Scientific Research Publishing

American Journal of Plant Sciences, 2021, 12, 1425-1435
https://www.scirp.org/journal/ajps
ISSN Online: 2158-2750
ISSN Print: 2158-2742

Absence of Fruit Mexican Fly (*Anastrepha ludens*) in Pitaya de Mayo (*Stenocereus pruinosus*)

Ntumbua Ngeya[1], Ma. de Lourdes Yáñez-López[1*], Miguel A. Armella[2]

[1]Biotechnolgy Department, Universidad Autónoma Metropolitana, Iztapalapa, Mexico City, Mexico
[2]Biology Department, Universidad Autónoma Metropolitana, Iztapalapa, Mexico City, Mexico
Email: *lyanez@xanum.uam.mx

How to cite this paper: Ngeya, N., de Lourdes Yáñez-López, Ma. and Armella, M.A. (2021) Absence of Fruit Mexican Fly (*Anastrepha ludens*) in Pitaya de Mayo (*Stenocereus pruinosus*). *American Journal of Plant Sciences*, **12**, 1425-1435.
https://doi.org/10.4236/ajps.2021.129100

Received: August 5, 2021
Accepted: September 20, 2021
Published: September 23, 2021

Abstract

Pitaya de mayo (*Stenocereus pruinosus*) exportation is considered feasible especially to the United States of America (USA) using the adequate preservation and transportation techniques. One of the exportation requirements is that pitayas, as well as any other tropical fruits, have to be free from Mexican fruit fly contamination and certified by the Food National Sanitary, Iniquity, and Quality Service. This review proved that this fruit is not attacked by the Mexican fruit fly *A. ludens* or any other Anastrepha species. The fruit fly may be found in some States of Mexican Republic such as some tropical regions but not in the semi-arid regions where cacti fruits are grown.

Keywords

Pitaya, Cacti Fruits, Oaxaca, Infestation, Fruit Trading

1. Introduction

In Mexico, there is a wide diversity of edible cacti fruit producers such as "pitaya de mayo" (*Stenocereus pruinosus*) which quickly grows in the arid zones of Mexico such as Mixteca Oaxaqueña and Poblana, as compared to the primary, traditional crops. In these semi-arid regions, rainfall is just 500 - 700 mm in a year with an absence of rain period ("canicula") of near 40 days, which coincides with the usual primary crops' flowering period, which makes harvest losses. The pitaya de mayo grows in pronounced slopes and severely eroded soils [1].

The Mexican fruit fly, specially *Anastrepha ludens,* is a pest insect that causes damage to mango and citrus producers. Its natural distribution is from the United States of America, southern Mexico, Central America up to Brazil [2]. Its adap-

tation and reproduction ability has made them a problem in the field because the economic loss caused to the fruitculture industry; a female may oviposit up to two thousand eggs, and her life cycle is a maximum of 40 days [3].

The infested fruit shows little drillings as oviposition signals, but these or other damage symptoms are difficult to detect in early infestation stages; the damage occurs within the fruit before external signs, such as decay, are observed [4]. The adult female attacks the fruit; she drills the fruit epicarp to oviposit. The infestation symptoms differ in various fruits; infested grapefruit frequently shows a golden color that becomes darker before it ripens. The larva is detected when it comes out of the fruit, slowly moving as it falls to the soil, while the infested fruit remains upon the tree; In Marsh grapefruit, the larva damages the inner central part of the fruit, and it moves outward, destroying most of the mesocarp [5].

In 1992 the Mexican Federal Government established the National Campaign against the Mexican Fruit Fly to control, suppress, and eradicate all four species considered most economic importance: *A. ludens, A. obliqua, A. striata,* and *A. serpentina* to avoid the exotic fruit flies' establishment. The eradication technology is the base of the "Pest Integrated Handling" (PIH) that involves monitoring (insects trapping and fruit sampling) and control (specific bait aspersion, cultivation activities, natural enemies, as well as sterile flies release). These harmonious activities application seeks to free-fly-zones to allow healthy fruit production with the optimum phytosanitary quality and facilitate access to national and international markets [6].

