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A N I N T E R N A T I O N A L J O U R N A L

Adult Feeding and Mating Effects on the Biological Potential and Parasitism of *Trichogramma pretiosum* and *T. acacioi* (Hym.: Trichogrammatidae)

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ABSTRACT

This work was carried out to study the effects of adult feeding and mating on the biological potential and parasitism of Trichogramma pretiosum and T. acacioi (Hymenoptera: Trichogrammatidae) to improve their use in biological control programs. Both species presented higher parasitism and longevity whenever adults were fed. Fed and unmated T. pretiosum females led to low parasitism whereas T. acacioi females did not present parasitism whatsoever. Egg viability of T. pretiosum was similar for fed and mated individuals, but T acacioi showed lower values for this parameter when unfed and without mating. Unmated females produced only males while mated ones had more than 60% female descendents for both Trichogramma species. Therefore, mated and fed female parasitoids should be released in crop systems to increase the biological control.

Key words: Biological control, parasitoid feeding, parasitoid mating

INTRODUCTION

Egg parasitoids of the genus *Trichogramma* (Hymenoptera: Trichogrammatidae) are used in biological control programs of different pests because they parasitize more than 200 pest species, mainly of the Lepidoptera order (Pratissoli et al., 2004). *Trichogramma* spp. are largely used, but it is necessary to identify their species and strains per region, because generally they are more adapted to local climate, habitat and pest (Botelho, 1997). Species selection is based on laboratory and field trials to study the parasitoid behavior, host preference and tolerance to climate (Pratissoli et al., 2004). However, biotic and abiotic factors, including mating and feeding, might affect these biological characteristics which could influence their efficiency (Berti and Marcano, 1991; Mcdougall and Mills, 1997; Thomson and Hoffmann, 2002).

Nectar and pollen are food source for *Trichogramma* adult in the field (Andow and Rish, 1987; Wellinga and Wysoki, 1989) and they affect their longevity and fecundity (Berti and Marcano, 1991; Mcdougall and Mills, 1997). These effects are important to select the best species or even strains for biological control

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program since the control effectiveness might vary between the strains of the same species.

Arrhenotoky is the most common *Trichogramma* reproduction type when fertilized and unfertilized eggs originate diploid females and haploid males, respectively. The complete parthenogenesis also occurs with both fertilized and unfertilized eggs originating diploid females. This may influence the control efficiency and persistency in the field. Fecundity might predict the success of parasitoids in the field (Thomson and Hoffmann, 2002). To study the parasitoid necessity of food supply previously its releasing is crucial in order to offer the best condition for the parasitoid to succeed in the field. Therefore, the objective of this study was to evaluate the effects of adult feeding and mating on the biological potential and parasitism of *T. pretiosum* and *T. acacioi*.

MATERIAL AND METHODS

Specimens of *T. pretiosum* and *T. acacioi* were obtained from the egg parasitoid mass rearing colonies. The colonies started from insects collected in tomato fields in Venda Nova do Imigrante, ES, Brazil at 750 meters (L5) and 1000 meters (L8) of altitude, respectively. Insects were reared in glass vials (8 x 2 cm diameter) using sterilized *Anagasta kuehniella* Zeller eggs (Parra et al., 1989).

The biological characteristics of *T. pretiosum* and *T. acacioi* were evaluated in climatic chamber at 25±1^{o}C, 70±10% of relative humidity and 14:10 (L:D). The design was completely random with four treatments and 10 replications for each *Trichogramma* species. The treatments with both *T. pretiosum* and *T. acacioi* were: 1) unmated female without food; 2) unmated with food; 3) mated female without food; 4) mated with food.

Parasitoids were individualized in glass vials (3.5 x 0.5 cm diameter) immediately after the emergence with 40 *A. kuehniella* eggs glued on cardboards (Hassan, 1997). One male and one female were used per replication in the treatment of mated individuals while only one female was placed per vial in the unmated treatments. Honey droplets were placed on the inner walls of the vials in the treatments with food. These vials were tapped with polyvinyl chloride (PVC) transparent film and placed in climatic chambers. Females were allowed to lay eggs and they were removed after a period of 24 h. Eggs and female adults were observed daily until emergence and adult female deaths. The number of eggs parasitized, developmental time, viability, and female longevity were evaluated. Data were submitted to ANOVA and means were compared with Tukey test (P=0.05).

RESULTS AND DISCUSSION

The percentage of parasitism by *T. acacioi* unmated females with food (53.75±7.21%) was significantly higher than that of unmated females without food (13.00±9.05%) (Table 1). Similarly, mated females with food parasitized significantly more (68.90±5.26%) than mated females without food (0.00±0.00%) (Table 1). The same results were observed with high parasitism by unmated fed females of *T. pretiosum*. (85.00±9.59%) compared to unmated females without food (64.50±14.18%) (Table 1). Mated females with food parasitized more eggs (83.50±4.69%) than mated females without food (23.50±12.50%) (Table 1). This showed the importance of food supply for massive rearings or adult field releases of these parasitoids in biological control programs.

