Occurrence and Distribution of Mites and Ticks (Acari) of Public Health Importance on the Island of Oahu

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Abstract. The Vector Control Branch of the Hawaii Department of Health has accumulated a large volume of written inspection data on pests of public health for the island of Oahu. Mite complaints provided the fifth greatest amount of arthropod pest information available, following mosquito, other fly, flea and bee complaints; and tick complaints provided the ninth greatest amount of arthropod pest information, following ants, cockroaches and centipedes. The objectives of this study were to conduct a survey of the occurrence of mite and tick complaints on Oahu over a 10-year period, determine their distribution over time, graphically compare mite and tick occurrence within and between district/areas, and correlate mite and tick occurrence and distribution with season. Mite and tick data were drawn from inspection reports from 1990 to 1999, population information was obtained from Hawaii Census and State of Hawaii Data Books, 125 district/area geographic locations were defined, and mite and tick occurrence and distribution were adjusted for population and mapped using ArcView GIS 3.2. Most mite activity was reported within the central, south and east urban districts. The south urban districts of the island showed the highest number of complaints, and the levels of mite activity were highest during the spring, summer and fall. There were a very small number of mite problems around the ports of entry, mainly the airport. The primary mite species recorded were *Dermatophagoides pteronyssinus* (Trouessart), the European house dust mite; *Ornithonyssus bursa* (Berlese), the tropical fowl mite; *Glycyphagus domesticus* (De Geer), the grocer's itch mite; *Pyemotes boylei* Krczal, the straw itch mite; and *D. farinae* Hughes, the American house dust mite. The main sources of mite infestations were house dust, birds, stored food products, fiber-type furniture, dried plant materials and bean pods. Tick activity was mostly reported within the leeward urban districts. South and west urban districts showed the highest number of complaints, and the levels of tick activity were highest during the winter, summer and fall. There were very few tick problems around the ports of entry. The primary tick species identified was *Rhipicephalus sanguineus* Latrielle, the brown dog tick. The main sources of tick infestations were dogs that were taken into a tick infested location or poorly cared for, especially if the dog was relocated on premises, removed from the premises or died. Mite and tick activity is being maintained in urban areas by human activities. As a result, dermatitis from mite infestations is possible as well as disease transmission between dogs by ticks, especially along leeward Oahu. The results indicate that educational programs should be carried out in late winter for mites and late spring for ticks, and that residential mite and tick surveys may be concentrated in a limited number of district/areas.

Key words: Mites, ticks, *Dermatophagoides pteronyssinus, Dermatophagoides farinae, Ornithonyssus bursa, Glycyphagus domesticus, Pyemotes boylei, Rhipicephalus sanguineus*, public health, vector control, Oahu, GIS

Introduction

The Vector Control Branch (VCB) of the Hawaii 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 districts/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 mites and ticks.

Mites and Ticks of Hawaii. Of at least 521 species of mites in Hawaii (Tenorio and Nishida 1995), about 32 species are considered to be of public health concern (Ikeda 1982). These important species fall into three general ecological groups: free-living predacious forms, free-living phytophagous forms and ectoparasitic forms. Five of these mite species have been commonly found on the island of Oahu. They are *Dermatophagoides pteronyssinus* (Trouessart), the European house dust mite; *D. farinae* Hughes, the American house dust mite; *Ornithonyssus bursa* (Berlese), the tropical fowl mite; *Glycyphagus domesticus* (De Geer), the grocer's itch mite; and *Pyemotes boylei* Krczal, the straw itch mite.

Dermatophagoides pteronyssinus was first recorded as *D. scheremetewskyi* Bogdanow collected from a rug on Oahu in 1959 by F. H. Haramoto (Haramoto 1961, Garrett and Haramoto 1967, Sharp and Haramoto 1970, Goff 1987), and *D. farinae* was found to be well established in house dust on the islands of Oahu, Maui, Kauai and Hawaii by 1968 (Sharp and Haramoto 1970). *Ornithonyssus bursa* was reported to have "caused some trouble to human beings" in 1943 by Zimmerman (1944), and was found to be common in nests of English sparrows and mynah birds. It was likely already present by 1930 when Erhorn (1931) "related several instances of dwellings being infested by chicken mites" due to mynah bird nests. *Glycyphagus domesticus* was determined to be new to the Hawaiian fauna by E. W. Baker in 1945 from specimens collected on Oahu (Zimmerman 1956). *Pyemotes boylei* was originally described in Honolulu by H. Krczal in 1959 from specimens collected from *Cryptotermes brevis* (Walker), the drywood termite, and *Araecerus levipennis* Jordan, the koa haole seed weevil, by W. W. Boyle, but it was likely present in Hawaii much earlier since it is morphologically very similar to and it was probably misidentified as *P. ventricosis* (Newport) (Vaivanijkul and Haramoto 1969, Goff 1987). All specimens available for examination from before 1959 were found by Goff (1987) to be *P. boylei* and it was probably in Hawaii as early as 1911, when E. M. Erhorn reported the discovery of *P. ventricosis* as the cause of "Kiawe itch" (Erhorn 1913, Vaivanijkul and Haramoto 1969). There are nine species of ticks in Hawaii (Tenorio and Nishida 1995). Two of these species, *Rhipicephalus sanguineus* Latrielle, the brown dog tick, and *Otobius megnini* (Duges), the spinose ear tick of cattle and horses, are of public health importance (Ikeda 1982, Nishida and Tenorio 1993). And, of these two species, only *R. sanguineus* has been encountered during inspections on Oahu. Although already very abundant, it was first formally recorded on Oahu in 1921 (Fullaway 1922).

