

# TERMITES ON CEYLON TEA ESTATES

D. J. W. Ranaweera

---

## Introduction

This account of the commoner termites associated with injury to plants and buildings on Ceylon tea estates is an attempt to gather together information gained during the past sixty years in Ceylon. The writer has worked in the Entomology division of the Tea Research Institute of Ceylon since 1928 and, although not previously directly concerned with work on termites, is familiar with work done during this period. The last detailed work on termites associated with tea in Ceylon was carried out by F. P. Jepson (1928, 1929, 1929a, 1930, 1933). Later information is available in the records of the Tea Research Institute, including recent work on the control of *Neotermes militaris* Desn. (Austin, 1957, 1958) and it seems therefore useful to gather this information together.

Tea is grown in Ceylon at elevations ranging from near sea level to over 7,000 feet. It is customary to speak of low-country (0-2,000 feet), mid-country (2,000-4,000 feet), and up-country (above 4,000 feet) tea districts; in addition, there is the south-west monsoon zone which experiences the south-west monsoon and, in varying degrees, the north-east monsoon as well, and the north-east monsoon zone which does not experience the S.W. monsoon and therefore has a much drier climate for most of the year. There is thus a wide variety of climatic conditions within a relatively small area and this is reflected in the different insect pests which occur in the various tea districts.

Mention should also be made of the shade trees which are traditionally interplanted in tea, and of green-manure plants used in young tea; these, as well as tea, are attacked by termites. The commonest shade trees are *Grevillea robusta*, dadap (*Erythrina lithosperma*), *Gliricidia maculata*, various species of *Albizzia* including *falcata* (= *mol ccana*) and *sumatrana*, and various *Acacia* spp. including *decurrens* and *pruinosa*. In addition, gum trees (*Eucalyptus* spp.) are commonly grown on non-tea areas and other species occasionally attacked by termites are *Casuarina* sp. and the Tung tree, *Cedrella toona*, and the green manure plants of *Crotalaria* spp. and *Tephrosia* spp.

Mention is made only of those termite species which are directly or indirectly injurious to plants and buildings on tea estates, although, however, many more species exist in the tea-growing areas of Ceylon. The shape of the head and arrangement of the teeth on the mandibles of soldier castes are valuable specific characters and are an important aid to identifying the species. Illustrations of soldier heads in the collection of the Tea Research Institute, kindly identified by the Forest Entomologist of the Forest Research Institute (Dehra Dun), India in 1956 are given (Figs. 1-14), and the damage caused to plants by some species is described. Where records are available, notes on habits and the nature of the damage caused are also mentioned.

Termites responsible for causing damage on tea estates may be divided into three main groups according to the nature of the damage and the nesting habits:

1. Firstly, there are those termites which are directly injurious to tea and to the shade trees interplanted in tea. They form nests within the wood of healthy or unhealthy plants in order to feed upon them as long as any tissues which afford them nourishment remain. These 'live-wood' or non-subterranean termites are regarded as primary pests.

2. Secondly, there are termites indirectly injurious to plants. Nests are formed in the soil outside the plants, either in mounds or underground, and the termites feed upon dead and rotten wood, diseased bark, dead snags, tree stumps, decaying roots and like material. These subterranean termites are primarily scavengers, and are only secondary pests.

3. Thirdly, there are termites which attack woodwork in buildings, particularly bungalows and tea factories. Two types of termites come under this group: (a) termites which nest in the soil and invade buildings for the purpose of attacking wood inside while maintaining direct communication with the ground for moisture; (b) dry-wood termites which are able to feed and live in dry wood, seasoned and unseasoned, without having any connection with the ground.

The following termite species are dealt with in this paper:—

#### **Kalotermitidae**

*Neotermes militaris* Desneux  
*Neotermes greeni* Desneux  
*Glyptotermes dilatatus* Bugnion and Popoff  
*Glyptotermes jepsoni* Kemner  
*Cryptotermes ceylonicus* sp. n.  
*Cryptotermes dudleyi* Banks  
*Cryptotermes perforans* Kemner

#### **Rhinotermitidae**

*Coptotermes ceylonicus* Holmgren  
*Coptotermes formosanus* Shiraki  
*Heterotermes ceylonicus* Holmgren

