EVALUATION OF NEEM TRITERPENES AS OVIPOSITIONAL AND FEEDING DETERRENTS TO THE TEA MOSQUITO BUG, *Helopeltis antonii* Sign. ON CASHEW

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree

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DECLARATION

I hereby declare that this thesis entitled "**Evaluation of neem triterpenes as ovipositional and feeding deterrents to the tea mosquito bug, *Helopeltis antonii* Sign. on cashew**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Certified that this thesis entitled "Evaluation of neem triterpenes as ovipositional and feeding deterrents to the tea mosquito bug, Helopeltis antonii Sign. on cashew" is a record of research work done independently by Mr. K. Angaiah, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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We, the undersigned members of the Advisory Committee of **Mr. K. Angaiah,** a candidate for the degree of Master of Science in Agriculture with major in Agricultural Entomology, agree that the thesis entitled **"Evaluation of neem triterpenes as ovipositional and feeding deterrents to the tea mosquito bug, *Helopeltis antonii* Sign. on cashew"** may be submitted by Mr. K. Angaiah, in partial fulfilment of the requirement for the degree.

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Dedicated to
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INTRODUCTION

Cashew (*Anacardium occidentale* L.) is a major cash crop grown in India, Brazil, Kenya, The Philippines and some other tropical countries. India ranks first in area (5.39 lakh hectares) and production (3.49 lakh tonnes of raw nuts). More than 60 species of insects attack the crop during its different stages of the growth (Pillai, 1980). The tea mosquito bug, *Helopeltis antonii* Sign. is considered to be the most serious pest of cashew causing upto 50 per cent yield losses.

The nymphs and adults suck the sap from tender shoots, inflorescence, immature nuts and apples. The infested shoots develop black lesions which gradually dry up. The average damage to tender shoots was estimated from 14 (Sathiamma, 1977) to 25 per cent (Abraham, 1958; Pillai, 1980). Similar type of damage to inflorescence results in blossom blight and as much as 48 per cent panicle damage was reported by Sathiamma (1977). The infestation on immature nuts develops characteristic eruptive black spots and finally such nuts shrivel and fall down. Pillai (1980) estimated the nut damage and fruit drop to the extent of 15 and 12.29 per cent respectively due to the infestation of the pest.

Timely plant protection plays a key role in cashew cultivation. Earlier workers reported that the tea mosquito bug can be effectively controlled by application of three sprays of 0.05 per cent endosulfan from the time of emergence of new flush to fruit set. Recent studies conducted by Godase et al. (1993) indicated that 0.05 per cent monocrotophos, 0.1 per cent carbaryl, 0.05 per cent endosulfan and 0.07 per cent phasalone were the most effective insecticides against tea mosquito bug when applied at the time of emergence of new flushes and two sprays thereafter at an interval of one month.

In general it can be stated, without fear of contradiction, that scheduled application of insecticides have caused problems like residues in soil, water, air, food and fodder, adverse effect on non-target organisms, development of resistance in pests to insecticides, and induction of resurgence of target and non-target pests. For these reasons, importance of insecticidal botanicals and their use as candidates for inclusion in the arsenal of weapons for pest management has increased during recent years. Among the numerous ingredients of plants studied during the last 20 years, extracts and compounds from the neem tree, Azadirachta indica A. Juss have attracted the special attention of entomologists and phytochemists all over the world. The neem tree is known to possess some amount of toxic principles in all its parts which act as feeding or ovipositional deterrents against many insects.

The use of neem products for practical pest management in cashew, to a certain extent, is hampered on the one hand by the non-availability of standard commercial neem preparations in the market. On the other hand, neem being the alternate host for *H. antonii*, an apparently genuine apprehension that neem products may not be effective against this insect also existed.

The present studies were taken up to evaluate commercial neem products for the effective management of populations of *H. antonii* Sign. with the following objectives.

1. To evaluate the feeding deterrency of commercially available neem products through contact action of treatments in the test insect, *H. antonii*.

2. To evaluate the feeding deterrency of the neem products through translaminar action of treatments on the test insect.

3. To evaluate the ovipositional deterrency of the neem products in the test insect.

Plate 1. Necrotic lesions on tender shoots caused by feeding of nymphs of *H. antonii*

Plate 2. Dried up twig following development of necrosis

Plate 3. Adult male of *H. antonii*

Plate 4. Adult female of *H. antonii*

Review of Literature

REVIEW OF LITERATURE

The mirid bug, Helopeltis antonii Sign., commonly known as 'tea mosquito' is considered to be the most serious pest of cashew in view of the heavy economic losses it can cause to the crop. The pest incidence is reported to be severe in most of the cashew growing tracts of Kerala, Karnataka, Goa, and Maharastra on the West Coast and also in Tamil Nadu in the east coast (Pillai et al., 1976).

2.1 Nature of feeding and damage

The nature of damage caused by H. antonii has been described by various authors (Abraham, 1958; Pillai and Abraham, 1975; Sathiamma, 1977; Ambika and Abraham, 1979). Adults and immature stages suck sap from tender shoots, leaves, floral branches, developing nuts and apples. The injury made by the suctorial mouth parts of the insect causes the tender shoots and floral branches to exude a resinous substance, which on exposure to air gets hardened.

The surrounding tissues become necrotised and a brown or black lesions are formed in a few hours presumably due to the action of phytotoxin present in the saliva. Adjacent lesions coalesce and finally the affected shoots dry up. In certain endemic areas, the entire flush dries up and the trees present a scorched appearance. The damage on inflorescence is more concentrated around the nodal region. The lesions on tender panicles coalesce and the tissues are subsequently colonised by several species of fungi and result in "inflorescence blight". The immature nuts infested by this pest, develop characteristic eruptive spots and finally such nuts shrivel and fall off. Pest infestation in the early stages of fruit setting and development of nuts results in the immature fruit drop.

The feeding activity of the pest is higher during morning hours before 9 am and in the evening hours after 4 pm (Abraham and Nair, 1981). The number of feeding punctures ranged from 78 to 235 for a final instar nymph, 16 to 238 for adult females and 11 to 59 for adult males with mean values of 114, 97, and 25 respectively during 24 h period (Sathiamma, 1977).

2.2 Extent of damage

The extent of damage to plant parts and the resultant yield loss were estimated by different workers. Abraham (1958) estimated the average damage to be 25 per cent in tender shoots and 15 per cent in tender nuts while according to Sathiamma (1977) average of 14.0 per cent of shoots, 48.5 per cent of panicle and 32 per cent of fruits were damaged.

Severe infestations have been found to cause a loss of production to the extent of 30-40 per cent (Desai et al., 1977). Inflorescence blight alone contributed upto 30 per cent yield loss (Anon, 1966).

2.3 Morphology

The morphometrics of adults and immature stage of H. antonii have been presented by Ambika and Abraham (1979). The adult bug is reddish brown with a black head, red thorax and black and white abdomen. A knobbed process arises from the dorsal aspect of the thorax of both sexes which is erect, tapering and the apex being swollen and funnel shaped. Nymphs are small, ant-like and orange coloured.

2.4 Bio-ecology

The bio-ecology of H. antonii has been studied by several authors (Anonymous 1974, 1976, 1977, 1981, 1982, Ambika and Abraham, 1979; Sathiamma, 1984).

2.4.1 Eggs

The eggs are generally inserted into tender shoots, inflorescence stalks, leaf mid rib and petiole either singly or in groups of 2-6. The site of oviposition can be recognised by the presence of a pair of silvery white thread like chorionic processes of unequal size projecting outside the plant tissue.

2.4.2 Nymphs

There are five nymphal instars. The incubation period lasts for 6-7 days and the nymphal period is 10 days at a temperature range of 24-32°C and relative humidity of 47-100 per cent (Pillai *et al.*, 1976). The duration of the first nymphal instar is 3-3.5 days and the second instar lasts for 2.4 days. The third instar moults in about 2-4 days. Fourth instar moults in 2 to 5 days (Ambika and Abraham, 1979). The nymphal period was maximum during the period October-December (Devasahayam, 1985).

2.4.3 Adult

The adult longevity varies from 4 to 14 days for males and 4 to 24 days for females. Total life cycle occupied 22 to 35 days (Sudhakar, 1975).

2.4.4 Fecundity and oviposition period

Oviposition period is 4-5 days. Fecundity is found to vary from 10 to 60. Duration of oviposition and fecundity of females were maximum during the period January-March. The incubation period of eggs was maximum during the period July-September (Devasahayam, 1985). Ambika and Abraham (1979) reported that 25 $\pm$ 0.5°C was most suitable for fertilisation and oviposition and 28 $\pm$ 0.5°C was ideal for embryonic development and progeny production.

2.4.5 Seasonal abundance

The population build up of *H. antonii* in Kerala commences during October-November, synchronising with the emergence of new flushes and reaches its peak in January when the trees are in full bloom. The pest was almost completely absent during the monsoon period on older trees (Pillai and Abraham, 1975). However on young trees, the populations are observed throughout the year since the pattern of flushing in these trees is protracted (Sathiamma, 1977). At Vittal, *H. antonii* was active in the field during November-April with a high incidence during January-February (Rai, 1981). At Goa, the build up of pest population and its damage commenced from October-November onwards. Peak pest population occurred during February. No damage was observed during June-September period (Sundararaju, 1984).

2.5 Control strategies against *H. antonii*

Several control strategies were reported for effective protection of cashew against *H. antonii*.

2.5.1 Chemical methods

Earlier recommendations for the control of the pest included spraying of phosphamidon at 0.03 per cent in combination with fungicides in view of the reported involvement of both the insect and fungus in the causation of inflorescence blight (Anon. 1966 and 1969). Bio-efficacy studies were conducted by several authors at several locations and the efficacy of insecticides in controlling the infestation were reported. DDT, carbaryl, endrin and dieldrin (Damodaran and Nair, 1969); endosulfan (Nambiar et al., 1973); quinalphos and endosulfan (Muthu and Baskaran, 1979); endosulfan, carbaryl, phosphamidon and quinalphos (Nair and Abraham, 1982); carbaryl and phosalone dusts (Nair and Abraham, 1983), phosphamidon and carbaryl (Nair and Abraham, 1984), quinalphos, formothion, and diazinon (Singh and Pillai, 1984); endosulfan, monocrotophos and phosalone (Sundararaju, 1984) monocrotophos and endosulfan (Chatterjee, 1989); methyl parathion, endosulfan, monocrotophos and carbaryl (Samiayyan, 1989), endosulfan, carbaryl, quinalphos and phosphamidon (KAU, 1989) were reported to be effective.

2.5.2 Other methods

Topical application of JH analogues, farnesyl methyl ether at 0.5 μ on early 5th instar nymphs did not result in moulting, but they were transformed into 6th instar supernumerary nymphs which had juvenile characters (Ambika and Abraham, 1979). Spraying of aqueous spore suspension of fungus, Aspergillus flavus on H. antonii resulted in 22.5-47.5 per cent mortality within 24-48 hrs of appearance of symptom (Sathiamma and Saraswathy, 1990).

2.6 Use of plant products for pest management with special reference to neem

Many species of plants are known to possess a variety of chemical substances which act as antifeedants, repellants, juvenile hormone mimics, insectistats and insecticides. Among the numerous ingredients of plants studied during the last 20 years, extracts and compounds from the neem tree, Azadirachta indica A. Juss have attracted special attention of entomologists and phytochemists all over the world. The entire neem tree is said to possess some amounts of toxic principles which act either as insect antifeedant or growth regulator or insecticides, to protect itself from the multitude of pests.

Azadirachtin was one of the first active ingredients isolated from neem tree. It has a deterrent, antiovipositional, antifeedant, growth disturbing and fecundity and fitness reducing properties on insects. Later, salanin, salannol, salannol acetate, 3-deacetyl salanin, azadiradion, 14-epoxy azadiradion, gedunin, nimbinen and deacetyl nimbinen referred to as triterpenes in general and as limonoids in particular were isolated from the neem tree (Jones et al., 1989).

2.6.1 Effect of neem products on population build up and mortality of sucking insects

Different neem based products were applied through different methods on plants and their bio-efficacy against different sucking insects was reported by several authors.

2.6.1.1 Leaf hoppers

The water extracts of neem cake at 5-10 per cent concentration had been found to suppress Nephotettix sp. population on rice plants (Durairaj, 1984). Jayashree (1984) observed that neem oil and karanji oil 10:1 at 3 per cent recorded less population of cotton leaf hopper, Amrasca biguttula biguttula (Ishida) at 41 and 48 Days After Spraying (DAS). A mixture of neem cake and urea in the ratio of 5:1 applied basally reduced the infestation of Nephotettix sp. (Velusamy et al., 1987). Mohan (1988) reported that the root immersion of seedlings for 24 hrs in 5 per cent Neem Seed Kernel Extract (NSKE) reduced the population of A. biguttula biguttula by 24 per cent in brinjal. Saxena et al. (1989)

suggested that roots of 21 day old rice seedlings were soaked in 5000 ppm neem seed bitter solution for 12 h before transplanting reduced *Nephotettix* spp. population significantly at 50 Days After Transplanting (DAT).

2.6.1.2 Plant hoppers

Saxena *et al*. (1979) found that 12 per cent spray of neem oil reduced the incidence of *Nilaparvata lugens* Stal. The water extracts of neem cake at 5 to 10 per cent concentration had been found to suppress *N. lugens* (Durairaj, 1984). Rajasekaran *et al*. (1987) observed that foliar application of NSKE at 5 per cent caused 25 to 40 per cent mortality of *N. lugens*. Mohan (1980) reported that NSKE at 2.5 per cent High Volume (HV) treatment recorded lowest population of *N. lugens* followed by NSKE at 5 per cent.

2.6.1.3 Bugs

Raguraman (1987) observed that neem oil 3 per cent and NSKE 5 per cent applied on single spray recorded less population of rice earhead bug on 7 and 14 days after treatment as compared to control.

2.6.2 Effect of neem products on orientational response and settling behaviour of sucking insects

Heyde *et al*. (1984) found that an Ultra Low Volume

(ULV) spray application of 3 per cent neem oil, only fewer adults of *N. lugens* alighted on treated rice plants. An ULV application of 3 per cent neem oil on rice plants, only 36 per cent of *N. lugens* alighted on treated plants. Insect arrival decreased progressively with oil concentration increases (Heyde *et al*., 1985). Neem oil 25 and 50 per cent ULV and 10 per cent LV application, deterred the BPH adults effectively from alighting on treated plants and reduced the food intake and egg laying by female *N. lugens* (Raguraman, 1987).

