Technical note

Lethal effects of foliar pubescence of solanaceous plants on the biological control agent *Copidosoma koehleri* Blanchard (Hymenoptera: Encyrtidae)

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Summary

Adults of the parasitoid wasp *Copidosoma koehleri* Blanchard were exposed to leaves of five solanaceous plant species with widely different densities of glandular trichomes. No trichome related mortality was observed on *Capsicum anthem* L., or three wild potato species, *Solanum pinnahsectum* Dun., *S. chacoense* Bitt. or *S. polytrichon* Rydb., species with low to medium densities of trichomes. Trichome related entrapment was observed on leaves of tomato, *Lycopersicon esculenhum* Mill., which had significantly more dense tetralobulate glandular trichomes than other plant species. Results are discussed in relation to interactions between host plant resistance and biological control and the implications for integrated pest management for potato tuber moth, *Phthorimaea operculella* Zeller.

Introduction

The potato tuber moth, *Phthorimaea operculella* Zeller, is a significant pest of solanaceous crops in many countries including Australia (Dillard *et al.* 1993). Horne (1990) suggested that a guild of parasitoid biological control agents can significantly reduce *P. operculella* populations in unsprayed potato crops. Trials which augmented existing parasitoid populations with *Copidosoma koehleri* Blanchard by introduction of pupal cases, indicated that such a technique could be a useful component of a pest management strategy which integrated biological and cultural methods (Horne 1991). Of the three parasitoid species established in Australia, *C. koehleri* an egg parasitoid specific to *P. operculella* (Callan 1967), appears most suited to mass rearing for inundative biological control because it is polyembryonic, with each parasitized host producing an average of 30 parasitoid pupae (Horne 1991).

However, *P. operculella* has a strong preference for oviposition on foliage which is hairy rather than smooth (Fenemore 1980), and Gurr (1995) has hypothesized that such behaviour may be a defensive adaptation, reducing parasitism by *C. koehleri.* Such an effect may be operate via a sub-lethal mechanism, in which parasitoid searching is slowed by leaf hairs, and/or by a lethal effect, in which parasitoids are affected by glandular trichome exudates. The aim of this study was to test for the operation of the latter mechanism.

This has significant implications for the development of integrated pest management in potatoes since breeding for insect resistance via increased tri-chome density is being attempted (Kalazich and Plaisted 1991).

Materials and method

Plants of three wild potato species, *Solanurn chacoense* Bitt., *S. pinnatisectum* Dun. and *S. polytrichon* Rydb. were grown from tubers of common origin and those of *Capsicum annuum* L. cv. Yolo Wonder and *Lycopersicon esculentum* Mill. cv. Tommy Toe were grown from seedlings purchased from a commercial nursery. Plastic cylinders with nylon mesh caps were used as cages of 500 mL capacity, each holding the youngest fully expanded leaf excised from one of the test plants. The petiole was inserted into a 2 mL vial of water and the vial sealed to prevented parasitoid entry (preliminary trials showed that this can account for considerable mortality).

Adult *C. koehleri* females less than 24 hours old from two pupal cases (mean = 59, range 26–94) were exposed to leaves in these cages for a 24 hour period at 26°C and under artificial lighting (16 hour light: 8 hour dark). Parasitoids were from a laboratory colony (Institute for Horticultural Development, Knoxfield, Victoria).

The experiment was temporarily replicated with fresh parasitoids being exposed to leaves of each of the five species on three occasions over a 72 hour period. Immediately after each 24 hour exposure, parasitoids were killed with ethyl acetate and leaves were examined for entrapped parasitoids. Untrapped insects were examined for the presence of trichome exudates on body parts using a ×20 binocular microscope.

Data were analysed by analysis of covariance using leaf surface area and the total number of parasitoids per cage as co-variates. Leaf area was estimated by photocopying leaves and weighing the excised image, then entering the weight into a regression formula. The formula was derived by regressing the known area of 10 pieces of photocopy paper (100 mm^2 to 10 000 mm^2) against their weight. Trichome densities were determined by observations of a 7 mm^2 transect on leaves from three specimens of each plant species.

Results and discussion

No trichome related mortality was observed on leaves of *C. annex*, *S. chacoense*,

Table 1. Glandular trichome associated mortality of *Copidosoma koehleri* from 24 hours exposure to solanaceous plants.

