

CONFORMATION OF THE AMBULACRUM OF *VARROA JACOBSONI* OUDEMANS (MESOSTIGMATA: VARROIDAE): A GRASPING STRUCTURE

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ABSTRACT - Contrary to common belief, the authors suggest that the ambulacrum of the adult females *Varroa*, *Euvarroa* and probably of *Tropilaelaps* is not a sucker or a sticky pad but a structure with protractile claw-like sclerites as shown by SEM analysis. These claw-like sclerites may work as crochets to grasp the hairs of the bee and allow the mites to move rapidly on the adult bees and other substrata. The conformation of the ambulacrum may explain why mites are not able to move in dusty or wet surfaces, as noted by Sadov et al. (1980). The humidity and the solid particles may interfere with the grasping abilities of the mites. Immature stages of *Varroa* and *Euvarroa* do not seem to have ambulacral claw-like projections as those found in the adults. This is probably due to the fact that the young forms walk on smooth surfaces, as on the bee larvae and the interior of the cell. The morphology, function and origin of the ambulacrum of Varroidae, *Tropilaelaps* and other phoretic mites are discussed.

INTRODUCTION

According to Krantz (1978) the pad-like or sucker-like empodium present in some mites substitute the empodial claw and the empodium frequently persist in the absence of the true claws as a claw-like pretarsal extension. The acarids that live on animals with hairs or feathers have developed several methods of attaching to the host. Among these are: the chelicerae and pretarsal claws (see Houck & Oconnor, 1991). The mesostigmatic feather mites hold themselves primarily by the tarsal suckers (Fain, 1981). The mites of the family Varroidae and *Tropilaelaps clareae* Delfinado & Baker (Laelapidae) belong to Mesostigmata and are parasites of honey bees (*Apis*). The Mesostigmata also include numerous families of primitive predaceous mites. Some species of these incidentally enter the hive and prey upon other mites (Eickwort, 1988). Other mites that are usually phoretic on bees, wasps, and other arthropods, have well developed tarsal claws to grasp on their hosts.

In order to escape the cleaning or grooming action of the bees, a phoretic or parasitic mite has to have a good apparatus for clinging or holding on to the bee's body while also allowing for fast movement, a morphology that allows them to hide under the abdominal sclerites or other hidden areas of the body or finally to

use areas of the bee's body where the grooming actions are less effective e.g. the dorsal part of the thorax. Ritter & Schneider-Ritter (1988) found that *T. clareae* mites are frequently observed around the head area and between the thorax and the abdomen of the bee. According to Delfinado-Baker (1988) the preferred attachment sites and *Varroa* morphology enable the mites to withstand being brushed off by the bees during cleaning and pollen gathering. The *Varroa* mites hold on to the bee tightly with their legs, though they are capable of moving rapidly over the bee (De Jong et al., 1982). The phoretic capability has made it possible for *V. jacobsoni* to survive for long intervals on the adult bees in the absence of brood (Akimov et al., 1988 a). *Braula caeca* adults, the bee louse (Diptera), use the same safe spot of the thorax between the wings as the adult *Varroa* (pers. obs.; Mobus and Connor, 1988). Toshkov et al. (1977) stated that among the weak points in the biology of *V. jacobsoni* were the organs for holding which are vulnerable to substances not harmful to the bees e.g. sugar and dusts (pers. obs.). Studies of individual organ systems such as the ambulacrum make possible the understanding of the specializations for living in an ecological niche (Akimov et al., 1988a) and to develop physical methods to control mites.

DESCRIPTIONS OF THE AMBULACRUM OF *VARROA* AND OTHER ECTOPARASITIC MITES OF HYMENOPTERA

There is contradiction in the literature about the presence of a sucker or claws in the ambulacra of Varroidae and *Tropilaelaps*. According to Smirnov (1977) "the tarsus of each leg of *Varroa* ends with a sucker. The suckers are very large having complicated structures functioning according to the pneumatic and pumping principle of the haemolymph. Sadov et al. (1980) indicate that the pretarsus of the 2nd and 4th pair of legs of *Varroa* serve as a suction apparatus for attaching to the substratum and as an aid in locomotion. They also state that the pretarsus is not adapted for movement over wet or dusty surfaces and that the mite is unable to move over a horizontal surface if the pretarsus is covered with particles smaller than its funnel-like extension. Mobus and Connor (1988) state that *Varroa* mites have sticky pads and not claws to retain a foothold on the bees.

The family Varroidae was described as "claws if present not well developed" (Delfinado and Baker, 1974). Delfinado-Baker and Aggarwal (1987) described the adult female *Varroa underwoodi* with a well developed, membranous ambulacrum with strong basal sclerites and without claws, and those of the male as being reduced membranous, sucker-like, and without claws. The deutonymph was described with reduced sucker-like structure and without claws or ambulacra. Delfinado-Baker (1988) stated that *E. sinhai* shared with *V. jacobsoni* a number of morphological characters, among them: the complete absence of ambulacral claws in all of the developmental stages including the adults: However, Delfinado and Baker (1974) noted that in adult *Varroa* the tarsal claws do not appear developed while in *E. sinhai* they are developed and simple. Delfinado-Baker (1984) described the female protonymph and deutonymph as well as the adult male, *V. jacobsoni* with the ambulacra of all legs lacking claws. Delfinado-Baker (1987, 1988) described *E. sinhai* protonymph and deutonymph, as well as the adult male and female, with membranous, sucker-like reduced ambulacra in all the legs. Delfinado-Baker et al. (1985) described the protonymph of *Tropilaelaps* with small paired claws and fleshy empodium on the legs II-IV, while for the deutonymph they mentioned small paired claws and fleshy pulvillus respectively.

