Longitarsus echii and its impact on Echium plantagineum (Paterson’s curse): the insect for the Mediterranean rainfall range of the weed?

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Summary Since the release program for biological control of Echium plantagineum started, the establishment of insects in the drier Mediterranean rainfall areas of Australia has been poor. To rectify this poor establishment in low rainfall regions, the winter active flea beetle, Longitarsus echii, was imported from Mediterranean Europe, cleared through quarantine and insects supplied to collaborating State Departments for mass rearing by 1997. L. echii has now been released at 100 sites across temperate Australia and established at greater than 80% of sites. To confirm the ability of L. echii to limit the growth and reproductive potential of E. plantagineum, a fully replicated randomised block field experiment was conducted in the winter of 1998. The experiment was designed to measure insect feeding, pasture competition and their interaction. Plant reproductive effort and mortality was not affected by L. echii larval feeding alone but was reduced 90% by pasture competition. In combination with pasture competition larval feeding increased weed mortality by 26% and reduced reproductive effort a further 75% and 93% for moderate and high rates of larval feeding.

Keywords Biological control, below ground herbivory, plant competition, Boraginaceae, flea beetle.

INTRODUCTION

Echium plantagineum is a weed of temperate pastures in Australia, dominating a wide range of Mediterranean to continental climatic conditions (Piggin and Sheppard 1995). Its climatic range appears wide in Australia when compared to the native range, but subtle differences in rainfall patterns between Australia and the Mediterranean, in addition to reduced interspecific competition in the exotic environment, might explain this. The wide range of climatic conditions that E. plantagineum can dominate could make it difficult for any one species of insect to limit the vigour of the weed. The redistribution project for the biological control insects of E. plantagineum has been releasing the crown weevil, Mogulones larvatus, since 1993, the root weevil, Mogulones geographicus, since 1995 and the flea beetle, Longitarsus echii, since 1996. Following multiple releases of these insects in Australia, the success of establishing and damaging their host has varied widely across the country. Establishment rates, population growth rates and impacts have been observed to be lower, especially for M. larvatus, in areas of typically late autumn rainfall (Sheppard et al. 1999). Part of the reason for this is believed to be the limited capacity of M. larvatus to aestivate successfully when the summer break can be as long as six months and where adults weevil mortality can approach 100%, i.e. beyond April, which is typical of the autumn break in the states of Western and South Australia.

The mass rearing of L. echii in Canberra, Perth, Frankston and Mudgee has shown adults are most abundant in winter and early spring, a perfect time to become active in regions of late seasonal breaks. One of the concerns with L. echii as an effective biological control insect was that, even if it did emerge in large numbers after summer, would subsequent larval feeding in late winter and spring reduce E. plantagineum size and seed production? To confirm the ability of L. echii to successfully aestivate through an extended summer and to measure impact on its weedy host, controlled experiments were conducted to measure these factors.

MATERIALS AND METHODS

Biology of L. echii L. echii is a halticic beetle [Coleoptera: Chrysomelidae] native to the Mediterranean regions of southern Europe and North Africa. L. echii is univoltine and adults emerge after autumn rain from earthen cells up to 20 cm below ground. Adults feed on the foliage of E. plantagineum and after 1–2 weeks lay eggs directly on the taproot of the plant. Larvae hatch after 2–3 weeks and feed in the cortex of the taproot and secondary roots. If there are sufficient larvae on a plant, the entire root system will be destroyed and feeding can continue into the crown, killing the plant. When feeding is complete, larvae leave the plant, form an earthen cell in the soil and pupate. Adults remain in the earthen cell until autumn rain stimulates them to emerge and start a new generation in the following autumn/winter (for more information see Wapshere 1982).

Laboratory experiment To accurately record adult emergence after summer, L. echii was reared in a fibreglass tub 1100 mm × 1100 mm by 300 mm deep at the CSIRO Black Mountain laboratory Canberra. The tub had 16 holes drilled in the bottom and placed on
a pallet to improve drainage. The tub was filled with soil and 36 rosettes of *E. plantagineum* grown for two months in 150 mm pots were transplanted in the last week of June 2001. An aluminium cage covered with a thrip mesh, the same dimensions as the tub and 1000 mm high was secured to the tub. In the last week of July, 100 adults of *L. echii* were added to the tub that was also covered by a polycarbonate roof so rainfall and soil moisture could be regulated. In autumn, a potted plant of *E. plantagineum* was added to the tub and was actively watered from May to promote emergence and adults of *L. echii* were collected weekly.

**Field experiment** The trial was conducted at the CSIRO experimental station, Ginninderra ACT in 1998 in a fenced area. Seeds of *E. plantagineum* were germinated in a mixture of perlite/vermiculite in May. Seedlings were pricked out into 50 × 150 mm tubes and grown in a glasshouse at 10/20°C for three weeks when they were moved outside to harden off before transplanting into the field. Plants where selected for uniformity of size, at the six to eight leaf stage and 200 mm high was secured to the tub. In the last week of June 2001. An aluminium cage covered with a polycarbonate roof so rainfall and soil moisture could be regulated. In autumn, a potted plant of *E. plantagineum* was added to the tub and was actively watered from May to promote emergence and adults of *L. echii* were collected weekly.

