Compatibility of *Leptothrips mali*[1] with *Stethorus punctum*[2] and *Orius insidiosus*[3]: Predators of *Panonychus ulmi*[4]

M. P. PARRELLA, J. P. McCAFFREY AND R. L. HORSBURGH

Department of Entomology, Shenandoah Valley Research Station, Virginia Polytechnic Institute and State University, Steeles Tavern, Virginia 24476

ABSTRACT

Environ. Entomol. 9: 694–696 (1980)

The individual or joint potential impact of *Leptothrips mali* (Fitch) with *Stethorus punctum* LeConte or *Orius insidiosus* (Say) on the European red mite (*Panonychus ulmi* (Koch)) was evaluated in the laboratory. At a mite density of 45/arena, *L. mali* with *S. punctum* killed significantly more *P. ulmi* than *L. mali* or *S. punctum* alone. No difference was observed in total mites killed when the combination of *L. mali* or *O. insidiosus* was compared with individual *L. mali* and *O. insidiosus*. In 75% of replicates where *L. mali* was combined with *O. insidiosus*, the latter killed and consumed the thrips.

The European red mite, *Panonychus ulmi* (Koch) is a perennial pest of apple trees in Virginia (Cagle 1946). A preliminary survey of the predaceous fauna associated with this mite in central Virginia apple orchards (Parrella et al. 1978) revealed that the most abundant predator was *Leptothrips mali* (Fitch) and that other predators, particularly *Stethorus punctum* LeConte and *Orius insidiosus* (Say), were present in large numbers. All these predators were commonly found on the same mite infested apple tree. Before a control program for *P. ulmi* could be developed utilizing *L. mali* as the major predator supplemented with *S. punctum* and *O. insidiosus*, it was necessary to determine if these predators were compatible. Laboratory studies were designed to investigate the control potential of combinations of *L. mali* and these two predators for biological control of *P. ulmi*.

Materials and Methods

Interaction arenas (Fig. 1) were prepared by placing 3 apple leaves (ca. area of 50 cm^2 each) adaxial side down on a 0.5 cm layer of water-saturated cotton in plastic petri dishes (15 cm d × 2 cm deep). Each leaf was carefully cleaned with damp cheesecloth before placement on the cotton. The leaves were arranged so that they overlapped and formed a circle. An apple leaf was cut into 1 × 3 cm sections and glued (Elmer's Glue-all®) on the points of overlap to provide a bridge between leaves. Stickem® was applied to the inner and outer perimeter of the leaves with a fine artist's brush to keep predators and mites on the leaves. The area available to the mites and predators remained constant between replicates and treatments. A small section of apple leaf was placed in the center of each leaf and held with a minuten pin. This served as refuge for the predators. Adult female *P. ulmi* were transferred to the leaves at the rates of 15 and 45/arena with replicates including *L. mali* and *S. punctum* and 45 and 90/arena with *L. mali* and *O. insidiosus*. Mites were allowed to acclimate for 2 h before predators were added. *L. mali* were reared in the laboratory on all stages of the European red mite (Parrella and Horsburgh 1978) and *S. punctum* and *O. insidiosus* were collected in apple orchards infested with high populations of *P. ulmi*. The field collected predators were provided with a diet of *P. ulmi* for at least 8 h in the laboratory before each test. Four day old 2nd instars of *L. mali*, 3rd and 4th instars of *S. punctum* and 5th instars of *O. insidiosus* were used. Predator combinations (predator ratio 1:1) were made by transferring one *L. mali* and either one *S. punctum* or *O. insidiosus* to opposite leaves in the arena. The *L. mali-S. punctum* and *L. mali-O. insidiosus* combinations were replicated 6 and 4 times, respectively, at the 2 mite densities. Controls were established with mites only (predator ratio 0:0) and with each predator alone (predator ratios 0:1, 1:0). Controls were replicated 5 and 4 times for the *L. mali-S. punctum* and *L. mali-O. insidiosus* combinations respectively, at the 2 mite densities.

Before the predators were added, a microscopic examination of the leaves was made for mites caught in the Stickem. The trapped mites were removed and new mites added to the arena.

