

SOME OBSERVATIONS OF THE HABITS AND DISTRIBUTION  
OF *TROCHOMETRIDIDIUM* CROSS, 1965 (ACARINA : PYEMOTIDAE) <sup>1</sup>

BY

Earle A. CROSS <sup>2</sup> and George E. BOHART <sup>3</sup>

SUMMARY

The geographical and host distributions of *T. tribulatum* and *T. chinensis* are expanded on the basis of new records and a key to the species is given.

Life history studies show *T. tribulatum* to be a fungivore, occurring only in cells containing dead bee larvae. Finding from laboratory rearings are discussed.

ZUSAMMENFASSUNG

Die Geographische- und Wirtsverbreitung von *T. tribulatum* und *T. chinensis* wird, auf die Grundlage neuer Kenntnis, erweitert, und ein Bestimmungsschlüssel der Arten darstellt. Lebensgeschichtestudien zeigen dass *T. tribulatum* ein Pilzfresser ist, sondern nur mit toten Bienenbrut vorkommt. Laboratoriumsergebnisse sind verhandelt.

\*  
\* \* \*

This paper is the first in a series concerned with the habits of certain mites associated with western bees and particularly with the alkali bee, *Nomia melanderi* Ckll. Main study areas were bee nesting sites in Utah, Wyoming, and Idaho (Table I). Studies were carried out primarily in 1955-56 and 1965-66.

*Trochometrididium tribulatum* was described by CROSS (1965), who found it to be associated with dead larvae of the halictine bee *Halictus farinosus* Smith in Utah. Notes concerning its life history accompanied the description. CROSS and BOHART (1969) briefly discussed the photic behavior of the species. Under the name *Siteroptes chinensis*, Mahunka (1966) described a second species (redrawn here, Fig. 1) from a Chinese wasp. The two species are easily separated in the following key :

- 1 (a.) Dorsals III distinctly larger than laterals III and longer than dorsals IV (Fig. 1-1). *chinensis*  
1 (b.) Dorsals III subequal to laterals III and less than half as long as dorsals IV.. *tribulatum*

A series of *chinensis* <sup>4</sup> was recently collected at Nabire, Netherlands New Guinea (by N. WILSON), from the body of a sphecoid wasp, and Dr. S. MAHUNKA has kindly sent us a series of *tribu-*

1. This study was financed in part by NIH Grant AI 06567 to the senior author.

2. Department of Biology, University of Alabama, Tuscaloosa, 35486.

3. U.S.D.A., E.R.S., Wild Bee Pollination Laboratory, Utah State University, Logan, 84321.

4. Comparisons made with the holotype (*chinensis*) or a paratype (*tribulatum*) by Cross.

*latum*<sup>4</sup> taken from the bodies of the scarab beetles *Aphodius* sp. and *Ossibia* sp. in northwestern Sudan, thereby greatly enlarging the known geographical ranges of both species. The latter record also represents a marked departure from the hymenopteran hosts associated with *tribulatum* in the U.S. Perhaps the beetles became infested by mites dispersing from bees or wasps nesting in the same soil. Presently-known geographical and host ranges of the two species are given in Table I.

TABLE I. — Geographical and Host Distribution of *Trochometridium*.

