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* (Muesebeck, 1958), *Doryctobracon areolatus* (Szépligeti, 1911), *D. fluminensis* (Costa Lima, 1938), *Opis 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, Diaz & Uchoa-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; SÁLES 1996; CANAL et al. 1995; SALLES 1996; AGUILAR-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. 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.
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 the 3rd-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 pulate and allow the emergence of flies or their parasitoids (UCHÔA-FERNANDES & ZUCCHI 1999). Only 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):

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

\[
\% \text{V. L3} \text{ (Percentage of the viability of third instar larvae).}
\]

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

\[
\% \text{C.P.} = \frac{\text{N.R.P.} \times 100}{\text{N.L3}}
\]

\[
\% \text{C.P.} = \text{The percentage of total parasitism rate;}
\]

\[
\text{N.R.P.} = \text{Number of recovered parasitoids;}
\]

\[
\text{N. L3} = \text{The number of 3rd-instar larvae of frugivorous flies.}
\]

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 Zoològia 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; SALLIES 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 parasitizing 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. 1995; OVRUSKI & FIDALGO 1994; CANAL et al. 1995; LEONEL Jr et al. 1995, 1996; SALLIES 1996; AGUIAR-MENEZES & MENEZES 1997; LÓPEZ et al. 1999).

Figitidae

Four species 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 specimens
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 Trybiographa are larval endoparasitoids that emerged from Neosilba spp. puparia.

All eucolines 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 Eucoliiinae have been used as biological control agents of some economically important fruit flies: Aganaspis daci (Weld, 1951) (oriental species) and A. pelleranoi (Bréthes, 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 eucolines 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 eucolines 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.

All the eucolines 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 parasitising 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 eucolines have been characterized as larval endoparasitoids of lonchaeids, other authors have found species of Odontosema and Aganaspis parasitising 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 Trybiographa 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).

Nevertheless, 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)

<table>
<thead>
<tr>
<th>Host Fruits</th>
<th>Sites (samples)</th>
<th>Index Larvae/fruit (n)</th>
<th>Index Larva/kg of fruit</th>
<th>Taxa of Frugivorous flies</th>
<th>Emerged flies n</th>
<th>Taxa of Parasitoids</th>
<th>Parasitoids and Parasitism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anacardiaceae</td>
<td>Hog plum, Spondias lutea L. 640 (7.43)</td>
<td>Aquid. (3)</td>
<td>2.86</td>
<td>246.84</td>
<td>1,834 Tephr.</td>
<td>Tephritidae Anastrepha spp. A. obliqua (581)</td>
<td>1,145</td>
</tr>
<tr>
<td>Red mombin, S. purpurea L. 484 (6.88)</td>
<td>Anast. Aquid. (8)</td>
<td>1.18</td>
<td>83.43</td>
<td>570 Tephr.</td>
<td>229</td>
<td>40.17</td>
<td>Braconidae A. anastrephae (1) U. anastrephae (2)</td>
</tr>
<tr>
<td>Anonaceae</td>
<td>Sugar-apple, Annona squamosa L. 39 (5.70)</td>
<td>Anast. (4)</td>
<td>1.10</td>
<td>7.54</td>
<td>43 Lonch.</td>
<td>Lonchaeidae Neosilba sp.</td>
<td>41</td>
</tr>
<tr>
<td>Duguetia furfuracea</td>
<td>St. Hil. 204 (11.46)</td>
<td>Aquid. Terenos (8)</td>
<td>1.15</td>
<td>20.42</td>
<td>234 Lonch.</td>
<td>Lonchaeidae Neosilba sp.</td>
<td>200</td>
</tr>
<tr>
<td>Caryocaraceae</td>
<td>Caryocar brasiliense Camb. 562 (77.25)</td>
<td>Aquid. Rochedo (15)</td>
<td>7.06</td>
<td>51.35</td>
<td>1 Tephr.</td>
<td>Tephritidae A. sororcula (1)</td>
<td>1</td>
</tr>
<tr>
<td>Combretaceae</td>
<td>Tropical almond, Terminalia catappa L. 443 (15.32)</td>
<td>Aquid. (10)</td>
<td>6.23</td>
<td>180.16</td>
<td>2,595 Tephr.</td>
<td>Tephritidae Anastrepha spp. (3) A. zemlika (1) C. capitata (2,131)</td>
<td>2,134</td>
</tr>
<tr>
<td>Euphorbiaceae</td>
<td>Cassava fruits, Manihot esculenta Crantz 1,760 (4.12)</td>
<td>Faz. Ranchinho, Rochedo (4)</td>
<td>0.36</td>
<td>154.85</td>
<td>638 Tephr.</td>
<td>Tephritidae Anastrepha spp. A. montei (76) A. pickelli (1)</td>
<td>140</td>
</tr>
<tr>
<td>Mimosaceae</td>
<td>Inga, Inga laurina (Sw.) 1,545 (11.43)</td>
<td>Aquid. (6)</td>
<td>0.35</td>
<td>47.59</td>
<td>77 Tephr.</td>
<td>Tephritidae C. capitata</td>
<td>50</td>
</tr>
<tr>
<td>Myrtaceae</td>
<td>Araçu, Psidium sp. 1,313 (10.38)</td>
<td>Aquid. (5)</td>
<td>0.60</td>
<td>76.01</td>
<td>789 Tephr.</td>
<td>Tephritidae Anastrepha spp. A. sororcula (167) A. striata (79) A. fraterculus (3)</td>
<td>517</td>
</tr>
</tbody>
</table>
Larval endoparasitoids (Hymenoptera) of frugivorous flies

