NATIVE HYMENOPTERAN PARASITOIDS ASSOCIATED WITH *ANASTREPHA* SPP. (DIPTERA: TEPHRITIDAE) IN SEROPEDICA CITY, RIO DE JANEIRO, BRAZIL

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Abstract

Parasitoids associated with five species of *Anastrepha* were recovered from host fruits that belong to 12 species of plants growing in Seropedica city, Rio de Janeiro, Brazil. We recovered six native hymenopteran parasitoid species: *Doryctobracon areolatus* (Szépligeti), *Utetes* (*Bracanastrephae*) *anastrephae* (Viereck), *Opius bellus* Gahan (Braconidae, Opiinae), *Aganaspis pelleranoi* (Brèthes) (Figitidae, Eucoilinae), *Trichopria anastrephae* Lima (Diapriidae, Diapriinae) and an unidentified species of Pteromalidae. The most abundant parasitoid species was *D. areolatus*, representing 61.8% of all parasitoids. The parasitoid species recovered were well established in a wide diversity of fruit and *Anastrepha* fly species, including economically important pests such as *A. fraterculus, A. obliqua* and *A. sororcula*. The analysis of the relative abundance of the recovered parasitoids in different fruit species suggests, at least for the three encountered opiine parasitoids, that the host-parasitoid relationship was influenced by certain physical characteristics such as size and weight of the host fruit. Our results support the original proposal of M. Aluja and J. Sivinski (pers. comm.) that some native host plant species for the *Anastrepha* flies facilitate parasitoid multiplication. They deserve attention as natural enemy reservoirs and may be important to biological control strategies within fruit fly integrated management programs.

Key Words: biological control, fruit flies, tritrophic relationship, Braconidae, Figitidae, Diapriidae

Resumen

Parasitoides asociados a cinco especies de *Anastrepha* fueron recuperadas de frutos hospederos pertenecientes a 12 especies de plantas, en el municipio de Seropedica, Rio de Janeiro, Brasil. Se recuperaron seis especies de parasitoides himenópteros: *Doryctobracon areolatus* (Szépligeti), *Utetes* (*Bracanastrephae*) *anastrephae* (Viereck), *Opius bellus* Gahan (Braconidae, Opiinae), *Aganaspis pelleranoi* (Brèthes) (Figitidae, Eucoilinae), *Trichopria anastrephae* Lima (Diapriidae, Diapriinae) y una especie no identificada de Pteromalidae. La especie más abundante fue *D. areolatus*, representando 61,8% de todos los parasitoides. Las especies recuperadas de parasitoides están bien establecidas en una amplia diversidad de especies de frutos y moscas *Anastrepha*, incluyendo especies plagas como *A. fraterculus, A. obliqua* y *A. sororcula*. El análisis de la abundancia relativa de los parasitoides recuperados en las diferentes especies de frutos sugiere que por lo menos para los tres parasitoides Opiinae colectados, la relación parasitoide-hospedero fue influenciada por ciertas características físicas tales como tamaño y peso de los frutos hospederos. Nuestros resultados apoyan la original propuesta de M. Aluja y J. Sivinski (comunicación personal) de que algunas especies de plantas nativas hospederas de moscas *Anastrepha* facilitan notablemente la multiplicación de los parasitoides y así merecen atención como depósito de éstos agentes de mortalidad y como herramientas para las estrategias de control biológico dentro de los programas de manejo integrado de las moscas de las frutas.

Most frugivorous tephritid species in Brazil belong to the genus *Anastrepha* Schiner (Zucchi 1988). Of the 94 reported Brazilian species, four are serious pests: *Anastrepha fraterculus* (Wiedemann), *Anastrepha grandis* (Macquart), *Anastrepha obliqua* (Macquart), and *Anastrepha sororcula* Zucchi (Morgante 1991; Zucchi 2000). Traditionally, insecticidal bait sprays have controlled these species, although some attempts to apply classical or augmentative biological control have been made in Brazil (Carvalho et al. 1999). Braconid parasitoids, mainly Opiinae, have been included in the majority of these biological control programs, and continue to be emphasized in augmentative programs against *Anastrepha* species in the New World because of their relative host specificity and ease of production (Clausen et al. 1965; Wharton 1997; Knipling 1992). *Diachasmimorpha longicaudata* (Ashmead), an exotic Old-world opiine, was recently introduced into Brazil and has been mass-released in a attempt to control *Anastrepha* populations on an area-wide basis in some regions (Nascimento et al. 1998). Information about the native natural enemies of the fruit flies, mainly parasitoids that might overlap in their niches with introduced species, is important to avoid the displacement of valuable biocontrol agents (see Samways 1997; Sivinski et al. 1998).