Dermatophagoides pteronyssinus and *D. farinae* and house dust mite allergy are most commonly associated with asthma, perennial rhinitis (post nasal drip), and childhood eczema or atopic dermatitis (Sharp and Haramoto 1970, Ebeling 1975, Ikeda 1982, Tenorio and

Nishida 1995). *Ornithonyssus bursa* is primarily a parasite of poultry, pigeons, sparrows, mynahs and other birds, but it also attacks man and causes itching by both its bite and crawling over the skin (Baker et al. 1956, Ikeda 1982). In some individuals, the irritating bite develops into prolonged, intense itching and painful dermatitis (Nishida and Tenorio 1993, Denmark and Cromroy 2003). Also known as the furniture mite, *G. domesticus* is often associated with fiber-type furniture and is mycetophagus (Ikeda 1982), but it has caused dermatitis in man from infested stored food products (Ebeling 1975) as well as furniture. *Pyemotes boylei* causes a severe dermatitis known as "kiawe itch" or "straw itch" (Baker et al. 1956, Vaivanijkul and Haramoto 1969, Ikeda 1982). A rosy red, pruritic skin lesion develops on each bite site that often presents a raised, whitish area with a small, central vesicle. Intense itching of the lesion leads to rubbing and scratching that usually break the central vesicle which allows the possibility of secondary infection. Fever, headache, backache and asthma can also accompany itching if a person is bitten extensively. *Rhipicephalus sanguineus* is principally parasitic on dogs and rarely attacks man (Ebeling 1975, Ikeda 1982), and is not known to have been a vector of disease in man in Hawaii (McQuiston et al. 1999, Sasaki 2000, Bratton and Corey 2005). However, *R. sanguineus* is the vector for canine ehrlichiosis (*Ehrlichia canis*) (Chapman 2000, Sasaki 2000, Skotarczak 2003), a potentially fatal disease in dogs. In other parts of the world, *R. sanguineus* is the primary vector for boutonneuse fever or tick-borne typhus (*Rickettsia conorii*) (Ikeda 1982) and canine babesiosis (*Babesia canis*), a sporozoan blood parasite (Ebeling 1975, Homer et al. 2000).

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 1990-1999. 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

Mite activity during the winter of 1990 was mostly very light (1–3 complaints) with a light peak (4–8 complaints) occurring in the south district/area of Kalihi Kai. Complaints were mainly found in south Oahu and in the lower east side of the island. In winter 1991, very light mite activity was scattered along south, lower east and lower central Oahu. Mite activity slightly decreased as compared to the preceding fall. Mite activity in winter 1992 was very light around south and lower east Oahu with light peaks occurring in Lanikai and Olomana-Pohakupu on the east side of the island. Overall activity was comparable to that in the fall of 1991, and had decreased in the south and increased in lower east Oahu. Winter 1993 mite activity was reduced by about half from that in fall 1992, and spread across south, central and west Oahu. There was a light peak in activity in Waikele in central Oahu. Mite activity in the winter of 1994 was slightly reduced from that in the fall, and was sparse and spread across south, central and west Oahu. A light peak occurred in the central district/area of Halawa Valley. The winter of 1995 saw a slight increase in mite activity over the previous fall. Activity was mainly in south Oahu where it peaked lightly in Kakaako. A light peak was also found in the area of Sunset Beach on the north shore. Mite activity in winter 1996 decreased both in occurrence and in the areas of the island reporting problems. There was a concentration in activity from Kalihi Kai to Kaimuki-Waialae in south Oahu with a light peak in Kalihi Kai. Reported mite activity in winter 1997 was nearly zero. Only the excluded Airport district/area in south Oahu reported mite activity. The mite activity in winter 1998 was less than one-third that of the fall. Very light activity was found in Kahala in south Oahu and a light peak occurred in Lanikai on the east coast. Finally, mite activity in the winter of 1999 was one-sixth the activity in the fall. Very light activity was found in Hawaii Kai in south Oahu.

