THE COCONUT LEAF-EATING CATERPILLAR, *NEPHANTIS SERINOPA* MEYRICK, A REVIEW

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ABSTRACT

Works conducted on the life history and habits, seasonal abundance, natural enemies, biological control, chemical control, and integrated control of coconut leaf-eating caterpillar, *Nephantis serinopa* Meyrick are reviewed. Problem areas on the control of this serious pest in India and Sri Lanka are then identified. Additional studies on the fields for each aspects of the pest are suggested to come up with possible source of materials necessary in formulating a feasible integrated control measures which are both economical and effective.

INTRODUCTION

The coconut leaf-eating caterpillar, *Nephantis serinopa* Meyrick (Lepidoptera: Cryptophasidae), is a serious pest of coconut in India and Sri Lanka. In India, it is prevalent in Kerala throughout the coastal and backwater areas. It has also been observed in Tamil Nadu, Andra Pradesh, Karnataka, Orissa, West Bengal, Bihar, Maharashtra and Gujarat. Its present distribution indicates that this pest is gradually spreading to new areas including the interior regions.

The caterpillars form galleries or runways made of silk and excrement on the underside of the leaflets where they feed and live (Fig. 1). They feed on the lower surface of leaves causing the leaflets to turn brown (Fig. 2). During severe infestation, the older leaves appear scorched (Fig. 3) with only the younger leaves at the center appearing green (Jayarathnam, 1941b). Seedlings (Fig. 4) as well as mature palms are attacked.

The yield of coconut may be reduced drastically if infestation is severe especially in areas where the palms are overcrowded or where the soil is poor. Severe damage to leaves usually result to reduction in the number of flower spikes produced, increase in immature nutfall and retardation of growth.

In India, *N. serinopa* was comparatively rare prior to 1920 although the importance of this pest to the local coconut industry has drawn the attention of many workers as early as 1922. Since then a great deal of work on the various aspects of the pest had been conducted. Presently, this pest is the most important lepidopterous pest of coconut in India. Therefore, it is appropriate to review the work done so far in order to identify problem areas which may require more immediate attention to facilitate the application of effective control measures in order to keep the population below the economic injury level.

LIFE HISTORY, HABITS AND SEASONAL ABUNDANCE

Life History

The life cycle of *N. serinopa* has been studied by several workers. Rao *et al.* (1948) mentioned that a female can lay as many as 350 eggs. The eggs are laid on the underside of the leaflets near old larval galleries. The incubation period varies from 3 to 7 days. However, this period may be prolonged due to variable temperature and relative humidity as cited by Antony (1962).

The caterpillar is pink with black head and dark thoracic plates (Fig. 5). There is some disagreement among workers regarding the number of instars that the larvae undergo. Lever (1969) mentioned that there are 5 instars, Nirula *et al.* (1951a) cited 6 instars while Antony (1962) observed 7 instars. The larva also undergoes a prepupal period. The larval period lasts from 5 to 8 weeks.

The pupal period ranges from 9 to 14 days. Pupation occurs in the larval galleries. The adult is a grayish moth with pale forewings with dark specks. The male moth lives about 7 days while the female lives only 5 days. The complete life cycle lasts about 2 to 2½ months. Different workers have observed variations in the period required to complete the different developmental stages. This may be due to variability in temperature and humidity under which the studies have been conducted.

Habits

Observation made by Nirula *et al.* (1951a) and Antony (1962) showed that the moths are nocturnal in habit. They are not attracted to light and are sluggish in nature. They are poor fliers and when the moths are resting, wind or light has very little effect on them.

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According to Antony (1962), the sluggish nature of the moths may have caused the slow spread of the pest resulting to localized infestations. More detailed studies on the flight range and pattern, breeding habits and behavior of moths are still needed to show their effects on the spread of the pest to new areas.

Mating has not been observed in captivity so that eggs laid by female moths in the laboratory were all infertile. However, field-collected eggs were found to be fertile and would hatch normally.

Seasonal Abundance

Nirula (1956) cited that *N. serinopa* was present in the west coast of India almost throughout the year. However, the pest assumed serious proportion only during the summer months (March to May). The onset of the monsoon rains marked the decrease of the pest population. He mentioned that the galleries in which the caterpillars live became flooded and this favored the spread of fungal and bacterial infection. This condition also favored the multiplication of other natural enemies (to be discussed later) of the insect.

The population of *N. serinopa* starts to build-up in January, reaching its peak in March. However, Nirula (1956) cited that peak populations were recorded in April and May. Sathiamma *et al.* (1973) recorded the peak period in June. The discrepancy may be due to seasonal differences from year to year. Joy and Joseph (1972a) agreed to this summer peak as they observed severe infestation during the hot season only. On the other hand, the lowest population was recorded during November to December.

