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SPATIAL AND TEMPORAL DISTRIBUTION OF AILANTHUS PESTS, ELIGMA NARCISSUS AND ATTEVA FABRICIELLA

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ABSTRACT

The spatial and temporal distribution of the two major pests of *Ailanthus triphysa,* viz.. *Atteva fabriciella* and *Eligma narcissus* have been studied in a 10 ha plantation over a period of three years at Thattekkad in Kothamangalam Range, Kerala. The larval population of both the pests was monitored in 18 transects, covering the entire plantation, at regular intervals.

A. fabriciella was present almost throughout the study period at varying intensities whereas incidence of *E. narcissus* was erratic. The two insects followed a clustered pattern *of* distribution, both over space and time, which was also influenced by both biotic and abiotic factors of the locality. Phenology of *Ailanthus* in the Thattekkad plantation showed considerable variation among individual trees and it may have affected the pest population level. Rainfall was another important environmental factor. Incidence of *A. fabriciella* was negatively correlated with rainfall, but incidence of *E. narcissus,* had no such correlation. The species composition and population level of natural enemies, also varied in different localities. At Thattekkad, 5 species of bird predators of both pests and the chalcid, *Brachymeria hime attevae,* which parasitise pupae of *A. fabriciella* were prevalent. At Chatha-mattom, a reduviid bug, *Panthous bimaculatus* reported here for the first time as a predator of both the pests occurred in good numbers. At Erumeli. no major parasite or predator was noticed.

There was no difference in the intensity of infestation by either of the two pests between monoculture plantations and plantations raised under teak.

A search for other insects feeding on *A. triphysa* resulted in 12 new records of insects associated with the species.

Field experiments to study the cause of stunted growth in *A. triphysa* plantation at Erumeli showed that stunting *is* mainly due to the damage caused by the insect, *A. fabriciella.*

DISTRIBUTION OF PESTS OF *AILANTHUS TRIPHYSA* IN YOUNG PLANTATION

Introduction

Two major insect pests of *Ailanthus* spp. are *Atteva fabriciella* (Lepidoptera : Yponomeutidae) and *Eligma narcissus* (Lepidoptera : Noctuidae). Earlier investigators (Chatterjee *et a/.,* 1989; Mathur *et a/.,* 1970; Varma, 1986) have studied the biology, seasonal occurrence and intensity of damage caused by the two pests. In Kerala, the two pests mentioned above are very common in forest plantations of *A. triphysa* and often cause serious damage both in nurseries and young plantations (Varma, 1986).

In the case of forest pests, it is often noted that the pest population reaches high densities during certain times of the year and then declines or even disappears during the rest of the year. This is understandable in the case of polyphagous insects with seasonal availability of prefered host plants. but not in the case of insects like *A. fabriciella* and *E. narcissus* which are very selective in their feeding habits. *E. narcissus* does not have any alternative hosts recorded so far and *A. fabriciella* is reported feeding on leaves of the shrub, *Quassia indica* (Mohanadas and Varma, 1984). Q. *indica* is seen in coastal areas and are not usually seen near forest plantations.

It is common knowledge that the distribution and abundance of forest pests and the host plants vary in time and space. Thus it is often essential to study the population dynamics of a forest pest to understand the factors responsible for its buildup or decline. Such factors could be either intrinsic or extrinsic. Knowledge about them helps in prediction of pest outbreaks and proper use of pesticides. In the present study the spatial frame work was confined to a 10 ha *A. triphysa* plantation in the Central Forest Circle and the time extended to three years.

Materials and Methods

Study area

The study was conducted in a 5 - year - old *A. triphysa* plantation at Thattekkad in Kothamangalam Range (Fig. 1). The total extent of area was 10 ha and was earlier planted up with *Dalbergia* which failed to establish.

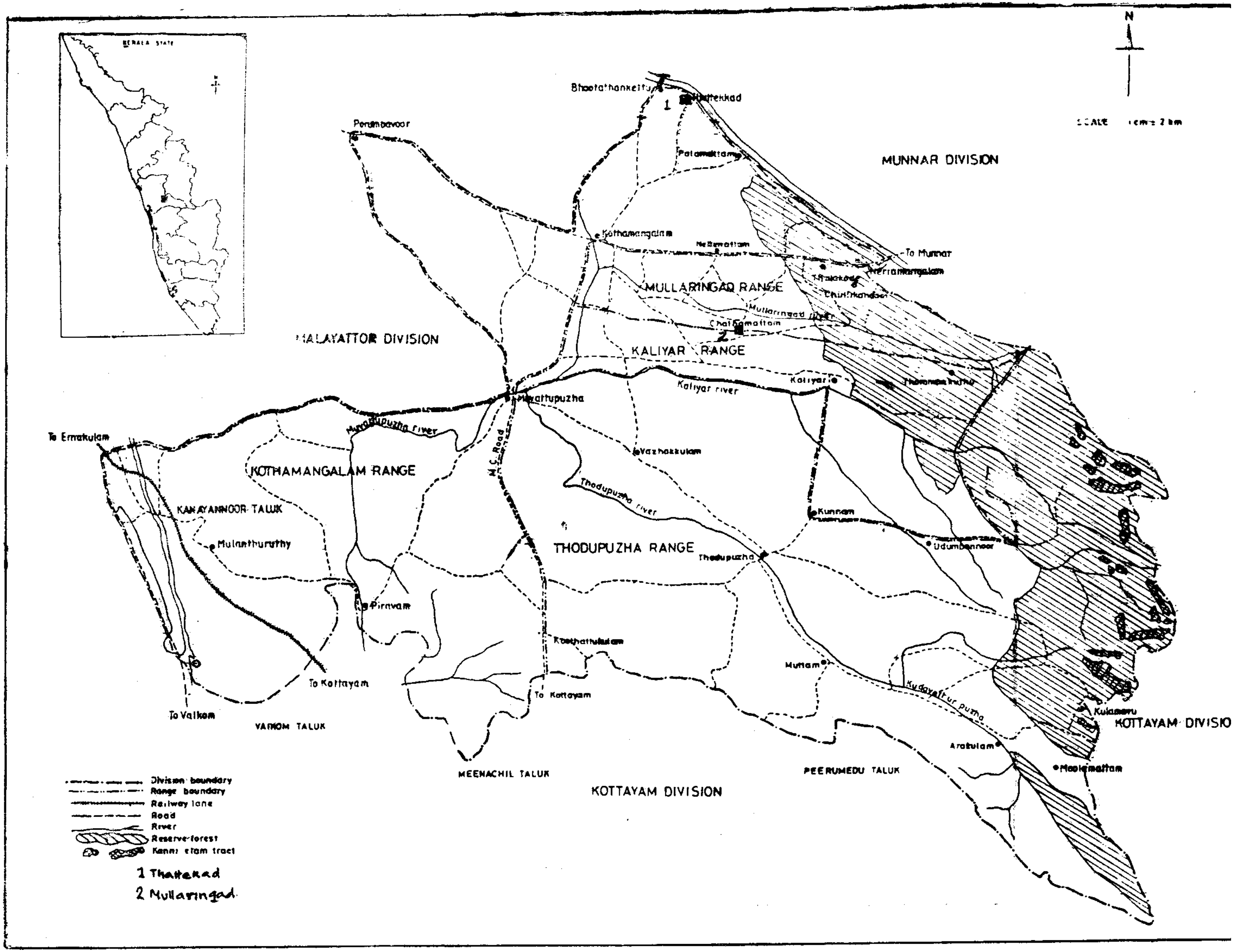


Fig. 1 Map of Kothamangalam Forest Division showing study locations

Methods

Within the plantation, 18 transects were taken covering the entire plantation (Fig. 2). There was a motorable road passing through the plantation, which separated the plantation into two blocks. Transects 1 - 10 were on the right hand side of the road which covered the bulk of the plantation and transects 11 - 18 were on the left hand side of the road.

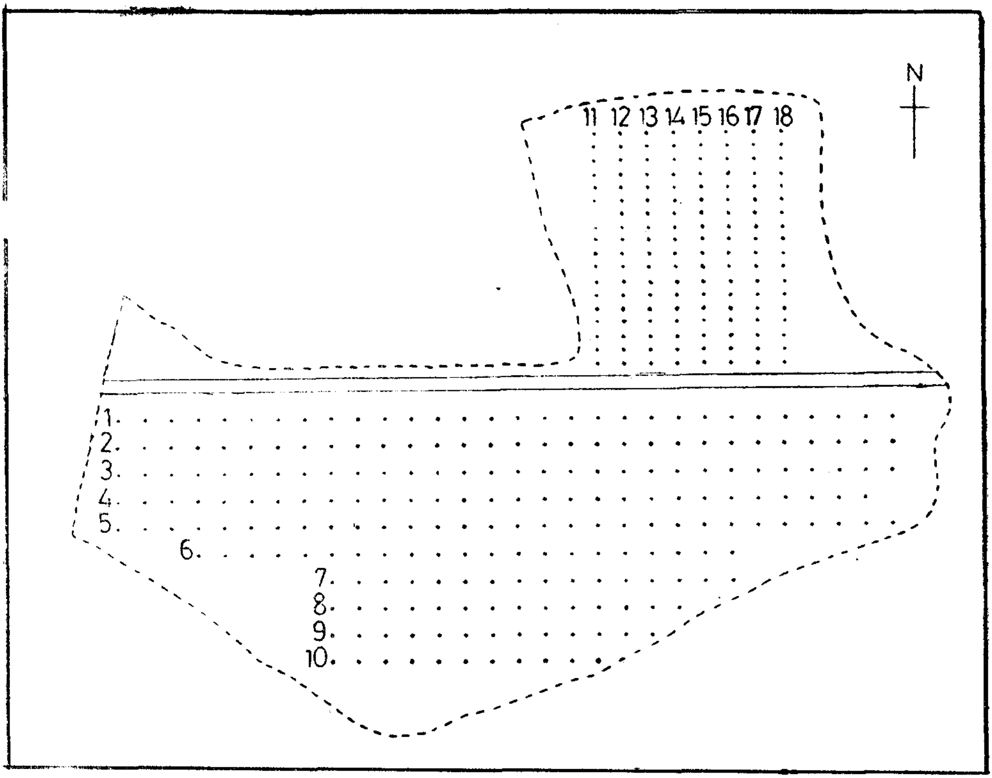


Fig. 2 Study plot at Thattekkad showing transects

The ideal ecological sample unit was considered as a line transect as suggested by Taylor (1984) and non-destructive sampling was employed. Each transect was 10 metres apart and the outer rows of plants towards the road were avoided to rule out possible edge effect. The planting espacement was 2 X 2 m. The total number of plants observed / sampled was 543. The maximum number of plants in a transect was 145 and the minimum number was 20. In the case of transects in which over 100 plants were present, every fifth plant was marked and observations confined to those plants whereas in other transects. all the plants were observed.

