MORPHOMETRY AND BIOLOGY OF LARVAL INSTARS OF *ALCTEROGYSTIA CADAMBAE*, HEARTWOOD BORER OF TEAK IN INDIA

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VEERANNA R & REMADEVI OK. 2011. Morphometry and biology of larval instars of *Alcterogystia cadambae*, heartwood borer of teak in India. Teak (*Tectona grandis*) is one of the most favoured timbers in the world and is used for many products and services. In north Canara Circle of Karnataka, India the heartwood borer, *Alcterogystia cadambae*, is found to cause substantial damage to teak trees. From morphometric estimations of larvae collected in the field, and by applying Dyar's law, it was ascertained that there were seven stages of instars. The laboratory rearing using artificial diet also revealed that larvae moulted six times to have seven instars in its larval life. The duration of the first to seventh instar was 32.2, 13.0, 38.0, 31.0, 30.5, 33.0 and 43.0 days respectively. The total larval duration was 207 days.

Keywords: Head capsule, Dyar's law, artificial diet, larval duration, infestation, Cossidae

VEERANNA R & REMADEVI OK. 2011. Morfometri dan biologi instar larva *Alcterogystia cadambae* (Lepidoptera: Cossidae), pengorek teras kayu pokok jati di India. Pokok jati (*Tectona grandis*) merupakan satu daripada kayu yang paling diminati di dunia dan diguna untuk pelbagai produk serta kegunaan. Di utara Bulatan Canara, Karnataka, India *Alcterogystia cadambae* iaitu sejenis pengorek teras kayu telah mengakibatkan kerosakan teruk pokok jati. Daripada anggaran morfometri larva yang dikutip di lapangan, dan menggunakan hukum Dyar, didapati bahawa terdapat tujuh peringkat instar. Pemeliharaan larva di makmal menggunakan makanan tiruan juga menunjukkan bahawa larva bersalin kulit enam kali, iaitu terdapat tujuh instar dalam kitar hidup larva. Tempoh instar pertama hingga ketujuh masing-masing ialah 32.2 hari, 13.0 hari, 38.0 hari, 31.0 hari, 30.5 hari, 33.0 hari dan 43.0 hari. Tempoh keseluruhan peringkat larva ialah 207 hari.

INTRODUCTION

Teak (*Tectona grandis*) is one of the most favoured timbers in the world and is known for its strength, durability and attractive appearance. The ever-increasing need for teak timber resulted in the establishment of large-scale plantations throughout the world (Tewari 1992). A great deal of research has been conducted on teak tree and its pests. The stem borers, *Alcterogystia cadambae*, *Dihammus cervinus*, *Indarbela quandrinotata*, *Sahyadrassus malabaricus*, *Xyleutes ceramica* and *Zeuzera coffeae*, feed on the woody tissue of the tree (Sudheendra-Kumar 1994). *Alcterogystia cadambae* (Lepidoptera: Cossidae) is one of the more important pests and has assumed major pest status in several plantations in Kerala, Tamilnadu and Karnataka states (Mathew 1990). The caterpillar of this insect characteristically tunnels into the wood of standing trees causing the deterioration of timber. It was reported that in north Canara Circle of Karnataka the incidence of this pest was as high as 15–20% (Lingappa et al. 1991).

The extent of damage and impact of biodeterioration on the timber quality of teak caused by *A. cadambae* (Remadevi & Veeranna 2005) and the distribution pattern and predisposing factors leading to the infestation of the pest have been studied (Veeranna & Remadevi 2007a, b). However, since the larvae live inside the heartwood for many months, the number of larval instars, morphological features and also duration of each instar are not known. This study was conducted to determine the number of larval instars, duration of instars and their morphology.

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MATERIALS AND METHODS

Eggs

Field studies were conducted in Gunjavathi plantation in Yellapur division of north Canara Circle of Karnataka. Eggs obtained from adults collected from the field were used for this study. The moths which settled on bark of trunks at dusk were collected in plastic container and immediately released in cages and the eggs laid were collected. Adults were also collected using a Robinson light trap installed in infested plantations. In the laboratory, each pair of moths was reared in a cage (0.5 × 0.5 × 0.75 m) made of wire mesh all round except for the base which was wood and front side, a glass door. Honey solution (10%) soaked in cotton balls was served as food for the adults. The inner side of the cage was lined with muslin cloth, which made collection of eggs easy. Eggs were also collected from cracks, crevices, debarked areas, lopped branches and girdles on trees. Eggs laid by moths in light traps set up in plantations were also collected for rearing of the pest in laboratory.

