REVIEWS

Biological control of St John's wort (*Hypericum perforatum*) in New Zealand: a review

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Summary

Three insect species, *Chrysolina hyperici*, *C. quadrigemina* and *Zeuxidiplosis giardi* were introduced into New Zealand for the biological control of St John's wort, *Hypericum perforatum*. The introduction, establishment and current status of these insects are reviewed. Both *C. hyperici* and *Z. giardi* established well, but *C. quadrigemina*, the most successful species overseas, has not adapted to New Zealand conditions. In some areas, St John's wort has been reduced significantly by a combination of *C. hyperici* and pasture improvement.

Introduction

St John's wort, *Hypericum perforatum* L. (Guttiferae), has a wide natural distribution, extending from the British Isles, throughout Europe to North Africa and north-west Asia (Clapham *et al.* 1962). The plant occurs in a wide range of habitats, but particularly on open, stony or disturbed ground. The only consistently unsuitable habitats appear to be dense shade or very wet soils (Johansson 1962). However, in spite of apparent tolerance of St John's wort to a wide variety of environmental conditions, the plant is rarely, if ever, accorded weed status in its natural habitat (Wilson 1943; Pritchard 1960). But, as with many other plants (e.g. see Salisbury 1961), St John's wort has become a weed after establishment in new environments outside its home range. In some situations — notably California and parts of Australia — it is a weed problem of major significance on uncultivated, extensively grazed rangelands where the use of herbicides or intensive pasture management is either impractical or uneconomical.

The leaves and flowers of St John's wort contain a photodynamic pigment, known as hypericin, which causes a photosensitization disease (hypericism) in sheep and cattle that have fed on the plant. Affected animals display oedema of the ears, face and muzzle, and subsequent mummification of the skin. Scabs and sores result from animals rubbing affected areas; sheep may lose wool and cattle, hair. In addition, photosensitized stock may show a hypersensitivity to water i.e. violent convulsions and muscle spasms followed by stiffening and immobilization occur when animals are dipped or driven across streams (Simmonds 1967; Connor 1977).

The first New Zealand record of St John's wort was from Great Barrier Island in 1869 and the earliest South Island record was of a garden escape in the Dunedin Field Club Catalogue of 1896 (Jessep 1970). St John's wort produces many small seeds which become sticky when wet. It thus seems reasonable to expect that seed would have spread by stock movements, shipments of hay, chaff and seeds, on vehicles and agricultural implements, and possibly by water and wind. Whatever the method, spread in New Zealand was certainly rapid and, by 1943, Miller (1944) described St John's wort as a 'widely distributed noxious weed in low rainfall areas, causing considerable concern to farmers'.

New Zealand insect introduction

1. **Chrysolina hyperici** *(Forster) (Coleoptera: Chrysomelidae)*

In December 1943, 30 000 adults of a leaf-feeding beetle *C. hyperici* were imported from Australia for control of St John's wort (Miller 1970). This insect was chosen for an entirely pragmatic reason: it was the only species to have reached a sufficiently large population for collection and redistribution. The insects were all released in the Awatere Valley, Marlborough, after 1 day in quarantine at the Cawthron Institute, Nelson. Extensive starvation tests using *C. hyperici* had been conducted in Britain and Australia (Currie and Garthside 1932) and 13 years of Australian experience had confirmed its host specificity.

The initial release proved extremely successful. *C. hyperici* readily established and by December 1946 its population was sufficiently large for collection and redistribution to Cromwell and Arrowtown in Otago. By December 1947, over 180 ha of densely infested country in the Awatere Valley had been cleared of St John's wort. From 1947 to 1950, *C. hyperici* was distributed to a large number of locations throughout New Zealand (Figure 1), although it should be noted that most of the North Island releases were intended for control of a related weed, tutsan (*Hypericum androsaemum* L.). Figure 1 may be incomplete because local redistribution of populations was often carried out by the (then) Department of Agriculture and probably by enthusiastic farmers.

