

Leaflet No. 2/79-80



**Government of Union of Myanmar
Ministry of Forestry
Forest Department**



**Observations on A Root-Borer of Young Plantation
Teak in Prome Forest Division**

Aung Zeya
Forest Research Institute
February, 1980

Acknowledgements

I am indebted to U Tin Maung Kyi, Divisional Forest Officer, for his report and help in all ways possible; U Y.ACC. Doo, My Divisional Head, for his unstinted support; U Ohn, Deputy Director administrating the Director-General's office for taking time off his many and varied duties to read the draft; Dr. G.R. Armstrong, Chief Technical Advisor, for his critical eye; and last but not least to U Sein Maung Wint, Director, FRI, for allowing me to carry out the present observations.

Observations on A Root-Borer of Young Plantation Teak in Prome Forest Division

By
Aung Zeya
Forest Research Division
Forest Research Institute
Yezin

Abstracts

The species identity of the insect has not yet been established but the general external morphology and life cycle are described and its systematic position discussed. Method of attack and nature of injury caused by the insect have been studied. The probable cause of attack on teak by this insect and development of possible methods of control are also discussed. Studies on transmission and the effect of injuries caused by the insect are still in progress.

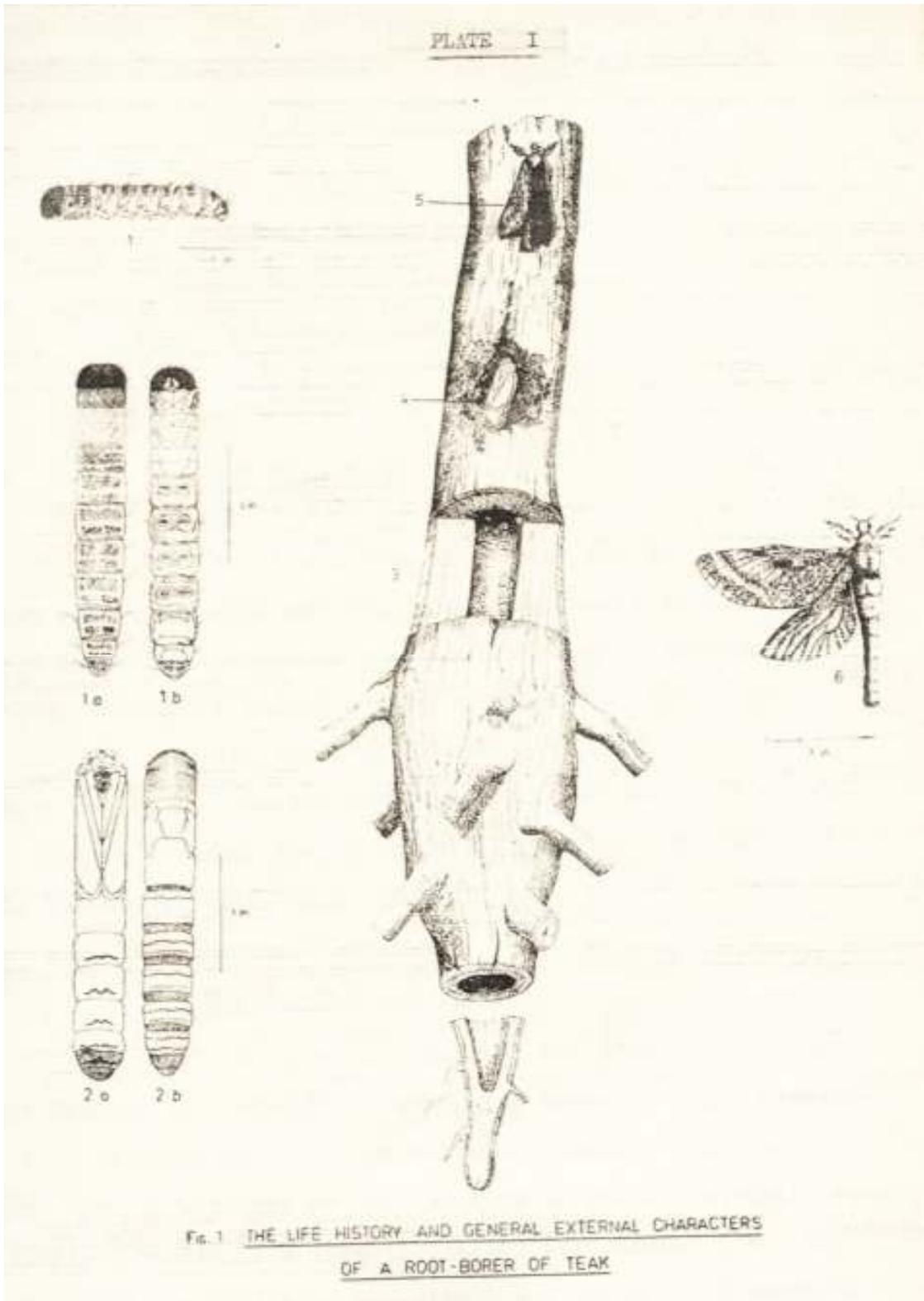
Contents

	Page
Acknowledgement	i
Abstracts	ii
1. Introduction	1
2. Materials and Methods	4
2.1 Development of Plantations.. .. .	4
2.2 Collection of Material	4
A. Larvae	4
B. Affected Host-Tree Specimens	4
C. Adults	4
I. Field Trapping	6
ii. Laboratory Rearing	6
3. Results	8
Collection of Material and Rearing of Larvae	8
The Insect: Description of Various Metamerphic Stages	9
Moth	9
Mature Larva	12
Pupation, Pupa And Emergence	12
Oviposition	12
Method of Attack and Nature of Injury	16
Attack on other Tree Species by the Insect	16
Systematic Position of the Insect	17
Main Characters of the Order Lepidoptera	17
Key Characters of the Family Hepialidae.	18
(After Imms 1964)	
Main Characters of the Suborder Monotrysia	19
(After Imms 1964)	
Main Characters of the Superfamily Hepialiidea	19
(After Imms 1964)	
Main Characters. of the Family Hepialidae	19
(After Imms, 1964)	
Key Characters of the Family Hepialidae	19
(After Hampson, 1892)	
Main Characters of Family Hepialidae	19
(After Hampson, 1892)	
Key Characters of the Genus <u>Phassus</u>	19
Main Characters of the Genus <u>Phassus</u>	19
4. Discussion	19
Systematic Position of the Insect	19
Larva	21
Method of Attack by the Insect on Teak	21
Other Host Trees of the Insect	22
Significance of Weeding	22
The Probable Cause of Attack by the Insect on Teak	23
Possible Methods of Control	23
Silvicultural Control	
Chemical Control	24
5. References

Description of Plate 1
The life history and general external characters of
a root-borer of teak.

1. Mature larva, lateral view
- 1a. Mature larva, dorsal view
- 1b. Mature larva, ventral view
- 2a. Pupa, ventral view
- 2b. Pupa, dorsal view
3. Teak stump showing injury
4. Pupa half-protruding through entrance hole just before emergence
5. Adult moth just after emergence
6. Adult moth set and mounted to show external characters

PLATE I



1. Introduction

In June, 1976, a report was made by the Prome Divisional Forest Officer on a stem-borer attacking two-year-old plantation teak in South Nawin Forest Reserve. Examination showed that the damage was done by the larva of an insect belonging to the family Curculionidae (weevil family) which bored its way into the pith for pupation; the attack was found to be sporadic and it disappeared in the years following the attack; bore holes measuring about 1/10 inch in diameter found on the main stems of a few trees also disappeared in two years. But during the examination, another type of borer was noted. The Larva of this borer attacked young teak trees by girdling the bark and sapwood of the main stems almost totally at about two to three inches above ground level before boring its way into the heart-wood and making its way downwards along the center of the tap-root. Further examinations showed that although no evidence of sudden death of the tree was observed due to this borer, the injury remains on the tree and the stem can break at the girdle during excessive crown movement. General weakness of young trees resulting from attack by this borer was also observed. The incidence rate was estimated to be about three per cent in the compartment that was examined. The insect, therefore, was taken up for study.

