Diversity and Abundance of Hymenopterous Parasitoids Associated with Anastrepha fraterculus (Diptera: Tephritidae) in Native and Exotic Host Plants in Misiones, Northeastern Argentina

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DIVERSITY AND ABUNDANCE OF HYMENOPTEROUS PARASITOIDS ASSOCIATED WITH *ANASTREPHA FRATERCULUS* (DIPTERA: TEPHRITIDAE) IN NATIVE AND EXOTIC HOST PLANTS IN MISIONES, NORTHEASTERN ARGENTINA

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ABSTRACT

Some Major host species used by the tephritid fruit flies *Anastrepha fraterculus* (Wiedemann) and *Ceratitis capitata* (Wiedemann), including *Acca sellowiana* (O. Berg) Burret, *Campomanesia xanthocarpa* O. Berg, *Psidium guajava* L., *Prunus persica* (L.) Batsch, *Eriobotrya japonica* (Thunb.) Lindl., *Citrus reticulata* Blanco var. Murcott, *C. aurantium* L., *C. paradisi* Macfadyen var. Dalan Dan, and *C. paradisi* var. Sudashi, were sampled for fruit fly larvae between Feb and Dec 2000 in the northernmost section of the Paranaense forest, in the Province of Misiones, NE Argentina. Both *A. fraterculus* and *C. capitata* were obtained from these host plant species, with *A. fraterculus* accounting for 93% of all tephritid puparia identified. Ten species of larval-pupal parasitoids were recovered from *A. fraterculus*: *Doryctobracon areolatus* (Szépligeti), *D. brasiliensis* (Szépligeti), *Utetes anastrephae* (Viereck), *Opius bellus* (Gahan), *Diachasmimorpha longicaudata* (Ashmead) (Opiinae, Braconidae), *Odontosema anastrephae* Borgmeier, *Lopheucoila anastrephae* (Rohwer), *Aganaspis pelleranoi* (Brèthes) (Eucoilinae, Figitidae), *Asobara anastrephae* (Muessebeck) (Alyssinae, Braconidae), and *Aceratoneuromyia indica* (Silvestri) (Tetrastichinae, Eulophidae). All these parasitoids, with the exception of *D. longicaudata* and *A. indica*, are native to the Neotropical region. No parasitoids were recovered from *C. capitata* puparia. *Asobara anastrephae* and *O. anastrephae* are newly recorded in Argentina, whereas *D. brasiliensis*, *U. anastrephae*, and *L. anastrephae* are newly reported in Misiones. The eucoiline *A. pelleranoi* was the most abundant parasitoid species. *Acca sellowiana* and *P. guajava* harbored the highest parasitoid abundance and diversity.

Key Words: fruit flies, host plants, parasitoids, diversity, abundance, Argentina

RESUMEN

Las especies de plantas hospederas *Acca sellowiana* (O. Berg) Burret, *Campomanesia xanthocarpa* O. Berg, *Psidium guajava* L., *Prunus persica* (L.) Batsch, *Eriobotrya japonica* (Thunb.) Lindl., *Citrus reticulata* Blanco var. Murcott, *C. aurantium* L., *C. paradisi* Macfadyen var. Dalan Dan, y *C. paradisi* var. Sudashi fueron colectadas entre Febrero y Diciembre de 2000 en la sección más norteña de la selva Paranaense (Misiones, noreste argentino). De estas plantas hospederas se obtuvieron dos especies de Tephritidae: *Anastrepha fraterculus* (Wiedemann) y *Ceratitis capitata* (Wiedemann). La primera especie de tefrítido representó el 93% de todos los puparios identificados. Se recuperaron 10 especies de parasitoides larvo-pupales de *A. fraterculus*: *Doryctobracon areolatus* (Szépligeti), *D. brasiliensis* (Szépligeti), *Utetes anastrephae* (Viereck), *Opius bellus* (Gahan), *Diachasmimorpha longicaudata* (Ashmead) (Opiinae, Braconidae), *Odontosema anastrephae* Borgmeier, *Lopheucoila anastrephae* (Rohwer), *Aganaspis pelleranoi* (Brèthes) (Eucoilinae, Figitidae), *Asobara anastrephae* (Muessebeck) (Alyssinae, Braconidae) y *Aceratoneuromyia indica* (Silvestri) (Tetrastichinae, Eulophidae). Todas estas especies de parasitoides, con la excepción de *D. longicaudata* y *A. indica*, son nativas de la Región Neotropical. No fueron recuperados parasitoides de puparios de *C. capitata*. Las especies *A. anastrephae* y *O. anastrephae* son nuevos registros para Argentina, mientras que *D. brasiliensis*, *U. anastrephae* y *L. anastrephae* son nuevas citas para Misiones. El eucoilino *A. pelleranoi* fue la especie de parasitoide más abundante. Las plantas hospederas *A. sellowiana* y *P. guajava* manifestaron los valores más altos de diversidad y abundancia de parasitoides.