The different characteristics of the egg such as morphological peculiarities, incubation period and hatching time were noted. The morphological characteristics of the egg were studied under microscope and measurements were taken using ocular and stage micrometers. The eggs were placed in Petri dishes lined with moist blotting paper for hatching. The newly emerged larvae were allowed to feed on chips of fresh teak bark for initial establishment.

Larval instars

Larvae, hatched from eggs and reared in the laboratory using artificial diet (Mathew et al. 1990) till pupation and moulting, were observed to estimate the total number of instars. The morphology and biology of all instars were studied. The bark of infested trees was also peeled and chipped to observe the earlier instars of larvae. The larvae could be located easily in the folds and also below the bark due to their pinkish colour. Two or three heavily infested teak trees in the plantations were randomly selected and cut in different months. The logs were split and chipped at different planes to collect the different larval stages inside them. Larvae were also collected from randomly selected live trees by chipping out the wood at places where symptoms of infestation were visible. The Dyar's law was applied to ascertain the actual number of larval instars. According to this rule, head capsule of caterpillars grow in geometrical proportion, increasing in width at each moult by a ratio of about 1.4, which is a constant for a given species. In our study, this rule was used to ascertain the stages of the field-collected larva by measuring the width of head capsules of different larval stages. Larvae with similar head capsule widths were then grouped together.

Morphological characteristics, duration, moulting and feeding behaviour of the larvae were observed in the laboratory. Dimensions of the different instars were measured using measuring scale while that of the head capsules, using ocular and stage micrometer.

RESULTS AND DISCUSSION

Different instars were available throughout the year but the number of larvae was highest in August and September (Figure 1). Developmental periods and the measurements of life stages of *A. cadambae* reared on artificial diet are given in Table 1.

In the laboratory, gravid females laid eggs on the wall of the cages. Before laying of eggs, the female secreted a gelatinous substance which pasted 35–40 eggs together. After two to three days, the substance dried and made it difficult for the eggs to be detached. A female moth laid an average of about 300 eggs in captive condition. In the field, the eggs were laid in small cracks and crevices or depression on the bark of trees. Human activities such as lopping or breaking of branches or debarking of trees for marking purposes, damaged the bark and this provided sites for egg laying.

Eggs were pale brownish in colour measuring 1.9 × 1.4 mm in size and were more or less spherical in shape with one end pointed and other end oval. The chorion had a reticulate sculptured pattern resembling the bark of teak and this made the eggs difficult to detect.

Under laboratory conditions, during the initial three days, eggs were soft and pale brownish in colour. The colour became darker gradually and by the tenth day, it was black. The dark mandibles of larva were seen from the outside of the egg as dark spots. The appearance of dark spots on the eggs indicated that they will hatch the next day.