2.6.3 Effect of neem products on ovipositional behaviour of sucking insects

Spraying of neem derivatives on plants which may not directly affect the insect externally but it may cause a detrimental effect on fecundity and hatchability of eggs. The effect of neem products on egg laying activity and hatchability of eggs have been evaluated by many workers against sucking insects.

2.6.3.1 Leaf hoppers

Heyde *et al*. (1985) reported that rice plants treated systemically or topically with neem oil at concentration higher than 6 per cent reduced the fecundity of *Nephotettix virescens* (Distant) significantly. Adults of *N. virescens* were caged on rice plants that had been sprayed with 100, 500 or 2500 ppm neem seed bitter extract which reduced the reproductive fitness of insect (Saxena and Barrion, 1987). Velusamy et al. (1987) found that 1.0 to 2.0 per cent neem oil reduced oviposition of N. virescens. Root immersion of rice seedlings for 24 hours in 5 per cent NSKE reduced oviposition and hatchability of N. virescens (Abdul Kareem et al., 1988). Abdul Kareem et al. (1989) observed that rice plants were sprayed at 5000 ppm neem seed bitter aqueous solution showed only fewer eggs laid and reduced the hatchability of eggs drastically.

2.6.3.2 Plant hoppers

Neem seed extracts reduced egg deposition by brown plant hopper in rice seedlings (Islam, 1984). Velusamy et al. (1987) reported that the rice plants treated with neem oil at 1 and 2 per cent, neem seed kernel extract at 5 per cent and neem cake at 5 per cent significantly reduced the oviposition of N. lugens. Rice plants treated with 5000 ppm neem seed bitter solution drastically reduced the number of eggs laid by N. lugens (Abdul Kareem et al., 1989). Mohan (1989) observed that the plants treated with NSKE at 10 per cent Low Volume (LV), NSKE at 5 per cent HV and neem oil at 2 per cent recorded less number of eggs of N. lugens. The percentage of hatching was lower in NSKE at 5 per cent HV treated plants.

2.6.3.3 Bugs

Ochse (1981) found that Dysdercus fasciatus (Sign.) females derived from 5th instar nymphs, topically treated with MNSKE, produced only 59 per cent of the number of eggs produced by untreated eggs. Neem oil affected the emergence rate from the eggs of treated bugs, D. fasciatus was 33.1 per cent compared with 45.9 per cent of solvent control bugs (Ochse, 1981). Topical application of crude extracts of neem on 5th instar nymph of Dysdercus koenigii (Fabr.) adversely affected the reproduction, fecundity, hatchability and survival of F_1 generation (Jaipal and Zilesingh, 1985).

Dorn et al. (1987) investigated that 7.8 to 125 ng of the topically applied azadirachtin per female of Oncopeltus fasciatus (Dallas) reduced the number of deposited eggs by 20 per cent of that of the control and higher concentrations caused complete sterility. Bhathal et al. (1991) showed that the extracts of neem and Ageratum conyzoides considerably reduced the hatchability of eggs of D. koenigii.

2.6.4 Effect of neem products on feeding behaviour of sucking insects

2.6.4.1 Leaf hoppers

Phloem feeding was erratic on neem oil treated rice plants with an increase in salivation and xylem feeding by N. lugens (Schoonhoven, 1982). Heyde et al. (1984) reported that the food intake of N. virescens was significantly reduced on rice plants sprayed with 1 to 50 per cent emulsion of neem oil, whereas the test insects fed normally on plants sprayed with a vegetable oil. Saxena and Khan (1985) observed that the phloem feeding by N. virescens, as monitored by an electronic device, on plants sprayed with 1.25, 2.5, 5 or 10 per cent neem oil was significantly lower than acetone treated control plants.

Saxena and Khan (1986) studied the phloem feeding by N. virescens on rice plants kept in areas permeated with odour of 6, 12 or 25 per cent neem oil which reduced the feeding significantly. This was associated with a significant increase in insect's probing frequency, xylem ingestion and salivation period. Root immersion of rice seedlings in 2500 ppm neem seed bitter aqueous solution for 25 second significantly reduced the duration of phloem feeding. This was accompanied by a corresponding significant increase in frequency of probing, salivation period and xylem feeding (Saxena and Boncodin, 1988a).

2.6.4.2 Plant hoppers

Insect feeding was deterred on neem oil treated plants. In a 60 minutes observation period, starved *N. lugens* females avoided seedlings treated with 50 per cent or 100 per cent neem oil for 15 to 22 minutes, even after alighting on them were restless and took more than 30 minutes searching for feeding sites (Saxena *et al*., 1981). Heyde *et al*. (1984) found that the food intake of homopterous insects, *N. lugens* and *Sogatella furcifera* (Horv.) was significantly reduced on rice plants sprayed with 1 to 50 per cent emulsion of neem oil, whereas the test insects fed normally on plants sprayed with a vegetable oil.

Saxena *et al*. (1984) observed that food intake by *N. lugens* was low even on plants grown on soil incorporated with neem cake. Experiments with neem oil or petroleum ether extracts of seed kernels of Chinaberry in laboratory and green house showed their potential as strong antifeedants in the control of *N. lugens* (Chiu, 1985).

2.6.5 Effect of neem products on growth and development of sucking insects

Application of neem products on insects which induce or reduce the growth rate of nymphs and also causes prevention of ecdysis leads to malformation, interference of moulting process and leads to death of insects.

2.6.5.1 Leaf hoppers

Foliar application of neem oil and enriched formulated NSKE resulted in disturbances of the moulting process, extension of the nymphal period and a dose dependent mortality in N. virescens (Heyde et al., 1984).

The growth and development of Nephotettix spp. was disrupted by spray application of neem seed bitter solution on rice plant at 10,000 ppm (Saxena et al., 1987).

2.6.5.2 Plant hoppers

Heyde et al. (1984) showed that 3 per cent neem oil interfered with growth of N. lugens. Foliar application of neem oil and enriched formulated NSKE resulted in disturbances of the moulting process, extension of the nymphal period and a dose dependent mortality in some homopterous insects, such as N. lugens and S. furcifera (Heyde et al., 1984). The development of BPH nymphs was significantly reduced on TN 1 rice seedlings when 2 per cent neem cake was mixed with water soaked seeds for 48 hours (Abdul Kareem et al., 1987).

Saxena and Barrion (1987) observed that NSKE at 500 ppm on N. lugens which reduced the frequency of meotic cells. The growth and development of N. lugens and S. furcifera were disrupted by spray application of neem seed bitter solution on rice plant at 10,000 ppm (Saxena et al., 1987).

Mohan (1989) observed that the percentage of nymphs of N. legens was low in 5 per cent NSKE HV, 10 per cent NSKE LV and neem oil 2 per cent HV. The development period was longer in neem treated rice plants when compared to control. The nymphal period was high on NSKE 10 per cent LV and 5 per cent NSKE LV treatments.

2.6.5.3 Bugs

Application of one µl of methanolic neem leaf extract per 5th instar nymph of East African Coffee bug, Antestiopsis orbitalis behuana (Westw.) resulted in adults with deformed wings and pronotum (Leuschner, 1972). Ochse (1981) reported that application of azadirachtin (0.2 ml) on test insects and food at the same time, all treated 5th instar nymph of O. fasciatus died before ecdysis. A similar result was obtained, after topical application of methanolic NSKE at 0.02 and 0.2 per cent on old instars, as most of them died before ecdysis or during moulting. Some individuals that moulted successfully died during the following moult.

Koul (1984) found that azadirachtin treatments resulted in prolonged development, wing deformities, implasticization of wing lobes, development of wingless adult and nymphal mortality in D. koenigii. Dorn et al. (1987) reported that the treatments of nymphs of O. fasciatus with azadirachtin in concentrations ranging from 62.5 ng to 250 ng per last instar nymph prevented ecdysis and higher concentrations (500 ng to 16 µg/nymph) prevented apolysis.

2.6.6 Effect of neem products on survival of sucking insects

Many workers noted that all first instar nymphs emerging from treated eggs may not reach the adult stage at specific period due to mortality occurring in different instars.

2.6.6.1 Leaf hoppers

Neem oil reduced the survival of N. virescens and its transmission of the rice tungro virus (RTV) in rice seedlings (Mariappan and Saxena, 1983). Heyde et al. (1984) observed that survival of N. virescens was greatly reduced when the insects were caged in pairs on rice plants treated with neem oil at a concentration higher than 6 per cent. Mixture of custard-apple oil and neem oil in 1:1, 1:4 proportions at 5, 10 or 20 per cent concentrations were significantly more effective in reducing N. virescens survival and RTV transmission than spray application of individual oils in rice seedlings (Mariappan and Saxena, 1984). Narasimhan and Mariappan, (1988) observed that rice seedlings when sprayed with seed oils of neem and crude extracts of neem cake, neem oil gave highest mortality of *N. lugens*. Root immersion of rice seedlings in neem seed bitter solution at 2500 ppm decreased the survival of newly emerged adult females significantly after 2 days exposure to systemically treated plants (Saxena and Boncodin, 1988b).

2.6.6.2 Plant hoppers

Heyde *et al*. (1984) observed that survival of *N. lugens* and *S. furcifera* was greatly reduced when the insects were caged in pairs on rice plants treated with neem oil at a concentration of higher than 6 per cent. The duration of survival of *N. lugens* decreased markedly on rice seedlings that had been sprayed with neem oil at the concentrations of 3, 6, 12, 25 or 50 per cent (Saxena and Khan, 1984). Saxena and Khan (1985) reported that neem oil reduced the survival of *N. lugens* and suppressed the transmission of both grassy stunt and ragged stunt viral diseases. Females of *N. lugens* topically treated with 2.5 or 5 µg neem oil per insect or caged on rice plants sprayed with more than 3 per cent neem oil, failed to produce normal courtship signals. At higher concentrations, most of the females did not emit signals and males could not locate them (Saxena *et al*., 1989).

2.6.6.3 Bugs

Treatment of adult females of O. fasciatus with azadirachtin (0.25 µg and higher) caused high mortality and the longevity was reduced to 11 days or less (Dorn et al., 1987).

2.7 Safety of neem products to natural enemies of pests and other useful organisms

Apart from evaluating the efficacy of neem products against crop pests, pests of public health and veterinary importance, the safety aspects in relation to natural enemies like parasitoids, predators and pollinators like honey bees etc. have been studied by many workers.

NSKE at 2 per cent did not adversely affect the emergence of the parasite, Telenomus remus Nixon from the eggs of Spodoptera litura (F.) (Joshi et al., 1982). Neem oil at 5 per cent was not toxic to the predator mirid bugs, Cyrtorhinus lividipennis (Reuter) (Chelliah and Rajendran, 1984). NSKE at 10 per cent spray it was found to be safer to the wolf spider, Lycosa pseudo annulata (B.) in the rice ecosystem (Saxena et al., 1984). Spraying aphid mummies with neem oil did not prevent the normal emergence of the parasitoids, Diaeretiella rapae (McInt.) and Aphidius cerasicola (Schauer, 1985).

Predaceous coccinellid beetles survived the application of a formulation with high neem oil content (Srivastava and Parmar, 1985). Neem oil 5 per cent spray significantly reduced the germination of the conidia of the entomopathogenic fungus, Metarhizium anisopliae (Metsch) (Aguda et al., 1986). Various solvent extracts of neem seed kernel (Pentone, acetone, ethanol, methanol) were considerably more toxic to spider mite, Tetranychus cinnabarinus (Boisd.) than its predator, phytoseiulus persimilis (Athias-Hen.) (Mansour et al, 1987).

Soil treatment with 5 per cent ground neem seed kernels increased the progeny of earth worm, Eienia foetida by 25 per cent (Rossner and Zebitz, 1987). Margosan - 0 proved to be non toxic to honey bee workers even after direct application upto 4418 ppm of azadirachtin per ha (Schmutterer and Holst, 1987). NSKE at 2 to 5 per cent were found safer to the predatory mite, Amblysieus pruni on cotton (Tamil Selvi, 1990).

2.8 Commercial formulation of neem

Apart from using the different crude neem preparations like neem leaf extract, neem oil, neem seed extract, neem cake etc., a few neem formulations, have been developed by various entrepreneurs and have been evaluated by different workers.

Rice grains treated with 1000 ppm of Margosan-O® repelled red flour beetle, Tribolium castaneum Herbst (Jilani et al., 1987). Topical application of Margosan-O® at 2 µl to the abdomen of last instar nymphs of Blatta orientalis (L.) reduced the growth and increased the mortality (Alder and Uebel, 1987). At 100 ppm it induced complete mortality within 4 days in red cotton bugs, Dysdercus sp. (Opendekoul, 1988). Neemark® containing 0.05 per cent azadirachtin gave excellent control of boll worms and enhanced the seed cotton yield (Phadke et al., 1988).

Materials and Methods

MATERIALS AND METHODS

Laboratory experiments were conducted at the College of Horticulture, Vellanikkara during 1993-94 to evaluate the effect of commercially available neem products on feeding and ovipositional behaviour of the tea mosquito bug, *Helopeltis antonii* Sign.

3.1 Rearing and maintenance of stock culture of the test insect, *H. antonii*

Fourth and 5th instar nymphs of tea mosquito bug collected from the field were used to establish nucleus culture of the insect. The nymphs were reared on fresh cashew twigs kept in glass jars. The cut ends of the twigs were placed on moist cotton plugs. Fresh twigs were introduced everyday into the container, after removing the dried ones. Immediately on emergence of adults, they were transferred to separate jars. Healthy fresh twigs were introduced into the lantern chimney for adults feeding. Adults were sexed and released into separate jars for breeding and oviposition. Eggs were deposited by the female after copulation. Twigs containing the eggs were removed and kept it in petridishes with moist filter papers for the emergence of nymphs. Moulting of the nymphs was monitored and availability of stages of the test insect of precisely known age was ensured.

3.2.1 Commercial products of neem selected for evaluation against *H. antonii*

Several commercial preparations based on neem are now available in the market. Of these, three products were selected for studies on bio-efficacy against *H. antonii* along with neem kernel suspension prepared and used as the local check. The details are given in Table 1.

