SUSCEPTIBILITY OF THREE PARASITOIDS OF *HELIOTHIS VIRESCENS* TO FIELD RATES OF SELECTED COTTON INSECTICIDES

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Abstract

Susceptibility of three parasitoids, *Cardiochiles nigriceps* Vierick, *Cotesia marginiventris* (Cresson), and *Microplitis croceipes* (Cresson), of *Heliothis virescens* (F.) to field rates of various insecticides used in control of pests in cotton was determined. The fourteen insecticides used for comparisons between *C. nigriceps* and *M. croceipes* were acephate, azinphosmethyl, bifenthrin, chlorpyrifos, dicrotophos, dimethoate, cyfluthrin, cyhalothrin, cypermethrin, endosulfan, methyl parathion, oxamyl, profenofos, and thiodicarb. All of these insecticides, except for thiodicarb, were extremely toxic to *M. croceipes*. Treatment with the five insecticides, thiodicarb, acephate, oxamyl, azinphosmethyl and cypermethrin, resulted in higher survival for *C. nigriceps* adults than treatment with the other nine insecticides. Cypermethrin was less toxic to *C. nigriceps* females than the other three pyrethroids tested. The fourteen insecticides used for the studies on *C. marginiventris* included: acephate, azinphosmethyl, bifenthrin, cyhalothrin, cypermethrin, endosulfan, esfenvalerate, fipronil, methomyl, methyl parathion, oxamyl, profenofos, thiodicarb, and Pirate. Eleven of these fourteen insecticides were extremely toxic to *C. marginiventris*, causing 92-100% mortality of adult wasps, whereas treatment with thiodicarb, oxamyl, and acephate resulted in lower mortality of *C. marginiventris* males and females. For both male and female *C. marginiventris*, thiodicarb and oxamyl were less toxic than acephate. Esfenvalerate was the least toxic pyrethroid for *C. marginiventris* females. Selective use of the insecticides which resulted in higher survival could conserve these native biological control agents increasing their effectiveness.

Introduction

Cardiochiles nigriceps Vierick, *Cotesia marginiventris* (Cresson), and *Micro-plitis croceipes* (Cresson) and are native parasitoids of *Heliothis virescens* (F.). *M. croceipes* also parasitizes *Helicoverpa zea* (Boddie). *H. virescens* and *H. zea* are serious pests of numerous field crops. Both *C. nigriceps and M. croceipes* have been reported as predominant parasitoids attacking their respective hosts on spring wild host plants (Snow et al. 1966, Lewis & Brazzel 1968, Smith et al. 1976, Mueller & Phillips 1983, Stadelbacher et al. 1984). These parasitoids are also important in the control of *H. virescens* and *H. zea* in cotton (Bottrell et al. 1968, Burleigh & Farmer 1978, King et al. 1985). *Cotesia marginiventris* (Cresson) is an important natural enemy of 21 lepidopteran species (Marsh 1979). McCutcheon et al. (1990) reported that *C. marginiventris* is often the most prevalent parasitoid of soybean looper, *Pseudoplusia includens* (Walker), a lepidopterous pest of soybean and cotton in South Carolina. The beet armyworm, *Spodoptera exigua* (Hübner) has in recent years been a serious pest in cotton in the southeast. Natural control of the beet armyworm by a large and diverse complex of natural enemies can suppress populations of this pest below economically-damaging levels (Ruberson et al. 1994).

Since insecticide treatments can disrupt natural enemy complexes, determin-ing the susceptibility of a natural enemy to insecticides is important in understanding the impact of these insecticides on natural enemy populations in the field. We conducted this study to determine mortality of this natural enemy exposed by direct contact with lowest recommended field rates of formulated insecticides presently used in control of insect pests in cotton.

Materials and Methods

Rearing

Laboratory colonies of *C. nigriceps*, *C. marginiventris*, and *M. croceipes* were maintained in cages (85 x 44.5 x 30 cm) with a supply of honeywater (1:1) at 70% RH, 25°C, and a photoperiod of 14:10 (L:D) h. Parasitoids were reared from larvae of *H. virescens* using the procedures of Powell & Hartley (1987). Host larvae were reared on an agar soybean flour-wheat germ diet (King & Hartley 1985) at 27°C, 50% RH, and a photoperiod of 15:9 (L:D) h.

