Toxicity of endosulfan to spined citrus bug, *Biprorulus bibax*, and some of its egg parasitoids

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Summary

The toxicity of endosulfan against adult *Biprorulus bibax* and four of its hymenopterous egg parasitoids was examined in laboratory bioassays. An LC_{99} of 32.0 mg L^{-1} and LC_{50} of 9.0 mg L^{-1} were obtained for *B. bibax*. Adult *Trissolcus oenone*, *Trissolcus oeneus* and *Anastatus biproruli* had LC_{99}'s and LC_{50}'s of <15 and <5 mg L^{-1}, respectively. *Trissolcus ogyges* had an LC_{99} of 132.1 mg L^{-1} and an LC_{50} of 27.0 mg L^{-1}. Orchard applications of endosulfan at 28 or 35 mg L^{-1} prevented damaging outbreaks of *B. bibax* for 11.2 and 12.1 weeks, respectively. These applications appeared to have minimal impact on egg parasitism of *B. bibax*. Endosulfan at 35 mg L^{-1} is considered to be compatible with integrated pest management in citrus and is suggested as a treatment for *B. bibax* when egg parasitoids are ineffective.

Introduction

The spined citrus bug, *Biprorulus bibax* Breddin, is a relatively recent addition to the pest fauna of citrus in inland southern Australia. It was detected for the first time at Yanco in the Murrumbidgee Irrigation Area (MIA) in 1975, and damaging populations are now common in this area as well as in Sunraysia and along the Upper Murray. Adults and nymphs of this native stink bug feed on citrus fruit, particularly lemon and mandarin and large populations cause considerable damage and economic loss (Summerville 1931, Hely *et al.* 1982).

A management strategy for *B. bibax* based on conservation of natural enemies, particularly egg parasitoids, has recently been developed (James 1992). However, chemical intervention is often still required usually in mid–late summer when parasitism declines (James 1989, 1990, 1992). Some of the chemical treatments currently registered for *B. bibax* in New South Wales, Victoria and South Australia (malathion, methidathion, diazinon) are extremely disruptive to the citrus ecosystem and can precipitate outbreaks of other pests such as scale insects. In addition, these treatments characteristically lead to resurgences of *B. bibax* populations within four weeks (James unpublished data). An effective, yet selective chemical treatment for *B. bibax* which does not unbalance the citrus ecosystem is required.

This paper presents laboratory data on the toxicity of endosulfan to *B. bibax* and four of its egg parasitoids. A field rate developed from this data was then evaluated and results discussed with regard to the role of endosulfan in integrated management of *B. bibax*.

Materials and methods

Laboratory bioassays

Adult *B. bibax* were obtained from a laboratory colony maintained at Yanco. Bugs were reared at 25 ± 1°C, 15 hour photophase and supplied with unripe lemons as food. All bugs used in bioassays were at least two week old adults with equal numbers of males and females. A 350 g L^{-1} emulsifiable concentrate formulation of endosulfan was tested against *B. bibax* using a Potter precision spray tower. Bugs (10 per concentration) were placed in glass petri dishes for spraying then immediately transferred to plastic cups (7 cm diameter) with muslin lids and held at 30°C for 72 h. Four serial dilutions were used and 5 mL of liquid was sprayed onto each petri dish per concentration. The spraying pressure was 50 kPa and provided even coverage. Once a dose-mortality range was identified the test was replicated three times and a water only treatment was included in each replicate as a control. Bugs were provided with a lemon for food during the holding period. Mortality was assessed after 72 h and individuals were considered dead if they were unable to maintain a normal posture or walk normally when prodded.

Bioassays were also conducted against four hymenopterous egg parasitoids of *B. bibax* (*Trissolcus oenone* (Dodd), *Trissolcus ogyges* (Dodd), *Trissolcus oeneus* (Dodd) (Scelionidae) and *Anastatus biproruli* (Girault) (Eupelmidae)) (James 1990). Laboratory colonies of the four parasitoids were established from parasitised *B. bibax* eggs obtained from a number of different locations in southern New South Wales. Parasitoids were maintained at Yanco under the same conditions as *B. bibax* using eggs of *B. bibax* as hosts. Adult wasps anaesthetized with CO_2 were transferred from rearing cages to disposable plastic cups (30 mL) (10 per cup) capped with muslin gauze. The same formulation of endosulfan was tested against the parasitoids using the Potter precision spray tower. Wasp activity was reduced by placing the cups in a cool esky (5–10°C for 10–15 minutes) which allowed safe removal of the lids before spraying. Four or five serial dilutions were used and 5 mL of liquid was sprayed onto one cup per concentration. The spraying pressure was 50 kPa and provided even coverage of bottom and sides of the cup. Once a dose-mortality range was identified the test was replicated three times and a water only treatment was included in each replicate as a control. Wasps were held in the treated cups at 25°C and mortality assessed after 48 h. Individuals were considered dead if unable to maintain a normal posture or walk normally.

