THE FEEDING BEHAVIOR AND BIOLOGY OF *PARAPRONEMATUS ACACIAE* (ACARINA: TYDEIDAE)[1]

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Abstract

Although the tydeid mite, *Parapronematus acaciae* Baker, was previously reported as being a predator of the citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), laboratory studies proved it was not a predator of *P. oleivora*, the citrus red mite, *Panonychus citri* (McGregor), or the Texas citrus mite, *Eutetranychus banksi* (McGregor). However, four complete generations of *P. acaciae* were reared on *Penicillium digitatum* Sacc. and *Colletotrichum gloeosporioides* Penzig, two common leaf-inhabiting fungi. One generation from egg to adult took approximately 15-18 days at a temperature of 25±2°C. Larvae fed readily on the fungi, as did what appeared to be the two nymphal stages. Prospects for the biological control of the citrus rust mite are also discussed.

The citrus rust mite, *Phyllocoptruta oleivora* (Ashmead), is considered the major phytophagous mite injurious to citrus in Florida. By comparison, the natural enemies attacking the rust mite are considerably fewer in number and appear less effective than those attacking other phytophagous mites. Except for *Hirsutella thompsonii* Fisher, an entomogenous fungus reported as being the major factor in the natural control of populations of the rust mite (Muma 1955, 1958), only the neuropteran, *Coniopteryx vicina* Hagen, the Cecidonyiini, *Delphastus pallidus* (LeConte), and a few predatory mites are listed as natural enemies of the rust mite (Muma et al. 1961).

Of the predaceous mites reportedly attacking the citrus rust mite, a tydeid recently described by Baker (1965) as *Parapronematus acaciae* (previously referred to as *Pronematus* sp.) has been mentioned as a predator exhibiting an affinity for the rust mite (Muma et al. 1961, Muma 1965). However, this host-predator relationship was not based on observed feeding, but rather on a comparison of population densities in the field. The following studies were therefore conducted to evaluate more critically this presumed host-predator relationship as a prerequisite to subsequent introductions of predators for the biological control of the citrus rust mite.

Laboratory Studies

Feeding Responses to Various Candidate Mite Prey Species: Because of their prevalence when *P. acaciae* is present in the field, the citrus rust mite, *P. oleivora*, the citrus red mite, *Panonychus citri* (McGregor), and the Texas citrus mite, *Eutetranychus banksi* (McGregor), were exposed to *P. acaciae* in the laboratory to determine the predatory nature of *acaciae*.

Groups of 5 healthy female *P. acaciae* collected in the field and starved

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for approximately 48 hours were placed in each of 5 rearing units similar to those described by McMurtry and Scriven (1965). Each unit contained a 3.8 cm^2 substrate of blackened cardboard that, in turn, was bordered by a water-saturated Cellucotton strip-type barrier. A water interface between the cardboard and Cellucotton was essential to prevent the mites from escaping. In tests with *P. citri* and *E. banksi*, 10 adult mites were added to each of 3 units and 2 units devoid of host mites served as a check. In the tests with *P. oleivora*, 20 adult mites were exposed to attack. If the host mites inadvertently escaped or died of natural causes, new host material was added accordingly. Each test was discontinued upon death of all candidate predators. Temperature was maintained at 25±2°C and a relative humidity at 60±10% throughout the test.

TABLE 1.—MEAN LONGEVITY, TOTAL EGG PRODUCTION AND PERCENTAGE PREY CONSUMPTION BY *Parapronematus acaciae* IN THE PRESENCE AND ABSENCE OF ASSUMED HOSTS*.

Host	Material	Mean longevity (days)	Total egg production	Percent prey consumption
P. oleivora	Present	8.4	5	0
	Absent	7.8	16	0
P. citri	Present	5.9	3	0
	Absent	6.5	3	0
E. banksi	Present	5.3	0	0
	Absent	6.0	0	0

*Results based on 3 replications or a total of 15 adult female *P. acaciae*.

Mean adult longevity, total egg production, and the percentage consumption of prey by *P. acaciae* in the presence and absence of host materials were recorded daily and are presented in Table 1.

For all candidate prey species, *P. acaciae* failed to attack and consume any of the available adults; in fact, it actively avoided the larger spider mites. Generally speaking, the qualitative features such as rate of search, hunger, and attack cycle that give a distinctive character to predation (Holling 1966) appeared to be absent.

No noticeable differences in mean adult longevity and total egg production were obtained either in the presence or absence of host material. However, egg production by *P. acaciae* was sometimes high when food was entirely absent; apparently, frequent feeding is not essential to optimum production.

Since the possibility existed that *P. acaciae* might react atypically on an artificial substrate, we used detached, detritus-free citrus leaves as a substrate in a second series of unreplicated tests, and both rust mite eggs and adults were offered as prey. Other conditions remained the same.

Predation was not observed on eggs or adult rust mites. Furthermore, no apparent difference occurred in mean longevity or egg production due to the presence or absence of the possible hosts. However, after 6-8 days, a fungus, subsequently identified as *Penicillium digitatum* Sacc., was observed growing on the surface of a detached leaf and further observation revealed that *P. acaciae* was apparently feeding on the conidia ascending from this branched mycelial growth.

