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Are NZ *Pinus radiata* plantations threatened by fine wilt nematode *Bursaphelenchus xylophilus?*

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ABSTRACT

An extensive survey of the health of both plantation and amenity Pinus radiata in California was carried out. The primary aim was to assess the extent and importance of Bursaphelenchus xylophilus there. From the results of this survey and an extensive literature review we conclude that Pinus radiata growing in its natural range or as an exotic species is under no particular threat from B. xylophilus.

INTRODUCTION AND PROBLEM ANALYSIS

The pine wood nematode, *Bursaphelenchus xylophilus* (Steiner and Buhrer) Nickle (= *B. lignicolus* Mamiya and Kiyohara) causes a serious wilt disease of pines in Japan; annual losses of native Japanese pines (*Pinus densiflora* Sieb. et Zucc. and *P. thunbergii* Parl.) are about two million cubic metres of timber (Anon., 1981). During 1980 the Japanese Government allocated 35 million dollars for control procedures (Dropkin and Linit, 1982).

In 1979 pine tree deaths associated with *B. xylophilus* were found in the United States (Dropkin and Foudin, 1979). Subsequent research showed that the nematode is native to North America and must have been introduced into Japan, presumably about the turn of the century (Dropkin *et al,* 1981a; Holdeman, 1980). In contrast to the Japanese experience, widespread mortality of pines has not been recorded in the United States (Dropkin *et al*, 1981a; Nickle, 1981; Wingfield, 1983). This is not surprising; indeed it is what we have come to expect from a native pest that has co-evolved with its hosts. In the United States *B. xylophilus* has been recorded from 34 states (Linit *et al,* 1983) and from more than 20 species of both native and exotic pines as well as from two species each of *Cedrus, Larix* and *Picea*. By far the most common host reported is *P. sylvestris* L. (Linit *et al,* 1983. It is interesting to note that *P. sylvestris* belongs in the same subsection (Critchfield and Little, 1960) of the genus *Pinus* as the very susceptible Japanese pines.

Recently *B. xylophilus* has been reported from the Nanjing area of China where it is causing extensive mortality to *Pinus thunbergii* (Cheng, 1983).

The main vectors of *B. xylophilus* are various species of *Monochamus* (Cerambycidae) (Dropkin *et al,* 1981a; Mamiya and Enda, 1972) although other insect genera are associated with *B. xylophilus* to a lesser extent (Linit *et al,* 1983).

Considerable work has been carried out in both Japan and the United States to assess the susceptibility of various pine species to *B. xylophilus* (Dropkin *et al,* 1981a; Futai and Furono, 1979; Kondo *et al,* 1982; Wingfield *et al,* 1984).

There are many contradictions in the literature; most of these can be plausibly explained, but some cannot. In general, Japanese work indicates that members of the subsection Sylvestres of the genus *Pinus* are most susceptible to the disease (although some, e.g. *P. massoniana* Lamb., are apparently resistant) and that most American species of pines are resistant to a greater or lesser degree. Inoculation studies in the United States (e.g. Dropkin and Linit, 1982) have often given conflicting results and generally more species have been reported susceptible to the disease than indicated by the Japanese work. On the whole, the Japanese work has indicated that the species *Pinus radiata* D. Don is moderately resistant, and it has been stated by Bird (1976) that *P. radiata* is resistant to pine wilt nematode. However United States workers have reported it to be highly susceptible (Dropkin *et al,* 1981; Dropkin *et al,* 1981b). This apparent contradiction probably arises because of differences in the age of trees studied. In the United States, nearly all of the inoculation studies have been carried out using seedlings, whereas much of the Japanese work used older trees, very often in a plantation situation. Similar differences in reported susceptibility exist for other pine species. For example, in Japanese inoculation studies *P. echinata* Mill. and *P. strobus* L. (two North American pines) were ranked as highly resistant, i.e., no trees were killed (Kobaysashi, 1978; Mamiya, 1972), but in inoculation tests with seedlings of these species United States workers recorded 100% mortality (Dropkin and Foudin, 1979). There are dangers in drawing conclusions about a disease that affects older trees from studies carried out on seedlings. Work done on seedlings can only provide clues as to what might happen in a forest or plantation. Of great significance are the results of Wingfield *et al,* (1984). These workers inoculated large numbers of *P. banksiana* Lamb., *P. resinosa* Ait. and *P. nigra* Arn. in a forest situation with *B. xylophilus* and failed to kill or damage any of them. The inoculum used was sufficient to kill other more susceptible species, and seedlings of the above three pine species were killed in greenhouse inoculation studies.

The susceptibility of *Pinus radiata* to *B. xylophilus* is of considerable importance for those countries such as New Zealand which have a large commercial investment in this species. To highlight the importance of *Pinus radiata* to New Zealand's forest economy we can do no better than quote Sutton (1984) – "Industrial forestry in New Zealand is based almost entirely on one species – radiata pine (*Pinus radiata* D. Don). Radiata pine plantations now occupy about 900,000 ha and are being increased by about 40,000 ha each year. These plantations supply New Zealand with almost all its six million cubic metres of domestic wood demand plus the equivalent of another four million cubic metres for export. The supply of wood will increase and by 2010-2015 New Zealand will be exporting, in one form or another, 25 million cubic metres of radiata pine".

