Studies on the biology of Indonesian Scolytoidea

by

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1. *Xyleborus fornicatus* Eichh. as a primary and secondary shot-hole borer in Java and Sumatra.

Introduction

A small black *Xyleborus* sp., early identified as *X. fornicatus* Eichh., the well-known shot-hole borer of tea in Ceylon, was found to occur as a destructive primary borer of *Schleichera oleosa* (fam. *Sapindaceae*), the kesambi tree, in forest plantations in Java, and as a borer of more or less secondary tendencies in tea, castor (*Ricinus*) and, incidentally, in a large number of other woody plants, in Java and Sumatra, all in the twenties and early thirties.

With regard to the peculiar habits of the local borer, which were of special interest to forestry and which appeared to differ in some respects from what had become known from Ceylon, some observations were made and material collected where opportunities presented themselves. In the present paper the details are fully elaborated to complete a few preliminary notes published a long time ago (Kalshoven, 1924, 1925).

Taxonomics

The shot-hole borer of tea in Ceylon was considered to be identical with *X. fornicatus* Eichh. — described from Ceylonese specimens without host-plant record in 1868 — since the appearance of a paper of Blandford in 1896. However, Eggers (1922) came to the conclusion because of its more markedly curved elytra, that the Ceylonese tea borer belonged to a different species, which he described as *X. fornicatior* in 1923. At the same time he enumerated some specimens collected in India and New Guinea (hosts unknown) and a borer in rubber (*Hevea*) in Java as identical with the true *X. fornicatus* Eichh. Sampson (1923) who also had studied a long series of the beetles — including material from Java submitted by me in 1922 — found himself unable to accept *X. fornicatior* as a good species.

Beeson (1930) elaborating the viewpoint of Eggers — which had been confirmed by Speyer (1923) from observations in Ceylon — separated the extensive material at his disposal into two sub-species: (a) *X. fornicatus* subsp. *fornicatus* Eichh., 2.4—2.5 mm, basal third of elytra more or less flattened and horizontal, found in castor and 6 occasional hosts, distributed over Ceylon, India, Burma, Tonkin and Java, and (b) *X. fornicatus* subsp. *fornicatior* Egg., 2.2—2.35 mm, elytral curve more convex, from tea and 4 leguminous hosts, occurring in Ceylon, India (2 localities) and Java, Bogor. He remarked that the given characters were

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fairly constant and that colonies and broods of the 2 subspecies were readily distinguished. However, isolated individuals, with transitional characters and no biological data, could not be assigned satisfactorily.

GADD (1946) on the whole substantiated the viewpoint of BEESON, although he found intermediate forms between the two sub-species and proved that specimens of the borer from tea would breed in castor and vice-versa.

SCHEDL recently identified an extensive series of beetles collected from tea in Ceylon during a renewed research of the borer's status, all as *X. fornicatus* Eichh. again (see JUDENKO in the Symposium 1956).

The submission to the specialists of specimens from my collection led to the following results: BEESON identified specimens from kesambi in Margasari and from castor in Bogor (both in Java) as *fornicatior*, and those from kesambi in Bodjonegoro, Java and from tea in Siantar, N.E. Sumatra as *fornicatus*. EGGERS labelled as *fornicatior* a specimen from kesambi, Bodjonegoro and one from *Citrus*, Bogor. Moreover, there are single specimens labelled *X. fornicatior* det. EGGERS, from tea at Bahbirong Ulu, and from the Nagahuta Tea Estate in N.E. Sumatra, leg. CORPORAAL, in the collection of the Zoological Museum, Amsterdam, and from tea, Tjibadak, Java, 1902, and from 'Java coll. Hagedorn 1915' in the Leiden Museum. *X. fornicatus* Eichh. det. EGGERS, is only represented in the Amsterdam Museum by 1 specimen from Java and 2 from Sumatra, including one from Siantar, leg. CORPORAAL 1919, without host indication but certainly found in tea (see later paragraph).

From the files of the Institute of Plant Diseases in Bogor it could be traced that the specimen from the HAGEDORN collection, now in Leiden, was submitted in 1910 by DAMMERMAN, who had collected the borer from diseased *Hevea* in the Preanger District in Java. Therefore the labelling of the specimen as a paratype of his *fornicatior* by EGGERS is in contra-distinction to his claim made in his paper of 1922 that the borer in *Hevea* belongs to the true *fornicatus* Eichh.

