variable: North Kaluaa and Pualii have very little, Central Kaluaa and Palikea a moderate amount, and Puu Hapapa is severely affected. Most of the large *U. kaalae* at Puu Hapapa died or had heavy branch dieback over the winter of uncertain causes; while it was quite dry, it is possible that rust infection contributed to the losses.

Figure 4: Underside of a *Urera kaalae* leaf at Puu Hapapa, showing a dense covering of yellow urediniospores characteristic of heavy mamaki rust (*Pucciniastrum boehmeriae*) infection.

7.3.2 *Drosophila substenoptera*

Surveys for this species have focused on finding new populations. Based on collection records, it requires moderately tall, non-boggy wet forest with its host plants, *Cheirodendron* sp. (olapa) and *Polyscias*

Figure 5: Distribution of *Drosophila substenoptera* observations in the 2015-16 reporting year and earlier records from 2013-15.

(=*Tetraplasandra*) *oahuensis* (ohe mauka), a habitat which is relatively uncommon since these trees tend to occur most abundantly in short-stature forest near summit crestlines. Currently, there are three known PUs for *D. substenoptera* – Palikea, Kaala-Kalena, and Opaeula (Figure 5). PU trends are only graphed for Palikea as the other two PUs have insufficient numbers of survey days. At other sites *D. substenoptera* is highly sporadic, typically occurring as single individuals observed only once during a day. This rarity has undoubtedly hampered our ability to detect it at new sites.

Waianae Range

Monthly monitoring in the northern portion of Palikea MU has been ongoing since May 2013 (33 survey days total, 9 in the current reporting period; Table 2). Aside from a large flush in late May 2013, numbers of *D. substenoptera* and another endangered species, *D. hemipeza*, have been consistently low, but they have always been present. In contrast to *D. montgomeryi*, abundance of *D. substenoptera* tends to increase in the summer rather than winter, somewhat correlated with *D. hemipeza* and the common *D. crucigera* but not *D. punalua* (Figure 6). At the Kaala-Kalena PU, three new sites were surveyed (Kalena summit ridge, Kaala transect, and Kaala northeast face). No flies were found, but the Kaala sites are promising and will be revisited.

Site	Days	Max No.
Palikea	9	5
Kaala	5	0
Lihue	1	0
Koloa	2	0

Table 2: Survey effort for *D. substenoptera* across all potential sites in 2015-16 reporting period, in survey days.

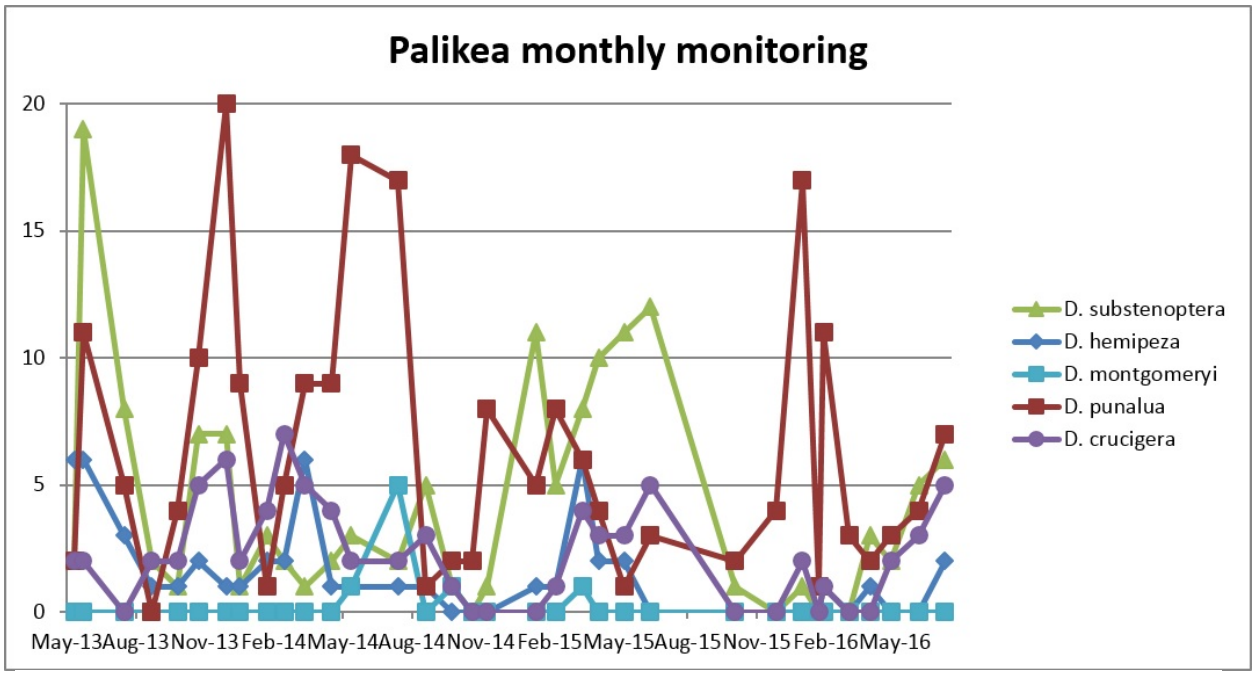

Figure 6: Monthly monitoring results for all species at Palikea, from May 2013 to July 2015.