Plant species	% Mortality[A]	Adjusted mean[B]
L. esculentum	2.68	4.9811 b
C. annuum	0.00	-0.4453 a
S. chacoense	0.00	-0.8771 a
S. pinnatisectum	0.00	-0.2886 a
S. polytrichon	0.00	-1.3701 a
LSD (P=0.01)	–	1.168

Values followed by the same letter are not significantly different at P=0.01.
[A] Mean of three replicates—individuals either trapped on leaves or with oxidized exudates on body.
[B] Means adjusted for co-variates: leaf surface area and number of parasitoids per cage.

Table 2. Glandular trichome densities of solanaceous plants.

Plant species	Glandular trichomes[A]			
	Tetralobulate		Ovoid	
	Upper leaf	Lower leaf	Upper leaf	Lower leaf
L. esculentum	62.3 b	45.7 c	0.0 a	0.0 a
C. annuum	1.0 a	1.3 a	0.0 a	0.0 a
S. chacoense	0.0 a	17.0 b	0.0 a	1.0 a
S. pinnatisectum	0.0 a	4.0 a	3.6 b	21.3 b
S. polytrichon	0.7 a	24.7 b	3.0 b	0.0 a

Values within a column followed by the same letter not significantly different at P=0.05 (Analysis of variance and Tukey's pairwise comparisons).
[A] Counts per 7 mm^2.

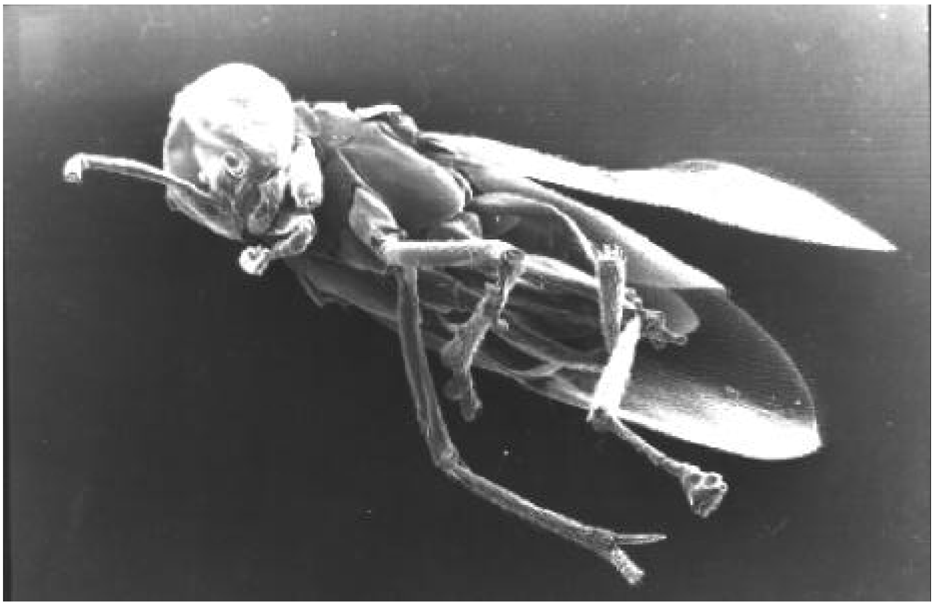

Figure 1. Scanning electron micrograph of entire *Copidosoma koehleri* adult removed from a leaf of *Lycopersicon esculentum* showing oxidized glandular trichome exudate on rear right tarsus.

S. polytrichon or *S. pinnatisectum*, but significantly more parasitoids, an average of 2.68 per cent, were affected when caged on leaves of *L. esculentum* (Table 1). These were either stuck to leaf surfaces or had deposits of oxidized trichome exudate present on tarsi (Figures 1 and 2).

Lycopersicon esculentum had significantly more dense tetralobulate trichomes on upper and lower surfaces than other plant species in this study (Table 2). Gibson (1971) suggested that lethal effects of trichomes are linked to their density since the chance of contacts with trichomes rises with their density and, for aphids, movement was seriously impaired only after several dozen or a few hundred contacts. Observations of leaf surfaces in the vicinities of entrapped parasitoids in this study support this notion with dozens of trichomes showing dark oxidized exudates at their tips rather than the pale glistening tips typical of intact trichomes. Furthermore, trichome deposits on parasitoids were evident only following exposure to leaves of *L. esculentum* which had significantly more dense tetralobulate trichomes than other plant species.