Insecticide Susceptibility

A laboratory spray chamber (Bouse et al. 1970) was used to topically treat adult wasps. The chamber was calibrated to deliver 56 liter/ha, using a single TX 6 cone nozzle, moving at 3.2 km/hr and maintaining 2,109 g/cm² pressure at the spray nozzle. Height of the nozzle above the spray surface was 30.5 cm. For *C. nigriceps* and *M. croceipes*, the fourteen insecticides and the field rates (kg [AI]/ha) sprayed were oxamyl (0.175), thiodicarb (0.84), endosulfan (1.05), acephate (1.05), azinphosmethyl (0.175), chlorpyrifos (0.7), dicrotophos (0.28), dimethoate (0.28), methyl parathion (0.35), profenofos (1.05), bifenthrin (0.084), cyhalothrin (0.035), cyfluthrin (0.042) and cypermethrin (0.056). For *C. marginiventris*, the fourteen insecticides and the field rates (kg [AI]/ha) included: acephate (1.05), azinphosmethyl (0.175), bifenthrin (0.084), cyhalothrin (0.035), cypermethrin (0.056), endosulfan (1.05), esfenvalerate (0.05), fipronil (0.035), methomyl (0.175), methyl parathion (0.35), oxamyl

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(0.175), profenofos (1.05), thiodicarb (0.84), and Pirate (0.28). Water alone was sprayed for controls.

Before spraying, insects were aspirated into petri dishes (100 x 15 mm), lightly anesthetized with CO_2 and immediately placed uncovered on the spray surface in the chamber for treatment. A treatment replicate consisted of 5 male and 5 female adult parasitoids of each species. Each control replicate included 3 male and 3 female adult parasitoids of each species. A treatment was sprayed, and the control was sprayed a few minutes later. Sprayed insects were then placed in an environmental chamber maintained at $25 \pm 2^\circ$C, 50 ± 5% RH and a photoperiod of 14:10 (L:D) h. After 24 h these insects were checked for dead and live individuals. There were 5 replicates for each insecticide resulting in 25 individual parasitoids treated per insecticide. A split block design was used.

A mean of 100% mortality was obtained for many of the treatments in this study. Thus, analysis of variance was not an appropriate test because the assumptions of homogeneity of variance and normal distribution were not met. Confidence intervals for percentage mortality based on the binomial distribution are shown in Tables 1 and 3. Mortality data were compared between insecticides and between *C. nigriceps* and *M. croceipes*. Mortality data for five chemicals for *C. nigriceps* (Table 2) and for three chemicals for *C. marginiventris* (Table 4) did meet the assumptions for an analysis of variance test. In this case, percentage mortality data were converted to arc-sine values and analyzed by analysis of variance (ANOVA) (SAS 1988). Means were separated by a least significant differences test.

Results and Discussion

Response of male and female *M. croceipes* and *C. nigriceps* to the various insecticides studied are shown in Tables 1 and 2. All of the fourteen insecticides tested, except for thiodicarb, were extremely toxic to *M. croceipes*. Treatment by thiodicarb resulted in significantly ($P < 0.05$) lower mortality for *M. croceipes* males and females than treatment by the other chemicals tested.

In contrast to *M. croceipes*, nine of the fourteen insecticides caused high mortality for *C. nigriceps* adults. Treatment with acephate resulted in significantly ($P < 0.05$) lower mortality for *C. nigriceps* than for *M. croceipes*. Mortality also was significantly ($P < 0.05$) lower for *C. nigriceps* than *M. croceipes* when wasps were treated with oxamyl.

Results for the five insecticides which caused lower than 96-100% mortality for *C. nigriceps* adults are shown in Table 3. For both males and females, thiodicarb and acephate were significantly ($P < 0.05$) less toxic than the other three insecticides. Cypermethrin was significantly ($P < 0.05$) less toxic to *C. nigriceps* females than the other three pyrethroids tested.

Eleven of the fourteen insecticides tested were extremely toxic to male and female *C. marginiventris*, causing 92-100% mortality of adult wasps (Table 4). Treatment with three insecticides (thiodicarb, oxamyl, and acephate) resulted in significantly higher survival of *C. marginiventris* adults than was found with the other insecticides tested. For both male and female *C. marginiventris*, thiodicarb and oxamyl were significantly less toxic than acephate (Table 5). Of the three insecticides used in boll weevil control, (oxamyl, azinphosmethyl, and methyl parathion) oxamyl was the least toxic to *C. marginiventris*. Esfenvalerate was the least toxic pyrethroid for *C. marginiventris* females.