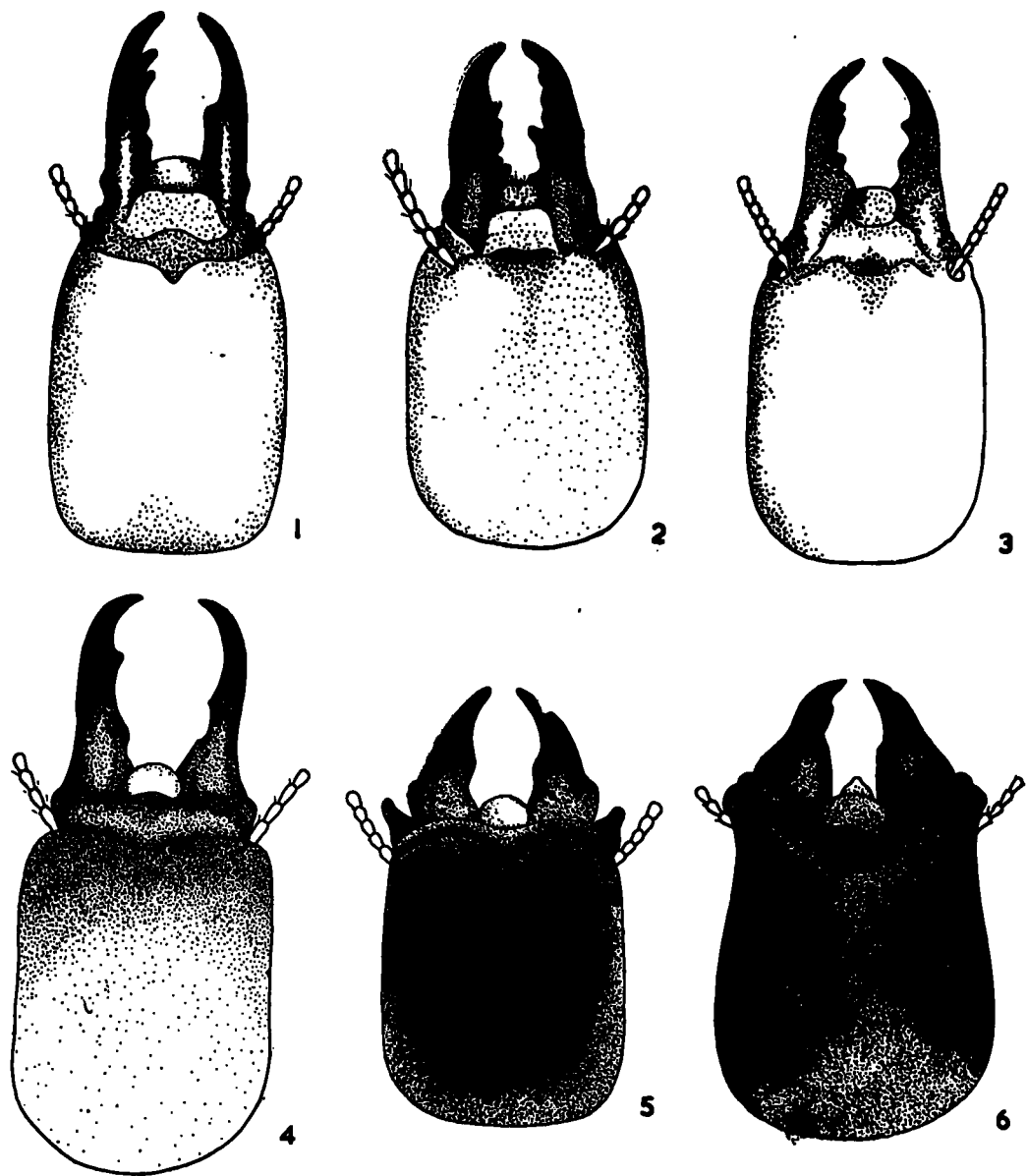
#### **Termitidae**

*Hospitalitermes monoceros* Koenig  
*Hypotermes obscuriceps* Wasmann  
*Microcerotermes greeni* Holmgren  
*Nasutitermes ceylonicus* Holmgren  
*Odontotermes ceylonicus* Wasmann  
*Odontotermes horni* Wasmann  
*Odontotermes redemanni* Wasmann

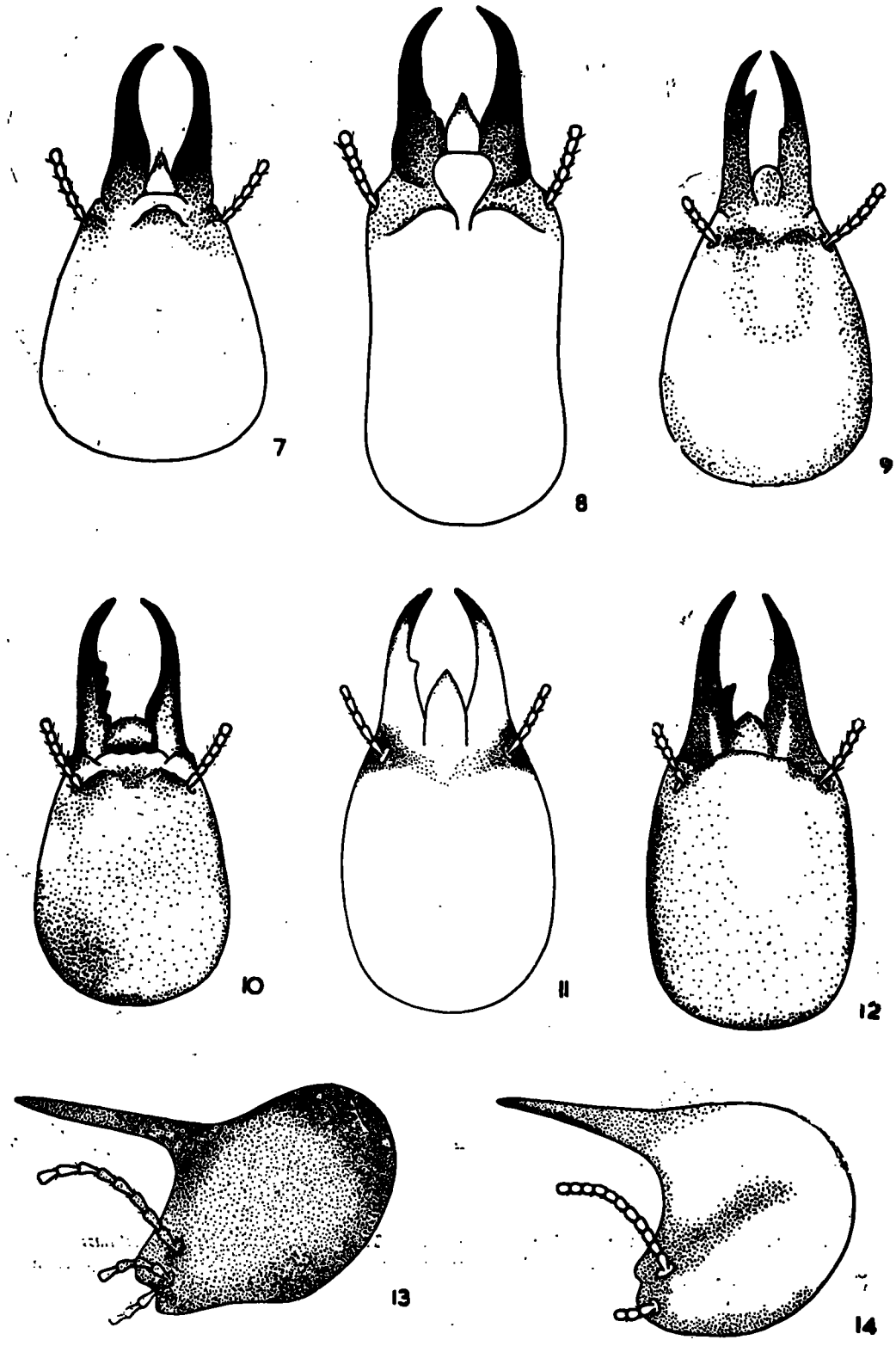
**Field key to soldier termites** (to be used in conjunction with the illustrations of soldier heads (Figs. 1-14).

1. Head drawn out in front as a nose-like projection.....2  
Head not so drawn out; mandibles visible, pincer-like and large.....3

2. Top of head making an obtuse angle with the 'nose' in profile. Head constricted behind the antennae. Segments of the antennae long, cylindrical, dark brown. Mandibles clearly visible under a lens....*Hospitalitermes* (Head purple-brown.....*Hospitalitermes monoceros* (Fig. 13))
- Top of head and 'nose' forming a straight line together in profile. Head not constricted behind the antennae; segments of the antennae rounded, yellow. Rudimentary mandibles, not visible.....*Nasutitermes* (Head yellow-brown.....*Nasutitermes ceylonicus* (Fig. 14))
3. Pronotum (neck shield) as broad or broader than the head, more or less rectangular. Termites living in live wood of tea or shade trees; or dry-wood termites in buildings.....4  
Pronotum not as broad as head, not approximately rectangular.....9
4. Head cylindrical, hollowed out in front, with a rough surface, dark brown to black.....*Cryptotermes*, 5  
Head more or less flattened, ovoid or rectangular, yellow to dark-brown .....7
5. Mandibles short and stout, one-third of the length of the head. Head black ..... 6
- Head brown at base, black towards the mandibles. Mandibles long, black, about half the length of the head. Left mandible with one tooth not more than half-way from the tip. Right mandible with one small tooth .....*Cryptotermes dudleyi* (Fig. 4)
6. Mandibles with no teeth.....*Cryptotermes ceylonicus* sp. n. (Fig. 5)  
Left mandible with one tooth about one-fourth of the way from the tip; right mandible not toothed.....*Cryptotermes perforans* (Fig. 6)
7. Antennae with 15-17 segments; large species 3/8 inch long (or more) ..... *Neotermes*, 8.  
Antennae with 11-12 segments; small species about 2/8 inch long.....  
*Glyptotermes*.  
(Head slightly raised between the antennae to form two points. Mandibles brownish-black. Left mandible unevenly toothed. Right mandible with one tooth not more than half-way from the tip and serrated below.....(*Glyptotermes dilatatus* (Fig. 3)).
8. Mandibles straight at base, black towards the tip. Left mandible with two prominent teeth, the first tooth not more than one-third of the way from the tip, and with two serrations below the second tooth. Right mandible with a single tooth half-way from the tip and the rest of the margin smooth.....*Neotermes militaris* (Fig. 1).  
Mandibles black, broad at base. Left mandible with two teeth; first tooth not less than one-third of the way from the tip and with three serrations below the second tooth. Right mandible with one tooth half-way from the tip and the margin above the tooth with small serrations .....*Neotermes greeni* (Fig. 2).
9. Opening of frontal gland large and conspicuous, labrum (upper lip) pointed, pronotum oval.....*Coptotermes*.  
(In *Coptotermes ceylonicus* (Fig. 7) the mandibles are brown, slender and sickle-shaped, without any teeth).  
Opening of frontal gland small, pronotum not oval.....10.



