

Field infestation level of *Zaprionus indianus* Gupta and *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) in *Ficus carica* L. (Rosales: Moraceae) and *Rubus idaeus* L. (Rosales: Rosaceae) in the Northeast of Buenos Aires province

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Nivel de infestación a campo de *Zaprionus indianus* Gupta y *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) en *Ficus carica* L. (Rosales: Moraceae) y *Rubus idaeus* L. (Rosales: Rosaceae) en el noreste de la provincia de Buenos Aires

RESUMEN. En los últimos años se han detectado en Argentina dos especies exóticas de drosófilidos, *Zaprionus indianus* Gupta y *Drosophila suzukii* (Matsumura). En esta nota se reporta la detección más austral de *Z. indianus* en Argentina y se estima el nivel de infestación a campo causado por ambas especies de drosófilidos en higos (*Ficus carica* L.) y frambuesas (*Rubus idaeus* L.).

PALABRAS CLAVE. Drosófilido. Especies invasoras. Mosca africana de los higos. Moscas de las frutas.

ABSTRACT. Two exotic fruit flies species, *Zaprionus indianus* Gupta and *Drosophila suzukii* (Matsumura), were detected in Argentina in recent years. In this note, the southernmost detection of *Z. indianus* in Argentina and an estimation of the field infestation level caused by both drosophilid species on figs (*Ficus carica* L.) and raspberries (*Rubus idaeus* L.) are reported.

KEYWORDS. African fig fly. Drosophilid. Fruit flies. Invasive species.

The introduction of exotic species can cause severe impacts on the ecosystem equilibrium and the agroecosystem sustainability. In the last 15 years, two exotic drosophilid species were detected in Argentina: *Zaprionus indianus* Gupta and *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae). *Zaprionus indianus*, known as the "African fig fly", is an Afrotropical species and its first record in South America was in the

state of São Paulo in Brazil (Vilela, 1999). In Argentina, it was detected in Corrientes, Misiones, Chaco, Formosa, Salta, Jujuy, Tucumán and Santa Fe provinces (Soto et al., 2006; Lavagnino et al., 2008; Imberti, 2016; Gonsebatt et al., 2020). This drosophilid develops and feeds on a wide variety of decaying fruits (Vilela, 1999; Lavagnino et al., 2008; Imberti, 2016). However, in Brazil it was responsible for 40% of fig losses (*Ficus carica*

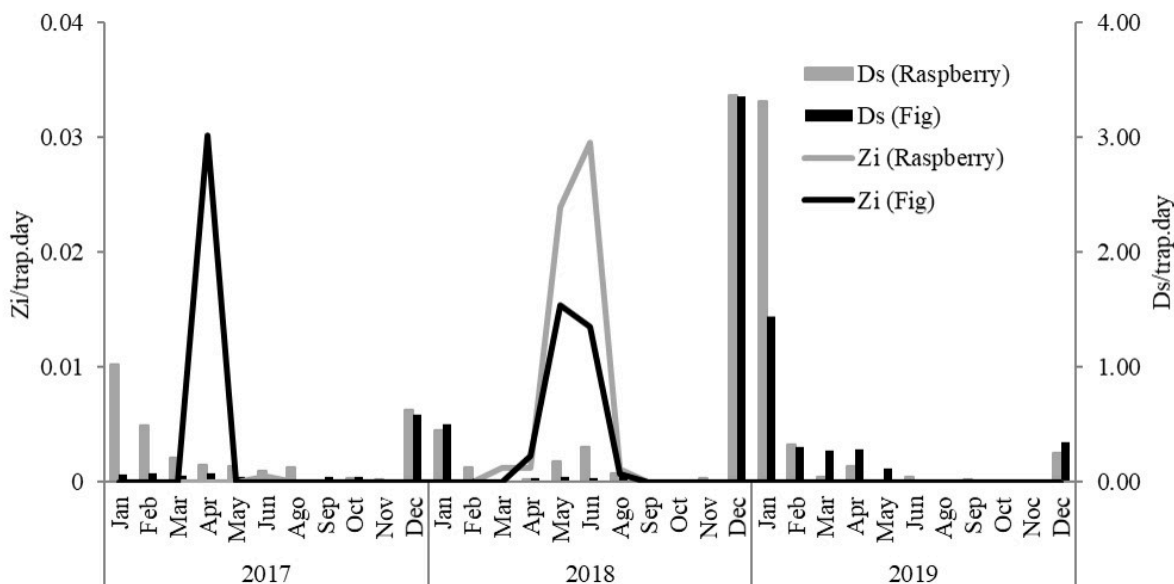


Fig. 1. Mean captures *per trap per day* of *Zaprionus indianus* (Zi) and *Drosophila suzukii* (Ds) in different years and fruit orchards.

