# Occurrence and Distribution of Flies (Diptera: Calliphoridae and Muscidae) of Public Health Importance on the Island of Oahu

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**Abstract.** The Vector Control Branch of the Hawaii State Department of Health has accumulated a large volume of written inspection data on pests of public health for the island of Oahu. Fly related problems, excluding both mosquitoes and odor complaints that often lead to fly breeding violations, provided the second greatest amount of arthropod pest information available, after mosquitoes. The objectives of this study were to conduct a survey on the occurrence of fly complaints on Oahu over a 10 year period, determine their distribution over time, graphically compare fly occurrence within and between district/areas, and correlate fly occurrence and distribution with season. Fly data were drawn from inspection reports from 1990-1999, population information was obtained from Hawaii Census and State of Hawaii Data Books, 125 district/area geographic locations were defined, and fly occurrence and distribution were adjusted for population and mapped using ArcView GIS 3.2. Overall, reported fly activity was found to occur fairly evenly across the island's districts. Lower elevation areas around the perimeter of Oahu had the greatest number of complaints and the levels of fly activity were highest during the winter and summer. The primary fly species recorded were *Phaencia cuprina* (Wiedemann), the bronze bottle fly; *Musca sorbens* Wiedemann, the dog dung fly; *Chrysomya megacephala* (Fabricius), the Oriental blow fly; and *M. domestica* Linneaus, the house fly. The main breeding sources were food garbage and slop, pet and farm animal dung, dead animals, and rotten fruits. Fly populations are being maintained in urban and agricultural districts by human activities. As a result, disease transmission is possible, especially in the lower elevation, urban and agricultural areas of Oahu. These results indicate that educational programs should be carried out in late fall and late spring, and that residential fly surveys may be concentrated in a limited number of district/areas.

**Key words:** Flies, *Musca domestica*, *Musca sorbens*, *Phaenicia cuprina*, *Chrysomya megacephala*, public health, vector control, Oahu, GIS

## Introduction

The Vector Control Branch (VCB) of the Hawaii State Department of Health was created in 1970 with the merging of Rodent Control and Mosquito Control programs. The VCB is a statewide inspection, education, regulatory, prevention and control program primarily concerned with the vector-borne diseases of dengue fever, murine typhus, leptospirosis and West Nile virus. Vector Control Inspectors deal with other arthropods of public health importance in addition to insect disease vectors and vertebrate pests. As a result, the VCB has accumulated a large volume of mainly hand-written inspection data on pests of public health importance for the island of Oahu. The objectives of this study were to conduct a survey of the occurrence of public health arthropod pest problems on Oahu over a 10-year period (1990–1999), obtain a general list of arthropod related problems and determine their distribution over time, graphically compare pest occurrence within and between district/ areas, correlate pest occurrence and distribution with season, and identify target areas for more efficient application of prevention, control and education programs. We report here the results obtained for flies in the families Calliphoridae and Muscidae.

**Flies of Oahu.** Of 360 non-native fly species, excluding mosquitoes, present in Hawaii (Tenorio and Nishida 1995), only four have been major domestic pests on Oahu. These are *Musca domestica* Linneaus, the house fly; *M. sorbens* Wiedemann, the dog dung fly; *Phaenicia cuprina* (Wiedemann), the bronze bottle fly; and *Chrysomya megacephala* (Fabricius), the Oriental blow fly. *Musca domestica* was first recorded in Hawaii by Thompson in 1868 in the Diptera of the "Eugenies Resa" (Grimshaw 1901, Hardy 1981, DuPonte and Larish 2003a), and apparently arrived in the islands along with the Polynesians because it was here before contact with Westerners (Illingworth 1923, Hardy 1960, Tenorio and Nishida 1995). Joyce (1950) found *M. sorbens* in Hawaii in 1949 (Wilton 1963, Legner et al. 1974, Hardy 1981, Tenorio and Nishida 1995, DuPonte and Larish 2003b) and, although it was already well established, *P. cuprina* was not reported in Hawaii until 1947 (James 1947, Joyce 1954, Hardy 1981, DuPonte and Larish 2003c). Hardy (1981) reviewed insect collections for *P. cuprina* and found the oldest record to be from Oahu in January 1914. *Chrysomya megacephala* was first collected in Kona, Hawaii in July 1892 by Grimshaw (1901) (Hardy 1981, DuPonte and Larish 2003d). In addition, minor pest problems have been caused by isolated, short-lived and/or seasonal infestations of fly species in the families Chironomidae (midges), Drosophilidae (vinegar flies), Phoridae (hump-backed flies), Psychodidae (moth flies), Sarcophagidae (flesh and small dung flies) and Sciaridae (dark-winged fungus gnats).