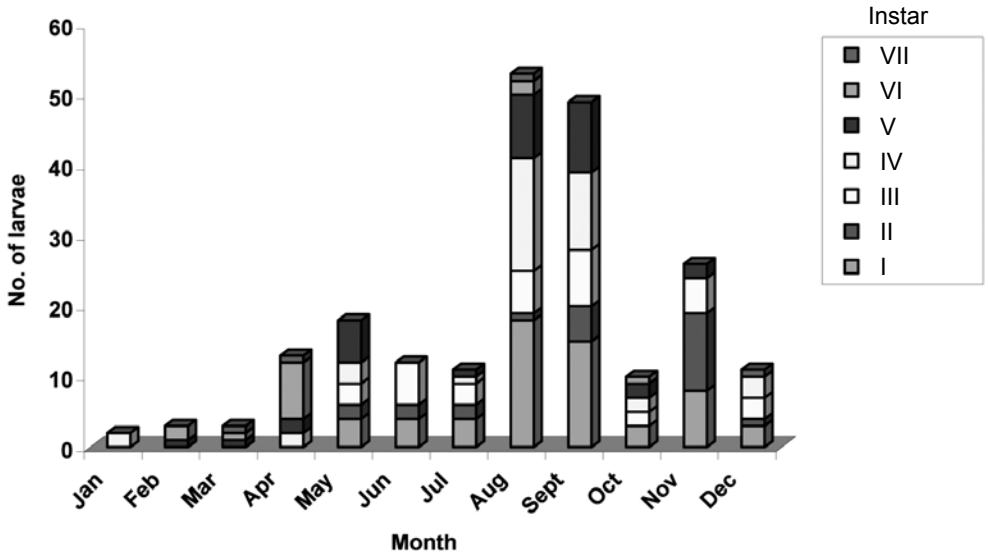

Figure 1 Distribution of larvae in instar I to VII in different months of the year

The larva bit the chorion to facilitate eclosion. In about 2 to 3 min, the head came out through the cut end of chorion and the larva started feeding on the chorion along the cut ends. When the hole was big enough for protrusion, the larva emerged out of the shell and consumed most part of the eggshell. The process of hatching took 30 min to 4 hours. The newly hatched larva measured 3 mm in length and 1 mm in width and was pale pinkish in colour. The present study found the incubation period of *A. cadambae* to be 17 ± 1.5 days (Table 1). Similar observations were made by Mathew (1990) in Kerala, a state adjacent to Karnataka. The incubation period of *Parapta paradoxa* was 17–19 days (Mesbah et al. 1993) and *Zeuzera multistrigata*, 10–12 days (Thangavelu & Isa 1992).

There were seven larval instars and morphometry of head capsule of different instars is given in Table 1. Width of head capsules of larvae ranged from 0.61–4.60 mm. The larva became inactive before moulting and ceased feeding. The head capsule was separated in 30–40 min. The newly formed head was bright yellow in colour and devoid of dark pigments. The process of moulting was completed within 8–10 hours. The colour of head capsule turned to dark pinkish. The larvae were pinkish in colour throughout the different instars. The later stage larvae showed aggressive behaviour and were voracious feeders. When two larvae were kept together in the same container, they started biting each other with their strong mandibles.

The first instar larvae were very active and started feeding on sapwood diet provided. The larvae grew very fast initially, attaining a length of 9 mm within 10 days. The larvae turned darker pink as instars progressed. The newly hatched larvae lodged in the axils of side shoots, in the crevices or injuries on the bark or in sites of earlier infestations. In the field they were located just below the bark of the tree. By third instar, the larvae had moved into the heartwood of the tree and were feeding voraciously. The fourth instar larvae showed aggressive behaviour in laboratory conditions. The duration of the instars varied from first to seventh instar, i.e. 32.2 ± 1.7, 13 ± 1.4 , 38 ± 1.5 , 31 ± 1.5, 30.5 ± 1.15 , 33 ± 1 and 43 ± 1 days respectively.

The lengths and widths of first to seventh instar were 15.5 ± 0.5 and 1.5 ± 0. 5, 18.3 ± 0.5 and 2.5 ± 0.5, 23.4 ± 1.1 and 3.5 ± 0.5, 30.3 ± 3.3 and 4.6 ± 0.5, 31.6 ± 2.0 and 4.8 ± 0.8, 41 ± 2.4 and 6.6 ± 0.8, and 46.8 ± 2.8 and 7.0 ± 0.08 mm respectively.

The lengths and widths of head capsules for the seven instars were 0.67 ± 0.05 and 0.61± 0.02, 1.54 ± 0.17 and 1.32 ± 0.12, 1.95 ± 0.13 and 1.84 ± 0.39, 2.82 ± 0.36 and 2.46 ± 0.17, 3.31 ± 0.27 and 2.96 ± 0.26, 3.64 ± 0.36 and 3.42 ± 0.40, and 5.08 ± 0.19 and 4.68 ± 0.04 mm respectively.