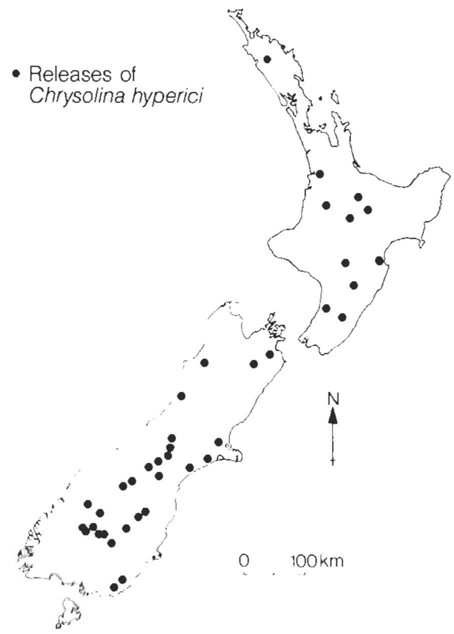

Figure 1 Release sites of the St John's wort beetle, *Chrysolina hyperici*, 1943–50.

2. **Chrysolina quadrigemina** *(Suffrian)*

A second leaf-feeding beetle, *C. quadrigemina*, was introduced from Australia in 1963. It is the more successful

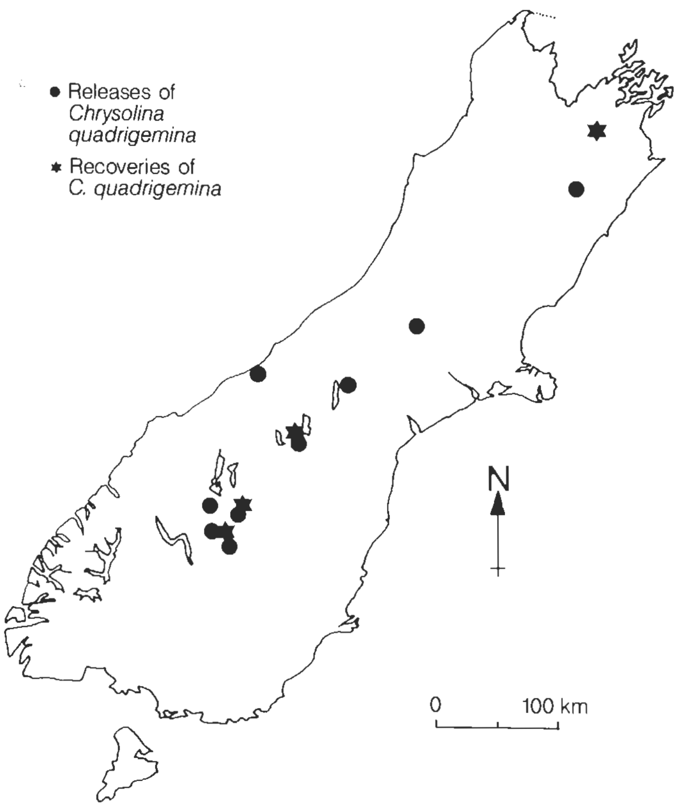

Figure 2 Release sites of the St John's wort beetle, *Chrysolina quadrigemina*, 1965–68. Recovery sites (1977–84) are also indicated.

