Control of the Straw Itch Mite (Acari: Pyemotidae) with Sulfur in an Insect Rearing Facility

LAWRENCE M. HANKS, JAMES S. McCELFRESH, JOCELYN G. MILLAR, AND TIMOTHY D. PAINE

Department of Entomology, University of California, Riverside, California 92521

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ABSTRACT The ectoparasitic mite *Pyemotes tritici* (Lagrèze-Fossat & Montané) (Acari: Pyemotidae) caused paralysis and reduced longevity in eucalyptus longhorned borer, *Phoracantha semipunctata* F., under laboratory rearing conditions. Application of dusting sulfur to logs that contained pupating borers greatly reduced densities of mites on emerging adult beetles and increased beetle survivorship. Uniform application to all logs in a glasshouse effectively eradicated the mite infestation. A bioassay showed that sulfur may physically impede the dispersal of immature mites by adhering to the cuticle, but sulfur vapor did not act as a toxin.

KEY WORDS Acari, *Pyemotes tritici*, sulfur, *Phoracantha semipunctata*

THE MITE *Pyemotes tritici* (Lagrèze-Fossat & Montané) is a common insect parasite of nearly cosmopolitan distribution (Moser 1975). This species also causes severe dermatitis in man, which has earned it the common name straw itch mite (Moser 1975). The biology of this species was reviewed by Moser (1975), Bruce & LeCato (1980), Bruce (1983), and Bruce & Wrensch (1990). This mite is capable of extremely rapid population increase because the developmental cycle requires <1 wk and the ovoviviparous females produce as many as 350 offspring. More than 90% of the progeny are females, which are sexually mature at birth. The young mites seek new hosts and pierce the host integument with their chelicerae to feed on the hemolymph. Injection of a toxin during feeding causes rapid paralysis of the host (Tomalski et al. 1988).

More than 100 species are known hosts of *P. tritici*. These are primarily Coleoptera, Hymenoptera, and Lepidoptera, but also include Homoptera, Strepsiptera, and Diptera (Cross et al. 1975, Bruce & LeCato 1980, Bruce & Wrensch 1990). The wide host range and high reproductive potential of this mite may make it useful as a biological control agent (Bruce & LeCato 1980, Bruce 1983), although it apparently cannot survive on some insect species (Drummond & Casagrande 1989).

P. tritici is often a pest in insect rearing facilities (Butler 1972, Kuhne 1981; references in Cross et al. 1975). Helal & El-Sebay (1980) report that another mite in this genus, *P. herfsi* Ondenmans, attacked all life stages of the eucalyptus longhorned borer, *Phoracantha semipunctata* F., in a laboratory situation. *P. tritici* appeared in our laboratory colony of *P. semipunctata* and soon developed high population densities. This beetle is a pest of Eucalyptus and has recently colonized California (Hanks et al. 1990).

Several acaricides have been employed to control pyemotid species (e.g., Muttrie & Anderson 1984, Dinabandhoo & Dogra 1980). Sulfur, the earliest acaricide (Watterson 1988), has been used in the control of mites and is specific against mites (Jeppson et al. 1975), but has been considered ineffective against pyemotids (Jeppson et al. 1975, Muttrie & Anderson 1984). We tested the potential of sulfur as a control agent against *P. tritici* in a rearing colony of *P. semipunctata*.

Materials and Methods

P. semipunctata larvae feed in the cambium of dead or dying Eucalyptus and when mature, tunnel into the sapwood to construct a pupal cell, packing the opening to the surface with frass and wood chips. From August to October 1990, *Eucalyptus* logs that contained prepupal late stage larvae and pupating *P. semipunctata* were cut into ≈1 m lengths and placed in nine cages (1.3 m high, 0.65 m deep, and 0.55 m wide) covered with nylon screen (not fine enough to prevent passage of mites). These cages, completely filled with logs, were kept in a glasshouse at 30 ± 5°C and were separated by <1 m. The humidity in the glasshouse was not controlled and had a mean of ≈40% RH. Adult beetles emerged from the logs at night, and cages were examined every morning for beetles. Beetles were removed and placed into screen cages in the laboratory and provided with 5% sucrose solution. In early April 1990, the beetles appeared sluggish and died

shortly after emergence. Examination of the dead beetles revealed that they were infested with *P. tritici*, particularly under the elytra. Great numbers of mites were observed moving throughout the cages.