Translation provided by the authors.

There are 2 tephritid fly species in Argentina that have a major economic impact: the native *Anastrepha fraterculus* (Wiedemann) (South American fruit fly) and the exotic *Ceratitis capitata* (Wiedemann) (Mediterranean fruit fly). These pests represent an obstacle for fruit crop expansion and for diversification plans in the northeastern Argentinean provinces of Misiones, Corrientes and Entre Ríos (Guillén & Sánchez 2007). In this Argentinean region there are important *Citrus*-growing areas and patches of native forest locally known as the "Selva Paranaense" (Cabrera 1976), where *A. fraterculus* and *C. capitata* infest both wild and cultivated native and exotic fruit species (Turica & Mallo 1961; Putruelle 1996; Segura et al. 2006).

Ogloblin (1937) and Turica & Mallo (1961) are the only previous studies of the native parasitoid fauna of *A. fraterculus* in the northernmost extension of the Argentinean Paranaense forest. Since then, the exotic fruit fly parasitoids, *Diachasmimorpha longicaudata* (Ashmead) and *Aceratoneuromyia indica* (Silvestri), were recovered from *A. fraterculus* pupae in Misiones (Schliserman et al. 2003; Ovruski et al. 2006). Both *D. longicaudata* and *A. indica*, natives of Southeast Asia, were introduced during the 1960s and released in limited numbers in several fruit-growing areas of Argentina, including Misiones (Ovruski et al. 2000), and these are the only exotic parasitoids currently established in Argentina.

The aim of the present study is to survey wild and cultivated fruit species commonly infested by *A. fraterculus* and *C. capitata* with the purpose of providing more detailed information on the diversity, abundance, and distribution ranges of hymenopterous parasitoid species associated with both tephritid species in Misiones, northeastern Argentina, as well as to record the degree of infestation and parasitism in each fruit species.

Materials and Methods

Fruit collections were made weekly between Feb and Dec 2000 in Caraguatay (26°66'S, 54°75'W, elevation 193 m), Laharrague (26°50'S, 54°77'W, 159 m), and Montecarlo city (26°57'S, 54°45'W, 161 m) localities of the Misiones province, NE Argentina. The region has a temperate-warm humid climate with a summer average temperature of 25°C, and a winter average temperature of 16°C. It rains periodically all year long, and the annual rainfall varies from 1,500 to 2,500 mm (Anonymous 1992). The original native vegetation is the subtropical rainforest locally known as the "Selva Paranaense", which has been intensely modified into agricultural and managed forest areas (Cabrera 1976).

The fruit samples consisted of fallen ripe fruit (40-50%) and ripe fruit still on the tree (50-60%). Table 1 contains fruit tree species surveyed, with information on mean individual weight of fruit, status (exotic or native and wild or cultivated), common name, and plant family. Fruit were mainly collected in forest patches adjacent to citrus groves covered with wild native vegetation, and orchards located at the experimental station "Campo Experimental Laharrague", an agricultural area maintained by the National Institute of Agricultural Technology (Instituto Nacional de Tecnología Agropecuaria, INTA). No insecticides were applied in any of the collection sites.

Fruit samples were processed in the laboratory of the Montecarlo Experimental Agricultural Station (Estación Experimental Agropecuaria Montecarlo, EEAM)—INTA located in Montecarlo city. Fruits collected from tree and from the ground were kept separate. All fruits in the sample were weighed and rinsed with a 20% solution of sodium benzoate. Each sample was placed in a plastic tray (55 × 40 × 20 cm) with sand in the bot-

Table 1. Plant family, fruit species, average individual fruit weight, and number of trees sampled in Misiones, NE Argentina, during 1-year study (2000).

Plant Family	Fruit species and (common name)	Status	Mean (± SD) individual fruit weight (g) (n = 100 fruits)
Myrtaceae	*Acca sellowiana* (O. Berg) Burret (feijoa)	Native, Wild	18.9 ± 2.7
	Campomanesia xanthocarpa O. Berg (guabirá)	Native, Wild	4.9 ± 1.6
	Psidium guajava L. (guava)	Exotic, Wild	30.1 ± 2.1
Rosaceae	*Prunus persica* (L.) Batsch (peach)	Exotic, Cultivated	38.8 ± 6.9
	Eriobotrya japonica (Thunb.) Lindl. (loquat)	Exotic, Wild	8.1 ± 2.9
Rutaceae	*Citrus aurantium* L. (sour orange)	Exotic, Cultivated	250.8 ± 64.5
	C. paradisi Macfadyn var. Dalan Dan (grapefruit)	Exotic, Cultivated	336.9 ± 46.5
	C. paradisi Macfadyn var. Sudashi (grapefruit)	Exotic, Cultivated	234.5 ± 28.7
	C. reticulata Blanco, var. Murcott (mandarin orange)	Exotic, Cultivated	99.3 ± 15.3

