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SEASONAL INCIDENCE AND POSSIBLE CONTROL OF IMPORTANT INSECTS PESTS IN PLANTATIONS OF AILANTHUS TRIPHYSA

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ABSTRACT

Ailanthus triphysa is one of the fast growing tree species grown in plantations in Kerala. The two major pests noticed were *Atteva fabriciella* (Lepidoptera : Yponomeutidae) and *Eligma narcissus* (Lepidoptera : Noctuidae). The seasonal occurrence, damage intensity, natural enemy complex and possible control of these pests were investigated.

E. narcissus feeds on all the leaves at times of pest outbreaks whereas attack by *A. fabriciella* is confined to the terminal portion of the plants. After a heavy attack by *E. narcissus*, new foliage appears in about two weeks. Repeated attacks can result in complete defoliation and may affect the growth of the plants. Damage by *A. fabriciella* can result in the formation of epicormic branches or partial or even complete death of the terminal buds, thus causing loss in height growth,

The two pests were commonly distributed throughout Kerala, wherever *Ailanthus* is grown. Seasonal incidence of pests was studied in a 2-year old *A. triphysa* plantation at Pothuchadi in Peechi Range of Trichur Division over a period of 24 years. *A. fabriciella* was present almost throughout the year. However, the population was comparatively low during the monsoon period. In general, incidence of *A. fabriciella* was high between October and December in the study area. A peak in the population of *E. narcissus* was observed only during September to December in one year; during other periods the insects were practically absent. Based on the present data, the population trend of the two pests cannot be generalised because pest incidence was noticed in other localities at other times of the year. Pest outbreaks were noticed more often in young plantations and nurseries; older plantations were generally free from damage.

Quassia indica, a shrub which belongs to the same family as that of *Ailanthus* was found as an alternative host of *A. fabriciella;* no other alternative host plant has been reported so far for the two pests

Many mortality factors were found to operate under field conditions against the two pests which include – a tachnid *(Sarcophaga* sp.), a chalcid *(Brachymeria hime attevae),* a nematode *(Hexamermis* sp.), an ant *(Crematogaster perelegans),* a fungus *(Paecilomyces farinosus)* and a bacterium *(Bacillus firmus).* Of these the microbial pathogens, the fungus and the bacterium, appear to exert maximum pressure, especially to *E. narcissus.*

Selected insecticides -quinalphos (Ekalux), monocrotophos (Nuvacron) cypermethrin (Cymbush) - were screened in the laboratory against the pests and tested further under field conditions. The use of microbial pathogens in the control of the pests seems promising, but needs further studies.

Key words: *Ailanthus triphysa*, *Eligma narcissus*, *Atteva fabriciella*, seasonal incidence, natural enemies, chemical control.

INTRODUCTION

Ailanthus is a fast growing'tree genus of considerable economic 'importance. Species that occur in India are *A. excelsa A. grandis* and *A. triphysa* (syn: *A. malabaricum).* Large-scale plantations of *Ailanthus* are being grown in many parts of India. This is also a tree species being popularised under social forestry (Sandhu, 1984). The wood of this tree species is mostly used in match, packing case and paper pulp industries.

In Kerala, *Ailanthus* is raised in plantations by the Forest Department over large areas. It is also grown in house compounds in many places where match industries are prevalent. The commonly planted species is *A. triphysa. A. excelsa* is grown only in drier parts of the State and *A. grandis* is seen in a small patch near Kodanad.

The two major pests noticed in *Ailanthus* in Kerala, as elsewhere in India, are *Atteva fabriciella* Swed. (Lepidoptera: Yponomeutidae) and *Eligma narcissus indica* Roth. (Lcpidoptera: Noctuidae). The larvae of the above two moths cause serious damage to young plants of *Ailanthus.* From studies conducted in Tamil Nadu (Mathur *et al.,* 1970) and in Maharashtra (Chatterjee *et al.,* 1969), the life-history, natural enemy complex and some methods of control of the two pests are known. It is reported that these pests cause defoliation which results in retardation of growth of the trees. It is also indicated that *E. narcissus* would be a more serious pest in Southern India compared to *A. fabriciella* (Chatterjee Sen–Sarma, 1968). However, our knowledge on the ecology of these pests under Kerala conditions is meagre and hence attempts were made to study their seasonal incidence, nature and intensity of damage and natural enemies so as to develop suitable methods of control.

REVIEW OF LITERATURE

A short review on the biology, parasite-complex and suggested control measures of the two major pests are given below separately.

Atteva fabriciella Swed.

The important life stages of *A. fabriciella* are shown in Fig. 1. Some basic information on the biology and morphology of *A. fabriciella* have been given by Fletcher (1914), Beeson (1941) and Mathur (1957, 1961). More recently the external morphology and distinguishing characters of the male and female pupae of *A. fabriciella* have been described by Singh and Sarma (1979). Detailed investigations on the biology and ecology of this pest were carried out (Mishra & Pandey 1966) in Uttar Pradesh and in Madhya Pradesh (Mathur *et al.*, 1970).

The female moths are active at night and remain concealed during dav time under the leaves. Eggs are laid during night either singly or in small groups, preferably on young buds and tender leaves. Eggs are small and pale green in colour. Incubation period is about 2-3 days, but can vary depending upon the season.

The larval period is reported to be from 13-28 days under laboratory conditions but under field situation, the period may vary. There are five larval instars. It is stated (Mathur *et al.*, 1970) that sometimes the larvae undergo a sixth moult also.

The mature larva constructs a loose cocoon and pupates. Pupa is slender,. orange brown to pale yellow brown in colour. Depending on the temperature the pupal period ranges from 4-14 days.

Mathur *et al.*, (1970) have shown that under normal situation, *A. fabriciella* undergoes about nine generations annually and overlapping of generations occur. In general, the population declines very much during summer months. In Dehra Dun, it was noticed that during the summer months, at least two generations of *A. fabriciella* passed through on the fruits of *Ailanthus* (Misra, 1973) and each generation lasted for about a month. The population fluctuates considerably in each generation,. depending on the climatic conditions and also on the presence or absence of parasites and predators. Mathur (1957) has shown that the natural enemy complex of *A. fabriclla* is very poor. It is also further suggested that owing to the webbing nature of the insect, it probably escapes attack from parasites and predators (Mathur *et al.*, 1970).

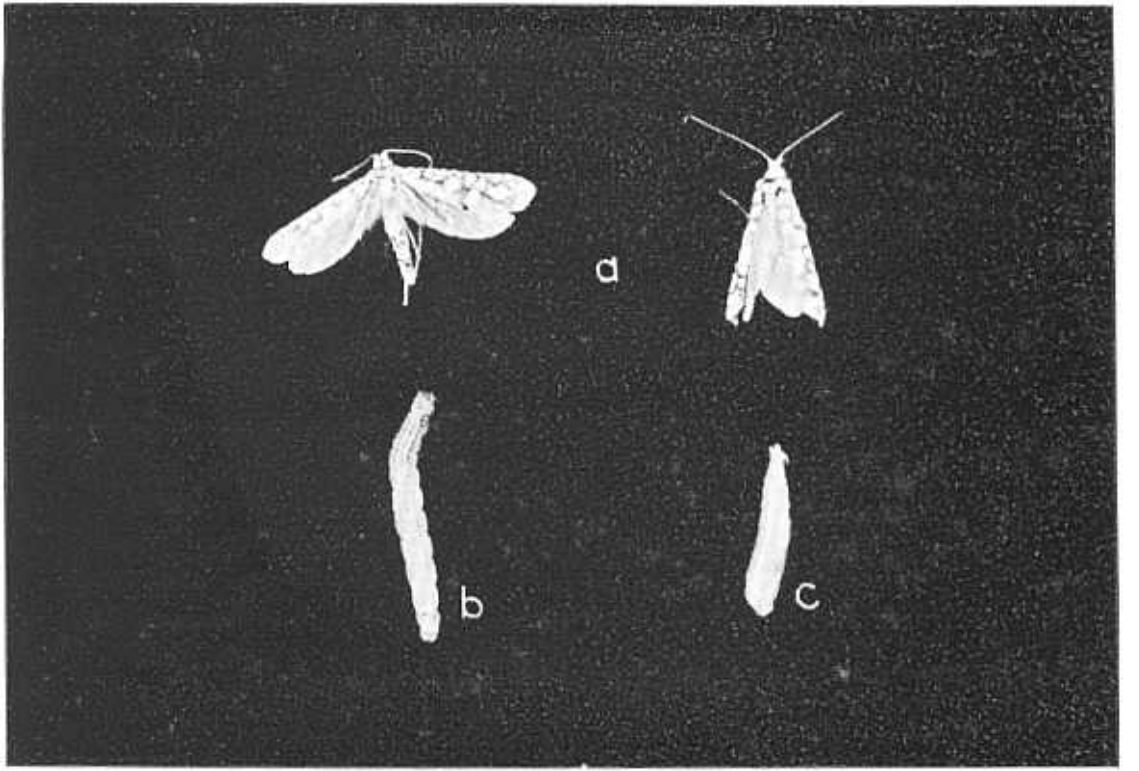
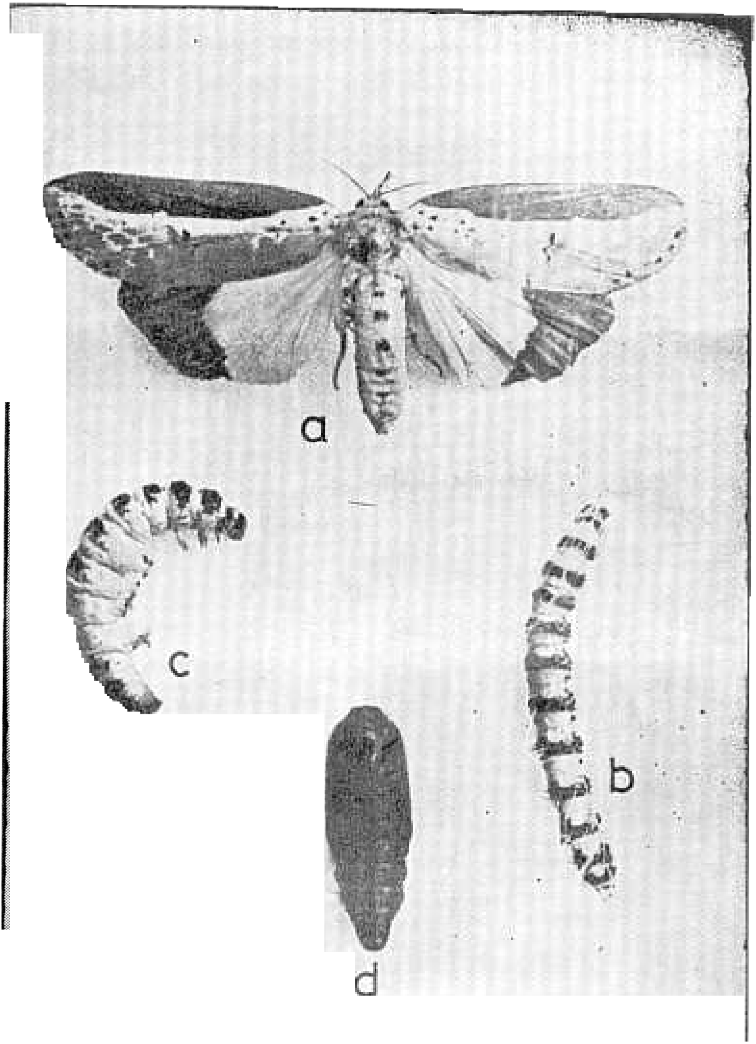


Fig. 1. Life-stages of *Atteva fabricilla*. a-adult, b-larva, c-pupa.


a
b
c
d

Mathur *et al.,* (1970) suggested that insecticidal sprays may be reqired at feast during the initial five year period of establishment of A. *excelsa* to ave them from attack by *A. fabriciella.* They tested organochlorine insecticides like DDT, BHC and endrin, both under laboratory and in small-scale field trials and found all of them to be effective. The effectiveness of newer insecticides was also evaluated later under laboratory conditions (Singh & Gupta 1978; Singh & Misra 1978)

A management strategy was suggested (Mathur *et al.,* 1970) employing silvicultural cum biological means to check the spread of *A. fabriciella.* It was reported further (Mathur *et al.,* 1970) that in S.Chanda Division in Maharashtra, *Ailanthus* plantations were practically free from damage by *A. fabriciella,* because of the mixed planting with species such as *Boswellia serrara, Dalbergia paniculata, Erythrina suberosa* and *Gmelina arborea.* They indicated that such a vegetational complex would facilitate multiplication in the number of parasites and predators which may take care of *A. fabriciella* as well.