Table 1. Details of neem products tested against *H. antonii*

Sl. No.	Trade name	Azadirachtin content	Formulation	Source
1.	Neem kernel suspension (NKS)	--	Suspension	Indigenous preparation
2.	Godrej Achook	300 ppm	WSP	Godrej Agrovet Ltd. Bombay
3.	Nimbecidine	300 ppm	Ec	T. Stanes and Company Ltd., Coimbatore
4.	Rakshak	1500 ppm	Ec	M/s Murkumbi Manufacturing, Belgaum, Karnataka

3.2.2 Dosages of products tested for bio-efficacy against *H. antonii*

The doses of neem products tested included one dose recommended by the manufacturers and three higher doses. For each of the products, four different concentrations were prepared by diluting the commercial formulation with required amount of tap water. The details of doses are given in Table 2.

Table 2. Doses of neem products tested against *H. antonii*

Sl. No.	Neem kernel suspension (per cent)	Nimbecidine (per cent)	Godrej Achook (per cent)	Rakshak (per cent)
1.	2	0.4	0.4	0.2
2.	4	0.8	0.8	0.4
3.	8	1.6	1.6	0.8
4.	16	3.2	3.2	1.6

3.3 Evaluation of the effect of neem products on the ovipositional behaviour of *H. antonii*

Healthy tender twigs of cashew were collected from the field and examined under microscope to ensure the absence of eggs. Each of treatment vide para 3.2.2 (Tables 1 and 2) was applied on three tender twigs of cashew by using an atomiser and this was replicated four times. These treated twigs were dried for 15 minutes under ceiling fan and were kept in an upright position inside the lantern chimney. These chimneys were covered with muslin cloth held in position by rubber band. A pair of male and female insects was collected from the stock culture (vide para 3.1) and these were released into the chimneys and were kept at room temperature.

3.3.1 Fecundity

The twigs were removed after 24 hours, and were examined under microscope. The number of eggs, number of eggs per site and the number of egg laying sites were counted and noted. While retaining the test insects in the chimneys, fresh twigs treated (vide para 3.3) were introduced every day to the chimney. The total number of egg laying sites, duration of egg laying and the number of eggs deposited per female were recorded until the death of female insect and the data were tabulated and analysed.

3.3.2 Percentage of egg hatch

The twigs which were removed from the chimneys (vide para 3.3.1) and were transferred to petridishes containing moist filter paper every day. The number of first instar nymph emerging from these twigs was observed and recorded.

Plate 5. Eggs of _H_. _antonii_ embedded in the mid rib of tender leaves; chorion processes seen projecting out

Plate 6. Eggs of _H_. _antonii_, excavated from the tender shoots

3.3.3 Survival of nymphs

The survival of first instar nymphs was determined by allowing them to feed on fresh cashew twigs. This was continued till they died or emerged into adults.

3.4 Evaluation of the effect of selected neem products on the feeding by H. antonii on cashew

To estimate the rate of feeding of H. antonii as influenced by different doses of neem products, radio active phosphorus (32_p) was utilised. Entire cashew seedlings were radio labelled with 32_p prior to spraying them with neem products at different doses. The test insects were released on the radio active seedlings and the effects of neem products were evaluated by estimating the radio activity in the body content of the insects.

3.4.1 Radio labelling of cashew seedlings

Fifteen milli curies of 32_p (carrier-free) were transferred to a conical flask and volume of the solution in the flask was diluted to 15 ml. After thorough mixing, the solution containing 100 μ Ci of 32_p was transferred to separate conical flasks containing 275 ml distilled water and the solutions was mixed well. Cashew seedlings raised in polythene bags were selected and brought to the laboratory.

Plate 7. Radio labelling of cashew seedlings with ^{32}P prior to treatments

The selection was based on uniform age of one month and the presence of at least 4 tender leaves at the top. These seedlings were carefully uprooted without damage to the roots. The roots were then washed of the adhering soil particles before their transfer to the flasks containing radio active solution at the rate of one seedling per flask.

The seedlings were placed in such a way that, the root portions were fully immersed in the radio active solution. The seedlings were allowed to absorb 32_p for a period of 24 hours. They were then removed from the flasks and the roots were washed with distilled water. The seedlings were then introduced into another set of conical flasks containing distilled water alone for further studies.

3.4.2 Evaluation of translaminar feeding deterrency of treatments on *H. antonii*

The radio labelled cashew seedlings prepared earlier (vide para 3.4.1) were used for this experiment.

Each treatment was applied to five radio labelled seedlings which constituted five replications. Each of the seedlings was sprayed carefully using an atomiser such that the spray solution fell only on the upper surface of the leaves, while protecting the lower surface of the leaves. These seedlings were used for release of test insect. Before the release of test insect, the treated upper leaf surface was carefully covered with filter papers and the plants were caged. Two fourth instar nymphs of the test insect (para 3.1) per seedling were then released and confined to the lower leaf surfaces. Two sets of control were maintained. In one set, radio labelled seedlings were used as untreated control. The test insects were released on them after spraying distilled water. In another set of radio labelled seedlings, the insects were released without neem product or distilled water sprays. The insects were allowed to feed for two days before analysing their body contents for quantification of radio activity. Insects from both controls were pooled.

3.4.3 Evaluation of contact deterrency of neem products to test insect released on treated radio labelled plants

Another set of radio labelled cashew seedlings were selected for testing the efficacy of different treatments in inducing contact deterrency in the test insect (para 3.1). For this five seedlings constituted five replications. Whole seedlings were sprayed with different treatments. Two sets of untreated radio labelled plants served as controls (as described vide para 3.4.2).

The plants were enclosed in a fine nylon net before releasing the test insects. The insects were allowed to feed

Plate 8. Nymphs of <u>H.</u> <u>antonii</u> released and confined on radio labelled seedlings - (Contact action)

for 48 hours before quantifying the radio activity in their bodies.

3.4.4 Estimation of radio activity

The test insects were removed from the seedlings after 48 hours of feeding and collected in scintillation vials. These vials were kept in an oven at about 50 to 60°C for 2 minutes to ensure the death of test insects. These vials were taken out from the oven and the body contents of the test insects were dissolved by adding 5 ml of di-acid mixture (nitric acid and perchloric acid @ 2:1). The contents of the vials were transferred to 100 ml conical flasks which were kept on a hot plate for an hour to facilitate digestion. These digested materials were then transferred to radio active free scintillation vials. The volume was made up with distilled water.

The radio activity was determined by Cerenkov Counting technique in a microprocessor-controlled Liquid Scintillation Counter (Rack beta of LKB Wallac). The radio activity of the body contents of the test insects was taken as an indication of the rate and quantum of feeding of the test insects on the radio labelled and treated seedlings.

Statistical analysis

The data were analysed statistically using CRD (Panse and Sukhatme, 1985). Necessary transformations were done before the analysis. Treatment means were compared using Duncan's Multiple range test (DMRT).

Results

RESULTS

The results of the experiments (as described in Materials and Methods) were tabulated and analysed statistically and presented in this chapter in Tables 3 to 11. The results are also graphically presented in Fig.1 to 9.

4.1 Evaluation of the effect of neem products on the ovipositional behaviour of *H. antonii*

4.1.1 Effect of different neem products at different doses on the number of egg laying sites of *H. antonii*

The data on number of egg laying sites produced by *H. antonii* on cashew twigs treated with different doses of the four neem products were analysed and mean values are presented in Table 3 and depicted in Fig.1. The ANOVA is presented in Appendix-II.

The number of egg laying sites ranged from 25 to 60 in different treatments with neem products as compared to the maximum number of 63 recorded in the untreated control.

In treatments with NKS, a significant reduction in number of egg laying sites was noticed in all the tested doses. This was more pronounced at 8 and 16 per cent doses. However, these two treatments were on par with each other.

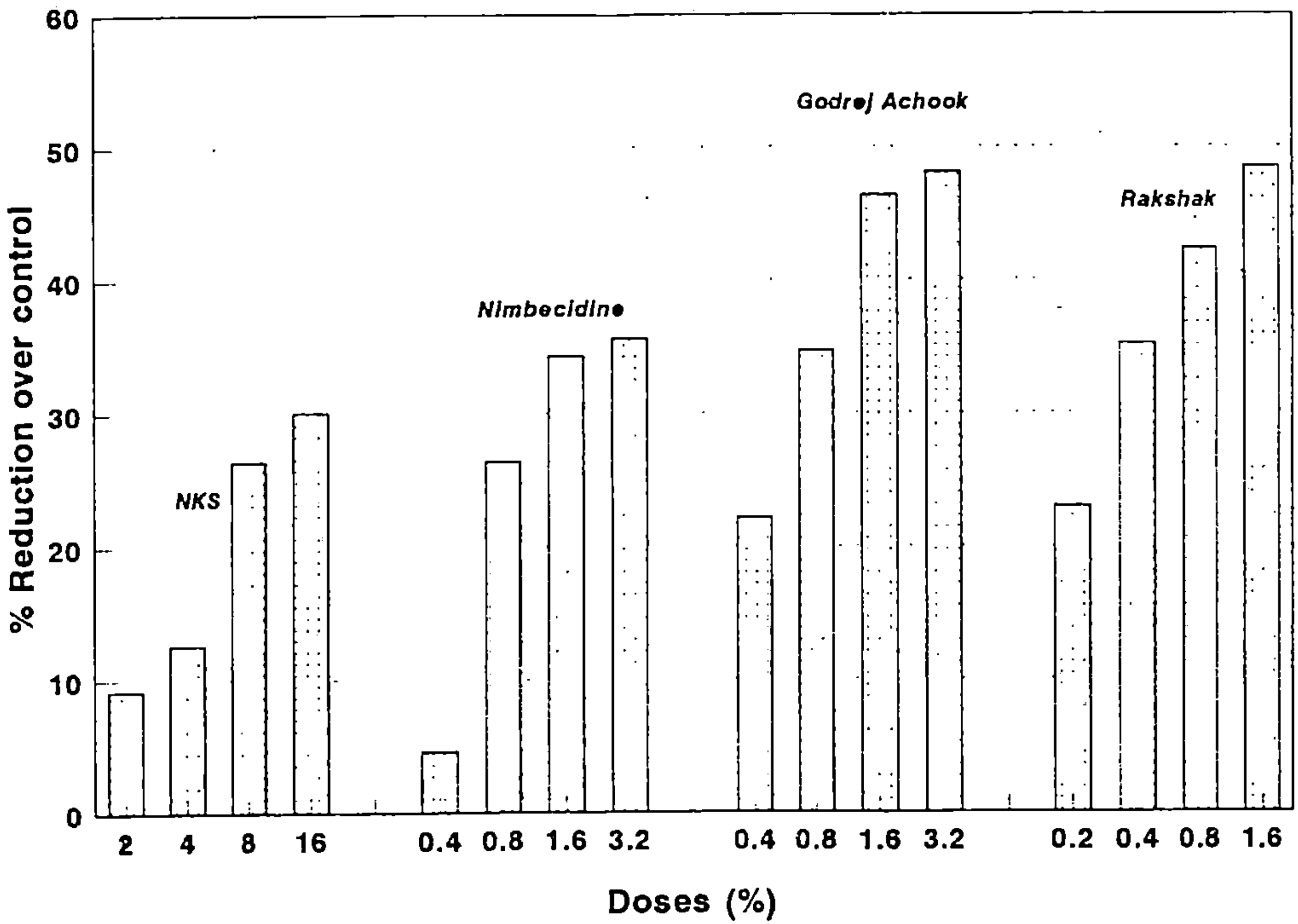
Table 3. Mean number of egg laying sites of *Helopeltis antonii* on cashew twigs treated with different neem products at different doses

Treatment	Doses (per cent)	Number of egg laying sites	
		Mean	Range
1. Neem kernel suspension	2	54.25 (7.36)a	50.0-60.0
	4	52.25 (7.23)ab	47.0-56.0
	8	44.00 (6.63)cd	40.0-46.0
	16	41.75 (6.46)cd	36.0-46.0
2. Nimbecidine	0.4	57.00 (7.55)a	52.0-63.0
	0.8	44.00 (6.61)cd	38.0-57.0
	1.6	39.25 (6.23)de	31.0-45.0
	3.2	38.50 (6.20)de	33.0-43.0
3. Godrej Achook	0.4	46.50 (6.81)bc	42.0-52.0
	0.8	39.00 (6.24)de	37.0-42.0
	1.6	32.00 (5.64)f	26.0-39.0
	3.2	31.00 (5.57)f	29.0-34.0
4. Rakshak	0.2	46.00 (6.78)bc	42.0-49.0
	0.4	38.75 (6.22)de	35.0-43.0
	0.8	34.50 (5.87)ef	32.0-39.0
	1.6	30.75 (5.54)f	30.0-33.0
Control	-	59.75 (7.73)a	57.0-63.0

Figures given in parentheses are transformed values ($\sqrt{x}$)

Treatment means followed by common letters do not significantly differ at 5% level

Fig. 1. EFFECT OF NEEM PRODUCTS ON No. OF EGG LAYING SITES



The mean number of egg laying sites was significantly lower in three higher doses of Nimbecidine as compared to control while the 0.4 per cent dose was on par with the control.

Godrej Achook showed considerable decrease in number of egg laying sites at higher doses of 1.6 and 3.2 per cent which were on par with each other. In treatments with Rakshak, a significant decrease in number of egg laying sites was recorded in all the tested doses. At 0.8 and 1.6 per cent, the mean number of egg laying sites were 34.5 and 30.75 respectively. The lowest number of egg laying sites was recorded by Rakshak at 1.6 per cent.

Among the different treatments, NKS at 2 per cent and Nimbecidine at 0.4 per cent showed the maximum number of egg laying sites which were on par with the control. At 0.8 per cent, Godrej Achook showed a distinct reduction in number of egg laying sites. However the extent of reduction was less pronounced in treatments with Nimbecidine.

The number of egg laying sites was very low in Godrej Achook at 3.2 per cent dose and Godrej Achook and Rakshak at 1.6 per cent which however, were on par with each other. Nimbecidine at 0.8 per cent and two higher doses of NKS at 8 and 16 per cent showed similar trend in reduction of number of egg laying sites. The number of egg laying sites at higher doses of Nimbecidine, 0.4 per cent dose of Rakshak and 0.8 per cent dose of Godrej Achook were on par with each other but significantly lower than the untreated control.

4.1.2 Effect of different neem products at different doses on duration of egg laying of *H. antonii*

The data relating to the influence of neem products on duration of egg laying were subjected to statistical analysis and the mean values are presented in Table 4 and graphically presented in Fig.2. The ANOVA is presented in Appendix-II.

The treatment effects were significant in affecting the duration of egg laying by the females.

The duration of egg laying ranged from 4 to 14 days in different treatments with neem products while it ranged from 9 to 11 days in the untreated controls. The number of days of egg laying decreased with increasing doses in each of the four neem products tested.

