Chapter 2

BIOLOGY AND LIFE HISTORY OF *ACARAPIS DORSALIS* AND *ACARAPIS EXTERNUS*

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There are three mites in the genus *Acarapis* that are specific to the western honey bee (*Apis mellifera* L.). One of them is an internal parasite, *Acarapis woodi* (Rennie). The other two are external parasites, *Acarapis dorsalis* Morgenthaler and *Acarapis externus* Morgenthaler.

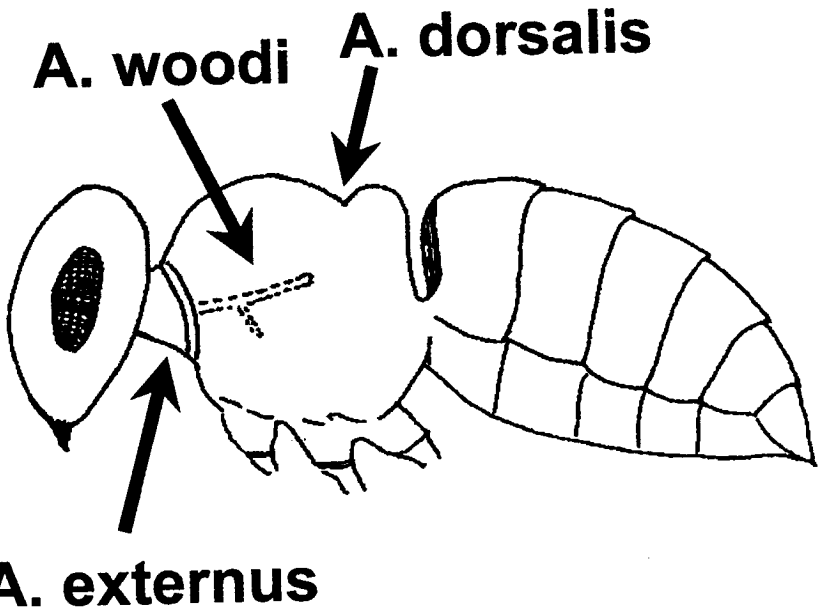
An external mite, which was morphologically different from *A. woodi*, was reported as early as 1926, five years after *A. woodi* was described by Rennie[31]. Morgenthaler proposed the name *A. externus* and later observed that this mite breeds on the underside and sides of the neck of a host bee[23]. Morison[27] detected external mites on the bee thorax that differed from Morgenthaler's, and these were designated *A. dorsalis*. However, both external *Acarapis* were not described until 1934 by Morgenthaler[26].

The two external *Acarapis*, like *A. woodi*, are blood feeders[29]. They have been reported to cause no visible symptoms of injury to bee

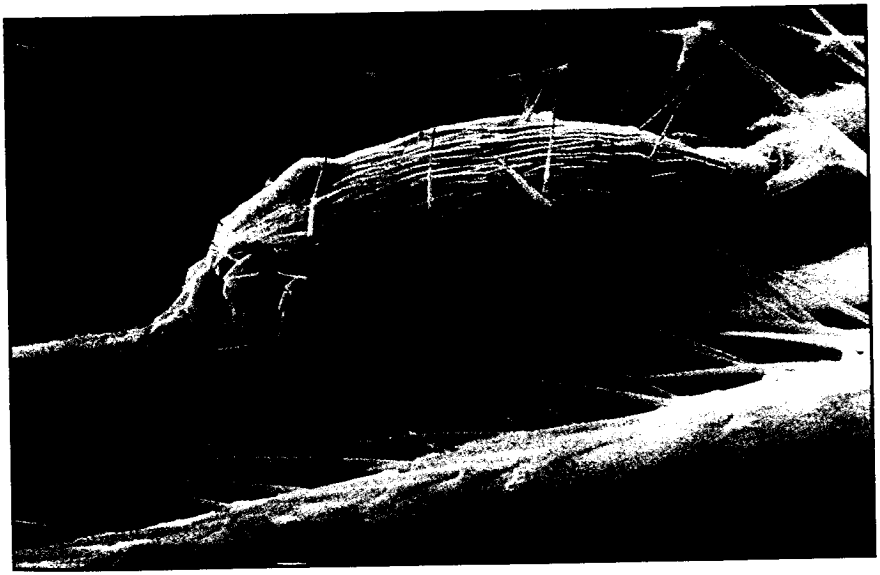
hosts[14,16], and Shaw & others[33] believed that there was no relationship between the prevalence of external *Acarapis* and colony performance. Both external *Acarapis* are generally considered harmless parasites of honey bees, although *A. externus* may cause wing loss or malfunction[12]. Ibay[24] also reported mortality of experimental colonies in Oregon that were highly infested with both external *Acarapis*. Thus, these mites may be more troublesome for honey bees than generally believed. However, the pest status of these two species has never been thoroughly investigated.