The insect under study belongs to the order Lepidoptera (butterflies and moths) and family Hepialidae (swift moths). Information as to the original host tree of this insect was unavailable from local residents but the larva was reported by these sources to have served as bait for fishing. Although accounts of teak being attacked by stem-borers having certain similarities to the root-boring insect under study had been given by various authors (Troup, 1921, Atkinson, 1931; Beeson, 1961; Moore, 1941; Kaufman, 1968), no detailed studies have apparently been made of these insects, and their descriptions of the insects as well as the method of attack and the nature of injury caused differed from the present findings.

The root-borer under study occurred in the pure teak plantations in South Nawin Forest Reserve on the East Pegu Yoma range 43 miles by road East of Prome at about latitude 18°54' N and longitude 95°48' E 1/. Meteorology Department. The development of the plantation in which the present observations were made began during 1974-75 planting season. The elevation of the area is estimated to be between 1000-1200 ft. (about 305-366 m.) above sea level 2/. Departmental Instructions for Forest officers in Burma. App. VII, pages 217-217. The area may be termed as having rough, steep, hilly terrain and a sandy loam soil. The average annual rainfall during 1961-75 period was 95.59 in. (1295 mm) with the heaviest average monthly rainfall of 9.99 in. (252.64 mm.) occurring in July. The average temperature during the same period ranged from a minimum of 71.4 F (21.9 C) to a maximum of 91.2 F (33.2 C) with peak average monthly temperatures reaching 102.5 F (39.16 C) during April 1/.

The type of forest in the South Nawin Forest Reserve in which the teak plantations have been established following clear felling of all trees may be classified as dry upper mixed deciduous forest 2/. The presence of Bamboosa polymorpha (kyathaung wa) of poor growth and Dendrocalamus strictus (myin wa) was observed in this forest reserve together with the dominant tree species of Tectona grandis (kyun), Xulia dolabriformis (pyinkado), Terminalia tomentosa (taukkyan), Adina cordifolia (hnaw), Millettia pendula (thinwin), Pterocarpus macrocarpus (padauk) and other tree species of lesser commercial value such as Lagerstroemia villosa (zaungbale), Oroxylum indicum (Kyaungsha), Wendlandia glabrata (thitpyu) and Homalium tomentosum (myaukchaw),

1/. Meteorology Department.

2/. Department Instructions for Forest officers in Burma. App. VII, pages 214-217.

PLATE II



Fig. 2. Teak plantations in South Mawin Forest Reserve, Prome Forest Division Note unworked area in left foreground.



Fig. 3. Two-year-old teak plantation. Note difference between the sizes of trees in the background and the one in the foreground.

PLATE II a



One-year-old teak tree showing root system.



Two-year-old teak tree showing root system.

2. Materials and Methods

All observation and collection of material for this study were made in compartments 49 and 50 of pure teak plantations in the South Nawin Forest Reserve.

2.1. Development of Plantations

The development of plantation in which the present studies were made began in 1974-75 planting season as a monoculture under the system of taungya cultivation (Pl. II, figs. 2,3). The plantations were developed after usual land preparation operations following teak extraction. Land preparation included clear felling of all remaining trees after extraction of high value timber, burning and site clearing. Seed sowing was employed at 6 ft. spacing for compartment 49 and at 9 ft. for compartment 50. Weeding in teak plantations was originally carried out for four successive years beginning from the year of development; the number of annual weedings during the four years was three times for the first and second years, twice during the third, and once during the fourth (3,3,2,1)1/. But the frequency of weeding was changed in 1977 to twice each year for two years beginning from the year of development (2,2)2/. In 1978 this frequency was changed to three times during the first, twice during the second, and once during the third year beginning from the year of development (3,2,1)3/. The weeding frequency currently practiced beginning from 1979 in three times during the first year, twice per year during the second and third, and once during the fourth beginning from the year of development (3,2,2,1)4/.

1/. Forest Dept.Head Office Letter No. 10817-10687/Bha (GA) 41, Dated 30-6-76.

2/. Forest Dept.Head Office Letter No. 10921-10986/Gagyi (Kha) 61, Dated 25-10-77.

3/. Forest Dept.Head Office Letter No. 11316-11371/ Gagyi (Kha) 61, Dated 3.11.78.

4/. Forest Dept.Head Office Letter No. 13723-13783/ Gagyi (Kha) 61, Dated 2-10-79.

2.2. Collection of Material

a) Larvae

Since damage is caused by this insect while in the larval stage by boring into the wood, it was necessary to remove the affected tree to collect larvae. The stem of the affected tree was first sawn off about 11/2 ft. from ground level. The lateral roots were then cut off before the tap-root was dug out of the ground taking care that the whole length of the tap-root was removed without injury because in all affected trees examined the larvae were found to bore their way unerringly down the tap-root. The stump was then sawn into two inch transverse sections after pushing the larva down the tunnel with a plug of cotton wool to a depth of three inches before each two inch section was sawn so that the larvae may not be injured or cut in two. The larva emerged from the tunnel in the last three-inch section when the cotton plug was removed (Pl. III, figs. 4,5).

B) Affected Host-Tree Specimens

By using the above method but without the sectioning of the stump, the larvae together with the host-tree specimens were obtained (Pl, III, fig.4).

C) Adults

The short life span and duration of emergence period in addition to the camouflage colouration of the moth rendered timing of field collection of adults using nets or traps in remote areas with limited facilities critical. Therefore, the following methods were employed for collection of adults.

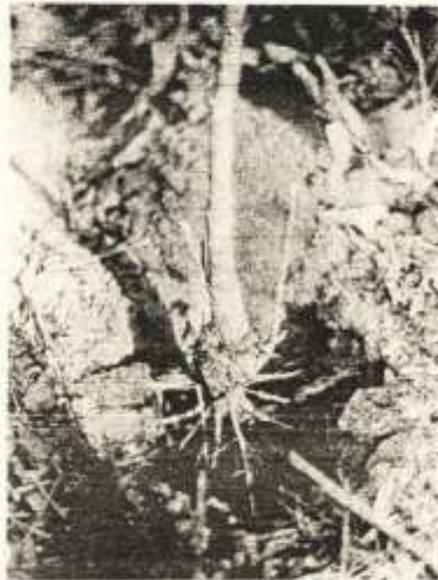


Fig. 4. Two-year-old affected teak tree showing injury and exposed roots.