Eligma narcissus indica Rotb.

Some information **on** the biology of this pest has been given by Fletcher (1914) and then Bhasin and Roonwall (1954) recorded it as a defoliator of *A. excelsa.* More detailed study on the various aspects of this pest was conducted by Chatterjee *et al.,* (1969) at Topslip in Tamil Nadu. *E. narcissus* has been reported as the most serious pest of Ailanthus in Southern India (Chatterjee & Sen Sarma, 1968). More recently, the various life-history stages of the species have been described in detail by Roonwal (1982). Several races of *E. narcissus* have also been recognised .and the one that occurs in the Indian and Indo-China regions has been identified as *E. narcissus indica* Rothschild (Roonwal, 1982). *E. narcissus* is distributed all over India, feeding on *A. excelsa A. triphysa* and *A. grandis* and also on other species like *A. glandulosa* in China, *A. kurzii* in Burma and Andamans, *A. fauveliana* in Cambodia, *A. mollis* in Eastern Malaya and *A. moluccana* in Molluccas.

Figure 2 shows the important life stages of *E. narcissus.* The moths have a dark grey-brown forewing with an irregular and diffuse white band from base to apex with a few black spots **on** the basal and subbasai portions. The hindwing is bright yellow with a black border **on** the apical portion, head and thorax greyish brown and the abdomen is golden yellow in colour with a series of black spots on the dorsal and lateral sides. The female moths lay eggs in groups of 5-55 on the under surface of tender leaves.

Larval period is 22-23 days normally. Young larva is yellowish green with white hairs all over the body. Mature larva is bright yellow in colour with a black head, black bands on the dorsal surface of the body and white long hairs all over the body

surface. The mature larvae make a boat-shaped cocoon out of the bark of the host tree and pupate within. They pupate in'groups on the host tree. Pupae are reddish brown in colour. When disturbed, the pupae produce a rattling sound which may be a means to drive away the predators. Pupal period varies from 15-17 days.

E. narcissus takes more than a month to complete the life-cycle. It is reported that there are eight generations of *E. narcissus* per year with the possibility of a ninth. As in the case of *A. fabriciella,* overlapping of generations occur.

Though some parasites- and predators have been recorded on *E. narcissus* (Chatterjee *et al ,* 1970), it is stated that the level of parasitism was very low under natural conditions. The only suggested control measure is biological cum silvicultural in which presence of other tree species along with *Ailanthus* is expected to prevent epidemic build up of the pest by .giving a chance for the parasites to multiply on various hosts (Chatterjee *et al.,* 1970). Artificial rearing and release of parasites of *E. narcissus* is also recommended. During high pest build up, hand picking and killing of larvae employing labourers is suggested as a mechanical control measure. There is no report on the control of this pest using chemicals.

SEASONAL OCCURRENCE AND DAMAGE INTENSITY OF THE PESTS

INTRODUCTION

Attack by *E. narcissus* and *A.fabriciella* in young plantations and nurseries of *Ailanthus* have been brought to our notice several times by the State Forest Department, Preliminary investigations also indicated that this is a serious problem, but the incidence of pests was quite erratic and hence control measures were difficult to implement. Thus, it was necessary to collect systematic data on the seasonal occurrence and damage intensity of the pests on *Ailanthus* to develop appropriate control strategies.

MATERIALS AND METHODS

Study area

Seasonal incidence of the major pests and other insects feeding on *A. triphysa* was monitored in a 2-yearold plantation at Pothuchadi in Peechi Range (Fig. 3). The plantation was raised in about 40 ha, at an espacement of 2x 2m during 1981, after clearfelling a moist deciduous forest. It is bordered on one side by a natural forest, on two sides by teak plantations and the fourth by agricultural land, adjacent to the catchment area of the Peechi dam.

Pest incidence was also recorded from nurseries and young and older plantations of *Ailanthus* in a few other localities in the State.

Incidence of pests and damage assessment

At Pothuchadi monthly (or more frequent when required) observations were made in six selected plots of 100 plants each. Each plot consisted of 5 rows of 20 trees each and were separated by about 20 meters. The total effective number of plants was only 532. During each visit, each plant was examined thoroughly and the number of larvae, either *E. narcissus* or *A. fabriciella*, present were counted and recorded separately on data sheets. In addition, general observation in other areas within the 40ha plantation was made to ascertain the presence of pests, if any, outside the study plats.

The nature of damage caused by the pests was observed in the plants within the study plots. The level of defoliation due to *E. narcissus* feeding was scored visually as follows—0 · no leaf damage; 1 · less than 5%; 2 - 6 to 50%; 3 · 51 to

95%; 4 - 96% to 99% and 5 - 100%. The incidence of *A. fabriciella* and course of events taking place due to terminal bud damage caused by this species were also assessed. The loss in height increment due to *A. fabriciella* attack wasfound out. Initial height of 532 plants in the study plot was taken. After an attack by the insect there were two groups of plants—206 in which the terminal bud was in tact and 326 in which terminal bud was affected. The height increments in the above two groups were compared using Cochran's weighted t test,

RESULTS AND DISCUSSION

Nature of damage

E. narcissus larvae feed on young and mature leavesand cause defoliation (Fig. 4). At times of heavy infestation as many as 20-40 larvae may be seen on each rachis of the compound leaf (Fig. 5) and because of their conspicuous colouration and abundance it will appear as if the whole plantation will be defoliated, Total defoliation may sometimes be caused in nurseries (Fig 6). When all the leaves are eaten up, larvae may also sometimes feed on the green parts of the stem. In nurseries, when all the leaves of a seedling were eaten up, the larvae were found to move on to the neighbouring ones but the same was not observed in the plantation. In nurseries, the defoliated seedlings will put forth new leaves in about two weeks, time, Repeated defoliation may retard growth of the plants.

A. fabriciella feeds only on the tender leaves and other soft tissues of the terminal portion of the plant. The larvae web around the tender leaves and feed from within (Fig. 7). Older leaves are not usually preferred by the larvae. The number of larvae at a time in a web mass may vary from 6 to 10. In a plant, often more than a single branch is attacked in addition to the terminal shoot. Because of the dark colour of the larvae it is often difficult to distinguish them from the small opening buds at the terminal portion. Very often, when the tender leaves are fully eaten up, the larvae may also bore into the soft tissues of the terminal portion and result in partial or complete damage of the terminal buds.

Incidence of terminal bud damage

Within the study plots, damage to terminal buds caused by *A. fabriciella* was noticed in January 1984 (Fig. 8). Such plants were marked and observed regularly. Out of the 532 plants under observation 326 (i. e., 61%) showed damage to terminal bud. Thus, there were two groups of plants—206 in which the terminal buds were intact and 326 in which terminal portion had some kind of damage.

The difference in height growth between the above two groups of plants within a period of 18 months was compared. Initial height of all the 532 plants were

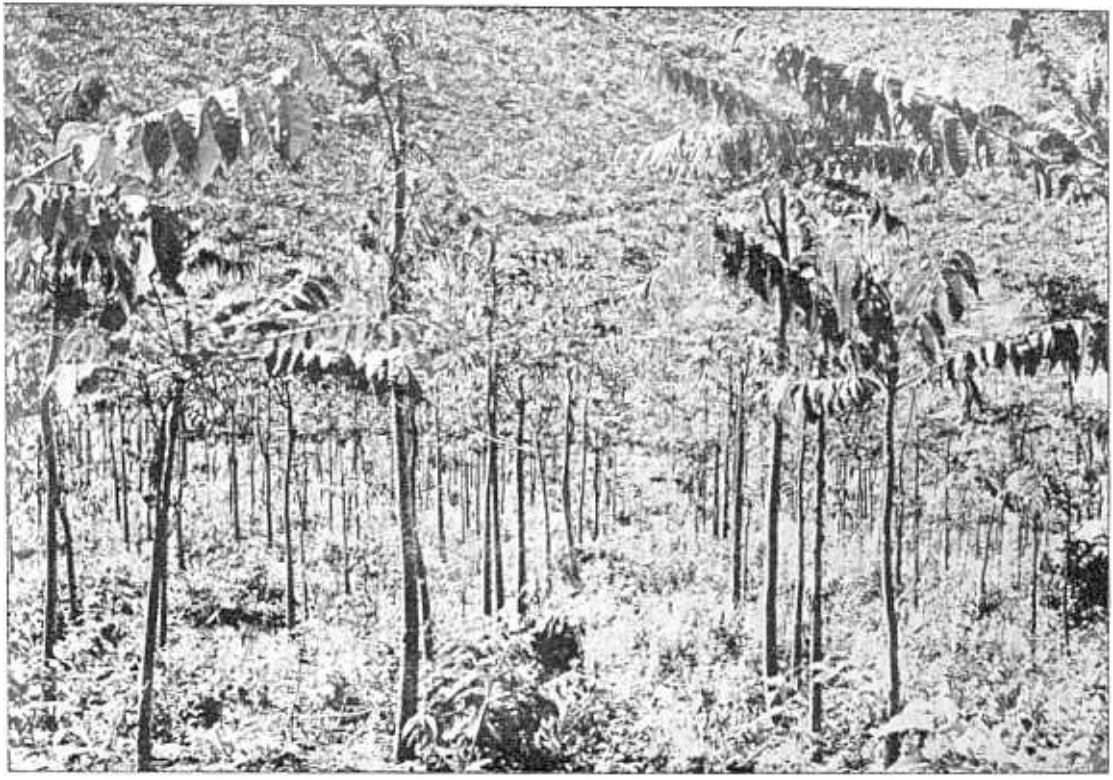


Fig. 3. A general view of the 2-year old *A. triphysa* plantation at Pothuchadi.

