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Manoj H

Department of Entomology, College of Agriculture, Navile, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Jayalaxmi Narayan Hegde

Department of Entomology, College of Agriculture, Navile, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Rajashekharappa K

Department of Entomology, College of Agriculture, Navile, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Kencharaddi RN

Department of Entomology, College of Agriculture, Navile, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Ramakrishna Hegde

Department of Entomology, College of Agriculture, Navile, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Sundararaj R

Department of Entomology, College of Agriculture, Navile, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Sunil C

Department of Entomology, College of Agriculture, Navile, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Shashank PR

Department of Entomology, College of Agriculture, Navile, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Darshan

Department of Entomology, College of Agriculture, Navile, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Corresponding Author:**Manoj H**

Department of Entomology, College of Agriculture, Navile, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Biology of teak defoliator *Hyblaea puera* Cramer pest on teak *Tectona grandis* Linn. f. from Karnataka (India)

Manoj H, Jayalaxmi Narayan Hegde, Rajashekharappa K, Kencharaddi RN, Ramakrishna Hegde, Sundararaj R, Sunil C, Shashank PR and Darshan

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Abstract

Teak (*Tectona grandis* Linn. f.) is an important world tropical timber species preferred all over the world and growing naturally in India, Burma and Thailand. It is indigenous to India and the Southeast Asian tropical region. Because of its versatile range of uses and valuable timber. Teak is widely distributed in India and grows in dry and moist deciduous forests. In India, it is found in Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Chhattisgarh, Madhya Pradesh, Rajasthan, Uttar Pradesh, Manipur, and Orissa. India has over 5,00,000 hectares of teak plantations, with 9.77 million hectares of natural teak. In Karnataka, teak forests cover an area of 78,552.1 hectares, with the Uttara Kannada district known for its large teak forest area of 45,232.69 ha. *Hyblaea puera* Cramer, (Lepidoptera: Hyblaeidae) is a major pest of teak. The observations were recorded on the biology of the pest in Shivamogga, Karnataka under laboratory conditions. The pre-mating period of both sexes of moth was one to three days after emergence. Mating occurred during night and lasts for about an hour. It was revealed that the incubation period varies from 1 to 2 days with an average of 1.53 ± 0.71 days. The larvae passed through five instars and total larval period varies from 12 to 19 days with an average of 15.50 ± 4.95 days. Pupal period ranges from 6 to 7 days with an average of 6.54 ± 0.71 days. Total life cycle varied from 24 to 30 days with an average of 27.50 ± 3.54 days. Pest completed 8-10 generation in a year from June to December.

Keywords: *Hyblaea puera* Cramer, lepidoptera, Hyblaeidae and *Tectona grandis* Linn. f.

Introduction

Teak (*Tectona grandis* Linn. f.) is an important old world tropical timber species preferred all over the world and growing naturally in India, Burma and Thailand. It is indigenous to India and the Southeast Asian tropical region. Because of its versatile range of uses and valuable timber, it has been used for a range of products and services in several countries. It is considered the "King of timber species" and is also called "Green gold." It is a deciduous tree that grows straight and has a cylindrical bole, sparse canopy, and deep root system, which together make it more suitable for agroforestry systems. It is considered the heart of the wood industry, with durability, strength, workability, polishing qualities, and versatile utility, which offers a distinctive position in worldwide timber trees.

It represents a genus of tropical hardwood trees in the Verbanaceae family. They are large trees, growing as high as 30-40 m, and are deciduous in the dry season in India. It is commonly known as 'saka, sagum, sagaun, or saguwan'. It is well known for its versatile timber quality.

It constitutes high-class timber, which has resulted in large-scale plantations both within and outside its range of natural distribution. Teak is a species of significant ecological and socio-economic importance throughout the tropics. Many farmers and floating schemes have started raising teak under irrigation.

In addition to being excellent timber, teak has many other uses. Its wood contains a kind of scented oil that renders any box or wardrobe repellent to white ants and other insects. The leaves yield a dye that is used locally to color clothes and edibles. These are used as packing material and for making cheap leaf cups, plates, and umbrellas.

