OCCURRENCE OF *CERATITIS CAPITATA* AND *ANASTREPHA FRATERCULUS* (DIPTERA: TEPHRITIDAE) ON CULTIVATED, EXOTIC FRUIT SPECIES IN THE HIGHLAND VALLEYS OF TUCUMAN IN NORTHWEST ARGENTINA

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ABSTRACT

Fruits from 6 exotic, cultivated fruit species were collected in the Tafí and Calchaquí valleys between Jan 2000 and Jan 2002 to determine the occurrence of *Ceratitis capitata* (Wiedemann) and *Anastrepha fraterculus* (Wiedemann) and the corresponding fruit infestation levels. The valleys are situated in the western semiarid highlands of Tucumán province (NW Argentina) and the altitude ranges from 1,800 to 2,014 m above sea level. The fruit species surveyed were *Cydonia oblonga* Miller, *Malus domestica* Borkh., *Prunus armeniaca* L., *P. domestica* L., *P. persica* (L.) Batsch, and *Pyrus communis* L. (Rosaceae). Out of a total of 2,129 puparia recovered from infested fruit, 2,112 (98.8%) were *C. capitata* and only 27 (1.2%) *A. fraterculus*. *Ceratitis capitata* was recovered from all fruit species and it was the dominant species. *Anastrepha fraterculus* was only recovered from *C. oblonga*, *P. persica* and *P. domestica*. All *Prunus* species and *P. communis* were the host plants that were infested most by *C. capitata*. The infestation data of *C. oblonga*, *P. communis* and *M. domestica* demonstrated that these 3 fruit species were acceptable host plants for *C. capitata* in Tucumán. This study provides the first record of both *C. capitata* and *A. fraterculus* infesting fruit species in semiarid highland valleys in Tucumán, and it also expands the altitudinal range of distribution of these two tephritid species to 2,014 m within the Tucumán province.

Key Words: fruit flies, host plants, distribution, Argentina, Tucumán

RESUMEN

Se presentan los resultados de una colecta de frutas de seis especies de plantas exóticas y cultivadas realizada en los Valles de Tafí y Calchaquí entre enero de 2000 y enero de 2002, con el objetivo de determinar la presencia de *Ceratitis capitata* (Wiedemann) y *Anastrepha fraterculus* (Wiedemann) y los niveles de infestación en fruta. Ambos valles están situados en el sector montañoso semiárido del oeste de la provincia de Tucumán (noroeste de Argentina), y presentan una rango altitudinal entre 1.800 y 2.014 metros sobre el nivel del mar. Las especies frutales colectadas fueron *Cydonia oblonga* Miller, *Malus domestica* Borkh., *Prunus armeniaca* L., *P. domestica* L., *P. persica* (L.) Batsch y *Pyrus communis* L. (Rosaceae). De un total de 2.129 puparios obtenidos de frutas infestadas, 2.112 (= 98,8%) fueron *C. capitata* y solo 27 (= 1,2%) fueron *A. fraterculus*. *C. capitata* fue obtenida de las seis especies frutales y fue dominante en todas ellas. *A. fraterculus* fue solo obtenida de *C. oblonga*, *P. persica* y *P. domestica*. Todas las especies del género *Prunus* y también *P. communis* fueron las plantas hospederas más infestadas por *C. capitata*. Los datos de infestación en *C. oblonga*, *P. communis* y *M. domestica* mostraron que éstas tres especies son hospederas adecuadas para el desarrollo de *C. capitata* en Tucumán. Este artículo aporta el primer registro de *C. capitata* y *A. fraterculus* infestando frutas en los valles montañosos semiáridos del oeste de Tucumán, y también expande el rango altitudinal de distribución de estas dos especies de tefrítidos en Tucumán hasta los 2,014 metros sobre el nivel del mar.

Translation by the authors.

In Argentina, the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), and the South American fruit fly, *Anastrepha fraterculus* (Wiedemann) are serious polyphagous pests that attack several plant families. The medfly is widely distributed throughout Argentina (Guillén & Sánchez 2007). The native *A. fraterculus* is mainly restricted to NW Argentina (Tucumán, Salta, Jujuy, and Catamarca), NE Argentina (Misiones, Corrientes, and Entre Ríos) and fruit-producing areas of La Rioja, San Juan, and Buenos Aires (Central Argentina) (Guillén & Sánchez 2007).

