NEOTERMES MILITARIS.

C. B. REDMAN KING.

Although there is a vast amount of literature dealing with Termites, partly on account of their extremely interesting social habits, and partly because their appetite for structural timbers forces our attention upon them, there is much to be learned about *Neotermes militaris*, frequently found at high elevations in tea bushes. Most of our knowledge to date is to be found in the writings of Mr. F. P. Jepson and Dr. J. C. Hutson, of the Department of Agriculture, which have been published in the Annual Reports of the Director of Agriculture, Bulletin 86 of the Department of Agriculture, and *The Tropical Agriculturist*, to which reference has been made.

During 1937 I have been enabled to explore carefully about five acres of badly infested tea in the Maskeliya district, as a result of which much useful information has been obtained. This

area was completely cleared, and every bush dug out and examined with regard to termite attack. I would take this opportunity of thanking the directors of the Standard Tea Co. of Ceylon, Ltd. and their agents, Messrs. George Steuart & Co. for permitting me a free hand in this work; and also Mr. R. C. P. Adams, Superintendent of Gouravilla Estate, whose cordial co-operation very greatly assisted this undertaking.

INTRODUCTION

The origin of *Neotermes militaris* in tea may be traced to survival from the days when the jungle trees were felled to provide land for tea growing. Since colonies hollow out the trees in which they live, and these excavations extend down into the roots, it is certain that infested timber must have been left in the ground which subsequently passed on colonies to the tea.

The tea to which reference was made above was planted just fifty years ago, and the very great majority of bushes examined were of this age. The progress of the infestation in the tea, and all quantitative details will be discussed towards the end of these notes. In the meantime it will be as well to set forth some account of the biology of this species, and of the damage inflicted.

NOMENCLATURE

First of all, as to its name. It has mildly puzzled many that, whereas it once used to be known as *Calotermes militaris*, its first name is now given as *Neotermes*. The whole genus of *Calotermes* contains many species, all of which infest wood; they are generally known as "dry-wood" termites, as they attack either dead wood or structural timbers. A few of these, however, are commonly known as "dampwood" termites because they assail living trees. This difference of habit, with slight structural modification, was sufficient to give them the new name *Neotermes*; and so by this name they are now known.

HISTORY

According to Jepson [1] the earliest record of termites as a tea pest is 1890, but the locality is not stated. The species *militaris* was first described in 1904. Since then it was said to be mostly noticeable in the Kelani Valley in 1908. There is no further mention until 1914 and 1915 which gave records in Norwood and Bogawantalawa respectively. In 1919 it becomes "prevalent" on tea at different elevations, attacking seed bearers fairly high up, and in 1920

"is well established on many tea estates." There are further brief allusions in subsequent years, until in 1925 we find an investigation of *Neotermes militaris* begun by the Department of Agriculture, and from this time most of our present knowledge dates. After some time in experimenting, the development of small colonies was sucessfully carried out in the laboratory at Peradeniya, referred to in various Administrative Reports.

Subsequently a standard method of control was developed by Jepson, using Paris Green as a poison which is injected into the infected bush. This is described by him in Bulletin 86 of the Department of Agriculture, "The control of *Calotermes* in living plants" and recommended further by him in *The Tropical Agriculturist*, Vol. LXXV (1930).

BIOLOGY

Termites are difficult insects to study, owing to their concealed mode of life, yet many interesting facts about the life of the community have been obtained in laboratory and field. If a tea bush containing a colony of *militaris* be examined, probably only two castes will be noticed, the workers and the soldiers. In the majority of termite species, the worker is an adult form, *i.e.*, one which has reached its final stage and can go no further.* In the whole group of *Calotermes* the "workers" are not adults, but full-grown nymphs. Any of these may go a step further and become soldiers or sexual forms. Careful examination may reveal nymphs of various sizes, in different stages of growth. Also there may be a number of full size nymphs with wing-pads showing; these will further develop into winged forms. Under laboratory conditions the wing-pad stage may be reached in about 5 years [2], the fully winged state being reached in another $2\frac{1}{2}$ to $3\frac{1}{2}$ years [3].

