Oviposition by *Toxotrypana curvicauda* (Diptera: Tephritidae) in small to medium-size cuaguayote and papaya fruits with low sugar content

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Management of any insect population needs an accurate knowledge of its biology, ecology, and behavior (Aluja et al. 1994). Oviposition behavior studies reveal physical and chemical attributes of fruits that attract gravid females for oviposition (Arredondo et al. 2010). Monophagous and stenophagous tephritids are attracted by chemical, visual, and tactile stimuli, and are selective when choosing oviposition sites (Papaj 2000).

In fruit flies with small numbers of hosts, such as the papaya fruit fly, *Toxotrypana curvicauda* Gerstaecker (Diptera: Tephritidae), fruit volatiles are used for selecting host plants, whereas other chemical and visual cues are used to locate oviposition sites (Díaz-Fleischer et al. 2000; Papaj 2000; Aluja & Mangan 2008). Papaya is the most important and best-known host of *T. curvicauda*. Females prefer to oviposit in immature, green, medium-sized (11.6 cm), and ovoid-shaped papaya (*Carica papaya* L.; Capparales: Caricaceae) fruit with flesh thinner than 1.8 cm (Peña et al. 1986; Landolt et al. 1988; Landolt & Reed 1990). It is possible that the female gauges the amount of sugar present in the flesh of the papaya fruit to determine suitability for oviposition, as reported for *Dacus tryoni* (Froggatt) (accepted name: *Batrocera tryoni* [Froggatt]) (Eismann & Rice 1985) and *Anastrepha obliqua* (Macquart) (Fontellas-Bryalha & Zucoloto 2004) (both Diptera: Tephritidae).

There are other hosts of *T. curvicauda*, one of which is *Jacaratia mexicana* A. DC. (Capparales: Caricaceae) (Castrejón-Ayala & Camino 1991), a plant known in Mexico as cuaguayote. There is no information on the oviposition behavior of *T. curvicauda* in relation to fruit of the cuaguayote tree; this study is the first report of characteristics of cuaguayote fruits selected by *T. curvicauda* for oviposition.

Mature larvae, obtained from naturally infested papaya fruit from our papaya grove, were placed in cylindrical plastic containers (500 mL) with sterilized soil (300 mL) and were incubated at 25 ± 2 °C, 40 to 60% RH, and a 12:12 h L:D photoperiod. One 6- to 8-d-old female (50.0 ± 20 mg, mean ± SD) was held with one 4- to 8-d-old male in a transparent plastic cylinder container (4.5 cm diameter × 9 cm height) between 9:00 a.m. and 3:00 p.m. for mating. The mated female was then introduced into an acrylic cage (30 × 30 × 30 cm) with either an immature papaya or a cuaguayote fruit for a maximum of 4 h for oviposition. Immature damage-free fruits were collected either from our papaya grove or from our cuaguayote trees early in the morning of the test day. Oviposition experiments were carried out at 25 ± 2 °C, 40 to 60% RH, between 11:00 a.m. and 4:00 p.m., the time period for most ovipositions under field conditions (Aluja et al. 1997). Eighty immature fruits of each species were tested individually. Mated females were used once and then discarded.

For each fruit with oviposition, we measured the color (RGB) of the skin, the total length (cm) of the fruit, the thickness (cm) of the flesh, the force needed to puncture the flesh (penetration force in Newtons), the amount of total solids (°Brix as a proxy for sugar content) in a drop of juice obtained from the flesh, and the section of the fruit (proximal, median, or distal) with eggs. After oviposition, fruits were dissected and the number of eggs inside each fruit was counted.

Toxotrypana curvicauda oviposited in 17 and 14 papaya and cuaguayote fruits, respectively. More eggs (250) were oviposited in small papaya fruit (9.3 to 12.4 cm length) (n = 12), than in medium-size papaya fruits (14.3 to 19.2 cm length; 96 eggs; n = 5; χ^2 = 35.127; df = 1; P < 0.001). Conversely, in cuaguayote fruits, more eggs (222 eggs, n = 8) were oviposited in medium-size fruits (21.4 to 24.2 cm length) than in small ones (18.5 to 21.3 cm length; 134 eggs; n = 6; χ^2 = 10.549; df = 1; P < 0.001). There was no oviposition either in large (> 19.2 cm) papaya or in large (> 24.2 cm) cuaguayote fruits.

Toxotrypana curvicauda oviposited 100% of the eggs in papaya with low total solids, but 88% of the eggs in cuaguayote with low total solids (Table 1). When compared by hardness, most of the eggs were oviposited in papaya rated medium, and few in papayas rated soft or hard. Similar numbers of eggs were laid in cuaguayote rated either medium or hard, and few in cuaquayote rated soft (Table 1). Fruits with flesh thinner than 1.9 cm accumulated 92% and 86% of eggs oviposited in papaya and cuaguayote, respectively (Table 1).

No differences were observed in the RGB spectra of the papaya (averages: R = 104, G = 131, and B = 57; n = 17) and of cuaguayote fruits (R = 126, G = 135, and B = 64; n = 14).

