BIOSECURITY AND APHIDS IN NEW ZEALAND

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ABSTRACT

About 110 introduced aphid species (Hemiptera: Aphididae) have been recorded in New Zealand. Only 12 indigenous species have been recorded. On average there has been about one new aphid incursion into New Zealand per year over the last 130 years although this rate has declined dramatically in recent years. The origins of introduced aphids appear to include most parts of the globe. Many introduced aphids damage economically important plants through their feeding and transmitting plant viruses. Less quantifiable environmental impacts include injury to native plants and the displacement of native aphids on their host plants. Aspects of aphid biology, such as small size, parthenogenetic reproduction, high reproductive rates, short generation time, rapid dispersal and eruptive population dynamics, pose particularly difficult challenges for aphid biosecurity in New Zealand.

Keywords: aphids, biosecurity, economic impact, pathways to entry.

INTRODUCTION

Aphids (Hemiptera: Aphididae) are small insects (1.5 – 3.5 mm long) closely related to the adelgids and phylloxerids. They have complex life histories that often include different morphs, such as winged forms for dispersal. They reproduce both sexually and asexually, sometimes producing eggs for overwintering but otherwise laying live young. They have telescoping generations and high reproductive rates (Blackman & Eastop 2000). Aphids are major pests of temperate agricultural and horticultural crops and forest trees, causing damage either directly by feeding or indirectly by transmitting plant viruses (Minks & Harrewijn 1989). The Aphididae is predominantly a northern temperate group, richest in species in North America, Europe and Central and East Asia (Blackman & Eastop 2000), with about 4700 species in 599 genera (Remaudière & Remaudière 1997). Aphid genera and species are considered to be under-represented in the tropics and southern hemisphere, including New Zealand, compared to the northern hemisphere (Heie 1994).

Currently, there are about 120 aphid species in New Zealand (D.A.J. Teulon, unpubl. data). Although most of these have been introduced, and many of them are pests, there remain many more species that pose a biosecurity threat to New Zealand. In their monographs of world aphid species, Blackman & Eastop (1994; 2000) list 1758 aphids on trees and 445 aphids on crops (there is some overlap in these publications), most of which are not found in New Zealand. Teulon et al. (1999) listed about 70 species not found in New Zealand but considered to be of biosecurity significance based on their present distribution and economic status, their likelihood of causing economic damage in New Zealand and their present rate of movement throughout the world.

Although the number of introduced aphids establishing in New Zealand has reduced dramatically over the last 10 years, the recent introductions of the Monterey pine aphid (*Essigella californica*) and the lettuce aphid (*Nasonovia ribis-nigri*) emphasise that these insects are still an important biosecurity concern for New Zealand. This review quantifies the aphid invasion of New Zealand, summarises its impact and examines the pathways to entry and establishment of introduced aphid species. In this paper aphid common names, according to Blackman & Eastop (2000), are used in preference to scientific names.

New Zealand Plant Protection 55:12-17 (2002)

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THE APHID INVASION

One of the most obvious characteristics of the New Zealand aphid fauna is that most species are introduced. About 90% of the approximately 120 species of aphids in New Zealand are not indigenous including all the recognised pest species. A similar proportion of non-endemic species has been recorded from Australia (Carver et al.1991). Figure 1 illustrates the number of 'first records' for each decade for introduced aphids in New Zealand. While the first record may not be equivalent to the date of the first introduction (e.g. some cryptic species may not have been recognised immediately), it does indicate the rate of aphid invasion. On average there has been close to one aphid introduction per year since 1860. Since 1990 this rate has reduced dramatically.

