BEAUFORTIA

SERIES OF MISCELLANEOUS PUBLICATIONS

ZOOLOGICAL MUSEUM - AMSTERDAM

No. 101 Volume 9 May 25, 1962

Observations on Coptotermes havilandi Holmgr. (javanicus Kemn.) (Isoptera)

by

L. G. E. KALSHOVEN*)

(Honorary Assistant, Zoological Museum, Amsterdam)

SEQUENCE AND SCOPE OF OBSERVATIONS

The first find of a colony of a *Coptotermes* species smaller in size than the wellknown *C. curvignathus* Holmgr., was made while I was inspecting *Acacia tomentosa* trees growing on the forest boundary near Tanggung, in the teak area east of Semarang, in August 1920. The colony inhabited a deep fissure situated in the fork of a living tree. In the following years what appeared to be the same species was found on dry timber in a few other localities of the same area, and also, by my co-worker F. VERBEEK, in the forests near Randublatung and Tjepu, all in Central Java. In 1926/1927 the first complaints were received of damage done by this termite in a godown in Surabaya, East Java, and to a house at Bogor, West Java. Gradually more evidence came to hand of its not infrequent occurrence in the lowland forests and its occasional invasion of buildings in various parts of the country.

In 1934—1937 observations on this *Coptotermes* were included in a scheme for incidental investigations into the termite life in the teak forests surrounding the field laboratory at Gedangan, near Semarang. Data on the attack on dry and green trunks of certain timbers were collected and a preliminary, rather unsuccessful search was made for the site of the central nest. The species was also included in various experiments. At Bogor some observations could be made concerning its occurrence in buildings and part of a colony was brought to the laboratory. Some results of these investigations have already been published (KALSHOVEN, 1941, 1952, 1955).

P. A. BLIJDORP taking over direction of the forest entomological investigations at Gedangan in 1940, succeeded in finding the central parts of the nests and the royal cell. This was published in his note of 1941. The

*) Received February 28, 1962.

personnel of the field laboratory added some data on this matter during the Japanese occupation of Java in 1943.

In my book on the pests of Indonesian crops issued in 1950, I gave a short resumé about the habits and economic status of the species.

IDENTIFICATION

The first samples of the species in question, collected by me in the teak forests were handed to N. A. KEMNER, who had joined the staff of the Institute for Plantdiseases at Bogor for a short period. No identifications were received, however, before his monograph on the Termites of Java was published in Sweden in 1934 (see below).

In 1928 I submitted some newly acquired samples of the termite to OSCAR JOHN, Riga, viz. four samples from the teak forests, one from a house in Bogor, and one from the godown at Surabaya. He identified them all with *Coptotermes travians* Hav. described in the soldier and worker castes from Malaya and Borneo, and found to be injurious to houses in Singapore (1894). The occurrence of *travians* outside Malaya/Borneo had already been mentioned by HOLMGREN (1914), who had identified as such specimens from three localities in East Sumatra (two of the samples consisting of imagines only) and also alates taken at light at Bogor. JOHN himself had collected what he considered to be this species in East Sumatra (see his publication of 1925).

In 1934 it appeared that KEMNER had identified two of my samples from the teak woods with his *C. javanicus* n.sp. which he had collected himself at Bogor and which he considered to be closely allied to *C. gestroi* Wasm. from Burma. The specimens of a third sample were mentioned by KEMNER as very similar to *C. parvulus* Holmgr. from India, and a fourth, small sample, containing three soldiers of comparatively small dimensions, KEMNER had described as *C. kalshoveni* n.sp.

With regard to the incongruity between JOHN'S and KEMNER'S identifications I addressed myself in 1934 to Prof. S. LIGHT, who had elaborated a method to distinguish species of the difficult genus *Coptotermes* by taking many measurements and calculating indices. He identified additional specimens from the teak forest of Java, as well as a sample from Bandjermasin, S.E. Borneo, as *C. javanicus* Kemn., a sample including alates from Bogor as *havilandi* Holmgr., and a small sample from the teak forest as *C. travians**). A sample from S. Sumatra and one from Bangka Island, consisting of specimens about the same size as those from Java, were not further identified than as *Coptotermes* sp..

These determinations added to the complexity rather than clearing the situation. *C. havilandi* had originally been described from the winged caste

*) LIGHT (1937) recording the find added: "From large piece of wood teak forest, Kedorngdjati". This is inaccurate and must be read: from an abandoned *Neotermes* cavity in a standing teak tree, Kedoengdjati, Febr. 1927. The locality is quite near to Gedangan.

collected in Siam (now Thailand) (HOLMGREN 1912). Later, winged specimens from Malaya were identified with the species, the range of variation being altered somewhat (HOLMGREN 1913b), and he listed a single imago taken at Banyuwangi, East Java, as belonging to *havilandi* (1913 a). The soldiers and workers of the species had remained unknown. In SNYDER's catalogue *C. javanicus* Kemn. is mentioned as a synonym of *C. havilandi,* for which synonymy Prof. A. E. EMERSDN has taken the responsibility, as he kindly informed me. M. AHMAD in his key to the Indomalayan Termites (1958) based upon his studies of the Chicago collection under Prof. EMERSON's direction, also places *javanicus* as a synonym of *havilandi.* In this key the measurements of the head of the imago and soldier are somewhat different from the range given by HOLMGREN and KEMNER.

