

SEASONAL AND REGIONAL VARIATION IN THE SUCCESS OF
ORGANISMS IMPORTED TO COMBAT SKELETON WEED
CHONDRILLA JUNCEA L. IN AUSTRALIA

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INTRODUCTION

A good account has been given at the two previous symposia of this series, of the discovery and potential of various European organisms for the possible control of skeleton weed *Chondrilla juncea* L. in Australia (Wapshere, 1970a, 1973). The aim of the present account is to report on the progress at the Australian end of the programme for the first time. To date, four organisms have been imported, the last only very recently has yet to be liberated. This paper deals with each of the three released species in turn and concludes by reporting the noticeable effects in the plant population so far.

The different areas inhabited by C. juncea in Australia

It is first necessary to recapitulate a little on the variations in climate in the Australian range of *C. juncea*, much of which has been summarised by Groves and Hull (1970) and Wapshere (1970b). Frequent reference will be made to four localities in particular. In the southern and western region, the climate is Mediterranean with hot dry summers. This dry sandy area is known as the Mallee and typified by the locality Parilla. Some of this country is irrigated during the summer. In the central regions, rainfall is higher, increasing, particularly in summer, from west to east while temperatures decrease in the same direction. Wagga and Canberra are in this belt which contains the highest densities of *C. juncea*, Wagga being typical of the mixed farming areas where *C. juncea* was first a problem, while Canberra is similar but significantly cooler all year. Finally in the north, typified by Tamworth, rainfall is again higher and falls predominantly in the summer.

The Chondrilla rust fungus Puccinia chondrillina Bubak et Syd.

This fungus was originally reported as possibly having the greatest potential for damaging *C. juncea* (Wapshere, 1970a, Hasan and Wapshere, 1973) and was imported into Australia in 1971. This was a highly significant event in Australian

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quarantine procedures and was the climax to three years of intensive testing and discussion (Hasan, 1972). The initial field release of this organism at different sites and its extremely rapid spread have been reported recently (Cullen, Kable and Catt, 1973). Suffice to say that it established extremely successfully and at Wagga, dispersal to 1 metre was apparent after one generation, to 8 km after four generations and to 320 km after twelve generations, some seven months after release. The rate of spread was attributed to the high density of the weed, suitable weather conditions and the susceptibility of the common form of *C. juncea* in Australia to the strain of *P. chondrillina* imported. The amount of effort expended in Europe to ensure this last point was therefore well justified (Hasan, 1972).

There are three forms of *C. juncea* (an apomict) distinguishable in Australia (Hull and Groves, 1973) two of which are much more restricted in distribution though quite possibly spreading. The specificity of the strain of *P. chondrillina* introduced is such that although the original isolate from Vieste in Italy was able to attack the two more restricted Australian forms (albeit less vigorously) (Hasan, 1972), after the prolonged rearing necessary (on the common form) and importation to Australia it was no longer able to do so. These two forms therefore remain completely free of attack at present. Whether consideration will ever have to be given to the testing and importation of strains more suitable for these forms will depend on the effect produced by the other organisms and naturally on the stability of the rust-host specificity at this level.

The intensity of the attack on *C. juncea* by *P. chondrillina* is dependent on the availability of spores and the frequency of occurrence of suitable conditions for germination. While the former has occasionally been limiting, the latter is the vital condition for success or failure, a prolonged period of good conditions naturally leading to an enormous supply of spores by population increase.

The spores of *P. chondrillina* germinate and infect the tissue of *C. juncea* generally overnight and require free surface water to do so, the time required depending on temperature. Hasan and Jenkins (1972) established the upper and lower temperature limits for this process and while at the upper end of the scale the figure is high and would seldom be limiting (providing moisture were present), the lower one is much closer to conditions which would be experienced in the field. It is not surprising therefore that when limitations have been apparent in the field in Australia they can be traced to either low overnight temperatures or reduced availability of moisture. Seasonal and geographical variation in these have produced most of the variation in intensity of attack by *P. chondrillina* as summarised in Table 1.

The ratings given in this table correspond to particular levels of mean disease incidence for all plants examined on each occasion (200-2,000 plants depending on site and season).

