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STUDIES ON THE HOST-PARASITE RELATIONSHIP OF PHANEROGAMIC PARASITE(S) ON TEAK AND THEIR POSSIBLE CONTROL

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INTRODUCTION

Woody angiospermic parasitic plants, commonly known as mistletoes infest trees throughout the world. In India some of the vernacular names for these parasites on various tree species are *Banda* or *Bandba, Panda* (Hindi), *lthikanni* (Malayalam), *Manda* (Bengali), *Banje, Banduka* (Kannada), *Othu* (Tamil), *Bajinike* (Telugu). According to Webster's Third International Dictionary, mistletoes are hemiparasitic evergreen shurbs that have dichotomously branching stems, thick persistent leathery leaves, including numerous species of the family Loranthaceae- Good (1974) defined mistletoe as any aerial parasite belonging to the families - Viscaceae, Loranthaceae, Santalaceae and Myzodendraceae. Most of the species are distributed in tropical and subtropical regions and occasionally in temperate regions.

Mistletoes were one of the earliest parasites of plants recognised by Albertus Magnus around 1200 AD (Horsfall & Cowling 1977). They cause sometimes major problems for the horticulturists as well as the foresters. Usually these autotrophic semiparasitic plants flourish on the trunk, branches or the aerial roots of the trees. The parasites make contact with their host plants by a complex organ called haustorium (Kuijt 1977; Kuijt & Toth 1976) and through this organ they draw their nutrients and water from the host plants. Good account of haustorial system of *Dendrophthoe* and the related genera with which we are concerned has been given by Menzies (1954), Singh (1962) and Hamilton & Barlow (1903).

The family Loranthaceae has been divided into two subfamilies Loranthoi-deae and Viscoideae. Recently these two subfamilies have been recognised as two distinct families, Lordnthaceae and Viscaceae (Maheswari *et a/.,* 1957; Barlow 1964; Good 1974). B. H. Danser is considered to be the authority on the species identification of Loranthaceae and some of his famous works are listed (Danser 1929, 1940, 1941). Literature on the taxonomy, embryology, biology, physiology, host-parasite relationship etc. of various species have been well documented by Gill &Hawksworth (1961), Kuijt (1969), Hawksworth & Wiens (1972), Johri & Bhatnagar (1972).

In India several species of mistletoe have been recorded on various forest and fruit trees (Brandis 1906; Rao 1923; Fischer 1926; De 1945; Koppikar 1948; Bagchee 1952; Singh 1962). Except for some isolated work on its distribution, host range, taxonomy, embryology and control, mistletoe problem has hardlv attracted any attention of plant pathologists in India. No attempt has been made to determine the extent of damage due to mistletoe attack, which is absolutely necessary for planning any control or management measures,

Mistletoe on teak was recorded as early as 1867 by Dr. Cleghorn from Nilambur (Lushington 1896). It is one of the-major pests of teak in Kerala (Fig. 1). In some of the plantations in Kerala, more than 80% of the trees are infested with this parasite leading to a heavy loss. Heavy attack of this parasite on young trees have often led to total failure of plantations in Nilambur. These plantations were

Fig. 1. a) A severely mistletoe infested teak plantalion. b) A tree dead due to mistletoe attack.

clear felled much before they attained rotation age (Ranganathan 1982). Since the time it was recorded on teak, physical removal of clumps by lopping the infested branches from individual trees, is being practised by the Forest Department.

Teak is the major hardwood species in the state and Kerala Forest Research Institute has recognised the problem posed by the mistletoe on it as the most important pathological challenge. In the past four years attempts have been made to appraise the economic and other damages caused by this parasite (Gnanaharan *et al.*, 1983). Work has been carried out on the epidemiology, and on the management of the parasite through chemical control. A simple gravity flow tree-injection technique has been developed and standardised to infuse water soluble compounds into the trees (Ghosh & Balasundaran 1980). Though some of the herbicides infused into the trees using the above technique, have selectively killed the parasite clumps without harming the host (Ghosh *et al.,* 1982), the experiments are still in their preliminary stage. For any recommendation to be made to manage this parasite in the teak plantation, however, much more has to be Jearned regarding epidemiology of the parasite infestation, physiology of the host and the parasite, biology of the parasite and the cost-benefit analysis of the recommended management practice, if there is any. In the following chapters we have discussed some of our observations. Each chapter is broadly divided into introduction, review of similar work done elsewhere, if any, materials and methods, results and discussions.

EPIDEMIOLOGICAL STUDIES

An epidemic is the progress of the disease in time and space and is a part of the ecosystem. A plant disease is the result of interaction between host, pathogen and the environment. Study of the spread and development of diseases and pests within a plantation is absolutely essential to plan any management practice to control them (Scott & Bainbridge 1979; Kranz & Hau 1980).

The environmental factors affecting the occurrence and intensity of mistletoe infestation are poorly understood. Usually the clumps of the parasite establish well in drier areas (comparatively) in open sunny places, on the tree tops in plantations specially at the edges of the dense forests (Troup 1921; Fischer 1926; Gill & Hawksworth 1961). There is a lot of published literature on dwarf mistletoes (members of the genus *Arceuthobium).* However, hardly any data are available on the climatic, physiographic or biotic factors influencing the epidemics of mistletoe on teak or other species.

This chapter deals with preliminary studies on the biology of the teak mistletoe, its distribution in Kerala, host species, phenology and the biotic factors or the natural enemies interfering with their growth.

Materials and Methods

a) Collection and identification of commonly occurring mistletoes :

In the course of our study, a collection of the mistletoes was made from teak plantations as well as other neighbouring forest plantation species and horticultural crops. Both the host and the parasite species were identified.

b) Distribution of mistletoe in teak plantations in Kerala:

Informations on the occurrence, severity and mortality of trees due to mistletoe attack in various teak plantations were obtained from forest ranges. Field surveys were then conducted to study their distribution in plantations and to assess the extent of damage caused by them. Working plans for all the forest divisions were referred to ascertain the occurrence and relative severity of the attack.

c) Phenological studies on the host and the parasite:

Flushing, flowering and fruiting period of both, the host and the parasite were noted at monthly intervals in the teak plantations at Trichur and Nilambur Divisions for three years. Observations were recorded on 100 trees chosen at random covering three different localities on each of the two divisions.

d) Biotic factors or natural enemies of teak mistletoe:

While taking observations on the mistletoe, visiting various plantations and the natural teak forests, occurrence of natural enemies like caterpillars, viruses, interfering with normal growth of mistletoes were also recorded.

Results and Discussion

a) Collection and identification of commonly occurring mistletoes:

It was interesting to note that with teak, only one species of mistletoe was associated which was identified as *Dendrophthoe falcata* (Linn. f.) Ettingh. var. *pubescens* Hook. f. The species identification was confirmed by Prof. Dr. E. Govindarajalu, Presidency College, Madras (Fig. 2). The specimen is deposited in the herbarium of Botany (Taxonomy) Division of the institute. The salient characters of the species are as follows:

Dendrophthoe falcata (Linn. f.) Ettingh var. *pubescens* Hook. f., is a large woody, evergreen, semi-parasitic much branched shrub, branches upto **3** m long bark grey, amooth with numerous lenticels. Leaves pale green to green, simple, opposite or alternate, 8-15 cm long by 3.5 - 8 cm wide, oblong or elliptic-oblong, base acute or rounded, apex acute or obtuse thickly coriaceous; lateral veins 4-6 pairs, secondary veins inconspicuous; petiole 0.3-1.2 cm long. Flowers bracteate in axillary racemes. Peduncle, pedicels and calyx minutely pubescent. Calyx short, tube truncate or minutely toothed. Corolla slightly curved about **3** cm long; pale yellow, lobes 5, about 0.5 cm long, linear. reflexed, green. Fruit a berry, oblong, about 1 cm long, smooth, pink, crowned by the cup shaped calyx.

The basal portion of the parasite, the point of attachment to the host tissue, is a swollen mass formed by the tissue of the parasite, known as holdfast. The whole mass of the parasite, commonly known as mistletoe clump (Fig. **2)** usually hangs down from the host branches.

Distribution of different species of mistletoe on various host trees were recorded (Table 1). From the table it is evident that *Dendrophthoe falcata* (Linn. **f.)** Ettingh. var. *pubescens* Hook. f. is the most common mistletoe. In addition to *Tectona grandis* Linn. f. this parasite was also collected from *Albizia odoratissima* (Linn. f.) Benth., *Alstonia scholaris* (Linn.) R. Br., *Careya arborea* Roxb., *Ceiba pentandra* (Linn.) Gaertn, *Dalbergia latifolia* Roxb., *Ficus exasperata* Vahl. *Gmelina arborea* Roxb., *Lagerstroemia reginae* Roxb., *Bombax ceiba* Linn. and *Schleichera oleosa* (Lour.) Oken.

D. falcata (Linn. f,) Ettingh, which is very similar to *D. falcata* var. *pubescens* is found to attack, horticultural crops like *Artocarpus heterophyllus* Lamk., *Syzygium jambos* (Linn.) Alston and *Psidium guajava* Linn.. *Macrosolon parasiticus* (Linn.) Danser, is found to attack *Grewia tiliifolia* Vahl, *Terminalia crenulata* Roth and *T. paniculata* Roth.. *Helicanthes elastica* (Desv.) Danser, the most common species occurring on *Mangifera indica* Linn., is also the predominant species on *Hevea braziliensis* (HBK.) Muell. Arg., *Anacardium occidentale* Linn., *Casuarina equisetifolia* J. R. and G. Forst., *Psidium guajava* Linn. and *Achras sapota* Linn.. *Scurrula parasitica* Linn. is widely seen on *Grewia tiliifolia* Vahl and was also collected as hyperparasite on *D. falcate* var. *pubescens.* *Macrosolon capitellatum* (Wight & Arn.) Danser, is also found attacking *Artocarpus heterophyllus* Lamk.

