HOST RANGE AND HOST CHOICE OF TRICHOGROMMA PLATNERI

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ABSTRACT

Trichogramma platneri Nagarkatti (Hymenoptera: Trichogrammatidae) is a native egg parasitoid used for augmentative biological control of Cydia pomonella Linnaeus (Lepidoptera: Tortricidae). In no-choice tests of host range successful attack and emergence was observed from five lepidopteran families (Pyralidae, Tortricidae, Gelechiidae, Sphingidae, Noctuidae) and from the green lacewing, Chrysoperla carnea Stephens, (Neuroptera: Chrysopidae). However, pairwise choice tests found higher levels of attack and greater reproductive success on the larger eggs of the noctuid and sphenid. Whether host suitability can be used as a measure of potential impact on non-target hosts in the field is currently being evaluated.

INTRODUCTION

The codling moth, Cydia pomonella, is the key pest of walnuts in California. Increased resistance to Guthion and other synthetic insecticides has decreased the effectiveness of codling moth control (Varela et al., 1993). Augmentative releases of an egg parasitoid, Trichogramma platneri have proved to be effective on an experimental scale (Mills, 1998). Before T. platneri can be used on a commercial scale for codling moth control in walnut orchards, its potential environmental impacts must be assessed. Over the past 10-15 years there has been increasing concern about the possible adverse impacts of biological control (Howarth, 1991; Lockwood, 1993; Simberloff and Stiling, 1996).

The host range of the natural enemy is particularly important when a generalist control agent such as Trichogramma spp. is used. Trichogramma species have a wide host range and are known to attack 400 species, from 203 genera, in 44 families and 7 orders (Li, 1994). Bai et al. (1995) found T. minutum parasitized four species in three families (Geometridae, Noctuidae, Tortricidae) in a no-choice situation. T. nr ivalae also attacks species in three families: Noctuidae, Nymphalidiae and Papilionidae (Bjorksten and Hoffman, 1995). Choice tests have found host size to be an important factor for both natural host eggs from different species (Bjorksten and Hoffman, 1995) and artificial host eggs (Nurindah et al., 1999). Host suitability appears to be variable not only between species but also among different strains of the same species (van Dijken et al., 1986; Wuhrer and Hassan, 1993). Although T. platneri is native to California, its use in augmentative control requires the release of larger numbers of adult parasitoids than would be present naturally. An assessment of host range and suitability would be a significant advance in assessing the potential for non-target effects from inundative releases of this parasitoid.

Here we report the outcome of no-choice host range tests and pairwise host choice tests conducted in the laboratory. The six host species were from two orders (Lepidoptera, Neuroptera) and six families, and represent a range of egg shapes and sizes. These tests are part of a larger study including field assessment of host range.

MATERIALS AND METHODS

All host eggs used in these experiments were either frozen or irradiated when 24 hours old to halt larval development and stored at 5°C no more than 7 days until exposed to T. platneri. Short periods of freezing and cool storage of eggs does not affect their acceptability to Trichogramma (Nagarkatti et al. 1991, Daumal and Boine 1994). Six species were used in these tests and all pairwise combinations tested: C. carnea, C. pomonella, Ephesia kuehniella Zeller, (Lepidoptera: Pyralidae), Helicoverpa zea Boddie, (Lepidoptera: Noctuidae), Manduca sexta Linnaeus, (Lepidoptera: Sphingidae), Sitotroga cerealella Olivier, (Lepidoptera: Gelechiidae). The characteristics (shape, weight) of each potential host egg were recorded (Table 1). T. platneri, C. carnea and S. cerealella were supplied by Rincon-Vitova Insectaries (Ventura, CA), H. zea by Ecogen Inc. (Langhorne, PA), M. sexta by Carolina Biological Supply, (Burlington, NC), C. pomonella by Sterile Insect Release Program (Osoyoos, BC) and E. kuehniella was reared at UC Berkeley.

To determine physiological host range 30 1-day old, mated, naive, honey fed females were individually presented with a card of 20 eggs in glass vials (92x28x28mm) and incubated at 25°C and 16L:8D for 24 hours. Honey was provided during this time. The position and activity of each female was recorded at 15 minute intervals over the first two hours and last two hours of the oviposition period to determine the proportion of time spent in contact with the eggs. Pairwise choice tests followed a similar protocol except approximately 10-15 eggs of each host were presented to the parasitoids on the same card.
TABLE 1

Egg characteristics of the six hosts presented to *Trichogramma platneri* and sex ratio, size and egg load of the emerged parasitoids.

<table>
<thead>
<tr>
<th>Species</th>
<th>Egg shape</th>
<th>Mean fresh weight ± SE (mg)</th>
<th>Mean hind length ± SE (mm)</th>
<th>Mean 24h egg load ± SE</th>
<th>R² of egg load/size</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Chrysoperla carnea</em></td>
<td>Cylindrical, smooth</td>
<td>0.08 (0.004)</td>
<td>0.178 (0.002)</td>
<td>45.00 (2.18)</td>
<td>0.60</td>
</tr>
<tr>
<td><em>Cydia pomonella</em></td>
<td>Flattened, smooth</td>
<td>0.06 (0.002)</td>
<td>0.165 (0.002)</td>
<td>39.90 (2.33)</td>
<td>0.78</td>
</tr>
<tr>
<td><em>Ephesia kuehniiella</em></td>
<td>Ovoid, smooth</td>
<td>0.06 (0.001)</td>
<td>0.155 (0.001)</td>
<td>26.48 (0.58)</td>
<td>0.05</td>
</tr>
<tr>
<td><em>Helicoverpa zea</em></td>
<td>Hemispherical, ridged</td>
<td>0.11 (0.003)</td>
<td>0.189 (0.003)</td>
<td>60.79 (2.88)</td>
<td>0.58</td>
</tr>
<tr>
<td><em>Manduca sexta</em></td>
<td>Spherical, smooth</td>
<td>0.72 (0.28)</td>
<td>0.208 (0.002)</td>
<td>85.49 (2.54)</td>
<td>0.58</td>
</tr>
<tr>
<td><em>Sitotroga cerealella</em></td>
<td>Ovoid, ridged</td>
<td>0.05 (0.002)</td>
<td>0.144 (0.002)</td>
<td>16.89 (1.99)</td>
<td>0.14</td>
</tr>
</tbody>
</table>