Figures 1-6. Heads of soldier termites (not to scale): 1. *Neotermes militaris*; 2. *Neotermes greeni*; 3. *Glyptotermes dilatatus*; 4. *Cryptotermes dudleyi*; 5. *Cryptotermes ceylonicus* sp. n.; 6. *Cryptotermes perforans*.



Figures 7-14. Heads of soldier termites (not to scale): 7. *Coptotermes ceylonicus*; 8. *Heterotermes ceylonicus*; 9. *Odontotermes redemanni*; 10. *Hypotermes obscuriceps*; 11. *Odontotermes ceylonicus*; 12. *Odontotermes horni*; 13. *Hospitalitermes monoceros*; 14. *Nasutitermes ceylonicus*.

10. Left mandible with three teeth on inner margin.....11.  
 Left mandible with one tooth.....12.
11. Head creamy-yellow, rectangular in shape; three teeth on left mandible are very small and near the base of the inner margin.....  
*Heterotermes ceylonicus* (Fig. 8).  
 Head light-brown, oval; three teeth on left mandible are prominent and near the middle of inner margin.....*Hypotermes obscuriceps* (Fig. 10).
12. Head brown, near-rectangular in shape; mandibles brown-black. Left mandible with a single prominent tooth two-third of the way from the tip. Right mandible untoothed.....*Odontotermes horni* (Fig. 12).  
 Head brown, broad behind, narrowing sharply towards the front. Mandibles brown. Left mandible with a single tooth less than one-third of the way from the tip. Right mandible with a small tooth half-way from the tip.....*Odontotermes redemanni* (Fig. 9).  
 Head light-brown, rectangular in shape. Mandibles brown. Left mandible with one tooth half-way from the tip. Right mandible untoothed.....*Odontotermes ceylonicus* (Fig. 11).

### Termite Biology

Termites are often known as 'white ants' but they belong to the relatively primitive insect order Isoptera not to the highly developed Hymenoptera, which includes the ants, bees and wasps. The similarity of social organization of the two orders has been responsible for this misnomer, but in structure and development the termites differ greatly from the true ants.

The size and composition of the colony in termites varies greatly. In the highly organized species of the family TERMITIDAE, many of which build the well-known termite mounds, the numbers in one colony may run to hundreds of thousands, with several well-defined castes. In the more primitive KALOTERMITIDAE, or dry-wood termites, the colony may never be larger than a few hundred individuals.

Generally, a colony is started by a winged pair. The winged forms emerge in large numbers from the parent nest at certain seasons of the year, usually after the commencement of the rainy season. Those few which escape the many birds, reptiles and mammals which feed on them come together in pairs, shed their wings, and find a suitable site to found new colonies in the soil, in cracks of dead branches or in structural timber, according to the habits of the particular species. After mating, the female of the pair starts to lay eggs which the parents look after until the larvae develop. In a typical termite colony, the main types or castes met with are workers, soldiers and reproductive forms.

At first, all the larvae develop as workers which are blind, apterous (wingless), with whitish soft bodies but with efficient jaws, since it is their function to collect food, feed the other castes and construct the dwelling. The primitive dry-wood termites have no distinct worker caste; the work of the colony is done by nymphs whose development to the winged adult stage is controlled according to the needs of the community. In this family the parent queen undergoes very little or sometimes no increase in size. In the TERMITIDAE, the parent queen develops an enormously distended abdomen to accommodate her massive ovaries so that she has the appearance of a large white grub.

As the colony develops, some larvae develop as soldiers, which are wingless and may easily be recognized by their larger chitinised heads and powerful jaws.

Their main function is to defend the colony against invasion by enemies. Though represented by both sexes, they are sterile. The shape of the head and jaws of the soldier caste is an important specific character in identification.

Ultimately, when the colony is well-established, some larvae develop with wing pads on their shoulders. These are the nymphs which will become winged termites and at certain times of the year, prior to the swarming season, large numbers of the adult winged reproductive caste may be found in the nest. There may also be 'supplementary reproductive,' or neotenic, forms present which are sexually mature but unable to fly out. They are light brown in colour, paler than the winged reproductive forms, and may be either without wings or possess short wings. It is one of the characteristics of the termite colony that should either parent be lost or lose its powers, the development of some nymphs as supplementary reproductives is hastened, so that they may take over. The females of this form do not become greatly enlarged and each lays fewer eggs than the old queen but the combined total may be much greater. They may also be found in subsidiary colonies which have developed from sections of the original colony by accidental separation.

Termites feed on sound or decaying wood and on other plant materials such as humus, grass, fungi, etc. This is practised by the workers of all families that possess them, by the young reproductive forms of the *KALOTERMITIDAE*, and the older nymphal stages of most species. Other castes, including soldiers, many reproductive forms and young stages are fed by the workers by regurgitation of half-digested food or extrusion of it from the rectal pouch. Many species possess in their intestines a rich fauna of symbiotic Protozoa which can digest the cellulose in wood.

Termites play an important role in the breakdown of dead woody plant materials and the return of nutrients to the soil. The role of subterranean termites has also been compared to that of earthworms, in that by means of their underground activities they keep the soil in constant circulation, rendering it permeable to air and moisture. They are by no means, therefore, solely injurious to the agriculture and buildings of man.

## **1. TERMITES DIRECTLY INJURIOUS TO LIVING PLANTS**

### **FAMILY KALOTERMITIDAE—DRY-WOOD TERMITES.**

Members of this rather primitive termite family, unlike those of the highly specialised families, *TERMITIDAE* and *RHINOTERMITIDAE*, do not nest in the soil; nor do they travel through soil or under covered runways to reach their objectives. They make a series of galleries in living or dead plants, logs and wood, without constructing true nests. Of the four genera recorded in Ceylon, namely, *Cryptotermes* Banks, *Glyptotermes* Froggatt, *Kalotermes* Hagen and *Neotermes* Holmgren, two have so far been associated with damage to plants and one with damage to buildings on tea estates.