**Table I.**

<table>
<thead>
<tr>
<th>Host Fruits</th>
<th>Sites</th>
<th>Index Larvae/fruit (n)</th>
<th>Index Larva/kg of fruit</th>
<th>3rd instar recovered larvae (n)</th>
<th>Taxa of Frugivorous flies (n)</th>
<th>Emerged flies n</th>
<th>Taxa of Parasitoids</th>
<th>Parasitoids and Parasitism (n)</th>
<th>% total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rutaceae</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orange, <em>Citrus sinensis</em> L. 2,246 (357.26)</td>
<td>Anast. Aquid. Terenos (179)</td>
<td>2.43</td>
<td>15.95</td>
<td>89 Tephr.</td>
<td><strong>Tephritidae</strong> <em>A. turpiniae</em> (2) <em>C. capitata</em> (66)</td>
<td>68</td>
<td>76.40</td>
<td><strong>Figitidae</strong> <em>L. anastrephae</em> (164) <em>T. infuscata</em> (18) <em>A. nordlinderi</em> (12)</td>
<td>194</td>
</tr>
<tr>
<td>Tangerine, <em>Citrus reticulata</em> (L.) 134 (21.60)</td>
<td>Anast. Aquid. Terenos (14)</td>
<td>2.65</td>
<td>16.43</td>
<td>355 Lonch.</td>
<td><strong>Lonchaeidae</strong> <em>Neosilba</em> spp.</td>
<td>3,360</td>
<td>60.97</td>
<td><strong>Figitidae</strong> <em>L. anastrephae</em> (47) <em>A. nordlinderi</em> (4)</td>
<td>51</td>
</tr>
<tr>
<td><strong>Solanaeaceae</strong></td>
<td>Solanum viarum Dun. 789 (10.39)</td>
<td>Aquid. (5)</td>
<td>0.37</td>
<td>27.81</td>
<td>289 Lonch.</td>
<td><strong>Lonchaeidae</strong> <em>Neosilba</em> spp.</td>
<td>246</td>
<td>85.12</td>
<td><strong>Figitidae</strong> <em>L. anastrephae</em> (2)</td>
</tr>
<tr>
<td><strong>TOTALS / MEANS</strong></td>
<td>14 plant species 20,166 fruits 648,66 kg of biomass</td>
<td>4 sites (283)</td>
<td>2.07</td>
<td>72.82</td>
<td>11,298 Tephr. 11,246 Lonch</td>
<td><em>Anastrepha</em> spp. <em>C. capitata</em></td>
<td>4,814 2,637</td>
<td>7,451 1 Tephr. Lonch.</td>
<td><strong>Braconidae</strong></td>
</tr>
</tbody>
</table>

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

Viaraum Dun. (Solanaeaceae) 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 (Eucolliinae). 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: *Spoedias 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 1), 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 successfully adapted to Tropical almond, in other Brazilian regions (Ronchi-Teles & Silva 1996; Silva et al. 1998).

Acknowledgements. To José Zorandir Nogueira (in memoriam) and his wife, Dina Cândida Fajardo, for their friendship and incentive in the collecting of fruits at their farm, Fazenda Ranchinho, Rochedo, Mato Grosso do Sul; Dr. Valmir A. Costa, Instituto Biológico, Campinas, São Paulo, for the identification of the Pteromalidae species; IBAMA-Mato Grosso do Sul (Jacob Ronaldo Kuffner) and MAARA-Mato Grosso do Sul (Celso Luiz Antoniali) for the donation of two vehicles to the Universidade Federal de Mato Grosso do Sul for the constant support; Conselho Nacional de Desenvolvimento de Pesquisa e Pós-Graduação, Universidade Federal de Mato Grosso do Sul for assisting the “Projeto (Celso Luiz Antoniali) for the donation of two vehicles to the Grosso do Sul (Jacob Ronaldo Kuffner) and MAARA-Mato Grosso do Sul (Celso Luiz Antoniali) for the donation of two vehicles to the Universidade Federal de Mato Grosso do Sul for the constant support; Conselho Nacional de Desenvolvimento Científico e Tecnológico-CNPq for the scholarship to the first author (1995 to 1997); Ubirazilda Maria Resende, for helping in the identification of the plant species and Professor Elisabeth A. Flunker (Wl, USA) for the final revision of the English version.

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