Though less than three per cent of parasitoids were affected in the 24 hour periods used in this study, field longevity of this species is longer. During the summer adults of *C. koehleri* typically survive for six days in field cages with access only to water (personal observation) and, in the laboratory, starved adults typically survive for three days, even without water (P.A. Horne personal communication). Thus, there is potential for far longer exposure to trichomes and gradual accumulation of trichome exudates. Such an effect may be particularly significant at low *P. operculella* densities (the aim of pest management) when the parasitoid is required to search foliar surfaces for relatively long periods for host eggs. Furthermore, such lethal effects of trichomes on *C. koehleri* may be in addition to sub-lethal effects resulting from non-glandular leaf hairs.

However, Obrycki (1986) reported the adverse effects of trichomes on various beneficial insects to be less severe in the field than in laboratory or glasshouse test situations. Consequently the levels of entrapment observed in this study may be reduced in the field by factors such as parasitoid vigour being superior to that of colony members.

Observations of this study establish that one potentially important biological control agent of a significant pest of solanaceous crops may be adversely affected by glandular trichomes. From a tritrophic evolutionary perspective these observations suggest that a herbivorous insect may be able to exploit antixenosis defence mechanisms of the host plant for its own protection from parasitism. However, the extent to which plant defences also lead to neonate mortality in *P. operculella*, prior to the establishment of leaf mines, has yet to be determined.

Valencia (1984) has reported glandular trichome densities of between 8.87 mm^2 and 3.77 mm^2 for 10 cultivars of the cultivated potato and since these densities are lower than those found to lead to parasitiod mortality in this study it is unlikely that biological control by *C. koehleri* would be impaired to a large extent in current potato cultivars. However, such an effect could be significant in more densely pubescent tomatoes and in potato clones bred for insect resistance based on trichomes. Further work is planned to quantify sub-lethal effects of foliar pubescence and whether parasitiod performance is significantly impaired under field conditions.

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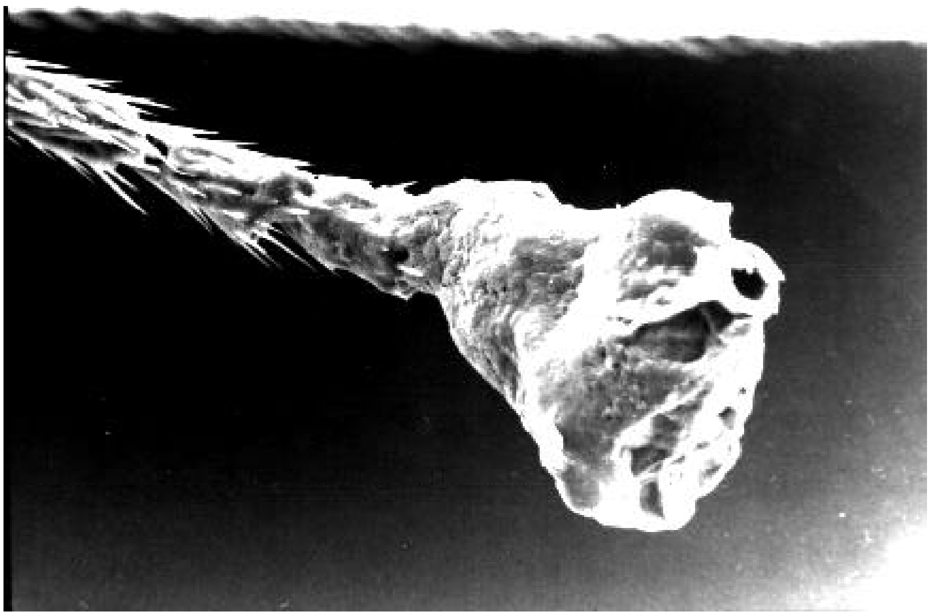

Figure 2. Scanning electron micrograph of terminal portion of rear right tarsus of *Copidosoma koehleri* adult removed from a leaf of *Lycopersicon esculentum* showing oxidized glandular richome exudate.

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