Species	Host	Localities <sup>5</sup>
<i>T. tribulatum</i> Cross, 1965	Hymenoptera	
	Apoidea	
	<i>Nomadopsis scutellaris</i>	a,b
	<i>Nomadopsis anthidius</i>	a,b
	<i>Calliopsis andreniformis</i>	a,b,c,d,h
	<i>Calliopsis coloradensis</i>	a
	<i>Oreopasites scituli</i>	b
	<i>Halictus farinosus</i>	a
	<i>Halictus ligatus</i> (worker) <sup>6</sup>	d
	<i>Sphecodes arvensiformis</i>	a
	<i>Nomia melanderi</i>	a,b,e
	<i>Nomia nevadensis</i> <sup>6</sup>	?
	<i>Nomia bakeri</i> <sup>6</sup>	g,i
	<i>Melissoides fimbrioides</i> <sup>6</sup>	d
	Tiphiidae	
	<i>Myrmosa unicolor</i>	e
	Mutillidae	
	<i>Dasymutilla</i> sp.	f
	Sphecoidea	
	<i>Motes argentata</i>	b
	"Sphecid"	e
<i>T. chinensis</i> (Mahunka, 1966)	Coleoptera	
	<i>Aphodius</i> sp.	Darfur Prov., Sudan
	<i>Ossibia</i> sp.	" " "
<i>T. chinensis</i> (Mahunka, 1966)	Hymenoptera	
	"Wasp"	Hsin-hui, Canton Prov., China
	"Sphecoid wasp"	Nabire, Netherlands New Guinea

<sup>5</sup> a, Cache Co., Utah; b, Franklin Co., Idaho; c, Lawrence Co., Kansas; d, Hale Co., Alabama; e, Fresno, Yolo Co., California; f, Anne Arundel Co., Maryland; g, LaSalle Co., Texas; h, Woodbury Co., Iowa; i, Tamaulipas, Mexico.

<sup>6</sup> These hosts are dubious. The finding on *H. ligatus* and on *M. fimbrioides* are probably transfers which occurred in the killing jar.

CROSS and BOHART (1969) stated that 20-40 per cent of newly-emerged male *N. melanderi* and 16-25 per cent of newly-emerged females in southern Idaho (Preston site) carried phoretic female *T. tribulatum*, mite numbers declining with bee age. A maximum of 45 mites was found on one young male bee, 6-12 being a more usual number. No statistical difference in mite numbers between bee sexes was found to occur. Approximately 3 per cent (7 of 255) of cells constructed by *N. melanderi* females were found to be infested. Limited data on *Nomadopsis scutellaris* (Fowler) and *N. anthidius* Fowler from the same nesting sites indicates a similar level of cell infestation (4 of 93,  $\pm 4$  per cent). More recently, July, 1970, a cell of *Calliopsis coloradensis* Cress, a related panurgine bee, was found infested at Logan, Utah. Incidence of mites on adults of these species is unknown, but 2 of 8 male and 2 of 4 female *Calliopsis andreniformis* Smith were found to be infested in Alabama. One of three specimens of *Oreopasites scituli* Ckll. at Preston, a cleptoparasite of *Nomadopsis*, was found to carry 6 female *T. tribulatum*, mostly on or near the coxae. Present evidence indicates that the mite is normally found associated with soil-inhabiting insects which nest gregariously; however, panurgine bees may be preferred hosts. Infestation of a bee site can be sporadic and temporary; the mite was not found with *H. farinosus* in 1965-66 at the originally infested site, although the site was being studied intensively during that period. It has not been found at all on other large alkali bee sites in west-central Utah, in central Wyoming, central Idaho, and eastern Washington, all under intensive study for a minimum of 10 years.

Recently infested cells were found to contain 1-3 young female mites, but in 3 of 4 cells containing more than 1, the cell, while sometimes containing some pollen, was filled with dirt or otherwise abnormal. No successful (gravid) female was ever found in such a cell. Five cells were found (3 of *Nomadopsis* & *Calliopsis*; 2 of *Nomia*) to contain gravid females and each of these but one contained a single female. The exception contained many females of varying sizes, probably of at least 2 generations. The number of founding females was not known in the latter case. SHINN (1967) implies single female infestations in the 2 infested cells which he studied. Gravid females were found only in completed cells.

