

STIMULO-DETERRENT DIVERSION OF *ELDANA SACCHARINA* (LEP: PYRALIDAE) AND *XANTHOPIMPLA STEMMATOR* (HYMENOPTERA: ICHNEUMONIDAE) - PRELIMINARY RESULTS.

DE CONLONG¹ AND B KASL²

¹South African Sugar Association Experiment Station, Private Bag X02, Mount Edgecombe, 4300. South Africa.

²Ecophysiological Studies Research Program, Department of Zoology, University of the Witwatersrand, Johannesburg, South Africa.

Abstract

Plant species emit specific semiochemicals when attacked by insects. These make plants unpalatable or repellant to herbivores, and/or attract natural enemies of herbivores attacking the plant. It is hypothesized that sugarcane, because of selection for higher sucrose, among other required traits over the years, has had the ability to produce semiochemical bred out of modern varieties. This may explain why no parasitoids are found attacking *Eldana saccharina* Walker in sugarcane, while they are commonly found on this insect in adjacent indigenous host plants. Some plants emit these semiochemicals as natural metabolic by-products. Preliminary work on attractant properties of indigenous grass and legume species on a pupal parasitoid of *E. saccharina* has been completed. In olfactometer trials, *Xanthopimpla stemmator* Thunberg was attracted to *Melinis repens* and the South African variety of *M. minutiflora* in preference to sugarcane. In cage trials, *X. stemmator* parasitism (%) was higher on *E. saccharina* pupae when sugarcane was in association with South African (21%) and Kenyan (33%) *M. minutiflora*, *M. nerviglumis* (19%) and *Desmodium uncinatum* (17%) than when sugarcane was the only plant (14%).

Research is continuing on effects of these plants on other indigenous parasitoids, and into the creation of a sugarcane agroecosystem incorporating these plants, thereby reducing *E. saccharina* populations with no reduction in sugarcane yield.

Introduction

There are 100 000 chemicals produced by 200 000 flowering plants, most of which are not directly essential to the plants (Metcalf and Metcalf, 1992). Many of these are emitted as volatiles, which, through evolutionary processes, have become chemical messages to insects (semiochemicals), either deterring or attracting them. Plant volatiles are generally used by parasitoids as long range signals to find their host's habitat (Howse *et al.*, 1998). Once in the host's habitat, they may use a variety of other cues as short-range signals. It is likely that wild ancestors of modern crop species had defence mechanisms that included production of these volatiles. However, through selective breeding, plants with these defence mechanisms may have been lost in favour of plants with high product yields (Pickett and Woodcock, 1993). It is hypothesised that modern sugarcane has lost its volatile defence mechanism, thus explaining why indigenous parasitoids have not followed *E. saccharina*

into, and why new association parasitoids have not stayed in the sugarcane habitat (Conlong, 1994).

With knowledge of such plant volatiles, new control methods against pests can be applied. Pests can be attracted into non-crop plants that produce volatiles attractive to them. Schulthess *et al.* (1997), show that *E. saccharina* females prefer to oviposit on *Pennisetum polystachion*, but progeny survival is zero. Other plants emitting volatiles deterring pests from feeding or oviposition can be intercropped with commercial crops to deter pests from these (Howse *et al.*, 1998). This strategy has been termed the 'push-pull' strategy (Pyke *et al.* 1987) or 'stimulo-deterrent diversion (SDD)' (Verkerk *et al.*, 1998). More recently in Kenya, a combination of non-host plants attracting ovipositing moths around outskirts of crop fields, and others repelling pests and attracting parasitoids intercropped within cereal crop fields, significantly decreased stalk borer infestation in the crops, and increased larval parasitism of borers by *Cotesia sesamiae* Cameron (Hymenoptera: Braconidae) (Khan *et al.*, 1997).

Research was initiated into determining whether plants used by Khan *et al.* (1997), but sourced in South Africa, elicited similar responses from *E. saccharina* and its parasitoids. This paper describes the response of the pupal parasitoid *Xanthopimpla stemmator* Thunberg (Hymenoptera: Ichneumonidae) to volatiles emitted from these plants, and its parasitism response to *E. saccharina* exposed in cages containing sugarcane only, and sugarcane and one each of the non-host plants. *X. stemmator* is not indigenous. It was imported as a 'new association' parasitoid from Mauritius, where it was established on *C. sacchariphagus* pupae in sugarcane. It has accepted *E. saccharina* pupae, and a strong laboratory culture has been established.

