Larval endoparasitoids (Hymenoptera) of frugivorous flies (Diptera, Tephritoidea) reared from fruits of the cerrado of the State of Mato Grosso do Sul , Brazil

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Abstract. This paper presents a five years survey of endoparasitoids obtained from the larvae of frugivorous Tephritidae and Lonchaeidae flies. The insects were reared from cultivated and wild fruits collected in areas of the cerrado in the State of Mato Grosso do Sul, Brazil. The flies obtained from 14 host fruit species were eight *Anastrepha* species, *Ceratitis capitata* (Wiedemann, 1824) (Tephritidae); *Dasiops* **sp.** and *Neosilba* **spp.** (Lonchaeidae). Eleven parasitoid species were collected: Braconidae - *Asobara anastrephae* (Muesebek, 1958), *Doryctobracon areolatus* (Szépligeti, 1911), *D. fluminensis* (Costa Lima, 1938), *Opius bellus* Gahan, 1930 and *Utetes anastrephae* (Viereck, 1913); Figitidae - *Aganaspis nordlanderi* Wharton, 1998, *Lopheucoila anastrephae* (Rhower, 1919), *Odontosema anastrephae* (Borgmeier, 1935) and *Trybliographa infuscata* Gallardo, Díaz & Uchôa-Fernandes, 2000 and, Pteromalidae – *Spalangia gemina* Boucek, 1963 and *S. endius* Walker, 1839. In all cases only one parasitoid emerged per puparium. *D. areolatus* was the most abundant and frequent parasitoid of fruit fly species, as was *L. anastrephae* in *Neosilba* **spp.** larvae. This is the first record of *A. nordlanderi* in the midwestern Brazilian region.

Keywords. Biocontrol; fruit fly; Lonchaeids; parasitoids.

INTRODUCTION

The flies of the Tephritidae and Lonchaeidae families (Tephritoidea) are the most important insect pests of fruit and vegetables grown in the world, specially in the Neotropical region. The control of such flies by parasitoids has been considered an important component of integrated pest management (IPM) and also one of the safest methods for man and environment. The biological control program of fruit flies around the world have used exotic parasitoids (Hernández-Ortiz *et al*. 1994; Salles 1996) which, besides enduring environmental adaptation difficulties (usually being species from another country or continent), may cause contrary effects upon the native parasitoids. More attention must be given to the use of native parasitoids in such program, mainly when they are abundant and have a performance similar or only somewhat inferior to that found in effective exotic species.

There is little research on native parasitoids of frugivorous tephritoids in Brazil (Leonel Jr. *et al*. 1995, 1996; Canal *et al*. 1995; Salles 1996; Aguiar-Menezes & Menezes 1997), in spite of their enormous potential as biological control agents of fruit flies (López *et al*. 1999) and frugivorous lonchaeids. The aim of this study was to survey native parasitoids of fruit flies [*Anastrepha* **spp.**, *Ceratitis capitata* (Wied.)] and frugivorous lonchaeids (*Neosilba* **spp.** and *Dasiops* **sp.**) obtained in the laboratory in cultivated and wild fruit species from cerrado

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vegetation of the State of Mato Grosso do Sul (midwestern Brazil).

MATERIAL AND METHODS

The fruits were collected from January 1993 to March 1997, from "Cerrado" vegetation of Anastácio (20º 31' 36" S / 55º 50' 12" W, 170 m), Aquidauana (20º 39' S / 55º 19' 50" W, 173 m), Rochedo (19º 57' 30" S / 54º 53' 10" W, 398 m) and Terenos (20º 26' 12" S / 54º 04' 54" W, 308 m) municipalities and brought to the laboratory. The parasitoids were recovered from frugivorous larvae of the families Tephritidae and Lonchaeidae. Each sample was placed in a plastic container, from which the3rd-instar larvae exited and fell into plastic trays with water. Larvae were recovered every 12h by pouring the material through a sieve with a mesh of 1 mm diameter, so tephritids and lonchaeids maggots were kept separate in different containers, in order to pupate and allow the emergence of flies or their parasitoids (Uchôa-Fernandes & Zucchi 1999). Only *Spondias lutea* L., 1758 (Anacardiaceae) and *Terminalia catappa* L., 1758 (Combretaceae) data, from fruit collected in 1993, were obtained by the usual methodology that consisted of placing fruits over trays containing a fine layer of sterilized sand. In this case, the puparia were recovered through sand sifting.

