BIOSECURITY IMPLICATIONS OF EXOTIC BEETLES ATTACKING TREES AND SHRUBS IN NEW ZEALAND

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ABSTRACT

A survey of exotic beetles that attack trees or shrubs in New Zealand found 51 species of mainly Australian (58%) and European (25%) origin. In addition, three biological control agents have been released against woody adventive plant pests. The host range of most species is restricted to exotic crop and ornamental plants in New Zealand. Nine polyphagous borers sometimes attack dead wood of indigenous species, and at least one polyphagous root feeder may attack indigenous trees, but the ecological impact of these species on indigenous forests appears negligible. However, some of the wood and bark borers as well as several defoliators are important pests of exotic crop and amenity plants. Although this suggests that exotic phytophagous beetles pose a greater biosecurity threat to exotics than to indigenous species, a greater surveillance effort in New Zealand's indigenous forests appears necessary to detect potentially harmful invasions.

Keywords: invasion, Coleoptera, host range, insect, tree.

INTRODUCTION

The colonisation of New Zealand by Polynesians and Europeans has led to the accidental or intentional introduction of numerous exotic plants and animals. Today there are over 2000 plant, nearly 100 vertebrate and over 2000 invertebrate species that are naturalised exotics (Atkinson and Cameron 1993; Ministry for the Environment 1997). The impact of invasive plant pests and mammalian herbivores and predators on New Zealand's ecosystems is well recognised (Atkinson and Cameron 1993). Many indigenous species have not been able to compete with the colonisers because the New Zealand fauna and flora evolved during the last 80 million years in geographic isolation and in the almost complete absence of mammals. Evidence of this is the loss or decline of numerous species during the last few centuries (Ministry for the Environment 1997), although the loss of habitat, hunting, and other human-caused disturbances have also contributed. Among the insects that have invaded New Zealand's indigenous habitats, the common wasp, *Vespula vulgaris* (L.) (Hymenoptera: Vespidae), has been particularly successful, and represents a well-documented, significant threat to indigenous invertebrates (Beggs and Rees 1999) and birds (Beggs and Wilson 1991). There are also a number of important insect pests of trees that have become established (Scott 1984; Charles 1998) or are being regularly intercepted at the border (Bain 1977; Keall 1981; Ridley *et al.* 2000). However, it appears that these species primarily attack exotic trees, and that very few of them pose a significant threat to indigenous forests (Ridley *et al.* 2000). Elsewhere, for example in North American forests, the effects of introduced forest insects have been dramatic and the subject of much research (Liebhold *et al.* 1995; Niemelä and Mattson 1996; Wallner 1996). During the last century, the European gypsy moth, *Lymantria dispar* L. (Lepidoptera: Lymantriidae), regularly defoliated millions of hectares of indigenous North American oak forests, which resulted in considerable tree mortality and significant changes in tree species composition of forests (Gottschalk 1990). Instances where introduced pest species have changed the composition of indigenous forests have been discussed

by Smith (1976). Until recently there was no general information on the impact of established exotic phytophagous insects on New Zealand's indigenous forests (Ridley *et al.* 2000).

We are conducting a detailed review of the origin and host range of exotic insects that attack trees and shrubs in New Zealand to increase our understanding of the ecology of herbivorous insect invasions and to determine the potential threat from these species to our indigenous and exotic forests. This article presents the initial results for exotic beetles (Coleoptera) that feed on trees or shrubs.

MATERIALS AND METHODS

Data on exotic beetles attacking trees or shrubs, as well as host plant records were compiled from (i) the Forest Health database maintained by Forest Research, Rotorua, (ii) specimen labels in the National Forest Insect Collection (FRNZ) at Forest Research and (iii) unpublished records of exotic forest pests (J. Bain, unpublished manuscript; R. Zondag, unpublished manuscript). Additional data on established insects and their host plants were obtained from Spiller and Wise (1982), Kuschel (1990) and relevant publications cited therein and in Klimaszewski and Watt (1997). We also consulted several New Zealand entomologists with expertise in this area to verify the completeness of our data. Unfortunately, we were unable to obtain data from the MAF Plant Pest Information Network (PPIN) which maintains a substantial data base on plant pests and their host associations. However, PPIN data cover primarily the agricultural sector and would probably not contribute much additional information about forest pests.

