ENTOMOLOGICAL PROBLEMS IN NEW ZEALAND FORESTS

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INTRODUCTION

The devastation of the indigenous forests of New Zealand since the arrival of white settlers has reduced them to only about 14.5 million acres (22% of the total land area). On the other hand, 1.04 million acres have been planted in exotic forest, of which 870,000 are in plantations larger than 50 acres. *Pinus radiata*, our main exotic forest tree, occupies over 562,000 acres (65%) of these holdings. *Pinus ponderosa* (including the unpromising variety *scopulorum*), occupies 86,000 acres, *Pinus nigra* 69,000 acres, *Pseudotsuga menziesii* 62,000 acres and *Pinus contorta* 26,000 acres. The remainder is occupied by less important species of *Pinus*, various species of *Larix, Eucalyptus, Cupressus, Chaemaecyparis, Abies, Picea* and other genera.

The largest areas of exotic plantations are situated in the Rotorua–Tokoroa–Taupo area where *P. radiata* has been planted in extensive monocultures. Overseas entomologists have emphasised the vulnerability of these forests to attack by insects, but so far their fears have proved unfounded. With the exception of the heavy mortality associated with attack by *Sirex noctilio* (F.) and its associated fungus, no epidemics have occurred. However, epidemics of a defoliator have occurred in the Eyrewell and Balmoral State Forests of the eastern South Island.

Epidemics of fungal diseases have been more spectacular. In the 1930s *Phomopsis strobi* killed and severely damaged many acres of *P. radiata*. At present the large monocultures in the North Island and some forests in the South Island are affected by *Dothistroma pini*, a needle cast fungus, which attacks *P. radiata* up to 15 years old, but not, apparently, older trees. *P. nigra* and *P. ponderosa* are attacked at any age. The ultimate impact of this disease cannot be predicted at present. A copper fungicide was aerially sprayed over 80,000 acres in 1967.

ENTOMOLOGICAL PROBLEMS IN N.Z. FORESTS

When considering the entomological problems in New Zealand forests a comparison should be made first with forests in the northern hemisphere. There, the number of species causing losses is far greater than here. To mention a few examples: Species of Scolytidae (bark beetles) have caused mortality over thousands of acres and the losses have been calculated in several thousand million board feet. Species of Tenthredinidae (sawflies) and Lepidoptera frequently cause severe defoliation; the spruce bud worm epidemic in Canada and the U.S. has continued for several decades and has caused heavy economic losses, and Dutch elm disease transmitted by insects has been responsible for widespread mortality.

New Zealand's forests have few insects capable of causing appreciable damage and in the last 15 years only a few species have reached epidemic levels. Scolytidae, both native and introduced, are present, but fortunately no potentially dangerous killers have become established. Defoliating sawflies capable of attacking forest trees are not known here. Of the wood borers, *Sirex noctilio*, with its associated fungus, is regarded as the most potentially harmful insect to the pine forests.

Most of the endemic insects of the indigenous forests are usually kept under control by biotic and environmental factors, though epidemics do occur at intervals.

It is vital to the future economy of New Zealand that, with the increased speed of travel and greater trade with other countries, timber-attacking insects, especially Scolytidae, should be prevented from entering. The first line of defence, the Quarantine Service, has intercepted insects in articles ranging from swizzle sticks to heavy timbers, and although it is unlikely that all of these species would have found New Zealand suitable for survival, the articles attacked by them have been treated or destroyed. A second line of defence is provided by the Forest Biology Survey, whose province is the living forests. Unfortunately, its inspections are limited to the exotic forests.

Three questions remain:

(i) How good will our quarantine service be in the future?

(ii) How long will it take for new pathogen to be detected after establishment?

(iii) What action will we then take?

THE INDIGENOUS FORESTS

The value of the indigenous forests, especially the protection forests, cannot be readily measured in terms of money. Loss of trees and shrubs in the high country has resulted in erosion and flooding in the lower reaches of our rivers. Browsing animals not only prevent regeneration but cause inestimable damage by removing soil and initiating biotic changes.

Cutover areas in millable native forests are usually left depleted and derelict and are not likely to produce a timber crop in the next century. Although enrichment plantings are carried out in such areas, these can, as yet, be regarded only as trials because only a small part of the yearly cut (between 25,000 and 30,000 acres) is being reafforested. Establishment of exotic forests in scrub and fern country is found to be easier.

