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Evaluation of attractants for the black fig fly (*Silba adipata* McAlpine, 1956) under laboratory conditions

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Abstract

The black fig fly (*Silba adipata* McAlpine, 1956) is one of the main pests affecting fig (*Ficus carica* L.) production in Mexico, causing yield losses of up to 88 %. Chemical control has shown limited effectiveness against this pest; therefore, an alternative for reducing its incidence is the use of traps baited with attractants. In this context, the objective of the present study was to evaluate potential attractants for the black fig fly under laboratory conditions. Three trap designs were tested, and it was determined that designs I and II, composed of interconnected acetate cubes with different dimensions, were suitable for attractant evaluation. Six crude extracts (hexanic, methanolic, and aqueous) obtained from fig and apple fruits, as well as a control treatment (ammonium sulfate and apple), were tested in traps containing attractants. The attractant potential was assessed based on the number of flies captured. The control treatment showed the highest effectiveness, capturing 28.20 % of the flies in trap design II and 29.59 % in trap design I, followed by the methanolic extract of apple, with captured 23.17 % in design II and 26.10 % design I. The aqueous extract of fig captured 20.46 % of the flies in trap design I and 23.17 % in trap design II, making it the third most effective attractant. In contrast, both the hexanic extract of fig and the aqueous extract of apple were the least effective attractants, with 0 % captures

Keywords: *Silba adipata*, attractants, trap designs.

Introduction

In Mexico, fig (*Ficus carica* L.) production has been promoted due to the growing demand for this fruit in international markets. In 2022, the Agri-Food and Fisheries Information Service (SIAP) reported the commercialization of fresh figs in 15 states across the country, with more than 11 500 t of fruit harvested. One of the main factors limiting production is the damage caused by the black fig fly (*Silba adipata* McAlpine), regarded as one of the most significant pests of fig crops worldwide.

The black fig fly is a monophagous frugivorous species native to the Mediterranean and the Middle East. It was first described by McAlpine (1956) in Italy, Cyprus, and Greece (Abbes et al., 2021). Adults are glossy black, measuring 3.5 to 4.5 mm in length, with reddish eyes and brown legs. They primarily feed on the sweet exudate of ripe figs and on the milky sap of fig trees released from injured plant tissues (Katsoyannos, 1983).

In 2019, the first detections of *S. adipata* in commercial fig orchards were reported in the municipality of Ayala, Morelos, Mexico (SENASICA, 2021). The economic impact of this pest is because larvae feed on the tissues of the syconium, which creates internal mines. Infestation of immature figs often results in premature fruit drop (Katsoyannos, 1983), leading to losses of up to 88 % of the

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production (Flores, 2022). Because this pest was recently introduced in Mexico and there is no specific information on its chemical control, the use of traps baited with attractants represents an alternative strategy to reduce its incidence. The objective of this study was to evaluate the effect of different attractants on the black fig fly (*Silba adipata*) under laboratory conditions.

Materials and Methods

Biological material

Third-instar larvae were obtained from infested fig fruits collected from a fig orchard located in La Manzanilla, Xochiapulco, Puebla, at 19° 50' 34.5" N and 97° 38' 17.7" W, an elevation of 1 842 MASL (Figure 1).

This area belongs to the physiographic province of the Sierra Madre Oriental and has a humid temperate climate with abundant summer rainfall. Annual precipitation ranges from 1000 to 1200 mm and mean annual temperature ranges between 14 to 16 °C (INEGI, 2000).

Experimental site

The study was conducted in the Agricultural Phenology Laboratory of the Department of Crop Science at the Universidad Autónoma Chapingo, Estado de México.

Rearing medium for *Silba adipata*

Larvae were placed in glass containers with a base of absorbent paper and cotton moistened with a 50 % sucrose solution and incubated at 23 ± 0.1 °C, until adult flies emerged.

