Proceedings of the X International Symposium on Biological Control of Weeds
4-14 July 1999, Montana State University, Bozeman, Montana, USA
Neal R. Spencer [ed.]. pp. 875-880 (2000)

Endemic Biodiversity, Natural Enemies, and the Future of Biological Control

ROWAN M. EMBERSON

Ecology and Entomology Group, Soil, Plant and Ecological Sciences Division,
P.O. Box 84, Lincoln University, New Zealand

Abstract

In recent public comment on proposed introductions for biological control of weeds in New Zealand, the issues of dilution of endemic biodiversity and homogenization of the fauna, have been raised as a reason for not introducing biological control agents. Although the impact of biological contol agents can be shown to be minimal in this process, the issue of homogenization appears to be gaining currency with government agencies and regulators. The main current causes of homogenization of the fauna and flora in New Zealand, and probably in most other countries, come from the purposeful introduction of plants for horticultural and other purposes, often with minimal assessment of their weediness, followed by their subsequent naturalization, and the accidental introductions of insects and other invertebrates. In New Zealand, naturalized alien plant species already outnumber native species and adventive insects are estimated to comprise 13% of the insect fauna. Only about 2.5% of all exotic insects have been introduced for biological control purposes. Up to the present, 20 carefully screened, host specific, species of insects have been established for biological control of weeds. These represent less than 1% of the exotic insect fauna. Recent developments in the regulatory environment outside New Zealand, suggest that the issue of global homogenization of the fauna and flora is also being considered in other jurisdictions, and has the potential to place severe limitations on the practice of classical biological control, even though the contribution of biological control agents to the process is almost negligible in most places.

Keywords: endemic biodiversity, faunal homogenization, exotic insects, New Zealand

New Zealand has a long history of biological control attempts, dating back to the late 19th century.

Many programs were aimed at biological control of vertebrates, insects and other arthropods, and weeds (Cameron *et al.* 1989). Partly as a consequence of the serious non-target, though predicted, impact of mustelids (Buller 1877), which were introduced for rabbit control, on native birdlife (King 1984), New Zealand now has extremely stringent regulations governing the introduction of biological control agents. The current regulations are administered by the Environmental Risk Management Authority (ERMA). These regulations involve preparation of a detailed proposal, public notification, extensive written comment from government agencies and other interest groups, and the possibility, if requested, of public hearings. All ERMA's costs, including those of public hearings, are borne by the proposer of the introduction.

As various interest groups have gained more experience, the focus of comment on

proposed weed biological control introductions has tended to shift from direct impacts, such as conflicts of interest and host specificity, though these still attract comment, to more indirect ecosystem impacts. For example, the possibility of providing alternate hosts for parasitoids of native insects and thus potentially affecting the populations of these insects, or, the likelihood of competion with native insects for nectar by adults of lepidopteran biological control agents. Impacts like these, though generally thought to be minor, are extremely difficult to predict with any reliability.

One novel issue that has been raised in comment on several recent proposals is the impact on the integrity of endemic biodiversity by dilution of the indigenous insect fauna with exotic species released for biological weed control. Examples of comments received on an Importation Impact Assessment for the proposed introduction of *Oxyptilus piloselllae* Zeller (Lepidoptera: Pterophoridae) for biological control of hawkweed, *Hieracium pilosella* L. (Asteraceae) (Syrett et al.1997) are:

"My concern stems from the need for overall caution over the importation of a **limitless number of alien species**, which have the potential to displace endemic New Zealand species…."

"The addition of **untold new alien species** can only be detrimental to the long term goal of preserving our endemic diversity …"

"It may be better environmental management to put up with the status quo than to **deliberately flood** New Zealand with more alien insects."

(my bolding)

These comments were made on a proposal to import the first of five insects that had been identified as highly host specific and damaging to *H. pilosella*, following a study that had shown there was only very minor insect herbivory by generalist insects on the plant in New Zealand (Syrett and Smith 1998). *Hieracium pilosella* has become one of the most prominent plants in many drier grasslands, in both the North and South Islands of New Zealand (Treskonova 1991), and has the ability to severely reduce the pastoral and conservation values of these communities.