Protection against insects has never been attempted in native forests because of the belief that biotic factors soon bring sudden increases in population under control. Besides, the native forests are regarded as uneconomical once the standing crop has been sold. Consequently, their relevant insect fauna has received scant attention. Some indigenous insects are said to kill trees, but their importance has not been critically evaluated.

For example, the beech buprestid, *Nascioides enysii* (Sharp) is regarded by some as the main killer of *Nothofagus*, but is it primarily responsible? The health of trees before attack and the nature of the damage caused by the insect need to be taken into account. Unpublished current work has shown that a species of wilt fungus (*Ceratocystis* sp.) is introduced by pinhole borers (*Platypus* spp.) and evidence has been found that these borers will attack apparently healthy, as well as weakened and recently dead, *Nothofagus*. So far, it is known that the fungus may kill the cambium, and that the borer attack is often concurrent with that of the beech buprestid. Such investigations, if continued, could lead to a different view of the role of *Nascioides*.

After the epidemic of *Proteodes carnifex* (Butl.) in 1954 which extended over 50,000 acres in the southern part of the South Island, mortality of *Nothofagus solandri* var. *cliffortioides* was attributed to mass attack by *Nascioides*. In this instance the role of insects other than these two has not been considered.

Mortality asssociated with *Nascioides* usually appears a few years after beech has been felled and the canopy opened up. The question is whether, with better hygiene after felling (removal of dead material), such mortality would occur. With poor hygiene, insects breeding in the slash could kill the trees by mass attack after emergence. Exposure of trunks to direct sunlight may adversely affect the cambium layer and encourage localised attack. These are simple possibilities, but it would need a team of plant physiologists, silviculturists and entomologists to investigate them. However, such a study may demonstrate a system of management suitable for our native beeches.

Aenetus virenscens (Dbld.), the ghost moth, is responsible for considerable damage not only to beeches in the North Island, but also to other hardwoods. The holes it makes extend high up the trunk and branches and beech regeneration is attacked while the trees are still young. The holes permit the entry of wood-rotting fungi which further damage the timber. There is no known cure.

The dying of *Metrosideros* (rata) and *Weinmannia* (kamahi) have not received the attention they warrant, perhaps because the insects involved are regarded as of minor importance. And insects appear to be unimportant in the degeneration of *Podocarpus totara* and *P. hallii* (totara). *Beilschmiedia* (tawa) and *Dacrydium cupressinum* (rimu) in the North Island. Whether in these four species faunal climax has been reached is conjectural at present.

In podocarp forest and the kauri forest remnants of Northland little insect damage occurs.

THE EXOTIC PINE FORESTS

Forest nurseries

Damage caused by grassgrubs (mainly species of *Costelytra* and *Odontria*) and weevils, such as *Graphognathus leucoloma* (Boh.) and *Xyrostygnus binodulus* Broun, have been reported on several occasions. A few larvae per square foot will result in heavy losses, so control should aim at complete eradication. Regular checks for the presence of larvae should be made and, if found, an insecticide should be applied. That recommended is dieldrin, at a minimum rate of 2 lb. of active ingredient per acre per year. The rate is high but the cost is relatively low per 1,000 seedlings. It is sometimes necessary to give a second application at the same rate in autumn.

Originally, DDT was used at a rate of 5 lb. per acre and it is still used in some nurseries at a rate of 2 lb. per acre; but an amount of 15 lb. applied in one nursery did not give immediate control, hence the change to dieldrin. Little work has been done during the past five years with other insecticides to control soil-inhabiting insects in forest nurseries.

Establishment of planted stock

In 1967 failures in establishing *Pinus radiata* and *Pseudotsuga menziesii* were reported in clear-felled pine forest from many parts of the North Island. The losses were attributed to *Hylastes ater* (Payk.) and grassgrub larvae.

The importance of the part played by *Hylastes ater* is doubtful, as it usually selects weakened seedlings for attack. Whether, in the circumstances, mass attack would have killed the seedlings is a controversial point. Trials with insecticides are being made to eliminate the insects suspected of causing the mortality.

Much remains to be explained, however, since in the Karioi Forest no mortality has occurred in *P. contorta* plantings and, in the high risk areas of the Eyrewell State Forest, mortality associated with *H. ater* in planting trials has been as low as 0.2 per cent.

Factors involved in other places may be the condition of planting stock, the method of site preparation and the weather during planting.

The establishment of *P. radiata* in scrub- and grassland has on several occasions resulted in heavy losses which have been attributed to grass-grubs. Protection with 2 lb. of DDT or dieldrin per 1,000 plants, applied as a spray, has given good results. Such applications are not used regularly as they would increase the cost of establishment.

