Capture of *Diaprepes abbreviatus* (Coleoptera: Curculionidae) in Frass Extract-Baited Traps in Citrus

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ABSTRACT In field trapping studies in central Florida during the fall of 1981 and the spring, summer, and fall of 1982, more *Diaprepes abbreviatus* (L.) were captured with frass or frass extracts than with other treatments. Extracts of frass from male weevils in traps captured more males or females than extracts of frass from female weevils. Extracts of frass in methanol captured more weevils at high than at low concentration.

Diaprepes abbreviatus (L.) is an important weevil pest of sugarcane, citrus, and other crops in the Caribbean Basin (Woodruff 1968). It was first reported in Florida by Woodruff (1964), and 2,630 ha in and around the infested area was quarantined by the Florida Division of Plant Industry in 1968. *D. abbreviatus* has since spread beyond the original quarantine areas and now poses a threat to the major citrus and sugarcane areas in Florida. Because there is no efficient method for detecting *D. abbreviatus* populations, weevil-produced attractants have been sought.

Adult weevils emerge from the soil in spring (April through June) and in fall (October through December) and often aggregate in large numbers on an individual plant of a given host species, leaving nearby hosts undisturbed (Wolcott 1936, Woodruff 1968). Schroeder (1981), in an outdoor cage study, suggested a possible chemical basis for this behavior by showing that *D. abbreviatus* adults congregated on citrus plants on which the opposite sex was first allowed to crawl and feed. Beavers et al. (1982) reported a similar result in a laboratory olfactometer and in field trapping studies. However, subsequent efforts to identify a specific behavioral response to frass or associated materials or extracts thereof in the laboratory have been unsuccessful. In November 1981, we began field testing a trap design using extracts of weevil frass in an effort to develop a detection method. Tests were conducted in the fall of 1981 and the spring, summer, and fall of 1982.

Materials and Methods

Handling of Insects. *D. abbreviatus* adults were field collected and maintained in laboratory colonies on citrus foliage. A colony of ca. 1,000 insects was divided into groups of ca. 600 males and females (1:1), ca. 200 males only, and ca. 200 females only in separate cages at 25 ± 3°C under natural lighting. Cages were 61 by 61 by 91 cm; they were fabricated of a wood frame and screen wire with a 0.32-cm-mesh hardware cloth bottom. A glass plate was placed below the cage bottoms to collect frass, citrus leaf bits, and other possible excreta (hereafter referred to as frass). Daily collections were stored at −20°C until use.

Preparation of Extracts. For test 1, 20 g of frass from the colony of males and females (1:1) was extracted in a blender with 150 ml of chloroform/methanol/water (1:2:0.8) monophasic solvent (Bligh and Dyer 1959). A similar extract of citrus leaves (20 g in 150 ml) was also prepared. For test 2, 16.5 g each of frass from male weevils, frass from female weevils, and air-dried citrus leaves, respectively, were extracted in 200 ml of chloroform. For test 3, 20 g of frass from the colony of males and females (1:1) was extracted in 225 ml of chloroform. The dry solid residue (test 3) was reextracted in 225 ml of methanol to achieve, as nearly as possible, a complete separation of chemical constituents in the two solvents. For test 4, 20 g of citrus leaves previously extracted with 225 ml of chloroform were reextracted with 225 ml of methanol. In tests 2 through 4, extractions were performed in a Soxhlet extractor for 12 h.

Field Tests. The trap design used was described by Schroeder and Jones (1983). Field tests were initiated whenever field populations of *D. abbreviatus* were located, and they continued as long as weevils were present. In field tests, traps were suspended from rigid supports so that the skirt touched foliage in the upper canopy of citrus trees. When traps were inspected (once every 24 h for the duration of the test), weevils were removed and counted by sex, and the traps were rebaited. For extract-baited traps, two cotton dental wicks (1 cm in diameter by 2.5 cm long) per trap were impregnated with 2 ml of extract.

In test 1 (28 days in November 1981), 10 traps baited with frass extract and 10 baited with solvent were placed singly in the tops of randomly selected small trees (ca. 2.5 m high) in a replanted section of a weevil-infested citrus grove. No two traps were closer together than 7.5 m.

In test 2 (25 days in May and June 1982), twenty

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Table 1. *D. abbreviati*
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Treatment
Frass extract (male)
Frass extract (female)
Citrus leaf
Check (chloroform)

Means within columns, f

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Test 3 (12 days in
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Daily capture was
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Results

Test 1 gave the fol
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and 10.6 ± 4.2 femal
males and 1.2 ± 1.
captures with frass
greater ($P = 0.01$) tha

Table 2. *D. abbreviati*
in concentrations of 1 a

Treatment
Chloroform 0.1×
Chloroform 1×
Methanol 0.1×
Methanol 1×
Check

Means within columns, f

Table 1. *D. abbreviatus* response to traps in 2-m-high citrus trees baited with chloroform extracts of frass from male or female beetles or of citrus leaves when traps were in a low-density emerging population for 25 days