When hollowed, the wood exudes a type of gum that is used in pan masala. Teak flower juice is used for the common cold. It satisfies the appetite and relieves headaches and acidity. It is used extensively in India for building construction materials, furniture, and cabinet making columns and beams in conventional houses due to its better shape and retention ability. It is also popular in marine construction. It is also used for indoor flooring and as a veneer on indoor furnishings. Large quantities of valuable commercial timber are regularly exported from India, and they also have medicinal value (Anonymous, 1999) [1].

Farmers have chosen teak because of its high timber value, ready market, and assured returns. Under intensive management conditions, teak grows faster than it does under natural conditions. The extent of teak growth in 40 years under rain-fed conditions can be achieved in 15 years under drip irrigation (Phadke, 1995) [9]. Teak is the most valuable commercial timber tree species in India.

Teak is one of the important hardwood species in the tropics, growing naturally in nearly 9.0 m.ha of southern tropical deciduous forest of peninsular India situated below 24° N latitude.

According to the latest forest report of the Forest Survey of India (FSI) in 2023, the total forest and tree cover of the country is 8,27,356.95 km² which is 25.17% of the geographical area of the country. The total forest cover has an area of 7,15,342.61 km² (21.76%), whereas the tree cover has an area of 1,12,014.34 km² (3.41%) according to the India State of Forest Report (FSI, 2023) [2]. The current assessment shows an increase of 156.41 km² in the forest cover at the national level compared to the previous assessment. The total forest and tree cover of the country increased by 1445.81 km² compared to the last assessment in 2021.

Teak is widely distributed in India and grows in dry and moist deciduous forests. In India, it is found in Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Chhattisgarh, Madhya Pradesh, Rajasthan, Uttar Pradesh, Manipur, and Orissa. The first teak plantation in India was established in 1846 in Nilambur, Kerala (Tewari, 1992) [14].

India has over 5,00,000 hectares of teak plantations, with 9.77 million hectares of natural teak. In Karnataka, teak forests cover an area of 78,552.1 hectares, with the Uttara Kannada district known for its large teak forest area of 45,232.69 ha (Rathod *et al.*, 2024) [10].

Teak is a premier timber in Karnataka, and Dandeli teak is famous in Karnataka and is mainly used for building purposes. Timber is a basic human need and is currently being utilized for window doors, cupboards, beds, roofs, *etc.* (Javaregowda, 2005) [4].

Teak is one of the most extensively studied timber species for insect pests. Nearly 280 insects have been found to be associated with teak throughout the country. All stages of teak growth, from seed to mature trees, are attacked by insects (Mathur, 1960; Mathur and Singh, 1960; Tewari, 1992) [5, 6, 14]. Many of these insects are minor or occasional pests, and only a few are recognized as major pests.

The teak defoliator, *Hyblaea puera* Cramer is the most widespread and serious pest. Outbreaks occur almost every year in India over extensive areas. During these outbreaks in the early flushing period of teak, trees usually suffer a total

defoliation, sometimes there is partial defoliation later in the growth season. Studies in young teak plantations at Nilambur in Southern India showed that defoliation by *H. puera* caused loss of 44.10 percent of the potential wood volume increment (Nair *et al.*, 1996) [8].

Materials and Methods

Study on biology and life cycle of teak defoliator (*Hyblaea puera* C.) was carried out during kharif season of 2021 under laboratory conditions in Department of Entomology, College of Agriculture, Navile, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka (India). The larva was collected from the teak plantation of Agriculture and Horticulture Research Station, Bavikere, Karnataka India. The collected larvae were brought to the laboratory and kept in the perforated rearing boxes of 35 cm × 30 cm × 25 cm size. During study period, new and soft leaves were fed to the larva and boxes were also kept clean by removing the old and half fed leaves every day. After pupation of larva in silken cocoon, cocoons were shifted to separate rearing box of equal size with steerage to facilitate aeration. Newly and supple leaves of teak were provided as feed in the morning by replacing old leaves once pupation. After pupation of larva in silken cocoon, they were relocated to distinct rearing box of equal size. The pupae thus made were studied under binocular microscope and sexed by examining the position and distance between anal and genital slits. Male and female pupa was kept in distinct rearing box for the emergence of adults.

