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NEW ACTIVITIES IN BIOLOGICAL CONTROL OF WEEDS IN AUSTRALIA. III. ST. JOHN'S WORT: *HYPERICUM PERFORATUM*

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ABSTRACT

Two beetles, *Chrysolina hyperici* (Forster) and *C. quadrigemina* (Suffrain) which were introduced into Australia in the 1930s were re-introduced in 1980. *C. hyperici* has only been recovered rarely in recent years, and while *C. quadrigemina* became established, produced large populations and aided control in several areas, it did not reduce the weed in much of eastern Australia. New populations of both species were collected from southern France in areas eco-climatically similar to problem areas of the weed in Australia.

A small, isolated colony of *Agrilus hyperici* (Creutzer), a root-boring beetle released in 1939 and 1940, was re-discovered in New South Wales in 1980. A laboratory colony may be established and wider distribution may ensue in 1981. The status of the gall midge, *Zeuxidiplosis giardi* Kieff., first released in Australia from 1953 to 1955, is also discussed.

Other potential candidates for release in Australia against St. John's wort are discussed.

INTRODUCTION

The history of biological control of St. John's wort, *Hypericum perforatum* L. (Guttiferae), with its beginnings by Australia in the 1920s and subsequent spread to several other countries, is well-documented (Currie and Garthside 1932, Currie and Fyfe 1938, Wilson 1943, 1960, Holloway 1948, Clark 1953, Smith 1951, 1958, Villaneuva and Faure 1964, Henderson and Anderson 1966, Given 1967, Huffaker 1967, Harris *et al.* 1969, Harris and Peschken 1971, Peschken 1972).

Australian workers liberated 8 of 12 species of insects which were imported from overseas (Wilson 1960). The most successful of these species is *Chrysolina quadrigemina* (Suffrain) (Coleoptera:Chrysomelidae); *C. hyperici* (Forster) became established in some areas, but is now scarce in southeast Australia because of an unsuitable environment (discussed below), partial infertility and predation by native Australian insects, spiders and birds (Currie and Fyfe 1938, Currie 1940, Wilson and Campbell 1943, Clark 1953, Wilson 1960).

In California, seasonal distribution of precipitation and temperature is generally favourable for the most successful biological control agent of St. John's wort there, *C. quadrigemina*, and unfavourable to recovery of attacked plants (Huffaker 1967). In this situation, nearly all plants attacked died as a result of a single severe attack by larvae of *C. quadrigemina*. Similar effects were recorded in some areas of Canada (Harris *et al.* 1969, Harris and Peschken 1971), Western Australia and South Australia (Huffaker 1967). Some Australian farmers also incorporated pasture improvement (addition of superphosphate and seeding), which hindered re-establishment of the weed. *H. perforatum* persists today in these areas mainly in shaded conditions.

In much of southeastern Australia, however (including New South Wales, the Australian Capital Territory and Victoria), the occurrence of the weed on old gold dredgings (where there are few suitable aestivation sites for the beetles) and a combination of burning, afforestation, alternate cropping and abandonment, and lack of competing vegetation, has resulted in the beetles having a much-reduced effect (Huffaker 1967). Consequently, St. John's wort still infests

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thousands of hectares of hilly country in Australia, especially from Tamworth, New South Wales, in the north, to Beechworth, Victoria, in the south. In these latter areas, higher altitudes with higher rainfall, and relatively dense stands of native trees (particularly *Eucalyptus* spp.) provide a habitat for St. John's wort in which the present populations of *Chrysolina* spp. are ineffective. The presence of St. John's wort in these areas significantly reduces their value for grazing.

Another problem with the *Chrysolina* spp. in Australia is their slow rate of population increase and their apparent lack of mobility. They have taken from 6 to 10 years to reach population levels which reduced the weed significantly, and recovery of heavily-attacked stands has occurred (Huffaker 1967). Even today beetle populations fluctuate widely in the field. For example, beetle populations introduced in the 1960s built up to levels at which they destroyed much of the weed near Wellington and Cassilis, New South Wales, in the mid- to late-1960s, then dropped to levels at which they had a negligible effect on the plants. The weed thus recovered to pest proportions in each of these areas until 1978/79, when massive waves of adult *C. quadrigemina* emerged and significantly reduced the plant populations (Delfosse, unpubl. data). Such waves of emergence have also been noted in other areas of New South Wales (Clark and Clark 1952). In British Columbia, no post-colonization increases were noted in some areas for 4 to 13 years (Harris 1962, Harris *et al.* 1969, Harris and Peschken 1974). The reasons why this cycling occurs in Australia are currently being investigated.

ASYNCHRONIZATION OF *CHRYSOLINA* SPP.