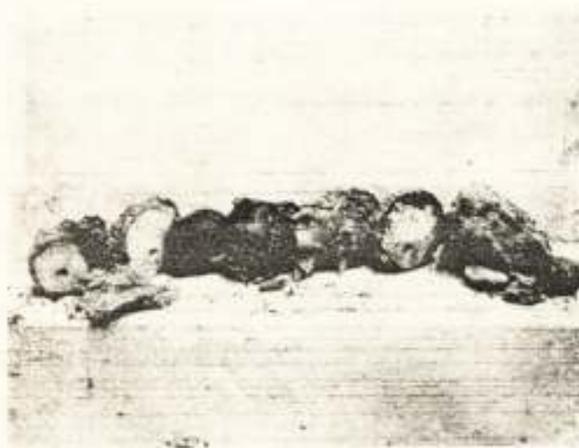


Fig. 5. Four-year-old affected teak stump after sectioning to extract larva.

i) Field Trapping

15 micron-thick plastic sheeting was used for trapping adult moths. Using needle and thread two foot long sleeves were sewn loosely round the trunks of affected trees covering the emergent holes. Each of the sleeves was tied with jute strings at both ends. Since this method of using plain plastic sheeting for sleeving collected large amounts of moisture inside the sleeves, holes were made in the plastic sheeting before sleeving using a paper punch. Some moisture still collected in the sleeves.

ii) Laboratory rearing

Larvae were collected in early March using methods described for collected of larvae and affected host-tree specimens in (1) and (b).

The larvae collected which were still in their natural habitat were packed in thick plastic bags and transported to the laboratory study and rearing. The teak stumps with the larvae inside them were stood upright in earthen pots containing water. The pots were then placed in wire mesh cages. To prevent water from entering the feeding chambers and drowning the larvae, not more than four or five inches of the stumps were allowed to be immersed in water (Pl. IV, figs. 6,7).

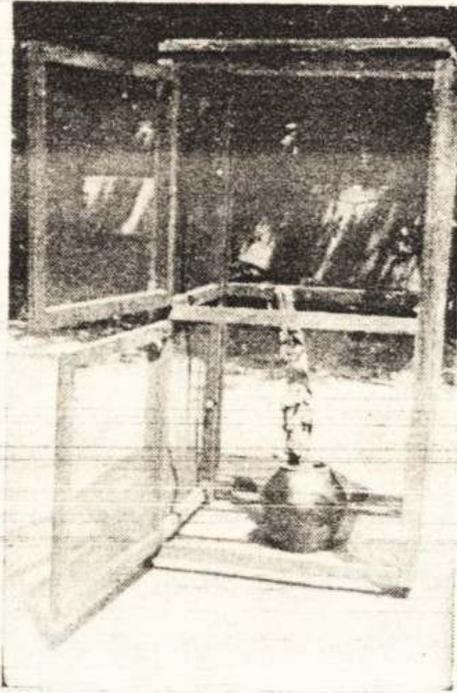
PLATE IV

Fig. 6. Materials and method used for rearing the root-borer.

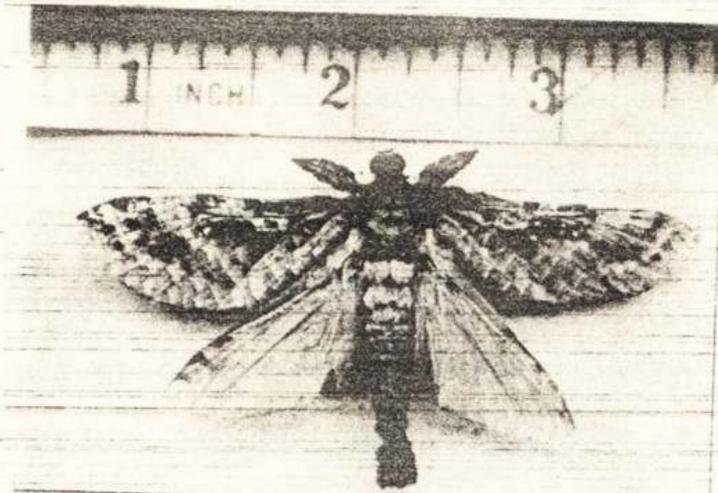
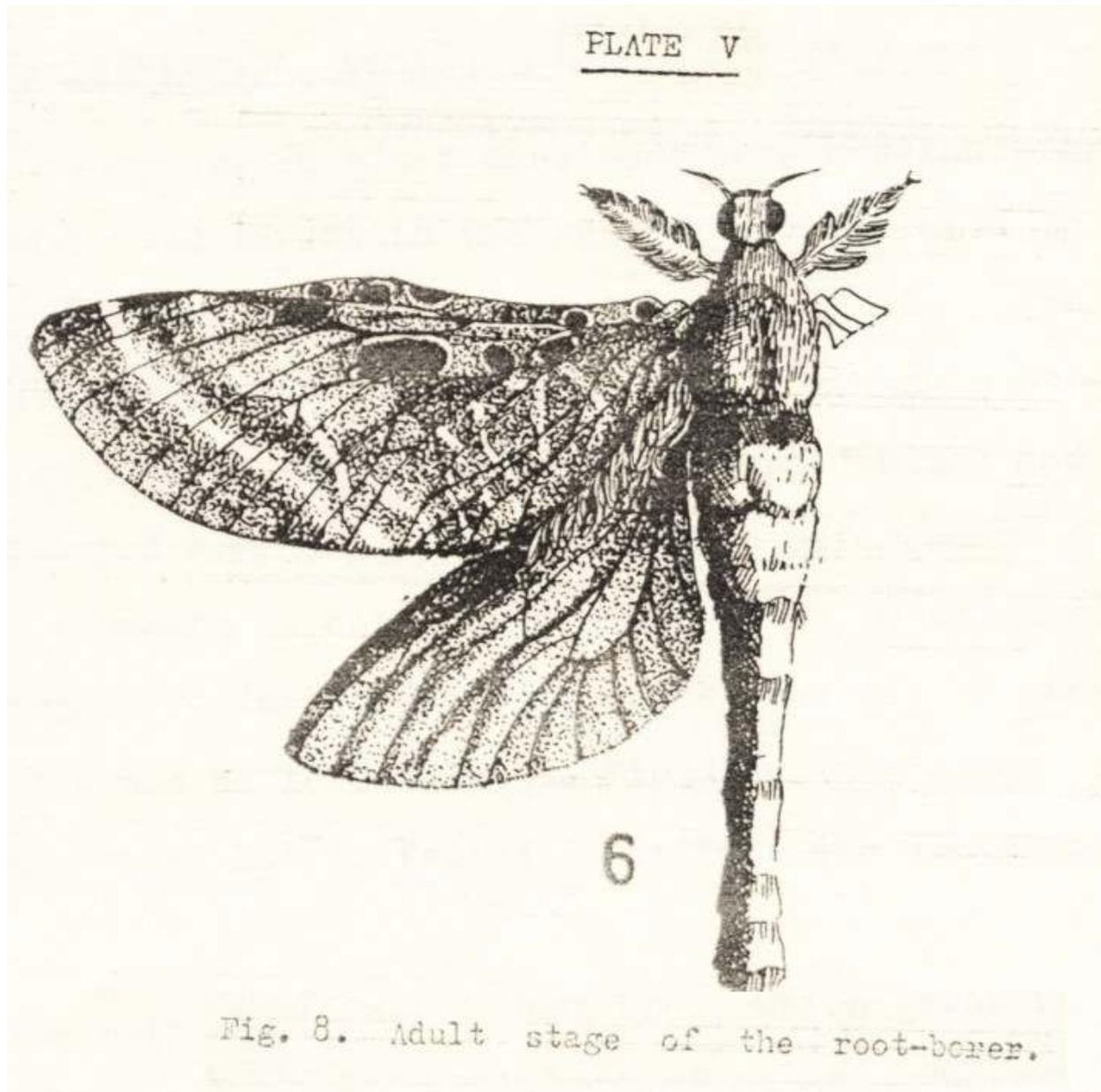


Fig. 7. Adult stage of the root-borer.



