NOTE

Effects of Neem (*Azadirachta indica* A. Juss) on Predators of *Nezara viridula* (L.) (Hemiptera: Heteroptera: Pentatomidae)[1]

Mumuni Abudulai,[2] B. Merle Shepard, and Paula Levin Mitchell[3]

Clemson University, Coastal Research and Education Center 2700 Savannah Highway, Charleston, South Carolina 29414 USA

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Predators are important mortality agents of *Nezara viridula* (L.) (Hemiptera: Heteroptera: Pentatomidae), a highly polyphagous pest species with cosmopolitan distribution on agricultural and horticultural crops (Panizzi 1997). Ants and coccinellids attack eggs and nymphs of *N. viridula* in the field causing significant mortality (Ragsdale et al. 1981). However, control programs for *N. viridula* almost always include synthetic chemical insecticides (Hoffmann et al. 1987) that negatively impact nontarget beneficial organisms (Croft 1990). As a result, this approach is often not compatible with sustainable integrated pest management. This problem has led to an increased interest in alternative materials that are less destructive to biological control organisms than synthetic insecticides for integrated pest management programs (Schmutterer 1997).

The effects of neem (*Azadirachta indica* A. Juss) extracts on insects have received considerable attention (Mordue & Blackwell 1993). The major active ingredient in neem, azadirachtin, has low mammalian toxicity and yet it is effective against 413 insect species from several orders (Singh & Saxena 1999). Neem compounds act on insects in various ways, including repelling adults and larvae, disrupting the developmental processes, inducing adult sterility, and disturbing adult behavior (Schmutterer 1990, Mordue & Blackwell 1993).

Except for a few reports, the effects of neem on insect predators have not been investigated adequately (Lowery & Isman 1995, Schmutterer 1997). Schmutterer (1997) reported that neem products are safe to spiders, numerous beneficial insects, and eggs of predators such as coccinellids, with only slight side-effects observed under semifield and field conditions. In direct toxicity tests, Tedeschi et al. (2001) reported noxious effects of neem to the predator, *Macrolophus caliginosus* Wagner (Hemiptera: Heteroptera: Miridae), but found no significant differences in mortality and fecundity of surviving females compared with controls 5 d after treatment. Qi et al. (2001) tested the effects of exposure of predators

[1]Accepted for publication 2 June 2004.
[2]Present address: CSIR-Savanna Agricultural Research Institute, P. O. Box 52, Tamale, Ghana.
[3]Department of Biology, Winthrop University, Rock Hill, South Carolina 29733 USA.

indirectly to neem seed extracts by feeding adults of *Harmonia conformis* (Boisduval) (Coleoptera: Coccinellidae) and larvae of *Mallada signatus* (Schneider) (Neuroptera: Chrysopidae) with larval prey, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae), that had eaten neem oil solution. They reported that 50- and 200-ppm azadirachtin treatments were not toxic to *H. conformis* adults and *M. signatus* larvae, but there were negative effects on metamorphosis and pupal survival in *M. signatus.*

The present studies were conducted to evaluate the effects of the commercial neem formulation Neemix 4.5 EC (Certis USA, Columbia, Maryland) on predators of *N. viridula* eggs in the field. These data may be useful in the development of a pest management approach that integrates biological control with neem for control of *N. viridula* in cowpea.

Colonies of *Nezara viridula* were established from bugs collected from fields of collards (*Brassica oleracea* L.) and green beans (*Phaseolus vulgaris* [L.]) in Charleston, South Carolina. Bugs were reared on green beans in metal screen cages (36 × 36 × 36 cm) in a rearing room at 24 ± 0.5°C room temperature, 55–65% RH, and a photoperiod of 14:10 (L:D) h. Egg masses were harvested daily from paper towel strips that were used as oviposition sites in the cages and were either used for colony maintenance or kept frozen at –20°C (Powell & Shepard 1982) until ready for use.