Spring 1990 mite activity was found across all areas of the island, and was about two times as that in the winter. A light peak was present in Kahaluu-Waihee Valley on the east coast and there was a concentration in mite activity in south Oahu from Kamehameha-Alewa Heights to Kapahulu-Diamond Head with a heavy (16–24 complaints) spike occurring in Kakaako. Mite activity increased slightly in spring 1991 with very light activity occurring in south, east and west district/areas, and a moderate (9–15 complaints) peak was found in Punaluu on the east coast. In the spring of 1992, overall mite activity was comparable to that in the winter, but was spread across south, east and central district/areas. A moderate peak was present in Hawaiiloa Ridge in south Oahu. Mite activity in spring 1993 was similar overall to winter activity except for activity being reported on the east side of the island rather then in central Oahu and all activity being very light. Spring 1994 mite activity increased by greater than two times the winter activity and most of the complaints occurred in south Oahu. A Light peak was found in Maunawili on the east side and there was a moderate spike in Mokuleia on the north shore. Mite activity in the spring of 1995 increased noticeably and was spread out around the island. All activity was very light and it mostly occurred in south Oahu. Spring 1996 mite activity increased from that in winter 1996 and was more spread out across the island. Activity peaked lightly in Lanikai and Haiku Village and Plantations in east Oahu, and in Pupukea on the north shore. There was an increase in mite activity in spring 1997. A light peak occurred in Pupukea on the north shore, and there was very light activity in several south and east district/areas. Mite activity during the spring of 1998 was very light and about three times that of in the winter. Lastly, spring 1999 showed increased mite activity by 10 times the winter activity, but it remained

very light overall. Occurrence was fairly evenly spread out across the island.

The number of district/areas reporting mite activity in the summer of 1990 was similar to that in the spring, with activity mainly occurring in south and lower east Oahu. Light peaks were found in Downtown in south Oahu, and in Olomana-Pohakupu and Kahaluu-Waihee Valley in the lower east side of the island. A moderate spike occurred in Kakaako on the south coast. The overall level of mite activity in summer 1991 was also similar to the activity in the spring. There were light peaks in Kakaako in south Oahu and in Lanikai on the east coast. There was a small cluster of very light activity on the east side of the island from Kaneohe to Haiku Village and Plantations. Mite activity increased in the summer of 1992 and was found in all major areas of the island. Light peaks in activity occurred in Hahaione Valley in south Oahu and in Pupukea on the north shore, and there was a moderate spike in Kalani Valley on the south side of the island. Summer 1993 mite activity increased overall to about three times that in the spring. Most of the activity occurred in south Oahu, including light peaks in Downtown and Portlock. Light activity also occurred in Yacht Club Knolls and Terrace on the east coast. As in 1993, summer 1994 showed increased mite activity overall. There were light peaks in Portlock, Heeia Kea on the east coast, and in the Sunset Beach area and Waialua on the north shore. During the summer of 1995, mite activity was mostly on the leeward side of the island and was comparable overall to the spring activity. Activity peaked lightly in Waikiki-Kapiolani Park in south Oahu and in Waianae on the west coast. Mite activity in summer 1996 decreased around the north, east and west sides of the island and increased in south Oahu. Mite activity peaked lightly in the central district/area of Halawa Valley and in Maunawili in the east. A moderate spike occurred in Kalihi Kai in south Oahu and mite activity was concentrated from Kalihi Kai to Kapahulu-Diamond Head. Mite activity in summer 1997 was over double that in the spring. The activity was very light and was found mostly in south Oahu. The mite activity in south Oahu in the summer of 1998 increased by about two times from that in the spring. A light peak in activity occurred in the south district/area of Niu Valley. Mite activity increased in summer 1999, but was very light and was concentrated between Kalihi and Wilhelmina Rise-Maunalani Heights in south Oahu.