Regeneration of Pinus radiata

Regeneration of *P. radiata* in Kaingaroa State Forest after summer felling is generally good, though it varies. A considerable reduction in the number of seedlings occurs during the following two years. Frost, fungal diseases, and intraspecific competition render the seedlings susceptible to attack by *H. ater*. In better sites, where regeneration is high, the reduction may be beneficial, but in poorer sites supplementary planting to replace losses is often necessary.

Little or no regeneration occurs after winter felling because birds, mainly chaffinches, and mice eat the seeds. The extermination of the birds and mice would, of course, be the answer. However, control of birds may result in wide repercussions and possibly upset the existing biotic balance. Aerial seeding with 2 lb. thiram-coated seed, has resulted in good strikes and reduction in cost of establishment. Thiram acts both as a fungicide and a bird-repellent.

Lepidopterous defoliators

Several species belonging to the family Geometridae (8 spp.), Tortricidae (4 spp.), and Psychidae (1 sp.) attack the foliage of exotic forest trees. Only one of these, *Selidosema suavis* (Butl.) has, on occasions, reached epidemic levels and caused serious defoliation. These outbreaks have occurred only in Eyrewell and Balmoral State Forests.

The first occurred in 1951–52 and in September 1952 the total area infected was approximately 8,000 acres. After a trial spraying over 500 acres in February 1952 to establish techniques, approximately 7,000 acres were sprayed from the air with DDT in September–October of that year, although the entomologists doubted its desirability. The spraying was most successful, but two weeks later a polyhedral virus disease was evident amongst the caterpillars, which after another two weeks, reduced the population to normal in the 1,000 acre control area. In some localities in both forests defoliation after the end of the epidemic was severe, only the last three or four branch whorls remaining green. Epidemics occurred again in 1956–57 and in 1960–62.

The 1957 epidemic was not as severe as that of 1951–52 and was shorter. The 1960–62 epidemic was as serious as that in 1951–52; both were in Eyrewell Forest only. During these epidemics a watch was kept on the population levels of the caterpillar, parasite and predator complex, and especially on the increase of the polyhedral virus in the caterpillars. From these studies the time at which the epidemic would end was predicted and so no chemical was applied.

Eyrewell Forest suffered from severe windblow in 1964 which resulted in the destruction of it as a living laboratory for the study of *S. suavis*. During the salvaging of the area *H. ater* created a problem by infesting export logs. There was fear that *Hylastes* would also affect re-establishment, but it did not.

Woodborers

The only woodborer responsible for killing pine trees in New Zealand is the introduced *Sirex noctilio*. It is regarded as the most potentially harmful insect for our pine stands and, with its symbiotic fungus, usually kills trees weakened by other causes. The heaviest mortality occurred between 1946–51 when, in the Rotorua district, 25–30 per cent of the trees were killed over 300,000 acres. In one area the stocking of 15-year-old stands was reduced from 700 to 85 trees per acre. It was fortunate not only that the losses occurred when the radiata pine was not being used on a large scale but also that mortality was generally confined to suppressed and malformed trees. The resultant thinning could be regarded as beneficial in that it permitted greater increments in the survivors. The mortality started after the drought of 1946 had weakened the trees, the numbers of the insects increased and, over the years, by repeated and mass attack, caused serious losses. Scattered mortality still occurs, but this is often associated with incorrectly applied silvicultural practices such as thinning and pruning just prior to and during the flight season and excessive doses of arboricide in thinning by poison. The numbers of the wood wasp are being considerably reduced by the presence of newer, effective biological control agents and the more intensive thinning schedules of recent years have reduced its habitat.

Mortality in older *P. radiata* stands in the Kaingaroa Forest has been very low during the past five years and total basal areas* of stems per acre have risen above those which are regarded as safe. Although little is known about the resistance of the older trees to *Sirex*, it may be that, when adverse conditions such as drought occur, losses could become high. In the younger stands a close watch is being kept on the mortality after defoliation by *Dothistroma pini*.

Although four species of parasites of *Sirex* were already established before 1962, several other parasites have been introduced since and are being bred in the laboratories of the Forest Research Institute. The breeding has met with varying success: three species have now been released; the outcome of the breeding of two is still in doubt and two are known to have failed.

A nematode infection of *Sirex*, discovered in 1962, is an additional important factor in its biological control. Infection, which results in complete sterilisation of the adults, has been found in up to 95 per cent of the population in one locality. Such a high degree of infection has never been recorded for the combined insect-parasite-complex of the wood wasp in New Zealand. Introduction of this nematode to areas where it does not occur are being made.