In general, disease transmission by flies is primarily through the mechanical transfer of pathogens from a fly's body, regurgitated saliva and stomach contents, and excrement (Ebeling 1975, Toyama 1982). Flies are known vectors of bacillary dysentery (*Shigella dysenteriae*), shigellosis (*Shigella*), conjunctivitis (*Haemophilus* and *Streptococcus*), trachoma (*Chlamydia trachomatis*) and *Campylobacter* enteritis (*Campylobacter jejuni*); and are suspected of transmitting amoebic dysentery (*Entamoeba histolyica*), typhoid fever (*Salmonella enterica* Typhi), salmonellosis (*Salmonella*), tuberculosis (*Mycobacterium tuberculosis*), cholera (*Vibrio cholerae*), tularemia (*Francisella tularensis*), anthrax (*Bacillus anthracis*), leprosy (*Mycobacterium leprae*), yaws (*Treponema pallidum*), poliomyelitis (Poliovirus), infectious hepatitis (Hepatitis A virus), and eggs of pinworms (*Enterobius vermicularis*), whipworms (*Trichuris trichiura*), hookworms (*Necator americanus* and *Ancylostoma*), roundworms (*Ascaris lumbricoides*) and tapeworms (*Echinococcus granulosus*) (Hayes 1958, James and Harwood 1971, Ebeling 1975, Toyama 1982, Chin 2000, Hald et al. 2004). Human myiasis, the entry of fly larvae into the human body via festering wounds, ingestion, eyes and other body openings, occasionally occurs in Hawaii. These cases are usually facultative or accidental in nature. *Musca domestica* is a vector of dysentery, *Campylobacter*, tuberculosis, fowl cholera, poultry tapeworm and Newcastle disease. *Musca sorbens* is a vector of trachoma and has been implicated in transmitting a variety of viruses, bacteria and parasites to animals and man. It is also a major source of annoyance in addition to being a health concern because it is very attracted to the human body, especially to open wounds. *Phaenicia cuprina* breeds heavily in garbage, has invaded homes, and has caused myiasis of wounds in humans and animals. *Chrysomya megacephala* vectors dysentery and typhoid fever, causes myiasis of diseased tissue, and breeds in large numbers in animal carcasses, food waste and garbage on farms.

This is one of a series of six related papers submitted for publication in the *Proceedings of the Hawaiian Entomological Society.*

## Materials and Methods

**Study area.** Oahu is the third largest and most populous of the Hawaiian Islands. It is home to ~900,000 people, has a highly urbanized southern coast, and extensive growth has recently occurred in the central and Ewa Plains areas of the island. Oahu's climate is characterized by a two-season year, mild and fairly uniform temperature conditions, striking marked geographic differences in rainfall, and a general dominance of trade-wind flow. For a more detailed description of the area of study, see Leong and Grace (2009) or Leong (2008).