FEEDING RESPONSES TO TWO SPECIES OF FUNGI: To rule out the possibility of fortuitous feeding and to determine the reproductive potential and the survival and developmental rates of *P. acaciae* on the leaf fungus, we placed detached citrus leaves harboring sparse patches of fungus and void of mites in the rearing units; also, instant mashed potato (R. T. French Company, Rochester, N.Y.) was sometimes added to the leaf surface to facilitate fungal growth. Then 16 female and 6 male adult *P. acaciae* collected in the field were placed on a selected leaf that supported an excellent growth of *P. digitatum* and *Colletotrichum gloeosporioides* Penzig, a lesion fungus of citrus. Observations were made daily for 43 days, at which time leaf decay became too extensive to allow further study.

Almost immediately after exposure, adult *P. acaciae* began feeding on the fungi (Fig. 1). However, as fungal development increased, the adult

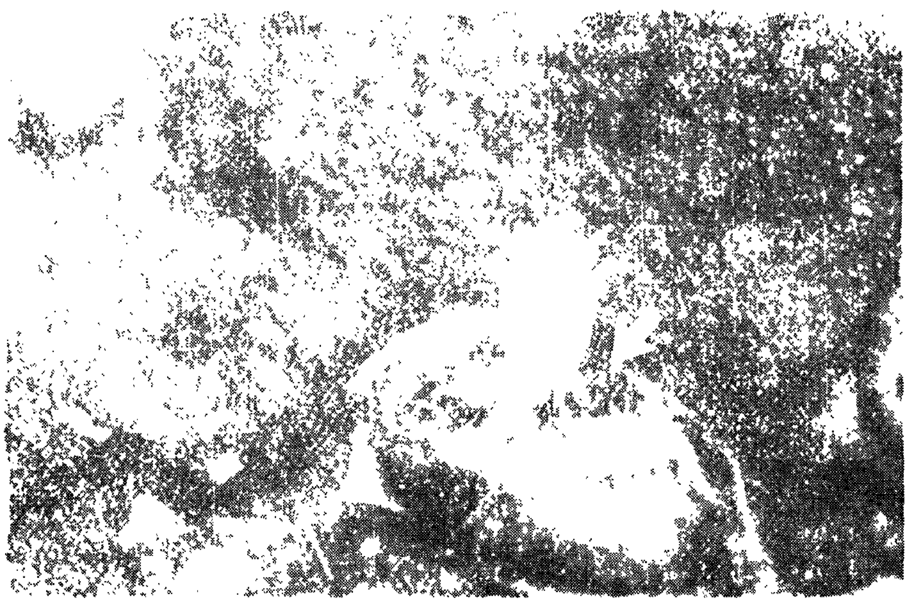

Fig. 1. An adult of *Parapronematus acaciae* feeding on the lesion fungus, *Colletotrichum gloeosporioides*. The darkened area (arrow) represents a fungus-free area resulting from previous mite feeding.

mites become more selective and fed more frequently on *C. gloeosporioides* and less on *P. digitatum*.

While they were feeding on the yellowish lesion fungus, the mites acquired an amber coloration that was not confined to the intestinal tract but dispersed virtually throughout the body cavity. Subsequent feeding studies in which an unidentified fungus was used that produced green conidia likewise produced a green coloration in the mites.

Two complete generations were reared on a single leaf infested with fungus; 3rd and 4th generations were continued by transferring F_2 adults to a new leaf. One generation from egg to adult took approximately 15-18 days at a temperature of 25±2°C.

TABLE 2.—A COMPARISON OF POPULATION DENSITIES OF *Paraprонematus acaciae*, AND THE CITRUS RUST MITE, *Phyllocoptruta oleivora*, ON TREES TREATED AND UNTREATED WITH UC-21149.

Sampling dates	Treatment*					
	A		B		Check	
	P. oleivora	*P. acaciae*	*P. oleivora*	*P. acaciae*	*P. oleivora*	*P. acaciae*
4/22/67	8	28	0	44	128	24
5/18	0	84	0	116	1,901	64
6/13	0	56	0	72	4,044	80
6/27	0	108	0	96	10,490	60
7/25	0	224	8	176	4,568	64
8/23	4	20	4	20	128	16
Total	12**	520†	12**	524†	21,259	308

*Treatments A and B represent nearly rust mite-free plots resulting from the application of UC-21149 10% G, 1 oz., and UC-21149 10% G, 2 oz. per in. trunk diameter, respectively. Each treatment based on four replications of two trees each, or 200 leaves per treatment.

**These population totals are significantly different from the check at the 1% level of confidence.

†These population totals are not significantly different from the check at the 1% level of confidence.

Two weeks after introduction of the mites, 86 eggs were counted on 1 leaf. The number of eggs laid per female per day was not recorded but it appeared to average about 1.4 per day. Eggs were usually laid at random, though they were occasionally found in groups of 3 or 4 along the midrib of the leaf or surrounding a tuft of fungus. Periodically, females were observed moving about the leaf carrying partially laid eggs.