According to SENASICA (Sanitary, Safety and Food Quality National Service in Spanish), fruit orchards like the pitaya de mayo need to be certified. This agency protects agriculture, water, and cattle ranchers from pests and diseases of economic importance and quarantine. Besides, it regulates and promotes the application and certification of food risk reduction systems and agricultural food quality to facilitate the vegetable and animal foods national and international commerce.

SENASICA [7] determines that the necessary documents to export Pitaya de mayo to the United States of America are:

- Exports system's declaration,
- Sworn declaration of origin,
- Origin certificate,
- Phytosanitary certificate,
- Commercial invoice,
- Transport documents,
- Referral guide (Ministry of Foreign Trade).

We have done an exhaustive review about Mexican fruit fly (mainly *A. ludens*) to be able to request the pitaya de mayo orchards' certification from SENASICA.

Mexican fruit fly specialist, states that this is an insect that mainly attacks citrus orchards such as oranges, limes, and grapefruits in paper called "Genetic

Structure of Populations of *Anastrepha ludens* (Diptera: *Tephritidae*) in Mexico" [8]. In the same article, she talks about an experiment she and her colleagues made collecting Mexican fruit fly larvae from 7 different States of Mexico: Durango, Chiapas, Morelos, Yucatán, Tamaulipas, Veracruz, and San Luis Potosí. They experimented with oranges, limes, and grapefruits. Farmers are making many efforts for their economy's sake in Mexico by getting an aggregate value produce.

Pitaya de mayo has many quality characteristics that make it healthy food, such as the following nutritional value report by Penelo [9]: It provides 54 calories; 84.4% water; 1.4 g proteins; 13.2 g carbohydrates; total fats: 0.40 g; 0.5 g fiber; 8 mg vitamin C; 10 mg Ca; 1.3 mg Fe; 26 mg P.

According to Penelo [9], it may retard cellular aging; it reinforces the immunological system by stimulating white cells, red cells, and platelets production; it has an anti-inflammatory effect; it helps us regulate the intestinal transit, and its seeds have a laxative effect; it regulates blood sugar levels; it stimulates collagen production; it enhances iron absorption (needed to avoid or combat iron deficiency anemia); it is excellent for bones and teeth formation; because it is rich in water and low in carbohydrates its consumption is perfect for people under a diet.

In natural environments, *A. ludens* seem to be present in ecosystems under 900 m [10], especially in a tropical and semitropical environment

2. Mexican Fruit Fly (*A. ludens*) Features

Most features are present, generally in Mexican fruit flies of this genus.

This fly is native to Northeast Mexico [11], and it is distributed in all Central America through Brazil [2]. It has dispersed to citrus fruits from the Western coast of Mexico through Texas, where detection, sampling, and eradication campaigns establishment have been made.

3. Morphology

According to Loera [12], the most updated source, the Mexican fruit fly's morphology is as follows:

Adult. Its size is greater than the domestic fly. Its color is yellowish-brown, similar to other species from the genus *Anastrepha* [4].

Head. It has yellow "genas[1]" and vortex, a moderately developed face and without a middle bulge. It has hardly distinguished ocellar "setas"; with two pairs of orbital silks; a regular antennal length [13].

Thorax. It has chestnut brown or black macro-silks; "meso-notus" and presutural area with no dark spots but with light yellow sublateral stripes; "scutellar" shield suture with a diffuse and extended black, laterally extended strain; with "acrostichal bristles" silks; light yellow scutellum; a meso-pleuron with no differentiated dark pattern, a weak "katepisternum" silk; its sub-scutellum has a dark stain on each side which sometimes extends to the "methanoto," and they grad-

[1]All anatomical terms are according to https://en.wikipedia.org/wiki/Glossary_of_entomology_terms.

ually decrease in wideness [13].

Wings. Their strips are light yellow [4], with the strip complete generally joins the rib band, but can also be separate; the hyaline stain on the R_1 apex is always present. S and V stripes are always disconnected with the distal, are either complete, or, sometimes, separated from the proximal arm in its higher side portion, with a moderate apical curvature of the "muein" [13].

