BENOMYL INHIBITION OF *COTESIA (= APANTELES) MARGINIVENTRIS*[1] SURVIVAL IN FOUR LEPIDOPTEROUS HOSTS[2]

T. G. Teague,[3] D. L. Horton,[4] W. C. Yearian, J. R. Phillips
Department of Entomology
University of Arkansas
Fayetteville, AR 72701
(Accepted for publication Nov. 6, 1983)

ABSTRACT

Four noctuid larvae, *Heliothis zea* (Boddie), *Spodoptera exigua* (Hubner), *Pseudoplusia includens* (Walker), and *S. ornithogalli* (Guenee) were reared on semi-synthetic diet in which varying concentrations of the carbamate fungicide benomyl were incorporated. These larvae were exposed to parasitization by *Cotesia (= Apanteles) marginiventris* (Cresson), and the effect of the fungicide on parasitism and host survival determined. Successful parasite emergence from *H. zea, S. exigua,* and *P. includens* was significantly reduced ($P = 0.01$) as benomyl concentration increased. Parasite emergence from *S. ornithogalli* was reduced, but a significantly significant dosage response was not evident. Implications of these findings, including a possible deleterious effect on natural biological control following benomyl application, are discussed.

Key Words: Fungicide, biological control, soybean insect pests.

J. Entomol. Sci. 20(1): 76-81 (January 1985)

INTRODUCTION

The carbamate fungicide benomyl is widely used in a number of crop production systems, including soybean, peanuts, and a variety of vegetable and fruit crops. This use can result in undesirable interactions with some beneficial arthropods and their hosts. Benomyl was found to be mildly toxic to the lady beetle, *Strethorus punctum* (LeConte) (Colburn and Asquith 1973). It was ovicidal and directly toxic in the predaceous mite *Amblyseius fallacis* (Garman) (Nakashima and Croft 1974), and was found to act as an ovipositional repellant to the whitefly parasite *Encarsia formosa* Gahan (Irving and Wyatt 1973).

Benomyl is commonly used as a drug to suppress microsporidian infections in laboratory insect colonies (Hsiao 1973). Teague (unpublished data) observed decreased parasite emergence from field collected *Heliothis* spp. larvae when they were fed semi-synthetic diet containing benomyl compared to larvae fed similar diet without benomyl. Subsequent laboratory studies by Horton et al. (unpublished data) indicated benomyl inhibited emergence of *Microplitis croceipes* (Cresson) (Hymenoptera: Braconidae) from *Heliothis* spp. larvae which had been fed semi-synthetic diet containing benomyl at concentrations greater than 10 ppm.

The braconid, *Cotesia (= Apanteles) marginiventris* (Cresson),[5] is a common larval parasite of a number of economically important lepidopterous pests. These

[1] Hymenoptera: Braconidae
[2] Published with approval of the Director, Arkansas Agric. Exp. Stn.
[3] Present address: Department of Entomology, Texas A & M University, College Station, TX 77843.
[4] Present address: Extension Entomology Department, University of Georgia, Athens, GA 30602.
[5] The genus *Apanteles* has been revised, and *marginiventris* now lies in *Cotesia* (Mason 1981).

include *Spodoptera exigua* (Hubner) (Wilson 1933), *Heliothis virescens* (F.) (Snow et al. 1966; Boling and Pitre 1970; Harding 1976), *Pseudoplusia includens* (Walker), *Trichoplusia ni* (Hubner) (Boling and Pitre 1970), *H. zea* (Boddie), *Plutella xylostella* (L.) (Harding 1976), and *Plathypena scabra* (F.) (Mueller and Kunnalaca 1979). With its wide host range, *C. marginiventris* may play an important role in pest population regulation in several agroecosystems. This study examines the potential impact of benomyl on successful parasitization by *C. marginiventris* of four noctuid hosts including its effect on host survival.