There are different kinds of *Trichogramma* release techniques (Pinto, et al. 2003) but for all of them, it is crucial to offer a source of food such as honey droplet for example to the parasitoid. These parasitoids normally feed on nectar and pollen of wild flowers in natural conditions (Andow and Rish, 1987; Wellinga and Wysoki, 1989; Hohmann et al., 2002). However, the energy and time consumed in this activity may be saved and used to increase the parasitism by offering an artificial food supply close to the releasing points in the field. Adult feeding also increased the parasitism by *T. perkinsi* and *T. australicum* (Somchoudhury and Dutt, 1988). However, this characteristic could vary from species to species because fed and unfed *T. demoraesi* females showed similar parasitism rate (Santa-Cecília et al., 1987).

Other factors besides adult feeding such as strains, parasitoid species, host quality and temperature can affect the parasitism of *Trichogramma* spp (Lopes, 1988; Maceda et al., 2003; Pinto and Tavares, 1992; Pratissoli et al., 2004). The parasitism of *T. buesi* on *Pieres rapae* eggs reached a maximum of 36.4% when its females were fed with honey (Abbas, 1989) and *T. pretiosum* showed 80% of parasitism on *Anagasta kuehniella* eggs (Tironi, 1992). These are examples of how different species fed with honew could still have different parasitism capacity.

Besides adult feeding, mating is also important because *T. acaioi* and *T. pretiosum* showed different parasitism rate for the mated and unmated females. However, it also differed for females fed or not fed. Mated females without feeding had the lowest parasitism by both *T. pretiosum* and *T. acacioi*. Unmated *T. pretiosum* females had parasitism of 64.5% without food while those mated and unfed had 23.5% parasitism (Table 1).

Table 1 - Adult feeding and mating effects on fecundity, biological potential and parasitism rate of *Trichogramma pretiosum* and *Trichogramma acacioi* (Hym.: Trichogrammatidae) (25 ± 1 ºC, 70 ± 10% RH and 14 hours L:D). Means±SE followed by the same letter in the column for each strain are statistically similar to each other by Tukey test (P=0.05).

Treatment	**Parasitism (%)**	**Viability (%)**	**Sex ratio**	**Longevity (days)**
Trichogramma pretiosum (L5)				
Unmated females without food	64.50 ± 14.18 b	95.26 ± 1.08 a	0.00 ± 0.00 b	2.50 ± 0.22 c
Unmated females with food	85.00 ± 9.59 a	93.78 ± 3.79 a	0.00 ± 0.00 b	11.20 ± 1.58 a
Mated females without food	23.50 ± 12.50 c	92.53 ± 0.39 a	0.64 ± 0.09 a	2.60 ± 0.16 c
Mated females with food	83.50 ± 4.69 a	95.15 ± 1.36 a	0.63 ± 0.04 a	7.80 ± 1.30 b
Trichogramma acacioi (L8)				
Unmated females without food	13.00 ± 9.05 c	85.52 ± 7.52 b	0.00 ± 0.00 b	1.70 ± 0.21 b
Unmated females with food	53.75 ± 7.21 b	96.62 ± 1.71 a	0.00 ± 0.00 b	7.50 ± 0.37 a
Mated females without food	0.00 ± 0.00 c	-	-	2.00 ± 0.00 b
Mated females with food	68.90 ± 5.26 a	95.29 ± 1.34 a	0.69 ± 0.03 a	6.90 ± 1.02 a

Similarly, unmated *T. acacioi* females without food had a parasitism of 13% while this value was 0% for those mated without food (Table 1). This might be explained by the lack of energy for laying eggs that mated females certainly faced after the depletion of energy during mating, but the presence of honey prevented reduction on parasitism and even increased the parasitism for *T. pretiosum* and *T. acacioi*. Unmated and fed females of *T. pretiosum* had high parasitism rate (85.00±9.59%). This value was the maximum for this species on the eggs of this host since it did not differ from mated and fed females (83.50±4.69%) (Table 1). However, unmated and fed females of *T. acacioi* had lower parasitism (53.75±7.21%) than mated and fed ones (68.90±5.26%) (Table 1). Therefore, female parasitoids should be released after being fed and mated.

