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Technique for Rearing Mite-Free Southern Pine Beetle, *Dendroctonus frontalis* Zimmermann (Coleoptera: Scolytidae), Adults[1]

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ABSTRACT Southern pine beetles can be reared free of phoretic mites from naturally infested bark if the bark is removed from the tree and air dried. Bark removal does not reduce the number of beetles that emerge. On the average fewer than 1% of the beetles emerging from removed bark carried one or fewer mites, and 85% of the beetles emerging from attacked bark carried one or more mites. Seven species of mites were found on beetles emerging from attached bark.

About 15 species of mites are commonly transported by the southern pine beetle (SPB), *Dendroctonus frontalis* Zimmermann 1868 (Moser and Roton 1971, Kinn 1976), with the proportion of phoretized flying adults conservatively estimated at 40% (Moser 1976).

The trophic habits of these phoretic mites range from predaceous, mycophagous, nematophagous, or saprophagous to various combinations of feeding preferences. Some are detrimental to the SPB, others are neutral or beneficial (Kinn 1967, 1980, Moser, 1975, Wilson 1980). Many numerous and complex relationships exist among these mites and the SPB; hence mites should be excluded from studies to determine the capacity of SPB to attack trees and produce broods in the absence of selected associates.

At present there are no efficient methods for obtaining large numbers of SPB free of phoretic mites. Mechanically removing mites invariably injures the beetles because the elytra have to be lifted. Rearing beetle adults from eggs on artificial media is tedious and time consuming; very few adults are produced (Bridges 1979).

Kinn (1979) first documented that desiccation of the phloem killed some mite species. Subsequent studies by the authors showed that desiccation might severely reduce or eliminate all mite populations, resulting in virtually no phoretic mites on emerging beetles. In this study we decided to see whether mite-free populations of SPB could be reared from desiccated host material.

Materials and Methods

Four loblolly pines (*Pinus taeda* L.) infested with SPB were cut during February, May, August, and December 1980. The trees were from a natural stand about 35 years old in Catahoula Ranger District of the Kisatchie National Forest. Trees were felled when the SPB broods were pupae in the outer bark. Pupae do not carry phoretic mites (Roton 1978).

Samples were taken from the bole area where the pupal stage was most concentrated and where competition from other bark beetle species was least. Typically, the sample area extended 5 m through 11 m from ground level. No attempt was made to normalize infested bole heights within trees (McClelland et al 1979), because it was not our objective to sample tree populations systematically.

The infested bole area of each tree was divided into five sections. Each section was subdivided into three sample bolts trimmed so each contained 2,880 cm^2 of bark area. The uppermost bolt of each section was a survey bolt. A sixth survey bolt was taken from just below the first section. The other two bolts of each section were randomly assigned to one of two treatments. For one treatment, the bark was removed and exposed to the air inside the laboratory for 36 h. For the other treatment (control) the bark was not removed. Material from both treatments was placed in individual rearing cans inside the laboratory and kept at about 20°C and 50% relative humidity. The can interiors were dark with little or no air movement.

The survey bolt of the middle section was used to determine how long mites survived on the inner surface of drying bark. The mite surveys were made <24 h after the bolts were cut, then daily until mites were no longer observed.

In a preliminary survey at the start of the experiment, all the bark of the other five survey bolts was examined to establish which species of mites were present and to estimate their relative abundance.

Inner bark moisture was measured with a model RC-1 Delmhorst moisture detector. Readings were taken from the mid-section of the five survey and five control bolts of each tree <30 min after they arrived from the field. Moisture readings were also recorded from the inner bark of the five stripped bolts per tree.

Data were analyzed using the Statistical Analysis System.[2] To determine the effect of bark removal on beetle emergence an analysis of variance was run using a split-plot design. The whole units were locations along the infested bole, and the subunits were treatments. The response variable was the total number of beetles that emerged. To determine which species of mites the beetles carried most often, a split-plot design was used with locations on the infested bolt as the whole units and mite species as the subunits. Duncan's multiple range test was used to compare means.

[1]Trade names and company names are included to identify equipment used, and do not constitute endorsement by USDA. Received for publication 29 October 1982; accepted 11 July 1983.
[2]SAS Institute, Inc., SAS Circle, Box 8000, Cary, NC 27511.