On 8 April 1990 the logs in seven cages were liberally dusted (≈20 ml per cage) with sulfur (FMC Corp., Philadelphia, Pa.). Two cages that were interspersed with the sulfured cages were left untreated as controls. We evaluated the abundance of mites on beetles in the sulfur and control treatments on 1 May 1990 (3 wk after the initial sulfur application), and again on 10 May 1990. To determine if we could completely eradicate the mite from the rearing facility, sulfur was applied to all cages including the two control cages on 11 and 12 May 1990. We determined the abundance of mites on beetles on 15, 16, and 20 May 1990.

To estimate the densities of mites on individual beetles, adult beetles that had emerged during the night were collected and frozen, the elytra were then removed, and the whole insect was placed in a beaker with 5 ml of 75% ethanol. The beaker was sonicated (Branson Ultrasonics Corp., Danbury, Conn.) for 1 min. This procedure effectively dislodged mites from the host, even inside the spiracles. The ethanol was then poured into a petri dish and the mites were counted under a dissecting microscope to determine the mite density per host individual.

Beetles that were infested by only a few mites were usually paralysed or appeared conspicuously sluggish at the time they were collected from the cages. We compared the treatments by determining survivorship of beetles (proportion surviving for a minimum of 1 wk after collection from cage) over 1-wk periods beginning 16 April (which was 8 d, or ≈1 mite generation after the first application of sulfur to the treated cages). We continued to collect beetles until 21 June 1990, one month after the second application of sulfur to all cages, including the control cages.

To examine the mode of action of sulfur against mites, we did the following bioassay. Mite-infested beetle adults and pupae were tightly wrapped in aluminum screen to permit handling without dislodging the mites. One infested beetle was placed in the center of a 100-mm diameter plastic petri dish lid. Three black plastic caps from 1-dram glass vials were arranged in a triangle around the beetle at a distance of ≈2 cm. Survivorship and activity of the dispersing immature mites were quantified by daily counts of living mites on the upper surface of these caps. The 100-mm petri dish lid was then placed inside a 150-mm diameter plastic petri dish and covered. The inside walls of the larger petri dish were brushed with mineral oil to prevent mites from escaping. Four treatments were applied: (1) sulfur vapor (4 g of sulfur scattered on the bottom of the large petri dish, leaving the beetle and the inside of the smaller petri dish free of sulfur); (2) sulfur contact (0.5 g of sulfur was applied directly on the beetle and around the inside of the small Petri dish); (3) cornstarch control (0.5 g of cornstarch [Best Foods C.P.C. International, Englewood Cliffs, N.J.] was applied as in the sulfur contact treatment to determine if other dusts affected mite dispersal); and (4) blank control (nothing added to either petri dish). Living mites were counted daily in the four treatments for 6 d.

Mite count data were log transformed and survivorship data were arcsine transformed before analysis (Sokal & Rohlf 1981). Analyses of time series data (where counts were made successively on different days) were analyzed by repeated-measures ANOVA, and means were separated by the Tukey's mean separation test (SAS Institute 1988). Differences between treatment means in other data sets were tested with the Kruskal–Wallis χ^2 approximation test (Proc NPAR1WAY [SAS Institute 1988]). All tests were done at $P = 0.05$.

Results

Mites attacked the adult beetles as they emerged from logs. They attached to soft tissues such as intersegmental membranes under the elytra. When cracks developed in dry logs and exposed the beetle pupal cells, mites also attacked beetle prepupae and pupae. Mite feeding caused an irreversible paralysis in adults and greatly reduced longevity, from 35 d for healthy beetles to as little as 1 d for mite-infested individuals. Mites were present on all paralyzed beetles, but long-lived beetles were always free of mites.