The soldiers are easily recognised by their large chestnut-coloured heads (*vide* Vol. X, Part III, Plate I, Fig. 7), but relatively only a few will be found in a colony. Their purpose is that of defence, the huge head and jaws being adapted to this end, but on account of this very development they are unable to feed on wood, like the nymphs; the latter, however, supply their needs in this respect by offering, when solicited, a drop of regurgitated liquid food or else a drop of liquid fæcal matter. This latter substance is also used as a cement for plugging up holes or galleries. Sometime of these plugs are massive in size compared with that of the insects, yet it appears to be formed entirely of this material. When still wet it

* *Vide* Previous article *Tea Quarterly*, Vol. X, Part III.

mixes with water, some of it going into solution, the rest settling into a sediment of very fine particles after the lapse of a considerable time, these particles being about one two-thousand-five-hundredth of-an-inch or less across (3-10μ).

In a small proportion of occupied tea bushes the fully *winged adults* may be found, waiting patiently for the day of release. In ground nesting termites these winged adults appear only a short time before flight. This is not so certain in the case of *militaris*. A certain bush containing the adults ready for flight was marked and covered with fine netting in the hope of discovering when liberation took place. But although examined from time to time over a period of months no definite evidence of escape was found, and the winged termites could be found in the bush on each examination. It seems therefore that either they may be retained in the nest for a very long time, or else perhaps they escape just a few at a time.

The Founding of a Colony—is due to a winged pair. Winged termites leave the colony at some time or other at present quite unknown; and we remain as yet quite uninformed of the conditions necessary for this. They fly up a little distance into the air, pair off, seek a wound in some tall tree, then burrow in and finally mate. The resulting union produces eggs, from which the new colony arises. The parents are usually known as the "king" and "queen", but as they cannot be said to rule, and their only function is the production of young, "colony parents" or "founders" would be a more apposite term. The first offspring which hatch are tended by the parents and fed until they can look after themselves; they then take over the task of looking after the young, and in general the task of workers. The nest is first of all extended from the initial, nuptial, chamber by a single gallery or two down into the tree, where branches are formed and gradually the hollow so characteristic of this species is created, and continued down into the root system (*vide* Plate I).

The Origin of a Colony in a Tea Bush (as distinct from seed bearers)—appears to be different from that in trees in that it does not originate from a winged pair. It seems to be always the case that attack originates in a root and passes upwards, and there is strong evidence to support this view. In the upper Maskeliya Valley, these termites are only found on one side of the river, which is some ten to twenty yards wide. Yet in the course of about fifty years no termites have as yet been found in the tea on the other side. If colonisation originated, at least in part, from winged pairs, it is not too much to expect that tea bushes on the right bank of the

