DROSOPHILA POPULATIONS IN THE OLA'A TRACT, HAWAII VOLCANOES NATIONAL PARK, 1971-1986

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INTRODUCTION

Hawaii has an enormous fauna of flies of the family Drosophilidae. Hardy and Kaneshiro (1981) listed 508 described species of which only about 26 are exotic species, introduced recently into the islands (Titus et al. 1985). Many new endemic species exist in collections but remain to be described.

This large fauna includes about 120 species of a group commonly called the "picture-wings"; approximately 26 of these are endemic to the island of Hawaii. Of the latter, 18 have been recorded within the confines of Hawaii Volcanoes National Park where they breed on natural substrates provided by the endemic plants (Carson 1976). The breeding site of each species tends to be somewhat host-specific and females of these species do not oviposit on introduced plants or fruits. Fortunately for the geneticist, most species can be tricked into ovipositing in the laboratory, particularly by offering them extracts or small bits of host plants. Rearing the larvae to adults ordinarily presents no problem. In 1971-72, a series of census counts of picture-winged species were carried out in the Ola'a tract in the Park, especially as accessed from the Wright Road. Such censuses were renewed in 1980 (see Carson 1982a) and have been continued up to the present time. The purpose of the present paper is to expand the 1982 abstract and compare the results of collecting in the past five years with the data from fifteen years ago in order to assess the possibility of long-term changes in population sizes or species composition.

MATERIALS AND METHODS

Although the picture-winged species are large and conspicuous flies, they are always scarce and hard to find. Each specimen is ordinarily captured individually by locating it in nature and then imprisoning it under a 95 x 25 mm shell vial. The vegetation in the vicinity of host plants is searched for flies resting in natural positions. Each collector works alone in an assigned area and catches all specimens that are seen. To aid in the process, baits are used. One collector on one morning or afternoon will distribute about 250cc of fresh fermented banana mash in small aliquots at eye level at about 20 spots on tree trunks, vines or the rachises of tree ferns. The area covered by a single collector is

roughly a circle about 40 m in diameter, or the equivalent in linear extent. Since 1980, each collector has been expected to deploy 8-10 thin plastic sponges that have been saturated with commercial mushrooms that have been fermented for about a week with baker's yeast (Kaneshiro et al. 1977). These are attached to the vegetation by push-pins. Once these baits are in place, the collector circulates through his or her area for two or three hours, collecting all specimens. At the end of this time, the flies obtained by all collectors in the general area are brought together, counted and identified as to species. A simple statistic, "picture-wings per man-hour of collecting" is calculated. In recent years, most of the specimens have been released again into the forest as a conservation measure.

In evaluating the comparison between the earlier collections and the later, it should be borne in mind that the technique of baiting with mushrooms was not used at all in the 1970's. It is very effective and probably doubles the efficiency of collection.

RESULTS AND DISCUSSION

The facts of the various censuses are given in Figures 1 and 2. In the one year from April 1971 through February 1972, a total of 1222 flies were caught; mean collecting success was 9.6 specimens/man-hour. The heavy collections in the second half of the year have not been equalled at any later time, despite the use of the efficient mushroom technique. In 1971-72, however, there were a number of windfalls of very large Metrosideros trees and much of the collecting was done near these falls. Each Metrosideros in this area is a giant vegetational complex, emerging way above the tree ferns, with quite large specimens of many other substantial tree-species (Cheirodendron, Clermontia, Myrsine, etc.) growing on the host tree epiphytically. Most of the collecting was done at that time by collectors clambering in, around and underneath the windfall, collecting many specimens without necessary recourse to baits. There have been fewer such windfalls in this area in the last five years and this method of collecting has not been often employed.

In the five years 1981-1985, 1467 specimens were captured, at the rate of 8.2/man-hour. This does not appear to be a very different rate from the period fifteen years earlier. Figure 1 depicts the number of picture-wings per man hour over the period of study. Several clear points emerge. First, the extensive drought period of 1981-82 and a later one in 1984 appear to be reflected in a reduced number of flies being found during the following year. The rather long lag period reflects the fact that the flies of these cool forests are rather long-lived as adults and have rather long life-cycles. The fluctuations in flies per man-hour from month to month probably reflect the fact that most species have rather abrupt, non-cyclic flushes of abundance. This is probably due to sudden exposure of breeding sites, as, for example, when branches are broken during a windstorm, providing decaying plant material to oviposition by the flies.

