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HYPERPARASITES: AN OPTION FOR THE BIOCONTROL OF WEEDS

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ABSTRACT

If a biocontrol insect of known potential has failed to control a weed because of heavy parasite-induced mortality, it is proposed that hyperparasites could be imported to control the primary parasite. A reduction in primary parasite numbers could permit the phytophagous insect to increase in numbers and cause greater damage to the weed.

INTRODUCTION

Exploration for insects to control weeds has traditionally centred on the discovery of suitable phytophagous species. This method has been used successfully in the past and is obviously the correct and logical way to undertake a weed biocontrol program.

However, where parasitism by native species has limited the degree of control exercised by an exotic phytophagous insect, it may be worth considering the possibility of reducing the suppressive effect of the parasites. A hyperparasite, by attacking the primary parasite, may reduce its population, thus lessening mortality in the phytophagous insect population and so increasing the damage to the weed. It should be emphasized that this is not advocated in place of introducing phytophagous species but rather as an option which could be used where a species of known potential is controlled by parasites. For example, the weed *Eupatorium adenophorum* (Sprang.) is controlled by the gall fly, *Procecoidochares utilis* Stone (Diptera:Tephritidae), in Hawaii, but in Australia it is very heavily attacked by native parasites and its control of the weed is severely limited (Clausen 1978). There are also a number of insects which have been imported into Australia for weed biocontrol and whose failure to control the weed is due to high levels of parasitism by native parasites. For example, *Anania haemorrhoidalis* (Guen.) (Lepidoptera:Pyraustidae) and *Neogalea esula* (Druce) (Lepidoptera:Noctuidae) were introduced into Australia for the control of *Lantana camara* L. but were prevented by heavy parasite attack from reaching population levels high enough to control the weed (Willson 1968).

Hyperparasites are well represented in the hymenopterous superfamilies of Ichneumonoidea, Chalcidoidea, Proctotrupoidea and Cynipoidea. Oviposition may be directly on or into a primary parasite or indirect by ovipositing into the host phytophagous insect (Doutt *et al.* 1976). Direct hyperparasites which attack the primary parasite are often found in chalciodoid families such as Eulophidae, Pteromalidae, Eurytomidae, Torymidae and Chalcididae as well as in other families, whilst indirect hyperparasites in which the females oviposit in the host insect on the chance that they may contain primary parasites can be found in families such as Ichneumonidae, Encyrtidae and Aphelinidae (Doutt *et al.* 1976).

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DISCUSSION

(i) Effect of hyperparasites on host populations

There is not a great deal known about the effectiveness of hyperparasites in controlling primary parasite populations. Hyperparasites have not been used as biocontrol agents and their potential usefulness is still theoretical.

Studies of hyperparasites in the field do suggest that they can reduce parasite populations. Askew (1971) records that the introduction of the hyperparasite, *Quaylea whittieri* (Girault) (Hymenoptera:Chalcidae), into California has reduced the effectiveness of the primary parasites, *Metaphycus lounsburyi* (Howard) (Hymenoptera:Chalcidae) and *Scutellista cyanea* Motschulsky (Hymenoptera:Chalcidae), of the citrus black scale. Simpson *et al.* (1979) suggest that, by causing a 50 per cent reduction in the population of the primary parasite, *Bathyplectes curculionis* (Thompson) (Hymenoptera:Ichneumonidae), of the alfalfa weevil, *Hypera postica* (Gyllenhal) (Coleoptera:Curculonidae), hyperparasite-induced mortality reduces the efficiency of parasite control of the weevil. Telford (1961) suggested that hyperparasites were important in triggering outbreaks of some insects such as the lodgepole needle miner, *Coleotechnites milleri* (Busck.) (Lepidoptera:Gelechiidae). Debach (1949) tested the effect of a hyperparasite on a primary parasite population by using an insecticide which retarded the hyperparasite, *Lygocereus* sp. (Hymenoptera:Calliceratidae), but not the primary parasite, *Anarhopus sydneysis* (Timb.) (Hymenoptera: Encyrtidae), of *Pseudococcus longispinus* (Targ.) (Hemiptera:Pseudococcidae), and concluded that the hyperparasite-induced mortality of the primary parasite did indeed suppress the latter's population and permit the mealybug population to increase. The logic that if a host insect population can be controlled by a primary parasite then the latter's population can be controlled by a hyperparasite appears to be borne out by these studies.