L.) harvest in the main productive region of São Paulo, because it can feed on this fruit while it is still on the tree (Castro & Valente, 2001; Stein et al., 2003).

Drosophila suzukii, commonly known as the “Spotted wing drosophila”, is a species native to Asia that has successfully invaded different geographical areas, due to its high reproductive rate, wide tolerance to environmental conditions and the international fruit trade (Kimura, 2004; Calabria et al., 2012). *Drosophila suzukii* is considered an important pest of ripening soft fruits because the females have a serrated ovipositor that allows them to go through the epicarp of healthy fruits. It has also been found in many other fruit species including figs (Walsh et al., 2011; Cini et al., 2012; Riquelme Virgala et al., 2016).

Since *D. suzukii* was recorded in Argentina in 2014 (Cichón et al., 2015; Santadino et al., 2015), adult samplings have been carried out on fruit crops in the Northeast of Buenos Aires province. In April 2017, adults identified as *Z. indianus* were collected in traps placed on a fig crop in the city of Mercedes, which is the first record of this species in this province. There are not studies that describe the relative abundance and incidence of both flies in their shared host in this region. The aims of this note are to report this new record of *Z. indianus* in Argentina, and to estimate the infestation level of both drosophilid species on figs and raspberries (*Rubus idaeus* L.) under field conditions.

Adult sampling was carried out in a fig orchard in Mercedes (34°41' S; 59°24' W) and a raspberry crop in Lobos (35°11' S; 59°16' W), both located in Northeast of Buenos Aires province, during three harvest seasons from 2017 to 2019. Traps were crafted from 600 ml plastic bottles with 16 circular holes 0.5 mm diameter and bottom wrapped with yellow tape. Traps baited with

apple vinegar (200 cc) were placed 10 m apart and hanged from branches of fig trees or raspberry plants 1 m aboveground. The lure was renewed every 15 to 25 days. In the laboratory, drosophilid specimens were counted and identified using keys and descriptions (Castrezana, 2007; Van der Linde, 2010; Vlach, 2013) under a stereoscopic microscope (model Stemi 508, Zeiss®). Samples of ripe fruit without previous damage were taken at the same time and locations. These fruits were not previously treated with insecticides. In the laboratory, each fruit was weighted and individually placed in ventilated containers in a GC-300 growth chamber (Lab. Companion ®) under controlled conditions (23 ± 2 °C, relative humidity 60 ± 10%, photoperiod 16L:8D), until the development of adults.

The proportion of infested fruit (Incidence of damage) and the mean flies developed *per gram* of damaged fruit (Severity of damage) were estimated for each fruit and fly species. Two Generalized Linear Models with binomial and negative binomial distributions were fitted to assess the variation on Incidence and Severity, respectively. The post-hoc Tukey's multiple comparison test was used to evaluate the effect of fruit species, fly species and their interaction. Infested fruits at the same time by the two drosophilid species were analyzed separately. Statistical analyses were performed using the computer package R (R Core Team, 2020) and a P-value of less than 0.05 was considered statistically significant. Furthermore, to compare the abundance of both drosophilid species in each fruit, a Relative Abundance Index for the harvest season x (RAI_x) was calculated according to the formula proposed by Segura et al. (2006): $RAI_x = Ds / (Ds + Zi)^2$, where Ds and Zi are the number of emerged adults from fruits of *D. suzukii* or *Z. indianus*, respectively. The index ranges

Fruit fly	Figs		Raspberries	
	Incidence	Severity	Incidence	Severity
Ds	9.54 ± 3.19 a	0.11 ± 0.01A	61.11 ± 3.19 b	3.03 ± 0.09 C
Zi	7.77 ± 1.59 a	0.28 ± 0.02 B	2.14 ± 0.94 c	0.40 ± 0.16 B

Table I. Mean (\pm SE) from three harvest seasons (2017-2019) of Incidence (% of fruit damaged) and Severity (mean flies developed *per gram* of fruit) of damage of *Drosophila suzukii* (Ds) and *Zaprionus indianus* (Zi) on fig and raspberry fruits
Lowercase letters show significant differences between Incidence by Tukey's test ($P < 0.05$). Capital letters show significant differences between Severity by Tukey's test ($P < 0.05$).

from 0 (exclusive presence of *Z. indianus*) to 1 (exclusive presence of *D. suzukii*), and when both species are present in similar abundance, the index ranges between 0.33 and 0.66. If one species has higher abundance than the other, the index ranges between 0.01 and 0.32 (more *Z. indianus*) or from 0.67 to 0.99 (more *D. suzukii*).