Thereafter, newly emerged male and female adult for mating and egg laying. The reared was carried out under common temperature of 28 to 35 °C and light of the laboratory was switched off during night time. Egg laid by female as collected quiet with the help of camel hair brush from inside the reared box. Total number of eggs laid per day was counted slowly, for studying the incubation period and the hatching percentage of eggs, freshly laid eggs were observed on inside rearing box the day-to-day in morning and evening till hatching. Average incubation duration and hatching percentage was then calculated found on total number and duration of different larva instar, freshly hatched larvae were in closed distinctively in similar size rearing box with the help of a moist camel hair brush. A set of five larvae was kept and provided with supple leaves as their food. The food was provided to larva and observed day to day in the morning for the modification of instar till they attained last instar. The total larval duration was calculated from the date of egg hatching to the date of pupa formation. Full grown larva was underlay dormant and important to take food before entering pre pupa stage. The pre pupa duration was considered from the date of prevent feeding to the date of formation of cocoon. Pupa period was calculated on the base of date of cocoon formation and the date of adult emerged. Newly emerged male and female moths were paired and straitened in a rearing box containing newly foliage of teak. A moist cotton swab of sucking sponge dipped in 5% honey solution was establish as food to the adults. Pre oviposition duration was calculated from date of emergence of adult female to the date of commencing the egg laying.

Table 1: Biology and life cycle of teak defoliator, *Hyblaea puera* reared on teak leaves under laboratory condition

Sl. No.	Particulars		Period in days		Mean $\pm$ SD
			Minimum	Maximum	
1.	Egg period		1	2	1.53 $\pm$ 0.71
2.	Hatching (%)		66.00	82.62	74.31 $\pm$ 11.75
3.	First instar larva		2	3	2.52 $\pm$ 0.71
4.	Second instar larva		2	4	3.00 $\pm$ 1.41
5.	Third instar larva		2	3	2.58 $\pm$ 0.71
6.	Fourth instar larva		3	4	3.32 $\pm$ 0.71
7.	Fifth instar larva		3	5	4.12 $\pm$ 0.71
8.	Total larval period (days)		12	19	15.50 $\pm$ 4.95
9.	Pre-pupal period (days)		1	2	1.58 $\pm$ 0.71
10.	Pupa	Male	5	6	5.53 $\pm$ 0.71
11.		Female	6	7	6.54 $\pm$ 0.71
12.	Adult				
13.	Longevity	Male	5	9	7.06 $\pm$ 2.83
14.		Female	6	9	7.52 $\pm$ 2.12
15.	Total life span	Male	24	30	27.06 $\pm$ 4.24
16.			25	30	27.50 $\pm$ 3.54
18.	Fecundity		58	152	105.00 $\pm$ 66.47

Results and Discussion

Study on biology of *Hyblaea puera* that lay eggs was mostly found on lower surface of inside rearing box under laboratory condition; however, some lay eggs were also noticed on lower surface of plastic box. It was further noticed that oviposition was observed during night hours and eggs were laid singly sticking to the side of upper side surface of plastic box.

Egg

Site and pattern of oviposition

The female of *H. puera* was found to lay eggs on upper and lower surface of tender leaves under laboratory conditions but mostly on the lower surface of the medium stage of leaves. In laboratory, the eggs were also found on the iron net of wooden cage. Females were found to sit frequently on the leaf and touches the surface with ovipositor elegantly. Thereafter, it flapped the wings and laid the eggs. Oviposition was observed during night hours and eggs were laid singly sticking to the side of veins and mid rib.

Colour, shape and size

The freshly laid eggs of *H. puera* were striated, oblong and pale white in colour, which turned brown before hatching. The head and prothoracic shield of the larva could be seen through the transparent chorion under microscope just before hatching. During hatching, the larva made a hole in the shell and pushed its head out. The larva did not feed on egg shell.