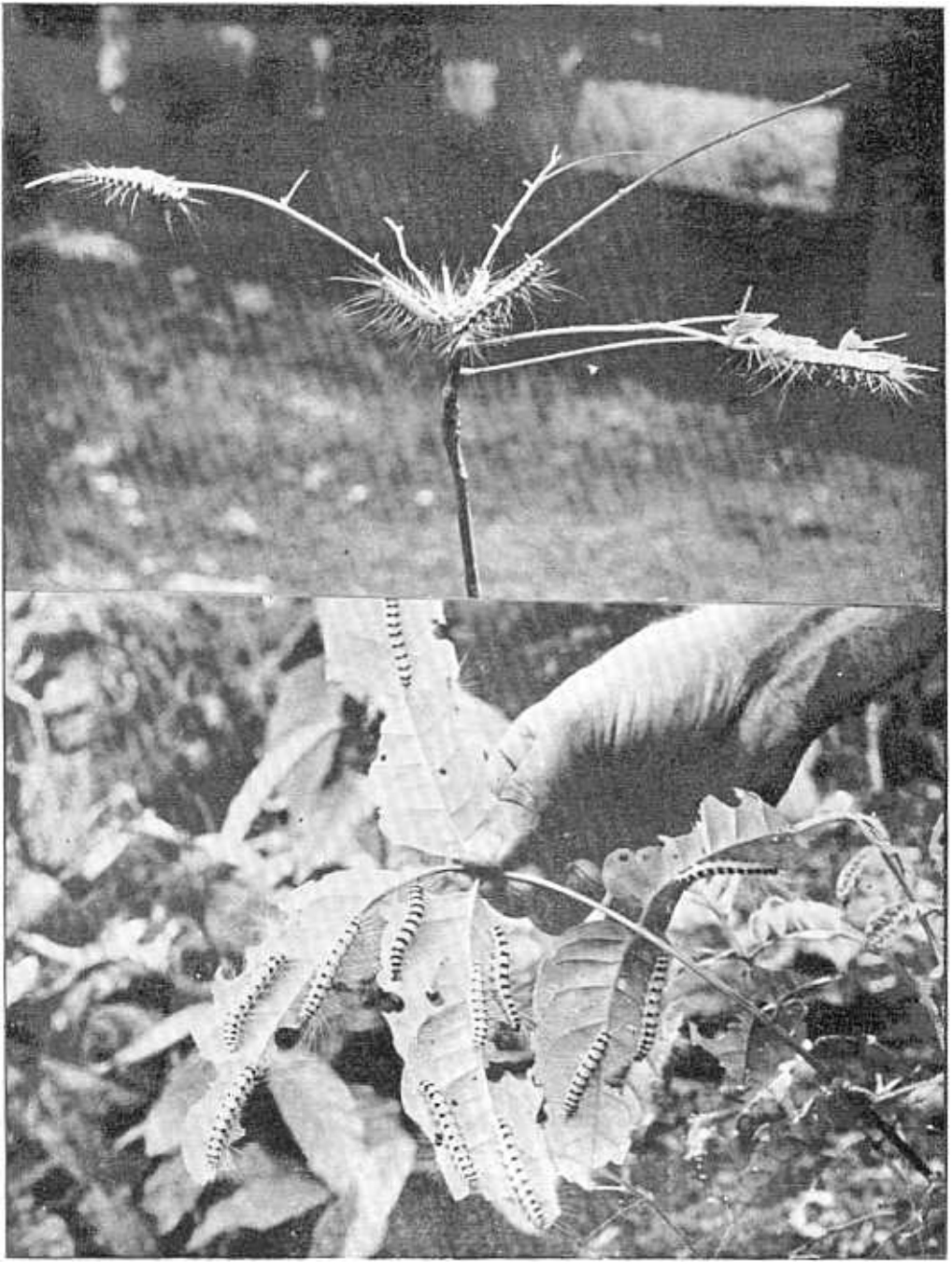


Fig. 4. Seedling of *A. triphysa* in a nursery damaged by larvae of *E. narcissus*.

Fig. 5. A group of *E. narcissus* larvae feeding on the branch of a 2-year old *A. triphysa* plant.

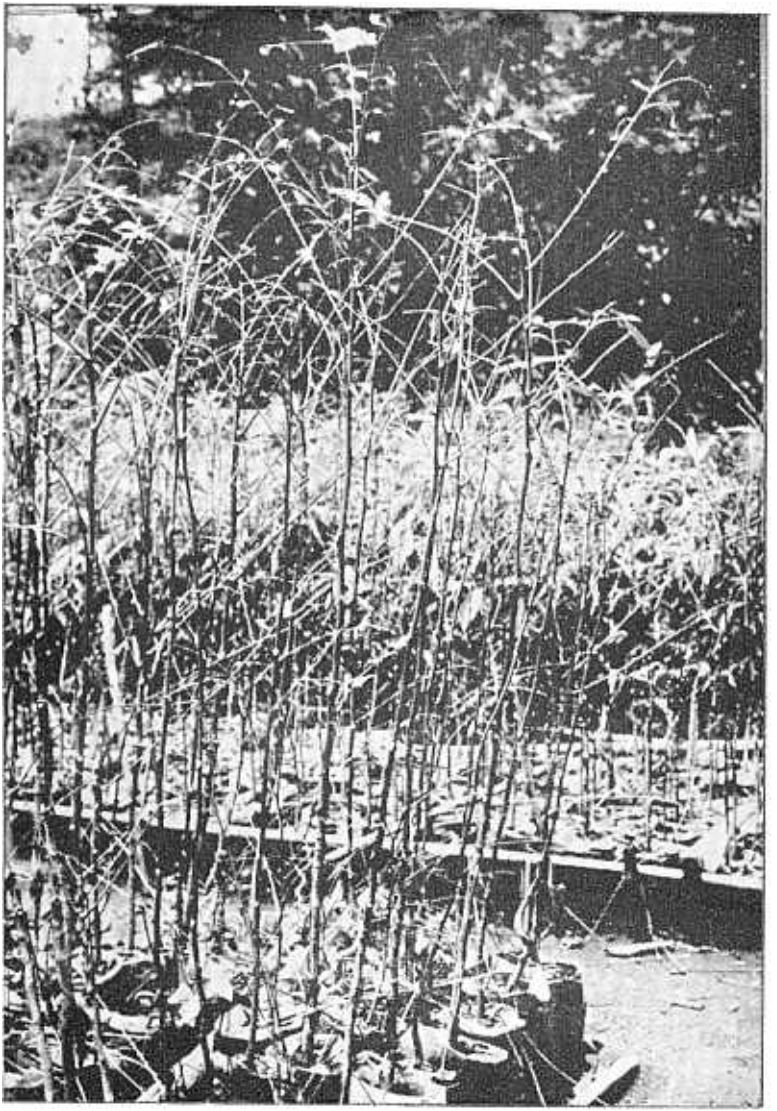


Fig. 6. A nursery of *A. triphysa* damaged by *E. narcissus* larvae.

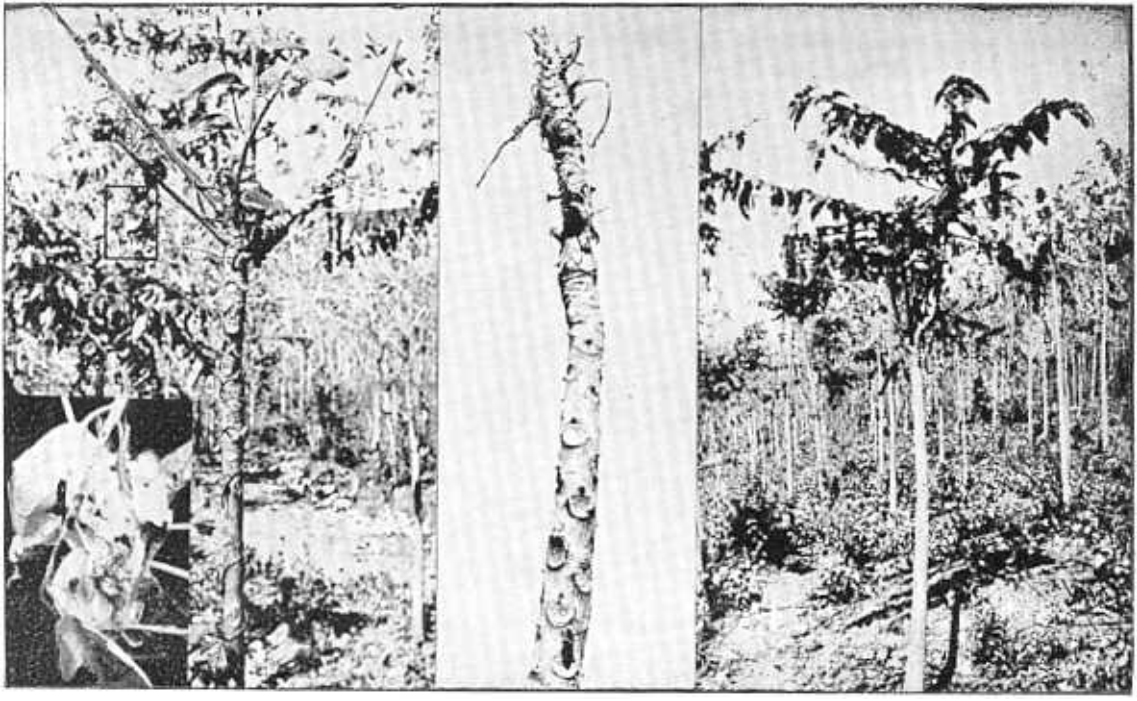


Fig. 7. Nature of damage caused by feeding of *A. fabriciella* larvae on a 2-year old *A. triphysa* plant.

Fig. 8. Terminal bud damage to *A. triphysa* by *A. fabriciella* larvae.

Fig. 9. *A. triphysa* plant showing branched top after attack by *A. fabriciella*.

taken in May 1983 i. e., before the attack by *A. fabriciella*. Damage by *A. fabriciella* occurred between September and December 1983. The second height measurements of all the 532 plants were taken in October 1984 i. e., before the next peak of attack by *A. fabriciella*. The analaysis of data showed that there was a height increment of 63% in the intact plants whereas only 55% height increment in the terminal bud affected plants, In otherwords the loss in height increment in the affected plants was about 13% compared to the intact plants in an area covering 532 plants. The difference in height growth between the two group of plants was significant. Complete death of the plant due to terminal bud damage was never noticed, but drying and partial death of terminal portion occurred in a few plants.

One of the major consequences of terminal bud damage was forking/branching of the plants. The new shoots that come up after the initial terminal bud damage may be attacked again by *A. fabriciella*. Repeated attacks on the leading shoot will result in a number of branches and in some cases, even crooked boles (Fig. 9). During the period, the terminal buds of 5% of the plants in the study area were attacked and damaged by *A. fabriciella*, twice when there was heavy infestation of the pest. This definitely resulted in branching.

The terminal bud damage caused by *A. fabriciella* feeding was confirmed further by releasing a large number of field collected larvae of *A. fabriciella* on *A. triphysa* seedlings planted in an outdoor insectary. The terminal buds of all the five plants in which larvae were released, were found to be damaged within two weeks. In some plants, the larvae also moved on to nearby tender leaves and settled. All the five plants in which the terminal bud was damaged, showed presence of new shoots within a month's time.