Table 1; *Misiletoes collected* **from** *common tree species in Kerala*

Hosts	**Angiospermic Parasites**					
	Dendrophthoe falcara **var.** *pubescens*	*D. falcuta*	*Macrosolon parasiticus*	*Macrosolon capitellatus*	*Helicanthes elastica*	*Scurrula parasitica*
	1	**2**	**3**	**4**	**5**	**6**
Achras sapota	*				*	
Albizia odoratissima	*					
Alstonia scholaris						
Anacardium orcidentale		*			*	
Attocarpus heterophyllus	*					
Bombax ceiba	*					
Careya arborea					*	
Casuarina equisetifolia	*					
Ceiba pentandra	*					
Dalbergia latifolia			*			
Dalbergia sissoides	*					
Ficus cxasperata	*					
Gmelina arborea			*			*
Grewia tiliifolia					*	
Hevea braziliensis						
Logerstroemia reginae	*				*	
Mangifera indica		*				
Psidium guajava	*					
Schleichera oleosa		*				
Syzygium jambos	*					
Tectona grandis			*			
Terminalia crenulata			*			
Terminalia paniculata						

Fig. 2. a) The parasite *(Dendrophthoe falcata* var. *pubescens)* clump. b) Flowers of the **parasite**

In addition to the above species of Loranthaceae, some members of the Viscaceae are often found on some of the common trees and also as hyperparasites on woody mistletoes. *Viscum capitellatum* Sm. is found to parasltise on *Citrus* trees and also occurs as hyperparasites on *Dendrophthoe falcata* var. *pubescens* in Wadakkancherry Range of Trichur Division.

In mixed plantations of teak with *Terminalia crenulata* Roth and *T. paniculata* Roth, teak is always found to be infested 'with *D. falcata* var. *pubescens* while

Terminalia spp. by *Macrosolon parasiticus* (Linn.) Danser. Where as in mixed plantations of teak and *Bombax* both the species are infested with the same mistletoe species. As no controlled inoculation experiments were carried out, it is difficult to establish the host specificity. Our observations clearly show that the species have some host preference. Gill and Hawksworth (1961) concluded that no tree or shrub is immune to mistletoe attack under proper conditions, but often in a locality, a species of mistletoe may show distinct host preference. De (1941 & 1945) and Davidar (1980) also observed that in a particular forest type, mistletoes were highly host selective.

b) Distribution of mistletoe teak plantations in Kerala :

Teak is grown extensively in plantations in the state except in the high ranges. Mistletoes were found to occur in the plantations almost throughout with varying intensity (Fig **3**). Serious damage is caused mostly in teak plantations of North

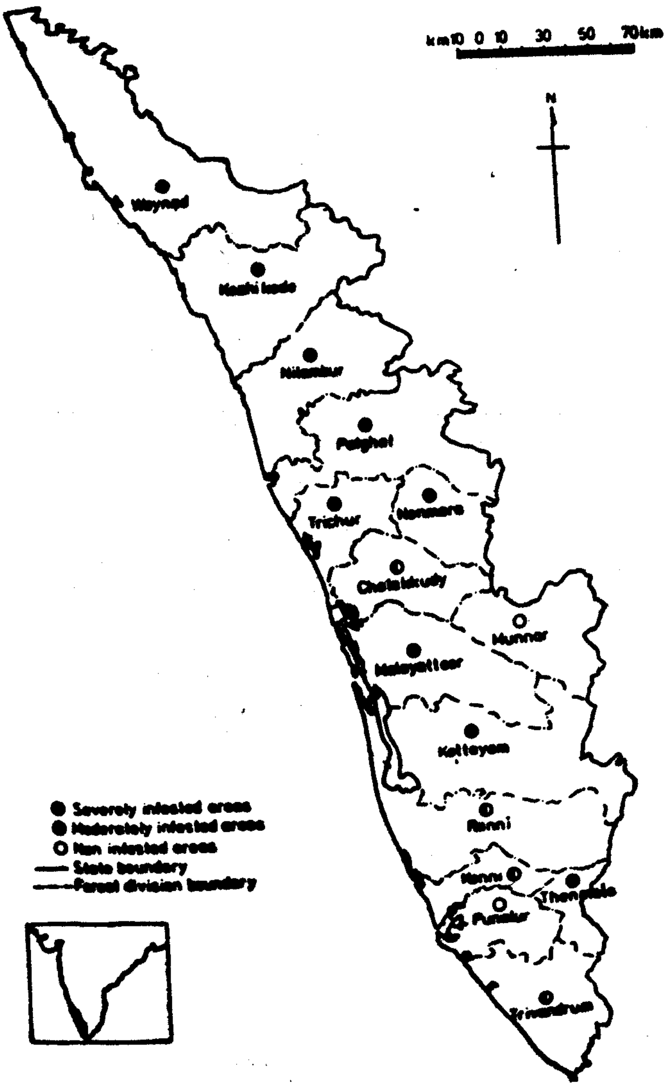

Fig. 3, Distribution of *D. falcata* var. *pubescens* in teak plantations of

and Central Kerala. In some localities all the plantations above the age of seven years are infested. Extensive survey in Nilambur Division showed that sometimes up to 86 percent trees are infested in plantations. In heavily infested plantations the parasites may deplete the host of its nutrients and kill them outright (Fig.1).

c) Phenological studies on the host and the parasite:

Teak is a deciduous tree, and for two to three months it is without leaves (Fig. 4). It is interesting to note that even within a short distance there is difference

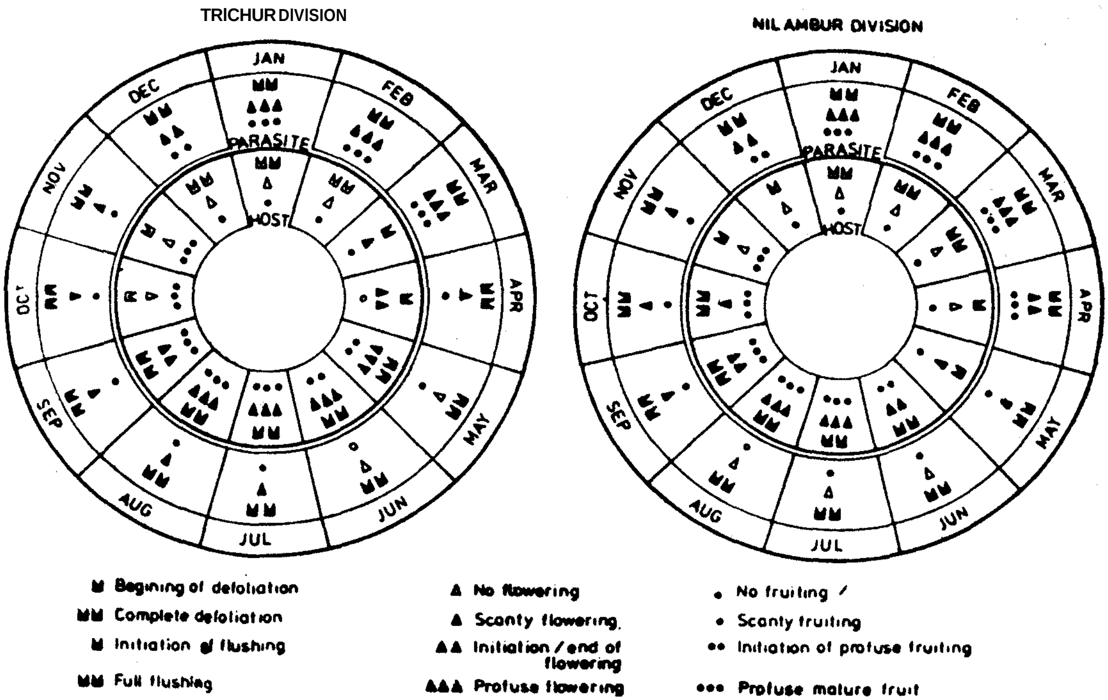

Fig. 4. Phenological behrviour of tho host and the parasite.

in the period of defoliation and flushing of teak in Trichur and Nilambur Divisions. But the total defoliation period is the same for both the places. This difference in flushing period may be due to microclimatic variations. When teak is completely defoliated, the trees are often left with evergreen mistletoe clumps.

Though a few fruits or flowers may be seen on the parasite throughout the year, profuse flowering and fruiting take place during December to April and this period usually coincides with the defoliation period of teak. Large number of pink coloured fruits attract a number of birds which feed on the fruits and disperse the seeds (Ali 1931; Davidson 1946). Mistletoe seeds do not have any seed coat but a viscid, fleshy and sweet pericarp directly covers the embryo and endosperm.

While feeding on the fruits the sticky seeds stick to beaks of the birds. When these birds visit other branches or trees and brush off the seeds from its beak, the seeds get stuck to the branches of the hosts and establish themselves under favourable conditions. Ali noted that the Tickell's flower-pecker (Dicaeum erythrorhynchos erythrorhynchos) actually plucks the ripe pink fruits and swallow; them three or four at a time one after another. The bird then retires on another branch or on an adjoining tree. After a couple of minutes it becomes restless and excretes the seeds. The excreted seeds are copiously covered with the viscous matter and stick to the branch where they germinate and may develop into new parasitic clumps.

d) Biotic factors or natural enemies of teak mistletoe:

During the course of our studies a number of natural enemies of the parasite were observed which can be potential agents for biological control (Fig. 5).

(1) Phanerogamic hyperparasite:

A hyperparasite, *Viscurn* capitellaturn Sm. was found to parasitise the teak mistletoe in some of the plantations in Trichur Division. Asurvey in two plantations of 'Wadakkancherry Range (Table 2) showed that 36.63 and 31.37 percent of the total clumps of the parasite, respectively in 1940 and 1941 year plantations, were affected by this hyperparasite. A number of hyperparasite clumps were found on the branches of the parasites which gradually dry up The hyperparasite was never found parasitic on teak. It is worth looking into the potentialities of this hyperparasite as an agent of biological control of teak mistletoe. Fischer (1926) and Rao(l923)observed hyperparasitism *of V.* capitellaturn on D.falcata. Pundir (1979) observed autoparitsitism of Helixanthera ligustrina (Wall) Dans. growing on some tree species In Ramgarh forests, Dehra Dun. These autoparasites kill the mother parasite beybnd the point of infestation.