After 3-5 days, the eggs of *P. acaciae* hatched into active larvae that were frequently observed feeding on the different leaf fungi, as did what appeared to be two nymphal stages.

FEEDING RESPONSES TO CITRUS POLLEN AND VARIOUS LEAF INHABITANTS:

Since *P. acaciae* appeared to have a nonpredatory nature, a more critical evaluation of its feeding habits with respect to food specificity was performed by exposing a given number of the adult mites to citrus pollen and other leaf inhabitants such as aleyrodid exuviae, *Aschersonia* (fungus) colonies, and dead armored scale. A number of detritus-free citrus leaves, each confied to a standard rearing unit, were used for these studies. Of the potential food sources, only pollen was supplied separately. Frequent observations were made daily for 3-4 days to determine actual feeding.

P. acaciae failed to feed on the various food sources though they examined all the materials occasionally. Presumably, the growth produced by more common leaf fungi, such as *C. gloeosporioides,* is a preferred food source.

FIELD STUDIES

POPULATION DENSITY IN THE PRESENCE AND ABSENCE OF RUST MITES IN THE FIELD: Under field conditions where the systemic action of UC-21149 (2-methyl-2-(methylthio)propionaldehyde *O*-(methylcarbamoyl)oxime) was being evaluated as a potential control agent for the citrus rust mite and spider mites, supplemental information was obtained about various predators including *P. acaciae.* Fifty leaves were randomly selected from each of 4 replications (2 trees/replicate) each month, and an estimate of the population density of each prevalent species was obtained by counting the number of mites obtained per leaf using a mite brushing machine (Henderson and McBurnie 1943).

As shown in Table 2, populations of *P. oleivora* were significantly reduced in the plots treated with UC-21149 from April through August, approximately 20 weeks after treatment; in the checks populations reached high number by late June. On the other hand, populations of *P. acaciae* failed to decline with the decrease in the populations of rust mites, and no significant difference was found in these populations in the treated and check plots. Thus, the theoretical model of host-parasite interaction generally referred to as the law of the periodic cycle proposed by Lotka-Volterra and Nicholson-Bailey for coexisting animal species did not function (Huffaker and Messenger 1964).

DISCUSSION AND CONCLUSIONS

Generally speaking, the genera of the family Tydeidae, of which *P. acaciae* is a member, are worldwide in distribution and appear quite diversified in their feeding habits; however, little is known about their biology. According to Baker and Wharton (1952) they appear to be predaceous on small insects and mites, and most species are found in moss and lichens or on plant leaves in association with other mite colonies. Likewise, until the present, *P. acaciae* has been suspected as being a predator of the citrus rust mite. However, the results of the present studies show conclusively that *P. acaciae* is an herbivore and possibly a scavenger rather than a predator. Although *P. acaciae* fed only on viable leaf fungi in the laboratory, it is possible that a scavenger-like, rather than a strictly herbivorous feeding habit, may exist under field conditions where succulent fungal growth might be absent periodically. Scavengers within the family Tydeidae have been reported on citrus. Muma (1961, 1965) found 6-8 species designated as *Tydeus* sp. active on various species of citrus.

Tydeus Californicus (Banks), commonly found on the underside of citrus and avocado leaves, was reported as being a predator of the citrus bud mite, *Aceria sheldoni* (Ewing), by Baker and Wharton (1952). Fleschner and Arakawa (1953) in California and Baker (1965) in the Delta region in Egypt reported that it was a plant feeder, but Fleschner and Arakawa observed no characteristic leaf injury. In addition, Baker (1965) reported that Smirnoff had observed *Lorryia formosa* Cooreman damaging citrus in Morocco. However, it is unlikely that *P. acaciae* feeds on citrus since no such feeding was observed in the laboratory. Also, feeding on the plants treated with UC-21149 would have presumably resulted in significant mortality in the treated plots.

The exclusion of *P. acaciae* from the recorded list of predators of *P. oleivora* decreases the few natural enemies of this major pest of citrus in Florida. Furthermore, recent biological studies on the neuropterous predator, *Coniopteryx vicina* Hagen, by Muma (1967) showed conclusively that *C. vicina* feeds and reproduces more readily on diets that include either whitefly eggs and nymphal crawlers of the 6-spotted mite, *Eotetranychus sexmaculatus* (Riley); for all practical purposes it is strictly a secondary feeder on the citrus rust mite. Thus the known complex of natural control agents is of minor importance in the control of the citrus rust mite in Florida and apparently native specific enemies of *P. oleivora* are totally absent with the possible exceptions of *Hirsutella thompsonii* and the predaceous mite, *Agistemus floridanus* Gonzalez.

The hypothesis, however, that *P. oleivora* is an introduced species in the Western Hemisphere is of great significance to biological control. Effective exotic natural enemies may occur in the Eastern Hemisphere, and, more specifically, in southeastern Asia, the original habitat of the citrus rust mite (Yothers and Mason 1930). The introduction into Florida of one or more specific natural enemies of *P. oleivora* native to the Eastern Hemisphere could prove to be of importance in the successful biological control of the citrus rust mite.

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