Among the treatments, NKS at 16 per cent dose significantly reduced the duration of egg laying, the lower doses being on par with the control. Godrej Achook and Nimbecidine at 1.6 and 3.2 per cent significantly reduced the egg laying while the two lower doses were on par with the control.

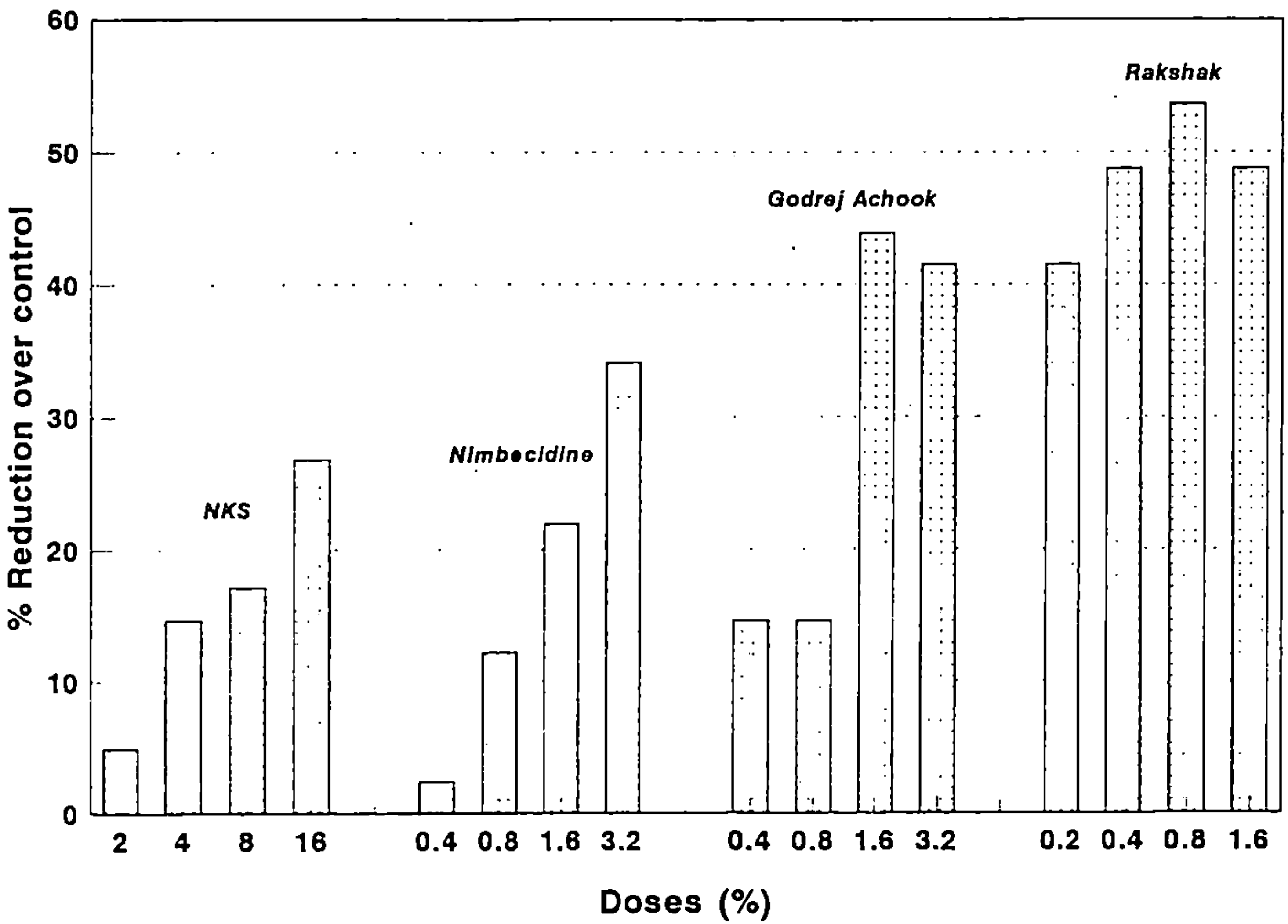
Table 4. Mean number of days of egg laying of *H. antonii* on cashew twigs treated with different neem products at different doses

Treatment	Doses (per cent)	Duration of egg laying (in days) Mean	Range
1. Neem kernel suspension	2	9.75 (3.11)ab	8.0-12.0
	4	8.75 (2.96)abc	8.0-9.0
	8	8.50 (2.89)abcd	6.0-12.0
	16	7.50 (2.73)cde	6.0-9.0
2. Nimbecidine	0.4	10.00 (3.14)ab	8.0-14.0
	0.8	9.00 (2.99)abc	8.0-10.0
	1.6	8.00 (2.83)bcd	7.0-9.0
	3.2	6.75 (2.59)def	6.0-8.0
3. Godrej Achook	0.4	8.75 (2.96)abc	8.0-9.0
	0.8	8.75 (2.95)abc	7.0-10.0
	1.6	5.75 (2.39)efg	5.0-7.0
	3.2	6.00 (2.45)efg	5.0-7.0
4. Rakshak	0.2	6.00 (2.44)efg	5.0-7.0
	0.4	5.25 (2.28)fg	4.0-6.0
	0.8	4.75 (2.18)g	4.0-5.0
	1.6	5.25 (2.29)fg	5.0-6.0
Control	-	10.25 (3.20)a	9.0-11.0

Figures given in parentheses are transformed values ($\sqrt{x}$)

Treatment means followed by common letters do not significantly differ at 5% level

Fig. 2. EFFECT OF NEEM PRODUCTS ON DURATION OF EGG LAYING



There was a significant decrease in duration of egg laying in all the doses of Rakshak as compared to control but these treatments were on par with each other.

A comparison of the products and their doses revealed that the lowest duration of egg laying was recorded by Rakshak at 0.8 per cent (4.75 days) followed closely by Rakshak 0.4 and 1.6 per cent, Godrej Achook at 1.6 and 3.2 per cent and Rakshak at 0.2 per cent. Thus the level of decrease obtained at 3.2 per cent dose of Godrej Achook was realised by 0.2 per cent Rakshak.

4.1.3 Effect of different neem products at different doses on number of eggs laid by female of *H. antonii*

The data on fecundity of females of *H. antonii* as influenced by different treatments were analysed statistically and results are presented in Table 5 and depicted in Fig.3. The ANOVA is presented in Appendix-II.

The number of eggs laid per female ranged from 36 to 87 in different treatments with neem products as compared to the maximum number of 82 recorded in the untreated control.

Among the different treatments, NKS at 2 per cent produced the highest number of eggs (75.50 eggs per female) which was on par with the untreated control. The higher

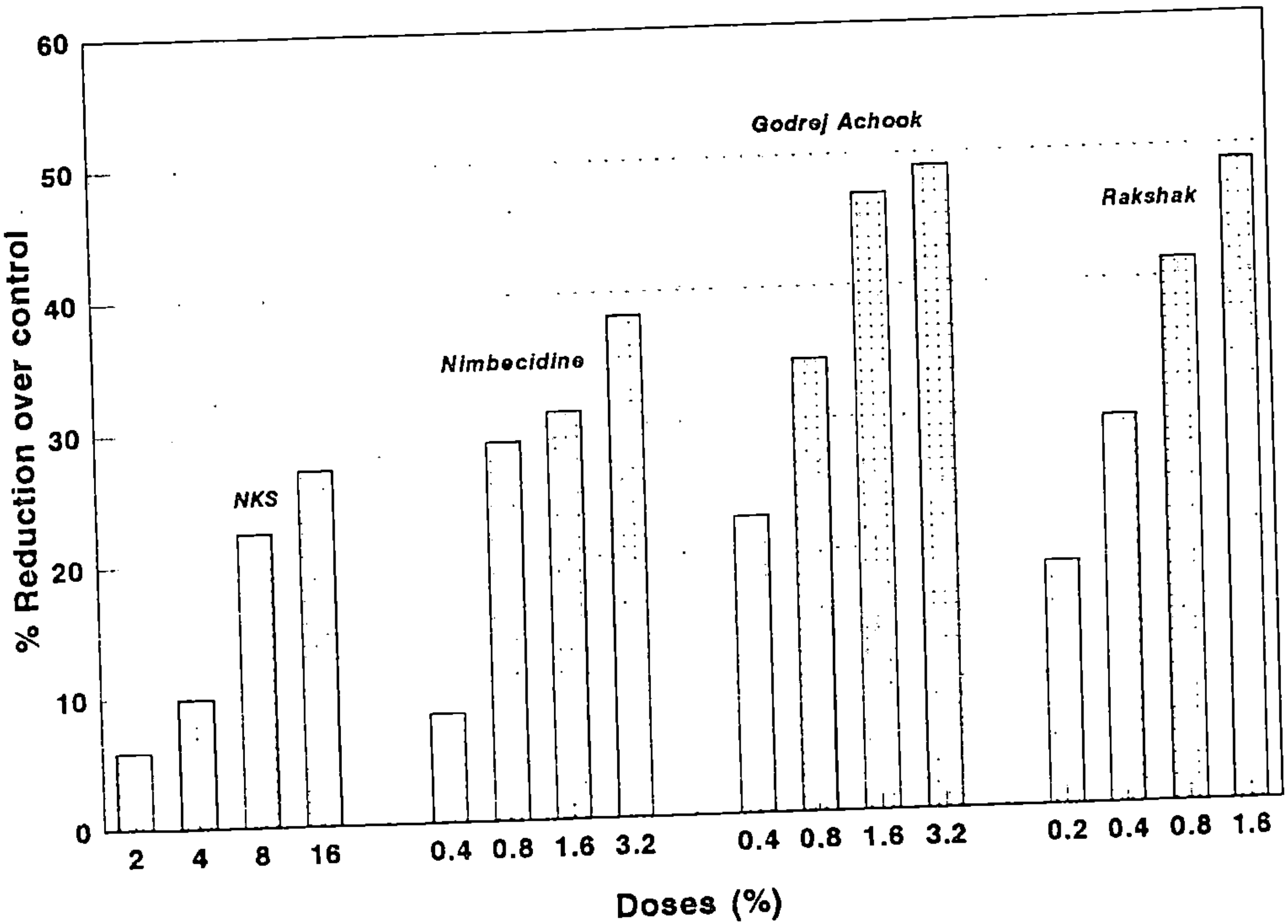
Table 5. Mean number of eggs laid by females of *H. antonii* on cashew twigs treated with different neem products at different doses

Treatment	Doses (per cent)	Number of eggs laid per female: Mean	Range
1. Neem kernel suspension	2	75.50 (8.69)ab	72.0-79.0
	4	72.25 (8.50)abc	62.0-72.0
	8	62.25 (7.89)cde	59.0-69.0
	16	58.50 (7.65)def	56.0-64.0
2. Nimbecidine	0.4	73.50 (8.56)ab	67.0-87.0
	0.8	57.00 (7.51)defg	42.0-75.0
	1.6	55.25 (7.42)defg	48.0-63.0
	3.2	49.50 (7.01)fgh	36.0-59.0
3. Godrej Achook	0.4	62.00 (7.86)cde	52.0-72.0
	0.8	52.50 (7.24)efg	48.0-58.0
	1.6	42.50 (6.51)h	37.0-48.0
	3.2	40.75 (6.37)h	37.0-48.0
4. Rakshak	0.2	65.25 (8.08)bcd	60.0-68.0
	0.4	56.50 (7.51)defg	49.0-65.0
	0.8	47.00 (6.85)gh	43.0-53.0
	1.6	41.00 (6.40)h	39.0-44.0
Control	-	80.25 (8.96)a	78.0-82.0

Figures given in parentheses are transformed values ($\sqrt{x}$)

Treatment means followed by common letters do not significantly differ at 5% level

Fig. 3. EFFECT OF NEEM PRODUCTS ON No. OF EGGS LAID/FEMALE



concentrations of 8 and 16 per cent showed significantly lesser number of eggs laid, i.e. 62.25 and 58.50 respectively.

Treatment with Nimbecidine at 0.4 per cent was on par with the control while the treatments at 0.8, 1.6 and 3.2 per cent registered significant decrease in reproductive rate, the mean number of eggs being 57.00, 55.25 and 49.50 respectively. However, there was no significant difference in the number of eggs laid in treatments with Nimbecidine at 0.8 and 1.6 per cent.

A notable decrease in the fecundity was detected in treatment with Godrej Achook in all the four tested concentrations as compared to control. The lowest recorded fecundity of 40.75 was seen in treatment with Godrej Achook at 3.2 per cent.

A drastic reduction in number of eggs laid was also noticed in Rakshak at all the tested doses which showed a decreasing trend with incremental doses of Rakshak.

There was no significant difference in fecundity when the twigs were exposed to 4 per cent NKS and 0.4 per cent Nimbecidine. Treatment with 8 per cent NKS was on par with that of Godrej Achook at 0.4 per cent.

Adults of H. antonii on twigs treated with higher doses of Godrej Achook at 1.6 and 3.2 per cent and Rakshak at 1.6 per cent concentrations showed minimum fecundity with 42.50, 40.75 and 41.00 eggs per female respectively. In treatment with Godrej Achook at 3.2 per cent, the number of eggs laid by single female recorded was 40.75, which was lower than Nimbecidine treatment (49.50) at the same dose. In the case of Rakshak, the number of eggs laid per female on twigs treated with 0.4 and 1.6 per cent was lower than those recorded in Godrej Achook and Nimbecidine treatments at corresponding doses.

4.1.4 Effect of different neem products at different doses on hatchability of eggs of H. antonii

The data on the number of eggs hatched out of the total number of eggs laid by females of H. antonii on twigs treated with different neem products were analysed statistically. The mean percentage values are presented in Table 6 and represented in Fig.4. The ANOVA is presented in Appendix-II.