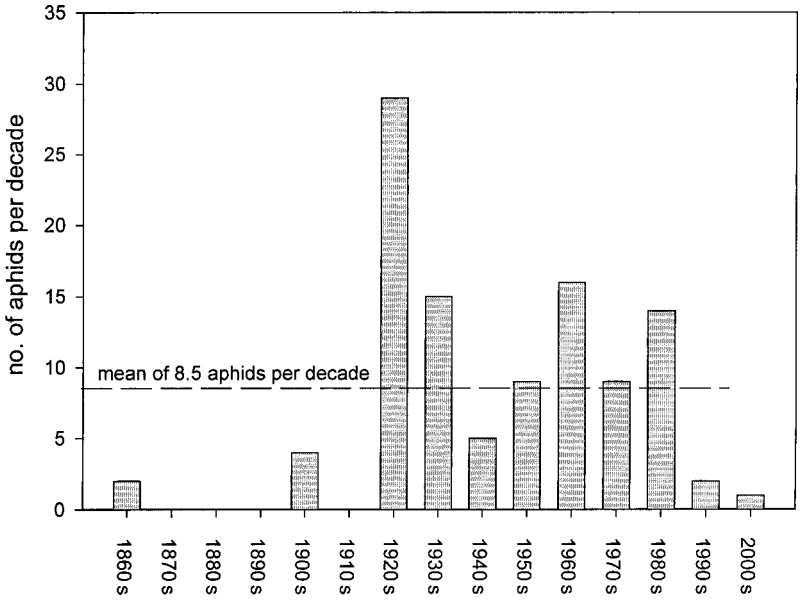

FIGURE 1: Number of introduced aphids in New Zealand by decade since 1860. Dates are established from first collections from various sources. Of the 110 aphid species, dates could not be found for five species.

The 110 or so introduced aphids constitute a significant proportion of the 2600 exotic insect species estimated to be in New Zealand (Emberson 2000). Their importance is increased by the fact that many of these species are economic pests (see below). Furthermore, in terms of the ratio between introduced and indigenous species (110/12) the aphids probably represent one of the most invasive insect species in New Zealand.

ECONOMIC IMPORTANCE

Aphids are the major pests of temperate agriculture throughout the world. In New Zealand many are important pests of arable, vegetable, fruit and ornamental plants as well as forest trees (Lowe 1973; Scott 1984). Of the 110 introduced species in New Zealand, 90 are listed in Blackman & Eastop (1994, 2000) as actual or potential pests of trees and crops. Scott (1984) listed 31 aphids as pests on various plants in New Zealand, while 16 aphid species have been reported in the index of the proceedings of this conference,

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from1948 to 1997, and in abstracts since then. Many more species are mentioned within the manuscripts themselves. Forty-one introduced aphids in New Zealand have been reported to transmit at least one plant virus with some species being able to transmit a considerable number (e.g. melon aphid (*Aphis gossypii*): 50 different viruses; green peach aphid (*Myzus persicae*): 100 different viruses) (Blackman & Eastop 2000).

The following examples indicate the extent of economic loss associated with introduced aphids in New Zealand. Grundy (1989) estimated that the rose grain aphid (*Metopolophium dirhodum*) and barley yellow dwarf virus (BYDV) contributed to about $5-6 million/year of yield loss (in 1988 dollars) in all cereal crops. In winter wheat in Canterbury, Bicknell & Greer (1999) estimated that the cereal aphid (*Rhopalosiphum padi*) and BYDV resulted in an annual loss of over $3.7 million (in 1999 dollars), with up to a $10 million loss in a year of severe outbreak. Wine production in New Zealand would be very difficult without rootstocks resistant to the grape phylloxera (Scott 1984). The spruce aphid (*Elatobium abietinum*) is one of the main factors preventing spruce cultivation in New Zealand (Zondag 1983). Control of aphid transmitted viruses is one of the principal reasons for the existence of the increasingly valuable potato seed industry in New Zealand, which produces 27,000 tonnes annually (L. Hickman, pers. comm.). The recent introduction of the lettuce aphid into New Zealand has incurred economic losses of over $200 000 in about two months (Stufkens et al. 2002). As these examples show, significant economic losses are associated with introduced aphids and it is therefore imperative that future introductions are minimised.

