AN ABSTRACT OF THE THESIS OF

PONGTHEP AKRATANAKUL for the degree MASTER OF SCIENCE
(Name) (Degree)

in Entomology presented on June 11, 1975
(Major Department) (Date)

Title: BIOLOGY AND SYSTEMATICS OF BEE MITES OF THE FAMILY VARROIDAE (ACARINA: MESOSTIGMATA)

Abstract approved: Signature redacted for privacy.
Dr. Dennis M. Burgett

The bee mites Varroa jacobsoni Oudemans and Euvarroa sinhai Delfinado and Baker (Family Varroidae) are reported for the first time from Thailand. V. jacobsoni was found parasitizing colonies of Apis cerana indica F. and A. mellifera L. E. sinhai was observed in association with drones of A. florea F.

The biology of both mite species was investigated. It was found that the life cycles of V. jacobsoni and E. sinhai are bionomically similar, since the larva complete its development within the egg, the first stage to appear is the protonymph. The protonymph is followed by the deutonymph, which then moults to the adult male or female. Only the female of either species was found to be phoretic on adult honey bees. All other developmental stages inhabit the inside of the bee brood cell.

The systematics of the family Varroidae also is reviewed. Taxonomic descriptions of the egg, protonymph,

deutonymph and male of *E. sinhai* are presented here for the first time. New data on the immature stages of *V. jacobsoni* also are included.

Biology and Systematics of Bee Mites of the Family Varroidae (Acari: Mesostigmata)

by

Pongthep Akratanakul

A THESIS

submitted to

Oregon State University

in partial fulfillment of the requirements for the degree of

Master of Science

Completed June 11, 1975

Commencement June 1976

APPROVED:

Signature redacted for privacy.

Assistant Professor of Entomology
in charge of major

Signature redacted for privacy.

Head of Department of Entomology

Signature redacted for privacy.

Dean of Graduate School

Date thesis is presented June 11, 1975

Typed by Deanna L. Cramer for Pongthep Akratanakul

ACKNOWLEDGEMENTS

I am grateful to my major professor; Dr. D. Michael Burgett, Apiculturist, for his kindness, support, and understanding, and especially for introducing me to the science of Apiculture; to Dr. Gerald W. Krantz, who opened the new field of Acarology to my knowledge, for his kindness, encouragement, counsel and advice, and also for serving on my graduate committee. I wish to thank Dr. Don F. Grabe of the Agronomic Crop Science Department for serving as my minor advisor.

Sincere appreciation is extended to the Department of Entomology, Kasetsart University, Bangkok, Thailand, for providing facilities for this study during July-September, 1974.

Thanks is also due to Dr. Paul Oman, the former Acting Head of the Department; Dr. Carl S. Koehler, Head, Department of Entomology, Oregon State University, for their assistance.

To my mother and all members of my family, I thank you for your faith, confidence, support, understanding, concern, and love.

TABLE OF CONTENTS

LIST OF PLATES

LIST OF TABLES

BIOLOGY AND SYSTEMATICS OF BEE MITES OF THE FAMILY VARROIDAE (ACARI: MESOSTIGMATA)

INTRODUCTION

Attempts to establish the common honey bee, *Apis mellifera* L. in South East Asia have been made many times, but with limited success. One of the limiting factors is the presence in Asia of ectoparasitic bee brood mites.

Mites have been known to associate with honey bees since 1904 when Oudemans recorded *Varroa jacobsoni* Oud. parasitizing the Indian honey bee, *A. cerana indica* F., in Java, Indonesia. The economic importance of mite pests of honey bees has been recognized since the early twentieth century when a great loss of honey bee colonies occurred in England. The disease was called "Isle of Wight Disease", and the causative agent was identified as a tracheal endoparasitic mite, *Acarapis woodi* Rennie (Rennie, White, and Harvey, 1921). However, Baily (1963) stated that the Isle of Wight Disease was a disease of uncertain origin. Despite the fact that *V. jacobsoni* has been known since 1904, the economic importance of honey bee brood mites has only recently been recognized. Another mite, *Tropilaelaps clareae* Delfinado and Baker, was recorded parasitizing *Apis* broods in the Philippines (Delfinado and Baker, 1961). Both *V. jacobsoni* and *T. clareae* cause problems in colonies of both the commercial Indian honey bee and the common honey bee in many Asian countries. Morse (1966), suggested that these parasitic mites may have had an adverse effect on the development of the beekeeping industry in Asia.

Little is known about the systematics and life history of *V. jacobsoni*. Baker and Wharton (1952) listed the genus *Varroa* in the subfamily Hypoaspidinae, family Laelaptidae (= Laelapidae). The discovery of a related species, *Euvarroa sinhai* Delfinado and Baker, in a colony of the dwarf honey bee, *A. florea* F., found in India, caused Delfinado and Baker (1974) to propose the family Varroidae to accommodate the two genera, *Varroa* and *Euvarroa*.

Sevilla (1963) made an attempt to work out the life history of *V. jacobsoni* but he found only the protonymph, the deutonymph, and the adult female. Kulikov (1965) suspected that the mite is viviparous.

The bionomics of varroid mites is essentially unknown. Little is understood of the biology of *V. jacobsoni* and none of *E. sinhai*. Problems concerning the taxonomic descriptions of the mites still need to be investigated. Only adults of *V. jacobsoni* and only an adult female of *E. sinhai* were described by Delfinado and Baker (1974).

We do know that the mites in this new family are likely to have their geographical origins in southern Asia. Nevertheless, there are countries in this region from which there have been no reports of varroid mites.

Objectives of the Research

1. To discover whether mites of family Varroidae are associated with the honey bees in the genus *Apis* in Thailand.
2. To investigate and evaluate problems concerning systematics and bionomics of the family Varroidae.
3. To add to the taxonomic descriptions of previously unknown stages of mites in the family Varroidae.

REVIEW OF LITERATURE

Systematics of Varroidae

The parasitic honey bee mite, *V. jacobsoni*, was first described by Oudemans (1904). The adult female mites were found parasitizing a colony of the Indian honey bee, *A. c. indica*, in Java. In describing this new mite species, Oudemans proposed the genus *Varroa*. Despite the fact that only adult females were found at that time, Oudemans did not hesitate to list the new genus in the subfamily Laelaptinae. Baker and Wharton (1952) listed *V. jacobsoni* in the laelapid subfamily Hypoaspidinae.

Gunther (1951) received specimens of *V. jacobsoni* from his colleague Mr. John Reid, who found the mite on the *A. c. indica* in Singapore. Gunther misidentified the mite, describing it as a new species, *Myrmozercon reidi*. He also misinterpreted the adult female specimens he had as being deutonymphs. Delfinado (1963) pointed out that *M. reidi* is a synonym of *V. jacobsoni*. Sevilla (1963) during the course of his investigation on the bionomics of *V. jacobsoni* could not find the egg nor the adult male mite.

In 1974, the family Varroidae was proposed by Delfinado and Baker (1974) to accommodate *V. jacobsoni* and *E. sinhai*. The latter species was found on the dwarf honey bee, *A. florea*, in India and was identified by the authors as a new species in a new genus. The major features considered by

Delfinado and Baker in distinguishing Varroidae from related families in the Mesostigmata are the modified structure of the chelicerae which completely lack the fixed digit, and the number of gnathosomal setae. These features were utilized by Oudemans in proposing the genus *Varroa*, but he misinterpreted the absent fixed digit of the chelicera as the movable digit.

Biology and Distribution of Varroidae

Limited information is available on the biology of Varroidae. Our knowledge of *V. jacobsoni* has accumulated from the observations conducted by Sevilla (1963), Kulikov (1965), and Poltev, *et al.* (1967). Concerning *E. sinhai*, only the taxonomy of the adult female was mentioned by Delfinado and Baker (1974). Nothing has been written on the biology of the animal. The presence of the mite on *A. florea*, and the structure of its gnathosoma caused the authors to state that *E. sinhai* is a parasite of the honey bee.

Sevilla (1963) investigated the life history of *V. jacobsoni* but was not able to determine all of the developmental stages of the animal. He stated that the adult females entered the open bee cell prior to capping and that the young mites fed on larval and pupal bees through the host's cuticle. Feeding by the mite left prominent white spots on the bee. It was unclear whether or not the adult mite fed on the adult bee.

Kulikov (1965) stated that the adult *V. jacobsoni* evidently fed on the haemolymph of the bee, and possibly on the regurgitated contents of the honey sac. Still, in his investigation, Kulikov could not find the male mite. He also mentioned that *V. jacobsoni* was a viviparous animal, a point also mentioned by Delfinado and Baker (1974).

Poltev, *et al.* (1967) indicated that during winter in U.S.S.R. the female *V. jacobsoni* stayed on the clustering bees. Choi and Woo (1973) pointed out that the period of developments of the female and the male of *V. jacobsoni* were ten and six days, respectively.

Since 1963, deleterious effects to the honey bee colonies caused by *V. jacobsoni* have been widely recognized in south Asian countries. The mite has been reported causing problems in The Philippines (Sevilla, 1963; Morse, 1966; Morse and Laigo, 1968), India (Phadke, *et al.*, 1966; Kshirsagar, 1967; Gupta, 1967; Atwal and Dhaliwal, 1969; Punjabi and Saraf, 1969), and Vietnam (Stephen, 1968). Delfinado (1963) summarized the economic injuries and the status of the parasite in South East Asia.

In addition to southern Asia (which is believed to be geographical origin of mites in the family Varroidae; Akratanakul and Burgett, 1975), *V. jacobsoni* has been reported from the U.S.S.R. (Kulikov, 1965; and Poltev, *et al.*, 1967). The occurrence of this parasite in China (Akratanakul and Burgett, 1975; Kulikov, 1965; and Crane, 1968), Japan (Sakai and Okada, 1973), and South Korea (Choi and Woo, 1973) indicates the ability of the mite to survive in sub-temperate and temperate areas as well as in tropical regions of southern Asia. The presence of *V. jacobsoni* in Bulgaria (Velichkov and Nachev, 1973) indicates the potential for the invasion of the parasite into beekeeping regions of Western Europe.

Crane (1968) pointed out that up until 1968 there were no reports of mites parasitizing *A. florea*. Delfinado and Baker (1974) stated that *E. sinhai* was a parasite of *A. florea* although no supporting evidence was given.

Control Measures Against *V. jacobsoni*

Sevilla (1963) recommended the removal of native bees from the vicinity of introduced *A. mellifera* to help deter the spread of *V. jacobsoni*. Since the mite seems to prefer drone brood over worker brood, Kulikov (1965) suggested the destruction of drone cells in a colony, followed by applications of chemotherapeutic agents. He stated that Folbex (Chlorobenzilate) and phenothiazine are more effective than naphthalene or tobacco smoke. He recommended two-three strips of Folbex for fumigating a 12-frame colony.

Poltev, *et al.* (1967) stated that phenothiazine provided good mite control. Laigo and Morse (1969) suggested that Folbex gave some degree of control. Velichkov and Nachev (1973) proposed that complete erradication of _V. jacobsoni_ might be possible by applying three to four phenothiazine treatments during the first three days after the autumn brood has emerged.

A report from Japan (Sakai and Okada, 1973) stated that using "Anti Mite Chemical" gave satisfactory results. A later report from Korea (Choi and Woo, 1973) mentioned "Hyang-Su", an extract from several native plants, gave better control than Folbex or Neobex (Neobex is another trade name for chlorobenzilate).

MATERIALS AND METHODS

Collection of Material

Khonkaen province (Fig. 33) was selected as a study site because colonies of the dwarf honey bee, A. Florea, were reported to be extremely abundant. The province is approximately 570 km northeast of Bangkok. Colonies of the dwarf honey bee were collected in cloth bags and brought to the laboratory at the Department of Entomology, Kasetsart University, Bangkok, Thailand. A total of 106 colonies of A. florea were collected during July and August 1974. Cloth bags were also used to obtain wild colonies of A. c. indica. Colonies of A. c. indica were collected from Nakorn-Rajsima and Smut-Prakarn Province (Fig. 33).

Laboratory Methods

Brood combs and adult bees collected from the field were brought to the laboratory at Kasetsart. All sealed brood cells and uncapped late larval instar cells were examined. Since the parasites are rather large, the mites in the bee cells can easily be seen with the unaided eye. Adult bees were killed by freezing so that the mites on the adult bee could be conveniently observed. Samples of flying bees were collected in the field with an insect net.

Brood cells were opened with fine forceps. The larval and pupal bees were removed gently from the cells and examined for the presence of mites. The mites were removed from the bees with a moist fine camel hair brush (No. 000) and placed in 9 cm diameter petri-dishes. Mites were provided with a living larval or pupal bee. The petri-dishes were then placed in an incubator, set for 80 percent RH and 34°C. Comb sections containing bee brood also were used occasionally for holding the mites. Some live mites were kept in plastic drug capsules (8 mm in diameter and 2.3 mm in length), provided with an individual bee in each capsule.