The viability of 3rd-instar larvae (L3) and the percentage of emergence of frugivorous flies were calculated according to the following formula, adapted from Nascimento *et al*. (1984):

$$\%\ V.\ L3 = \frac{\text{Number of emerged flies} \times 100}{\text{Total No. of L3} - \text{No. of emerged parasitoids}}$$

% V.L3 (Percentage of the viability of third instar larvae).

The combined larval parasitism rate (total parasitism) by hymenopterans was calculated using the formula:

$$\%\ C.P. = \frac{N.R.P. \times 100}{N.L3}$$

% C.P = The percentage of total parasitism rate;
N.R.P.= Number of recovered parasitoids;
N. L3 = The number of 3rd-instar larvae of frugivorous flies.

The voucher specimens of tephritids, frugivorous lonchaeids and their parasitoids were deposited in the Coleção Zoológica, Universidade Federal de Mato Grosso do Sul, Campo Grande (ZUFMS) and Departamento de Entomologia, Fitopatologia e Zoologia Agrícola, Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba (ESALQ). The herborized samples of the host plants were deposited in the Herbário Central, Universidade Federal de Mato Grosso do Sul, Campo Grande and in the Coleção de Botânica, Departamento de Biologia, Universidade de São Paulo, São Paulo.

RESULTS AND DISCUSSION

From January 1993 to March 1997, 283 samples were collected, totaling 648.66 kg of biomass and 20,166 fruits of 14 plant species; 193 corresponded to *Citrus* **spp.** (Rutaceae) and 90 to other fruits. Some 11,298 mature larvae of Tephritidae were obtained, emerging as: 4,814 adults of *Anastrepha* **spp.,** 2,637 *Ceratitis capitata*, 225 braconids and 23 pteromalids. Also, 11,246 larvae of Lonchaeidae were recovered, giving one adult of *Dasiops* **sp.**, 7,677 *Neosilba* **spp.** and 279 Eucoilinae (Figitidae) parasitoids (Table I). In all cases only one parasitoid emerged per puparium.

Parasitoid species composition (Table I)

Braconidae

Asobara anastrephae (Muesebek) (5 specimens), *Doryctobracon areolatus* (Szépligeti) (166 specimens), *D. fluminensis* (Costa Lima) (12 specimens), *Opius bellus* Gahan (17 specimens), *Utetes anastrephae* (Viereck) (23 specimens) and two unidentified braconids were obtained. All recovered braconids were associated with Tephritidae larvae (*Anastrepha* **spp.** and *C. capitata*). Generally, the braconid species found in this survey correspond to those already registered in other Brazilian regions (Canal *et al*. 1995; Leonel Jr *et al.* 1995, 1996; Salles 1996; Aguiar-Menezes & Menezes 1997). However, *D. fluminensis* which after its description by Costa Lima (1938) has not been collected since, was found in 1993 in Fazenda Ranchinho, municipality of Rochedo, Mato Grosso do Sul. In this survey, *D. fluminensis* was obtained from larvae feeding on cassava fruits, *Manihot esculenta* Crantz, 1766 (Euphorbiaceae), probably parasiting *A. montei* Costa Lima, 1934.

Doryctobracon areolatus was the most abundant braconid, achieving 31.38% of the parasitoid adults and 74.67% of the braconids (Table I). That species shows a worldwide distribution and has been considered an important native parasitoid species attacking the genus *Anastrepha* in neotropical countries. Surveys carried out in Brazil and in other countries have shown that *D. areolatus* is the most dominant, frequent and abundant species among the parasitoids of fruit flies (Jirón & Mexzon 1989; Hernández-Ortiz *et al.* 1994; Ovruski & Fidalgo 1994; Canal *et al*. 1995; Leonel Jr. *et al*. 1995, 1996; Salles 1996; Aguiar-Menezes & Menezes 1997; López *et al*. 1999).