In this survey we have systematically sampled native and exotic plant species growing in the city of Seropedica, RJ, a region with abundant wild hosts and backyard gardens, aiming to identify larval-pupal fruit fly parasitoids. As far as we are aware, no biological control of *Anastrepha* spp. has been attempted in the sampled area, thus the results should reflect the natural status of fruit fly natural enemies in the area.

Materials and Methods

From November 1997 to April 1999, fruit samples from 12 different plant species of six families, all known to be potential tephritid hosts, were collected in backyard gardens and in areas of wild vegetation throughout the city of Seropedica, Rio de Janeiro state, in the southeast of Brazil (22°45'S latitude, 43°41'W longitude, and 33 m above sea level).

The fruit samples included eight native species: Surinam cherry (*Eugenia uniflora* L.), Brazilian cherry (*Eugenia brasiliensis* Lam.), jaboticaba (*Myrciaria cauliflora* Berg.), guava (*Psidium guajava* L.) (all Myrtaceae), hog-plum (*Spondias mombin* L.), Spanish prune (*Spondias purpurea* L.) (Anacardiaceae), abiu (*Pouteria caimito* Radlk.) (Sapotaceae), and inga (*Inga affinis* de Cand.) (Leguminosae). Four exotic species were also included: mango (*Mangifera indica* L.) (Anacardiaceae), carambola (*Averrhoa carambola* L.) (Oxalidaceae), loquat (*Eriobotrya japonica* Lindl.) (Rosaceae), and tropical almond (*Terminalia catappa* L.) (Combretaceae).

Samples of mature fruits were randomly collected from the ground under host trees, and placed in labelled paper bags. Subsequently, they were taken to the laboratory of the "Centro Integrado de Manejo de Pragas *Cincinnato Rory Gonçalves*" (CIMP CRG) at the "Universidade Federal Rural do Rio de Janeiro" located in the city of Seropedica. In the laboratory, they were removed from the collection bags. Each fruit species was placed separately in plastic sieves, which, in turn were placed on top of plastic containers with sand at the bottom as a pupation substrate. These containers were kept at ambient temperature and humidity. Following this, every second day they were inspected to ascertain if the sand needed to be moistened. At that time, if the pupae were formed, the sand was sifted to remove the pupae, which were then placed in plastic boxes on sand that was moistened, when necessary, and covered with organdy for holding until emergence of flies and parasitoids.

All emerged flies and parasitoids were preserved in vials filled with 70% alcohol until identified. The Tephritidae and some parasitoid species were identified by the authors with the aid of available literature (Zucchi 1978; Steyskal 1977; Leonel Junior 1991). J. A. Guimarães (ESALQ/USP, Piracicaba, SP) made the identification of some parasitoid species. Voucher specimens were placed in the entomological collections of CIMP CRG.

In this study, associations among parasitoids and fruit flies were assumed when only one species of tephritid emerged from one sample of the fruit species.

Results and Discussion

We sampled 2,720 fruits from 12 plant species infested under natural conditions by tephritid larvae. *Anastrepha* and parasitoid specimens were recovered from every plant species. A total of 3,313 *Anastrepha* flies and 1,234 parasitoids was recovered.

Five *Anastrepha* species, *A. fraterculus* (Wiedemann), *A. sororcula* Zucchi, *A. obliqua* (Macquart), *A. distincta* Greene, and *A. serpentina* Wiedemann were recovered. Egg and pupal parasitoids were not found in our collections; because all of the *Anastrepha* were collected as larvae, they would not have been obtained even if present in the area. Most of the parasitoids (97.6%) belonged to the family Braconidae. Specimens of the Figitidae, Diapriidae, and Pteromalidae represented less than 3% of all parasitoids recovered.

Six species of larval-pupal hymenopteran parasitoids were reared in association: *Doryctobracon areolatus* (Szépligeti), *Utetes* (*Bracanastrephae*) *anastrephae* (Viereck), *Opius bellus* Gahan (Braconidae, Opiinae), *Aganaspis pelleranoi* (Brèthes) (Figitidae, Eucoilinae), *Trichopria anastrephae* Lima (Diapriidae, Diapriinae) and an unidentified species of Pteromalidae.

D. areolatus was the most abundant parasitoid species (61.8% of all recovered parasitoids). Its greater relative abundance was previously reported by Aguiar-Menezes & Menezes (1997) collecting in Itaguai city, Rio de Janeiro and by Canal et al. (1995), Leonel Junior et al. (1995) and Matrangolo et al. (1998) collecting in other parts of Brazil. This species is one of the most common and widespread native parasitoids of *Anastrepha* in the New World, ranging from Mexico to Argentina (Wharton & Marsh 1978; Baranowski et al. 1993; Aluja et al. 1990; Katiyar et al. 1995; López et al. 1999). *Utetes anastrephae* and *O. bellus* comprised 27.2 and 8.7% of all parasitoids recovered, respectively. *A. pelleranoi* and *T. anastrephae* were rarely encountered during this study. The few specimens of these species represented only 1.8 and 0.3% of all parasitoids, respectively.