**Study methods.** A comprehensive arthropod pest data set was extracted from Hawaii State Department of Health Vector Control Branch inspection reports from 1990 to 1999. Population data were obtained from Hawaii Census 1990 and 2000 and The State of Hawaii Data Books from 1990 to 2004. The Vector Control inspection reports were reviewed and compiled into general pest categories using the reported problem on the original complaint. All together, a total of 8,936 individual pest problems were found from which 27 pest categories plus a miscellaneous category were obtained. One-hundred twenty-five district/area geographic locations with varying populations were established using community structure, geographic features and inspection report designations, and the raw pest occurrence data for each district/area were standardized by dividing by the estimated population and multiplying the decimal number generated by 10,000. District/areas with populations of less than 500 were excluded from occurrence analysis. The resulting transformed pest occurrence data were mapped on a traditional four-season basis using ArcView GIS 3.2 to create 40 maps for each of 10 major pest categories along with four additional maps each showing cumulative seasonal activity. Pest occurrence was graphically compared within and between district/areas, and pest occurrence and distribution were correlated with season. Finally, pest occurrence and distribution were evaluated using inspection data, including species identifications. See Leong and Grace (2009) or Leong (2008) for a more complete description of methods.

## Results

Fly activity during the winter of 1990 was mainly found along south Oahu and there were noticeably fewer problems across the east, north shore and central areas. In winter 1991, the majority of the complaints were on the leeward side of the island and most of these were found in south Oahu. Overall fly activity at least doubled as compared to the preceding fall. Fly activity in winter 1992 was mainly in the south and lower east district/areas. Winter 1993 fly activity was reduced from that in 1992 and more spread out across the island. One heavy spike (16–24 complaints) in activity occurred in Halawa Valley in central Oahu. A sharp drop in fly activity occurred in the winter of 1994. Even so, moderate fly activity (9–15 complaints) was found in Waiahole-Waikane in east Oahu. The winter of 1995 saw an increase in fly activity over the previous fall with over twice as many district/areas on the leeward side of the island reporting problems than the windward side. Moderate fly activity occurred in Mokuleia on the north shore and in Mikilua in west Oahu, and a heavy spike was found in Wailupe on the south coast. Fly activity in winter 1996 again increased over the previous fall with the majority of the activity occurring on the leeward side of the island. A moderate peak in activity occurred in the area of Honokai Hale on the west coast of Oahu. The fly activity in winter 1997 followed the same general pattern as in the previous two years with activity occurring in Niu Valley and Hahaione Valley in south Oahu, Heeia Kea on the east coast, and Waialua on the north shore. The fly activity in winter 1998 slightly decreased and was more distributed over the island. Moderate spikes in activity occurred in Waiahole-Waikane on the east side and Mokuleia on the north shore.

Finally, fly activity increased in the winter of 1999 with activity mainly occurring in the south and lower east district/areas. A moderate peak in fly activity occurred in the area of Yacht Club Knolls in east Oahu.

Spring 1990 fly activity occurred mostly along the south and east coasts of Oahu and in about the same number of district/areas as in the winter, but there was a noticeable increase in the level of activity in a few south and central districts. Moderate peaks in fly activity were found in Kakaako, Iwilei and West Loch Estates along leeward Oahu. Fly activity was reduced in spring 1991 with activity mainly occurring in south and central Oahu. In spring 1992, fly activity decreased, and occurred only in the eastern half of south Oahu and the lower east coast of the island. Activity was found in Kakaako and Niu Valley on the south shore, and Waimanalo and Lanikai on the east side. Fly activity increased in spring 1993 from that in the winter with activity occurring mainly in south and central Oahu. A heavy peak was found in Mokuleia on the north shore. Spring 1994 fly activity increased and the activity was well distributed across the island. Activity occurred in the Sunset Beach area on the north shore, Iwilei in the south, Kahuku along east Oahu and Waianae Valley in the west. Fly activity also increased in spring 1995, especially in south Oahu, but the overall level of activity of individual sites decreased. Fly activity spiked moderately in Kalama Valley in south Oahu. Spring 1996 fly activity decreased overall from that in winter 1996 and the majority of the activity occurred on the leeward side of the island. There was a decrease in fly activity in east and west Oahu in spring 1997, and a noticeable grouping of activity from Kamehameha Heights to Diamond Head in the south. Fly activity in spring 1998 was much reduced and was well spread out across the island. Lastly, spring 1999 showed decreased fly activity overall with increases on the north shore and in west Oahu, and decreases in south, east and central Oahu. A moderate peak in activity occurred in the Honokai Hale area along west Oahu.