Although it is not accepted that monocultures *per se* are inherently vunerable to outbreaks of pests and diseases (Bain, 1981; Chou, 1981) it is recognized that New Zealand has a huge investment in its radiata pine monocultures and all practical steps should be taken to protect the resource, particularly from overseas pests and diseases that are not present in New Zealand. The absence of serious insect pests, and to a lesser extent diseases, is a major reason why radiata pine has been so succesful in New Zealand. The first, and arguably best, line of defence against overseas pests is sound quarantine, i.e., prevent establishment in the first place. New Zealand has very

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stringent and vigorously implemented quarantine requirements, controlling the importation of material that affects forestry.

If *Pinus radiata* is susceptible to pine wilt nematode New Zealand plantations must be considered to be at risk. But just how great is this risk? In an attempt to answer this question we considered the following points:

1. Pine wilt disease is a very serious problem with pines in Japan.
2. *Pinus radiata* has been shown to be susceptible in some inoculation studies using seedlings.
3. Known vectors of the nematode, including *Monochamus alternatus* Hope, have been intercepted at New Zealand ports on many occasions (Bain, 1974; Bain, 1977; Milligan, 1970).
4. Although it is evident that the nematode was introduced into Japan from North America none of its vectors was introduced with it. *M. alternatus* is a native of Japan.
5. There are no species of *Monochamus* in New Zealand.
6. It is hard to imagine any New Zealand Cerambycidae acting as efficient vectors of the nematode. *Hexatricha pulverulenta* (Westwood) is a possible candidate (i.e. it is a cerambycid that feeds on green twigs and breeds in dead material) but it is nowhere near so abundant as *Monochamus* is in Japanese or North American pine forests.
7. We are not aware of any records of Lamiinae (the subfamily to which *Monochamus* belongs) becoming established outside their natural range.

Considering all seven points together it would appear that the nematode is unlikely to establish itself in New Zealand unless a suitable vector, i.e. a species of *Monochamus,* is also introduced and becomes established. This is entirely possible, although previous experience would indicate that it is unlikely (point 7).

The collection of further information on the susceptibility of *P. radiata* and on the incidence of the disease in native stands of trees was considered essential to assessing the risk for New Zealand plantations, and the adequancy of present quarantine regulations.

METHODS

To assess the extent and importance of *B. xylophilus* in radiata pine in California an extensive survey was carried out between July 11 and August 15, 1984. Trees sampled were mainly in the coastal region from Eureka in the north to Santa Barbara in the south. All native mainland populations were surveyed, along with a wide range of plantation and ornamental trees. Particular attention was paid to areas where the trees were under stress. Samples, comprising wood chips, increment cores, or branch segments, were collected from healthy, unhealthy and dead trees, and also from logs and branch debris. Nematodes were extracted from the samples using the Baermann funnel technique and concurrently subsamples were placed on *Botrytis cinerea* Pers. ex FR. cultures on potato dextrose agar and incubated for up to 30 days.

RESULTS

During the course of the survey many areas of forest were visually assessed for unhealthy trees, and hundreds of trees were examined. In the laboratory, nematodes were extracted and/or cultures made from more than 100 samples. However not a single record of *B. xylophilus* was obtained. We found no evidence of unexplained mortality or tree decline. On the contrary, our survey showed radiata pine to be in excellent condition even in areas of extreme stress. Except in one area in Oakland (an amenity plantation badly affected by wind, drought, and soil subsidence) the survey revealed no more than about a dozen recently dead or dying trees.

CONCLUSIONS

B. xylophilus has been recorded from California previously (Holdeman, 1980; Holdeman and R. Hackney, pers. comm.) and the authors know of two records from radiata pine, one from Siskiyou County and one from Monterey County. In neither of these instances was *B. xylophilus* implicated in any way with tree death or decline (Holdeman, 1980; Holdeman, pers. comm.).

These records coupled with the results of the present survey, strongly suggest that, although *B. xylophilus* is present in radiata pine in California, the level of infection is low and the nematode is not associated with mortality or decline in tree health. Recorded vectors of *B. xylophilus, Monochamus* spp, are present in this region (Keen, 1952; Rawlings, 1960; J. Chemsak, pers.comm.) so an absence of vectors is not the reason for the paucity of *B. xylophilus* there.

We also conclude that *B. xylophilus* poses no threat to radiata pine in California, a situation which is unlikely to be any different in New Zealand. On the basis of this study and an extensive review of the literature we suggest that New Zealand requires no additional quarantine practices or regulations aimed *specifically* at the exclusion of *B. xylophilus* and/or its vectors.

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