During each observation, the occurrence and number of larvae of both insects - *A. fabriciella* and *E. narcissus,* present on the foliage were counted and recorded on data sheets. The pupal count of both insects were also taken. but could not be used for pest distribution studies because larvae of both insects were found to pupate on many non host plants. On the other hand larvae of both the insects were highly specialised feeders and always confined to the host plants and the density of pests in each transect was determined by the actual number of larvae observed per plant. Since the observations were confined to the host plants in the transects, a reliable estimate of the pupae was not possible. But this data was useful in assessing pupal parasitization in *A. fabriciella.*

Analyses of the data on spatial and temporal distribution of pests

Data on larval population of both the insects were used for the analysis. Data gathered from transects 1-10, which constituted the major portion of the plantation were used to analyse the spatial pattern of pest incidence.

The following approaches were employed in the analysis of the data (Campbell and Madden, 1990).

Mapping

This is one of the widely accepted techniques to understand the spatial pattern of distribution, wherein it provides a rapid visualisation of the pattern in a given area. This method was employed as the first step to understand the density or severity of the distribution of the two pests. This method also gives indication of the pest incidence over time.

The indices of dispersion

The mean-to-variance ratio (MV) is a simple index of dispersion to calculate and forms the basis for many other indices. The MV ratio is calculated using the data from all the transects by dividing the sample variance by sample mean. MV = s^2/x, where s^2 is the sample variance and x is the sample mean. This index is also used in understanding the temporal pattern of distribution of the pests.

Discrete distributions

This technique is mainly employed to indicate whether a spatial pattern is random or non-random. Several distributions were fitted to the frequency data to understand the spatial pattern, such as Poisson distribution (to Indicate randomness), the negative binomial distribution (to indicate aggregation) and the binomial distribution (to indicate regular or uniform pattern).

Distributions were fitted to data gathered for months during which larval population was very high.

Runs analysis

Runs analysis is employed for detecting clustering of infested plants in rows (Campbell and Madden, 1990). This test was carried out only in transects 11-18, where data on pest incidence in all the plants in a row were available.

The percentage of rows with clustering was also calculated for each month.

Phenology of *A. triphysa* in the study area

To understand the phenological state of the plants in the experimental area, each plant in a transect was scored visually for a period of one year, (May 1987 to April 1988) on monthly basis as follows - 0 - leafless; 1-all mature leaves; 2-low flushing 3-medium flushing and 4-high flushing.

Monitoring larval / pupal mortality

Observations were taken on the natural enemies which attacked the larvae and pupae of both the pests. When pupae of *A. fabriciella* were present on the sampled plants in the transects, those with parasite emergence hole were noted to assess the extent of parasitization. Also, pupae collected from outside the transect lines were reared out in the laboratory to look for parasite emergence.

During peak periods of insect incidence, the potential impact of avian predators was also assessed. At a selected spot within the experimental plot, the birds coming and feeding on larvae of *A. fabriciella* or *E. narcissus* were observed for about an hour either in the morning or in the evening.

The spiders which were frequently seen on the host plants were collected, identified and their predatory potential assessed under laboratory conditions.

Pest incidence on roadside *Ailanthus* plants

From Kothamangalam DFO's office to the experimental plot at Thattekkad. covering about 10 Km, there were *Ailanthus* plants (single or in groups) on the roadside. These plants were located either in homesteads or in office compounds. The distribution of the plants under each kilometer was as follows :

Distance	No.plants/trees	
	Groups	Isolated
Km 1	20	—
Km 2	—	4
Km 3	8	-
Km 4	16	2
Km 5	—	3
Km 6	—	4
Km 7	—	—
Km 8	—	4
Km 9	—	5
Km 10	40	8
Total plants	84 +	30 = 114

During each month, the occurrence of both pests on the marked plants was recorded.

Pest incidence in other localities

During 1987, a survey of pest incidence was made on some of the *Ailanthus* plantations, covering the southern, central and northern forest circles.

Weather records

Monthly rainfall data, recorded at Bhoothathankettu, very close to the study area were collected. Monthly rnean rainfall during the 3-year study period was calculated. Correlation between rainfall (current and lagged) and pest incidence was examined.

Results and Discussion

Spatial pattern of the distribution of pests at Thattekkad plantation

A. fabriciella : Mapping of incidence of *A. fabriciella* in the 10 ha study plot showed that *A. fabriciella* was present almost in all transects throughout the year with varying intensities (Fig. 3). The three basic patterns of distribution of an insect population are regular, random or clustered. In practice all that can be effectively measured in routine sampling programme is the mean and variance. Based on the MV ratio values (Fig. 4) it is seen that the larval population of *A. fabriciella* falls into the clustered group. If the MV

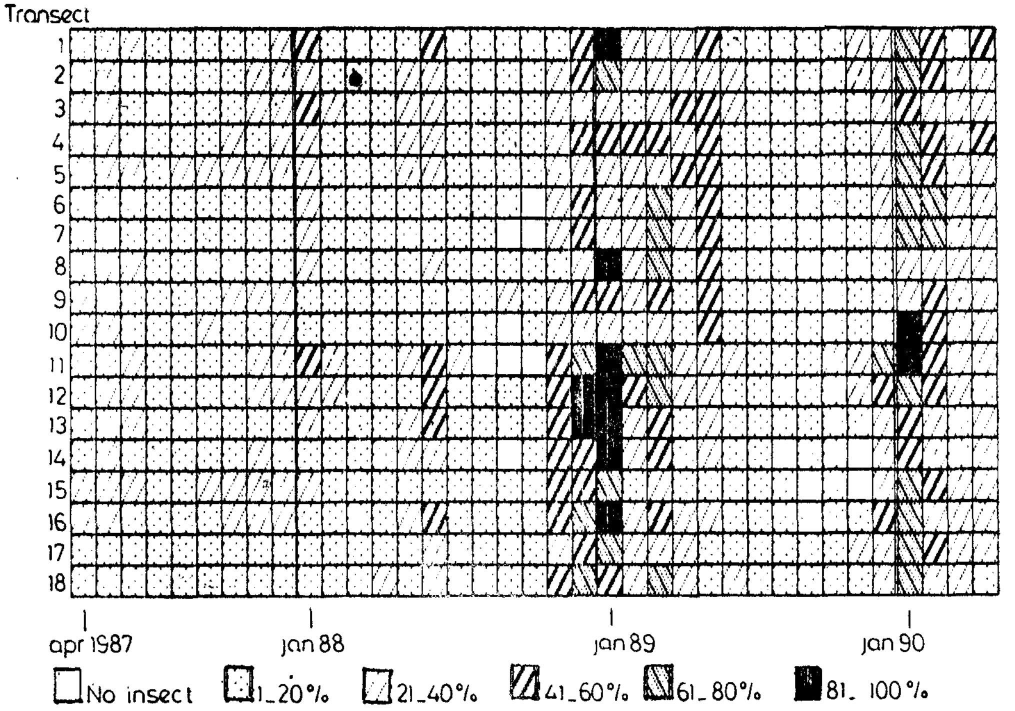


Fig. 3 Distribution of *A. fabriciella* in 18 transects at Thattekkad

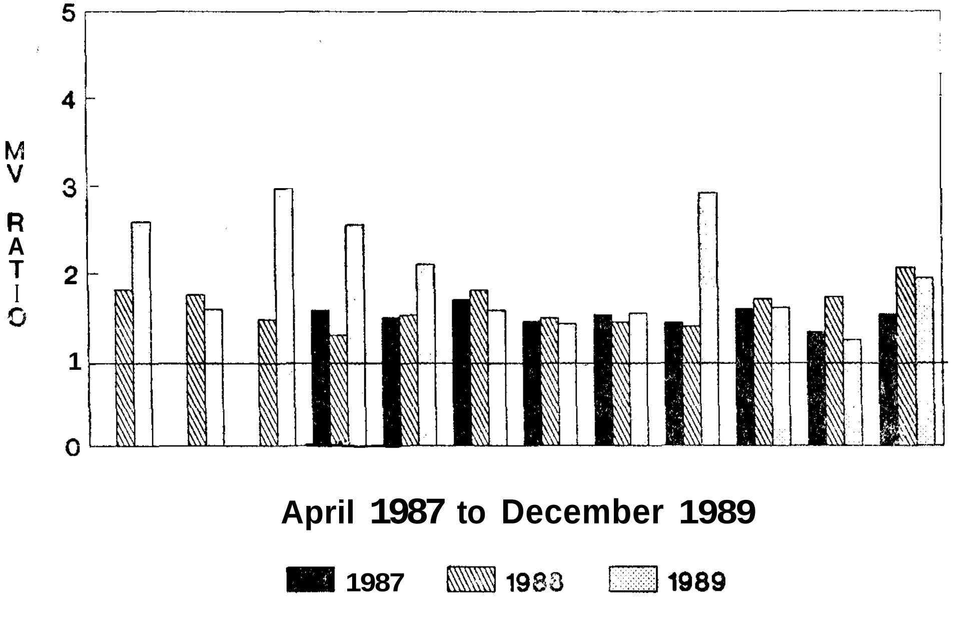


Fig. 4 MV ratio - *A. fabricella* incidence at Thattekkad

ratio is less than 1, it follows a regular spatial pattern, if it is equal to 1 it follows a random pattern and if the values are greater than 1. it follows a clustered pattern. In this case, it can be seen that the MV ratio of samples was greater than 1. The negative binomial distribution fitted very well to the data on a few selected months, during which *A. fabriciella* population was very high from both transects 1-10 and 11-18. Either Poisson or binomial distribution did not fit the data. This further confirms that the spatial pattern is clustered and also that whenever the pest buildup was high, the same pattern of clustering continued.

The result of the runs analysis carried out with data from transects 11-18 also showed clustering of *A. fabriciella* infested plants within the rows during certain months. Though *A. fabriciella* population was present on most rows, clustering was noticed only on a few rows. The percentage of rows which showed clustering is given in Table 1. During June 1989, 3 rows showed clustering and in February 1989, 2 rows showed clustering. Otherwise only one row showed clustering on most occasions.

Table 1 Percentage of rows of *A. triphysa* showing clustering of *A. fabriciella.*

Months	% of rows clustered			
	1987	1988	1989	1990
January		—	—	—
February		—	25.00	12.50
March		12.50	12.50	—
April		12.50	12.50	—
May	—	—	—	—
June	12.50	12.50	37.50	
July	12.50	12.50	—	
August	—	—	—	
September	—	—	—	
October	—	12.50		
November	12.50	12.50	12.50	
December	—	—	12.50	

E. narcissus : During 1987, the larval population of *E. narcissus* was restricted to transects 1 - 10. Transects 11 - 18 across the road were completely free from *E. narcissus* larvae throughout 1987 and up to May 1988 (Fig. 5). During October - November 1987, the population buildup was very high in the transects 1 - 10. During December 1988, another buildup was noticed which was distributed almost throughout the area, covering both transects 1 - 10 and 11 - 18. In the case of *E. narcissus,* the population buildup was quite erratic and the larvae were not continuously present in the study area. Closer examination showed that the eggs of *E. narcissus* were seen on a few plants within the plantation at a time when no larvae or pupae were present during the preceding months.

