Inventory and bioecological aspects of parasitoids of the genus *Trichogramma* (Hymenoptera: Trichogrammatidae) associated to *Erinnys ello* (Linnaeus) (Lepidoptera: Sphingidae) in cassava crops

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ABSTRACT. This work aimed to study the population dynamics, to determinate the species of *Trichogramma* occurring in cassava crops in the city of Lavras, Minas Gerais State, Brazil, as well as to evaluate biological parameters of those parasitoids associated to *Erinnys ello* (Linnaeus, 1758). This study was carried out from January of 2000 to February of 2003, in plants taken at 15-days intervals. The collected eggs were kept in laboratorial climatic chambers at 25±2ºC, RH of 70±10% and 12h photophase. During the collecting period, variations were observed in the population dynamics of *Trichogramma* spp.. Variations were also observed in the months of high rainfall when, due to the high host occurrence, the parasitoids presented the highest population density. The average rate of natural parasitism of *E. ello* eggs was 52.6%, the sex ratio was 0.8, and deformation was 0.4%. Two species were notified on *E. ello*: *Trichogramma demoraesi* Nagaraja, 1983 and *Trichogramma pretiosum* Riley, 1879.

Key words: biological control, *Manihot sculentum*, natural enemies, *Trichogramma*, Trichogrammatidae.

RESUMO. Inventário e aspectos bioecológicos de parasitóides do gênero *Trichogramma* (Hymenoptera: Trichogrammatidae) associados a *Erinnys ello* (Linnaeus) (Lepidoptera: Sphingidae) em cultura da mandioca. Objetivou-se neste trabalho realizar o levantamento populacional, determinar as espécies de *Trichogramma* que ocorrem no município de Lavras, Estado de Minas Gerais, Brasil, associadas à cultura da mandioca, bem como avaliar parâmetros biológicos desses parasitóides em *Erinnys ello* (Linnaeus, 1758). As coletas foram realizadas de janeiro de 2000 a fevereiro de 2003, em plantas tomadas ao acaso durante um período de busca de uma hora, em intervalos médios de 15 dias. Os ovos coletados foram mantidos no laboratório em câmaras climáticas reguladas a 25±2ºC, UR de 70±10% e fotofase de 12 horas. Durante o período de realização desse estudo, observaram-se variações na flutuação populacional de *Trichogramma* spp., sendo que nos meses de elevada precipitação pluviométrica, em função da maior disponibilidade do hospedeiro, os parasitóides apresentaram maior densidade populacional. A taxa de parasitismo natural média realizada por *Trichogramma* spp. foi de 52,6%, a razão sexual foi de 0,8, a ocorrência de deformações foi de 0,4%, sendo notificadas duas espécies em ovos de *E. ello*: *Trichogramma demoraesi* Nagaraja, 1983 e *Trichogramma pretiosum* Riley, 1879.

Palavras-chave: controle biológico, *Manihot sculentum*, inimigos naturais, *Trichogramma*, Trichogrammatidae.

Introduction

The genus *Trichogramma* Westwood, 1833 represents an efficient insect group in the natural and applied biological insect pests control in several crops of agricultural and economic importance. Currently, about 18 species of this parasitoid occur naturally in 23 countries. Among these species, 10 different *Trichogramma* spp. have been reared and used in mass releases to control pests on corn, sugarcane, apple, rice, cotton, sugar beet, vegetables, vineyard, and forests (Smith, 1996; Hassan and Abdelgader, 2001; Abdelgader and Hassan, 2002). These parasitoids are widely distributed in several agroecosystems and play an

important role in the biological control of lepidopterous pests.

The use of the biological control method to suppress pest populations is expanding in Brazil. Haji *et al.* (1995) observed that the parasitism of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) eggs in tomato crops by *Trichogramma pretiosum* Riley (Hymenoptera: Trichogrammatidae) was 68% and 43%, under greenhouse and field conditions, respectively, in the São Francisco Valley (Vale do São Francisco).

The use of *Trichogramma* spp. in pest management is due to researches and technologies developed to obtain, identify, mass rear, biology studies, and behavior and field releases of the species (Haji *et al.*, 1995; Zucchi and Monteiro, 1997; Alencar *et al.*, 2000). However, several studies have mentioned specific and intra-specific differences related to the insects fitness and biotic potential for that genus (Beserra and Parra, 2003), the employing of strains adapted to the regional environmental conditions being important to increase the chances of success in applied biological pests control programs.