Most workers agreed that climatic factors caused fluctuations of pest population in the field. Antony (1962) cited that fluctuation in population was due mainly to variability in temperature while Sathiamma *et al.* (1973) said that humidity was directly correlated to pest population. He explained that the greater prevalence of *N. serinopa* in the coastal and backwater areas where relative humidity was higher further supported the influence of relative humidity on pest abundance.

Joy and Joseph (1972a) observed that the population density of palms, soil type, soil temperature and use of intercrops were some of the main factors that affected the incidence of *N. serinopa* in certain areas. However, further studies need to be conducted to relate these factors that he cited causing outbreaks to other factors such as fecundity of females, viability of eggs, presence of natural enemies and others.

NATURAL ENEMIES

Parasites

N. serinopa is attacked by a number of parasites during various stages of its development. Parasites have played an important role in keeping the population of this pest at lower level in the field. The earliest studies conducted on the parasites of this insect was reported in early 1920s. Rohwer (1921) described *Elasmus nephantidis* Rohwer as a parasite of this insect. Ramachandra Rao (1924 and 1926) listed the natural enemies of *N. serinopa* in the Mangalore area. Rao and Cherian (1927 and 1928) described the life history of *E. nephantidis* and *Perisierola* sp. Cherian (1928) studied the life cycle of *Microbracon serinopa* Wesmael while Ferriere (1930) described *Trichospilus pupivora* Ferriere as a parasite of *N. serinopa* in his notes on Asiatic Chalcidoidea.

In 1956, Nirula made a review of the natural enemies of *N. serinopa.* One of the important parasites cited was *Perisierola nephantidis* Muesebeck. Jayarathnam (1941a) and Kurian (1954) have described the life history of this parasite. Further studies on *P. nephantidis* were made by Antony and Kurian (1960) and Kurian and Antony (1961) who also described its habits, host preferences, and life cycle. V. Rao (1961) recorded a new tachinid parasite, *Thalairosoma gracilis* Mesnil attacking the larvae. *Apanteles taragamae* Viereck was observed to parasitize very young larvae.

Lever (1969) cited 5 pupal parasites of *N. serinopa* which included: *Stomatoceras sulcatiscutellum* Girault, *Brachymeria nephantidis* Gahan, *Xanthopimpla punctata* Fabricius, *Trichospilus pupivora* Ferriere, and *Goryphus nursei* Cameron. All of them are hymenopterous parasites. Sheshagiri Rao and Dharmaraju (1967) reported that *Eurytoma* sp, paratisizes the pupa. Another pupal parasite observed in the field was *Aprostocetus israeli* Mani and Kurian. Joseph *et al.* (1973) and Joy and Joseph (1972b and 1973) reported that *Neobrachymeria nosatoi* Habu was an important pupal parasite of this pest.

Although many species of parasites attacking *N. serinopa* have been cited in the literature and some species were studied extensively, to date no systematic survey has so far been done to catalog the natural enemies of this pest in all coconut growing regions of India (Nagarkatti, 1973).

Predators

A number of predators also attack *N. serinopa* in the field. The adult and gurb of *Parena laticineta* Bates and *Phlaeodromius nigrolineatus,* 2 species of carabid beetles, feed on *N. serinopa* caterpillars in their galleries. A reduviid bug, *Sphedanolestes aurescens* Dist. and an anthocorid bug, *Triphleps* sp., have been observed to feed on the eggs and larvae of the pest. The mite *Pijemotes ventricosus* Newport attacks the larvae in southern India but without much effect during severe infestation. Ants and spiders were also observed feeding on eggs and larvae in the field. The periodical visit of migratory birds during certain seasons and their predation on caterpillars keep the pest population down in certain areas.

Microorganisms

Certain species of fungi and bacteria attack the larvae and pupae of *N. serinopa*. Antony and Kurian (1961) studied the pathogenicity of the bacterium, *Serratia marcescens* Bizio, which was observed to infect the larvae in laboratory cultures. They found that it causes septicemia which accounted for 70% mortality of larvae exposed to sprayed leaflets. It always caused death of larvae if inoculated but the effect was variable when the pathogen was ingested depending upon the stage of the larva when infected. Although only very few studies have been made on the effects of microorganisms on *N. serinopa*, it may be worthwhile to do further work on this field.

BIOLOGICAL CONTROL

As early as 1922, entomologists were already aware of the importance of natural enemies in keeping the population of *N. serinopa* under control. Some indigenous and introduced species of parasites have been quite amenable to laboratory rearing and utilization in the field as biological control agents. They include hymenopterous species belonging to the families Chalcidae, Braconidae, Eulophydae, Bethylidae and Elasmidae.