Seasonal occurrence of the pests

The two major pests, *A. fabriciella* and *E. narcissus* are found wherever *Ailanthus* is grown in Kerala. The occurrence of pests was noticed in forest plantations as well as in isolated plants grown in house compounds. Regular observations on the incidence of pests are confined to the study area at Pothuchadi, but less systematic observations were also made in other localities.

A. fabriciella was present almost throughout the year (Table 1). The population was either very low or nil during the peak monsoon period (June-July). During June-July 1983, *A. fabriciella* was not noticed. But during the same period (June-July) in subsequent years—1984 and 1985, a very small population of *A. fabriciella* was found. A somewhat high population build-up of *A. fabriciella* occurred in October-November 1983, but then it gradually came down. Another build up of *A. fabriciella* started from October 1984 onwards, reaching its peak during February 1985 (Fig. 10)

Table 1. Number of infested plants and mean number of larvae per plant at different periods of observation in the study area.

Month & Year	*A. fabriciella*		*E. narcissus*	
	Infested plants out of 100	Mean no. of larvae per infested plant	Infested out of 100	Mean no. of larvae per infested plant
June 1983	0	0	0	0
July	0	0	0	0
August	0.8	1.5	0	0
September	1.3	4.9	4.5	7.8
October	8.5	3.0	18.9	3.0
November	21.4	3.0	26.7	2.6
December	15.6	1.8	25.0	1.7
January 1984	0.9	2.4	1.1	2 0
February	0	0	1.1	3.5
March	1.7	2.0	2.6	1.6
April	1.5	2.5	0.6	2.5
May	3.4	2.0	0	0
June	0.4	I.5	0	0
July	0.6	2 8	0	0
August	2.3	2.0	0	0
September	1.9	1.8	0	0
October	9.9	2.8	0.8	2.0
November	15.0	2.6	0	0
December	15.8	2.7	0	0
January 1985	24.6	6.0	0	0
February	58.8	4.0	0	0
March	31.4	1.4	0	0
April	19.4	1.8	0	0
May	2.3	1.8	0	0
June	0.4	2.0	0	0
July	0.4	2.0	0	0

An increase in the population of *E. narcissus* was observed only between September 1983 and January 1984. By August 1983, larvae of *E. narcissus* were observed and it gradually increased reaching a maximum level of infestation during November 1983. Then the population level gradually decreased. A small residual population was noticed between April and June 1984. Thereafter *E. narcissus* was

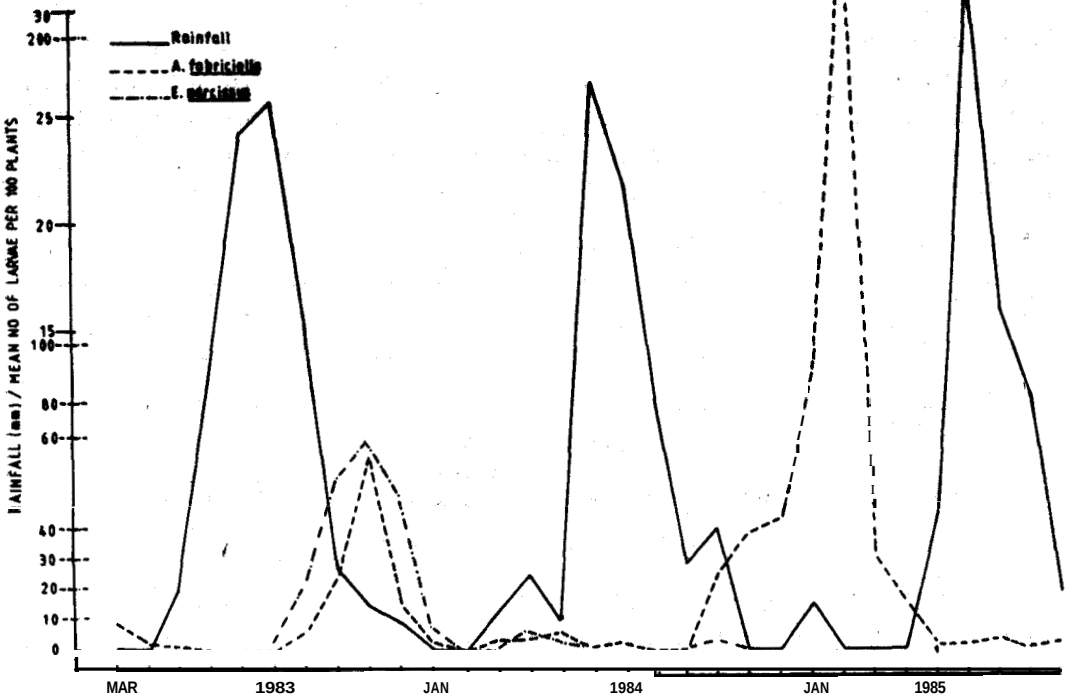


Fig. 10. Seasonal incidence of *A. fabriciella* and *E. narcissus* in the study area at Pothuchadi'

practically absent. Defoliation caused by *E. narcissus* feeding was less than 5% except between September and December 1983 during which period defoliation went up to nearly 25%. However, in some nurseries complete defoliation has been noticed.

During the peak periods of pest incidence 20-58% of the plants in the study plots were found infested by *A. jabriciella* and over 25% of the plants with *E. narcissus.* The number of plants infested out of 100 and the mean number of larvae present per plant are given in Table 1.

Based on the data gathered from the study plots, there was some seasonal trend in the occurrence of *A. fabriciella,* but not for *E. narcissus.* However, even this trend of *A. fabriciella* cannot be generalised because observations show that insects when absent at Pothuchadi were present in other localities. Hence prediction of pest build up in a particular season or time of the year becomes difficult. It indicates that regular observations over longer periods may be required to know definite trends in the population fluctuation of these pests. In general, insect incidence was low during rainy season, but there was no definite correlation between

rainfall and pest incidence. Various climatic factors other than rainfall, parasites, predators etc., may also influence the changes in pest population.

insects, other than *A. fabriciella* and *E. narcissus* feeding *on Ailanthus* are less, compared to other forest tree crops like teak, eucalypt etc. (Table 2). During the course of the present study, five more insects were found associated with *Ailanthus* They were the bagworm, *Eumeta crameri,* a grass-hopper (unidentified), two Hemipteran bugs, *Ketumala* sp. and a mealybug (undetermined) and the stemborer, *Sahyadrassus malabaricus.* Of these, only the mealybugs appear to do some damage to the plant.

Table 2. List of insects associated with *Ailanthus*

Sl. No.	Order	Insect	*Ailanthus* species	Reference
1.	Thysanoptera	*Neoheegeria indica Hood*	*A. excelsa*	1
2.		*Perissothrips parviceps Hood*	"	1
3.	Isoptera	*Termes ceylonicus* Holmgr.	*A. triphysa*	1
4.	Orthoptera	Grasshopper (unidentified)	"	2
5.	Coleoptera	*Sphenoptera medoeris* Keri.	*A. excelsa*	1
6.		*Eucorynus crassicornis* Fabr.	*A. triphysa*	1
7.		*Tropiderespavier* Les.	"	1
8.		*Lyctoxylon japonus* Reit.	"	1
9.		*Rhaphipodus subopacus* Gahan	"	1
10.		*Diboma procera* Pas.	*A. excelsa*	3
11.	Hemiptera	*Hemilecanium umbricans* Green	*A. excelsa*	1
12.		*Pseudococcus lilacinus* Cock.	"	1
13.		Mealybugs (unidentified)	*A. triphysa*	2
14.		*Ketumala* sp. nr. *Fuscomarginata* Hamp.	"	2
15.	Lepidoptera	*Phyllocuistis hagnopa* Mey.	*A. triphysa*	1
16.		*Eligma narcissus indica Roth.*	*A. excelsa*	1
17.		*Atteva fabriciella* Swed.	*A. triphysa*	1
18.		*Atteva niveigutta* Walk.	*A. excelsa*	1
19.		*Philosamia cynthia* Prury	*A. excelsa*	1
20.		*Lithoeolletis drepanata* Meyr.	*A. triphysa*	1
21.		*Gerontha captiosella* Walk.	"	1
22.		*Sahyadrassus malabaricus* (Moore)	"	2
23.		*Eumeta crameri* West.	"	2

1, Bhasin and Roonwall (1954); 2, Present finding; 3, Misra (1978

A few plants of *A. triphysa*, planted in the insectary for experimental purposes were found to be severely attacked by mealybugs (Fig. 11)but under field conditions, this problem was not serious. Earlier two coccid bugs viz *Hemilecanium umbricans* and *Pseudococcus lilacinus* are reported to feed on the sap of shoot of *A. excelsa* (Bhasin & Roonwal 1954). The stem borer, *S. malabaricus* was also found to infest 15 plants in the study area (Fig, 12), but did not cause serious damage. Of these, one was found killed after a few months. When the plant was uprooted and examined, tunnelling by the borer was observed. But the plant was also infected with some fungal disease. Hence the primary cause of death is uncertain. Beedon (1941) had listed about 30 host species for *S. malabaricus* to which 16 species have been added recently by Nair (1983). *A. triphysa* is recorded here as a new host for *S. malabaricus.*

Pest incidence in other localities

In Kerala, both the major pests, *E. narcissus* and *A. fabriciella* are found in all the *Ailanthus* growing areas. Specific observations at different times during the study period showed that the damage varied from mild to heavy (Table 3). Regular observations were not possible in all Iocalities and hence the level of pest build-up during periods other than the particular time of observation, was not known. In most places both the pests were present in varying numbers. Older plantations of *A. excelsa* in Walayar, older plantations of *A. triphysa* in Wynad and a few trees of *A. grandis* in Kodanad were found to be practically free from any pest during the time of observation. Most of the nurseries visited had pest problems due to either one or sometimes

Susceptibility of different clones of *A. triphysa* to *E. narcissus*

Twelve clones of selected plus trees of *A. triphysa* from Kerala, maintained by the Genetics Division of the Institute were screened against *E. narcissus*. Three polythene bagged seedlings from each of the clones were assembled in a netted cage and a large number of field collected larvae introduced. In 24 hours, all the leaves in the seedlings, belonging to various clones were equally eaten up, showing that they are susceptible to *E. narcissus.*

Susceptibility of *A. grandis* to *A. fabriciella* and *E. narcissus*

In another set of experiments, five polybagged seedlings of *A. grandis* and *A. triphysa* each were kept together in a cage and 30 larvae each of both *E. narcissus* and *A. fabriciella* were introduced. Twenty four hours' observation showed that both the insects preferred *A. triphysa* leaves and *A. grandis* was practically untouched. When the experiment was repeated on another occasion, five seedlings of *A. grandis* were kept along with a single seedling of *A. triphysa* and both *E, narcissus* and

Table 3. Pest occurrence in *Ailanthus* in some localities in Kerala.

