RECENT WORK ON THE ASSESSMENT OF THE BIOLOGICAL CONTROL POTENTIAL OF THE *CHONDRILLA JUNCEA* ORGANISMS [1]

A.J. Wapshere

C.S.I.R.O. Biological Control Unit
335, Avenue Abbé Paul Parguel
34 - Montpellier (France)

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INTRODUCTION

At the First International Biological Control Symposium a method for assessing the biological control potential of organisms attacking weeds was discussed (Wapshere, 1970). The method was applied to the assessment of the potential of five specific organisms attacking skeleton weed, Chondrilla juncea L., in Southern France and the Spanish Costa Brava. The five organisms were the rust, Puccinia chondrillina Bubak & Syd., the aphid, Uroleucon (Dactynotus) chondrillae Nev., the aphid, Chondrillobium blattnyi Pint., the powdery mildew, Leveillula taurica Arnaud form chondrillae Jacz. and the Eriophyid mite, Aceria chondrillae Can.

Since that time investigations have been carried out in South-eastern Italy and in eastern Greece and more organisms apparently specific to Chondrilla have been studied in the same way. The new organisms are another powdery mildew, a form of Erysiphe cichoracearum D.C., the Cecidomyid gall midge, Cystiphora schmidti Rubs., and the root feeding Pyralid moth, Bradyrrhoa gilveolella Tr. This paper outlines the biological potential of both the new and the previously studied organisms in the light of the much larger area now covered.

METHOD

The method of assessment previously described (Wapshere, 1970) was based on detailed field observations of the effect of the biological control organisms on populations of Chondrilla juncea in situations as closely similar as possible to Australian infestations, observations of the organism's life history, parasitisation, reactions to its ow n density, etc., observations of potential under laboratory and field-cage conditions and finally adjustment of the assessment because of any differences between European and Australian conditions.

CLIMATES OF THE REGIONS STUDIED

The three regions studied represent a climatic transect from cooler, wetter S. France and Costa Brava (average annual daily temperatures 13-15.5°C, average annual rainfall 570-950 mm.) via warmer, drier S.E. Italy (average annual daily temperatures 15.7-17.2°C, average annual rainfall 460-600 mm.) to the hot, dry, eastern coast of Greece (average annual daily temperatures 15.9-17.4°C, average annual rainfall 380-480 mm.). The S.E. Italian regions and the drier parts of the Greek coast correspond to two major areas of skeleton weed infestation in Australia, the Riverina and the Mallee, respectively.

THE BIOLOGICAL CONTROL POTENTIAL OF THE CHONDRILLA ORGANISMS

Puccinia chondrillina - The further work has confirmed the biological control potential of this rust fungus. It has been observed to damage plants at all stages and to produce definite reductions in population levels of C. juncea in all parts of the climate transect down to the lowest rainfall levels. It is consistently effective each year,

although there are yearly fluctuations in levels of infestation. Moreover, casual observations in Spain and Turkey indicate that it is equally damaging in continental climates similar to those of the Australian Chondrilla localities.

Its main parasite, Darluca filum, already occurs in Australia. There seems every reason to suppose it should be as effective in infesting and damaging C. juncea throughout its climatic range in Australia as it is in the Mediterranean.

Aceria chondrillae - This Eriophyid mite which causes the flower and shoot buds to be replaced by a leafy gall has a negligeable effect on established populations of skeleton weed and would principally act by reducing seed production. Although predators are known they do not stop the rapid development of massive infestations. It was found to decline in frequency of occurrence from cold regions, whether dry or relatively wet, to the hot dry parts of the transect. Although it could act as an effective agent reducing seed production in the cooler parts of the Australian infestation, it may only just establish itself in the hottest, driest regions.

Uroleucon (Dactynotus) chondrillae - As previously noted (Wapshere, 1970), this aphid is not particularly damaging to Chondrilla requiring very high population levels to damage the plant or reduce seed production. The aphids readily emigrate when density rises on a given plant. Populations fluctuate during the season and have also been found to remain low for several years and only reach high levels of infestation in occasional years. Moreover, like Aceria chondrillae, this aphid appears to be better adapted to the cooler climates. Its potential under Australian conditions must be considered slight and the intrinsic biological disadvantages listed above suggest that any advantage the aphid would receive because of the absence of its major parasites would be insufficient to outweigh the disadvantages.

Chondrillobium blattnyi - This aphid has been found in the laboratory to damage rosette plants severely at relatively low infestation levels. It is attacked by some parasites and by fungus species but epidemics of these organisms are not obvious in the field. It is relatively rare and of very inconsistent occurrence in the field. Surprisingly it is found most consistently in Greece. For these reasons it seems that colony levels sufficient to produce damaging infestations in C. juncea populations would depend on a very unusual set of environmental conditions which seemingly are unlikely to exist in Australia. It is therefore of doubtful potential as a biological control agent despite its ability to damage the plant.