Abdomen. All its "tergitos" are yellow. The female has a segment VII of variable length, but almost two-fold longer than the abdominal length; the eversible membrane has big, strong hooks disposed of in a triangular way; her ovipositor ("oviscapto") is 3.2 - 5 mm long with a long tip and little rounded teeth, sometimes scarce and weak that occupies less than the apical half. The male has moderate, long, thick "surstilos" but acute at the tip, short and robust presser silks ("prensisedas") located almost in the middle part, with a well-developed "distifalo" [13].

Egg. It is 1.37 - 1.6 mm long and 0.18 - 0.21 mm wide in its front part, white, thin in its back. The micropyle is beside the anterior pole, and there is an opaque net near it, which is made of irregular and elongated pentagons and hexagons at the back part of the egg; there are also different "chorion" openings in the polygons at the anterior egg terminal [14]. According to Smith & Peña [2] Egg incubation requires near four days. Female oviposits "either in epicarp or mesocarp of ripening fruit". Eggs can be oviposited singly or in clusters. Larval development requires about 14 days. "Larva pass through three instars before emerging from the fruit and burrowing into the ground to pupate" [2].

Larva. It is white, 9 - 11 mm long, and 1.5 mm diameter, with a cylindrical, elongated, ventrally curved shape. It has mouth hooks in its frontal part, its flattened caudal terminal, eight fusiform ventral areas (undifferentiated between thorax and abdomen), eleven body segments besides the head; the last instars are 9 - 12 mm long [4]. The oropharynx apparatus has 12 - 16 tracheal carinas [15]. It has a cephalon-pharyngeal skeleton with an extensive and convex hook, two-fold longer than wide, an equally wide hypostome, a long dorsal bridge, and a longer pharyngeal plate than the one dorsal wing plate and with extended pharyngeal support. The anterior spiracles are small, chitinized, light yellow, asymmetrical, moderate depression, and 18 tubules (seldom 12-17) [4]. The outer spiracles are located at the upper part of the horizontal middle line, they are elongated with angulated dorsal two upward and the ventral one angulated downward on each side of the center part; each spiracle has three wide yellow entrances; a pair of small tubercles are found at the upper and lower parts of each of the back spiracles; the anal lift is big, and each anal lobule is bulky, bifid, and dark brown [16].

Pupa. It is cylindric, 5.5 - 7.5 mm long, and 2 - 3.25 mm in diameter, it is light to dark red, with 11 segments, the last one being prominent. The front spiracles are darker than the larva ones. The red-brown back spiracles are located under the horizontal middle line; each spiracle has three wide yellow entrances, overdefined bumps. The red-black anal plates are big, elliptical [16]. According to

Smith & Peña [2] the basic life cycle of these diverse species is very similar.

4. Control Methods

Due the importance of this insect for the fruit agriculture many systems of control have been studied in the past. The most effective is the irradiation of larvae [15] [17] with the attempt to sterilize males that do not have offspring when breed with wild females. These methods have problems, like the attack of larva and pupae by bacteria [18] and that it depends on the efficiency of mating system of the fly [19]. Another control methods include the use of parasitoids, both fungus [20] and insects [21]. However, the improvement of attracting mass traps is still one of the most important control systems [22].

5. Fruit Flies Species and Hosts

Fruit fly as genus can attack many tropical fruits (Table 1). Neither in the list of Table 1 neither the species reported in Table 2 show no species of cactus family reported to by attacked by species of *Anastrepha*. All attacked fruits are from tropical regions and not from arid ones.

In Mexico, natural hosts of Anastrepha species are mango (*Mangifera indica*), mixed citrus spp fruits (*Rutaceae*), also two native *Rutaceae* species, *Sargentia greggii* and *Casimiroa edulis* [24] [25]. Occasionally it infests peach fruits (*Prunus persicae*) and some fruits from *Myrtaceae* family plants [17] [26]. Most of them are fleshy sweet fruits, growing like trees (Table 2).