I have myself checked the width of the soldier's head capsule — and sometimes a few other dimensions — in some 50 samples from Java. This material appears to be rather uniform, the head-width corresponding with the one given by KEMNER, 1.06—1.20 mm. But in some samples the soldiers were slightly smaller or larger, the total range being 1.0—1.35 mm. (AHMAD gives 0.98—1.14 for this value). Curiously enough, the number of joints in the soldier's antennae was found to be mostly 14, and exceptionally 13 or 16, while KEMNER mentions 15—18. Still, Dr. W. V. HARRIS, who was kind enough to investigate several samples from my collection, convinced himself that they all belonged to one species which sufficiently agrees with KEMMER's *javanicus* and is to be distinguished from HAVILAND's *travians.* While accepting the priority of the name *havilandi,* as stated by Prof. EMERSON, I have still mentioned the synonym in the title, to emphasize that my paper deals with the species properly described in its various stages by KEMNER.

SITE OF THE PRINCIPAL NEST AND ITS CONSTRUCTION

As in other, non-mound-building *Coptotermes* species the colonies of our Javanese species inhabit extensive systems of cavities and galleries, including in soms parts large concentrations with a peculiar structure, one of which — the most difficult to trace — is the central nest, the others being subsidiary nests.

According to BLIJDORP the central nest must be looked for in the excavated core of infested dead and dying trunks, but in well advanced cases it is to be found in the soil underneath the trunk between the roots. About the royal cell BLIJDORP reports that it "is usually to be found at some height in the trunk" and "is often situated more or less excentrically in a massive unattacked piece of wood". The pen-and-ink drawing illustrating his paper makes the impression that the cell is excavated in the wood itself. However, in a portfolio with BLIJDORP's original notes, I found a coloured drawing of another cell, attributed to *C. havilandi,* which shows that it may be a compact clump which can be detached. This agrees better with the author's statement that the cell is made of the same material as the rest of the nest, viz. light brownish woodpulp cemented together with faeces, a rather

brittle substance. The cell has a simple construction with a low, only roughly arched ceiling and is connected by wide galleries with the rest of the nest. When the inner parts of the nest had been laid open and the cell was reached, BLIJDORP found it empty as a rule, but the queen, supported by numbers of workers, could be located elsewhere fleeing from the disturbance. Brood cells and nurseries form a part of the central nest. Subsidiary nests, not containing any brood, have been found at a considerable distance from the feeding places, particularly so, where several trunks had been attacked by the same colony. Besides the normally functioning centre of populous and extensive colonies, BLIJDORP found one or more royal cells with brood cells obviously no longer in use, in more or less abandoned tree skeletons. Commenting on the apparent mobility of the queen the author concludes that in such cases it had moved, accompanied by the workers, a long distance to a new residence. This explanation sounds quite plausible.

Some further details on the situation of the nest-parts in special cases have been found in the original notes made during the field work, several of them by the Javanese assistant WARNO. They may be briefly cited here.
(1) Colony in and under a 10 m long trunk of *Albizzia lebbeckioides,* lying on the ground, felled some 5 years ago; basal part, 40 cm in diameter, and top turned into a labyrinth-like mass; a portion of 4 m below the top still consisting of solid wood and only the core honeycombed; here large numbers of eggs and young stages found but no royal cell; galleries connecting the nest with the old stump and roots; Nov. 1934 (for sketch of the groundplan see KALSHOVEN 1941).
(2) Infestation of a dead *A. lebbeckioides* trunk, 10 m high, 20 cm in diameter, honeycombed over 6 m; at its base at a depth of 40 cm, a nest 20 cm broad and high; no nurseries found nor the royal pair; 22 Dec. 1934 (WARNO).
(3) Infestation of a rotten *Acacia leucophloea,* 9 m high, 30 cm in diameter; galleries extended over a distance of 8 m to a living tree of the same kind, 25 m high, 60 cm in diameter, where a dry branch of 2,5 m was infested and the trunk attacked over 5 m; nest found at a distance of 2 m from the dead trunk in an old stump of *Butea frondosa,* central part 40 cm high, 30 cm broad; some small brood present; the queen captured near the opened nest; 22 December 1934 (WARNO).
(4) Infestation of a dead *Bauhinia malabarica,* 5 m high, 17 cm in diameter; at its base a subterranean central nest, 36 cm broad, 15 cm high; numerous eggs and young stages present, but a cavity in the nest, looking like a royal cell, found empty; 29 Dec. 1934 (WARNO).
(5) Infestation of a broken, dead *Acacia leucophloea* trunk, still standing 9 m high, 43 cm in diameter; a top part of 5 m lying on the ground; nest at a distance of 1.4 m built in and around an old teak stump (plate 1); nest subspherical, 50 cm in diameter; a small subsidiary nest situated between the infested trunk and the main nest; a circuitous gallery connecting various parts, exposed over a length of 12.8 m; 13 Febr. 1935 (KALSHOVEN/WARNO).