According to Akimov et al. (1988b) the ambulacrum of *Varroa* is composed of several sclerites bound together by membranes, while according to Delfinado Baker (pers. com.) the sclerites of the pictures shown in this publication and those of Akimov and

Yastrebstov (1988) may be identified as a median sclerite (Fig. 2Aa), two claw-like structures (Fig. 2b) and the sustentacular sclerites (Fig. 2B) which surround the terminal portion of the ambulacrum to form a sucker. Delfinado-Baker (pers. com.) noted that the *Varroa* tarsal claws are not true claws of the ambulacrum. According to Krantz (pers. com.) the photo of figure 2 shows the median (Fig. 2A) and lateral membranes (Fig. 2b) (*sensu* Akimov et al., 1988b) of the ambulacrum often referred to *in toto* as the ambulacral sucker, while according to G.T. Baker (pers. com.) in *Varroa* "claws are lacking but the ambulacrum and the basal sclerites are well developed and enlarged", and what is seen in the micrographs here presented "is a collapsing and shrinking of the ambulacrum and that the sclerites are drawn over the sunken ambulacrum". However, ambulacra of several mites studied under the scanning microscope had similar conformation and homologous and symmetrical sclerites.

The deutonymphs and adults of ameroseiid, laelapid and chaetodactylid mites that are phoretic on a variety of arthropods (Krantz, 1978) including wild bees, wasps and *A. mellifera* do not possess suctorial ambulacra. Instead they have an empodium and one or two well developed (tarsal) claws which are used to grab the host's hair (Baker and Delfinado-Baker, 1983; Baker and Delfinado-Baker, 1985; Delfinado-Baker et al., 1983; Baker et al., 1984; Baker et al., 1987). However, some species of the genera mentioned by them have a suctorial plate on the venter (Baker et al., 1987; Baker and Delfinado-Baker, 1983).

MORPHOLOGY AND FUNCTION OF THE *VARROA* AMBULACRUM AND OTHER PHORETIC MITES

The ambulacrum of the adult male and female *Varroa* is a claw-like complex (Fig. 1) composed of two large basal sclerites (Fig. 2AB): the dorsal sclerite is a shell-like structure (Fig. 3A) with an terminal spur-like medial claw (Fig. 2a), and two lateral opposing flat and apically pointed claw-like extensions (Fig. 2b). The ventral sclerite (Fig. 2B) ends in two apical claws (Fig. 2c) which have an opposite position to the lateral claw of the dorsal sclerite. The spur-like medial claw (Fig. 2a) of the dorsal sclerite fits between the two lateral and ventral claws (Figs. 2 & 4). The locomotory apparatus allows the adult females to walk or to grasp the setae of the bees as noted by Colin and Richard (1988) and is not a sucker-like structure as mentioned by other authors.



Figures 1-4. Scanning electron micrographs of the ambulacrum of the female *Varroa jacobsoni*. 1- Two legs showing the ambulacra (x 410). 2- Frontal view showing the clawlike structures (x 2480). 3- Dorsal view of ambulacrum (x 1650). 4- Ventral view of ambulacrum (x 1650) A- Dorsal structure. B- Ventral structure. a- Dorsal claw. b- Laterodorsal claw. c- ventral apical claw.

POSSIBLE ORIGIN OF THE AMBULACRUM OF VARROIDAE AND *TROPILAELOPS*

According to Akimov et al. (1988 a), *T. clareae* is adapted to nidicolous habitats associated with nesting social insects. Other Laelapidae and some Ameroseiidae mites are associated with nests of stingless bees: Apidae Meliponinae (Baker and Delfinado-Baker et al., 1983; and Baker, 1985) and honey bees (Baker and Delfinado-Baker, 1983). Some chaetodactylids are associated with solitary anthophorid bees (Baker et al., 1987). According to Fain (1981) it is probable that Psoroptidae, parasitic on mammals, and the Epidermoptidae, parasitic on birds, derived directly from nidicolous Pyroglyphidae. *T. clareae* was originally taken from field rats nesting near bee-hives and from a collection of dead bees in Philippines (Delfinado and Baker, 1961). Field rats were considered as an alternate hosts by Atwal and Goyal (1971). It is common to find mice nests in even strong colonies, where they may survive the winter (pers. obs., Morse, 1980). That Varroidae and *Tropilaelaps* may have evolved from nidicolous Acari may also be suggested by the presence of sperm transfer organs in the chelicerae of the males. This phenomenon is rather common among the nidicolous Acari (Akranatanakul, 1975; Krantz, 1978). Nidicolous mites of rodents and birds are known to feed on blood (Krantz, 1978) while Varroidae and *Tropilaelaps* feed on the haemolymph of the bees. According to Akranatanakul (1975) the reproductive function of the nidicolous male mites occurs in a confined space; a phenomenon that also occurs in Varroidae and *T. clareae*.

That Varroidae and *T. clareae* may have evolved from nidicolous mites as suggested by the fact that in Varroidae and *Tropilaelaps* males are much smaller and less sclerotized than the females resembling nymphal instars (Delfinado and Baker, 1974). According to Krantz (1978) in some nidicolous parasites dimorphism may be pronounced. Varroidae adult males and probably those of *Tropilaelaps* do not feed at all, this could be due to their nidicolous origins. According to Krantz (1978) many of the Hypoaspidini genera (Laelapidae) are routinely found in the nest of mammals or arthropods or on insects and some species (e.g. *Pneumolaelaps*) are restricted to the nests and bodies of bumble bees.

To know the micromorphology of the ambulacrum of phoretic mites may help to understand their parasitic or symbiotic relationships with their hosts, as well as their phylogeny. This knowledge may also be used to dislodge the adult *Varroa* from the bees and other substrata by physical methods of control.

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