The mean number of mites infesting beetles was significantly lower in sulfur-treated cages than in control cages on both the 1 May and 10 May sampling dates (Table 1). The means for sulfured cages were low and were similar between dates, but the mean for 10 May control cages was nearly twice that of the 1 May sample, showing that the mite population was increasing in untreated controls.

Three days after application of sulfur to the control cages, the mite infestation levels declined dramatically from 39 ± 12 mites per host on 10 May to 1.1 ± 0.54 on 15 May (second and third data points in Fig. 1A. The means for 10 and 15 May were significantly different [Kruskal–Wallis statistic = 13.37, $P = 0.0003$]). The mean number of mites per host fell to 0 by 20 May (Fig. 1A).

Survivorship of emerged beetles (those free of mites) was uniformly higher in the cages treated with sulfur than in the control cages during the first 4 wk (Fig. 1B) (Treatment effect: $F = 12.6$, df = 1, $P = 0.003$ [means significantly different, Tukey means separation test, $P < 0.05$; time and

Table 1. Summary of Kruskal–Wallis analysis of numbers of mites infesting individual beetle hosts on 1 and 10 May 1990

Date	No. mites/beetle, $\bar{x}$ ± SEM		Statistic[a]	P
	Control cages	Sulfur cages		
1 May	20 ± 5.2 (n = 15)	3.3 ± 1.2 (n = 15)	16.1	<0.0001
10 May	39 ± 12 (n = 10)	2.9 ± 1.2 (n = 15)	13.4	<0.0002

[a] Kruskal–Wallis chi-square approximation.

interaction effects were not significant]). However, weekly survivorship in the control cages remained <60% and was as low as 24% until sulfur was first applied to all cages including control cages on 11 May (first arrow, Fig. 1B). After 11 May, survivorship increased to levels near those of the sulfur treatment cages. The second application of sulfur to all cages on 21 May (second arrow, Fig. 1B) was followed by an increase in survivorship to 100% in all cages after 2 wk.

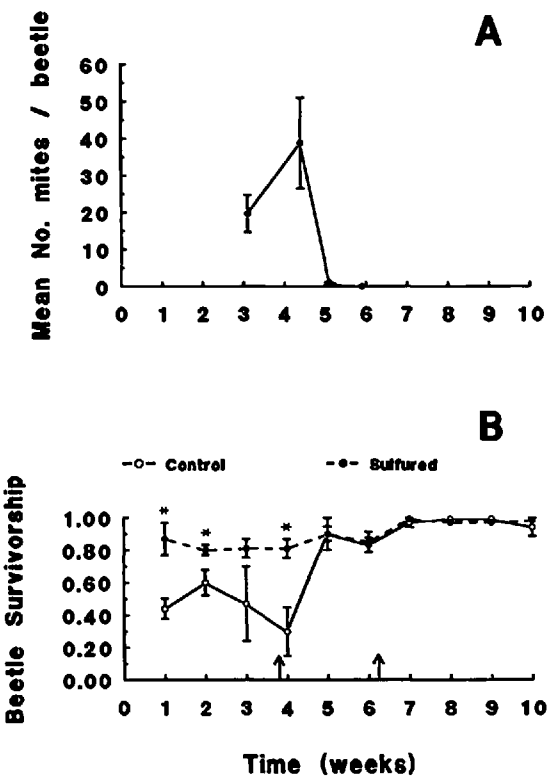

Fig. 1. (A) Number of mites present on individual eucalyptus longhorned beetles emerging in the control cages over a 10-wk period. Means ± SEM are presented. Sample sizes were 15, 12, 13, 12, and 15 beetles for successive data points. (B) Relationship between weekly survivorship of beetles emerging in control cages (open dots) and sulfured cages (closed dots) and time in weekly intervals. Survivorship was calculated using all beetles that emerged during each weekly interval. *, pairs of means are significantly different (P < 0.05; Tukey's means separation test [SAS Institute 1988]). Sample sizes were 56, 84, 96, 188, 134, 169, 239, 170, 108, and 70 beetles collected in weeks 1–10, respectively. Arrows indicate dates when sulfur was applied to all cages, including the control cages.