Development of Trap Desings for Attractant Evaluation

A total of three trap designs were evaluated as potential attractant devices for *S. adipata* under laboratory conditions. Six crude extracts (hexanic, methanolic and aqueous) obtained from fig and apple fruits, and a commercially available attractant used as a control, were tested.

Three trap designs were developed:

Trap Design I (TD-I) consisted of a structure made from transparent acetate sheets, which allowed direct observation of insect behavior and minimized the loss of volatile compounds emitted by the attractants. Seven acetate cubes, each measuring 22 cm^3, were constructed, and different attractants were placed in each cube. The cubs were interconnected via a central rectangular prism measuring 66 × 22 × 22 cm (Figure 2). This configuration allowed free movement of the flies between the compartments, facilitating the simultaneous evaluation of different attractants.

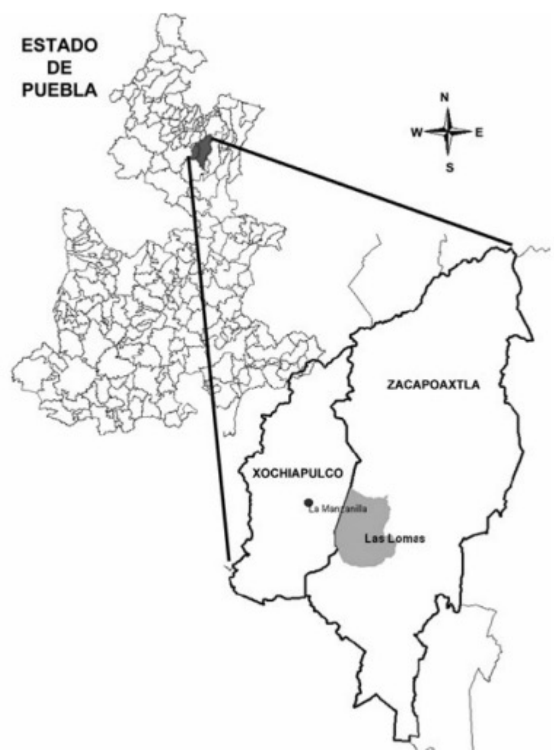

Figure 1. Geographical location of La Manzanilla, Xochiapulco, Puebla.

Source: Pérez et al., 2010.

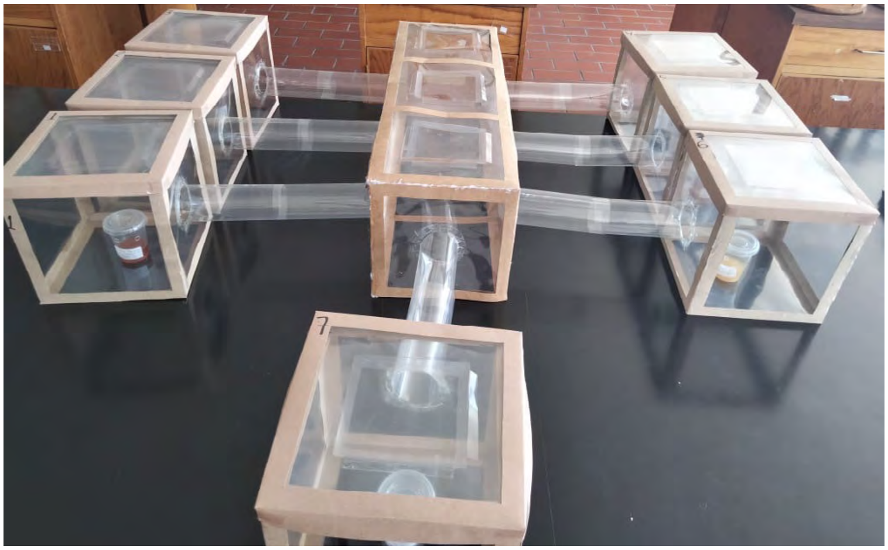

Figure 2. Trap Design I for evaluating attractants for the black fig fly (*Silba adipata* McAlpine) under laboratory conditions.