Researches made in Brazil aiming to know and identify *Trichogramma* spp. are insufficient and, in most cases, carried out to study hosts considered pests of agricultural importance. Querino and Zucchi (2003a) accomplished inventory of the *Trichogramma* species in forests and verified the occurrence of many species of that genus, including six new species.

Querino and Zucchi (2003b) also verified the presence of that natural enemy parasitizing various lepidopterous species in agricultural crops. Four species were described for the first time among lepidopterous. Up to the current days, 28 species of *Trichogramma* were described in Brazil.

The knowledge of the *Trichogramma* species occurring in different regions of Brazil, on several hosts, is of prime importance in the biological control (Parra and Zucchi, 2004), ensuring the right employing of the most appropriate benefit to control the target pest. According to Parra *et al.* (2002), the knowledge is crucial, and if it is neglected, may cause intra-specific competition, decreasing the biological control efficacy.

Due to the occurrence of *Trichogramma* spp. in Brazilian cassava crops, controlling the cassava moth, *Erinnys ello* (Linnaeus, 1758) (Lepidoptera: Sphingidae), this work was elaborated, aiming to study the population dynamics of *Trichogramma* spp., to determine the species of that parasitoid that occur in cassava crops in the city of Lavras, Minas Gerais, Brazil, and to evaluate the bioecological aspects associated to that pest's natural enemy.

Material and methods

This work was carried out in cassava crops (1 to 1.5 years old), located near to the *Campus* of the "Universidade Federal de Lavras" (Ufla), in the city of Lavras, Minas Gerais State, Brazil, at 21º 14'S, 45º 00' W, and 918 m height. The collectings were done from January 2000 to February 2003.

Verifying the occurrence of genus *Trichogramma* parasitoids associated to *E. ello*, samplings of pest eggs were accomplished on cassava plants. The samplings were collected on plants at random, in zigzag, each collect during 1 hour, always in the morning. The intervals between collects were of fifteen days.

The collected eggs were carried to the Insect Biology Studies Laboratory of the Department of Entomology of Ufla and maintained under controlled conditions at 25±2ºC, RH 70±10%, and 12h of photophase, until the development of either parasitoids or caterpillars of *E. ello*. After the parasitoids emergence, the emergence success, the percentage of abnormal parasitoids and the sex ratio of these parasitoids were determined.

For each sampling, some male specimens belonging to the genus *Trichogramma* were taken and assembled in lamina. This material was labeled and sent to specialists for species identification, which was accomplished by observing the male genital.

The data obtained were submitted to variance analysis and, when the F-test was significant, grouping Scott-Knott test (Scott and Knott, 1974) was done, to compare the means. Data referring to the percentage of abnormal individuals, parasitization by other natural enemies and percentage of unviable eggs were transformed to $\sqrt{X + 0,5}$. Also, Pearson's correlation analysis was done between the evaluated biological features and the climatic factors. The analyses were performed using the SAS program (SAS Institute, 2001).

Results and discussion

The *Trichogramma* spp. and *E. ello* populations suffered variations during the collecting period. The constant changes of climatic factors as temperature, insolation, and relative humidity might have influenced the insects' development. During the months of January, February, and March 2000; and March and April 2002, the highest average of collected *E. ello* eggs was observed, with values of 26.0, 28.8, 27.8, 28.5, and 27.5 eggs, respectively (Table 1). During the months of January, February,

and March, 2000; and March and April 2002, high rainfalls and higher temperatures were observed (Figure 1).These climatic factors might have favored the development of *E. ello*. The largest occurrence of the insects-pest favors the parasitism for *Trichogramma* spp., which was also more abundant in those periods (Table 1).

The periods between May and December of 2000, May and October 2001 and from June to December of 2002 presented the lowest averages of collected *E. ello* eggs, varying from zero, during August and September 2001, to 13.5 eggs in December 2000 and October 2002. It was also observed significant reduction in the rate of parasitism for *Trichogramma* spp. in those periods (Table 1).

The natural parasitism rate by *Trichogramma* spp. presented high values mainly in January and February, 2000; April 2001; and February and March, 2002; with averages of 76.0%, 77.7%, 83.4%, 75.5%, and 83.1%, respectively (Table 1 and Figure 1). This variation is also associated to changes in the temperature during the same period, being observed larger values in the natural parasitism rate in periods of temperatures above the average and periods of rainfall above 200 mm (Figure 1). In the remaining months, the natural parasitism presented lower values, which varied from 17.1% in December, 2001 to 67.9% in July, 2002.