tom as pupation medium for larvae. All trays were kept inside a room at 26 ± 2°C and 65 ± 10% relative humidity for 4 weeks. Afterwards, fruits were dissected to find larvae or puparia in the pulp. Live larvae were allowed to pupate and were then added to the other pupae collected from the same sample. The sand inside trays was sifted 2 times each week to collect tephritid pupae, which then were transferred to glass vials (11 cm high and 6 cm of diameter) containing sterilized humid sand at the bottom. Puparia of *C. capitata* and *Anastrepha* Schiner were separated based on pupal characters (White & Elson-Harris 1992).

Parasitoid specimens were identified to species by the authors P. S, S. O., and R. W. Fruit flies were identified by S. O. using Zucchi's (2000) taxonomic key. The nomenclature corresponds to Wharton (1997) for the Opiinae and Wharton et al. (1998) for the Eucoilinae. Parasitoid and fly specimens were placed in the entomological collections of the Miguel Lillo Foundation (Fundación Miguel Lillo, FML) (Tucumán, Argentina), EEAM (Misiones, Argentina), and Texas A&M University (Texas, USA). All plant species were identified by author O. De Coll.

The rate of parasitism was calculated by dividing the total number of adult parasitoids emerging from pupae obtained from a fruit sample by the total number of pupae recovered from that 1 fruit sample and multiplying it by 100 (Aluja et al. 2003). Fruit infestation levels were obtained by dividing the total number of pupae obtained from a fruit sample by the total weight of the sample (Aluja et al. 2003).

Results

A total of 261.35 kg of fruit was processed during this study (Table 2). Only *A. fraterculus* was recovered from *P. guajava*, *A. sellowiana*, *E. japonica*, and *C. xanthocarpa*, whereas both *A. fraterculus* and *C. capitata* were recovered from the remaining fruit species. *Ceratitis capitata* constituted 93, 38, 15, 20, and 25% of the total recovered fly puparia from *C. aurantium*, *C. reticulata*, *C. paradisi* var. Dalan Dan, *C. paradisi* var Sudashi, and *P. persica* (Table 2).

The highest infestation rates by *A. fraterculus* were found in *P. guajava* and *A. sellowiana*, and the lowest levels in the *Citrus* species (Table 2). Infestation patterns by *C. capitata* were low and ranged from 0 to 14 pupae per kg of sampled fruit (Table 2).

Five species of opiine Braconidae, 3 species of eucoiline Figitidae, 1 species of alysiine Braconidae, and 1 species of tetrastichine Eulophidae, all larval-pupal parasitoids, were recovered from *A. fraterculus* pupae. The parasitoids comprised *Doryctobracon areolatus* (Szépligeti), *D. brasiliensis* (Szépligeti), *Utetes anastrephae* (Viereck), *Opius bellus* Gahan, *Diachasmimorpha longicaudata* (Ashmead) (Opiinae, Braconidae), *Odontosema anastrephae* Borgmeier, *Lopheucoila anastrephae* (Rohwer), *Aganaspis pelleranoi* (Brèthes) (Eucoilinae, Figitidae), *Asobara anastrephae* (Muessebeck) (Alyssinae, Braconidae), and *Aceratoneuromyia indica* (Silvestri) (Tetrastichinae, Eulophidae). All these parasitoid species, with the exception of *D. longicaudata* and *A. indica*, are native to the Neotropical region. No parasitoids were recovered from *C. capitata* puparia.

Nine parasitoid species were found attacking *A. fraterculus* larvae in *A. sellowiana*, which had the most diverse assemblage of parasitoids (Table 3). In 3 of the fruit species, only a single parasitoid species was associated with *A. fraterculus* larvae (Table 3). Nearly 80% of the figitid parasitoids were recovered from fruit gathered from the ground. On the contrary, approximately 60% of the braconid parasitoids were obtained from fruit collected from the tree canopy (Table 3). Percent parasitism was variable and ranged from 0 to 15% in the different fruit species found to be hosts of *A. fraterculus* in the study area (Fig. 1).

Discussion

Six findings are noteworthy: (1) a higher proportion of *A. fraterculus* than *C. capitata* were found in 90% of the host plants surveyed, (2) the diversity of native *A. fraterculus* parasitoids was high in the northernmost section of the subtropical Paranaense forest, (3) the new data extended the known distribution of *A. fraterculus* parasitoids, (4) the permanent establishment of *A. indica* in the Paranaense biogeographical region was confirmed, (5) the eucoiline *A. pelleranoi* was relatively abundant and had an uncharacteristically wide host plant breadth, and (6) the importance of host plants of the Myrtaceae family, such as the *A. sellowiana* and *P. guajava*, harbored unusually high levels of parasitoid diversity and abundance.