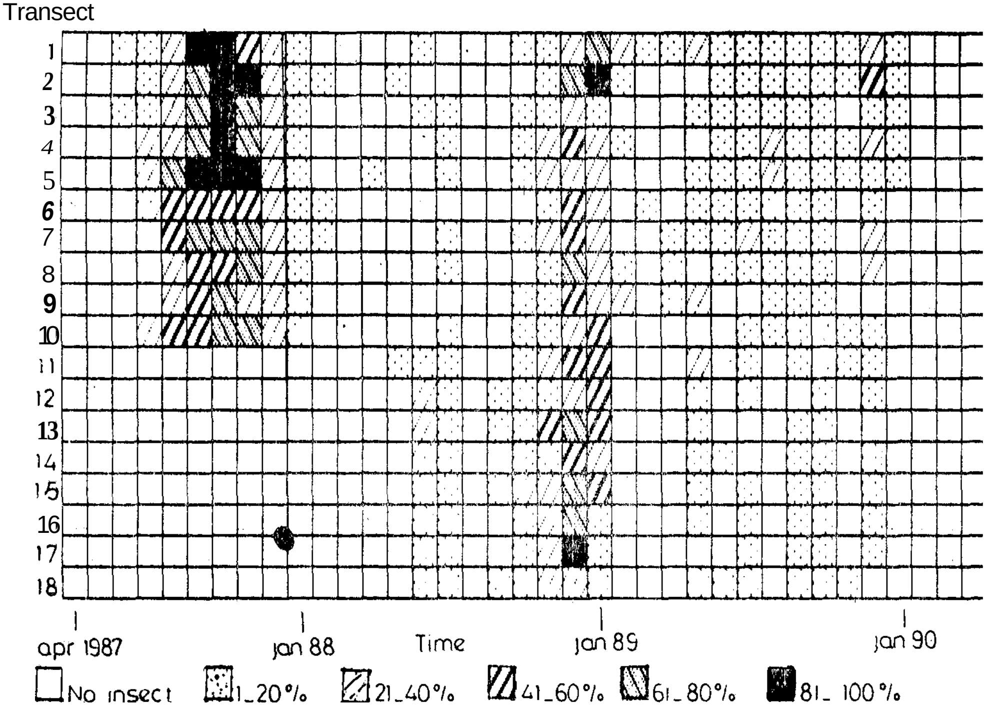


Fig. 5 Distribution of *E. narcissus* in 18 transects at Thattekkad

Whenever *E. narcissus* larval population occured, it also followed a clustered pattern (Fig. 6). The negative binomial distribution also fitted very well with data on larval population on a few selected months, during which *E. narcissus* population was very high. Thus, for *E. narcissus* also, the spatial pattern of distribution followed a clustered pattern.

Temporal pattern of distribution of pests at Thattekad plantation

A. fabriciella: Mapping of the incidence of *A. fabriciella* in the study area gives a general picture of the nature and intensity of distribution during the

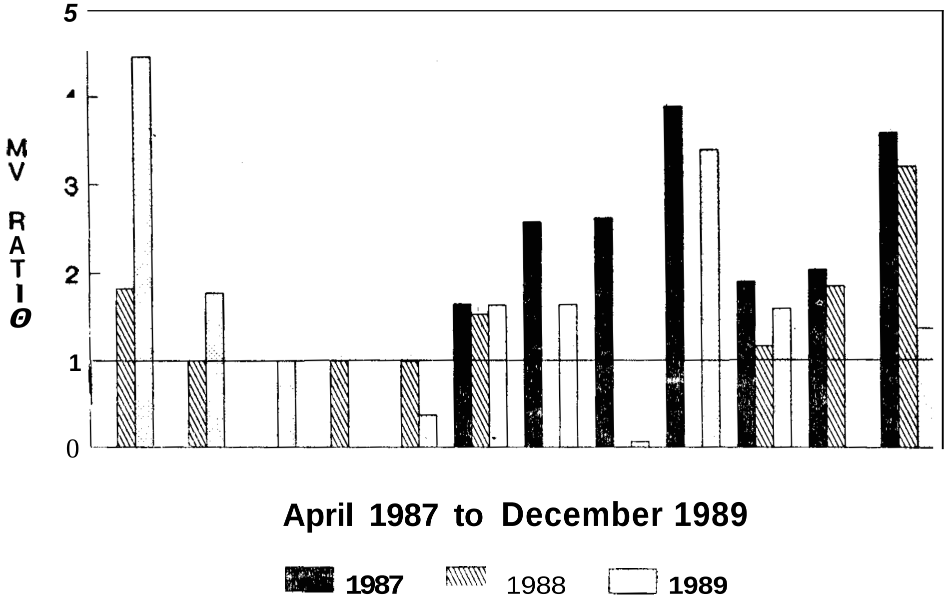


Fig. 6 MV ratio - *E. narcissus* incidence at Thattekkad

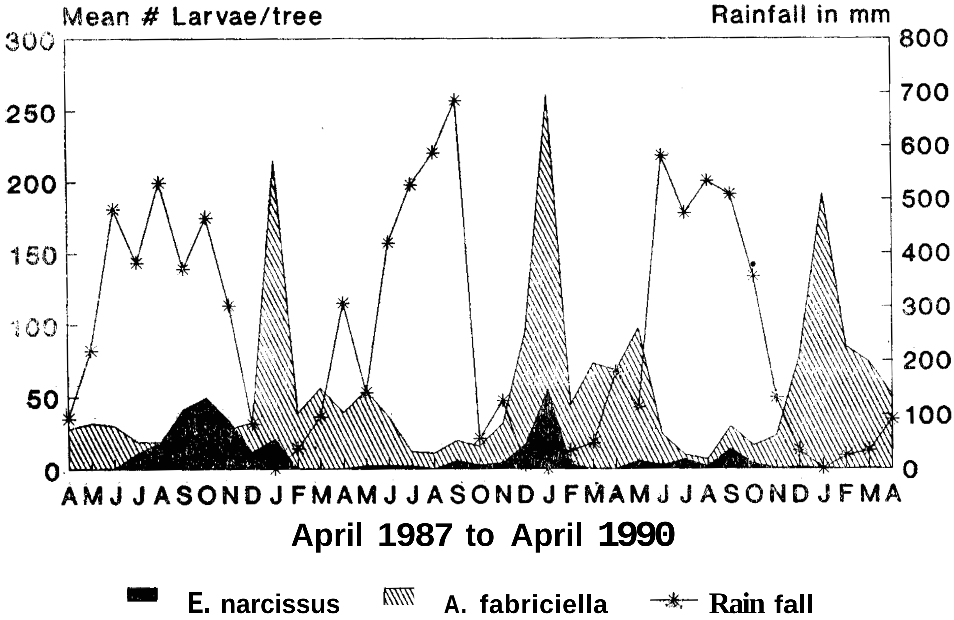


Fig. 7 Intensity of infestation of *A. fabriciella* and *E. narcissus* in the study area at Thattekkad along with average monthly rainfall

3-year period (Fig. 3). The larval population of *A. fabriciella* was present almost throughout the year, However, during 1988 - '89 and during 1989-'90. the larval population reached a peak level from December to January, which was not observed during the same period in 1987-'88. The pattern of infestation in all transects, covering the entire plantation was similar over time. A decline in larval population was observed in all the three years from June - October, during which period there was heavy rain (FIg. 7).

The data collected from all the transects show that the population of *A. fabriciella* followed a clustered pattern over time. The decline in the population of *A. fabriciella* during definite periods in an year (June - October) is indicative of the possible correlation between rainfall and pest incidence (Fig. 7).

E. narcissus : In the case of *E. narcissus,* the larval population did not show any definite pattern of occurrence over time and was quite erratic.

In transects 1-10, during 1987, the *E. narcissus* larval population reached a high level during September-November and then gradually declined by February 1988. Again a small peak in population was noticed during January 1989 and then it came down and was present only in very small numbers or even absent during the rest of the study period.

In transects 11-18, *E. narcissus* larval population was totally absent throughout 1987 and only in November 1988, a small buildup of pest population was seen. The same population declined during February 1989 and thereafter *E. narcissus* larvae were present only in very small numbers or absent in the study area. In the case of *E. narcissus* also, whenever there was a build-up, it followed a clustered pattern temporally. While studying the nature of pest incidence in a pure and mixed stand of *A. triphysa* at Chathamattom (Chapter III), a peak in the population of *A. fabriciella* was noticed during December-February. In general the population of *A. fabriciella* came down drastically during July-September, when the rainfall was very high. Unlike *A. fabriciella* an increase in the population of *E. narcissus* was observed only in December 1988 and there were also periods during which *E. narcissus* larvae were totally absent. Though the two plantations at Thattekkad and Chathamattom are situated at a distance of about 30 Km by road, the pattern of occurrence of the two pests over the time, showed similarity.

A number of studies on population ecology are concerned with explaining changes in abundance of a population over time and space (Taylor and Taylor, 1977; Taylor, 1986). In temperate forests, fluctuation of lepidopteran pests has been studied in greater details (Mason, 1987; Berryman 1986, 1988; Myers, 1988, Watt *et al.,* 1990). but we lack detailed information on the pest population dynamics under tropical conditions, especially on forest insects. The present study shows that the distribution pattern of both the pests is clustered. both temporally and spatially. With data on abundance of adult moth catches using pheramone traps, Fitt *et al.,* (1989) showed that two species of *Helicoverpa* (Noctuidae) followed a clustered distribution both in time and space. *A. fabriciella* was present in small numbers and reached a a high density during December-January in both 1988.'89 and 1989-'90. But this trend was not shown during 1987-'88. In this context, it may be pointed out that the insect-plant interaction play a major role in the population dynamics of many forest pests. During 1987-'88 *Ailanthus* leaves were older and mostly infected with the fungi. sooty mould which would have adversely affected the survival of the pests by changing the quality of the leaves. Also the number of rainy days in a month was more during 1987, compared to rest of the period. Though no definite reason could be attributed to the clustered pattern of the distribution of *A. fabriciella,* it is possible that plants with tender foliage may occur in groups and adult female moths would prefer such plants as oviposition sites, for better survival of the emerging larvae. Thus a clustering of infected plants can occur. In the case of *E. narcissus,* though the larval population buildup was erratic, when the density of populatlon increased, it followed a clustered pattern. At the onset of the buildup of *E. narcissus,* the eggs were seen all on a sudden on a few plants. This indicates that the adult moths of *E. narcissus* come from outside the study area and lay eggs on the tender foliage and a fresh buildup starts. In otherwords a resident population of *E. narcissus* was not observed in the study area, as seen in the case of *A. fabriciella.*

Phenology of *A. triphysa* in the Thattekkad plantation

The data on phenology collected over a period of 12 months showed that at no time, the plants were completely devoid of leaves, However, the flushing pattern varied widely amongst the plants In general, the flushing period ranged from late November to March, but was not uniform in all plants. Many plants had a combination of both old and new leaves during different months in an year. During 1987 (September to December) and in 1988 (January), the flushing scores were either 1 or 2 (all mature leaves or low level flushing) and most leaves in the study area were infected with the fungi, sooty mould. This fungal attack on *Ailanthus* leaves is reported to occur in some localities during June - December (Sharma *et al,* 1985) Such a situation was not observed during the rest of the study period.