Figitidae

Four especies in four genera of Eucoilinae were found in the present study: *Aganaspis nordlanderi* Wharton (16 specimens), *Lopheucoila anastrephae* (Rhower) (230 specimens), *Odontosema anastrephae* (Borgmeier) (6 specimens), *Trybliographa infuscata* Gallardo, Díaz & Uchôa-Fernandes (24 specimens) and three unidentified specimens. This is the first record of *A. nordlanderi* in the midwestern Brazilian region. *T. infuscata* was described from specimes

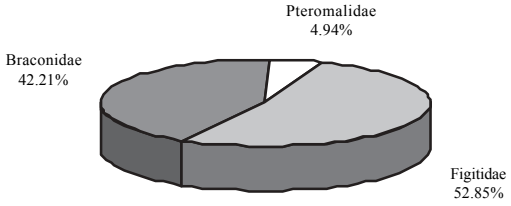

Fig. 1. Families of hymenopteran parasitoids (n= 527) reared from frugivorous larvae in 14 host fruit species from the cerrado, Mato Grosso do Sul, Brazil (January 1993 to March 1997).

parasitising larvae of *Neosilba* **sp.** infesting oranges in Anastácio, Terenos, and from *Caryocar brasiliense* Camb. 1828, fruits ("pequi") (Caryocaraceae), collected in Aquidauana (GALLARDO *et al*. 2000). The adults of *Trybliographa* are larval endoparasitoids that emerged from *Neosilba* **spp.** puparia.

All eucoilines were associated with the Lonchaeidae larvae of the genus *Neosilba*. These solitary endoparasitoids lay their eggs in the larval stages of Cyclorrhaphous Diptera and emerge as adults from the puparium of their hosts. They are important natural enemies of phytophagous dipterans (WHARTON *et al*. 1998). Two species of Eucoilinae have been used as biological control agents of some economically important fruit flies: *Aganaspis daci* (Weld, 1951) (oriental species) and *A. pelleranoi* (Brèthes, 1924) (neotropical species) and, this latter species has been mass reared and released in orchards in Argentina and Mexico for the control of tephritid pests (WHARTON *et al*. 1998).

The eucoilines made up almost 53% of the total of the recovered parasitoids (Fig. 1). *L. anastrephae* was the species with the highest abundance and the most frequent in the samples, totaling 82.44% of the eucoilines collected (Fig. 2). This parasitoid species has high potential as a biological control agent for lonchaeid pests of the genus *Neosilba*, specially in *Citrus* orchards in Mato Grosso do Sul, where the parasitism of this species is constant, in spite of the frequent insecticide sprays.

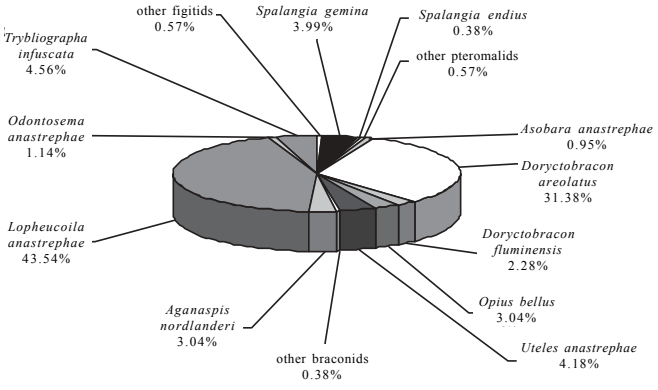

Fig. 2. Percent of the species of hymenopterans (n= 527) parasiting larvae of frugivorous flies from 14 host fruit species from the cerrado, Mato Grosso do Sul, Brazil (January 1993 to March 1997).