CROSS (1965) believed *Trochometridium* to be parasitic in a manner similar to the closely-related genus *Pyemotes*. His inference was based on the stout, piercing chelicerae of the female, on the fact that the mite was never found with a healthy bee, and upon its presumed phyletic position. This surmise is at least largely incorrect. Thirteen naturally-infested cells (of *H. farinosus*, *N. melanderi*, *Calliopsis* spp., and *Nomadopsis* spp.? were found by us. None contained living bees and all, with possible exception of the 2 cells of *H. farinosus*, contained either the remains of the bee egg or of very young larvae together with a sizeable amount of pollen. The 2 cells of *H. farinosus* appeared to contain larger (dead) larvae and little pollen. Infested cells likewise always contained visible amounts of filamentous fungal mycelium, its density and moisture content seemingly varying according to the stage of infestation. Those cells infested with a mite in the pre-ovipositional stage always contained a dense cottony, wet mass of mycelium (Fig. 5), but in cells containing mite eggs or young, the mycelium tended to be sparse and usually concentrated near the remains of the bee or in the area directly beneath the mite (Fig. 6). In 2 instances, cells containing typical dense, cottony mycelium contained young dead bee larvae but no mites.

In summary, (1) developing female mites were rarely found in cells containing a bee larva more than 1/4 grown, (2) no developing mite was ever found in an unfinished cell, *i.e.*, one lacking an egg or larva, (3) no developing mite was ever found in a cell with a living bee, (4) suitable conditions for development appeared to exist in some cells which, nevertheless contained no mites.

We suggest that (1) there is probably a very narrow time span within which the mite is able to successfully develop within a cell. Cells that are too young or cells which contain larvae over 1/4 grown seem generally unsuitable, (2) the presence of the egg or young bee larva is in some way necessary for mite development.

We are still unable to say whether *T. tribulatum* females successfully infest only those cells in which the egg or very young larva has died, or whether they are directly responsible for its death by, e.g. feeding or by inoculating it with or promoting the growth of a pathogenic fungus or bacterium. Several reasons may be advanced for mite failure to successfully invade cells with larger larvae. (1) Prepupae and, presumably, larvae, secrete an antibiotic, which is active at least against certain bacteria (BIENVENU *et al.*, 1968). (2) The size and activity of a large larva could physically prevent the mite's establishment or it could be immune to an inoculation or bite which would kill the egg or small larva.