All dead mites were preserved in 70 percent ethanol in small vials and brought to the Acarology Laboratory, Department of Entomology, Oregon State University for study.

RESULTS

Biology of *Varroa jacobsoni* and *Euvarroa sinhai*

Varroa jacobsoni Oudemans and *Euvarroa sinhai* Delfinado and Baker, both are parasites of honey bees in the genus Apis. *V. jacobsoni* is widely recognized as a serious pest of *A. mellifera*, the introduced honey bee, and *A. c. indica*, a native honey bee species in South Asia.

Delfinado and Baker (1974) described *Euvarroa sinhai*, a new genus and species of mite found in a colony of *A. florea* in India. Despite their statement that *E. sinhai* is a honey bee parasite, there was no information nor evidence to indicate how the animal was associated with *A. florea*. The bionomics of the mite were unreported.

Since *V. jacobsoni* has been reported as a serious pest of the honey bees since 1904, the mite currently is more widely recognized than *E. sinhai*. This is especially true as regards published information concerning the biology of the two animals.

Distribution of the Varroidae

Table 1 lists those countries where *V. jacobsoni* has been recorded. While the dwarf honey bee, *A. florea*, is native to South Asia and is very abundant in South East Asia, the only report on the occurrence of *E. sinhai* is from India (Delfinado and Baker, 1974).

Table 1. Distribution of *Varroa jacobsoni* Oudemans.

Country	Host	Authority
Indonesia	*Apis cerana indica*	Oudemans (1904)
Singapore	*A. c. indica*	Gunther (1951)
Peoples Republic of China	*A. mellifera*	*
The Philippines	*A. mellifera*	Delfinado (1963)
Hong Kong	*A. mellifera*	Delfinado (1963)
U.S.S.R.	*A. mellifera*	Kulikov (1965)
India	*A. c. indica*	Phadke, *et al.* (1966)
South Vietnam	*A. mellifera*	Stephen (1968)
Japan	*A. mellifera*	Sakai & Okada (1973)
Bulgaria	*A. mellifera*	Velichkov & Nachev (1973)
South Korea	*A. mellifera*	Delfinado & Baker (1974)
Thailand	*A. mellifera*	Akratanakul & Burgett (1975)
Thailand	*A. c. indica*	Akratanakul & Burgett (1975)

*1. Cited in Kulikov (1965)

2. Cited in Crane (1968)

3. Two specimens (January 1959) Acarological Collection, Department of Entomology, Oregon State University, Corvallis, Oregon.

I report here for the first time the occurrence of *V. jacobsoni* and *E. sinhai* from Thailand. *V. jacobsoni* was found parasitizing *A. c. indica* and *A. mellifera*. *E. sinhai* was found infesting colonies of *A. florea* in Khonkaen, a northeastern province of Thailand.

Life Cycle

Varroa jacobsoni

Observations on colonies of *A. c. indica* infested with *jacobsoni* yielded the following results: the developmental stages found were egg, protonymph, deutonymph, and adults. Eggs, both nymphal stages, and males were found associated with immature bees inside the cells. Only adult female mites were found associated with the adult bee.

The life cycle of *V. jacobsoni* occurs primarily inside the bee cell. The female mite enters the cell of a late larval instar bee prior to capping, and deposits her eggs singly inside the cell. The first immature stage to appear following eclosion is the protonymph, which transforms to the deutonymph and, finally, to the adult. The nymphal stages of the mite feed on the haemolymph of the larval or pupal bee through the bees' integument often at the intersegmental membranes. All steps of the metamorphosis of the mite occur inside the bee cell and are synchronized with the transformation of the larval bee to the adult stage.

Kulikov (1965) misinterpreted the egg of *V. jacobsoni* in his description, describing it in the translation of his paper as a "... transparent, watery-white, sphere-shaped larva." Based on this misunderstanding, he concluded that the mite was viviparous. Choi and Woo (1973) misidentified the deutonymph of the mite as the larva of the male. The authors reported that the total developmental period of the female mite was ten days and six days for the male.

Euvarroa sinhai

The life cycle of *E. sinhai* is very similar to that of *V. jacobsoni*, i.e., the mated female enters the cell of a late larval bee prior to capping, and attaches her eggs to the developing bee larva or pupa. Eggs are occasionally attached to the lower portion of the bee cell. As in *V. jacobsoni*, the first active instar to appear is the protonymph, followed by the deutonymph and adult stages. Sex of the mite can be distinguished in the deutonymph.

Of all the 106 colonies of *A. florea* examined, I found the drone brood of six colonies to be infested by *E. sinhai*. The number of mites observed per cell varied from one to 15, averaging 5-9 per cell. Only the female is associated with the adult drone.

During the course of this study, the free living larval form of *E. sinhai* was not seen. Whether or not *E. sinhai* had a distinct larval stage was not certain. A number of mite eggs collected from drone cells were dissected in order to determine whether a pharate larva is present. Microdissections were carried out in 70 percent ethanol using a stereo microscope, minuten pins and fine forceps.

Well-formed pharate larvae were found within eggs which exhibited an opaque chorion. Additional dissections revealed that the early phases of protonymph development also took place within the eggs that exhibited a translucent chorion. It is possible that an egg with a translucent chorion is more mature than an egg that exhibits an opaque chorion.

This phenomenon indicates why the larva has never been found. It develops within the egg to become the protonymph while the egg becomes more mature. The protonymph is the first stage to hatch from the egg.

Feeding

Observations on feeding behavior of *V. jacobsoni* and *E. sinhai* indicate that all developmental stages except the adult males feed on the haemolymph of the host. The extreme modification in the structure of the male chelicerae for mating (Figs. 10 and 23) probably makes feeding impossible.

It was observed that the presence of mites in the bee cell is correlated with the appearance of tiny white spots of less than 1 mm in diameter throughout the cell, and sometimes on the bee. These spots were described by Sevilla

(1963) as a regurgitated product of the bee. I found these to be fecal deposites of the mites.

Sevilla (1963) reported that V. jacobsoni prefers to feed on the thorax and abdomen of the bee host. Kulikov (1965) stated that the abdominal segments of the host are preferred over the head or thorax. However, no specific favored feeding site of V. jacobsoni was found during this study. It was observed that immature E. sinhai often are found on both the thorax and the abdomen of drone brood of A. florea. The wing pads of the developing pupa appears to be a preferred feeding site for immature E. sinhai. They also were seen attached to the pleural area of the thorax, and to the venter of the abdomen.

Feeding by the adult V. jacobsoni and E. sinhai begins while the host bee is still a late larval instar. Feeding continues throughout the pupal stage of the host. It is not known whether the females of the two mite species feed on adult bees, although it seems likely that female V. jacobsoni may feed on clustering bees during the cold season in sub-temperate and temperate areas, when brood rearing has ceased.

Phoretic Behavior

Only the adult females of V. jacobsoni and E. sinhai have been observed to be phoretic. They attach to the host bee as it emerges. Sevilla (1963) reported only one specimen of V. jacobsoni per carrier bee. Kulikov (1965) stated that the favored attachment sites for V. jacobsoni are the dorsum and the scuttellar region. If the female V. jacobsoni and E. sinhai do not successfully attach themself to the emerging bees, or the hosts do not survive to become adults, the mites leave the cells and wander over the comb surface searching for a carrier bee.

V. jacobsoni is more commonly phoretic on drones than on workers. However, E. sinhai was found only on the drone of A. florea. The maximum number of E. sinhai found on carrier drones was four. Females of E. sinhai often are found attached to the venter of the bee's abdomen, at the scutellar region on the thorax, or between the thorax and the abdomen.

When the host bee is disturbed, E. sinhai will leave the bee and will search in active manner for another carrier or for an open brood cell.

Experiments were conducted comparing the attractiveness of dead and living drones to the two mite species by letting the mites search in a defined area (9 cm diameter petri-dish). The experiment showed that when dead and living drones were provided to the mites simultaneously, the mites would attach only to the living drones. If only dead drones were provided, the mites attached to the drones, but subsequently the mites positioned themselves on the uppermost portion of the dead bees waiting to contact and attach to a passing object. This was demonstrated by passing a fine (No. 000) camel hair brush in front of the mites. They will grab onto the brush in an aggressive manner.

Injuries and Economic Impact of Varroid Mites

Euvarroa sinhai

At present, E. sinhai has been found associated only with A. florea. While the larval or pupal bees usually die in heavily infested bee cells, injury to the bee is not always fatal. Heavily infested bee brood changes in color from creamy white to light purple and then finally dark. The dead body of the larval or pupal bee becomes soft, and somewhat liquified. Bee mortality is most common among late larval or late pupal instars.

If the infested drone larvae of A. florea survive to the adult stage, there are no abnormalities present on the drones aside from occasional deformed wings.

The level of infestation in colonies of A. florea is variable. However, queenless colonies usually are more heavily infested than queenright colonies.

Varroa jacobsoni

Despite the fact that E. sinhai seems not to be economically important to the beekeeping industry at present, V. jacobsoni poses a severe problem in the development of a beekeeping industry in Asia, and to certain beekeeping areas of Europe (Table 1).

Sevilla (1963) described the gross symptoms of *V. jacobsoni* infestation as a decrease in colony strength. Another conspicuous effect is the occurrence of abnormal bees in the colony. These bees have undeveloped if not mutilated wings. Infestations of the mite also are evidenced by the irregular pattern of the sealed brood cells. This is caused by the opening of cells and discarding of the dead bee brood by the worker bees.

Capped drone cells containing infested bees have an irregular shape cap. The outer margin of the caps shrink and the caps become somewhat cone-shaped, usually with small holes terminally.

Kulikov (1965) stated that the injury inflicted on honey bee colonies by *V. jacobsoni* generally consists of the debilitation of the colony, the weakness of the emerging workers and drones, possible loss of the brood, and the appearance of smaller, deformed bees.

Systematics of the Family Varroidae

Delfinado and Baker (1974) proposed the family Varroidae to accommodate the two mite genera associated with the honey bees of the genus *Apis*: *Varroa* Oudemans, and *Euvarroa* Delfinado and Baker. At present, each genus is represented only by its type species: *V. jacobsoni* Oudemans, and *E. sinhai* Delfinado and Baker.

Family Varroidae

Delfinado and Baker (1974) utilized Oudemans' diagnosis for the genus *Varroa* as the basis for the characterization of the new family Varroidae. Descriptive features mentioned are: 1) complete lack of the fixed cheliceral digit; 2) number and arrangement of gnathosomal setae; and 3) reduction of palp and leg chaetotaxies.

The following descriptions are derived in part from Delfinado and Baker (1974).

Female

Body relatively large, hairy, strongly sclerotized, with an entire well developed dorsal shield covered with a dense pattern of simple or barbed setae, no pores present on the shield. Venter with sternal shield well developed, ornamented with reticulate pattern, with three pairs st. 1-st. 3 or more of sternal setae, lyrifissures may be present or absent. Epigynial shield well developed and usually fused with the ventral shield, bearing more than 10 setae; anal shield well developed, with three anal setae, i.e., two paranal setae, and one post-anal, anus terminal, cribrum present in post-anal region. Stigmata and peritremes situated lateroventrally, peritremes strongly looped;

peritremal shield (when present) is weakly sclerotized. Metasternal shield may or may not be fused with the sternal shield. Endopodal shields half circling posterior portions of coxae IV, setae may be present on the shields. Metapodal shields present, with or without associated setae. Tritosternum bifurcate, lightly sclerotized, tritosternal base smooth or reticulate, with small spines. Venter of gnathosoma with three pairs of setae, two pairs of hypostomal setae hyp. 1 - hyp. 2, and a pair of deutosternal setae, one pair of hypostomal seta hyp. 3 is absent. Capitular groove with series of pointed deutosternal teeth. Corniculi bladelike, slender, tapering distally. Chelicerae short, simple, completely lacking fixed digit; movable digit dentate with two teeth, with pointed tip, without seta, suitable for piercing. Palp 5-segmented, palpal apotele markedly well developed, two tined, basal tine reduced in size. Legs strongly formed; tarsi II-IV divided into discrete basi- and telotarsi, ambulacra membranous, pad-like, relatively expanded, with claws or remnant of claws; trochanters II-III each with five setae.

Habitat: associated with immature or adult honey bees within or outside bee cells.

Male

Similar to female except for the following: body lightly sclerotized, dorsal shield usually covered with simple setae. Venter with holoventral shield, with or without lyrifissures, anal shield fused to or separates from the holoventral shield. Metapodal shields poorly developed or absent. Genital aperture at anterior margin of sternal shield. Chelicerae relatively large, with movable digit highly modified, tube-like, broadly tapered to a blunt tip and deeply grooved.