3. Results

Collection of Material and Rearing of Larvae

Affected host tree specimens with the lice larvae inside were collected as described in 2(a) and (b) in the materials and methods section and transported back to the laboratory in thick plastic bags with the open ends of the bags securely tied with rubber bands. They were found to be able to withstand such a method of transportation for at least two weeks without

death or apparent damage. The stumps sprouted leaves after two weeks when stood upright in earthen pots containing water as described and the larvae went on living until pupation.

Larvae thus reared went on to pupate at about the same time as those in the field (i.e. during May).

The insect: Description of various metamorphic stages

Moth. Altogether, 18 adult specimens were obtained by rearing field collected larvae in the laboratory, but only one intact specimen is available at present for study. Of the other specimens that emerged three escaped while making photographs of live specimens, six emerged with deformed wings and the rest were damaged beyond recognition due to unforeseen circumstances. Attempts at collecting adult moths in the field using sleeve traps have failed due to various reasons. A single adult specimen was collected in the field as it emerged from the entrance hole, but it failed to inflate its wings and was deformed.

The moth (Pl. IV, fig. 7; Pl. V, fig. 8) has somewhat narrow fore wings of light brown colour tinged with pink and variable patterns in dark brown which gives the insect a coloration resembling the bark of trees. The head is rounded, covered with brown hairs, almost two thirds of it occupied by the compound eyes; antennae very short with the length about the hemispherical circumference of the head. Thorax covered with short brown hairs. Forewings with 6 spots along costal margin made up of brown scales, the proximal most spot occurring almost at base of wing unmarginated but the other 5 unequally spaced spots margined with pink; one brown, rather rounded spot at base of cell more or less below the second spot along the costal margin and another elliptical spot made up of dark brown scales just below the third, fourth and fifth spots along costal margin; at the apical end of the elliptical dark brown spot is a small but conspicuous patch made up of white scales. Hind wings almost totally pink with a narrow, sharply tapering pennant-like strip made up of long, pink hairs along almost two thirds the length of the costal margin, the hairs becoming brown in colour towards the apical end of the strip; two quite distinct, round, brown spots and a patch of brown present towards the distal apical third along costal margin. Fore and mid legs covered with long, brown hairs making the legs appear as elongated spades; hind legs normal and sparsely covered with hairs. Abdomen long and tapered but broadened again at the posterior end; the first two segments of the abdomen covered with conspicuously long, brown hairs tinged distinctly with pink and less thickly covered with hairs on the third. Length about 45 mm. Wing span about 75 mm. The adult lived for not more than 6 days.

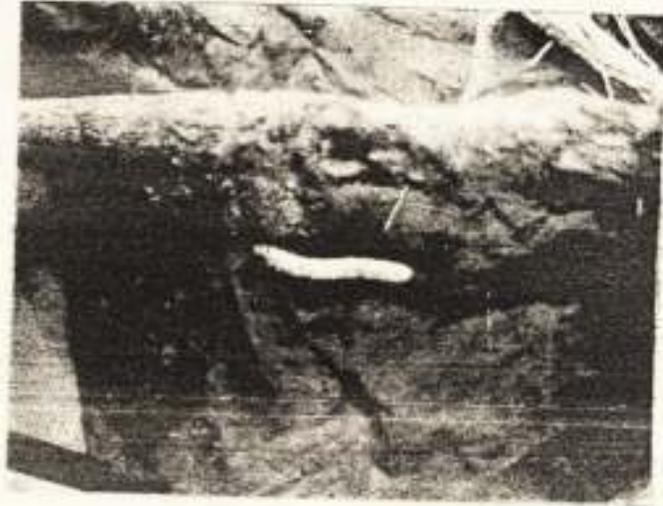
PLATE VI

Fig. 9. Mature larva shown against three-year-old affected teak stump.



Fig. 10. Mature larvae; viewed from lateral side (top) and ventral side (bottom).

PLATE VII



Fig. 11. affected teak trees in the laboratory showing pupae protruding through the entrance hole a few days before emergence. Note the injury caused by the larva of the root-borer.



Fig. 12. Pupal stage of the root-borer.

Mature Larva

About 2¼ To 2½ Inches Long, Creamy White In Colour, Cylindrical In Shape But Slighted Tapers Towards The Posterior End, Smooth, Hairs Inconspicuous (Pl. VI, Figs. 9,10). Head Dark Brown With An Almost Circular Shape When Viewed Facially And Extremely Chitinised And Roughened To The Extent Of Forming Into A Hard Shield. Thorax Chitinised Bearing Three Pairs Of Normal Thoracic Legs; Whole Of The First Thoracic Segment Brown And Heavily Chitinised, Lerga Of The Other Two Thoracic Segments Light Brown And Less Chitinised. Abdomen 10 Segmented, The Terga Of Segments 1-8 Each Bearing A Large Anterior And Two Smaller Posterior Chitinised Plates; 5 Pairs Of Crocheted Abdominal Legs On Third, Fourth, Fifth, Sixth And Ninth Segments. Only A Single Larva Has Been Found So Far In Each Effected Tree. The Larval Life Lasted For About 11 Months.

Pupation, Pupa and Emergence

In nature, pupation takes place near the entrance hole but at a slight distance downwards inside the bore hole with the head directed towards the entrance hole; in laboratory rearings, the anterior third of the pupa protruded outside into the free air through the entrance hole (Pl. VII, fig. 11) for some time making spiral contortions before emergence; tranverse wavy rows of chitinous teeth on the abdominal segments, (Pl. VII. Fig. 12:Pl.I, figs. 2a, 2b), one each on the dorsal side of the fourth, fifth, sixth, seventh and eighth segments which are placed slightly anteriorly on the segments, and one each on the ventral side on the fifth, sixth, seventh and eighth segments which are placed slightly posteriorly on the segments; single tubercle with two smaller tubercles of chitinous teeth placed posteriorly on ventral side of ninth segment; these rows of chitinous teeth and tubercles assist the pupa in its progress towards the entrance hole or emergence. The pupa is brown with the darker brown head ventrally placed; the head, the first thoracic segment and part of the second thoracic segment forming a hard, roughened dark brown coloured shield. Pupation usually took place early in April. The emergence period began just after the first heavy showers in early May and ended by the third week of the month.

Oviposition

Since no live male moths were collected, oviposition of fertilized females was not observed. But a chance collection of a late emerging female moth in the field as it emerged from its pupal skin in late afternoon enabled observation of its oviposition. The femal, however, failed unaccountably to inflate its wings resulting in a deformed specimen. The femal began laying eggs about four hours after emergence. It laid about 20,000 eggs during the first hour and another 20,000 during the next 24 hours. It continued to lay about 500 eggs daily for the next two days. The eggs were laid in profusion resembling grain being pumped out of a grain-hose. They were white when laid but turned black in about 45 minutes; they were about 0.20 mm. in length and 0.10 mm. in width, oval in shape having pointed ends; they were non-sticky. The incubation period has not been determined since no hatching took place from the unfertilized eggs. The incubation period probably was very short since by June the tunnels bored by the larvae had advanced to a considerable length down the centre of the stem.



Fig. 13. affected teak tree showing girdle made by the larva just above ground level.



Fig. 14. Two-year-old affected teak tree showing injury caused by the root-borer.

PLATE IX



Figs. 15 - 18. Clockwise from top left. Tectona grandis (teak) .
Croxylum indicum (kyaungsha). Wendlandia glabrata
(thitpyu). Lagerstroemia villosa (zaungbale).