The individual difference in flushing pattern noticed in the plantation may be due to the fact that the genetic source of the seed material could be different. With regard to the insect buildup in the study area, it may be seen that although the tree samples were from the same population grown under identical conditions, the insect population that they support varied. This could be due to the difference in the host quality, especially the availability of tender leaves. However. enough foliage was available for both the pests to feed on and hence food source cannot be considered as a limiting factor for the survival of the pests, *E. narcissus* fed even on older leaves, but *A. fabriciella* preferred tender leaves. Though the two insects share the same host plant, there was no interspecific competition and also it may be noted that both the pests are well adapted to reach high denstties periodically, without destroying their food plant

Mortality factors

Parasites

The pupae of *A. fabriciella* were found parasitized by the chalcid, *Brachymeria hime attevae* (Fig. *8).* During the study period in the months of January, February and May in 1988, over 20% of parasitism due to the above parasite was observed. This was a period during which pest incidence was not very high. During other period; parasitism was only 5-10%. It may be mentioned that a real estimate of pupal parasitism was not possible, because *A. fabriciella* larvae pupated even on other plants and bushes and in the present study the pupal count for parasitic incidence was confined to the plants in the transects

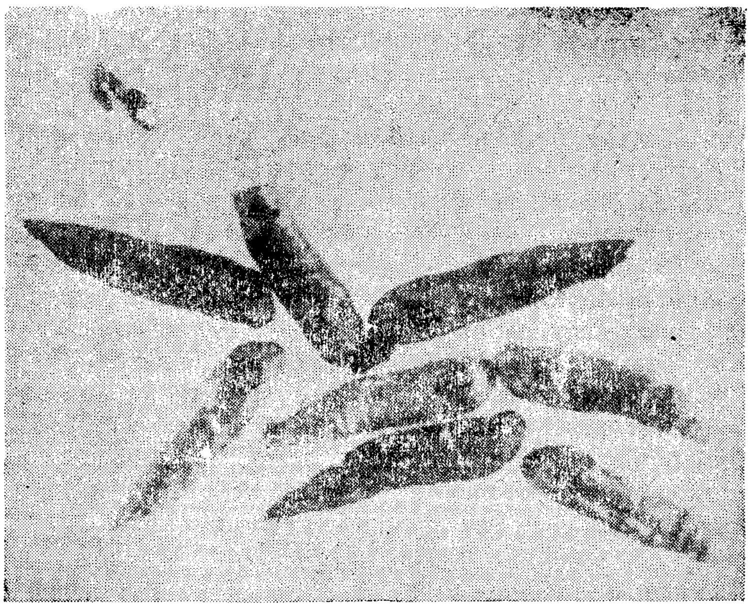


Fig. 8 Parasitized pupae of *A. fabriciella*

In the case of *E. narcissus* the pupae were found killed during 1987 in good numbers by the fungal pathogen, *Paecilomyces farinosus.*

Larval parasites of either *A. fabriciella* or *E. narcissus* were not observed in the study area.

Predators

a) spiders : Though a number of spiders were frequently seen, none of them were found to prey upon either of the pest larvae in the field. Most of thern are usually seen resting an *Ailanthus* foliage. The most commonly noticed spiders belonged to 7 species of *Sclticidae.* one species of *Lyssomenidae.* one species of Thomisidae *(Strigoplus netravati* Tik) and one species of Oxyopidae *(Oxyopes shweta* Tik). Some of the spiders were tested in the laboratory and were not found *to* prey upon either *E. narcissus* or *A. fabriciella* larvae.

b) Insects : The reduviid bug, *Panthous bimaculatus* was found to feed on *E. narcissus* larvae during 1987. The eggs of *E. narcissus* were also found eaten up by ants (unidentified), occasionally. Also on a few occasions, the robber flies (unidentified) were found *to* prey upon *A. fabriciella* larvae.

c) Birds : Among the predators, the birds seem to devour the maximum number of pest larvae during peak periods of infestation. Although over 15 species of birds were observed gleaning on the *Ailanthus* foliage during different periods in an year, only five species were found to predate on either *E. narcissus* or. *A. fabriciella* or both. (Table 2).

Table 2 Bird predators of the pests of *Ailanthus* at Thattekkad

SI. No	Common name	Scientific name
1.	Black drongo	*Dierrus adsimillis*
2.	Black headed Oriole	*Oriolus xanthonus*
3.	Green Bee eater	*Mesopsis orientalis*
4.	Golden Oriole	*Oriolus oriolus*
5.	Paradise tlycatcher	*Terpiphone paradisi*

Most birds were found predating, when *E. narcissus* larvae move on to the stem of *Ailanthus* for pupating. Bee - eaters on many occasions were found *to* collect *A. fabriciella* larvae, while the latter decend to the ground on Silken thregds. The birds usually rested on the close by older teak or rubber plantation. collected the insect from the *Ailanthus* plants and went back to the resting place. The birds took a heavy toll of larvae, especially when the pest density was high. In addition to the birds listed above, the following birds viz. Racket tailed Drongo, Cuckoos, Brown flycatcher and Jungle crow were also found to predate on larvae of *E. narcissus* or *A. fabriciella* in an experimental plot of *A. triphysa* at KFRI subcentre at Nilambur (K. Mohanadas, personal communication). Earlier, Chatterjee *et al.,* (1969) have reported *Oriolus xanthonus* as a bird predator of *E. narcissus* larvae.

Effect of rainfall on pest buildup

Rain seems to be an important environmental factor which affects the pest population buildup. Figure 7 shows the monthly incidence of pest build-up aginst the corresponding monthly rainfall. The analysis of the data (Table 3) shows that *A. fabriciella* incidence is negatively correlated with rain. The coefficient of linear Correlation between monthly incidence of *A. fabriciella* and monthly rainfall with and without lag also showed negative correlation. However, in the case of *E. narcissus* there was no significant correlation between rainfall and pest incidence.

Table 3 Analysis of correlation between pest incidence and rainfall

insect	Linear correlation coefficient		
	r_0	r_1	r_2
A. fabriciella	-0,5761**	-0.5425**	-0.3453'
E. narcissus	0.0727	0.1849	0.2354

** Significant at P = 0.001
* Significant at P = 0.01

r_0 - Between pest incidence and rainfall both of the same month
r_1 - Between pest incidence and rainfall one month previously
r_2 - Between pest incidence and rainfall two months previously

A number of parasites, predators and entomogsnous microorganisms bring about control of pest populations in nature. The data on the natural enemies of the pests of *Ailanthus* indicata that the predators or parasites, when occur naturally in a locality find use only in that particular locality. The host insects are generally distributed in a patchy manner and the predators may have to search out for them. Based on qualitative information it may be said that at Thattekkad, the bird predator incidence is density-dependent, but the observed density-independance of the pupal parasite of *A. fabriciella* needs confirmation.

The spider fauna is varied and probably rely on a complex assemblage of different types of prey, other than the pest insects. This does not mean that the spider fauna in the ecosystem fail to feed on pests of *Ailanthus.* Probably more detailed investigations would be required to understand the role of spiders as effective predators against pests of *Ailanthus.*

The environmental factors, especially rain affects the pest population buildup of *A. fabriciella* Thus a combination of various factors such as natural enemies, food quality and weather have contributed in checking the population buildup. In the case of *E narcissus,* adult movement from nearby infested areas to the experimental plot is a possibility At the initiation of the *E. narcissus* buildup only eggs were seen first and no pupae/larvae or adults, were seen during the previous months in the study plots. On the other hand a small population *of A. fabriciella* was always present in the study area.

Pest incidence on roadside *Ailanthus* plants

In general. the roadside *Ailanthus* plants supported only a low level of pest population. The data on the occurrence of the larvae of the two pests collected on a monthly basis for two years are given below.

A. fabriciella : The incidence of *A. fabriciella* on the roadside *Ailanthus* plants did not show any definite pattern during the two years (Fig. 9) *A. fabriciella* was noticed on more number of occasions in *Ailanthus* planted in groups than in isolation. In 1988, except in the months April and June, *A. fabriciella* was present in at least some of the plants located within the 10 Km distance. Except in very few cases, the incidence of *A. fabriciella* was riot repeatedly shown in the same plants over the months. In 1989, the data gave a different picture except that in the case of *Ailanthus* grown in groups, there was some similarity on pest occurrence just as seen during 1988. In 1989. *A. fabriciella* was totally absent in the 10 Km distance only during the month of September.

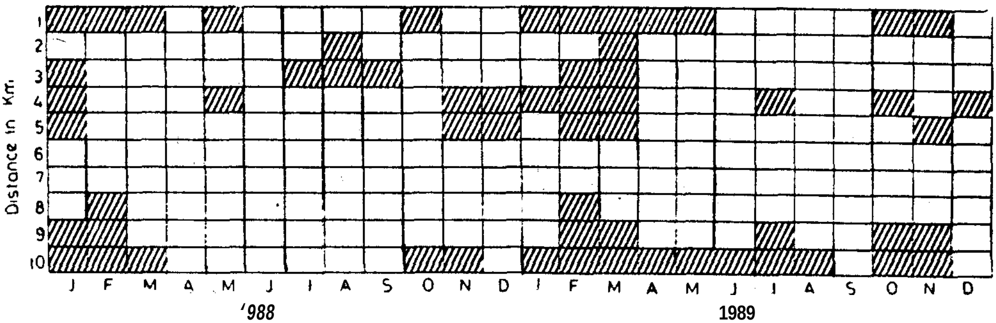


Fig. 9 Incidence of *A. fabriciella* on roadside *Ailanthus* plants

E. narcissus : The incidence of *E. narcissus* on roadside plants was totally absent in both the years from January to June (Fig. 10). During the rest of the months i. e.. from July to December, *E. narcissus* occurred on some plants without showing any definite pattern over the two years. However, *E. narcissus* larvae occurred for a few months continuously in *Ailanthus* planted in groups.

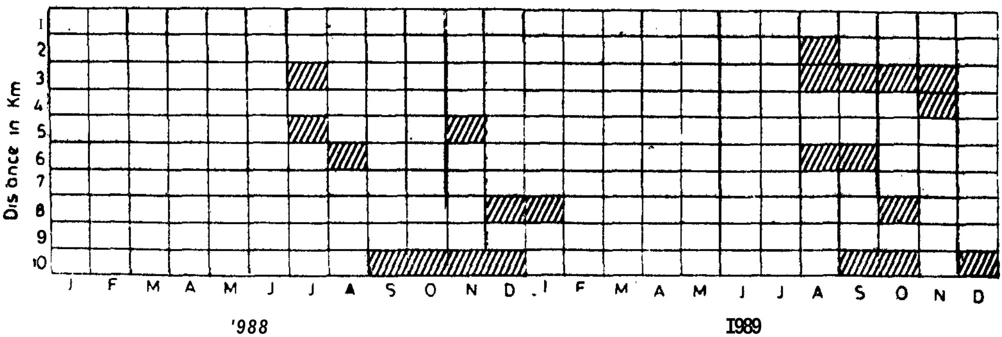


Fig 10 Incidence of *E. narcissus* on roadside *Ailanthus* plants

With regard to the roadside *Ailanthus* plants, though the data are qualitative in nature, did not show any definite pattern both in time and space. Incidence of *A. fabriciella* was noticed on more number of plants on more occasions than *E. narcissus.* The occurrence of *A. fabriciella* was more pronounced in *Ailanthus* planted in groups than in isolated plants. One major reason for this could be the monophagous nature of *E. narcissus* and also the non-availability of the only known alternative host, *Q. indica* for *A. fabriciella.* Both the pests do not feed on other leaves and hence the pest population may survive for sometime in *Ailanthus* planted in groups because of the availability of food source in more quantities. This does not mean that *A. fabriciella* will spare isolated *Ailanthus* plants. *E. narcissus* larvae were practically absent on roadside plants during the months, January to June on both the years and during this time the leaves were full of dust, dry and *E. narcissus* larvae may not prefer to feed on such leaves. The roadside environment is different from a plantation and many other factors may also affect the quality of the host leaves. Though *Ailanthus* plants were available at every kilometer distance, there was no consistancy on the occurrence of the pests and the spreading from one place to another within the 10 Km distance was mainly restricted probably due to non-availability of sufficient quantity of prefered food for the pests to survive for longer periods.