Location	Species	Plantation/Nursery	Period of observation	Insect present	Intensity of damage
Kodanad Perumbavoor Malayattoor Alwaye	*A. triphysa*	Nursery	March 1983	*Eligma*	Mild to moderate
Nilambur (KFRI Sub Centre)	*A. triphysa*	1980 plantation	Nov. 1983	*Eligma, Atteva*	Moderate
Periya (Mananthody)	"	Nursery	Nov. 1983	*Eligma, Atteva*	Mild to heavy
Muliaringad (Kothamangalam)	"	I983 plantation	Dec I983 March 1985	*Eligma, Atteva*	Moderate to heavy in some patches
Perumthodu (Kodanad)	*A grandis*	Older trees and two nursery beds	July 1983	Nil	Nil
Walayar (Palghat)	*A. excelsa*	1974 plantation	Oct. 1983	*Atteva*	In Oct 1983, a few *Atteva* larvae seen on the lower branches of a few trees, otherwise free of damage
Kannoth (Wynad)	*A. triphysa* mixed with teak, Bombax or Mahogony	1954, 1970, 1974 and 1980 plantation	Jan. 1985, April 1985	Nil	Nil
Peechi (KFRI Campus)	*A. triphysa*	Nursery	March 1984	*Eligma*	Heavy
Pazhad (Kodanad)	*A. triphysa*	1985 plantation	March, July, Aug., Sept. 1985	*Eligma, Atteva*	Heavy

Fig. 11. *A. triphysa* plant (inside the insectary) attacked and killed by mealy bugs.
Fig. 12. *A. triphysa* plant attacked by the borer, *S. malabaricus* at Pothuchadi.

A. fabriciella larvae introduced. Partial feeding on *A. grandis* by *E. narcissus* was found once the *A. triphysa* leaves have been eaten up completely. *A. fabriciella* leaves remained on *A. triphysa* seedlings and did not make any attempt to feed on *A. grandis* leaves. Various instars of *E. narcissus* were allowed to feed on A. *grandis* seedlings alone and it was found that feeding was very less compared to those of *A. triphysa* leaves. Some of the older larvas pupated on the stem of A. *grandis* seedlings,

In general, it appears that *A. grandis* may not be a preferred host for both *E narcissus* and *A. fabriciella* compared to *A. triphysa*. However, ,Chatterjee *et al.* (1969) have stated that *E. narcissus* feeds on A. *grandis* in Sikkim, Assam, Darjeeling and in North East India.

An alternative host plant of *A. fabriciella*

Alternative host plants of *Ailanthus* pests are poorly known. During the present study *Quassia indica,* a shrub belonging to the same family as that of *Ailanthus* i. e., Simaroubaceae, was recorded as a new alternative host of *A. fabriciella*. *Q. lndica* ia a shrub seen in the evergreen forests of west coast and along the backwaters of Kerala. *A. fabriciella* larvae web the leaves of *Q- indica* and feed from within and were found throughout the year.

Feeding experiments in the laboratory showed that *A. fabriciella* collected from *Q. indica* also feed on *A. triphysa* leaves and completed the life-cycle and vice-versa. However, during limited laboratory experiments, another species of *Quassia* viz *Q. amara* (indigenous to Brazil and Guiana) was not fed upon by *A. fabriciella* larvae. *Boswellia serrata* Roxb. ex Coleter, belonging to the family Burseraceae was recorded as an alternative host of *A. fabriciella* by Beeson (1941). However, Mathur *et al.*, (1970) reported that A. fabriciella larvae failed to feed on *B. serrata* leaves and also in nature they could not find *A. fabriciella* as a pest of *B. serrata*.

No alternative host *E. narcissus* has been reported and none were encountered during the course of present study.

NATURAL ENEMY COMPLEX OF *AILANTHUS* PESTS

INTRODUCTION

Usually a number of parasites including entomogenous microorganisms bring about partial control of pest populations in nature. Also the use of parasites, predators and pathogens has been advocated in recent years to prevent environmental hazards posed by indiscriminate application of pesticides. In this context, the role played by natural enemies such as bacteria, fungi, viruses, insect parasites and predators which bring about reduction in pest populations becomes extremely important. Though we have information on the parasites and predators of some of the major forest pests in India (Beeson, 1941; Rao & Bennett 1969; Sankaran 1976; Patil & Thontadarya 1983; Sudheendrakumar, 1986), so far there has not been any serious attempt to make practical use of them in pest control.

During the course of the present study, attempts were made to collect and identify some of the natural pest control agents associated with *A. fabriciella* and *E. narcissus*. The potential of some promising microbial pathogens encountered during this study, was also evaluated under laboratory conditions.

MATERIALS AND METHODS

During the pest incidence at Pothuchadi, both *A. fabriciella* and *E. narcissus* larvae were collected and reared in plastic jars in the laboratory to obtain parasites. In addition, dead/parasitised/diseased larvae or pupae were collected from the study area and from other localities. The parasites were got identified through Commonwealth Institute of Entomology, U. K.

A fungus was found *to* infect larvae and pupae of *E. narcissus* in the field. The fungus was cultured on potato dextrose agar (PDA) medium, isolated and sent to Commonwealth Mycological Institute, U. K. for authentic identity. The pathogenicity of the fungus was tested under laboratory conditions as follows.

Field collected larvae (various instars) of both *E. narcissus* and *A fabriciella*. fed on caged *A. triphysa* seedlings for a day, were used for the study. In the case of *E. narcissus*, late and early instar larvae were selected and tested separately. The spore suspension was prepared in sterile water from a 7-day-old culture of the fungus. Two concentrations of spores—·104 and l05 per ml were tested. In one set of experiment, the larvae were directly sprayed with spore suspension using an atomiser.

These larvae were transferred to plastic jars (14 x 11 cm) containing surface sterilized leaves of *A. triphysa.* In another set of experiment, three leallets of *A. triphysa* sprayed with spore suspension of the fungus were kept in plastic jars and healthy larvae introduced. In the case of *A. .fahriciella,* only the effect of direct application of spore suspension was evaluated. Control sets were sprayed with sterile water. Observations on mortality, pupation, adult emergence, etc., were taken at the end of 24 h, 48 h and 72 h after inoculation. There were three replicates with 10 larvae each for each treatment.

Some larvae of *E. narcissus* were also found killed due to bacterial infection. These dead larvae were brought to the laboratory, the gut contents and the body ooze of the infected larvae were streaked on nutrient agar medium and incubated at $27 \pm 2°c$ for 24-36 hours. For authentic identification of the bacterium, the culture was sent to Commonwealth Mycological Jnstitute, U. K.

The pathogenicity of the bacterium was also tested in the laboratory. The inoculum was prepared from a 48-72 h old culture of the organism grown on nutrient agar medium by suspending the culture in sterile distilled water. The suspension was standardised to give an absorbance of 1 OD at 420 nm with a viable count of 1×10^{10} CFU/ml.

Leaves of *A. triphysa* were sprayed with the bacterial suspension or painted using a brush, dried under fan and transferred to plastic jars. The test insects (various instars) were collected from the field and maintained on leaves of *A. triphysa* for a day in the laboratory before the experiment. Ten test larvae each were introduced into the jar containing treated leaves. There were three replicates and the experiment was repeated during December 1983, May 1984 and September 1984. Fresh untreated leaves of *A. triphysa* were offerred to the larvae, whenever necessary. In control set, the leaves were sprayed with sterile water. Mortality was recorded at the end of 24 h, 48 h and 72 h.

RESULTS AND DISCUSSION

Parasites

A list of parasites and predators recorded on *E. narcissus* and *A. fabriciella* are given in Table 4.

Mostly the late instar larvae of *E. narcissus* larvae were found parasitised by *Surcophaga* sp. in the field (Fig. 13). In September 1983, about 50 larvae, suspected to be parasitized were brought to the laboratory and reared on caged seedlings of *A. triphysa.* When the larvae pupated, they were separated and kept in plastic

Table 4. Natural enemies of ***A. fabriciella*** and ***E. narcissus***

Parasite/micro-organism/Predator	Species	Host staee attacked	Reference
A. fabriciella			
Parasites	***Erachymaria hime attevae*** (Chalcidae)	Larva	1. 2
	Bessa remota (Tachinidae)	,,	I
	Carcelia sp. (Tachinidae)	,,	1
Nematodes	***Mermis*** sp. (Mermithidae)	,,	3
	Hexamermis sp. (Mermithidae)	,,	2
Predators	***Parena nigrolineata*** (Carabidae)	,,	1
	Crebator unbana (Mantidae)	,,	1
	Hestiasula brnneriana (Mantidae)	,,	I
	Humbertiella ceylonica (Mantidae)	,,	1
E. narcissus			
Parasites	***Eufachina civiloides*** (Tachinidae)	,,	4
	Strumia inconspicuella (Tachinidae)	,,	4
	***Sarcophaga* sp.** (Tachinidae)	,,	2
Predators	***Humhertiella ceylonica*** (Mantidae)	,,	4
	Oriolus xanthonus maderapatanus (Oriolidae)	,,	4
	Crematogaster* sp.** nr. ***percelegans (Formicidae)	Egg	2
Fungi	***Beaveria bassiana***	Larva	4
	Paecilomyces farinosus	Larva and pupa	2
Bacteria	***Bacillus firmus***	Larva	2

1, Mathur *et a/.* 1970; 2, Present finding; 3, Misra, 1978%; 4, Chatterjee *et a/.* 1969

containers. From 14 pupae a total of 22 parasites emerged showing that more than one parasite had emerged from at least a few pupae. During December 1985, when there was a heavy build up of *E. narcissus,* 100 pupae were collected and 20 of them were found parasitized by *Sarcophaga.* Harris (1984) indicated doubt regarding the parasitic nature of the *Sarcophaga.* However, the present findings clearly show that at least this particular species of *Sarcophaga,* the identity of which could not be ascertained, could be parasitic. Beeson (1941) reported *Sarcophaga dux* as a parasite on locust. Another species, *S. antilopa* is recorded as a parasite of the teak defoliator, *Hyblaea puera* (Chatterjee & Misra, 1974). Other recorded parasites on *E. narcissus* include *Euctachina civiloides* and *Strumia inconspicuella* which were not obtained during the present study,

The only parasite that was found associated with *A.fubriciella* was the chalcid, *Brachymeria hime attevae* which was also reported by Mathur *et al.* (1970). This parasite was collected once from the study area and another time from Pezhad at Kodanad Since only a few instances of parasitism on both the pests of *Ailanthus* were observed during the study, the level of parasitization could not be found out quantitatively.

Nematodes

Parasitization of *A.fubriciella* larvae by a nematode was observed during the rainy season (July-August) in 1984 and 1985, at Pothuchadi and from Institute Campus at Peechi. The infected larvae became inactive and died in a couple of days. Each dead larva showed the presence of more than one parasite. The nematode was identified as *Hexamermis* sp. (Fig. 14). The size of the nematode larvae varied from 10 to 24 cm in length. Parasitization of *A. fabriciella* larvae by another mermithid viz. *Mermis* sp. has been reported (Misra 1978). Also many other forest insects are known to be parasitized by mermithids (Chatterjee & Singh 1965; Chatterjee *et al.,* 1968). Usually there will be only a single parasitic worm per host, but multiple parasitism is also reported (Chatterjee *et al.,* 1968). The identity .of most of these parasitic worms at species level is not known. So also the exact mechanism of parasitization by these soil dwelling nematode is not clearly understood.