(2) Delias eucharis Linn, Caterpillar:

Another potential agent for biological control was found to be the caterplllars of the butterfly *Delias eucharis* Linn.; widely seen in teak plantations in Nilambur Division. They feed on the teak mistletoe leaves and tender branches, causing *heavy* defoliation which may lead to the destruction of the clumps The attack of the caterpillar is common during rainy seasons *Delias eucharis* was found to be a potential biological agent for control of *D.* falcata growlng on cotton plants (Varma & Sain 1976).

(3) Yellow mosaic virus:

In various plantations of Nilambur Division, a large number of parasite clumps were found affected by a serious yellow mosaic symptom, possibly due to 8 virus', infection. The infected parasite clumps are stunted in igrowth. The leaves of the virus infected clumps are small in size, with pale yellow green patches. Severe mosaic symptoms are seen on the tender foliage. The infection was more prevalent between March and April.

Fig. 5. Natural enemies of teak mistletoe.

a

b

a & b) The hyperparasite *Viscum capitellatum* on branches of teak mistletoe.

c

c) The butterfly, *Delias eucharis*. Caterpillars of the insect damage the mistletoe.

Table 2: ***Occurrence of hjrperparositr, Viscum capitellatum on teak mistletoe in tHo platations in Wadakkancherry Renge***

Plantation	Mistletoe infested teak in the plantation	Infested teak with hyperparasite in the plantation	Hyperparasite infested mistletoe clumps
1940 (10 ha)	28.44%	12.89%	36.93%
1941 (10ha)	**33.00%**	10.00%	31.37%

(4) Mammals feeding on the parasite

It was observed that Malabar Giant Squirrel, *Ratufe indica maxima* (Schreber) feeds voraciously on the leaves and tender branches of the parasite. The common Bonnet macaque, *Mecaca radiata* (Geoffray) was observed consuming the ripe fruits of the parasite in Karulai, in large numbers. The seeds could be observed in the faecal material of the monkeys.

A number of fungi have been recorded as hyperparasite on mistletoe clumps. Ramakrishnan and Ramakrishnan;(1948 & 1950) reported *Puccinia luculenta* and *Uromycesnilagricus* **on** the clumps of *Loranthus* spp.. George and Edathil (1979) recorded *Phytophthora meadii* and *Oidium heveae* on *Loranthus* spp. growing **on** rubber. Several fungi have also been recorded on dwarf mistletoes. Parmeter and associates (1959) found that *Colletotrichum gloeosporioides* kills the clumps of *Arceuthobim campylopondum* f. *abictinum* in California. in the course of our study we did not come across any fungal infection on the teak mistletoe.

ASSESSMENT OF LOSS

Angiospermic parasites have a serious impact on the productivity of the host. Loss caused by dwarf mistletoes *(Arceuthobium)* on temperate trees has been reviewed by Gill and Hawksworth (1961). The degree of damage depends upon the species of the parasite, host susceptibility, age of the host, life-cycle, longevity of the parasite, etc. Economic impact of mistletoes on trees may be qualitative or quantitative, including reduction in tree vigour and growth increment, deterioration of timber quality, poor fruit and seed setting, drying of branches, etc., which are the predisposing factors for attack by other pests as well as for the premature death of the trees (Drummond 1978; Walters 1978; Wilcox *et a/.* 1973; Piirto et al. 1974).

Amongst the different species used in raising forest plantations in India sal (De 1941, 1945) and teak (Lushington 1896; Koppikar 1948) have been reported to be damaged by mistletoes and pines (Bagchee 1952; Bakshi & Puri 1971) by dwarf mistletoes. Data on qualitative or quantitative loss of timber is not available. No attempt has been made to assess the loss caused by these parasites on horticultural crops also. In Nilambur Forest Division, young teak plantations have been clear felled due to poor growth and high rate of mortality caused by heavy mistletoe infestation (Ranganathan 1982).

An attempt was made to determine quantitative as well as qualitative loss due to mistletoe infestation on teak. As the history of mistletoe infestation in the plantations were not known, it was not possible to assess the exact volume loss of timber, Under controlled conditions, it was possible to study the loss in increment of the teak due to mistletoe attack.

Materials and Methods

1. QUANTITATIVE LOSS:

a Extent of mistletoe infestation in teak plantation in Nilambur:

To find out the extent of parasite infestation on trees, the following teak plantations in Nilambur Oivision (page 14) were surveyed during June-July 1979.

A systematic sampling pattern was adopted separately for Karulai and Nilambur ranges of the Nilambur Forest Division as discussed below.

Three beats per specific age were selected at random. If the number of beats was less than 3 all of them were considered for assessment. Beatwise assessment was made as following.

a. When the planting lines were identifiable, trees were marked from the lines, lst, 51st, 101st, etc, for observation. In each line lst, llth, 2lst, etc. trees were observed for mistletoe infestation.

Year of the Plantation	Locality and area of Plantation (ha)	
	Karulai Range	Nilambur Range
1973	Poolakapara (16.00) Ezhuthukal (144.85) Nedunkayam (65 .00)	Kariemmuriem (58.75)
1963	Choorakandi (59.50) Mundakadavu **(32.58)**	Edakkode (50.37)
1953	Moochala (60.88)	Walluvassery (6.43) Pokode - 1 (5.06) Pokode - 2 (4.37)
1943	Ingar (69.04)	Walluvassery-1 (9.87) Walluvassery-2 (7.20) Chathanparai (9.19)
1933	No plantation	Elangeri (3.68) Panayamcode (9.43) Nellikutha (7.41)

b. When the planting lines were not identifiable, trees were selected at random at the rate of 10 trees per ha, for observation.

Number of mistletoe clumps on the marked trees were noted visually. Mean number of parasite clumps and the percentage of the infested trees were calculated.

b. Increment loss due to mistletoe attack:

Experiment was started in May 1980, in a 1971 and a 1949 plantations at Nedunkayam in Karulai Range and Panayamcode in Nilambur Range, respectively. Experimental trees were marked and grouped under the following catagories and each group considered as a treatment.

With mistletoe	Mistletoe removed physically (MR)	Without mistletoe (WOM)
66 trees in both Karulai and Nilambur ranges were marked and left as such. The number of parasite clumps on each tree was noted.	All parasite clumps were removed physically from 50 trees of Karulai and 55 trees of Nilambur by cutting off the branches bearing the parasitic clumps.	54 trees at Karulai and 74 trees at Nilambur were marked. These trees did not have any mistletoe clumps when the experiment was started

Girth at breast height (GBH in cm) of the trees were taken once in six months, May and September each year. Increase in number of clumps due to new infestation, or decrease in nurnber of clumps due to daath of the older clumps, and death of the trees due to heavy mistletoe infestation were recorded. In the treatments mistletoe removed (MR) and without mistletoe (WOM) any clump appearing as fresh infestation was removed carefully as soon as they were. visible, with least damage to the host. The GBH incremants for the three years (1980 - 1983) for the three groups were compared using Analysis of Variance test. The mean GBH increments were compared using Duncan's Multiple-Range Test.

Another group of 54 trees at Karulai and 53 trees at Nilambur, without mistletoe were also selected, to study the effect of pruning of branches on GBH. A few branches were pruned from these trees arbitrarily and the mean GBH increments compared using 't' test.

II. QUALITATIVE LOSS:

Effect of mistletoe on physical properties of Wood:

Wood samples were collected from trees in the girth class 130 - 150 cm from the final felling areas at Moolathumanna and Vattikkal in Nilambur Division, from two groups of trees viz., WOM (apparently non-infested trees) and WM with 10 or more clumps (severely infested trees). Four trees were marked **by** random process under both the groups and 1 m long bolts were collected from the bottom-most portion of the merchantable timber of each tree. The heartwood portion of bolts were converted into scantlings of size 6 x 6x100 cm. Nine scantlings were obtained from WOM tree bolts and eight from WM. They were air seasoned and cut into 5 x 5 x 75 cm pieces.

The specimens were tested for bending strength on an universal testing machine according to ISI specifications (1970). From the static bending test data, modulus of rupture (MOR), modulus of elasticity (MOE), work to proportional limit (Wp) and work to maximum load (W max) were calculated. After the static bendinq tests, blocks 5 x 5 x 2.5 cm were cut at the centre portion of the test specimen or at the place of failure, and were utilised to determine the moisture content and specific gravity.

Results and Discussion

1. QUANTITATIVE LOSS:

a. Extent of mistletoe infestation in teak plantations in Nilambur:

In Nilambur Forest Division, 1943 teak plantation showed the highest percentage (85.94) of infested trees and also the individual trees showed largest mean number **(3.73)** of mistletoe clumps (Table 3). The 1963 plantations had the lowest percentage (46.85) of infested trees as well as lowest mean number of clumps (1.00). The 1973 Plantation had no mistletoe infestation. The data showed that the number of infested trees as well as mean number of clumps on individual trees increase with the age of the plantation.

Table **3.** ***Extent of mistletoe infestation on teak at individual Runges as well as in the Division as a whole, in Nilambur Forest Division***

Year of Plantation	Mean and estimated range" (in parantheses) of mistletoe clumps			Percentage of trees attacked by mistletoe		
	Karulai Range	Nilambur Range	Nilambur Division	Karulai Range	Nilambur Range	Nilambur Division
1933	No Plantation available	2.26 (0-10)	2.26 (0-1 0)	No Plantation available	73.79	73.79
1943	4.46 (0–14)	21 8 (C–9)	3.73 (0–13)	92.50	73.56	85.94
1953	2.03 (0-10)	1.40 (0–6)	1.90 (0-9)	57.96	65.61	59-53
1963	1.30 (0–6)	0.48 (0–3j	1.00 (0-5)	53.59	35.1 2	46.85

'99 percent times number of mistletoe clumps are expected to lie within the estimated range.

