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Chemosterilants to Control Bark Beetles . . .

tepa shows promise in preliminary test

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ABSTRACT: In a preliminary study, two chemosterilants--tepa and hempa --were tested for their effects on the fertility of adult bark beetles (*Ips confusus* [LeConte]). Hempa was ineffective. Tepa proved 97 percent effective in reducing egg hatch, when applied at 10 µg./10 mg. body weight to both parents. The possibility of using a chemosterilant and the male sex pheromone jointly to attract and sexually sterilize insect populations in the field shows promise.

RETRIEVAL TERMS: *Ips confusus*; chemosterilants; sterilization; tepa; hempa; bark beetles; control.

Recent research on controlling bark beetles (*Ips confusus* [LeConte]) has centered on attracting the insects by artificial means, and then sexually sterilizing field populations. Wood et al. (1966) and Silverstein et al. (1966) have reported on the synthesis of the sex pheromones produced by males of *Ips confusus*. This development brings closer to practical usefulness a reliable way of using pheromones and chemosterilants in concert to control this bark beetle.

Schwerdtfeger and Ehrhardt (1966) tested the chemosterilant apholate (2,2,4,4,6,6-hexakis[1-aziridinyl]-2, 2,4,4,6,6-hexahydro-1,3,5,2,4,6-triazatriphosphorine) by applying 0.5 percent (v/v) water sprays to pine logs immediately before attack by *I. typographus* (LeConte). Logs had to be sprayed three times before appreciable effects were obtained: 74.2 percent of the eggs hatched as against 95 percent in the controls. Wood and Stark (1966) worked with gamma radiation (CO_{60}) to sterilize *I. confusus*. They found that a radiation level of between 6,000 and 7,500 roentgens was effective.

In a preliminary laboratory test, we applied two chemosterilants--tepa and hempa--on *I. confusus*. Tepa strongly reduced the larval population, but showed no clear margin of safety between sterility and toxicity. Survival of parents was sharply reduced at the highest concentration. Hempa had no effect, except at the highest concentration, where both survival and length of egg gallery were reduced.

Materials and Methods

We collected the beetles from the University of California Blodgett Experimental Forest, El Dorado County, from ponderosa pine (*Pinus ponderosa* Laws.), mainly as mature larvae, pupae, and callow adults. The insects were reared from 1-m. bolts placed in a screen cage 1.2- by 2.4- by 2.1 m. in the laboratory.

Tepa[1] (tris [1-aziridinyl] phosphine oxide) was formulated in a solution of equal parts of acetone and methanol. Hempa[1] (hexamethyl-phosphoric triamide) was formulated in acetone. All stock solutions and serial dilutions from these materials were made immediately before use and based on the active ingredient in the technical material.

Beetles that emerged during a 24-hour period were separated by sex, using the epistomal tubercle on the male

[1]Samples of both chemosterilants were supplied by Dr. Alexej B. Borkovec, Pesticides Chemicals Research Branch, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Md.

Table 1.--*Mortality of Ips confusus 3 days after treatment with tepa and hempa*[1]

Chemo-sterilant	Beetle sex	Untreated	Concentration[2] (µg./µl.)							
			0	.1	.5	1	5	10	50	100
			Percent							
Tepa	♂	20	0	5	11	6	6	0	26	0
	♀	17	17	18	24	15	10	27	35	65
Hempa	♂	0	0	--	--	--	11	0	10	15
	♀	10	10	--	--	--	21	5	0	0

[1]Held in groups of 10 in petri dishes with moist filter paper, 20 to 40 insects/entry.

[2]Insects treated with 1 µl./10 mg. body weight.