In the fall of 1990, there was a decrease in mite activity in south and east Oahu. A light peak occurred in Oneawa-Aikahi Park in east Oahu. During the fall of 1991, overall mite activity was comparable to the summer activity and remained very light to light as well. However, complaints increased in south Oahu and decreased elsewhere around the island, and showed a concentration of reports from Punchbowl-Pacific Heights to Kahala. A light peak in activity occurred in Mariners Ridge. The mite activity in fall 1992 was, again, similar overall to that of in the summer. The activity was mainly in south and lower east district/areas. Light peaks occurred in Iwilei and Waialae Iki on the south shore, and in the east district/area of Lanikai. Fall 1993 saw a decrease in the number of district/areas reporting mite activity to less than half the summer activity. Only very light activity was reported and activity occurred only in south and lower east Oahu. There was a noticeable decrease in mite activity in the fall of 1994 with no activity being reported on the north shore or in central Oahu. Light peaks in mite activity were found in Fort Shafter and Iwilei along the south shore. Fall 1995 mite activity showed a slight overall decrease and occurred mainly on the leeward side of the island. Light peaks were found in Moanalua Valley and Kakaako in south Oahu. In fall 1996, mite activity decreased in south and central Oahu, and increased on the north and west shores. There were light peaks in the Sunset Beach area along the north shore and in the south district/area of Kapolei, and a moderate spike in activity in Maili Kai on the west coast. An overall decrease in mite occurrence and distribution occurred in the fall of 1997. Light mite activity was found in Fort Shafter in south Oahu and a moderate spike was present in Punaluu along the east coast. In fall 1998, mite

activity decreased by about half from that of in the summer. All activity was very light and no activity was reported on the north shore. Other than a very heavy spike in mite activity in Mokuleia on the north shore, activity in fall 1999 occurred only in south Oahu as very light complaints. A small cluster of activity was present from Waikiki-Kapiolani Park to Wilhelmina Rise-Maunalani Heights.

Most mite activity was reported within the central, south and east urban districts (Figures 1a–d). The south urban districts of the island showed the highest number of complaints, and the levels of mite activity were highest during the spring, summer and fall. There were a very small number of mite problems around the ports of entry, mainly the airport. 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.

The tick category did not contain enough data to make annual, seasonal mapping very useful. As a result, a description of annual, seasonal mapping results for ticks is not included. Tick activity was mostly reported within the leeward urban districts (Figures 2a–d). South and west urban districts showed the highest number of complaints, and the levels of tick activity were highest during the winter, summer and fall. There were very few tick problems around the ports of entry. 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 mite species recorded were *Dermatophagoides pteronyssinus* (~32.0%; n = 550), the European house dust mite; *Ornithonyssus bursa* (~11.3%), the tropical fowl mite; *Glycyphagus domesticus* (~10.5%), the grocer's itch mite; *Pyemotes boylei* (~3.1%), the straw itch mite; and *D. farinae* (~2.9%), the American house dust mite (Table 1). *Dermatophagoides pteronyssinus* occurrence often overlapped with *G. domesticus, D. farinae* and *Cheyletus eruditus*, a predaceous mite; and, although very few *C. eruditus* (~1.3%) cases were recorded, its occurrence was probably much higher and would be found among the *Cheyletus* sp. (~7.3%). Other notable mite species recorded were *Sarcoptes scabiei* (~1.1%), the scabies mite; *Ornithonyssus bacoti* (~0.7%), the tropical rat mite; *Acarus siro* (~0.9%), the grain mite; and *Tyrophagus putrescentiae* (~0.2%), the mold mite. The main sources of mite infestations were house dust, birds, stored food products, fiber-type furniture, dried plant materials and bean pods. Humans and rodents were the sources of infestation for *S. scabiei* and *O. bacoti*, respectively.

Over 19 species of mites were recorded in Vector Control inspections (Table 1) with most of the specimens identified being collected by vacuum sampling. Except for the larger mite species such as *O. bursa* and Tetranychidae, usually *Tetranychus* sp., much of the mite complaints received were due to dermatitis, biting and/or crawling sensations without a visible insect to which to attribute the problem, or the complainant observed mites that could not be visually confirmed by Vector Control Inspectors. If a past or current mite infestation or biting insect problem could not be confirmed, then an environmental cause such as "cable mite" or "paper mite" dermatitis was suspected (Ebeling 1975, Ikeda 1982, Pinto 1989, Pinto 1993). This type of problem was not uncommon in business and governmental offices in south Oahu. In some cases, the behavior of the complainant, his or her physical condition, the description of the problem given, and specimen identifications negative for biting mites indicated probable delusions of parasitosis or delusory parasitosis. An extreme example is a case in which the complainant was adamant that mites or bugs were burrowing into the skin, changing colors and jumping or flying from place to place. This individual showed

multiple skin sores from which attempts were made to dig out the offending parasites.

Of the mite species recovered from house dust, the five most prevalent listed in their order of occurrence were *D. pteronyssinus, G. domesticus, D. farinae,* Oribatida, and *C. eruditus.* This differed noticeably from an internal Vector Control Branch memo (Furumizo 1994) that listed *D. pteronyssinus, D. farinae, G. domesticus, T. putrescentiae* and *A. siro* as the five most common house dust mite species. Two well known itch mite species, *T. putrescentiae* and *A. siro* did not occur as frequently as expected. *Dermatophagoides pteronyssinus* was nearly ubiquitous, *G. domesticus* was usually associated in furniture with a noticeable accumulation of dander or found in dust samples from kitchen areas, and Oribatida were present where indoor planters were located or soil could be tracked in from outdoors.