The mating or feeding did not affect egg viability of *T. pretiosum* (Table 1). This viability was lower for unmated females without food (85.52±7.52%) than for unmated and fed (96.62±1.71%) and mated and fed (95.29±1.34%) females of *T. acacioi*. However, even the lowest viability rate (85.52±7.52%) might be adequate for *Trichogramma* species (Almeida, 1998). *T. galloi* had similar results on *Diatraea saccharalis* eggs with adult emergence of 90.47% (Cônsoli and Parra, 1994), and for *T. distinctum* on *A. kuehniella* and *D. saccharalis* eggs that had viability of 80.7% and 31.05%, respectively (Lopes and Parra, 1991). Also, it is important to point out that mating and feeding are not the only factors that can affect egg viability. Temperature was also described in the literature as a key factor since the viability of parasitized eggs by *Trichogramma* spp. decreased at extremes temperatures (Pratissoli et al., 2005).

Adult feeding did not affect the sex ratio of both species but unmated females of *T. pretiosum* and *T. acacioi* produced only males when fed or not fed (Table 1). Similarly, the sex ratio was similar of *T. pretiosum* females fed or not matted (Table 1). This parameter was not evaluated for *T acacioi* because mated females without food did not lay eggs (Table 1). However, only mated females had sex ratio different from zero for both species showing the great importance of mating to have female descendants (Table 1). This occurred because most *Trichogramma* species reproduced by arrhenotoky, with haploid males being originated by unfertilized eggs and diploid females from fertilized ones (Hohmann et al., 2002). Mated parasitoid females keep the male sperm to manipulate the sex ratio of their descendents by controlling the sperm access to their eggs during laying (Boivin et al., 2004; Doyon and Boivin, 2005). The results showed the importance to use matted females at releases, mainly when females descendants were needed. However, some species of the genus *Trichogramma* present reproduction by thelytoky where both fertilized and unfertilized eggs originate diploid females (Hohmann et al., 2002).

The female longevity was influenced by feeding and indirectly by mating for both species. *T. pretiosum* unmated females without food lived only 2.50±0.22 days while unmated fed females were alive up to 11.20±1.58 days. Also, mated females that survived 2.60±0.16 days without food had their lifespan increased to 7.80±1.30 days when fed (Table 1). Similarly, *T. acacioi* unmated females without food lived only 1.70±0.21 days while those with access to food survived 7.50±0.37 days. *T. acacioi* mated females without food that lived 2.00±0.00 days, survived 6.90±1.02 when fed (Table 1). The increase in longevity is important to allow this biological control agent to find the host in the field. This increases the chances of a biological control program using *Trichogramma* to succeed. The longevity of *T. minutum* also increased when fed. The females fed with honey lived 26.4 days while those without food source lived only 3.5 days (Leatemia et al., 1995). Adults of *T. carverae* and *T. brassicae* lived longer with food (Gurr and Nicol, 2000). However, not all species or strains of the genus *Trichogramma* have longer longevity when fed which shows the importance of studies addressing this subject. *T. demoraesi* females had similar longevity of 11 days whether fed or not fed (Santa-Cecília et al., 1987).

Mating also influenced the adult longevity, mainly for *T. pretiosum*. Unmated and fed females lived 11.20±1.58 days and mated lived only 7.80±1.20 (Table 1). However, this decrease in longevity of mated females was more related to the depletion of the body energy during mating. This suggested that unmated females could be also used for biological control, mainly when the second generation of the parasitoid in the field is not of great importance. This might be the example of annual crops. However, it is important to consider that unmated females just produce males what can compromise the maintenance of the parasitoid in the environment. This would be probably prejudicial to the success of the biological control, mainly regarding to perennial crops. Moreover, the adult longevity of *Trichogramma* might vary with the host (Bai et al., 1995) or temperature which was normally inversely proportional to the longevity (Abbas, 1989; Maceda et al., 2003). Thus, it could be concluded that mated and fed females should be released for the biological control in the field against lepidopteran pests. Results showed increased efficacy of *T. pretiosum* and *T. acacioi* in the field and gave important guidelines for mass rearing and parasitoid releases.

RESUMO

Os efeitos do acasalamento e alimentação no potencial biológico e parasitismo de *Trichogramma pretiosum* e *Trichogramma acacioi* (Hymenoptera: Trichogrammatidae), foram estudados objetivando-se aprimorar o uso dessas espécies no controle biológico. O parasitismo e longevidade dos adultos de ambas as espécies foram maiores para fêmeas alimentadas e o parasitismo foi nulo e baixo para fêmeas acasaladas e não-alimentadas de *T. acacioi* e *T. pretiosum*, respectivamente. A viabilidade de ovos parasitados por *T. pretiosum* foi semelhante entre os tratamentos, mas para *T. acacioi* houve uma menor viabilidade do parasitismo realizado por fêmeas sem acasalamento e sem alimento. Descendentes de *T. pretiosum* e *T. acacioi* sem acasalamento produziram apenas machos, enquanto fêmeas acasaladas tiveram mais de 60% dos descentes fêmeas para as duas espécies de *Trichogramma*. Portanto, fêmeas acasaladas e alimentadas devem ser liberadas para o controle biológico.

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