Table 2.--*Effect of tepa and hempa applied topically to both sexes of Ips confusus, on production of offspring in cut bolts*

Treatment	Dosage active ingredient	Total parent adults		Egg gallery length per attack	Larval mines per attack		Reduction in offspring[1]
		At start	Survivors		Range	Av.	
	µg./µl.	*No.*	*No.*	*Pct.*	*Cm.*	*Number*	*Pct.*
Controls:							
Untreated	0	30	23	77	10.0	4-43	21.6	--
Solvent[2]	0	30	24	80	13.3	13-42	30.0	--
Tepa	5	30	21	70	12.2	0- 6	2.3	91.1
Tepa	10	30	18	60	10.8	0- 4	.8	96.9
Tepa	20	30	14	47	10.5	0- 1	.1	99.6
Controls:							
Untreated	0	21	14	67	10.7	19-67	37.0	--
Solvent[3]	0	30	16	53	9.6	0-52	23.8	--
Hempa	1	30	25	83	15.5	24-76	48.5	0
Hempa	10	30	23	77	14.5	19-69	37.4	0
Hempa	100	30	13	43	7.6	0-34	15.2	48.0

[1]$\frac{\text{Larval mines in control - larval mines in treatment}}{\text{Larval mines in control}} \times 100.$

[2]Acetone/methanol (1/1).

[3]Acetone.

(Lyon 1955) and stridulating organ on the female (Wood 1961).

Each adult, immobilized over ice, was treated topically on the ventral abdominal region with an ISCO Model M microapplicator,[2] using a 1/4-cc. tuberculin syringe and 27-gauge needle. The insects were treated in groups of 10, from lowest to highest concentration, at the rate of 1 µl. of solution/10 mg. body weight. The highest concentrations of 20 and 100 µg./µl. for tepa and hempa, respectively, were selected after preliminary tests by topical application to establish the maximum sublethal dose (table 1).

We treated the males first and introduced them singly to fresh ponderosa pine bolts 10 to 15 cm. in diameter (sometimes split in half) and 15 cm. long. A small hole was drilled through the bark to accommodate the beetle and was capped with half a No. 000 gelatin capsule held in place by an insect pin. The females were similarly treated and introduced 1 day later; one for each male in the morning and one in the afternoon.

Each bolt with a single attack (one male and two females) was held in a gallon-size cylindrical food container at 70° ±2°F. until opened for examination 14 to 21 days later. Each test was replicated 10 times (seven for the untreated hempa control) for each concentration of chemosterilant and each control.

Results and Discussion

All eggs had hatched in the controls, and the earliest larvae were mature and appeared healthy at the time of inspection. With few exceptions, eggs in the tepa treatment were oviposited in normal fashion, but failed to hatch. Egg gallery length and pattern were not greatly affected (table 2; fig. 1). The median dose of 10 µg./µl. was 97 percent effective in reducing hatch, yet caused only a moderate increase in mortality of parents over the controls.

Tepa has been tested on two other coleopterous insects. Topical application of 25 µg. of tepa to Japanese beetle adults of both sexes reduced hatch 96 percent, though some adverse effect was noted on longevity of treated insects (Ladd 1966). Male banded cucumber beetles fed tepa-treated collard foliage and mated with untreated females resulted in an egg hatch of 18 percent as against 61 percent in the controls (Creighton et al. 1966).

The effectiveness of tepa warrants further study to determine (a) to what extent male and female *I. confusus* are sterilized when treated separately, (b) whether treated beetles are sexually competitive with untreated members, and (c) whether reattacking parents retain sterility. A chemosterilant effective on both sexes would be desirable because the male *I. confusus* attacks the host first (Struble and Hall 1955) and produces a pheromone that attracts a mass invasion by both males and females (Wood 1962; Wood and Vité 1961; Vité and Gara 1962).

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[2] Instrumentation Specialties Co., Inc., Lincoln, Nebraska. Trade names and commercial products and enterprises are mentioned solely for necessary information. No endorsement by the U. S. Department of Agriculture is implied.