Habitat: associated with immature bee inside the bee cell.

Genus Varroa Oudemans 1904

Varroa Oudemans, 1904 a, Entomol. Ber. (Amst.) 18:161.
1904 b, Notes Leyden Mus. 24:216.

Type species: Varroa jacobsoni Oudemans, by original designation.

Female

Dorsal shield entired, covered with setae of moderate length, with stout lanceolate setae at lateral margin of the shield. Sternal shield with five-six pairs of setae, i.e., st.1-st.4 plus auxillary setae, and four-six pairs of associated lyrifissures. Metasternal and sternal shields fused. Endopodal and metapodal shields markedly well developed. The latter densely covered with setae. Movable digit of the chelicera with two teeth. Palpal trochanter bearing only one seta.

Male

Body lightly sclerotized, dorsal shield covered with simple setae. Venter with holoventral shield, lyrifissures associated with sternal setae, ventral region behind coxae IV covered with dense simple setae. Palpal trochanter with only one seta as in female.

Varroa jacobsoni Oudemans

Synonyms: Varroa ricinus Oudemans (1904 c)
Myrmozercon reidi Gunther (1951)

Female (Figs. 1, 4, 6 and 9)

Length of idiosoma avg 1056 microns; width avg 1540 microns (n = 5). Body wider than long; dorsal shield entire, covered with dense pattern of barbed setae of varying length, with 21-23 stout lanceolate setae at lateral margins of the shield (Fig. 1, Plate I). Sternal shield bearing 5-6 pairs of setae; st. 1 - st. 4, and two pairs of auxillary setae associated with st. 3 and metasternal setae, st. 4 (Fig. 1, Plate I). Auxillary setae associated with st. 4 may be absent. Epigynial shield fused with ventral shield, covered with more than 100 setae (Fig. 1, Plate I). Peritremes looped backward, stigmata situated between coxae III-IV (Fig. 4, Plate II). Metapodal shields well developed, triangular in shape; endopodal shields triangular, relatively large, each with 5-6 setae inserted posterolaterally on the shields

(Fig. 1, Plate I). Tritosternal base with small spines (Fig. 6, Plate II). Epistome simple; corniculi blade-like, shorter than chelicera (Fig. 6, Plate II). Movable digit of chelicerae with two teeth (Fig. 9, Plate III). Capitular groove with small, greatly reduced deutosternal teeth (Fig. 6, Plate II). Palpae with reduced chaetotaxy (Table 3), palp trochanter with only one seta. Legs stout, robust, strongly curved, with long simple setae, ambulacra expanded, remnant of claws present; leg chaetotaxies shown in Table II.

Male (Figs. 5 and 10)

Length of idiosoma avg 715 microns; width avg 698 microns (n = 5). Dorsal shield covered with moderately dense simple setae. Venter with fused sternal, ventral, and genital shields; anal shield discrete. Sternal region with five pairs of setae, st.1 - st.4 plus a pair of auxillary setae, associated five pairs of lyrifissures (number of setae and lyrifissures may be variable). Peritreme shorter than that of the female, unlooped, directed anterolaterally, situated between coxae III-IV (Fig. 5, Plate II). Palpal setal numbers, especially on palp trochanters, reduced as in female. Palp trochanter with single seta as in female (Table III). Legs and ambulacra as in female.

Deutonymph (Figs. 3 and 8)

Length of idiosoma avg 1015 microns; width avg 1482 microns (n = 2). Body weakly sclerotized, wider than long as in female. Dorsal shield entire, covered with dense, moderately long simple setae. With exception of the anal shield, ventral sclerites not distinctly separated; sternal region with five pairs of setae. Stigmata and peritremes adjacent to coxae IV, peritreme flower-like, consisting of radiating petal-like platelets, extending anteriorly only a short distance from the stigmata, unlooped (Fig. 3, Plate II). Tritosternal base smooth, lack of tiny spines. Movable digit of the chelicerae with two distinct teeth (Fig. 8, Plate III). Palpal chaetotaxy as shown in Table III. Deutosternal teeth as in adults. Legs weakly formed, uncurved, ambulacra poorly developed.

<u>Protonymph</u> (Figs. 2 and 7)

Length of idiosoma avg 776 microns; width ave 720 microns (n = 2). Body ovoid, longer than wide, dorsal and ventral shields as in deutonymph. Three pairs of setae (st. 1 - st. 3) inserted on the sternal region and four pairs on the genital-ventral region. Ventral region behind coxae IV covered with dense simple setae. Stigmata and peritremes located between coxae III-IV. Peritremes as in deutonymph, but extending anteriorly a shorter distance (Fig. 2, Plate II). Tritosternal base as in deutonymph. Movable digit of the chelicerae without distinct teeth (Fig. 7, Plate III). Deutosternal teeth weakly developed. Palpal chaetotaxy as shown in Table III. Legs and ambulacra as in deutonymph.

Egg

Ivory white, ovoid, 390 x 300 microns (n = 2), ornamentation indistinct.

Habitat and Hosts: Immatures and male of *V. jacobsoni* are associated with larva or pupa of the honey bees *Apis cerana indica* F. and *A. mellifera* L. within the bee cells. Female *V. jacobsoni* is either associated with the adult or immatures of the two honey bee species within or outside the bee cells.

Remarks

In characterizing *V. jacobsoni* Delfinado and Baker (1974) overlooked the weakly developed deutosternal teeth found to be present in immature and adult forms (Fig. 6, Plate II). A discrepancy also was noted in the chaetotaxies of femora of legs I-II of the female (10-8 rather than 11-10 as observed during this study). Variations of this type may reflect intraspecific variability of leg setal characters.

Genus *Euvarroa* Delfinado and Baker 1974

Euvarroa Delfinado and Baker, 1974, J. Wash. Acad. Sci. 64 (1):4-10

Type species: *Euvarroa sinhai* Delfinado and Baker, by original designation.

Diagnosis

Female

Body ovoid ornamented with reticulate pattern; dorsal shield covered with long setae, with strong lanceolate setae at the posterolateral edge of the shield (Fig. 18, Plate IX). Sternal shield covered with three pairs of setae, st. 1 - st. 3, without associated lyrifissures; metasternal shields free, small, each with a seta st. 4 situated anterolateral to the shields; metapodal shields present (Fig. 18, Plate IX). Stigmata adjacent to coxae IV; peritremes each extended posteriorly, then loop anteriorly (Fig. 26, Plate XI). Movable digit of chelicera with two teeth as in genus *Varroa* (Fig. 21, Plate X). Palp trochanter with two setae. Deutosternal teeth triangular, with pointed tips, markedly well developed (Fig. 15, Plate VII).

Male

The male of *Euvarroa* is like that of *Varroa* in modification of the movable digit of the chelicera (Fig. 23, Plate X). Palp trochanter with two seta (Fig. 16, Plate VII). Deutosternal teeth well developed as in female.

Euvarroa sinhai Delfinado and Baker

Euvarroa sinhai Delfinado and Baker (1974). J. Wash. Acad. Sci. 64(1):4-10.

Female (Figs. 15, 18, 21 and 26)

Length of idiosoma avg 998 microns; width avg 994 microns (n = 5). Doesal shield entire, covered with simple of moderately long setae, about 39-40 long lanceolate setae inserted at the posteromarginal edge of the shield (Fig. 18, Plate IX). Sternal shield rectangular with three pairs of st.1 - st.3 inserted on the shield without associated lyrifissures (Fig. 18, Plate IX). Epigynial shield fused with ventral shield, forming a pear-shape sclerite with five pairs of setae (number of setae on the shield may vary) [Fig. 18, Plate IX]. About 21-26 pairs of setae present on the region adjacent to anal and ventral shields (Fig. 18, Plate IX). Peritremes strongly looped, not extending beyond coxae IV (Fig. 26, Plate XI). Metapodal shields small, oval in shape, situated anterolateral to the ventri-anal shield which is relatively large (Fig. 18, Plate IX). Endopodal shields small, triangular in shape (Fig. 18, Plate IX). Parapodal shields weakly sclerotized, extending to coxae l. Tritosternal base covered with small spines (Fig. 15, Plate VII). Gnathosoma similar to that of *V. jacobsoni*; movable digit of the chelicerae with two teeth as in *V. jacobsoni* (Fig. 21, Plate X); corniculi blade-like, about the same length as the movable digit of the chelicera, strongly developed (Fig. 15, Plate VII). Capitular groove decorated with two-three rows of heavily sclerotized deutosternal teeth (Fig. 15, Plate VII). Palpal chaetotaxy as shown in Table III. Legs short, stout, legs II-IV each with distinct basitarsus and telotarsus, strongly curved as in *V. jacobsoni*; ambulacra with remnant of claws as in *V. jacobsoni* (Fig. 29, Plate XII). Leg chaetotaxies as in Table II.

Male (Figs. 16, 17, 23, and 28)

Length of idiosoma avg 886 microns; width avg 723 microns (n = 4). Body ovoid, lightly sclerotized; dorsal shield covered with moderately dense simple setae of moderate length. Venter with holoventral shield, with three pairs of setae, st. 1-st. 3, in the sternal region, and seven pairs of setae in genito-ventral region (extra setae may be present) [Fig. 17, Plate VIII]. Metapodal shields present but not well formed (Fig. 17, Plate VIII). Peritremes rounded, flower-like, each consisting of radiating platelets resembling a whorl of flower petals (Fig. 28, Plate XI). Movable digit of chelicera tubular, broadly tapered to a blunt tip as in male of *V. jacobsoni* (Fig. 23, Plate X). Palpal chaetotaxy as in Table III.

Deutonymph (Figs. 12, 14, 20, 22, 25, and 27)

Length of idiosoma avg 911 microns; width avg 806 microns (n = 4). Body lightly sclerotized, ovoid in shape. Dorsal shield covered with moderately dense simple setae; setae on marginal edge of the shield not markedly different in size from the other setae on the shield. Venter sclerites weakly sclerotized, continuous; with four pairs of setae in sternal region and six pairs on epigynial-ventral region; anal shield free (Fig. 12, Plate V). With 22-24 pairs of setae densely covering the integument behind coxae IV (Fig. 12, Plate V). Peritremes rounded, like those of male but are somewhat larger (Fig. 25, Plate XI). Tritosternal base smooth (Fig. 14, Plate VI). Corniculi as in female but not as strongly developed (Fig. 14, Plate VI). Movable digit of chelicerae dentate as in female, with two sharp teeth (Fig. 20, Plate X). Palpal chaetotaxy as in Table III. Legs not strongly formed, uncurved; ambulacra weakly developed. Legs II-IV 7-segmented as in female. Leg chaetotaxy as in Table II.

Protonymph (Figs. 11, 13, 19 and 24)

Length of idiosoma avg 743 microns; width ave 629 microns (n = 3). Body weakly sclerotized, shape ovoid as in deutonymph (Fig. 11, Plate IV). Venter sclerites weakly developed, contiguous as in deutonymph; but with three pairs of setae in the sternal region (Fig. 11, Plate IV). Anal shield free. With two pairs of setae inserted adjacent to the anterior angles of the anal shield (Fig. 11, Plate IV). Peritremes dumbell-shape, each consisting of platelets as in deutonymph (Fig. 24, Plate XI). Tritosternal base smooth as in deutonymph (Fig. 13, Plate VI). Movable digit of the chelicera edentate, with pointed tip (Fig. 19, Plate X). Deutosternal teeth and corniculi as in deutonymph and adults, but not strongly sclerotized (Fig. 13, Plate VI). Palpal chaetotaxy as in Table III. Legs and ambulacra as in deutonymph (Fig. 11, Plate IV).

Egg

Ivory white, ovoid, 350 x 510 microns (n = 3), ornamentation indistinct.

Habitat and Host: Immatures and male of *E. sinhai* are found associated with larval and pupal drones of *Apis florea* within the bee cells. Adult female mite can be seen either within the bee cell associated with larval or pupal bees or outside the bee cell attached to the adult drone of *A. florea*.

Remarks

As noted earlier, presence or absence of deutosternal teeth cannot be used to distinguish the genera *Euvarroa* and *Varroa* since, contrary to Delfinado and Baker's (1974) observations, both have deutosternal teeth. In addition, it has been verified that *E. sinhai* does in fact have a tritosternum, although not strongly developed. Other characters utilized by Delfinado and Baker, i.e., the presence or absence of lyrifissures and differences in palp and leg chaetotaxies, are valid criteria for distinguishing Euvarroa and Varroa. In examining leg chaetotaxies of Euvarroa, some discrepancies have been found in setal number on particular segments. These include the numbers of setae on trochanters I-III (3, 3, 4 rather than 6, 5, 5), femora III-IV (5, 4 rather than 8, 7), and genua IV (8 rather than 9-11).