### **Genus *Neotermes* Holmgren**

The only two local species recorded are considered to be primary pests of a number of living woody plants in tea estates. The attack is usually confined to heartwood.

## *Neotermes militaris* Desneux

Jepson (1928) has noted that this species was observed by the first Government Entomologist in Ceylon, E. E. Green, in 1890, but the species was named by Desneux (1904). Previous papers from Ceylon refer to it as *Calotermes militaris*. It has also been recorded as a minor pest of tea in Java (Menzel, 1929).

Of the live-wood termites, this species causes the most damage to tea, and the later stages of attack are unmistakable at pruning time by the wide galleries formed by hollowing-out of the heartwood of the trunk and main branches. Attacks are mostly at elevations between 3,500 and 4,500 feet, particularly in the Maskeliya district; hence, it is commonly known as the 'Up-country Tea Termite'. A few cases have however been recorded where it has attacked tea and *Grevillea robusta* at somewhat lower elevations. The damage caused to tea was considered serious at one time and investigations on the biology and control were carried out by the Department of Agriculture from 1925 (Jepson, 1930). However, King (1937) and later Austin (1958) produced evidence that the damage caused had been greatly over-estimated.

Most KALOTERMITIDAE in Ceylon do not usually extend their galleries in plants below ground level. Normally, a winged pair, after leaving the parental nest and subsequent loss of wings (de-alation), gain entrance at a wound or to a dying branch of a tree. Neoteinic reproductive forms do not usually form independent or subsidiary colonies unless the de-alated female is killed or removed. *N. militaris*, however, appears to be an exception since it feeds on roots. Colonies in tea bushes do not appear to originate above ground from a winged pair, but seem always to start at a root. The termites then work upwards to reach the main root, extending tunnels to other side roots and to the main stem and branches. So far, in many hundreds of tea bushes examined, no entrance holes have been found in branches or main stems above ground, whereas in shade trees such as *Grevillea* and *Albizia* entrance holes have sometimes been traced to weak spots in branches above the ground.

The occurrence of *militaris* in tea is thought to have originated when jungle was cleared for tea planting and infested jungle tree stumps were left in the tea fields. Green (1907) thought that the migration of *militaris* from bush to bush was through root contact and this view was later supported by King (1937).

Although a few alate (winged) reproductive forms have been found inside some tea bushes which had been subjected to severe termite damage, their emergence from these bushes, when kept under observation for several months, was not observed. It is possible, however, that when unfavourable conditions prevail inside a bush or when the host bush is reduced to a mere shell, a few individuals are occasionally released to form new colonies.

A colony of *N. militaris* normally contains 3,000 to 5,000 individuals including a large number of nymphs equipped with short, as well as long, wing-pads. A striking feature, noticeable in some well-established colonies, is the presence of an unusually large number of neoteinic reproductive forms; brachypterous (short-winged) as well as apterous (wingless), sometimes numbering nearly a hundred. Out of several hundreds of colonies examined at different times of the year only about one per cent contained macropterous (fully-winged) forms. The queen, which is brown in colour and only slightly larger than the rest of the members, moves freely inside the colony. Eggs are laid freely inside galleries and are not confined to any particular part.

In a tea field with 3,000 to 4,000 bushes to the acre and with well established root systems it is quite possible for termites to migrate from bush to bush through root contact; contiguity of roots from different bushes affords the opportunity for dispersion. Groups of termites may get isolated from the parent nest and be able to found independent colonies with the aid of neotenic forms, and thus exist as subsidiary colonies in the same bush or in adjoining plants.

King (1937) observed that the movements of termites from bush to bush had been extremely slow and that they abandoned a bush after it had been occupied for a period of over 15 years. He also observed that twelve per cent of infested bushes had been only partially eaten up and then abandoned. The longevity of individual termites under natural conditions is not known. Under laboratory conditions in Ceylon, adult winged forms have been produced from eggs in eight and half years (Pinto, 1941).

#### Damage to tea bushes

Early stages of infestation pass unnoticed, sometimes for years, until galleries in branches reach the pruning level which is about two feet above ground. Tea bushes at this elevation are normally pruned once in three or four years. As the attack proceeds, numerous longitudinal galleries are made in roots, stem and branches, gradually hollowing the bush out (Figure 15). During these depredations it is only the heartwood that is consumed. The sapwood is untouched and carries on the functions of the plant. Thus, the attacked bush shows no external signs of injury and continues to grow until a very late stage of the attack. Very often, hollowed-out cavities in stems and branches are filled up with an earth-like substance composed mainly of termite faecal matter, into which adventitious roots sometimes grow from the inner wall after termites have vacated the bush. For unknown reasons *N. militaris* sometimes abandons a healthy tea bush partly excavated, although at other times leaving only a thin shell.

Infestations always occur in patches confined to groups of bushes, averaging about ten in a patch; the maximum recorded in one patch being 190.

Host plants: Tea (*Camellia sinensis*) appears to be the favourite host. Besides tea, the following plants are attacked: *Acacia decurrens*, *Acacia* sp., *Albizzia falcata* (= *moluccana*), *Casuarina* sp., *Cedrella toona*, *Crotalaria anagyroides*, *Erythrina lithosperma*, *Eucalyptus* sp., *Grevillea robusta*, *Tephrosia vogelii*.

#### *Neotermes greeni* Desneux

This species was named after E. E. Green by Desneux (1908) from material collected from Ceylon tea. There appear to be no records from other countries. This termite has a wide distribution in low-country and mid-country estates up to 3,500 feet, and occurs very occasionally at higher elevations. It is frequently recorded on *Grevillea robusta*. The habits are somewhat similar to those of *N. militaris* in that they nest in living and dead plants. However, the entry into the host plant appears always to be by a winged adult pair at a weak spot in the trunk or a branch.

Migration through root contact has never been recorded. On establishment of a colony inside a plant, a network of galleries is made by eating away wood, mainly the heartwood, to form a honeycomb structure (Figure 17), not completely hollowing the wood as does *N. militaris*. In advanced stages of an attack, sapwood and bark are also eaten, killing the plant. Galleries rarely extend below soil level.