Observations, made 24 h after predators were introduced into the arenas, included the number of mites killed, those caught in the Stickem and the condition of the predators. The mites oviposited during the test; uneaten mite eggs were also counted after 24 h. The petri dishes were kept in a Sherer-Gillette® environmental chamber at 23.9 ± 1°C, RH between 80–100%, and a 14 h photoperiod.

Statistical Analysis

Analysis of variance and the Student-Newman-Kuels Test were used to determine significant differences between treatments for the mean number of mites killed and uneaten mite eggs present. The F max test (Sokal and Rohlf 1969) was employed to determine homogeneity among the variances. Only the mite egg data from the *L. mali-S. punctum* interaction at the initial mite density of 15/arena required a transformation (Log (X + 1)) before analysis.

Results

No significant differences ($P > .05$) were detected in the number of mites killed between the combination of *L. mali* and *S. punctum* (1:1) and each predator individually (1:0, 0:1) at a density of 15 mites/arena (Table 1).

[1] Thysanoptera: Phlaeothripidae. Received for publication February 1, 1980.
[2] Coleoptera: Coccinellidae.
[3] Hemiptera: Anthocoridae.
[4] Acarina: Tetranychidae.

0046-225X/80/0506-9403$00.75/0

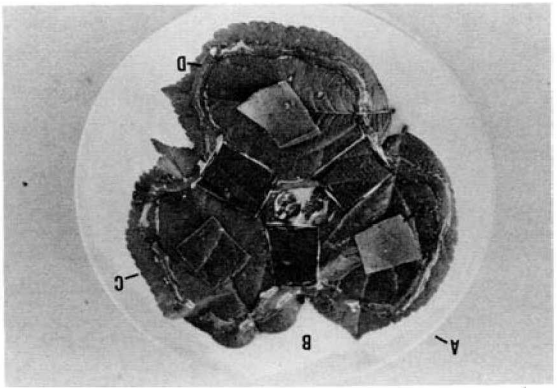

FIG. 1.—Interaction arena: A—plastic petri dish, B—water saturated cotton, C—apple leaves, D—Stickem barrier, E—leaf section fastened with a minuten.

All petri dishes with predators (1:1, 1:0, 0:1) had significantly more ($P < .05$) mites killed than the control (0:0). The number of mite eggs did not differ significantly ($P > .05$) between the combination of predators (1:1) versus *L. mali* alone (1:0) but differed significantly ($P < .05$) when compared to *S. punctum* alone (0:1). The control (0:0) had significantly more ($P < .05$) eggs than all arenas with predators (1:1, 1:0, 0:1); the number of mite eggs in arenas with solitary predators (1:0, 0:1) did not differ significantly ($P > .05$).

At the higher mite density of 45/arena (Table 1), the number of mites killed by the predator combination (1:1) was significantly greater than *L. mali* (1:0) and *S. punctum* (0:1) alone ($P < .05$ and $P < .10$, respectively). There was no difference ($P > .05$) in the number of mites killed between individual predators (1:0, 0:1) and all arenas with predators (1:1, 1:0, 0:1) differed significantly ($P < .05$) from the control. Arenas with individual predators (1:0, 0:1) and the control (0:0) had significantly more ($P < .05$) eggs present after 24 h than arenas with the predator combination (1:1). No adverse effects on the condition of the predators were observed after 24 h in replicates of *L. mali* and *S. punctum* individually (1:0, 0:1) or combined (1:1). Competition between *L. mali* and *S. punctum* may have occurred; the total number of mites killed by the individual predators exceeded that killed by the predators combined.

Table 1.—Effects of Predation of *L. mali* and *S. punctum* Individually and in Combination on *P. ulmi* in Leaf Arenas.

Initial Mite Density	Ratio of *L. mali*: *S. punctum*[a]	$\bar{X}$ No.[b] Mites Killed	$\bar{X}$ No.[b] Uneaten Mite Eggs
15/arena	(1:1)	14.1 a	0.3 c
	(1:0)	11.0 a	2.1 bc
	(0:1)	13.0 a	3.1 b
	(0.0)	2.3 b	18.5 a
45/arena	(1:1)	34.5 a	13.8 b
	(1:0)	21.1 b	36.3 a
	(0:1)	23.8 ab	51.3 a
	(0:0)	6.8 c	45.2 a

[a] 1:1 replicated 6 times; 1:0, 0:0, 0:0 replicated 5 times.
[b] Recorded after 24 h; means within each initial mite density in the same column followed by the same letter are not significantly different ($P > .05$), Student-Newman-Kuels Test. At initial mite density of 45/arena, 1:1 and 0:1 differ significantly ($P < .10$) in the no. of mites killed.