Predators

Crematogaster perelegans, an ant was found to feed on eggs of *E. narcissus.* Predation on eggs of *E. narcissus* by this ant species was found only once in the field and further observations and experiments will be required to establish this. Other than the ant. no other predatory species could be found. Other recorded predators on *E. narcissus* and *A. fabriciella* (Table 3) include some mantids, a cerambicid beetle and a bird. Bird predation on insect pests of other forest crops

like teak is quite common, hut no bird was observed to feed on larvae of either *E. narcissus* or *A. fabriciella.* It is possible that the presence of hairs on the body surface of *E. narcissus* may repel birds from accepting them and because of the concealed nature of living of *A. fabriciella,* they may also escape attack from birds.

Fungal pathogen

Many species of fungi are known to attack and kill insects in nature and the incidence of fungal attack ranges from occasional to large-scale mortality. Between September and December 1983, many larvae and pupae of *E. narcissus* were found infected by a fungus and were completely covered by the fungal mycelia. The fungus was cultured and identified as *Paecilomycesfarinosus.*

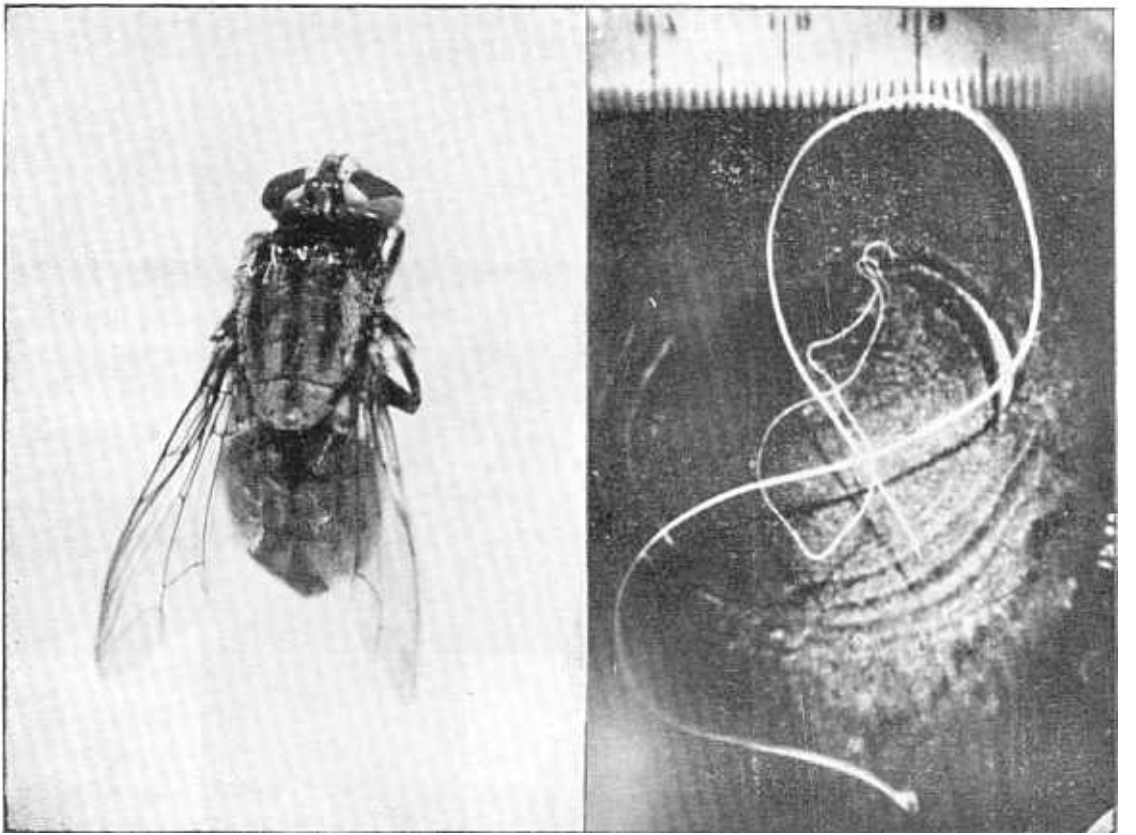
The pathogenicity of *P. farinosus* was confirmed in the laboratory against *E. narcissus* and *A. fabriciella.*

In control sets, there was no mortality in both late and early instar larvae of *E. narcissus* and those of *A. fubriciella.* When late instar larvae of *E. narcissus* were sprayed with fungal spore suspension, 83-100% mortality was obtained with in 48 h. In the case of early instar larvae infection amongst the test insects was rather fast and death occurred within 24 h (Table 5). Infected insects showed profuse growth of fungal mycelium all over the body (Figs. 15, 16). Though some of the inoculated late instar larvae pupated, most of them did not emerge (Fig. 17) and some of the emerged adults were covered with fungal mycelia (Fig. 18) which died within a few hours of emergence.

In experiments where the larvae of *E. narcissus* were released on fungal spore treated leaves, only 77-93% mortality occurred (Table 5). Compared to the direct application of fungal spore suspension on to the test larvae, here a longer period of *12* h was required to bring about over 90% mortality of the test insects. However, over SO% mortality was observed within 48 h. after release of insects on to the treated leaves,

In the case of *A. fabriciella,* with direct spore application, 100% mortality was recorded after 72 h. and over *80%* of the test larvae were dead (Figs. 19, 20) within 48 h.

Thus the pathogenicity of *P. farinosus* to both *E. narcissus* and *A. fubriciella* was confirmed in laboratory experiments. The fungus, *Paecilomyces* occurs on a wide range of substrata all over the world and almost all species are parasitic on insects, sometimes causing epidemics also (Brown & Smith, 1957). Recently Bajan *et al.* (1982) have demonstrated the use of *P. farinosus* as one of the agents in the biological control of colorado beetle, *Leptinostarsa decemlineata.* Another fungus, *Beaveria bassiana,* has been reported from *E. narcissus* (Chatterjee & Sen-Sarma, 1968), hut its pathogenicity was not



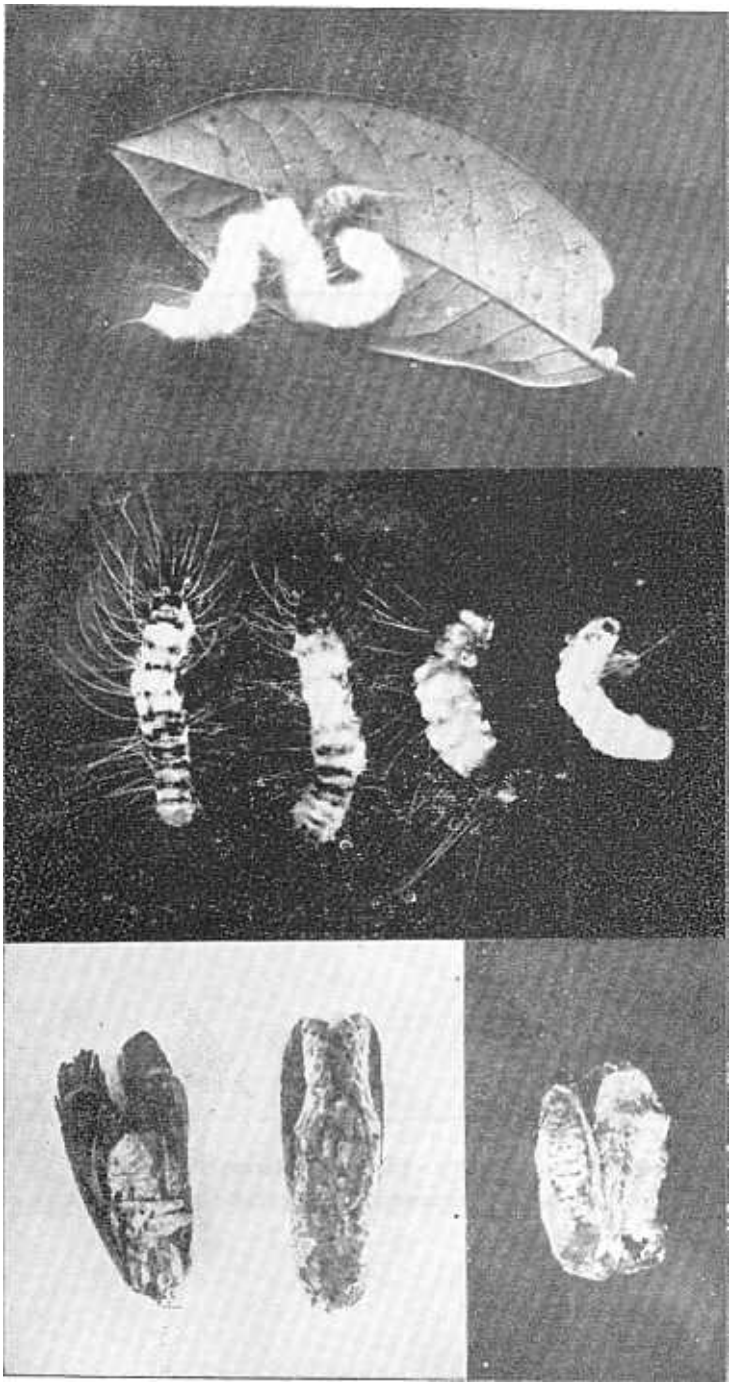


Fig. 15. Larvae of *E. narcissus* parasitized by the Fungus, *P. farinosus* under laboratory experiments
Fig. 16. Dead larvae of *E. narcissus* by the fungus, *P. farinosus* collected from the field
Fig. 17. Pupa of *E. narcissus* parasitized by the Fungus, *P. farinosus* under laboratory experiments
Fig. 18. Adult moth of *E. narcissus* parasitized by *P. farinosus* in laboratory experiments

Table 5. Effect of *P. farinosus* on larvae of *E narcissus* and *A.fabriciella* in artificial inoculation trials

Insect/larval stage	Treatment	% mortality of larvae*						% of larvae pupating		% of adults emerging
		Spore Conc. I			Spore Conc. I1			Spore Conc. I	Spore Conc I1	
		24 h	48 h	72 h	24 h	48 h	72 h			
E. narcissus										
Early instar	Control (No treatment)	0	0	0	0	0	0	0	0	100.0
"	Direct application of spores	100.0	0	0	100.0	0	0	0	0	0
"	Spores applied on leaves	26.6	50.0	93.3	40.0	73.3	90.0	0	0	0
Late instar	Control (No treatment)	0	0	0	0	0	0	6.7	0	93.3
"	Direct application of spores	83.3	100.0	0	66.6	83.3	0	0	16.7	0
"	Spores applied on leaves	13.3	80.0	0	36.6	63.3	16.6	20.0	0	**0**
A. fabriciella										
(various instars)	Control (No treatment)	0	0	0	0	0	0	0	6.7	93.3
,,	Direct application of spores	—	—	—	33.3	83.3	100.0	0	0	0

* 3 replicates of 10 larvae each

Spore Conc. I, 104 spores/ml

Spore Conc. 11. 105 spores/ml

The incidence of *P. farinosus* infection on *E. narcissus* under natural condition was also observed in an I-year-old *A. triphysa* plantation at Pezhad in Amathodn Section of Kodanad during August 1985. The 10 ha plantation was heavily attacked by both *E. narcissus* and *A. fabriciella*. Nearly 1 ha was surveyed and pupae from 100 plants at random were collected to find out the intensity of parasitization by the fungus. Out of the 216 pupae of *E. narcissus* collected, 138 were infected (over 60%) by the fungus, *P. farinosus* (Fig. 21). Unlike in the case of *E. narcissus*, no parasitized larvae or pupae of *A. fabriciella* were found infected with the fungus in the field.