MATERIALS AND METHODS

Neonate *H. zea* (bollworm), *P. includens* (soybean looper), *S. ornithogalli* (yellow stripped armyworm), and *S. exigua* (beet armyworm) were reared in separate 266 ml waxed paper cups on a modified pinto bean diet (Burton 1969) containing benomyl at concentrations of 0, 15, 25, 40, and 55 pm. Parasitism was effected utilizing a technique similar to that described by Boling and Pitre (1970). For each treatment, one 2-day old mated *C. marginiventris* female was released in a cup containing ca. 30 2-day old larvae of a single species. Each female was used only once. After 24 hrs host larvae were removed from ovipositional cups and isolated in individual 30 ml clear plastic diet cups containing diet of like benomyl concentration. Equal numbers of non-parasitized larvae were handled similarly. All host larvae were reared to pupation or death at ca. 27°C with a photoperiod 16L:8D and ca. 55% RH.

The experiment was designed as a 6 × 4 × 2 factorial with treatments and replications conducted simultaneously. Oviposition cups containing ca. 30 larvae served as single parasite replicates. Each treatment was replicated four times in both parasitized and non parasitized groups, except *S. ornithogalli* treatments which were replicated five times. Host mortality due to fully emerged parasite larvae (successful parasitism), host mortality without parasite emergence, and host survival (host pupation) were recorded. Inhibition of successful parasitism at various benomyl concentrations was calculated using a probit analysis, maximum likelihood method. Parasitized larvae which succumbed prior to parasite emergence emergence were randomly selected for dissection and examined for the presence of parasite larvae. Experimental results were subjected to analysis of variance and least significant difference test. Inhibition of parasitism at various benomyl concentrations was calculated using probit analysis, maximum likelihood method.

RESULTS

Emergence of *C. marginiventris* from *H. zea, P. includens,* and *S. exigua* that were reared on treated diet was significantly reduced ($P = 0.01$) as benomyl concentration increased (Fig. 1). Suppression of parasite emergence from *H. zea* showed a pronounced response to benomyl concentrations. The EC_{50} value, the median effective concentration of benomyl in diet required to reduce successful parasite emergence by 50%, was 7.0 ppm for *H. zea.* When dead *H. zea* which had been exposed to ovipositing parasites but from which no parasite emerged were dissected, various stages of dead *C. marginiventris* were commonly found. Similar observations were not made from dead *H. zea* larvae in the control group.

The reduction in parasite emergence from *S. exigua* and *P. includens* fed benomyl treated diet was comparable to that from *H. zea.* The EC_{50}'s for *C. marginiventris*