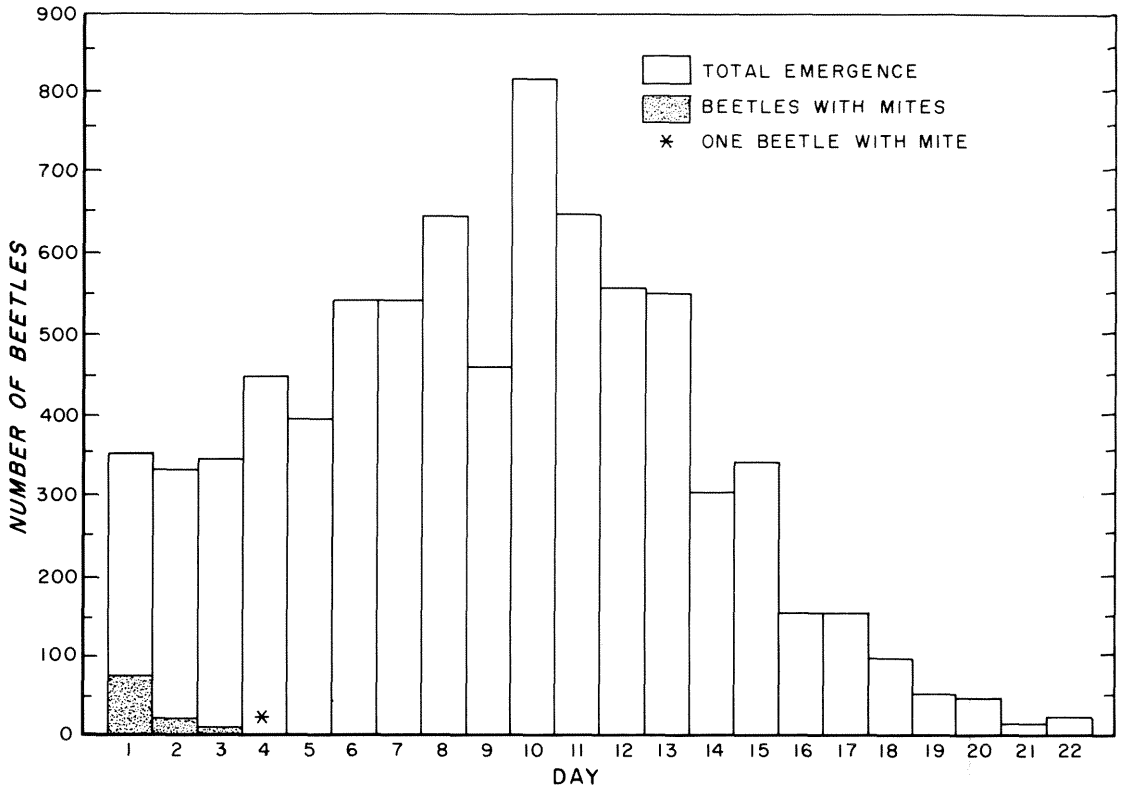

FIG. 1. Beetle emergence from removed bark.

Results

The 7,826 brood adults emerging from the removed bark were essentially mite free; a little over 1% carried mites. All of the 107 beetles with mites emerged within 4 days (Fig. 1). Of the 8,065 brood adults emerging from the attached bark (control), 85% carried at least one mite (Fig. 2).

Bark removal did not affect the number of beetles that emerged; there were no statistically significant differences in the mean number of beetles that emerged due to location along the infested bole (Table 1).

In the preliminary survey of the inner bark, we located all mite species later found phoretic on emerging SPB (Table 2). *Tarsonemus ips* was the most common mite with *Dendrolaelaps neodisetus* and *Tarsonemus krantzi* next most numerous. In the control treatment, beetles most often carried *Tarsonemus ips*. Beetles with *Dendrolaelaps neodisetus* and *T. krantzi* were the next most numerous (Table 2). Mites carried by beetles from the removed bark reflect those found in the control treatment. In addition to these, the preliminary survey also revealed *Macrocheles boudreauxi* Krantz 1965, *Eugamasus lyriformis* McGraw and Farrier 1969, and *Proctolaelaps hystricoides* Lindquist and Hunter 1965, which were not found on the emerging SPB; these mites were

Table 1. Number of beetles emerging from bolts with bark intact (control) or bark removed

Bole section[a]	$\bar{x}$ No. of emergent beetles[b]	
	Bark intact	Bark removed
1	405	380
2	444	539
3	354	332
4	437	355
5	375	350

[a]Bole sections were numbered starting with the lowest section.
[b]Mean of four trees.

Table 2. Mite species and number of southern pine beetles that carried them.

Mite species	Beetles per bolt[a]	
	Bark intact	Bark removed
Tarsonemus ips Lindquist 1969	277a	4.35a
Dendrolaelaps neodisetus Hurlbutt 1967	107b	1.30b
Tarsonemus krantzi Smiley & Moser 1974	102b	1.00b
Trichouropoda australis Hirschmann 1972	52bc	0.40b
Histiogaster arborsignis Woodring 1963	14bc	0.30b
Ereynetoides scutulis Hunter 1964	1c	0b
Proctolaelaps dendroctoni Lindquist & Hunter 1965	<1c	0b

[a]*Mean of 20 bolts. Column means followed by the same letter are not significantly different at the 0.05 level.