Although the number and size of fruit samples surveyed during this study were relatively small, the data suggest that *A. fraterculus* appears to be more abundant than *C. capitata* in wild native, "feral" exotic, and cultivated exotic fruit species, with the sole exception of *C. aurantium*, in the northernmost portion of NE Argentina. Both *A. sellowiana* and *P. guajava* wild fruit species were principal reservoirs from which *A. fraterculus* could spread to *Citrus*-growing areas. Similar observations have been made by Ovruski et al. (2004, 2005) in NW Argentina. As noted by Norrbom (2000), fruits in the family Myrtaceae are the principal hosts of *A. fraterculus*.

The alysiine *A. anastrephae* and the eucoiline *O. anastrephae* are 2 new native *A. fraterculus* parasitoid species recorded for Argentina. Before this study, 11 neotropical parasitoid species asso-

TABLE 2. TOTAL NUMBERS OF *A. FRATERCULUS* AND *C. CAPITATA* PUPAE AND ADULTS, AND DEGREE OF INFESTATION RECORDED FOR 8 FRUIT SPECIES COLLECTED IN MISIONES, NE ARGENTINA DURING 1-YEAR STUDY (2000).

Collection sites and months	Host plant species	No. of samples	Total No. and weight (kg) of fruit sampled	Total No. of recovered *A. fraterculus* pupae and adults		*A. fraterculus* pupae/kg of fruit (mean ± SD)	Total No. of recovered *C. capitata* pupae and adults		*C. capitata* pupae/kg of fruit (mean ± SD)
Laharrague (Feb)	*P. guajava*	3	142 (3.5)	312	105	90.01 ± 10.51	—	—	—
Laharrague (Feb-Mar)	*A. sellowiana*	12	611 (11.9)	2.285	559	176.74 ± 76.67	—	—	—
Laharrague (May-Sep)	*C. aurantium*	12	191 (44.2)	12	2	0.17 ± 0.31	159	58	4.21 ± 1.82
Laharrague (Jun-Sep)	*C. reticulata* var. Murcott	24	327 (33.2)	120	35	4.90 ± 3.89	72	34	1.51 ± 1.55
Laharrague (Sep-Oct)	*C. paradisi* var. Dalan Dan	14	257 (80.5)	188	88	1.72 ± 1.10	32	12	0.11 ± 0.26
Laharrague (Sep-Oct)	*C. paradisi* var. Sudashi	11	104 (24.3)	44	8	1.92 ± 0.52	11	3	0.39 ± 0.68
Laharrague (Sep-Oct)	*E. japonica*	11	959 (12.6)	266	112	19.01 ± 14.28	—	—	—
Laharrague (Oct-Nov)	*P. persica*	7	271 (11.1)	81	21	6.87 ± 1.58	14	2	1.68 ± 1.47
Laharrague (Oct-Dec)	*C. xanthocarpa*	4	509 (1.6)	50	27	32.09 ± 18.18	—	—	—
Caraguatay (Mar)	*P. guajava*	12	675 (19.9)	2.447	748	121.62 ± 11.26	—	—	—
Montecarlo (Oct-Nov)	*P. persica*	9	427 (18.5)	439	145	36.41 ± 27.63	158	37	8.92 ± 4.78

TABLE 3. PARASITOIDS OF *A. FRATERCULUS* RECOVERED FROM RIPE FRUITS COLLECTED FROM GROUND AND FROM THE TREE CANOPY FROM DIFFERENT HOST PLANT SPECIES IN MISIONES, NE ARGENTINA (2000).

