MELIGETHES PLANIUSCULUS (HEER) (NITIDULIDAE) AN INFLORESCENCE-FEEDING BEETLE, WITH GOOD POTENTIAL AS BIOLOGICAL CONTROL AGENT FOR *ECHIUM PLANTAGINEUM*

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Summary This paper summarizes the specificity, biology and impact of the inflorescence feeding beetle, *Meligethes planiusculus* on *Echium plantagineum*. Literature reviews and host specificity tests have confirmed that *M. planiusculus* development is restricted to the genus *Echium*. Beetle populations were followed in field samples of *E. plantagineum* flowering cymes collected throughout the flowering period in southern France. Oviposition occurred throughout the season and there was a partial second generation towards the end of the flowering period. In a controlled experiment, *E. plantagineum* plants attacked by *M. planiusculus* produced 65% less seed than control plants. These features give *M. planiusculus* good potential as a biological control agent for *E. plantagineum*.

INTRODUCTION

Echium plantagineum (L.). (Boraginaceae: Lamiales), a winter annual of Mediterranean origin is a major pasture weed of temperate Australia. Since the lifting of a high court injunction in 1988 *E. plantagineum* has been the subject of a CSIRO Division of Entomology biological control project. Wapshere (1985) proposed a suite of phytophagus insects that attack *E. plantagineum* throughout its life cycle that he considered to be capable of reducing the competitive ability of the weed through a reduction in both plant size and reproductive ability. To date the leaf mining moth, *Dialectica scalariella* (Zell.), the crown weevil, *Mogulones larvatus* Schultze, the root weevil, *M. geographicus* (Goeze) and the stem-boring beetle, *Phytoecia coerulescens* Scop., have been released.

Attacking the plant during seed production is now one of the aims of the project. Wapshere (1985), indicated that the cyme feeding moth *Ethmia bipunctella* F. and the tingid bugs *Dictyla echii* (Schrank) and *Dictyla nassata* (Puton) warranted consideration as biological control agents because of their ability to limit seed production. Unfortunately, host specificity testing has shown all three species to be polyphagous (M. Smyth unpublished data, Shepherd 1996). A second cyme feeding moth, *Ethmia terminella* Fletcher (Heer), and a inflorescence-feeding beetle *Meligethes planiusculus* (Nitidulidae) were the subject of a detailed comparative study in France in 1994. *E. terminella* was found to be unsuitable due to temporal asynchrony and poor affinity for the proposed host. *M. planiusculus* was found to be abundant, potentially damaging and potentially specific (Compton 1988, M. Smyth unpublished data). This paper summarizes work to date on the biology, host specificity and impact of *M. planiusculus* on *E. plantagineum* relevant to biological control.

HOST SPECIFICITY

Meligethes is almost exclusively an old world genus comprising approximately 250 species. There are about 125 European species (Schenkling 1913, Easton 1951, 1956, Spornraft 1967, Audisio 1988). More than 97 % of European species have host ranges restricted to one or a few closely related genera in a single plant family (Easton 1951, 1956, Spornraft 1967, Audisio 1988). In order of decreasing frequency the plant families are Lamiaceae, Brassicaceae, Fabaceae, Boraginaceae, Cistaceae, Rosaceae and Poaceae. The six known species in the *planiusculus* subgeneric group are all associated with the Boraginaceae and are circum-Mediterranean to western Asian in distribution. At least three of these species have only been reared from *Echium* spp. (Easton 1951, 1956, Spornraft 1967) and two others only reared from *Trichodesma* spp. (Audisio 1988). *M. planiusculus* has only ever been reared from *E. plantagineum,* and *E. italicum* L. (Compton 1988). Easton (1951, 1956) considers *E. vulgare, E. creticum* L., *E. giganteum* L. and *E. micranthum* Schoush are hosts and suggests many other *Echium* species in the Canary Islands are hosts. Given that the adults are pollen feeders, they have been occasionally collected from a broader range of flowering plants outside the flowering period of the larval host plant, including the genera *Salvia*, *Asphodelus*, *Senecio*, and *Leontodon* (Easton 1951, 1956). However, they are more frequently collected from other Boraginaceae e.g. *Borago officinalis* L. (Easton 1956) and *Cynoglossum officinale* L. (Caillol 1954). Easton (1956) found only males on *B. officinalis* (material having not been sexed from other collections) and concludes from his studies that non-*Echium* species do not support the life cycle of *M. planiusculus.*