Trap Design II (TD-II) was made using acetate sheets. Cubes measuring 10 × 22 × 22 cm were used and interconnected through a rectangular prism measuring 30 × 10 × 10 cm (Figure 2).

Trap Design III (TD-III) was made using seven 1-L polyethylene terephthalate (PET) bottles. Different attractants were places in each bottle. The bottles were interconnected with 3/4” (19.1 mm) diameter, 30-cm-long rubber hoses leading to a central bottle with a larger capacity of 10 L (Figure 3).

Baited Trap

A baited trap was incorporated into each of the trap designs, consisting of a transparent polypropylene cup (Reyma® No. 4). Five holes, each 5 mm in diameter, were drilled around the midsection of the cup (Figure 4) to evaluate the effectiveness of the attractants used.

Plant Material Collection

Fruits of fig (*Ficus carica* L.) and apple (*Malus domestica* L.) were collected from an orchard in La Manzanilla, Xochiapulco, Puebla. The fruits were washed and cut into approximately 1 cm^3. The resulting samples were placed in 15 x 22 cm non wove fabric bags and frozen at -20 °C for 24 h in a vertical freezer (frigidaire). The frozen plant material was then lyophilized using a Labconco Freezone 4.5 Liter Benchtop Freeze Dry System for 5 days until constant weight. The lyophilized samples were stored in seal bags until use.

Preparation of Crude Extracts

Aqueous extract. A total of 100 g of each lyophilized material was weighed, mixed with 150 mL of distilled water, and boiled for 90 min. The supernatant was collected, concentrated by evaporation, and stored in amber bottles at 4 °C until use.

Hexanic extract. A maceration extraction was performed using lyophilized fig and apple material. A total of 587 g of lyophilized fig and 382 g of lyophilized apple were placed in separate 5-L containers, and 3 L of hexane solvent was added to each. The mixtures were allowed to macerate at room temperature for 48 h. After maceration, the extracts were filtered and concentrated under reduced pressure using a rotary evaporator (Buchi RE120 and Buchi 461 water bath). This process was repeated four times. The concentrated crude extract from each extraction was placed in amber bottles and stored at 4 °C. The final yield was 4 g of hexanic fig extract and 3 g of hexanic apple extract.

The residual plant material was air-dried at room temperature for 24 h to allow any remaining hexane to volatilize, leaving the material solvent-free. The residues from both fruits were then subjected to methanolic extraction.

Methanolic extract. The plant material residues from the hexane extraction were subjected to a second extraction using methanol as the solvent. The same procedure described for obtaining the hexane extracts of both fruits was followed. A total of four successive methanol extractions were carried out for each sample (fig and apple). As a result, 220 g of methanolic fig extract and 167 g of methanolic apple extract were obtained. The extracts were stored under refrigeration at 4 °C in amber glass bottles until being used as attractants.

Control. A solution was prepared by mixing 1 L of distilled water, 20 g of ammonium sulfate, 100 g of ground apple and 1 g of Roma® soap, and the components were mixed until having a homogeneous mixture. The solution was

Figure 3. Trap Design III for evaluating attractants for the black fig fly (*Silba adipata* McAlpine, 1956) under laboratory conditions.

Figure 4. Baited trap

then placed in amber glass bottles and stored under refrigeration at 4 °C until being used as an attractant.

Statistical analysis

The attractant capacity of the extracts was evaluated based on the number of flies captured. The assays were conducted in triplicate, and the results were analyzed using the Student-Newman-Keuls multiple mean comparison test ($P \leq 0.05$).

Results

It was observed that TD-III showed no capture of flies for any of the attractants evaluated (Table 1). This result suggests that the design is not suitable for attractant evaluation under laboratory conditions. This may have been due to the shape of the design and, in particular, the material used. During experimental observations, it was noted that the rubber hoses released a strong, characteristic odor. It is likely that this odor interfered with the volatile compounds of the extracts used as attractants, reducing their effectiveness and hindering the movement of flies toward the different traps.