After 24 hours the egg cards were removed and incubated under the conditions described above for 7 to 9 days. Any *T. platneri* that emerged were held for 24 hours with honey before data collection. For the no-choice tests sex ratio, female egg load and size (i.e. hind tibia length) were measured for each vial. For the pairwise choice tests the numbers of emerged males, females and total offspring (including unemerged pupae) were recorded. A host suitability index (ratio of parasitoid offspring/host eggs) was calculated from the emergence data and the absolute difference in value determined for each pairwise comparison. Vials with no parasitism in either host were excluded from analysis.

RESULTS

All six hosts were parasitized successfully by *T. platneri* in the no-choice tests. A significant linear relationship between size (hind tibia length) and female egg load was found for all six hosts (Table 1). Analysis of covariance initially suggested that both host (*F*₂, *₇₃₁ = 5.09, *P* < 0.001) and offspring size (*F*₁, *₇₃₁ = 249.88, *P* < 0.001) had an effect on egg load i.e., the six regression lines had different slopes. Further examination showed that the slope of the relationship between female size and egg load was similar for four of the six hosts (e.g., *C. carnea*) with the exception of *E. kuehniiella* and *S. cerealella* (Fig. 1). When these two species are excluded from the analysis of covariance only size has a significant effect on egg load (*F*₁, *₄₁₇ = 172.24, *P* < 0.001).

*T. platneri* spent significantly more time on the larger *M. sexta* and *H. zea* host eggs (Fig. 2) than other hosts offered in the choice tests (Kruskal-Wallis, *H*₁₄ = 168.74, *P* < 0.001). A greater proportion of females were also reared from larger host eggs such as *M. sexta* in the choice tests (Kruskal-Wallis, *H*₅ = 150.60, *P* < 0.001, Fig. 3). The other species offered in the choice test did not affect offspring sex ratio significantly. The absolute difference in host suitability index was significantly larger for comparisons of *M. sexta* with other hosts, particularly *C. carnea* and *S. cerealella* (ANOVA, *F*₁₄, *₄₇₅ = 40.72, *P* < 0.001, Fig. 4).

DISCUSSION

The relationship between offspring size and egg load suggests that the reproductive capacity of *T. platneri* is determined primarily by female size not the nutritional quality of the host egg. However, marginal host species such as *E. kuehniiella* depress reproductive capacity such that larger females develop fewer eggs than would be expected. The reduced reproductive capacity of *T. platneri* reared from *E. kuehniiella* and *S. cerealella* compared with other hosts suggests that commercially-reared parasitoids may be of poorer quality than is desirable.

The higher host suitability index for *M. sexta* demonstrates that given a choice between hosts of different sizes, *T. platneri* laid more eggs in the larger hosts. *T. australicum* also laid more eggs in larger hosts when offered a size range of artificial eggs (Nurindah *et al.*, 1999). This suggests that larger hosts may be more vulnerable to parasitism if exposed to *T. platneri* in the field. Once *T. platneri* selected a particular host for oviposition the allocation of male/female eggs was determined only by the host chosen, the other host present had no apparent effect. A greater proportion of females emerged from the three largest hosts (*M. sexta, H. zea, C. carnea*) although *C. carnea* and *H. zea* received fewer offspring in total compared to *M. sexta*.

From these results there is a possibility of interference between *T. platneri* and the beneficial predator, *C. carnea*. Under a choice situation there was not a significant difference in investment between the target pest (*C.
pomonella) and the non-target host (C. carnea). Eggs of the noctuid, H. zea, were also equally acceptable when offered with the target pest. Field tests of ecological host range are needed to determine if measures of host suitability can be used as an index of potential non-target impacts in the field.

Fig. 1. Linear regression of egg load and size (hind tibia length) for Trichogramma platneri females reared from Chrysoperla carnea (solid line, hollow circles, y = 890.5x – 133.4) and Ephesia kuehniella (dashed line, filled circles, y = 302.1x – 20.1).

Fig. 2. Percentage of time spent by Trichogramma platneri in contact with host eggs during choice tests. N = Chrysoperla carnea, C = Cydia pomonella, E = Ephesia kuehniella, H = Helicoverpa zea, M = Manduca sexta, S = Sitotroga cerealella. Bars with different letters are significantly different (P < 0.05).

Fig. 3. Mean number of female Trichogramma platneri offspring as a percentage of the total reared from each host used in choice tests. Letters and host abbreviations as in Fig. 2.
Fig. 4. Absolute difference in host suitability index (parasitoid offspring/host eggs) for each pairwise host comparison. Letters and host abbreviations as in Fig. 2.

ACKNOWLEDGMENTS
Research funded by the University of California Statewide Integrated Pest Management Project.

REFERENCES


158