Because of New Zealand's reliance on exotic crop plants, including forestry and ornamental tree and shrub species, plant protection research has tended to focus on exotic rather than indigenous plants (Ridley *et al.* 2000). This could have led to a bias in our data, such that attacks on indigenous plants would be under-represented. However, this potential bias is unlikely to affect the overall results of the study because significant attacks on indigenous plants would probably have been noticed anyway.

RESULTS AND DISCUSSION

There are at least 356 exotic beetle species established in New Zealand (Klimaszewski and Watt 1997). Our survey of beetles that attack parts of trees or shrubs revealed 51 accidentally introduced species and three additional species that have been released as weed biocontrol agents against exotic woody plant pests (Table 1). The latter have been excluded from the analysis because they were intentionally released, and they were subjected to comprehensive host specificity tests prior to release so that attacks on non-target plants would be unexpected. Among the accidental introductions, 12 beetle families are represented, with Curculionidae (24 species, including 10 Scolytinae), Cerambycidae (9 species) and Chrysomelidae (6 species) contributing the most species (Table 1). When classified by feeding guild, wood borers are the largest group, followed by root feeders, bark borers and defoliators (Table 1). This suggests that wood and bark-boring beetles pose a higher invasion risk than external feeders such as defoliators, presumably because the former are easily imported in infested wood products and packaging. However, recent invasion trends (1988-1997) assessing all insect orders show that defoliators and sapsuckers predominate among the species attacking trees or shrubs (Ridley *et al.* 2000). Most introduced beetles are from Australia representing about 58% of the species of known origin, followed by European species (Fig. 1). Thus, it appears that the origin of these exotic beetles reflects the proximity of Australia as well as Australian and European trade relations which traditionally predominated. This could be explained by the resulting high 'propagule pressure' from these areas, which is generally assumed to be one of the correlates of invasion success (Williamson 1996).

The majority of host records for exotic beetles are from exotic plants. The complete list of exotic host plants for all species is beyond the scope of this paper but can be obtained from the authors. There are substantially fewer records of attacks on indigenous trees or shrubs than on exotics, and with few exceptions these species

TABLE 1: Exotic beetles attacking trees or shrubs in New Zealand: the year of their first record in New Zealand and their region of origin.Feeding guild, Species (Family¹, Year, Origin²)

Root feeders

Asynonychus (= *Pantomorus*) *cervinus* (Boheman)³ (Curculionidae, 1937, S.Am.); *Graphognathus leucoloma* (Boheman) (Curculionidae, 1944, S.Am.); *Otiorhynchus ovatus* (L.) (Curculionidae, 1936, Eur.); *Otiorhynchus rugosostriatus* (Goeze) (Curculionidae, 1940, Eur.); *Otiorhynchus sulcatus* (F.) (Curculionidae, 1866, Eur.); *Phlyctinus callosus* Boheman (Curculionidae, 1893, S.Afr.); *Steriphus diversipes lineata* (Pascoe) (Curculionidae, 1925, Aus.); *Heteronychus arator* (F.) (Scarabaeidae, 1937, S.Afr.)

Bark borers

Cryphalus wapleri Eichhoff (Scolytinae, 1946, Aus.); *Hylastes ater* (Paykull) (Scolytinae, 1929, Eur.); *Hylurgus ligniperda* (F.) (Scolytinae, 1974, Eur.); *Phloeosinus cupressi* Hopkins (Scolytinae, 1926, N.Am.); *Scolytus multistriatus* Marsham (Scolytinae, 1989, Eur.)