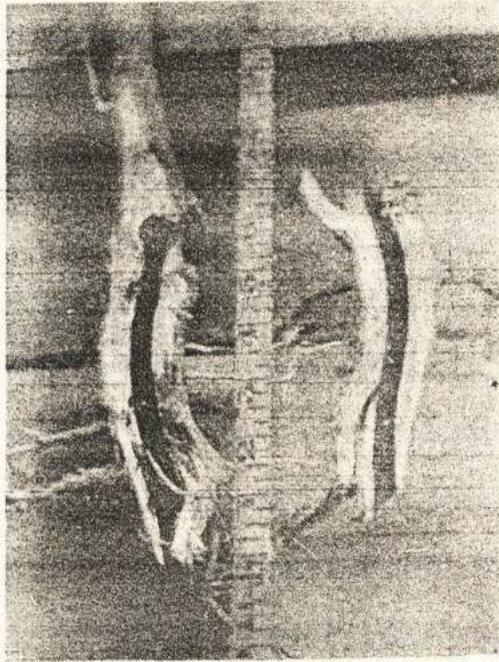
PLATE X

Fig. 19. Longitudinally sectioned three-year-old affected teak stump showing injury.

Method of Attack and Nature of Injury

Probably only very few eggs that were deposited in crevices of the bark survived and hatched. So far, only one larva has been found in each affected tree. The attack was found to begin with the girdling of the bark about 2-3 inches above ground level (Pl. VII, fig.11, Pl. VIII, fig. 13). At first, the girdle was made just deep enough for the growing larva to enable itself to move easily along the tunnel while it builds a loose, fluffy covering over the tunnel with silk and pieces of the bark ; this covering was spread evenly over tunnel and resembled the bark of the tree (Pl. IX, fig. 17). A deeper tunnel was eventually formed in place of the shallow girdle. Under this cover, the larva bores its way deeper into the sapwood, usually leaving a strip of sapwood about an inch in length along the girdle. By about October the larva already has bored its way into the heart-wood towards the centre of the stem from a point along the tunnel, and by that time reached some distance downwards along the centre of the stem into the tap-root. The larva then makes its way down the centre of the stem and along the tap-root without puncturing it (Pl. X, fig. 19). Although no evidence of sudden death of the tree has been observed due to this borer, the injury remains on the tree and the stem can break at the girdle during excessive crown movement (Pl. VIII, fig. 14). General weakness of young trees resulting from attack by this borer has, however, been observed. The attack was first observed on both weak and vigorously growing two-year-old plantation teak trees and the attack continued on five-year-old teak trees having girths of 12 inches and heights of 10-12 feet in the same locality. The incidence rate has been estimated to be about 3% in compartment 49 of the plantation. Transmission of this insect to other tree species and a slight increase in incidence rate on teak and other tree species have been observed after a period of four years.

Attack on Other Tree Species by the Insect

When observations of the insect under study were made in 1976 and 1977, no other tree species except teak were observed in compartment 49, and teak was the only species attacked by the insect under study; teak in compartment 50 which is separated from compartment 49 by a 30 ft. wide road was unattacked by the insect. But during observations made in 1978 the presence of fast growing tree species such as Oroxylum indicum (kyaungsha), Wendlandia glabrata (thitpyu) and Lagerstroemia villosa (zaungbale) were observed in compartment 49, and of these three species o. indicum was found to have been attacked by the insect under study in addition to teak (Pl. IX, fig. 16). In compartment 50 only a single, vigorously growing teak tree was observed to have been attacked by the insect in 1978, but three more vigorously growing trees were found attacked in 1979. Examination of compartment 49 in 1979 showed that W. glabrata, L. vilosa and o. indicum have grown to heights of 10-15 ft. and girths of 8 ½ -10 inches and all three species have been found to be attacked by the insect in addition to teak (Pl.IX, figs. 15,16,17,18). The dimensions of teak trees in compartment 49 at that time were observed to have been generally less than those of the three fast growing tree species mentioned above. Presence of large numbers of vigorously growing o. indicum trees was also observed along forest road aprons and gullies that have not been worked for plantation development, and examination of these trees revealed that almost all of them had been attacked by the insect.

Systematic Position of the Insect

The insect under study has been classified as belonging to the order Lepidoptera, family Hepialidae and genus Phassus.

Main Character of the order Lepidoptera

On the whole the adults exhibit a remarkable constancy as regards their fundamental structure.

Insects belonging to the order Lepidoptera possess two pairs of membranous wings; cross-veins few in number. The body, wings and appendages clothed with broad scales. Mandibles almost always vestigial or absent, and the principal mouth parts generally represented by the maxillae. Larvae eruciform, peripneustic, frequently with 8 pairs of limbs. Pupae usually more or less obtect, and generally enclosed in a cocoon or an earthen cell; wing tracheation complete.

A high degree of consistency in the fundamental structure of insects belonging to this order has led to great difficulties in evolving a division of the order into major groups for classificatory purposes. The following key characters by Imms (1964) and Hampson (1892) were used for the classification of the insect under study.

Key Characters of the Family Hepialidae (after Imms, 1964)

1. Adult without functional though sometimes with vestigial mandibles, maxilla without lacinia, galea more or less haustellate unless the mouth parts are very reduced. Larvae with a triangular post-clypeus and not more than 7 pairs of abdominal legs.
2. Female with 1 or 2 genital openings behind sternite IX. Wings more or less distinctly aculeate. Male sternite IX without a saccus ----- Suborder Monotrysia.
3. Venation of fore and hind wings much alike, hind wings Rs 3 or 4 branched, R₁ separate from Sc, frenulum not developed.
4. Female bursa corporatrix, common oviduct and rectum all opening separately behind sternite IX; sternite VIII and IX without apodemes. Male sternite IX a small widely U-shaped sclerite. Fore wing with a strong humeral veinlet and a long jugum, hind wing without costal spines, aculei not numerous. Larvae subterranean, with 5 pairs of crochet-bearing abdominal legs. Pupa obtect, with rudimentary mandibles ----- Super family Hepialoidea.
5. Both main branches of M running through the cell.
6. M₄ oblique, forming a Y-vein with Cu_{1a}, R₂₊₃ with a long fork, Sc in fore wing rarely, hind wing with 2 anal veins. Tabiae without spurs. Maxilla with galea and palpi rudimentary ----- Family Hepialidae.

Main characters of the suborder Monotrysia (after Imms, 1964).

Female with one, rarely two genital apertures on sternite IX; wings always aculeate.

Main characters of the Superfamily Hepialodae (after Imms, 1964)

Venation of fore and hind wings similar. Female with 2 genital openings on segment IX.

Main characters of the Family Hepialidae (swift mths) (after Imms, 1964).

Antennae very short, mouth parts vestigial; wing-coupling apparatus of jugate type; the jugal lobe elongate and resting upon the hind wing. Tibial spurs absent.

Key characters of the family Hepialidae (after Hampson, 1892)

- I. Antennae rarely knobbed; frenulum generally present, and always in the forms that have knobbed antennae.
- B. Fore wing with vein 5 from lower angle of cell nearer 4 than 6.
 - a. Hind wing with more than 8 veins
 - a'. Proboscis absent, no mandibles nor ligula-----
Hepialidae.

Main characters of Family Hepialidae (after Hampson, 1892).

Proboscis absent; palpi usually absent. Antennae very short and filiform. Legs short and without spurs. Fore wing with vein Ia forming a fork with b of separate; a bar from vein 12 to the costa near the base. Hind wing with 12 veins, three internal veins; a bar from vein 12 to the costa near the base; vein-lets in the cell of both wings forked. Frenulum absent.

