Occurrence of Anastrepha fraterculus and Ceratitis capitata (Diptera: Tephritidae) in Organically Grown Rubus (Rosales: Rosaceae), in Two Contrasting Environments of Northwestern Argentina

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Occurrence of Anastrepha fraterculus and Ceratitis capitata (Diptera: Tephritidae) in organically grown Rubus (Rosales: Rosaceae), in two contrasting environments of northwestern Argentina

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The Mediterranean fruit fly, Ceratitis capitata (Wiedemann) (Diptera: Tephritidae), and the South American fruit fly, Anastrepha fraterculus (Wiedemann) (Diptera: Tephritidae), are widely distributed in Argentina, including the northwestern province of Tucumán (Segura et al. 2006; Guillén & Sánchez 2007; Ovruski et al. 2010). Tucumán is one of the most important berry-exporting regions of the country (Kirschbaum 2011). In Tucumán, the presence of fruit flies, especially C. capitata, determines methyl bromide treatments to fresh blueberries exported to the United States (Pérez & Mazzone 2012). In recent years, researchers, fruit growers, and consumers have been increasingly interested in small fruits such as blackberries (Rubus fruticosus; Rosaceae) and raspberries (Rubus idaeus L.; Rosaceae) because of their content of basic nutrients, fiber, vitamins, and phenolic compounds (Anco et al. 2000; Harborne & Williams 2000; Souza et al. 2014). Additionally, they are considered a good alternative crop for small-scale growers because of low production costs and relatively low levels of susceptibility to pests and diseases (Hussain et al. 2016).

In Tucumán, berries are grown in 2 contrasting regions: the humid piedmont and the semi-arid intermontane valley of Tafi (Zuccardi & Fadda 1985). Given that raspberry and blackberry are minor (but expanding) crops in Tucumán, information about their phytosanitary aspects is scarce and fragmented (Reguilón et al. 2015), and they were not included in previous local studies as possible fruit fly host plants.

Periodic sampling in both regions was performed during 2 production seasons, 2013 and 2014, with 3 and 4 sampling dates, respectively, in each region. The first sampling dates in Monte Grande were 6, 14, and 20 November (corresponding to stage III, stage II, and stage I, respectively), and those in Tafí del Valle were 5, 13, and 19 November. Subsequently, sampling dates in Monte Grande were 6, 14, and 20 November (corresponding to stages III, II, and I, respectively), and those in Tafí del Valle were 5, 13, and 19 November. During these 2 production seasons, 2013 and 2014, ripe fruit (stage III, according to Bisognin et al. 2015) from plants of 3 blackberry cultivars (878, Navaho, and Tupi) were collected from an organic orchard in Monte Grande (27.0000°S, 65.4000°W; 350 m altitude), at the department of Famaillá (Tucumán Province, Argentina), in the humid piedmont (Zuccardi & Fadda 1985). In addition, in 2016 ripe fruit samples of the blackberry cultivar 878 and the raspberry cultivar Heritage were collected from an organic farm in Tafi del Valle (26.8666°S, 65.6833°W; 1,900 m altitude), another department of Tucumán Province, in the intermontane semi-arid valleys (Zuccardi & Fadda 1985). No pesticides were applied.

Rubus crops are harvested in spring (Nov–Dec) and summer (Jan–Mar) in Monte Grande and Tafi del Valle, respectively. Consequently, sampling dates in Monte Grande were 6, 14, and 20 November, and those in Tafi del Valle were 5, 13, and 19 November. Each fruit sample was individually packaged and taken to the laboratory, divided into 2 replicates of 20 to 30 fruits each, and placed into plastic containers (20 × 30 cm) with sand at the bottom for larval pupation. The lids of the containers were removed and replaced by voile fabric to allow air exchange and to prevent insects from escaping. The containers were kept at about 25 °C and 60 to 70% RH for 20 d. Tephritid adults from each clamshell were recovered weekly, identified (Zucchi 2000), and counted. The reported fruit infestation level was based on the number of fruit fly adults per fruit and kg of fruit. Precipitation (P) and evapotranspiration (ET) data were obtained from a weather station located nearby Monte Grande. The hydric balance (HB) was calculated by subtracting ET from P (HB = P – ET).

Annual precipitation varied from 2013 to 2014. The first can be considered a dry year (low precipitation and 8 mo with negative HB), whereas 2014 could be described as a humid year (high precipitation and 4 mo of negative HB) (Fig. 1).

The total weight and number of analyzed fruit in 2013 and 2014 are shown in Table 1. In 2013, the occurrence of fruit flies was observed only on the last sampling date, 13 December. Ceratitis capitata pupae were recorded in fruit samples of the blackberry cultivars 878 (3 pupae) and Tupi (3 pupae); adults of A. fraterculus emerged from fruits of Tupi (2 adults). This is the first report of the occurrence of A. fraterculus and C. capitata on blackberries in northwestern Argentina, although with low infestation levels (Table 1). In 2014, A. fraterculus was observed in 878 and Tupi, whereas C. capitata ap-

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peared only in Tupi, at higher infestation levels than in 2013 (Table 1). During this study, no fruit fly was recorded from Navaho blackberries.