Identification and detection. Morphological characteristics separating the three *Acarapis* species are meager and confined to the adult females[14]. Eckert[16] and Delfinado-Baker and Baker[14] found only a few morphological differences between the three *Acarapis* species. *A. externus* has a larger body and longer terminal segments of leg IV compared to *A. woodi* and *A. dorsalis*. The distance between the two spiracles is shorter in *A. woodi* than it is for *A. dorsalis* and *A. externus*. The shape of the posterior margin of the coxal plate between leg IV is different between the three species. The coxal plate in *A. dorsalis* has a posterior margin that is more deeply cleaved than it is in *A. woodi*, while *A. externus* has a nearly straight posterior margin. Eckert suggested that the characteristic of *A. externus* of excreting and using gummy substances, presumably secreted by the female before laying eggs to fasten them together, can be used to separate it from *A. dorsalis* which lays eggs singly in the dorsal scutoscutellar groove of the bee thorax.

Due to their small size and morphological similarities, the three *Acarapis* species are most usually identified by location on the bee host (Fig. 2.1). *A. externus* is found on the underside of the neck, the membranous area between the head and thorax, and in the tentorial pits of the head. *A. dorsalis* uses the dorsal groove of the thorax between the scutum and scutellum, while *A. woodi* infests the tracheae. Like *A. woodi*, both external *Acarapis* are migratory and have been collected from other parts of the honey bee such as wings, propodeum, thorax near the bases of the wings, and on the first segment of the abdomen[5,16,24,32,33] (Fig. 2.2). Their ability to use the same areas for aggregation or reproduction further complicates the identification of external *Acarapis* species.



▲ *Fig. 2.1 Location of the three species of* Acarapis *on an adult honey bee.*



▲ *Fig. 2.2 Adult female of* Acarapis dorsalis *on the wing vein of a honey bee.*

Life history. Because the adults of external *Acarapis* are migratory, limited information on their life history is available. Several attempts have been made to culture *Acarapis* in the laboratory, but none has been successful[16,18,24]. *Acarapis* mites undergo all life stages (egg, larva, nymph, and adult) on a single bee host. The eggs are unusually large, being about the same size as the adult female that lays them. The larva has six legs of which one pair is well developed and two pairs underdeveloped. The larva is an active feeder, while the nymph is a non-feeding stage[14,16,27]. Like *A. woodi*, males are distinguished from females based on body size and the number of hairs on the tibia of leg IV. Males are usually smaller with one long hair on tibia IV, while females are bigger with two tibial hairs[14]. Like the larvae, adult *Acarapis* mites are parasitic on honey bee hosts. They have long cheliceral stylets with which they feed on the host bee[13].

Life cycle comparisons. Marked, newly emerged bees were introduced into mite-infested colonies to determine the life cycle periods of external *Acarapis*. They have been estimated to be 8-10 days[16,24,32], which is about four days less than that of tracheal mites[3,6,18,25,32]. The developmental time of *A. externus* is similar to that of *A. dorsalis*. However, differences in the length of egg and larval/nymphal stages are noted (Table 2.1). Egg incubation takes only three days in *A. externus* as compared to four days in *A. dorsalis*. The larval stages, however, require one day longer (5-6 days). Males emerge earlier than females.

The female to male ratio is 1.9:1 to 3:1 for *A. dorsalis*[7,20] and 1:1 to 2.1:1 for *A. externus*[6,20]. The highest numbers of females are observed during fall months. The apparent abundance of females in both species suggests that males are shorter-lived than females, and thus observed ratios may be influenced by the life history or behavior of the mites.

The longevity of external *Acarapis* has not been studied. However, studies of *A. woodi* show that adult mites can live about 40 days[18,30]. Longevity of external *Acarapis* may be less than that of *A. woodi*, considering that the external species exploit less-protected microhabitats outside the bee's body. When the host bee dies, all life stages of *A. dorsalis* die by about 72 hours[27].