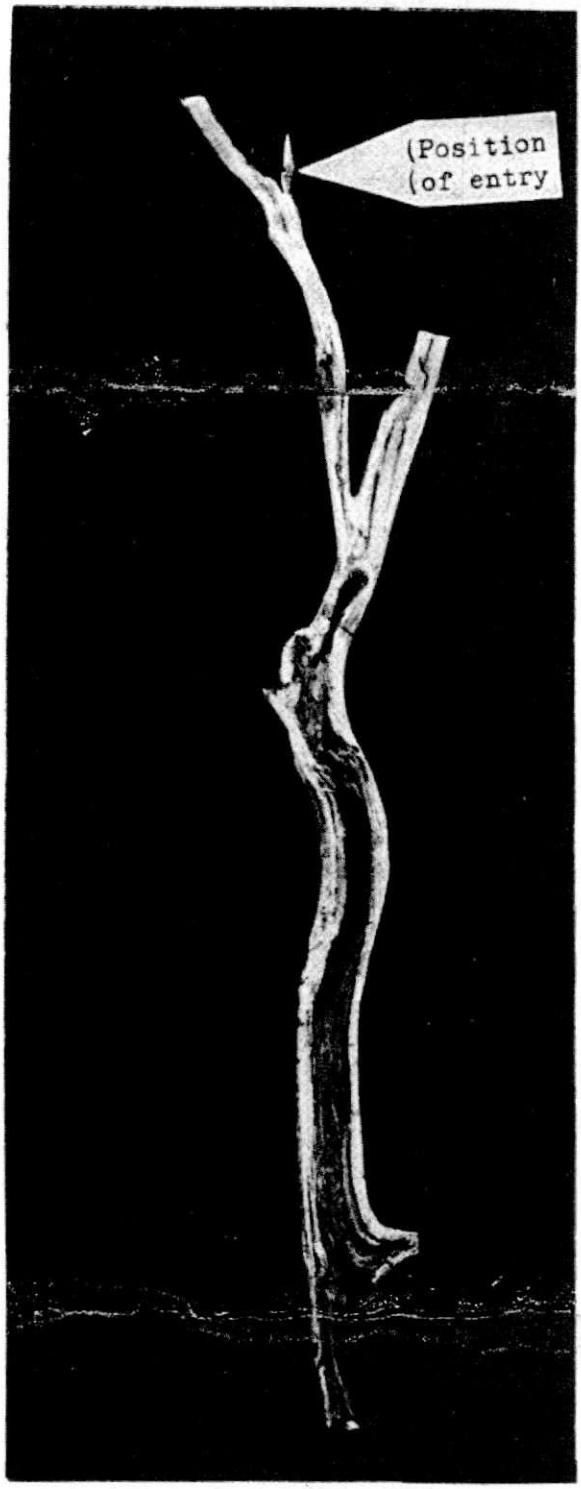

PLATE I.

Albizzia moluccana attacked by *N. militaris*, reconstructed after splitting open. The point of entry is shown near the top, about 16 feet above ground level.

river would be infested by this time. On the other hand, if infestation of tea bushes through the root system is the only method of propagation, it is easy to see that the river is a perfectly natural and effective barrier. Not long ago a large Albizzia on the termite-free side of the river was cut down and found to have a colony of *militaris* in it which was well up in the trunk and had not reached ground level. The tree was over 200 yards from the nearest infested tea on the other side of the river; others have also been found infested here. This is sufficient to show that the winged termites can fly sufficientiy far to cross this river and attack a tree some distance from its course. As yet none have been discovered on the tea on this side of the river, so that it is highly probable that they came from the left bank where colonies are numerous both in tea and Albizzias.

The question of *subterranean progress* requires comment. Experiments have shown that *militaris* will not travel through soil in search of bushes. A few hundred termites were placed a few inches from a tea bush and covered with soil. Subsequent examinations showed them to be all in the same place, and gradually they died without making any attempt to forage about. The bush was not attacked, and they do not seem capable of *hunting*. Hence the only method of progress from bush to bush that appears open to them is to take advantage of the contiguity of two roots, each from a different bush.* It is most probable that all tea bushes are attacked in this way, and it would seem that the better the root systems, the better chance is there of dispersion. This particularly applies to closer planting which may be expected to enhance this tendency, as when, for instance, in the area dug up, to which reference has already been made, a patch of 190 adjacent bushes had been attacked, and in 51 of these living termites were found. This tea had been planted more or less haphazard, no rows were discernible, and there were well over 6,000 bushes to the acre.

This being the case it is probably wrong to speak of one colony per bush, as it is quite possible and even probable that one colony may occupy more than one bush at the same time. The following patches of adjacent bushes, each containing living termites, were found in this field — 11, 10, 8, 7, 7, 7, 6, 6, 6, and several groups of five and less bushes.

If the above view is correct, it would seem that the *longevity of a colony* in tea may be exceedingly long indeed, hundreds of years, perhaps. Their progress from bush to bush is very slow, and as long as there are new bushes in subterranean contact, it is difficult

* This idea was first put forward by E. E. Green (4).

to see what will stop it. On the other hand the longevity of a colony in a single bush is definitely limited. In the tea examined, 1,351 bushes were found with living termites and 3,438 had been attacked and abandoned. It is, of course, not possible to say how many different colonies transferred themselves to tea when first planted. But if we assume that a colony stays in a bush 15 years, and then moves to a new one, in 46 years there will be three abandoned bushes. and one new one containing the colony. This also holds good if the initial figure is 12, 13 or 14 years. The ratio today is about 5 bushes abandoned to 2 containing living termites, so that the figure in question may be more than 15. Jepson [5] states "bushes may have been infested for ten or more years."

Much less is known about the life cycle of individual termites. Under laboratory conditions, as stated above, fully winged termites may be produced in about 8 years. On the other hand the complemental wingless adults can be produced in 9 months [6]. It will be remembered that the workers are immature, and not only may remain in that state for 7-8 years, but may live much longer.