The total weight and number of analyzed fruit in 2016 are shown in Table 1. Pupae and adults of *A. fraterculus* were observed in blackberry (878) and raspberry (Heritage) fruit samples along the monitoring period, although this insect was not present in blackberry on the last sampling date. No individual of *C. capitata* was recorded during this study. In total, 144 adults and 23 pupae of *A. fraterculus* were found in raspberry, whereas in blackberry only 29 adults and 4 pupae were recovered. This is the first report of the occurrence of fruit flies in raspberry fruits in northwestern Argentina, and with high infestation levels (Table 1). Infestation levels of *A. fraterculus* varied considerably between host plant species within the genus *Rubus* (Table 1). Raspberries were infested more than blackberries. Infestation levels in raspberries were 2.4 and 6.1 times higher than in blackberries, in terms of fruit flies per kg and fruit flies per fruit, respectively.

It is known that for tephritids, in general, first rains stimulate adult emergence from overwintering pupae in the soil, causing fruit flies to become active after periods of relatively high humidity (Bateman 1972). Therefore, rain, soil water content, and air RH may have been involved in the determination of the time of fruit fly emergence in the present study. However, fruit fly abundance should be tracked for several more years for confirmation. In 2014, *A. fraterculus* was nearly twice as abundant as *C. capitata*. The absence of *C. capitata* in Tafí del Valle might be related to climatic and host-related issues (Duyck et al. 2006; Ovruski et al. 2010; Flores et al. 2016).

Future research should include monitoring of fruit flies in neighbor fruit plants, occurrence of natural enemies, and fruit fly preference for blackberry varieties. These monitoring tools will be useful for improving organic berry production.

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**Summary**

In Tucumán (northwestern Argentina) during 2013 and 2014, *Anastrepha fraterculus* (Wiedemann) (Diptera: Tephritidae) and *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) were found infesting organically grown blackberries in the humid piedmont region (Monte Grande, Famalía). In 2016, only *A. fraterculus* was found infesting organically grown blackberries and raspberries in...
En Tucumán (noroeste de Argentina,) durante 2013 y 2014 se encontraron *Anastrepha fraterculus* (Wiedemann) (Diptera: Tephritidae) y *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) infestando zarzamoras orgánicas en la región del pedemonte húmedo (Monte Grande, Famaillá). En 2016, sólo se encontró *A. fraterculus* infestando zarzamoras y frambeas orgánicas en la región templada semiárida (Tafi del Valle), donde estudios realizados en años anteriores mostraron la coexistencia de ambas especies de mosca de la fruta con prevalencia de *C. capitata* sobre *A. fraterculus*, pero en otras especies frutales. Cabe señalar que en este estudio, encontramos que *A. fraterculus* tenía una notable preferencia por las frambeas sobre las moras. Estos son los primeros registros de ocurrencia de moscas de la fruta en *Rubus* (Rosales: Rosaceae) en el noroeste de Argentina y amplían el rango de especies hospedantes para las moscas de la fruta en la región. Los niveles de infestación en moras en la región húmeda fueron muy bajos, mientras que en la región semiárida fueron relativamente altos. Sobre la base de nuestras observaciones, hipotetizamos que las lluvias de primavera, la humedad del suelo y la humedad relativa determinan el momento de aparición de las moscas de la fruta en moras en la región húmeda. La abundancia de la mosca de la fruta se debería seguir durante varios años más para probar esta hipótesis. Además, las moscas de la fruta no se recuperaron de las muestras de fruta de la variedad de zarzamora Navaho, lo cual es interesante desde una perspectiva agronómica y científica.

Palabras Clave: mosca de la fruta; mora; frambea; preferencia de hospedero; Tucumán

**Sumario**

**En Tucumán (noroeste de Argentina,) durante 2013 y 2014 se encontraron *Anastrepha fraterculus* (Wiedemann) (Diptera: Tephritidae) y *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) infestando zarzamoras orgánicas en la región del pedemonte húmedo (Monte Grande, Famaillá). En 2016, sólo se encontró *A. fraterculus* infestando zarzamoras y frambeas orgánicas en la región templada semiárida (Tafi del Valle), donde estudios realizados en años anteriores mostraron la coexistencia de ambas especies de mosca de la fruta con prevalencia de *C. capitata* sobre *A. fraterculus*, pero en otras especies frutales. Cabe señalar que en este estudio, encontramos que *A. fraterculus* tenía una notable preferencia por las frambeas sobre las moras. Estos son los primeros registros de ocurrencia de moscas de la fruta en *Rubus* (Rosales: Rosaceae) en el noroeste de Argentina y amplían el rango de especies hospedantes para las moscas de la fruta en la región. Los niveles de infestación en moras en la región húmeda fueron muy bajos, mientras que en la región semiárida fueron relativamente altos. Sobre la base de nuestras observaciones, hipotetizamos que las lluvias de primavera, la humedad del suelo y la humedad relativa determinan el momento de aparición de las moscas de la fruta en moras en la región húmeda. La abundancia de la mosca de la fruta se debería seguir durante varios años más para probar esta hipótesis. Además, las moscas de la fruta no se recuperaron de las muestras de fruta de la variedad de zarzamora Navaho, lo cual es interesante desde una perspectiva agronómica y científica.**

**Key Words: fruit fly; blackberry; raspberry; host preference; Tucumán**

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