6. Pest Control

In 1992 the Mexican Federal Government implemented the National Campaign

Table 1. The four most important Mexican fruit fly species in Mexico, out of the 30 existent ones, from the *Anastrepha* genus [23].

Anastrepha ludens	*A. obliqua*	*A. striata*	*A. serpentina*
Orange	Mango	Guava	Mammee apple
Mango	Medlar	Myrtle	Sapodilla
Grapefruit	Red plum		Star apple
Peach	Yellow plum		Yellow sapota
Tangerine			
Citron			
White sapota			
Lime			
Real lemon			
Apple			
Pear			
Quince			
Italian lemon			

Table 2. Mexican fruit fly (*Anastrepha ludens*) host plants (Modify from Loera, 2017 [12] with data from Hernández-Ortíz, 1992, 2007 [13] [26]).

Scientific Name	Family	Reference	Common name English/Spanish	Record***
Annona cherimola Miller**	Anonaceae	[5]	Custard appñe/Chirimoya	rc
Annona reticulata L.	Anonaceae	[5]	Sugar apple/Anona roja	rc
Annona squamosa L.	Rutaceae	[27]	Sweetsop/Zaramuyo	rc
*Casimiroa edulis Llave & Lex***	Rutaceae	[5] [24] [28]	Whitezapote/Zapote blanco	rhbd
Citrus aurantifolia (Christm.) Swingle	Rutaceae	[5]	Key lime/Lima ácida or Limón Mexicano	ruo
*Citrus aurantium L.**	Rutaceae	[5] [24] [28]	Bitter orange/Naranja agria	rhbd
*Citrus limetta Risso**	Rutaceae	[5] [29] [30]	sweet lime/Lima	ruo
*Citrus máxima Burm.**	Rutaceae	[5] [28]	Pummelo/Pomelo	rhbd
*Citrus medica L.**	Rutaceae	[30].	Citron/Cidra	ruo
*Citrus paradisi Macfad**	Rutaceae	[5] [24] [30]	Grape fruit/Toronja	rhbd
*Citrus reticulata Blanco**	Rutaceae	[5] [28] [30] [31]	Mandarin orange/Mandarina	ruo
*Citrus sinensis L.**	Rutaceae	[5] [24] [29]	Sweet orange/Naranja dulce	rhbd
*Cydonia oblonga Miller**	Rosaceae	[5]	Quince/Membrillo	ruo
*Mammea americana L.**	Clusiaceae	[5] [24]	Mammee/Zapote Mamey	ruo rc
*Mangifera indica L.**	Anacardiaceae	[5] [24] [28] [29] [31]	Mango/Mango	rhbd
Sideroxylon capiri A. (A. D.C.) Pittier	Sapotaceae	[30]	Tempisque	ruo
*Prunus pérsica (L.)**	Rosaceae	[5] [29]	Peach/Durazno	rhbd
*Psidium guajava L.**	Mirtaceae	[5] [29] [31] [32]	Guava/Guayaba	ruo
*Punica granatum L.**	Punicaceae	[5] [29]	Pomegranate/Granada	ruo
*Casimiroa greggii Chang***	Rutaceae	[5] [24] [25]	Yellow zapote/Chapote amarillo	rhbd
*Spondias purpurea L.**	Anacardiaceae	[5]	Purpule Mombin/Ciruela morada	rc
*Syzygium jambos (L.)***	Mirtaceae	[5]	Rose apple/Pomarrosa	ruo
Psidium sartorianum (Berg)	Mirtaceae	[26]	Little guava/Arrayan	ruo
Capsicum Pubensens (Ruis and Pavon)	Solanaceae	[33]	Hot Chile Peppers/Chie manzano	

*Fruit in quarantine: Susceptible to be infested, there is a phytosanitary treatment, which reduces the risk of dissemination of the plague (NOM-075-FITO-1997, 1998). **Fruit in Absolute Quarantine: Fruits highly susceptible to be infested there is no phytosanitary treatment there is a high risk of dissemination (NOM-075-FITO-1997, 1998). ***rhbd: there are historical records in databases; ruo: there are single or occasional records; rc: doubtful records require confirmation (Hernández-Ortiz, 2007).