Wood borers

Anobium punctatum de Geer (Anobiidae, 1875, Eur.); *Derophtinus granicollis* Lea (Anobiidae, 1969, Aus.); *Ernobius mollis* L. (Anobiidae, 1930, Eur.); *Hadrobregmus australiensis* Pic (Anobiidae, 1937, Aus.); *Lyctus brunneus* (Stephens) (Bostrichidae, 1903, N.Am.); *Arhopalus tristis* (Mulsant) (Cerambycidae, 1963, Eur.); *Aridaeus thoracicus* (Donovan) (Cerambycidae, 1954, Aus.); *Bethelium signiferum* (Newman) (Cerambycidae, 1840, Aus.); *Callidiopsis scutellaris* (F.) (Cerambycidae, 1935, Aus.); *Coptocercus rubripes* (Boisduval) (Cerambycidae, 1931, Aus.); *Didymocantha obliqua* Newman (Cerambycidae, 1960, Aus.); *Nathrius brevipennis* (Mulsant) (Cerambycidae, 1993, Eur.); *Phoracantha semipunctata* (F.)⁴ (Cerambycidae, 1873, Aus.); *Tessaromma undatum* Newman (Cerambycidae, 1902, Aus.); *Dryophthorus* sp.⁵ (Curculionidae, 1975, unknown); *Mesites pallidipennis* Boheman (Curculionidae, 1958, Eur.); *Neolaemosaccus narinus* (Pascoe) (Curculionidae, 1939, Aus.); *Pselactus spadix* (Herbst) (Curculionidae, 1886, Eur.); *Stenoscelis hylastoides* Wollaston (Curculionidae, 1941, S.Afr.); *Agrypnus variabilis* (Candèze) (Elateridae, 1870, ?); *Rhyssonotus nebulosus* (Kirby) (Lucanidae, 1950, Aus.); *Syndesus cornutus* (F.) (Lucanidae, 1961, Aus.); *Mordellistena* sp. (Mordellidae, 1981, ?); *Amasa truncatus* (Erichson) (Scolytinae, 1930, Aus.); *Ambrosiodmus compressus* (Lea) (Scolytinae, 1972, Aus.); *Coptodryas eucalyptica* (Schedl) (Scolytinae, 1975, Aus.); *Xyleborinus saxeseni* (Ratzeburg) (Scolytinae, 1963, Eur.); *Xylosandrus solidus* (Eichhoff) (Scolytinae, 1978, Aus.); *Amarygmus* sp. (*A. tristis* sensu Blackburn) (Tenebrionidae, 1956, Aus.)

Defoliators

Dicranosterna semipunctata (Chapuis) (Chrysomelidae, 1996, Aus.); *Ocrosopsis subfasciata* (Saunders) (Chrysomelidae, 1980, Aus.); *Paropsis charybdis* Stal (Chrysomelidae, 1916, Aus.); *Pyrgoides* sp.⁶ (Chrysomelidae, 1976, Aus.); *Trachymela catenata* (Chapuis) (Chrysomelidae, 1992, Aus.); *Trachymela sloanei* (Blackburn) (Chrysomelidae, 1976, Aus.); *Gonipterus scutellatus* Gyllenhal (Curculionidae, 1890, Aus.)

Seed feeders

Araeceris palmaris (Pascoe) (Anthribidae, 1894, Aus.); *Storeus albosignatus* Blackburn (Curculionidae, 1939, Aus.)

Biological control agents

Apion ulicis (Forster) (Apionidae, 1931, Eur., seed feeder on *Ulex europaeus*); *Bruchidius villosus* F. (Chrysomelidae (Bruchidae), 1987, Eur., seed feeder on *Cytisus scoparius*); *Lochmaea suturalis* Thomson (Chrysomelidae, 1996, Eur., defoliator of *Calluna vulgaris*)

¹Scolytidae have recently been included with Curculionidae as the subfamily Scolytinae. To distinguish this taxon from the conventionally separate Curculionidae, we list them here as 'Scolytinae'.

²Aus., Australia; Eur., Europe; N.Am., North America; S.Afr., Southern Africa; S.Am., South America; ?, unknown.

³Larvae of *A. cervinus* are root feeders, adults are defoliators.

⁴*Phoracantha semipunctata* has incorrectly been recorded as *Phoracantha recurva* Newm. (Clark 1938; Spiller and Wise 1982).

⁵This is an undescribed species (May 1993).

⁶This species has only been recorded by Kuschel (1990) and is possibly not established.

FIGURE 1: Origin of exotic beetles attacking trees or shrubs in New Zealand, excluding agents introduced for the biological control of weeds.

attack dead or rotting wood (Table 2). In addition, there are several records of root-feeding species which are generally less host specific, but only for the weevil *Asynonychus cervinus* has attack on indigenous trees been recorded (Table 2). Several *Otiorhynchus* species and *Phlyctinus callosus* (Table 2) probably also attack indigenous trees or shrubs. These weevils are highly polyphagous root feeders that have been recorded from a wide variety of plant taxa, including several exotic trees and shrubs. However, none of the dead-wood borers or root feeders are known to have a significant ecological impact on indigenous plants. Despite this, several of the wood borers have become notable pests in economic terms. For instance, the house borer, *Anobium punctatum* (Table 1), is a serious pest of exotic and indigenous structural timber (Table 2) in residential dwellings (Hosking 1978). A number of other wood and bark boring species also rank highly as quarantine pests, and their presence in export timber frequently requires fumigation of such material (Brockerhoff and Hosking, in press).