No statistically significant differences were observed for TD-I and TD-II regarding the number of flies captured (Table 1), indicating that both designs were effective for fly attraction under laboratory conditions.

It is important to note that both TDs were constructed from transparent acetate, maintaining the same design but with different dimensions. TD-I was 54.55 % larger than TD-II. This suggests that the difference in dimensions between the two designs had no effect on its performance in the evaluation of attractants under laboratory conditions.

Attractant evaluation

The most effective attractants were the control treatment (ammonium sulfate and apple), which captured 29.59 % of the flies in TD-I and 28.20 % in TD-II, followed by the methanolic apple extract, with 26.10 % in TD-I and

Table 1. Multiple mean comparison of attractants in each structural design using the Student-Newman-Keuls (SNK) test.

TD	ATY	HFE	HAP	MFE	MAE	AFE	AAE	ASA
TD-I	$\sqrt{NFC-1}$	1.0000 b	1.2440 ab	1.2761 ab	1.9001 ab	1.7454 ab	1.0000 b	1.9894 a
	NFC	0.0	0.5475	0.6284	2.6104	2.0464	0.0	2.9593
	PFC (%)	0.0	5.4750	6.2840	26.104	20.464	0.0	29.593
	K	0.57139	0.69553	0.77118	0.82581	0.86851	0.90356	0.93322
TD-II	$\sqrt{NFC-1}$	1.0000 c	1.2440 bc	1.1381 c	1.8214 ab	1.8214 ab	1.0000 c	1.9546 a
	NFC	0.0	0.5475	0.2953	2.3175	2.3175	0.0	2.8205
	PFC (%)	0.0	5.4750	2.9530	23.175	23.175	0.0	28.205
	K	0.46878	0.57063	0.63269	0.67751	0.71254	0.74130	0.76563
TD-III	$\sqrt{NFC-1}$	1.0 b	1.0 b	1.0 b	1.0 b	1.0 b	1.0 b	1.0 b
	NFC	0	0	0	0	0	0	0
	PFC (%)	0	0	0	0	0	0	0
	K	0	0	0	0	0	0	0

Means with the same letter in each trap design indicate no statistically significant differences at $P \leq 0.05$; NFC: number of flies captured. K are the minimum significant differences according to the Student-Newman-Keuls test. ASA: Ammonium sulfate + apple (Control); HFE: Hexanic fig extract; HAP: Hexanic apple extract; MFE: Methanolic fig extract; MAE: Methanolic apple extract; AFE: Aqueous fig extract; AAE: Aqueous apple extract.

23.17 % in TD-II (Table 1). According to Ng et al., (2020), methanol is a solvent that facilitates the extraction of flavonoid glycosides because these compounds are polar. Monagas et al. (2003) indicate that both polyphenols and carotenoids are present in significant quantities in apple (*Malus domestica* L.), including caffeic, quinic, and p-coumaric acids, which are polar in nature and can be extracted with methanol. This suggests that the compounds may be phenolic in origin and that some terpenes may also be present, contributing to the attractant capacity of the extract. Therefore, the methanolic apple extract shows strong potential as an attractant and could be a useful tool for managing *S. adipata*.

The aqueous fig extract captured 20.46 % of *S. adipata* in TD-I and 23.17 % in TD-II, with the latter showing the highest attractant performance (Table 1). In contrast, both the hexane fig extract (HFE) and the aqueous apple extract (AAE) were the least effective attractants, resulting in 0 % capture of *Silba adipata*. These findings agree with Salih et al., (2020), who reported poor polyphenol extraction from macerated or cooked samples when using water as the solvent. This suggests that these extracts lack the compounds of active ingredients needed to function as effective attractants.

Conclusions

When comparing the three structural designs developed, it was observed that trap designs I and II are effective for evaluating attractants under laboratory conditions.

The methanolic apple extract and the aqueous fig extract can be used as attractants for the control of the black fig fly (*Silba adipata* McAlpine, 1956).

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