SCIENTIFIC NOTE

Survey for Parasitic Honey Bee Mites in Hawaii (Acariformes: Tarsonemidae; Parasitiformes: Laelapidae, Varroidae)

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Abstract. A survey was conducted in Hawaii to determine the presence of three mite pests of honey bees (*Apis mellifera* L.): *Acarapis woodi* (Rennie), *Tropilaelaps clareae* Delfinado & Baker, and *Varroa destructor* Anderson & Trueman. A total of 837 random samples were taken from managed and feral bee colonies on the islands of Kauai, Oahu, Maui, and Hawaii. No mites were found in any of the samples. Data were analyzed employing the binomial distribution as a likelihood function. Results showed that there was a 99% probability that the unknown prevalence of mite infestation within the Hawaii honey bee population would be no greater than 0.55%. Thus, Hawaii can be considered to be free of parasitic honey bee mites at the present time.

Key words: *Acarapis woodi*, *Apis mellifera*, Hawaii, honey bee, mite, parasite, *Tropilaelaps clareae*, *Varroa destructor*

Introduction

Of the more than 40 species of mite known to be associated with honey bees (*Apis* spp.) (Eickwort, 1988), only three, *Acarapis woodi* (Rennie), *Tropilaelaps clareae* Delfinado & Baker, and *Varroa destructor* Anderson & Trueman (*V. jacobsoni* Oudemans *auct.*), are of major importance to apiculture, parasitizing the two economically important honey bee species, the cosmopolitan *A. mellifera* L. and *A. cerana* F., which is restricted to Asia. The latter two mites, however, which are brood ectoparasites, represent the far greater threat; *A. woodi*, an internal parasite that infests the mesothoracic tracheae of adult bees, is not considered to have an appreciable economic impact on healthy honey bee colonies (Gary & Page, 1989). *Varroa destructor*, in particular, has been a scourge of honey bee colonies worldwide (De Jong *et al*., 1982b). The mite feeds on hemolymph and develops on the immature stages of bees, often killing the host in the process; females are phoretic on adult bees. If the host survives, the resulting adult usually is deformed in some way and incapable of contributing to colony welfare. Colony population size dwindles over time, and, left untreated, a heavy infestation can kill a colony within three to four years. To combat the parasite, beekeepers must resort to the use of expensive pesticides. However, wild bee colonies have no defense; they have been reported to be dying out on the U.S. mainland, where *V. destructor* is well established (e.g., Kraus & Page, 1995). The biology and threat potential of *T. clareae* are similar (Burgett *et al*., 1983).

Whereas the distributions of *A. woodi* and *V. destructor* are widespread, *T. clareae* largely is restricted to south and southeast Asia and areas of the tropical Pacific (Matheson, 1993). None of the mites had ever been discovered in the Hawaiian Islands or in other isolated regions, such as Australia, New Zealand, and parts of Africa. However, in April 2000, the New Zealand Ministry of Agriculture and Fisheries reported the discovery of *V. destructor* in several apiaries south of Auckland. Evidence suggested that the infestation was longstanding (Benard & Thornton, 2000).

Establishment of *V. destructor* in New Zealand, which has in place beekeeping regulations among the most stringent in the world (Culliney, 1996), underscored the great potential for this parasite to invade the few remaining areas on Earth presently free of infestation. Although *V. destructor* and the other parasitic mites were not known to occur in Hawaii, no comprehensive survey had ever been made to demonstrate conclusively their absence. The present paper reports results of such a survey conducted on the four Hawaiian islands that have sizeable beekeeping operations and are exposed to international air and sea traffic, and thus might reasonably be expected to yield positive findings if bee mites were present.

Materials and Methods

Surveys were conducted on the islands of Kauai, Oahu, Maui, and Hawaii during 2000 and 2001. On each island, samples of honey bee workers were taken from randomly selected hives managed by commercial beekeepers. Feral colonies, when found, also were sampled. Bees were brushed from combs taken from the brood nest, and killed in 70% ethanol. Samples taken from the hives in each apiary were combined, each composite sample comprising a few hundred bees, and preserved in 70% ethanol in pint-sized mason jars for later examination. Throughout the four islands, 837 colonies were sampled in 138 apiaries and other sites containing a total known population of 7618 colonies.

In the laboratory, each jar was shaken vigorously by hand for one minute. This technique was found to detect over 92% of *V. destructor* in samples, and has the added advantage of allowing large numbers of samples to be examined for ectoparasitic mites in a short time, facilitating the detection of low-level infestations (De Jong *et al*., 1982a). The contents then were poured through a number 6 U.S.A. standard testing sieve (6 mesh; W.S. Tyler, Inc., Mentor, OH) to retain bees and on through an underlying piece of white cheesecloth to catch any dislodged mites. The cloth and inside of each emptied sample jar then were carefully examined. Both *V. destructor* and *T. clareae* are large, brown-colored mites (idiosoma dimensions: ~1100 x 1600 ?m and 960 x 550 ?m, respectively; De Jong *et al*., 1982b), and can be seen readily with the unaided eye.