The apparent lack of attack on indigenous trees and shrubs by exotic Coleoptera indicated by our data was unexpected since some of our exotic beetles are considered serious pests in New Zealand. For example, *Paropsis charybdis* and *Dicranosterna semipunctata* (Table 1) are known to severely defoliate *Eucalyptus* spp. and *Acacia* spp., respectively, in New Zealand. Repeated defoliation by these species can cause tree mortality (Bain and Kay 1989). The elm bark beetle, *Scolytus multistriatus* (Table 1), poses a significant threat to elms, *Ulmus* spp., because it is one of the vectors of the fungal pathogens, *Ophiostoma ulmi* and *O. novo-ulmi*, which cause the fatal Dutch elm disease (Gadgil *et al.* 2000). These and other highly host-specific beetle species only attack their natural host plants which are exotic trees and shrubs. The host range of each of these beetle species usually consists of a few taxonomically close plant species that have no near relatives among New Zealand's indigenous flora. Thus, our indigenous tree and shrub flora, with its many endemic species, appears not to be at a great risk from exotic beetles. A preliminary analysis of the impact of insects on New Zealand's forests suggests these results also apply to other insect taxa (Ridley *et al.* 2000). Conversely, North American forests are threatened by Eurasian insects because these continents share many plant genera (Niemelä and Mattson 1996). These

TABLE 2: Exotic beetles that have been recorded feeding on indigenous trees or shrubs in New Zealand, and their host range.

Species and family or subfamily	Host range summary	Host species (indigenous species are underlined, for exotic species, only genera are listed)	Source ¹
<i>Anobium punctatum</i> (Anobiidae)	polyphagous wood borer of dead exotics and natives	<i>Dacrycarpus dacrydioides</i> , <i>Dacrydium cupressinum</i> , <i>Crataegus</i> , <i>Cupressus</i> , <i>Cytisus</i> , <i>Eucalyptus</i> , <i>Pinus</i> , <i>Populus</i> , <i>Pseudotsuga</i> , <i>Salix</i> , <i>Sequoiadendron</i>	1, 2
<i>Hadrobregmus australiensis</i> (Anobiidae)	polyphagous wood borer of dead exotics and natives	<i>Metrosideros excelsa</i> , <i>Leucopogon fasciculatus</i> , plywood, <i>Cupressus</i> , <i>Acacia</i> , <i>Pinus</i>	3
<i>Aridaeus thoracicus</i> (Cerambycidae)	oligophagous wood borer of a dead native	<i>Avicennia marina</i> ssp. <i>australasica</i>	2
<i>Mesites pallidipennis</i> (Curculionidae)	polyphagous wood borer of dead exotics and natives	<i>Nothofagus</i> sp., <i>Pinus</i> , marine driftwood	2, 4, 5, 6
<i>Lyctus brunneus</i> (Bostrichidae)	polyphagous wood borer of dead exotics and natives	<i>Beilschmiedia tawa</i> , <i>Knightia excelsa</i> , <i>Nothofagus</i> spp., <i>Bambusae</i> sp., <i>Eucalyptus</i> , <i>Fraxinus</i> , <i>Magnolia</i> , <i>Populus</i> , <i>Quercus</i> , <i>Ulmus</i>	2, 7
<i>Amasa truncatus</i> (Scolytinae)	polyphagous wood borer of dead exotics and natives, also in live eucalypts	Broods found in <i>Kunzea ericoides</i> , <i>Leptospermum scoparium</i> , <i>Knightia excelsa</i> , <i>Metrosideros robusta</i> , <i>Metrosideros excelsa</i> , <i>Weinmannia racemosa</i> , <i>Acacia</i> , <i>Albizia</i> , <i>Eucalyptus</i> . Adults found boring in most of the above spp., also in <i>Prumnopitys taxifolia</i> , <i>Pinus</i> , <i>Pseudotsuga</i> , <i>Vitex</i>	2, 3, 8, 9
<i>Ambrosiodmus compressus</i> (Scolytinae)	polyphagous wood borer of dead or dying exotics and natives	Broods found in <i>Acacia</i> , <i>Chamaecytisus</i> , <i>Eucalyptus</i> , <i>Pinus</i> , <i>Prunus</i> . Adults found boring in <i>Coriaria arborea</i> , <i>Kunzea ericoides</i> , <i>Melicytus ramiflorus</i> , <i>Acacia</i> , <i>Pinus</i> , <i>Pseudotsuga</i>	2, 9, 10
<i>Coptodryas eucalyptica</i> (Scolytinae)	polyphagous wood borer of dead or dying exotics and natives	<i>Melicytus ramiflorus</i> , <i>Corynocarpus laevigatus</i> , <i>Ulmus</i> , <i>Acacia</i> , <i>Ligustrum</i>	2, 10
<i>Amarygmus</i> sp. (<i>A. tristis</i> sensu Blackburn) (Tenebrionidae)	polyphagous borer in decaying tree stumps of exotics and natives	<i>Avicennia marina</i> ssp. <i>australasica</i> , <i>Eucalyptus</i> , <i>Pinus</i>	2, 11
<i>Asynonychus cervinus</i> (Curculionidae)	polyphagous root feeder (larvae) of exotics and natives; defoliator (adults) of exotics	Larvae on roots of <i>Corynocarpus laevigatus</i> , <i>Entelea arborescens</i> , <i>Acacia</i> , <i>Actinidia</i> , <i>Cirsium</i> , <i>Citrus</i> , <i>Clematis</i> , <i>Cytisus</i> , <i>Fuchsia</i> , <i>Pinus</i> , <i>Rosa</i> , <i>Solanum</i> , <i>Talauma</i> , <i>Vinca</i> . Adults defoliate <i>Citrus</i>	2, 4, 5, 12, 13
<i>Otiorhynchus ovatus</i> , <i>O. rugosostriatus</i> , <i>O. sulcatus</i> , <i>Phlyctinus callosus</i> (Curculionidae)	polyphagous root feeders of exotics, probably also of natives	On live roots of numerous species, including some shrub and tree species	2, 4, 5, 6, 12