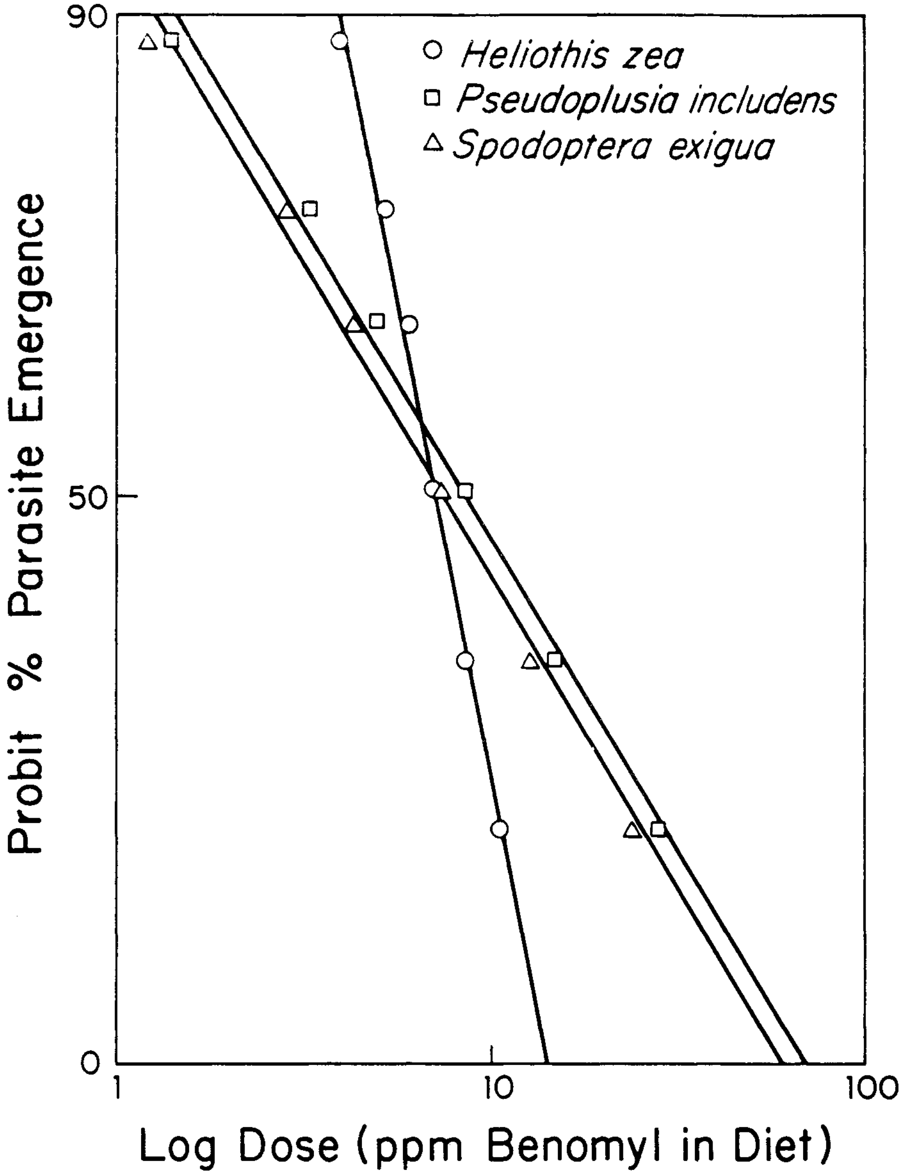

Fig. 1. Successful *C. marginiventris* emergence from hosts reared on semi-synthetic diet containing different concentrations of benomyl.

parasitized *S. exigua* and *P. includens* were 7.3 and 8.4 ppm benomyl in diet, respectively. As with *H. zea,* random dissections of *S. exigua* and *P. includens* parasitized larvae reared on benomyl treated diet frequently revealed dead *C. marginiventris* larvae.

In many cases, parasitized *H. zea, S. exigua,* and *P. includens* larvae from which there was no parasite emergence, were observed to remain in the 2nd or 3rd instar for 20 - 30 days following parasite oviposition. Normally, parasite emergence from 2nd or 3rd instar larvae occurs at 6 - 10 days following oviposition (Boling and Pitre 1970). Dissections of these live hosts revealed one or several live 2nd or 3rd stage *C. marginiventris* larvae which appeared to have ceased development.

At the concentrations tested, benomyl had no significant effect on *C. marginiventris* emergence from *S. ornithogalli*. Parasite emergence ranged from 93.2% at 0 ppm to 83.3% at 55 ppm and did not necessarily decrease over the dosage range.

Benomyl, at the concentrations tested, appeared to have little effect on survival and development of non-parasitized host larvae (Fig. 2). These results support