		Parasitoids recovered from fallen fruit			Parasitoids recovered from fruit still on the tree		
Fruit Species	Parasitoid Species	Total No.	% in sample[1] (Mean ± SD)	Mean No. of adults per kg fruit (± SD)	Total No.	% in sample[1] (Mean ± SD)	Mean No. of adults per kg fruit (± SD)
P. guajava	*A. pelleranoi*	93	15.7 ± 7.2	7.1 ± 2.7	24	5.7 ± 4.4	2.5 ± 2.0
	D. areolatus	43	6.5 ± 3.6	3.2 ± 2.0	59	12.9 ± 5.9	6.0 ± 3.8
	D. brasiliensis	20	2.9 ± 2.3	1.5 ± 1.2	30	6.3 ± 4.3	3.1 ± 2.5
	U. anastrephae	1	0.1 ± 0.3	0.1 ± 0.2	2	0.4 ± 1.2	0.2 ± 0.6
	O. anastrephae	2	0.4 ± 1.5	0.2 ± 0.6	0	—	—
	L. anastrephae	1	0.1 ± 0.2	0.1 ± 0.3	1	—	—
	O. bellus	0	—	—	1	0.3 ± 1.1	0.1 ± 0.5
A. sellowiana	*A. pelleranoi*	91	19.6 ± 12.2	18.7 ± 16.6	30	8.4 ± 4.6	6.0 ± 4.2
	D. areolatus	24	6.4 ± 4.2	5.3 ± 5.7	35	9.0 ± 6.8	6.5 ± 5.2
	D. brasiliensis	26	5.9 ± 4.1	4.8 ± 4.2	25	8.7 ± 8.4	4.9 ± 3.0
	A. indica	7	1.2 ± 2.9	1.0 ± 2.4	0	—	—
	D. longicaudata	4	0.8 ± 2.0	0.6 ± 1.7	1	0.2 ± 0.7	0.2 ± 0.6
	U. anastrephae	1	0.3 ± 1.2	0.1 ± 0.3	2	0.4 ± 1.0	0.3 ± 0.7
	O. bellus	1	0.3 ± 1.2	0.1 ± 0.3	1	0.2 ± 0.7	0.2 ± 0.6
	A. anastrephae	0	—	—	2	0.4 ± 1.4	0.3 ± 1.2
	O. anastrephae	1	0.2 ± 0.6	0.3 ± 0.9	0	—	—
P. persica	*A. pelleranoi*	25	20.8 ± 31.4	1.8 ± 3.9	8	1.9 ± 4.4	0.5 ± 1.1
	D. areolatus	4	3.8 ± 12.6	0.3 ± 0.9	7	8.1 ± 13.0	0.5 ± 0.8
	D. brasiliensis	1	0.2 ± 0.9	0.1 ± 0.3	1	0.2 ± 0.8	0.1 ± 0.2
	U. anastrephae	0	—	—	1	0.3 ± 1.3	0.1 ± 0.3
C. reticulata	*A. pelleranoi*	1	1.4 ± 3.8	0.1 ± 0.1	0	—	—
C. paradisi var. Dalan Dan	*A. pelleranoi*	7	4.5 ± 8.9	0.1 ± 0.1	0	—	—
C. xanthocarpa	*A. pelleranoi*	2	9.8 ± 15.9	1.2 ± 1.4	0	—	—
E. japonica	*A. pelleranoi*	12	18.5 ± 19.5	2.4 ± 2.9	0	—	—
	D. areolatus	2	2.3 ± 5.2	0.5 ± 0.9	6	7.1 ± 7.9	0.9 ± 1.1

[1]Proportion in sample considering the total number of adults that emerged (both parasitoids and fruit flies).

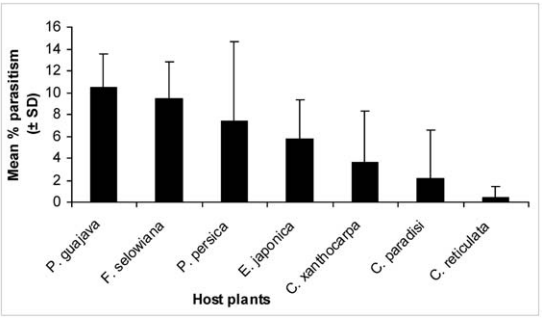

Fig. 1. Mean (± SD) parasitism percentage recorded in 7 host fruit species of *A. fraterculus* collected in Misiones, NE Argentina.

ciated with *A. fraterculus* on native and exotic host fruit species had been found in Argentina (5 Braconidae, 4 Figitidae, and 2 Diapriidae) (Ovruski et al. 2005). In decades old studies, *D. areolatus*, *O. bellus*, and *A. pelleranoi* were the only native parasitoid species recovered from *A. fraterculus* in Misiones (Ogloblin 1937, Turica & Mallo 1961).

The present detection of *Asobara anastrephae* represents the southernmost collection of this species. It was previously reported in association with *Anastrepha* spp. in Panama, Colombia, and Brazil (São Paulo, Mato Grosso do Sul, Rio Grande do Norte, Goiás, and Amazonas states) (Ovruski et al. 2000; Canal & Zucchi 2000; Souza Filho et al. 2009). Previous to this study, *Odontosema anastrephae* had only been recorded from *Anastrepha* spp. in Brazil, Costa Rica, and México (Guimarães et al. 2003). Possibly, *O. anastrephae* is widespread throughout the Neotropical Region (Wharton et al. 1998).

This study also corroborates the permanent establishment of the exotic parasitoid species *A. indica* on *A. fraterculus* in northeastern Argentina. Previously, *A. indica* had only been recorded from *A. fraterculus* pupae obtained from guava fruits approximately 38 years after its first release in Misiones (Ovruski et al. 2006). The specimens of *D. longicaudata* recorded in this study had been previously cited by Schliserman et al. (2003) and their collection marks a new southern limit for their distribution (26°50'S, 54°77'W). This exotic opiine species also had been found at 23°06'S latitude and 64°24'W longitude in the NW Argentina (Oroño & Ovruski 2007).