Incubation period

The incubation period under laboratory condition varied from 1 to 2 days with an average of 1.53 $\pm$ 0.71 days (Table 1).

Hatching percentage

It can be concluded from the Table 1 that, the hatching percentage of *H. puera* was found to be varied from 66.0 to

82.62 with an average of 74.31 $\pm$ 11.75 under laboratory condition.

Larva

In order to study the various larval instars of *H. puera*, newly hatched larvae were reared individually on fresh leaves of teak till they pupated. The data obtained on body length and width, head capsule and duration of different larval instars are presented here under.

First instar larva

The neonate larva was greenish yellow with black coloured head. There were few hairs all over the body. The larva was sluggish which became active after some time and started moving on the leaf surface, then settled at one place, feed on the chlorophyll content of leaves.

The duration of first instar larvae varied from 2 to 3 day with an average of 2.52 $\pm$ 0.71 (Table 1).

Second instar larva

The second instar larva was greenish dark than earlier instar. There were scattered hairs on all over the body. The head was black coloured.

The larval period of second instar ranged from 2 to 4 days with an average of 3.00 $\pm$ 1.41 days (Table 1).

Third instar larva

Third instar larva of *H. puera* was pale greenish to grey in colour with black coloured head. There were scattered hairs all over the body of third instar larva and segmentation was clearly visible.

The duration of third instar larva varied from 2 to 3 days with an average of 2.58 $\pm$ 0.71 days (Table 1).

Fourth instar larva

The appearance of the fourth instar of *H. puera* was entirely changed. The colour of the larva was purple grey dorso-laterally and grayish green latero-ventrally. The head was black coloured. The body was sparsely provided with short hairs.

The duration of fourth instar larva varied from 3 to 4 days with an average of 3.32 $\pm$ 0.71 days (Table 1).

Fifth instar larva

The fifth instar larva was dark purple grey dorso-laterally and greenish yellow latero-ventrally with a pale indistinct longitudinal line along the centre of the back and two clear zigzag sub-dorsal white lines on each side of the central line. Another clear white lateral line was observed just above the spiracles running along each side of the larva which demarked the upper grey and lower yellow colour with black coloured head capsule. The body of the larva covered with short hairs.

The duration of fifth instar larva varied from 3 to 5 days with an average of 4.12 $\pm$ 0.71 days (Table 1).

Number of larval instar

During present studies, *H. puera* was observed to passes through five larval instars when reared on teak.

Total larval period

The data on total larval period indicated that, it ranged from 12 to 19 days with an average of 15.50 $\pm$ 4.95 days (Table 1).

Pre-pupa

The last instar larva desisted feeding and found searching for a suitable place, where it caused remain sluggish. This indicated the beginning of pre-pupal stage. The caudal region was firmly attached to the leaf, the body was shrunken during the formation of pre-pupa with contraction at length and appendages. The larva formed flimsy white cocoon in a triangular leaf fold by adjoining leaves or dead fallen dried leaves and became quiescent. After that, larva made final moult and pupated. The colour of the pre-pupa was pale yellowish.

The data presented in Table 1 revealed that, the duration of pre-pupal stage varied from 1.0 to 2.0 days with an average of 1.58 ± 0.71 days.

Pupa

Site of pupation

The pupation of *H. puera* took place underneath the leaves especially on the basal half portion. The larva cut the leaf into pieces and webbed out them with fascal pellets. If there was absence of leaf litter on the ground, pupation took place within leaves of undergrown or on partially eaten teak leaves.

Shape, colour and size

The newly formed pupa of *H. puera* was of obtect type and initially yellowish and gradually reached dark purplish brown colour. The pupae were broadly rounded anteriorly but tapering posteriorly. Abdomen was distinctly marked into ten segments and well defined dark brown spiracles were visible on 4th to 9th abdominal segments. Genital and anal aperture was also clearly seen. Genital aperture of male was situated on 9th abdominal segment whereas, that of female was on the 8th abdominal segment. Anal aperture in both cases was on the 10th abdominal segment.