When Karulai and Nilambur ranges were considered individually, trees in Karuiai plantations had a greater mean number of clumps. Except in 1953 plantation, the percentage infested trees in Karulai was greater than in Nilambur. As no teak plantation of 1933 was available in Karulai range, the data of Nilambur is not comparable. It is difficult to interpret the above differences, between the two ranges. Several factors like site quality, epidemiological factors, availability of birds for dispersal of mistletoe seeds etc., are involved. Increased mean number of clumps and the higher percentage of infested trees in older plantations of both the ranges may **be due** to the fact that the chahces of the birds frequenting the older trees with bigger canopy size are more.

b. Increment loss due to mistletoe attack:

To test the initial comparability of the GBH of trees WM, MR and WOM, the analysis of variance test of the initial GBH of the trees was carried out (Table 4a & b). Initial girth of trees with different treatments varied significantly in Karulai 1971 plantation whereas this was not significant in the older plantation (1949) of Nilambur range. From the mean table 4 (a) it is evident that in Karulai, trees WM as well as MR have more GBH than the trees WOM. Though it is highly speculative, it may be possible that initially trees WM and MR were growing vigorously with bigger canopy size which might have given the birds a better chance to visit, thereby depositing mistletoe seeds. Whereas in the older plantation

(1949) of Nilambur, trees are more or less of the same girth class with uniform canopy size, attained after the mechanical as well as silvicultural thinning operations.

Table 4a: ***Mean Initial GBH (cm) of Expcrimental Trees with Mistletoe, Mistletoe Removed und Without Mistletoe***

Locality	With mistietoe	Mistletoe removed	Without mistletoe
Karulai 1971 Plantation	40.467	41.564	37.207
Nilambur 1949 Plantation	74.258	72,977	73.625

Table 4b; ***Analysis of Initial GBH of Trees, with Mistlatoe, Mistletoe Removed and Without Mistletoe***

Source of variation	Karulai 1971 Plantation				Nilambur 1949 Plaritation			
	SS	DF	MSS	F	SS	DF	MSS	F
Treatments	547.09	2	273.55	5.64*	49.32	2	24.66	0.16
Error	8104.49	167	48.53		29134.78	192	151.74	
Total	8651.58	169			29184.10	194		

• Significant at 5 percent level.

There was no effect of controlled pruning of branches from the trees, WOM (Table 5). The GBH increment of the pruned trees WOM were not significantly different from the unpruned WOM trees during 1980-1983.

Table 5: ***Effect of Pruning of Teak Branches on Mean GBH Increment (μ in** cm)

Location	Without mistletoe μ_1	Without mistletoe branch pruned	Whether $\mu_1 = \mu_2$
Karulai 1971 Plantation	3.093	2.871	Yes
Nilambur 1949 Plantation	1.280	1.090	Yes

"t" test at 5 percent level of significance.

The mean growth increment of the trees WM when compared to trees WOM, showed significant difference in both the young and the old plantations. The retardation of growth (Fig. 6) of the trees WM from trees WOM is 41.64 and 37.18 percent in Karulai (1971) and Nilambur (1949) plantations, respectively.

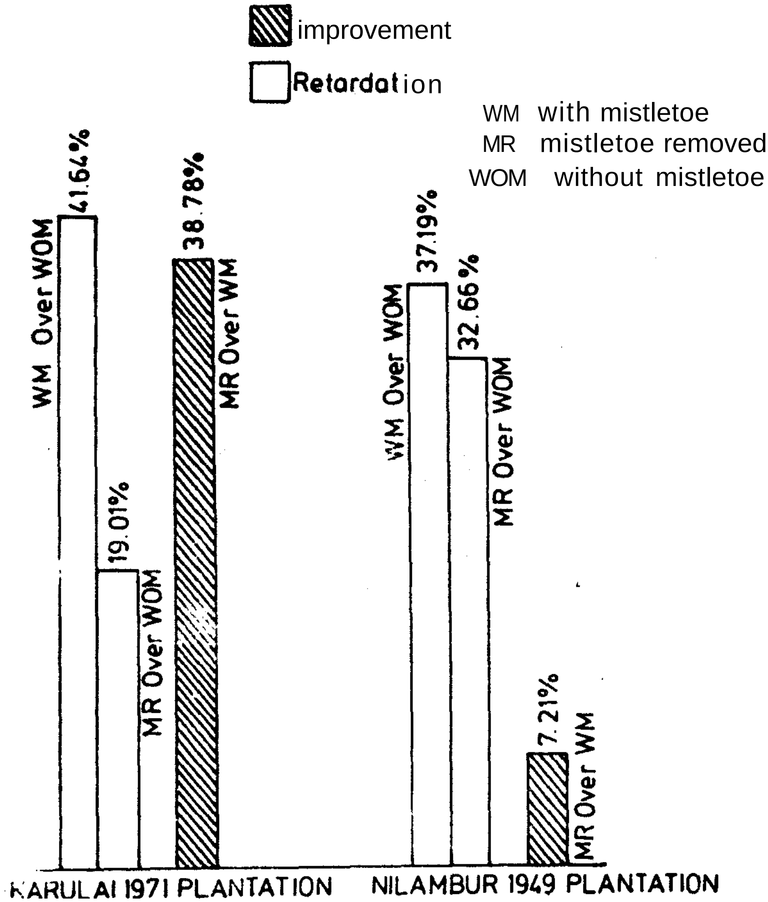

Fig. **6. Improvement/retardation in GBH increment of the trees during 1980-1983.**

Analysis of growth increment in Karulai (1971) plantation, after the removal of the parasite clumps, showed significant difference, during 2nd and 3rd year, whereas in Nilambur (1949) plantation growth increment was not significantly different after the removal of the parasite (Table 6). Probably the younger trees are able to recoup the lost vigour due to mistletoe infestation rapidly than the older trees, once the parasites are removed from them.

In Karulai (1971) plantation, the analysis of variance of increment (GBH) of the trees under the three groups of treatment, showed significant difference between them (Tables 7a & b). Duncan's Multiple Range Test showed that the growth increment of the trees WOM and MR do not differ significantly. However, growth increment of trees WOM is significantly higher than that of trees WM. Whereas WM trees when compared with MR trees, did not differ significantly. Though there is 38.78 percent improvement after removal of the parasite (Fig. 6) the improvement

Table **6:** ***Comparison of Mean GBH increment (μ in cm) of trees, with mistletoe. mistletoe removed and without mistletoe***

Locality	Year of observation	With mistletoe μ_1	Mistletoe removed μ_2	Whether $\mu_1 = \mu_2$	Without mistletoe μ_3	Whether $\mu_1 = \mu_3$
Karulai 1971	1980-81	1.591	1.606	Yes	2.528	No
Plantation	1981-82	2.564	4.120	No	4.583	No
	1982-83	1.260	1.790	No	2.167	No
Nilambur 1949	1980-81	0.697	0.777	Yes	1.301	No
Plantation	1981-82	0.905	0.955	Yes	1.318	No
	1982-83	0.811	0855	Yes	1.223	No

The treatment- means, μ_1, μ_2 and μ_3 are compared, using the "t" test at **5** percent level of significance.

Table **7** a: ***Mean yearly GBH increment (cm) of trees with mistletoe, mistletoe removed, and without mistletoe***

Year	Karulai 1971 Plantation With mistletoe (WM)	Karulai 1971 Plantation Mistletoe removed (MR)	Karulai 1971 Plantation Without mistletoe (WOM)	Nilambur 1949 Plantation With mistletoe (WM)	Nilambur 1949 Plantation Mistletoe removed (MR)	Nilambur 1949 Plantation Without mistletoe (WOM)
1980-8I	1.591	1.606	2.528	0.697	0.777	1.301
1981-82	2.564	4.120	4.583	0.905	0 955	1.318
1982-83	1.260	1.790	2.167	0.811	0.855	1.223
Mean	1.805	2.505	3.093	0.804	0.962	1 280

Table 7 b: Analysis of variance of the GBH increment of trees, with mistletoe, mistletoe removed and without mistletoe, and comparison of mean GBH increment for 1980-83

Source of variation	Karulai 1971 Plantation SS	DF	MSS	F	Nilambur 1949 Plantation SS	DF	MSS	F
Between column mean	2.494	2	1.247	6.777'	0.405	2	0.203	50.750*
Between row mean	7.508	2	3.754	20.402*	0.029	2	0.015	3 750
Residual	0.736	4	0.184		0.014	4	0.004	
Total	10.738	8			0.448	8		

'Significant at 5 percent level.

DUNCAN'S MULTIPLE RANGE TEST

Karulai Range			Nilambur Range		
WOM	MR	WM	WOM	MR	WM

was not statistically significant. Probably the period of observation far the present study is too short for obtaining the significant improvement.

In the older plantations at Nilambur (1949) also, there is significant variation in the mean growth increments under all the three groups of treatments (Tables 7a & b). The Multiple Range Test showed that the mean growth increment of the trees WOM is significantly higher than those of WM trees and also MR trees. However, as in Karulai 1971 plantation, WM trees and MR trees did not differ significantly in growth increment, though there is 7.21 percent improvement in growth.

Mortality (Table 8) of the trees infested with mistletoe in younger (1971 plantation is much more (27.27%) than in the older (1949) plantation (1. 52%) As expected, mortality is nil in both the plantations when trees were without mistletoe or the mistletoes were removed from them.