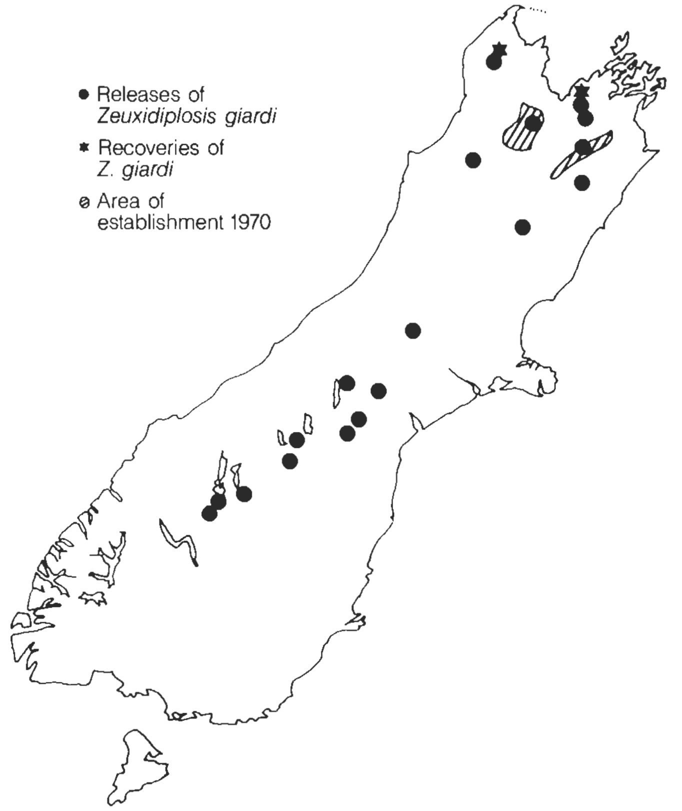

Figure 3 Release sites of St John's wort gall midge *Zeuxidiplosis giardi*, 1963–76. Hatching indicates area of establishment in 1970. Recovery sites (1984) are also indicated.

of the two *Chrysolina* spp. in both Australia and California (Huffaker 1967; Delfosse and Cullen 1982). Over 100 000 beetles were released (Figure 2) between 1963 and 1968, but few recoveries have been made. Four males were identified from beetles collected at Ben Ohau in 1977, and in 1984 beetles were recovered from Central Otago and Marlborough (Fraser and Emberson, in press).

3. Zeuxidiplosis giardi *Kieffer* (*Diptera: Cecidomyiidae*)

Z. giardi was introduced, also from Australia, in 1960–61. Larvae of this fly cause galls by feeding on terminal shoots of *H. perforatum* (Wilson 1943). Releases were made at a number of South Island sites (Figure 3), but successful establishment has been restricted to the area around Nelson. Part of this work has been reported by Given and Woods (1964).

Current situation

St John's wort is widely distributed throughout the South Island tussock grasslands east of the main ranges, particularly in the Waitaki and Clutha river catchments. Relatively severe infestations, which are of concern to local runholders, occur in several areas. The weed is no longer gazetted as a noxious plant, but to what extent this change in status is attributable to the introduced insects is unclear.

No quantitative studies were undertaken before or immediately following releases of insects, but in some cases the effect of *C. hyperici* was sufficiently dramatic for its impact to be assessed qualitatively. Observations on weed densities following beetle establishment are available from only a few sites. Interestingly, results tend to vary considerably from site to site. In the Awatere Valley, the weed population was progressively reduced following the introduction of *C. hyperici*, and has remained at a low level ever since (Miller 1970; Moore 1976). It should be noted, however, that pasture improvement and rabbit control programs may also have played a part in reducing St John's wort infestations in the Awatere over this period. On Benmore Station in the Waitaki, a 'complete kill' of St John's wort was reported in 1953, but by 1961 the weed population had recovered and the beetle was reported to be 'apparently not effective' (Department of Agriculture field reports held in DSIR files). From the Lilybank and Mt Gerald Stations, near Lake Tekapo, a series of reports from the runholders, local authorities and DSIR workers indicates that St John's wort has continued to spread unchecked in spite of the establishment of *C. hyperici* (DSIR files). Circumstantial evidence from Aspinall (1981) suggests that successful biological control was achieved in the Matukituki Valley. It seems that the level of control achieved by *C. hyperici* has varied considerably both spatially and temporally.

Data collected from Lake Selfe, Canterbury, between December 1982 and July 1983 indicate that adult *C. hyperici* are present for most of the year, but are most numerous in January and February (N. G. Hancox, unpublished data). Eggs were found in December and January, and from April onwards. The peak of larval feeding occurred in mid-December. Very high populations of adult beetles were observed a month earlier at Clyde, Central Otago, in December 1984 (B. Fraser, pers. comm.). They were associated with heavily defoliated St John's wort plants (Figure 4) which did not subsequently recover that season. Thus flower and seed production were totally suppressed locally.