The number of *Trichogramma* spp. emerged per egg of *E. ello* varied from 15.0 to 31.5 individuals, with an average of 21.4 individuals per egg (Table 1). In some cases, the emergence of 40 *Trichogramma* spp. adults from only one host egg was observed.

The percentage of total parasitism (parasitism by *Trichogramma* spp. and other natural enemies) also varied during the collect periods, reaching averages of 85.0% of control (Table 1) in some periods of the year.

In some periods without rain reduction in the parasitism rate was also verified. This could be attributed to a decrease in the pest population (Figure 1). These results coincide with those obtained by Querino (2002), who verified reduction in the occurrence of several species of *Trichogramma* when the rainfall was smaller.

From August to Sptember 2001 the presence of host eggs in the plants was not observed. This might have occurred due to both the lack of rain during the previous months and the temperature decrease. These climatic factors cause fall of cassava plants leaves, reducing the laying sites and, consequently, the laying of *E. ello*. The occurrence of *Trichogramma* spp. is related to the presence of host eggs in the crop. This fact limited the presence of this parasitoid during the aforementioned period.

The medium percentage of individuals of *Trichogramma* spp. presenting abnormalities was relatively low (0.4%) (Table 1), being the highest values found in *E. ello* eggs containing great number of parasitoids, possibly due to the reduction in the food availability into the host eggs.

The sex ratio of the parasitoids, collected during this study, was 0.8 (Table 1). Among the collected individuals, it was observed a great number of parasitized eggs containing only females.

In several collected samples, it was also verified the occurrence of parasitoids belonging to other genus (Table 1), but that also contributes to *E. ello* natural biological control. Among the collected eggs, the presence of unviable *E. ello* eggs was verified; hence those eggs were not parasitized and did not originate caterpillars.

The percentage of caterpillars from collected eggs, according to previous calculation, was high in the months with warm temperatures, when parasitoid action was also lower (Table 1).

It was verified that the average of collected *E. ello* eggs presented positive correlation with temperature, rainfall, and relative humidity (Table 2), showing thus a possible increment in pest occurrence associated with increasing values of those climatic factors. The parasitism by *Trichogramma* spp. was positively correlated with temperature and rainfall, being the last one factor significant at 10% only (Table 2), which might have happened associated to highest host availableness in the periods of larger rain incidence and higher temperatures. However, the total parasitism (parasitism of *Trichogramma* spp. added to the occurrence of other parasitoids) showed a positive correlation only with temperature (Table 2).

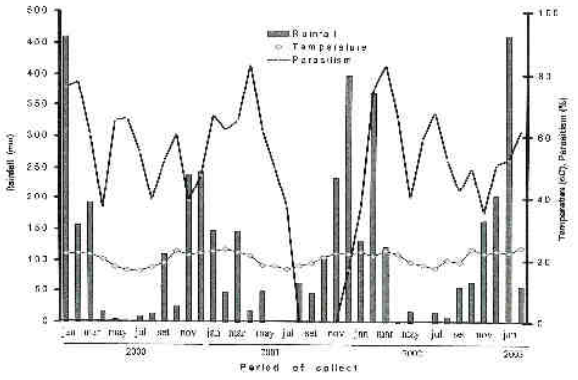

Figure 1. Variation of rainfall and temperature medium values *versus* parasitism accomplished by *Trichogramma* spp. on eggs of *Erinnys ello,* during the collecting period.

Table 1. Average of collected eggs, percentage of parasitism by *Trichogramma* spp., number of parasitoids per egg of *Erinnys ello*, percentage of individuals of *Trichogramma* spp. with abnormalities, sex ratio of emerged *Trichogramma* spp., occurrence percentage of other parasitoids, total parasitism, number of unviable eggs and percentage of caterpillars from collected eggs. Lavras, Minas Gerais State, Brazil, 2003.