Pupal period

The duration of pupal stage varied from 5 to 6 days (Av. 5.53 ± 0.71 days) in case of male, while 6 to 7 days (Av. 6.54 ± 0.71 days) in case of female (Table 1).

Adults

Immediately after emerging from the pupa, adult took a rest for some time to stretch and hardened its wings and other body parts. Once the body acquired normal structure and hardened, the adult moved about looking for the food. The compound eyes were deep brown in colour and were located laterally on the head. It possessed a pair of setaceous antennae on the dorsal side of the head between the compound eyes. The female moth was bigger in size as compared to male with abdominal hairs and thoracic hairs. The male and female moth well developed with head and grayish red-brown thorax and with abdomen was black brown with orange segmental bands. The fore wing was reddish brown with streaks and suffused bands of dark colour, while hind wing was dark brown with a curved orange scarlet edged band transversally across the middle and a similar patch on the margin near the anal angle.

The data on measurements of body length and breadth revealed that, body length of male varied from 13 to 17 mm (Av. 15.00 ± 2.82 mm) and breadth varied from 18 to 36 mm (Av. 27.00 ± 12.72 mm), while the body length of female varied from 11 to 19 mm (Av. 15.00 ± 5.65 mm) and breadth varied from 24 to 38 mm (Av. 31.00 ± 9.89 mm) (Table 1).

Fecundity

In laboratory, the egg laying capacity recorded during the

study varied from 58 to 152 eggs, with an average of 105.00 ± 66.47 eggs per female (Table 1).

Longevity

The results presented in Table 1 revealed that, the longevity of female varied from 6.0 to 9.0 days (Av. 7.52 ± 2.12 days), while that of male varied from 5 to 9 days (Av. 7.06 ± 2.83 days).

Total life cycle

It is evident from the data presented in Table 1 that, the total life cycle starting from egg to death of adult male varied from 24 to 30 days (Av. 27.06 ± 4.24 days) on teak, while that of female varied from 25 to 30 (Av. 27.50 ± 3.54 days). Thus, there was no significant difference in life cycle of male and female.

Katagall (1991) [3] described that the moths were found to feel the surface of the leaf with ovipositor, moved briskly on the leaf, flapped the wings and then laid the eggs. Oviposition was observed during night hours. Eggs were laid singly sticking to the side of veins and midrib of teak leaves. Freshly laid eggs of *H. puera* on teak were small, greenish white in colour, ovoid in shape with striated chorion. The eggs measured about 0.91 to 1.08 mm in length and 0.52 to 0.64 mm in width, dark head of the young larva inside the egg shortly before hatching under laboratory temperature of 27 ± 1 °C and 80 ± 5 percent relative humidity. The incubation period recorded was 2 to 3 days. The freshly emerged larva was greenish yellow with a black coloured head and prothoracic shield which was lighter in colour than the head. The length and breadth of first instar larva reared on teak varied from 1.68 to 2.33 mm and 0.24 to 0.36 mm, with 0.33 to 0.38 mm in width of head capsule, respectively. The second instar larvae were stout and darker than first instar. Head and prothoracic shield were dark in colour, setae and brown coloured pinacula were conspicuous by their appearance. The length and breadth of second instar larva measured 3.66 to 5.49 mm and 0.50 to 0.58, respectively. The head capsule measured about 0.60 to 0.72 mm in width. The third instar larva resembled the second instar, except for size and colour where it became pale greenish to grey. The length and breadth of third instar measured from 8 to 10 mm and 0.75 to 1.0 mm. The duration of third instar ranged from 2 to 3 days. The length of fifth instar larva varied from 24 to 30 mm. The duration of fifth instar larvae ranged from 3 to 7 days. Tilakaratna (1995) [15] studied the life history of *Hyblaea puera*, a pest of teak (*Tectona grandis*) under the laboratory conditions with the objective of determining the duration and behaviour of various stages of the insect's life under Sri Lankan conditions. It was found that the complete life cycle took 21-33 days. The duration of the different stages viz., egg (incubation period), larva, pupa and adult included 2-3, 11-16, 4-7 and 4-7 days, respectively. Nachane *et al.* (1999) [7] observed that the small minute oval eggs of about 1 mm size were laid mostly on the underside of tender leaves by *H. puera*. Most of them were laid singly near the veins. However, few of the eggs laid in batches of 2 to 3 were also noticed. The incubation period recorded as 2 to 3 days. The duration of first instar of *H. puera* ranged from 3 to 4 days. The larva was initially greenish black and later turned to dark black with black head capsule (with advancement of age) and measured 4 to 4.5 mm in length when reared on teak. The duration of second instar was 2 to 3 days. The