Unlike Zimmerman (1944) and Erhorn (1931) who reported bird mites were found to be common in nests of English sparrows and/or mynah birds, *O. bursa* infestations were more recently found to be caused by pigeons, doves and Java rice birds roosting or nesting on window ledges, beams or in attic spaces of houses and buildings. The bird activity was often associated with a nearby food source such as a restaurant, uneaten pet food left out, or direct feeding with bird seed, cooked rice or bread. Java rice birds were especially a problem since they would peck through attic vent screens. *Pyemotes boylei* related mite complaints are known from infested koa haole, kiawe and monkeypod (Vaivanijkul and Haramoto 1969, Ikeda 1982, Nishida and Tenorio 1993, Tenorio and Nishida 1995) and were also found in this study to occur due to beetle infested dried plant materials such as leis. However, *P. boylei,* also recorded as *P. tritici,* complaints were most often caused by infested koa haole or Formosan koa seed pods around homes or in parks.

The primary tick species recorded was *Rhipicephalus sanguineus* (~100.0%; n = 80), the brown dog tick (Table 2). No other established tick species were found to be a public health concern. The main sources of tick infestations were dogs that were taken into a tick infested location or poorly cared for, especially if the dog was relocated on premises, removed from the premises or died.

Human ehrlichiosis has not been reported to occur in Hawaii, but canine ehrlichiosis has been in Hawaii for well over 20 years and is vectored by *R. sanguineus* (Sasaki 2000). Canine ehrlichiosis is a serious disease in dogs that was the subject of a MidWeek news article in April 2000, "Canine AIDS" (Chapman 2000). Fortunately, however, it is not known to infect humans (Sasaki 2000) and no incident of *R. sanguineus* biting a human was recorded in Vector Control inspections. Other important dog related tick species have occasionally been recorded on Oahu, including *Amblyoma americana* (Linnaeus), the lone star tick; *Dermacentor variabilis* (Say), the American dog tick; and *Ixodes pacificus* Cooley & Kohls, the Pacific tick, (Garrett and Haramoto 1967, Goff 1987). *Dermacentor variabilis* is of most interest among these tick species since it is likely to be found on man as well as dogs, is a common cause of tick paralysis, and is a vector of Rocky Mountain spotted fever (*Rickettsia rickettsii*) and tularemia (*Francisella tularensis*) (Ebeling 1975); and was identified in an internal Vector Control Branch memo (Leong 2000) as the tick found attached to a Tantalus/Round Top resident's ankle two days after returning from a trip to Georgia and New Jersey. The resident was treated with doxycycline soon after the tick was discovered, and no symptoms other than swelling, mild rash and itching were reported.

This survey has determined that mite and tick activity is being maintained in urban areas by human activities. As a result, dermatitis from mite infestations is possible, as well as disease transmission between dogs by ticks, especially along leeward Oahu. The results indicate that community or island-wide educational programs should be carried out in late winter for mites and late spring for ticks, and that residential mite and tick surveys may be concentrated in a limited number of district/areas according to complaints received.

Table 1. Mite species occurrence as determined by a sampling of 550 mite-related inspection reports.

Species	%	Mean	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
Acarus siro	0.9	0.5	0	3	0	0	2	0	0	0	0	0	5
Arystidae	0.2	0.1	0	0	0	0	0	0	0	0	1	0	1
Cheyletus sp.	7.3	4.0	7	0	5	2	1	4	3	8	6	4	40
C. eruditus	1.3	0.7	0	0	1	0	1	1	1	0	1	2	7
Dermatophagoides sp.	9.5	5.2	2	4	11	15	4	5	10	0	1	0	52
D. evansi	0.2	0.1	1	0	0	0	0	0	0	0	0	0	1
D. farinae	2.9	1.6	4	3	3	1	0	0	0	2	1	2	16
D. pteronyssinus	32.0	17.6	22	18	15	7	15	23	21	17	17	21	176
Euroglyphus sp.	0.2	0.1	0	1	0	0	0	0	0	0	0	0	1
Feather mites	0.4	0.2	2	0	0	0	0	0	0	0	0	0	2
Glycyphagus sp.	6.5	3.6	10	10	9	0	0	0	1	0	5	1	36
Gl. domesticus	10.5	5.8	1	1	4	5	5	9	9	9	8	7	58
Grallacheles bakeri	0.4	0.2	0	0	0	0	0	0	0	0	0	2	2
Ornithonyssus sp. (= bird mites)	7.6	4.2	6	4	5	4	4	5	3	3	6	2	42
O. bacoti	0.7	0.4	0	0	1	0	1	0	1	1	0	0	4
O. bursa	11.3	6.2	14	6	2	4	6	8	11	0	5	6	62
O. sylviarum	0.2	0.1	1	0	0	0	0	0	0	0	0	0	1
Oribatida (= Oribatei)	1.6	0.9	2	0	0	0	0	0	2	0	3	2	9
Pyemotes sp.	0.5	0.3	3	0	0	0	0	0	0	0	0	0	3
P. boylei (= ventricosus)	3.1	1.7	6	2	2	1	2	0	1	0	0	3	17
Sarcoptes scabiei	1.1	0.6	0	0	1	0	2	2	1	0	0	0	6