There are signs that similar reservations towards biological control are becoming apparent in other jurisdictions, e.g. the proposal to control tamarisk, or salt cedar, in the South Western United States (DeLoach *et al.* 1996). In these cases there seems to be a reluctance to accept the long term serious impact that invasive weeds may have on whole ecosystems.

If allowed to pass unchallenged, assertions such as those mentioned have the potential to threaten the continued practice of biological control, which ironically, in many situations is the best, and least environmentally damaging currently available, means of safeguarding the integrity of biodiversity in habitats vulnerable to invasive plants.

In New Zealand at least, these issues are also based on a lack of understanding of the make up of the flora and fauna, but nevertheless seem to be gaining support with commentators and possibly with regulators. This paper provides an analysis of the size of the adventive vascular plant flora and insect fauna in New Zealand and discusses the implications of the analysis for weed biological control.

The New Zealand Flora and Fauna

New Zealand's early separation from Australia in the late Cretaceous (Stevens 1990) and its isolation, 1,400 km from the nearest landmass, has resulted in the evolution of a highly endemic flora and fauna. This was first disturbed when New Zealand was settled

Table 1.
Numbers of vascular plant species in New Zealand, April 1999

Category	No. of plant species
Native	449
Endemic	1,627
Extinct	2
Total indigenous	2,079
Naturalised	1,796
Casual with very small wild populations	313
Total adventive	2,109
Only in cultivation	22,257

Source: All New Zealand species database, CHR Herbarium, Landcare Research, Lincoln, New Zealand

by Polynesians about 7-800 years ago (Holdaway 1999) and more particularly by Europeans in the mid 19th century. After a period of trying to make New Zealand look like a part of Europe in the South Pacific, by introducing European plants, birds, and mammals (McDowell 1994), New Zealanders have increasingly come to value the indigenous flora and fauna. The reality is, however, that there are now more introduced vascular plants with more or less self sustaining populations in the wild than there are indigenous species (Landcare Research Herbarium 1999) (Table 1), and a significant number of these are weeds or have become invasive.

The situation with the insect fauna is less clear. The most recent estimate of the size of the New Zealand insect fauna suggested a total fauna of around 20,000 species (Emberson 1998), though other estimates have ranged as high as 40,000 (i.e., Kuschel 1990). The only recent estimate of the number of adventive insect species in New Zealand suggested 1,000 or 1,100 species (Taylor and Smith 1997). This estimate seems far too low based on three recent studies of different parts of the fauna:

Kuschel (1990), in a study of the coleopteran fauna of about 40 ha of secondary forest, as well as fields, sea shore and gardens in the Auckland suburb of Lynfield, distinguished nearly 1,000 beetle species, of which 229 species were judged to be exotic.

There are believed to be about 100 species of exotic aphids in New Zealand (Teulon pers. comm.).

At least 56 species of exotic thrips have been recorded from New Zealand, out of a total fauna of 119 species (Mound and Walker 1982, 1986).

It would be surprising if these 380+ adventive species, from three strongly circumscribed groups, constituted a third of all exotic insects in New Zealand.

Methodology similar to that used by Emberson (1998) to estimate the size of the New Zealand insect fauna can also be used to estimate the number of adventive species. Since 1982, 28 species-level revisions of taxonomically defined groups of New Zealand insects have been published in the series *Fauna of New Zealand*. These have treated 1,071

species, or about 5% of the estimated insect fauna. Of the species treated, 138 or 13% were considered exotic. If these revisions treat a more or less random sample of the insect fauna, then the proportion of exotic species in the total fauna should be similar to that in the sample. This would imply that an exotic fauna of 2,600 species has established, mostly since European colonisation.

Taking this number, it is possible to put biological control introductions into some sort of perspective. Until the end of 1991, 221 natural enemies for biological control had been released in New Zealand (Cameron et al. 1993). Most were introduced for what, by today's standards, would be ill-considered attempts to control two indigenous pasture pests, *Costelytra zealandica* (White) (Coleoptera: Scarabaeidae), an endemic white grub, and several species of *Wiseana* Viette (Lepidoptera: Hepialidae), the tunnel-dwelling, leaf-feeding caterpillars of endemic ghost moths. Perhaps fortunately, this particular program was almost entirely unsuccessful. Only 71 of these 221 introductions of natural enemies have established, 65 of these are insects.