against the fruit flies to control, suppress, and eradicate four species considered economic importance: *A. ludens, A. obliqua, A. striata,* and *A. serpentina* to avoid exotic fruit flies' establishment. The eradication technology is the base of the Integral Pest Handling System (IPHS) that comprises monitoring actions (fruit trapping and sampling) and control (specific bait aspersion, cultural activities, natural fly's enemies, and sterile flies release). The harmonic application of these activities is directed to achieve the pest prevalence and establish flies' free zones to allow the optimum phytosanitary quality fruit production and facilitate its

access to national and international markets [6] [2]. We also asked farmers to set traps in their orchards with diverse types of baits and they say they have not found any Mexican fruit fly.

7. Pitaya de Mayo (*Stenocereus pruinosus*) Features

Stenocereus pruinosus (also known as *S. griseus*) is a cactus species native to northern South America and the Antillas Islands. In Mexico, its distribution is in the deciduous forest, in Puebla, Oaxaca, Guerrero, with reports from Tamaulipas and Veracruz. However, similar species, also called "pitayas," are distributed in other states like Queretaro, Jalisco (mostly *S. queretaroensis and S. fricci).* Although it has been argued whether this species reached Mexico in natural ways or it was brought in ancient times by original human groups [34], now it is part of this deciduous forest, along with other members of the family, in such a way that during the dry season they outstand vegetation (**Figure 1**).

From the natural environment, some arms from the plant (botanically branches) were collected and sow to reproduce asexually and produce almost monospecific orchards **Figure 2**.

Pitayas flowers from February to march and fructify in May (the reason for its common name). Since the branches of Pitaya are almost vertical (**Figure 2**), the sun rays reach the floor, and the environment becomes drier. Data gathered from our group indicates that the floor temperature might reach 50˚C and above 40˚C on the air during the fruiting [35] and relative humidity (RH) of around 20%. The presence of *A. ludens* appears to be positively related to temperature and inverse associated with humidity [2]. Although, it is not clear the relation of *A. ludens* presence with temperature and humidity [30]. However, Aluja [15] indicates that the presence of adults is on 80% RH. In the case in Pitaya, neither larva nor adults were reported in the orchards using Mc. Phail traps. Besides, fruit development is when the highest temperatures are in the area plus the driest season since, in the north of Oaxaca, the dry season starts in October and

Figure 1. Image of deciduos fores during dry season in Oaxaca, Mexico.

Figure 2. *S. prunosus* orchard.

Table 3. Bromatological contents Pitaya de Mayo in %.

Variety	JARRA	CENIZA	OLLA
Proteins	1.64 ± 0.04	1.72 ± 0.03	1.55 ± 0.03
Carbohydrates	6.66 ± 0.10	4.57 ± 0.09	5.04 ± 0.12
Lipids	0.11 ± 0.05	0.19 ± 0.06	0.18 ± 0.04
Fiber	4.37 ± 0.15	6.10 ± 0.18	5.64 ± 0.16
Humidity	86.48 ± 0.01	85.76 ± 0.02	86.51 ± 0.03
Ashes	0.74 ± 0.01	1.66 ± 0.12	1.08 ± 0.04

last until June

Another possible explanation of why there is not Mexican Fruit Fly in Pitaya de Mayo could be related to the nutritional benefits of the products. As mention before, attacked species are One of the fruits where *Anastrepha ludens*, mango, has been said 71% for Ataulfo variety [36]. Of course, this might change between cultivars; however, this is one of the sweetest varieties. Table 3 presents the nutritional values of the three more common varieties of Pitaya cultivated in Oaxaca obtained by US.

