# EFFECTS OF ABAMECTIN ON *PHIDIPPUS AUDAX* (HENTZ) (ARANEAE: SALTICIDAE) WHEN INGESTED FROM PREY[1]

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## ABSTRACT

*Phidippus audax* (Hentz) were allowed to feed on bollworm, *Heliothis zea* (Boddie), larvae which had ingested diet containing three concentrations of abamectin. Significantly reduced weight gain was noted for spiders feeding on the treated larvae and toxicity effects were visible in most of the spiders within 48 h. Over 80% of the spiders that fed on larvae from diet containing 10 ppm abamectin were either torpid or dead, and 100% of spiders that fed on larvae from diet containing 40 ppm abamectin were torpid or dead.

Key Words: *Heliothis zea,* bollworm, avermectins, spiders, prey, toxicity, *Phidippus audax.*

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## INTRODUCTION

The newly discovered class of macrocyclic lactones called avermectins have shown high potencies as toxicological agents against several agricultural pests. These soil actinomycete-produced compounds apparently act by inhibiting nervous signal transmissions at the neuromuscular junctions of arthropods (Putter et al. 1981). The discovery of this class of compounds, originally showing significant antihelminthic activity, was described by Campbell et al. (1984). Putter et al. (1981) reported the insecticidal properties of avermectin $B_{1a}$ (AVM) against eight arthropod species in the orders Coleoptera, Lepidoptera [including the bollworm, *Heliothis zea* (Boddie)], Acarina, and Homoptera. Subsequent reports of insecticidal activity of the avermectins have shown them to be effective against southern armyworm, *Spodoptera eridania* (Cramer); tobacco budworm, *H. virescens* (F.) (Anderson et al. 1986); boll weevil, *Anthonomus grandis grandis* Boheman; *Heliothis* spp. (Wright et al. 1985); German cockroach, *Blattella germanica* (L.) (Cochran 1985); *Liriomyza* spp. leafminers (Brown and Dybas 1982); and the alfalfa weevil, *Hypera postica* (Gyllenhal) (Pienkowski and Mehring 1983). AVM was also shown to be a potent inhibitor of reproduction in the red imported fire ant, *Solenopsis invicta* Buren (Lofgren and Williams 1982).

The mode of action of abamectin (ABM, MK-936), a mixture of avermectins $B_{1a}$ and $B_{1b}$, on the *Heliothis zea* nervous system was investigated by Agee (1985a,b). He found that ingestion of ABM caused general torpidity and loss of muscular function within 16 h of ingestion, while topical application of ABM had no effect on sensory or motor action nerve potentials. Studies by Fritz et al. (1979) indicate

[1] In cooperation with the South Carolina Agricultural Experiment Station. This article reports the results of research only. Mention of a proprietary product does not constitute endorsement or a recommendation for its use by the USDA.

that AVM is a gamma-aminobutyric acid agonist that inhibits postsynaptic potentials without affecting cholinergic nervous systems. Thus, animals affected by these compounds tend to become inactive or torpid and may remain alive for a considerable time after ingesting the compounds.

Musuclar paralysis with resulting starvation, water loss, and other unknown physiological effects are probably factors in the effectiveness of the avermectins at low dosages and the period of torpidity before death. A concentration of 0.025% AVM in soybean oil bait caused queen sterility and loss of all brood of *S. invicta* within 4 weeks in laboratory tests, and in field tests, up to 87% control of colonies was achieved with rates of 0.12, 0.25, and 0.47g/ha (Lofgren and Williams 1982). Cochran (1985) reported that AVM at concentrations of 6.5 ppm and higher on food produced 87 - 100% mortality of *B. germanica* after 10 days feeding, and mortality in survivors continued to increase up to 30 days after ingestion. Thus, the effects of the avermectins appear to be prolonged due either to stability of the compounds or to their causing permanent damage to the neuro-motor system.

In the present study, we investigated the possibility that a toxic dose of ABM might be ingested by a predator from larvae of *H. zea,* which had ingested the material from treated diet. The predator chosen was a jumping spider, *Phiddippus audax* (Hentz), which had been collected while feeding on *H. zea* larvae in the field (Whitcomb and Bell 1964).

## MATERIALS AND METHODS

*Heliothis zea* were cultured in the laboratory on a wheat germ diet similar to that described by Adkisson et al. (1960), but modified by substituting cottonseed flour for casein as a protein source (Moore 1986). The insects were held in a constant LD 16:8 photoperiod at 26.5 ± 2° C and 40 ± 10% RH. Third-instar larvae from the rearing colony were weighed and placed on the same diet containing 0, 10, 20, or 40 ppm of ABM and allowed to feed for 24 h. After 24 h, the larvae were removed from the diet, reweighed, and then offered to *Phidippus audax* spiders. These spiders were field collected (penultimate stage) from overwintering aggregations on the Pee Dee Research and Education Center farm. They were fed on untreated *H. zea* larvae for 2 weeks prior to inclusion in the test. Each spider was weighed prior to being offered the ABM-treated larva, and was reweighed 24 h after feeding on the treated larva. Afterwards, the spiders were held for 48 h and observed for mortality and loss of physical mobility. Only *H. zea* larvae still capable of at least limited movement when probed were given to the spiders and only spiders which actually fed on the larvae were used for observations. Replications consisted of four groups of 10 spiders for each concentration of ABM fed to the larvae.