Neemix®, a commercial neem formulation containing 4.5% azadirachtin as the active ingredient, was used in this study. The formulation was diluted with distilled water to form a solution of 0.5% (225 ppm azadirachtin a.i.) for the tests. This concentration was the rate used for *N. viridula* control in the field (Abudulai et al. 2003). A 1-ml quantity of neem solution or distilled water was applied with a pipette to an egg mass and spread over the surface using a fine camel-hair brush.

A neem-treated and a water-treated egg mass were placed on opposite sides of individual cowpea plants. Small strips (2 × 4 cm) cut from white index cards containing *N. viridula* egg masses were stapled to the under surface of leaves. Twenty egg masses (10 pairs) were randomly placed in each of four plots measuring 20 × 30 m. Eggs were placed in the field when plants were in the late podding stage on 12 August 2000. The experiment was repeated beginning on 16 August 2001. Egg masses were examined briefly in the field at least two times a day, beginning on the day following placement, and any predators feeding on them were noted. After 7 d, egg masses were collected and eggs were counted. All missing and partly eaten eggs were considered damaged by predators.

The response of predators to neem was measured by placing untreated *N. viridula* egg masses in neem-treated fields. Treated plots were sprayed with 0.5% aqueous neem solution (with 210.4 g azadirachtin per ha) using a tractor-mounted boom (5.5-m swath width). Untreated plots served as controls. On the day after treatment, 20 egg masses, each glued to an index card strip (2 × 4 cm), were fastened under cowpea leaf surfaces in each plot (30 × 15 m) using paper clips. Field experiments began on 15 August 2000 and 21 August 2001. As with the previous test, experimental egg masses were observed twice daily in the field; any predators feeding on them were noted. After 7 d, egg masses were removed from the field and counts were taken.

All plots were arranged in a randomized complete block design with four replications. Data were analyzed by using *t*-tests to compare treated and untreated egg masses or plots. Means were separated at $P < 0.05$ (SAS Institute 1996).

Egg predation was not significantly different between neem-treated and water-treated eggs in 2000 and 2001 ($t = 1.02$, 2000; $t = 0.17$, 2001; df = 3; $P > 0.05$; Fig. 1A). Similarly, percent predation on eggs in treated and untreated plots was not significantly different in 2000 and 2001 ($t = 0.42$, 2000; $t = 0.67$, 2001; df = 3; $P > 0.05$; Fig. 1B). These results suggest that neem treatments did not affect predation of *N. viridula* eggs in the field.