Most eggs were oviposited in the middle section of papaya and cuaguayote fruits (82.3% and 77.8%, respectively) followed by the proximal section (11.7% and 16.7%, respectively). Fewer than 6% of eggs were deposited in the distal section of either kind of fruit. Similar numbers of eggs were oviposited in papaya (20.4 ± 6.6) as in cuaguayote (25.4 ± 13.1) fruits (t = −1.4; df = 29; P = 0.172). In both hosts, eggs were found in the fruit cavity directly beneath the oviposition site very close to the seed. Eggs found in papaya formed a chain or a bouquet, whereas in cuaguayote they formed bouquets or aggregates. Our observations indicate that seeds of immature cuaguayote are very similar to those of immature papaya fruits; and immature seeds are the feeding sites of neonates (Peña et al. 1986). Naturally infested cuaguayote

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Table 1. Number of eggs oviposited by *Toxotrypana curvicauda* females either in papaya or in cuaguayote fruits with regard to total solids, fruit hardness, flesh thickness, and number of fruits of each host in which the papaya fruit fly oviposited.

		No. of eggs laid in	
Variable	Category of the variable	Papaya	Cuaguayote
Total solids (as °Brix)	Low (4.1–7.9)	346 (*n* = 17)	315 (*n* = 12)
	Medium (8.0–11.8)	0 (*n* = 0)	18 (*n* = 1)
	High (11.9–16)	0 (*n* = 0)	23 (*n* = 1)
Hardness (N)	So`ft (6.2–10.7)	42 (*n*=2)	148 (*n*=6)
	Medium (10.8–15.3)	243 (*n* = 12)	160 (*n* = 6)
	Hard (15.4–19.9)	61 (*n* = 3)	48 (*n* = 2)
Thickness (cm)	Low (1.1–1.4)	115 (*n* = 6)	127 (*n* = 5)
	Medium (1.5–1.8)	204 (*n* = 10)	180 (*n* = 8)
	High (1.9–2.2)	27 (*n* = 1)	49 (*n* = 1)

fruit seeds showed clear signs of damage by larvae. However, mature larvae remained in the cavity of cuaguayote fruit as the pulp is not as thick as that of papaya.

Our results showed that most oviposition by *T. curvicauda* occurred in either small papaya fruits or medium-size cuaguayote fruits with low sugar content. Skin color, flesh hardness, and flesh thickness had no effect on oviposition. Oviposition on small to medium-size immature papaya was reported previously (Landolt 1985; Landolt & Reed 1990). Our results also support the hypothesis that high concentrations of sugar in the fruit prevent oviposition (Díaz-Fleischer & Aluja 2003; Fontellas-Bryalha & Zucoloto 2004). Aluja et al. (1994) reported greater infestations in the papaya variety 'Hawaiian,' which has small and sweet fruit, and lesser infestation in papaya varieties 'Cera amarilla' and 'Cera Roja,' which have large fruits.

Toxotrypana curvicauda females were found to oviposit in both papaya and cuaguayote in the laboratory; however, laboratory adults reared from cuaguayote were smaller, lighter, and produced fewer eggs than wild adults reared from papaya (Jiménez-Pérez & Villa-Ayala 2009). Thus, it may be advantageous to this species to use papaya as its host.

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Summary

The papaya fruit fly, *Toxotrypana curvicauda* Gerstaecker (Diptera: Tephritidae), has several known hosts apart from the commercially valuable papaya (*Carica papaya* L.; Capparales: Caricaceae), among them *Jacaratia mexicana* A. DC. (Capparales: Caricaceae), known in Mexico as cuaguayote. Most studies on the papaya fruit fly have been carried out with *C. papaya* and have neglected the other known host for this fly. We characterized papaya and cuaguayote fruits in which *T. curvicauda* oviposits in terms of color, length, hardness and thickness of flesh, total solids (as °Brix), and the section (proximal, middle, and distal) of the fruit where the eggs were deposited. *Toxotrypana curvicauda* females oviposited in medium-size to small but not large fruits of either papaya or cuaguayote. Moreover, females oviposited only in low–sugar content papaya fruits, and mostly (about 88%) in low–sugar content cuaguayote fruits with a small fraction (about 12%) of the eggs laid in medium-size and large fruits. The other variables had no effect on oviposition behavior. This is the first report of *T. curvicauda* oviposition behavior with respect to cuaguayote.

Key Words: *Jacaratia mexicana*; oviposition behavior; alternative host; °Brix; sugar content

Sumario

La Mosca de la Fruta de la Papaya *Toxotrypana curvicauda* Gerstaecker (Diptera: Tephritidae) tiene varios hospederos aparte de la comercialmente importante papaya (*Carica papaya* L.; Capparales: Caricaceae), entre ellos *Jacaratia mexicana* A. DC. (Capparales: Caricaceae) conocida en México como cuaguayote. La mayoría de los estudios realizados con esta mosca han sido en *C. papaya* prestándole poca atención a los otros hospederos. Caracterizamos los frutos de papaya y cuaguayote que la *T. curvicauda* oviposita de acuerdo a su color, longitud, dureza, contenido de sólidos totales (como °Bx), y la parte del fruto (proximal, media y distal) donde oviposita sus huevecillos. Las hembras de la *T. curvicauda* ovipositan frutos de pequeños a medianos con bajo contenido de azúcar. Las otras variables medidas no modificaron el comportamiento de oviposición. Este es el primer reporte del comportamiento de oviposición de la *T. curvicauda* en cuaguayote.

Palabras Clave: *Jacaratia mexicana*; comportamiento de oviposición; hospedero alternativo; °Bx; contenido de azúcar

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