The results of the test for *C. marginiventris* are similar to those for *C. nigriceps* adults. Thiodicarb, oxamyl, and acephate were less toxic the other insecticides tested (Tillman 1995). However, only thiodicarb was relatively non-toxic to *M. croceipes* adults when these parasitoids were exposed to this insecticide along with oxamyl and acephate. In conclusion, results of these tests indicate that *C. marginiventris*, *C. nigriceps* and, to a lesser extent, *M. croceipes* are relatively tolerant of only a few insecticides. Selective use of these insecticides should facilitate conservation of these native biological control agents.

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Table 1. Response of male and female *M. croceipes* and to topically applied insecticides at lowest recommended field rate.

Insecticide	Mean percentage of mortality (± 95% CI) *M. croceipes* males	females
thiodicarb	44 (28-60)	0 (0-14)
oxamyl	100 (86-100)	92 (84-100)
acephate	100 (86-100)	100 (86-100)
azinphosmethyl	100 (86-100)	100 (86-100)
chlorpyrifos	100 (86-100)	100 (86-100)
dicrotophos	100 (86-100)	100 (86-100)
dimethoate	100 (86-100)	100 (86-100)
methyl parathion	100 (86-100)	100 (86-100)
profenofos	100 (86-100)	100 (86-100)
endosulfan	100 (86-100)	100 (86-100)
bifenthrin	100 (86-100)	100 (86-100)
cyhalothrin	100 (86-100)	100 (86-100)
cyfluthrin	100 (86-100)	96 (88-100)
cypermethrin	100 (86-100)	96 (88-100)

Table 2. Response of male and female *C. nigriceps* to topically applied insecticides at lowest recommended field rate.

Insecticide	Mean percentage of mortality (± 95% CI) *C. nigriceps* males	females
thiodicarb	0 (0-14)	0 (0-14)
oxamyl	92 (84-100)	60 (44-76)
acephate	0 (0-14)	36 (20-52)
azinphosmethyl	100 (86-100)	88 (76-96)
chlorpyrifos	100 (86-100)	100 (86-100)
dicrotophos	100 (86-100)	100 (86-100)
dimethoate	100 (86-100)	100 (86-100)
methyl parathion	100 (86-100)	100 (86-100)
profenofos	96 (88-100)	100 (86-100)
endosulfan	100 (86-100)	100 (86-100)
bifenthrin	100 (86-100)	100 (86-100)
cyhalothrin	100 (86-100)	100 (86-100)
cyfluthrin	96 (88-100)	96 (88-100)
cypermethrin	100 (86-100)	88 (76-96)

Table 3. Response of male and female *C. nigriceps* to five topically applied insecticides at lowest recommended field rate.[1]

Insecticide	Rate (kg [AI]/ha)	Mean percentage of mortality males	females
thiodicarb	0.84	0 a	0 a
acephate	1.05	0 a	36 b
oxamyl	0.175	92 b	60 c
azinphosmethyl	0.175	100	88 d
cypermethrin	0.056	100	88 d

[1] Values within a column followed by the same letter are not significantly different ($P > 0.05$); comparisons were based on LSD. All data were transformed by arc-sine transformation before analysis.

Table 4. Mortality of male and female *C. marginiventris* to topically applied insecticides at lowest recommended field rate.

Insecticide	Mean percentage of mortality (± 95% CI) males	females
thiodicarb	16 (4-24)	4 (0-8)
oxamyl	32 (16-44)	8 (0-16)
methomyl	100 (86-100)	100 (86-100)
endosulfan	100 (86-100)	100 (86-100)
acephate	84 (72-92)	52 (32-60)
azinphosmethyl	100 (86-100)	100 (86-100)
methyl parathion	100 (86-100)	100 (86-100)
profenofos	100 (86-100)	100 (86-100)
esfenvalerate	96 (88-100)	80 (68-92)
bifenthrin	92 (84-100)	96 (88-100)
cyhalothrin	100 (86-100)	100 (86-100)
cypermethrin	96 (88-100)	92 (84-100)
fipronil	100 (86-100)	100 (86-100)
AC 303,630	100 (86-100)	100 (86-100)

Table 5. Mortality of male and female *C. marginiventris* to three topically applied insecticides at lowest recommended field rate.[1]

Insecticide	Rate (kg [AI]/ha)	Mean percentage of mortality males	females
thiodicarb	0.84	16 a	4 a
oxamyl	0.175	32 a	8 a
acephate	1.05	84 b	52 b

[1] Values within a column followed by the same letter are not significantly different ($P > 0.05$); comparisons were based on LSD. All data were transformed by arc-sine before analysis.