PROC. V INT. SYMP. BIOL. CONTR. WEEDS, BRISBANE, AUSTRALIA, 1980: 499–505

PRELIMINARY OBSERVATIONS ON *LONGITARSUS JACOBAEAE* INTRODUCED FOR THE CONTROL OF RAGWORT IN AUSTRALIA

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ABSTRACT

A population of *Longitarsus jacobaeae* (Waterhouse) introduced from France showed no signs of an adult diapause in the laboratory and delayed development was observed in only a small proportion of eggs. Newly emerged adults held in the field from early summer showed normal egg production and development despite hot, dry conditions. Ovipositing adults released in autumn produced second generation adults in late summer instead of early summer. These results conflict with previous work.

INTRODUCTION

In Australia, ragwort, *Senecio jacobaea* L. (Compositae), is an important weed of Tasmania and high rainfall areas of Victoria, where it decreases productivity in pastures, and by virtue of the pyrrolizidine alkaloids it contains, decreases vigour and increases mortality in cattle (Parsons 1973). Control by herbicides or management is expensive or difficult and there have been several attempts at biological control, using the moth *Tyria jacobaeae* L. (Lepidoptera:Arctiidae) (Bornemissza 1966, Schmidl 1972).

The flea beetle *Longitarsus jacobaeae* (Waterhouse) (Coleoptera:Chrysomelidae) has been successfully established in North America for ragwort control (Frick 1970) and has been effective in suppressing this weed (Hawkes and Johnson 1976). This species was introduced to Australia in 1977 and released in the field in 1979. Some of the initial observations on this species are described and compared with what was expected from the North American experience.

EUROPEAN POPULATIONS OF *L. JACOBAEAE*

The phenology of *L. jacobaeae* in Europe has been described by Newton (1933) for England, by Frick (1971) for a Swiss biotype from Delemont and by Frick and Johnson (1973) for an Italian biotype from near Rome. The phenologies are distinct and are represented diagrammatically in Figure 1. In England there is no delay in oviposition by the adults or in hatching of the eggs in summer, though eggs laid in autumn persist through the winter due to low temperatures. In the Swiss biotype however, hatching of the eggs is delayed for three to four months over summer, while in the Italian biotype, reproductive maturity of the adults is similarly delayed, eggs hatching normally after oviposition in autumn. The Swiss and Italian life cycles were of particular interest, as they had been examined in detail and Australian environments containing ragwort were intermediate beween the very different climates to which these life histories were adapted.

Compared with its Australian distribution the European climatic zones containing *S. jacobaea* are generally either cooler, e.g., southern England (type V(IV); Walter and Leith 1960), drier, e.g., north western France $V(IV)_2$) or their rainfall is distributed differently, e.g., central Europe. *S. jacobaea* does not

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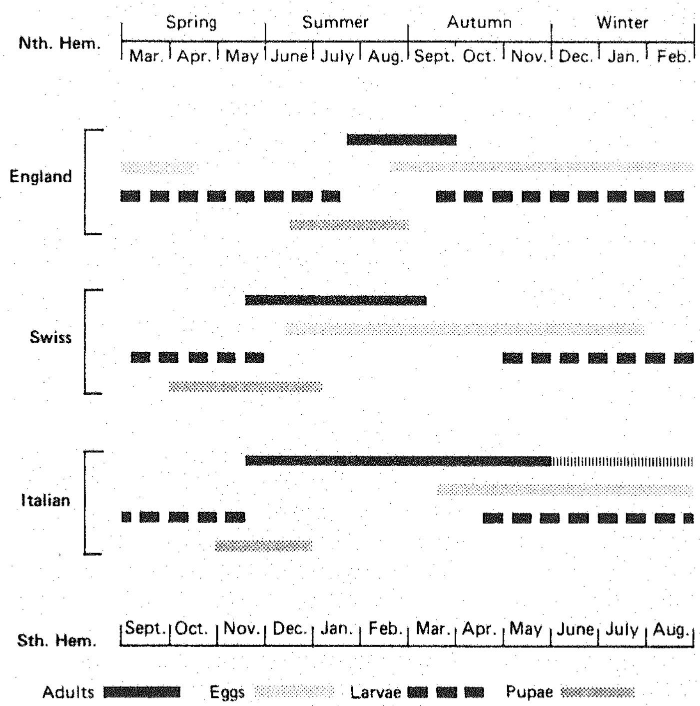

Figure 1. Diagrammatic representation of the life cycle of *L. jacobaeae* in England and of the Swiss and Italian biotypes.

extend into more southern areas of Europe where higher temperatures and a more Mediterranean distribution of rainfall would match the areas of its Australian distribution more closely. The population of *L. jacobaeae* imported to Australia was obtained from around Anonnay, central France. Anonnay is at the edge of the European distribution of *S. jacobaea*, has a type $V(IV)_1$ climate and abuts upon the areas of more Mediterranean climate extending north from southern France. It was considered a reasonable climatic compromise when obtaining a founder population from *S. jacobaea* (A.J. Wapshere, pers. comm.). (The Italian biotype studied by Frick and Johnson [1973] was in fact obtained from the closely related *S. erraticus* Bert.)

