Seasonal abundance of the *Apis mellifera* L. ectoparasites *Acarapis dorsalis* Morgenthaler and *Acarapis externus* Morgenthaler (Acari: Tarsonemidae) in Oregon

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Introduction

Acarapis dorsalis Morgenthaler and *Acarapis externus* Morgenthaler are ectoparasites of western honey bees (*Apis mellifera* L.) and are felt to have a cosmopolitan distribution (Clinch 1976; Clark 1985). For reproductive and feeding functions, these *Acarapis* species have effectively partitioned the adult bee host. *Acarapis externus* is found on the ventral portion of the neck while *A. dorsalis* is restricted to the dorsoscutellar groove of the thorax. Like the endoparasitic mite, *Acarapis woodi* (Rennie), these two external *Acarapis* species are hemophagic parasites (Orosi-Pal 1934; Bailey 1963). However, their pathogenicity to infested hosts has never been investigated (Bailey 1963).

External *Acarapis* were first discovered in the United States in New York in 1930 and identified as *A. dorsalis*. *A. dorsalis* and/or *A. externus* were later found in 22 other states (Eckert 1961; Shaw *et al.* 1961; Royce *et al.* 1988). In Oregon, a 1986 search for external *Acarapis* revealed the ubiquity of both species throughout the state (Royce *et al.* 1988).

Acarapis dorsalis was reported to be more prevalent than *A. externus* in Britain (Bailey 1981) but results of surveys done in British Columbia (Clark 1985) and New Zealand (Clinch 1976) showed that *A. externus* is the more common species. The reasons for differences in regional interspecific prevalence rates are difficult to explain; they could be due to sampling methods or they could reflect regional environmental conditions that favor one species. The interactions between species within an individual colony have yet to be completely understood. Delfinado-Baker and Baker (1982) believe that the world distribution of the two external *Acarapis* are the same. However, *A. externus* has higher population density and thus, has been more frequently observed and collected than *A. dorsalis*.

The seasonal population fluctuations of these two *Acarapis* species have been studied by several researchers but contradictory results have been reported. In California, *A. dorsalis* was found to have peaks of infestation during the spring and fall (Eckert 1961). Clinch (1976) observed that external *Acarapis* population in colonies in New Zealand were highest in fall and spring and lowest in summer. In Massachusetts (Shaw *et al.* 1961) and in western Canada (Clark 1985), the highest external *Acarapis* infestations were observed in spring and summer.

This study was undertaken to clarify these conflicting reports by determining the trends of external *Acarapis* infestations within colonies under conditions of the U.S. Pacific Northwest. Sex ratios of both species were also estimated from our available data.

Materials and Methods

The seasonal abundance of the two external *Acarapis* species was initially investigated by monitoring six colonies for *A. dorsalis* and four colonies for *A. externus*. Monitoring for *A. dorsalis* infestations was done from August 1986 to August 1988. For *A. externus*, colonies were monitored from August 1987 to January 1989. One colony from the *A. dorsalis*-infested hives and two colonies from the *A. externus* experimental group died during the winter of 1988.

About 100 bees from each colony were sampled from honey combs at weekly intervals. Individual bees were taken directly from the combs and placed in stoppered beakers containing ca. 95% CO_2. This was done to prevent any transfer of mites between sampled bees. Bee samples were frozen following collection for later examination. Subsamples of 30 individual bees

Abstract

The seasonal population fluctuations of *Acarapis dorsalis* and *Acarapis externus* were monitored. Highest *A. dorsalis* infestations were recorded in spring months (March to June) and late summer (August to September). For *A. externus*, the highest levels of infestation were observed in October and November. The lowest infestation rates for *A. dorsalis* were observed in January and July. *A. externus* also had a low percent infestation in July. Both species were observed to be multivoltine since all developmental stages were present throughout the year. However, fecundity decreased during the winter months (December to January). The average female:male ratios were established at 1.9:1 for *A. dorsalis* and 2.1:1 for *A. externus*.