It can be seen from the table that the percentage hatchability of eggs ranged from 39.58 to 69.42 in different treatments with neem products as against 59.45 to 68.24 in the

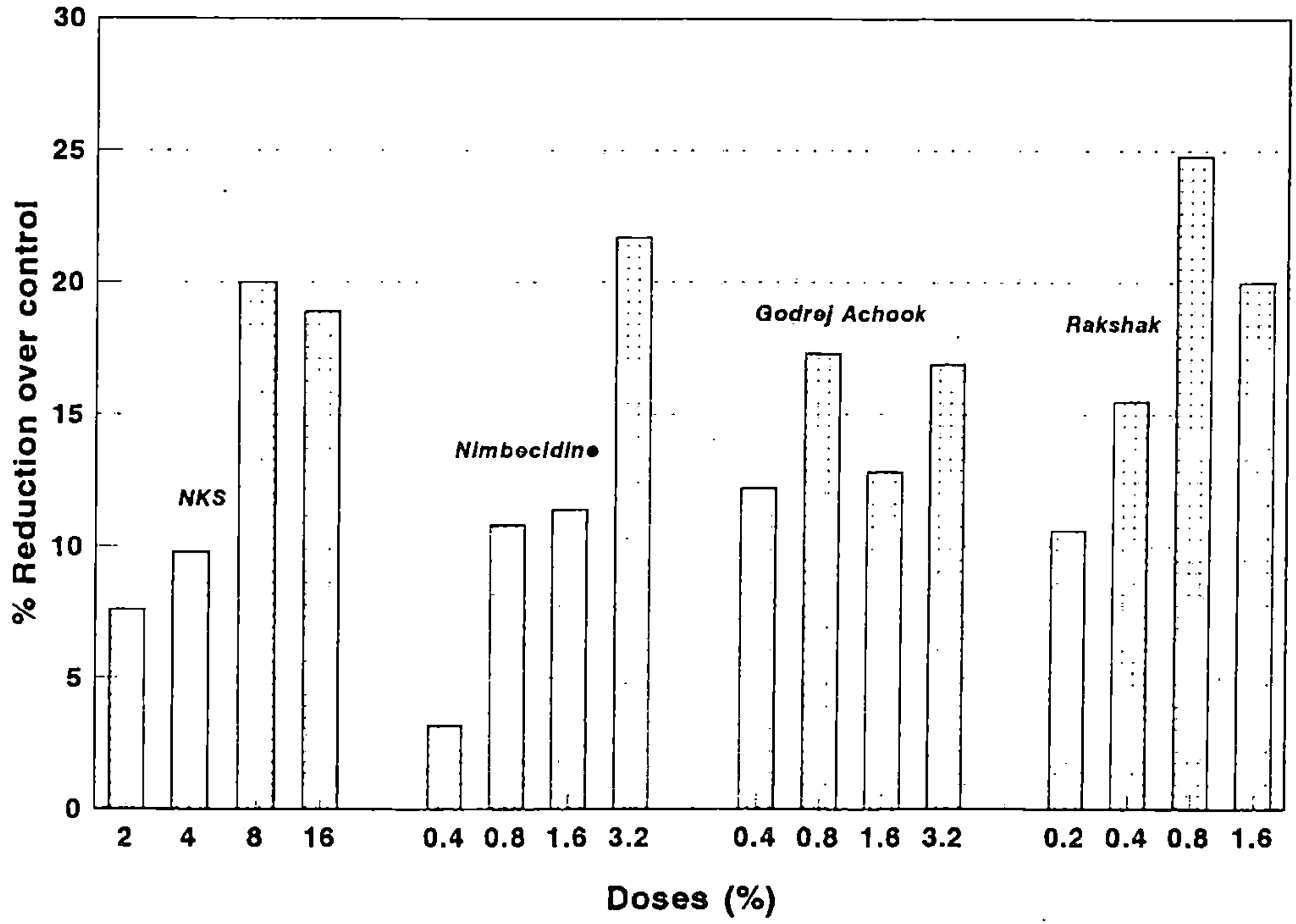
Table 6. Mean percentage values of hatchability of eggs of *H. antonii* on cashew twigs treated with different neem products at different doses

Treatment	Doses (per cent)	Percentage egg hatch	
		Mean	Range
1. Neem kernel suspension	2	60.08 (7.61)	52.30-64.16
	4	58.69 (9.75)	46.26-67.82
	8	52.06 (19.94)	49.01-55.07
	16	52.68 (18.99)	48.43-59.64
2. Nimbecidine	0.4	62.94 (3.21)	59.15-69.42
	0.8	58.01 (10.80)	46.42-66.66
	1.6	57.60 (11.43)	49.01-61.66
	3.2	50.89 (21.74)	41.66-62.26
3. Godrej Achook	0.4	57.08 (12.23)	40.38-68.05
	0.8	53.78 (17.30)	39.58-67.91
	1.6	56.73 (12.76)	40.54-68.75
	3.2	54.00 (16.96)	48.78-58.29
4. Rakshak	0.2	58.16 (10.56)	55.38-60.29
	0.4	54.98 (15.45)	46.15-63.26
	0.8	48.89 (24.82)	43.47-51.16
	1.6	52.02 (20.01)	43.90-58.97
Control	-	65.03	59.45-68.24

Figures given in parentheses denote per cent decrease over control

Treatment means do not significantly differ at 5% level

Fig. 4. EFFECT OF NEEM PRODUCTS ON HATCHABILITY OF EGGS



untreated controls. The treatment effects were not significant at 5 per cent level.

The hatchability in all the four doses of NKS was on par with that in control. Nimbecidine at 3.2 per cent reduced hatchability while the three lower doses on par with the control. There was no difference in hatchability with all the four doses of Godrej Achook as compared to the control. Rakshak at 0.8 per cent dose exhibited lower hatchability which incidentally was the lowest recorded hatchability (48.89 per cent).

In terms of percentage reduction in hatchability, Rakshak at 0.8 per cent and Nimbecidine at 3.2 per cent were superior recording reduction of 24.82 and 21.74 respectively, over control.

4.1.5 Effect of different neem products at different doses on survival of nymphs of *H. antonii*

The data relating to the influence of neem products on duration of nymphal stages were subjected to statistical analysis and the mean values are presented in Table 7 and represented in Fig.5. The ANOVA is presented in Appendix-II.

The effect of different concentrations of neem products on nymphal duration manifested in the form of a

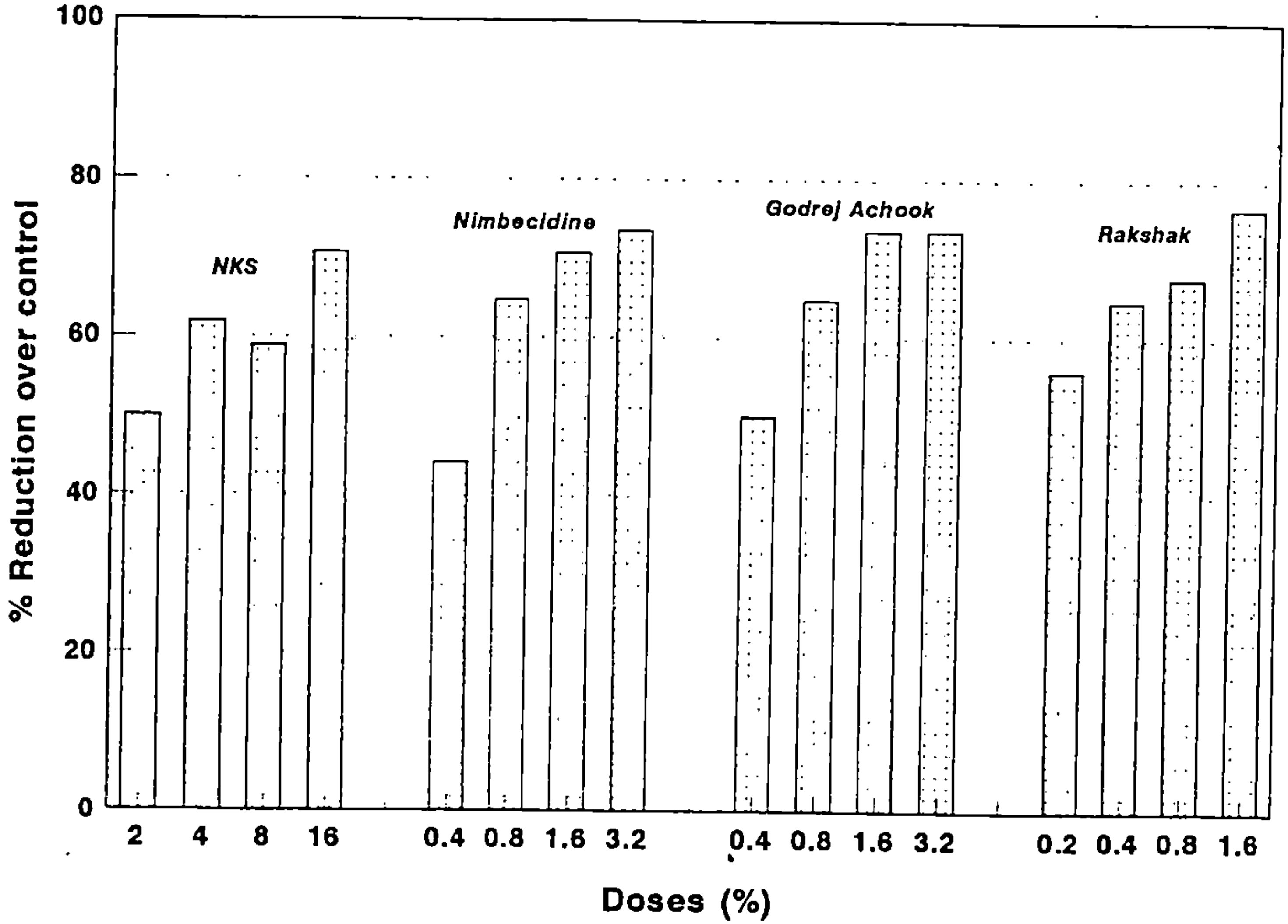
Table 7. Mean duration of nymphs of *H. antonii* emerged from cashew twigs treated with different neem products at different doses

Treatment	Doses (per cent)	Survival of nymphs (in days)	
		Mean	Range
1. Neem kernel suspension	2	4.25 (2.05)bc	3.0-6.0
	4	3.25 (1.79)bcdef	2.0-4.0
	8	3.50 (1.85)bcde	2.0-4.0
	16	2.50 (1.54)def	1.0-4.0
2. Nimbecidine	0.4	4.75 (2.18)b	4.0-5.0
	0.8	3.00 (1.72)cdef	2.0-4.0
	1.6	2.50 (1.57)def	2.0-3.0
	3.2	2.25 (1.49)ef	2.0-3.0
3. Godrej Achook	0.4	4.25 (2.05)bc	3.0-6.0
	0.8	3.00 (1.72)cdef	2.0-4.0
	1.6	2.25 (1.49)ef	2.0-3.0
	3.2	2.25 (1.47)ef	1.0-3.0
4. Rakshak	0.2	3.75 (1.93)bcd	3.0-4.0
	0.4	3.00 (1.72)cdef	2.0-4.0
	0.8	2.75 (1.65)cdef	2.0-3.0
	1.6	2.00 (1.39)f	1.0-3.0
Control	-	8.50 (2.91)a	7.0-10.0

Figures given in parentheses are transformed values ($\sqrt{x}$)

Treatment means followed by common letters do not significantly differ at 5% level

Fig. 5. EFFECT OF NEEM PRODUCTS ON DURATION OF NYMPHAL STAGE



significant decrease in nymphal duration of *H. antonii* due to different treatments as compared to control.

The range in the nymphal duration for the different treatments was between 1.0 and 6.0 days while it ranged from 7 to 10 days in untreated control. Among different treatments, maximum nymphal period was exhibited by those exposed to Nimbecidine at 0.4 per cent (4.75 days).

The duration of nymphal stage was maximum in treatment with NKS at 2 per cent and this was minimum at 16 per cent. All the doses of NKS significantly reduced the nymphal duration as compared to control. In the case of Nimbecidine also, a significant reduction in nymphal duration was seen in all the doses.

Shortening of nymphal duration to 2.25 days was seen in Godrej Achook at 1.6 and 3.2 per cent. In the case of Rakshak also, the nymphal duration in all the tested doses showed drastic reduction as compared to control.

A remarkable reduction in duration of nymphal stage was recorded in the case of Nimbecidine at 3.2 per cent and the two higher doses of Godrej Achook (i.e. 1.6 and 3.2 per cent) which were on par with each other. Nymphs lived for relatively longer period of 3.0 days at 0.8 per cent of

Nimbecidine and Godrej Achook and 0.4 per cent of Rakshak which were on par with each other.

NKS at 16 per cent and Nimbecidine at 1.6 per cent showed similar impacts on nymphal duration. The duration of the nymphal stage was lowest (2.0 days) at 1.6 per cent of Rakshak while longest nymphal duration (4.50 days) was recorded at NKS 2 per cent and Godrej Achook at 0.4 per cent.

4.2 Evaluation of the effect of neem products on the feeding by *H. antonii* on cashew

4.2.1 Evaluation of translaminar feeding deterrency of treatments on *H. antonii*

The assessment of feeding rates of *H. antonii* from the lower surfaces of leaves as influenced by different treatments applied to upper surfaces of leaves was expressed in terms of radioactive counts of the bodies of test insect as shown in Table 8 and depicted in Fig.6. The ANOVA is presented in Appendix-III.

Treatment effects were not significant in affecting the feeding rate. NKS treatments did not significantly affect the feeding rates through translaminar effects. All the doses tested were on par with the control.