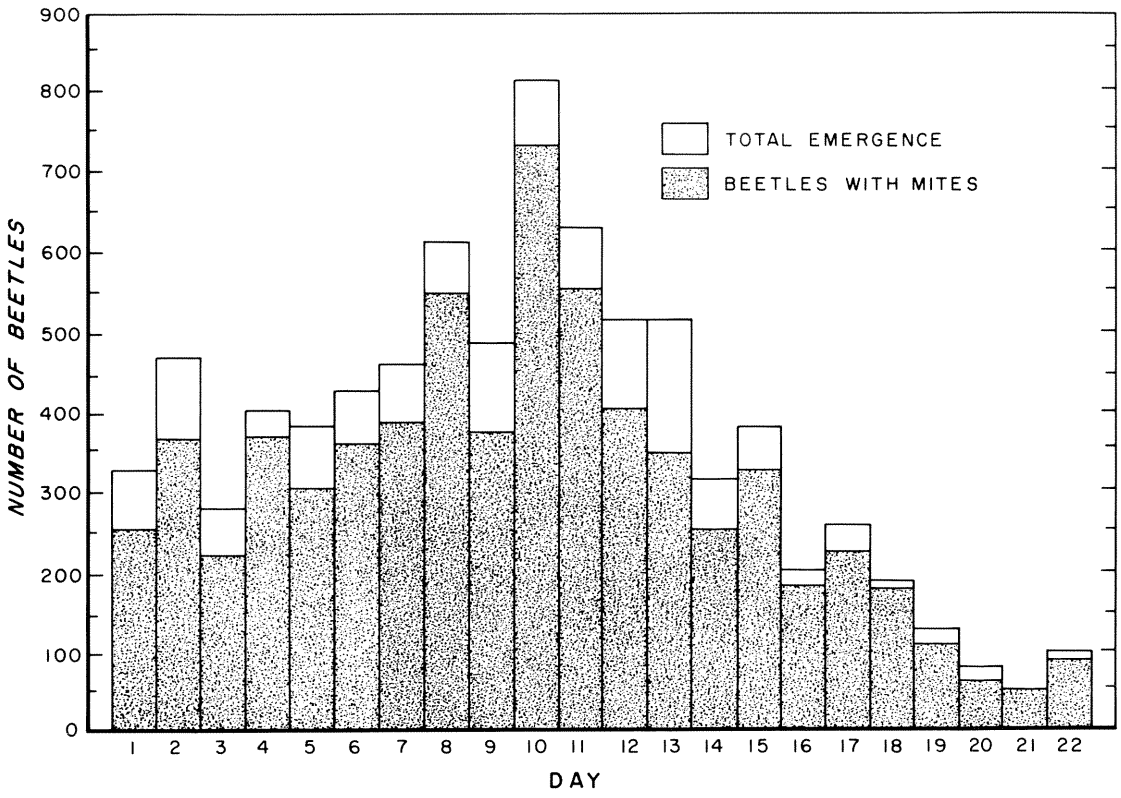

FIG. 2. Beetle emergence from intact bark.

infrequent. *Macrocheles boudreauxi* and *E. lyriformis* are phoretic on SPB (Moser and Roton 1971). *Proctolaelaps hystricoides* commonly occurs in SPB galleries; although it has never been observed to ride SPB, it is phoretic on two beetle associates of SPB.

Mites could be found at any time on the inner bark of control bolts, but they disappeared from the survey bolt within 24 h after bark removal. This coincided with a drop in moisture. The initial moisture content of inner bark in intact bolts was 35 to 50% dry weight and gradually dropped to 25 to 35% during the 20 to 30 day emergence period. Inner bark moisture content of removed bark dropped from 50% to about 7% within 24 h and remained at that level throughout the emergence period.

Discussion

The procedure of bark removal provides an easy and efficient way of providing large numbers of mite-free beetles. To be reasonably sure of obtaining mite-free beetles from removed bark, one should keep only those beetles emerging after the fourth day.

Moser (1976) reported that 39.6% of SPB adults carry mites. We found more (85%), but Moser's study was based on SPB from sticky traps and the loosely attached mites were probably dislodged by the stickum.

One source of mite-free beetles in nature may be bark flakes created by woodpeckers. Although we have neither reared nor examined any beetles from bark flakes, we have seen flakes in the field with SPB emergence holes on the inner bark surface when the inner bark lies face-up on the ground.

Because brood adults emerging from bark flakes may not carry mites, their ability to perpetuate the population in forest stands may be reduced. The absence of *Tarsonemus* mites would lessen the number of *Ceratocystis minor* (Hedgcock 1906) Hunt 1956 (bluestain fungus) ascospores transported to attacked trees (Bridges and Moser 1983); the absence of *Dendrolaelaps neodisetus* Hurlbutt 1967 and other nematode feeders could raise the incidence of nematode parasitism in the bark beetles (Kinn 1980).

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