larva of *H. puera* passed through five larval instars. Javaregowda (2005) [4] from Uttara Kannada, reported the reproductive behaviour of *H. puera* and suggested that adult moths laid eggs singly either close to the midrib or the veins on the underside of the leaves. Differences in the duration of development of each stage were noticed in all the three periods of the year. The incubation, larval and pupal duration varied from 1.0 to 3.0, 13.5 to 14.5 and 5.0 to 9.0 days, respectively. There were five larval instars with pre-pupal stage. Sharma *et al.* (2013) [12] conducted the biology of the pest, *H. puera* in Jammu under laboratory conditions. The pre-mating periods of both sexes of moth were one to three days after emergence. Mating occurred during night and lasted for about an hour. Characteristic courtship behaviour was exhibited by the adult moths. Pre-oviposition period was 20-24 hours and the mean oviposition period was 6 days. It was revealed that the incubation period varied from 1.5 to 3.05 days with an average of 2.51 ± 0.648 days. The larvae passed through five instars and total larval period varied from 15.2 to 20.15 days with an average of 17.62 ± 1.64 days. Pupal period ranged from 6.2 to 8.4 days, with an average of 7.16 ± 0.85 days. Total life cycle varied from 21.4 to 28.15 days, with an average of 24.79 ± 2.42 days. Pest completed 7 generations in a year from June to November. Tripathy *et al.* (2018) [16] conducted a study on the biology of *H. puera* both at normal laboratory condition and in BOD incubator with 14:10 photoperiod, 32 ± 18 °C temperature (Day: Night) and 70 percent relative humidity. The study revealed that there were five larval instars and duration as well as weight of larvae and pupae did not differ much in both the cases of study. Mean larval period was 15.31 days and that of pre pupa, male and female pupa were 1.35, 5.45 and 6.82 days, respectively when reared in normal laboratory condition fed with teak leaves. Female and male adults longevity were found as 8.80 and 8.05 days, respectively. Seervi *et al.* (2022) [11] studied on biology and life cycle of *Hyblaea puera* C. (Lepidoptera: Hyblaeidae) during Kharif season of 2020 under Laboratory conditions in Department of Entomology, Institute of Agriculture Sciences, Bundelkhand University, Jhansi (U.P). The common laboratory conditions viz., 30 °C temperature and 73 percent relative humidity (RH) were maintained during the current investigation. Results revealed that there were five larval instars. Average larval duration was 13.83 days and that of pre-pupa, male and female pupa were 2.29, 4.39 and 7.0 days, respectively when reared under common laboratory conditions and fed with teak foliage. The longevity of male and female adult was found to be 6.05 and 7.50 days, respectively. The pre-oviposition, oviposition and post-oviposition duration were found to be 2.22, 3.00 and 3.28 days, respectively. Average number of eggs laid by the female during its life cycle was found to be 119.21. The total life cycle of male and female was 25.95 and 26.00 days, respectively.

Conclusion

Based on the present study, it can be concluded that much difference was not observed in duration of total life cycle, including male and female longevity in populations of teak defoliator reared on teak leaves in the laboratory conditions. The total larval duration was 15.50 days. Mean longevity of male and female moths was 7.06 and 7.52 days, respectively. Total number of eggs laid per female was 105.00. Life cycle of male and female adult was completed

within 27.06 and 27.50 days, respectively. Overall, it can be concluded that integrated pest management (IPM) strategy should be formulated to control teak defoliator during early stages of larval growth as the late instar stages cause very high damage to the teak plants.

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