#### *Laboratory Rearing of T. tribulatum*

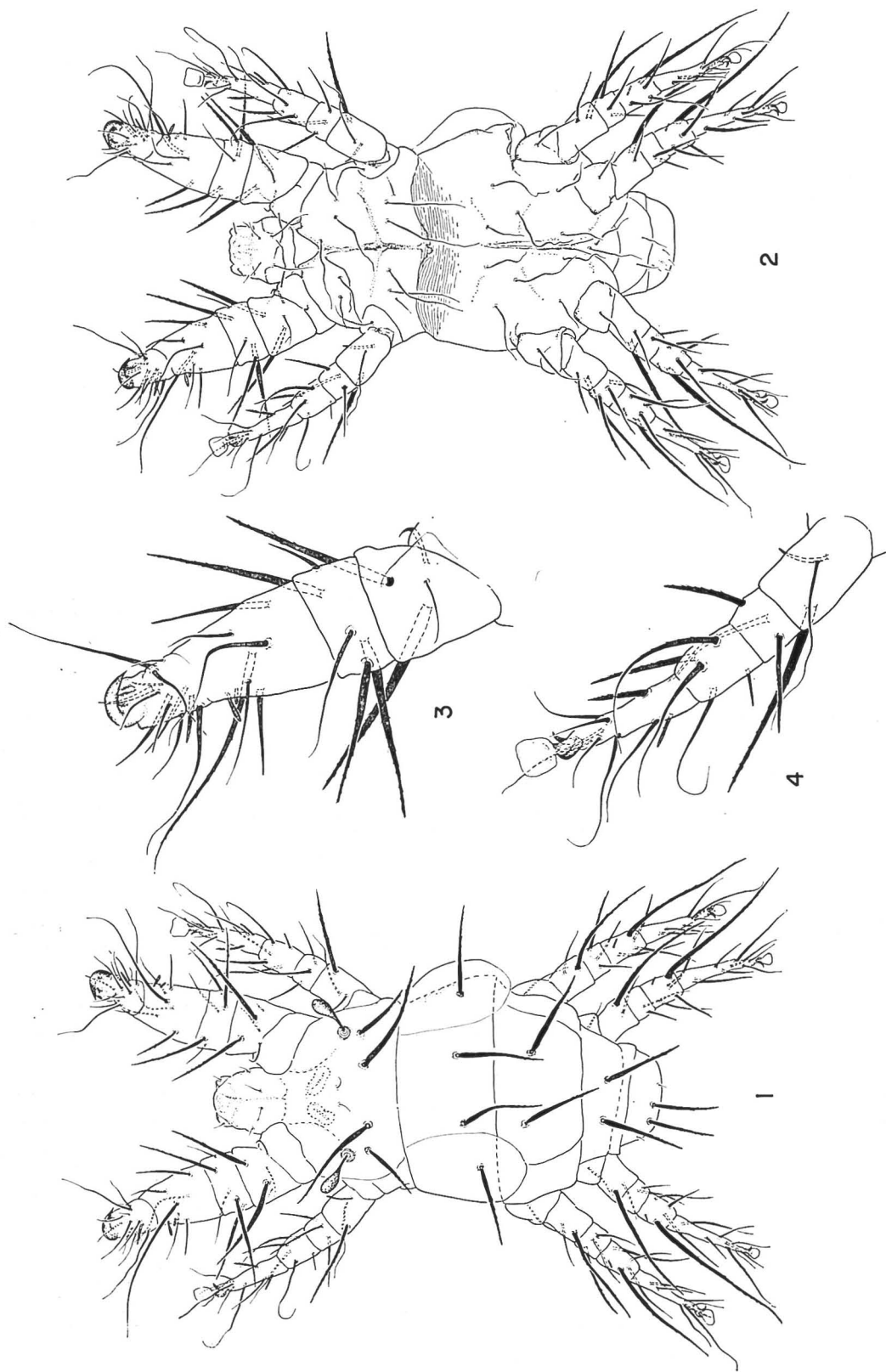
On July 8, 1965, at the Preston site the first gravid female *Trochometridium* was found in a cell of *Nomadopsis*. The mite was suspended in a dense, cottony mass of mycelium which filled the entire cell (Fig. 5). Using standard sterile techniques, attempts to rear females on laboratory-grown fungal cultures were initiated immediately. Inoculations of scrapings from bee cell walls, fungal hyphae in cells, pollen from cells, and young, phoretic female *Trochometridium*, living and dead, were placed onto one or more of the following agars: Difco Yeast-Dextrose, Difco Tomato-Juice, Difco Potato-Dextrose, and Sabouraud's. Cultures were held at (air-conditioned) laboratory temperature which fluctuated between 65 and 80° F. Laboratory relative humidity varied but was in the neighborhood of 50 per cent.

Twelve of approximately 60 young female *Trochometridium* introduced into such fungal cultures underwent some degree of physogastry. Seven of these reached only a diameter of 600  $\mu$  or less, at which point swelling stopped and the mites died without producing eggs. The remaining 5 became greatly enlarged (900-1300  $\mu$ ) and produced eggs. Inocula for these 5 cultures were (1) dead *Trochometridium* females taken from hairs of alkali bees which had been held at approximately 40° F for 7 days (3 cultures); (2) dead young *Trochometridium* female from a culture dish held at lab temperature for about 2 weeks (1 culture); (3) scrapings from an infested *N. melanderi* cell without heavy hyphal growth (1 culture). Successful cultures were grown upon all agars except Sabouraud's, and upon a pollen ball with dead young larva removed from an alkali bee cell.

Of the 5 young females becoming greatly physogastric, 4 were taken from alkali bees held in a cold room at about 40° F for 4-14 days. Origin of the fifth female is unknown. The females were placed on cultured mycelia only after good growth had begun.