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were examined for the presence of all stages of both mite species. Unfortunately, the presence of A. *dorsalis* in hives designated for the study of A. *externus* seasonal abundance complicated data collection. This complexity was due to the ability of both *Acarapis* species to use the wings and wing axillaries for migration and sometimes for reproduction. All adult mites found on these areas were therefore mounted in Hoyer's solution and identified to species under phase contrast microscopy. Since males and immatures of A. *dorsalis* and A. *externus* are difficult to distinguish, all were considered to be A. *dorsalis* in this study since most females observed on the wings were identified as this species. We are confident that this consideration being made did not significantly affect our abundance and sex ratio estimates (especially for A. *externus*) since only a small proportion of the mite population was observed on those parts of the bee host. Percent infestation was calculated based on the number of bees with live mites. Males were differentiated from females based on the body size and the number of setae on tibia 1V. Males are usually smaller than females and possess one long seta, while females have two long tibial setae (Delfinado-Baker and Baker, 1982; Royce *et al.*, 1988). Larvae were not differentiated from pharate nymphs. The sex ratio (F:M) for A. *dorsalis* was estimated from the phenology data using five colonies while the sex ratio for A. *externus* was estimated from data obtained using the two colonies concurrently infested by both *Acarapis* species.

Results and Discussion

Acarapis dorsalis

Figure 1a shows the phenology of A. *dorsalis* for two years (August 1986 to August 1988). Relatively high infestations were recorded in spring months (March to June) when new adult worker bees started to emerge, thus providing a new cohort of hosts for the mites, and during late summer (August to September), which coincided with the decrease in brood rearing activity inside the colonies. This observation corroborates the findings of Shaw *et al.* (1961) in Massachusetts and by Clark (1985) in western Canada.

Infestation levels were generally low in the winter months (December to January), which illustrates the adaptation of an obligate parasite's population to that of its hosts. During this period in temperate beekeeping regions, such as Oregon, a protracted break in brood rearing occurs. At this time, only the longer-lived bees populated the hives and thus, no new hosts were available for the mites. The most attractive age for a bee to become infested by A. *dorsalis* was reported to be 1-15 days (Eckert 1961; Ibay 1989). Consequently, limited food resources may reduce the reproduction rate of the parasitic mite. A distinct drop in the level of infestation was observed in July of both years of observation. This month coincided with the peak bee emergence inside the hive and thus, could indicate the dilution of mite population due to the high number of new hosts which do not become infested, *i. e.*, the parasite infestation rate cannot increase at the same rate as the host population. In November, mite prevalence declined which was probably due to the reduction in the amount of brood reared by the bees during this month. The same trend

of mite infestation was recorded during the second year of observation.

All the life stages of *A. dorsalis* were present throughout the sampling period (Figure 1b). The constant presence of immatures indicates that the mites reproduced continuously throughout the year. However, fecundity decreased during the winter months. A photo of *A. dorsalis* appears in figure 6.

Acarapis externus

The population fluctuation of *A. externus* from two colonies during the period of August 1987 to January 1989 is shown in Figure 2. The two colonies used for this experiment were concurrently infested with *A. dorsalis*, which may have complicated our data because of possible interspecific competition. In these colonies, *A. externus* was observed to be more abundant than *A. dorsalis* both at colony and individual levels. It is interesting to note that a relatively small percentage of worker bees were found to be parasitized by both species, a phenomenon also noted by Burgett *et al.* (1989). The infestation rates of both species fluctuated throughout the experimental period. The levels of infestation began to decrease in December, reaching a minimum in July.

For *A. externus*, the highest rate of infestation was observed in October and November. Likewise, the number of mites per infested bee was relatively high during these months (Figure 3b), a time when bee colonies have a higher proportion of older bees as brood production and emergence of young bees were on a decline. This observation suggests that age of bee hosts has little effect on *A. externus* population, which corroborates the findings of Ibay (1989). By marking newly emerged bees and taking samples every five days for 40 days, she observed that the percent infestation and the number of *A. externus* per infested bee remained relatively high on bees up to 35 days old. Having high mite load on older bees for this *Acarapis* species may be advantageous for mite dispersal through drifting of older foraging adults. This apparent lack of host age preference of *A. externus* seems to be contradictory to the reported preference of *A. dorsalis* and *A. woodi* to younger bees. For both mite species, the highest number of mites per bee was observed on bees 1-15 days of age (Morgenthaler 1931; Eckert 1961; Royce *et al.* 1988; Ibay 1989).