More recently a considerable number of my samples from different hosts, including kesambi, tea, castor and rubber in Java and Sumatra, have all been identified as simply *X. fornicatus* Eichh. by SCHEDL. This authority mentioned *X. fornicatior* Egg. only once in his many taxonomic papers on Indomalayan Scolytidae, viz. for specimens found in *Tephrosia maxima* in Pasuruan by F. A. T. Th. VERBEEK, II.1929 (SCHEDL 1951).

All this goes to justify the conclusion that there has been much diversity of opinion between the specialists and that specimens from the same hosts in Java and Sumatra have been placed in both forms recognized by BEESON and EGGERS.

My own recent re-examination of all material at hand has led me to the opinion that a separation of the series from various hosts in Java and Sumatra into two forms, *fornicatus* and *fornicatior*, is virtually impossible, especially not on the basis of the averred diversity in the curvature of the elytra seen in profile. However, various samples do show some difference in size. The specimens from kesambi and various incidental hosts in the plains of C. and E. Java are rather uniform, the ♀♀ ranging in size from 2.3—2.45 mm, the ♂♂ from 1.3—1.7 mm. The same can be said for the samples from castor and several other occasional hosts in Bogor and environments in West Java. One sample from teak in Bandjar,

W. Java, 50 m, and a few from the hills and mountainous parts up to some 1000 m in W. Java and C. Java have a slightly larger size on the average, several ♀♀ specimens measuring 2.4—2.55 mm (the few ♂♂ available 1.6—1.65 mm) and some coming quite near to *X. xanthopus* Eichh. (see next paper in this series). The range of samples from Sumatra is not comprehensive enough for ascertaining similar differences; the size of the specimens combined range from 2.3—2.55 mm.

Consequently I have not attempted to arrange the records and observations, to be mentioned in the present paper, in accordance with any special forms or subspecies.

Primary attack on kesambi, *Schleichera oleosa*

Records of infestations observed

1. A severe infestation by the shot-hole borer of the kesambi trees standing in rows in a 4-year old mixed plantation of teak/mahogany, was observed by Dr. R. Wind — who was in charge at the time of the Silvicultural Section of the Forest Research Institute at Bogor — in the Margasari range near Tegal, C. Java in June 1920. There were two plots of this mixture in a series of experiments on interplanting teak, sown at 2.5 × 2.5 m spacing, with various more or less shade bearing species, the kesambi being intended for filling up the spaces. The whole plantation had developed satisfactorily so far, but a number of the kesambi plants appeared to have been attacked recently and even partially killed by the borer. Other species had been hardly affected at all.

I made additional entomological observations in this Margasari plantation for a few days about 3 weeks later.

The following cases of similar occurrence of the borer came to my attention in subsequent years:

2. Serious damage to kesambi plants where they had been mixed with the light-demanding *Acacia leucophloea* in a plantation in the teak area south of Bodjonegoro, reported in September 1923 and examined October 1923.

3. Traces of infestation, new and old, found in the kesambi growing under a 9-year old *Dalbergia latifolia* stand which had been mixed with the first species, at Klangon, Mount Pandan, 300 m, same area as before, May 1924.

4. A reported attack by a shot-hole borer on *Adenanthera microsperma* saplings, which could be traced to an outbreak of the *Xyleborus* in kesambi plants growing in nearby young experimental plantations at Gadungan, Paree, Kediri, X.1924.

5. Old traces and more recent scars, not yet overgrown, on kesambi plants in a teak/*Actinophora* plantation in Margasari, XII.1924.

6. Damage to, and death of kesambi plants caused by the borer in a 10-year old mixed teak stand in the Tjaruban range, Madiun District, reported by the Forest Service, with samples submitted, May 1929.

7. Advanced infestation of a group of some 20 specimens of kesambi of 1—6 cm. diameter, which had grown spontaneously under the high canopy of an old teak stand near Telawa, Semarang, IV.1932. Several of the smallest sprouts killed.

With the exception of case 6, I examined these infestations during short inspections in the field.

Details of the attack during the outbreak phase.

The particulars given in this and the next paragraph are based mainly on the observations made in the Margasari plots in July 1920 (case 1); the shorter investigations of cases 3 and 6 have provided additional information.

The female beetles swarm in day time, mainly at noon. They crawl on the stems in search of places to start their borings. Entrance is gained often in the folds (cushions) of thick bark at the base of side branches and forks, and, in thinner limbs, at the leafscars and small crevices.

When the boring activity of the mother beetle is well under way small cylinders of compressed frass are pushed from the holes. The brownish dust spills over the stems and ground and is somewhat more conspicuous where it accumulates on the leaves of climbers growing around the stems. Where boring operations are finished or interrupted, the mother beetle sits at the entrance of the hole, plugging it neatly with its cylindrical body.