Considering in addition the 7 females which became partially physogastric, sources of inocula were: dead young *Trochometridium* females as above (2 cultures); scrapings from infested cells (3 cultures); sub-inoculation from a successful lab fungal culture (2 cultures). Four of the females were subjected to a period of cold as described above, 1 had been given only 12 hours of cold, and 2 were newly-hatched and were taken directly from the natal cell.

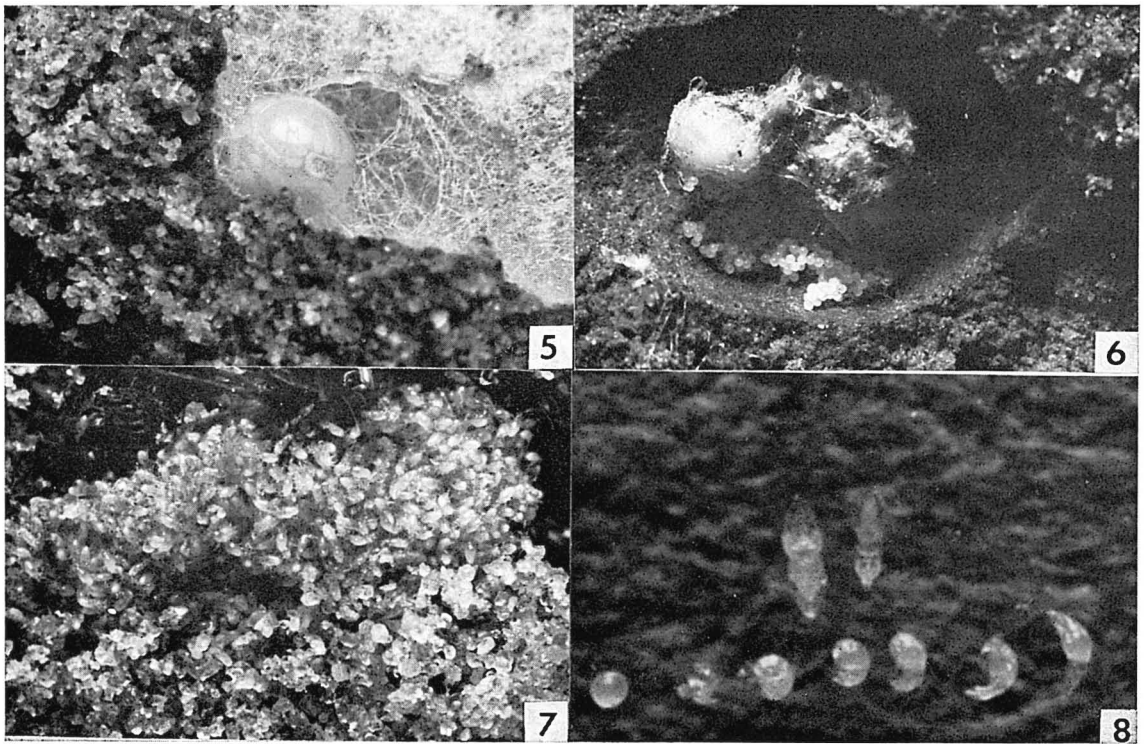
Although some females became greatly swollen and produced offspring, we point out that, overall, our results were inconsistent in this respect and the failure rate was high. No combination of factors was found which gave uniform results. Moreover, even in the case of females attaining the greatest size, fecundity in the laboratory seems lower than that found in nature. Probably, neither a period of lowered temperature, a time lapse, or association with an adult bee (and the attendant phoresy) are necessary to *initiate* physogastry in *Trochometridium*. Perhaps



FIGS. 1-4 : *Trochometridium chinensis* (Mahunka). Female, Nabire, New Guinea.  
 1) Dorsum ; 2) Venter ; 3) Right leg I, ventral aspect ; 4) Right leg II, ventral aspect.

our laboratory environment lacked, to some degree, at least one necessary releasing stimulus or perhaps the order of presentation of such stimuli was not entirely correct. It now seems clear that *Trochometruidium* is a fungivore, in this respect exhibiting greater affinity to *Siteroptes* than to *Pyemotes*. The data are also consistent in indicating that the mite develops successfully only in recently-completed cells containing either a dead egg or newly-hatched larva. We still are unable to answer the question of its relationship to the developing bee. If, for example, it should kill the latter by piercing it, does the ensuing fungal growth develop from a random sample of spores extant in the cell? If so, then it would seem that suitable fungi should be common species, but they could be rare if carried by the mite.