ENVIRONMENTAL IMPACTS

While the impact of introduced aphids in the productive sectors is evident, their impact on natural systems is not well documented and certainly not quantified. Some introduced aphids are known to infest indigenous plant species (e.g. Cottier 1953), but there have been few reports of damage. Nevertheless, we have seen large populations of introduced aphids (and sometimes plant damage) on a number of native plants including up to five aphid species on *Aciphylla*, melon aphid on *Myoporum*, leaf curling plum aphid (*Brachycaudus helichrysi*) on *Ozothamnus*, and green peach aphid and potato aphid (*Macrosiphum euphorbiae*) on *Parsonsia*. Introduced aphids may also spread viruses to native plants. Davis & Guy (2001) have implicated introduced cereal and grass inhabiting aphids in the transmission of the introduced barley yellow dwarf and cereal yellow dwarf viruses to native grasses. The impact of the viruses on these plants is unknown (Davis & Guy 2001). Another concern is the displacement of indigenous aphids by introduced aphids. The introduced *Aphis* nr *epilobii* is relatively common on native *Epilobium* but the indigenous *Aphis nelsonensis* has not been seen on this plant since 1965 (M.A.W. Stufkens, unpubl. data).

A related concern is the impact of biological control agents intentionally introduced to control introduced pest aphid species. At least one aphid parasitoid, *Aphidius ervi*, has been implicated in attacking indigenous aphids (Carver 2000) and we are currently investigating other instances.

PATHWAYS TO ENTRY

Aphids are capable of reproducing parthenogenetically (without sex) so there is no requirement for females to find males to produce viable offspring. The disproportionate number of introduced aphids in New Zealand that do not reproduce sexually (e.g. foxglove aphid (*Aulacorthum solani*) and potato aphid) (Cottier 1953; Lowe 1973) suggests that parthenogenetic clones (adults or nymphs) were the initial colonists for some species in this country. However, it may also reflect the absence of primary hosts in New Zealand. For example, the primary hosts of cereal aphid (also known as bird cherry oat aphid) are *Prunus padus* and *P. virginiana*. Nevertheless, eggs are also a suitable life stage for colonisation because their relatively long dormancy would allow them to survive long periods without sustenance.

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There appear to be two main pathways for the entry of introduced aphids: firstly as passengers on plants and produce and secondly by wind. A significant number of aphid species are thought to have entered New Zealand on plant material, especially during early European colonisation (Lowe 1973). These could have been as adults, nymphs and/or eggs. Winged adult aphids are apparently capable of flying or being blown across the Tasman Sea from Australia (Close & Tomlinson 1975), and Lowe (1973) suggested that some species may have arrived here in a similar manner from even further afield. The relative importance of these two pathways has important implications for biosecurity. If aphid invasion is primarily by air then it is very difficult to keep these, and organisms with a similar biology, such as thrips, out of this country. Once they are established, other aspects of the biology of aphids make them very difficult to contain and eradicate (see below).

New Zealand has many cosmopolitan aphid species (e.g. cabbage aphid (*Brevicoryne brassicae*), cereal aphid and woolly apple aphid (*Eriosoma lanigerum*)) which could have arrived from a number of different places. Some species have a clear European origin (e.g. large blackberry aphid (*Amphorophora rubi*) and small European raspberry aphid (*Aphis idaei*)), while others are likely to have come from North America (e.g. apple grass aphid and *Thripsaphis foxtonensis*). The proximity to Australia makes it a likely origin for invasive species. Several aphids were found in New Zealand within one year of their first appearance in Australia (blue-green lucerne aphid (*Acyrthosiphon kondoi*), Cameron & Walker 1989). Other aphids appear to have taken longer to arrive from Australia, e.g. fescue aphid (*Metopolophium festucae*). Conversely, New Zealand may have been the source for some aphid introductions into Australia (e.g. pea aphid (*Acyrthosiphon pisum*) and rose grain aphid). Furthermore, a number of aphids have Asian origins (e.g. *Sitobion miscanthi* and *Micromyzus* nr *katoi*). It is difficult to determine the origin of the most recent introductions. The Monterey pine aphid was found in New Zealand and Australia at much the same time. It is native to California but has recently been found in Europe. The lettuce aphid has not yet been found in Australia but is otherwise widely spread throughout the world.

A cursory examination of the possible points of entry for recent aphid introductions (since 1981) shows a bimodal distribution between Auckland and Canterbury. This is a probable reflection of the presence of aphid researchers in Auckland city and Lincoln. It is interesting to note that up to 50% of new records since 1981 have been found in the Lincoln suction trap which has been operating continuously over this period (D.A.J. Teulon, unpubl. data).