Table 8: ***Effect of mistletoe on growth rate and mortality of trees with mistletoe, mistletoe removed and without mistletoe, During 1980 -1983***

Treatments	Karulai 1971 Plantation		Nilambur 1949 Plantation	
	GBH/Year (cm)	Percent mortality	GBH/Year (cm)	Percent mortality
With mistletoe	1.805	27.27	0.804	1.52
Mistletoe removed	2.505	Nil	0.862	Nil
Without mistletoe	3.093	Nil	1.280	Nil

It is interesting to note that the harmful effect of the parasite is more drastic in fast growing younger trees of Karulai (1971) plantation than in the older trees of Nilambur (1949) plantations. It was evident from Table 8 that the rate of growth improved with the removal of the parasites.

It. QUALITATIVE LOSS:

Effect of mistletoe on physical properties of wood:

Strength and physical properties of the test samples were corrected to a moisture content of 12 percent (Table 9 a & b). Statistical analysis of the data (Table 10), showed a significant difference between the two groups i. e., WOM and WM trees, in modulus of rupture (MOR) and work to maximum load (W max). Apparently wood from WOM trees had 16 percent higher MOR values compared to wood from severely mistletoe infested trees; whereas in the case of W max it was 63 percent higher than the wood from the infested trees. Though modulus of elasticity (MOE) and work to proportional limit values (Wp) were lower for the wood samples from the mistletoe infested trees, they were not significantly different from the wood from apparently non-infested trees

Table 9a: *Strength and physical properties datg for noninfested woad (0 clumps)*

No,	MOR (kg/cm²)	MOE (kg/cm²)	Wp (kg. cm/cm²)	Wmax (kg cm/cm³)	Specific gravity
1	891.3	130 774	0.37	0.83	0.596
2	1007.4	126 921	0.10	0.88	0.672
3	948.8	113 248	0.18	0.98	0.500
4	1094.4	136 330	0.29	1.13	0.687
5	999.3	124 794	0.26	0.97	0.587
6	918.4	105 597	0.25	0.73	0.575
7	929.9	111 787	0.14	0.77	0.626
8	1009.3	121 481	0.39	0.66	0.700
9	959.5	100 201	0.26	0.98	0 616

Table 9b: *Strength and physical properties data for severely mistletoe infested wood (10 and above clumps)*

No.	MOR (kg/cm2)	MOE (kg/cm2)	Wp (kg. cm/cm2)	Wmax (kg. cm/cm3)	Specific gravity
1	840.9	106 387	0.16	0.51	0.576
2	945.3	118 954	0.16	0.56	0.631
3	827.6	103 217	0.27	0.43	0.656
4	864.9	108 093	0.12	0.72	0.604
5	957.0	99 594	0.18	0.93	0.581
6	614.6	68 782	0.19	0.40	0.461
7	877.8	144 858	0.21	0.40	0.749
8	794.1	110 064	0.27	0.37	0.665

Table 10: *Comparison of strength and physical properties data between noninfested wood (A) and severely mistletoe infested wood (B) and 'F' values from ANOVA*

	MOR (kg/cm2)		MOE (kglcm2)		Wp (kg. cm/cm2)		Wmax (kg. cm/cm3)		Specific gravity	
	A	B	A	B	A	B	A	B	A	B
Average	973.2	840.3	119 015	107 494	0.25	0.19	0.88	0.54	0.618	0.615
S.D.	58.0	99.9	11 351	19 732	0.09	0.05	0.14	0.18	0.059	0.078
C. V. (%)	6.0	11.9	9.5	18.4	36.9	25.7	16.1	33.9	9.6	12.7
F	10.18*		1.97(n.s.)		2.03 (n.s.)		16.50'		0.004(n.s.)	

n. s. = not significant
* = significant at 5% level of significance.

The correlations between MOR and MOE and MOR and specific gravity, were not calculated as the sample size was too small to give any meaningful indications. MOR and MOE values of Kerala teak was reported as 959 kg/cm^2, and 119,600 kg/cm^2 respectively (Chaudhury & Ghosh 1958). These values compared well with the present values of 973 kg/cm^2 and 113, 015 kg/cm^2, MOR and MOE respectively, of the wood samples from the apparently non-infested trees.

As the history of mistletoe-infestation of the plantations is not known, there are possibilities that trees which did not have any clump at the time of felling might had infestations during the life time. Also, the tree which had more than 10 clumps at the time of felling, was unlikely to have had this level of infestation throughout the growth period. As these data were not available, the variation in the strength properties is attributed to difference in the degree of infestation within the infested trees.

MANAGEMENT OF TEAK MISTLETOE

In spite of the fact that the mistletoes take a heavy toll in horticulture and forestry, very little attention has been paid in India, to control these parasites systematically. Due to their bushy nature the management' of teak mistletoe may look easy but in practice it is not so, because; the epidemiological factors, biology of the parasite and the host-pathogen relationship, are not fully studied. Linnard (1861) compiled the informations on the control of mistletoes in forestry. Measures to combat mistletoes are dealt under the broad outlines of silvicultural, biological and chemical control.

Silvicultural Control:

In Horticultural plantations, mistletoes are removed periodically along with fhe annual tree pruning or sometimes under the "tree clearing" programmes. De (1941) and Davidson (1945) recommended lopping or pruning off mistletoe infested branches in sal forests. To remove the mistletoe infested branches from the trees, Koppikar (1848) advocated the public consensus with the popular slogan, "kill loranthus and save trees", with co-operation of the various public departments. Removal of the parasite is being practised in teak almost since it was noticed in the Nilambur plantations (Lushington 1896; Brand 1941). During 1866-1 867 the parasite was removed from about 180 ha teak plantation. Brand (1941) recommended that parasite removal should be carried out during each thinning operation in teak plantations and this practice should be continued after the final silvicultural thinning once in five years until the final felling. In recent times a schedule has been prescribed for mistletoe clearing from taak plantations by the Kerala Forest Department (Brand 1941).

Dwarf mistletoes have long been recognised as one of the most damaging diseases of conifers in USA and Canada. In the USA alone, the estimated annual loss due to mistletoes is 7.5 million of timber (Stewart 1978). It was noted that after removal of the parasites the trees gain vigour but it is impossible to sanitate completely an infested stand. Kuijt (1955) is of the opinion that pruning is too expensive to be of any real practical value in large scale forest management, but may be economical for the orchards and individual trees. Possible control of vector or the pollinator birds for mistletoe management, has been discussed (Ali 1931; Davidson 1945); but it has never been practised, since our present knowledge on the biology and ecology of thess birds are limited

Hambali (1978) suggested small scale planting of ornamental trees or hedge plants which produce small sweet berries, such as *Muntinga calabura L*, *Carmona retusa* (Vahl.) Masamune, *Bridelia monica* (Lour.) Marr. These plants are known to produce alternate food for the mistletoe frequenting birds.

Genetical resistance to infection resulting from co-evolution of the forest trees and their pathogens has been the main principle of disease control in the natural ecosystem (van der Plank 1875). The possibilities of breeding and selection of dwarf mistletoe resistant trees haye gained some recognition lately in USA (Roth 1978).

Biological Control:

In connection with epidemiology, we have listed a number of biological entities which destroy the parasite clumps. Present knowledge on these parasites are insufficient to use them for biological control.

Chemical Control

In India and Australia, limited attempts have been made to control tree mistletoes chemically. Chemicals have been sprayed directly on the patasites or have been infused to the host by injection or frill girdling.

2, 4-0 formulations were sprayed successfully in Australia for killing mistletoes OR eucalypts (Hartigen 1949; Greenham *eta/.* 1951). Several chemicals and mineral oil sprays were tried to combat *Dendrophthoe falcata* on trees (Seth 1958; Singh 1959).

Phytotoxic effect on mistletoe was noticed accidentally, in India by Kadambi. while injecting sandal trees with mercury and copper compounds to combat spike disease in Karnataka. He observed that copper sulphate had no effect on the spike Symptoms but killed the mistletoe clumps (Kadambi 954). Latsr copper sulphate was injected into *Dalbergia* sissoo by boring small holes round the stem. He also injected Fernoxone into the trees to kill *Scurrula pu/veru/enta* (Kadambi 1954). Seth (1957 & 1958) found that the results of injection were erratic and that ths chemicals were highly toxic to some of the host trees. In Australia, control af mistletoe on eucalypts by injecting 2,4-D into the tree trunks has beep recommended (Greenham *et* a/. 1951; Nicholson 1955; Greenham & Brown 1967; Brown & Greenham 1965). Kerala Forest Department failed to eradicate teak mistletoe by injecting copper sulphata and Fernoxone in Nilambur (Anonymous 1962). Singh (1962) argued that spraying of effective chemicals will be of greater practical use than tree-injection.

In teak plantations in Kerala, though sufficient prescription has been stipulated in the Forest Department Working Plans, parasite removal remained erratic or .discontinued due to ecnnomic and administrative 'reasons. Also no attempt has been made to calculate the cost-benefit ratio of the operation. This laxity has aggrayated the mistletoe problem and an alternate practice to combat it in teak plantations has become imperative. Keeping all these problems in mind, it was decided to attempt control of teak mistletoe by tree-injection of selective herbicides.

Materials and Methods

Several methods of tree-injection using pressure have been developed in USA, Canada and South Africa (Pinkas *et a/.* 1973: Schwarz *et al.* 1978; van Alfen & Walton 1974: Prasad 1975; Nair 1981) to combat tree diseases. These methods were found to be too sophisticated and expensive to be introduced in Indian Forest

Plantations, A cheaper device for infusion of any water soluble dompound into teak, using commonly available materials, was developed (Ghosh & Balasundaran 1980).

As there is no standard laboratory testing technique available, standardisation of tree-injection technique for application as well as screening of the chemicals was carried out in suitable plantations in Nilambur and Peechi ranges.

a) Development of the tree-infusion device and its standardisation :

The infusion device consists of locally fabricated metallic nozzles, which are tightly screwed in holes drilled in the sapwood of the tree trunk at a height of one metre above the ground (Fig. 7 a, b, c). Nozzles are connected to a distributor through pressurised polythene tubes, which in turn is connected to a disposable glucose-saline set collected from hospitals. The set consists of a reservoir, dripping-device and a regulator cock. The whole assembly is filled with 0.2 percent aqueous solution of tracer dye, rhodamine B. Flow of the solution could be regulated and monitored through the dripping device.