Whereas the overall abundance of flies seems not to have changed,

Figure 1. Population size estimates for fourteen "picture-winged" Drosophila species at selected sites in the Ola'a Tract along Wright Road. LAST S,H: last specimens of D.silvestris and heteroneura collected. WASP: first appearence of Vespula pennsylvanica. STORM: occurrence of a major defoliating windstorm.

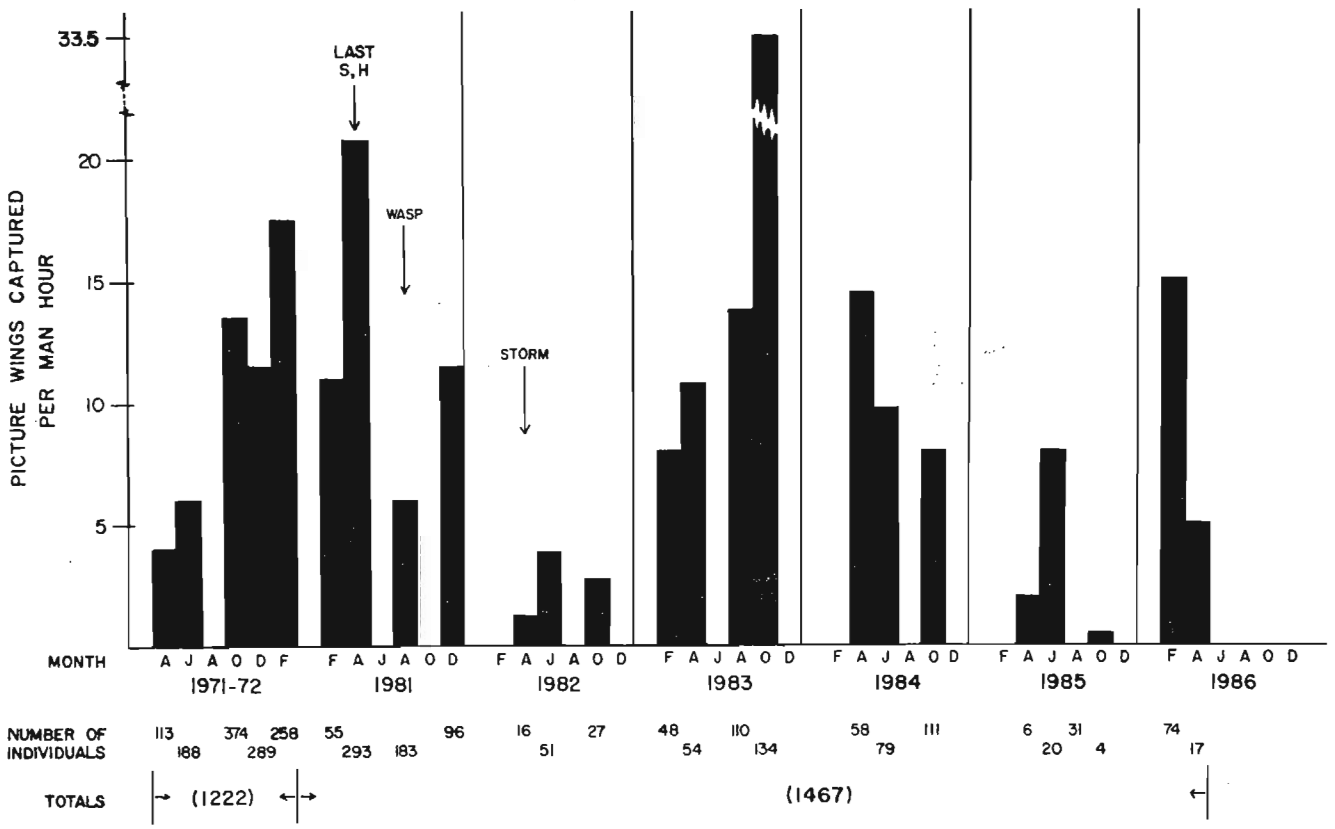
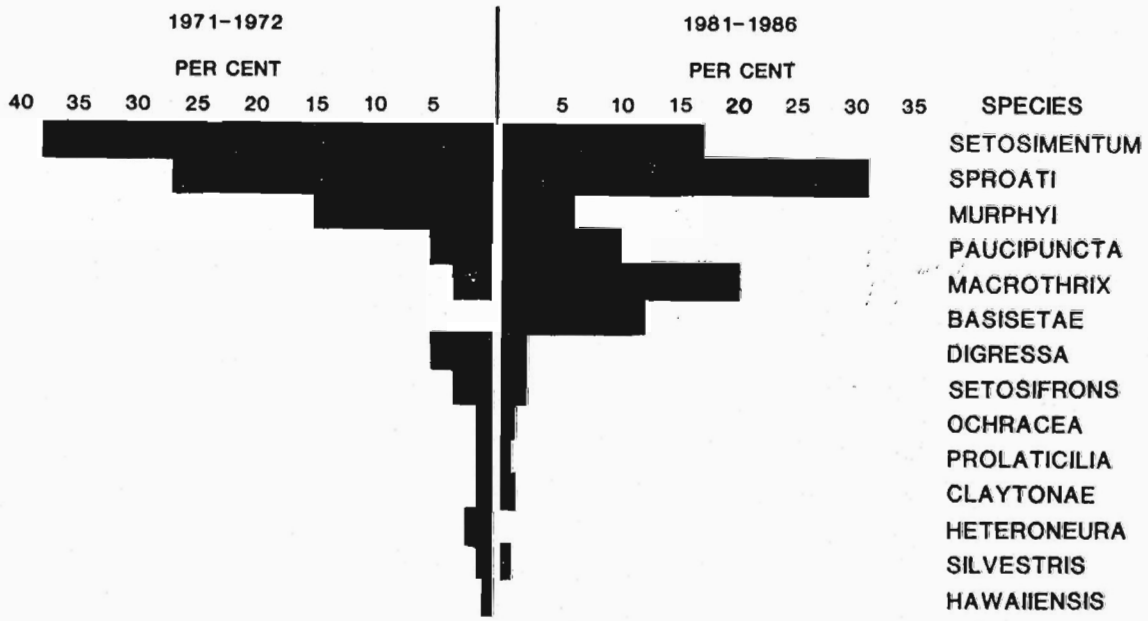