Bacterial pathogen

During September-December 1983, when there was a pest build-up in the study area, a few larvae of *E. narcissus* were found dead and hanging on the leaves showing symptoms of bacterial infection. The bacterium isolated from such dead larvae was gram positive, rod-shaped and sporulating and was identified as *Bacillus firmus* Breadmann & Werner. Morphologically *B. firmus* is very much similar to *B. subtilis* (Gibson & Gorden, 1974). In laboratory tests, when *E. narcissus* larvae were released on *A. triphysa* leaves treated with the bacterial preparation, they stopped feeding by 18–24 h and 80-100% mortality was observed within 72 hr, thus confirming the pathogenicity of *B. firmus*. The dead larvae turned dark in colour, the body became soft and on slight touch yielded a black ooze. very much similar to septicaemia (Fig. 22). In all cases, the pathogen could be reisolated from the dead larvae. The experiment was repeated at three different times and yielded consistent results. In controls, there was no death and all the larvae pupated and adults emerged as usual.

Many species of the genus *Bacillus* viz. *B. popilliae, B. cereus, B. thuringiensis, B. sphaericus,* ete., are known *to* be pathogenic on insects. Of these *B. thuringiensis* is widely used as a microbial insecticide Commercial preparations of *B. thuringiensis* are available and are used successfully against a number of lepidopteran pests of agricultural and forestry importance In the case of *B. thuringiensis,* the protein crystals present in the bacterium are tlie toxic agent, which bring about the death of the host. The bacterial preparations have no contact toxicity and once infested, the epithelial cells in the gut of the host are killed, thus making the larvae unable to feed normally. In the present laboratory experiments also, feeding by larvae on leaves treated with bacterial preparation was very less. Hence, even if the complete death of larvae occurs only after some time, damage to leaves by feeding of the larvae can be stopped much earlier.

The exact mode of action of *B. firmus* is not known. Preliminary studies using both light and scanning electron microscopy do not reveal the presence of any crystal

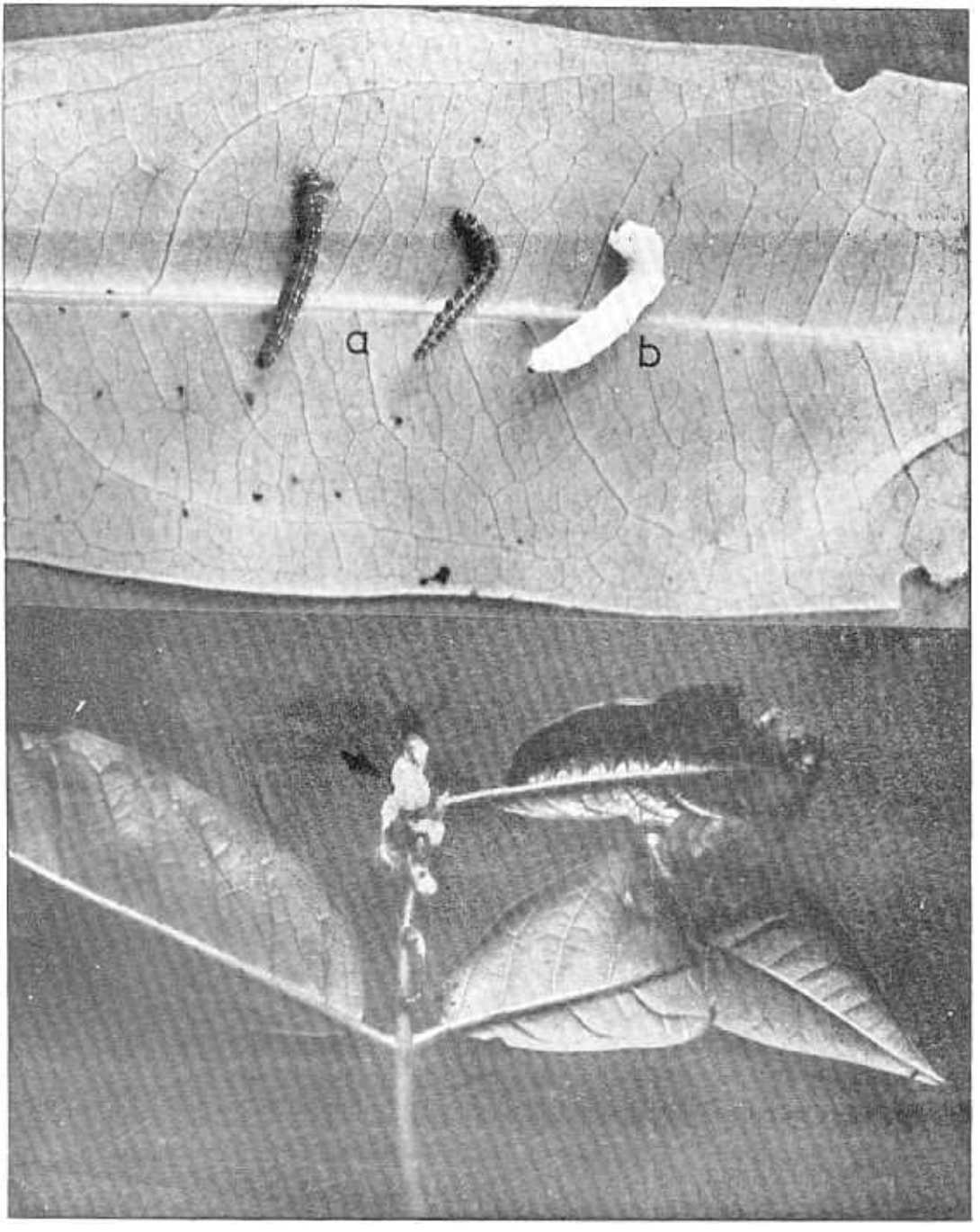


Fig. 19. *A. fabriciella* larvae parasitized by *P. farinosus* in laboratory experiments a- normal b- parasitized

Fig. 20. A group of *A. fabriciella* larvae killed by the spore application of the fungus, *P. farinosus* under laboratory conditions

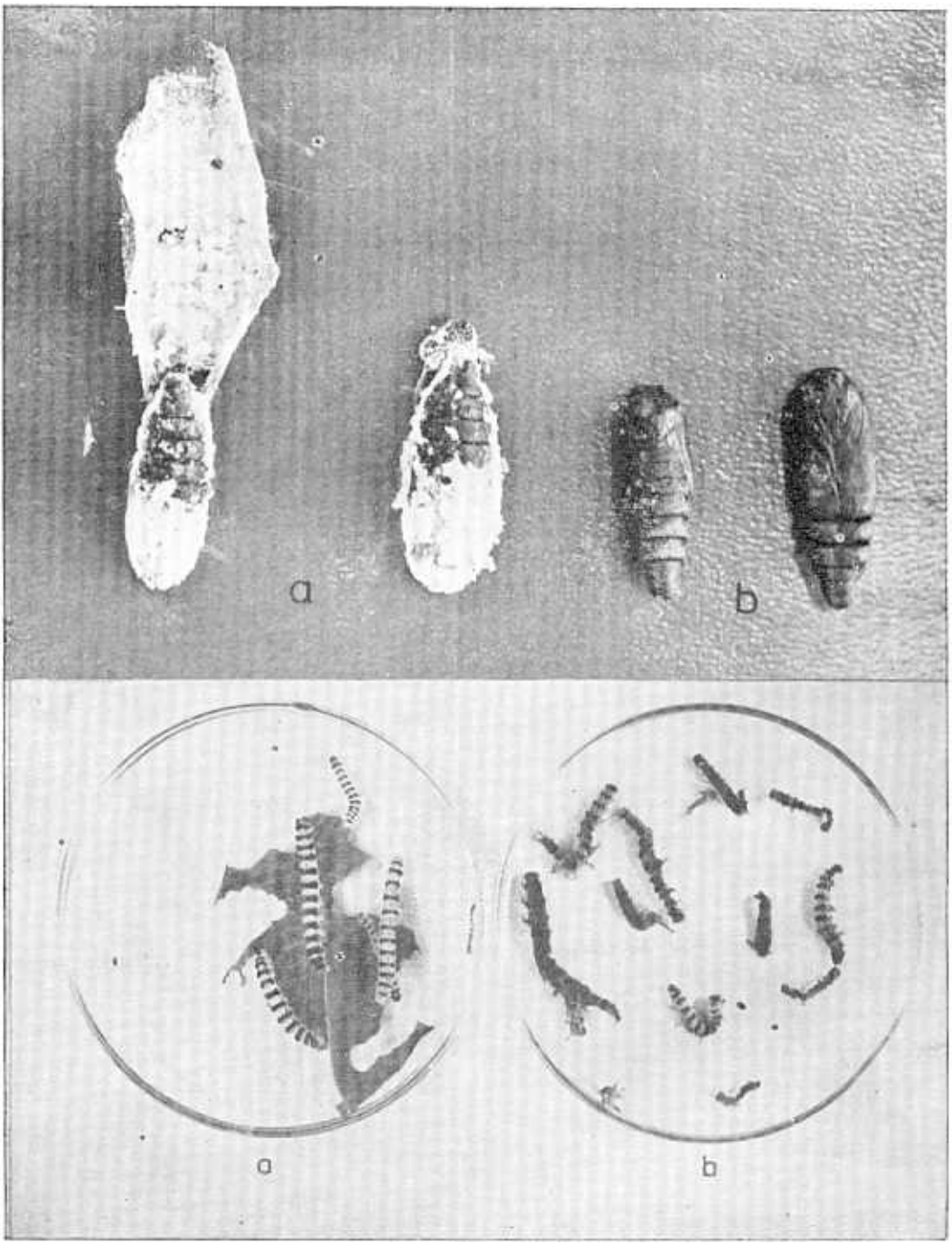


Fig. 21. Pupae of *E. narcissus* collected from Pezhad (Kodanad) during a natural infestation by the fungus, *P. farinosus*. a-infected, b-normal.

Fig. 22. *E. narcissus* larvae parasitized by the bacterium, *Bacillus firmus* in laboratory experiments. a-normal, b-infected.

in *B. firmus.* Only further studies on this bacterium will bring out more information on its mode of action. This is the first report of *B. firmus* as an insect pathogen.

The bacterial spore preparation of *B. firmus* was also tested against *A. fabriciella,* but was not effective. However preliminary experiments on larvae belonging to the same family as that of *E. narcissus,* i.e.. Noctuidae, showed effectiveness. It is suspected that this bacterium may have some host specificity which needs further confirmation.