THE DAMAGE DONE IN TEA BUSHES

Initial attack in a tea bush usually begins in a side root, and a channel is excavated along it until it reaches the main root. At first other channels are made upward into the main stem, and later the wood separating these is gradually eaten away, leaving the well-known characteristic cavity. Further galleries are eventually driven up into the branches, where they may be seen when the bush is pruned (Plate II).

It is here necessary to observe that all this work is done in the heart wood of the bush, and none of the living tissue surrounding the central core is touched, as long as it is in a healthy condition. If the bush becomes diseased, and the active portion of the wood is killed, it may then be invaded by the termites.

What therefore is the effect of termites on the tea bush ? The damage done is purely mechanical. It does not interfere with growth. A bush with or without its heart wood continues to grow as before. Even in this condition it is mechanically sound, unless the bush is very young, or except where a gallery may traverse a stem of small section. The statement has been made more than once that these termites will reduce the frame to a mere shell, as others do in structural timbers. This is not my experience, unless the outer wood has first been attacked by some disease. A healthy bush can sustain these attacks and continue to grow and flush without apparently being any the worse. Sometimes it is able partially to

fill the hollow with callus tissue, as may be seen in Plate III. At any rate for a great number of years the tea bush appears to be in no way discommoded by cavities due to termite activity.

PLATE II.

An example of fresh galleries revealed by pruning (in this case by *N. greeni*). A bush such as this may be selected for the Paris Green treatment.

Plate IV shows one cut open, displaying the hollow within which extends into both roots and branches. Neither of these bushes had living termites within; their age from the time of first attack is probably greatly in excess of 15 years. Many similar bushes were dug up.

The *food* of *militaris* of course consists of the wood in which it lives, and the various secretions and excretions to which reference was made in the former paper [7]. The wood is usually the sound

heart wood of the tree or bush it happens to be in. The excreta in this case are liquid which on drying become an amorphous patch. But occasionally the termites may be found in diseased wood when conditions appear to be drier, and then the excreta take the form of the well-known pellets so characteristic of dry-wood termites. In the former case, the tea bush is duly vacated, leaving it little the worse, but when found in a well rotted bush they seem to remain until it is almost completely finished. This may be due to the fact that disease has rotted away the roots and they are unable to escape. When termites are found in these moribund bushes it is usually considered that the insects are the cause of the condition of the bush, but this is not the case. We have seen that termites leave a healthy bush after years of residence, but wood-rotting organisms may kill a bush, whether or no termites are present; the incapable state of such bushes may therefore be ascribed to wood-rot. I have never found a disease-free bush which appeared to be in the least danger of being killed by *militaris*.

CONTROL

In order to eliminate *militaris* from tea bushes it is necessary to destroy the entire colonies, and this can be done in two ways:—

1. By means of poison.
2. By uprooting bushes containing living termites and destroying them.

(1) *Poison*.—At one time fuel oil or other unpleasant liquid was poured into hollows in the bushes to get rid of the termites. But all this could do was to kill a few individuals by contact and render the immediate neighbourhood repellant. The remainder would take refuge further down and probably invade a fresh bush.

From America came the idea of using a fine arsenical powder applied to the surface of the bodies of the termites. Their habits of life induce them to groom each other thoroughly; and during this process particles of poison are ingested, leading to death. The corpse is scavenged by eating it, and the scavenger dies in turn. In this way the poison is eventually passed round the entire colony. Jepson [9] introduced this method in 1926, using Paris Green, and found it to be efficient. Since then a great deal of treatment in this manner has been carried out. The usual plan is to bore a hole about $\frac{1}{4}$-in. wide in the main stem of a bush with a long auger, pump in a little powder by means of a rubber bulb enema, and plug the hole with putty, clay or some similar material. Now while the

PLATE III.

Tea bush hollowed by *N. militaris*, cut away to show extensive growth of callus tissue within.

