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Food attractants to increase pheromone-baited trap performance for *Scyphophorus acupunctatus* (Coleoptera: Dryophthoridae) in mezcal maguey

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Agave weevil, *Scyphophorus acupunctatus* Gyllenhal (Coleoptera: Dryophthoridae), is the main pest on wild and cultivated agave in Mexico (González-Hernández et al. 2007; Aquino Bolaños et al. 2014). In Guerrero State, this weevil infests wild, semi-cultivated, and cultivated maguey for producing mezcal (*Agave vivipara* L. = *Agave angustifolia* Haworth, and *Agave cupreata* Trel. & Berger; Asparagaceae) (Barrios Ayala et al. 2006; P. F.-C. unpublished data). Conventional management tactics (i.e., pesticide applications) have been inefficient to control agave weevil populations mainly because of the cryptic habits of this weevil, which completes its life cycle inside the agave boll (P. F.-C. unpublished data).

A pheromone-baited trap system is the standard tool for monitoring adult populations of *S. acupunctatus* on blue agave in Mexico (Figueroa-Castro et al. 2013). The use of agave tissue as a bait was proposed by Rojas et al. (2006). Further, Figueroa-Castro (2014) confirmed the need to bait pheromone traps with agave tissue (300–400 g) to synergize the response of agave weevils to pheromone-baited traps, increasing the number of captured weevils.

However, this system has some inconvenience. Firstly, although agave tissues may be obtained directly from infested agave plants, the recommended practices to eliminate infested plants can make it difficult to find them, and in this case it is necessary to obtain the tissues from healthy agave plants with a commercial value (plants in growth stages, shoots from rhizomes of parental plants, termed "hijuelos"). Secondly, time is required for plant selection, dissection, and for preparing the bait. Thirdly, each plant with a commercial value but used as bait represents a future loss in mezcal yield. With the objective to find an efficient, economic, and practical food bait, 2 alternative food attractants (banana and pineapple ripe fruits) were evaluated to synergize the response of agave weevil to synthetic pheromone-baited traps in the mezcal maguey area.

Traps of the type TOCCI (4 L white buckets) used in this study were handmade (Figueroa et al. 2016a). Each trap was baited with a dispenser of synthetic aggregation pheromone of *S. acupunctatus* (Tequilur®, FeroCompS, Mexico City, Mexico) and 300 g of the food attractant. The food attractant was placed inside a 0.5 L plastic container with holes (0.5 cm diameter) and sprinkled with malathion insecticide (Malathion 1000®, Anajalsa, S. A. de C. V., Jalisco, Mexico) (10 mL/L of water). The pheromone dispenser was changed monthly and the food attractant every 15 d.

The experiment was performed from 29 Jan to 21 May 2016 in a 4-yr-old espadín maguey (*A. vivipara*, *A. angustifolia*) plantation, in El Rancho Frío (18.38678°N, 99.16611°W; 1,120 m asl), located in Quetzalapa, Huitzuco de los Figueroa, Guerrero, Mexico. We evaluated the following treatments: 1) empty trap without synthetic pheromone and food attractant but with soapy water (control), 2) trap baited with pheromone but without food attractant, 3) trap baited with pheromone and 300 g of vegetative tissue of papalote maguey, 4) trap baited with pheromone and 300 g of vegetative tissue of espadín maguey, 5) trap baited with pheromone and 300 g of ripe banana, and 6) trap baited with pheromone and 300 g of ripe pineapple.

Traps were placed at ground level, near an agave plant, spatially distributed in a square pattern (as recommended by Figueroa-Castro et al. 2016b), with a distance between traps of 50 m. The experiment was established in a completely randomized experimental design, each treatment with 4 replications. Traps were checked biweekly for 5 sample dates. On each visitation date, we emptied the traps and collected the captured weevils. Specimens were taken to the laboratory of Agricola Production at the Universidad Autónoma del Estado de Morelos (Cuernavaca, Morelos, Mexico) to be counted and sexed based on the morphology of the final abdominal segment (Ramírez-Choza 1993).

Statistical analysis was performed using SAS/STAT® software (SAS Institute 2004). The data were analyzed by analysis of variance (ANOVA) using proc GLM. Prior to ANOVA, data were checked for normality (Shapiro–Wilk test) and homogeneity of variances (Bartlett test), and data transformation was not necessary. Treatment means were separated with a Tukey test ($\alpha = 0.05$). A chi-squared test was applied to determine differences in the number of females and males caught in traps.

The number of agave weevils captured was affected by the treatments, and we found statistical differences between treatments ($F = 14.30$; df = 5,15; $P < 0.0001$). Traps baited with the synthetic pheromone and any food bait (papalote maguey tissue, banana, or pineapple) captured significantly more weevils than traps baited only with pheromone. Empty traps did not capture weevils (Fig. 1).