(6) Nest in dying *Acacia tomentosa* tree, 35 cm in diameter; core honeycombed forming a 'pipe' of 9 cm diameter; comb extended in the soil to a depth of 50 cm; queen encountered in the comb near the base but no royal cell found; a subterranean gallery followed over 76 m; 15 Dec. 1940 (BLIJDORP).
(7) Colony in a dying *Adenanthera pavonina,* 25 cm in diameter; core honeycombed from 1 m above the base to 5 m, along a 'pipe' 8 cm broad; a gallery descending from the trunk appears to be connected with the stump of a teak tree at 7 m distance, which contains a nest; however no nursery and no royal pair found; 13 Jan. 1941 (BLIJDORP).
(8) Colony in a dead, slanting trunk of *Adenanthera pavonina,* 50 cm in diameter, 8 m long, the core over its entire length converted into a comb, 35 cm in diameter; at one meter above ground-level the central part of the nest, the royal cell situated near the solid wood cylinder; just beneath it the cavities with eggs; at a lower level the nurseries with the initial larval stages; two compartments indicated on the sketch as 'store rooms'; the queen was caught in its cell, the king was not found; 13 Jan. 1941 (BLIJDORP).
(9) Nest in dead *Butea frondosa* trunk of 40 cm diameter; from 1 m upwards the core honeycombed over 4 m; the royal cell at 3 m above ground level, but royal pair not encountered; a small gallery extending through the base to a nearby log of *Albizzia lebbeckioides,* which was heavily infested, and to a lightly infested dead *A. procera*; 19 Febr. 1941 (BLIJDORP).
(10) Colony in dying *Albizzia lebbeckioides,* 30 cm in diameter, the core honeycombed up to 12 m; the comb, 19 cm in diameter, extending unto a depth of 15 cm in the soil; at one meter high in the trunk an empty royal cell; at 70 cm a royal cell containing the queen; 23 April 1941 (BLIJDORP).
(11) Nest in a still green *A. lebbeckioides,* 15 m high, 21 cm in diameter; at 30 cm from the base a hole from which protrudes a part of the nest; after the tree had been felled and sawn into short lengths the queen was found amongst the debris on the soil and the king in the midst of young larval stages at 90 cm from the base; the 'pipe' in the core was 3 m long and 10 cm wide; 9 May 1941 (WARNO).
(12) Colony in a recumbent *Acacia leucophloea* trunk of 3 m length, 16 cm in diameter, the core honeycombed; the main nest found in an adjacent old *Macrotermes* hill, 30 cm high; the royal cell situated at a depth of 13 cm; 29 Dec. 1941 (BLIJDORP).
(13) Nest in a dying, leafless *Albizzia lebbeckioides,* 15 m high, 13 cm in diameter, 8 cm wide comb extending in the core from 2 m above the base to 4 m; queen encountered in the central part; 10 March 1943 (WARNO).
(14). Nest in nearly dead and broken *A. lebbeckioides,* 6 m high, 30 cm in diameter; about half of the trunk honeycombed from the base to the top; 9 'queens' found in the comb; 11 March 1943 (WARNO).
(15) Nest in a stump of an *A. lebbeckioides* tree, 90 cm in height, 15 cm in diameter with a 4 m long shoot growing from the top; the core of the upper 80 cm part of the stump honeycombed and containing the royal pair at 70 cm above ground level; 16 March 1943 (WARNO).

(16) Half rotten stump of same species; 50 cm high, 10 cm across, the top covered with an incrustation of the termite; comb in the core 25 cm high and 8 cm broad; colony including a queen and numerous young larvae; 16 March 1943 (WARNO).
(17) Half rotten trunk of same species, still standing, top missing, 9 m high and 70 cm in diameter; the outside showing many signs of the presence of the nest; most of the wood from the base to the top honeycombed and destroyed; a central part of the nest in the core of the trunk-base, 1 m high and 30 cm broad, with a great crowd of the termites including a queen; 18 October 1943 (WARNO).

I presume that BLIJDORP based his conclusions mainly on the investigation of the six nests (nos. 6—10 and 12 of the list) which had been dug out and laid open under his supervision. Most probably the royal cell found in no. 8 is the one figured in his paper. The occupation of an old *Macrotermes* hill specified in the field note on no. 12, was apparently considered to be an exeptional case and is not mentioned in his paper. The various details in the other notes in great part confirm his conclusions but some of them give the impression that there is a greater variation in the situations of the nests than might be concluded from his communication. The discovery of not less than 9 'queens' ('radja') in nest no. 14 by the Javanese assistent, could perhaps be explained by the assumption that in this colony neoteinic reproductives had been formed, but no specimens have been preserved.