Koolau Range

In December 2013, a single *D. substenoptera* was observed at Lower Opaeula MU, the first record of the species in the Koolau range since 1972. In early 2015, it was sighted again in the same area. Historically, *D. substenoptera* was more widespread and abundant on this side than in the Waianae range. However, collection effort has been limited due to the difficulty in accessing areas of intact habitat for this species. OANRP surveys in the Koolaus for *D. substenoptera* have been relatively few due to higher priorities elsewhere, and concentrated in only a few sites. Surveys this year at Koloa did not find any of this species. Finding additional Koolau populations is a high priority for this species; Helemano, Poamoho, and Kaukonahua have yet to be surveyed. Lower Opaeula and Koloa will continue to be checked given the extremely high quality of habitat there and low observation rate at sites where *D. substenoptera* is known to be present. Appropriate breeding habitat, of taller non-boggy forest, is surprisingly limited given the wide distribution of *Cheirodendron* on other islands under similar climatic conditions, and often occurs only on steep slopes or in the bottom of drainages that are weedy and difficult to access.

7.3.3 *Drosophila obatai*

Drosophila obatai was rediscovered in Manuwai Gulch MU in 2011, 40 years after the previous record in 1971. It breeds in rotting stems of *Chrysodracon* (=*Pleomele*) spp. (halapepe), which suffers from very low reproduction rates but remains widespread in the northern Waianae range thanks to its longevity. It is currently known from seven sites in four potential PUs (Makaleha, Manuwai, Palikea Gulch, and Pulee), although three of these are within 1,200 m of each other and could potentially form one contiguous population. While it almost certainly was contiguous until recently, native forest in general and *Chrysodracon* in particular is now much more fragmented, and moving between patches of host trees more difficult for the flies.

Site	Days	Max No.
Manuwai	1	0
Lihue - Mohiakea	1	0

Table 3: Survey effort for *D. obatai* across all potential sites in 2015-16 reporting period, in survey days.

Surveys for *D. obatai* in 2015-16 were few due to the limited survey time available and a focus on monitoring *D. montgomeryi* (Table 3). Only Manuwai and South Mohiakea were visited, and no

Figure 7: Distribution of *Drosophila obatai* observations from 2013-15, with known *Chrysodracon* spp. sites and all survey points in the Waianae range.

D. obatai were found. Given the lack of records even at Manuwai, where it has recently been most common, and the already-perilous state of this species, the upcoming year will focus more heavily on finding new sites and establishing its continued presence at previous ones.

7.3.4 Other Rare *Drosophila*

During the course of surveys, four additional rare *Drosophila* were found in management units where *D. montgomeryi* and *D. substenoptera* occur (Table 4). A fifth, *D. craddockae*, was found at Makua. Most of the rare species that had been found in previous years were not seen this year, due to the generally poor conditions (dry winter and wet summer) and reduced survey effort.

Table 4: Non-target rare *Drosophila* observed during surveys, July 2015–June 2016.

Species	Sites	Total Obs.	Max. No.
D. craddockae	Ohikilolo	2	2
D. divaricata	Kaluaa, Hapapa	25	5
D. hemipeza	Palikea, Hapapa	2	1
D. nigribasis	Kaala	10	5
D. oahuensis	Kaala, Koloa	12	4

Drosophila craddockae is closely related to *D. pullipes* of Hawaii and *D. grimshawi* of Maui Nui. Like the former, it is a specialist on *Wikstroemia* spp., an unusual host. While its host is abundant, *D. craddockae* is rarely observed, and has been found only sporadically at widely separated localities in recent years. Only two were seen, at the same time at Ohikilolo. This is a new site record for the species, the sixth in our surveys.

Drosophila divaricata is closely related to the more common *D. inedita*, but can be easily distinguished by its much larger size and slightly different wing pattern. The host plant is unknown. It has generally been rare, but was observed regularly in North Kaluaa, and occasionally at Central Kaluaa and Puu Hapapa in 2015–16.

Drosophila hemipeza is the only listed endangered species on Oahu that is known to be extant but does not occur on Army lands or OIP/MIP action areas, although it historically occurred at Kahuku Training Area and West Makaleha Gulch adjacent to Makua. It has been consistently found at Palikea MU but always in low numbers for several years; occasional individuals have shown up at Puu Hapapa as well. Only two were seen this year, both at Palikea.

Drosophila nigribasis breeds in *Cheirodendron*; it is related to *D. substenoptera* but appears to favor wetter habitats. In our surveys, it is restricted to Koloa and the vicinity of Kaala summit.

Drosophila oahuensis is also a *Cheirodendron* breeder, and appears to span the habitat range of *D. nigribasis* and *D. substenoptera*, including both the near-summit area of Kaala and wet-mesic sites such as North Haleauau Gulch in Lihue. The majority of both *D. nigribasis* and *D. oahuensis* came from one site on the west side of Kaala.