Table 1. (coneinued)

Species	%	Mean	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
Tetranychidae (= Tetranychus sp.)	1.1	0.6	1	0	0	1	0	1	1	0	1	1	6
Tyrophagus sp.	0.4	0.2	0	0	0	0	1	1	0	0	0	0	2
Ty. putrescentiae	0.2	0.1	0	0	0	0	0	0	0	0	1	0	1
Total	100.0	55.0	82	52	59	40	44	59	65	40	56	53	550

Table 2. Tick species occurrence as determined by a sampling of 130 tick-related inspection reports.

Species	%	Mean	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
Rhipicephalus sanguineus	100.0	8.0	16	7	3	7	3	11	7	6	9	11	80
Total	100.0	8.0	16	7	3	7	3	11	7	6	9	11	80

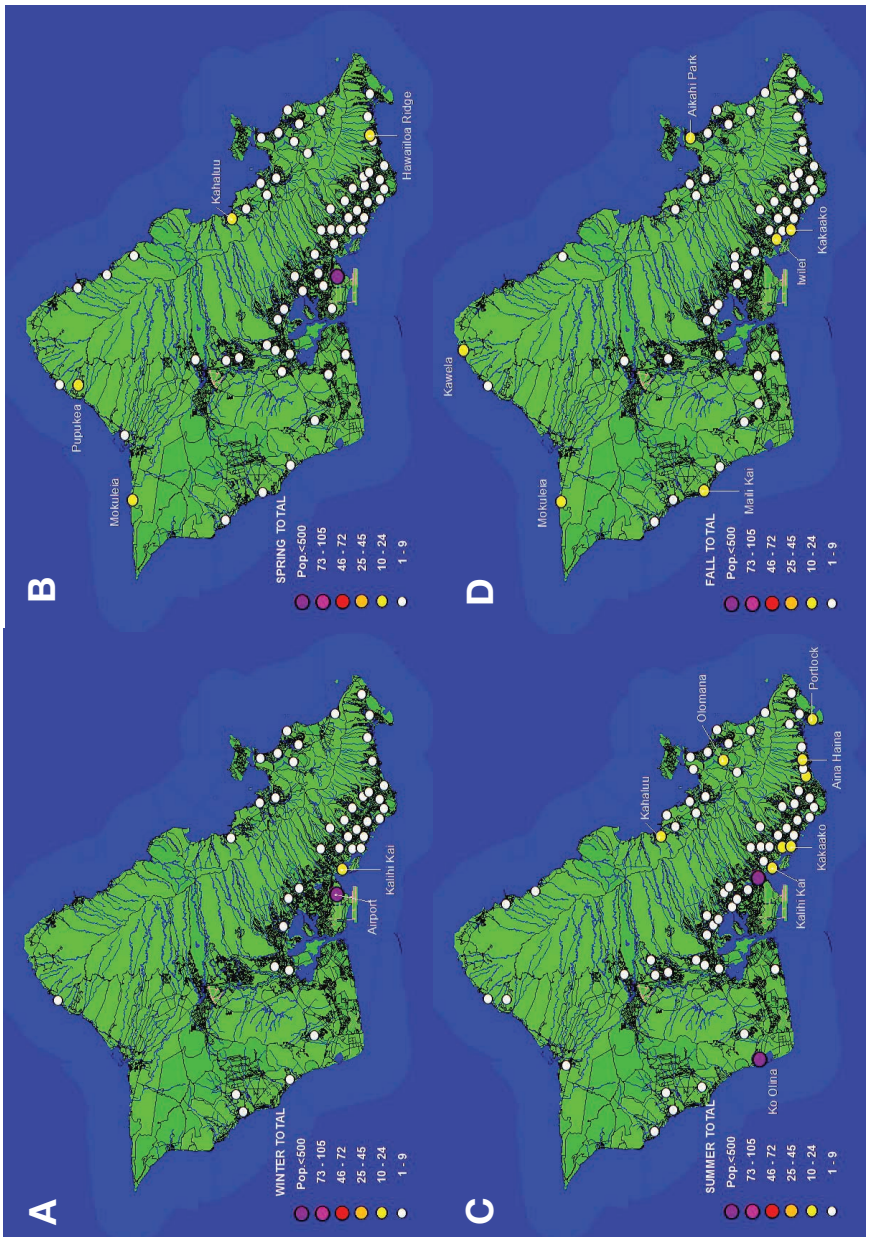

Figure 1. Mites, seasonal totals (1990–1999).