Since no 'before and after' data are available from the time of release, a recent trial was carried out using an insecticide exclusion technique to measure the effect of *C. hyperici* (Syrett

Figure 4 Defoliated St John's wort plant, from Clyde, Central Otago, December 1984.

and Hancox 1985). Plots of St John's wort plants at Mt Gerald Station were sprayed with fenvalerate (0.8 g a.i./10 litres) from 1983–85 to suppress the beetle. Results showed that in spring, when beetle larvae were feeding actively, significantly more St John's wort stems were present in these plots than in unsprayed controls.

The gall midge, *Z. giardi*, has established well and reaches high densities in the stony river beds of the northern South Island. It is also present, though only in low numbers, to an altitude of 830 m in North West Nelson where there is considerable winter snowfall. Given and Woods (1964) noted that the midge was most successful on young seedlings and on autumn and winter prostrate growth. Given (1967) observed that where pockets of maximum galling occurred there was no flowering, and that seedlings were killed by midge activity. There are probably four summer generations and one winter generation of *Z. giardi* in New Zealand, the most prolific being the last summer generation. The winter generation hibernates in the early pupal stage (Given and Woods 1964). More recently, however, *Dimeromicrus* sp. (Hymenoptera: Torymidae) has been recorded from *Z. giardi* in the Nelson area. It is not known whether mortality from this parasite is significant.

Discussion

The biological control program against St John's wort in New Zealand has not been as successful as the California program in which *C. quadrigemina* has been outstandingly effective (Huffaker and Kennett 1959). In areas where *C. quadrigemina* thrives this species has had a more dramatic effect on St John's wort infestations than has *C. hyperici* anywhere. Huffaker (1967) attributes this to two main factors. The Mediterranean-type climate of California closely matched the climatic requirements of the insect and the insect-induced stress on the plant was augmented by drought. Drought conditions were experienced by plants immediately after spring defoliation by beetle larvae; this sequence of events effectively prevented recovery of the attacked plants. Mediterranean-type climatic conditions in parts of Australia (which are suitable for *C. quadrigemina*), in combination with pasture management, have led to good control being effected there also (Delfosse and Cullen 1982; Campbell and Delfosse 1984). In other climatic areas of Australia, particularly where pasture improvement cannot be practised, control is ineffective. In Canada, mixed populations of *C. quadrigemina* and *C. hyperici* are present. In some areas *C. quadrigemina* is as effective as in California and Australia but in others *C. hyperici* is the predominant insect species which controls St John's wort (Harris and Maw 1984). Harris (1962) showed that *C. hyperici* is better suited to survival in a cold winter climate than is *C. quadrigemina*. In parts of Canada, eggs of *C. quadrigemina* laid in early autumn hatch and develop to third instar by winter, resulting in high levels of mortality from early winter frosts. Later oviposition by *C. hyperici* (as also occurs in New Zealand) ensures that a large part of the population enters the winter in the relatively cold-hardy egg stage. *C. hyperici* has also been shown to be an effective control agent in Chile and Hawaii (Julien 1982).

Reports on work with the gall midge *Z. giardi* indicate a wide range of effectiveness. The insect failed to establish in Canada. In Australia and California it established but is reckoned to be of little consequence, while in Hawaii the excellent control achieved by a combination of *Chrysolina* spp. and *Z. giardi* is mainly attributable to the gall midge (Julien 1982). In South Africa, the gall midge kills seedlings and reduces flowering (Julien 1982). In Hawaii, the gall midge is active all year round, resulting in a spectacular reduction in St John's wort density. It has been suggested that the range of *Z. giardi* is limited by severe winter frosts (Harris *et al.* 1969) which could account for its failure to establish in Canada.

While we have not experienced in New Zealand the consistently spectacular results achieved with *C. quadrigemina* in California, striking effects of *C. hyperici* have occasionally been observed. *C. hyperici* is well established throughout the country and the gall midge is numerous in the northern part of the South Island. St John's wort is no longer the problem in New Zealand that it has been in the past and at least part of the credit for this must go to the biological control program.

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