The genus Euvarroa differs markedly from Varroa in having two palp trochanteral setae (only one in Varroa), and in having only three pairs of seta, st. 1-st. 3, in the sternal shield (5-6 pairs in Varroa). In addition, differences exist in leg chaetotaxy, especially on genua and tibia of legs II-III (11-11, 11-11 in Varroa but 10-10 and 10-10 in Euvarroa).

Table II. Leg chaetotaxies of *V. jacobsoni* and *E. sinhai*

	Leg	Coxa	Trochanter	Femur	Genu	Tibia
V. jacobsoni						
Female	I	2	5	11	12	13
	II	2	5	10	11	11
	III	2	5	8	11	11
	IV	1	6	7	9-11	10-11
E. sinhai						
Female	I	2	6	10-12	11	12*
	II	2	5	10	10	10
	III	2	5	7	10	10
	IV	1	6	6	10	11
Deutonymph	I	2	6	11	11	12
	II	2	5	9	10	10
	III	2	4	7	10	10
	IV	1	5	5	9	11
Protonymph	I	2	4	11	6	8
	II	2	4	7(8)	6	7
	III	2	4	5	6	7
	IV	1	4	4	5	7

* Usually 12 rarely 13.

Table III. Palpal chaetotaxies of *V. jacobsoni* and *E. sinhai*.

	Trochanter	Femur	Genu	Tibia
V. jacobsoni				
Female	1	2 (rarely 3)	2 (rarely 3)	7-8
Male	1	2	2	8
E. sinhai				
Female	2	2 (rarely 3)	1 (rarely 2)	8
Male	2	2	1	8
Deutonymph	2	2	1	8
Protonymph	0	2	1	8

DISCUSSION

Being the successful ectoparasitic mites of the honey bees, the mites V. jacobsoni and E. sinhai have accomplished their radiative adaptations by synchronizing their lives closely to the host bees.

In their immature forms, V. jacobsoni and E. sinhai have to totally depend on the larval or the pupal bees. The life cycle of these mites has a limited period of acceptable host forms, i.e. the prepupae and pupae stages of the host. In this regard, the mites have abbreviated immature life stages, i.e., they have shortened their development by reducing one of the developmental stages, the larva. Generally, mites in the suborder Mesostigmata have a life cycle as follows: egg, larva, protonymph, deutonymph, and adult. If the ecological niche is not optimum, i.e., if food is limited, mites in this group may become viviparous, i.e., the larva is the first stage to appear (Filipponi and Francaviglia, 1964). However, in the case of V. jacobsoni and E. sinhai, instead of eliminating the egg stage, the mites reduced the period of larval life. The larvae of V. jacobsoni and E. sinhai develop within the eggs. This is rather unusual for mites.

The males of V. jacobsoni and E. sinhai do not have to live long to finish their sole biological function, mating. During the course of this study, males of both mite species were never found outside of the brood cells. The males appeared very sluggish. Observations on males of these two mite species collected from brood cells indicated that the adult males have a shorter life than that of the adult females. While the females live longer than a week, the males rarely live more than two or three days. The extreme modification of the chelicerae of the males of *V. jacobsoni* and *E. sinhai* as sperm transfer organs does not permit feeding. This phenomenon is rather common among the nidicolous acari. The reproductive function of the nidicolous male mites occurs in a confined space. In the case of *V. jacobsoni* and *E. sinhai*, it is very likely that mating of the mites occurs inside of the bee cell since it is the only place where the males and females are found together.

The females of *V. jacobsoni* and *E. sinhai* require a longer adult life. Their bodies are heavily sclerotized and well protected with the strong, entire dorsal shield, and strongly built ventral shields. The body of the females is laterally compressed, an adaptation for their phoretic relation with the adult host species.

In examining the structure of the chelicerae of all stages of *V. jacobsoni* and *E. sinhai*, the chelicerae lack the fixed digit. The movable digit of the chelicerae of all but adult males is tapered to a pointed tip suitable for piercing the host's integument. The movable digit of the protonymphs of *V. jacobsoni* and *E. sinhai* are simple, edentate. The movable digit of the chelicerae of the deutonymphs and females are dentate, with two pointed teeth. The stoutness of the movable digits of the chelicerae of the deutonymphs and females is possibly an adaptation of the parasities for feeding, i.e., as the larval bee transforms to become the pupa, the integument of the bee becomes thicker.

E. sinhai was found parasitizing only drone brood of *A. florea*. *V. jacobsoni* was reported to prefer drone brood over worker's (Sevilla 1963; Kulikov, 1965). Possible factors determining why the parasitic honey bee mites prefer drone rather than worker broods are:

1. The larger size of the drone and its cell when compared to that of the worker.
2. The drone has a longer immature life than the worker.
3. The passive and drifting behavior of the drone.

In *A. florea* the size of the drone and its cell are much larger than that of the worker. The body length of the drone pupa is 11 mm and of the worker pupa, 6 mm. The width of the drone cells is 4 mm; and of the worker cells, 3 mm. The developmental period of drone and worker immature forms (egg stage is excluded) of *A. florea* is 19.5 and 17.8 days, respectively (Sandhu and Singh, 1960). These are probably the main factors determining why only the drone brood of *A. florea* is attacked by the mite *E. sinhai*.

The disparity between the cells and immature body masses of drones and workers is not so great in the two honey bee species A. mellifera and A. c. indica. Still, the body and the cell size of drones are slightly larger than those of workers. However, during the immature development (egg stage is excluded) of the two castes, drones and workers, of A. mellifera and A. c. indica, a large time differential is seen. It takes 18 and 21 days for the worker and the drone of A. mellifera, and 18 and 20.5 days for the two castes of A. c. indica (Morse, 1974; Rahman and Singh, 1947). These differences may explain why drones of A. mellifera and A. c. indica are more preferred by V. jacobsoni than workers.

However, another factor, the different behavior of drone and worker honey bees, must be considered. The drones are always passive when compared to the workers. The passive behavior of the adult drones may facilitate the adult female mites phoresy on the drones. The drifting of drones from colony to colony also aids in the mites dispersal.

Despite possible factors determining host preference of the honey bee mites, an unknown factor, possibly the biochemical and/or the physiological interaction between the parasites and hosts, may play some role in the discussed phenomenon.

Four out of six infested colonies of A. florea found in this study were queenless. When comparing the four infested queenless colonies to the two infested queenright colonies, the queenless colonies were much more severely infested by the parasitic mite. This phenomenon, that laying worker nests were much more severely infested by the parasitic honey bee mite, indicates that such colonies are less able to tolerate the parasites. The same situation also occurs in colonies of *Apis* spp. when attacked by other pests, i.e., wax moths, or another bee mite *Tropilaelaps clareae* (Morse and Laigo, 1969). This supports the thesis that normal, queenright, populous, colonies of *Apis* spp. may better tolerate infestations than the less populated, queenless nests.

Problems concerning the mites of the honey bees are more prevalent in Southeast Asia than the other beekeeping areas of the world. South Asia is believed to be the geographic origin of the honey bees of the genus *Apis*. The presence and abundance of the three species of the honey bee, i.e., *Apis dorsata* F., *A. florea*, and *A. c. indica*, supports the hypothesis. It is possible that South Asia is also the geographic origin of the honey bee mites in the family Varroidae, *V. jacobsoni* and *E. sinhai*. At present, *V. jacobsoni* has been reported causing problems in beekeeping areas throughout Asia and Europe (Akratanakul and Burgett, 1975). Recently, *E. sinhai* has been reported for the first time from India (Delfinado and Baker, 1974) and now from Thailand. This parasitic honey bee mite species may occur in other countries in South and Southeast Asia as well, but there are no such reports so far. Whether or not *E. sinhai* is capable of causing problems for other *Apis* species is unknown, and needs to be investigated.

It was suggested that the mite problem occurring in Asia might be responsible for the limited success of the establishment of the beekeeping industry with *A. mellifera* (Delfinado, 1963; Morse, 1966; Morse and Laigo, 1968).

CONCLUSION AND SUMMARY

This is the first time that parasitic mites (family Varroidae) of the honey bees, Apis spp., are reported from Thailand. Two species of mites, V. jacobsoni and E. sinhai, were studied. V. jacobsoni was found associated with A. mellifera and A. c. indica. Colonies of A. florea were found parasitized by E. sinhai.

V. jacobsoni was found infesting the colonies of the wild Indian honey bee, A. c. indica, in the central and northeastern provinces. The same mite was also found parasitizing the introduced A. mellifera in an apiary in the northern province. Previously, neither the taxonomy nor the life history of V. jacobsoni were clearly understood. Kulikov (1965) and Delfinado and Baker (1974) suspected that the parasite was viviparous. This study reports the life cycle, dispersal movements, selection of hosts, and distribution of V. jacobsoni. Egg, protonymph, deutonymph, and sexual adults are described.

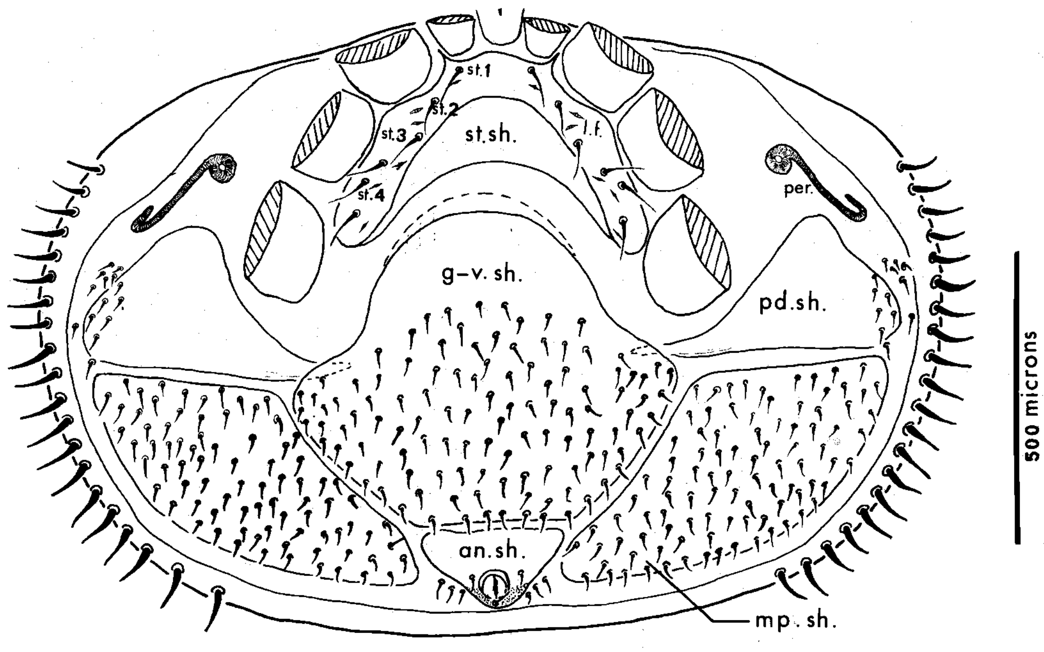
Previously, only the adult female of E. sinhai was known (Delfinado and Baker, 1974). Delfinado and Baker stated that E. sinhai was an ectoparasite of the honey bee, but without supporting evidence. This study indicates that this animal is an ectoparasite of A. florea. The mated female lays her eggs inside the host cell. The eggs hatch to become protonymph. The succeeding stages are the deutonymph and adult, respectively. Dissections of the mite's egg revealed that the missing stage, the larva, develops to become the protonymph within the egg. The protonymph is the first stage to appear from the egg. Taxonomic descriptions of the egg, protonymph, deutonymph, and male of E. sinhai; and also the life history of the animal are reported here for the first time.

Host selection of the two mite species is different, i.e., E. sinhai is a parasite of A. florea while V. jacobsoni selects A. mellifera and A. c. indica as its hosts. The life cycles of these two mites are quite similar. Only adult females were found to be phoretic on adult honey bees. Fecundated female mites enter the opened brood cell prior to capping, and the immature mites develop to become sexual adults inside the cells. Mating of the mites may also take place in the sealed cells. If its host survives, a mated female mite will attach itself to the emerging host (phoresis). If the host dies, the mated female will move to another open brood cell and begin to oviposit.

Despite the fact that E. sinhai, so far, has been found attacking only the wild honey bee, A. florea of south Asia; V. jacobsoni has been reported from all beekeeping areas in Asia, and recently from Europe. V. jacobsoni poses problems to beekeepers who keep either A. c. indica or A. mellifera.