Powdery mildews - It has now been discovered that two powdery mildews attack C. juncea, Erysiphe cichoracearum and Leveillula taurica form chondrillae (Hasan, this meeting). Both attack both rosette and flower shoot but E. cichoracearum is particularly obvious and damaging to rosettes in spring in S.E. Italy where it causes considerable reduction of plant populations but is less damaging in S. France and absent from Chondrilla infestations in Greece. Although the effect of E. cichoracearum infestations on Chondrilla plants in the field is second only to Puccinia chondrillina it would seem to be climatically adapted to only the Riverina part of the Australian skeleton weed infestation.

On the other hand Leveillula taurica is at its most damaging on the flower shoot causing obvious reduction in growth and seed production and is at its maximum in Greece where it is the most damaging flower shoot organism. In S.E. Italy and S. France it is less effective. It is regarded as a fungus of sub-tropical cultivations and has much greater potential for the drier parts of the weed's Australian infestation than E. cichoracearum.

The three major fungus species, P. chondrillina, E. cichoracearum and L. taurica play a much greater role in controlling C. juncea populations in the Mediterranean than any of the arthropod species.

All the organisms discussed above occur throughout the climatic transect in both eastern and western Mediterranean and eastwards into southern Russia.

The two other organisms, the moth, Bradyrrhoa gilveolella, and the Cecidomyid, Cystiphora schmidti, only occur in eastern Europe and the eastern Mediterranean and also eastwards into Southern Russia. They have only been studied in detail in Greece and to a much lesser extent in Yugoslavia.

Cystiphora schmidti - This small cecidomyid midge produces pustulate galls on the rosettes and flowering shoots of Chondrilla species. There is apparently no crowding effect and whole plants are observed to be covered by pustules. Under these conditions rosette leaves are damaged and curl up and the growth of the flower shoot is strongly retarded with consequent reduction in seed production. Generations of the cecidomyid are continuous from early spring to late autumn and in dry South-Eastern Greece heavy, damaging infestations rapidly build-up by early summer and continue until the death of the flower shoot. Heavy infestations also occur in the drier parts of the Peloponessos but along the wetter parts of Western mainland Greece and the very much wetter Adriatic coast of Yugoslavia the cecidomyid is almost absent despite reasonable Chondrilla levels. It is also rarer in colder North-Eastern Greece. It is clearly best adapted to warm, dry, Mediterranean climates similar to those of the Riverina and Mallee regions of Australia. It is extraordinarily heavily attacked by hymenopterous parasites in S.E. Greece (up to 99%, Caresche, personal communication) but can still reach very damaging levels. It is possible that parasite attack in Australia might not occur or be considerably less and, if this is the case, the midge should be an extremely effective biological control agent.

Bradyrrhoa gilveolella - The caterpillars of this Pyralid (Phytlcid) moth live in a cocoon of silk, soil particles and latex from Chondrilla plants and feed on the root of the plant just below the surface layer of the soil. The caterpillars are relatively large and during their feeding cut long, deep trenches into the root of the weed, destroying the regenerating buds in the process. Small rooted plants are cut through and killed by a single larva. Many larvae are found feeding on the roots of large plants. The individual larva of this moth is individually the most destructive organism investigated to date. The moth was known in Eastern Europe and Southern Russia and discovered in Greece during this study. However, the moth's behaviour in the dry parts of Eastern Greece is unusual. Each year, large numbers of larvae are found from late August until late November but most disappear during winter and there are very few larvae in spring. In

Northern Greece, near the Bulgarian border, populations are more stable. There does not appear to be sufficient levels of parasitisation, fungal attack or disease to explain this winter disappearance. The large influx of moths in mid-summer can apparently only be explained by migration from stable populations in Bulgaria and Rumania where dense Chondrilla populations are known to occur and the winter disappearance by some form of climatic inadaptability to the warm, wet, Greek winters.

For these reasons the potential of this insect for the climatic regions of Australia similar to Greece is much less than at first appeared although it might be of more potential in the colder parts of the range of C. juncea in Australia.

DISCUSSION

The results briefly discussed above illustrate in a striking way the importance of detailed, continuous and widespread ecological studies in understanding the potential of biological control organisms. Four good examples illustrate the importance of such studies.

The Chondrilla rust, P. chondrillina, which on the evidence provided by studies of other Puccinia species would have been considered to be effective only in relatively wet climates has been found to be equally damaging at all rainfall levels down to the driest.

The comparison of different sites and situations where one or more of the organisms are rare or absent enables separate assessments of their biological control potentials to be made. Thus, comparing S.E. Italy where E. cichoracearum is particularly important with Eastern Greece where L. taurica is almost the only mildew demonstrated that the former was most destructive at the rosette stage and the latter damaged severely only the flower shoot.