The bioassay to determine the mode of action of sulfur showed that the numbers of active immature mites in the arena were high in both the blank control and the sulfur vapor treatments (Fig. 2) (means not significantly different, Tukey means separation test, $P > 0.05$), suggesting that sulfur did not kill mites by vapor action. In contrast, the number of active mites in both the sulfur contact and cornstarch treatments were substantially lower than either the blank control or sulfur vapor treatments (Fig. 2) (means significantly different; Tukey means separation test, $P < 0.05$). Reduced activity of mites in these two treatments suggests that mites may have been inhibited by the physical characteristics of dust. This conclusion was supported by microscopic observation of dispersing mites in the arenas; sulfur and cornstarch particles adhered to the bodies of mites, impeding or even preventing their movement.

Discussion

On 1 May 1990, <1 mo after application of sulfur to the treatment cages, the densities of mites infesting hosts was 6 times higher in the control cages than in the cages treated with sulfur. The mite density in the control cages had nearly doubled 9 d later, suggesting that the mite population was rapidly increasing in the absence of sulfur. In fact, high densities of mites covered

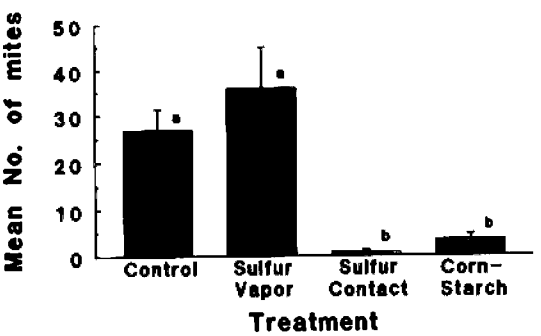

Fig. 2. Mean number of active immature mites present on black plastic vial caps in bioassay arenas. Means ± SEM are presented. Means with the same letters were not significantly different ($P > 0.05$; Tukey's means separation test [SAS Institute 1988]).

the walls of the control cage on 10 May. Four days after application of sulfur to the control cages, densities of mites declined to very low levels, reaching 0 mites per beetle after 9 d.

Weekly survivorship of beetles that emerged from logs remained nearly twice as high in the cages treated with sulfur as in the control cages for 1 mo after the initial sulfur application. Mortality that persisted at low levels in the sulfur cages during weeks 0 through 5 most likely resulted from immigration of mites from the heavily infested control cages to adjacent cages treated with sulfur. Only after all cages in the glasshouse had been treated with sulfur did the incidence of morbidity in adult beetles and the numbers of mites infesting beetles decline to zero.

The effect of sulfur on mites is apparently a physical inhibition of dispersal and prevents colonization of new hosts. Cornstarch also appeared to be effective in reducing the activity of immature mites. However, its applicability in control situations may be limited by its potential attractiveness to ants and cockroaches. The potential of cornstarch and other types of dust as acaricides requires more investigation.

We conclude from this study that dusting with sulfur may be an effective method of controlling *P. tritici* in insect rearing colonies. Because this acaricide is fairly specific to mites (Jeppson et al. 1975), it did not affect the longevity and fecundity of beetle hosts (L.M.H., unpublished data). Sulfur is also inexpensive and of negligible toxicity to man and many other organisms (Jeppson et al. 1975, Watterson 1988); therefore, this chemical may be useful in containing populations of mites that are reared in biological control programs, in reducing losses from mites in insect rearing colonies, and in eradicating mites that are a nuisance to humans and livestock.

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