Anastrepha fraterculus attacks approximately 80 species (Norrbom 2004), and *C. capitata* attacks more than 300 species throughout the world (Copeland et al. 2002). Previous reports have not always followed procedures to determine host un-

equivocally; a host record should state if the infestation occurred under natural conditions (i.e., field), or when fruit is artificially exposed to female flies, and it is necessary to verify if the larvae complete development in the fruit and pupate and if the emerging adults produce viable progeny (Cowley et al. 1992; Aluja et al. 2004).

The aim of this study was to determine the occurrence of *A. fraterculus* and *C. capitata* and report infestation rates on cultivated, exotic fruit in the western semiarid highland valleys of Tucumán.

Materials and Methods

The collecting sites are located between 26°20' and 26°70'S and between 65°40' and 66°10'W at an altitude between 1,815 and 2,014 m above sea level in the high, western mountainous region of the Tucumán province (NW Argentina), locally known as the Tafí and Calchaquí valleys (Alderete 1998). The latter one spreads from Tucumán to both Catamarca and Salta provinces in the north. The region is characterized by valleys surrounded by vast semi desert plains and high mountains devoid of native fruit fly host plants, but fruit is grown commercially in irrigated oases. The climate varies from desert (cool, dry winters and hot summers; occasional frosts in winter and scanty rains in summer; a mean temperature of 16°C and annual rainfall <200 mm BWkwb, according to the Köppen classification) to semiarid or steppe-dry (cool, dry winters and mild to hot, rainy summers; a mean temperature of 18°C and annual rainfall <300 mm (BSkwb, according to the Köppen classification)] (Torres-Bruchmann 1977; Sesma et al. 1998). Further details on site coordinates, altitudes, geographic units, and climate are provided in Table 1.

The native vegetation of the valleys is represented by a high-elevation deciduous xerophyte forest, mainly characterized by deep-rooted shrubs adapted to a semiarid environment (i.e., *Cercidium praecox* (Ruiz & Pavón) Harms (Leguminosea), *Larrea divaricata* Cav (Zygophyllaceae),*Acacia caven* Molina (Fabaceae) and *Prosopis ferox* (Griseb.) (Mimosaceae)) (Cabrera 1976). Vegetation in this Argentine phyto-geographical region, locally known as "Provincia Fitogeográfica del Monte", has been partially removed to establish irrigated agricultural or shepherding areas and urban districts with orchards and backyard gardens (Torres-Bruchmann 1977).

Fruit samples were collected monthly from Jan 2000 to Jan 2002. Each sample consisted of 5-6 ripe fruits randomly harvested from a tree canopy and also of 5-6 fruits collected from the ground below the tree canopy. Six cultivated, exotic plant species, all belonging to the Rosaceae family, were sampled in the study area. Table 2 provides a complete list of fruit species collected,

Table 1. General description of fruit sampling sites in highland valleys in Tucumán, NW Argentina. Sampling was carried out between Jan 2000 and Jan 2002.

Collection Site	Argentine geographic unit	Altitude (m)	Southern latitude	Western longitude	Climate[1]	Description of collecting site
Colalao del Valle	Calchaquí Valley	1,815	26°22'	65°56'	BWkwb	Rural area with small orchards
Amaicha del Valle	Calchaquí Valley	1,978	26°33'	65°55'	BWkwb	Rural area with small orchards
Tafí del Valle	Tafí Valley	2,014	26°52'	65°43'	BSkwb	Orchards and backyard gardens with fruit trees surrounded by urban houses; rural area with small orchards

[1]Köppen classification; for description see text.

TABLE 2. PLANT SPECIES BELONGING TO THE ROSACEAE FAMILY SAMPLED IN THE TAFÍ AND CALCHAQUÍ VALLEYS, TUCUMÁN, NW ARGENTINA, BETWEEN JAN 2000 AND JAN 2002.