Of all larval-pupal/prepupal parasitoids collected, *A. pelleranoi* and *D. areolatus* were the most abundant. This pattern has also been reported in similar surveys carried out in NW Argentina (Ovruski et al. 2004, 2005) and in the southern portion of NE Argentina (Ovruski & Schliserman 2003; Ovruski et al. 2007). In all those studies *D. areolatus* represented between 48 and 61% of the total number of specimens identified, while the *A. pelleranoi* ranged between 14 and 28%. By contrast, in the present study 48% of 605 parasitoids recovered were *A. pelleranoi*.

Both *D. areolatus* and *A. pelleranoi* frequently have been recovered from several wild, exotic, and native fruit species in Latin America (Aluja 1999; Sivinski et al. 2000; Ovruski et al. 2000; Souza-Filho et al. 2009). In the present study the only parasitoid species found in association with large-sized, introduced fruit species, such as *Citrus paradisi* and *C. reticulata*, was *A. pelleranoi*. This information is consistent with data published by Schliserman & Ovruski (2004) who collected 2,820 *C. aurantium* fruits in NW Argentina but recovered *A. pelleranoi* as the only parasitoid. Previous studies by Sivinski et al. (1997) in Mexico and Ovruski et al. (2004) in Argentina showed that *A. pelleranoi* mostly parasitized *Anastrepha* larvae in fallen fruit by entering through fissures in the fruit. Large fruits with a thick pericarp allows *A. pelleranoi* to exploit a larval resource that is unavailable to species such as *D. areolatus*, which forages at canopy level (García-Medel et al. 2007) and always oviposits by drilling through the pericarp from the outside of the fruit (Sivinski & Aluja 2003). Data reported in Table 3 corroborated the differences in the foraging patterns between the figitid *A. pelleranoi* and the opiines *D. areolatus* and *D. brasiliensis*. In the cases of the other parasitoid species identified in this study, the total number of adults recovered were quite low (Table 3), and no definitive conclusions can be achieved. However, previous reports by Sivinski et al. (1997), López et al. (1999), and García-Medel et al. (2007) indicated that *O. anastrephae* preferentially attacks larvae in fallen fruit upon the ground, *U. anastrephae* forages at canopy level, and *D. longicaudata* can parasitized larvae at ground level, and also in the canopy.

Two members of the family Myrtaceae, *A. sellowiana* and *P. guajava*, generated 87% of all parasitoid specimens recovered from *A. fraterculus* pupae, and showed the highest diversity values. Similar studies conducted in tropical and subtropical forests of México (López et al. 1999; Sivinski et al. 2000), Brazil (Aguiar Menezes et al. 2001; Souza-Filho et al. 2009), NW Argentina (Ovruski et al. 2004, 2005) and Bolivia (Ovruski et al. 2009) highlighted the importance of wild or "feral" *Psidium* species and other native Myrtaceae species as reservoirs for native *Anastrepha* parasitoids. In general, Myrtaceae fruits have several characteristics, such as thin pericarp, soft endocarp, volatiles, color, and size that may favor parasitoid success, either by increasing attractiveness to wasps or by establishing easier host larva detection (Sivinski et al. 1997; Ovruski et al. 2000). Our samples of *C. xanthocarpa*, however, suggest that not all myrtaceans are equally

attractive. Our data point to the need for more thorough monitoring of fruit fly host plants over several years to assess seasonal and annual variation in impact of parasitoids upon natural populations of *C. capitata* and *A. fraterculus* in NE Argentina.

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References Cited

Aguiar-Menezes, E. L., Menezes, E. B., Silva, P. S., Bittar, A. C., and Cassino, P. C. R. 2001. Native Hymenoptera parasitoids associated with *Anastrepha* spp. (Diptera: Tephritidae) in Seropedica city, Rio de Janeiro, Brazil. Florida Entomol. 84(84): 706-711.

Aluja, M. 1999. Fruit fly (Diptera: Tephritidae) research in Latin America: myths, realities and dreams. Anais Soc. Entomol. Brasil 28: 565-594.

Aluja, M., Rull, J., Sivinski, J., Norrbom, A. L., Wharton, R., Macías-Ordoñez, R., Díaz-Fleischer, F., and López, M. 2003. Fruit flies of the genus *Anastrepha* (Diptera: Tephritidae) and associated native parasitoids (Hymenoptera) in the tropical rainforest biosphere reserve of Montes Azules, Chiapas, México. Environ. Entomol. 32: 1377-1385.