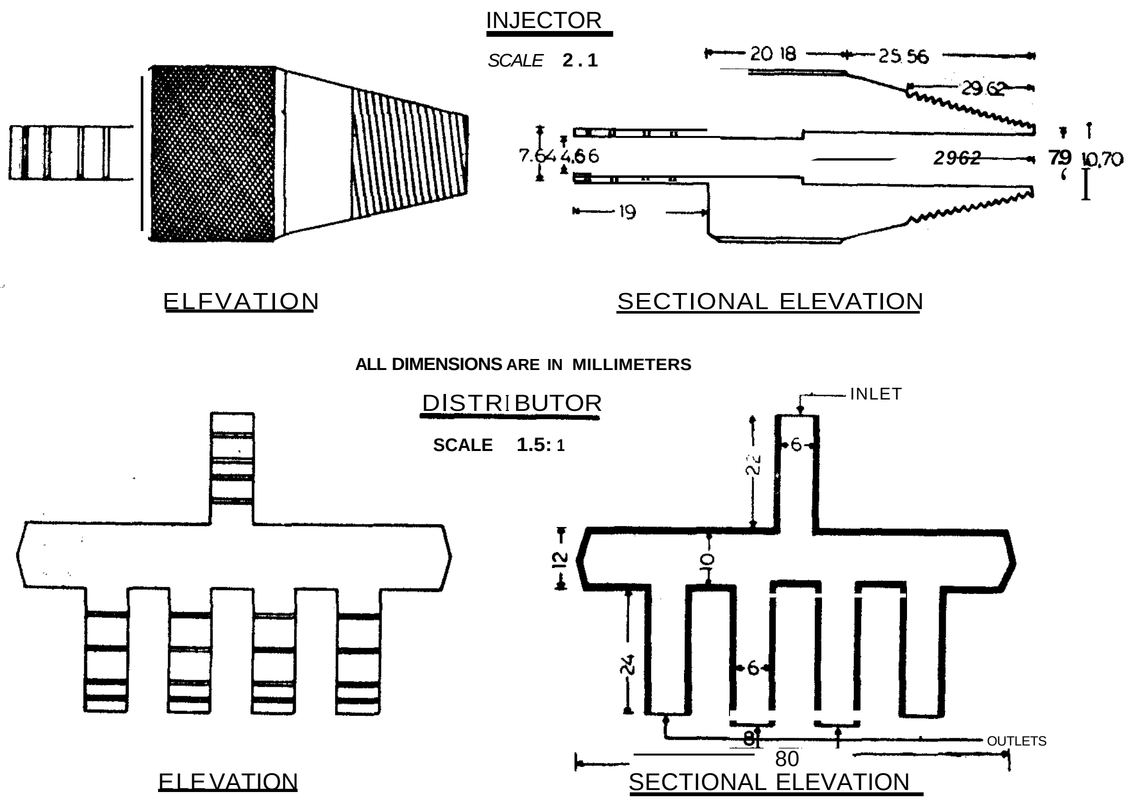

Fig. 7 a) A component assembly of tree injection device.

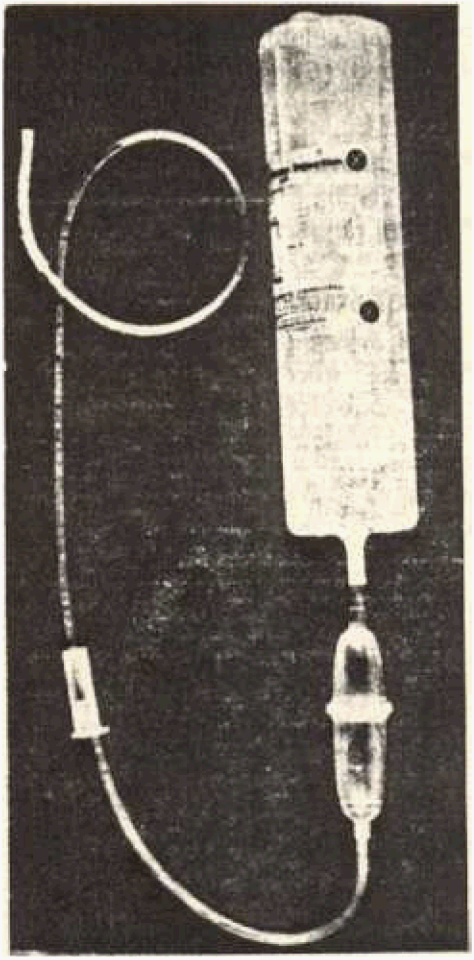

Fig. 7. b) A disposable reservoir with dripping device. c) Tree injection assembly on teak.

To find out the appropriate time of the day for application and the distribution of the dye in various parts of teak, a time-course experiment was set up. Trees were injected with dye at four hourly interval for 24 hours. Intake of tracer dye, and the rate of flow could be calculated by counting the drops per minute. Similarly, the uptake of the dye (ml/min) was monitored oncg in every month from 7 AM to 6 PM for two years to find out the suitable month for infusion.

b. Screening of Weedicides:

Following weedicides were procured through the courtesy of manufacturers dealers for screening against teak mistletoe.

Trade/common name of. the weedicide	Manufacturer/dealer
Weedar 96	AGROMORE
Weedar 32	AGROMORE
Weedone 48	AGRQMORE
Weedex	AGROMORE
Karmex	AGROMORE
Basalin	BASF
Basagran	BASF
Sencor	BAYER
Copper Sulphate	BOH
Dual	CIBA-GEIGY
Igran	CIBA-GEIGY
Stomp	CYANAMID
Afalon	HOECHST
Gramoxone	ICI
Fernoxone	ICI
Tolkan	MAY & BAKER
Dalapan	MYSORE AGRO CHEMICALS
Atrataf	RALLIS
Tafazine	RALLIS

One litre each of three concentrations, 500, 1000 and 5000 ppm. of aqueous solutipns of weedicides were injected into infested trees. Six herbicides, selected after preliminary screening were further used in the concentrations of 0.05 to 0.30 percent a.i. All the concentrations used were replicated four times.

Effect of the chemical both on the host and the parasite were noted systematically. Following score card was developed to record relative effectiveness of the ,chemicals on the host as well as on the parasite.

Symptom on		Relative reaction
Host	Parasite	
Blotching or scorching of young leaves.	Yellowing of leaves.	+ (mildly effective)
Wilting of leaves and the young buds	Wilting of leaves, young shoots and flowers followed by heavy defoliation.	++ (moderately effective)
Defoliation, splitting of bark and discolouration of wood along the path of the chemical Such trees usually die.	Drying of leaves, flowers and fruits. Ultimate drying and death of the whole parasite clump.	+++ (highly etfective)

RESULTS AND DISCUSSION

a) Standardisation of injection technique:

It was noted that the uptake of dye is more in the morning between 7 AM and 10 AM (Fig. 8a). Within two hours, the dye reached a height of about 20m which could be detected visually in the stem, branches, veins and veinlets of both host and the parasite (Fig. 8 b). Maximum intake of the dye was found to be in the months of June, July and August (Fig. 9), the peak period of rainy season. During hot and dry season, intake is very slow (Table 11).

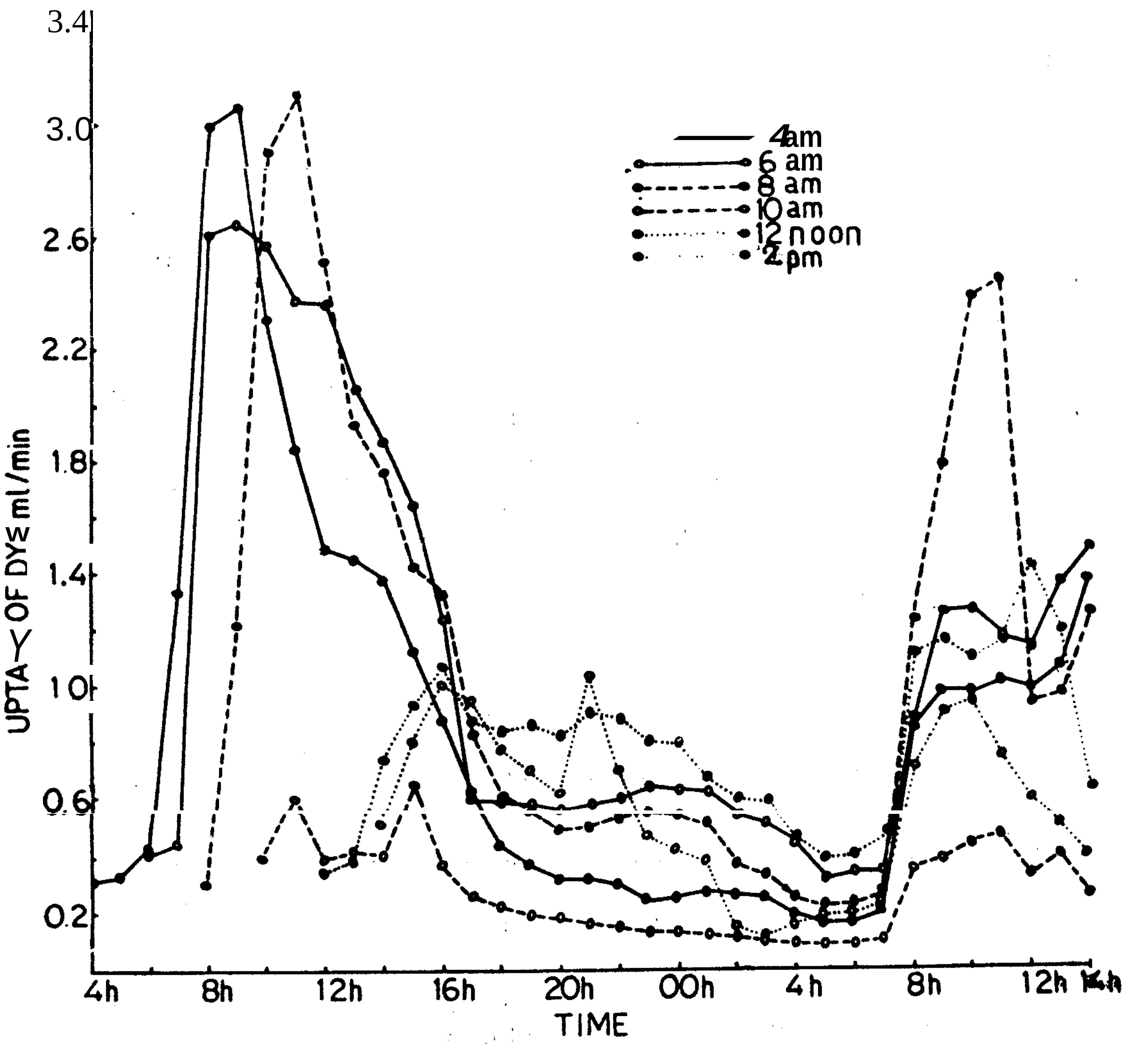

Fig. 8. a) Time-course experiment on the pattern of dye uptake during 24 h. Individual lines show the pattern of uptake by different trees when infusion started at 4 am., 6 am, 8 am., am., 12 Noon and 2 pm.