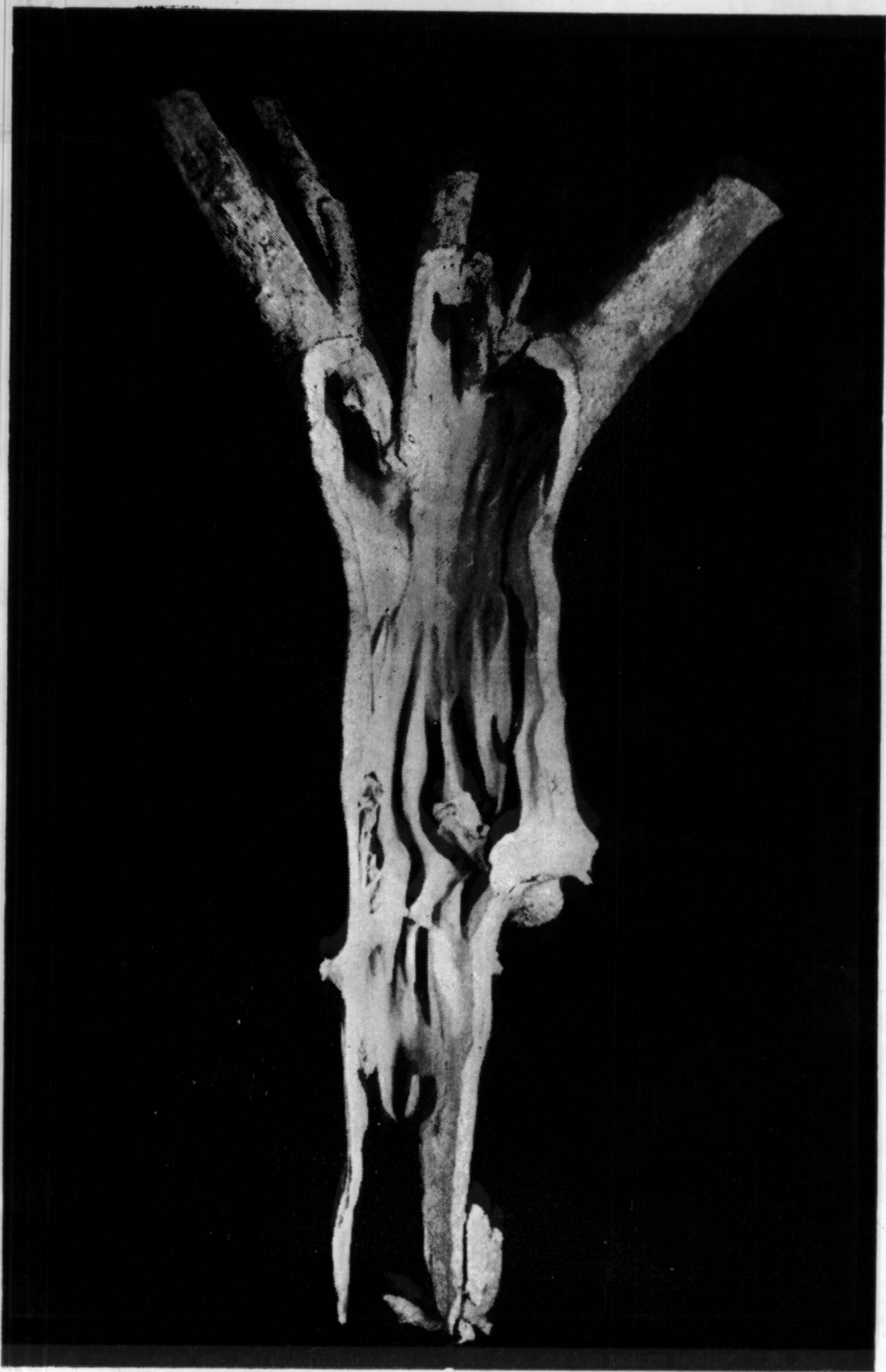


Figure 15. Vertical section of a tea bush hollowed out internally by *Neotermes militaris*.

Figure 15. Vertical section of a tea bush hollowed out internally by *Neotermes militaris*.



Figure 16. Vertical section of a tea bush showing small galleries in the heartwood above soil level caused by *Glyptotermes dilatatus*.



Figure 17. Section of a branch of *Grevillea robusta* showing galleries of *Neotermes greeni*.



Figure 18. The effect of scavenging termites on a tea bush that has suffered from sun-scorch and wood-rot. Note the deep furrows in the main branches where the termites have cleaned up dead wood.

The number of individuals in a colony is about the same in both species but the number of neoteinic reproductive forms is conspicuously low in *N. greeni*; not more than half a dozen per colony on the average.

Fortunately, damage caused to tea by this termite is very localised. Attacks are usually confined to a few isolated bushes, sometimes in small groups. *Grevillea* appears to be a favourite host plant; full-grown trees are sometimes killed and a characteristic appearance of attacked trees is the dying back of the tops.

Host plants: *Grevillea robusta*, *Albizzia falcata*, *Camellia sinensis*, *Erythrina lithosperma*.

### Genus *Glyptotermes* Froggatt

Two of the four species recorded locally are associated with living plants on tea estates. The nesting habits are somewhat similar to *Neotermes greeni*.

#### *Glyptotermes dilatatus* Bugnion and Popoff

This species was described by Bugnion and Popoff (1910) from material collected in Ceylon as *Calotermes dilatatus*. This is the smallest of the three termites that eat into the heartwood of living plants. It is widely distributed at elevations below 3,000 feet and is commonly known as the 'Low-country Tea Termite'. Colonies are smaller than those of *N. greeni* and contain very few neoteinic forms.

Normally an adult de-alated pair enter a host plant through a weak spot above ground to establish a colony and then work upwards or downwards in the main stem and branches. They make a network of galleries similar to that of *N. greeni* in pattern but smaller in size, in the heartwood and not forming hollowed-out cavities (Figure 16). Galleries seldom extend below soil level. More than one independent colony may sometimes exist in one tea bush. Occasionally, after making a series of galleries in heartwood, termites attack the sapwood and bark causing eventual death of the plant.

It has been frequently observed that the majority of tea bushes attacked by *G. dilatatus* are in a poor condition due to various causes such as wood rot, die-back of branches, partial recovery after pruning on account of depleted starch reserves in roots (a common occurrence in low-country estates), or *Ustulina* root disease. A healthy plant in a vigorous condition of growth is seldom attacked. It would thus appear that the damage caused by this termite is largely confined to accelerating the death of unhealthy plants. Attacks are not confined to groups or patches of bushes but distributed throughout a field at random.

Host plants: *Albizzia falcata*, *Albizzia* sp., *Camellia sinensis*, *Erythrina lithosperma*, *Grevillea robusta*.

#### *Glyptotermes jepsoni* Kemner

This species was described by Kemner (1932) and observations were recorded by Pinto (1941). It appears to be restricted to the Maskeliya and Pundaluoya districts at elevations between 3,000 and 4,000 feet, and records of it are few. It has been noted on *Albizzia* and *Cedrella toona* but not so far on tea. Attacks are usually restricted to portions above ground but in one instance termites were found in a tree stump below ground level. They prefer dead to live wood. There are no specimens in the Institute's collection and it is not illustrated here.

## FAMILY RHINOTERMITIDAE—MOIST-WOOD TERMITES

Members of this family have a more highly developed social organisation than the KALOTERMITIDAE, with thousands of individuals in a colony, consisting of all the three normal castes; workers, soldiers and reproductive forms. They nest in the soil and in old tree roots well below ground and are not known to build mounds in Ceylon, although some species are known to form superstructures in other countries.

### *Coptotermes formosanus* Shiraki

Ahamed (1953) has recorded this termite as a recent introduction to Ceylon. It is one of the most destructive termites of the Orient and has the ability, not known to be possessed by other subterranean termites, of living without ground connection when there is a suitably located constant water supply above ground (Light and Pickens, 1934).

### *Coptotermes ceylonicus* Holmgren

This is principally a scavenging termite which also attacks buildings in Ceylon. It is included in the group of termites directly injurious to living plants as it has been observed to attack healthy tea bushes rather severely at times, by eating away healthy roots and branches.