From December 1987 up to April 1988, a drastic decrease in the level of *A. externus* infestation was observed. The reasons for this decrease were not clear. However, reduced brood production and probably death of infested bees with the mites on or before this period were important factors to be considered.
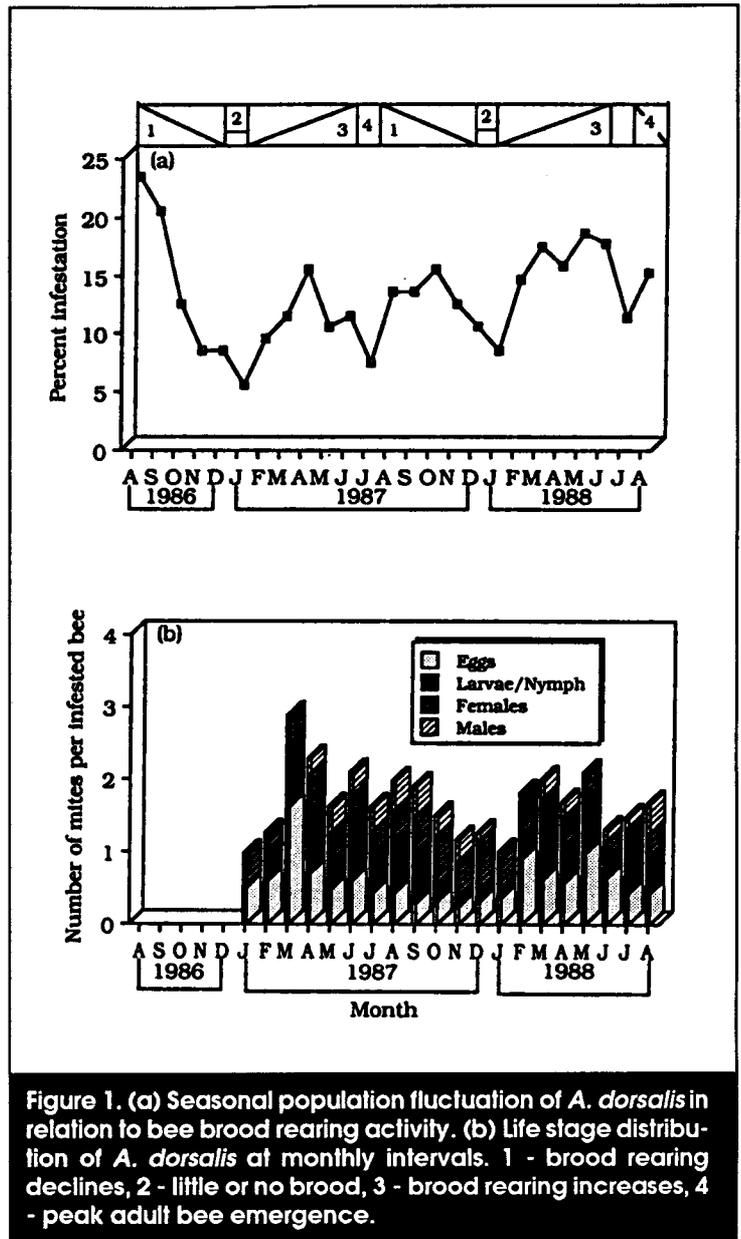

Figure 1. (a) Seasonal population fluctuation of *A. dorsalis* in relation to bee brood rearing activity. (b) Life stage distribution of *A. dorsalis* at monthly intervals. 1 - brood rearing declines, 2 - little or no brood, 3 - brood rearing increases, 4 - peak adult bee emergence.

Like *A. dorsalis*, *A. externus* reproduced throughout the year with fecundity decreasing during the winter months (Figures 3a and b). This result was not in agreement with previous reports stating that *A. externus* increases its reproduction during late fall and in winter when winter cluster forms within the colony (Anonymous, 1932; 1933).

The infestation rates of both species from the two colonies that died in February 1988 and the two surviving colonies are shown in Figures 4a and b, respectively. A higher rate of infestation by the two *Acarapis* species was observed in the colonies that died than in

the surviving ones. We do not wish to suggest any mortality causation by this observation. An increasing percent of *A. dorsalis* infestation (50.38%) with a relatively high percentage of bees concurrently infested by both species (45.5%) were also noted (Figure 4a). Infestation by *A. externus* remained at high levels although a slight decrease was noted during the winter months. In the two surviving colonies, there was an overall decline in the rates of *Acarapis* infestation in February (Figure 4b). This observation suggests a correlation between the infestation rate and mortality, or survival, of bee colonies during the winter months. We feel this hypothesis needs further study.