Dose mortality data for all bioassays were corrected for control mortality (Abbott 1925) and analysed by probit analysis (Finney 1971).

Field evaluation

Two rates of endosulfan (28 and 35 mg L^{-1} or 8 and 10 mL of 350 g L^{-1} emulsifiable concentrate per 100 L water) were selected as experimental field rates for *B. bibax*. These rates are close to the LC_{99} level (32 mg L^{-1}) obtained in the laboratory bioassays against *B. bibax*. During 1990–92, twenty lemon growers in the MIA and at Barham on the River Murray, were advised to use either of these rates in controlling damaging *B. bibax* populations (>20 motiles per hour search, James 1989, 1992). In all cases sprays were applied using conventional airblast sprayers. Post-treatment populations of *B. bibax* and egg parasitoids were monitored at weekly or fortnightly intervals by conducting one hour orchard searches and collecting egg batches. Egg batches were held in the laboratory at 25°C and incidence of parasitism recorded.

Results

Laboratory bioassays

Data from laboratory bioassays are summarized in Table 1. *T. oenone*, *T. oeneus* and *A. biproruli* were more susceptible to

Table 1. Toxicity of endosulfan to *B. bibax* and four hymenopterous egg parasitoids in laboratory bioassays.

Species	n tested	Slope ± SE	LC_{50} (95% CL) (mg L^{-1})	LC_{99} (95% CL) (mg L^{-1})
B. bibax	150	4.23 ± 1.4	9.0 (8.0–11.0)	32.0 (18.0–58.0)
T. oenone	150	8.43 ± 0.2	2.5 (2.3–2.7)	4.7 (3.8–5.8)
T. ogyges	150	3.4 ± 0.3	27.0 (22.4–32.7)	132.1 (78.6–221.9)
T. oeneus	200	4.3 ± 0.7	4.2 (3.7–4.7)	14.3 (9.2–22.4)
A. biproruli	150	3.3 ± 0.1	1.8 (1.5–2.2)	9.2 (5.5–15.5)

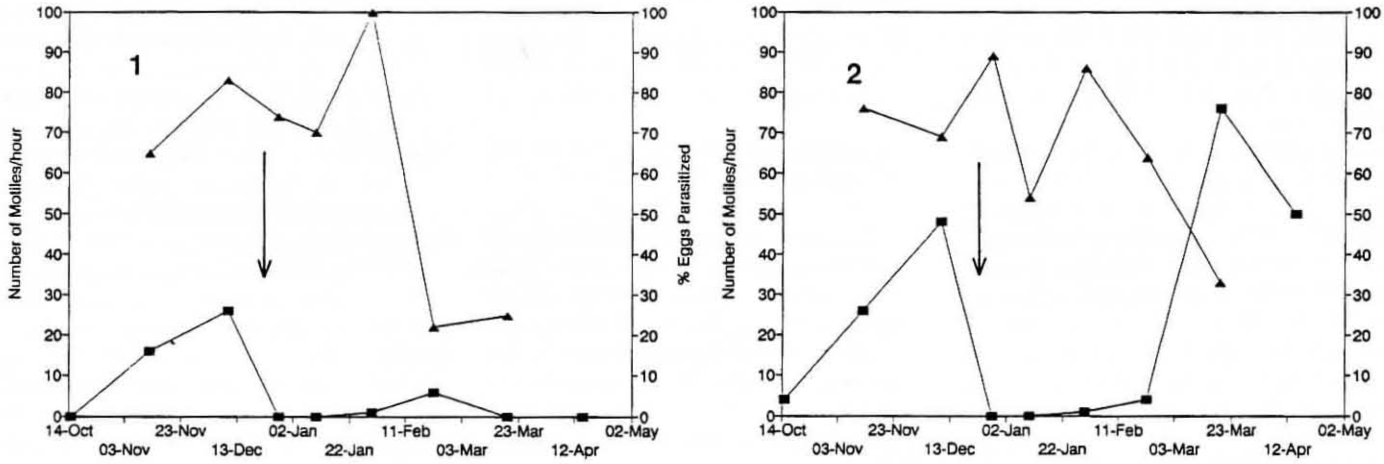

Figure 1. Abundance of *B. bibax* motiles and incidence of egg parasitism by *T. oenone* and *A. biproruli* in two orchards at Barham during 1990–91. Arrows indicate applications of endosulfan (35mg L^{-1}), ■ motiles hr^{1} and ▲ % parasitism.

endosulfan than *B. bibax*, while *T. ogyges* was substantially less susceptible.