This means that about 2.5% of exotic insects and 0.35% of the total New Zealand insect fauna is the result of biological control introductions. Or conversely, allowing for a eight species of deliberately introduced bees and one dung beetle, 97% of all exotic insect species in New Zealand are the result of entirely accidental, unscreened introductions and recent natural establishment.

Introductions of biological control agents of insect pests in New Zealand have slowed to a trickle, as regulations have tightened. This has been mainly due to problems of demonstrating host specificity. There have been no new introductions for six years, though at least one major project, with several possible introductions, is under consideration.

Introductions for weed biological control have continued during the past decade at the rate of 0 to 3 introductions per year (mean of 1.25 per year for the 1990's). These introductions have been permitted largely because there are established procedures for demonstrating host specificity (Wapshere 1974, 1975). Further introductions may be jeopardised, however, by the regulatory costs and by ill-conceived concerns about the threat to the integrity of endemic biodiversity by dilution with weed biological control agents. Though accepting the need for a parsimonious approach to biological weed control, in which the minimum number of agents are introduced to successfully control the weed, it is necessary to put the situation into perspective (Table 2).

Table 2.
Numbers of insect species released for biological weed control in New Zealand.

Category	No. of species
Total insect agents released	33
Agents did not establish	4
Agents recently introduced, outcome uncertain	9
Agents established	20

If all nine recently introduced species established, it would make a total of 29 established, alien insect species, introduced for biological control of weeds, over the last 72 years. This would still represent only 1.1% of the adventive insect fauna of New Zealand and little more than 0.1% of the total insect fauna, hardly a significant contribution to dilution of endemic insect biodiversity.

It should also be remembered that these introductions are carefully screened monophages or restricted oligophages, targeted at invasive problem weeds. In contrast many of the accidentally introduced species are generalists with a wide host range and include a number of very destructive social wasps and ants. Some of these accidental introductions, besides causing massive economic losses, also have direct impacts on indigenous biodiversity of insects and other organisms (Beggs and Wilson 1991, Harris and Oliver 1993).

One of the ironies of the whole debate on preservation of endemic biodiversity has been the relative ease with which new plant species could be introduced to New Zealand and many other countries. Yet it is well known from historical data and recent studies (Lonsdale 1994) that a proportion of these introductions will almost certainly become invasive weeds, with the potential to disrupt whole ecosystems. This easy introduction for plant species contrasts with the difficulty and cost of introducing carefully targeted biological control agents for those same plants when they become weeds.

The exotic flora is almost certainly having a massive, though largely unmeasured, impact on indigenous insect biodiversity. Dr E. G. White (personal communication) has measured an actively decreasing diversity of lepidopteran species, at a landscape scale, in the pastoral areas most heavily infested with *H. pilosella*, across the Mackenzie Basin in the inland South Island. Very few other studies, on a landscape scale, have attempted to measure the impacts of weeds on insect biodiversity, but it is very hard to believe that large scale, dense infestations of invasive weeds do not have an impact on indigenous insect biodiversity. Biological control is usually the only sustainable option for amelioration in such situations.

One of the benefits of ERMA is that for the first time all introductions of new organisms, plants, animals, and fungi into New Zealand will be on a more or less equal footing. It is notable that proposed introductions of new species of vascular plants for the nursery trade have almost halted.

Conclusions

Insect introductions of biological control agents are insignificant in diluting indigenous biodiversity.

Instead preservation of the integrity of indigenous biodiversity requires a focus on new plant species and accidental insect introductions.

An inbalance has existed between the costs of introducing new plant species and the biocontrol agents needed to suppress those plants that become invasive.

Acknowledgments

John Marris, Eric Scott, and Pauline Syrett have all read earlier versions of this manuscript, I am very grateful for their constructive critiscism.

References

Beggs, J.R., and P.R. Wilson. 1991. The kaka (*Nestor meridionalis*), a New Zealand parrot

endangered by introduced wasps and mammals. Biol. Conserv. 56: 23-38.