The first concerted effort to use indigenous beneficial species to control this pest in India was carried out in 1924 to 1931 in Malabar, South Kanara by the Madras government. Breeding and liberation of parasites were discontinued for a time because the population of the pest was kept in check. However, biological control activities were resumed in 1938 and continued until 1948 and according to Rao *et al.* (1948) the operations were successful.

A pupal parasite, *Trichospilus pupivora*, has been mass-reared in the laboratory and released in the field at the rate of one million per month as cited by Jayarathnam (1941b). *Perisierola nephantidis* has also been mass-reared for the same purpose. However, these two attempts did not succeed as cited by Lever (1969).

In 1947, *N. serinopa* outbreaks were recorded in the deltaic regions of West and East Godavari districts. Again liberation of parasites was resorted to for the control of the pest. Dharmaraju (1952) observed that bethylids and braconids could be established easily in the field. However, few eulophids could be recovered and only during the cooler periods of the year. Several other attempts to establish this eulophids species in the east coast, where it was drier, also failed. Nirula (1956) reported that although field releases of this species were made in Srayikad (Quilon) in 1950, parasitization was quite low. The larval parasite *Spoggosia bezziana* appeared to be better suited to drier conditions according to Rao (1971, personal communication).

A study of the efficiency of several parasites in the field was conducted by George *et al.* (1977) in the Alleppey District. They reported that 29.43% of the larvae and pupae were parasitized. Based on the total percent parasitized, larvae were attacked by bethylids (8.54%), elasmids (3.24%) and braconids (0.80%) and the pupae by chalcids (14.55%) and eulophids (2.29%). The highest percent larval parasitization was observed in September and lowest during November and December. Only slight variation in percentage pupal parasitization was observed. The parasites that exercised a significant role in the control of *N. serinopa* pupae were the chalcids *Neobrachymeria nosatoi* and *Brachymeria nephantidis*. However, due to the difficulty of breeding chalcid parasites both economically and in large numbers, these species were not utilized for laboratory multiplication and field liberation. Among the larval parasites tested, bethylids showed the most promise. According to Dharmaraju (1952), braconids are also promising for field introduction especially in the coastal areas.

Very little information is available regarding the effect of beneficial insects on the intensity and distribution of *N. serinopa* in various coconut growing areas in India. Nagarkatti (1973) had identified that this problem needs immediate attention and suggested a systematic survey of the pest-parasite complex. She was skeptical about continuing the mass rearing and liberation of indigenous parasites to control pest outbreaks because of this lack of information. She cited that parasites which are easily cultured have been used for biological control work with little study made on their habitat/host preferences, feeding habits and other characteristics and that no statistical analysis have been made to support claims of their effectiveness in the field.

Very little work has been done on the introduction of exotic parasites to control *N. serinopa*. The tachinid fly *Spoggosia bezziana* has been imported from Sri Lanka for mass multiplication and liberation. However, evaluation of its efficiency is still going on and no conclusive results are yet available.

Kurian *et al.* (1976) have reviewed the work done to date on the biological control of *N. serinopa*. From the information available, it is evident that for parasites to be effective, periodic releases of laboratory-reared insects must be done. A continuous evaluation of the pest-parasite ratio in areas where they are liberated must be made to study the effectiveness of the parasites and the interaction of the pest, its parasites and hyperparasites.

CHEMICAL CONTROL

As early as 1919, Pillai had suggested that contact and stomach poisons could be used for the control of *N. serinopa*. Pillai (1922) recommended spraying of young palms with Paris green.

Nirula *et al.* (1951b) pioneered the work on the chemical control of *N. serinopa* in India. They have tested DDT in both the laboratory and field for the control of caterpillars. Nirula (1956) conducted field trials using DDT and BHC and concluded that these insecticides were effective in controlling *N. serinopa*. Nirula (1958) compared the effectiveness of DDT, BHC, Toxaphene, DDD and lead arsenate against the pest and their results showed that DDT and BHC gave very good control. DDT at 0.2% killed 80% of the caterpillars in two weeks while at 0.1% concentration it was effective only as prophylactic spray. On the other hand, BHC at 0.2%, lost its toxicity in 6 to 10 days. The chemical sprays did not affect the pupae of *N. serinopa.*

Several concentrations of Dieldrin, 0.01% to 0.20%, were tested in the laboratory against fifth instar larvae (Pillai and Kurian, 1960). The highest mortality observed was 82% during 7 days exposure to sprayed leaflets. They recommended 0.05% Dieldrin which killed 77% of the caterpillars. Increasing the Dieldrin concentration to 0.20% gave only 5% increase in the kill.