Sex Ratio

The sex ratio (F:M) for *A. dorsalis* was observed to be 1.9:1. The highest number of females were observed in fall while more males were recorded during summer (Figure 5a).

For *A. externus*, the highest number of both females and males was observed in fall and the lowest number was noticed in spring (Figure 5b). The sex ratio also was skewed in favor of females with a ratio of 2.1:1. This estimate is not in agreement with Brugger's (1936) 1:1 sex ratio. Lindquist (1986) cited a varying sex ratio of 2.1 through 1:1 to 2.3 by *A. dorsalis* and *A. externus*. He further stated that this discrepancy on reported sex ratios was probably due to sampling methods and migratory behavior of the mite. For *A. woodi*, Royce (1989) postulated that host age is an important factor in the sex ratio determination of this *Acarapis* species. She observed that younger hosts have sex ratios that favor females while in older hosts a more even ratio was noticed.
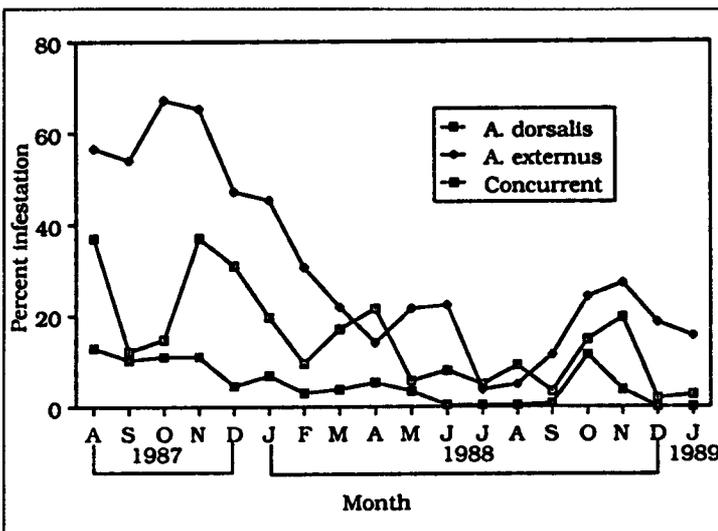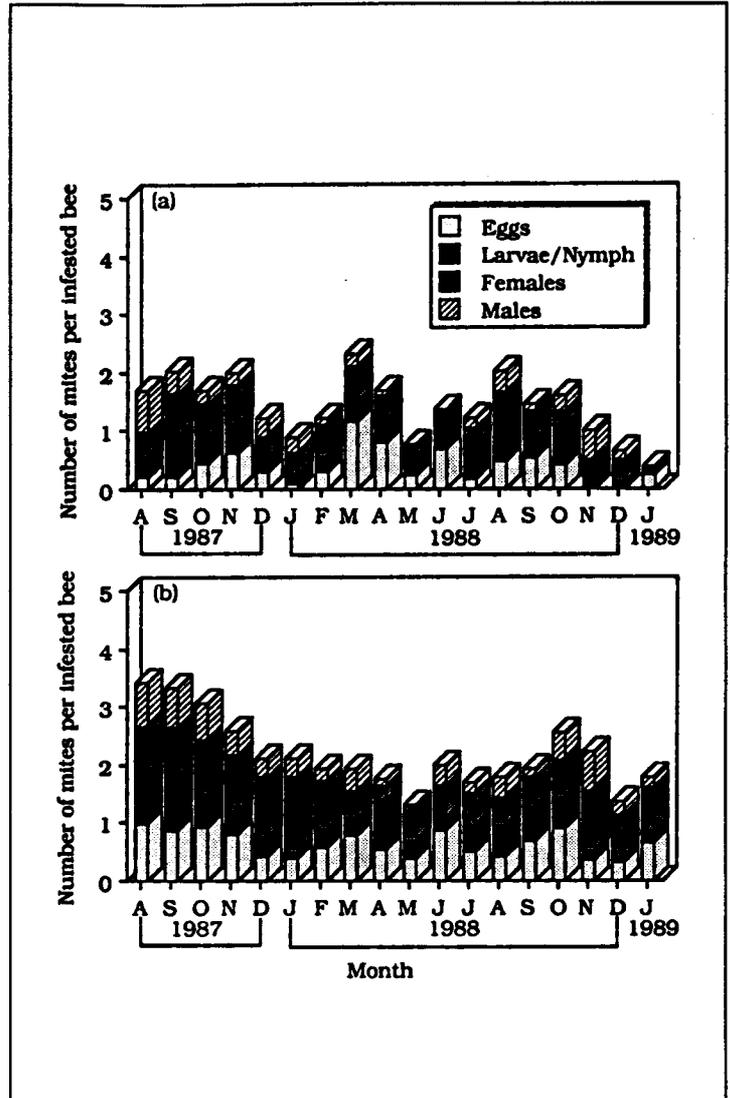