At present, it is clear that V. jacobsoni is economically more important than E. sinhai. The ability of V. jacobsoni to survive on the clustering bees during the cold season of sub-temperate and temperate areas enables the parasite to disperse to beekeeping areas throughout the world (Akratanakul and Burgett, 1975). Whether or not *E. sinhai* is able to attack the commercial honey bees, *A. c. indica* and *A. mellifera* is not known. Control measures against ectoparasitic mites of the honey bees are not yet well established. These problems need to be investigated.

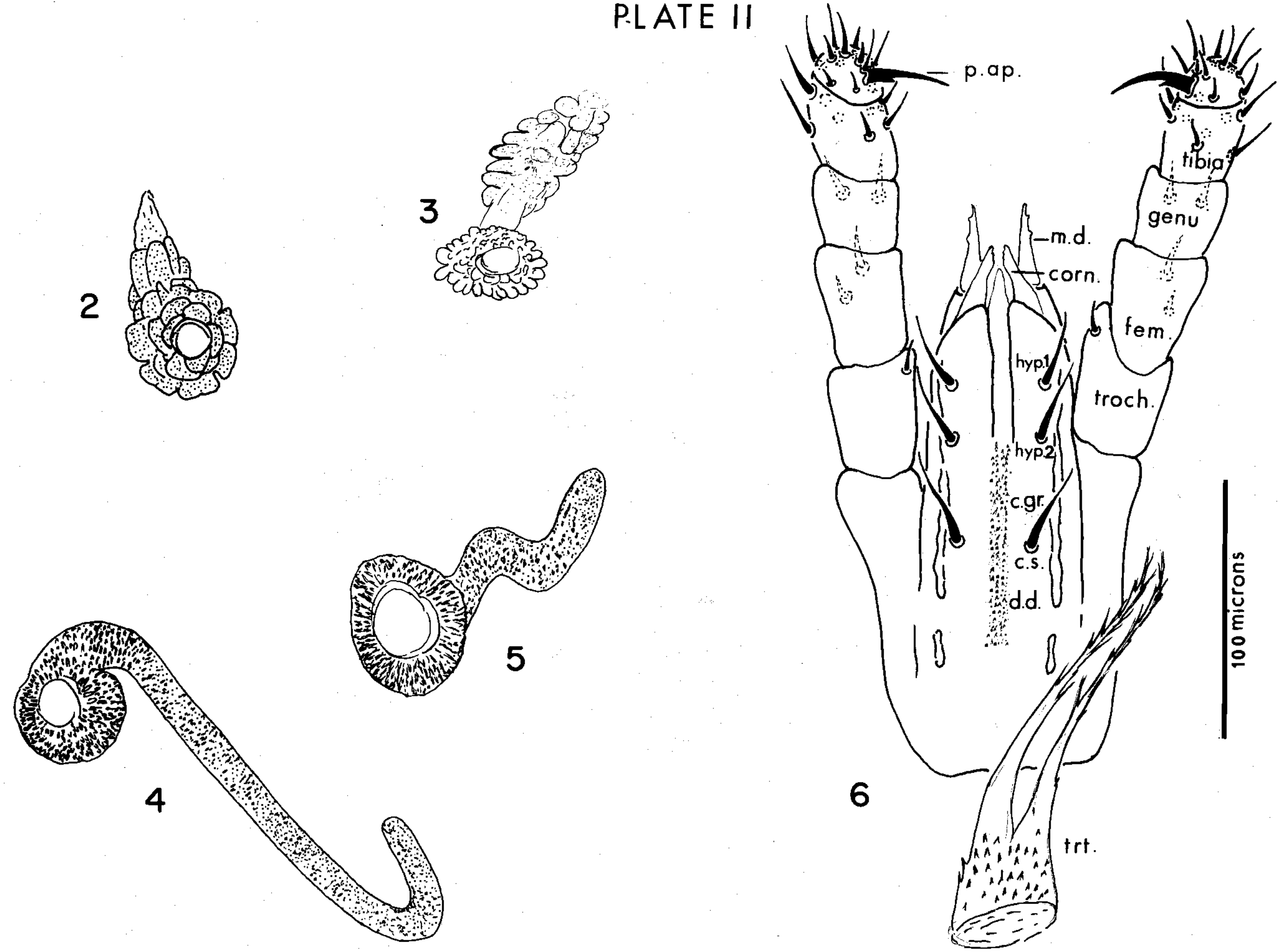
PLATE I



V. jacobsoni Oudemans

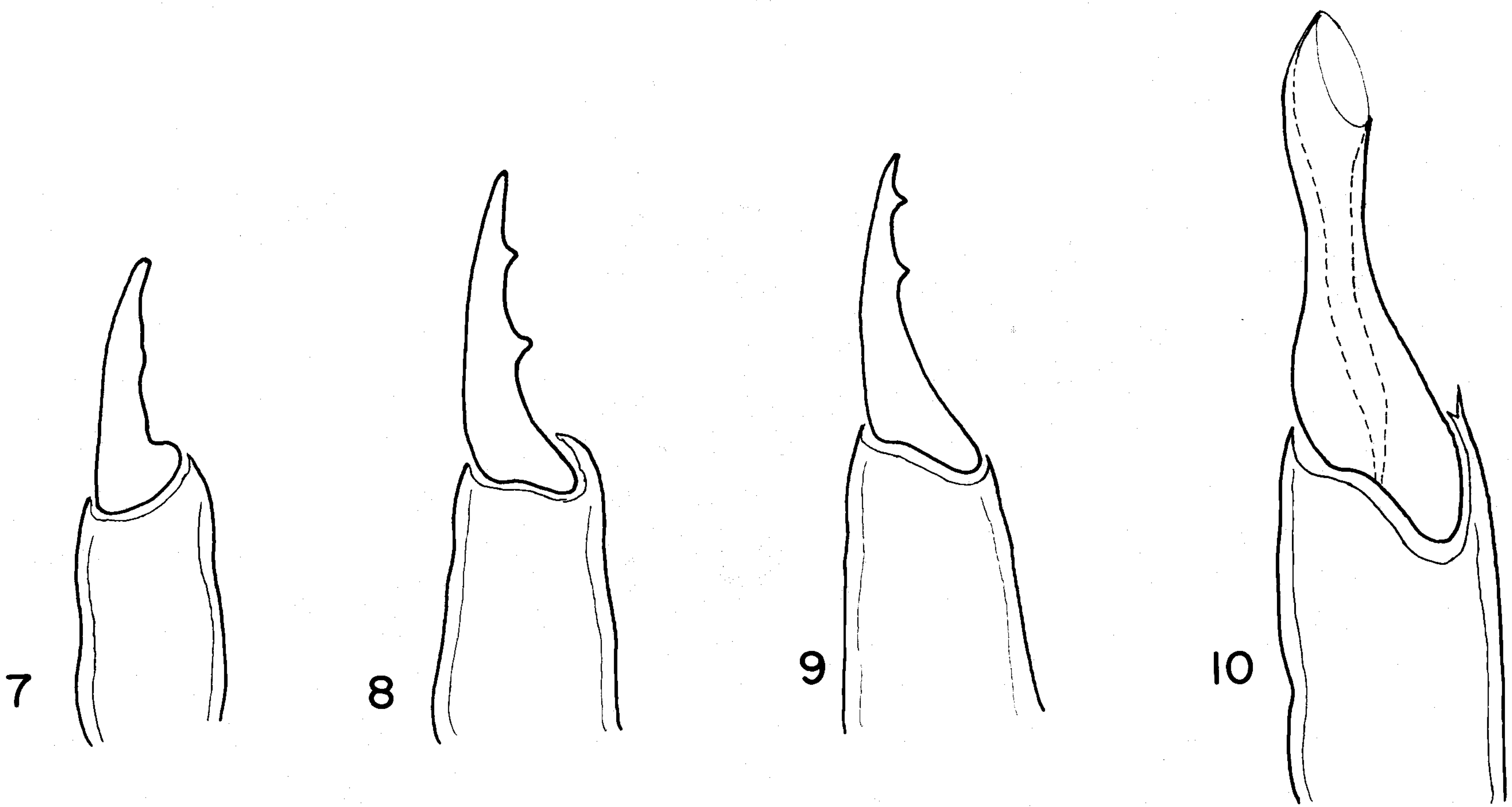
Figure 1. Venter of female.

PLATE II



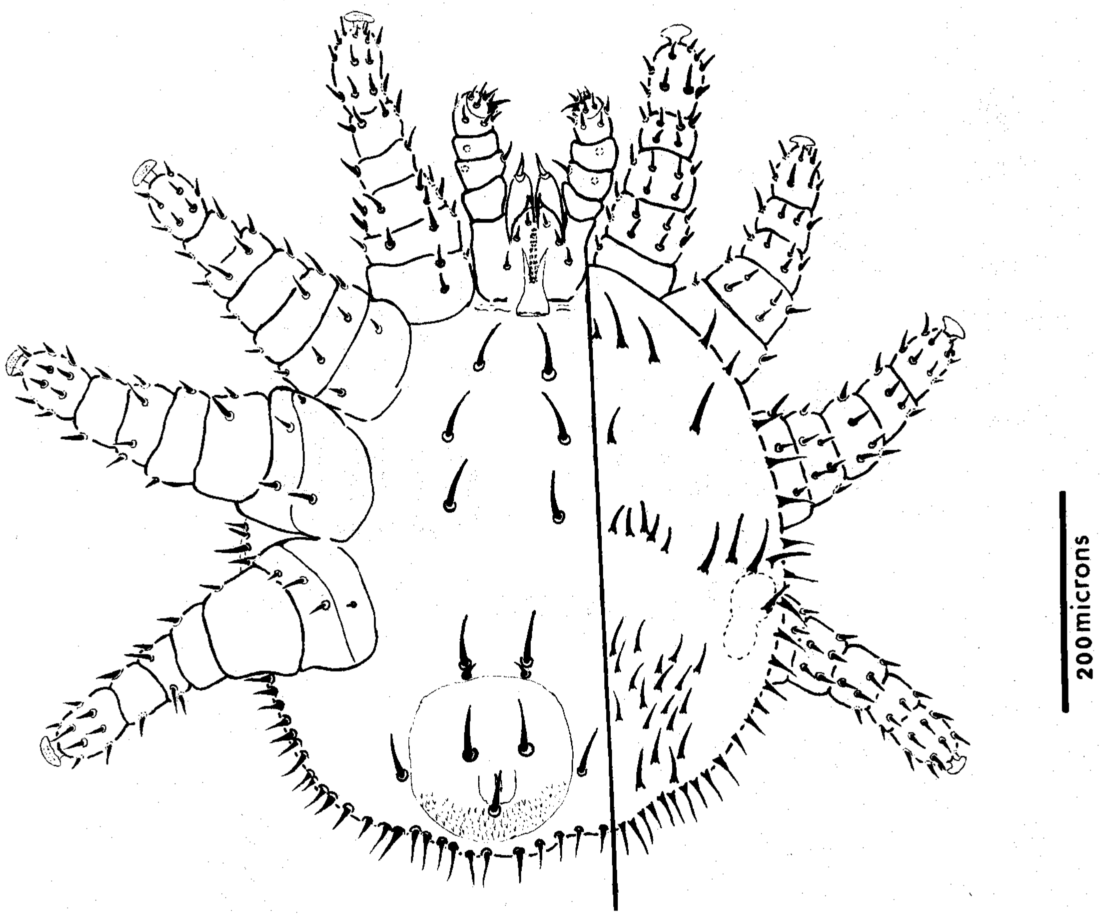
Varroa jacobsoni: Figs. 2-5. Stigmata and peritremes of protonymph, deutonymph, female, and male, respectively.
Fig. 6. Gnathosoma and tritrosternum of female.

PLATE III



<u>Varroa</u> <u>jacobsoni</u>: Figs. 7-10. Chelicerae of protonymph, deutonymph, female, and male, respectively.