Month	Average of collected eggs	Parasitism by *Trichogramma*	T/E[1]	%D[2]	SR[3]	Other[4]	Total parasitism	Unviable eggs	CCE (%)[5]
January-2000	26.0 a	76.0 a	21.5 a	0.0 b	0.8 a	3.2 a	79.2 a	4.0 a	16.8 c
February-2000	28.8 a	77.7 a	17.3 a	0.0 b	0.9 a	2.2 a	79.9 a	7.8 a	12.3 c
March-2000	27.8 a	60.3 b	22.5 a	0.6 b	0.9 a	2.6 a	62.9 a	13.4 a	23.7 c
April-2000	17.0 c	36.8 c	17.5 a	0.3 b	0.8 a	3.2 a	40.0 b	13.8 a	46.2 b
May-2000	13.5 d	65.1 b	21.3 a	0.2 b	0.9 a	0.0 a	65.1 a	4.2 a	30.7 c
June-2000	11.0 d	65.7 b	21.5 a	0.4 b	0.8 a	5.0 a	70.7 a	4.2 a	25.1 c
July-2000	10.0 d	55.0 b	23.4 a	0.1 b	0.8 a	5.0 a	60.0 a	5.0 a	35.0 c
August-2000	13.0 d	39.4 c	24.0 a	0.8 b	0.8 a	0.0 a	39.4 b	0.0 a	60.6 b
September-2000	12.0 d	52.1 b	22.0 a	0.4 b	0.8 a	0.0 a	52.1 a	0.0 a	47.9 b
October-2000	13.0 d	60.7 b	18.5 a	0.2 b	0.8 a	4.2 a	64.9 a	3.6 a	31.5 c
November-2000	11.0 d	39.2 c	29.5 a	1.5 a	0.8 a	5.0 a	44.2 b	4.2 a	51.6 b
December-2000	13.5 d	47.5 c	19.5 a	0.0 b	0.9 a	8.3 a	55.8 a	6.7 a	37.5 c
January-2001	15.0 c	66.7 b	24.3 a	0.2 b	0.8 a	3.3 a	70.0 a	6.7 a	23.3 c
February-2001	18.0 c	61.9 b	31.5 a	1.8 a	0.8 a	0.0 a	61.9 a	8.1 a	30.0 c
March-2001	20.0 b	65.0 b	25.5 a	1.5 a	0.8 a	7.5 a	72.5 a	10.0 a	17.5 c
April-2001	17.5 c	83.4 a	16.5 a	0.2 b	0.8 a	0.0 a	83.4 a	0.0 a	16.6 c
May-2001	12.5 d	61.6 b	15.0 a	0.0 b	0.8 a	3.4 a	65.0 a	3.4 a	31.6 c
June-2001	10.0 d	50.0 b	22.5 a	0.1 b	0.8 a	5.0 a	55.0 a	5.0 a	40.0 c
July-2001	10.0 d	37.5 c	23.5 a	0.0 b	0.8 a	0.0 a	37.5 b	10.0 a	52.5 b
August-2001	0.0 e	-	-	-	-	-	-	-	-
September-2001	0.0 e	-	-	-	-	-	-	-	-
October-2001	11.5 d	-	-	-	-	3.4 a	3.4 c	5.9 a	90.7 a
November-2001	15.0 c	-	-	-	-	3.4 a	3.4 c	23.4 a	73.2 a
December-2001	17.0 c	17.1 c	25.5 a	0.1 b	0.8 a	0.0 a	17.1 c	14.6 a	68.3 a
January-2002	21.5 b	37.1 c	22.5 a	0.2 b	0.8 a	11.9 a	49.0 a	9.0 a	42.0 c
February-2002	22.5 b	75.5 a	22.0 a	0.4 b	0.8 a	0.0 a	75.5 a	0.0 a	24.5 c
March-2002	28.5 a	83.1 a	24.3 a	0.2 b	0.9 a	1.9 a	85.0 a	2.2 a	12.8 c
April-2002	27.5 a	65.7 b	24.3 a	0.3 b	0.9 a	0.5 a	66.2 a	12.0 a	21.8 c
May-2002	17.4 c	40.2 c	23.9 a	0.3 b	0.7 a	0.0 a	40.2 b	19.9 a	39.9 c
June-2002	12.9 d	59.2 b	26.3 a	0.5 b	0.8 a	0.0 a	59.2 a	8.2 a	32.6 c
July-2002	11.4 d	67.9 b	22.8 a	0.5 b	0.8 a	2.5 a	70.4 a	6.0 a	23.6 c
August-2002	12.7 d	52.9 b	21.9 a	0.3 b	0.9 a	0.0 a	52.9 a	5.8 a	41.3 c
September-2002	11.5 d	42.3 c	22.8 a	0.4 b	0.8 a	4.8 a	47.1 b	10.4 a	42.5 c
October-2002	13.5 d	50.3 b	21.9 a	0.3 b	0.8 a	3.6 a	53.9 a	7.9 a	38.2 c
November-2002	12.0 d	35.4 c	23.5 a	0.3 b	0.9 a	3.8 a	39.2 b	12.9 a	47.9 b
December-2002	12.0 d	51.3 b	23.3 a	0.1 b	0.8 a	6.2 a	57.5 a	4.5 a	38.0 c
January-2003	15.8 c	52.8 b	22.9 a	0.3 b	0.9 a	0.9 a	53.7 a	7.7 a	38.6 c
February-2003	20.5 b	62.0 b	23.4 a	0.1 b	0.9 a	1.9 a	63.9 a	7.5 a	28.6 c
Average	15.3	52.6	21.4	0.4	0.8	2.90	55.5	7.4	37.1
Standard Error	1.18	7.78	2.9	0.2	0.1	2.7	7.4	3.6	7.5
C.V. (%)	10.17	20.78	19.64	16.62	7.89	62.80	18.81	41.68	14.92