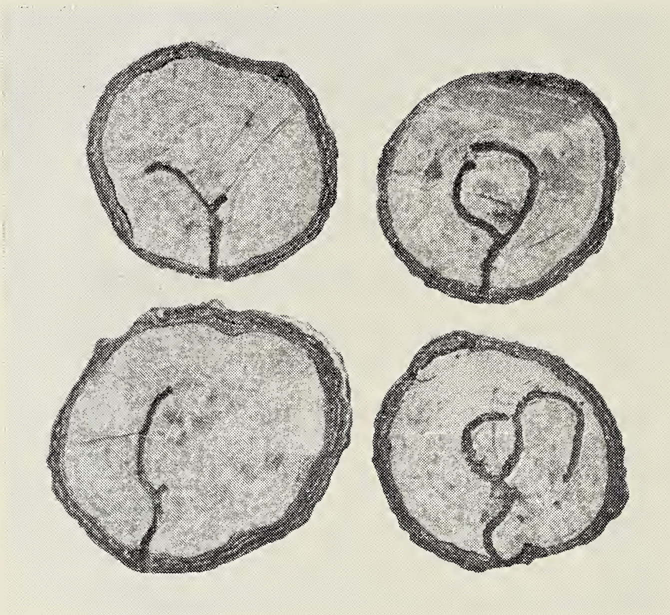

Photo VAN DEN BERG
Zool. Museum, Amsterdam

Fig. 1. Cross-sections of galleries of *Xyleborus fornicatus*, originating from primary attack on kesambi trees. In both galleries at the left the excavation of the second branch has just been started. (Natural size).

Often some dirt or sap oozes from fresh holes, drying to form brown patches on the bark. In some instances white froth exudes from the hole (observed in Margasari only). The liquid gives off a distinct sour smell of yeast, and it attracts a number of insects, mostly flies and ants, but also an occasional Cetonid beetle. Some dipterous larvae (probably of a Drosophilid, see JEPSON 1921, GADD 1941) may be seen moving in it. The galleries in small stems can be easily laid open with a knife and chisel. Most of them run straight through the bark into the wood, and soon bend off parallel to the circumference. The more advanced are bifurcated or trifurcated in a horizontal plane, showing the usual pattern of these borers (see fig. 1). In top-parts and branches the galleries may spiral up and down in the wood cylinder or run in the pith.

In several cases, however, tunnels are excavated in the bark itself, where it is

2.5—4 mm thick with a thin corky outer layer, and initial galleries may even be wholly situated in the bast. This peculiar and important feature has not been observed in infestations of other hosts by the same borer, or in other *Xyleborus* species, as far as I know.

The development of the ambrosia fungus coating the wall of the tunnels and causing a brown discolouration of the surrounding tissues may be observed in tunnels from 0.5 cm length up. In more advanced stages the wall of the tunnels has turned black, only the newly excavated ends being still whitish.

Eggs may be found in small clusters, slightly sticking together, in the galleries, as well as the white mobile larvae in various stages of development and the pupae which make fidgety movements with the abdomen.

The small, apterous males, often looking immature in colouration, may be present in mature broods. They have been seen moving outside the tunnels on the infested limbs, but only under laboratory conditions, and here it was also observed that they are able to gnaw little holes of 2 mm in bark tissue.

Newly emerged young ♀ beetles caged with newly cut limbs of the host will often readily bore into it, but no breeding has succeeded in the laboratory.

In the cases where the white sour-smelling froth exudes from the holes the galleries are rather wet inside and partially filled with a starch-like substance. No mother beetle is to be found in them and where larvae of the borer are still present they are motionless or decaying.

Size of the broods

Only a few notes on countings of the broods in plants primarily attacked by the shot-hole borer have been preserved:

Nr.	Host	Gallery system		Composition of the brood							Number of offspring
		development	length in cm	mother beetle	eggs	larvae	pupae ♀	pupae ♂	young adults ♀	young adults ♂	
1	*Schleichera oleosa*	initial tunnel	0.8	1	2						
2	(kesambi)	beginning of furcation	2.5	1	7	10					17
3		2 branches in bast, 2 in wood		1	3	3	3		5	1	15
4		tri-furcated		1		12			4	2	18
5		bifurcated		1		9	3	3			15
6		,,		1		5	1		12	2	20
7		,,		1					6	1	
8	*Inga vera*		6.3	1		1	2		3		
9	(see p. 157)		6.4	1		4	1		1	1	

It will be clear that the last column gives only the least number of progeny which, at the time of opening the gallery, could be expected to be finally raised. In nrs. 7, 8 and 9 some of the young adults may have left the gallery already. One male is formed against some 9 females. The occurrence of 3 male individuals (pupae) in one gallery, as noticed in nr. 5, must be looked upon as very exceptional.