Part of the reason for the failure of *Chrysolina* spp. to control *H. perforatum* in southeastern Australia is that they are out-of-phase with the environment. The original *C. hyperici* populations were imported from England in 1930/34 and released in those same years; those of *C. quadrigemina* were imported from 1937/39 from France and released in 1938/39 (Wilson 1960). As mentioned above, *C. quadrigemina* in particular was very successful in controlling the weed in the areas of Australia with a near-Mediterranean climate. The areas where the weed remains a problem in Australia do not have a true Mediterranean climate; instead of long, dry summers followed by heavy autumn to winter rains, some summer months may have more rain than winter months.

This leads to several problems, as discussed by Huffaker (1967). First, although the beetles cannot pupate in hard soil under extremely dry early summer conditions (Harris *et al.* 1969; Huffaker and Kennett 1952), they also cannot enter aestivation under continuously wet conditions. About a month or more in aestivation is required, and autumn rains are conducive to ending aestivation and initiating reproduction. If egg deposition comes after autumn rains, as in parts of California, temperatures will be sufficiently cool to assure that broods will develop slowly, in synchronization with the weed. In much of Australia, however, summer rains bring beetles out of aestivation very early, which causes broods to reach maturity 1½ to 3½ months earlier than in equivalent periods in California. Adults then emerge in early winter and since they cannot enter aestivation under wet conditions, adult mortality is high. The defoliation which occurs at this time is also not conducive to St. John's wort control, with as high as 80 per cent recovery of plants. Additionally, those individuals which manage to 'aestivate' under dry winter conditions (and thus remain in aestivation up to four months longer than optimum) have a higher degree of mortality. Should heavy winter rains occur after such early 'aestivation', heavy mortality then occurs.

THE PROGRAM

Chrysolina spp. **(Coleoptera: Chrysomelidae)**

The C.S.I.R.O. Biological Control Unit in Montpellier, France, collected both *Chrysolina* spp. from areas eco-climatically similar to those Australian areas where St. John's wort is still a problem (A.J. Wapshere, pers. comm.). Several shipments of both species were received in quarantine in Canberra during 1979. As of July 1980, over 106 000 eggs have been produced by f_{1} adults (about 38 000 *C. hyperici* and 68 000 *C. quadrigemina*). These are presently being prepared for release.

Seven experimental sites have been secured: Tamworth, Wellington, Orange, Tuena, Queanbeyan and Adaminaby, New South Wales, and Beechworth, Victoria. Preliminary data on the weed and the existing *Chrysolina* spp. populations (essentially 100 per cent *C. quadrigemina* at all sites) has been taken. *C. hyperici* or *C. quadrigemina* alone or combined will be released at the sites, and both plant and insect populations studied in ensuing years.

The question of identification of old vs. new populations of *Chrysolina* spp. will be basic to evaluation of the effects of the new populations. In cooperation with other C.S.I.R.O. scientists we are attempting to determine if the two populations have distinct isozyme signatures. Preliminary indications are that the populations are distinct in some isozyme systems. We hope that it will be possible to follow the establishment and possibly increasing proportion of the field population attained by the newly-introduced populations by reference to their isozyme signatures. Experimental laboratory crosses have commenced in order to gain insight into what might be expected if crosses occur readily in the field.

Agrilus hyperici **(Creutzer) (Coleoptera: Buprestidae)**

This beetle was imported into Australia from France from 1938/40, and released in Victoria in 1939/40 and in New South Wales in 1940 (Wilson 1960). It was also released in California and Canada (Holloway 1964, Harris *et al.* 1969). Wilson (1960) reported that the species became established in Victoria and New South Wales, but did not become widespread or control the weed significantly (perhaps due to competition with the *Chrysolina* spp.). However, T.G. Campbell (pers. comm.) found that the Victorian release site was destroyed by fires and afforestation, and that *A. hyperici* had only been recovered from the New South Wales site once in recent years. However, in late May 1980, the New South Wales site (near Mudgee) was inspected, and *A. hyperici* was found (T.G. Campbell and K. Pullen, pers. comm). At the time of the original release this site was extremely heavily infested with St. John's wort. During the 1980 inspection, however, it was discovered that the plants were very sparse (about 4 to 6 plants per 10 to 15 m^2), and larvae of *A. hyperici* were found in about 50 per cent of the inspected roots. The beetle was found about 500 m from the original point of release, the last 200 m being on an uphill slope under a dense cover of *Eucalyptus*. *A. hyperici* was found equally in the lower, open areas and higher, shaded areas.

C. quadrigemina was found in low numbers at this same site. Therefore, it is questionable as to just how much effect *A. hyperici* has had. We hope to clarify this in the current program.

A colony of *A. hyperici* was collected from this site and returned to the laboratory in Canberra. Provided that a viable colony can be established, releases of *A. hyperici* will be made at the seven sites listed below.

Zeuxidiplosis giardi Kieff. (Diptera:Cecidomyiidae)

Mention should be made of this gall midge, released in Australia during 1953/55 (Wilson 1960). It is widely established and is noted for its more frequent occurrence in damp, shaded situations. However, in Australia, it has never increased to damaging population levels such as have been observed in Hawaii and South Africa (S. Neser, pers. comm). The reasons for this are at present unknown.