Field evaluation

Data on the efficacy of 28 and 35 mg L^{-1} rates of endosulfan against *B. bibax* in twenty lemon orchards are presented in Table 2. The effect of 35 mg L^{-1} applications on *B. bibax* and egg parasitoid (*T. oenone* and *A. biproruli*) populations at two Barham orchards during 1990–91 is shown in Figure 1. Endosulfan rates of 28 and 35 mg L^{-1} removed *B. bibax* from orchards for mean periods of 5.2 and 6.8 weeks, respectively. Applications made after November usually prevented the occurrence of damaging populations for the rest of the season. Best results were obtained when all orchards in a district were treated simultaneously (e.g., orchards 13–16).

The impact of these rates of endosulfan on (*T. oenone* and *A. biproruli*) populations as measured by percentage parasitism of *B. bibax*, appeared to be minimal (Figure 1).

Table 2. Control of *B. bibax* in 20 lemon orchards following application of endosulfan at 28 or 35 mg L^{-1}.

Date of Spray	Orchard	Rate (mg L^{-1})	Period of freedom (weeks) from *B. bibax*	Period of freedom (weeks) from damaging *B. bibax* populations (20 motiles/hour search)
26.2.90	1	35	2	5*
26.2.90	2	35	2	5*
11.3.90	3	35	4	4*
11.3.90	4	35	2	4*
21.3.90	5	35	2	4*
22.3.90	6	35	4	4*
19.11.90	7	35	10	18*
23.11.90	8	35	6	20*
24.11.90	9	35	10	20*
2.12.90	10	35	12	18*
20.12.90	11	35	3	12*
20.12.90	12	35	3	12*
10.11.91	13	35	12	17
10.11.91	14	35	11	17
10.11.91	15	35	13	17
10.11.91	16	35	13	17
23.1.91	17	28	2	10*
8.2.91	18	28	6	10*
18.11.91	19	28	4	9
12.12.91	20	28	9	16
Means (28 mg L^{-1})			5.2±1.3	11.2±1.4
Means (35 mg L^{-1})			6.8±1.1	12.1±1.6

* Period of freedom extended to end of the season

Discussion

In New South Wales and Queensland endosulfan is currently recommended at a rate of 200 mg L^{-1} for control of *B. bibax*. The results of this study demonstrate good control of this pest can still be achieved with rates as low as 28 or 35 mg L^{-1}. In addition, these rates appeared to have little effect on the incidence of egg parasitism, indicating endosulfan may play an important role in integrated management of *B. bibax*.

The close correspondence between the laboratory derived LC_{99} value for endosulfan and the successful field rates was remarkable. Laboratory bioassays are often unsuccessful in predicting field rates because of application inefficiencies and environmental factors. In most cases growers used at least 2000 L of spray per hectare providing excellent tree coverage. All sprays were applied in warm (>22°C), sunny weather when bugs were active and present on outer canopies. At these low rates it is likely to be essential bugs have direct contact with the spray to receive a fatal dose. In using commercial growers in the field evaluation it was not possible to incorporate control blocks. However, the consistent results achieved from the large number of cases monitored over a 22 month period, strongly indicate the efficacy of low-rate endosulfan against *B. bibax*.

Laboratory bioassays showed three of the four species of *B. bibax* egg parasitoid to be more susceptible to endosulfan than *B. bibax*. It is likely that most individuals of *T. oenone*, *T. oeneus* and *A. biproruli* which come into direct contact with 28 or 35 mg L^{-1} rates of endosulfan in citrus orchards will die. *T. ogyges* is less susceptible than *B. bibax* to endosulfan and should survive even direct contact with low rate sprays. The absence of any inhibitory effect on parasitism by *T. oenone* and *A. biproruli* following endosulfan sprays in two Barham orchards was typical of all treated orchards. Residues of low-rate endosulfan are unlikely to remain active against *T. oenone* and *A. biproruli* for long and developing parasitoids within host eggs are likely to be unaffected (Orr 1988). Low-rate endosulfan should also have minimal effect on populations of *Aphytis melinus* De Bach, an important parasitoid of red scale, *Aonidiella aurantii* Maskell (Davies and McLaren 1977, James 1993).

Casual observations made in orchards in this study following endosulfan applications indicated no obvious effect on spider, lacewing or praying mantid populations.

The application of endosulfan at 28–35 mg L^{-1} is clearly an effective, yet non-disruptive treatment for *B. bibax* which is compatible with integrated pest management in citrus. A rate of 35 mg L^{-1} is suggested but should only be used when egg parasitoids become ineffective, which is usually in January to February. A single application at this time should control *B. bibax* for the rest of the season.

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