8. Conclusion

Based on the results that we have found after this review, we can conclude that pitaya de mayo exportation is feasible, starting by the United States of America, the primary consumer. One of the exportation requirements is that pitayas must be irradiated treatment before being exported to the U.S.A. Their orchards are free from Mexican fruit fly contamination and certified by the Food National Sanitary, Iniquity, and Quality Service. This fruit is not attacked by the Mexican fruit fly *A. ludens* nor any other *Anastrepha* species. Therefore, it is possible to achieve the orchards' certification based on this review results. Undoubtedly the fruit fly may be found in some States of Mexican Republic such as some tropical

regions of Puebla and Oaxaca but not in the semi-arid regions where cacti fruits are grown. Our data help us to suggest to void the requirement of be irradiated to the pitaya from the Mixteca region facilitating the exportation procedure.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Martínez, J., *et al.* (2010) Principales cultivares de Pitaya en Puebla y Oaxaca. Inifap. Sagarpa. Snics. Sinarefi. https://www.gob.mx/cms/uploads/attachment/file/168840/Cultivares_de_Pitaya_en_Puebla_y_Oaxaca.pdf

[2] Smith, D. and Peña, J.E. (2002) Tropical Citrus Pests. In: Peña, J.E., Sharp, J.L. and Wysoki, M., Eds., *Tropical Fruit Pests an Pollinators*, CABI, London, 430 p. https://doi.org/10.1079/9780851994345.0057

[3] Rodríguez, C. (2019) La mosca mexicana de la fruta, plaga que ocasiona daños y pérdidas económicas a productores. De Reporteros. http://dereporteros.com/2019/01/28/la-mosca-mexicana-la-fruta-plaga-ocasiona-danos-perdidas-economicas-productores

[4] Weems H.V., Heppner, J.B., Steck, G.J., Fasulo, T.R. and Nation, J.L. (2001) Mexican Fruit Fly *Anastrepha ludens* (Loew) (Diptera: Tephritidae). Entomology Circular No. 16. EENY-201. Florida Department of Agriculture and Consumer Services, Division of Plant Industry. 5 p.

[5] Baker, A.C., Stone, W.E., Plummer, C.C. and McPhail, M. (1944) A Review of Studies on the Mexican Fruit Fly and Related Mexican Species. U.S.D.A. Miscellaneous Publication No. 531, 155 p.

[6] NOM-023-FITO-1995 (Norma Oficial Mexicana). Por la que se establece la Campaña Nacional contra Moscas de la Fruta. Secretaria de Agricultura, Ganadería y Desarrollo Rural. DOF (Oficial Federación Daily, Published on February 11, 1999).

[7] SENASICA (Servicio Nacional de Seguridad Inocuidad y Calidad Alimentaria Alimentaria), Lineamientos para la Exportación de Productos con Tratamiento de Irradiación, SAGARPA, Mexico, 2015. https://www.gob.mx/cms/uploads/attachment/file/167283/Lineamientos_para_la_Exportaci_n_de_Productos_con_Tratamiento_de_Irradiaci_n.pdf

[8] Molina-Nery, M.C., Ruiz-Montoya, L., Zepeda-Cisneros, C.S. and Liedo, P. (2014) Genetic Structure of Populations of *Anastrepha ludens* (Diptera: Tephritidae) in Mexico. *Florida Entomologist*, **97**, 1648-1661. https://doi.org/10.1653/024.097.0439

[9] Penelo, L. (2018) Pitaya: Propiedades, beneficios y valor nutricional. La Vanguardia, 2018. https://www.lavanguardia.com/comer/materia-prima/20180720/45956036053/pitaya-fruta-propiedades-beneficios-valor-nutricional.html#:~:text=Tiene%20forma%20ovalada%2C%20con%20espinas,es%20muy%20dulce%20y%20agradable

[10] Berrones-Morales, M., Vanoye-Eligio, V., Coronado-Blanco, J.M., Gaona-García, G. and Sanchez Ramos, G. (2020) Species Diversity of Fruit Flies (Diptera: Tephritidae) through Different Ecosystem in a Neotropical Transition Zone in Mexico. *Journal of Insect Conservation*, **24**, 219-231. https://doi.org/10.1007/s10841-019-00192-4