Scientific name	Common name	Mean individual fruit weight (g)[1] (±SD)	Fruiting season	Fruit sampling period
Cydonia oblonga Miller	Quince	311.5 ± 29.2	Jan-Feb	Jan-Feb
Malus domestica Borkh.	Apple	144.9 ± 17.4	Feb-May	Mar -Apr
Prunus armeniaca L.	Apricot	40.0 ± 5.3	Jan-Feb	Jan
Prunus domestica L.	Cultivated Plum	74.5 ± 9.1	Jan-Feb	Jan-Feb
Prunus persica (L.) Batsch	Peach	69.9 ± 8.6	Dec-Jan	Dec-Jan
Pyrus communis L.	Pear	45.1 ± 4.7	Jan-May	Jan-Feb

including their common and scientific name, fruit size (measured as mean individual fruit weight) of each species, fruiting season and period when fruits were sampled. All fruit trees sampled were located in small orchards and backyard gardens in rural and urban areas. No insecticides were applied in any of the collecting sites.

Each fruit sample was placed individually into a cloth bag, which was transported to the CIRPON institute (Research Centre for the Population Control of Harmful Organisms) in San Miguel de Tucumán (26°50' S, 65°13' W; altitude 426 m). At the laboratory, fruit samples were placed in Styrofoam boxes (20 × 20 × 30 cm) with sand at the bottom for larvae to pupate. Each Styrofoam box contained only 1 fruit sample and all cages were kept inside a room at 26 ± 2°C and 60 ± 10% relative humidity (RH) for 4 weeks. Tephritid puparia from each box were recovered weekly, identified and counted. *Ceratitis capitata* puparia were distinguished from *Anastrepha* Schiner ones based on pupal characteristics (White & Elson-Harris 1992) and puparia were transferred to plastic Petri dishes containing sterilized humid sand. Each Petri dish was then placed inside a sealed wooden box as described by Ovruski et al. (2004). All wooden cages were kept inside a rearing room at 25 ± 1°C and 75 ± 5% RH for 3 months. Once a week all emerged flies were recovered from the cages and adults were identified and counted.

Fruit flies were identified by S. Ovruski using the taxonomic key by Zucchi (2000). Fly specimens were placed in the entomological collection of the Fundación Miguel Lillo (FML; San Miguel de Tucumán, Argentina).

The fruit infestation level reported was based on the number of fruit fly pupae per fruit or per kg of fruit obtained from one sample. Means and Standard Deviation (SD) were calculated as summary statistics for the fruit infestation level.

RESULTS

Detailed fruit survey data per collecting site are shown in Table 3. A total of 1,852 fruits (227.3 kg) were collected. The number, weight, and host for fruit collected were as follows:

383 (115.7 kg) from *Cydonia oblonga* Miller, 281 (40.0 kg) from *Malus domestica* Borkh., 135 (5.5 kg) from *Prunus armeniaca* L., 283 (20.6 kg) from *P. domestica* L., 510 (34.1 kg) from *P. persica* (L.) Batsch, and 260 (11.4 kg) from *Pyrus communis* L. *Ceratitis capitata* was recovered from all fruit species, whereas *A. fraterculus* was only found in *C. oblonga*, *P. domestica* and *P. persica*. A total of 2,129 puparia was recovered from infested fruit, 2,112 of which (98.8%) were *C. capitata* and 27 (1.2%) *A. fraterculus*. Only 746 (35.0%) of the puparia produced adult flies: 739 (99.2%) *C. capitata* and 7 (0.8%) *A. fraterculus*. The proportion of *A. fraterculus* adults emerging from *C. oblonga*, *P. persica* and *P. domestica* was low (2.9%, 1.6% and 0.4%, respectively). *A. fraterculus* was only recovered from fruit samples collected in Tafí del Valle, while *C. capitata* was found in all study sites (Table 3).