Buller, W.L. 1877. On the proposed introduction of the polecat into New Zealand. Trans. Proc. N. Z. Inst. 9: 634-635.

Cameron, P.J., R.L. Hill, J. Bain, and W.P. Thomas [eds.]. 1989. A Review of Biological Control of Invertebrate Pests and Weeds in New Zealand 1874 to 1987. CAB International, Wallingford, United Kingdom.

Cameron, P.J., R.L. Hill, J. Bain, and W.P. Thomas. 1993. Analysis of importations for biological control of insect pests and weeds in New Zealand. Biocontr. Sci. Tech. 3: 387-404.

DeLoach, C.J., D. Gerling, L. Fornasari, R. Sobhian, S. Myartseva, I.D. Mityaev, Q.G. Lu, J.L. Tracy, R. Wang, J.F. Wang, A. Kirk, R.W. Pemberton, V. Chikatunov, R.V. Jashenko, J.E. Johnson, H. Zheng, S.L. Jiang, M.T. Liu, A.P. Liu, and J. Cisneroz. 1996. Biological control programme against saltcedar (*Tamarix* spp.) in the United States of America: progress and problems, pp. 253-260. *In* V. C. Moran and J. H. Hoffmann [eds.], Proceedings of the IX International Symposium on Biological Control of Weeds, Stellenbosch, South Africa, 19-26 January 1996.

Emberson, R.M. 1998. The size and shape of the New Zealand insect fauna, pp. 31-37. *In* Ecosystems, Entomology and Plants, The Royal Society of New Zealand, misc. ser. 48: 1-160.

Harris, R.J., and E.H. Oliver. 1993. Prey diets and population densities of the wasps *Vespula vulgaris* and *V. germanica* in scrubland-pasture. N. Z. J. Ecol. 17: 5-12.

Holdaway, R. 1999. A spatio-temporal model for the invasion of the New Zealand archipelago by the Pacific rat *Rattus exulans.* J. Roy. Soc. N. Z. 29: 91-105.

King, C.M. 1984. Immigrant Killers. Introduced Predators and the Conservation of Birds in New Zealand. Oxford University Press, Auckland, New Zealand.

Kuschel, G. 1990. Beetles in a suburban environment: a New Zealand case study. DSIR Plant Protection Report 3: 1-118.

Lonsdale, M. 1994. Inviting trouble: introduced pasture plants in Northern Australia. Austral. J. Ecol. 19: 345-354.

McDowell, R.M. 1994. Gamekeepers for the nation: the story of New Zealand's acclimatization societies, 1861-1990. Canterbury University Press, Christchurch, New Zealand.

Mound, L.A., and A.K. Walker. 1982. Terebrantia (Insecta: Thysanoptera). Fauna N. Z.. 1: 1-113.

Mound, L.A., and A.K. Walker. 1986. Tubulifera (Insecta: Thysanoptera). Fauna N. Z. 10: 1-140.

Stevens, G. 1990. Geological evolution and biotic links in the Mesozoic and Cenozoic of the Southwest Pacific. Acta XX Congr. Internat. Ornith. 1:361-382.

Syrett, P., L.A. Smith, and G. Grosskopf. 1997. Introduction of *Oxyptilus pilosellae* (Lepidoptera: Pterophoridae) into New Zealand. Unpublished Importation Impact Assessment, prepared for The Hieracium Control Trust, by Landcare Research, Lincoln, New Zealand. 32 pp.

Syrett, P., and L.A. Smith. 1998. The insect fauna of four weedy *Hieracium* (Asteraceae) species in New Zealand. N. Z. J. Zool. 25: 73-83.

Taylor, R., and I. Smith. 1997. The State of New Zealand's Environment. The Ministry for the Environment, Wellington, New Zealand.

Treskonova, M. 1991. Changes in the structure of tall tussock grasslands and infestation by species of *Hieracium* in the Mackenzie country, New Zealand. N. Z. J. Ecol. 15: 65-78.

Wapshere, A.J. 1974. A strategy for evaluating the safety of organisms for biological weed control. Ann. Appl. Biol. 77: 201-211.

Wapshere, A.J. 1975. A protocol for programmes for biological control of weeds. PANS 21: 295-303.