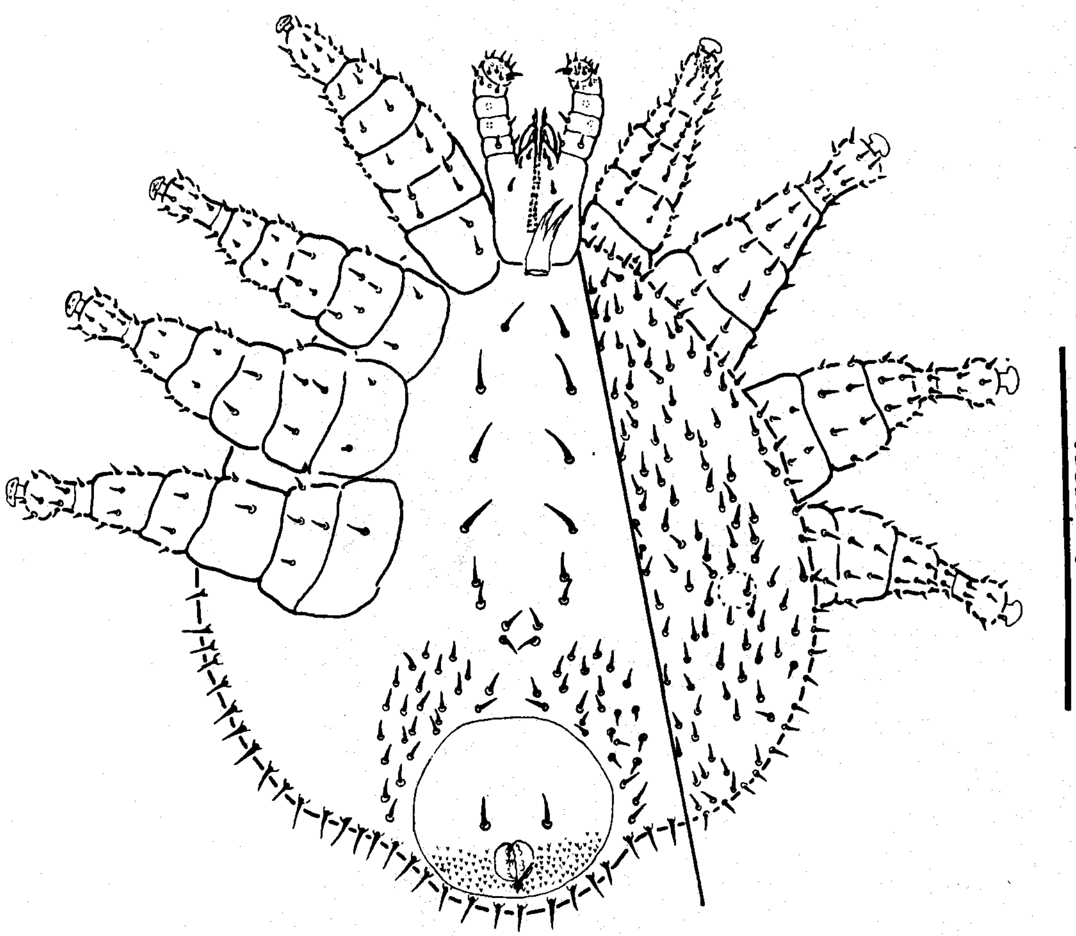
PLATE IV



Euvarroa sinhai

Figure 11. Protonymph.

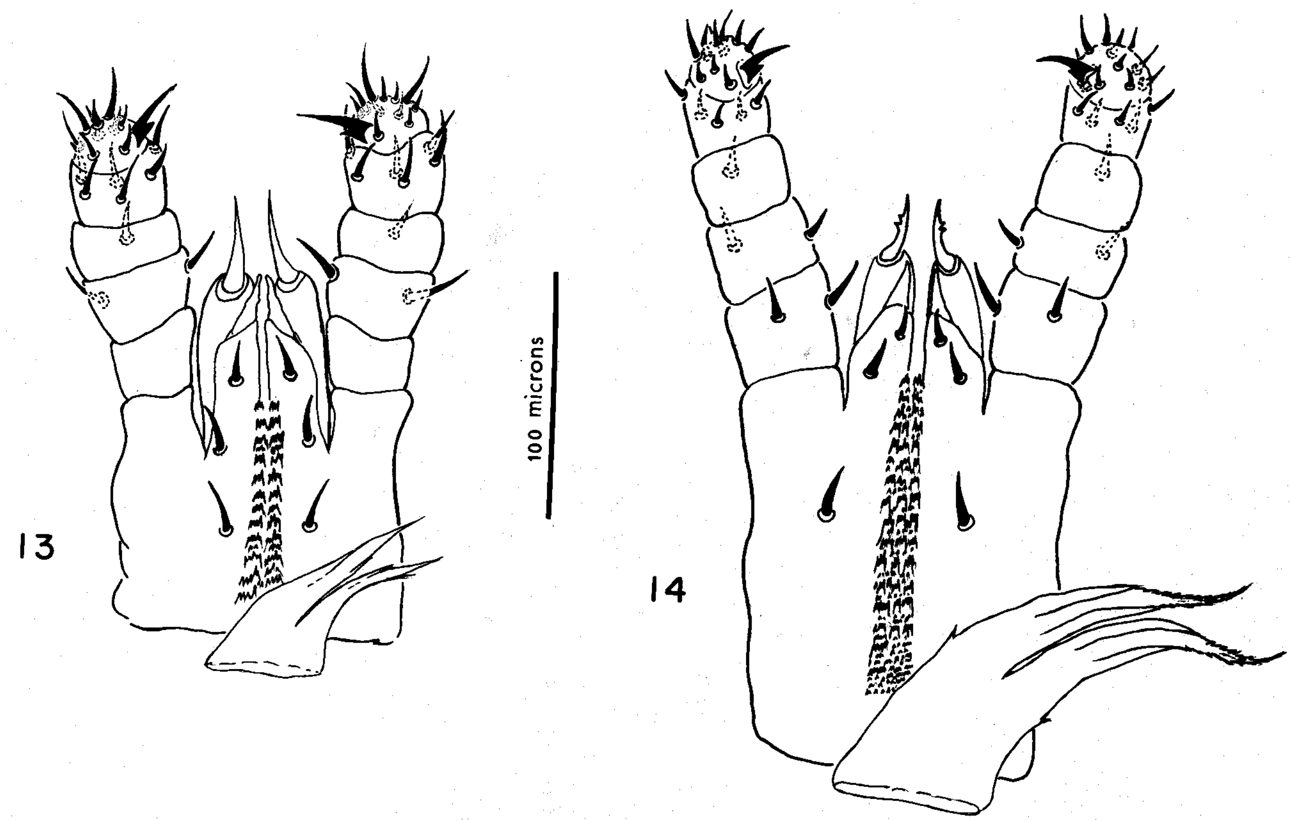
PLATE V



Euvarroa sinhai

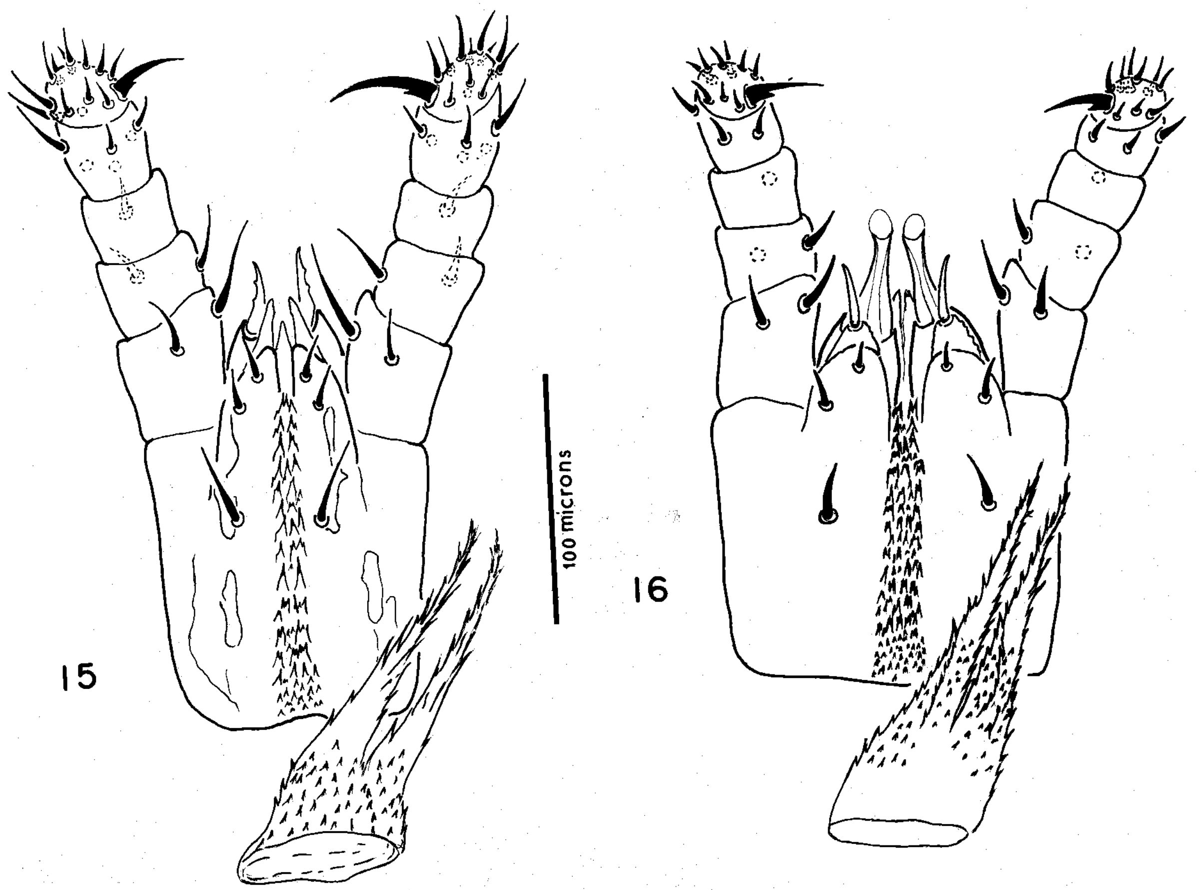
Figure 12. Deutonymph.

PLATE VI



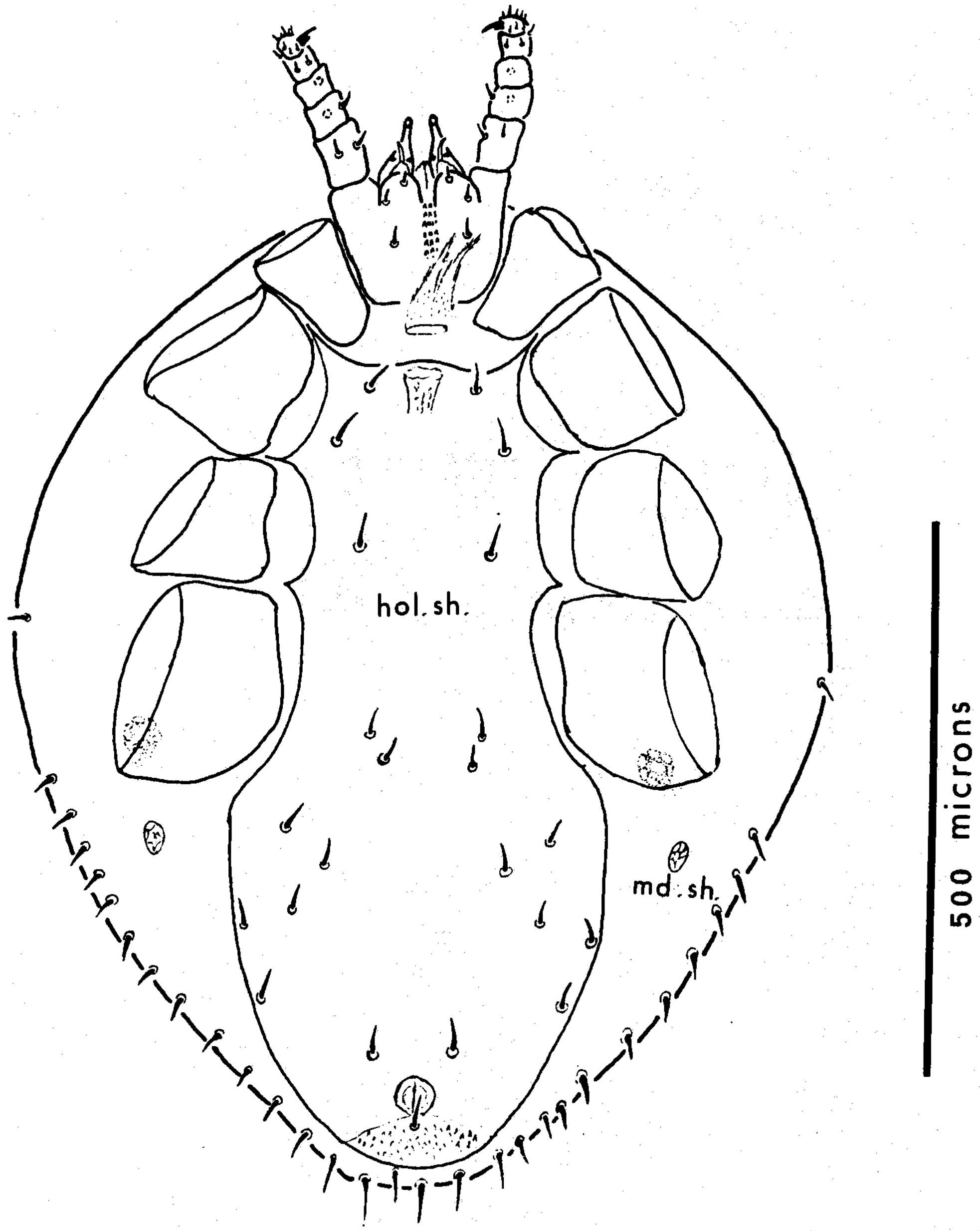
<u>Euvarroa</u> <u>sinhai</u>: Figs. 13-14. Gnathosoma and tritosterna of protonymph and deutonymph.