[1]Average number of *Trichogramma* spp. emerged per egg of *Erinnys ello*; [2] Percentage of abnormal *Trichogramma* spp. emerged from *Erinnys ello* eggs; [3] Sex ratio of *Trichogramma* spp.; [4] Percentage of *Erinnys ello* eggs parasitized by natural enemies of different genus; [5] Percentage of *Erinnys ello* caterpillars from non-parasitized collected eggs.

Table 2. Correlations (r) of Pearson and test value (z) among climatic factors and biological features of *Trichogramma* spp. collected from January 2000 to February 2003 on cassava crops. Lavras, Minas Gerais State, Brazil.

Biological features	Evaluated factor/correlations (r)/test value (z)					
	Temperature (ºC)		Rainfall (mm)		Relative humidity (%)	
	r	z	r	z	r	z
Collected eggs	0.6006	3.4422 ⋆⋆⋆	0.6040	3.4728 ⋆⋆⋆	0.6614	2.0408 ⋆⋆
Parasitism of *Trichogramma* spp.	0.5289	3.9610 ⋆⋆⋆	0.7514	1.1999 ⋆	0.2067	0.9207 ns
Other parasitoids	0.0276	0.1234 ns	-0.1111	-0.4998 ns	-0.2054	-0.9385 ns
Total parasitism	0.2159	2.2711 ⋆⋆	0.0643	0.2881 ns	0.2342	1.0776 ns
Trichogramma spp. / *E. ello* egg	-0.2401	-1.0780 ns	0.2678	1.2114 ns	-0.1140	-0.5004 ns
Abnormal individuals (%)	0.0204	0.0891 ns	0.1506	0.8682 ns	0.0427	1.0609 ns
Sex ratio	0.1309	0.5753 ns	0.2590	1.1688 ns	0.2971	0.3563 ns
Unviable eggs (%)	0.1131	0.5090 ns	0.0604	0.2705 ns	0.1390	0.6278 ns
Collected caterpillars (%)	0.1367	1.6323 ⋆	-0.1442	-0.6679 ns	-0.3275	-1.1884 ns

⋆ Significant at 10% by the *t*-test; ⋆⋆ Significant at 5% by the *t*-test; ⋆⋆⋆ Significant at 1% by the *t*-test; ns = not significant in any likelihood level by the *t*-test.

The features related to the percentage of other parasitoids occurrence, number of *Trichogramma* spp. per *E. ello* egg, deformation of the collected parasitoids and percentage of unviable eggs did not suffer influence of any of the studied climatic factors (Table 2).

Regarding to the occurrence of *Trichogramma* spp., the presence of two species was noticed in Lavras: *Trichogramma demoraesi* Nagaraja, 1983 and *Trichogramma pretiosum* Riley, 1879. Querino (2002) related the occurrence of *T. demoraesi* parasiting *E. ello* eggs in the cassava crop (*Manihot utilissima*), in the City of Piracicaba, São Paulo State, Brazil, and confirmed the occurrence of this parasitoid species in Lavras, Minas Gerais State.

Conclusions

Parasitoids of the genus *Trichogramma* occurred naturally associated to *Erinnys ello* during the period of January 2000 to February 2003, in Lavras, Minas Gerais State.

Trichogramma spp. had an important role in *Erinnys ello* population regulation in Lavras, Minas Gerais State, during the period of this study, with an average parasitism of 52.6% of the collected eggs.

Climatic factors such as temperature and rainfall influenced the occurrence of *Trichogramma* spp. and of its host *Erinnys ello* during this study.

Trichogramma pretiosum and *Trichogramma demoraesi* were the species occurred in Lavras associated to *Erinnys ello* during the period of January 2000 to February 2003.

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