There was a slight increase in the number of district/areas reporting fly activity in summer 1990 from that in the spring with a moderate peak in activity occurring in Halawa Valley in central Oahu. There was a light increase in the level of fly activity in summer 1991 and the affected district/areas were well scattered across the island. Fly activity peaked moderately in Mahinui-Kokokahi on the east side and Mokuleia on the north shore. Fly activity also increased lightly in the summer of 1992 from in the spring. Several district/areas on the northern half of Oahu reported activity including on the north shore in Haleiwa and in east Oahu in Maunawili. Summer 1993 fly activity increased noticeably above that of spring and winter with most of the affected district/areas occurring on the leeward side of Oahu. Fly activity peaked moderately in south Oahu in Kalani Valley and Kuliouou. Summer 1994 showed increased fly activity in the south Oahu district/areas. Activity was reported in the Sunset Beach area of the north shore, West Loch Estates in central Oahu, Hahaione Valley on the south side, and in Lanikai and Kahuku along the east coast. Summer 1995 fly activity showed a light decrease overall with much of the activity occurring in the south and central district/areas. A heavy spike in fly activity occurred in Kawela on the north shore. Overall fly activity in summer 1996 increased from that in the spring and was similar to the winter activity. A moderate spike in fly activity occurred in the Honokai Hale area of west Oahu and the fly activity was clearly concentrated on the leeward side of the island. A slight increase in fly activity occurred in summer 1997 with activity being reported in Pupukea on the north shore and Waiau in central Oahu. The fly activity in the summer of 1998 doubled from that in the spring. A moderate spike in activity occurred in Mokuleia on the north shore. Fly activity declined on the north shore as well as in the east and west district/areas of Oahu in summer 1999. Activity occurred mainly from Mililani Town in central Oahu to Kahala on the south shore and a moderate peak was found in Kunia in central Oahu.

In the fall of 1990, fly activity decreased overall from that in the summer and was fairly spread out over the island. During the fall of 1991, the number of district/areas affected and levels of site activity increased to nearly double the summer activity. A moderate peak in fly activity occurred in Waikele in central Oahu and a heavy spike was recorded for Kakaako on the south shore. There was an increase in fly activity in fall 1992 with reported activity shifting from the northern areas of the island into central and west Oahu. As in the winter, spring and summer, the district/areas with consistent fly activity were in the eastern half of the south shore and the lower east coast. The highest activity occurred in south Oahu with complaints being found in Kakaako, Kahala, Waialae Nui, Hahaione Valley and Portlock. Fall 1993 saw a noticeable decrease in the number of district/areas reporting fly activity. There was an overall decrease in fly activity in the fall of 1994 with most of the affected district/areas occurring on the leeward side of the island. There was decreased fly activity in fall 1995 to less than half of that in the summer. Activity was found in Kalihi Kai and Iwilei on the south coast, and in Maili Kai in west Oahu. In fall 1996, fly activity also decreased by about half with activity being found in south Oahu and on the west coast of the island. An overall increase in fly activity from in the summer occurred in the fall of 1997. Increases in the number of district/areas affected and level of site activity were found in the eastern half of south Oahu and along the lower east shore. Moderate peaks in fly activity occurred in Iwilei and Kakaako on the south shore of the island. In fall 1998, fly activity was comparable to that of in the summer with a moderate peak occurring in Kalani Valley on the south shore. Finally, there was a slight increase in overall fly activity in fall 1999 with activity mainly occurring in leeward district/areas. Moderate peaks in fly activity were found in Kalani Valley in south Oahu and in the Honokai Hale area of the west side of the island.