On artificial diet, the total larval period lasted 207 ± 11.2 (range 214–221) days. Field-collected larvae of different stages (instar ascertained by their head capsule width) were also reared on artificial diet in the laboratory. They were

Table 1 Developmental duration and morphometry of egg and larval instars of *Alcterogystia cadambae*

Stage of insect	Duration (days)		Egg/body length with (mm)		Egg/body length width (mm)		Head capsule length (mm)		Head capsule width (mm)	
	Range (n = 10)	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Egg	14–19	17 ± 1.5	1.90–2.00	1.90 ± 0.05	1.3–1.5	1.42 ± 0.80				
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I	30–34	32.2 ± 1.70	15.0–16.0	15.5 ± 0.5	1.0–2.0	1.5 ± 0.5	0.64–0.76	0.67 ± 0.05	0.61–0.64	0.61 ± 0.02
II	11–14	13.0 ± 1.40	18.0–19.0	18.3 ± 0.5	2.0–3.0	2.5 ± 0.5	1.47–1.65	1.54 ± 0.17	1.18–1.47	1.32 ± 0.12
III	36–40	38.0 ± 1.50	24.0–26.0	23.4 ± 1.1	3.0–4.0	3.5 ± 0.5	2.06–2.47	1.95 ± 0.13	1.94–2.12	1.84 ± 0.39
IV	30–32	31.0 ± 1.50	28.0–34.0	30.3 ± 3.3	4.0–4.8	4.6 ± 0.5	2.30–3.12	2.82 ± 0.36	2.18–2.65	2.46 ± 0.17
V	30–31	30.5 ± 1.15	32.0–36.0	31.6 ± 2.0	4.0–5.0	4.8 ± 0.8	2.95–3.59	3.31 ± 0.27	2.95–3.40	2.96 ± 0.26
VI	32–34	33.0 ± 1.00	38.0–44.0	41.0 ± 2.4	5.0–7.0	6.6 ± 0.8	3.59–4.13	3.64 ± 0.36	3.34–3.89	3.42 ± 0.42
VII	42–44	43.0 ± 1.00	45.0–49.0	46.8 ± 2.8	6.0–7.2	7.0 ± 0.8	4.89–5.25	5.08 ± 0.19	4.60–4.72	4.68 ± 0.04

usually bigger in size compared with those reared on artificial diet. The duration of stages in field-collected larvae also varied from those reared on diet from the hatching stage onwards. The total duration for the seven instars for the field-collected larvae was 218.8 ± 15.8 (192–234) days.

In the laboratory the later instar larvae showed aggressive behaviour. When larvae were kept together, they attacked each other. Early instar larvae were killed by later instar larvae. Similar observations were reported by Saliba (1977) for *Xiphidium redtenbacheri* and *Zeuzera coffeae*, whereby the former fed on grubs of the cerambycid borer *Cerambyx dux* in Malteso Isles. In this study, the larval growth and rate of feeding were slow in the later instars. A later stage larva is capable of surviving up to three months without feeding. Larval dormancy during unfavourable climatic condition has been reported in *Xyleutus ceramica* (Beeson 1941).

Larval stages of other cossids have also been studied. The larvae of *Paranthrene robiniae* grew to full size within the cambium of hardwood trees after 12–13 weeks of development, but univoltine individuals underwent further one to eight instars and required at least 254 days to pupate (Leppla & Clare 1985). In a much earlier study, it was reported that the number of larval instars of *P. robiniae* varied even within broods, from 8 to 31, and the mean head capsule width varied from 0.96 to 6.65 mm (Solomon 1973). *Phragmataecia castaneae* had one generation per year with eight larval instars and measurement of head widths showed that the growth increment between adjacent instars was approximately 1.3 mm (You et al. 1994).

All cossids studied so far by various workers show that the larval period is very long and that there is mostly one generation per year. In this laboratory study, the total larval period of *A. cadambae* was 207 days while under field conditions, it was 218 days. These findings are similar to results obtained by Mathew (1990) and Bhandari and Upadhyay (1986). The authors reported respectively that the teak carpenterworm in Kerala took 249 days for completion of various life stages, while the trunk borer of *Diospros melanoxylon* in Madhya Pradesh took 300–330 days. *Zeuzera multistrigata*, a pest of muga silkworm host trees, had one generation per year and larval stages lasted for 160–168 days (Thangavelu & Isa 1992). The larval stages of *Phyllocrania paradoxa*, a serious pest in fig orchards in Egypt, lasted for 338–372 days (Mesbah et al. 1993). Thus, it is clear that most of these cossids have several larval instars as well as long larval periods and annual life cycle.

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