Age preferences. Like *A. woodi*, *A. dorsalis* prefers young worker bees 1-15 days of age[24,27,32,33]. However, preference studies reveal that *A. externus* can maintain its population on older bees[24]. Prevalence of *A.*

externus remains relatively high on bees 35 days of age. Thus, *A. externus* is more capable than *A. dorsalis* of surviving on older bees. This behavior may be advantageous for mite dispersal by allowing them to relocate on older drifting forager bees. Queens are rarely infested with external *Acarapis*[7,16].

Distribution. Morgenthaler found *A. externus* throughout Switzerland in 1930. Infestation by *A. externus* has also been observed in *Apis cerana* F. in Japan[4,15]. External *Acarapis* have been recorded in Scandinavia, Australia, New Zealand, Europe, the former USSR, North and South America, and Africa[4]. Both external *Acarapis* were found infesting *A. mellifera* in Iran[28]. In the United States, the first external *Acarapis* detected was *A. dorsalis* in New York in 1930. *A. dorsalis* or *A. externus* were later found in 24 other states[7,16,19,32,33].

A. dorsalis is reported to be more prevalent than *A. externus* in Italy[17], Britain[4], Washington[7], and Oregon[24]. However, surveys done in Switzerland[27], New Zealand[9], British Columbia[8], and Iran[28] show that *A. externus* is the more common species. Delfinado-Baker and Baker[14] believe that the world distribution of the two external *Acarapis* is similar. However, *A. externus* has a higher population density and thus has been more frequently observed and collected than *A. dorsalis*[4]. The reasons for differences in regional interspecific prevalences are unclear.

Table 2.1 Life cycle comparison of the three *Acarapis* species.

life stage	duration (hours)		
	A. dorsalis†	*A. externus*†	*A. woodi*††
egg	96	72	72
immature	96-120	120-144	264
egg-laying to adult	192-216	192-216	336

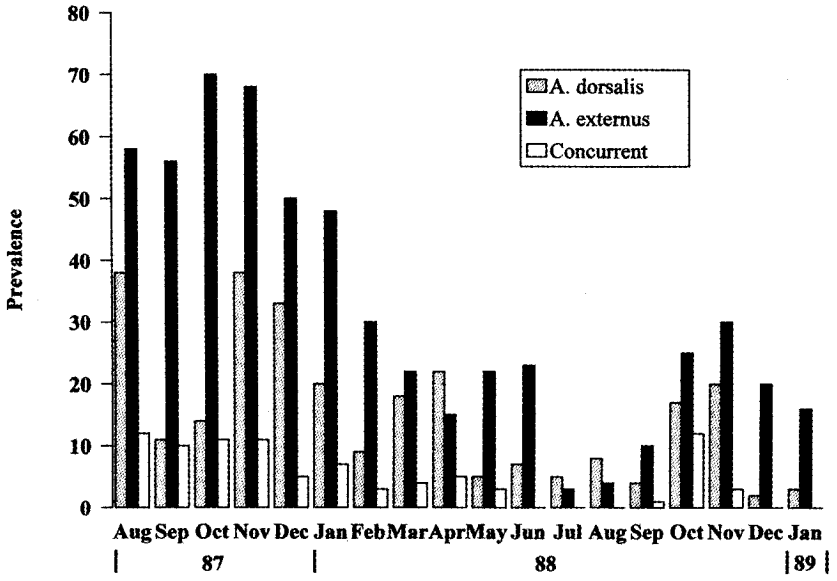
†After Ibay[24]

††After Royce & others[32]

However, they could be due to sampling methods or to regional environmental conditions that favor one species over the other.

Population dynamics. The seasonal population fluctuations of the two external *Acarapis* vary. In California, *A. dorsalis* is found to have peaks of infestation during the spring and fall[16]. Clinch[9] observed that external *Acarapis* populations in honey bee colonies in New Zealand are highest in fall and spring and lowest in summer. In Massachusetts[33] and in western Canada[8], the highest external *Acarapis* infestations are observed in spring and summer. The highest *A. dorsalis* infestations in Oregon are recorded in spring months (March to June) and late summer (August to September)[20] (Fig. 2.3). For *A. externus*, the highest prevalences are observed in October and November. The lowest prevalences for *A. dorsalis* are observed in January and July. *A. externus* also has a low infestation rate in July.