From the results obtained it is difficult to draw definite conclusions on the relative importance of various mortality factors operating upon the two pest populations of *Ailanthus.* In the study area where regular Observations have been made, *A. fabriciella* was present almost throughout whereas *E. narcissus* was seen in good numbers only between August and December in 1983. Natural infestation by insect parasites or nematodes was restricted to a few number of pests alone. Of the two pests, *A. fabriciella* was practically free from any major attack by insect parasites. However, Chatterjee & Sen-Sarma (1968) have stressed the need for further work on mass breeding and release of *Brachymeria hime attevae* and *Bessa remota* for the biological control of *A. fabriciella.*

Based on the present field observations and laboratory experiments, the fungus, *P. farinosus* appears promising as a biological control agent against both *E. narcissus* and *A. fabriciella* and the bacterium, *B. firmus* against *E. narcissus.* However, further studies under field conditions will be required to assess the full potential of these two agents in the control of the pests in a practical way.

CHEMICAL CONTROL TRIALS

INTRODUCTION

Many commonly available insecticides have been tested in the past against pests of *Ailanthus.* Mathur *et al.,* (1970), based on field trials, reported that organochlorine insecticides, like DDT, BHC and aldrin are effective in controlling *A. fabriciella.* Later, Singh & Gnpta (1978) tested 20 commonly available insecticides under laboratory conditions and found formothion, chlordimeform, quinalphos, monocrotophos, pyrethrum and carbaryl to be effective in decending order, in comparison to DDT. Singh & Misra (1978) also screened a microbial insecticide, thuricide with *Bacillus thuringiensis* as active ingredient against a number of forest pests including *A.fabriciella* in the laboratory. Thuricide was only moderately effective against *A. fabriciella.* Recently Dwivedi & Chattoraj (1982) tested the efficacy of a chemosterilent, hempa against *A. fabriciella* in the laboratory. Studies on the control trials against *E. narcissus* are practically nil. It may be because *E. narcissus* is not regarded as major pest of *Ailanthus* in northern India, where most of the work in the past have been carried out.

Some of the other suggested control methods in the management of *Ailanthus* pests include silviculrural-cum-biological means like maintaining natural strips of original vegetational complex between adjacent plantations, mixed plantations of *Ailanthus* and developing techniques for mass breeding and release of parasites. However, biological means of control as suggested above was never experimentally proved or put to practice due to practical difficulties.

During the present study it was found that in nurseries and in young plantations, one of the pests or sometimes even both the pests are encountered and in some instances in an epidemic level. In such situations, insecticidal application may become necessary to contain the spread of the pests. Experiments were therefore carried out to test efficacy of selected insecticides against *E. narcissus* in the laboratory and against *A. fabriciella* under field trials. One of the effective insecticide was also tested against *E. narcissus* under field conditions.

MATERIALS AND METHODS

Laboratory tests

E. narcissus larvae (various instars) collected from field and maintained on caged seedlings of *A. triphysa* were used for the experiments. The following

commercial formulations of insecticides — quinalphos (Ekalux 25 EC). monocrotophos (Nuvacron 36 EC), cypermethrin (Cymbush 25 EC) and PP 321 (Karate 5 EC) were tested at 3 concentrations (Table 5). Lower concentrations of insecticides were used in the case of synthetic pyrethroids. The required concentrations of each insecticide solution were thoroughly sprayed on to three leaves of *A. triphysa* using an atomiser and the solution air-dried. Ten larvae each were introduced into a plastic jar (14x11cm) and allowed to feed on the treated leaves. There were 3 replicates for each concentration of insecticides tested. Mortality was observed at the end of 24 h.

Field trials

A small–scale field trial for control against *A. fabriciella* was carried out at Pothuchadi at a time, when the pest population reached its peak during March 1985. Three blocks of 200 plants each were marked out and 50 plants in each block were given one treatment. Quinalphos and monocrotophos were used at 0.05% solutions and cypermethrin at 0.01% solution. Spraying was done using a rocker sprayer. Each plant received about 200 ml of spray solution and care was taken to drench the terminal portion of the main stem and other branches of the plant well, where *A. fabriciella* larvae are usually present. While taking the observations, two rows of plants on either side and two rows from the centre were excluded to avoid any possible border effect. Thus, out of the 50 treated plants, observation was confined to 24 plants.

The level of infestation was assessed by observing the presence and number of *A. fabriciella* on each plant prior to insecticidal application. To assess the effectiveness of the insecticides, observations were made on the second day after the treatment followed by two fortnightly and the last one after a month.

The effectiveness of quinalphos (Ekalux) was tested against *E. narcissus* in a nursery at KFRI Campus, Peechi and in a 5 ha area in a young plantation at Mullaringad.

RESULTS AND DISCUSSION

Laboratory experiments

All the insecticides tested against *E. narcissus* were equally effective at all concentrations (Table 6). The larvae fed very little on the treated leaves and more than 50% of the deaths occurred within six hours. Based on easy availability, cost and safety to man and animals, one of the insecticides viz. Ekalux was used in field trials.

Table 6. Effect of selected insecticides on *E. narcissus,* when applied to leaves of *A. rriphysa* in laboratory tests

Insecticide	Trade name	% mortality after 24 hours*				
		0.I	0.05	0.025	0.125	0.0625
Monocrotophos	Nuvacron 36 EC	100	100	100	—	—
Quinalphos	Ekalux 25 EC	100	100	I00	—	—
Cypermethrin	Cymbush 25 EC	—	—	100	I00	100
Cypermethrin	PP 321 (Karate 5 EC)	—	—	100	I00	100
Control		0	0	0	0	0

*Ten larvae per replicate and total of 3 replicates.

Field trials

The incidence of *E. narcissus* was quite erratic at Pothuchadi and hence no field trial could be laid out there against *E. narcissus.* However, a severe attack by *E. narcissus* was noticed during January 1984, in a large number of container seedlings of *A. triphysa* maintained in the Institute Campus. The seedlings were sprayed with 0.05% solution of Ekalux. By next day all the larvae were. found dead and about 400 dead larvae could be counted. Though all the plants were completely dcfoliated, in about two weeks time they flushed again. Also in January 1984, there was a severe attack of *E. narcissus* in an 1-year old *A. triphysa* plantation (30 ha) at Oonakal in Mullaringad Range of Kothamangalam. The local staff of the Forest Department was requested to spray 5 ha area with 0.05% Ekalux. The area was visited about 20 days after the treatment to assess the pest situation, In the untreated area, the incidence of *E. narcissus* was quite high, whereas in the treated area, insect damage was practically nil. Though the treatment appeared to be effective, the results could not be quantified due to practical difficulties.

Thus the effectiveness of quinalphos in controlling *E. narcissus* under field conditions has been confirmed. One litre of the insecticide, Ekalux 25 EC, was found to be sufficient to cover one hectare of the 2yr-old-plantation.

All the three insecticides tested against *A. fubriciella* in the field were effective (Table 7). The treatment remained effective at least upto 78 days after the treatment. Dead larvae were found on all treated plants, mostly entangled within the web, where it usually lives. Though a few larvae were Seen in one or two plants treated with monocrotophos, they also got killed in course of time. Monocrotophos, hcing a systemic insecticide, may take sometime for all the larvae to reed on the treated leaves and get killed. In the untreated plot,, the infestation continued more or less at the

same intensity for about 2 months. Further observations at different intervals npto 3 months showed that the treated plants were free from fresh attack by *A. fabriciella* for about $2^{1}/_{2}$ months. Rains started by the third month onwards, after the treatment and there was a general decline in the insect population. The treated plants showed abundance of foliage with intact terminal buds in comparison to the untreated plants where most of them had the terminal portion damaged.

Table 7. Effectiveness of selected insecticides against *A. fabriciella* in a 2 yr-old plantation of *A. triphysa*

Treatment	% Plants infected before treatment (7.3.85)	% of plants in which insects were present after					
		2 days (9.3.85)	18 days (25.3.85)	34 days (11.4.85)	60 days (6.5.85)	78 days (24.5.85)	102 days (17.6.85)
Control (untreated)	65.3	63.8	50.0	62.5	61.1	47.2	0
Quinalphos (Ekalux 25 EC)	69.4	0	0	0	0	0	0
Monocrotophos (Nuvacron 36 EC)	58.3	4.2	1.4	0	0	0	0
Cypermethrin (Cymbush 25 EC)	61.1	0	0	0	0	0	0

One of the insecticide found effective in the field trial i. e., quinalphos is a contact and stomach poison belonging to the organophosphorous group. Though in the present experiment, quinalphos remained effective for nearly 2½ months after treatment against *A. fabriciella,* this may not become true in all situations. Usually quinalphos remains effective only for about a month under field conditions and hence application of this insecticide may have to be repeated, if fresh outbreaks are noticed in the treated area after a month or so. Such a situation was not encountered during the present experiment. As discussed in chapter the incidence of pests cannot be predicted and hence properly timed prophylactic application of insecticides becomes difficult.

CONCLUSIONS AND RECOMMENDATIONS

The present study has shown that *Atteva fabriciella* and *Eligma narcissus* are the two major pests of *Ailanthus triphysa* in Kerala. Both the pests are distributed throughout Kerala, wherever *Ailanthus* is grown and cause serious problems in nurseries and young plantations. General observation indicates that older plantations are comparatively free from pest attack. The study reports for the first time an alternative host plant, *Quussia indica* other than *Ailanthus* spp. to support *A. fabriciella.*

E. narcissus larvae feed on all the leaves and cause defoliation in nurseries and young plantations. Sometimes, when all the leaves are eaten up, the larvae may also bore into the soft stem tissues. *A. fabriciella* feeds only on the tender leaves and other soft tissues of the terminal portion, including the terminal bud. Feeding by this insect often causes branching of the plants and retardation of growth due to drying up of the terminal buds. Earlier reports indicate that *E. narcissus* is a more serious pest than *A.* fubriciella in southern India. However, the present study shows that *A. fabriciella* appears to be a more serious pest because of the damage it can cause to the terminal buds of the plants.

The seasonal incidence of pests was found to be erratic. In the study area *A. fabriciella* was present almost throughout with a peak between September and January. However, *E. narcissus* occurred in large numbers only during September 1983 to January 1984 and at other times was practically absent. The same trend in population build up was not observed in other localities, where limited observations have been made. General observations indicate a low level of pest population during monsoon period (June-July).

Many mortality factors including insect parasites were found to operate under field conditions in checking the population build up of both the pests. Microbial pathogens, a fungus and a bacterium appear to exert good natural control of the pests, especially against *E. narcissus.*

Pest outbreaks, either by a single pest or in combination can be expected in nurseries and young plantations, though it is not possible to predict the time of occurrence based on the available data. Continuous observation over a longer period may be required to find out definite trends in population fluctuations. To apply control measures at the right time regular surveillance on pest build-up will

be required in each plantation. In yong plantations and nurseries, one of the following insecticides, quinalphos, monocrotophos or cypermethrin can be used which will give effective protection.

The studies also indicate the possible use of the fungus, *Paecilomyces farinosus* in the biological control of both the pests and also the use of the bacterium, *Bacillus firmus* against *Eligma narcissus.* The possibilities of these and other microbial agents in the management of the pests of *Ailanthus* are being studied.

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