Drosophila craddockae, widespread but extremely rare and sporadic.

Drosophila divaricata, restricted to Honouliuli in the southern Waianae range.

Drosophila hemipeza, very similar to *D. substenoptera* and also often seen waving its wings.

7.3.5 *Vespula pensylvanica*

This highly invasive social predatory wasp is considered a major factor in the decline of picture wing *Drosophila* on Maui and Hawaii. Little is known of its impacts on Oahu, where it is present but much less conspicuous. The typical life cycle of a yellowjacket colony consists of an individual fertilized queen starting a nest in the spring, building up numbers of workers slowly at first but with exponential growth, peaking in the fall when new reproductives (males and the next generation of queens) are produced. After the reproductives leave the colony it typically declines and the workers die off, but in warm climates such as Hawaii they may persist through the winter and grow to an exceptionally large size during a second summer, with tens or hundreds of thousands of workers.

Numbers at the two sites sampled are relatively modest compared to upper elevations of Hawaii or Maui. Still, they show a significant number of *Vespula* present at both during the summer, coinciding with the low period of *Drosophila* numbers. It is unclear if there is any causal relationship; *Vespula* numbers so far in 2016 have gone higher earlier at Palikea but remain zero at Hapapa, which is similar to the numbers of *Drosophila* seen (and thus unexpected since the relationship would be inverse if *Vespula* are limiting *Drosophila* numbers).

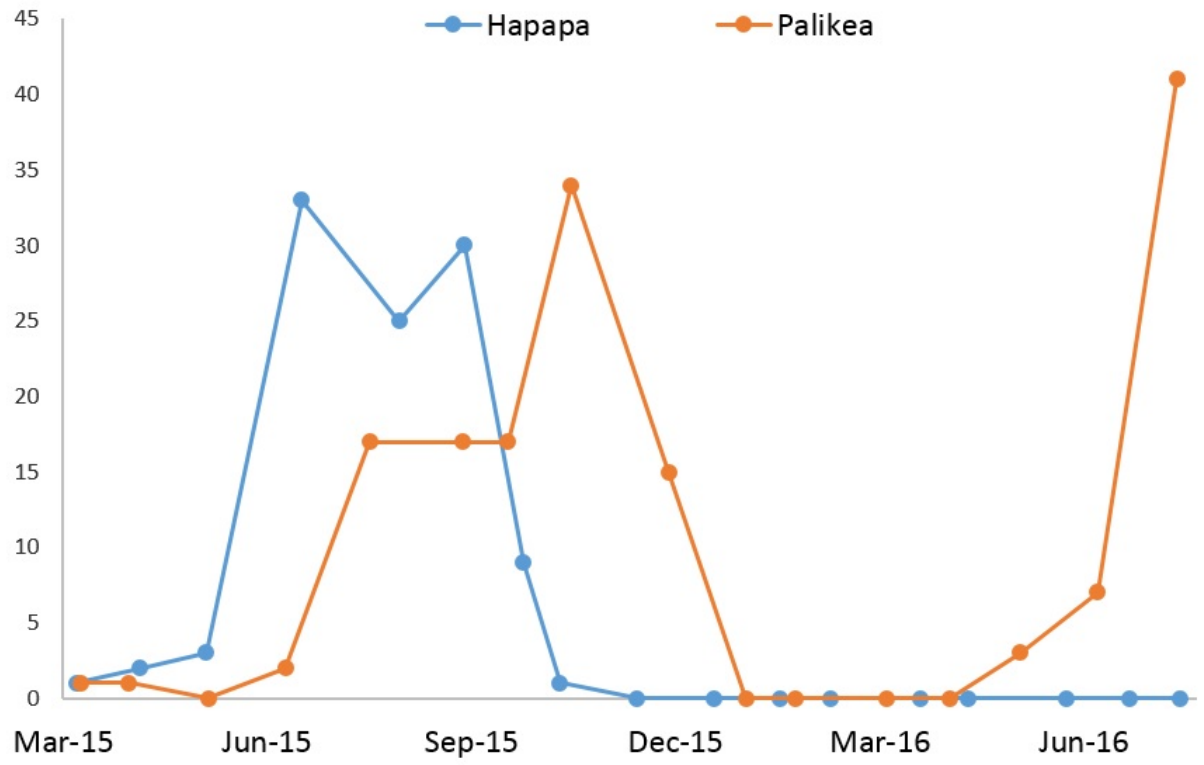

Figure 8: *Vespula pensylvanica* numbers at Palikea and Puu Hapapa (monthly total across 10 traps at each site).

We plan to continue monitoring at Palikea and Hapapa, since the current regime of maintaining 10 traps at each site can be done in conjunction with the monthly fly monitoring without additional effort. No other sites have both significant *Drosophila* populations and relatively open canopy suited to *Vespula* monitoring. At present, there are no plans to conduct control of *Vespula*, but this may be considered if populations increase in the future.