It is generally a low-country termite working below an altitude of 3,000 feet but has occasionally been found at elevations up to 4,500 feet. It has also been recorded in South India as a pest of living tea bushes (Ananda Rao, 1939). While establishing the nest in the soil, termites invade living plants to feed upon dead and living tissues beneath covered runways which maintain communication with the nest for necessary moisture supplies. A characteristic behaviour of the soldier is the ejection when disturbed of a milky-white fluid from a gland in the head.

Host plants: *Albizzia falcata*, *Camellia sinensis*, *Grevillea robusta*.

### Control measures for live-wood termites

More serious damage is caused by *N. militaris* than by other species, though this damage is largely confined to up-country. It is possible to adopt control measures when the wide galleries are revealed at pruning time, and control measures are pursued by a number of estates, particularly in the Maskeliya district.

One of the earliest measures adopted was to pour irritant fluids such as kerosene, liquid fuel and 'Brunolineum' into the exposed galleries after pruning. As noted, however, the hollowed-out galleries in many bushes were usually blocked up with the soil-like faecal matter which prevents such fluids from affecting more than a part of the colony, and these methods did not prove effective.

Jepson (1929a) first experimented with the blowing-in of Paris Green, with some success. The method was to bore a small hole in the main stem with a gimlet and to introduce about one-twelfth of an ounce of Paris Green with the aid of a rubber anema and then to plug the hole with putty or asphaltum. Jepson claimed that the dose was spread through the whole colony by termites eating those which had already succumbed to the poison. However, this method also did not work well in practice and the use of Paris Green was not recommended by the Institute because of the hazard in handling it.

Since the faecal matter, with which the termite cavities are blocked, appeared to contain some particles of soil it was thought that termites must come in contact with the soil at some time or other in order to collect these soil particles. Hence, in 1954, the first attempts with the newer organic insecticides involved experiments on the treatment of the soil around infested bushes with dieldrin and Chlordane. These soil treatments, however, proved totally ineffective and efforts were then transferred to working out a practical method of forcing insecticide into the galleries.

The method, referred to by Austin (1957), was as follows: At pruning time, the branches of bushes showing galleries were cut back in at least two places per bush to make sizeable entrance holes, large enough to insert the spray nozzle of an knapsack sprayer. Application of the insecticide was done on the same day immediately after cutting back, because termites quickly block the holes so formed. Dieldrin (or Chlordane) emulsion at the rate of one or two pints per bush was forced into the galleries at about 70 lb. pressure, using a pressure-retaining knapsack sprayer fitted with a nozzle with the swirl plate removed so as to force a thin jet of liquid down. This usually has the effect of cutting through the termite earth so that the insecticide is forced into the central galleries. Austin reported good results with this method and it has since worked well in practice. It is usually necessary to treat only a small percentage of the bushes in an affected field. Dosages have now been standardized at 0.1% dieldrin or 0.25% Chlordane emulsion, one to two pints per bush.

The use of this type of method against *N. greeni* and *G. dilatatus* is not possible because the galleries are so small. Fortunately, *greeni* is uncommon on tea and *dilatatus* occurs only on bushes which are unhealthy through other causes. When colonies are confined only to branches, the affected portions can be removed and destroyed. However, tea bushes often die from hard pruning in the low and mid-country, and this method is of limited usefulness. Replacement of the affected bushes is usually called for.

## 2. TERMITES INDIRECTLY INJURIOUS TO LIVING PLANTS

Several species of termites in this group, while maintaining their nests in the soil or in mounds outside the plants, travel through tunnels in the soil and invade plants in order to feed upon dead and decaying portions under the cover of earth runways whilst maintaining direct communication with the nest. They are merely attracted to dead and decaying wood present in bushes due to various causes such as attacks by Shot-hole Borer (*Xyleborus fornicatus* Eichh.) wood-rot fungi, branch canker, sun-scorch, mechanical damage and die-back of branches following pruning operations. Hence these scavenging termites are regarded as secondary pests. It is at elevations below 3,500 feet that this group is commonly found.

Scavenging termite activities in tea bushes, however, do cause a certain amount of injury at times. It is usual for termites to encase dead and dying portions of plants with earth prior to commencing feeding underneath. In order to reach these objectives they also construct earth runways on healthy stems and branches. This is a very common sight in many mid-country and low-country tea estates. Such constructions certainly do interfere with the normal growth in many plants.

Careful examination reveals that feeding underneath the runways is usually restricted to dead and moribund tissues; so that the main activity of the termites is the clearing away of dead tissues. By these operations, however, a certain amount of damage to healthy tissues around dead areas can occur by the exposure of living cambium and wood which, after desiccation and partial decay, is again destroyed by termites. Wounds are thus progressively enlarged with no callus being allowed to form.

Gradual removal of tissues from dead areas in branches affected by sun-scorch, and the dead tissues in main stems affected by wood-rot, causes the formation of small furrows which in due course get filled up with earth carried in by termites. During rainy seasons, tissues around this earth decay, providing more food. Continuous removal of these tissues results in the formation of deep hollows, sometimes down into the main stem, which gives the erroneous impression to the casual observer that healthy stems and branches have been eaten by termites (Figure 18). It is therefore evident that an essential factor for attracting scavenging termites is the presence of dead and decaying wood in tea bushes.

Scavenging termites frequently invade nurseries and new clearings, mainly due to the presence of large quantities of humus, leaf mould, decaying wood, bark and roots. When such food material is exhausted, termites turn their attention to the woody roots of living plants. In dry seasons they are sometimes forced to obtain moisture from succulent rootlets thereby causing the death of young plants.

During the process of consuming dead and moribund tissues of young plants caused by collar rot, deep planting, damage by chafer beetle larvae, mechanical damage, and adverse physiological conditions due to drought or water-logging, a certain amount of healthy tissues are also consumed; which, apart from delaying the recovery of plants, may cause untimely death. On several occasions *Odontotermes horni* Wasm., a scavenging termite, has been observed to kill young nursery plants by chewing young roots and stems.

#### FAMILY TERMITIDAE—SUBTERRANEAN TERMITES

This is the largest family of termites. Some members nest in the soil, with or without superstructures, while some others make carton nests in tree trunks, but connection with the ground is always maintained in order to ensure a continuous supply of moisture which is essential for their existence. A colony consists of many thousands of individuals which are the progeny of a single specialised queen.

##### Carton-nest building termites

###### *Hospitalitermes monoceros* Koenig

This species was described by Koenig in 1779 as *Termes monoceros* from material collected in Ceylon (Snyder, 1949). Holmgren (1913) described it as *Eutermes monoceros* after Wasmann (1902). It is commonly known as the Black Termite of Ceylon and does not appear to be recorded elsewhere. It makes carton nests in the hollows of tree trunks, sometimes attached to branches. They have the unusual habit, first recorded by Bugnion (1914) of making foraging expeditions over open ground unprotected by earthen galleries; this occurs at night and they return to the nest some hours after dawn. They frequent sickly tea bushes but do not feed on living wood. It has been recorded on four occasions from the mid-country.