Materials and Methods

In addition to sugarcane, the following grasses were tested:

Melinis repens

M. minutiflora (Australian)

M. minutiflora (Kenyan)

M. minutiflora (South African)

M. nerviglumis

Cymbopogon plurinodes

All emit aromatic volatiles and are useful fodder crops. *Melinis minutiflora* and the legume *Desmodium uncinatum* were used by Khan *et al.* (1997) in their successful intercropping trials.

A glass 2-way olfactometer (Steinberg *et al.*, 1992) was attached to a suction pump that pulled air over a six month old sugarcane plant enclosed in a clear nylon bag and attached to one arm of the olfactometer. The other arm was attached in a similar way to one of the non-host plants (two months old) listed above.

Female *X. stemmator* were introduced into the third arm and allowed one minutes to orientate. If a choice was immediately made, the female was left for 15 seconds longer for confirmation of the choice. If no immediate choice was made, the female was left for five minutes to allow it to make a choice. A choice was regarded as positive if the female moved past a mark made 5cm down from the arm junctions. Trials were repeated 20 times using 20 different females per plant choice.

Eight cages (1 x 1 m base and 2 m high), covered with green shade mesh were set up on plastic sheeting. Sandbags were placed around the base to keep the mesh in place and prevent insect escape. One of the listed non-host species was placed with a potted sugarcane plant in each cage. Each plant was set up in an opposite corner to sugarcane. Positioning was randomised. The control cage comprised two sugarcane plants. Different non-host species were rotated through different cages so that effect of cage position was eliminated.

E. saccharina pupae in drinking straw sections were attached with masking tape to plants in cages. One straw section containing two pupae was placed at the top of each plant, a second straw section with one pupa was placed in the middle, and a third straw section with two pupae placed at the bottom. Five pupae were thus attached to each plant, making a total of 10 pupae exposed per cage. Two mated six to 10 day old *X. stemmator* females were placed in each cage for four days, after which exposed pupae were removed, placed individually into cells of multicell trays, and observed every second day for adult emergence. Trials were replicated 10 times. A month after collecting pupae from cages, unemerged pupae were dissected and checked for *X. stemmator* oviposition puncture holes and/or parasitoid offspring. Sections of plastic drinking straw remained on plants so that pupae could be placed in the same positions for each repetition.

Results

No plants were significantly preferred over sugarcane by *X. stemmator* in olfactometer trials, although more females responded to different *Melinis* species used than to sugarcane. The most preferred plant was *M. nerviglumis*, followed by the South African variety of *M. minutiflora*. The following responses were recorded of *X. stemmator* females to sugarcane and the non-host plants *C. plurinodes* (50% and 45%; $\pm 2 = 0.05$; $p > 0.82$), *M. nerviglumis* (40% and 50%; $\pm 2 = 0.22$; $p > 0.64$), *M. repens* (25% and 70%; $\pm 2 = 3.56$; $p > 0.06$) and the South African variety of *M. minutiflora* (30% and 65%; $\pm 2 = 1.32$; $p > 0.25$) respectively.

Pupae exposed in cages on sugarcane accompanied by the African variants of *M. minutiflora* (21-33%), *M. nerviglumis*

(19%) and *D. uncinatum* (17%) showed higher parasitism than that recorded in the sugarcane control (14%). In contrast, there was lower parasitism of pupae exposed in cages with sugarcane and *C. plurinodes* (11%), *M. repens* (10%) and surprisingly, the Australian variant of *M. minutiflora* (10%).

In the field, however, *E. saccharina* pupae will normally only be found in sugarcane. All companion grasses tested were too small for *E. saccharina* development. Pupae placed on sugarcane in South African *M. minutiflora* and *M. nerviglumis* cages showed higher parasitism (27 and 26% respectively) than when pupae placed on both plants were considered. Similarly, parasitism of pupae placed on sugarcane in the *M. repens* cage also showed increased parasitism (13%). Even though no increased parasitism was recorded in pupae placed only on sugarcane in the Kenyan *M. minutiflora* cage, parasitism was still highest in this cage (30%). Similarly, parasitism of pupae on sugarcane in the Australian *M. minutiflora* cage remained lowest (8%).