Larvae internal feeders in wood or the roots of grasses etc.

Key characters of the genus *Phassus*

1. Palpi absent. Fore wing with a bar between vein Ib and median nervure.
2. Vein 10 of both wings not stalked with 8 and 9.

Main characters of the Genus *Phassus*

Pulpy absent. Antennae short and filiform. Fore and mid legs fringed with hair on both sides; hind legs aborted in male, the femur and tibia short, the latter with a curved tuft of long hairs, the tarsus more or less aborted, in some species only represented by a bristle. Both wings with veins 9 and 10 stalked; a forked vein-let in the cell, and vein 12 fringed with hair. Fore wing with a bar between vein Ib and median nervure.

The prothorax, consisting of two pieces is ankylosed to the mesothorax consisting of one large piece, being freely moveable on the mesothorax.

Larvae bores in trunks of trees.

4. Discussion

Systematic position of the insect

The insect under study has been placed in the order Lepidoptera and using the group and using the group family keys by Imms (1964) and Hampson (1892) it has been classified as *Phassus* sp. Belonging to the family Hepialidae.

Imms (1964) mentioned that "larvae of insects belonging to the family Hepialidae are subterranean feeding upon roots, or are internal feeders." Hampson (1892) in describing the genus *Phassus* belonging to the same family recorded the larvae of this genus to be borers in trunks of trees; however, no mention was made as to the living habit of *Phassus signifer* Walk. (Syn. *P. undulifer* Walk, char. Underscr., Het. P. 102, C&Sno.1623; *P. chalybeatus* Moore P.Z. S. 1879, 421; C&S no.1617) which he described to some detail. Kaufman (1968) in his account of teak production in Thailand mentioned *Phassus signifer* Walk. as a stem-borer of teak but gave no further detail of the insect. Atkinson (1931) reported the larva of *P. signifer* Moore to be a borer of teak timber and gave a brief account of the insect, but his description of the insect quite widely from that of Hampson (loc. cit.) and from the external characters observed on the insect under study. The markings on both fore and hind wings described by Hampson and Atkinson (loc.cit.) differed from each other as from the markings on the insect under study. Although Hampson gave a drawing of *p. signifer* Walk, and a brief general description, Atkinson's drawing of *P. signifer* Moore was unavailable, and the latter's description of the insect was also very brief made in very general terms, Furthermore, Atkinson in describing *P. signifer* Moore as a pest of teak did not make comparisons with Hampson's description of description of *P. signifer* Walk. nor did he mention the latter's account of the insect which renders the identification of the insect under study more difficult.

PLATE XI

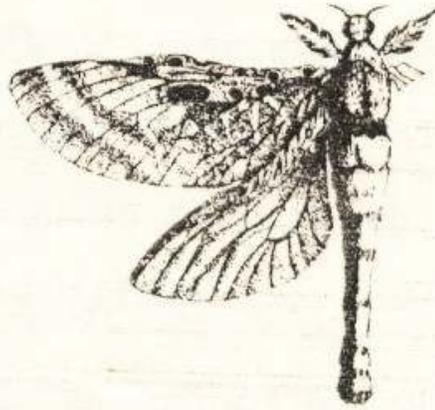


Fig. 20. Root-borer moth.

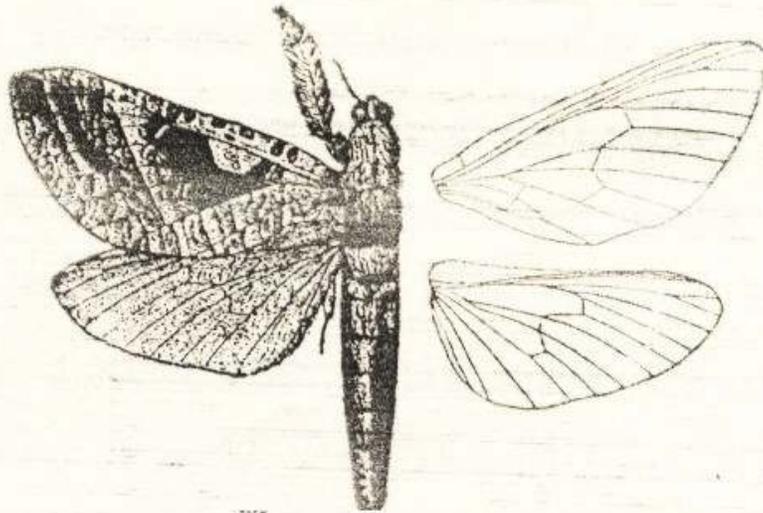


Fig. 21. Phassus signifer Walk. (after Hampson, 1892).

Hampson described the ground colour of the fore wing of *P. signifer* Walk. as yellowish flesh-colour or pale gray brown, whereas Atkinson described it as pinkish brown; the present studies showed that the ground colour of the insect was brown distinctly tinged with pink. Atkinson mentioned a large more or less triangular patch of ochreous brown in the center of each fore wing, bearing on its outer end two or three yellowish spots. The insect under study showed a more or less triangular dark brown patch in the center of the fore wing, but the presence of yellowish spots was not observed (Pl. IV, fig.7; Pl. V. fig. 8; Pl. XI, fig.20); instead, six distinct unequal and unequally spaced more or less round brown spots were observed along costal margin of which five, except the proximal most one are margined with pink. Hampson's drawing of *P. signifer* Walk (Pl.XI, fig.21) also showed 6 or 7 spots along costal margin of the fore wing, but the placement and size of the spots varied quite widely from that of the spots on the fore wing of the insect under study; two other very distinct dark brown spot-one margined with pink and more or less round lying below and adjacent to the second spot along the costal margin, and the other unimagined and distinctly elliptical lying almost directly below the third, fourth and fifth unequally spaced spots along the costal margin were also observed. No diffused streaks mentioned by Hampson were observed on the fore wing of the insect under study.

Hampson's description gave the colour of the hind wing as "flesh coloured". Atkinson stated that "the hind wings are of a decidedly pinker shade than the fore, and are unornamented"; the insect under study showed the decidedly pinker shade of the hind wings, but they are distinctly ornamented with a narrow sharply tapering, pennant-like strip made up of long, very pink hairs along almost two thirds of the length of the costal margin the hairs becoming brown in colour towards the distal or apical end of the strip; in addition, two quite distinct more or less round brown spots and a brown patch were also observed towards the apical third along the costal margin.

In describing *P. signifer* Moore. Atkinson did not give the wing venation of the insect. Hampson gave the wing venations of *P. signifer* Walk. but a comparison between wing venations of Hampson's *P. signifer* Walk. and the insect under study cannot be given because only external examinations could be made of a single intact adult specimen available for the present study.

Therefore, more specimens of the insect re needed to study both the external morphology and anatomy of the insect such as wing venation, wing coupling apparatus, legs, mouth parts and genitalia, and other larval and pupal characters before determination could be made of the insect's identity.

Larva

The general description of the larva of *P. signifer* Moore given by Atkinson compared will with the extenal characters of the larva of the insect under stud. Hampson, however, did not describe the larva of *P. signifer* Walk. in his account of the insect.