¹Sources are as follows: 1, Hosking (1978); 2, Forest Research, Forest Health Database; 3, Kuschel (1990); 4, May (1987); 5, May (1993); 6, Kuschel (1972); 7, Bain (1978); 8, Zondag (1977); 9, R. Zondag, unpubl. data; 10, E.G. Brockerhoff, unpubl. data; 11, Watt (1992); 12, Spiller and Wise (1982); 13, Scott (1984).

invasion patterns are consistent with the fact that most phytophagous insects are at least moderately host specific (Jaenicke 1990). Thus, the large impact European or Asian insect pests have had in North America (Liebhold *et al.* 1995; Niemelä and Mattson 1996) may not be expected in New Zealand's indigenous forests. Rather, insect pests from regions with a flora more similar to that of New Zealand, such as Tasmania and Chile, would probably pose a greater threat to New Zealand's forests (see Ridley *et al.* 2000). Nevertheless, some polyphagous Northern Hemisphere insects, such as gypsy moth, might well create havoc in our indigenous forests should they become established.

Exotic crops planted in New Zealand are at a greater biosecurity risk. Our examination showed that among the established beetle species, 21 are primarily associated with the Australian genera *Eucalyptus*, *Acacia* and *Ficus*, and eight are associated with *Pinus*, *Cupressus*, *Salix*, *Ulmus* and related genera. This suggests that the presence of many exotic plant genera, primarily from Australia and the Northern Hemisphere, greatly facilitates the invasion by beetle species associated with plants from these regions. Such exotic trees are likely to be under continued pressure from an ever increasing number of introduced pests despite our biosecurity efforts. However, to detect potential biosecurity threats it is not only essential to maintain vigilant border control and port environs surveillance, but also to monitor our indigenous forests. Because of our reliance on exotic crop species, including forest trees, the surveillance of indigenous forest trees and shrubs for insect pests is currently limited (Ridley *et al.* 2000) and new insect pests might go unnoticed for some time. This is exacerbated by our limited knowledge of indigenous insects. Even for beetles, only about 5,000 of the estimated 10,000 species in New Zealand (Kuschel 1990) have been described. Nevertheless, in most cases it should be possible to determine whether a new forest insect pest is indigenous or exotic.

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