**Laboratory experiment** In the over-summering trial, the emergence of *L. echii* from aestivation occurred over an extended period from May to August with peak emergence in July (Figure 2). In total, 2886 *L. echii* adults were collected from the rearing tub.

**Field experiment** Figure 3 shows the effect of the four treatments on plant size of *E. plantagineum*, which was highly significant (*F*<sub>3,81</sub> = 103.2, *P* <0.0001). After planting, the control plants grew vigorously with an average dry weight of 95 grams at the end of seeding. The addition of *L. echii* at the levels used in this experiment alone had little impact on *E. plantagineum*. Plant competition significantly reduced plant size by 94% (*t*<sub>42</sub> = 6.06, *P* <0.0001). The addition of *L. echii* to the plant competition treatment reduced plant size by a further 62% (*t*<sub>39</sub> = 2.97, *P* <0.01). In addition when the
level of \textit{L. echii} attack was taken into account, plants rated for a high level of larval feeding, shoot weight was reduced by 81\% relative to the plant competition treated \textit{E. plantagineum} ($t_{37} = 3.97, P <0.001$).

Figure 4 shows the effect of the four treatments on seed production of \textit{E. plantagineum}, which was highly significant ($F_{(3,81)} = 30.5, P <0.0001$). Seed number is closely associated with plant size and the treatment effects follow the same trend. \textit{L. echii} feeding alone had no effect on \textit{E. plantagineum} but pasture competition reduced seeding by 93\% ($t_{42} = 63.9, P <0.0001$). The addition of \textit{L. echii} in combination with pasture competition reduced seed production by a further 75\% ($t_{51} = 2.66, P <0.01$). In addition when the level of \textit{L. echii} attack was taken into account, plants rated for a high larval feeding, seed production was reduced by 93\% relative to the plant competition treated \textit{E. plantagineum} ($t_{39} = 3.9, P <0.001$).

Mean individual seed weights were not significantly different between treatments ($P = 0.36$). \textit{E. plantagineum} mortality was nil for the control and \textit{L. echii} but 8\% and 26\% for the plant competition and plant competition + \textit{L. echii} treatments respectively.

**DISCUSSION**

The rearing and aestivation experiment confirms what had been seen in mass rearing throughout the country, namely that peak emergence of \textit{L. echii} occurs through the middle of winter, with 63\% of adults emerging in July (Figure 2). Starting with a parental generation of 100 adults (50 females) a total of 2886 adults successfully emerged the following year. A total of 58 adults per female, potentially giving the \textit{L. echii} field populations a high intrinsic rate of increase even in climatic regions where the seasonal break can occur as late as July. The ability to successfully survive late season breaks has been confirmed by field observation in Western Australia where 84\% of \textit{L. echii} releases have established, even after the driest summer/autumn on record in 2001. Compared to the establishment rate of 16\% for \textit{M. larvatus} and 47\% for \textit{M. geographicus} in Western Australia, \textit{L. echii} is clearly the best insect for the climatic conditions experienced in that State.
or any region with late autumn breaks. The ability of L. echii to reproduce efficiently on E. plantagineum will have to be achieved under grazing conditions. L. echii will tolerate grazing better than the root and crown feeding weevils because only the adult stage of its life history is above ground and exposed to livestock (Smyth et al. 2000). Protection from grazing can only benefit the population growth of L. echii.

Whether L. echii population can successfully breed into large numbers or not, larval feeding will still need to reduce the growth and seeding of E. plantagineum significantly to reduce the dominance of the weed in Australian temperate pasture. In the field experiment, by itself, L. echii did not reduce the size or seeding of E. plantagineum (Figures 3 and 4). When E. plantagineum plant size was limited by pasture competition, the same level of L. echii attack reduced plant size by 62% and seeding by 75%. Mean individual seed weight was not significantly different between treatments, so reproductive effort was also reduced by 75%.

This experiment shows that once larval numbers per plant weight are high enough, plant growth and seeding can be significantly reduced. Encouragingly, when the level of larval attack was accounted for, plants rated for a high level of larval feeding had shoot weight and seed production reduced by 81% and 93%, respectively. If this level of reduced seed production is maintained through several seasons, soil seed banks and subsequent germination and recruitment of E. plantagineum will be reduced (Smyth et al. 1997). Importantly, the larval feeding damage to E. plantagineum in this experiment occurred at the same time as it would in the field, since peak adult emergence is in July (Figure 2) and adults were added to the plants in this experiment on 10 July. So, even though larval feeding of L. echii occurs late in the season (August–November) if sufficient numbers are present not only is plant size and seeding reduced, but also plant mortality is increased.

Making broad predictions about the likely success of a biological insect is difficult to do accurately. Many biological, climatic and management factors can affect the likely impact an insect herbivore may have on its host. However, in the case of L. echii, based on the data presented here, the prospects for this insect having an impact on E. plantagineum are very encouraging and its release across the widest possible range is the primary aim of national redistribution project for the biological control insects of E. plantagineum.

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REFERENCES