Control of Coptotermes curvignathus Holmgren with Chlorinated Hydrocarbons

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The nature of the attack on rubber trees by C. curvignathus is briefly described, with an indication of the degree of effectiveness of old-established control measures. Tests of a range of chlorinated hydrocarbon insecticides indicated that chlordane, aldrin and dieldrin are highly effective and give lasting protection against re-attack. The persistence of insecticidal activity in soil of chlordane, aldrin, dieldrin and endrin was assessed by exposing termites to treated soil in a standard manner. Six different soils were compared in this respect.

COPTOTERMES CURVIGNATHUS HOLMGREN is the only species of termite known to attack living rubber trees in Malaya. Indigenous to the country, it persists in plantations where the remains of the original jungle have not completely wasted away, attacking trees of all ages. Though it can attack perfectly healthy trees, its entry is facilitated by root disease or other injury which destroys the latex barrier; newly planted stumps are particularly liable to be attacked, and are quickly killed, often without any termites appearing above the soil. Termites affecting a healthy tree search for an easy point of entry, covering their runways on the trunk with mudwork. A mature tree may show no outward sign of an attack and, though the tap root and trunk are hollowed out, the tree can be tapped normally until it falls or is blown over.

Being social insects living in concealment, termites are difficult subjects to study and, in consequence, not much is known about their behaviour. It is believed that the nest of *C. curvignathus* is subterranean built within a submerged log or tree stump, from which tunnels run in all directions, linking up secondary nests in hollow trees or timber. It is not feasible to locate the main nest in order to destroy it. Insecticidal treatment applied to attacked trees contacts relatively few workers and soldiers; though they may be destroyed, others will attack neighbouring trees or, after the insecticide ceases to be active, will re attack the same tree. Regular inspection of badly infested young rubber has been necessary to discover and treat affected trees before they are seriously damaged. The materials used for termite control for many years were: mercuric chloride applied by pouring a 1% solution round the tree (the 'liquid' method), calcium cyanide and sodium silicofluoride applied by opening up the collar of the tree and dusting the roots (the 'crater' method), and white arsenic applied by injecting a small amount of the powder into the earth runs on the trunk (the 'trail injection' method). NEWSAM (1953) compared the three methods in mature rubber and concluded that all three were effective in driving termites away from attacked trees, but that the incidence of attack was little affected. Trail injection with white arsenic was satisfactory on mature trees, but not on young trees because of its tendency to burn the bark; for the latter, the solution of mercuric chloride was preferred.

The outstanding success of chlorinated hydrocarbon insecticides, starting with the war-time discovery of insecticidal activity of DDT and gamma benzene hexachloride, naturally led to their application to termite control problems. An up-to-date review of literature on this subject is given by SCHMITZ (1956).

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FIELD EXPERIMENTS WITH CHLORINATED HYDROCARBONS

Field tests with chlorinated hydrocarbons as soil insecticides against termites have been carried out on the Experiment Station of the Rubber Research Institute of Malaya since 1950, when an application of four ounces of benzene hexachloride dust containing 0.4% gamma isomer round the collar of mature trees was found to have no protective value. In the same year an unsuccessful attempt was made to protect stumps planted in an area heavily infested with termites. Either two ounces of benzene hexachloride dust containting 0.4% gamma isomer, or the same weight of 5% DDT dust or 5% toxaphene dust, was incorporated into the soil of the planting hole. The treatments did not prevent heavy losses of stumps.

A greater range of insecticides and formulations was available in 1952, some only as samples for experimental purposes. A test was put down in November of that year in a seven-acre low lying area planted with stumps. Dusts containing 0.5% gamma benzene hexachloride, 5% DDT or 5% toxaphene were incorporated into the soil of the planting hole at the rate of one pound per point. Wettable powders containing 0.065% gamma benzene hexachloride, 0.25% DDT or 0.25% toxaphene were watered round the stumps while planting, at the rate of two gallons per point, as were aqueous emulsions containing 0.025% gamma benzene hexachloride, 0.25% DDT, 0.187% chlordane, 0.12% aldrin or 0.09% dieldrin. The costs of the chemicals were taken into account in deciding the dosages applied.