D. areolatus also exhibited the broadest host range. It attacked larvae of all five *Anastrepha* species recovered and foraged for hosts in all of the plant species sampled (Table 1). The other parasitoid species were also generalists (i.e., attacking multiple fly species often in multiple hosts), with the exception of *T. anastrephae*, which was observed only in association with *A. fraterculus* in hog-plum. Lima (1962) had previously reported *A. fraterculus* as the host of *T. anastrephae*. We found *O. bellus* in association with *A. fraterculus* and *A. sororcula* in Surinam cherry. *Utetes anastrephae* and *A. pelleranoi* were associated with *A. fraterculus*, *A. sororcula* and *A. obliqua* in different host plants. Arrigoni et al. (1987), Leonel Junior (1991), Leonel Junior & Zucchi (1993), and Aguiar-Menezes & Menezes (1997) also identified the same guild of three species of Braconidae as parasitoids of *A. fraterculus, A. sororcula* and *A. obliqua*.

There was little or no host plant preference shown by *A. pelleranoi* and the opiine parasitoids. They attacked larvae in different plant species, as has also been observed by Hernandez-Ortiz et al. (1994), Ovruski (1994), Wharton et al. (1981) and López et al. (1999). However, we also found that the recovered parasitoid species differed in relative abundance among the different fruit species sampled (Table 2). Apparently, they were influenced by fruit characteristics, such as size, pulp depth and rind thickness.

In general, the recovered parasitoid species occurred in greater number in plant species with smaller fruits, such as Surinam cherry, Brazilian cherry and Spanish prune (Table 2). According to Leonel Junior (1991) and Sivinski (1991), smaller fruits with thin pulps and skins have a higher parasitism of fruit flies because the chances of the parasitoid finding and attacking the larva are greater. In larger fruits, the tephritid larvae receive protection against parasitoid attack by being sheltered under a great amount of pulp. Lathrop & Newton (1933), Lawrence (1981) and Glas & Vet (1983) reported that the opiines *Opius mellus*, *Diachasmimorpha longicaudatus,* and *Opius alloeum* find their host by vibrotaxis (larval movement). Per-

TABLE 1. RELATIONSHIP BETWEEN FRUIT FLIES, HOST PLANTS AND PARASITOIDS IN SEROPEDICA CITY, RIO DE JANEIRO, BRAZIL THROUGHOUT 1997-1999.

Parasitoids	Species of *Anastrepha*	Fruit host
Braconidae (Opiinae)		
D. areolatus	*fraterculus*	hog-plum, Spanish prune, guava, jaboticaba, Surinam cherry, Brazilian cherry, carambola, loquat, abiu, tropical almond
	obliqua	mango, hog-plum, Spanish prune, guava, jaboticaba, Brazilian cherry, carambola
	sororcula	mango, guava, jaboticaba, Surinam cherry, Brazilian cherry, carambola
	serpentina	abiu
	distincta	inga
U. anastrephae	*fraterculus*	Spanish prune, guava, jaboticaba, Surinam cherry, Brazilian cherry, carambola
	obliqua	mango, Spanish prune, Brazilian cherry, carambola
	sororcula	mango, Spanish prune, guava, Surinam cherry, Brazilian cherry, carambola
O. bellus	*fraterculus*	Surinam cherry
	sororcula	Surinam cherry
Figitidae (Eucoilinae)		
A. pelleranoi	*fraterculus*	Surinam cherry, Brazilian cherry, carambola
	obliqua	carambola
	sororcula	Brazilian cherry
Diapriidae (Diapriinae)		
T. anastrephae	*fraterculus*	hog-plum
Pteromalidae		
sp. indeterminate	*fraterculus*	hog-plum, carambola

TABLE 2. THE NUMBER AND THE RELATIVE ABUNDANCE OF PARASITOIDS IN THE DIFFERENT TEPHRITID HOST FRUIT SPECIES SAMPLED IN SEROPEDICA CITY, RIO DE JANEIRO, BRAZIL, DURING 1997-1999.