Pest incidence in other localities in Kerala

During 1987, a survey of pest incidence in the *Ailanthus* plantations. covering southern, central and northern circles (Table 4) showed that both the pests, either alone or in combination were present at varying intensities in most plantations. Incidence of *A. fabriciella* was noticed in older plantations also, causing damage to inflorescence and tender fruits.

Table 4 Pest incidence in *Ailanthus* plantations in different localities during 1987

Month	Location	Presence of *A. fabriciella*	Presence of *E. narcissus*
June	Mullaringad	—	—
	Thattekkad	+	+
August	Kottappara	—	+
September	Nagarampara	+	+
	Kannoth	—	
October	Erumeli	+	+
	Ayyappancoil	+	+
	Kannoth	—	
	Kottappara	—	+
November	Vellikulangara	+	+
December	Arippa	—	+
	Onthupacha	+	+

A COMPARISON OF PEST INFESTATION IN PURE vs MIXED PLANTATION

Introduction

It is generally believed that extensive monocultures of any crop, including tree crops may lead to serious pest problems. But to substantiate this we need data from a situation wherein we can compare the pest status of tree species grown in a heterogenous environment with that occuring as a pure plantation. Such situations are rare and hence we lack data on these aspects. An earlier study (Nair *et al.*,1986) on pest incidence in natural forests indicated that long-term experimental studies are required to examine the usefulness of mixed plantations in reducing pest incidence. They also concluded that at present there is no evidence to show that mixed plantations will be less pest prone than monocultures.

During the present study many plantations in different localities (Perurnannoor, Charupara, Namboodiri coupe, Chattamattom, Allungal and Ottakandam) in the Central Circle were visited to select a suitable mixed plantation of *A. triphysa* with *Bombax,* teak, maghogany or *Acacia.* In none of the above plantations a true mixture was available and they were mostly dominated by a single species. In many localities in Kerala, *A. triphysa* has been under-planted with older teak. Thus the scope of the study was limited to comparing pest incidence in a pure stand of *A. triphysa* with that grown under older teak.

Materials and Methods

Study area

The study was undertaken at Chattamattom, in Mullaringad Range of the Kothamangalarn Forest Division. About 30 ha have been planted up here with *A triphysa.* either as pure stand or under teak, eucalypts etc. during 1983-'84. In this area, a pure stand of *A. triphysa* and another stand planted under teak were selected. The two plots were situated at a distance of about 1.5 Km. From within each of these two stands, 1 ha area towards the interior (covering 2500 plants) was marked for observations.

Methodology

During each month, observation on incidence of both *A. fabriciella* and *E. narcissus* was recorded from a group of 250 plants at random in each location. The seasonal index (SI) of occurrence of the two pests in the two localities during 1988 - '89 (2 years) was calculated using the following formula –

$$SI = \frac{\text{Monthwise mean of insect incidence}}{\text{Overall mean}} \times 100$$

In addition to the above aspect, data on parasites and predators of the two pests in the locality, information on other insects which feed on *A. triphysa* and alternate hosts, if any, of the two pests were gathered. Data on the above aspects from this locality were collected mainly because of the fact that the plantation was close to the natural forest and also the flora and insect fauna within and around the *Ailanthus* plantation were rich.

Results

Pest incidence in the two localities

A. fabriciella was present with the same intensity in both the localities (Fig. 11). During 1988, 1989 and 1990, the incidence of *A. fabriciella* was more during December - February. The number of trees infested with *A. fabriciella* in both localities also did not show much variation.

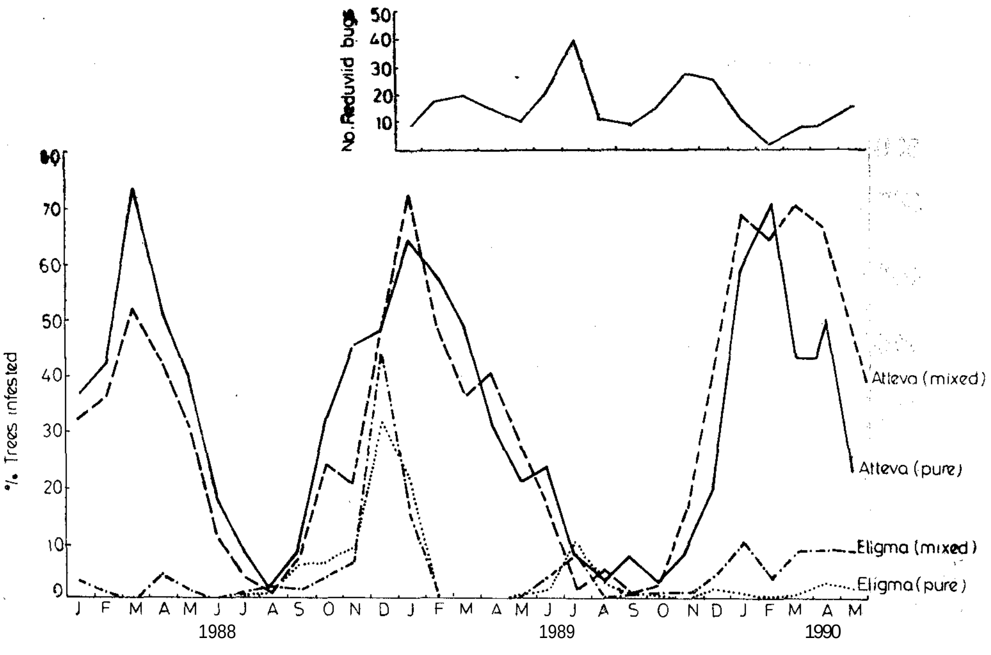


Fig. 11 Occurrence of *A. fabriciella* and *E. narcissus* at Chathamattom Inset shows incidence of the predatory bug, *P. bimaculatus* in the area from January 1989 *to* May 1990

E. narcissus was present in low numbers, compared to *A. fabriciella* in both locations (Fig. 11) The trend in infestation level was the same in both localities. Unlike *A fabriciella* a peak in *E narcissus* infestation was observed only during December 1988, which was uniform in both localities. On many months during the observation period, larvae of *E. narcissus* were practically absent in both localities.

The seasonal index on the occurrence of the two pests in the two localities, calculated for a period of 2 years showed no significant difference (Figs. 12 and 13)

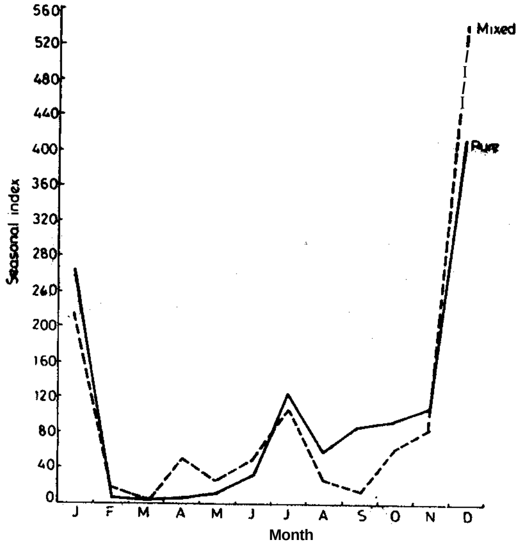


Fig. 12 Seasonal index of *E. narcissus* for the period 1988 - 89 at Chathamattom

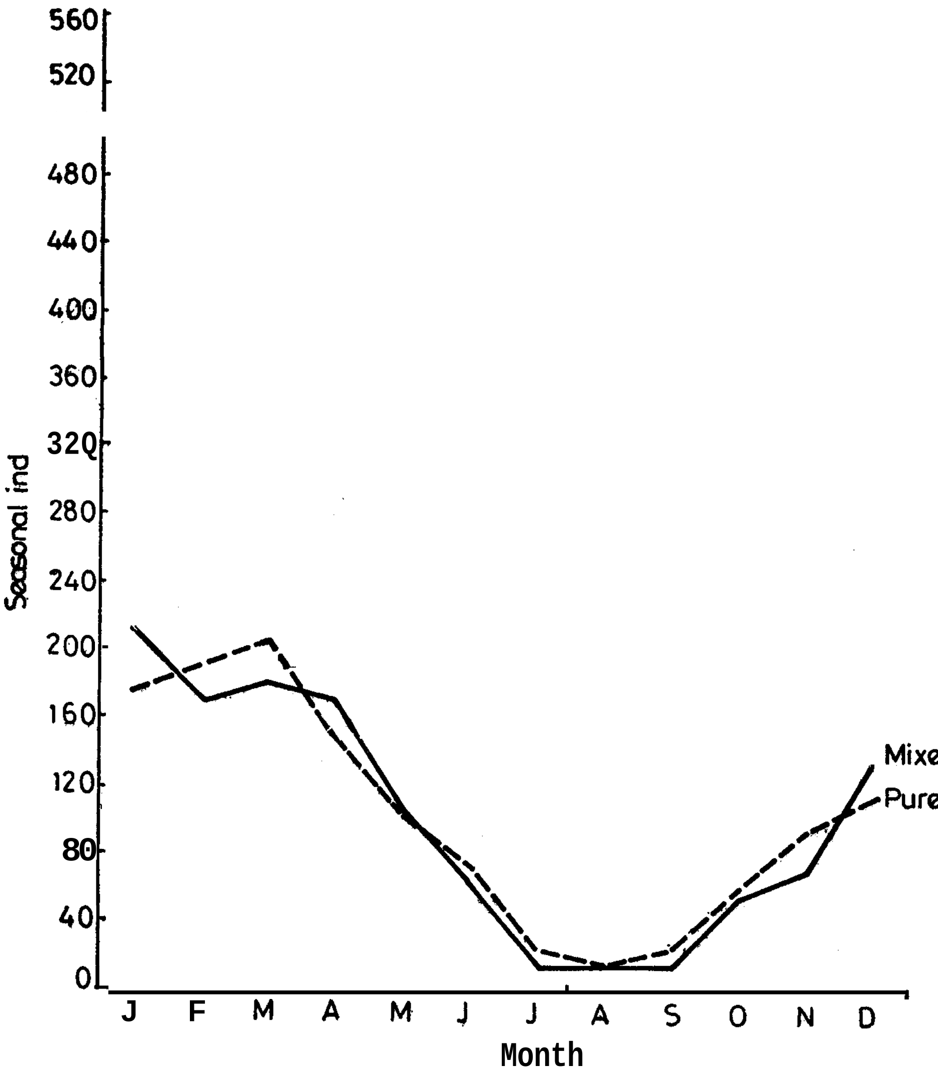


Fig. 13 Seasonal index of *A. fabriciella* for the period 1988-89 at Chathamattom

In general, the new flushes appeared mostly during late November and extended upto March. An increase in pest population, especially that of *A. fabriciella* was observed during the above period.