Table 2.—Effects of Predation of *L. mali* and *O. insidiosus* Individually and in Combination on *P. ulmi* in Leaf Arenas.

Initial Mite Density	Ratio of *L. mali*: *O. insidiosus*[a]	$\bar{X}$ No.[b] Mites Killed	$\bar{X}$ No.[b] Uneaten Mite Eggs
45/arena	(1:1)	25.3 a	31.5 a
	(1:0)	19.0 a	40.0 a
	(0:1)	18.3 a	42.8 a
	(0:0)	6.0 b	45.8 a
90/arena	(1:1)	44.8 a	27.0 a
	(1:0)	30.5 a	45.3 a
	(0:1)	39.3 a	50.8 a
	(0:0)	14.8 b	75.3 a

[a] Each combination replicated 4 times.
[b] Recorded after 24 h; means within each initial mite density in the same column followed by the same letter are not significantly different ($P > .05$), Student-Newman-Kuels Test.

The only significant differences ($P < .05$) in the number of mites killed with the *L. mali-O. insidiosus* interactions (Table 2) were between arenas with predators (1:1, 1:0, 0:1) and the control (0:0) at both initial mite densities. In 75% of the replicates where *L. mali* and *O. insidiosus* were combined (1:1) at both mite densities, *L. mali* was killed and fed upon by *O. insidiosus* (Fig. 2). Fewer mite eggs were present in treatments with predators (1:1, 1:0, 0:1) compared to controls; differences were not significant ($P > .05$).

After 24 h, mites caught in the Stickem ranged from 0 to 8% of the total/arena; most of the arenas had no trapped mites. Mites avoided direct contact with the Stickem; those found trapped in the barrier became entangled due to the initial excitement caused by transferring them to the arena or by movement in response to the predators.

Discussion

The interaction studies with *L. mali* and *S. punctum* show that at the higher initial mite density (45) the combination of these predators kill more *P. ulmi* than individual *L. mali* or *S. punctum*. At the lower mite density (15/arena), there was no difference because the individual predators consumed most all the mites in the arena;

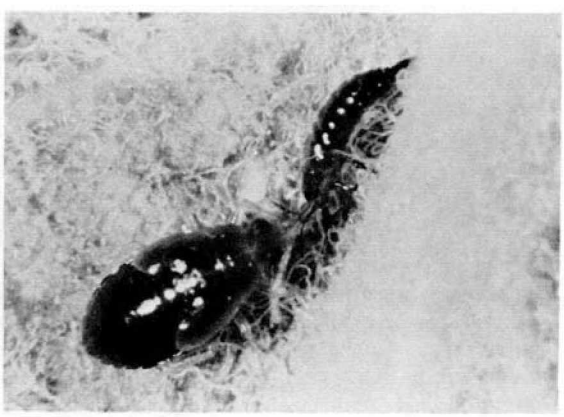

FIG. 2.—*O. insidiosus* (5th instar) feeding on *L. mali* (2nd instar).

73 and 86% of the mites were killed with *L. mali* and *S. punctum* alone, respectively, and 93% with the combination. With 45 mites/arena the maximum consumption rate of *L. mali* was almost reached (Parrella, unpublished data) and therefore the added predation by *S. punctum* caused significantly more mite mortality; 46 and 52% of the mites were killed with individual *L. mali* and *S. punctum*, respectively, and 76% for the combination. The feeding rates determined for *S. punctum* are less than have been reported previously (Colburn and Asquith 1971; Hull et al. 1977a), and may be related to the temperature (23.9°C) and larger feeding arenas used in this study and the leaf section placed in the center of each leaf. The latter not only provided an area for predators to hide but also for mites thus allowing them to avoid contact and possibly being eaten by predators. *L. mali* and *S. punctum* had similar feeding rates at each mite density. The photoperiod selected in this study (14/10) may also have affected feeding rates of the predators. *L. mali* and *O. insidiosus* feed on mites in total darkness, but feeding rates are reduced (Parrella and McCaffrey, unpublished data); *S. punctum* (Hull et al. 1977a) does not feed in the absence of light.