Because of the ubiquity of the three *Acarapis* species, multiple infestation of a colony is common. *A. dorsalis* is reported to be more common than *A. externus*[4,7,24]. A similar observation was noted when noninfested nuclei were inoculated with known *Acarapis* populations.



▲ *Fig. 2.3 Seasonal fluctuations in the percentage of bees infested (prevalence) with* Acarapis dorsalis. A. externus, *or both mites (concurrent) (after de Guzman & Burgett[20]).*

A. dorsalis showed a higher rate of infestation than *A. externus*[24]. This observation suggests that a critical population must be attained by *A. externus* to establish itself in a colony. Unless this critical population is reached prior to invasion by *A. dorsalis*, *A. externus* appears unable to maintain its population in the colony. Natural infestation of colonies showed that *A. externus* seems to be more predominant than *A. dorsalis*[19,20]. When the three *Acarapis* species are present, *A. woodi* seems to be the predominant species both at the colony and individual host bee levels[7,19]. This may be attributed to the ability of *A. woodi* to reproduce faster as indicated by the higher number of mites observed inside the tracheae[19]. This ability may also explain the comparatively high virulence of tracheal mites; more mites per bee means more feeding sites which are instrumental in secondary infections. A smaller proportion of bees was infested with all three *Acarapis* species at the same time[6,7,20]. The reasons for one species becoming more prevalent than others need to be studied, but they probably include differences in mite colonizing abilities, reproductive rates, or genetic differences in the host bees.

De Guzman[19] compared natural prevalences of the three *Acarapis* species in three stocks of honey bees and one of their hybrids that were used primarily for varroa mite research[21]. A commercial Italian stock from Louisiana had low *A. dorsalis* prevalences, but high prevalences of both *A. woodi* and *A. externus*. Colonies of the Hastings stock had high levels of both *A. woodi* and *A. dorsalis*. The susceptibility of Hastings to *A. externus* is unclear since results of two trials were not consistent. The ARS-Y-C-1 honey bee stock and an F_1 hybrid between Hastings and ARS-Y-C-1 were resistant to *A. woodi*[22] and *A. dorsalis*, but had high levels of *A. externus*. The longevities of these colonies harboring four species of mites were similar. However, their resistance levels to varroa mites differed[21]. The authors reported that the Louisiana stock which had lower levels of varroa died earlier than Hastings, F_1 hybrid, and ARS-Y-C-1, which had higher varroa mite infestations. However, this early death of the Louisiana stock colonies may have been influenced by the high levels of *A. woodi* and *A. externus* in the colonies. *A. woodi* is known to reduce longevity of infested bees[2]. Likewise, mortality had been observed in colonies free from *A. woodi* and varroa mites, but with high infestations of *A. dorsalis* (64%), *A. externus* (62%) and both species (49%) in Oregon[24]. The concurrent parasitism of the three *Acarapis* species and varroa mites in a honey bee colony may accelerate the decline of colony health. Thus, high infesta-

tions of the external *Acarapis* in addition to the presence of two major honey bee parasites (varroa and tracheal mites) in the colonies could be a co-factor in precipitating colony mortalities.

Control. External *Acarapis* mites are believed to be unimportant economically[3]. Their presence causes no measurable loss in the population or production of honey bee colonies[16]. But because they feed on their hosts' blood, it is possible that they have negative effects on infested bees. A few chemicals have been tested for the control of external *Acarapis*. However, none of these chemicals is registered for use in the United States. In New Zealand, Clinch and Faulke[11] obtained an 85% reduction in the number of infested bees when a single dose of 40 mg endosulfan per colony was fed in 2:1 sugar syrup. A second treatment applied after 19 days resulted in 98% decrease in infested bees. Subsequent study showed that fenbutatin oxide and trichlohexyltin hydroxide were more effective than endosulfan and safer than amitraz[10]. Sulfur dioxide vapors also decrease the number of external *Acarapis*[1]. The efficacy of menthol and Apistan (used to control tracheal and varroa mites, respectively) for the control of external *Acarapis* has not been studied. However, these two *Acarapis* mites are external parasites, thus they should be easier to control than tracheal mites which are protected inside the tracheae.

Summary. External *Acarapis* mites appear to be largely innocuous parasites of the western honey bee *Apis mellifera*. Unusual environmental conditions may trigger high infestation rates that could diminish the health of the colonies, but in most beekeeping circumstances treatment for the control of external *Acarapis* species is not necessary.

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