Figure 3. (a) Life stage distribution of *A. dorsalis* in colonies concurrently infested with *A. externus* (b) Life stage distribution of *A. externus* in colonies concurrently infested with *A. dorsalis*.

The apparent greater abundance of females in both species suggests that males are shorter-lived than females. An alternate explanation is that due to haplo-diploid sex determination in this group (Lindquist, 1986), a female bias can be assumed.

Acknowledgments

Figure 2. Seasonal population fluctuations of *A. dorsalis* and *A. externus* in two concurrently infested colonies.
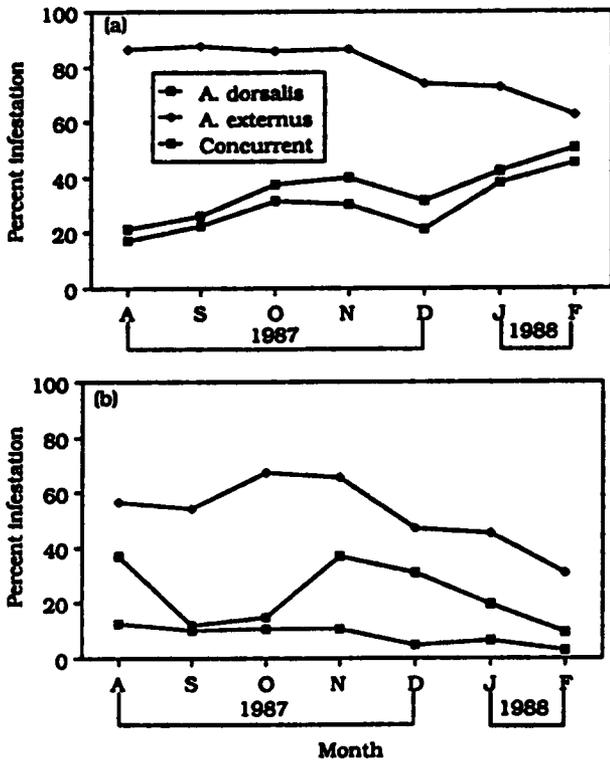
Figure 4. Percent infestations of *A. dorsalis* and *A. externus:* (a) two dead colonies (b) two surviving colonies.
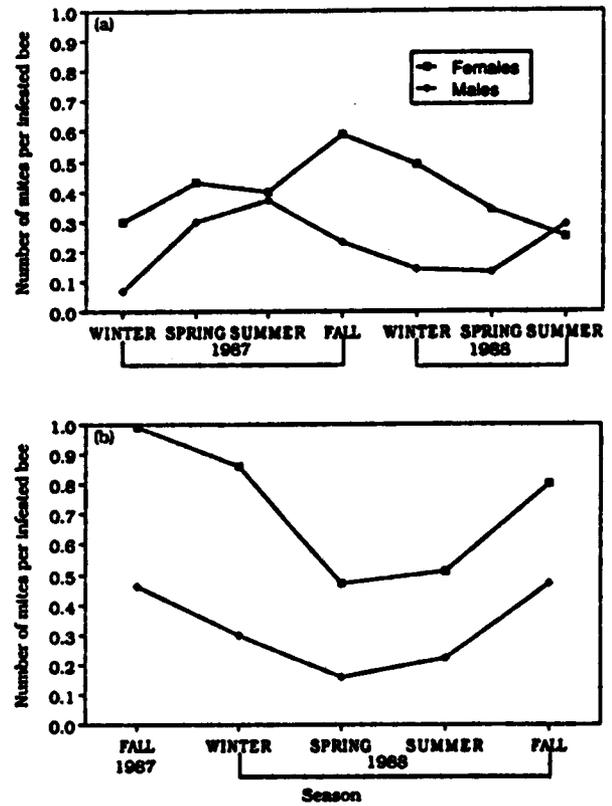

Figure 5. Seasonal sex ratio: (a) *A. dorsalis* (b) *A. externus.* WI - Winter, SP - Spring, SU - Summer, FA - Fall.