It can be seen from Figure 2 that compared with Leongatha and Deloraine which represent climates typical of Australian ragwort infestations, Vion, the closest meteorological station to Anonnay within the same climatic region, has less total rainfall, differently distributed, but the difference between the rainfall and temperature curves is similar during the critical summer period. Mean annual temperatures are similar, though the seasonal differential is greater for Vion. Leongatha, Deloraine and Vion all have higher temperatures and drier summers than Delemont, but lower temperatures and a wetter summer than Rome.

Frick and Johnson (1972) suggested that as the eggs of *L. jacobaeae* were very sensitive to drying, survival of eggs during summer would not have been possible in dry Italian climates but that Swiss climates would have been suitable. It was

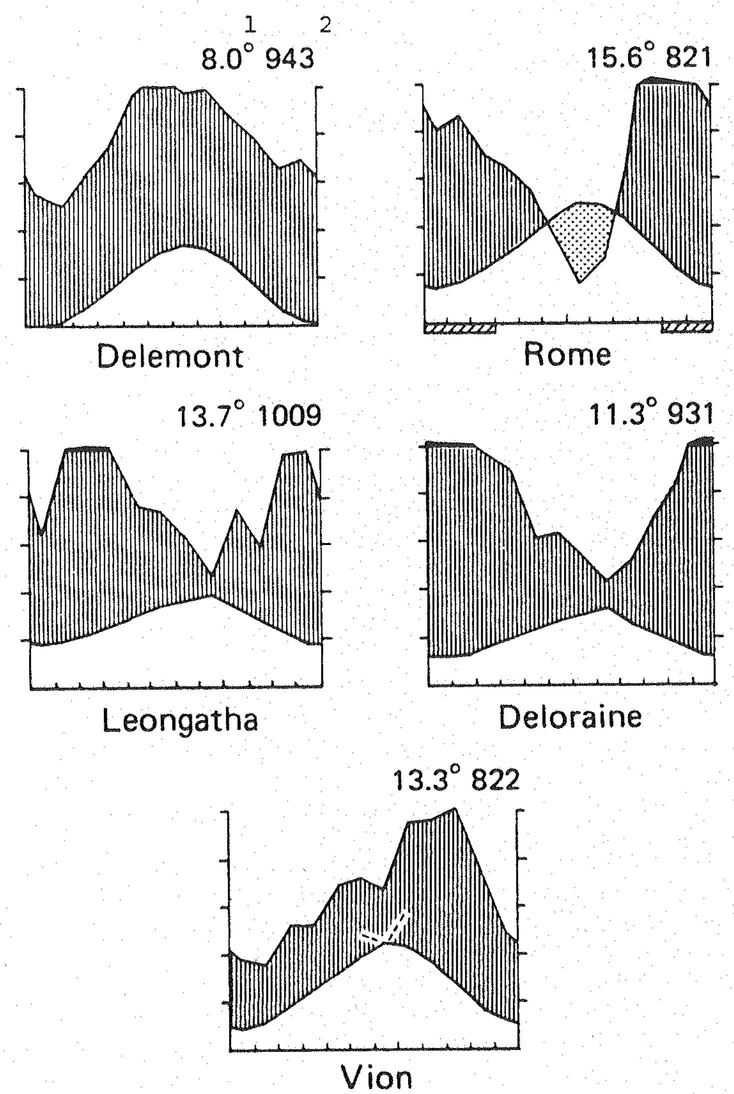

Figure 2. Klimadiagrams of regions of Europe and Australia representing origins and new environments of *L. jacobaeae* (after Walter and Leith 1960).

[1] Annual mean temperature °C.

[2] Annual precipitation in mm.

not known what combination of adult or egg aestivation, if any, the Anonnay population might have, though it was considered that an adult aestivation might be involved (A.J. Wapshere, pers. comm.).

THE AUSTRALIAN EXPERIENCE

Rearing and release

Following the experiences of Frick and Johnson (1972) in rearing *L. jacobaeae*, an extensive laboratory study was made of rearing conditions and the aestivation characteristics of the Anonnay population with considerable care taken to avoid laboratory selection (Cullen, unpub.). Two general points emerging from this are relevant to the present discussion. It was not possible to extend pre-oviposition time by any experimental procedure. However, egg development was sometimes prolonged in a small proportion of eggs. The majority of the population, under a wide range of conditions, showed no extension of the time taken for oviposition or in the hatching of the eggs.

Five hundred adults of this population (sex ratio 1:1) were released in each of two sites, one near Yarram, Victoria, and the other near Deloraine, Tasmania, in autumn 1979. The adults emerged and were held in short day-length conditions (L:D 10:14) and had commenced oviposition at the time of release. The eggs being laid were expected to hatch rapidly and it was therefore considered that larval hatching and subsequent development would be synchronized with the correct time of the year as described by the earlier workers, i.e. autumn to winter (Figure 1).