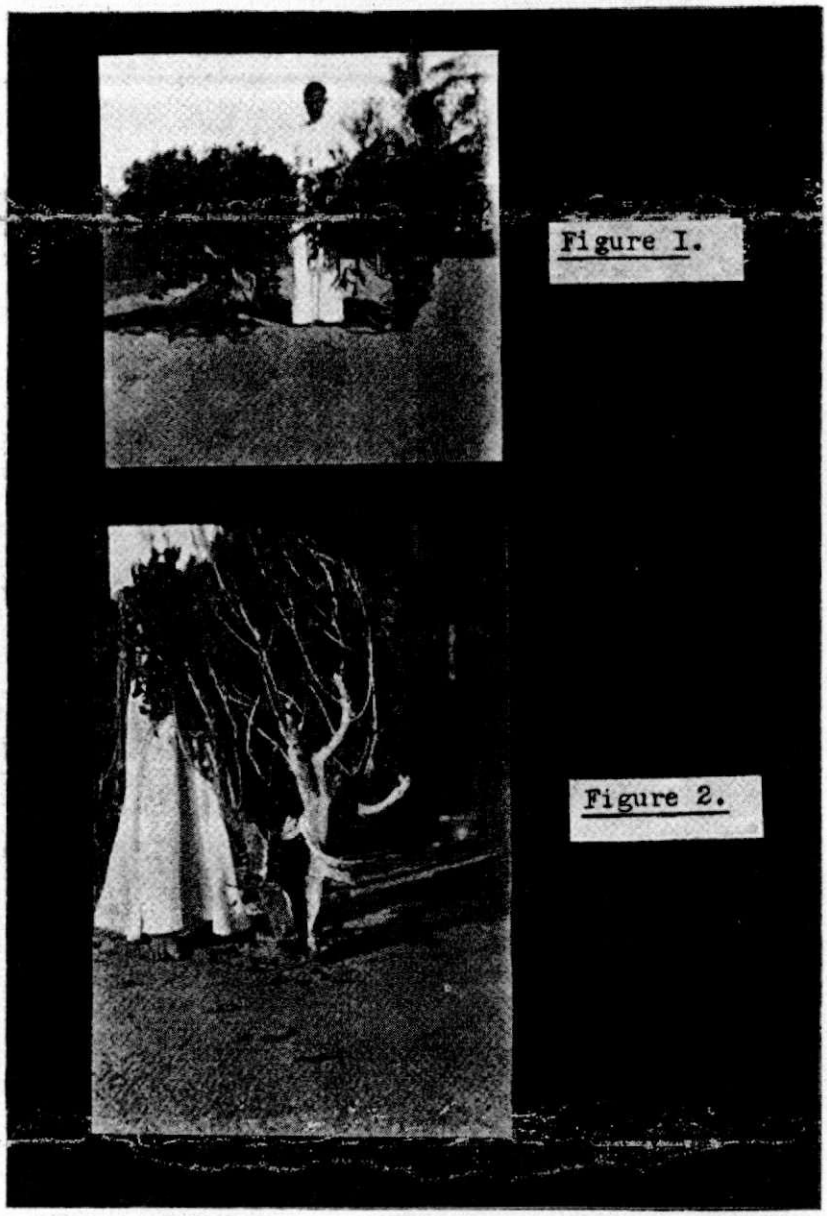

PLATE IV.

Fig. 1.—Two healthy bushes dug out, each containing large excavations, the work of *N. militaris*.

Fig. 2.—One of the two bushes cut open.

principal idea was sound enough, it often failed in practice, and this was largely due to the fact that in the nature of things it is difficult to know whether a bush contains termites or not. Bushes usually selected were those with cavities in the collar, and open above. This is by no means an indication of the presence of termites, the open top of the cavity demonstrating wood rot. There may or may not be termites in addition.

Another difficulty crops up even if there are living termites present, especially where the cavities are large, and this is caused by the presence of a muddy substance almost filling up the cavity. If the hole is bored into this, the powder at once is localised and may not fulfil its function at all.

It will be seen, therefore, that the method must necessarily be rather hit-or-miss. To reduce the error as far as possible, it would be advisable to adopt some such plan as follows: when a bush is pruned and shows a fairly clean cut hole (Plate II) in new wood, it should be marked in some way for treatment. All adjacent bushes should be examined for the same sign, and if found, also treated. No other criterion need be considered. This will narrow down the scope considerably, increase the probability of the presence of termites, and reduce the whole business to a simple plan. It should be added that unless a hollow is distinctly felt when the auger is at work, the powder should not be injected.