Although recently-introduced insect parasites from Europe, India and Japan have been found to be infected with nematodes, no such infection has been found in the two parasites established in New Zealand, *Ibalia leucospoides* (Hochenw.) and *Rhyssa persuasoria* (L.). Such precautions are taken in breeding the recently introduced parasites that only adults free from nematodes are released.

Termites

The incidence of native dry- and wet-wood termites, *Kalotermes brouni* Frogg. and *Stolotermes ruficeps* Brauer, in farm shelterbelts and woodlots of pine and larch has on several occasions made necessary the fumigation of logs intended for export. The attack by wet-wood termites usually extends no deeper than three inches into the branch stubs. The attack by the dry-wood termite extends into the heartwood and may render the logs useless for sawn timber. Attack is usually commoner in overmature trees, especially in farm woodlots and shelterbelts, where unhygienic conditions prevail. The problem may be considerably reduced by early pruning and by removing all dead logs and stumps, where the insects breed. Only on one occasion has the wet-wood termite been found infecting living pines (*P. taeda*) in forest areas.

Miscellaneous

Logs in stock-pile are often attacked under the bark by *Hylastes ater*. These will not cause any damage, but logs exported to other countries must be free from insects. Log stockpiles left too long in the forest have, on occasion, been attacked by pinhole borers, causing damage to the timber. Stacked sawn timber is often attacked by huhu beetles (*Prionoplus reticularis* White) but the damage is usually slight. About 10 inquiries a year are received about its attack on treated *P. radiata* timber. The young larvae hatch from the eggs and bore into the wood.

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* Basal area: area of cross section of stem, usually measured at breast height. When applied to a crop, the sum of all the stems or the total basal area per unit area.

Problems in the less important species of introduced pines are often greater than in *P. radiata*. In the Cupressaceae, woodborers such as huhu, two-toothed longhorn (*Ambeodontus tristis* Fabr.) and termites are often found breeding in the living trees, causing serious damage to the timber. Attack on spruces (*Picea alba* and *P. sitchensis*) by the spruce aphid (*Elatobium abietinum* (Walk.)) and the conifer spinning mite (*Paratetranychus unun-guis* (Jacobi)) results in poor growth, so that large scale plantings of these species have been practically abandoned.

THE EUCALYPTS

Opinion differs widely on the future of eucalypts as major forest trees for New Zealand. In my opinion several species of this genus may be used to advantage to restock derelict cutover areas, and plantings could add considerably to our hardwood resources. Some species are attacked more heavily than others. The main insect problem for some years has been *Paropsis charybdis* (Stal) which causes severe defoliation of several species. It is fortunate that some of the more promising are not attacked by this insect. Since the initial invasion of the North Island by *Paropsis* about 1955 defoliation has been heavy but, at present, its numbers are on the decline, probably as a result of a disease. The answer to the *Paropsis* problem is biological control. The introduction of parasites has been considered for several years. The main difficulty in obtaining them is that *P. charybdis* is comparatively uncommon in Australia, so parasites of closely related species which are more easily collected may have to be tried.

Not only would biological control be beneficial in deciding on the future plantings of suitable eucalypt species, but the aesthetic value of the landscape would also be enhanced if defoliation could be considerably reduced. For that reason alone biological control should be encouraged.

The attack of pinhole borer (*Platypus* spp.) on eucalypts used in enrichment plantings in indigenous forests is being investigated. The result is not death of the trees, but damage to the timber, the significance of which will not be known until mill studies have been made on logs from mature trees. But because few eucalypt enrichment plantings are more than 15 years old such material is not yet available.

Other introduced insects such as *Gonipterus scutellatus* (Gyll.), *Eriococcus coriaceus* Mask., psyllids, etc., are usually well controlled by the parasites and predators already introduced.

CONCLUSIONS

The approach to insect control in forests is more or less biological and relies, for both native and introduced insects, on appropriate biological control agents. As far as possible the use of insecticides should be limited and chemical control should be undertaken only after careful study has shown that biological controls are inadequate.

The problem would, in principle, not be any different even should one of the potentially more harmful insects become established. In that event changes in existing silvicultural practices might have to be devised.

SUMMARY

The main entomological problems of the indigenous, the exotic and coniferous forests of New Zealand are discussed. Insects which could cause serious mortality or growth losses should be prevented from entering this country. The control of forest insects already established in New Zealand depends mainly on natural and introduced biological agents and upon silvicultural practices. The use of insecticides is advocated in forest nurseries and when biological controls fail.