##### Mound-building termites

###### *Hypotermes obscuriceps* Wasmann

Wasmann (1902) originally described this species from Ceylon (Snyder, 1949). Snyder considers that *Odontotermes marshalli* described by Kemner in 1926 is synonymous. It builds low mounds and makes earthen galleries over tea

bushes and shade trees to feed on dead wood. It has been recorded mostly from the mid-country and the low-country and once from up-country.

#### *Odontotermes redemanni* Wasmann

This species was originally described by Wasmann in 1893 as *Termes Redemanni* from Ceylon (Snyder, 1949). It is one of the commonest mound-building termites in Ceylon and feeds on dead wood on tea and shade trees. It has been recorded mostly from the mid-country and on a few occasions from the low-country.

#### Soil-nesting termites with no mounds

*Nasutitermes ceylonicus* Holmgren (1911) and *Odontotermes ceylonicus* Wasmann (1902) were both described from Ceylon and are scavenging termites on tea and shade trees in the mid-country and low-country.

*Odontotermes horni* Wasmann (1902) is perhaps of more importance on tea estates since, although predominantly a scavenging termite, it does sometimes kill young tea plants in the nursery and in the field by eating the tender roots; this type of damage has been traced to *O. horni* on eight occasions in the low and mid-country. The species has been recorded on 10 occasions from low-country and 20 occasions from mid-country. Kemner (1926) also described a variety *hulsoni* of this species from Ceylon but this has not been collected by the Institute.

*Microcerotermes greeni* Holmgren (1912) is a soil-nesting species although some other species of this genus are carton-nest builders in trees; it was originally recorded from Ceylon. They are occasional feeders on dead wood in tea and *Grevillea*. A species of *Microcerotermes* has been recorded by Das (1958) as a fairly common pest attacking live wood of tea in Assam, but there is no record of this genus attacking live wood in Ceylon. (There are no specimens in the Institute collection and this species is not illustrated here).

#### Control measures

It is considered desirable as hygiene measures to maintain tea fields free of decaying woody material as far as is possible and particularly the tea bushes themselves of dead branches and snags, and, of course, to maintain the tea in a healthy vigorous condition by correct cultural methods. Scavenging termites do of course play a major part in the low and mid-country in the decay of the prunings of tea and the loppings of shade trees and thus assist the return of nutrients to the soil. Nevertheless, they do sometimes become a real nuisance, more particularly in poor fields, when chemical control is sometimes called for.

Mound-building species can be controlled, once the mound is located, by breaking open the mound and forcing 0.1% dieldrin or 0.1% aldrin emulsion into the inner galleries. The nests of subterranean species are difficult to locate, but, if located, dieldrin or aldrin emulsion may be applied. On bush frames after pruning, the earthen runways can be cleaned off and the soil around each bush for one foot radius treated with aldrin or dieldrin emulsion at a rate of 2 lb active ingredient per acre. Applications may only be done after pruning to avoid any possible contamination of made tea. If the insecticide is applied to the basal parts of the bush frames as well as the soil, applications are liable to lead to out-breaks of Tea Tortrix (*Homona coffearia* Nietner) through the temporary local destruction of the parasite *Macrocentrus homonae* Nixon (Cranham, 1960).

This is an unwanted side-effect of the spraying of dieldrin just after pruning for the control of Shot-hole Borer (*Xyleborus fornicatus* Eichh.), by far the most serious pest of mid-country tea in Ceylon. It is probable that the control of Shot-hole Borer, if achieved on a large scale, will greatly reduce the secondary attack by scavenging termites—firstly by the use of dieldrin and secondly by the greater health of bushes free from the borer.

The occurrence of *Odontotermes horni* causing damage to young plants in nursery beds is a special case and here the treatment of the soil of the beds before planting, with aldrin, dieldrin, or B.H.C., is an effective preventative, or the beds can be treated after attack is noticed.

### 3. TERMITES WHICH ATTACK WOODWORK IN BUILDINGS

Termite damage to bungalow and constructional timber and fittings in factories has been considerable in low-country and mid-country estates up to 3,500 feet elevation. Very occasionally, damage has been caused at higher elevations, up to 6,000 feet. Instances where the entire woodwork of buildings has been destroyed by termites, necessitating renewal at a cost of many thousands of rupees, have been known.

Both subterranean termites (RHINOTERMITIDAE and TERMITIDAE) and dry-wood termites (KALOTERMITIDAE) attack timber in Ceylon estate buildings. Subterranean termites nest below ground and invade buildings through weak spots. This group maintain uninterrupted connection with the ground to obtain sufficient moisture. Dry-wood termites (KALOTERMITIDAE) live above ground without any direct communication with the ground. They enter woodwork directly in the adult winged stage to form independent colonies and eat the wood away and are able to exist under dry conditions with very little or no moisture.

Most species in the subterranean termite group, when confronted with solid barriers, construct shelter tubes over them composed of earth and excrement beneath which they travel in darkness to reach the object. They are also able to gain access to roof timbers through lime mortar in brick walls, and cracks in masonry.

Termites gain entrance to tea factories very often through cracks in the foundation in the absence of a properly constructed termite-proof concrete barrier. Then they may work their way up through a hollow wall into wooden partition boards or window frames resting on the walls, or they may ascend an H-iron stanchion or other support sunk in the foundation and get to the upper floor boards.

Termites are not known to eat mortar or plaster but they are able to penetrate poor grades of mortar or old plaster. Certain species of *Coptotermes* in other countries are able to dissolve lime mortar by means of acidulous secretions from the frontal glands (Snyder, 1948).

The following records based on enquiries to the Institute from estates are few in number because most instances of damage are not reported; the records do however give some idea of the species involved.

*Coptotermes ceylonicus* Holmgren (1911) (RHINOTERMITIDAE) was described from material from Ceylon. It has been recorded on two occasions from low-country, four from mid-country and four from up-country, damaging factory

or bungalow timber. This is believed to be the commonest subterranean termite damaging timber in Ceylon. It is noted that the main distribution nest may be over 100 yards away from the building they invade.

*Heterotermes ceylonicus* Holmgren (1911a) is the other species of RHINOTERMITIDAE recorded as attacking timber in buildings. It has been recorded twice from mid-country.

Of the TERMITIDAE, *Hypotermes obscuriceps* has been recorded three times from mid-country, and once from up-country; *Odontotermes redemanni* four times from mid-country and once from up-country; *Nasutitermes ceylonicus* once from mid-country; *Odontotermes horni* once in low-country and four times in mid-country; and *Odontotermes ceylonicus* five times in mid-country.

Of the seven species recorded in Ceylon of the dry-wood termite genus *Cryptotermes* Banks (KALOTERMITIDAE) three species have been associated with damage to buildings on tea estates. *C.dudleyi* Banks (1918), which has a very wide world distribution, is the commonest and most destructive dry-wood termite in Ceylon. It has been recorded causing damage twice from low-country, six times from mid-country and three times from up-country. It is the largest of our dry-wood termites and has a larger number of individuals in a colony than with other species. *C.perforans* Kemner (1932) appears to have been recorded only in Ceylon. It has been noted causing damage twice in low-country and twice in mid-country. *C.ceylonicus* sp.n. (Pinto, 1941) has been collected from living trees and sawn timber from Ceylon. It has been recorded once in factory woodwork in the low-country. This species was collected by N. A. Kemner and was partly described by him in a manuscript which was not published. Pinto (1941) referred to the species and to Kemner's unpublished manuscript. Only the soldier head is figured here and it would appear that description of the species is still required. Kemner's manuscript name has meanwhile been retained.