Although fly activity was often higher on the leeward side of Oahu and concentrated around the eastern half of the south shore to the lower east side of the island, reported activity was found to occur fairly evenly across the island's districts overall (Figure 1A–D). Lower elevation areas around the perimeter of Oahu had the greatest number of complaints and the levels of fly activity were highest during the winter and summer. There were a small number of fly problems around the ports of entry with none being recorded in the fall months. However, the major ports of entry, Honolulu International Airport, Sand Island and Campbell Industrial Park, could not be evaluated by adjusting for population due to their low residential population.

## Discussion

The primary fly species recorded were *Phaencia cuprina* (~39.2%; n = 689), the bronze bottle fly; *Musca sorbens* (~29.2%), the dog dung fly; *Chrysomya megacephala* (~10.0%), the Oriental blow fly; and *M. domestica* (~9.0%), the house fly (Table 1). *Chrysomya megacephala* occurrence often overlapped with *P. cuprina*, and smaller numbers of Sarcophagidae, flesh and small dung flies; Psychodidae, moth fly; Phoridae, hump-backed fly; and Drosophilidae, vinegar fly, cases were also recorded. The main breeding sources were food garbage and slop (~45.0%; n = 451), pet and farm animal dung (~47.0%), dead animals (~5.8%), and rotten fruits (~1.6%) (Table 2). The major sources of fly infestations in residential areas were improperly bagged and/or accumulated loose garbage, and dog and cat feces accumulation (~39.5%). Agricultural lands and residential properties bordering farm land mainly experienced fly problems due to the improper use of slop or other food garbage, and wet chicken manure after heavy rains (~5.5%). Although the major ports of entry and other industrial district/areas had a relatively light number of fly complaints, occasional heavy infestations have occurred. Fly infestations in these district/areas were usually the result of improper handling of food waste or the presence of farm animal wastes.