The fact that host plant volatiles synergize the responses of weevils to the synthetic pheromone has been reported for several species (Tinzaara et al. 2007; Wibe et al. 2014). With regard to food attractants, the best food attractants in our study were papalote maguey tissue and

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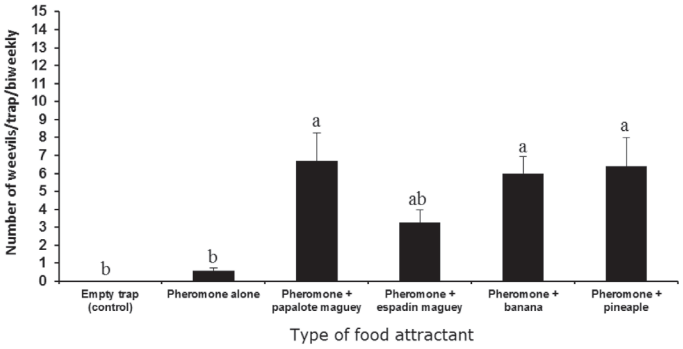


Fig. 1. Mean number of *Scyphophorus acupunctatus* weevils captured per trap biweekly, with various food attractants. Means were calculated from data of 5 biweekly samples. Treatments with similar letters are not significantly different (Tukey, $\alpha = 0.05$). Error bars indicate SE.

ripe banana and pineapple fruit; these fruit baits have been reported previously as food attractants for trapping other weevil species. Pineapple was evaluated by Valdés et al. (2005) and García-Ramírez et al. (2014) for trapping *S. acupunctatus* on tuberose plant (*Polianthes tuberosa* L. 'Perla' [Asparagaceae]). Figueroa-Castro et al. (2016b,c) used agave tissue for collecting *S. acupunctatus* in mezcal maguey and in blue agave. Bananas were tested by Al-Saoud (2011) for collecting *Rhynchophorus ferrugineus* (Olivier), and by Sumano et al. (2012) for trapping *Rhynchophorus palmarum* (L.) (Coleoptera: Dryophthoridae). Banana and pineapple fruit appear to be good food baits for the agave weevil, with similar captures as those reported for agave tissues, but with additional advantages. They 1) are cheaper than agave, 2) are abundant, 3) are easy to buy, and 4) have no direct impacts on agave production.

Significantly more *S. acupunctatus* females than males were captured in all the treatments. These findings were similar to previous reports (Macedonio-Guevara 2015; Figueroa-Castro et al. 2016c). Capturing a large number of females is very important, because it has a direct impact for decreasing future population densities of agave weevil.

Based on our results, for monitoring agave weevil populations on any cultivated agave we suggest baiting the traps with pheromone and 300 g of food attractants such as papalote maguey tissue, ripe banana, or ripe pineapple fruit. Future research should focus on the potential to use this trapping system for initiating management practices, for preventing establishment of agave weevil populations in new plantations, and as part of a mass trapping system for controlling the population density of this agave pest.

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Summary

The agave weevil, *Scyphophorus acupunctatus* Gyllenhal (Coleoptera: Dryophthoridae), is the main insect pest on maguey grown for mezcal beverage production in Guerrero, Mexico. We studied the effectiveness of several food attractants in pheromone-baited traps for capturing *S. acupunctatus* in mezcal maguey plantations. All of the tested food attractants synergized the response of the agave weevil to synthetic aggregation pheromone traps. Adding papalote maguey tissue, ripe banana, or ripe pineapple fruit increased the number of captured weevils in pheromone-baited traps. However, it is easier, cheaper, and more practical to use ripe banana or pineapple fruit as the bait attractant than using the agave tissue.

Key Words: agave weevil; food attractant; monitoring; pheromone trap

Sumario

El picudo del agave *Scyphophorus acupunctatus* Gyllenhal (Coleoptera: Dryophthoridae), es la principal plaga en maguey mezcalero in Guerrero, México. En la presente investigación se evaluó la efectividad de varios atrayentes alimenticios en trampas con feromona de agregación sintética para la captura de *S. acupunctatus* en plantaciones de maguey mezcalero espadín. Todos los atrayentes alimenticios empleados potencializan la respuesta de este picudo a las trampas con feromona sintética. Colocar tejidos de maguey papalote, fruta madura de plátano o piña incrementa el número de picudos capturados en las trampas con feromona. Sin embargo, emplear fruta madura de plátano o piña es más sencillo, económico y práctico que usar tejido de agave.

Palabras Clave: picudo del agave; atrayentes alimenticios; monitoreo; trampas con feromona

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