Anonymous. 1992. Atlas de la República Argentina. Editorial El Ateneo, Buenos Aires, Argentina.

Cabrera, A. 1976. Regiones fitogeográficas argentinas. Enciclopedia Agricultura y Jardinería. Ediciones ACME, SACI, Buenos Aires, Argentina, 135 pp.

Canal, N. A., and Zucchi, R. A. 2000. Parasitóides—Braconidae, pp. 119-126 *In* A. Malavasi and R. A. Zucchi [eds.], Moscas-das-frutas de Importância Econômica no Brasil. Conhecimento Básico e Aplicado. Holos Editora, Riberão Preto, Brasil.

García-Medel, D., Sivinski, J., Diaz-Fleischer, F., Ramirez-Romero, R., and Aluja, M. 2007. Foraging behavior by six fruit fly parasitoids (Hymenoptera: Braconidae) released as single- or multiple-species cohorts in field cages: influence of fruit location and host density. Biol. Control 43: 12-22.

Guillén, D, and Sánchez, R. 2007. Expansion of the national fruit fly control programme in Argentina, pp. 653-660 *In* M. J. B. Vreysen, A. S. Robinson and J. Hendrichs [eds.], Area-Wide Control of Insect Pests: From Research To Field Implementation. Springer, The Netherlands.

Guimarães, J. A., Gallardo, F. E., Diaz, N. B., and Zucchi, R. A. 2003. Eucoilinae species (Hymenoptera: Cynipoidea: Figitidae) parasitoids of fruit-infesting dipterous larvae in Brazil: identity, geographical distribution and host associations. Zootaxa 278: 1-23.

López, M., Aluja, M., and Sivinski, J. 1999. Hymenopterous larval-pupal and pupal parasitoids of *Anastrepha* flies (Diptera: Tephritidae) in Mexico. Biol. Control 15: 119-129.

Montoya P., Liedo, P., Benrey, B., Cancino, J., Barrera, J. F., Sivinski, J., and Aluja, M. 2000. Biological Control of *Anastrepha* spp. (Diptera: Tephritidae) in mango orchards through augmentative releases of *Diachasmimorpha longicaudata* (Ashmead) (Hymenoptera: Braconidae). Biol. Control 18: 216-224.

Norrbom, A. L. 2004. Host plant database for *Anastrepha* and *Toxotrypana* (Diptera: Tephritidae: Toxotrypani). Diptera Data Dissemination Disk 2, USDA-APHIS.

Ogloblin, A. 1937. La protección de los enemigos naturales de la mosca de la fruta (*Anastrepha fraterculus*). Almanaque Min. Agric. 3: 177-179.

Oroño, L. E., and Ovruski, S. M. 2007. Presence of *Diachasmimorpha longicaudata* (Hymenoptera: Braconidae) in a guiad of parasitoids attacking *Anastrepha fraterculus* (Diptera: Tephritidae) in northwestern Argentina. Florida Entomol. 90(2): 410-412.

Ovruski, S. M., and Schliserman, P. 2003. Opiine and eucoiline parasitoids (Hymenoptera: Braconidae, Figitidae) of *Anastrepha fraterculus* (Diptera: Tephritidae) in the citrus orchard areas in Corrientes, northeastern Argentina. Canadian Entomol. 135(6): 863-865.

Ovruski, S. M., Schliserman, P., and Aluja, M. 2004. Indigenous parasitoids (Hymenoptera) attacking *Anastrepha fraterculus* and *Ceratitis capitata* (Diptera: Tephritidae) in native and exotic host plants in Northwestern Argentina. Biol. Control 29: 43-57.

Ovruski, S. M., Aluja, M., Sivinski, J., and Wharton, R. A. 2000. Hymenopteran parasitoids on fruit—infesting tephritidae (Diptera) in Latin America and the southern United States: diversity, distribution, taxonomic status and their use in fruit fly biological control. Int. Pest Management Reviews 5: 81-107.

Ovruski, S. M., Wharton, R. A., Schliserman, P., and Aluja, M. 2005. Abundance of *Anastrepha fraterculus* (Diptera: Tephritidae) and its associated native parasitoids (Hymenoptera) in "feral" guavas growing in the endangered northernmost Yungas forests of Argentina with an update on the taxonomic status of Opiine parasitoids previously reported in this country. Environ. Entomol. 34(4): 807-818.

Ovruski, S. M., Schliserman, P., Decoll, O. R., Peñaloza, C., Oroño, L., and Colin, C. 2006. The establishment of *Aceratoneuromyia indica* (Hymenoptera: Eulophidae) in three biogeographical regions of Argentina. Florida Entomol. 89(2): 270-273.