The area was divided into plots of 100 contiguous points, each planted with two stumps. Each plot received one treatment, applied to 50 points only, alternating with untreated controls. In addition, three more treatments were combined with the three dust treatments. Wettable powders containing 6.5% gamma benzene hexachloride, 25% DDT or 25% toxaphene were suspended in a 2.5% tapioca flour paste at the rate of 2.5 lb per gallon; into these pastes the roots of additional stumps were dipped just before planting — as a third stump at each control point, about a foot and a half away from the untreated plants of the appropriate dust treatment.

Heavy incidence was expected as *C. curvignathus* was known to be present in some large jungle stumps in the area. Surprisingly, the number of points attacked during the first year was only twenty; thereafter there was no incidence in the treated area. Of the attacked points eleven were untreated controls compared with nine from the treated plants. These nine were made up of two treated with DDT dust, three with DDT paste, two with toxaphene dust and two with toxaphene paste. Compared with this, in the 45 acres of the rest of the field planted with stumps at the same time, and thought to be less liable to attack, the rate of incidence was two and a half times as high during the first two years.

Though the experiment did not bring out the relative merits of the different treatments, it indicated that benzene hexachloride, chlordane, aldrin and dieldrin might hold promise. It also indicated that emulsions are to be preferred to dusts, wettable powders and pastes.

Aqueous emulsions of these four insecticides were further tested for their protective value for stumps planted in November 1953, in a four-acre block. There were five plots each containing approximately 170 planting points with one stump; a central plot was left untreated while the surrounding four were treated with gamma benzene hexachloride, chlordane, aldrin and dieldrin at the same concentrations as in the previous experiment, but at the rate of half a gallon per point instead of two gallons. In the treated plots, too, one untreated control plant was left after every two treated points. Half the quantity of the insecticide was poured into the planting hole and the other half round the stump after filling the hole with earth.

Only fifteen plants were attacked during the first four months and none for eighteen months after that. The fifteen attacked plants comprised three treated with benzene hexachloride, five controls in the same plot, four controls in the chlordane treated plot and three controls in the dieldrin treated plot. There was a complete absence of attack in the central control plot during this period.

The experiment, apart from suggesting that benzene hexachloride is inferior to chlordane, aldrin and dieldrin, strengthened the belief that the latter are effective at low dosages and that their widespread use in an area may affect the whole colony, resulting in a drastic reduction in incidence.