From my own observation I have only one, somewhat detailed note at my disposal concerning case no. 5, where a large nest was dug out near the field laboratory and photographed (plate 1). The ground was a little raised in this site, as in a small *Macrotermes* hill, and the subspherical nest was covered by a layer of clay of 12 cm. The nest was well separated from the surrounding soil, but lime concretions, also found in the surrounding clay, had been built-in in the bottom of the nest. It proved to be possible to lift it with the supporting stump in its entirety. A vertical section through the nest shows a labyrinth of flat rooms, only 1.5—2 mm high, many of them horizontal, others being more or less concentrically arranged. Some larger rooms were 3—6 mm high; the partitions varied in thickness from 0.25—2 mm. Large as this structure may be, as no royal cell was found it has to be considered as a subsidiary nest.

The details given here and by BLIJDORP show that the nest construction of our Javanese *Coptotermes* is far more concentrated and advanced than KEMNER suggested in his publication of 1929.

THE GALLERY SYSTEM; PERIPHERAL PARTS OF THE NEST

A very important part of the connections between the nest concentrations and the feeding places consists of covered runways, which climb the trees in the forests and the foundations and walls of the houses in built-up areas. For the construction of the galleries various materials are used such as earth particles, crumbs of bark and wood, granules of mortar, etc., and this some-

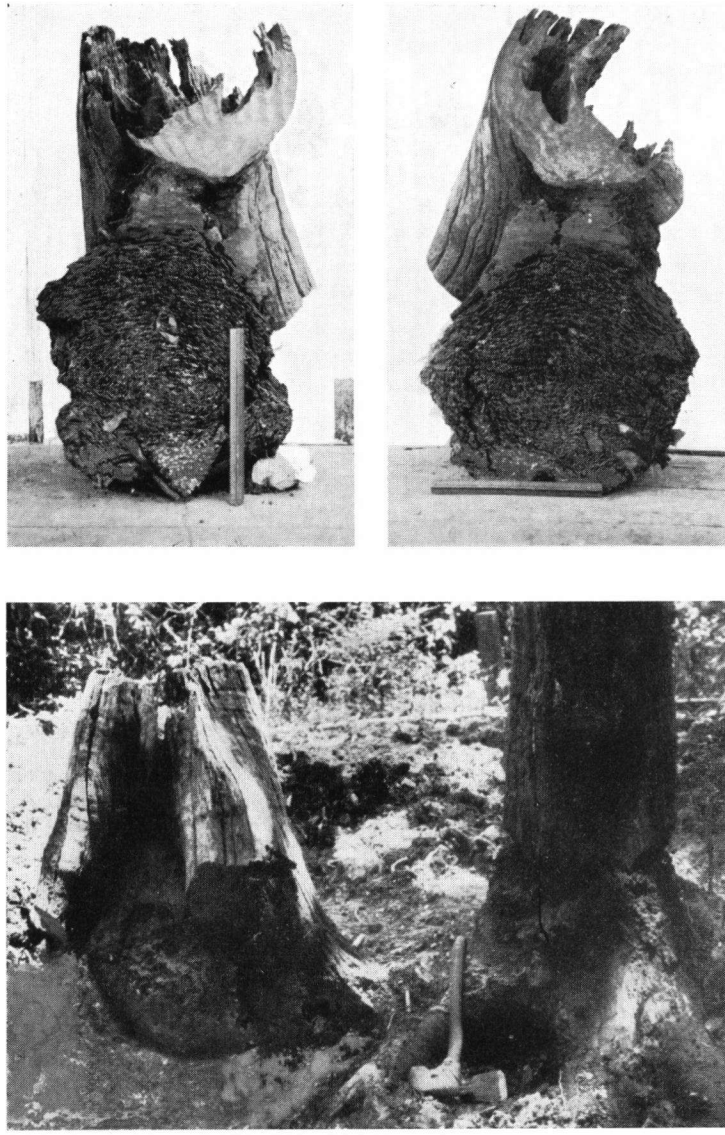

PLATE 1

Bottom: Unearthed subspherical nest of *Coptotermes havilandi* built in and under an old teak stump. Free space between the nest and soil is clearly visible. At the right: the base of a dead *Acacia leucophloea*, apparently the main feeding place of the colony (a Javanese axe placed on the fore-ground). *Top:* vertical section of the nest and stump, after the lump has been lifted from the ground. (The measuring staff is 30 cm). Gedangan, February 1935.

times give them the appearance of cardboard. All tunnels and galleries are lined on the inside with faecal matter, deposited in droplets which dry out in various shades, thus giving the walls the spotted, freckled appearance which is characteristic of most Rhinotermitinae. A feature which may help in recognizing *Coptotermes* tunnels is the frequent occurrence of white *Collembola* which freely move in the nest.