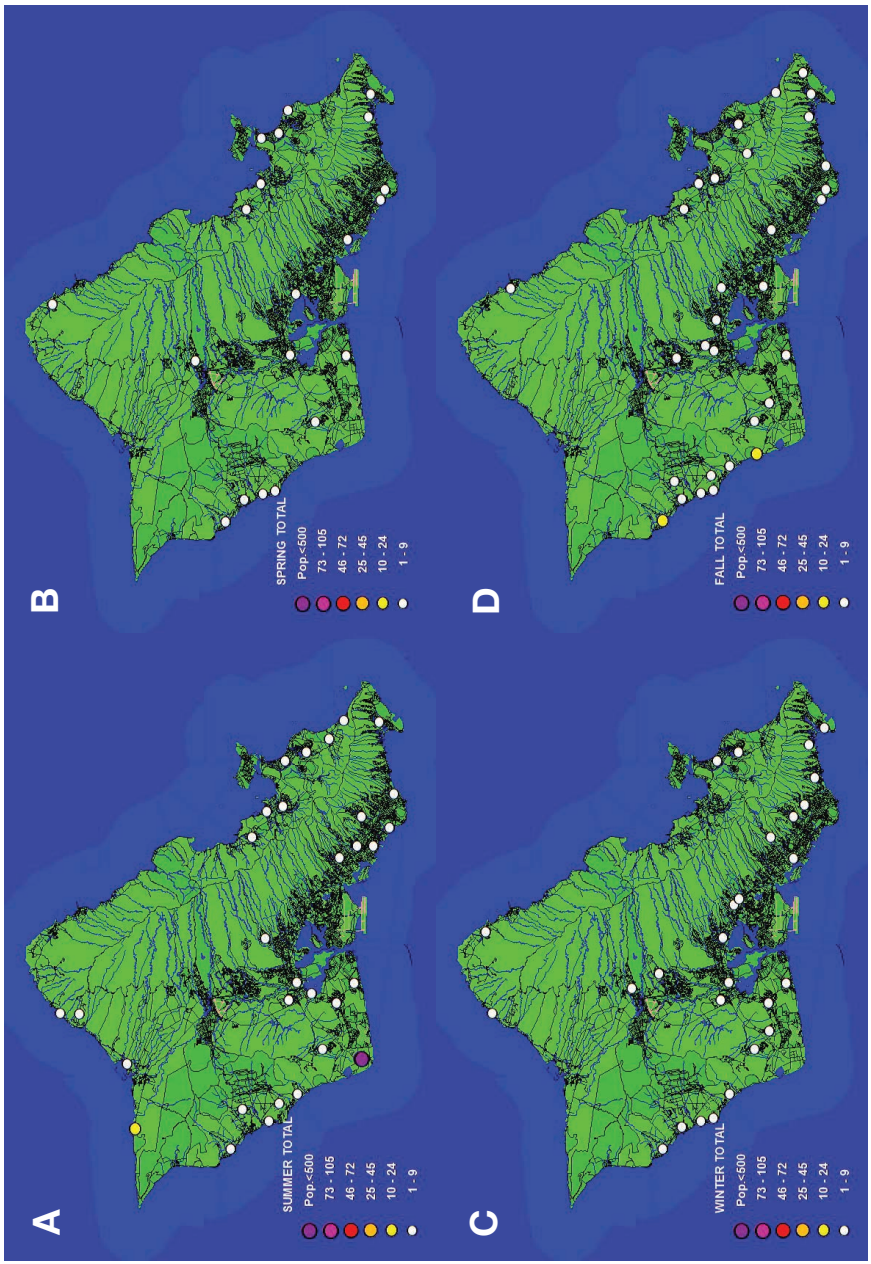

Figure 2. Ticks, seasonal totals (1990–1999).

Educational activities are currently conducted only on a limited basis during inspections. A broader educational program would help to prevent or reduce mite related respiratory illness in addition to dermatitis, and inform the public on how to prevent the introduction of a human disease carrying tick species together with how to control the tick already present on the island. Inspections conducted in response to complaints have confirmed the practicality of using small-target area surveys since mite infestations were usually restricted to the problem site reported and tick infestations normally occurred within one or two premises of the source.