As shown in Table 3, the infestation levels (number of pupae/kg of fruit) of *C. capitata* varied considerably among host plant species. The 3 *Prunus* species and *P. communis* were the most infested host plants. However, infestation levels in apricot were 3, 4, and 5 times less than those in pear, cultivated plum, and peach, respectively. The lowest infestation values were recorded in *M. domestica* and *C. oblonga*, but infestation in quince were 3-8 times higher than in apple. The infestation levels in *C. oblonga*, *P. persica*, and *P. domestica* varied slightly among the collecting sites. Infestation rates in the fruit species collected in Tafí del Valle were relatively stable during the years 2000 and 2001. The levels of infestation by *A. fraterculus* in quince, peach and plum were lower than those by *C. capitata*: 15, 18 and 35 times, respectively. The highest numbers of *C. capitata* pupae per fruit were recovered from *P. persica* and *P. domestica*, with a maximum of 4.4 and 4.1 pupae/fruit, respectively.

DISCUSSION

The current fruit fly survey provides the first records of fruit species infested by *C. capitata* and

TABLE 3. DETAILS OF FRUIT SAMPLES COLLECTED IN THE TAFÍ AND CALCHAQUÍ VALLEYS, TUCUMÁN, NW ARGENTINA, BETWEEN JAN 2000 AND JAN 2002.

	Host plants				Fruit Fly Species							
					C. capitata				*A. fraterculus*			
							Degree of infestation (mean ± SD)				Degree of infestation (mean ± SD)	
Sample date (month/year) and study site	Species	N° of samples	Total N° of fruits	Total weight of fruit sampled (kg)	Total N° of pupae	Total N° of adults	pupae/kg	pupae/fruit	Total N° of pupae	Total N° of adults	pupae/kg	pupae/fruit
Jan-Dec/2000												
Amaicha del Valle	*Cydonia oblonga*	6	67	17.0	51	16	2.0 ± 1.3	0.5 ± 0.3	0	0	0	0
	Prunus domestica	6	60	2.3	90	24	12.6 ± 13.7	1.5 ± 1.3	0	0	0	0
	Prunus persica	3	36	3.7	31	11	24.6 ± 21.1	0.9 ± 0.9	0	0	0	0
Jan-Dec/2000												
Colalao del Valle	*Cydonia oblonga*	5	50	12.5	17	7	1.3 ± 2.2	0.3 ± 0.6	0	0	0	0
	Prunus persica	4	40	2.5	39	8	15.8 ± 9.0	1.0 ± 0.6	0	0	0	0
Jan-Dec/2000												
Tafí del Valle	*Cydonia oblonga*	12	130	40.5	164	42	4.5 ± 4.0	1.3 ± 1.2	11	3	0.3 ± 0.9	0.09 ± 0.23
	Malus domestica	12	138	20.6	12	1	0.6 ± 1.5	0.1 ± 0.2	0	0	0	0
	Prunus armeniaca	6	67	2.6	14	3	6.0 ± 7.2	0.2 ± 0.3	0	0	0	0
	Prunus domestica	12	124	9.0	236	99	25.2 ± 22.8	1.9 ± 2.2	0	0	0	0
	Prunus persica	9	99	7.0	243	86	35.6 ± 28.0	2.4 ± 2.0	0	0	0	0
	Pyrus communis	12	131	5.9	75	21	13.2 ± 17.6	0.6 ± 0.8	0	0	0	0
Jan-Dec/2001												
Tafí del Valle	*Cydonia oblonga*	12	136	45.7	147	35	2.4 ± 2.6	0.8 ± 0.9	0	0	0	0
	Malus domestica	12	143	19.3	9	2	0.5 ± 0.9	0.1 ± 0.1	0	0	0	0
	Prunus armeniaca	6	68	2.9	21	6	7.1 ± 9.0	0.3 ± 0.4	0	0	0	0
	Prunus domestica	12	123	9.3	243	132	24.7 ± 24.5	2.0 ± 2.1	2	1	0.2 ± 0.7	0.02 ± 0.06
	Prunus persica	18	205	13.8	442	169	30.8 ± 31.1	2.1 ± 2.2	14	3	2.1 ± 2.2	0.06 ± 0.18
	Pyrus communis	12	129	5.5	87	15	17.0 ± 23.9	0.7 ± 0.9	0	0	0	0
Jan/2002												
Tafí del Valle	*Prunus persica*	9	106	7.0	181	62	26.6 ± 33.7	1.7 ± 2.2	0	0	0	0