TABLE 1

Incidence of *P. chondrillina* in different regions in the two years following liberation

		Canberra	Wagga	Tamworth	Parilla
Spring	1971	+	++	++	++
Summer	1971-72	+++	+++	+++	++
Autumn	1972	++	++	+++	+++
Winter	1972	.	+++	++	++
Spring	1972	+	+++	+	+++
Summer	1972-73	++	+	++	.
Autumn	1973	+++	++	+++	+
Winter	1973	++	++	++	++

- +++ abundant. plants severely damaged.
 ++ very common. plants appreciably damaged.
 + present. negligible damage to plant.
 . very low or absent.

The table contains several points of interest. The summer of 1971-72, the period of the initial epidemic spread, was obviously highly suitable in all areas except the driest (Parilla) where the rain in autumn restored the suitability of conditions. The summer of 1972-73, by way of contrast, was a drought summer in most areas except the north and the incidence of the fungus was greatly reduced. At Parilla, in the Mallee, it virtually disappeared along with the top growth of the plant, whereas the damper, cooler conditions in Canberra allowed it to remain at a satisfactory level. The lower temperatures of Canberra are reflected in the low incidence of *P. chondrillina* during the winter of 1972 when overnight temperatures were very low for long periods. In contrast the winter of 1973 has been mild and the incidence of *P. chondrillina* is quite high at present.

The autumn 1973 situation in the Mallee is a good example of a period when the amount of inoculum was limiting. Following the removal of the fungus during the 1972-73 summer it took a long time for infection to re-establish and increase again in such areas, despite a general suitability of conditions for infection. The only other occasion when this effect was noticeable was in Canberra in spring 1972 following the cold winter.

The variation observed so far is expected to be typical of the situation which will prevail with *P. chondrillina* and there seems little doubt that it will always be present somewhere in reasonable quantities and for most of the time it will be present everywhere certainly during the spring and autumn.

The Chondrilla gall mite Aceria chondrillae Can.

The biology of this eriophyid mite, another unusual organism for biological control, has been described by Caresche and Wapshere (in prep). It attacks the aerial buds of the plant forming galls instead of stems and flowers, thereby considerably reducing seed production. As the stems die in the autumn, the mites occupy the rosettes regenerating at this time and spend the winter there, though with no gall formation and no damage to the plant. In spring, the mites attack the new ascending stems. This mite was first colonised on experimental sites in the spring and summer of 1971-72, all colonies establishing successfully. In the season 1972-73 colonies of this mite were distributed on a wide scale and the results of this work and the progress of the earlier sites permit some tentative analysis at this stage.

The essential requirement for colonisation and increase of *A. chondrillae* is a supply of fresh, vigorous, aerial growing points. These are abundant in late spring and early summer but decrease during the summer and drastically so if there is little rain. The life of existing galls under dry conditions is also limited so the establishment of new colonies and the persistence of old ones became difficult in the drought summer of 1972-73. Injury to the plant, or rain in summer stimulates fresh growth and the importance of both was observed initially during the 1971-72 summer and more recently, when rain in late summer broke the 1972-73 drought. By early autumn, release sites in the formerly dry Mallee areas in particular were covered with severely galled plants.

The level of the population available to start gall formation in the spring depends on mortality within the rosettes during the winter and the numbers reaching those rosettes in autumn from the dying stems. The pattern of rainfall distribution in the late summer and autumn is again believed to exert its influence at this point, by affecting the time of regeneration of rosettes and hence determining the extent of the overlap in time of healthy galls containing mites and the essential overwintering sites, i.e. the rosettes. A lack of overlap in the autumn of 1972 is believed to be responsible for slow population increases in some sites in the following spring as winter survival has been shown to be adequate, even in the cold winter of 1972 in Canberra providing initial mite numbers were high (Cullen, unpublished data).

There is no evidence of predators playing a significant role in the population dynamics of this species at present. Mature galls in glasshouse conditions acquire some Phytoseids but these have not been observed in the field, a situation which was also found in Europe. In Europe (Caresche and Wapshere, in prep.) the clonal specificity of this mite was only slightly less than that of the rust fungus. This has also been borne out in Australia where gall development in the field has been limited to the common widespread form of the weed.

The Chondrilla gall midge Cystiphora schmidtii Riibs

This delicate, short-lived Cecidomyid lays eggs in the leaves and stems of the *Chondrilla* plant producing many galls, each normally containing a single developing

larva. This species was originally colonised at the same time as the gall mite i.e. during the spring and early summer of 1971 and again more extensively in 1972-73.