Sathiamma and Kurian (1972) tested Carbaryl, Dichlorvos, Methyl-O-demeton, Trichlorphon and Arprocarb for controlling the pest. Their results showed that Dichlorvos and Trichlorphon were the most effective with 90% mortality of larvae at 0.022% and 0.05% concentrations, respectively.

A field test was conducted by Sathiamma and Kurian (1970) on the effectivity of DDT, Malathion, Dieldrin and Lead arsenate in controlling *N. serinopa* in Purakkada, Alleppey District. Based on the results of three sprayings applied in May, August and November, it was found that Malathion was as effective as DDT in controlling the pest. They recommended Malathion because it costs less and had lower residual toxicity. Similar results were obtained when the same insecticides were tested in Kandappuram in March, June and September. However, in both cases, complete control was not achieved. A similar field experiment comparing Dieldrin and DDT showed inconclusive results.

Effect of Insecticides on Beneficial Insects

Until recently, studies on chemical control has been conducted mainly to screen insecticides based on their effectiveness to the pest without regard to their effect on the beneficial species associated with it. It has been found that adult parasites were highly susceptible to toxic residues left on the trees after spraying. According to Nirula (1956) when BHC was used to control *N. serinopa* in Declas islands near Quilon, there was an upsurge of the pest population one month after spraying. He said that this build-up of the pest population may be due partly to the killing of parasites. The results of a study to test the effect of BHC and Malathion showed that they could kill all the beneficial species reared in the laboratory.

Chandrika and Nair (1968) and Saradamma and Nair (1968) tested the effect of various insecticides on a eulophid parasite *(Trichorpilus pupivora)* and braconid parasite *(Bracon brevicornis)* of *N. serinopa.* They found that Trichlorphon, Diazinon and Dichlorvos were less toxic to the eulophid species and Dichlorvos was least toxic to the braconid species. These results were quite significant especially that Sathiamma and Kurian (1972) found, thru laboratory screening, that both Dichlorvos and Trichlorphon were very effective in killing *N. serinopa*. Field testing of these two chemicals need to be conducted to see how they will perform under field conditions and to find their effect on the parasites associated with the pest.

INTEGRATED CONTROL

Kurian *et al.* (1974) have looked into the feasibility of using integrated control for coconut pests. Results of other studies done so far point out to the fact that to obtain the most efficient control, spraying should be done with chemicals that are effective for *N. serinopa* but would be least toxic to its natural enemies. This could be done by finding more selective insecticides and timing of spraying when the beneficial insects are least susceptible. As already mentioned, Sathiamma and Kurian (1972) found that Dichlorvos and Trichlorphon were effective for controlling *N. serinopa* larvae in the laboratory. These same insecticides were also found to be least toxic to both eulophid and braconid parasites among several insecticides tested (Chandrika and Nair, 1968). However, their effectivity in the field must be tested first. Screening of more selective insecticides must continue and the effect of their residues to the parasites, like chalcids and bethylids, must be assessed continuously. Studies on residual toxicity to beneficial insects are of outmost importance since some insecticides may not be harmful to the parasites immediately after spraying but their degradation products may be toxic.

Various workers have sprayed infested palms during different months at different frequencies. Some criteria for determining when to spray would be the abundance of the pest as well as the season of the year. For example, if the population is slightly high just before the monsoon, there is little need to apply insecticide because the combined effect of biotic and physical factors will bring the population down. Furthermore, rain will wash the insecticide and nullify its effect. According to Sathiamma and Kurian (1972) peak population of *N. serinopa* was observed in June and April. To check possible outbreaks, close watch must be kept in the endemic areas from February to June. At the slight indication of increase in the pest population, spraying should be done followed by liberation of parasites after a time.

Some workers also advocate the use of strip spraying to prevent detrimental effect of complete spraying to the natural enemies. Strip spraying, if proven to be effective, may be tried along with liberation of parasites to enhance their efficacy.

CONCLUSION

We have endeavoured to present here a brief but comprehensive review of the work done on the leaf-eating caterpillar, *N. serinopa*. Additional studies on the fields suggested in this paper would help fill the gaps that exist at present. It would also facilitate formulation of feasible integrated control measures which are both economical and effective.

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Fig. 1. Galleries made by larvae of *Nephantis serinopa* on the underside of a coconut leaf.

Fig. 2. **Browning of leaflets caused by the feeding of larvae of the *N. serinopa.***

Fig. 3. Mature trees showing the typical damage caused by *N. serinopa.*

Fig. 4. Seedling showing the damage caused by *N. serinopa* larvae.

Fig. 5. Larvae of *N. serinopa* near its gallery made of silk and excrement.