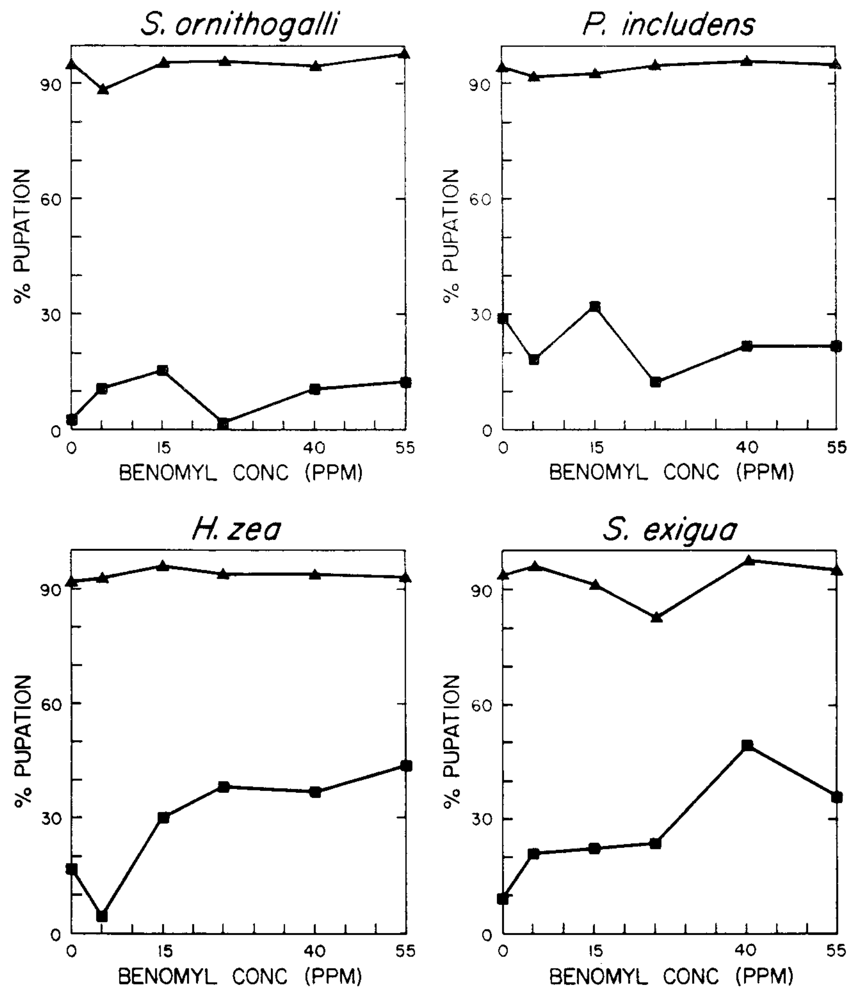

Fig. 2. Survival (% pupation) of four noctuid larvae, non-parasitized (▲) and parasitized (■) by *C. marginiventris*, when reared on semi-synthetic diet containing different concentrations of benomyl.

those of Livingston et al. (1978) who observed very low levels of benomyl toxicity to *H. zea* (LC_{20} 10,900 ppm) and *P. includens* (LC_{50} 3080.2 ppm).

Pupation (survival) of host larvae which had been exposed to parasites appeared to be affected in 2 species. As benomyl concentration increased mean host survival was significantly higher ($P = 0.01$) for parasitized *S. exigua* (Fig. 2). A similar increase in host survival was observed for *H. zea* at a less significant level ($P = 0.06$). Survival of parasitized *P. includens* and *S. ornithogalli* was not affected by the benomyl concentrations tested.

DISCUSSION

Differences in insecticidal susceptibility between parasite adults and their hosts is well documented (Lingren et al. 1972; Plapp and Vinson 1977; Rajakulendran and Plapp 1982). Susceptibility differences also have been noted between parasitized and non-parasitized hosts. Fix and Plapp (1983) observed that larvae of *H. virescens* parasitized by *Cardiochiles nigriceps* Viereck (Hymenoptera: Braconidae), were 14 × more sensitive to methyl parathion than non-parasitized larvae.

In the present study, we observed a decrease in *C. marginiventris* survival when *P. includens, H. zea,* and *S. exigua* host larvae were fed benomyl treated diet. This response to fungicide in host diet was not observed with *S. ornithogalli* at the benomyl concentrations tested. Reasons for lack of response in this host are unknown. In *P. includens,* benomyl did not impair the ability of the parasite to kill its host, but it did impede normal development of the parasite larva within the host. In parasitized *H. zea* and *S. exigua* fed benomyl treated diet, successful parasite oviposition occurred, but the inhibition of parasite development seen in *P. includens* may have been more pronounced since there was an increase in host survival as benomyl concentration increased. Dissections suggested that benomyl may have induced rapid parasite death at these higher concentrations. Early benomyl related parasite mortality could account for the higher host survival that occurred in benomyl fed *H. zea* and *S. exigua.* We suggest that in these hosts, death of the parasite larvae occurred before the parasite inflicted damage sufficient to kill its host. There was no indication of benomyl lessening the parasite's ability to kill *P. includens,* even at rates that precluded parasite emergence. It is possible that differential susceptibility of larval parasites and their hosts could result in selective mortality of parasitized hosts and/or parasites within the host.