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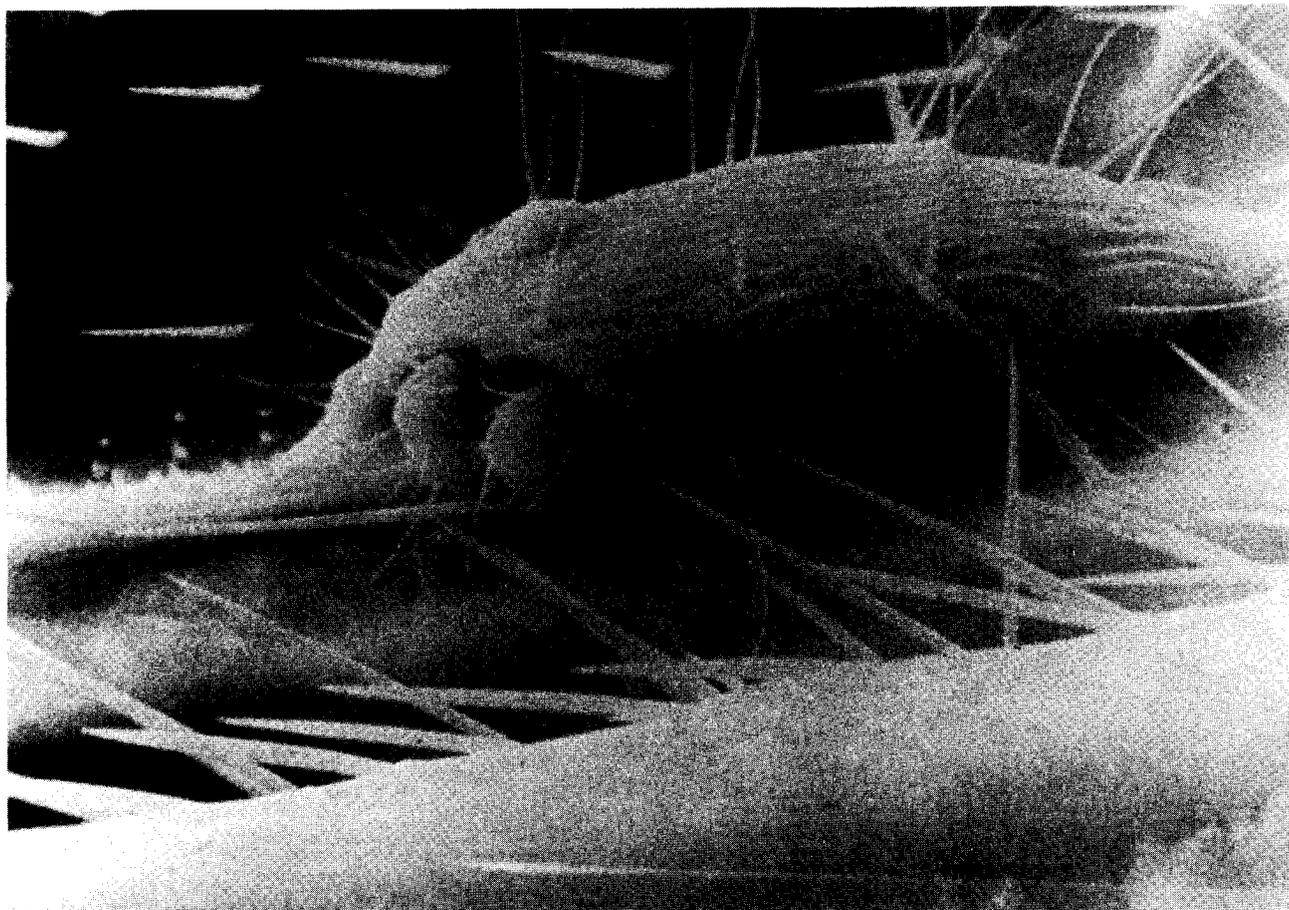ECKERT, J. E. 1961. *Acarapis* mites of the honey bee, *Apis*

Figure 6. Acarapis dorsalis adult on honey bee wing vein.

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