It would appear that since, probably, the bee secretes an antibiotic, its demise should allow the growth of cell fungi, at least one of which is favorable for the growth of the mite, and it would be advantageous for the mite to kill the bee. Also, probability of the mite finding the proper fungus in a cell is dependent upon the latter's commonness, unless the mite carries its own gemmules. Some evidence for this last exists if one considers that most of the successful laboratory rearings were derived from whole mites used as inocula. However, more success was obtained in starting cultures with dead mites than with living ones. Perhaps such fungi need an enzyme or nutritional breakdown product of decomposition to begin growth.



FIGS. 5-8 : 5) Newly gravid female *T. tribulatum* in cell of alkali bee. Note heavy cobwebbing of fungal mycelium. Female has attained maximum size but is an opaque dirty white ; 6) Older female *tribulatum* in cell of *Calliopsis coloradensis* Logan, Utah, together with remains of pollen ball. Note sparse mycelium. Egg mass is below ; 7) Clustering young females in cells of *Motes argentata*, Preston, Idaho. Cluster contained approximately 2255 females. Sand grains in foreground allow for comparison of size ; 8) Arbitrarily-chosen stages in development of *T. tribulatum*. Egg at lower left, successively more mature females to the right. Quiescent adult male (left) and female above.

If one assumes that the mite does not kill the bee, then the availability and selection of suitable cells must be explained.

Many bee cells are attacked by fungi and bacteria under natural conditions. BATRA, BATRA, and BOHART (1973) found 32 % of 6907 alkali bee cells to contain pollen spoiled by one or more of these microorganisms. The portion of this percentage containing fungi suitable for *T. tribulatum* is unknown, but the possibility exists that enough properly-infected cells exist in nature to provide a niche for the mite.

Mites could be attracted to properly infected cells by odor, or perhaps a certain fraction of cells are passively inhabited by mites whose success in reproducing is dependent upon the death of the bee with subsequent fungal growth of the proper sort. This latter hypothesis seems unlikely since mites were never found in healthy cells.

*Serratia*. In 1965, four cells containing dead bees and pollen balls were seen to contain noticeable colonies of the red bacterium *Serratia marcescens* Bizio \* together with at least discernible mycelial growth. Two of these cells also contained *Trochometridium*, one having a single physogastric female, the other unusual in containing many females in all stages. The bacterium was easily grown in the laboratory when innoculated onto pollen or onto yeast-dextrose or tomato-juice agar, but lost its color when transferred to tryptic soy broth. Positive cultures were also obtained from pollen, from cell-wall scrapings and from the internal body fluid of a dead, blackish alkali bee prepupa. The organism was not always visible in these cases.

Certain physogastric *Trochometridium* either ingest enough *Serratia* to turn them pink or the organism multiplies in the mite. The former is probably correct, since one female contained a dense red mass of the organism in addition to exhibiting a suffuse pink color. The body fluid of another female was noted to change from yellowish to pink overnight. In the same culture, some but not all eggs and quiescent forms had a pink tinge. We were unable to ascertain whether the *Serratia* in this case were external or internal.

*Development of the Female*. In the laboratory, female *Trochometridium* destined to become fully physogastric showed slight swelling after 24 hours, and reached the "light bulb" stage (400-600  $\mu$  in diameter) in 4-6 days. Full enlargement (1000-1300  $\mu$  in diameter) occurred 8-11 days after inoculation.