Host specificity testing using an AQIS approved test plant list compiled using Wapshere's (1974) centrifugal phylogenetic system have also been completed. These tests have shown *M. planiusculus* to be highly host specific; oviposition is limited to the genus *Echium* (M. Smyth and A. Swirepik unpublished).

BIOLOGY

Meligethes planiusculus over-winters as an adult before becoming active in early spring to feed, mate and oviposit. Eggs are laid in the terminal buds of the flowering cyme and take 4–6 days to hatch (Compton 1988). Upon hatching, first instar larvae mine through the calyx and petals to feed within the flower bud on the anthers, pollen and ovules, where they moult into second and final instar larvae. Final instar larvae are more mobile and move between flowers feeding on the developing seed. Once development is complete, the larvae drop from the flowers to pupate in the litter/soil. Adults begin to emerge 10 days later (Compton 1988) and feed mostly on pollen, developing ovules and maturing seed in open flowers of *Echium* spp., before over wintering in the litter/soil.

Meligethes planiusculus field oviposition and larval development were studied for the period flowering period of *E. plantagineum* during the 1995 season. Samples were taken as close to weekly as possible between 11 April and 7 July. One cyme was collected at random from each of 20 randomly selected plants at a field site near the village of Vauvert in southern France (48° 36'N, 28° 42'E). In the laboratory counts were made of any eggs and larvae found on each cyme. Larvae were classed as being either early or late instar. *M. planiusculus* oviposition and larval development occurred throughout the flowering period of *E. plantagineum* (Figure 1). Oviposition peaked early in the season (6 May), and then declined to zero on 7 June. A second peak in oviposition was recorded on 14 June. There was a second peak in early-instar numbers corresponding to the second peak in oviposition, but a second peak in late-instar numbers was not observed. The second peak in oviposition indicates that *M. planiusculus* enters a partial second generation. The absence of a second peak in late-instar larvae may result from the completion of this stage between sample dates.

Mean ambient temperature during this period was high (24.9° C) in comparison to the period corresponding to the first peak of late-instar development during May and early June (15.9° C). However the rapid senescence of *E. plantagineum* at the end of the flowering period is a more likely reason for the absence of late-instar larvae in the final sample. Late instar larvae are mobile and it is probable that as their food source became limited they began searching for food, during senescence this would prove largely futile. Therefore it appears that in this population the majority of *M. planiusculus* that entered a second generation failed to complete development on *E. plantagineum* during 1995. *M. planiusculus* under quarantine conditions in Australia has completed a partial second generation under long (14 hr) daylength conditions. In this instance plants continued to flower throughout larval development, supplying a continuous food source.