There were fewer mite eggs in the arena with *L. mali* alone than with the solitary *S. punctum*, even though there were fewer mites alive after 24 h in the latter. This may indicate a feeding preference for the egg stage by the thrips.

The interaction studies between *L. mali* and *O. insidiosus* indicated that these two predators were not compatible; in 75% of the replicates *Orius* killed and fed on *Leptothrips*. This was expected since members of the genus *Orius* (Wolff) are natural enemies of the Thysanoptera (Lewis 1973). However, despite *Orius* feeding on *Leptothrips*, there were more mites killed where these predators were combined than when they were tested individually (differences were not significant). Observations indicated that the first encounter between these predators would usually evoke an attack by *Orius*, but the first attack usually did not produce a successful capture. The success of the attack was dependent on whether the approach was from the front, side or rear of the thrips. *L. mali* produces a drop of liquid from its anal area which is forced onto an attacker with whip-like motions of its abdomen. Contact with this liquid (usually around the head), causes *Orius* to cease attack and begin cleaning itself. Due to this defense mechanism an attack from the rear of *L. mali* was rarely successful. In the interaction arena these predators were closely confined together and repeated *Leptothrips-Orius* confrontations occurred with *Orius* eventually feeding on *Leptothrips*. In a field situation the predator-predator contact might stimulate movement to other leaves which would reduce thrips mortality and possibly promote more efficient control at low prey densities (McMurtry et al. 1970). Also, the presence of other favorable prey for *Orius* might affect the frequency of *Orius* feeding on *Leptothrips* in the field.

The data presented in this study are only suggestive of what could happen in the apple orchard. Prey were not replenished as the experiment progressed and thus the predators decreased the food supply and had to spend more time searching. In the field, a predator upon consuming prey in one particular area can move to another area with new prey and begin feeding again (Hull et al. 1977a).

Research with *S. punctum* (Hull et al. 1977b) demonstrated that this predator responds to mite infested leaves and began ovipositing when mite populations ranged from 1 to 2/leaf. Knowledge of the response of *L. mali* and *O. insidiosus* to mite densities, information on how all these predators segregate the apple tree into their respective niches and further studies on the defensive and avoidance behavior exhibited by *L. mali* towards *O. insidiosus* would aid our understanding of the complex interspecific interactions of these predators and the consequences of such interactions as it relates to *P. ulmi*.

REFERENCES CITED

Cagle, L. R. 1946. Life history of the European red mite. Va. Agric. Expt. Sta. Tech. Bull. 87. 19 pp.

Colburn, R. and D. Asquith. 1971. Observations on the morphology and biology of the ladybird beetle, *Stethorus punctum*. Ann. Entomol. Soc. Am. 64: 1217–21.

Hull, L. A., D. Asquith and P. D. Mowery. 1977a. The functional responses of *Stethorus punctum* to densities of the European red mite. Environ. Entomol. 6: 85–90.

1977b. The mite searching ability of *Stethorus punctum* within an apple orchard. Ibid. 6: 684–8.

Lewis, T. 1973. Thrips. Their biology, ecology and economic importance. Academic Press, London and New York. 349 pp.

McMurtry, J. A., C. B. Huffaker and M. van de Vrie. 1970. Ecology of tetranychid mites and their natural enemies: a review. I. Tetranychid enemies; their biological characters and the impact of spray practices. Hilgardia 40: 331–90.

Parrella, M. P. and R. L. Horsburgh. 1978. Laboratory rearing of *Leptothrips mali*. J. N. Y. Entomol. Soc. 86 312–13 (Abstract).

Parrella, M. P., J. P. McCaffrey and R. L. Horsburgh. 1978. Population dynamics of some predators and their prey in Virginia apple orchards. Va. J. Sci. 29: 44 (Abstract).

Sokal, R. R. and F. J. Rohlf. 1969. Biometry. The principles and practice of statistics in biological research. W. H. Freeman and Co., San Francisco. 776 pp.