Parasites and predators

The following parasites and predators were found in different months during the study period in both localities.

	Species	Host
Parasite	*Brachymaria hime attevae*	*A. fabriciella* (Pupa)
Predator	*Eocanthecona furcellata* (Wolff)	*A. fabriciella* (larva)
	Panthous bimaculatus	*A. fabriciella.* *E. narcissus* (Larva)
Pathogen	*Paecilomyces farinosus*	*E. narcissus* (Pupa)

Among the parasites and predators, the reduviid bug, *Panthous bimeculatus* (sub-family Harpectorinae of the family Reduviidae) appeared promising as a control agent and hence detailed observations were made on its predatory potential both under laboratory and field conditions. Incidently this bug is reported as an insect predator for the first time.

Laboratory observations : The adult bug measures 20-25 mm. The colour of head, pronotum, rostrum, coxae and legs is brownish red, whereas the antennae, tip of the rostrum and under surface *of* the body are black (Fig. 14).

Field collected *P. bimaculatus* were successfully reared in the laboratory on larvae of either *E. narcissus* or *A. fabriciella* (Figs. 15a. b). When a 3 day-starved adult *P. bimaculatus* was offerred other lepidopteran larvae such as *Hyblaea puera* (Hyblaeidae), a pest of teak and *Hypsipyla robusta* (Phycitidae), a pest of mahogany, both were not acceptable Under laboratory conditions an adult bug normally feeds on 1 *E. narcissus* larva per day and rarely 2 per day whereas it consumed 2-3 larvae of *A. fabriciella* per day. An *E. narcissus* larva weighing 460 mg was drained out in about 45 minutes. Once fed, the bugs did not bother to predate on another larva immediately. The adult bugs survived without any food for over 10 days in the laboratory.

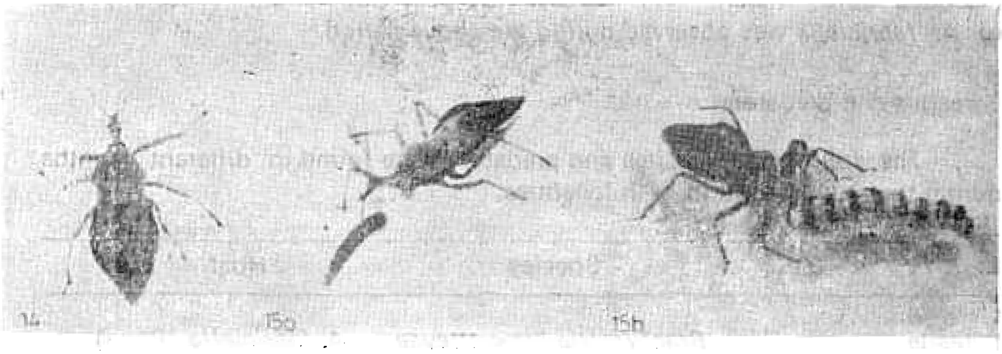


Fig. 14 An adult female bug of *P. bimaculatus*
Fig. 15a- Bug feeding on *A. fabriciella* in the laboratory
Fig. 15b Bug feeding on *E. narcissus* in the laboratory

In the laboratory, the female bug lays about 165 eggs in small batches (Fig. 16). which are glued to the substratum with a white gelatinous secretion. The eggs are cylindrical in shape with a transparent operculum (Fig. 17a. b). All the eggs hatched out by breaking open the operculum. The newly emerged nymphs had a tendency to crowd around and initially feed on the waxy secretion upon which the eggs were laid.

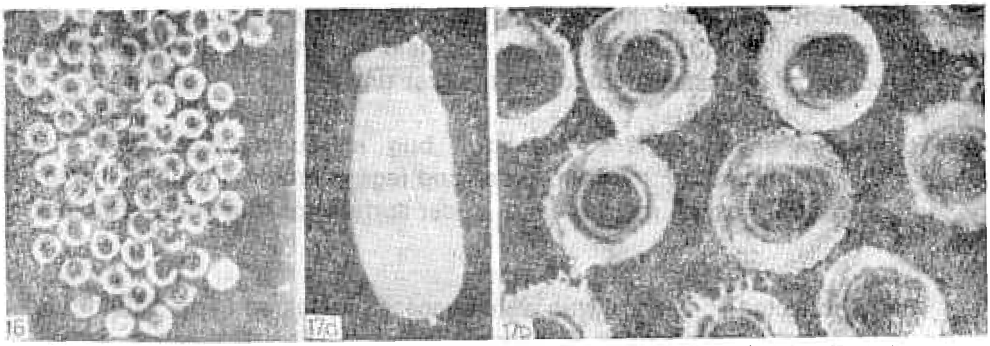


Fig. 16 Batches of eggs deposited by a female bug in the laboratory
Fig. 17a A single egg
Fig. 17b Egg showing the opercutum -

Field observations : The bug normally rests on *Ailanthus* plants or in other shrubs within the plantation. Various life stages of the bug including eggs were found in the field during different periods of the year (Fig. b). On disturbance the bug flew away swiftly with a buzzing noise, but while

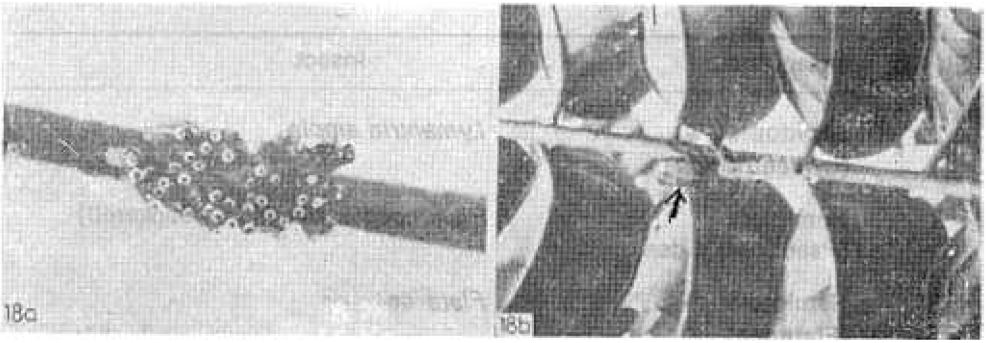


Fig. 18a Eggs of *P. bimaculatus* deposited on a branch of *A. triphysa* at Chathamattom

Fig. 18b A nymph of *P. bimaculatus* preying on *E. narcissus* larva at Chathamattom

preying they did not move away. As soon as the prey is located, the bugs attack them with the unfolded rostrum which is bent otherwise. In the field, the bugs were not usually seen feeding on any other insects. A monthly survey in the study area during 1989-90 showed that adult bugs were present more or less throughout the year (Fig. 11). A peak in the adult population of the bug was noticed during June-July, during which period the pest incidence was very low. But the population level of the bugs was monitored only based on the adult bugs sighted on the observed trees and hence it may not give a true picture. However, even when pest incidence was high, the bugs were present in both localities and caused mortality of both the pests.

Alternative hosts

The two pests, *E narcissus* and *A. fabriciella* were not found feeding on any other alternative hosts in the study area. However, *E. narcissus* larvae were found pupated on the bark of many other trees like teak, *Callicarpa tomentosa* etc. and also on the stem of the weed *Eupatorium.* Larvae of *A. fabriciella* were also found to pupate on the underground bushes. 'The only alternative host recorded is *Quassia indica* for *A. fabriciella* (Mohanadas and Varma 1984).

Insects associated with *A. triphysa*

In addition to the two major pests, *A. fabriciella* and *E. narcissus,* the following insects were found feeding on *Ailanthus* in the study area. However, none of these insects were observed to cause any serious damage to the crop. All the 12 insects listed (Table 5) are new records on *A. triphysa.*

Table 5 Insects associated with *A. triphysa*

Sl. No.	Insect order	Insect
1	Lepidoptera (Lymantridae)	*Lymantria ampla*
2	Hemiptera (Pseudococcidae)	*Planococcus lilacinus* (Cockerell)
3	Hemiptera (Flattidae)	*Flata* sp.
4	Hemiptera (Scuttelleriodae)	*Chrysocoris purperseus* Weston
5	Hemiptera (Cercopidae)	*Ptyelus neublus* (Fabricus)
6	Hemiptera (Pentatomidae)	*Nezara* sp.
7	Heteroptera (Fulgoridae)	*Kalidasa lanata* (Drury)
8	Coleoptera (Curculionidae)	*Lepropus femoralis* (fb)
9	Coleoptera (Curculionidae)	*Apoderus* sp.
10	Coleoptera (Curculionidae)	Spotted weevil (Unidentified)
11	Coleoptera (Chrysomelidae)	*Cryptocephalus sexsignatus*
12	Coleoptera (Chrysomelidae)	*Lema yetsuryi* Jac.

Discussion

The present study shows that there is no difference on the intensity of pest attack of both the pests in pure plantation as well as in *Ailanthus* planted under older teak. It is generally held that changing the habitat may bring down pest population (Way, 1977). Though *Ailanthus* planted under teak got more shade than planted in open, the former situation did not help in reducing the pest attack. Visual observations also indicated not much difference with regard to the growth of the plants in both localities especially with respect to height growth, which needs further confirmation.

The ecological basis for pest build up is quite cornplex and is often due to the combination of various ecological factors and monoculture could be one among that. 'Though in the present study the plot of *Ailanthus* planted under teak may not represent a true mixed plantation, the data show that such a mixing will not reduce pest incidence.

A fabriciella was present almost throughout the year, except during the peak monsoon period. On the contrary, *E. narcissus* population was erratic and whatever pattern observed was similar in both localities.

Being specific, effective and available in good numbers in the locality' the predatory bug, *P. bimaculatus* can be considered as an effective biocontrol agent. Except for the taxonomic account given by Distant (1904). nothing is known about this reduviid bug. In general, it was observed that the natural enemy cornplex varied in different localities. A predator or a parasite which occurs naturally in a particular locality may provide effective control only in that specific locality and may not simulate the same result in a different locality if introduced.

The number of insects reported to feed on *Ailanthus* spp. in India was only 23 (Bhasin and Roonwal, 1954; Misra, 1978; Varma, 1986). Though most of these insects cannot be considered as pests. the present finding of 12 new insects feeding on *A. triphysa* indicate that *Ailanthus* supports a rich fauna of phytophagous insects. The list may further increase, if intensive search is extened to other areas. Also some of these minor pests attaining pest status at a later stage cannot be ruled out.