The subterranean galleries are very flat and run at a depth of some 15 cm; this level may be abruptly lowered or raised without apparent reason. The tunnels tend to follow horizontal roots, the underside of logs, the contour of a terrace bordered by a hedge, etc.. The foraging area of a single colony must vary considerably as it depends on the age and size of the colony and on the varying proximity of the main subterranean and overground sources of food. A network of galleries over the woodwork of the roof in a house had a length of 40 m.

Gnawing and feeding on the wood is not done over broad patches on the outside surface but the termites penetrate directly into the solid mass, eating out very narrow slit-like rooms, parallel to each other or concentric with the growth rings of the timber, with more or less thin partitions left. The rooms are gradually widened and these larger cavities, occurring at some distance from the nest concentrations, are filled with coral-like deposits of faecal matter, a kind of brittle wood pulp or papier maché. Other empty spaces near the feeding places, are also filled with these typical structures. They were found in the abandoned cavities of *Neotermes* in teak trees which had become inhabited by *Coptotermes* (see KALSHOVEN 1930, plate XX figure 53). A beam wholly used up by the termites with only the outer shell left untouched, is like a wooden box filled with the labyrinth and when bamboo is attacked in houses the hollow core is neatly filled with a cylindrical comb (see the photographs in KALSHOVEN 1950, fig. 64). The oldest dry parts of these fillings are no longer inhabited.

THE NICHE FILLED BY THE TERMITE IN CULTIVATED TEAK FORESTS.

No observations are available concerning the particular role played by the termite in wild, natural forests. In the teak forests of Central Java they have drawn attention by their frequent attacks on dead, dying and green standing trunks of tree species other than teak, which trunks were apparently the main food source of populous colonies. It has also become evident that the fallen trunks of the same tree species are extensively exploited by the termite and may provide food for long periods. However such old logs of wild growing trees are comparatively scarce in the well tended and uniform teak plantations.

The species has rarely been seen building its galleries along dead trunks of teak and it does not seem to play a role of any importance in the breakdown of old teak stumps, nor have teak poles left in the forest after thinning operations appeared to be particularly attractive to it. Moreover *Coptotermes* takes little part in the clearance of small forest litter. In all these cases common species of *Macrotermes, Microtermes* and *Odontotermes* are far

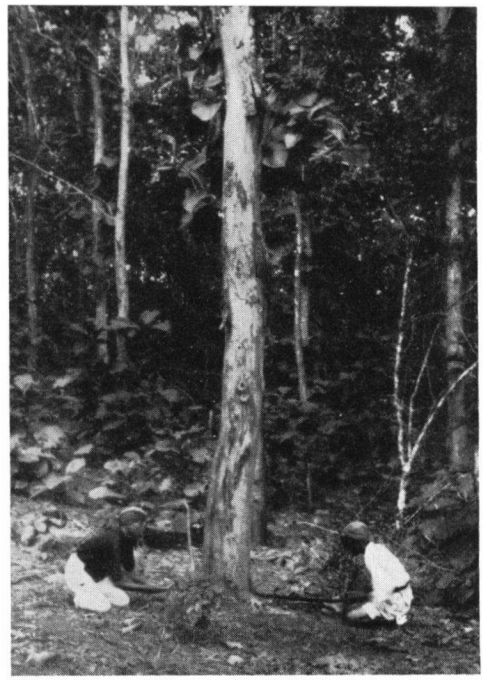

PLATE 2

Top: Coptotermes-infested trunk of *Acacia tomentosa* with broken-down crown, standing at the border of the teak forest. Two assistants engaged in felling the trunk with a whip-saw. *Bottom:* Two portions of the same trunk, split and showing the honeycombed core; at the left the corroded top; at the right a cross cut of the still fairly solid, though riddled, base of the trunk. On the fore-ground a Javanese axe with short handle. Gedangan, February 1935.

more active. During observations on the rapid extinction of *Neotermes* colonies in infested portions of teak trunks, sawn out and spread on the forest floor, *Coptotermes* was only present in four of the 40 instances in which subterranean termites had entered the cavities.

THE ATTACK ON LIVING TREES

BLIJDORP's studies of the nest places of *Coptotermes havilandi* (*javanicus*) in the teak forest of Gedangan led him to the conclusion that attacks on living trees are started in dead branches, snags and wounds occurring at some height on the trunks, and that the excavations are gradually extended downwards and upwards in the originally sound wood. As long as the colony has not succeeded in making a passage through the core to the soil, the covered galleries on the outer side of the trunk are used in maintaining a connection with the soil. BLIJDORP did not definitely specify whether the initial colonies are started in dead and damaged overground parts of the trees or are reached by exploratory runways of well established colonies which have their subterranean nest somewhere in the neighbourhood. Both modes of first entrance are apparently possible as may be concluded from the details on the nest situations already given and from the find of dealates in dead branches of standing trees which will be mentioned in the paragraph on swarming. In either case honeycombing of the core of the trees is extended little by little, the 'pipe' becoming wider and longer. BLIJDORP had a strong impression that this infestation ultimately led to the death of the tree. This may well be correct for the cavities formed in the core and approaching the wood layers still in function will more or less interfere with the sap-flow, particularly in the crown, and may cause part of the top to become dry. As weakening and deterioration of the tree proceeds, it provides the termite colony with an increasing amount of material to feed upon and to get stronger. Still this may be a lengthy process, as the length of the period from the first infestation to the final break-down depends on the original dimensions and vigour of the tree and the size of the colony.