## RESULTS AND DISCUSSION

Preliminary investigations showed that 40 - 90% of *H. zea* larvae fed on diets containing 10, 20, and 40 ppm ABM were killed within 48 h (Moore, unpub. data). Therefore, *H. zea* larvae were allowed to feed for only 24 h on the treated diets before being fed to the spiders. In most trials, the spiders attacked and fed on the treated larvae but frequently there was a significant decrease in weight gain by spiders which had fed on treated larvae as compared to spiders fed on untreated

larvae. *Heliothis zea* larvae fed on untreated diet gained an average of 24.5 ± 10mg after 24 h, while larvae fed on the diets containing ABM gained an average of 13.6 ± 11 mg in 24 h. The reduced weight gain in treated larvae may have resulted from decreased feeding, decreased assimilation, or loss of body fluids. Similarly, spiders fed on the larvae showed a decrease in weight gain from 22 ± 7 mg when fed untreated larvae, to 12.4 ± 5 mg when treated larvae were consumed. Thus, the ABM apparently had a rapid effect on spiders consuming the compound even though mortality may have been delayed.

Noticeably abnormal behavior, such as loss of balance and reduced reaction to probing, was shown by many of the spiders within 24 h, especially when fed *H. zea* larvae containing the higher doses of ABM. After 48 h, general muscular dysfunction, cessation of feeding, or morbidity was obvious among the spiders that had fed on the ABM-treated larvae (Table 1). Sixty-five percent of spiders feeding on the larvae that had fed on the diet containing 10 ppm ABM were sedated and 17% were moribund or dead. At 20 ppm ABM in the diet, over 90% of spiders that fed on the larvae were either torpid or moribund, and at 40 ppm, 100% of the spiders were sedated or killed by ingesting ABM from the body fluids of the *H. zea* larvae. Studies by Bull (1986), using radioactive labeled AVM, showed that *H. zea* rapidly excreted the AVM and also metabolized the compound to several transformation products. Thus, using consumption and weight gain as a measure of AVM causing specific levels of toxicity could be misleading. In addition, considerable variability in weight gain by the spiders occurred and the amount of chemical actually ingested could not always be related to toxicity symptoms. This was especially true for those spiders that fed on larvae which had fed on diet containing the higher amount of ABM.

Table 1. Ingestion of abamectin (ABM) by third-instar *Heliothis zea* (Boddie) larvae and subsequent ingestion by *Phidippus audax* (Hentz) that fed on the larvae, and the effects on the spiders after 48 h.

| ppm ABM in larval diet | No. spiders tested* | % Spiders torpid in 48 h† | % Spiders moribund in 48 h† |
|---|---|---|---|
| 0 | 37 | 0 b | 0 b |
| 10 | 29 | 65 a | 18 b |
| 20 | 31 | 38 ab | 53 a |
| 40 | 34 | 21 b | 79 a |

* Number of spiders actually feeding on larvae.

† Reading vertically, same letters indicate no significant difference; Student-Newman Keul's test, 0.05 level.

Previous reports on the toxicity of ABM to *H. zea* larvae have largely been based on surface sprays or residue exposure (Putter et al. 1981, Wright et al. 1985). Putter et al. (1981) reported an $LD_{90}$ of 1.5 ppm for *H. zea* on treated foliage. Anderson et al. (1986) reported an $LC_{50}$ of 0.006 ppm for *H. virescens* larvae on ABM-treated bean foliage, compared to an $LC_{50}$ of 0.72 μg/g body weight for topical applications of ABM. A more detailed study by Bull (1986) showed that AVM-$B_1$ was more toxic to 3rd instar *H. virescens* ($LD_{50}$ = 0.023 μg/larva) than to *H. zea* ($LD_{50}$ = 0.206 μg/larva), and that *Spodoptera frugiperda* (J. E. Smith) was largely unaffected by dosages as high as 10 μg/larva. He also found that even low dosages that did not cause short-term toxicity to *H. virescens* and *H. zea* caused

later developmental and pupation disruption. These and other studies indicated that feeding inhibition occurs before torpidity or death of the insect, so the amount of chemical actually ingested is difficult to determine. The high level of toxicity of the ABM inside the *H. zea* body indicates considerable stability of the compound or a degree of toxicity by the by-products of metabolism.

Under field conditions, Bull et al. (1984) found 82 and 98% degradation of ABM on cotton after 48 and 192 h, respectively, and indicated the compound may be wavelength and intensity sensitive. Mizell et al. (1986) confirmed that ABM became less toxic to spider mites more rapidly under sunlight than fluorescent light. Comparison of the toxicity of ABM to other chemicals used in insect control is limited in the literature. Anderson et al. (1986) reported topical $LD_{50}$'s for *H. virescens* for ABM and fenvalerate of 0.72 μg/g and 0.64 μg/g, respectively. Topical $LD_{50}$ values for AVM to *H. zea* and *H. virescens* were found to be 1 μg per larva for even late-stage larvae by Wolfenbarger et al. (1985). The topical $LD_{50}$ of fenvalerate, azinphosmethyl, and methyl parathion to *P. audax* spiders was previously reported by Roach (1983). In the present study, the $LD_{50}$ of 24.13 μg/g for fenvalerate topically applied to the spiders (Roach 1983) appears to be higher than the amount of ABM necessary to cause toxic effects when ingested.

Previous studies (Pfeiffer 1985, Grafton-Cardwell and Hoy 1983) have indicated that ABM is less toxic to predatory mites than to pest species. In the case of *P. audax*, which will only orient toward and attack moving prey (Freed 1984), ingestion of ABM would probably occur only when the prey had fed on a sublethal dose or had not succumbed to the ABM. Since *H. zea* becomes torpid within 24 h of feeding on ABM (Wright et al. 1985), the period when the spider could be affected by feeding on torpid larvae is limited. The results of the present study indicated ABM was toxic to *P. audax* by ingestion from treated *H. zea* larvae and thus may constitute a hazard to the spider when applied to field situations.

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