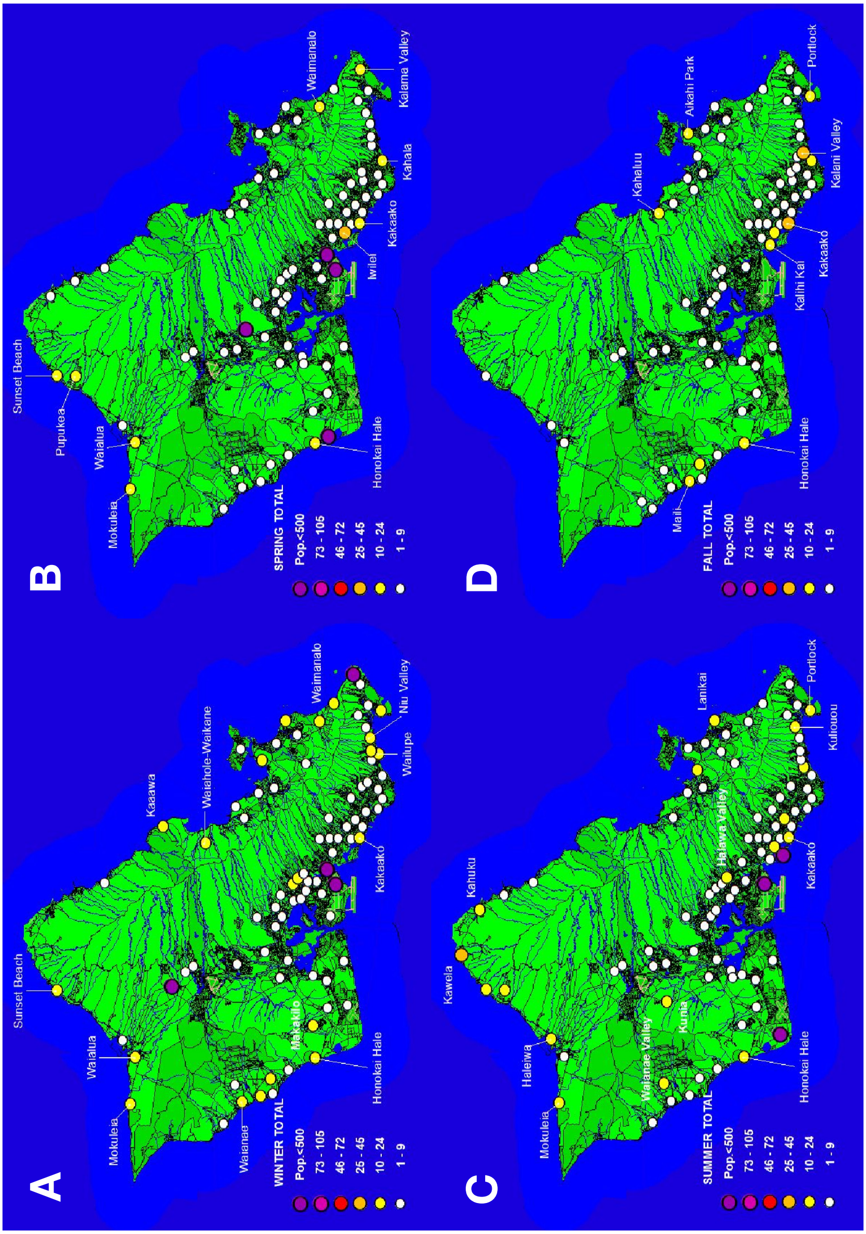


**Figure 1.** Flies, seasonal totals (1990–1999) for winter (A), spring (B), summer (C) and fall (D).

**Table 1. Fly species occurrence as determined by a sampling of 1,073 fly-related inspection reports.**

| Species | % | Mean | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chironomidae | 0.1 | 0.1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **1** |
| *Chrysomya megacephala* | 10.0 | 6.9 | 19 | 4 | 5 | 0 | 1 | 9 | 6 | 15 | 5 | 5 | **69** |
| *C. rufifacies* | 0.1 | 0.1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **1** |
| *Drosophila* spp. | 2.9 | 2.0 | 8 | 3 | 0 | 0 | 1 | 4 | 0 | 1 | 2 | 1 | **20** |
| *Hermetia illucens* | 0.1 | 0.1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **1** |
| *Musca domestica* | 9.0 | 6.2 | 6 | 6 | 4 | 5 | 3 | 16 | 12 | 4 | 3 | 3 | **62** |
| *M. sorbens* | 29.2 | 20.1 | 17 | 21 | 24 | 14 | 4 | 46 | 24 | 16 | 14 | 21 | **201** |
| *Ophyra chalcogaster* | 0.6 | 0.4 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **4** |
| *Phaenicia cuprina* | 39.2 | 27.0 | 33 | 24 | 16 | 6 | 8 | 53 | 33 | 41 | 24 | 32 | **270** |
| Phoridae | 0.7 | 0.5 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | **5** |
| *Placopsidella marquesana* | 0.1 | 0.1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | **1** |
| Psychodidae | 0.3 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | **2** |
| Sarcophagidae | 5.1 | 3.5 | 2 | 2 | 8 | 1 | 1 | 6 | 6 | 3 | 3 | 3 | **35** |
| Sciaridae | 0.4 | 0.3 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | **3** |
| *Tricharaea occidua* | 2.0 | 1.4 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 4 | 5 | 2 | **14** |
| **Total** | **100.0** | **68.9** | **85** | **62** | **59** | **27** | **20** | **141** | **84** | **88** | **56** | **67** | **689** |