A study was also made during 1979/80 of the fate of adults emerging and eggs developing during summer without any adult or egg aestivation. Some particularly relevant observations can be reported here. In the laboratory, a generation of adults was reared so as to complete development and emerge in synchrony with expected field emergence in early summer and in conditions simulating the field at that time. A series of these adults was held on living plants, in cages, in the field, such that as far as possible, they were exposed to field conditions, but they and their eggs were protected from predation and parasitism. Each month all surviving adults and all eggs laid were removed and counted, the adults then being returned to the cages with new plants.

A number of similar adults were also released in a large walk-in cage in early summer, and at intervals, newly hatched larvae were placed on plants, either caged in the field at Yarram (predators excluded) or held outdoors in Canberra.

Results

In accordance with the European situation, emergence of adults at the field release sites was expected in November to December. Examination of the Yarram release site in early December and in January, and of the Deloraine site in early December showed no evidence of adult emergence. However, in February one adult and several signs of feeding were observed at Yarram and in March, four adults and feeding damage were observed at Deloraine. In each case the adults were young suggesting that emergence had been in late January to February, i.e. late rather than early summer.

In the small cages containing adults from early summer, eggs were laid during the summer and large numbers of these hatched without delay. Despite very hot, dry conditions during January and February at Yarram, there was no sign of desiccation. Two observations were significant.

Large numbers of eggs were laid quite deeply, up to 4 cm into the soil around the crown of the plant, where they were well protected and appeared very healthy when examined. With examinations only monthly in summer, some of the earliest laid eggs had in fact already hatched when the plants were removed for examination, thus confirming that normal development occurred under rigorous summer conditions. Resulting larvae were found already tunnelling into the plants and developing normally.

Some eggs collected from the surface of the soil in the cages in midsummer showed signs of partial dehydration. When placed on moist filter paper the eggs absorbed water, regained their shape and proceeded to develop. As the eggs were of unknown age, it could not be assumed that there had been any delay in development of these. A number were set on one side in dry conditions for a further month, after which there was still no sign of development. These were then moistened and development commenced. It was not possible to determine what proportion of eggs to which this applied, but this ability to remain viable with delayed development under hot, dry conditions contrasts with the behaviour of the eggs of the Swiss and Italian biotypes described by Frick and Johnson (1972).

None of the potted plants colonized by larvae either at Yarram or at Canberra yielded adults during the 1979/80 season, suggesting that despite the early hatching and development of larvae in summer, no second generation of adults was likely. Eggs laid in early December outdoors in Canberra by the very first adults to emerge, yielded adults in March. Eggs laid by the same adults a few days later in the large cage at Yarram had not yielded any adults in the cage by June. Though material was held in the shade, temperatures were higher outside at Canberra than in the field at Yarram.

CONCLUSIONS

A large proportion of the *L. jacobaeae* population reared and released in Australia shows uninterrupted development under laboratory and field conditions. Delayed egg development occurs in a small proportion of the population under laboratory conditions but in the field, has been confirmed only for eggs kept under warm dry conditions. Even under such conditions in the field during summer, dehydration does not seem to be a significant mortality factor, development proceeding normally for large numbers of eggs and larvae. However, adults developing from these larvae have not appeared in the same season in the field, emergence apparently being delayed until spring.

The adults released free in the field in autumn did not seem to produce the next generation of adults until late the next summer, though as numbers were small, this requires confirmation. Frick and Johnson (1973) commented that aestivating adults may be difficult to find in midsummer but rainfall distribution was very different in the situation described by these authors and this explanation does not seem to be applicable to the present observations.

The simplest explanation of the observations made so far is that adults normally start reproducing in early summer, eggs hatch during summer and into autumn and adults appear the next summer. This fits the observations on adults exposed since early summer, and if by making field releases in autumn, the bulk of this summer development was missed it would explain why adults were only observed late in the next season. This would be basically similar to the phenology recorded in England (Figure 1), i.e. there is no adult or egg aestivation. The timing is slightly different, though this could be explainable in terms of Australian temperatures and different developmental rates and thresholds of the Anonnay population. However, it is known that egg development and early larval development are not delayed and are well in advance of the timing observed in England, so that the pupal or teneral adult stage must be very prolonged.

More curiously however, if neither an adult nor an egg aestivation is necessary, the significance of the extended development possible in some eggs is difficult to appreciate. Further, if continuous development can be satisfactory under these conditions and in England, why should it not occur in Switzerland? Compared with England, Switzerland is cooler but the adults emerge sooner.

Also, given the current findings on egg survival and hatching under hot, dry conditions, the necessity for an adult aestivation in Italy is perhaps not quite so clear.

Obviously, a complex situation of variation between populations exists in Europe. The eventual phenology of *L. jacobaeae* in Australia will be of considerable interest, as will be any light it sheds on this situation.

In conclusion, how this might fit into the control system should be considered. If *S. jacobaea* were growing undisturbed there might be cause for concern as the two year old plants which would contain the developing larvae could still seed, but die before the larvae developed, whereas if the plants are forced to perennate, e.g. by grazing damage, larval survival could be increased. Whether this is so will also be of considerable significance and interest.

ACKNOWLEDGEMENTS

We would like to thank E.E. Lewis, V.A. Crompton, I. Boardman and A. Walker for their assistance at various times in this project.

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