IMPACT OF *ATTEVA FABRICIELLA* ON GROWTH OF *AILANTHUS TRIPHYSA*

Introduction

It is often noticed that wherever *A. triphysa* has been grown in a plantation scale in Kerala, the growth is poor compared to the trees grown in isolated patches. especially in homesteads. The loss in growth has often been attributed to the conspicuous damage caused by two major insect pests, *E. narcissus* and *A. fabriciella.* Of the two pests, it has already been shown that *A. fabriciella* can cause economic damage by destroying the terminal shoots and repeated attacks can result in branching (Varma, 1986).

Since 1980, the State Forest Department has raised a number of *A. triphysa* plantations in different areas and this is also a popular tree under Social Forestry Programme. However, it is stated that most of these plantations do not fare well as commercially viable plantations.

During 1987, a continuous patch of about 20 ha *A. triphysa* plantation (planted in 1982 and 1983) was brought to our notice by the State Forest Department in Erumeli (Kottayam Forest Division), where there was a serious attack by *A. fabriciella.* Almost all plants were totally defoliated and many plants showed damage to terminal shoots. (Fig. 19). In subsequent months, the trees were also covered almost fully with weeds, especially by the climber, *Mikania micrantha* (Fig. 20). It was understood from the local forest officials that after the second year of planting, no cultural operations were carried out in the plantation and the same was subjected *to* insect attack and heavy weed cover. The area was also exposed to grazing and human activities. An experiment was laid out at Erumeli to find out whether damage due to *A. fabriciella* can result in retardation of growth in *A. triphysa.*

Materials and Methods

The study area was at Karikatoor in Erumeli Range of the Kottayam Forest Division. The total extent of the 1982 *A. triphysa* plantation was about 10 ha on the right hand side of the Kanakapalam - Vachoochura road. The age of the trees at the beginning of the study was 6 years.

Growth impact studies

Based on previous studies (Varma, 1986). it is known that unlike *E. narcissus. A. fabriciella* occurs almost throughout the year. Hence the approach was to protect a group of trees throughout the experimental period (2 years) agianst *A. fabriciella,* by monthly spraying of an insecticide and compare the growth performance with a similar group of unprotected trees. The following treatments were laid out -

T_1 - No treatment

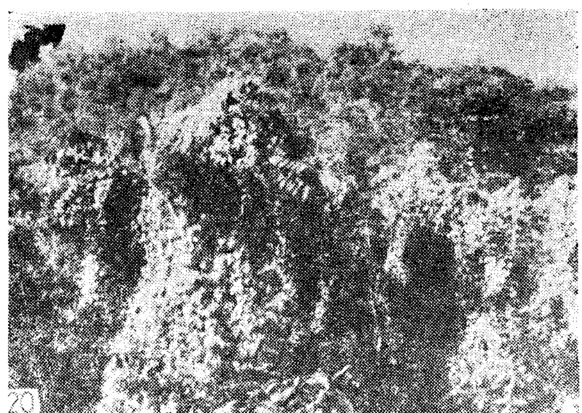
T_2 - Monthly application of insecticides to protect the trees against *A. fabriciella*

T_3 - Insecticidal application once in three months

T_4 - Insecticidal application once in six months

All the four treatments were given to 100 trees; 20 trees each replicated in five blocks in a randomised block design. Each row within the blocks were separated by five rows of trees (10 metres). The espacenrent was 2 x 2 m. Ten metre distance was also maintained in between the blocks. The weed growth on either side of the experimental rows was removed from time to time

(Fig. 21). In addition to the four treatments mentioned, a group of 100 trees (20 x 5) were marked in a single block adjacent to other blocks and kept free of weeds throughout the study period (Fig. 22) This was done because the area was full of weeds especially *Mikania* and it was of interest to know whether weeding alone would enhance the growth of *Ailanthus.*



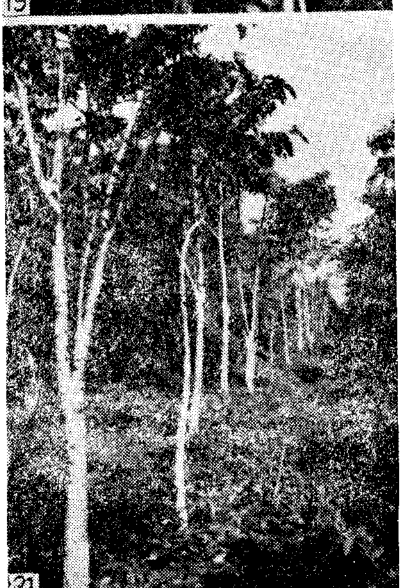


Fig. 19 A patch of *A. triphysa* trees at Erurneli plantation damaged by *A. fabriciella*
Fig. 20 *A. triphysa* trees completely covered with the weed, *Mikania micrantha* at Erumel
Fig. 21 Experimental row of *A. triphysa* at Erumeli showing line weeding
Fig 22 A view of the weeded plot of *A. triphysa* at

All the major weeds found in the experimental area were collected. identified and are listed in appendix 1.

Solution of Methyl parathion (Metacid 50 EC) at 0.1% a. i. was sprayed on to the leaves, using a Rocker sprayer. Care was taken to drench the terminal portion of the trees thoroughly.

Measurements : Initial height and girth at breast height (GBH) of all 500 trees were measured in February 1988, before applying the insecticide and thereafter at six - monthly intervals for two years.

The GBH measurements were converted to basal area. The differences among the treatments with respect to increments in height and basal area at the end of two years were tested for significance through analysis of covariance. The initial height and basal area measured during February 1988 were used as covariates in the respective analyses.

Field observations

Pest incidence : Observations on the incidence of *A. fabriciella* on all the treated and untreated group of trees, including trees in the weeded plot were taken every month. General information related to the occurrence of parasites or predators feeding on *A. fabriciella* in the experimental area was also collected.

Damage to inflorescence and tender fruits : Data on the nature and extent of damage caused by *A. fabriciella* to the inflorescence and tender fruits of *Ailanthus* were gathered. The above observations were limited to selected trees in Kothamangalam and Kottayam Forest Divisions and also on trees located in private compounds.

Results

Growth impact studies

The initial as well as final measurements of height and basal area are given in Table 6. Pair-wise comparison between adjusted treatment means showed that T_2 i. e. regular insecticidal application against *A. fabriciella* differed significantly from T_1 (unprotected), T_3 and T_4 (partially protected). There was no significant difference in growth increment among the treatments T_1 T_3 and T_4 (Table 7).

The percentage increase in height and basal area under different treatments with respect to initial measurements showed that protecting the plants against damage by *A. fabriciella* can result in increased growth (Table 8).

Table 6 Initial and final measurements of height and basal area under treatments 1 - 4

Block	T1 (unprotected)				T2 (Monthly protection)				T3 (Partial protection)				T4 (Partial protection)			
	+ INHT	++ FIHT	0 INBA	00 FIBA	INHT	FIHT	INBA	FIBA	INHT	FIHT	INBA	FIBA	INHT	FIHT	INBA	FIBA
1	2.74	3.74	16.73	32.05	2.85	4.09	18.31	33.02	2.89	3.97	20.24	36.59	2.29	3.25	12.16	18.68
2	2.52	3.20	12.95	21.91	2.46	3.46	12.71	30.54	2.56	3.27	11.22	21.68	2.49	3.23	11.76	20.09
3	2.51	3.02	13.61	19.62	2.98	4.12	20.98	40.33	2.67	3.36	16.27	23.18	2.51	3.35	14.49	25.88
4	2.76	3.41	18.79	24.74	2.67	3.66	16.64	29.69	3.40	4.39	21.54	33.26	3.33	4.35	23.82	39.00

\+ INHT — Initial height FIHT — Final height

0 INBA — Initial basal area 00 FIBA — Final basal area

Table 7 Analysis of co-variance table - height and basal area

		Height		Basal area	
Sources	df	MSS	F	MSS	F
Covariate	1	2.376	239.863**	460.93	72.652**
Block	4	0.088	8.913**	36.484	5.751**
Treatment	3	0.099	9.997**	32.836	5.176**
Residual	11	0.010	—	6.344	—

** Significant at $P < 0.01$

Table 8 Percentage increase in Height and Basal area with respect to initial measurements

Treatment	% increase in Height	% increase in Basal area
Control (T_1)	26.31	51.92
Monthly protection (T_2)	38 18	86.79
Partial protection (T_3)	29.17	59 13
Partial protection (T_4)	30.14	59 87

Since the weeded plot was taken as a single block, the data was analysed separately and compared individually with other treatments. Fair-wise comaprison between adjusted mean value of the weeded plot and other treatments (T_1, T_2, T_3 and T_4) showed that T_2 (monthly insecticidal application) differed significantly from the weeded plot with respect to height and basal area.

Though not strictly comparable, the measurements on height and GBH, taken from a group of trees (8 yr-old) maintained in a house compound, showed the average height of trees to be 11.5 m and the GBH to be 69.5 cm. These trees were also subjected to periodic damage by *A. fabriciella* and during flowering season, larvae of *A. fabriciella* damaged the inflorescence and tender fruits as well. Tree mortality was never observed due to attack by *A. fabriciella* in the experimental area. Rut rare cases of top drying and subsequent infection by pathogens could be noted.

Pest incidence

During January 1988, almost 90% of trees in the experimental area were found attacked by *A. fabriciella* (Fig. 23). After insecticidal application, the insect incidence came down and continued to remain at very low level in the monthly protected group of trees. In treatments, either sprayed once in 3 months or once in 6 months, the pest incidence was low during initial months following insecticidal application, but later it was on the increase. Even among the group of monthly sprayed trees, a maximum of 10-15 trees showed presence of *A. fabriciella* larvae. (Fig. 23). Here, most newly formed flushes were found attacked, which would have escaped insecticidal spray during previous month. However, there was a general decline in the population of *A. fabriciella* during the monsoon season even in the untreated group of trees, otherwise *A. fabriciella* was noted in almost all the trees in the unprotected and weeded plots.

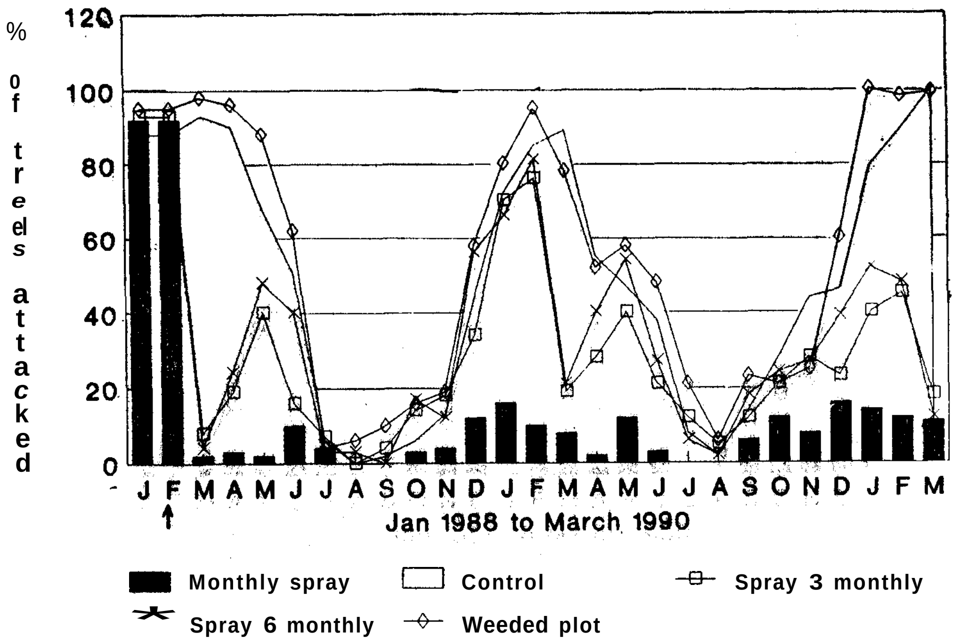


Fig. 23 Pest build up in *A. triphysa* before and after insecticide application in treated and control plots at Erumeli; arrow indicates time of first application of insecticide

Only the chalcid parasite, *Brachymeria hime attevae* was observed occasionally attacking pupae of *A. fabriciella.* In general, incidence of parasites/ predators on *A. fabriciella* was very low in the experimental area at Erumeli.