Table 8. Mean radio active counts of bodies of *H. antonii* on cashew seedling exposed to translaminar action of neem products

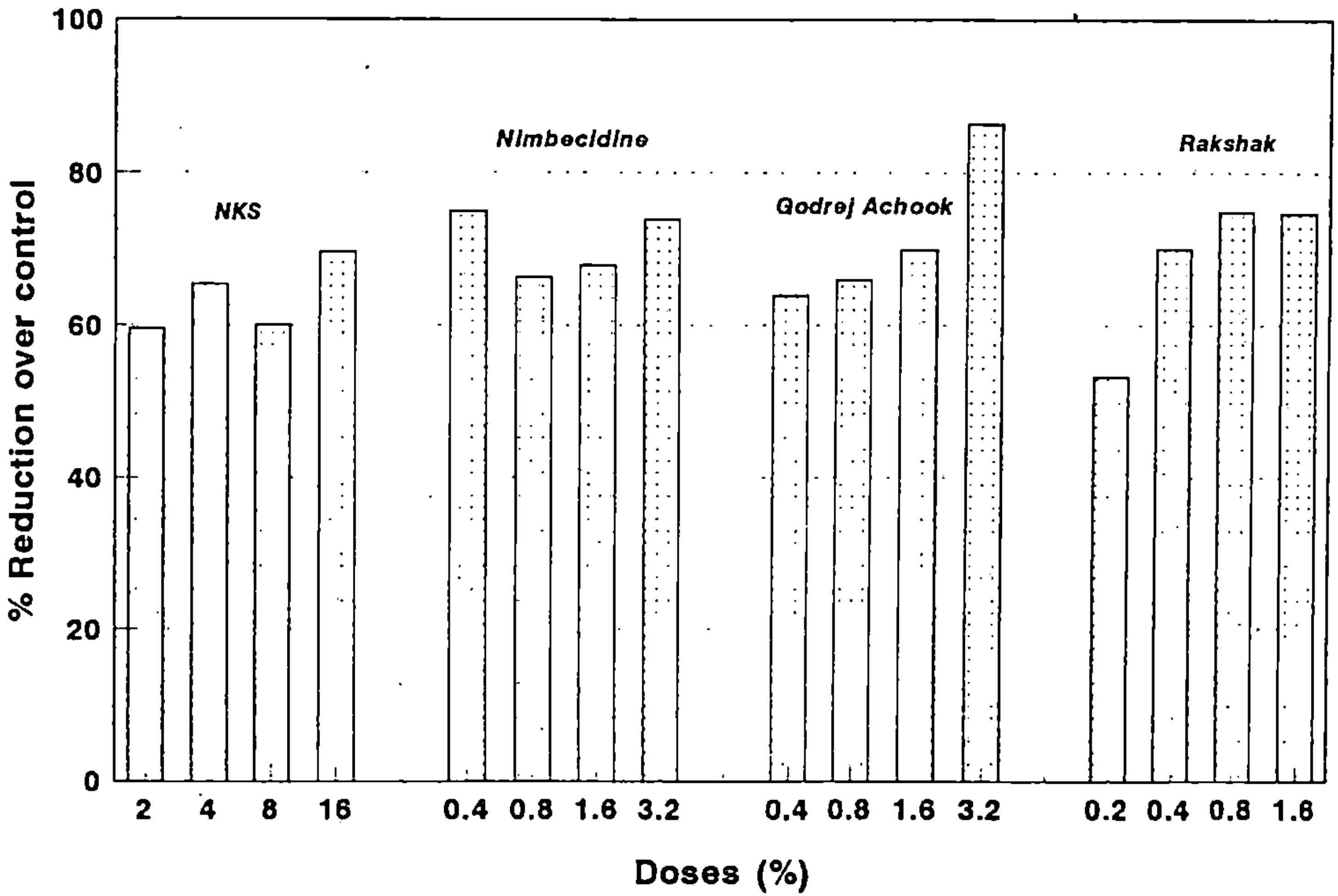
Treatment	Doses (per cent)	CPM	Per cent decrease over control
1. Neem kernel suspension	2	385.40 (2.37)	59.50
	4	329.35 (2.49)	65.39
	8	380.88 (2.46)	59.97
	16	289.25 (2.40)	69.60
2. Nimbecidine	0.4	238.00 (2.09)	74.99
	0.8	320.23 (2.44)	66.35
	1.6	306.23 (2.34)	67.82
	3.2	249.78 (2.28)	73.75
3. Godrej Achook	0.4	343.98 (2.46)	63.85
	0.8	324.20 (2.47)	65.93
	1.6	286.55 (2.39)	69.88
	3.2	129.10 (2.01)	86.43
4. Rakshak	0.2	445.58 (2.56)	53.17
	0.4	285.33 (2.42)	70.01
	0.8	240.03 (2.36)	74.77
	1.6	241.80 (2.20)	74.59
Control	-	951.63 (2.85)	

Figures given in parentheses are transformed values (logarithmic)

Treatment means do not significantly differ at 5% level

CPM - Radio active count per minute

Fig. 6. EFFECT OF NEEM PRODUCTS ON FEEDING
(Translaminar action)



translaminar action only at 0.4 per cent dose while the higher doses were on par with the control. Godrej Achook at 3.2 per cent reduced feeding rates. The lower doses were on par with each other and the untreated controls. Similar trend was observed in Rakshak treatment where only the 1.6 per cent dose showed perceptible decrease in the feeding rates. All other doses were on par with each other and with control.

The minimum feeding rate was noticed at 0.4, 3.2 and 1.6 per cent respectively for Nimbecidine, Godrej Achook and Rakshak which were on par with each other. All the tested doses of Rakshak resulted in reduction of feeding rate which showed a decreasing trend with increasing of doses. At 0.4 per cent of Nimbecidine, there was 74.99 per cent reduction in feeding rate while corresponding reduction for Godrej Achook was 63.85 per cent as compared to the control. There was 69.00 per cent reduction in feeding rate at 16 per cent NKS and 1.6 per cent Godrej Achook as compared to the control.

4.2.2 Evaluation of contact feeding deterrency of treatments on *H. antonii*

The quantum of radio activity in the body contents of nymphs of *H. antonii* which were allowed to feed on radio labelled cashew seedlings treated with different treatments was analysed and the results are presented in Table 9 and depicted in Fig.7. The ANOVA is given in Appendix-III.

The treatment effects were significant. Eventhough NKS at 8 per cent showed a decrease in feeding rate, all the four doses were on par with each other and with control. Nimbecidine treatments showed a decrease in feeding rates with increase in the doses. Feeding rate in Nimbecidine at 0.4 per cent was on par with control while all the three higher doses showed significant differences from control. The feeding rate was minimum in Nimbecidine at 3.2 per cent.

Godrej Achook in all the doses tested significantly reduced the feeding rates as compared to the control. The lowest feeding rate was seen in highest dose which was on par with 0.8 per cent dose of Godrej Achook. The feeding rate in the treatments with Rakshak was on par with the untreated controls, though the 1.6 per cent dose reduced the feeding rate.

4.2.3 Effect of translaminar action of treatments on number of feeding punctures developed by *H. antonii*

The data on the number of feeding punctures developed on cashew seedlings when the nymphs were confined on the leaf lamina after spraying the opposite surface with different treatments were analysed statistically and the mean values are

Table 9. Mean radio active counts of bodies of *H. antonii* on cashew seedling exposed to contact action of neem products

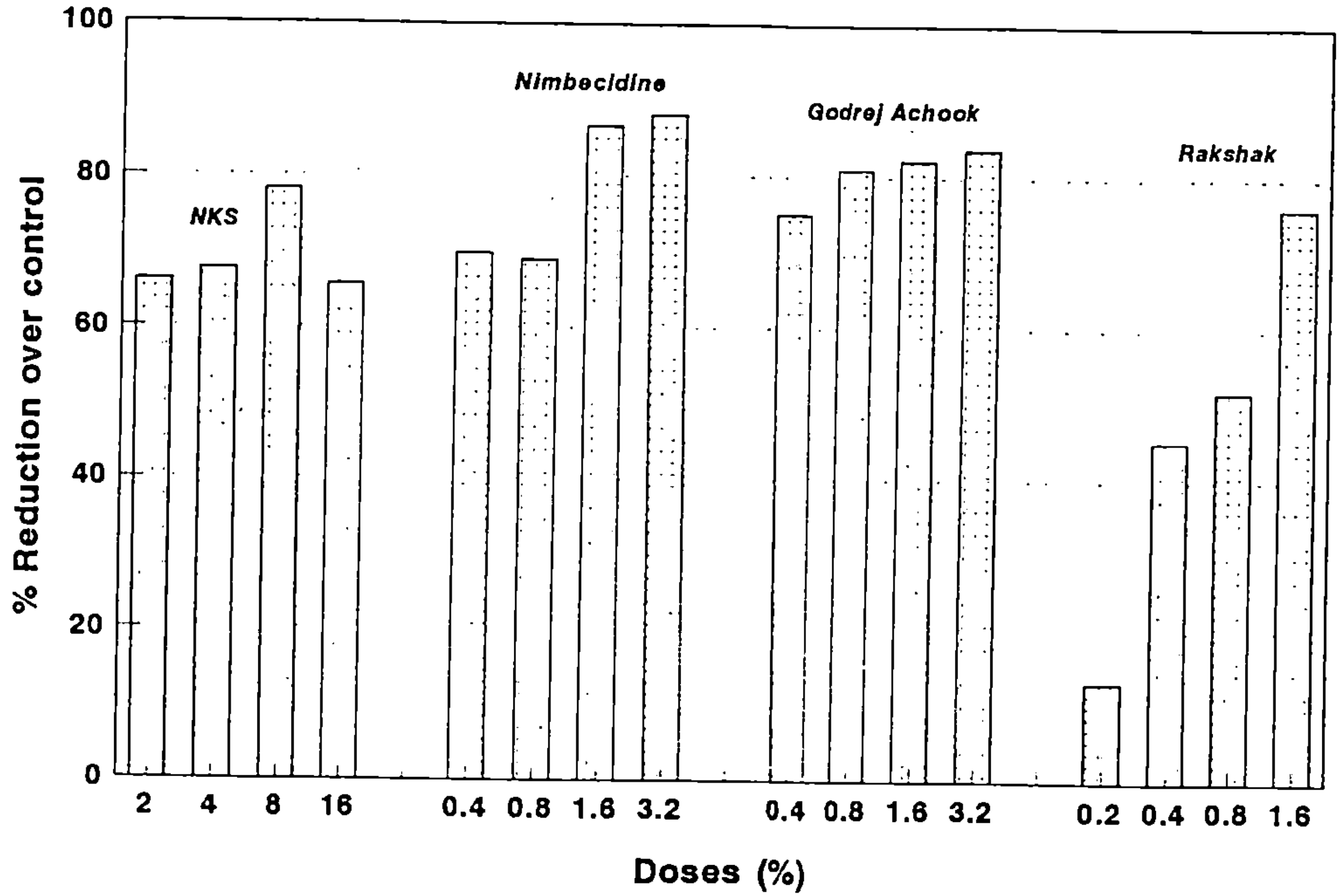
Treatment	Doses (per cent)	CPM	Per cent decrease over control
1. Neem kernel suspension	2	322.45 (2.41)abcd	66.12
	4	308.70 (2.39)abcd	67.56
	8	208.00 (2.29)abcd	78.14
	16	327.58 (2.30)abcd	65.58
2. Nimbecidine	0.4	287.38 (2.40)abcd	69.80
	0.8	295.23 (2.18)cd	68.97
	1.6	127.28 (2.08)cd	86.62
	3.2	112.65 (1.98)d	88.16
3. Godrej Achook	0.4	237.63 (2.24)bcd	75.03
	0.8	181.25 (2.13)cd	80.95
	1.6	169.28 (2.21)bcd	82.21
	3.2	154.85 (2.17)cd	83.72
4. Rakshak	0.2	826.00 (2.76)ab	13.20
	0.4	521.18 (2.65)abc	45.23
	0.8	459.00 (2.63)abc	51.76
	1.6	228.60 (2.34)abcd	76.04
Control	-	951.63 (2.85)a	

Figures given in parentheses are transformed values (logarithmic)

Treatment means followed by common letters do not significantly differ at 5% level

CPM - Radio active count per minute

Fig. 7. EFFECT OF NEEM PRODUCTS ON FEEDING
(Contact action)



presented in Table 10 and depicted in Fig.8. The ANOVA is given in Appendix-III.

The treatment effects were significant. The number of feeding punctures ranged from 5 in treatment with Godrej Achook at 3.2 per cent to 31 in treatment with Rakshak 0.2 per cent while they ranged from 27 to 38 in the untreated controls.

The lowest mean number of feeding punctures (7.00) was recorded in Godrej Achook at 3.2 per cent, while the highest number (29.0) was recorded in Rakshak 0.2 per cent. The three higher doses of NKS reduced the number of feeding punctures significantly over control. Nimbecidine and Godrej Achook significantly reduced the feeding punctures at all the doses tested, as compared to the control.

Among the different treatments, maximum number of feeding punctures was recorded in lower doses of 0.2 and 2 per cent in Rakshak and NKS respectively. At 1.6 per cent of Godrej Achook, there was significant reduction in number of feeding punctures was rendered out by treatment with Rakshak at the same dose (16.5). The effect in reducing the number of feeding punctures was relatively uniform at 0.4 and 0.8 per cent of Godrej Achook and one higher dose of Nimbecidine (3.2 per cent), The mean number of feeding punctures counted was

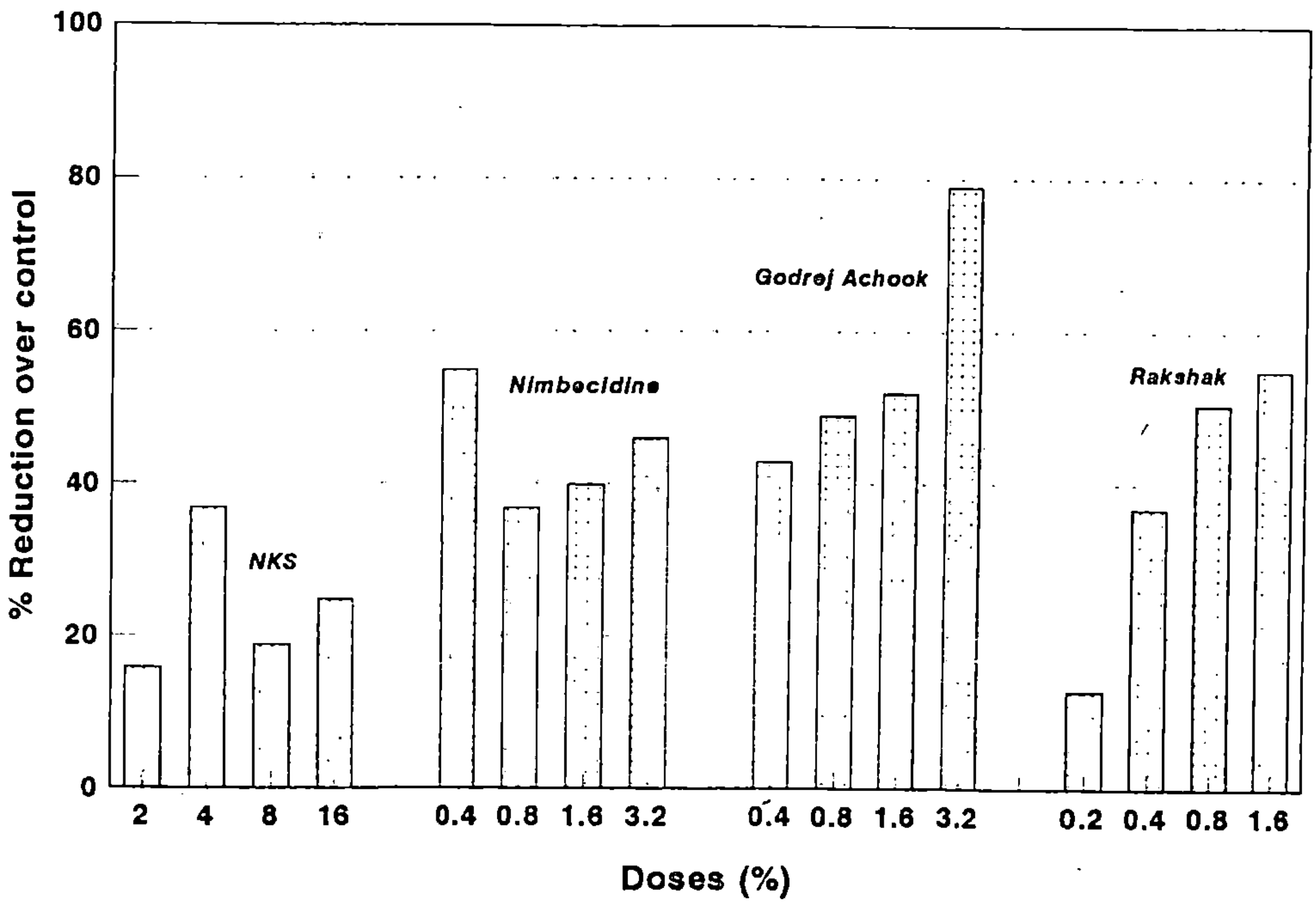
Table 10. Mean number of feeding punctures developed by *H. antonii* on cashew seedling exposed to translaminar action of neem products