As far as can be derived from the few figures, the rate of reproduction of *X. fornicatus* in kesambi possibly falls short of that of the species breeding in tea in Ceylon, where the number of offspring of one mother beetle may reach 25 individuals and even 34 individuals at its maximum (GADD 1941).

Effect on the trees. Their regeneration.

Kesambi trees do not show any loss of foliage or a change in its colour if they are not too severely attacked, but where horizontal galleries are made in the tops and branches they may break at this place. (This feature is one of the main causes of loss in infested tea plantations in Ceylon).

Photo VAN DEN BERG
Zool. Museum, Amsterdam

Fig. 2. Two views of same portion of kesambi stem showing scars left after the tunnelling of *X. fornicatus* in the bast and cambium of the living tree. Lower third: dead scales of bark with entrance hole, broken loose from the surrounding tissues. (In fresh cases the drying patches are sunk). Upper two thirds: similar dead bark pieces removed to expose the galleries in the cambium zone. (The affected patches of cambium are covered with callus under the adhering bark if the tree lives on) (× 2/3).

The discolouration of the tissues bordering the galleries has already been mentioned. Where the borer has tunnelled right through he bark into the wood a circular brown spot is formed in the outer bark, becoming more oval in a longitudinal section through the inner bark, and rather lengthened with vertical streaks in the cambium-zone. This indicates that the cambium is more sensitive to the introduced fungus. When the tunnels have been abandoned by the new generation of the borer and regeneration has set in, wound tissue replaces the killed part of the cambium and the small dead part in the bark is gradually lifted. In the long run, when the hole in the sap-wood has been occluded already, the only outward sign of the former attack is formed by the small, dead pieces of bark, with a hole in the centre, breaking loose from the surrounding layers and being gradually lifted and eventually shed.

Where galleries have been formed in the bark itself the process is a little different. The bark tissue and cambium is killed over 3 mm on both sides of the tunnel. These dead patches become sunk as a result of drying up and detach themselves along their irregular circumference from the surrounding, living bark tissue (fig. 2). If the attacked trees are still vigorous enough, the cambium forms wound tissue which overgrows the necrotic patches and lifts the scales of dead bark. Ultimately these scales crack and are shed or they may remain attached to the stem for a considerable time. A few auxiliary roots may sometimes grow at the base of formerly heavily infested trees.

Apparently trees only suffer a serious die-back or are killed to the root when they have been attacked simultaneously by a large number of borers or in short succession, this resulting in a severe loss of the vital cambium and adjacent layers and, thereby, in a total interruption of the sap-flow. On trees about 4 cm in diameter at breast-height, killed by the attack, 40—100 holes have been counted over a length of 75 cm. On trees which survived the attack in the same stand up to 20 holes were present over the same length.

The process of recovery may be extremely slow, especially during the dry season and where the kesambi is growing under an overshading principal crop.

Termites often start feeding on the dead outer layers of the bark and other dead portions and this, combined with the scales and lesions left by the borer attack, gives the trees a sickly and battered appearance.

Extent of the attacks. Size of trees and limbs affected.

There were two plots of the teak/mahogany/kesambi plantings in Margasari, 50 × 100 m in size and touching each other at one corner. The kesambi saplings had a diameter ranging from 2.5 to 4.5 cm at their base. In a few central parts. covering about ¼ of one plot and ⅛ of the other, some 80% of the kesambi plants were attacked and up to 8% were killed by the borer. In many other parts of both the plots about 50% of the trees were infested but no dead specimens were present. The remaining parts, mostly situated along the borders, adjacent to mature pure teak stands had about 20% of the kesambi attacked. As a rule the best developed specimens were infested. The unattacked plants in the centres of severest infestation were decidedly backward in growth. Top parts and branches less than 1.5 cm thick had not been bored into.

In the *Acacia leucophloea*/kesambi plantation of Bodjonegoro (case 2) the kesambi trees had reached a height of 6—8 m and a diameter at breast-height of up to 7—8 cm. They were overshaded by the wide spreading crowns of the Acacias. Some 4% of the kesambi had been killed down to the roots; in 12.5% the crown or side branches had died back, 62% showed shot-holes all over the stem but appeared to have withstood the attack quite well, 21% — again the most backward specimens — had remained free from the infestation. Curiously enough, no infestation was found in a row of kesambi plants of about the same dimensions growing in a nearby fire line.