Geographic analysis can help to target areas and times of the year for more efficient application of mite and tick prevention, control and education programs by continuously tracking mite and tick 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 mite or tick 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 mite or tick 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 mite or tick 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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Literature Cited

Baker, E.W., T.M. Evans, D.J. Gould, W.B. Hull, and **H.L. Keegan.** 1956. A manual of parasitic mites of medical or economic importance. Nat. Pest Control Assoc., New York. 170 p.

Bratton, R.L., and **G.R. Corey.** 2005. Tick-borne disease. Amer. Family Physician 71: 2323–2330.

Chapman, D. 2000. Canine AIDS. MidWeek, April 5: 3, 34.

Denmark, H.A., and **H.L. Cromroy.** 2003. Tropical fowl mite, *Ornithonyssus bursa* (Berlese) (Arachnida: Acari: Macronyssidae). Bulletin EENY-297. Univ. Florida, Gainesville. 3 p.

Ebeling, W. 1975. Urban entomology. Univ. Calif., Div. Agric. Sci., Berkeley. 695 p.

Erhorn, E.M. 1913. Notes and exhibitions. Proc. Hawaiian Entomol. Soc. 2: 206.

Erhorn, E.M. 1931. In discussion. Proc. Hawaiian Entomol. Soc. 7: 380.

Fullaway, D.T. 1922. Notes and exhibitions. Proc. Hawaiian Entomol. Soc. 5: 34.

Furumizo, R.T. 1994. Update to housedust mites in Hawaii. Internal Vector Control Branch Memo, Honolulu. 1 p.

Garrett, L.E., and F.H. Haramoto. 1967. A catalog of Hawaiian Acarina. Proc. Hawaiian Entomol. Soc. 19: 381–414.

Goff, M.L. 1987. A catalog of Acari of the Hawaiian Islands. Res. Extension Series 075. Univ. Hawaii at Manoa, Honolulu. 75 p.

Haramoto, F.H. 1961. Notes and exhibitions. Proc. Hawaiian Entomol. Soc. 17: 320–321.

Homer, M.J., I. Aguilar-Delfin, S.R. Telford III, P.J. Krause, and **D.H. Persing.** 2000. Babesiosis. Clinical Microbiol. Rev. 13: 451–469.

Ikeda, J.K. 1982. Acarina: mites and ticks. Vector Control Manual. Hawaii State Department of Health, Honolulu. p. 09-01 to 09-32.

Leong, M.K.H. 2000. Identification of an alien tick. Internal Vector Control Branch Memo, Honolulu. 3 p.

Leong, M.K.H. 2008. Occurrence and distribution of pests of public health importance on the island of Oahu. MS Thesis, Entomology. Univ. Hawaii at Manoa, Honolulu. 172 p.

Leong, M.K.H., and **J.K. Grace.** 2009. Occurrence and distribution of mosquitoes (Diptera: Culicidae) of public health importance on the island of Oahu. Proc. Hawaiian Entomol. Soc. Submitted.

McQuiston, J.H., C.D. Paddock, R.C. Holman, and **J.E. Childs.** 1999. The human ehrlichioses in the United States. Emerging Infectious Diseases 5: 635–642.

Nishida, G.M., and **J.M. Tenorio.** 1993. What bit me? : Identifying Hawai'i's stinging and biting insects and their kin. Univ. Hawaii Press, Honolulu. 72 p.

Pinto, L. 1989. Paper mites, cable mites and other mystery bugs. Pest Control, October: 16.

Pinto, L. 1993. Handle mystery bug treatment with care. Pest Control, October: 8, 114.

Sasaki, D. (ed.). 2000. No human ehrlichiosis in Hawaii. Communicable Dis. Rep., March/April: 8.

Sharp, J.L., and **F.H. Haramoto.** 1970. *Dermatophagoides pteronyssinus* (Trouessart) and other Acarina in house dust in Hawaii. Proc. Hawaiian Entomol. Soc. 20: 583–589.

Skotarczak, B. 2003. Canine ehrlichiosis. Ann. Agric. Environ. Medicine 10: 137-141.

Tenorio, J.M., and **G.M. Nishida.** 1995. What's Bugging Me? : Identifying and Controlling Household Pests in Hawaii. Univ. Hawaii Press, Honolulu. 184 p.

Vaivanijkul, P., and **F.H. Haramoto.** 1969. The biology of *Pyemotes boylei* Krczal (Acarina: Pyemotidae). Proc. Hawaiian Entomol. Soc. 20: 443–454.

Zimmerman, E.C. 1944. A case of bovine auricular myiasis and some ectoparasites new to Hawaii. Proc. Hawaiian Entomol. Soc. 12: 199–200.

Zimmerman, E.C. 1956. Notes and exhibitions. Proc. Hawaiian Entomol. Soc. 16: 18–19.