All the eucoilines registered in this study were associated with lonchaeids (Table I). Based on a survey in the region of Pelotas (Southern Brazil) related to native parasitoids of *A. fraterculus*, *Odontosema* **sp.** was listed among the parasitoids complex of the South American fruit fly (SALLES 1996). Although considering that the author applied the traditional methodology of fruit fly collecting, which kept all the insects together in the same container, probably *Odontosema* was parasiting Lonchaeidae larvae. As WHARTON *et al*. (1998) pointed out, if the larvae or pupae of frugivorous insects were kept together in the same rearing recipient until the emergence of adults, it will be possible to make a wrong association among the hosts and parasitoids.

In this survey, *O. anastrephae* emerged from larvae of *Neosilba* **spp.** infesting fruits of "pequi" (*C. brasiliense*). Although the eucoilines have been characterized as larval endoparasitoids of lonchaeids, other authors have found species of *Odontosema* and *Aganaspis* parasiting *C. capitata* and *Anastrepha* **spp.** larvae, as well as lonchaeids (WHARTON *et al*. 1981, 1998). WHARTON *et al*. (1998) pointed out that the records of the genus *Lopheucoila* and *Trybliographa* attacking tephritids in the New World need confirmation. In fact, our results show that *L. anastrephae* and *T. infuscata* were recovered only from *Neosilba* larvae (Lonchaeidae). Neverthless, in contrast to the results obtained by WHARTON *et al*. (1998), who found a preference of *Odontosema* for tephritids, with only 2% of this species being recovered from frugivorous lonchaeids, we found that *O. anastrephae* was associated only with *Neosilba* **spp.** larvae. According to LÓPEZ *et al*. (1999), in Mexico, *A. pelleranoi* and *O. anastrephae* were obtained from pupae of *Anastrepha* **spp.** in guavas. Although these authors have associated those parasitoids with *Anastrepha* species, they did not identify previously the larvae that exited from fruits. So, it is possible that that parasitoid, in fact, was parasitising lonchaeids, which also infest guavas.

Pteromalidae

Two species were reared, *Spalangia gemina* Boucek (21 specimens) and *S. endius* Walker (2 specimens). The pteromalids seem to be associated with pupae of Tephritidae. The species of the genus *Spalangia* attack exclusively puparia of dipterans (V. A. Costa, personal communication). In this study, probably the parasitism occurred in the puparia collected in the field, because fruits (*S. lutea* and *T. catappa*) from which these parasitoids emerged, were kept when traditional methodology was still being used (in 1993), i.e., all larvae were kept together in the same container.

The average of parasitism in the 14 fruit species was 3.03%. When the parasitism was calculated individually for the 14 fruit species, the indices ranged from 0.07% to 14.37%. The highest level was found in tangerine araçá (*Psidium* **sp.**), sugar-apple and orange, in decreasing order. In Guatemala, the combined percentage of parasitism of *Anastrepha* **spp.** and *C. capitata* varied from 0.04 to 7.85%, in 14 sampled species of fruits (ESKAFI 1990).

The fruits of *C. reticulata* (tangerine) and of *Solanum*

Table I. Infestation indices of frugivorous larvae (Diptera: Tephritidae and Lonchaeidae) and their association with parasitoids (Hymenoptera) in 14 host plants sampled from the Cerrado of Mato Grosso do Sul, Brazil (January 1993 to March 1997)