(ii) Host specificity

There are two aspects to be considered in an examination of the host specificity of a hyperparasite:

(a) The range of parasites which the hyperparasite will attack. Hyperparasites may be specific to the primary parasite or may attack a number of different species. For example, Evenhuis (1964) found that the aphid parasites, *Monoctonus cerasi* (Morshall) (Hymenoptera:Braconidae), *Ephedrus nitidus* Gahan (Hymenoptera:Braconidae) and *Binodoxys angelicae* (Halliday) (Hymenoptera:Braconidae), were attacked by the hyperparasites *Alloxysta* sp. (nr. *perplexa*) (Hymenoptera:Cynipidae), *Charips* sp. (Hymenoptera:Cynipidae) and *Alloxysta* sp. (Hymenoptera: Cynipidae), respectively. These hyperparasites were specific to their primary parasite hosts, although other hyperparasites such as *Lygocereus frontalis* (Thoms.) (Hymenoptera:Ceraphronidae) and *Asaphes vulgaris* Wlk. (Hymenoptera:Miscogasteridae) attacked all of the primary parasites, indicating that these hyperparasites were not host specific. The specificity of hyperparasites is important because it is undesirable that an introduced hyperparasite should attack other primary parasites, native or introduced, which may be controlling populations of phytophagous insects. The candidate hyperparasite should be shown to be restricted to the target primary parasite or to a closely related group. These studies should be analogous to those undertaken in insect biocontrol programs before a primary parasite is given approval for introduction. As care is taken in insect biocontrol studies to ensure that the parasites or predators introduced do not attack beneficial phytophagous species, it would also be necessary in weed biocontrol studies to ascertain that the hyperparasite will not attack useful parasites.

(b) The hyperparasite must attack only the primary parasite and not the phytophagous host, i.e., the candidate must be an obligate and not a facultative hyperparasite. Obviously a hyperparasite which would also parasitize the phytophagous host would be undesirable. Efforts to avoid the importation of facultative hyperparasites are also made when parasites are introduced for insect biocontrol. For example, based on laboratory tests, Weseloh *et al.* (1979) argued against the importation of *Anastatus kashmirensis* Mathur (Hymenoptera:Eupelmidae), an egg parasite of the gipsy moth, *Lymantria dispar* L. (Lepidoptera: Lymantriidae), into North America because it was considered that it could become a facultative hyperparasite of the gipsy moth larvae parasite, *Apanteles melanoscelus* (Ratzeburg) (Hymenoptera: Braconidae). In this case a facultative hyperparasite was considered undesirable because it could attack the primary parasite, whilst for the biocontrol of weeds a facultative hyperparasite would be undesirable because it could attack the phytophagous host.

(iii) **Situations appropriate for the use of hyperparasites**

The use of hyperparasites to enhance biological control of a weed might be of value under the following circumstances:

(a) Traditional weed biocontrol procedures have been undertaken but have not been successful.

(b) Phytophagous insects attacking the weed are prevented from exerting significant control because they are subject to a high rate of parasite-induced mortality. Hyperparasite attack of the primary parasite is minor or non-existent and it is considered likely that there is a source of suitable hyperparasites in an ecologically separate area.

If investigations under these circumstances disclose the presence of a suitable hyperparasite, then consideration could be given to its importation. A suitable hyperparasite would be one not already occurring in the target area, one which was an obligate hyperparasite and one whose host specificity was sufficient for the particular insect complex.

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