PREFERENCE OF LEGUMINOSAE

When more regular observations on the occurrence of *C. havilandi* in the teak forests of Gedangan were started in 1934, it was soon observed that the colonies were often associated with dying and damaged Leguminous trees. This was confirmed by BLIJDORP in 1941. The following table, based on all the notes available, gives, further particulars about the species of trees found harbouring the colonies and in which phase they were found to be infested.

The table shows at first sight that among the trunks and stumps found inhabited the Leguminosae are by far in the majority and that most tree species found to be attacked when still alive also belong to this family.

For a correct assessment of the figures it must be stated that *Albizzia lebbeckioides* trees grow spontaneously in the largely uniform teak plantations and old stands in the area concerned. Both *Acacia* species and *Butea*

		stump	dead trunk	dying tree	living tree	total
Albizzia lebbeckioides	Leguminosae	3	20	3	6	32
Alb. procera			3			3
Acacia tomentosa		4	4	1	3	12
Ac. leucophloea			6		1	7
Butea frondosa		1	1	3		5
Adenanthera pavonina			1	1	1	3
Bauhinia malabarica			2			2
						64
Swietenia mahagoni	Meliaceae		6			6
Toona sureni			2			2
Alstonia villosa	Apocynaceae		3			3
Actinophora fragrans	Tiliaceae	×	2			2
Sarcocephalus cordatus	Rubiaceae				1	1
Tarenna incerta			1			1
Tectona grandis	Verbenaceae		1		2	3
Glochidion sp.	Euphorbiaceae				1	1
Semecarpus heterophylla	Anacardiaceae		1			1
Areca catechu	Palmae		1			1
Cocos nucifera			1			1
						22

trees are often found along the borders and on blanks. Large specimens of *Albizzia procera, Bauhinia* and *Adenanthera* are somewhat less frequent. Among the non-Leguminous species the mahogany tree is often planted in artificial mixtures with teak. *Actinophora* is frequently found in places but at the time of investigation most trees of any size were killed by the zigzag-borer, *Agrilus kalshoveni,* and some of these were infested secondarily by *Coptotermes.* Many other non-Leguminous tree species not included in the list grow spontaneously in the teak forests, some of them being rather regular features, particularly along ravines and river banks, and in some places run wild, but none of them has been found attacked so far.

It is also striking that teak itself has so rarely been found infested, which confirms the remarks in the preceding paragraph. The few living trees found to have been inhabited by *Coptotermes* had been primarily infested by *Neotermes tectonae* and old cavities originating from the latter had been occupied temporarily by the former species.

All this indicates that *C. havilandi* is rather selective in its choice of host trees.

Invasion of buildings

In this section I will first discuss some cases that I had personally to deal with.

In 1926 what later appeared to be *Coptotermes havilandi* became very troublesome in a large godown in Surabaya where goods were stacked on mats of plaited bamboo spread on a well constructed floor. Somehow the

termites had found their way to the piles and had gnawed off the soft inside of the bamboo, leaving only the silicious skin. They had also attacked the lowest layer of sacks containing cassave flour, but had fed only on the jute.

In 1927 the termite was discovered feeding on a pile of discarded newspapers laying on the floor in a corner of the old house, which was used as field laboratory in Gedangan. The house was built of high quality teak wood; the frame rested on masonry pillars one meter high. Nowhere else in the building were any activities of the termite observed. Although the termites were regularly present in the yard and the annexes it was not until 1934 that a second invasion was observed. At that time they extended their galleries to the lowest part of the frame, feeding slightly on the teak wood.

An interesting infestation of the roof of a large, one storey building at Weltevreden (now Djakarta) was reported in 1930. The building had been vacant and somewhat neglected for a few years, and had recently been occupied by the post-office savings bank. It had the peculiarity that the high roof sloped down to the inside of the top of the outer walls, the rain water being caught in gutters and the parapet being freely exposed to the weather. The teak wood used for the roof appeared to be of a low grade with wide annual rings. It was first thought that there must be some galleries connecting the feeding places with the ground, but they could not be discovered. Fort safety's sake a layer of hard concrete was constructed at the upper rim of the foundations in order to block any passage of the termites. However, no lessening of the activities of the termites on the roof was observed. It further appeared that the termites made covered galleries over part of the tiles and extended their tunnels in the mortar of the exposed top of the walls, clearly to provide themselves with rain water during showers. As no central nest could be found and deterrents had no effect, the architect in charge decided to replace the roof timbers by an iron construction.