Figure 2. Frequencies, in per cent of all flies collected, of 14 species of "picture-winged" Drosophila species collected at the Ola'a Tract along Wright Road. Collections in 1971-1972 (left) are compared with those made in 1981-1986 (right).



when one compares the collection records for individual species composition, an interesting set of facts emerge (Figure 2). Although sproati , a Cheirodendron breeder, is about equally abundant in the two time periods, murphyi, and setosimentum are only about half as abundant in the later period as in the earlier one. Both breed primarily on Clermontia, a fact that may be significant in view of the apparent decline of some major species of this genus. D.basisetae and macrothrix have increased; the breeding site of the former is unknown but the increase of the latter is probably an artifact, in that many of the recent collections have been made near telephone pole #44, where there is an unusual concentrated stand of Pisonia trees, a very important host for this species. D. paucipuncta also seems to have increased. None of the rest of the species exceeds 5% of the collections in either year, so that they may be judged as rare under all circumstances. D. ochracea and prolaticilia breed on the canes of Freycinetia; both, as well as paucipuncta are much more abundant at lower elevations where this plant grows more luxuriously. One species, D. hawaiiensis breeds primarily on the slime fluxes of Acacia koa and is only a rare straggler along Wright Road in the best of times.

The two giant species, heteroneura and silvestris are especially interesting from the point of view of evolutionary biology; both have been the focus of many studies both in nature and in the laboratory (for a review and references, see Carson 1982b). In 1977, an extraordinary population flush of these two species occurred in the area, and a long-term genetic study of their natural populations was begun at that time. Unfortunately for this project, both species declined in a year or so to the rather low levels seen in 1971-72. The last specimen of thse two to be seen in this area was a single male silvestris collected in 1981 (see "last S,H" arrow in Figure 1).