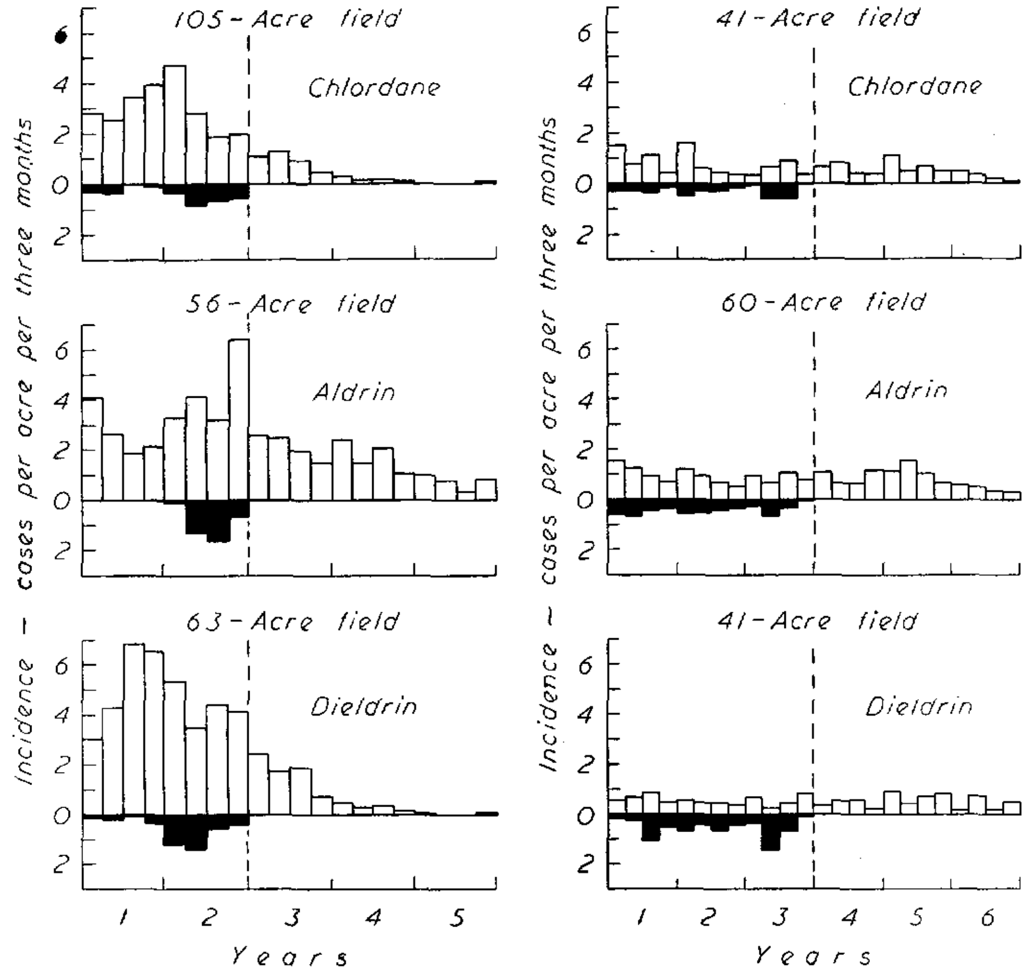

Figure 1. Termite incidence in three fields of immature (left) and mature rubber (right) under different treatments.

The low rates of attack in experimentally treated areas led to a different approach being tried to compare the relative effectiveness of these materials. Over the whole of a field of immature rubber one experimental treatment was given to attacked plants discovered during fortnightly inspections, the incidence rate being compared with that previously found under a standard treatment (one pint of 1% mercuric chloride). The four materials were tested at the rate of one pint per tree of the same concentrations as used before — 0.025% gamma benzene hexachloride, 0.187% chlordane, 0.12% aldrin and 0.09% dieldrin.

A few cases of re-attack of treated trees were noticed, some even within a month after treatment, in the field receiving the benzene hexachloride treatment, which was accordingly discontinued after six months. In the fields treated with chlordane, aldrin and dieldrin, the rate of incidence declined and treated trees remained free of reinfestation for over three years, except for three trees out of 980 treated with aldrin and one out of 532 treated with dieldrin. *Figure 1* illustrates the incidence of attack (clear) and re-attack (shaded) per acre per three months, in three fields, for two years under treatment with mercuric chloride and for three years under treatment with the new insecticides.

The minimum effective dose of these insecticides was still to be found; for this purpose they were used at the following reduced concentrations: chlordane 0.075% and 0.0375%, aldrin 0.05% and 0.025% dieldrin 0.03% and 0.015%, applying one pint of the emulsion per attacked tree. Over a period of more than two years there have been only few cases of re-attack of treated trees, and these have occurred where the soil is peaty. The effect of peat will be discussed later.

Following this success, chlordane, aldrin and dieldrin replaced mercuric chloride and white arsenic for routine treatment on the Experiment Station. In fields of immature rubber the diluted insecticides were used at the rate of one pint per tree, but in mature rubber the rate of application was doubled to allow for greater girth of the trees. In contrast with fields of immature rubber, the decline in incidence in mature fields was slow, though there were no cases of re-attack. *Figure 1* also illustrates the incidence of attack (clear) and re-attack (shaded) per acre per three months in three fields of mature rubber, for three years under the old treatment and three under the new. The slower decline may be explained by the large trees harbouring the pests for many years before they could be discovered and treated.