Treatment	Capture/trap ($\bar{x} \pm$ SD)			Sex ratio (male-female)
	Male	Female	Total	
Frass extract (male)	3.8 ± 3.3ab	4.0 ± 3.7b	7.6 ± 6.7ab	0.95
Frass extract (female)	7.6 ± 3.9a	4.6 ± 2.6b	12.6 ± 5.0a	1.70
Citrus leaf	3.0 ± 1.0ab	1.6 ± 1.3b	4.8 ± 1.3ab	1.90
Check (chloroform)	1.6 ± 0.9b	1.8 ± 3.6b	3.6 ± 2.1b	0.89

Means within columns, followed by different letters, are significantly different ($P = 0.05$), by Duncan's multiple range test.

traps were placed as described in test 1 in a randomized complete block design (four treatments in five blocks). Traps were baited with extracts of frass from male beetles and from female beetles, with extracts of citrus leaf, or with solvent.

Test 3 (12 days in October 1982) was conducted in large trees (ca. 4 m high) in a commercial, weevil-infested citrus grove. Twenty-five traps were placed five per tree in a randomized complete block design (five treatments in five blocks). Starting at magnetic north, traps were placed 72° of arc apart around the upper canopy and treatments were randomized among these positions. No two traps were closer than 2 m. Treatments were the chloroform and methanol frass extracts, their 1 in 10 dilutions, and an untreated check.

In test 4 (7 days in November 1982), 16 traps were placed as described in test 1. Eight traps were treated with the methanol extract of citrus leaf, and eight were treated with solvent.

Daily capture was recorded by sex and summed over the test period in all experiments. Data were transformed to $\sqrt{X + 0.5}$ and analyzed by a Student's t test where two means were compared. Two-way analysis of variance was used where there were more than two means; means were separated by Duncan's multiple range test.

Results and Discussion

Test 1 gave the following results (mean weevils per trap): frass extract captured 8.2 ± 4.4 males and 10.6 ± 4.2 females; checks captured 0.6 ± 0.5 males and 1.2 ± 1.5 females. Male and female captures with frass extract were significantly greater ($P = 0.01$) than with the checks. These data suggested the presence of an attractant in the monophasic extract. Subsequent tests were designed to segregate attractancy into aqueous-soluble or non-aqueous-soluble solvents.

Test 2 (Table 1), showed that numbers of males and total weevils captured in traps containing extracts of frass (in chloroform) from male beetles were significantly greater ($P = 0.05$) than numbers of weevils captured in the check. In test 3 (Table 2), the capture of male and total weevils in traps containing the 1× methanol extract was significantly ($P = 0.05$) greater than all treatments except the 0.1× and 1× chloroform extracts. No distinct partitioning of weevil capture into traps containing frass extracts in chloroform or in methanol occurred. In test 4, numbers of weevils captured in traps containing the methanol extract of citrus leaves or in checks were not different ($P = 0.05$). Field sex ratios were 1:1 during tests, but trap-captured weevils had a sex ratio of ca. 2:1 (males to females). Direct observations and laboratory actograph studies (unpublished data) indicate that males move more in a 24-h period than females, although other factors may contribute to increased male capture.

Data collection was hindered by sporadic, low-density field populations of weevils in the central Florida area. Experiments reported are from a larger body of field tests in which frass extracts consistently captured greater numbers of weevils than did other treatments.

Although the field trapping data presented here are by no means definitive, when tests 1 through 4 are viewed collectively, the following conclusions appear justified: weevil excrement or associated materials contain attractive substances dis-

Table 2. *D. abbreviatus* response to traps baited with sequential extracts (chloroform, then methanol) of weevil frass in concentrations of 1 and 1 in 10; traps were in 4-m-high citrus trees for 12 days

Treatment	Capture/trap ($\bar{x} \pm$ SD)			Sex ratio (male-female)
	Male	Female	Total	
Chloroform 0.1×	6.8 ± 2.6b	5.4 ± 3.5b	12.2 ± 4.0ab	1.3
Chloroform 1×	9.6 ± 4.4ab	4.4 ± 3.1b	14.0 ± 5.4ab	2.2
Methanol 0.1×	4.8 ± 3.6b	1.6 ± 1.1b	6.4 ± 4.0b	3.0
Methanol 1×	17.8 ± 14.8a	8.0 ± 6.1b	25.8 ± 20.0a	2.2
Check	5.6 ± 4.7b	2.4 ± 2.3b	8.0 ± 6.5b	2.3

Means within columns, followed by different letters, are significantly different ($P = 0.05$), by Duncan's multiple range test.

tinct from citrus constituents, which are at least in part extractable in chloroform or methanol; there is probably more than 1 active chemical; compared with check-captured insects, numbers of insects of both sexes captured with extracts of frass from male beetles (in chloroform) were greater than numbers of insects captured in traps baited with other treatments.

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