In the *Dalbergia* plot with lower storey of kesambi (case 3) the picture was more complicated. Growth had been very uneven here. In places where the *Dalbergia* had formed a close canopy the kesambi plants had almost disappeared. In other places they often showed die-back and necrotic parts in the bark, not caused by the borer. *Xyleborus* was found active only in the plants which had developed relatively well and did not show signs of other injurous factors. Old traces of abortive attacks by the borer on some *Dalbergia* trees in the immediate neighbourhood seemed to indicate a former infestation of kesambi plants which had reached a susceptible phase at the time.

In the unmixed plot of Paree (case 4) which had suffered a recent severe outbreak of the borer no counts were made but saplings covered all over with the scars of passed infestation were very numerous. Only a small number had been killed.

The infestation of the group of natural growth near Telawa (case 7) showed that even a small concentration of the food plant could lead to an outbreak of the borer with a 100% infestation, resulting in the death even of root suckers of pencil thickness only.

Natural termination of the attacks

The observations in the *Acacia*/kesambi plantation and the unmixed kesambi plot (cases 2 and 4), both made in the month of October, that is at the end of the normal 6-months dry season in C. and E. Java, taught that a severe attack may apparently soon come to an end through natural causes. The numerous traces of infestation of the trees looked rather recent but living stadia of the borer were no longer present, only a few dead beetles being found sticking in the entrance holes. (Material concerning case 2 and submitted in the first week of September still contained a few living beetles, but no young brood). A revival of the attack was not reported in these localities.

A re-examination of the Margasari plot (case nr. 1) in December 1924 brought to light that remarkably few changes had occurred since July 1920. No thinning operations had been carried out and the condition of the individual trees could be inspected with the aid of a groundplan made during the outbreak 4 years previously. The old shot-holes and necrotic patches in the cambium had been covered with new xylem of 0.5—1 cm thickness. Some specimens which had been marked dead at the time had grown new shoots at their base. The backward plants which had not been attacked had remained free and had attained a diameter of 2—4 cm. It was clear therefore that no continuation of the attack had taken place, nor a repetition in later years, but that the infestation had come to an abrupt stand-still soon after the date of the first examination. A further cursory inspection in 1931 again showed that the borer had not reappeared in this place.

Attacks on large kesambi trees

Kesambi trees of large dimensions — having grown spontaneously — are fairly common throughout the teak area of C. Java.

I made a search for signs of shot-hole borer attack on a dozen trees, up to 35 cm in diameter, standing in close vicinity of the infested Margasari plot in July 1920. Only one active beetle was found in its tunnel of 0.8 cm in the bark, but several traces of former attacks were detected. They had the form — as previously described — of small raised dry patches of bark with the shot-hole in the centre or, where regeneration had advanced still farther, of smoothed cicatrices. Parts of the original galleries and overgrown necrotic patches could be exposed after cutting into the wood.

Similar old traces which were scattered over the trunk and the main crown branches of mature kesambi trees were repeatedly observed in various localities afterwards. However, no attack whatsoever was found in trees, badly scarred by notches as a result of the custom of native wood-cutters, who believe that their axes will get sharper if they drive them in the hard kesambi trunks before starting their job.

Unsuccessful attack on other tree species in the outbreak centres

During and after the outbreaks of the kesambi borer signs of abortive attacks on young trees of other species were very often noticed in the same plantations or their immediate vicinity. In one instance (case nr 4) they had been even become more conspicuous to the casual observer than the attack on the kesambi itself. As some of the infested plots formed parts of experimental plantations of various mixtures of tree species several observations could be made and these may be summarized as follows:

Swietenia mahagoni and *macrophylla, Acacia leucophloea, Albizzia procera*, and *Adenanthera microsperma* had reacted to the attempts of the borer to enter the stem by a flow of gummy or resinous matter from the small holes, which had apparently impeded the borer's efforts to establish itself. The resin, often mixed with the flooded frass, hardened in clots and small stalactites.

Tectona grandis, Vitex pubescens, Peltophorum ferrugineum, Cassia fistula, Trema orientalis and *Ceiba pentandra* reacted by the exudation of sap, forming wet patches and dirty streaks from the holes downwards. No reaction was noticed in a *Homalium tomentosum* showing only shallow open bore holes.

In most of these cases the borer had succeeded in piercing the bark and penetrating the wood for a few mm, but no discolouration of the tissues had ensued and the beetles had disappeared or had been killed. In some instances a dead beetle was found sticking to the hardened crust of resin, demonstrating the effective reaction of healthy trees to the atack (fig. 3).