In the fig orchard, adults of both drosophilids were captured during the first and second harvest seasons, while in the third year only *D. suzukii* was recovered from the traps. In contrast, in the raspberry crop, while adults of *D. suzukii* were captured in the three seasons, *Z. indianus* flies were trapped only in 2018 (Fig. 1). Captures of *Z. indianus* were lower than *D. suzukii* in all seasons and fruit crops. Moreover, while the population of *D. suzukii* reached a peak in the summer, the adult captures of *Z. indianus* were higher in autumn (2017) and winter (2018) (Fig. 1). The low *Z. indianus* population dynamic predictability could be related to the recent introduction of this species and the consequent low genetic variability, which has been observed in this drosophilid in the Brazilian savanna (da Silva Döge et al., 2015).

A total of 283 figs and 234 raspberries were sampled overall in the three seasons. Fruits from both species were infested either by *D. suzukii* and/or *Z. indianus*, but with different levels of Incidence and Severity (Table I). A low proportion of figs was infested with *D. suzukii* or *Z. indianus*, without significant differences between them (Tukey's test, $P = 0.88$). In contrast, more than half of the raspberries evaluated were infested with *D. suzukii* which it was significantly higher than the proportion of fruit infested with *Z. indianus* (Tukey's test, $P < 0.0001$). It is important to note that all raspberries infested with *Z. indianus* were also infested with *D. suzukii*. Therefore, these fruits were not recorded with only *Z. indianus*. The Severity of damage by both flies in figs and by *Z. indianus* in raspberries was less than one larvae *per gram* of fruit, while this parameter was significantly higher in raspberries with *D. suzukii* where the Severity reached more than 3 larvae *per gram* (Tukey's test, $P < 0.0001$).

In the first year, figs were infested either with one or

another fruit fly species, in the second year, they were infested only with *Z. indianus*, and in the last year, fruits with only *D. suzukii* were recorded. Raspberries infested with *D. suzukii* were recorded during the three seasons, and only in the second year, fruits with both drosophilids sharing the same fruit were found. As a result, the *RAI* showed high variability for figs between years, but in raspberries it clearly showed a higher susceptibility to *D. suzukii* when compared to *Z. indianus* (Table II).

Previous studies have reported the occurrence of both *Z. indianus* and *D. suzukii* in wild and cultivated fruits (Van Timmeren & Isaacs, 2014; Bernardi et al., 2016; Lasa et al., 2016). Although *Z. indianus* is considered an opportunist and secondary pest, Bernardi et al. (2016) found that this species does not require prior injuries in strawberry to deposit its eggs. These authors proposed that the previous piercing of the fruit epidermis caused by *D. suzukii* females would facilitate further infestation by *Z. indianus*. Other studies have shown that even when *Z. indianus* oviposited in preharvest guavas, it could be related to fruit injuries not observed by visual inspection, because all these fruits were also infested by other fruit flies like *D. suzukii*, *Anastrepha* spp., or both (Lasa et al., 2016). These results are consistent with our observations on raspberries, since this fruit was infested with *Z. indianus* only when it had also been attacked by *D. suzukii*. In contrast, there was a proportion of figs infested only with *Z. indianus* and only one fruit was infested with both drosophilids. This observation agrees with other authors which have shown that *Z. indianus* do not need a previous damage to infest figs because females can oviposit on their ostiole base (Vilela et al., 1999; Goñi et al., 2001).

The last study about the geographic distribution of *Z. indianus* in Argentina shows that this species is widely distributed in the Northeast of the country (Lavagnino et al., 2008; Imberti, 2016) and the record of Goñi et al. (2001) in Montevideo, Uruguay (34°53' S) is the southernmost registered in America to date. Therefore, the record presented in this note extends the distribution of this species in Argentina and it is the most austral record in the continent. A recent study showed that even

Year	Figs	Raspberries
2017	0.09	1.00
2018	0.00	0.98
2019	1.00	1.00

Table II. Relative Abundance Index (RAI) values, of *Drosophila suzukii* and *Zaprionus indianus* by harvest season.

though *Z. indianus* is a tropical species, females are able to arrest ovarian development when exposed to winter conditions, and when higher temperatures return, they do not experience a significant fitness reduction, which is an overwintering characteristic that may facilitate *Z. indianus* invasion to higher latitudes (Lavagnino et al., 2020).

This note confirms that *D. suzukii* is fully established in the Northeast of Buenos Aires province and that *Z. indianus* is starting to colonize the region. Taking into account these results and that in this region there are a significant number of berry fruit growers, at the present time *D. suzukii* could be considered a species of higher risk than *Z. indianus* for local fruit production. Moreover, further studies about biotic and abiotic factors that could influence the population dynamics of both drosophilids are necessary for a better understanding of the variability observed between seasons.

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