Host Fruits n (kg)	Sites (samples)	Index Larvae/ fruit (n)	Index Larva/kg of fruit	3rd instar recovered larvae (n)	*Taxa* of Frugivorous flies (n)	Emerged flies		*Taxa* of Parasitoids	Parasitoids and Parasitism	
						n	Viability (%)		(n)	% total
Anacardiaceae										
Hog plum, *Spondias lutea* L. 640 (7,43)	Aquid. (3)	2.86	246.84	1,834Tephr.	**Tephritidae** *Anastrepha* spp. *A. obliqua* (581)	1,145	63.54	**Braconidae** *Asobara anastrephae* (1) *Doryctobracon areolatus* (3) *Utetes anastrephae* (7)	11	1.74
								Pteromalidae *Spalangia gemina* (19) *S. endius* (2)	21	
Red mombin, *S. purpurea* L. 484 (6.88)	Anast. Aquid. (8)	1.18	83.43	570 Tephr.	**Tephritidae** *Anastrepha* spp. (226) *A. obliqua* (99) *A. sororcula* (2) *A. turpiniae* (1) *Ceratitis capitata* (3)	229	40.17	**Braconidae** *A. anastrephae* (1) *U. anastrephae* (2)	3	0.52
				4 Lonch.	**Lonchaeidae** *Neosilba* sp. (1) *Dasiops* sp. (1)	2	50.00			
Annonaceae										
Sugar-apple, *Annona squamosa* L. 39 (5.70)	Anast. (4)	1.10	7.54	43 Lonch.	**Lonchaeidae** *Neosilba* sp.	41	95.35	**Figitidae** *Lopheucoila anastrephae* (2)	2	4.65
Duguetia furfuraceae St. Hil. 204 (11.46)	Aquid. Terenos (8)	1.15	20.42	234Lonch.	**Lonchaeidae** *Neosilba* sp.	200	85.47	**Figitidae** Non-identified	3	1.28
Caryocaraceae										
Caryocar brasiliense Camb. 562 (77.25)	Aquid. Rochedo (15)	7.06	51.35	1 Tephr.	**Tephritidae** *A. sororcula* (1)	1	100.00			
				3,966 Lonch.	**Lonchaeidae** *Neosilba* sp.	2,913	73.45	**Figitidae** *L. anastrephae* (10) *Odontosema anastrephae* (6) *Trybliographa infuscata* (6)	22	0.55
								Pteromalidae *S. gemina* (2)	2	0.07
Combretaceae										
Tropical almond, *Terminalia catappa* L. 443 (15.32)	Aquid. (10)	6.23	180.16	2,595 Tephr.	**Tephritidae** *Anastrepha* spp. (3) *A. zenildae* (1) *C. capitata* (2,131)	2,134	82.23			
				165 Lonch.	**Lonchaeidae** *Neosilba* sp.	140	84.85			
Euphorbiaceae										
Cassava fruits, *Manihot esculenta* Crantz 1,760 (4.12)	Faz. Ranchinho, Rochedo (4)	0.36	154.85	638 Tephr.	**Tephritidae** *Anastrepha* spp. *A. montei* (76) *A. pickeli* (1)	140	21.94	**Braconidae** *Doryctobracon fluminensis* (12)	12	1.88
Mimosaceae										
Inga, *Inga laurina* (Sw.) 1,545 (11.43)	Aquid. (6)	0.35	47.59	77 Tephr.	**Tephritidae** *C. capitata*	50	64.93	**Braconidae** Non-identified (1)	1	0.18
				467 Lonch.	**Lonchaeidae** *Neosilba* spp.	199	42.61			
Myrtaceae										
Araça, Psidium sp. 1,313 (10.38)	Aquid. (5)	0.60	76.01	789 Tephr.	**Tephritidae** *Anastrepha* spp. *A. sororcula* (167) *A. striata* (79) *A. fraterculus* (3)	517	65.53	**Braconidae** *D. areolatus* (63) *Opius bellus* (4)	67	8.49

Table I. Cont.