When this species was imported care was taken both in Europe and Australia to ensure the importation of a parasite-free stock. Further, not a single instance is known in Australia yet of parasitisation by any Australian parasites. Despite this lack of mortality and the fairly short generation time (19 days at 25°C) there has been only one real example of a dramatic population increase of this species so far. Elsewhere fortunes have fluctuated, as (Table 2) illustrates.

TABLE 2

The mean number of developing galls of *Cystiphora schmidti* per plant on a release plot at Wagga. 1972-73

Date	No. of galls
15— 8—72	0.01
4—10—72	2.54
15—11—72	12.64
19—12—72	10.09
31— 1—73	<0.04
13— 3—73	0.65
1— 5—73	2.00
6— 6—73	0.22
19— 7—73	<0.01

This shows on a logarithmic scale, the number of galls developing per plant on the main release site at Wagga over a complete season. In absolute density terms the decrease in summer would be more pronounced because of the decrease in plant density at that time. It would seem that the general picture is of increase in spring and autumn in all areas with limits often acting in summer and winter but varying in intensity at different sites. In winter low temperatures reduce activity, a factor most apparent in Canberra and least apparent in the warmer areas to the west and in the Mallee. In the summer while the decreased humidity probably decreases adult longevity, the condition of the plant seems all important, with very much decreased gall development occurring whenever plants begin to suffer from summer aridity (often reinforced by the effects of *P. chondrillina*). If the summer is less severe, as in Canberra, the population decrease is less at this time and the autumn peak has been higher than the spring peak. On the other hand, in the Mallee last summer, the drought conditions almost wiped out the populations, despite the original prediction of the midge's suitability for such areas. The one area where increase and spread has been spectacular is in the irrigated areas of the Mallee where winters are not

severe and the extra moisture in summer ensures a constant supply of fresh growth. During last summer, populations spread at least 16 km from the small nuclei present in spring, with many plants severely attacked.

In all areas where colonies are established it has been noticed that rosettes are much more heavily attacked if they are in the open on bare ground. A similar situation has been observed in Europe but it is not clear at present whether this is the result of a preference for such areas or whether other vegetation upsets the host finding behaviour of the adult or otherwise impedes its activity.

One major advantage of *C. schmidtii* is its ability to attack all three Australian forms of *C. juncea*, and especially where *P. chondrillina* has been severe on the common form, the other two forms have been more heavily attacked by the midge.

Preliminary effects on the weed population

There is little doubt that *C. juncea* in Australia is starting from a position of strength when the densities commonly occurring even at the end of a decline during a competitive pasture phase are so much higher than those occurring in Europe at the beginning of such a phase. In a situation where densities in excess of 500 plants/m² have been observed (and once over 1000 plants/m²) it will almost certainly initially take a few seasons to reduce such densities to anything like those prevailing in Europe after a single normal seasonal decline, under the influence of competition and damaging organisms. Overnight success is therefore not expected but in two years so far, some effects have been spectacular.

In its first season in the arid Mallee country, three months attack by *P. chondrillina* at the initial release point was sufficient to cause complete die-back of stems prior to flowering. A very few stems which regenerated were heavily attacked by the mite and the midge. A year later, with the added stress of drought, premature die-back was the rule throughout the region. When rain produced regeneration at a time when the level of fungus was too low to re-establish rapidly, late flowering was prevented by heavy galling by *A. chondrillae*. Where the rust was first established in this area there has now been no seed set for two seasons.

Both here and elsewhere the vigour of the plant is very much reduced, the dry weight of living weed tissue above ground being at present approximately one tenth of its value two years ago, though density has not declined greatly yet. In the wheat crop this last season, this lack of vigour showed as decreased competition and the production of higher yields despite the dry conditions. Frequently, farmers impressed by the rust fungus did not spray herbicide and still obtained increased yields. Where the three Australian forms of the weed occur together, the reduced vigour of the common form under attack from *P. chondrillina* has been immediately apparent. However at one site where *C. schmidtii* was released this summer on plants of one

of the rarer forms, attack by this species was sufficient to cause massive die-back of the stems and reduction of seeding.

In conclusion, it is fair to say that with the exceptions noted, all three organisms have fared as well or better than expected and the situation looks very promising.

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