## Control

The preventative and curative measures for termite attack in buildings have been dealt with by many authors (Jepson, 1929; Harris, 1961) and there is no need to repeat them here. However, a special problem in tea factories is that the constructional timber with which fresh and withered tea leaf will come in contact (the floors and tat frames of withering lofts) cannot be treated with any preservative that is liable to cause a taint or to leave insecticidal residues in made tea. A suitable quick-drying commercial product which is entirely safe and free from taint has not yet been found.

## Summary

An account is given of the commoner termites associated with damage to plants and buildings on Ceylon tea estates, and illustrations of the soldier heads and a field key for identification are given for 14 species.

*Neotermes militaris* Desn. is the most important live-wood termite attacking tea, though it is a minor local pest of tea. Control measures involving the injection of dieldrin or Chlordane into the galleries are described. Attack by scavenging termites on tea is very common in the mid-country—this is secondary damage after attack by Shot-hole Borer (*Xyleborus formicatus* Eichh.), sun-scorch, wood-rot and die-back which are all interconnected problems. Common species involved are

*Odontotermes horni* Wasmann, *Odontotermes redemanni* Wasmann and *Hypotermes obscuriceps* Wasmann. There is no true live-wood attack on Ceylon tea by a Termitid, such as *Microcerotermes* is reported to do in Assam. *Odontotermes horni* Wasmann sometimes eats the roots of young plants.

The species recorded attacking buildings are also noted, of which *Cryptotermes dudleyi* Banks is the most important dry-wood species and *Coptotermes ceylonicus* Holmgren, *Hypotermes obscuriceps* Wasmann and *Odontotermes* spp. are the commonest subterranean species.

### Acknowledgements

I wish to express my thanks to Mr J. E. Cranham, Entomologist of the Tea Research Institute of Ceylon, for his kind advice, guidance and encouragement in the preparation of the text. His help and painstaking correction of the manuscript are gratefully acknowledged. I also thank Dr D. L. Gunn, Director of the Institute, for permission to publish this paper.

### References

- AHAMED, H. (1953). Two new cases of introduction of termites—*Spolia zeylan.* 27: 35–36.
- ANANDA RAO, S. (1939). Tea Scientific Department.—*Adm. Rep. unit. Plant. Ass. S. India for 1938–1939*: 20–27.
- AUSTIN, G. D. (1957). Report of the Entomologist for 1956.—*Bull. Tea Res. Inst. Ceylon*, no. 38: 51–55.
- AUSTIN, G. D. (1958). Report of the Entomologist for 1957.—*Bull. Tea Res. Inst. Ceylon*, no. 39: 51–56.
- BANKS, N. (1918). The termites of Panama and British Guiana.—*Bull. Amer. Mus. nat. Hist.*, no. 38: 659–667.
- BUGNION, E. (1914). La biologie des termites de Ceylan. *Bull. Mus. Hist. Nat. Paris*, 20: 170–204.
- BUGNION, E. & POPOFF, N. (1910). Les *Calotermes* de Ceylan.—*Mém. Soc. Zool. France*, 23: 124–143.
- CRANHAM, J. E. (1960). The natural balance of pests and parasites on Ceylon tea, especially Tea Tortrix and Macrocentrus.—*Tea Quart.*, 23: 26–36.
- DAS, G. M. (1958). Observations on the termites affecting tea in North-east India and their control.—*Indian J. agric. Sci.*, 28: 553–560.
- DESNEUX, J. (1904). Notes termitologiques.—*Ann. Soc. Ent. Belg.*, 48: 146–151.
- DESNEUX, J. (1908). Variétés termitologiques.—*Ann. Soc. Ent. Belg.*, 51: 388–400.
- GREEN, E. E. (1907). Entomological notes.—*Trop. Agriculturist*, 28: 181–183.
- HARRIS, W. V. (1961). *Termites, their recognition and control*. 187 pp. London: Longmans.
- HOLMGREN, N. (1911). Ceylon—Termiten. In Escherich, *Termitenleben auf Ceylon*: 185–212. Jena.
- HOLMGREN, N. (1911a). Termitenstudien. 2. Systematik der Termiten. Die Familien Mastotermitidae, Protermitidae and Mesotermitidae. *K. Svenska Vetensk. Akad. Handl.*, 46: 1–88.
- HOLMGREN, N. (1912). Termitenstudien. 3. Systematik der Termiten. Die Familie Metatermitidae. *K. Svenska Vetensk. Akad. Handl.*, 48: 1–166.

- HOLMGREN, N. (1913). Termitenstudien. 4. Versuch einer Systematischen Monographie der Termiten der orientalischen Region. *K. Svenska Vetensk. Akad. Handl.*, 50: 1-276.
- JEPSON, F. P. (1928). A preliminary note on the distribution of the Ceylon tea *Calotermes*. *Yearb. Dep. Agric. Ceylon for 1927*: 19-21.
- JEPSON, F. P. (1929). The termite-proof construction of buildings in Ceylon. *Bull. Dep. Agric. Ceylon*, no. 85: 1-35.
- JEPSON, F. P. (1929a). The control of *Calotermes* in living plants. *Bull. Dep. Agric. Ceylon*, no. 86: 1-11.
- JEPSON, F. P. (1930). The control of tea termites. *Trop. Agriculturist*, 75: 191-195.
- JEPSON, F. P. (1933). Dry-wood-inhabiting termites as a possible factor in the aetiology of 'sprue'. *Ceylon J. Sci. (D)* 3: 1-46.
- KEMNER, N. A. (1926). Some termites from Ceylon. *Bull. ent. Res.*, 16: 379-392.
- KEMNER, N. A. (1932). Neue termiten aus der orientalischen region 1-2. *Ent. Tidskr.*, 53: 133-155.
- KING, C. B. R. (1937). *Neotermes militaris*. *Tea Quart.*, 10: 195-205.
- LIGHT, S. F. & PICKENS, A. L. (1934). American subterranean termites, their classification and distribution; in *Termites and Termite control*, 734 pp., Ed. C. A. Kofoid; Univ. Calif. Press, Berkeley.
- MENZEL, R. (1929). Beschrijving der verschillende plagen. *Arch. Theecult. Ned. Ind.*, 1: 25-26.
- PINTO, M. D. P. (1941). Some observations on the biology of the Ceylon *Calotermes*idae. *Indian J. Ent.* 3: 73-105.
- SNYDER, T. E. (1949). Catalogue of the termites (Isoptera) of the world. *Smithson. Misc. Coll.*, 112: 1-490.
- WASMANN, E. (1902). Termiten, Termitophilen und Myrmecophilen. Gesammelt auf Ceylon von Dr W. Horn. *Zool. Jahrb., Abt. Syst.*, 17: 99-164.