We have above noticed the effect of the Paris Green on the termites; it now remains to observe its effect on the wood. It was at one time thought to be quite harmless, but if any of the powder is left on the sound wood, there is a certain amount of penetration. If this happens to occur in the region of the cambium and other living tissue, the latter will be killed. The effect is local. The permeation of the tissue by the poison is at first rapid but slows down and stops entirely in a month or two. The final result is an elongated oval area of dead wood round the hole, the long axis being up and down the stem, extending some way into the wood. Unless the wood is cut into with a knife, this development remains for a long time unnoticed. When there has been sufficient growth in thickness, this area becomes outlined, since the area itself of course does not grow outwards. The rest of the bush does not appear to be affected in any way. If, however, the hole is drilled immediately underneath a branch the latter may be killed by the spread of the poison: such places should therefore be avoided, and a site be chosen as far as possible in the thickest part of the stem. Stems about an inch thick may be killed by the poison, but, by reasonable care in application, little danger may be apprehended, and the termites killed.

(2) *Removal of Bushes.*—The second way in which the problem may be faced is by the complete removal of bushes, with all roots, as is done in the case of *Poria*. If all bushes in a group are treated thus, taking due observance of the fact that the peripheral bushes are free from termites, the area may be planted up again at once. In the case of large areas which include both infested patches and uninfested bushes, it will be necessary, besides completely clearing the soil of all roots, to dig a trench about two feet deep about the area to prevent invasion from without. This accomplished, new tea may be planted as soon as convenient.

CONCLUSION

In *The Tropical Agriculturist* for August, 1926 we find the following words regarding *N. militaris*: "The chief scene of its activity is the Maskeliya district, where it is extremely destructive on a large number of estates." Also: "A bush attacked in this way is doomed and cannot be rebuilt. It is only a matter of time before it dies."

The above views are widely held, but no data have been brought forward to show the extent of destruction, or the percentage of bushes killed by the termite. When, therefore, the opportunity arose of investigating these questions on the spot, it was immediately seized: for such investigation not only involved the digging up of bushes and the examination of each one, but owing to the large number so treated one could more easily assess the status of the termite as a pest. In this case the five acres of tea were chosen in a situation considered to be the most severely infested by *militaris*. As observed above the area was planted up just fifty years ago on land cleared from jungle.

The following table gives the principal facts regarding examination and infestation:—

Total bushes examined	Bushes attacked by *N. militaris*		
	Total	Containing living termites	Abandoned
27,962	4,789	1,351	3,438
	=17.12%	= 4.83%	= 12.29%

It will be noticed that considerably more than twice as many bushes were found abandoned after being attacked as contained living termites, and nearly the whole of these were healthy and vigorous, with plenty of foliage. The few exceptions suffered from advanced woodrot. Of the total given above, 65 supplies had been attacked, and 26 of these abandoned.

We may summarise conclusions to be drawn from the information obtained, thus:—

(1). The progress of infestation over 50 years has been exceedingly slow.

(2). The termites will abandon a bush after infestation over a long period of years for no reason that we can at present understand.

(3). Although a good deal of the heart wood be eaten out, the damage done to the bush as far as growth is concerned appears to be very small.

(4). Therefore *N. militaris* cannot now be said to be "extremely destructive."

(5). A bush which is attacked cannot be said to be doomed. No bush examined had been killed or was in a moribund condition through the agency of termites.

(6). Rebuilding actually takes place in some cases, where extensive callus growth may be found within the cavity made by the termites. (*Vide* Plate III).

REFERENCES

(1). F. P. Jepson.—Year Book of Department of Agriculture, 1927, p. 20.

(2). J. C. Hutson.—Administration Report of the Department of Agriculture, 1932.

(3). J. C. Hutson.—Administration Report of the Department of Agriculture, 1935.

(4). E. E. Green.—*Tropical Agriculturist*, Vol. XXVIII, p. 181, 1907.

(5). F. P. Jepson.—Bulletin No. 86 of the Department of Agriculture.

(6). F. P. Jepson.—*Tropical Agriculturist*, Vol. LXXV, p. 191, 1930.

(7). C. B. Redman King.—*Tea Quarterly*, Vol. X, Part III, 1937.

(8). F. P. Jepson.—Bulletin No. 86 of the Department of Agriculture, p. 3.