[11] Berrones-Morales, M., Vanoye-Eligio, V., Coronado-Blanco, J.M., Gaona García, G.

and Sánchez Ramos, G. (2021) Natural Parasitismon *Anastrepha* spp (Diptera: Tephritidae) over Neotopical Region Boundaries in Northeastern Mexico. *Biocontrol Science and Technology*, **31**, 65-79. https://doi.org/10.1080/09583157.2020.1830029

[12] Loera Gallardo, J. (2017) Ficha Técnica: Mosca mexicana de la fruta *Anastrepha ludens* (Loew). Sagarpa. Senasica. México. https://www.gob.mx/cms/uploads/attachment/file/249395/Anastrepha_ludens_Loew.pdf

[13] Hernández-Ortiz, V. (1992) El género *Anastrepha* Schiner en México (Diptera: Tephritidae), Taxonomía, distribución y sus plantas huéspedes. Instituto de Ecología, Xalapa México.

[14] Carroll, L.E. and Wharton, R.A. (1989) Morphology of the Immature Stages of *Anastrepha ludens* (Diptera: Tephritidae). *Annals of Entomological. Society of America*, **82**, 201-214. https://doi.org/10.1093/aesa/82.2.201

[15] Aluja, S.M. (1993) Manejo integrado de la mosca de la fruta. Trillas, México.

[16] Greene, C.T. (1929) Characters of the Larvae and Pupae of Certain Fruit Flies. *Journal of Agricultural Research*, **38**, 489-504.

[17] Aluja, M. (1994) Bionomics and Management of Anastrepha. *Annual Review of Entomology*, **39**, 155-178. https://doi.org/10.1146/annurev.en.39.010194.001103

[18] Salas, B., Conway, H.E., Shuenzel, E.L., Hoppestard, K., Vitek, C. and Vaceck, D.C. (2017) *Morganella morganii* (Enterobacteriales: Enterobacteriaceae) Is a Lethal Pathogen of Mexican Fruit Fly (Diptera: Tephritidae) Larvae. *Florida Entomologist*, **100**, 743-751. https://doi.org/10.1653/024.100.0422

[19] Ruiz-May, E., Altuzar-Molina, A., Elizalde-Contreras, J.M., Arellano de ls Santos, J., Monribot-Villanueva, J., Guillen, L., Vázquez-Rosa-Landa, M., Ibarra-Laclette, E., Ramírez-Vazquez, M., Ortega, R. and Aluja, M. (2020) A First Glimpse of the Mexican Fruit Fly *Anastrepha ludens* (Diptera Tephritidae) Antena Morphology and Proteomein Response to Proteinaceous Attractant. *International Journal of Molecular Sciences*, **2**, 1-26. https://doi.org/10.3390/ijms21218086

[20] Toledo-Hernández, R.A., Toledo, J., Valle-Mora, J., Holguin-Meléndez, F., Liedo, P. and Huerta-Palacios, G. (2019) Pathogenicity and Virulence of *Purpureocillium lilacinum* K (Hypocreales: Ophiocordycipitaceae) on Mexican Fruit Fly. *Florida Entomologist*, **102**, 309-314. https://doi.org/10.1653/024.102.0204

[21] Ayala, A., Pérez-Lachaud, G., Toledo, J., Liedo, P. and Montoya, P. (2018) Hot Acceptance by Three Native Braconid Parasitoids Species Attacking Larvae of the Mexican Fruit Fly *Anastrepha ludens* (Diptera, Tephritidae). *Journal of Hymenoptera Research*, **63**, 33-49. https://doi.org/10.3897/jhr.63.23724

[22] Lasa, R., Ortega, R. and Rull, J. (2013) Towards Development of a Mass Trapping Device for Mexican Fruit Fly *Anastrepha ludens* (Diptera: Tephritidae) Control. *Florida Entomologist*, **96**, 1135-1142.