Cotesia marginiventris parasitizes a broad range of hosts and contributes to natural control in several crop production systems. With the prevalent usage of benomyl in some of these agroecosystems, our data indicate potential suppression of successive generations of *C. marginiventris* following benomyl application. Subsequent reduction in natural biological control could contribute to pest resurgence or secondary pest outbreak. Toxicological studies of benomyl's effect on parasite development along with broad field evaluation will be necessary to better understand this parasite-host-pesticide interaction.

ACKNOWLEDGMENTS

We wish to thank Margaret McClendon for host rearing, W. J. Lewis, ARS, USDA, Southern Grain Insect Research Laboratory, Tifton, GA, for providing our *C. marginiventris* culture, and Paul Teague for his assistance throughout the course of this effort.

LITERATURE CITED

Boling, J. D., and H. N. Pitre. 1970. Life history of *Apanteles marginiventris* with descriptions of immature stages. J. Kansas Entomol. Soc. 43: 465-70.

Burton, R. L. 1969. Mass rearing the corn earworm in the laboratory. USDA, ARS, 33-134. 8 pp.

Colburn, R., and D. Asquith. 1973. Tolerance of *Strethrous punctum* adults and larvae to various pesticides. J. Econ. Entomol. 66: 961-2.

Fix, L. A., and F. W. Plapp, Jr. 1983. The effect of parasitism on the susceptibility of the tobacco budworm to methyl parathion and permethrin. Environ. Entomol. (in press).

Harding, J. A. 1976. *Heliothis* spp.: Parasitism and parasites plus host plants and parasites of the beet armyworm, diamondback moth and two tortricids in the Lower Rio Grande Valley of Texas. Environ. Entomol. 5: 669-71.

Hsiao, T. H. 1973. Benomyl: a novel drub for controlling a microsporidian disease in alfalfa weevil. J. Invert. Pathol. 22: 303-4.

Irving, S. N., and I. J. Wyatt. 1973. Effects of sublethal doses of pesticide on the oviposition behavior of *Encarsia formosa.* Ann. Appl. Biol. 75: 57-62.

Lingren, P. D., D. A. Wolfenbarger, J. B. Nosky, and M. Diaz. 1972. Response of *Campoletis perdistinctus* and *Apanteles marginiventris* to insecticides. J. Econ. Entomol. 65: 1295-9.

Livingston, J. M., W. C. Yearian, and S. Y. Young. 1978. Insecticidal activity of selected fungicides: Effects on three lepidopterous pests of soybean. J. Econ. Entomol. 71: 111-2.

Mueller, A. J., and S. Kunnalaca. 1979. Parasites of green cloverworm on soybean in Arkansas. Environ. Entomol. 8: 376-9.

Nakashima, M. J., and B. A. Croft. 1974. Toxicity of benomyl to the life stages of *Ambylseius fallacis.* J. Econ. Entomol. 67: 675-7.

Rajakulendran, S. Victor, and F. W. Plapp, Jr., 1982. Comparative toxicities to five semisynthetic pyrethroids to the tobacco budworm (Lepidoptera: Noctuidae), an Ichnemonid parasite, *Campoletis sonorensis,* and a predator, *Chrysopa carnea.* J. Econ. Entomol. 75: 769-72.

Snow, J. W., J. J. Hamm, and J. R. Brazzel. 1966. *Geranium carolineanum* as an early host of *Heliothis zea* and *H. virescens* (Lepidoptera: Noctuidae) in the Southeastern United States, with special notes on associated parasites. Ann. Entomol. Soc. Am. 59: 506-9.

Wilson, J. W. 1933. The biology of parasites and predators of *Laphygma exigua* Huebner reared during the season of 1932. Fla. Entomol. 17: 1-15.