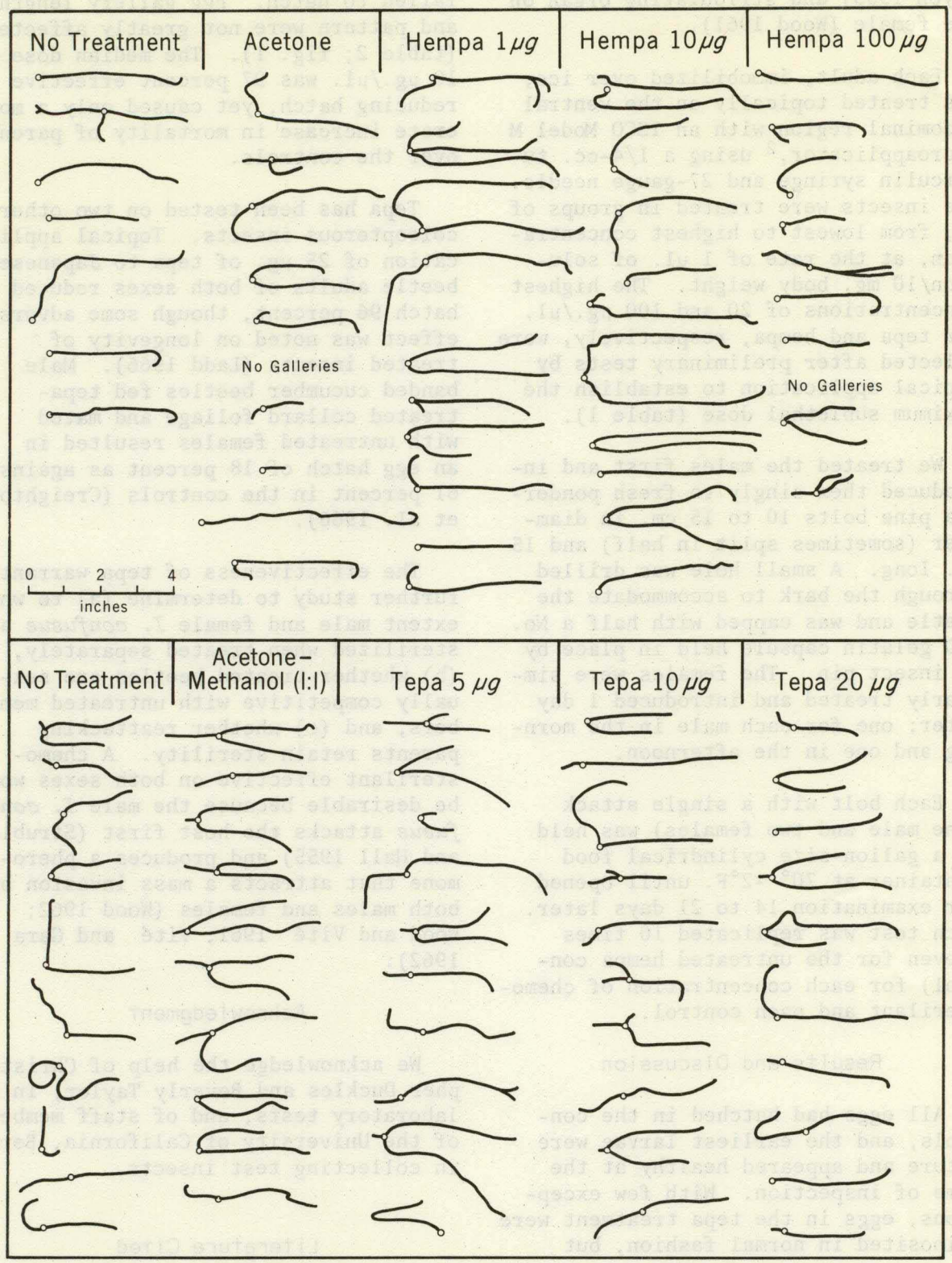

Figure 1.--*Larval mines of Ips confusus in cut bolts produced by adults treated with tepa and hempa.*

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