Damage to inflorescence and tender fruits

Insect attack on seeds of *A. triphysa* has been brought to notice by local forest officials. The damage intensity of seeds due to insect feeding was assessed when a group of twelve trees were cut from a private land, close to the *A. triphysa* plzntation at Thattekkad in Kothamangalam Forest Division. The seeds collected from six trees showed that about 60% of them were damaged partly or fully due to insect boring. Many trees had inflorescence and tender fruits which were webbed by larvae of *A. fabriciella* (Fig. 24). The tender leaves were also found infested by the larvae. Closer observations showed that rhe attack by larvae sets in during the formative stage of the fruit and invariably, tender fruits were devoured (Figs. 25a. b), thus preventing seed setting. Information gathered from other localities like Kannolh. Kottiyoor, Peruvannamuzhy etc. (E. P. Indira, Genetics Division, personal communication) also confirmed the above observation. A few isolated trees near Erumeli (Kottayam Forest Division) also showed regular attack on inflorescence and tender fruits during 1988-'89. Most of the above field observations were made during February-March, 1988. Further phenological observations during 1989 showed that the fruit setting period starts from January and then goes up to April. Incidently, in most localities, the occurrence of *A. fabriciella* was high during this period.

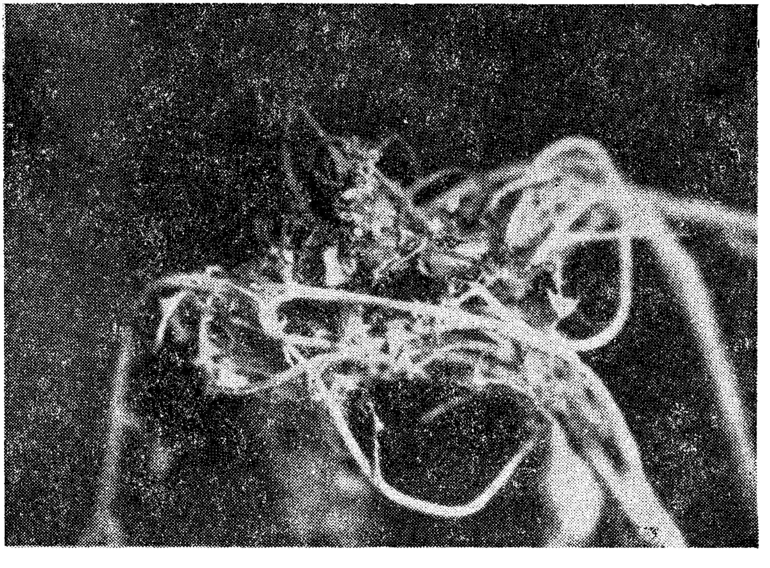


Fig. 24 *A. fabricella* larvae feeding on inflorescence of *A. triphysa*

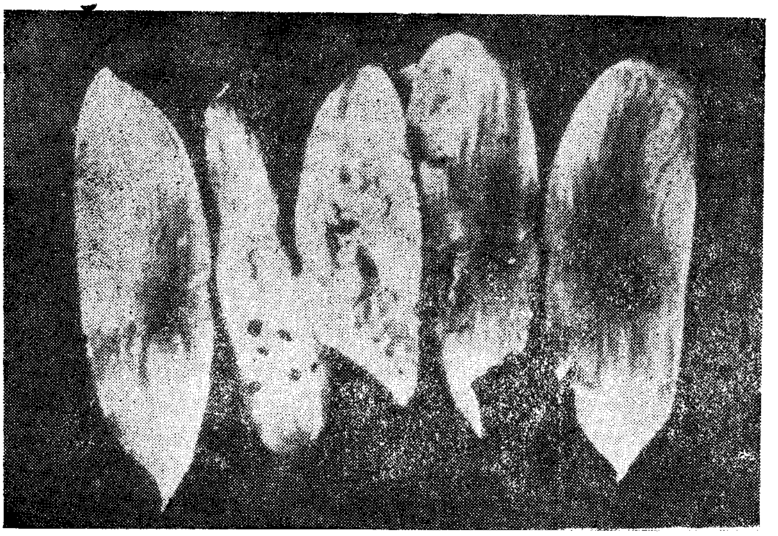


Fig. 25a Tender fruits of *A. triphysa* damaged by *A. fabriciella*

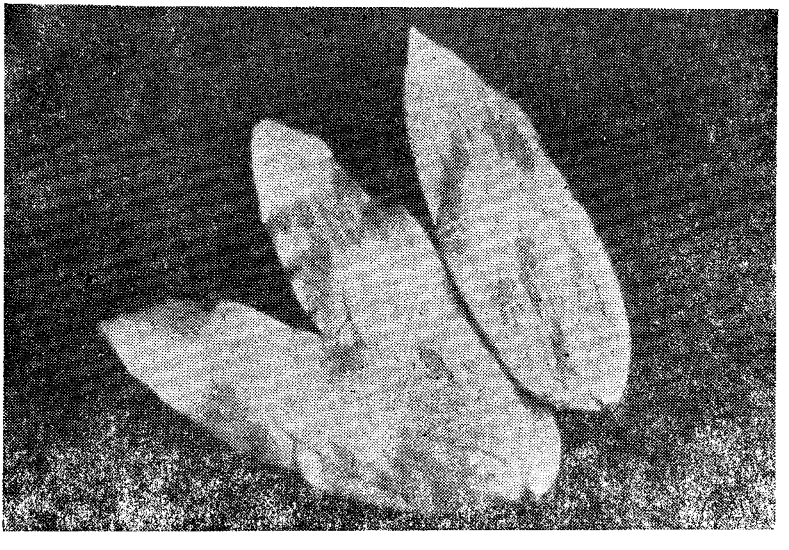


Fig 25b. Unattacked tender fruits of *A. triphysa*

Discussion

A. fabriciella is the most important factor responsible for the stunted growth of *A. triphysa* at Erumeii plantations. However, the above coriciusion cannot be generalised, because growth performance was comparatively better in many other localities. in spite of the damage caused by *A. fabriciella.* In a similar aged group of trees at Thattekkad. the average height was 11.5 *m* and GBH 69.5 cm. whereas at Erumeli under treatment 2, where regular insecticide application was given, the average height and GBH were 4 m and 20 cm respectively. Also in the experimental area at Thattekkad, a younger plantation (5 yr-old) showed better growth and many trees were about 8-10m in height and 25-30 cm in GBH. Earlier investigations on soil at the Erumeli plantation indicated that soil factors are not responsible for stunted growth. (Thomas P Thomas, Soil Science Division, personal communication). But unlike in other localities, weed growth was a major problem at Erumeli and the incidence of parasites / predators was low compared to data collected from Thattekkad and Chathamattom. Thus the locality factors may influence the growth of the crop. At Erumeli, *Mikania* infestation literally closes the canopy of *A. triphysa* trees in the plantation. Regular occurrence of this weed, over a period of time also would have contributed towards the stunted growth. It may also be mentioned that in all the four treatments weeding was an additional common treatment. A completely unweeded group of trees would have been an ideal control, but taking measurements or observing trees without removing the weed cover was not practical.

Though damage by *A. fabriciella* result in top drying and branching mortality of the trees seldom occurs. However, growth of the trees is adversely affected. The fact that *Ailanthus* grows well in homesteads and in other places singly or in small groups emphasises the need for more experimental data on the silvicultural aspects of this crop.

Since the crop is in demand in match and packing case industries, the possibility of planting them in strips near the existing plantations of teak or other species or under planting them with older teak in small blocks may be explored. Chemical control methods against pests of *Ailanthus* are feasible in high value nurseries, seed stands etc., but regular application of insecticides in plantations is not practicable due to obvious reasons. Based on the present experiment, the total cost of insecticidal spray (labour and chemicals) would be about Rs. 300/- per ha under strict supervision. In general, insect incidence is very low during monsoon and thus spraying would be required at least during 8 months in a year which amounts to Rs. 2,400 / ha. This may not be economically feasible lor a crop like *Ailanthus.*

Earlier studies both in the laboratory and in the field (Varma 1986) showed that *A. grandis* is not a preferred host for both *A. fabriciella* and *E. narcissus.* Thus it would be worth raising plantations of *A. grandis,* at least on an experimental basis.

CONCLUSIONS AND RECOMMENDATIONS

The two major pests of *A. triphysa* - *A. fabriciella* and *E, narcissus,* follow a clustered pattern of spatial distribution, especially during the time when pest population buildup is high. *A. fabriciella* occurs almost throughout the year with a marked decrease in the population during the monsoon. The population buildup of *A. fabriciella* is negatively correlated with rainfall. Occurrence of *E. narcissus* is erratic and is not correlated with rainfall.

There was no difference in the intensity of attack by either of the two pests between pure plantations and plantations raised under teak.

Field experiments at Erumeli demonstrated that stunting in *A. triphysa* is caused mainly due to the insect pest, *A. fabriciella.*

Based on the growth performance over the last 10 years, if *A. triphysa* is not considered as a suitable species to be raised in plantations, further expansion of this crop in pure plantations may be critically reviewed. Also raising *Ailanthus grandis.* which is resistant to the two major pests during preliminary investigations, may be taken up at least on an experimental basis.

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APPENDIX I

List of weeds collected and identified from Karikattoor, 1982 *Ailanthus triphysa* plantation.

1 *Mikanaia micrantha* — Climber
2 *Chromolaena odorata* — Shrub
3 *Lantana camara* var. *aculeata* — Shrub
4 *Calycopteris floribunda* — Climber
5 *Clidemia hirta* — Shrub
6 *Centrosema pubescens* — Climber
7 *Pothos scandens* — Climber
8 *Assystatia gangetica* — Herb
9 *Merremia tridentata* — Climber
10 *Triumfetta rhomboidea* — Herb
11 *Stachytarpheta* sp. — Herb
12 *Merremia umbellata* — Climber
13 *Ageratum houstonianum* — Herb
14 *Pterms quadrianrita* — fern

In addition, the following small trees were found growing naturally within the plantation.

1 *Manihot glaziovii*
2 *Cassia fistula*
3 *Macaranga peltata*
4 *Aporusa lindleyana*
5 *Cycas circinalis*
6 *Evodia lunu-ankenda*