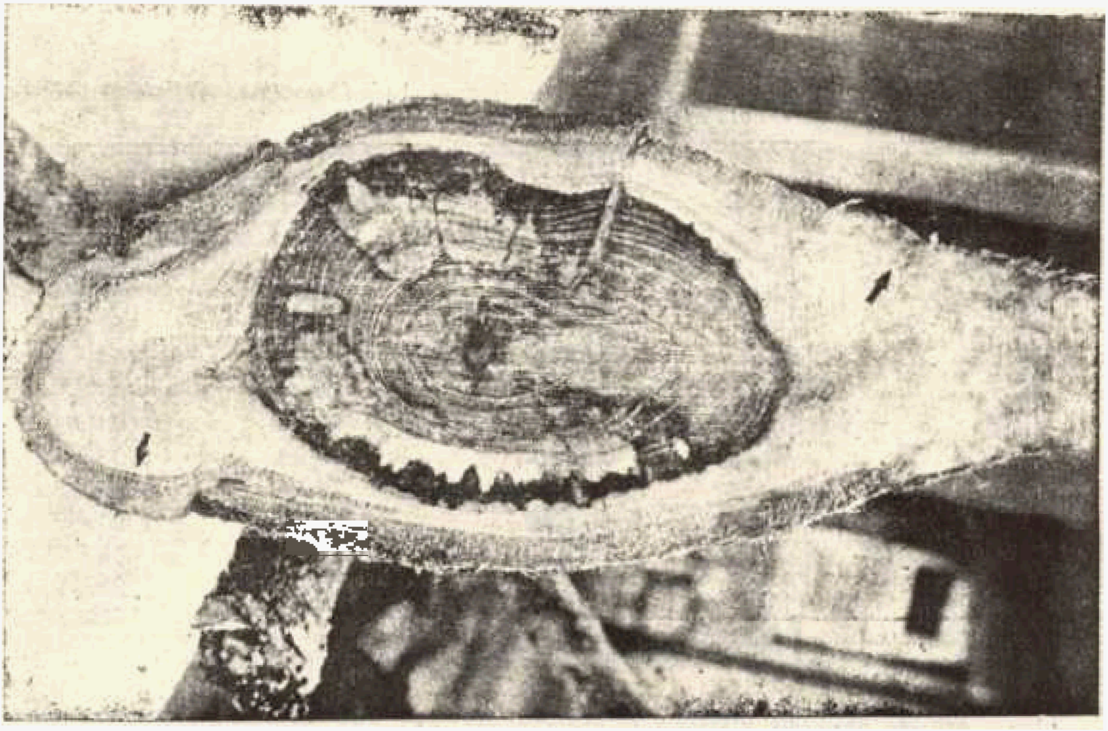

Fig. 8 b) Cross section of teak branch showing presence of dye.

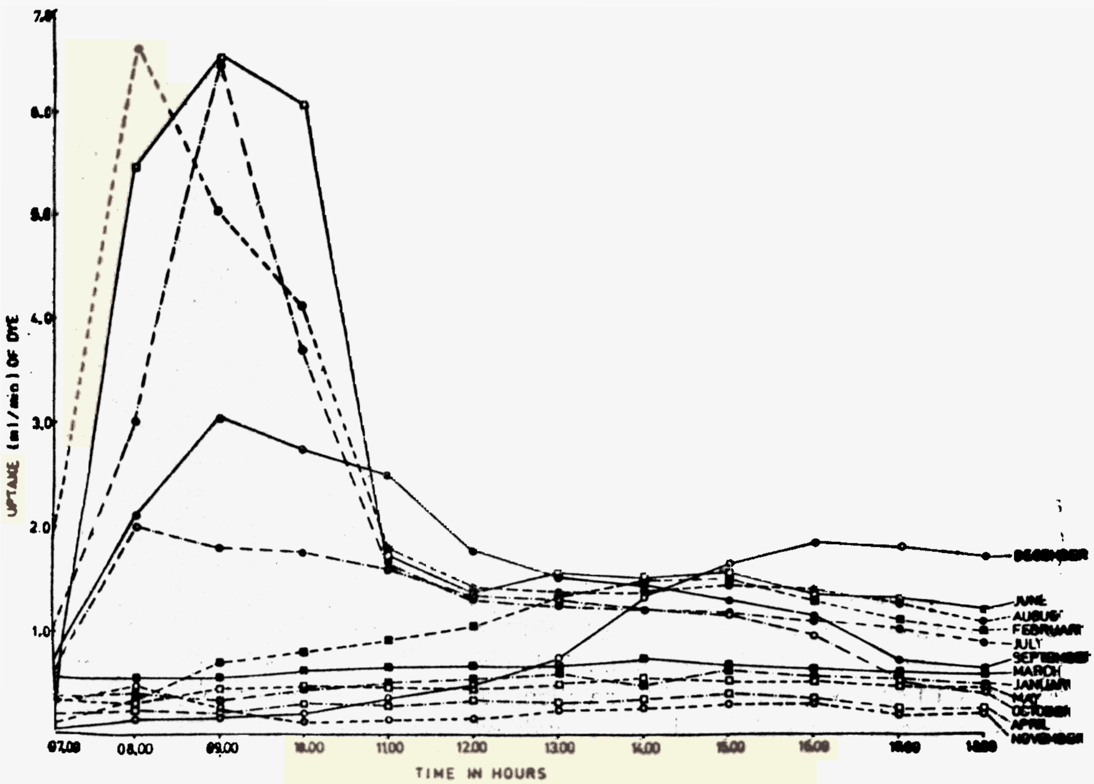

Fig. 9. Monthwise behaviour of dye uptake by teak.

Table 11: ***Monthly rainlfall, average temperature, wind speed and relative humidity data of Peechi for the year 1979-1981'***

Months	Rain Fall (mm)	Relative Humidity (Percent)	Temperature (°c)	Wind Speed (miles/day)
January	Nil	65.81-	26.72	150.06
February	Nil	68.36	28.47	121.48
March	6.55	70.50	30.84	107.31
April	86.60	77.57	30.95	111.11
May	84.82	78.90	29.96	103.23
June	1041.50	91.24	25.46	121.78
July	1124.69	94.20	24.90	103.86
August	619.69	92.36	25.64	106.12
September	319.35	82.28	27.12	97.96
October	123.65	83.20	27.39	83.55
November	134.25	80.77	27.61	89.64
December	4 80	69.39	27.27	138.42

* Data collected from Kerala Engineering Research Institute, Peeehi.

As no external pressure is applied, movement of chemicals depends on the physiological status of the tree as well as on the macro- and micro-climatic conditions of the environment. Using the technique, adequate quantities of water soluble chemicals could be infused into the trees economicallv and without polluting the environment.

b) Screening of chemicals:

Of the several herbicides screened, five of them viz., Afalan, Tolkan, Gramox: one, Dalapon and Sencor gave encouraging results (Table 12).Sencor, a metribuzin compound, was found to be most selectively effective. It was effective almost in all concentrations used. At higher concentrations (0.2 to 0.3 percent a.i). initially some blotching of the young leaves and defoliation of the host were noted (Fig. 10), specially during the dry season. Sencor, selectively killed the mistletoe on teak (Fig. 11) and also the same mistletoe species on *Bombax ceiba.* In the case of the other selectively effective chemicals, the clumps of the parasite were not destroyed fully. Though they got completely defoliated, new leaves appeared and the clumps revived in due course. These chemicals were rated as the second best effective chemicals. Copper sulphate and 2, 4-D compounds were found to be equally toxic for the host as well as the parasite. All these compounds first killed the parasite and in the long run killed the host. All 2, 4-D compounds in all concentrations caused splitting of the bark as well as discolouration of the wood along the path of the chemical and ultimately killed the tree. In lower concentrations the effect was gradual. Though copper sulphate (Kadambi 1954) and 2, 4-D compounds (Greenham *et al* 1851; Kadambi, 1954; Nicholson 1964; Brown and Greenham 1965) have been recommended to kill certain tree mistletoes in India and Australia, in our study we did not find any selectivity of these chemicals. Teak is extremely sensitive to both copper sulphate and 2, 4-D compounds when injected.