B. gilveolella at first sight, because of the considerable damage caused by each individual and because of its occurrence in Greece, appeared to have considerable potential. More detailed studies, however, revealed that this moth was apparently ill-adapted to the climates into which it would be introduced in Australia.

C. schmidti on the other hand appeared from recorded descriptions to be of only minor interest, since it is a small insect producing a pustule only a few millimetres in size. It has however been found to produce its highest and most damaging infestation levels in Greece in climates closely similar to those where biological control is needed in Australia.

It is clear from the above discussion that biological control potential of an organism is a facet of its overall ecological adaptability and that it can only be assessed by undertaking the types of studies used in the investigation of the organisms attacking Chondrilla juncea.

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DISCUSSION

ZWOLFER What is the taxonomic position of your moth? Is it possible that the disappearance of the moth in your observation area in southern Greece is due to a temporary transfer to another host plant?

WAPSHERE It is a Pyralid, Phyticidae, and as far as is known Bradyrrhoa gilveolella Tr. was studied by the Russians and is considered specific to Chondrilla species. Mr. Caresche has done some feeding tests and these have confirmed the results of the Russian investigators. It can feed on Taraxacum only in the laboratory but this is the only Cichoraceae it has been found to attack, so there doesn't seem to be the possibility of an alternate or secondary host. We also have another moth, Oporopsamma wertheimsteini (Rebl.) which is a Tortricid which makes almost exactly the same tunnels on Chondrilla and is also apparently specific to Chondrilla.

BARR Dr. Wapshere, I'm interested in this cecidomyid fly. How does it overwinter and what are the extremes in winter temperatures that this and some of the other insects are exposed to? Are low winter temperatures appearing to be limiting factors in some of your studies?

WAPSHERE The Chondrilla organisms were, I think, originally adapted to the continental climate of southern Russia, and there you have temperatures of minus 20°C in the winter. When the moth spread to the Mediterranean they have been exposed to much higher temperatures in the winter. We think one of the explanations why B. gilveolella doesn't succeed in Southern Greece is because it should diapause or rest but may not.

BARR What about the cecidomyid, how does it overwinter?

WAPSHERE Mr. Caresche has shown that Cystiphora schmidti Rübs overwinters in the prepupal stage and adults appear in the spring. From early spring to late autumn there is continuous attack if the plants are available. Presumably, in southern Russia, where the spring or the equivalent temperatures do not occur until much later in the year, it may have only one generation and may only have a little population peak. This is another point I didn't make. I think if we had gone by the literature and studied this particular organism in Poland and northern Germany where it had only been recorded until our study, we would have found just a little summer population existing, and nothing at all like the heavy infestation that we find in southern Greece.

CARESCHE I wanted only to say I observed that Cystiphora schmidti, the gall midge of Chondrilla, stopped developing when the temperature fell below +10°C and it resumed its development in the springtime when the temperature rose above +12°C.

CAVERS In one of your slides we saw a moth attacking a flowering plant. Does such an attack have any influence on the size of the seeds that are produced?

WAPSHERE This we don't know, we haven't had time to work on seed size.

CAVERS I believe that work on seed size might be most useful in assessing new methods for biological control. Secondly, have you looked at the possibilities of a latex industry in Australia?

WAPSHERE The Russians studied the plant and studied other plants including Taraxacum and Scorzonera all of which are Cichoraceae and all of which, like Chondrilla, produce fairly copious quantities of latex. In Russia there occur other Chondrilla species, some of which produce even more copious quantities of latex than our particular species. Another interesting point was that with insect attack, the amount of latex was greater on

the part of the plant attacked by the insect, and within calluses formed by the insect, than in the plant generally. They even attempted to gather up cocoons and use these as a source of latex. This work finished about 1935 because I think it wasn't economic and I think the same could be said for Australia.

ZWOLFER You started your work I think in a marginal part of the distribution area of Chondrilla. Is it correct to say that the more you moved to the center of the distribution area of the host plants, the greater became the diversity of insects associated with it.

WASPHERE Yes, I think this is the case.

BENNETT A high level of parasitism on cecidomyids is quite a common phenomenon. Investigations on a species of Baccharis in California by R. Doutt indicated that parasites play a very important role in regulating cecidomyid populations. Lab tests indicated that this cecicomyid, freed of natural enemies, really restricted plant growth. Similarly in our work on Eupatorium odoratum in Trinidad cecidomyids which are extremely scarce in the field because of parasitism, would otherwise have a retarding effect on the growth of the plant.

GERLING I wish to add something about cecidomyids. There is a cecidomyid that attacks alfalfa over all the Mediterranean region. It came into Israel, about five years ago and since that it has become a major pest and a lot of regions reverted from a no spraying system, to five to ten sprays a season only because of this cecidomyid. Recently I visited some places in Italy that grow alfalfa, and I found the rate of parasitization to be over 95% and no problems exist with this particular pest. This happened to be an economic plant, but the principle is exactly the same.

END OF DISCUSSION

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