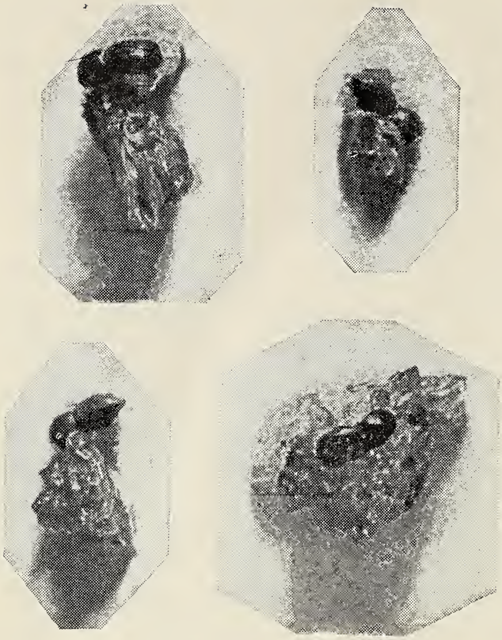

Photo VAN DEN BERG
Zool. Museum, Amsterdam

Fig. 3. Clots of dried resin with embedded beetles of *X. fornicatus*, found on *Acacia leucophloea* saplings after an abortive attack by the shot-hole borer. (× 5)

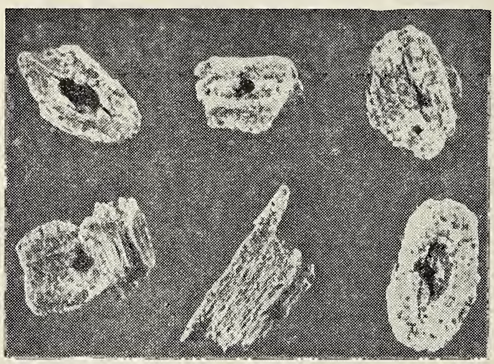

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Fig. 4. Dry encrusted pieces of bark with hole in the centre peeled off from the trunk of a *Dalbergia* tree which had withstood an attack of *X. fornicatus* a considerable time previously. Lower central piece seen from the side. (× 1½)

Where these trial attacks had taken place some time before, small patches of dry bark with a little hole in them were the only signs left.

In *Dalbergia latifolia* the traces of abortive attacks were rather conspicuous, drops of lac-red liquid were protruding from fresh holes, to turn black in the air afterwards. This liquid — called kino, and commonly formed as wound reaction in this species of tree — was absorbed by the bark tissue around the hole and proved to act as a preservative in the long run. Where the outer bark was weathering away afterwards by the usual agencies, including the activities of termites grazing the dead parts, the small dark cylindrical pieces of bark soaked with the kino (fig. 4), were left standing, this giving the trees a peculiar spotted appearance. This feature, somewhat similar to the traces of successful attack on kesambi trees, indicated the occurrence of numerous swarming beetles at some former period.

Once it was even found that a specimen of X. *fornicatus* had bored into the stem of a banana plant where it had been promptly flooded out by the glutinous substance which is profusely present in the sappy tissues.

No signs of attack were seen on specimens of *Lagerstroemia speciosa, Protium javanicum, Streblus asper* and *Alstonia scholaris,* although they were growing under the same conditions near the infested plants as the other species just mentioned.

Singular cases of evident or suspected primary occurrence of the borer in different hosts

In addition to the primary infestation of young kesambi trees a few instances were met with where X. *fornicatus* had attacked other plants, apparently not damaged by another cause. They are enumerated here:

1. Slight infestations of the stems of *Tephrosia* sp., 1.5 cm in diameter, on Bahbirong Ulu Estate near Siantar, N.E. Sumatra, V.1923. From the same estâte an attack on tea plants had been reported two years previously (see later paragraph on the occurrence of X. *fornicatus* in tea and castor).

2. Infestation of a sucker, 1—2 cm in diameter, which had grown from the trunk of a large *Inga vera* tree (an imported species, belonging to the Leguminosae) in the Experimental Garden, Bogor, II.1924. The top of the branch had died