Method of attack by the insect on teak

Beeson (1921) in his report on *P. signifer* Moore as a borer of teak states that "the caterpillar of this moth borers a gallery in the heart-wood which is carried from the mouth in the sapwood in a vertical direction downwards. *Duomitus ceramicus* (*Xyleutes ceramica*) on the other hand always carries its heart-wood gallery upwards. "Atkinson (loc. cit.) in his report on *P. signifer* Moore as a pest that does damage to teak timber mentioned that "the heart-wood gallery of this species, in contradistinction to that of the Bee-hole Borer, invariably runs downwards." But neither author mentioned the height of the tree at which the borer usually begins the attack although they both mentioned that the tunnel is of great length, frequently up to twenty inches." Neither did the authors mention that the tunnel extended to the tap-root, nor did they mention

the age or dimensions of the affected trees. In any case, present observations showed that the insect began attacking teak trees at a height of three inches at most from ground level, and the single larva that invariably inhabits each affected tree unerringly bored its way down the tap-root. The attack was first observed in two-year-old plantation teak trees and it has continued for four years up to the writing of this paper. The figures or plates relating to Atkinson's description of damage caused by *P. signifer* Moore were unavailable for comparison.

It may be mentioned here that an unidentified metallic blue beetle belonging to the family Cerambycidae has been observed in the tunnel made by the insect under study causing further damage during the later stage of the present observation. This has been discussed at length in the following sections.

Other host trees of the insect Beeson) 1961) gave the host tree of *P. signifer* (author unnamed) (identified later by N.B. Tindale as *Endoclitia chalybeata* Moore – M.L.R.; quoted from Beeson, 1961) as *Clerodendron infortunatum* L. . *Gmelina arborea* (Yemane), *Tectona grandis* (Kyun), and possibly also *Terminalia myriocarpa* (Ye-taukkyan), but did not mention the method of attack of the insect; the author mentioned the occurrence of five other species of the genus *Phassus* and gave brief accounts of them as follows: “(i) An unnamed species of *Phassus* attacks young living *Lagerstroemia flos-raginatae* in Assam; the caterpillar girdles the stem by cutting away the bark in a horizontal band about ¼ of an inch wide, and makes a tunnel running vertically upwards in the centre of the stem, length 4 inches, diameter about 1/8 of an inch. The tree deposits considerable extra wood and produces a dense mass of adventitious roots above the girdle. The moth emerges in February and March (ii) Another species attacks *Buettneria pilosa* in Burma. (iii) Another in *Gmelina arborea* in Burma emerging in May. (iv) Another in *Machilus edulis* in Bengal emerging in August. (iv) Another in *Strobilanthus nesianus* in Bombay emerging in June.. The author also mentioned possibility of the occurrence in Burma of an undescribed species of the genus *Phassus* and not the true *signifer* which attacks teak. The emergence period of this species is stated to be during “April – May and earlier.”

The present findings are that the insect under study attacked four species of trees namely, *Tectona grandis*, *Oroxylum indicum*, *Wendlandia glabrata* and *Lagerstroemia villosa*, and the emergence period was in May each year for four successive years. The age and size of the trees at which these tree species were attacked by the insect is discussed in the following sections.

Significance of weeding The development of compartment 49 of the pure teak plantations in South Nawin Forest Research in Prome Forest Division was begun during 1974-75 planting season. Sowing of seeds is usually done in May each year, and the growing season is considered to be usually between June and December; four year weeding schedule of 3, 3, 2, 1, was in effect at that time (re. Page 3). The three weeding during the first two years of plantation development being usually carried out in June, July – August and December, when observation of the insect under study were first made in October, 1976, there was a complete lack of large weeds such as *O. indicum*, *W. glabrata* and *L. villosa* in this compartment although a few trees of these fast growing, soft wood species were observed in the immediate vicinity of the plantations on land unworked for plantations development. Lack of these weeds was similarly noted during examination of the same compartment during April to June, 1977. This absence of weed trees may probably have been largely due to the efficiency of the weeding and the effectiveness of the weeding schedule. It may be mentioned here that compartment 49 was in its third year of development at that time and the first of the two weedings scheduled for the year had already been implemented at the time of the examinations; the second weeding for the year was also implemented during July – August

period, 1977 (personal communications with Divisional Forest Officer, Prome)¹/. However, large weeds such as those mentioned above began to appear in compartment 49 when it was examined in June, 1978, and one of the three fast growing species, namely *O. indicum*, was found to have been attacked by the insect. The compartment was in its fourth year of development at that time and single weeding for the fourth year according to the earlier four year weeding schedule was omitted because the order for change of the weeding schedule to 2,2 came into effect on 25 October 1977. In examining the same compartment in May, 1979 when it was its fifth year of development, it was observed that the three fast growing tree species mentioned above had grown to heights of 10-15 feet and girths of 8½ - 10 inches, and that all the three species, namely *O. indicum*, *W. glabrata* and *L. villosa*, had been attacked by the insect in addition to teak.

These general but important observations appeared to strongly indicate that an effective weeding schedule and efficiency in weeding operations is essential for proper plantation hygiene.

The probable cause of attack by the insect on teak

Insects belonging to the order Lepidopteron need a comparatively large amount of moisture to survive in dry areas and are fragile. Therefore, they usually live on soft and succulent parts of woody trees such as leaves and soft shoots or on herbaceous plants where moisture is bound to be abundant. They rarely live as borers on woody trees. They either lay their sticky eggs by sticking them on smooth stems or leaves covering them with hairs or scales, or between cracks in barks of trees when the eggs are non-sticky. In the latter case, the soft parts under the bark enable the young Larvae to survive better because they can chew their way in faster and thus become insulated against danger of attack at a faster rate. This probably is the reason for their preference to fast growing, soft wood tree species which are usually characterized by the possession of rough bark. Therefore, in the case of the Lepidopterous rootborer under study the insect probably has been compelled to adapt itself to boring into the more succulent part of deciduous teak, namely the root, for its survival in the absence of fast growing, soft wood trees in the well-weeded plantation; the lower part of the tree also appears ideal because of moistness due to soil water which is more or less retained by large fallen leaves and underbrush; in addition, it offers the insect a good place for concealment from danger.

Possible methods of control

It would appear from the foregoing discussion that weeding largely contributed to the hygiene of young monocultures in Prome Forest Division. An effective weeding schedule and efficiency in weeding operations could well be a remedy for the control of this insect in teak monocultures. But observations also appeared to indicate that in monocultures hygiene of planted areas of the plantations alone is not sufficient for the successful establishment of plantations. All areas within the plantation perimeter should be free of encroachment from all other tree species, since these could become reservoirs for insects having wide host ranges and high adaptability. Evidence of forest and agricultural insects becoming adapted to hosts other than their own when the supply of original hosts had depleted is well documented. And the ability of these insects to breed in large number of alternative food plants makes it difficult to prevent attack in young plantations and in nurseries adjoining natural mixed forests. Therefore, direct remedy becomes necessary first to reduce the number of these insects and then to eradicate them in the best manner possible at the most appropriate time.

It would seem appropriate to mention here that the insect that has been doing the most damage to teak in Burma since nearly 150 years ago causing losses estimated to approach US \$ 18, 000,000 ^{1/} is the beehole borer, *Xyleutes ceramica*, which is also a Lepidopterous insect. This insect is also known to live on a wide range of hosts including *Callicarpa arborea* (Daung-sat-pya), *Clerodendron infortunatum* (Petka), *Gmelina arborea* (Yemane) in Burma and *Vitex parviflora* in the Philipines.

The beehole borer has been left to adapt itself so perfectly to teak that more than 25 years of research on the insect conducted prior to the Second World War has not enabled foresters to contain it.

Therefore, the following may be suggested as part of forestry practice in teak plantation development.