A. fraterculus in semiarid environments in the western highland valleys of Tucumán. Our findings expand the altitudinal distribution of these 2 tephritid species to 2,014 m within Tucumán. Before this study, both fruit fly species had only been recorded in Tucumán at lower elevations (below 1,200 m) from xerophyte shrub land, locally known as "phyto-geographical Chaco region", to subtropical montane rainforest, commonly known as "phyto-geographical region of the Yungas" (Ovruski et al. 2003; Segura et al. 2006). Nevertheless, both *C. capitata* and *A. fraterculus* had been found before in 2 other localities of the Calchaquí valley: Cafayate (26°06'S, 65°57'W, 1,624 m) in the Salta province and Santa María (26°42'S, 66°02'W, 1,885 m) in the Catamarca province (Rosillo 1953). These records, though, are based on adult flies captured in traps hung in fruiting trees and not on adults reared from infested fruit. Similarly, *C. capitata* and *A. fraterculus* adults were also caught at 2,641 m in fruit-growing irrigated valleys of the northern dry highlands of the Jujuy province (NW Argentina) (Manero et al. 1989).

One host plant species of *A. fraterculus* (*C. oblonga*) has been previously reported in local Argentine journals or technical articles by Hayward (1960), Turica & Mallo (1961) and Nasca et al. (1981), although none of the authors provided any infestation data. These findings are presently confirmed by our results and *C. oblonga* should now formally be considered as a host of *A. fraterculus* in Argentina.

The infestation data regarding *C. oblonga*, *P. communis* and *M. domestica* reported in this study have demonstrated that these 3 fruit species are acceptable host plants for *C. capitata* in Tucumán. Similar observations were made by Nasca et al. (1996) and Segura et al. (2006) in dry habitats in the northwestern provinces of La Rioja and Catamarca, respectively, as the authors showed that quinces, pears, and apples were mainly infested by *C. capitata*. Although our results did not reveal any infestation of *P. communis* by *A. fraterculus*, this host species was previously identified by Nasca et al. (1996) as a sporadic host of *A. fraterculus* in the fruit-producing irrigated valleys of La Rioja.

In agreement with previous reports on several Argentine ecological regions (Nasca et al. 1996; Ovruski et al. 2003; Segura et al. 2006) *P. persica*, *P. domestica* and *P. armeniaca* were heavily infested by *C. capitata* in our study. Worldwide, these 3 *Prunus* species are among the most important hosts of the medfly (Copeland et al. 2002), but they are also relatively important host plants of *A. fraterculus* in Argentina (Ovruski et al. 2003; Norrbom 2004). Large populations of *A. fraterculus* have been reported in peach, plum and apricot in the subtropical montane rainforest of NW Argentina (Ovruski et al. 2003). In contrast, the 3 *Prunus* species sampled during the present study were only slightly infested by *A. fraterculus*. The environmental conditions in semiarid highland areas of Tucumán are probably more suitable for *C. capitata* than for *A. fraterculus*. The ability of *C. capitata* to use fruit in xeric and semi desert areas has been previously reported by several authors in different countries (Copeland et al. 2002; Vera et al. 2002; Israely et al. 2005). Another possible explanation is that *C. capitata* seems to adapt well to highly perturbed habitats with a predominance of exotic fruit species, such as backyard gardens of urban and rural houses and semi-commercial orchards, whereas *A. fraterculus* is mostly found in association with native and exotic "feral" fruit species in areas with wild vegetation throughout the Argentine subtropical rainforests (Ovruski et al. 2003, 2008, Schliserman 2005; Segura et al. 2006). These 2 characteristics, along with the active fruit traffic sustained by road transport (Guillén & Sánchez 2007), may be important factors that possibly allowed *C. capitata* to spread throughout unsuitable habitats. However, our data do not yet allow a precise analysis of the effect of the type of environment on dispersion of both *C. capitata* and *A. fraterculus* in the highland valleys of Tucumán. More exhaustive sampling in this region focused on the search of suitable wild hosts with continuous populations of *C. capitata* or *A. fraterculus* is necessary.

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