NATURE OF INTRODUCTIONS

By the time a new pest aphid species has been discovered in New Zealand it is usually well established. Soon after the initial detection of Monterey pine aphid it was found to be distributed over much of the North Island (A. Flynn, pers. comm.). Similarly, the lettuce aphid was already distributed widely around Christchurch when it was first identified in 2002 (Stufkens et al. 2002). Both the blue-green lucerne aphid and the pea aphid spread through most of New Zealand in less than one year (Cameron & Walker 1989). The rapid establishment and geographical expansion of aphid populations is probably a reflection of the aphid's small size, its ability to reproduce without mating, its large number of offspring and short generation time, and the ability of winged forms to fly or be blown large distances. Consequently, we know of no attempts to eradicate any aphid species after its accidental introduction in any country.

Another interesting and potentially significant feature of aphid invasions is the relatively high population levels reached early in their colonisation followed by a decline to relatively static lower levels. Barlow & Goldson (2002) described this phenomenon for blue-green lucerne aphid. They attributed the decline in blue-green lucerne aphid densities to a reduction in crop area and the use of aphid resistance cultivars. In Figure 2, Lincoln suction trap catches for rose grain aphid and Monterey pine aphid are illustrated. Data from Monterey pine aphid and the Courtenay suction trap have also been included because this trap is sited close to the Eyrewell forest where its host plant, *Pinus radiata*, is found. These species also show very high initial population densities followed by a sudden decline. Farrell & Stufkens

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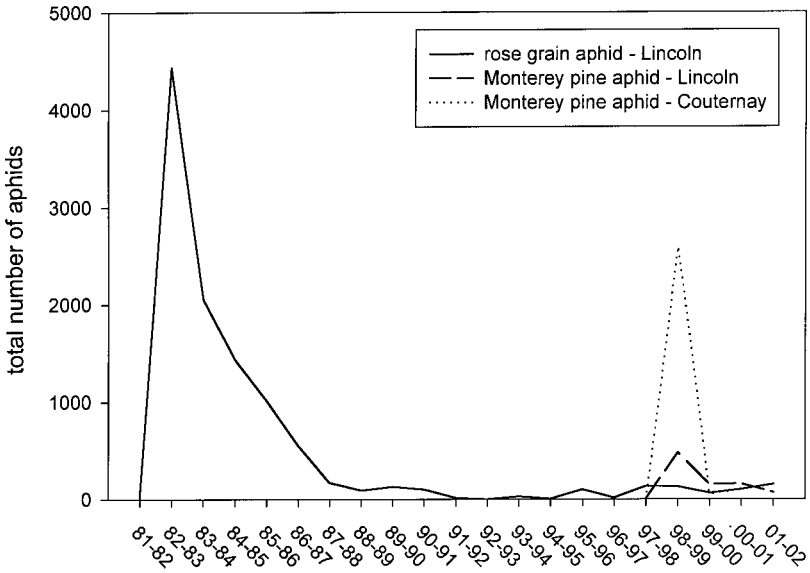

FIGURE 2: Total number of rose grain and Monterey pine aphids caught in the Lincoln suction trap (July to June year) and Monterey pine aphids caught in the Courtenay suction trap (January, February and March only).

(1990) attributed the decline in rose-grain aphid numbers to the introduction of a parasitoid. However, we know of no similar factor that would have caused the decline in Monterey pine aphid numbers. The reasons for these high population densities need to be examined as they facilitate the establishment and spread of aphid colonists in New Zealand.

SUMMARY

Aphids are one of the more invasive insect groups in New Zealand in terms of the total number established. The numbers of introduced species relative to the numbers of indigenous fauna is a cause for concern. Aphids have a significant economic impact on arable, vegetable, fruit and ornamental crops and forest trees and unquantified impacts on natural systems. The origins of introduced aphids appear to vary widely. Aspects of their biology, such as their small size, parthenogenetic reproduction, high reproductive rate, short generation time, rapid dispersal and eruptive population dynamics pose particularly difficult challenges for biosecurity in New Zealand.

ACKNOWLEDGEMENTS

We acknowledge Dr Victor Eastop, Natural History Museum, London, as a valuable source of information on New Zealand aphids.

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