SOIL TESTS

The relative effectiveness of these insecticides, and the time they will remain active in the field, was studied by exposing termites to samples of treated soil in a standard manner. Tests of this nature have been described by Hockenyos (1939), Shelford (1949) and Hetrick (1950).

C. curvignathus workers will survive for many days in petri dishes provided with moist filter paper for food and to keep the humidity high. For the test, the soil sample was evenly spread over the filter paper in a 9 cm dish, into which were placed ten workers selected from large numbers collected two days prior to the test. High humidity was maintained by spraying water on to the soil with a hand atomizer whenever the inner surface of the lid was found to be free of condensation.

The tests were made with samples of soil from fields that had received experimental treatments described earlier. The soil generally in these fields is a fine sandy loam with patches of peat overlying alluvial sand. Peaty areas were avoided when taking soil samples; otherwise trees were taken at random and soil collected from about two inches below the surface and close to the collar. Tests were repeated at intervals of three months, each time selecting a different tree for sampling. Duplicate dishes were set up with each soil sample, and there was an extra pair of dishes with untreated soil, as a check on the viability of the termites used in the test. Daily counts of dead and dying workers were made for two weeks. It was found that, in treated soils which retained their toxicity, the termites were in a dying condition at the end of twentyfour hours — lying on their backs with their legs twitching — and were dead by the second or third day. In soil which was only feebly toxic the termites, though affected, were still mobile after the first day, and they would take nearly a week to die.

SURVIVAL OF TERMITES PLACED IN TREATED SOIL

Concentration of insecticide applied	Period since soil treated (months)	Condition of termites after 24 hours exposure	Time for death (days)	Assessment of soil toxicity
0.0375% chlordane	15	dying	4	toxic
	18	affected	6	feebly toxic
	21	affected	7	feebly toxic
	24	active	10*	non-toxic
0.025% aldrin	15	dying	2	toxic
	18	affected	5	feebly toxic
	21	affected	5	feebly toxic
	24	active	10*	non-toxic
0.015% dieldrin	27	dying	2	toxic
	30	affected	5	feebly toxic
	33	affected	6	feebly toxic
	36	active	>14	non-toxic
0.187% chlordane	36	dying	3	toxic
0.12% aldrin	36	dying	3	toxic
0.09% dieldrin	36	dying	3	toxic
0.025% gamma BHC	3	active	>14	non-toxic
1% mercuric chloride	1	active	>14	non-toxic

* death due to fungus attack.

In preparing the Table, where the more significant results are set out, the early observations repeatedly showing the soils to be still toxic have been omitted, leaving only those which show when toxicity was being lost. In all the treatments recorded in the Table, the quantity of diluted insecticide applied round each tree was one pint. It is seen that 0.0375% chlordane and 0.025% aldrin persisted equally well, and that the concentration of dieldrin to give a comparable result would be less than 0.015%.

Further, the excellent retention of the higher concentrations of the same three materials, which remained fully toxic after three years, contrasts strikingly with the results obtained with gamma benzene hexachloride and mercuric chloride.

The poor performance in peat, already referred to, suggested that persistence might depend on soil type. To investigate this a pot test was carried out, starting in December 1954, with six soils: fine sandy loam, coarse sandy loam, lateritic soil, volcanic soil, coastal alluvial clay, and peaty soil. Emulsions of chlordane, aldrin and dieldrin, and of endrin (here tested for the first time) were all diluted with water to the same concentration of the active ingredient (0.05%) for mixing at the rate of 500 cc to six pounds of air-dry soil, in an eight-inch pot. The pots took only half the quantity of peat. The four sets of six pots, and a set of six pots containing untreated soils, were buried in an open place to about one inch from the rim. Each set was widely separated from the others, to prevent contamination.