At Bogor a few isolated cases of *Coptotermes* invasion in private houses of various types and ages have become known since 1927. In 1934 several cottages appeared to have been infested, which lined a road in a quarter built by the municipality, some 12—15 years previously. The termites were found almost exclusively to attack the roof timbers which were of various origins, no teak having been used. The galleries were built along girders, rafters, cross beams and the like, forming an extensive network. The damage done to the wood was very unequal, some large beams had already been hollowed. Concentration of the attack was particularly evident in places where rotting had set in, due to leakage or to incidental exposure to the rains. Some galleries on the upperside of ridge poles and even on the tiles indicated that the termites again met their need of moisture, at least periodically, during the frequent rains. Constructions similar to subsidiary nests were found in the corners of the roofs. No connection with the ground was evident but there were several possibilities for its existence. In one instance a gallery had been made from an infested girder downwards through a tube enclosing an electric wire. The gallery stopped at a plug contact before reaching the

ground. A thin leaden plate covering the but of a beam was found to be perforated by the termites.

An uncommon kind of damage was noticed in a governmental depot at Bandung, where the inner part of a coil of fire hoses appeared to be eaten through by the termites. The hoses were made of tanned hemp. (Report and sample received, October 1938).

Damage to packing cases containing match-boxes in a godown at Batavia (Djakarta) was reported by a trading firm in January 1941. Curiously enough the uppermost in a pile of six cases high were attacked and not those resting on the floor. Afterwards some rafters of teak wood in the roof of the building were found to be infested by the termites.

Other instances of infestation of buildings reported upon referred to a temporary wooden building of the government products museum at Djakarta; to office rooms at Tjililitan airport; to houses in the towns of Bandung and Tjilatjap (the latter built on a low damp site and simultaneously infested by two other species of termites); to employee's houses of a tea estate near Sukabumi where besides timberwork wall-paper was eaten; and to the house of a forest guard at Bandjar and of a villager near Gedangan.

All these cases which came to my notice incidentally and not as a result of any systematic survey, pointed to a probably wide distribution and frequent damage done to houses and property all over Java by this termite.

INVASION OF A TIMBER YARD

In a depot of the Forest Service at Tjepu, C. Java, where large quantities of sawn teak timber had been laid up under roof for a long period, severe infestation by *Coptotermes* was discovered in 1941. The timber was stacked on big sleepers which rested on piles raised only 30 cm above ground level. It was a low terrain where the clayey subsoil had been covered by a layer of sand 40 cm thick, but the latter had not improved the drainage sufficiently. The termites had built a network of galleries along the supporting structure. The tunnels emerged somewhere from the clay subsoil but could not be followed downwards and a nest could not be found. Most damage was done to bundles of laths where the termites could extend their galleries in the narrow interspaces and compartments which they could easily close with their building material. Other small assortments, not bundled, and large pieces of timber were invaded to a less extent and piles of timber in racks had practically remained free. In pieces of solid timber concentric cavities had been formed by the feeding of the termites on the least hard portion of the annual rings. Already about 10% of the stock had been made unmarketable, and the loss was estimated at thousands of guilders. Curiously enough similar piles of timber which had been stacked in the open, had not been attacked (Details taken from a report by P. A. BLIJDORP and F. W. RAPPARD).

A THRIVING COLONY IN A SHIP

In 1934 our advice was asked about measures to be taken in order to eradicate a termite colony which was very destructive to the woodwork of the bridge of a small tanker plying between Palembang, Sumatra, and other ports of S.E. Asia. A sample showed that a small *Coptotermes* — found by Dr. W. V. HARRIS to be identical with the Javanese species — was the culprit. The infestation had been discovered some six years previously, first in the wheel-house on the upperdeck, but it had not been recognized as the work of termites before two or three years had gone by. Several repairs had already been necessary. A recent short circuit caused by the penetration of the insects into a cabinet enclosing electric fuses had led to a renewed inspection which had brought to light far more extensive damage than had at first been suspected. Several parts of the panelling and the built-in furniture of the upper and quarter deck appeared to be infested and partly destroyed. Most of the parts eaten were made of deal, but some pine and oak had also been attacked. As the application of 3% sublimate — a popular remedy — did not prove effective, it was decided to replace all the white wood. During these repairs a very populous colony was removed from the settee in the captain's hut. Three months after the repairs had been effected the termites were still present in numbers in the radio operator's hut on the upper deck. It was also found that some of the wood was rotten in places. Additional repairs had to be made and now chlorinated hydrocarbon — advised by our office — was used for the protection of the wood that was not replaced. This was the end of the affair.

No swarming of the colony had been observed by the ship's crew. It was evident that, in addition to the rain falling on the decks, the water used for the regular cleaning of the decks, and probably retained to some extent by rotten parts, had been sufficient to meet the need of moisture of the populous colony.

SWARMING

Observations on the dispersal flight of the alates were made only a few times at Bogor all in the month of September. They made their appearance at twilight at 6 or 6.30 p.m., or after the night had fallen, even as late as 10.30, emerging in large numbers from slits in the woodwork of the houses quite near the ground. Numerous soldiers crowded around the opening. Where the emergence took place on the outside of the houses the winged specimens rose in the air, and they were not distracted by street lamps and other lights even when occurring at a relatively short distance. However, in the houses some specimens were attracted by lamp-light; they finally shed their wings and formed pairs.