Mites becoming only partially swollen most often reached their maximum size (225-750  $\mu$ ) about the 6th day after introduction, after which there was little or no increase in size.

*Oviposition*. In the manner of most pyemotids and scutacarids, insemination of *Trochometridium* females occurs at or proximate to the moment of birth (Cross, 1965). Mated females then usually pass through a season of barrenness, followed by a time of dispersal and location in a suitable niche. Niche location is usually followed by the onset of physogastry and reproduction. A list of the most obvious releaser stimuli of possible importance in initiating physogastry includes : food, unknown chemicals, time, chilling, and phoretic association with an adult insect. Oviposition begins when the mites attain a size of about 1 000  $\mu$  and, in our laboratory, continued until shortly before death. Two females studied produced heavily (about 50 eggs) the first 5 days of the oviposition period. The largest clutch for a single day was also about 50, laid on the 16th ovipositional day, after which the same female laid only a few more eggs before she died. One laboratory-reared female laid a total of 117 eggs over a period of 19 days ( $X =$

\* Det. O. THAMES, Dept. of Microbiology, Northwestern State University. Natchitoches, La.

6.2/day). This female died on the 25th ovipositional day. Another female, found only after oviposition had begun, laid a total of 180 eggs (the last 85 in the lab in 11 days). Under natural conditions, the total number of eggs per female may be higher than this. CROSS (1965) reported a single cell to contain 260 eggs, all presumably laid by only one of two gravid females inhabiting the cell. SHINN (1967) found "several hundred females in... two cells taken together." On August 3, 1965, we found a cell of the wasp *Motes argentata* (Pal.-Beauv.) nesting in the Preston alkali bee site to contain a cluster of 2255 young females (Fig. 7). Presumably, these latter were daughters of several mothers. Gravid females and/or clusters of young females occurred in cells of *Motes*, *H. farinosus*, *N. melanderi*, *C. andreniformis* in Utah, Idaho, and Kansas primarily in late July and early August (7/8/65, 7/27/65, 8/11/66, "late July and early August," 7/27/57, 8/3/65).

*Color.* It is normal for physogastric females to change from an opaque dirty white to a translucent yellow as they age. Oviposition was seen to occur only in translucent females, and eggs could often be clearly seen within these females.

Generation time for two laboratory-reared cultures was 16 and 25 days. In both cases, the first mite of the second generation to appear was a male but SHINN (1967) reported that 12 females were born in his cultures before the first male, who appeared about 48 hours later.

#### ACKNOWLEDGEMENTS

We wish to thank the following persons for assistance : Dr. Sandor MAHUNKA, National Museum, Budapest, allowed us to view the type of *T. chinensis*. Mr. William HALL, The University of Alabama, drew and inked the plate of this species. Mr. William P. NYE, Utah State University, took the photographs.

#### LITERATURE CITED

- BATRA (L.), BATRA (S. W. T.) and BOHART (G. E.), 1973. — The mycoflora of domesticated and wild bees (Apoidea). — Mycopathol. Mycol. Appl., **49** : 13-44.
- CROSS (E. A.), 1965. — The generic relationships of the Family Pyemotidae (Acarina : Trombidiformes). — Univ. Kansas Sci. Bull., **45** : 29-275.
- CROSS (E. A.) and BOHART (G. E.), 1969. — Phoretic behavior of four species of alkali bee mites as influenced by season and host sex. — J. Kansas Ent. Soc., **42** : 195-219.
- MAHUNKA (S.), 1966. — Zwei Neue Arten aus der Gruppe Tarsonemini aus China (Acari). — Vestn. Cs. Spol. Zool., **30** : 315-318.
- SHINN (A. F.), 1967. — A revision of the bee Genus *Calliopsis* and the biology and ecology of *Č. andre-niformis* (Hymenoptera, Andrenidae). — Univ. Kansas Sci. Bull., **46** : 753-936.

*Paru en Mars 1979.*

---