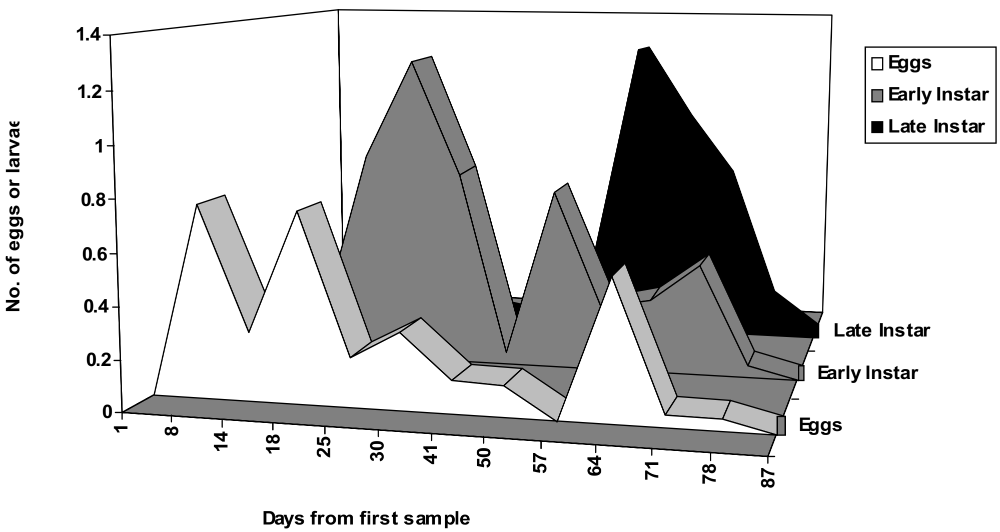

Figure 1. Field oviposition and larval development for *M. planiusculus* on *E. plantagineum*, 1995.

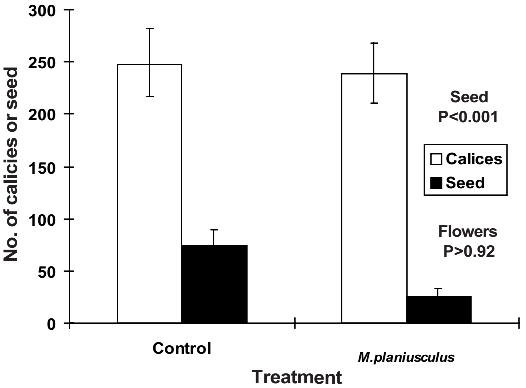

Figure 2. Mean number of calices and seed per plant, control and *M. planiusculus* attacked plants (±SE) (back transformed data).

IMPACT

To measure the impact of *M. planiusculus* on flower and seed production 64 *E. plantagineum* rosettes were paired for size (using root crown) diameter in April 1995. The resulting pairs of plants were then randomly planted out 1.5 m apart into an 8 × 8 block design in the grounds of the CSIRO Montpellier laboratory. Tube shaped nylon cages 1.2 m high by 1 m in diameter were placed over each plant. In May, 34 *M. planiusculus* adults were caged onto each 'attacked plant', while caged control plants were given two applications of the insecticide (Rogor® 1 mL L^{-1} + wetting agent) at weekly intervals to exclude any attack that may have occurred before caging.

Seed and calyx production were recorded on a weekly basis for a sub sample of 10% of the total flowering cymes per plant, selecting cymes produced over the entire flowering period. A minimum of two cymes per plant were selected for plants with a total cyme number less than ten. Analyses were based on Log_{10} transformed data, differences between treatment means were calculated using a paired T-test.

Calyx and seed production for the control and *M. planiusculus* treated plants are illustrated in Figure 2. A comparison of mean calyx production per plant showed that there was no significant difference between treatments. A similar comparison for mean seed production per plant, between treatments, demonstrated *M. planiusculus* significantly reduced seed production by 65%. Peak larval numbers coincided with the peak of seed loss (A. Swirepik, A. Sheppard and M. Smyth unpublished data.

CONCLUSION

Meligethes planiusculus is specific to the genus *Echium*. It is capable of completing a partial second generation on *E. plantagineum* which has implications for its use as a biological control agent in Australia. Although *E. plantagineum* flowers for a maximum of three months (Coste 1937) in southern France, in south eastern Australia the flowering period may be up to five months (Piggin and Sheppard 1995). Therefore, a second generation should increase the capacity of the agent to curtail seed production in Australia. A similar capacity has been recorded for another biological control agent of thistles by Woodburn and Cullen (1996).

The 65% reduction in seed set achieved by *M. planiusculus* may not be sufficient to force *E. plantagineum* recruitment to become seed limited. However *M. planiusculus* has been imported into Australia as one of a suite of agents to control *E. plantagineum*. To date the crown weevil *M. larvatus* (Sheppard in press) and the root weevil *M. geographicus* (G. Forrester, A. Sheppard unpublished data) have been shown to significantly reduce seed production, through a reduction in plant size prior to flowering. The additive effect that *M. planiusculus* should have to the activities of these other proven agents should greatly increase the potential for the biological control of *E. plantagineum*.

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