PLATE VII



<u>Euvarroa</u> <u>sinhai</u>: Figs. 15-16. Gnathosoma and tritosterna of female and male.

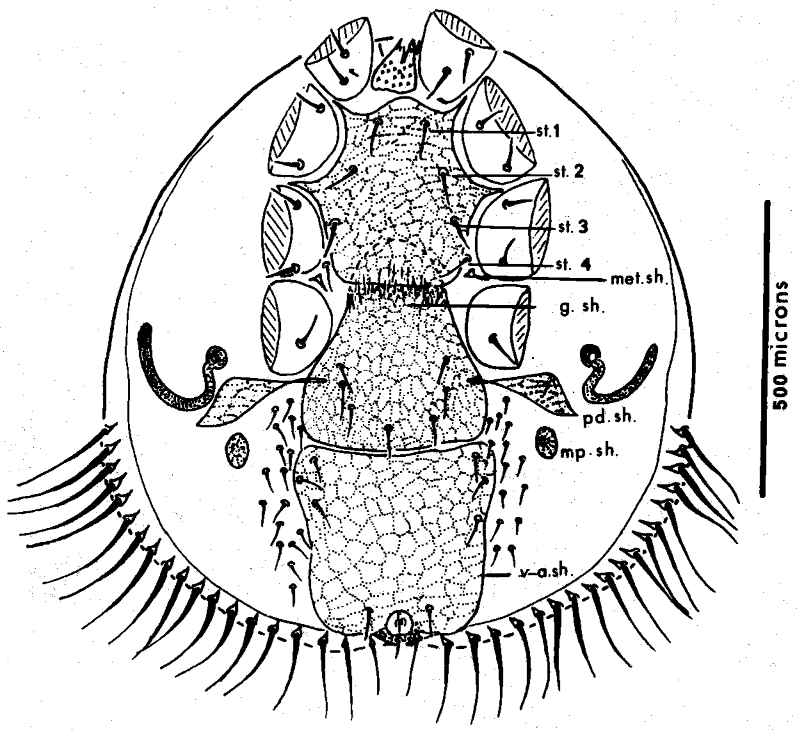
PLATE VIII



Euvarroa sinhai

Figure 17. Venter of male.

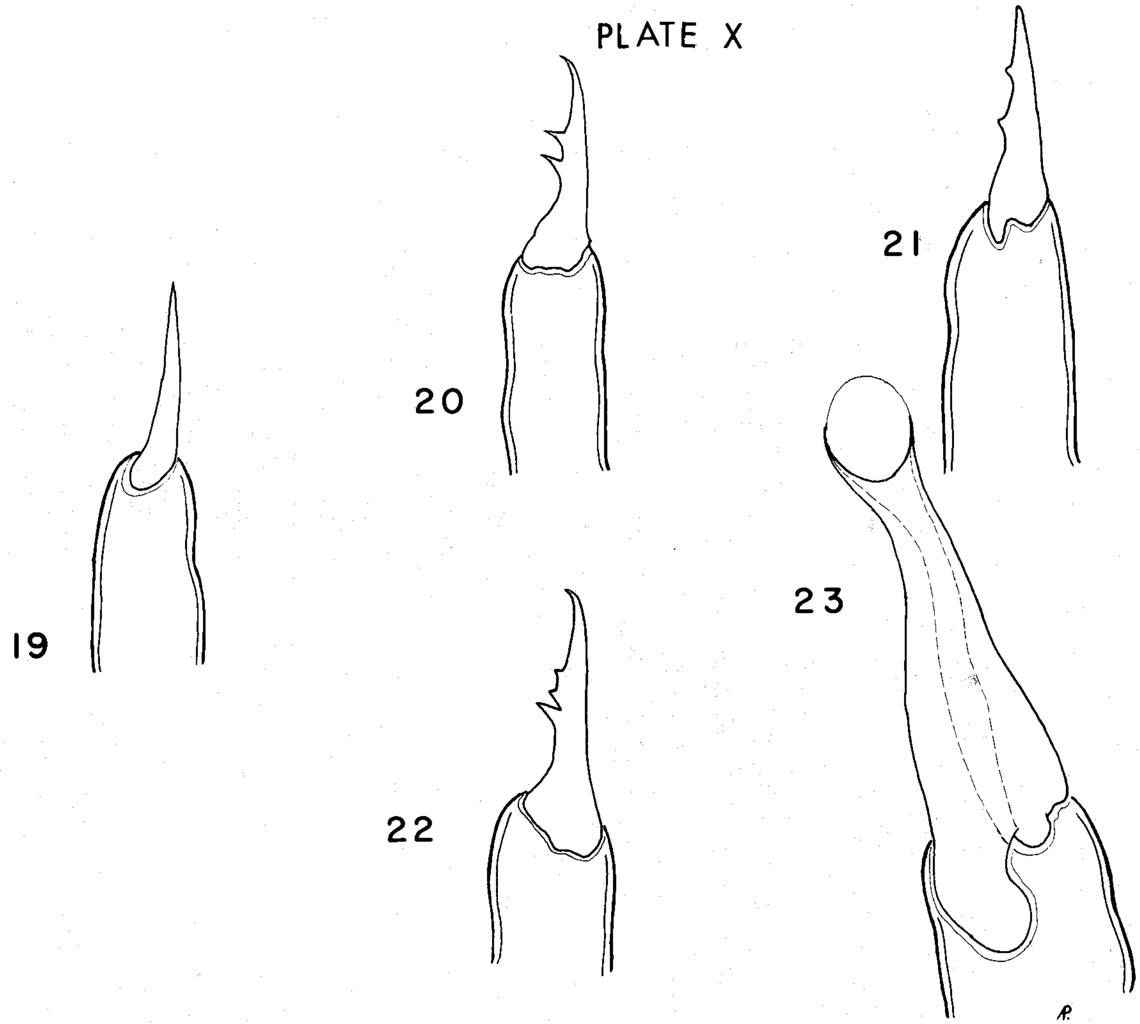
PLATE IX



E. sinhai Delfinado and Baker

Figure 18. Venter of female.

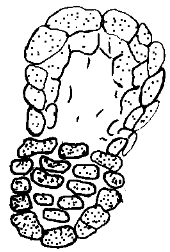
PLATE X



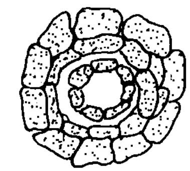
Euvarroa sinhai: Figs. 19-23. Chelicerae of protonymph, deutonumph (female), adult female, deutonymph (male), and adult male, respectively.

PLATE XI

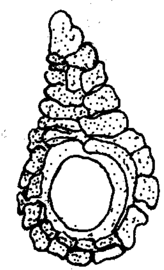
24



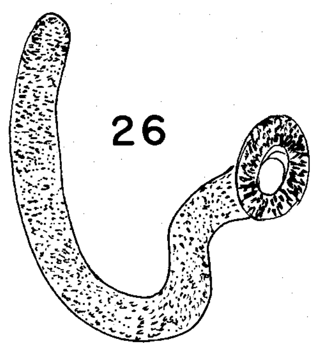
25



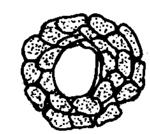
27



26



28



Euvarroa sinhai: Figs. 24-28. Stigmata and peritremes of protonymph, deutonymph (female), adult female, deutonymph (male), and adult male, respectively.

PLATE XII

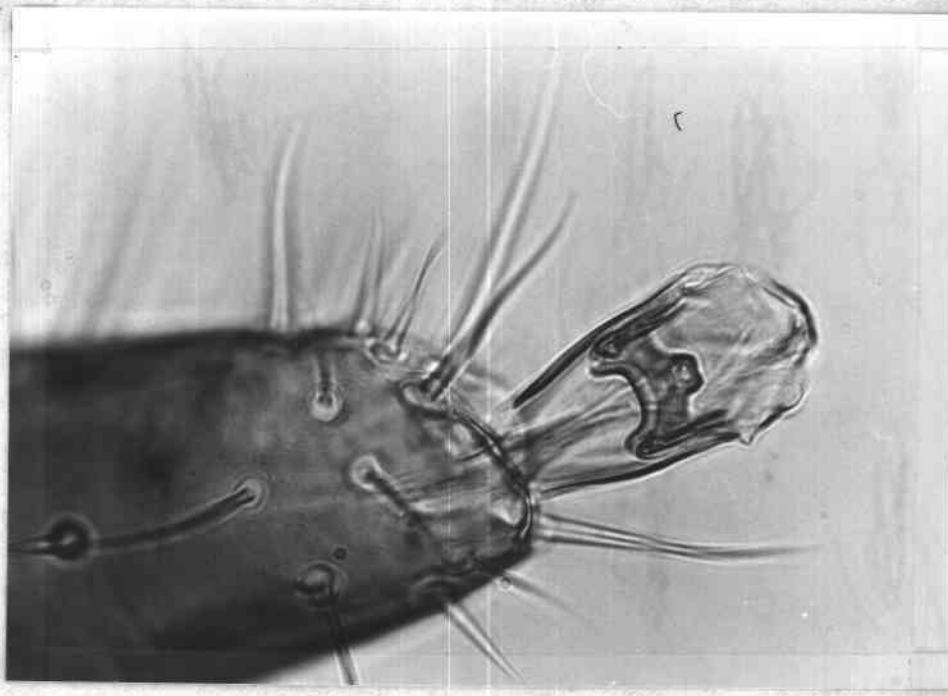


Figure 29. Ambulacrum of female E. sinhai.

PLATE XIII

Figure 30. Female E. sinhai on drone pupa of A. florea.

PLATE XIV

Figure 31. Male of E. sinhai on drone pupa of A. florea.

PLATE XV

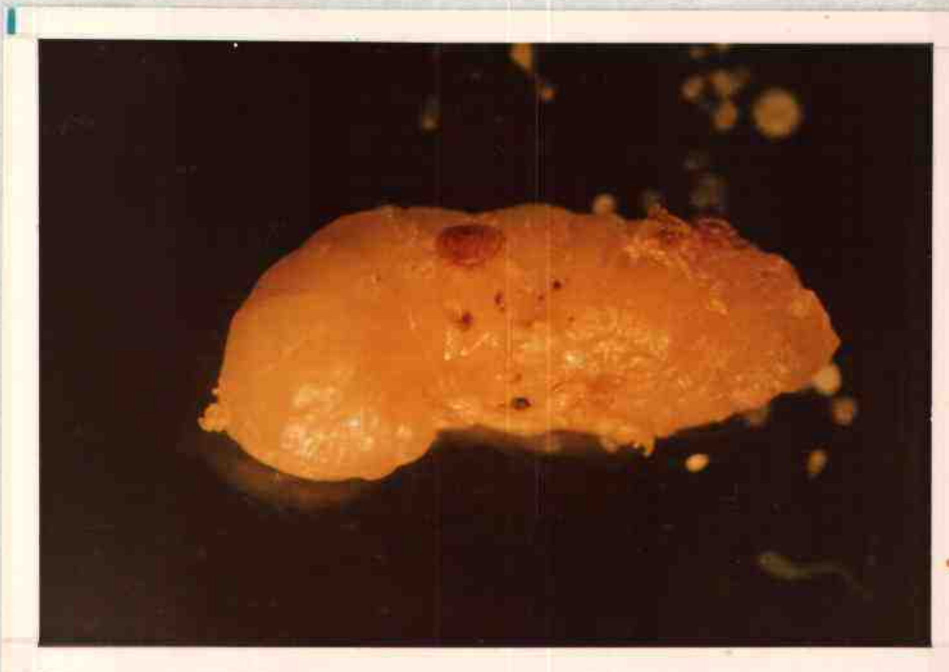


Figure 32. Larva of drone of A. florea parasitized by E. sinhai.