Treatment	Doses (per cent)	Number of feeding punctures in 48 h	
		Mean	Range
1. Neem kernel suspension	2	28.00 (5.29)ab	25.0-30.0
	4	21.00 (4.58)cd	19.0-23.0
	8	27.00 (5.19)b	25.0-30.0
	16	25.00 (4.99)bc	21.0-29.0
2. Nimbecidine	0.4	15.00 (3.87)f	13.0-18.0
	0.8	21.00 (4.58)cd	19.0-23.0
	1.6	20.00 (4.47)de	18.0-22.0
	3.2	18.00 (4.23)def	15.0-21.0
3. Godrej Achook	0.4	19.00 (4.36)def	17.0-21.0
	0.8	17.00 (4.12)def	15.0-19.0
	1.6	16.00 (3.99)ef	12.0-19.0
	3.2	7.00 (2.63)g	5.0-9.0
4. Rakshak	0.2	29.00 (5.38)ab	26.0-31.0
	0.4	21.00 (4.56)cd	15.0-27.0
	0.8	16.50 (4.06)ef	14.0-19.0
	1.6	15.00 (3.87)f	12.0-17.0
Control	-	33.25 (5.75)a	27.0-38.0

Figures given in parentheses are transformed values ($\sqrt{x}$)

Treatment means followed by common letters do not significantly differ at 5% level

Fig. 8. EFFECT OF NEEM PRODUCTS ON No. OF FEEDING PUNCTURES
(Translaminar action)



21.0 in the case of 4, 0.8 and 0.4 per cent respectively, for NKS, Nimbecidine and Rakshak. The number of feeding punctures in NKS at 2 per cent was on par with that in 0.2 per cent of Rakshak. The mean number of feeding punctures recorded was 15.0 in Nimbecidine at 0.4 per cent and in Rakshak at 1.6 per cent. At 0.8 and 1.6 per cent, the number of feeding punctures was relatively higher in Nimbecidine than in the case of Godrej Achook and Rakshak.

4.2.4 Effect of contact action of treatments on number of feeding punctures developed by *H. antonii*

The number of feeding punctures developed by *H. antonii* after 48 hours exposure to twigs treated with different doses of neem products were analysed statistically and the mean values are presented in Table 11 and depicted in Fig.9. The ANOVA is given in Appendix-III.

Treatment effects were significant. The number of feeding punctures ranged from a minimum of 4 in Nimbecidine to 32 in Rakshak among treatments. The number ranged from 25 to 38 in the untreated controls.

The number of feeding punctures was significantly lower in three lower doses of NKS as compared to the control. NKS at 8 per cent was significantly superior to the other three doses. All the doses of Nimbecidine significantly

Table 11. Mean number of feeding punctures developed by *H. antonii* on cashew seedling exposed to contact action of neem products

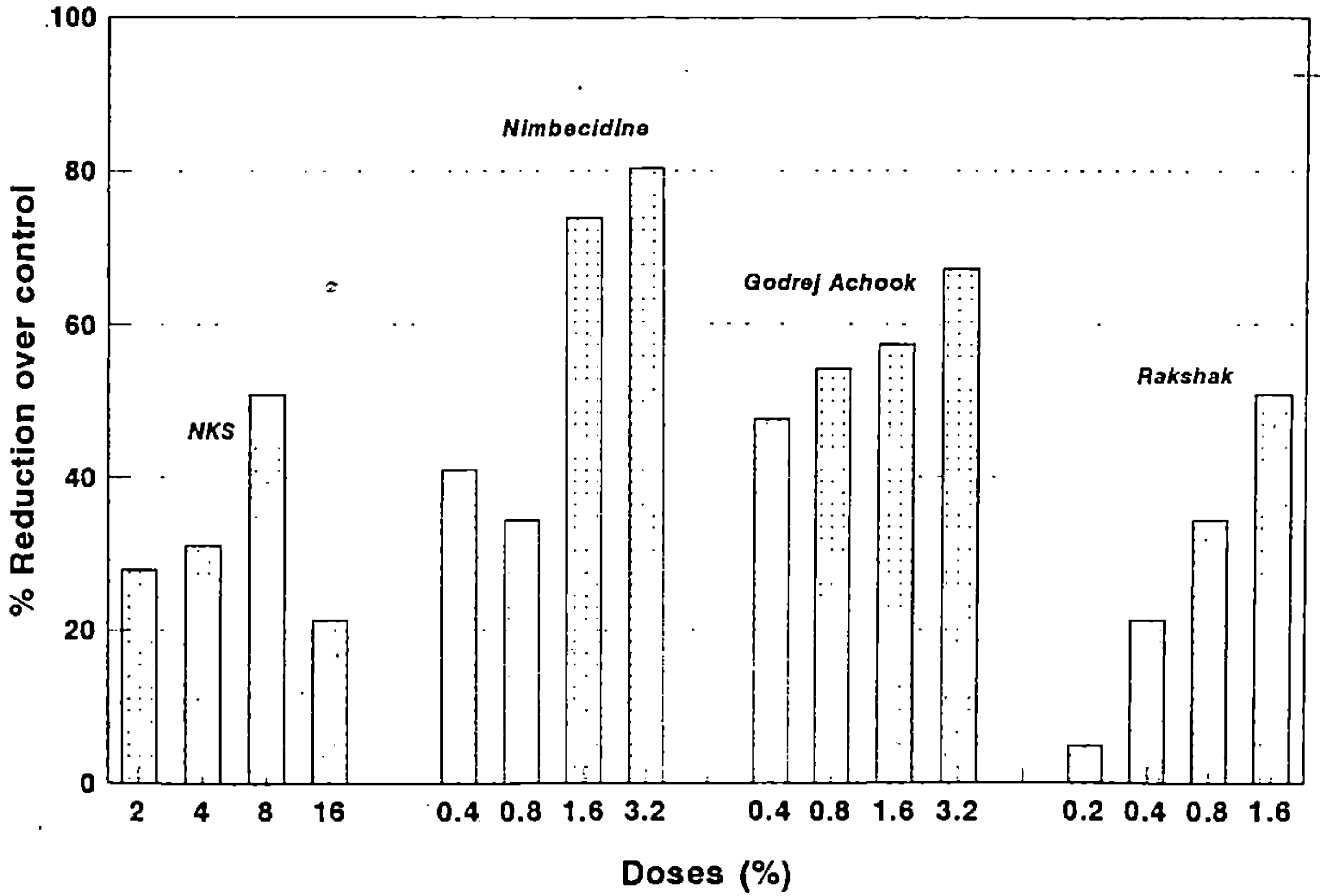
Treatment	Doses (per cent)	Number of feeding punctures in 48 h	
		Mean	Range
1. Neem kernel suspension	2	22.00 (4.68)bcd	18.0-26.0
	4	21.00 (4.55)cde	15.0-27.0
	8	15.00 (3.85)efgh	12.0-20.0
	16	24.00 (4.88)abc	19.0-29.0
2. Nimbecidine	0.4	18.00 (4.21)cdefg	12.0-24.0
	0.8	20.00 (4.42)cdef	13.0-27.0
	1.6	8.00 (2.81)ij	6.0-11.0
	3.2	6.00 (2.43)j	4.0-8.0
3. Godrej Achook	0.4	16.00 (3.97)defg	11.0-21.0
	0.8	14.00 (3.72)fgh	10.0-18.0
	1.6	13.00 (3.59)gh	10.0-16.0
	3.2	10.00 (3.15)hi	8.0-12.0
4. Rakshak	0.2	29.00 (5.38)ab	26.0-32.0
	0.4	24.00 (4.88)abc	22.0-27.0
	0.8	20.00 (4.42)cdef	16.0-23.0
	1.6	15.00 (3.85)efgh	11.0-19.0
Control	-	30.50 (5.51)a	25.0-38.0

Figures given in parentheses are transformed values ($\sqrt{x}$)

Treatment means followed by common letters do not significantly differ at 5% level

Fig. 9. EFFECT OF NEEM PRODUCTS ON No. OF FEEDING PUNCTURES

(Contact action)



reduced the number of feeding punctures. This reduction was more pronounced at 1.6 and 3.2 per cent doses.

All the doses of Godrej Achook reduced the feeding punctures significantly as compared to the control. The mean number of feeding punctures gradually decreased with increase in doses of Godrej Achook, which were significantly lower than control. Rakshak at 0.4, 0.8 and 1.6 per cent significantly reduced the number of feeding punctures while the 0.2 per cent dose was on par with the control.

Discussion

DISCUSSION

The biological effects of four commercial formulations of neem with reference to the ovipositional behaviour and feeding behaviour of H. antonii have been assessed in the present studies. The results obtained are discussed in this chapter.

5.1 Evaluation of the effect of neem products on the ovipositional behaviour of H. antonii

5.1.1 Effect of different neem products at different doses on the number of egg laying sites of H. antonii

The results of the study indicated that the higher doses significantly reduced the number of egg laying sites of the test insect. NKS 8 and 16 per cent and Nimbecidine at 0.4 and 0.8 per cent resulted in relatively lesser number of egg laying sites. Similarly the number of egg laying sites at 1.6 and 3.2 per cent doses of Godrej Achook was lower than in the case of Nimbecidine at the same doses. The present study clearly established that all the neem products reduced the number of egg laying sites as compared to the untreated control. The extent of reduction in the number of egg laying sites, however, was dependent on the product and the dosage.

There were no reports of studies with neem products on *H. antonii*. In earlier studies, with different sucking insects on various crops, several workers have reported a significant reduction in the overall fecundity (Islam, 1984; Heyde *et al*., 1985; Saxena and Barrion, 1987; Velusamy *et al*., 1987; Abdul Kareem *et al*., 1988 and 1989; Bhathal *et al*., 1991). One of the contributing factors for this reduction in overall fecundity could be the reduction in the number of egg laying sites caused by the neem compounds.

5.1.2 Effect of different neem products at different doses on the duration of egg laying of *H. antonii*

All the tested doses of the four neem products showed significant decrease in the duration of egg laying. The egg laying period in lower doses of NKS (2 and 4 per cent) and Nimbecidine (0.4 and 0.8 per cent) showed relatively lesser variation as compared to the control. However, at higher doses both these products significantly reduced the egg laying period. Similar trend was noted in the case of Godrej Achook.

Rakshak showed reduced duration of egg laying in all the doses tested. The shortened egg laying period was also noticed in higher doses of Godrej Achook (1.6 and 3.2 per cent). Eventhough the effect of neem products on the duration of egg laying by *H. antonii* and other sucking insects have not been reported earlier, the reduction in overall fecundity reported by several workers (vide para 5.1.1) could be partly attributed to the reduction in duration of egg laying.

5.1.3 Effect of different neem products at different doses on the number of eggs laid by female of _H. antonii_

The treatments with lower doses of all the neem products resulted in relatively more number of eggs per female than the corresponding higher doses, though, at all the doses, the number of eggs was significantly lower than that in control. Among the treatments,Godrej Achook (3.2 per cent) and Rakshak (1.6 per cent) showed relatively lesser number of eggs. Adults exposed to the treatments with these two products showed significantly lower fecundity than in the case of NKS and Nimbecidine at all tested doses. The higher doses of all the neem products significantly reduced fecundity. Thus it can be concluded that the fecundity is inversely related to the dose of the product.

Similar reductions in fecundity by several sucking insects following differently applied neem products were reported by several workers. Systemically and topically applied neem oil reduced fecundity of _N. virescens_ (Heyde _et al._, 1985). Neem oil when applied at 25 and 50 per cent ULV and 10 per cent LV applications reduced egg laying by

N. virescens (Raguraman, 1987) when rice plants were sprayed with 100, 500 and 2500 ppm doses of Neem Seed Bitter (NSB), the reproductive potential of green leaf hoppers was affected (Saxena and Barrion, 1987). Velusamy *et al.* (1987) also noticed that neem oil at 1 and 2 per cent reduced oviposition by *N. virescens*. Abdul Kareem *et al.* (1988) reported that root immersion of rice seedlings for 24 hours in 5 per cent NSKE considerably reduced the oviposition by *N. virescens*. 5000 ppm aqueous solution of NSB was also found to result in laying of fewer eggs by green leaf hoppers in rice (Abdul Kareem *et al.*, 1989). Brown plant hoppers laid fewer number of eggs on rice plants treated with neem seed extracts (Islam, 1984). Velusamy *et al.* (1987) reported that neem seed kernel extracts and neem oil treatments reduced oviposition by the BPH. Abdul Kareem *et al.* (1989) reported treatments with NSB drastically reduced the number of eggs laid by *N. lugens*. *Bemisia tabaci* (Genn.) laid lesser number of eggs when cotton foliage was treated with neem seed extract at 0.2 and 2.0 per cent (Caudriet *et al.*, 1985). Schauer (1985) reported that the aphid, *Acyrthosiphon pisum* (Harris) adults reared on plants treated with 20 ppm NSKE produced about one twelfth of nymphs as compared to untreated controls. Topical application of NSKE lead to the production of 41 per cent less eggs by *Dysdercus fasciatus* (Ochse, 1981). Dorn *et al.* (1987)

reported that topically applied azadirachtin reduced the number of eggs laid by Oncopeltus fasciatus.