Small numbers of adults, five at the most, were collected repeatedly at the light of varandahs in houses standing not far from the teak forests. The data noticed in the Semarang District were in the months of August and September (a single case in July), those in the more eastern Tjepu District in September to November.

No observations are available concerning the behaviour of the alates when alighting after their flight. However, a few pairs of dealates have been found in dead branches of teak trees, during an extensive search of these places for initial colonies of *Neotermes tectonae* (KALSHOVEN 1959). This points to the probability that new colonies can be started at a considerable height from the ground and this feature may also account for the occurrence of colonies in the roofs of houses and in the woodwork of ships in service, when sufficient moisture can be obtained directly from the rain or from leakages.

EXPERIMENTS AND LABORATORY OBSERVATIONS

As *Coptotermes* was found to be regularly present on the premises of the field laboratory at Gedangan, adjacent to the teak forest, is was decided in 1934 to include the species in some experiments. The resulting notes on the apparent attractiveness of certain materials for this termite and some other species, and on the ability of *Coptotermes* to locate pieces of wood placed as baits all over the terrain, have already been published (KALSHOVEN 1952, 1955). The species was also included in observations on the susceptibility to termite attack of some treated and untreated materials which had been presented for testing. The technique followed was very simple. Packages were made of the items to be investigated, with sheets of carboard paper between each two items, the whole package also being wrapped in cardboard. These test packages were placed on the floor of an outdoor bath-room which was often visited by the termites. By means of long rolls of newspaper a connection was established with the surrounding soil or places where the termite had lately been found active. As a rule the insects soon followed this way, attacking the inside of the rolls and using them as galleries. On reaching the packages they did not fail to cover them with their mud encasements and they started eating their way into the cardboard, thereby coming into close contact with the test pieces. Within some 6 weeks the first indications about the quality of the test materials could be obtained. In some cases the materials were not consumed but only gnawed off at the edges, showing that the termite could force its way through the matter not used as food. Such material had to be branded as not fully termite proof.

At headquarters in Bogor parts of a *C. havilandi* colony taken from an infested beam were kept for a while in glass boxes and flat artificial nests as used for observations on *Neotermes tectonae* (KALSHOVEN 1930). When only moist filter paper was added the termites started to clear away bits of dirt, loose particles and dead specimens, assembling them in some places and covering them with fragments torn from the paper and glued by their faeces. Along the margin of the paper and any folds they started to construct flimsy galleries using the same material. Small pillars, 1—1.5 mm broad and up to 12 mm high were built in a few day's time. When given earth they immediately entered it and began to build with the soil particles while in other places, droplets of faeces were deposited. Weak individuals

were eaten by their fellows. The soldiers did not take any part in these activities but posted themselves with raised heads round about and on elevated places. All these activities are similar to those encountered in other termites.

In the artificial nests made of a teak wood frame clasped between glass plates the workers started to tunnel right into the wood at the corners. Where a concrete frame was used — half cement half sand — they tried to do the same, removing small bits of the material. Where the glass plates and frame were in contact the seams were sealed with faeces. In confinement the termites did not seem to be influenced by light or shade but they were attracted by moist parts.

Small colonies numbering up to 200 workers and soldiers, could not be kept in normal condition in the containers for more than 3 or 4 weeks, even when pieces of wood were added for food. Often their bodies became shorter and flat, which was an indication that the moisture supply was insufficient; a more liberal supply of moisture, however, soon led to the growth of mould. Isolated soldiers were killed more quickly by mould than such as were in the company of workers.

In November 1934 a portion of an *Albizzia* trunk inhabited by a large part of a populous *Coptotermes* colony, was put in a deep zinc box and kept at the field laboratory. The contents were kept moist and pieces of dry wood and small piles of newspapers were supplied for food, at intervals. No escapes were possible. Occasionally we investigated whether the colony was still alive. This could be easily ascertained by the immediate appearance of soldiers when a gallery was opened, and by the holes eaten in the food. It could also be deduced from a rustling sound apparently caused by the soldiers knocking their heads against the substrate when disturbed and particularly audible when sheets of dry paper were present. Living specimens were noticed until June 1937; but no young brood had appeared then and no flight of alates had been observed. The workers had a lighter shade than usual, but the soldiers still looked quite normal. In October 1937 the colony appeared to be extinct. The experiment showed that a part of a colony isolated from its connection with the central nest and the royal pair, and with no approach to the soil, can survive for at least two years and six months, but cannot regenerate.

ACKNOWLEDGEMENTS

The author is much indebted to Dr. W. V. HARRIS, London and Professor A. E. EMERSON, Chicago for their most valuable information and advice concerning the taxonomy of the difficult genus *Coptotermes*. Some expenses going with the preparation of the paper have been favourably met by the UYTTENBOOGAART-ELIASEN STICHTING, Amsterdam.

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