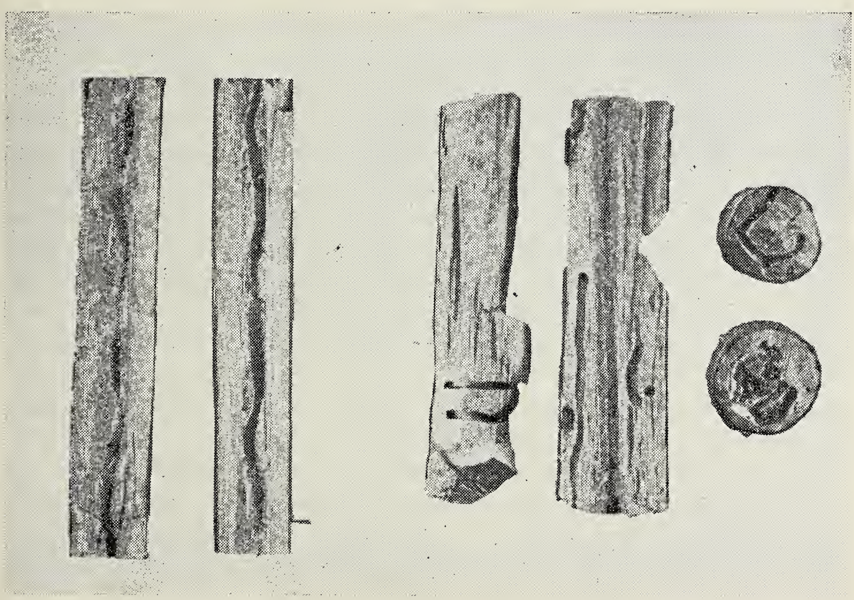

Photo van den Berg
Zool. Museum, Amsterdam

Fig. 5. Galleries of X. *fornicatus* made in singular cases of primary infestation. Left: in the pith of *Protium serratum* shoot. Right: in young branch of *Inga vera* tree (two vertical sections, two cross-sections). (Natural size).

back as a result of the borer's activities, but the basal part was still green and bearing leaves. About 10 galleries present, all containing healthy brood (see table on page 151 and fig. 5). The most recent infestation was found in the externally sound base of the branch.

3. Top part of a root-sucker of *Protium serratum* (not indigenous in Java, fam. Burseraceae) killed by the borer in the Botanical Garden at Bogor, XI.1924. Galleries extending in the marrow (fig. 5); some broods including a male present.

4. Kemloko tree (*Phyllanthus emblica,* fam. Euphorbiaceae) of 10 cm in diameter, found killed in the teak forest of Semarang, XII.1925. Bark already peeling off, numerous shothole galleries present on the surface of the exposed wood and in the sap-wood, even high up in the branches. Oval pieces of dead bark with a hole in the centre and loosening from the surrounding tissues showed that the attack had taken place while the tree was still alive. Only one dead specimen of X. *fornicatus* detected. Another tree, 16 cm in diameter, of the same species, standing next to it had the same scars in its bark. Here one living beetle was found in its gallery with little discolouration of the tissues. On a stump of a large dead side-branch several shot-hole galleries were to be seen. The case was considered to be a doubtful instance of primary attack by the borer.

5. Severe infestation of saplings of *Anthocephalus indicus* (fam. Rubiaceae) occurring in the young plantation Haurbentis in Bantam, VII.1940. No other causes of injury reported. Again, primary occurrence of X. *fornicatus* not proved.

Discussion and conclusions about the primary occurrence of X. fornicatus

The observations recorded in the foregoing paragraphs sufficiently show that X. *fornicatus* occasionally manifests itself as a true primary borer in Indonesia and that natural and artificial growth of young kesambi plants provide a major opportunity for breeding in the living tissues and building up dense populations. No sickly condition in the host is requisite, on the contrary the most developed individuals are attacked in the stands and backward plants remain free. That the outbreaks occur especially where the kesambi plants stand under the shade of other, more rapid growing trees — even as to become suppressed by the latter in the long run — is not the result of a weakened condition of the host-plant, but must be sought in other factors.

Similar evidence of the truly primary character of the *Xyleborus* attacks have been obtained for a long time past in Ceylon, where normal healthy tea plants are infested and manurial treatments, though favouring the condition of the plants and stimulating the regeneration, at the same time increase the liability of the plants to attack (GADD, 1941).

So far, the attacks on the kesambi have only attracted the attention when the infestation was already severe, so that part of the plants showed die-back or had succumbed. The initial stage has remained unobserved which may be explained by the fact that slightly and moderately infested kesambi plants have still their normal foliage, while the piles of the brownish wood dust are too inconspicuous to be noticed by the cursory observer.

Apparently the kesambi sprouts and saplings become attractive to the borer when the stem has grown to a thickness of one or a few cm, and remain suitable for breeding until they have reached a diameter at breast-height of about 10 cm.

It is still obscure why the plants become attractive in these stages. A similar phenomenon, however, has long been observed in the attacks on the tea bushes by the local race of *X. fornicatus* in Ceylon. Here the borer begins attacking the branches about 6 months after pruning. The incidence of infestation increases from month to month and reaches peak level in the second half of the second year, after which a natural decline in the rate of attack sets in in third year after pruning (GADD 1941, 1946).