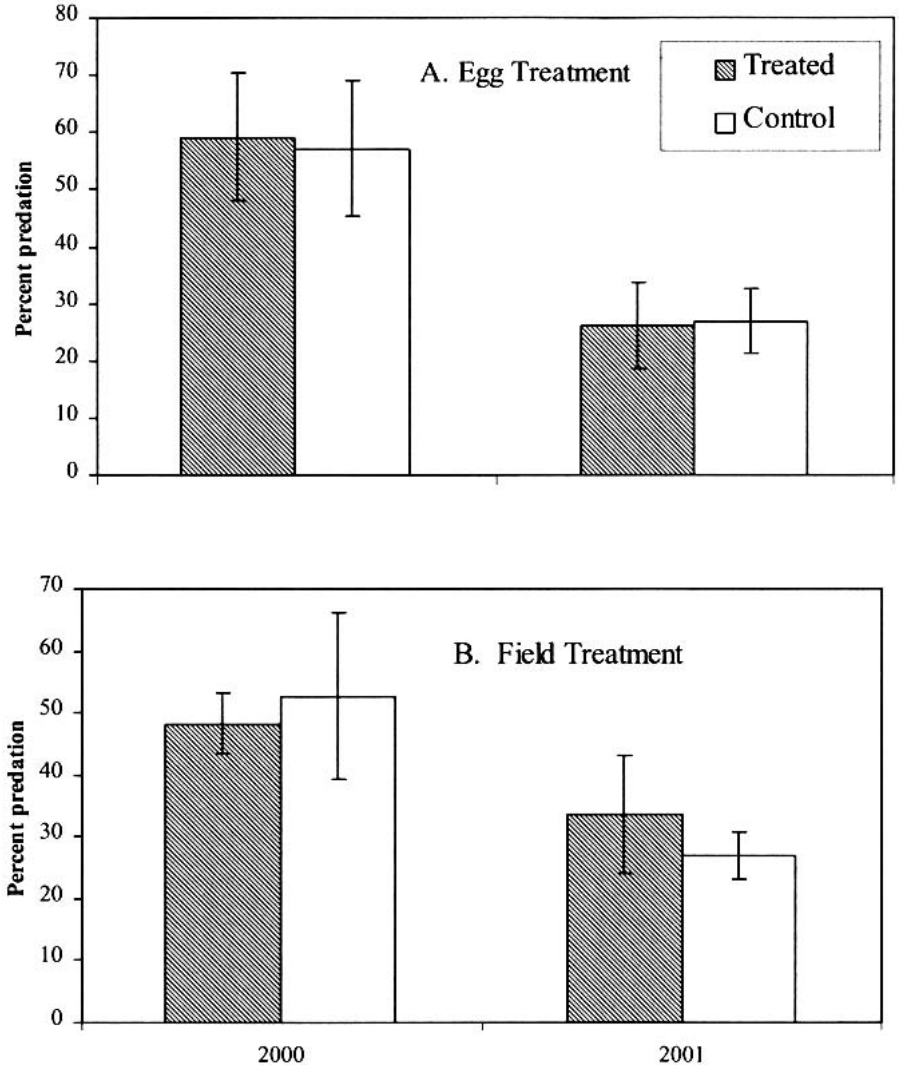

Fig. 1. Mean (± SE) percent predation on *Nezara viridula* eggs in 2000 and 2001. A, eggs were treated with neem or distilled water control. B, cowpea fields were treated with neem or untreated control. No significant differences were detected between the treatments ($P > 0.05$, *t*-test).

During the study, red imported fire ants, *Solenopsis invicta* Buren (Hymenoptera: Formicidae), were regularly seen preying on egg masses in the field. Also, *Coccinella septempunctata* L., *Coleomegilla maculata lengi* (DeGeer), and coccinellid larvae (Coleoptera: Coccinellidae) were observed preying on eggs. Other predators of eggs were *Geocoris punctipes* (Say) (Hemiptera: Heteroptera: Geocoridae), *Conoderus falli* (L.) (Coleoptera: Elateridae) and *Oecanthus celerinictus* Walker and *Gryllus* sp. (Orthoptera: Gryllidae). Other workers have reported that fire ants, coccinellids, and orthopterans are major predators of *N. viridula* eggs (Ragsdale et al. 1981, Stam et al. 1987, Justo 1994).

Several studies suggest that neem is nontoxic to ants and coccinellids. Schmutterer (1990) reported that feeding of *Ectatomma ruidum* (Roger) (Hymenoptera: Formicidae), with neem-contaminated larvae of *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) had no negative influence on the predator. Schmutterer (1997) also observed that feeding of neem to the red forest ant, *Formica polyctena* Foerster (Hymenoptera: Formicidae), led to a stimulation of egg production when low concentrations were used. In laboratory tests, Hoelmer et al. (1990) found that the commercial neem insecticide Margosan-O was not toxic to adult coccinellid predators held for up to 2 weeks on treated foliage. Also, Neemix was virtually nontoxic to larvae of *C. septempunctata* exposed to direct sprays in the laboratory (Banken & Stark 1997).

In summary, data from this study suggest that neem may not interfere with predation on *N. viridula* eggs. Egg parasitism by *Trissolcus basalis* (Wollaston) (Hymenoptera: Scelionidae), an important biological control agent, also is unaffected by neem treatment (Abudulai & Shepard 2003). Thus, neem could be an important component of an integrated pest management program in cowpea.

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