Host Fruits n (kg)	Sites (samples)	Index Larvae/ fruit (n)	Index Larva/kg of fruit	3rd instar recovered larvae (n)	*Taxa* of Frugivorous flies (n)	Emerged flies n	Emerged flies Viability (%)	*Taxa* of Parasitoids	Parasitoids and Parasitism (n)	Parasitoids and Parasitism % total
Guava, *Psidium guajava* L. 1,728 (89.78)	Anast. Aquid. Terenos (13)	2.53	48.62	3,993 Tephr.	**Tephritidae** *Anastrepha* spp. (2,494) *A. sororcula* (994) *A. turpiniae* (161) *A. striata* (50) *A. obliqua* (26) *A. zenildae* (19) *A. fraterculus* (9) *C. capitata* (382)	2,876	72.02	**Braconidae** *D. areolatus* (93) *U. anastrephae* (12) *O. bellus* (6) *A. anastrephae* (3) Non-identified (1)	115	2.75
				372 Lonch.	**Lonchaeidae** *Neosilba* spp.	292	78.49	**Figitidae** *L. anastrephae* (5)	5	
Guavira, *Campomanesia sessiflora* (Berg.) 8,179 (19.66)	Anast. Aquid. Rochedo Terenos (9)	0.10	42.52	712 Tephr.	**Tephritidae** *Anastrepha* spp. (286) *A. sororcula* (141) *A. zenildae* (4) *A. obliqua* (1) *C. capitata* (5)	291	40.87	**Braconidae** *D. areolatus* (7) *O. bellus* (7) *U. anastrephae* (2)	16	1.91
				112 Lonch.	**Lonchaeidae** *Neosilba* sp.	72	64.28			
Rutaceae Orange, *Citrus sinensis* L. 2,346 (357.26)	Anast. Aquid. Terenos (179)	2.43	15.95	89 Tephr.	**Tephritidae** *A. turpiniae* (2) *C. capitata* (66)	68	76.40			
				5,611 Lonch.	**Lonchaeidae** *Neosilba* sp.	3,360	60.97	**Figitidae** *L. anastrephae* (164) *T. infuscata* (18) *A. nordlanderi* (12)	194	3.40
Tangerine, *Citrus reticulata* (L.) 134 (21.60)	Anast. Aquid. Terenos (14)	2.65	16.43	355 Lonch.	**Lonchaeidae** *Neosilba* sp.	213	60.00	**Figitidae** *L. anastrephae* (47) *A. nordlanderi* (4)	51	14.37
Solanaceae *Solanum viarum* Dun. 789 (10.39)	Aquid. (5)	0.37	27.81	289 Lonch.	**Lonchaeidae** *Neosilba* sp.	246	85.12	**Figitidae** *L. anastrephae* (2)	2	0.69
TOTALS / MEANS 14 plant species 20,166 fruits 648,66 kg of biomass	4 sites (283)	2.07	72.82	11,298 Tephr. 11,246 Lonch	*Anastrepha* 4,814 *C. capitata* 2,637	7,451 Tephr.	44.83% T	225 **Braconidae** 23 **Pteromalidae**	527	3.03
					Neosilba 7,677 *Dasiops* 1	7,678 Lonch.	55.76% L	279 **Figitidae**		

Anast. (Anastácio); Aquid. (Aquidauana); Tephr. and T (Tephritidae) and Lonch. and L (Lonchaeidae).

viarum Dun. (Solanaceae) were infested exclusively by *Neosilba* **spp.** In oranges, 98% of adult tephritoids that emerged also belonged to this genus and all recovered parasitoids in these hosts were Figitidae (Eucoilinae). This suggests a specificity of this parasitoid subfamily to the lonchaeids. The economic importance of *Neosilba* species (as *Silba*) in *Citrus* and in other fruit trees has been pointed out in other Brazilian regions (Malavasi & Morgante 1980; Raga *et al*. 1996, 1997).

The mean of 3rd-instar larvae viability in the 14 host fruit species was 44.83% for Tephritidae and 55.76% for Lonchaeidae. Considering the number of 3rd-instar larvae per kg of fruit the highest infestation levels were: *Spondias lutea*, *Terminalia catappa*, *Manihot esculenta*, *S. purpurea*, *Psidium* **sp.** and *Caryocar brasiliense*, respectively. These results show a trend

of higher infestation levels in lighter and smaller fruits (Table I), according to the same observations of MALAVASI & MORGANTE (1980).

The tephritids colonized 10 host species, and the lonchaeids 11 among the 14 fruit species sampled. Anacardiaceae, Myrtaceae and Euphorbiaceae (cassava fruit) were infested mainly by tephritids, in which the infesting larvae were parasitized by braconids.

Terminalia catappa fruits were mainly attacked by *C. capitata*. This host plant is native to the Malay Peninsula (LIQUIDO *et al.* 1991) and *C. capitata* has become sucessfully adapted to Tropical almond, in other Brazilian regions (RONCHI-TELES & SILVA 1996; SILVA *et al.* 1998).

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