Ovruski, S. M., Schliserman, P., Oroño, L. E., Núñez-Campero, S. R., Albornoz-Medina, P., Bezdjian, L. P., and Van Nieuwenhove, G. A. 2008. Natural occurrence of hymenopterous parasitoids associated with *Anastrepha fraterculus* (Diptera: Tephritidae) in Myrtaceae species in Entre Rios, Northeastern Argentina. Florida Entomol. 91(2): 220-227.

Ovruski, S. M., Schliserman, P., Nuñéz-Campero, S. R., Oroño, L. E., Bezdjian, L. P., Albornoz-Medina, P.,

AND VAN NIEUWENHOVE, G. A. 2009. A survey of hymenopterous larval-pupal parasitoids associated with *Anastrepha fraterculus* and *Ceratitis capitata* (Diptera: Tephritidae) infesting wild guava (*Psidium guajava*) and peach (*Prunus persica*) in the southernmost section of the bolivian Yungas forest. Florida Entomol. 92 (2): 269-275.

PUTRUELE, M. T. G. 1996. Hosts for *Ceratitis capitata* and *Anastrepha fraterculus* in the Northeastern province of Entre Ríos, Argentina, pp. 343-345 *In* B. A. McPheron and G. J. Steck. [eds.], Fruit Fly Pests: A World Assessment of Their Biology and Management. St. Lucie Press, Delray Beach, Florida.

SCHLISERMAN, P., OVRUSKI, S. M., AND DECOLL, O. R. 2003. The recovery and permanent establishment of *Diachasmimorpha longicaudata* (Hymenoptera: Braconidae) in Misiones, northeastern Argentina. Florida Entomol. 86(4): 491-492.

SCHLISERMAN, P., AND OVRUSKI, S. M. 2004. Incidencia de moscas de la fruta de importancia económica sobre *Citrus aurantium* (Rutaceae) en Tucumán, Argentina. Rev. Manejo Integr. Plagas y Agroecología (Costa Rica) 72: 52-61.

SEGURA, D. F., VERA, M. T., CAGNOTTI, C. L., VACCARO, N., DECOLL, O. R., OVRUSKI, S. M., AND CLADERA, J. L. 2006. Relative abundance of *Ceratitis capitata* and *Anastrepha fraterculus* (Diptera: Tephritidae) in diverse host species and localities of Argentina. Ann. Entomol. Soc. America 99(1): 70-83.

SIVINSKI, J., AND M. ALUJA. 2003. The evolution of ovipositor length in the parasitic Hymenoptera and the search for predictability in biological control. Florida Emtomol. 86(2): 143-150.

SIVINSKI, J., ALUJA, M., AND LÓPEZ, M. 1997. The spatial and temporal distributions of parasitoids of Mexican *Anastrepha* species (Diptera: Tephritidae) within the canopies of fruit trees. Ann. Entomol. Soc. America 90: 604-618.

SIVINSKI, J., PIÑERO, J., AND ALUJA, M. 2000. The distributions of parasitoids (Hymenoptera) of *Anastrepha* fruit flies (Diptera: Tephritidae) along an altitudinal gradient in Veracruz, Mexico. Biol. Control 18: 258-269.

SOUZA-FILHO, M. F., RAGA, A., AZEVEDO-FILHO, J. A., STRIKIS, P. C., GUIMARÃES, J. A., AND ZUCCHI, R. A. 2009. Diversity and seasonality of fruit flies (Díptera: Tephritidae and Lonchaeidae) and their parasitoids (Hymenoptera: Braconidae and Figitidae) in orchards of guava, loquat and peach. Brazilian J. Biol. 69(1): 31-40.

TURICA, A., AND MALLO, R. G. 1961. Observaciones sobre la población de las "Tephritidae" y sus endoparásitos en algunas regiones citrícolas argentinas. Rev. IDIA (Argentina), Supl. 6: 145-161.

WHARTON, R. A. 1997. Generic relationships of opiine braconidae (Hymenoptera) parasitic on fruit-infesting Tephritidae (Diptera). Contributions American Entomol. Institute 30: 1-53.

WHARTON, R. A., OVRUSKI, S. M., AND GILSTRAP, F. E. 1998. Neotropical Eucoilidae (Cynipoidea) associated with fruit infesting Tephritidae, with new records from Argentina, Bolivia and Costa Rica. J. Hym. Res. 7: 102-115.

WHITE, I. M., AND ELSON-HARRIS, M. M. 1992. Fruit Flies Of Economic Significance: Their Identification And Bionomics. CAB international, ACIAR, Redwood Press Ltd., Melksham, UK, 601 pp.

ZUCCHI, R. A. 2000. Taxonomía. pp. 13-24 *In* A. Malavasi and R. A. Zucchi [eds.], Moscas-das-frutas de Importância Econômica no Brasil: Conhecimento Básico e Aplicado. Holos Editora, Riberão Preto, Brasil.