In the 1982a abstract, I suggested that the disappearence of these flies might be associated with the population flush of the recently-introduced predacious wasp, Vespula pennsylvanica (see "wasp" arrow in Figure 1). This was followed by a violent, defoliating windstorm that struck the area in 1982. At approximately the same time, neither heteroneura nor silvestris could be collected from many other formerly productive localities around the Big Island. The reason for these population declines is not clear. Interpretation is complicated by the fact that both the drought and the increase in the wasps occurred roughly simultaneously. In any event, our previous geographical studies have made it clear that the Ola'a tract appears to be close to the lower altitudinal range of these two species. Another point is that their principal plant host is the larger species of Clermontia, mentioned above, such as C. coerulea of the Kona side of the island and C. hawaiiensis, the main large species in the Volcano area. The latter species appears to be dying out in large areas around the island, and is currently exceedingly rare in Hawaii Volcanoes National Park.

CONCLUSIONS

The Drosophilidae of Hawaii, especially the large, newly-evolved "picture-winged" species of the Big Island, are a biological resource of great value. The island of Hawaii is geologically new and active and as bare lava flows are populated naturally from the adjacent areas, genetic changes in the populations of these species may sometimes occur. These changes can pertain to the natural selection of the genetic basis of either new adaptations or new species or both. Since the Drosophila species are especially amenable to genetic analysis, study of the dynamic action of evolutionary processes is possible with a precision not so easily available in other organisms. The existence of a major National Park astride these dynamically changing situations has made it possible for evolutionary biologists to begin recording events that may take centuries to unfold. This is one of the major unique scientific values to science of Hawaii Volcanoes National Park.

The richness and diversity of any drosophilid fauna in a natural forest community is an excellent indicator of the ecological health of the ecosystem, whether it be in a temperate or tropical region. Thus, when a forest is degraded by logging or clearing, the endemic drosophilids are soon strongly affected and are often replaced by cosmopolitan "weed" species. Applying this criterion to the Ola'a Tract, the diversity of native species is quite great and only about three non-endemic species are present. The diversity present today is approximately the same as when collections were first made in the area back in the 1960's during the early days of the Hawaiian Drosophila project. Despite the penetration of understory weeds and occasional violent storms, the major plant species that serve as hosts for the drosophilids appear to be surviving and reproducing. The area does not seem to be undergoing systematic degredation at the present time.

With regard to the conservation and management of the area, our workers have found that the pig fence around the portion of the tract on the volcano side of the road is quite effective in reducing pig damage and maintaining a good plant understory. I urge its maintenence. Should the encroachment of such ecosystem-altering weeds as banana poka occur in that area, prompt removal would seem to be mandatory.

The only "Drosophila plant" that seems to be seriously declining is Clermontia hawaiiensis. Except for a few specimens in the Thurston Lava Tube area and within the crater of Puu Huluhulu, specimens are hard to locate in areas where the species used to grow abundantly (see Rock 1919). There is some indication that the plants, at least in the Puna District, are affected by nodular growths that appear to be due to nematode infection. It's very minute seeds, within the orange fruits, appear to be distributed by birds, so that the decline of both birds and Clermontia may be reinforcing one another. A suggestion for the management of the situation may be offered. This would be to seed carefully selected remote margins of new lava flows in mesic areas. Such open flow edges appear to be a preferred location for the species where they are free from competition with introduced plants. The fresh lava, furthermore, might

provide a newly sterilized natural site free of infectious plant diseases.

In a broader context, however, the overall program for the preservation of the natural ecosystems in the Park seems to be excellent and will have the important side effect of also preserving the valuable invertebrate fauna. Accordingly, the entomologist and evolutionary biologist have very few specific recommendations to offer. As monitored at the Ola'a Tract, there seems to be no major decline of the larger Drosophila species, with the possible exception of Drosophila heteroneura and silvestris. Continued censusing of the picture-winged species at the Ola'a tract is planned.

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