5.1.4 Effect of different neem products at different doses on the hatchability of eggs of H. antonii

There was no significant reduction in the hatchability of eggs due to different treatments. However, a general decrease in the percentage of hatchability of eggs of H. antonii was noticed in all the treatments with neem products. Maximum reduction in hatchability was seen in the Rakshak treatments. Thus it can be seen that neither the neem product nor the dosage level has a marked effect on the hatchability of eggs. Effect of neem products on the hatchability of eggs of H. antonii are not reported earlier. However, a scanthrough the literature revealed some interesting results contrary to the findings of this study. Some sucking insects such as N. virescens, N. lugens, D. koenigii and D. fasciatus did show reductions in eggs hatchability following application of neem products.

Root immersion of rice seedlings in 5 per cent NSKE reduced egg hatch in N. virescens (Abdul Kareem et al., 1988). Neem seed bitters when sprayed on rice plants at 5000 ppm reduced the hatchability of N. lugens (Abdul Kareem et al., 1989). NSKE at 5 per cent applied on rice plants, reduced hatchability of eggs of the BPH (Mohan, 1989). Ochse (1981) noted that neem oil affected the emergence of eggs of D. fasciatus. Topical applications of crude extracts of neem were found to reduce hatchability of eggs of D. koenigii by Jaipal and Zile Singh (1985). Similarly considerable reduction in hatchability of eggs of the bug was noted by Bhathal et al. (1991). Viability of eggs of B. tabaci was affected by NSKE at 0.2 and 2.0 per cent doses on cotton foliage (Coudriet et al., 1985).

5.1.5 Effect of different neem products at different doses on the survival of nymphs of H. antonii

The different doses of neem products produced significant effects on the survival of first instar nymphs of the test insect. The lower doses of NKS caused maximum nymphal survival while higher doses showed minimum survival. A remarkable reduction in the nymphal duration was noticed with Nimbecidine at 3.2 per cent. Godrej Achook at 1.6 and 3.2 per cent and Rakshak also showed significant reductions in nymphal duration as compared to the control. At higher doses, all the neem products caused nymphal mortality in shorter periods indicating that the phenomenon was dose dependent. Similar works with H. antonii were not reported earlier. The present findings are in general agreement with the results obtained by some workers on other sucking insects (Mariappan and Saxena, 1983 ; Saxena and Khan, 1984 and Heyde, 1984). Mariappan and Saxena (1983) also reported reduced survival of nymphs of *N. virescens* and consequent reduction in transmission of RTV in rice seedlings following application of neem oil. Nymphal mortality of *D. Koenigii* was noticed by Koul (1984) following azadirachtin treatments. Mortality of nymphs of *B. tabaci* on cotton foliage treated with NSKE was reported by Coudriet *et al*. (1985). While similar result was reported by Schauer (1985) with pea aphids on *Vicia fabae* plants.

5.2 Evaluation of the effect of neem products on the feeding of *H. antonii* on cashew

In this experiment, the rate and quantum of feeding by nymphs of *H. antonii* as influenced by the different doses of the neem products was assessed. Since direct quantification was not possible, radiolabelling of seedlings was undertaken. The quantum of radio activity (CPM) in the test insects was taken as an index of quantum of feeding of nymphs when confined to the treated plants. Significant reduction in the radio activity counts indirectly indicated the feeding deterrency induced by the treatments.

5.2.1 Evaluation of translaminar feeding deterrency of treatments on *H. antonii*

When the nymphs of test insect were confined to the laminar surfaces after spraying the opposite laminar surfaces with neem treatments, no significant reductions in radio activity counts in their bodies was noticed. This indicated that the treatments did not exhibit translaminar feeding deterrency, as compared to untreated controls.

A reduction in feeding rate was noticed in all the tested doses of the commercial neem products as compared to the control, though not significant. Thus NKS exhibited greater feeding deterrency through translaminar effect than the other products. Reports of comparable studies with neem products on the feeding deterrency to *H. antonii* are lacking in literature. Hence a comparison is made with other sucking insects following application of neem products. Saxena *et al*. (1984) observed that food intake by *N. lugens* was low in rice plants grown in soils incorporated with neem cake. Heyde *et al*. (1985) reported that when rice plants were systemically treated with neem oil at doses higher than 6 per cent, feeding and fecundity of *N. lugens* were significantly affected. Saxena and Khan (1986) noted that feeding by *N. virescens* on rice plants kept in areas permeated with odour of 6, 12 or 25 per cent neem oil reduced the feeding significantly. This was associated with a significant increase in the insects probing frequency, xylem ingestion and salivation period. Saxena and Boncodin (1988a) noticed that root immersion of rice seedlings in aqueous solutions of NSB at 2500 ppm significantly reduced the duration of phloem feeding by N. lugens, S. furcifera and N. virescens. This, according to the authors, was accompanied by a corresponding significant increase in frequency of probing, salivation and xylem feeding. Sieve tube penetration by Myzus persicae (Sulz.) was significantly reduced by the presence of azadirachtin at 300 ppm concentrations (Nisbet et al., 1993).

Systemic presence of neem principles in plants sap affected the sustained feeding of rice vectors, thus preventing the spread of virus diseases. Saxena and Justo (1986) reported that RTV susceptible IR42 plants when treated with custard apple oil - neem oil mixture alone or incombination with neem cake - urea mixture had lower RTV incidence. Systemic application of NSB solution at 5000 ppm and further foliar spray with NSB at 10,000 ppm on rice seedlings reduced the N. virescens population and incidence of RTV at 50 DAT (Saxena et al., 1989).

5.2.2 **Evaluation of contact feeding deterrency of treatments on *H. antonii***

The quantum of radio activity in the body contents of nymphs of *H. antonii* after confining them on plants topically applied with different neem treatments indicated the feeding deterrency by contact action was significant.

The reduction in the feeding rate was less in NKS as compared to the commercial formulations. At 3.2 per cent dose, the reduction in feeding rate in Nimbecidine was 30.53 per cent while the corresponding reduction was 23.36 per cent in Godrej Achook. There was significant reduction in feeding rates in all the tested doses of Rakshak. Thus Rakshak exhibited greater feeding deterrency through contact action than the other products.

Comparable studies with neem products on *H. antonii* are not available in the literature. Hence similar works on other sucking insects are compared. Heyde *et al.* (1984) reported that food intake of *N. lugens*, *S. furcifera* and *N. virescens* was significantly reduced on rice seedlings sprayed with 1 to 50 per cent doses of neem oil. Saxena and Khan (1985) observed that phloem feeding by *N. virescens* on plants sprayed with 1.25 to 10 per cent neem oil was significantly lower. In a 60 minutes observation period, starved females of N. lugens avoided rice seedlings treated with neem oil for 15 to 22 minutes evenafter alighting on them (Saxena et al., 1987) indicating contact deterrency of the treatments. The reduced build up of RTV in neem treated rice plants (5.2.1) could be due to feeding deterrency through contact action also.

5.2.3 Effect of translaminar action of treatments on number of feeding punctures developed by H. antonii

The number of feeding punctures developed on leaves of cashew seedlings when nymphs were confined on leaf laminae after spraying the opposite surfaces with different treatments showed significant reductions as compared to untreated controls. A notable reduction in the number of feeding punctures was noticed at higher concentrations of all the four neem products. Godrej Achook and Rakshak were in particular, more effective than other treatments. Similar studies are not reported earlier.

5.2.4 Effect of contact action of treatments on the number of feeding punctures developed by H. antonii

The number of feeding punctures developed after confining the nymphs for 48 hours on treated seedlings was significantly lower than in untreated controls. The reduction in the number of feeding punctures followed a similar trend as the quantum of feeding by the test insect. The reduction in the number of feeding punctures was more marked in higher doses of all the neem products, indicating a dose relationship. Among the products, Rakshak at all doses tested resulted in lesser number of feeding punctures followed by Nimbecidine and Godrej Achook. The effect of contact action resulting in reduced number of feeding punctures are not reported earlier. However, a tendency for increased rate of probing was reported for many sucking insects (vide 5.2.1) along with increased salivation and xylem feeding. However, the necrotic lesions which develop after feeding by H. antonii are chiefly caused by injection of toxic saliva later then by simple probings. Thus the earlier reports that neem products induced increased probing could not be either confirmed or denied based on the present study.

Summary

SUMMARY

A set of experiments were conducted at the Department of Entomology, College of Horticulture, Vellanikkara, to ascertain the feasibility of utilizing the commercially available neem products for the management of population of H. antonii on cashew. With this objective, experiments were designed to test the bio-efficacy of the neem products in interfering with ovipositional and feeding behaviour of H. antonii following application on the plants.

The three commercial products namely, Godrej Achook, Rakshak and Nimbecidine were tested against a local preparation of NKS and untreated controls.

The study resulted in the following findings.

1. The treatment effects were significant in affecting the number of egg laying sites. Godrej Achook at 1.6 and 3.2 per cent and all the tested doses of Rakshak showed considerable decrease in number of egg laying sites as compared to other treatments.

2. A significant reduction in duration of egg laying was noticed at 1.6 and 3.2 per cent dose of Godrej Achook and Rakshak as compared to other treatments.

3. Adults of *H. antonii* when released on twigs treated with higher doses of Godrej Achook at 1.6 and 3.2 per cent and Rakshak at 1.6 per cent showed significant reduction in number of eggs laid per female. These treatments were comparatively superior to NKS and Nimbecidine at all the doses.

4. Eventhough the treatment effects were not significant, in term of percentage reduction in hatchability of eggs, Rakshak at 0.8 per cent and Nimbecidine at 3.2 per cent appeared to be better in reducing the hatchability.

5. Godrej Achook at 1.6 and 3.2 per cent and all the tested doses of Rakshak significantly reduced the nymphal duration as compared to other treatments.

6. None of the treatments significantly affected the feeding rate of nymphs through translaminar effects. However, all the tested doses of Rakshak and Godrej Achook resulted in reduction of feeding rate which showed a decreasing trend with incremental doses.

7. Treatment effects were significant in affecting the feeding rate through contact action. Nimbecidine and Godrej Achook at higher doses of 1.6 and 3.2 per cent showed significant reduction in feeding rate as compared

to other treatments. This was ascertained by employing radio activity for the first time in cashew.

8. Among different treatments, Nimbecidine and Godrej Achook at all the doses tested, significantly reduced the number of feeding punctures on treated seedlings through translaminar action of treatments as compared to other treatments.

9. The higher doses of Nimbecidine and Godrej Achook reduced the number of feeding punctures significantly on seedlings through contact action of treatments as compared to other treatments.

Based on the results obtained, it can be concluded that, neem products have exhibited significant biological effects in suppressing the population of *H. antonii*. Eventhough neem is an alternate host for the tea mosquito bug, neem derivatives altered the feeding and ovipositional behaviour. Neem products can be included in the list of plant protection chemicals for the management of *H. antonii* in cashew.

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* Originals not seen

Appendices

APPENDIX-I

Ambient temperature and humidity condition for the laboratory studies for the period from September, 1993 to September, 1994 (recorded at Vellanikkara)

Month	Temperature °C		Average relative humidity (%)
	Maximum	Minimum	
September '93	30.6	23.1	81
October	30.7	23.4	83
November	31.5	23.6	73
December	31.6	23.1	66
January '94	32.9	22.6	58
February	34.8	23.1	59
March	36.2	23.7	59
April	34.9	24.4	74
May	33.6	24.7	75
June	28.9	22.9	90
July	28.6	22.4	91
August	30.0	22.8	85
September	31.8	23.2	78

APPENDIX-II

Summary of analysis of variance tables of ovipositional behaviour of *H. antonii* on cashew twigs, treated with neem products, at different doses

Source	df	Mean squares				
		Number of eggs per female	Number of egg laying sites	Duration of egg laying	Hatchability of eggs	Nymphal survival
Treatments	16	2.586**	1.824**	0.448**	73.612 NS	0.535**
Error	51	0.188	0.109	0.050	63.103	0.065
Total	67					

** - Significant at 1 per cent level

NS - Not significant

APPENDIX-III

Summary of analysis of variance tables of feeding behaviour of *H. antonii* on cashew twigs, treated with neem products, at different doses

Source	df	Mean squares			
		Feeding (contact action)	Feeding (translaminar action)	Feeding punctures (contact action)	Feeding punctures (translaminar action)
Treatments	16	0.236*	0.138 NS	3.588**	2.172**
Error	51	0.112	0.143	0.229	0.097
Total	67				

** - Significant at 1 per cent level

* - Significant at 5 per cent level

NS - Not significant

ABSTRACT

Experiments were conducted at the Department of Entomology, College of Horticulture, Vellanikkara, to ascertain the feasibility of utilizing the commercially available neem products for the management of populations of tea mosquito bug, Helopeltis antonii Sign. on cashew, Anacardium occidentale L.

The effects of three neem products in altering the ovipositional behaviour and the feeding behaviour of H. antonii through contact and translaminar effects and the number of feeding punctures as affected by the contact and translaminar effects, were tested in comparison with NKS. Radio labelling of cashew seedlings prior to application of treatments and quantification of feeding based on the quantum of radio activity in the bodies of test insects fed on the treated seedlings was developed as a new technique.

The study resulted in the following findings.

1. Godrej Achook at 1.6 and 3.2 per cent doses and Rakshak at all the tested doses significantly reduced the number of egg laying sites.

2. Duration of egg laying was significantly reduced by Godrej Achook and Rakshak at 1.6 and 3.2 per cent doses.

3. Significant reduction in the total number of eggs laid was brought about by Rakshak 1.6 per cent and Godrej Achook at 1.6 and 3.2 per cent doses.

4. Rakshak at all doses and Godrej Achook at 1.6 and 3.2 per cent doses significantly reduced the nymphal duration. The nymphs failed to reach adult hood.

5. Feeding deterrency through contact action was exhibited by the treatments. Nimbecidine and Godrej Achook at higher doses were better.

6. The number of feeding punctures was influenced by the treatments through translaminar effects.

7. Development of feeding punctures was affected by the treatments through contact action also. Higher doses of Godrej Achook and Nimbecidine were better than the other treatments.

In conclusion it can be stated that the commercially available neem products showed a high degree of effectiveness in reducing the feeding and oviposition by *H. antonii*, eventhough the neem tree is an alternate host of the tea mosquito bug. The neem products can be included as candidates for the management of population of *H. antonii* on cashew.