Discussion

Pyke *et al.* (1987), Pickett and Woodcock (1993), Kahn *et al.* (1997) and Verkerk *et al.* (1998) provide examples of how improved knowledge of plant-pest-parasitoid ecology and interactions, including better knowledge of chemical ecology and its role between these trophic levels, led to improved pest control. In similar preliminary work with *E. saccharina*, *X. stemmator* and selected plant species, this paper shows evidence of improved parasitism. Best responses have been when *Melinis* species have been placed with sugarcane. These aromatic grass species emit volatiles causing the parasitoid to search in the vicinity of the plants for host cues (Khan *et al.*, 1997). This explains why almost twice the level of parasitism of *E. saccharina* pupae was recorded when they were placed on sugarcane in association with *M. nerviglumis* and Kenyan and South African varieties of *M. minutiflora*. *D. uncinatum* also causes *X. stemmator* to search more for its host when it is in association with sugarcane, than when sugarcane is by itself. The lack of response to Australian *M. minutiflora* shows possible differences between varieties of the same species. Australian *M. minutiflora* obtained from a commercial nursery in Australia, is extensively used for cattle fodder. Its strong odour is often carried through to milk of cattle that eat it, and because of this there has been an extensive programme to breed a less volatile variety with similar nutritional quality. The volatile that the parasitoid thus used in African varieties could have been bred out of the Australian variety, as explained by Pickett and Woodcock (1993). It also supports the hypothesis that the same ability of varieties to attract parasitoids to sugarcane infested by *E. saccharina* by using mechanisms such as plant volatiles, may have inadvertently been lost in the selection process of the SASEX sugarcane breeding programme.

This avenue of research is still in its infancy at SASEX. However, promising preliminary results indicate that much useful information may be obtained on parasitoid-non-host plant interactions using parasitoids found in *Cyperus papyrus* and *C. dives* plant communities (Conlong, 1990; 1994). This could lead to these parasitoids being attracted into adjacent sugarcane fields with some or combinations of some non-host plants.

Conclusion

In olfactometer trials *X. stemmator* responded to *M. repens* and *M. minutiflora* volatiles over those emitted by sugarcane. In addition, in cage trials, *X. stemmator* parasitised almost double the number of pupae exposed on sugarcane when in association with *M. nerviglumis*, Kenyan and South African varieties of *M. minutiflora* and, to a lesser extent *D. uncinatum*. These results encourage expansion of the project to attract known indigenous parasitoids into sugarcane fields, and to attract *E. saccharina* onto trap crops and away from sugarcane using non-host plants, in a scientifically designed agroecosystem.

REFERENCES

- Conlong, DE (1990). A study of pest-parasitoid relationships in natural habitats: an aid towards the biological control of *Eldana saccharina* (Lepidoptera: Pyralidae). *Proc S Afr Sug Technol. Ass.* 64: 111-115.
- Conlong, DE (1994). A review and perspectives for the biological control of the African sugarcane stalkborer *Eldana saccharina* Walker (Lepidoptera: Pyralidae). *Agriculture, Ecosystems and Environment* 48: 9-17.
- Howse, P, Stevens, I and Jones, O (1998). *Insect Pheromones and their uses in Pest Management*. Chapman and Hall. London.
- Khan, ZR, Ampong-Nyarko, K, Chiliswa, P, Hassanali, A, Kimani, S, Lwande, W, Overholt, WA, Pickett, JA, Smart, LE, Wadhams, LJ and Woodstock, CM (1997). Intercropping increases parasitism of pests. *Nature* 388: 631-639.
- Metcalf, RL and Metcalf, ER (1992). *Plant Kairomones in Insect Ecology and Control* Chapman and Hall, New York.
- Pickett, JA and Woodcock, CM (1993). Chemical ecology of plants and insects. Helping crops to help themselves. *Interdisciplinary Science Reviews* 18: 68-72.
- Pyke, B, Rice, M, Sabine, G and Zalucki, M (1987). The push-pull strategy-behavioural control of *Heliothis Australian Cotton Grower* May-June. pp 7-9.
- Schulthess, F, Bosque-Perez, NA, Chabi-Olaye, A, Gonou, S, Ndemah, R and Goergen, G (1997). Exchange of natural enemies of lepidopteran cereal stem borers between African regions. *Insect Sci Applic* 17: 97-108.
- Steinberg, S, Dicke, M, Vet, LEM and Wanningen, R (1992). Response of the Braconid parasitoid *Cotesia (=Apanteles) glomerata* to volatile infochemicals: effects of bioassays, setup, parasitoid age and experience and barometric flux. *Entomologia Experimentalis et Applicata* 63: 163-175.
- Verkerk, RJH, Leather, SR and Wright, DJ (1998). The potential for manipulating crop-pest-natural enemy interactions for improved insect pest management. *Bull Ent Res* 88: 493-501.