The size of the broods in the kesambi appears to be rather small, but the development from egg to adult may be completed in 18—31 days, according to observations made in Ceylon by GADD. A considerable increase in numbers may therefore take place in some 4 to 6 months.

Active infestations of the kesambi have been observed in the months March/May, a period which falls in the rainy season in C. Java. They had come to a stand-still in two instances examined in the month of October at the end of the pronounced dry season. This may be taken to be an indication that favourable conditions for breeding of the borer are prevalent during the rains, and this assumption is supported by the results of observations made in Ceylon that the borer requires moist conditions if it is to thrive. The susceptibility to attack of young kesambi trees, combined with the large number of host-plants available and with the relatively high humidity in the lower level of the dense, mixed stands, therefore, may be looked upon as the main factors leading to the outbreak of the borer.

It is another matter of speculation where the beetles which launch the initial attack on a new plantation come from. However, the many signs of passing attacks on mature trees and natural growth of kesambi and the not infrequent occurrence of the borer species as a secondary borer in plants of many kinds (see second part of this paper) make it clear that the borer may be present in small numbers over large areas all the year round.

The numerous attacks on healthy trees of other species in the vicinity of the outbreak areas demonstrate that the borer, when swarming, is not able to locate its preferred host with unfailing accuracy. This phenomenon calls to mind the observation, published by H. WICHMANN (1927) that bark-boring Scolytids attracted to a stack of fire-wood, also alighted on the base of the tree against which the fire-wood had been piled up, and started to bore into the healthy tissues. The explanation given is that the beetles tend to bore into any wood surface which is situated within a sphere of the attractant.

Some indication that an infestation can continue over a prolonged period or may repeat itself in the same plantation (but not in the same plants) was obtained in one case (nr. 3) only. In three instances it was observed that a severe outbreak came to an abrupt total stand-still and that the borer population had died out or disappeared. In Margasari no repetition of the infestation occurred within a period of at least 11 years.

The factors which play a prominent role in the termination of the outbreaks have not become clearly defined. No parasites or predators have been found, and the absence of specific enemies has also been observed in Ceylon. The dry period which occurs in Java from May till October might well be considered to be a marked untoward factor for the borer. Moreover the condition of the host-plant itself during the dry seasons may make it unsuitable for a breeding place of the species which is dependent on an abundant growth of the ambrosia fungus in the tissues of the host. The consequences of the borer's habit of extending its galleries in the bark which leads to temporary loss of cambium or to die-back and even outright death of the host-plants, may contribute to the unsuitability of the stand to serve as a breeding medium afer an outbreak.

Furthermore it is conceivable that the appearance and spread of an organism which destroys the ambrosia fungus — as described on p. 150 — may check the normal infection and growth of the nutrient fungus in the borer holes to some extent in a definite locality, but this cannot be substantiated by data from Ceylon.

Finally, changes in the physiology and vitality of the borer itself, after passing a 'virulent' stage, might be thought responsible for the natural dying out of a population. GADD (1941) found that a cessation of attack during the 3rd year after a pruning in tea gardens is due to some factor or factors that cause an increase in the percentage of beetles which abandon the newly formed galleries before ovipositing, and become increasingly deterrent as the attack progresses. Similar physiological changes have been observed at the end of epidemics of bark-boring Scolytids in Europe.

Research work in Ceylon has also taught that the borer does not spread readily over large distances and that no mass migrations take place to adjacent plantations (GADD 1946) This may explain the phenomenon we observed in Java that a row of kesambi trees was not affected near the outbreak centre in Bodjonegoro (case 2). In this connection it may be mentioned that no infestation of the kesambi plants in the susceptible stage was detected in the Semarang area in 1920, the year of the outbreak in Margasari. In fact in the first area, where most of the forest-entomological investigations were carried over a number of years, infestation of kesambi was noticed only once (case 7). All this makes it clear that outbreaks may be restricted locally.

It needs hardly be pointed out that in the instances of successful primary attack on other plants than kesambi, recorded in the previous paragraph, no extensive outbreaks could develop because of the simple fact that the number of host-plants present was so small.

(to be continued)

Literatuur over Roemenië. Dr. Eugen V. NICULESCU, Str. Dr. Sion 6, Raionul Gheorghiu-Dej, Bucuresti, R. P. Romina, wil de afleveringen verschenen van de Faune de la R.R.R. (21 fascicules) en van de Flore de la R.R.R. (5 vols.) ruilen tegen publicaties, die verschenen zijn in Nederland of in Frankrijk. Correspondentie in de Franse taal. Een lijst van de insectenafleveringen is te vinden in de laatste prijscourant van de heer CLASSEY. — LPK.