[23] SAGARPA (2015) Manejo Integrado de Mosca de la Fruta. Guía del Productor. Campaña Nacional Contra Moscas de la Fruta. http://cesavem.mx/img/MoscasdelaFruta/moscasdelafruta.pdf

[24] Bush, G.L. (1962) The Cytotaxonomy of the Larvae of Some Mexican Fruit Flies in the Genus Anastrepha (Tephritidae, Diptera). *Psyche*: *A Journal of Entomology*, **69**, 87-101. https://doi.org/10.1155/1962/20495

[25] Plummer, C.C., McPhail, M. and Monk, J.W. (1941) The Yellow Chapote, a Native Host of the Mexican Fruit Fly. U.S.D.A. Technical Bulletin No. 775.

[26] Hernández-Ortiz, V. (2007) Diversidad y biogeografía del género Anastrepha en Mé-

xico. In: Hernandez-Ortiz, V., Ed., *Moscas de la fruta en Latinoamérica* (*Diptera*: *Tephritidae*): *Diversidad*, *Biología y Manejo*, S y G editores, Distrito Federal, México, 167 p.

[27] Aluja, M.R., Guillen-Aguilar, J., de la Rosa, G., Cabrera, M., Celedonio-Hurtado, H., Liedo, P.F. and Hendrichs, J. (1987) Natural Host Plant Survey of the Economically Important Fruit Flies (Diptera: Tephritidae) of Chiapas, Mexico. *Florida Entomologist*, **70**, 329-338. https://doi.org/10.2307/3495066

[28] Aluja, M. and Martinez, E.I. (1984) Manejo integrado de las moscas de las frutas (Diptera: Tephritidae). Mexico, SARH, D.G.S.V. Programa Mosca del Mediterráneo. Mexico.

[29] McPhail, M. and Bliss, C.I. (1933) Observations on the Mexican Fruit Fly and Some Related Species in Cuernavaca, Mexico, in 1928 and 1929. U.S.D.A. Circular No. 255.

[30] Auja, S.M., Cabrera, M., Guilen, J., Cledonio, H. and Azora, I. (1989) Behavior of *Anastrepha ludens* and *A. serpentia* (Diptera Tephritidae) on Wild Mango Tree (*Mangifera indica*) Harbouring Three McPhail Traps. *Insect Science and Its Applications*, **10**, 309-318. https://doi.org/10.1017/S1742758400003544

[31] Herrera, A.L., Rangel, A.F. and de la Barreda, L. (1900) El gusano de la fruta (Instrypetas ludens I. D. E.). Boletín de la Comisión de Parasitología Agrícola No. 1, 1-28.

[32] Stone, A. (1942) The Fruit Flies of the Genus *Anastrepha*. United States Department of Agriculture, Miscellaneous Publication No. 439, 1-112.

[33] Thomas, D. (2004) Hot Peppers as a Host for the Mexican Fruit Fly *Anastrepha ludens* (Diptera: Tephritidae). *Florida Entomologist*, **87**, 603-608. https://journals.flvc.org/flaent/article/view/75367/73025 https://doi.org/10.1653/0015-4040(2004)087[0603:HPAAHF]2.0.CO;2

[34] Bravo-Holis, H. (1978) Las cactáceas de México Volume 1. UNAM (National Autonomous University of Mexico), Mexico.

[35] Torres-Caballero, M. (2017) Efecto del tamaño de la rama y orientación de la aréola en la producción de frutos de pitaya de mayo *Stenocereus pruinosus* (Cactaceae). M.Sc. Thesis, Metropolitan Autonomous University, Mexico City. http://tesiuami.izt.uam.mx/uam/aspuam/presentatesis.php?recno=17853&docs=UAMI17853.pdf

[36] Velez de la Rosa, R., Baldenebro, O.K., Sañudo, B.A. and Vergara-Jimenez, M. (2021) Fully Ripe Ataulfo Mango (*Mangifera indica*) Peel, Pulp and Isolated Fiber. Sources of Bioactive Component against Methabolic Syndrome. *Food Science and Nutrition*, **5**, 611. https://doi.org/10.1093/cdn/nzab044_042