Table 12: ***Chemicals screened against teak mistletoe***

Trade name	Chemical Name/Nature	Reaction on host1 parasite
Copper sulphate	Inorganic salt	A
Weedar 96	Methyl chlorophenoxy acetic acid	A
'Weedar 32	Methyl chlorophenoxy acetic acid	A
'Weedex	Methyl chlorophenoxy acetic acid	A
Weedon 40	Dichlorophenoxy acetic acid	A
Fernoxone	Dichlorophenoxy acetic acid	A
Afalon	Linuran	B*
Tolkan	Isoproturon	B*
Dalapon	Dichloropropionic acid	B*
,Gramoxone	Paraquat	B*
Sencor	Metribuzin	B***
Basalin	Fluchloralin	C
Stomp	Penoxalin	C
Basagran	Bentazon	C
Dual	Metolachlor	C
Igran	Terbutryn	C
Atrataf	Atrazine	C
Tafazine	Simazine	C
Karmex	Diuron	D

A : Effective against both, host and parasite
B : Selectively effective against parasite
C : Not effective
D : Erratic results
* : Degree of effectiveness

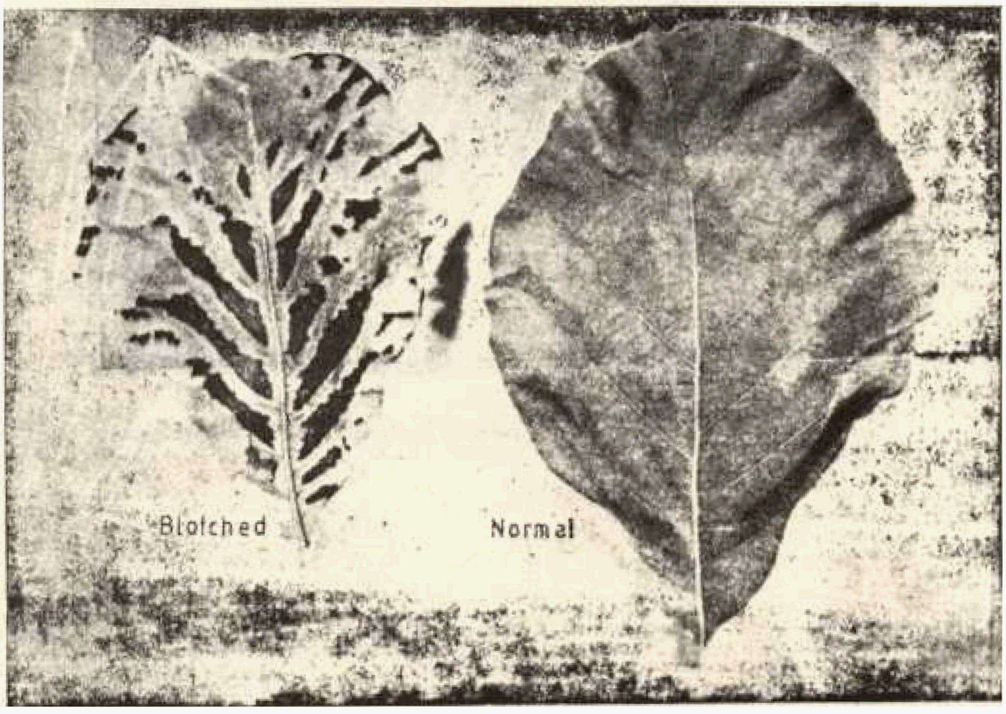

Fig. 10. Blotching symptom on young teak leaves due to higher concentration infusion of Sencor.

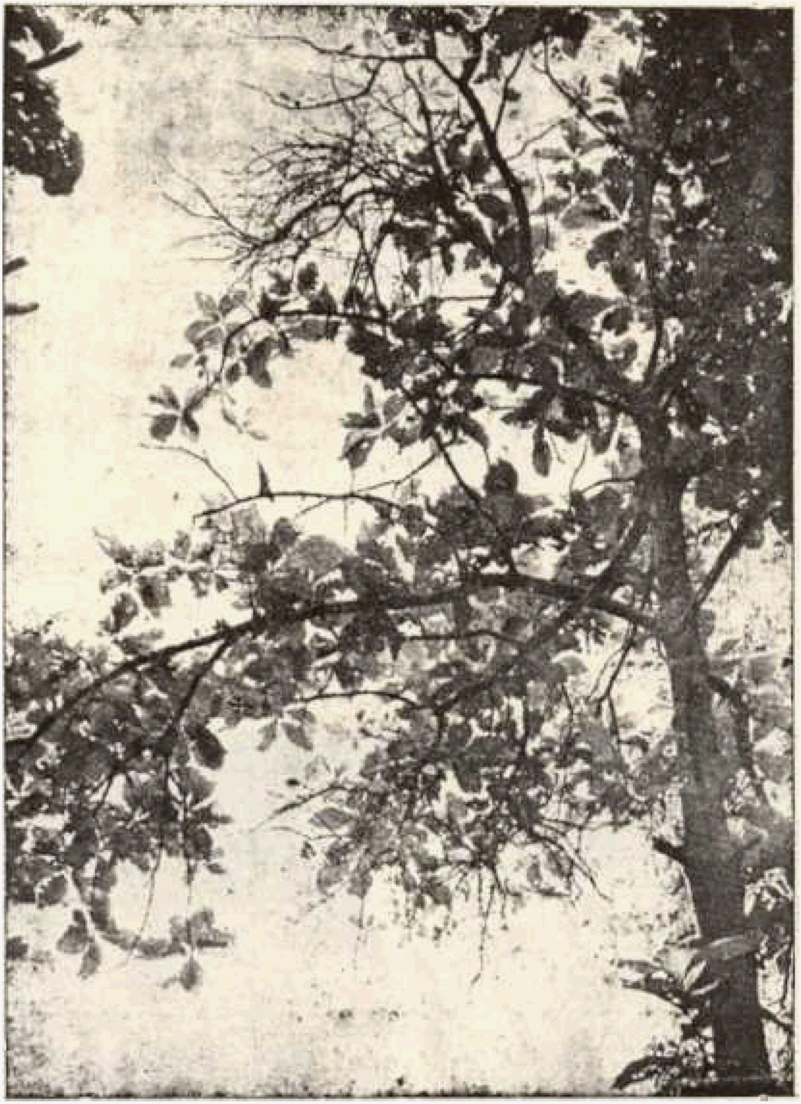

Fig. 11, Effect of Sencor on the parasite (Note the dried parasite clumps)

SUMMARY AND CONCLUSIONS

Teak is the major hardwood species in Kerala, grown extensively in planta, tions. The first plantation was established in India in 1842 by Mr. Chathu Menon in Nilambur (Kadambi 1972). Once it establishes after transplanting, teak does not have much pest and disease problem. Mistletoe, ***Oendrophthoe falcata*** var. ***pubescens*** is the most damaging parasite of teak in plantations which was noted in Nilambur as early as 1867, by Dr. Cleghorn. Some of the young plantations have been felled in Nilambur due to heavy attack of this parasite.

Though it is a serious problem, it failed to attract the attention of plant pathologists associated with Indian Forestry. Neither any effort had been made to find out the quantitative or qualitative loss of the timber due to the attack of this parasite, nor it was attempted to study the factors responsible for its epidemics. Since the time it was recorded, eradication of the parasite by lopping off the individual infested branches, is being practised by the Forest Department, under the forestry management operation.

The present study shows that in Kerala, teak is attacked by only .one species of mistletoe. Parasite infestation is more in the Central and Northern Circles than in the Southern circle and High Ranges. In Nilambur Division almost all plantations above the age of seven years are being attacked by mistletoes and in some plantations more than 85 percent trees are infested with the parasite.

It was estimated that during the period of 1880-83, in a 12 year plantation there is about 41.64 percent increment loss(GBH in cm) whereas in a 34 year old plantation it is about 37.18 percent. Also the mortality due to the parasite is about 27.27 and 1.52 percent, respectively in the 12 year and 34 year old plantations. Physical removal of the parasite during the study period (1980-83). improved the growth increment by 38.78 and 7.21 percent respectively in the above plantations; but this increment was not statistically significant. Probably the period of three years is too short for teak to gain significant increment after removal of the parasite. It was interesting to note that mortality was nil in both the plantations after lopping off the clumps from the plants, which itself is a considerable quantitative gain specially in the young plantations. On close observation it was noted that clumps of the parasite reappear due to fresh infestation during profuse flowering and fruiting period of the parasite.

Though sufficient prescriptions have been stipulated in the Forest Department Working Plans, it was impossible to eradicate the parasite. The practice remained erratic or discontinued for long periods due to various administrative and economic reasons.

It is with these problems in mind management of the parasite using chemicals was planned. Due to various economic problems and lack of sophisticated high power or aerial spray technology in India, it is not possible to spray chemicals in the forest plantations. Moreover, spraying of chemicals is likely to cause serious environmental pollution hazards, specially to the dense human population near the plantations as well as to the wildlife in the plantations. Before taking up the screening of the various selective plant killers, a device for tree-infusion of water soluble chemicals was developed and standardised. Using this cheap tree-injection device, desirable quantity of the chemicals could be introduced into the trees.

Of the several weedicides tested, Afalon, Tolkan, Dalapon, Gramoxone and Sencor selectively affected the parasite. However, in the case of Afalon, Tolkan, Dalapon and Gramoxone, the parasite clumps sprouted after sometime, whereas Sencor killed the clumps even with one treatment. Sencor was effective almost in all concentrations used. During hot season Sencor produced some blotching symptoms on the young leaves and shoots of the host in higher concentration. No drastic harmful effect on the host tree was noted.

Our study shows the potentialities of using selective weedicides for managing the mistletoe problem in teak. Follow up studies on the problem of mistletoe management by chemical control needs to be taken up in greater depth. Efficacy of more weedicides will be tested at different concentrations in different seasons. Assessment of volume gain due to treatment will be made over a longer period. Retention of the chemical in the plant will be studied using radio-tracer technique, and finally attempt will be made to calculate the cost/benefit ratio of the whole operation.

Also possibilities of managing mistletoes in teak plantations through the potential biological agents like the hyperparasite, *Viscum capite//atum* and caterpillars of the butterfly *Delias eucharis* will be looked into.

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