At monthly intervals the top three inches of soil was mixed and a sample taken into the test petri dish as before. The method of testing was made more sensitive than in the previous experiment, twenty termite workers being introduced into the dish for two hours only, after which they were transferred ten each to two petri dishes prepared with a small quantity of untreated soil of the same type. Observations on their condition were made immediately after exposure to the treated soil, again after four hours, twentyfour hours, and thereafter daily. While a treated soil retained its full toxicity, termites exposed to the sample appear feeble and are slow in their movements either at the time of transfer to untreated soil or within four hours after that, and are in a dying condition after twentyfour hours. As the toxicity diminished, the symptoms appeared more slowly. Termites which were still active three days after exposure generally lived for many days more. This criterion was taken as indicating that the soil had lost its toxicity. The periods taken for the different insecticides to be lost in the various soils are represented in *Figure* 2. After the forty months that the experiment has been running, dieldrin has lost its toxicity in clay but remains active in all the other soils with the exception of peat.

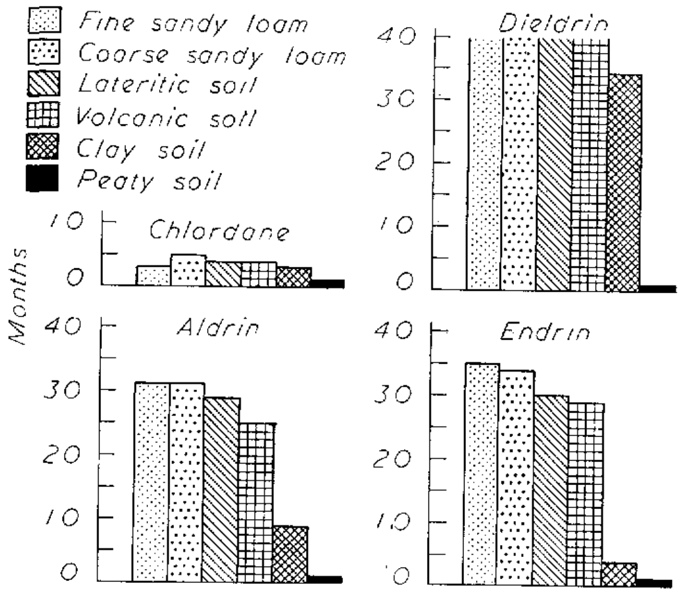

Figure 2. Persistence of chlordane, aldrin, dieldrin and endrin in different soil types.

DISCUSSION AND CONCLUSIONS

The insecticide chlordane and those related to it—aldrin, dieldrin and endrin — can be said to have solved the long existing problem of termite control in rubber plantations. In addition to being effective in soil at extremely low concentrations, their activity persists for long periods, forming an effective barrier against future attack. Applied to the soil in equal amounts chlordane becomes ineffective much earlier than the other three insecticides; dieldrin remains effective longest. Endrin, which persists about as well as aldrin, is excluded from practical use by its relatively higher price. To be about comparably persistent, the relative concentrations of dieldrin, aldrin and chlordane need to be approximately in the ratio 1:2:3.

Tests with different soil types have shown all the insecticides to be lost sooner in a coastal alluvial clay than in four inland soils tested. In peat they are all quickly inactivated, but it has been found, using aldrin, that the effect can to some extent be overcome by a large increase in dosage.

The cost of these insecticides at the very low rates of application needed is so small that it is feasible to treat every tree in an infested area, which will be effectively protected for a few years, the time depending on the soil type and the dosage. Further, their low toxicity to mammals makes them much safer materials to use than mercuric chloride and white arsenic, which have been the standard treatments for many years.

Apart from the inclusion of a further six months records in Figure 2, the paper is as presented to the Ninth Pacific Science Congress, Bangkok, 1957. It is published with the permission of the Organising Committee.

Pathological Division
Rubber Research Institute of Malaya
Kuala Lumpur *June*

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