A subsample of 20 bees from each apiary composite sample was dissected, and the mesothoracic tracheae examined under a stereomicroscope for presence of *A. woodi*, following procedures outlined in Shimanuki & Knox (2000).

Results and Discussion

On individual islands, with the exception of Maui, which has only one commercial beekeeper, with five apiaries and 227 hives, sampled apiaries, in general, tended to be broadly distributed (Fig. 1), serving to reduce the probability that geographically isolated mite infestations would go undetected. Both the alcohol-shake method and the dissections failed to detect mites in any of the samples taken from honey bee colonies on the four islands (Table 1).

Because negative results obtained in a limited sample can never prove absolutely the absence of a phenomenon, any conclusions drawn from a study of this kind must be based on probabilities. This study can be assumed to be a simple Bernoulli experiment (Lindgren, 1968), in which one of two outcomes is possible: a colony is either infested or it is not, and the probability that a colony is infested is independent of its spatial location and the incidence of infestation in nearby colonies. The number of infested colonies then fits a bino-

Figure 1. Approximate locations (in black) of apiaries containing sampled honey bee colonies on the islands of Kauai, Oahu, Maui, and Hawaii.

mial distribution with the following parameters: n = 837 colonies sampled, x = number of infested colonies in the sample, and p = probability that a colony is infested. To determine an upper confidence limit for p, the largest value of p, such that $\Pr[X \leq x] \leq$? (where X = the theoretical number of infested colonies in the population), must be found. Since $x = 0$, and a 99% upper confidence limit is sought, the formula reduces to:

$$\Pr[X = 0] \leq 0.01 \text{ or, in the present case, } \Pr[X = 0] = (1 - p)^n$$

Table 1. Results of 2000–2001 Hawaii honey bee mite survey.

Island	Date	Apiary	Mite Detection[1]	
			V.d./T.c.[2]	A.w.[3]
Hawaii	11/00	Avocado (H)[4]	-	-
	11/00	Bend of the Road (H)	-	-
	11/00	Bishop (H)	-	-
	11/00	Bus (H)	-	-
	11/00	Cactus (H)	-	-
	11/00	Carob (H)	-	-
	11/00	Davita 1 (H)	-	-
	11/00	Davita 2 (H)	-	-
	11/00	Dump (H)	-	-
	11/17/00	Ima Loa (B)	-	-
	11/17/00	Gatewood (B)	-	-
	11/00	Hole in the Wall (H)	-	-
	11/17/00	Home (B)	-	-
	11/00	Home (H)	-	-
	11/17/00	Hookena (B)	-	-
	11/00	Joanie's (H)	-	-
	11/00	Kapua (H)	-	-
	11/17/00	Keffer (B)	-	-
	11/00	Kim's (H)	-	-
	11/17/00	Kimball (B)	-	-
	11/00	Lancaster (H)	-	-
	11/00	Little Madeiro (H)	-	-
	11/00	Lower Powers (H)	-	-
	11/17/00	Macnut (B)	-	-
	11/00	Middle (H)	-	-
	11/00	Punaluu 1 (H)	-	-
	11/00	Punaluu 2 (H)	-	-
	11/00	Radha's (H)	-	-
	11/00	Rock Pile (H)	-	-
	11/00	Rosenfeld (H)	-	-
	11/17/00	Sam's (B)	-	-
	11/00	South Point (H)	-	-
	11/00	Upper Powers (H)	-	-
	11/17/00	Weldon's (B)	-	-
	11/00	Wood Valley (H)	-	-
	1/01	Ackerman (K)	-	-
	1/01	Alex (K)	-	-
	1/01	Alex's Dad (K)	-	-
	1/01	Banana (K)	-	-
	1/01	Barber Shop (K)	-	-
	1/01	Basque (K)	-	-
	1/01	Beth's (K)	-	-
	1/01	Bone Yard (K)	-	-
	1/01	Bridge House (K)	-	-
	1/01	Donkey Mill (K)	-	-
	1/01	Doris' (K)	-	-
	1/01	Double Gate (K)	-	-
	1/01	Eddie's (K)	-	-
	1/01	Erik's (K)	-	-
	1/01	Gamble (K)	-	-