^{1/}. Computation based on material from sandwell Rept. (1978).

vol. x 4040/2, P. 93, Vol. I, p. 145 and Rodger (in Beeson, 1921).

Silvicultural Control

1. It has been mentioned earlier that forests in South Nawin Forest Reserve are made up of tree species which are many and varied. All of these species were felled in areas marked for plantation development. But small areas that were considered unsuitable for plantation development were left unworked and unattended.

Since these small unworked areas with their wide variety of original flora can harbour insects such as the one under study having wide host ranges, they could be considered as potential reservoirs of insects that have capabilities of adapting themselves to teak when the numbers of original hosts are depleted or at times of insect overpopulation due to favourable conditions. Therefore, it appears only logical that in monocultures areas should not be left unworked or unattended within the plantation perimeter.

2. *O. indicum*, *W. glabrata*, *L. villosa* and other fast growing soft wood tree species standing within the perimeter of the plantations should be cut down from about one foot above the place of injury and the stumps removed and burnt; the stumps and the felled trees should not be left lying for any purpose since these might stay moist and sprout permitting further infestation.

3. Careful examination of all standing trees should be made beginning from the every first weeding operation. Since the appearance and location of injuries on affected trees are well established, no special skill or labour is needed to detect affected trees. These affected trees including teak can either be removed together with the stumps and destroyed and the areas vacated by the affected teak trees replaced with new trees or stumps, or they can be treated with an appropriate insecticide as detailed below before removal to ensure destruction of the insects which live concealed inside their boreholes. All of this apparently can be carried out during weeding without much extra cost.

The most appropriate time to carry out all the three control operations appears to be during each weeding. While the present weeding schedule appears to be an effective silvicultural practice a critical reappraisal of it should be made in the light of very large teak monocultures.

Chemical Control.

Insecticide treatment of the concealed insects should not be difficult since the entrance hole lies almost at ground level. The soft covering over the entrance hole should be removed first. One per cent solution of a non-residual contact-stomach-volatile insecticide

such as Malathion or Nogos should then be squirted down into the tunnel through the entrance hole using a plastic dropper which can be bought quite cheaply on the open market. Removal of affected trees after treatment is suggested since either disease or other insects may continue inflicting additional injuries through the wounds caused by the root-borer. It may be mentioned here that during the later stages of the present observations an unidentified metallic blue beetle belonging to the family Cerambycidae has been observed in the bore holes made by the insect under study causing additional injury. This unidentified beetle has earlier been observed causing serious damage to four-year-old plantation *Pyinkado* (*Xylia dolabriformis*) in East Katha Forest Division by attacking the trees from vine-caused injuries.

In conclusion, the results of the present observations suggest that there appear to be no record of a Lepidopterous root-borer attacking teak having characters that agree completely with those of the insect under study in the available literature on South East Asian forestry. This may probably be because of the peculiar method of attack by this borer which confused general observers or because a variety of *P. signifer*, or even a different species of the genus *Phassus* has adapted itself to teak through a different method of attack due to lack of its original host or hosts. On the other hand, it could well be a species yet undescribed. In any case, further studies are required and more specimens are needed to study both the external morphology and anatomy of the insect such as wing venation, wing coupling apparatus, legs, mouth parts, genitalia and other larval and pupal characters before determination could be made of the insect's identity. The results of these studies coupled with those obtained so far may indicate adaptive capabilities of forest insect, and may enable forecasting of insect outbreaks in teak monocultures that are projected for years ahead.

An effective weeding schedule and efficiency in weeding operations is essential for the control of and protection from this insect. This can eliminate large weeds such as *O. indicum*, *W. glabrata* and *L. villosa* that are potential reservoirs for the insect. And it is evident that an efficient system of weeding schedule should be worked out and put on trial. Careful conduct of these trials and the results obtained there from could reveal periodic situational pictures of plantations in their early and more manageable stages of development which could be used for successful plantation development.

There should not be any unworked areas within the plantation perimeter. If areas are left unworked, these areas should not be left unattended and all potential reservoir trees mentioned above should be cut down and the stumps removed at every weeding and burnt.

All affected teak trees should be removed together with the stumps during every weeding and burnt.

4. The use of a non residual contact-stomach-volatile insecticide solution in water such as Malathion or Nogos at one per cent concentration will add efficacy to all control measures since it will ensure the destruction of the larvae inside the stems which otherwise may pupate and escape from affected trees or stumps that may accidentally be left unburnt. To obtain this concentration of the insecticide either 4.5 ccs. of 100 EC Malathion or Nogos, or 9ccs of 50 EC formulation in one gallon of water is sufficient.

5. Complete spraying of the basal parts of all plantation teak trees with an insecticide having a residual half-life of about 50 days may be suggested so that the insect emergence period of about 30 days in the month of may would be covered and no contamination of forest creeks and rivers on which the rural residents depend for water would result when continuous heavy showers fall in the later months.

Allowing to grow more susceptible trees such as the three species mentioned above as bait or traps cannot be suggested because this will amount to increasing the population of an

insect which has an extremely high capability to perpetuate itself on teak as proved by the results of the present observations. Moreover, the dilution of teak monocultures with other extremely fast growing species would be equivalent to the development of a mixed forest in which teak would be dominated, and the concept of inducement of fast growth and high per acre yield would be defeated. At the same time there will be no guarantee that the forest would be free from the root-borer damage because the insect will certainly turn to teak at times of over-population. It must be borne in mind that the insect has shown its ability to even perpetuate itself on teak alone in the early stages of plantation development as proved by the present observations.

However, further studies on this insect are needed before a detailed schedule for the control of this insect could be worked out and applied.

References

1. Atkinson, D.J. (1931). Insect Damage to the Timber of Teak (Tectona grandis). Burma Forest Bulletin No. 26, p.3-4, Supdt., Govt. Printing and Stationary, Rangoon, Burma.
2. Atkinson, D.J. (1936). A Survey of the damage to teak timber by the beehole borer (Xyleutes ceramica Wlk.) throughout the main teak-bearing forest of Burma (Lepidoptera-Cossidae). Indian Forest Records (New Series). Entomology, Vol. II. 96pp. Manager, Government of Indian, Press, New Delih.
3. Beeson, C.F.C. (1921). The beehole borer of teak. A preliminary note on the ecology and economic status of Duomitus ceramicus, Wlk. in Burma. (Lepidoptera; Cossidae). The Indian Forest Records Vol. III, part III, Superintendent Government Printing, Calcutta, India. (1961). The Ecology and Control of the Forest Insects of India and the neighbouring countries, P. 462-464 Vasant Press, Dehra Dun, India. Copyright by the Government of India.
4. Hampson, G.F. (1892). The Fauna of British India including Ceylon and Burma. Moths – Vol. I. P. 9-10, 316, 318. Taylor and Francis, Red Lion Court, Fleet St., London.
5. Imms, A.D (1964). A General Text Book of Entomology Ninth edition, entirely revised by O.W Richards and R.G Davies. Methuen and Co. Ltd. London. p. 511-538.
6. Kaufman, C.M. (1968). Teak production and culture in Thailand. J. Forest. 66: 396- 399.
7. Moore (1949-50). Sil. Res. Rep., Bombay, in Kadambi, K (1972) Silviculture and management of teak. School of Forestry, Stephen F. Austin State Univ., Nacogdoches, Texas, Bulletin No. 34, p. 100.
8. Troup, R.S. (1921). The Silviculture of Indian Trees Vol.II. pp. 715, 729, Clarendon Press, Oxford.