Plant species (fruit no.)	Total of recovered parasites	Parasitoid species[1] and number of specimens (Relative abundance in %) in the fruit samples					
		Da	Ua	Ob	Ap	Ta	P
Exotic:							
M. indica (143)	19	19 (100)	—	—	—	—	—
E. japonica (330)	14	14 (100)	—	—	—	—	—
T. catappa (109)	18	18 (100)	—	—	—	—	—
A. carambola (144)	21	12 (57.1)	6 (28.6)	—	2 (9.5)	—	1 (4.8)
Native:							
I. affinis (179)	41	41 (100)	—	—	—	—	—
P. caimito (188)	49	49 (100)	—	—	—	—	—
M. cauliflora (302)	93	58 (62.4)	35 (37.6)	—	—	—	—
P. guajava (112)	32	19 (59.4)	13 (40.6)	—	—	—	—
E. uniflora (367)	290	19 (100)	62 (21.5)	107 (37.0)	4 (1.0)	—	—
E. braziliensis(390)	377	117 (40.5)	194 (51.5)	—	16 (4.2)	—	—
S. purpurea (330)	237	167 (44.3)	25 (10.5)	—	—	—	—
S. mombim (126)	43	212 (89.5)	—	—	—	4 (9.3)	2 (4.7)
Total (2,720)	1,234	763	335	107	22	4	3

[1]Da = *D. areolatus,* Ua = *U. anastrephae,* Ob = *O. bellus,* Ap = *A. pelleranoi,* Ta = *T. anastrephae*, and P = Pteromalidae.

haps vibrations produced by larvae feeding inside the fruit could be more easily perceived by parasitoid females in smaller fruits than in larger ones. However, the eucoilid *A. pelleranoi* enters previously existing holes in fruits to search for host larvae within the pulp (Ovruski 1994), and may not be as affected by fruit size as the braconids, which remain on the fruit surface and reach the host larvae inside the fruit with their ovipositor.

Of all the parasitoids recovered, *D. areolatus* was the species which occurred most frequently in all fruit species sampled, except in Brazilian cherry (Table 2). In some fruit species, it was the only braconid species recovered. This may be due to a relatively long ovipositor that allows it to reach larvae in both large and small fruits (see Gonçalves 1938, Matrangolo et al. 1998, Sivinski et al. 1997). On the other hand, *O. bellus* with the shortest ovipositor (only 0.68 ± 0.05 times longer than the gaster), and *U. anastrephae*, whose ovipositor is 0.81 ± 0.06 times the length of the gaster (Leonel Junior 1991), were more abundant in a narrow range of smaller fruits. *Doryctobracon areolatus*, which has the longest ovipositor of the species collected (2.04 ± 0.32 times longer than the gaster) (Leonel Junior 1991), became more efficient relative to co-occurring parasitoids as the size of fruits increased. In our study, *U. anastrephae* was relatively more abundant than *D. areolatus* only in Brazilian cherry, the smallest fruit sampled. As discussed by Sivinski et al. (1997), the native parasitoid species have interacted over a long period, and as a result their niches may have diverged. Besides ovipositor length, another factor may contribute to the competitiveness of *D. areolatus.* According to Matrangolo et al. (1998), *D. areolatus* is able to parasitize larvae of both second and third instars, while *U. anastrephae* and *Opius* spp. oviposit only in the last instar. This would allow *D. areolatus* to have access to larvae prior to the other parasitoids.

We also observed that the native parasitoid species from our study areas preferentially attacked *Anastrepha* larvae in native, wild fruit species (Table 2). More than 90% of all the parasitoids were recovered from native fruits. According to Lopéz et al. (1999), a switch from a native plant to an exotic one has interesting evolutionary and ecological implications because it probably allows fruit flies to escape parasitism. In their study in Veracruz, Mexico, it was observed that the parasitism in native hog-plum fruits placed at ground level was 80% compared to 18.2% in similarly treated mangos. The latter are both larger (up to 270 times larger than hog-plum) and exotic fruits.

One practical consideration that can be drawn from our study is that the low host specificity showed by the native parasitoid species suggests that their augmentation to control a particular species of pest fruit flies may be less effective than expected because they will forage on non-target species. On the other hand, according to M. Aluja and J. Sivinski (pers. comm.), since they attack hosts in a wide variety of plant species, and certain wild, native plants usually yield significant numbers of parasitoids, these plants serve as parasitoid reservoirs, particularly if they harbor non-pest tephritids. Such plants and associated insects could be managed to naturally augment parasitoid numbers and to sustain parasitoid populations in commercial orchards and in adjacent native vegetation (see also López et al. 1999; Aluja 1999). If so, a major challenge will be to develop vegetational designs that optimize pest regulation. This difficulty will only be overcome by further analyses of the nature and dynamics of the tritrophic relationships. Aluja (1996) has recently provided a detailed discussion on habitat manipulation (e.g., orchard design and trap-cropping scheme) as an alternative fruit fly management strategy. Such an approach was successfully tested by Aluja et al. (1997) with *Toxotrypana curvicauda* in papaya groves.

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