PLATE XVI

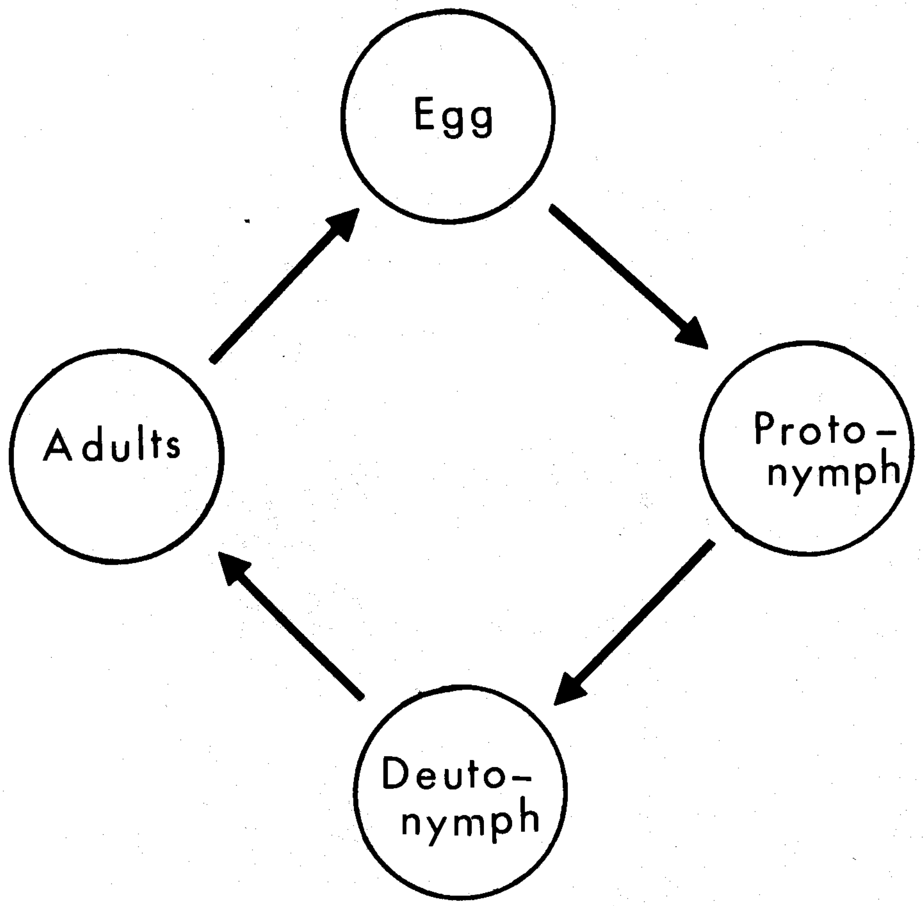


Figure 33. A schematic diagram of the developmental stage of mites Varroa jacobsoni Oudemans and Euvarroa sinhai Delfinado and Baker.

PLATE XVII

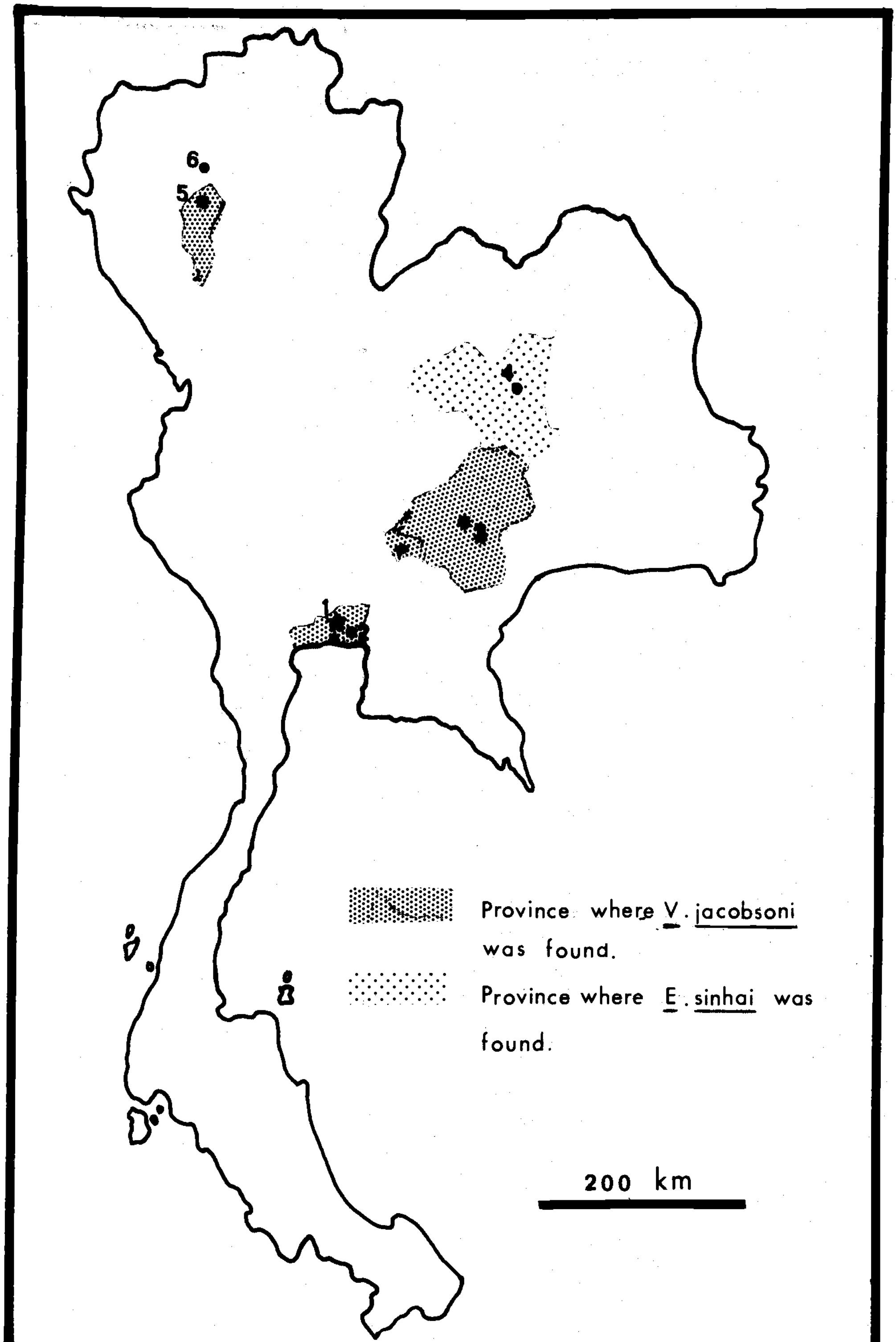


Figure 34. Map of Thailand.

1. Bangkok 2. Smut-Prakarn 3. Nakorn-Rajsima
4. Khonkaen 5. Lam Poon 6. Chieng Mai

BIBLIOGRAPHY

Akratanakul, P. and M. Burgett. 1975. Varroa jacobsoni Oudemans: A prospective pest of the honey bee (Apis mellifera L.) in the western hemisphere. Bee World (in press).

Atwal, A. S. and G. S. Dhaliwal. 1969. Some behavioural characteristics of Apis indica F. and Apis mellifera L. Indian Bee Journal 31:1-8.

Baker, E. W. and G. W. Wharton. 1952. An introduction to acarology. Macmillan Co., N.Y., 465 pp.

Bailey, L. 1963. Infectious diseases of the honey bee. Land Book Limited, London, 176 pp.

Choi, S. Y. and K. S. Woo. 1973. Studies on the bionomics of bee mite, Varroa jacobsoni Oudemans, and its chemical control. Research Reports of the Office of Rural Development, Suwon, Korea 15 (Livestock):35-43.

Crane, E. E. 1968. Mites infesting honey bees in Asia. Bee World 49(3):113-114.

Delfinado, M. D. 1963. Mites of the honey bee in South-East Asia. Journal of Apicultural Research 2(2):113-114.

Delfinado, M. D. and E. W. Baker. 1974. Varroidae: A new family of mites on honey bees (mesostigmata: Acarina). Journal of Washington Academy of Sciences 64(1):4-10.

Evans, G. O. and W. M. Till. 1965. Studies on the British Dermanyssidae (Acari: Mesostigmata) Part II external morphology. Bulletin of the British Museum (Natural History) Zoology 13(8):249-294.

Filipponi, A. and G. Francaviglia. 1964. Larviparita Facoltavita in alcuni Macrochelidi (Acari: Mesostigmata) associati a muscidi di interesse sanitario. Parasitologia 6(1-2):99-113.

Gunther, C. E. M. 1951. A mite from a bee hive on Singapore Island (Acarina: Laelaptidae). Proceedings of the Linnean Society of New South Wales 76(3-4):155-157.

Gupta, G. A. 1967. Varroa jacobsoni: A mite pest of Apis indica. Bee World 48(1):17-18.

Kshirsagar, K. K. and A. P. Percy. 1966. Further observations on the mites on Indian honey bee Apis indica in Kodaikanal. Indian Bee Journal 28(1):25-26.

Kulikov, N. S. 1965. Varrosis of bees. Pchelovodstvo 85(11):15-16. (BRA Translation E 879)

Laigo, F. M. and R. A. Morse. 1969. Control of the bee mites, Varroa jacobsoni Oudemans and Tropilaelaps clareae Delfinado and Baker with chlorobenzilate. Philippine Entomologist 1(2):144-148.

Morse, R. A. 1966. The beekeeping potential in the Philippines. Gleaning in Bee Culture 94(10):592-595.

_______________. 1974. The complete guide to beekeeping. E. P. Dutton & Co., Inc., New York, 207 pp.

_______________, and F. M. Laigo. 1968. Beekeeping in the Philippines. University of the Philippines College of Agriculture Farm Bulletin 27:1-56.

_______________. 1969. Apis dorsata in the Philippines. Philippine Association of Entomologists Inc. Monograph Number 1:1-96.

Oudemans, A. C. 1904(a). Acarologische Aanteekeningen XII. Entomologische Berichten Uitgegeven Door de Nederlandsche Entomologische Vereeninging 18:161.

_______________. 1904(b). Note VIII. On a new genus and species of parasitic acari. Notes Leyden Museum 24:216-222. (Original paper not seen.)

_______________. 1904(c). Acarologische Aanteekeningen XIII. Entomologische Berichten Uitgegeven Door de Nederlandsche Entomologische Vereeninging 24:169.

Phadke, K. G., D. S. Bisht, and R. B. P. Sinha. 1966. Occurrence of mite Varroa jacobsoni Oudemans in the brood cells of honey bees, Apis indica F. The Indian Journal of Economic Entomology 28:411-412.

Poltev, V. L., M. S. Dauydov and V. L. Sal'Chenko. 1967. Varroa disease and its control. International Beekeeping Congress Preliminary Scientific Meeting 21(2):245-249.

Punjabi, A. A. and S. K. Saraf. 1969. Occurrence of Varroa jacobsoni Oudemans in Kashmir. Indian Bee Journal 1:44.

Rahman, K. A. and S. Singh. 1947. Preliminary studies on the bionomics of the Indian honey bee. Apis indica F. Indian Bee Journal 9:6-8.

Rennie, J. P. B. White and E. J. Harvey. 1921. Isle of Wight disease in hive bees. Transactions of the Royal Society of Edinburgh 52(29):737-779.

Sakai, T. and I. Okada. 1973. The present beekeeping in Japan. Gleaning in Bee Culture 101(11):356-357.

Sandhu, A. S. and S. Singh. 1960. The biology and brood rearing of the little honey bee Apis florea F. Indian Bee Journal 22:27-35.

Sevilla, V. J. 1963. Observations on the life history and habits of three new acarine pests of honey bees in the Philippines. B. Sc. thesis, University of the Philippines. 42 pp.

Stephen, W. P. 1968. Mites: A beekeeping problem in Vietnam and India. Bee World 49(3):119-120.

Velichkov, V. and P. Nachev. 1973. Investigation about the Varroa jacobsoni disease - oud. (sic) in Bulgaria. International Beekeeping Congress Summary 24:49-50.

APPENDIX

Abbreviations Used in Text - Figures
(After Evans and Till, 1965)

an.sh.	anal shield
c.gr.	capitular groove (deutosternal groove)
c.s.	capitular seta
corn.	corniculi
d.d.	deutosternal denticles (deutosternal teeth)
fem.	femur
g-v.sh.	genito-ventral shield (epigynial-ventral shield)
hol.sh.	holoventral shield
hyp. 1-2	hypostomal setae
l.f.	lyriform fissure (lyrifissure)
m.d.	movable digit of chelicera
met.sh.	metasternal shield
mp.sh.	metapodal shield
pd.sh.	podal shield (endopodal shield)
per.	peritreme
p.ap.	palpal apotele
st. 1-3	sternal setae
st. 4	metasternal seta
st.sh.	sternal shield
troch.	trochanter
trt.	tritosternum
v-a.sh.	ventri-anal shield