Island	Date	Apiary	Mite Detection[1]	
			V.d./T.c.[2]	A.w.[3]
	1/01	Gene's (K)	-	-
	1/01	Greenwell Drone (K)	-	-
	1/01	Greenwell Queen (K)	-	-
	1/01	Home (K)	-	-
	1/01	John's (K)	-	-
	1/01	Kealia (K)	-	-
	1/01	Kelly's (K)	-	-
	1/01	Koga (K)	-	-
	1/01	Komo (K)	-	-
	1/01	Kona Gold (K)	-	-
	1/01	Napoopoo (K)	-	-
	1/01	Paik (K)	-	-
	1/01	Painted Church (K)	-	-
	1/01	Palani (K)	-	-
	1/01	Red House (K)	-	-
	1/01	Tomi Tomi Drone (K)	-	-
	1/01	Tomi Tomi Queen (K)	-	-
	1/01	Uncle Willy's (K)	-	-
	4/01	Air Sac (C)	-	-
	4/01	Avocado (C)	-	-
	4/01	Brittle Net (C)	-	-
	4/01	Cane (C)	-	-
	4/01	Cat's Claw (C)	-	-
	4/01	Compost (C)	-	-
	4/01	Corner (C)	-	-
	4/01	Dome (C)	-	-
	4/01	Don's (C)	-	-
	4/01	Dumpster (C)	-	-
	4/01	Gulch (C)	-	-
	4/01	Hilo (C)	-	-
	4/01	Hono (C)	-	-
	4/01	Iasco (C)	-	-
	4/01	Livingston (C)	-	-
	4/01	Lost Gate (C)	-	-
	4/01	Mill (C)	-	-
	4/01	Mud Flat (C)	-	-
	4/01	Nursery (C)	-	-
	4/01	Nut Shell (C)	-	-
	4/01	Pahala (C)	-	-
	4/01	Papaya (C)	-	-
	4/01	Pasture (C)	-	-
	4/01	Pot (C)	-	-
	4/01	Puna 1 (C)	-	-
	4/01	Puna 2 (C)	-	-
	4/01	Railroad (C)	-	-
	4/01	Round Up (C)	-	-
	4/01	Southgate (C)	-	-
	4/01	Tank (C)	-	-
	4/01	Tree Plot (C)	-	-
	4/01	Triangle (C)	-	-
	4/12/01	Home (E)	-	-

Island	Date	Apiary	Mite Detection[1]	
			V.d./T.c.[2]	A.w.[3]
Kauai	7/01	409 (T)	-	-
	7/01	Barking Sands 1 (T)	-	-
	7/01	Barking Sands 2 (T)	-	-
	7/01	Bonham (T)	-	-
	7/01	Camp (T)	-	-
	7/01	Coffee Pond (T)	-	-
	7/01	Coots (T)	-	-
	7/01	El Capitan (T)	-	-
	7/01	Hillside (T)	-	-
	7/01	K-4 (T)	-	-
	7/01	Kapu Bluff (T)	-	-
	7/01	Lindner (T)	-	-
	7/01	Mahi (T)	-	-
	7/01	Meadow (T)	-	-
	7/01	Mom's (T)	-	-
	7/01	New Quarry (T)	-	-
	7/01	Plumeria (T)	-	-
	7/01	Rocky Road (T)	-	-
	7/01	Snake (T)	-	-
Maui	7/18/01	Mac 4 (M)	-	-
	7/18/01	Mac 8 (M)	-	-
	7/18/01	Mac 10 (M)	-	-
	7/18/01	Mac 40 (M)	-	-
	7/18/01	Kaanapali Coffee (M)	-	-
Oahu	12/14/00	Damon Estate	-	-
	12/14/00	Damon-Kahaluu	-	-
	2/1/01	Kliks-Waikane	-	-
	2/1/01	Kliks-Maunawili	-	-
	6/26/01	Feral nest-Kaneohe	-	-
	8/9/01	Jefts (Kunia) 1	-	-
	8/9/01	Jefts (Kunia) 2	-	-
	8/9/01	Jefts (Kunia) 3	-	-
	10/30/01	Kliks-Diamond Head	-	-
	12/19/01	Kliks-Leahi	-	-
	12/27/01	Kliks-Nanakuli Ranch	-	-
	12/27/01	Kliks-Poamoho	-	-
Apiaries sampled:	138			
Hives sampled:	837			

[1]+ = positive detection; - = negative detection.
[2]V.d = *Varroa destructor*; T.c. = *Tropilaelaps clareae*; alcohol shake method.
[3]A.w. = *Acarapis woodi*; a sample of 20 worker bees from each apiary was dissected.
[4]B = Big Island Queens, C = Captain Cook Honey, E = East Hawaii Bees, H = Hawaiian Queen Co., K = Kona Queen Hawaii, M = Tropical Apiary Products of Maui, T = Garden Island Bees.

Solving for *p*, the equation becomes:

$$p = 1 - (0.01^{1/n})$$

Therefore, in the present study, a sample of 837 randomly selected honey bee colonies, in which no evidence of mite infestation is found, yields a 99% upper confidence limit of 0.0055 on the prevalence of infestation. In other words, there is a 99% probability that the unknown prevalence of infestation within the Hawaii honey bee population will not exceed 0.55%. The calculation assumes that an infinite honey bee population is sampled. However, in practice, there is little difference in upper confidence limit if a large, finite population (in this case, 7618 colonies) is substituted.

Although variable, infestation rates within bee colonies are known to reach as high as 90% for *T. clareae* (Burgett *et al*., 1983), 95% for *A. woodi* (Gary *et al*., 1989), and 100% for *V. destructor* (De Jong *et al*., 1984) where the mites are well established. The low theoretical probability of infestation derived in the present study indicates that, for all practical purposes, Hawaii can be assumed to be free of parasitic honey bee mites at the present time.

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