Other arthropods

Several species of arthropods are currently being investigated by the C.S.I.R.O. Biological Control Unit in Montpellier. One of these is the gall mite, *Phyllocoptes hyperici* Liro (Acari:Eriophyidae), which causes marked dwarfing of the recumbent rosette stems and of the flower shoot. Quarantine safety testing of this mite is now under way (A.J. Wapshere, pers. comm.).

Aristotelia morphochroma Walsingham (Lepidoptera:Gelechiidae) larvae cause die-back of the shoot tips of St. John's wort. It occurs in France in zones eco-climatically similar to the problem areas of the weed in Australia (A.J. Wapshere, pers. comm.). Wilson (1938)[2] found that there are three generations per year in southern France. In the first generation, overwintering second instar larvae become active in late winter. They feed inside *Hypericum* stems and pupate in early spring. Adults emerge in mid-spring. Second generation larvae feed in flowers and ovules of *Hypericum* and emerge as adults in early summer. Third generation larvae also feed in flowers and seed capsules, and adults emerge in early autumn. First instar larvae enter the tips of procumbent foliage, where they feed for a short period prior to mining the procumbent stems. In early winter they spin a small, white cocoon in the mined stem, and hibernate as second instar larvae. One important point about this species is that it is shade-loving, which may mean that it will be better-adapted to areas in Australia where St. John's wort is still a problem.

In this study Wilson did not find any other host plants for *A. morphochroma* than *Hypericum* spp. Preparations for host-specificity testing by C.S.I.R.O.'s Montpellier laboratory are now under way (A.J. Wapshere, pers. comm.).

Aphis chloris Koch (Homoptera:Aphididae) was imported into Australia from England from 1932/34 (Wilson 1960). However, this species was not liberated because there were doubts about its safety and potential effectiveness (Wilson 1938). After extensive host specificity testing involving 146 species in 63 families, Garthside (1930–37)[3] found that *A. chloris* was specific to *Hypericum* spp. This was confirmed in Canada where 13 species in 9 families were tested during 1978/79. This species was considered to have considerable potential and was released in Canada during 1979 (P. Harris, pers. comm.).

Actinotia hyperici Schiff. (Lepidoptera:Noctuidae) was imported into

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[2] Wilson, F. (1939). A brief account of the life-history of *Aristotelia morphochroma* Wals. (Gelechiidae) in the Var, France. Unpubl. C.S.I.R.O. Rept. 4 p.

[3] Garthside, S. (1930–37). Noxious weeds investigations. Farnham House Laboratory, Farnham Royal, Slough, England. Unpubl. C.S.I.R. Repts.

Australia from France in 1939 and 1940 (Wilson 1960). Like *A. chloris*, this noctuid was demonstrated to be specific to *Hypericum*, but was not released because workers at that time were concerned about its host specificity, purely on the basis that it is a noctuid.

This species was studied in southern France by Wilson from 1936–39[4]. There are two generations per year. Adults emerge from hibernating pupae in mid-spring, with males generally emerging first. First instar larvae feed on surface leaf tissues, and subsequent instars feed on whole leaves. Final instar larvae pupate in leaf litter at the soil surface at the bases of the plants. Pupation occurs in mid-summer, and second generation adults appear in late summer. Second generation larvae pupate in mid-autumn to early winter, in which stage they remain until the following spring.

In host specificity tests, Garthside (1939)[5] tested 50 species of plants, and 'the larvae showed not the slightest tendency to feed' on anything except St. John's wort. Further tests on the host range of this species are planned by C.S.I.R.O.'s Montpellier laboratory (A.J. Wapshere, pers. comm.).

DISCUSSION

The remaining problem areas of St. John's wort in Australia are characterized by hilly terrain, variable shade (principally by *Eucalyptus* spp.) and significant summer rainfall. These are often correlated with each other and with the land owner's inability to cultivate or sow with competitive pasture species.

This is in contrast to the more open, level country where *C. quadrigemina* in particular has contributed significantly to control and where this was coupled with pasture improvement which prevented resurgence by the weed.

The new populations of *Chrysolina* spp. and the new arthropod species must therefore be able to attack *H. perforatum* significantly in shade; be better synchronized with the climate; damage the weed sufficiently such that recovery during summer is insignificant; and achieve control in the absence of any assistance by farm management.

The task therefore is not easy, but several natural enemies are available which can be obtained from shady areas in equivalent climatic situations to the problem areas of St. John's wort in Australia, and perhaps most significantly, *H. perforatum* is in fact extremely difficult to find in shady areas in Europe (A.J. Wapshere, pers. comm.). There is thus some hope that the same situation can be obtained in Australia.

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4 Wilson, F. (1939). A brief account of the life-history of *Actinotia hyperici* Schiff. (Noctuidae). Unpubl. C.S.I.R. Rept. 3 p.

5 Garthside, S. (1939). Feeding tests with freshly hatched larvae of *Actinotia hyperici* F. Unpubl. C.S.I.R. Rept. 2 p.

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