**Table 2. Fly breeding sources as determined by a sampling of 874 fly-related inspection reports.**

| Breeding sources | % | Mean | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dead animals | 5.8 | 3.7 | N/A* | N/A | N/A | 0 | 3 | 3 | 6 | 4 | 5 | 5 | **26** |
| Fruits | 1.6 | 1.0 | N/A | N/A | N/A | 1 | 0 | 1 | 0 | 1 | 1 | 3 | **7** |
| Garbage/refuse/slop | 45.0 | 29.0 | N/A | N/A | N/A | 4 | 13 | 32 | 36 | 54 | 31 | 33 | **203** |
| Manure, bird/pigeon | 0.7 | 0.4 | N/A | N/A | N/A | 1 | 0 | 0 | 0 | 1 | 1 | 0 | **3** |
| Manure, chicken | 5.5 | 3.6 | N/A | N/A | N/A | 0 | 4 | 11 | 3 | 3 | 2 | 2 | **25** |
| Manure, dog/cat | 39.5 | 25.4 | N/A | N/A | N/A | 14 | 15 | 41 | 22 | 22 | 21 | 43 | **178** |
| Manure, pig/horse/cow/goat | 1.3 | 0.9 | N/A | N/A | N/A | 1 | 0 | 3 | 1 | 0 | 1 | 0 | **6** |
| Stored food | 0.2 | 0.1 | N/A | N/A | N/A | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **1** |
| Wastewater | 0.4 | 0.3 | N/A | N/A | N/A | 0 | 0 | 0 | 0 | 0 | 1 | 1 | **2** |
| **Total** | **100.0** | **64.4** | **N/A** | **N/A** | **N/A** | **21** | **36** | **91** | **68** | **85** | **63** | **87** | **451** |

*Data not available.

As in the late 1950s and early 1960s, garbage containers remain an important source of fly production, especially in garbage cans and dumpsters of apartment buildings, food establishments and public parks where unprotected refuse is commonly found. In fact, the current practice of at least twice-a-week refuse pick-up is essential for the control of fly breeding and the prevention of heavy fly infestations since mature maggot activity has often been found to be already present prior to scheduled pick-ups. Fly surveys in Honolulu, Kailua and Lanikai on Oahu by Wilton (1961) showed that breeding in garbage cans was most frequently positive for *P. cuprina* (88.2%) followed by *M. domestica* (35.3%) and *C. megacephala* (20.6%), and there was considerably more garbage can fly production in areas containing apartment buildings. Today, *M. domestica* is mainly a problem related to chicken farming and wet manure while *P. cuprina* and *C. megacephala* continue to be important garbage breeding species. In addition, *M. sorbens* has also continued to be a major source of annoyance in residential and public park areas as a result of dog and/or cat feces accumulation. A study carried out from September 1961 to March 1962 (Wilton 1963) found fly breeding in exposed, dry dog feces to be mainly *M. sorbens* (78.9%) and concluded that dog feces was a very significant factor in community fly problems. This 1990 to 1999 survey has determined that fly populations are being maintained in urban and agricultural districts by human activities. As a result, disease transmission is possible, especially in the lower elevation, urban and agricultural areas of Oahu where warmer temperatures encourage faster fly development and more prolific reproduction. No disease outbreaks were associated with any of the heavy fly infestations that occurred during the survey period, but the significant potential for disease transmission shows the importance of continued prevention activities. The results indicate that community or island-wide educational programs should be carried out in late fall and late spring to reinforce public awareness during the year, and that residential fly surveys may be concentrated in a limited number of district/areas according to fly complaints received. Educational activities are currently conducted only on a limited basis during inspections. Small area or neighborhood fly infestation surveys and area wide investigations encompassing Waianae through Nanakuli conducted in response to complaints have confirmed the practicality of using small-target area surveys. Once the species of fly causing the problem was identified, known breeding sites such as nearby garbage dumpsters or chicken farms located miles away could be targeted for inspections. As pointed out earlier, mainly light fly complaints were received for industrial parks and heavy commercial areas overall. Fortunately, the causes of these problems, even for the occasional heavy infestation, were easily identified and posed a limited public health concern.

Geographic analysis can help to target areas and times of the year for more efficient application of fly prevention, control and education programs by continuously tracking fly activity using Vector Control inspection reports. Improvements in methodology include using the actual number of complaints within a district/area and the severity of the fly infestation found together with data adjusted for population to more accurately determine the need for targeted survey, abatement and education efforts. For example, geographic analysis of transformed fly occurrence may flag a potential problem district/area for increased scrutiny, but additional action would be taken only if at least three complaints were received, the level of infestation was heavy and/or the fly problem was found to occur over an extensive area. The same deciding factors may be applied directly for the excluded district/areas with resident populations of less than 500.

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