



NEW RECORDS OF THE GENUS *ANASTREPHA* SCHINER, 1868 (DIPTERA: TEPHRITIDAE) IN THE ISTHMUS OF TEHUANTEPEC, OAXACA, MEXICO

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ABSTRACT

Five species of the genus *Anastrepha* Schiner are reported for the first time from the region of the Isthmus of Tehuantepec, Oaxaca. *A. bezzii* Lima, *A. minuta* Stone, *A. tumida* Stone, *A. furcata* Lima and *A. sp.* new species, of which last two are new records for Mexico. Some taxonomic aspects are discussed, as well as the relationship of the ecosystems present in the Isthmus of Tehuantepec with the vegetal communities of the Southern Hemisphere, possible diversification patterns of the species present in this region and their relationship with their congeners of Central and South America. With these new reports the number of *Anastrepha* species recorded in this state increased to 27.

Key words: Chimalapas, diversity, ecology, fruit flies, Oaxaca, taxonomy.

RESUMEN

Se reportan por primera ocasión cinco especies del género *Anastrepha* procedentes de la región del istmo de Tehuantepec, Oaxaca. *A. bezzii* Lima, *A. minuta* Stone, *A. tumida* Stone, *A. furcata* Lima y *A. sp.* nueva especie, de las cuales, las últimas dos representan nuevos registros para México. Se discuten algunos aspectos taxonómicos, así como la relación de los ecosistemas presentes en el istmo de Tehuantepec con las comunidades vegetales del hemisferio sur, los posibles patrones de diversificación de las especies presentes en esta región y su relación con sus congéneres de Centro y Sudamérica. Con estos nuevos reportes el número de especies registradas en este estado se incrementa a 27.

Palabras clave: Chimalapas, diversidad, ecología, moscas de la fruta, Oaxaca, taxonomía.

INTRODUCTION

The genus *Anastrepha* represents a group of fruit flies endemic to the new world, which currently includes 296 species recognized, with some more to describe and many to discover (Antonio-Hernández and García-Ramírez, in prep.), this genus is widely distributed in most of the continent, with greater presence in tropical and subtropical areas. According to Malavasi (2009), no species of this genus can be considered invasive of areas, due to all species are established within their probable area of origin. Most of the species attack only wild fruits of little economic importance, while others infest cultivated varieties, affecting fruit export programs, and are directly responsible for a considerable number of quarantine restrictions imposed by importing countries, causing a detriment in the economy of the producing countries (Antonio-Hernández and García-Ramírez, 2017).

MATERIALS AND METHODS

Study area

The present study was made from the review of specimens of the genus *Anastrepha* collected by the senior author and Alina Antonio-Ramos in activities periodic of trapping using Multilure® traps baited with hydrolyzed protein, in various localities associated with the tropical rainforest in Cerro Azul area and El Corte river, in the municipality of Santa Maria Chimalapas in the Isthmus of Tehuantepec, Oaxaca (Fig. 1).

Material examined

The examined material was preserved in vials with alcohol denatured at 70%, labeled with the information of provenance and identification of the specimens (species, place of collection, name of the collector, date of collection, number and sex of the specimens, geographical coordinates, altitude, type of vegetation and method of collection), using the techniques described by Márquez (2005).

Georeferencing

The geographical coordinates of collection sites of fruit flies were taken with a Magellan eXplorist 610® team and transferred in topographic plans of INEGI (1985, 1987, 1988, 1994, 2000), of the region of the Isthmus of Tehuantepec, scales 1:50 000 with the purpose of having a geographic database of the distribution areas of the various species of *Anastrepha*.

Institutions

The acronyms used in this work correspond to the institutions in which the specimens of *Anastrepha* were deposited after their study. IEXA: Entomological Collection of the Instituto de Ecología, A.C., Xalapa, Veracruz., México; USNM: National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA; and the various structures of the specimens were examined and photographed in CNRF-DGSV: Laboratory of Entomology and Acarology of the Centro Nacional de Referencia Fitosanitaria, Dirección General de Sanidad Vegetal, SENASICA-SAGARPA, Tecámac, Estado de México and ESCA-UAC: Laboratory of Entomology of the Escuela Superior de Ciencias Agropecuarias Campus IV, Universidad Autónoma de Campeche, in Escárcega, Campeche.

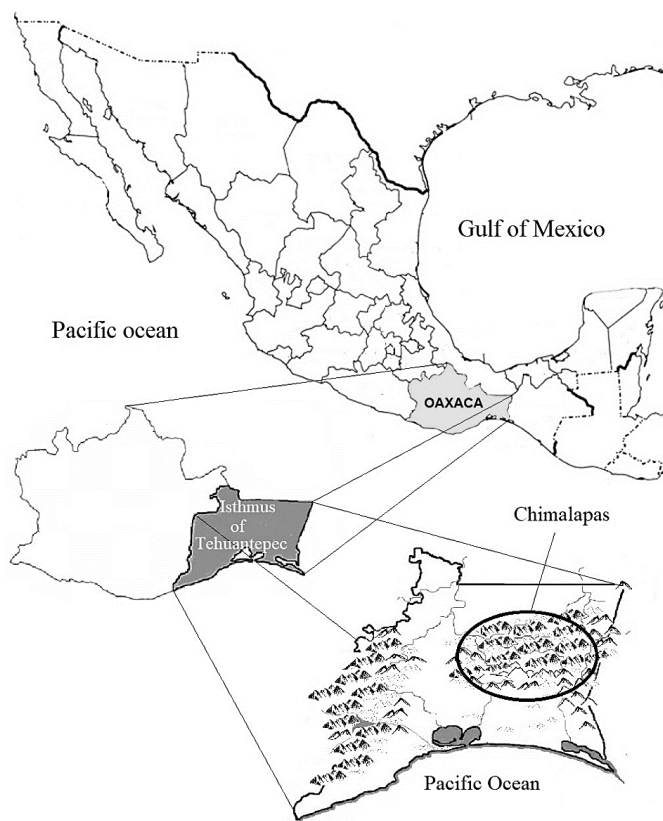


Fig. 1. Los Chimalapas, geographic location in the Isthmus of Tehuantepec.

Fruit flies identification

The specimens were examined and determined by Enrique Antonio-Hernández and María de Jesús García-Ramírez.

Images capture and editing

Photographs of the structures of the various *Anastrepha* species were taken in the CNRF-DGSV, with a digital camera Nikon® DXM1200 coupled to a stereoscopic microscope Nikon ECLIPSE® SMZ800 and a compound microscope Nikon ECLIPSE® E400. The general illustrations of

each species in dorsal view represent composite digital photographs, which were made by integrating various images of the structures of each species using Paint Microsoft®.

RESULTS

Five new records of the genus *Anastrepha* were identified for the state of Oaxaca, four of which belong to three groups (*fraterculus*, *robusta*, *mucronota*) besides a species without specific group. Of the five new records, two correspond to new reports for Mexico, including a new species for science. The species reported for the first time are *A. bezzii* Lima, *A. furcata* Lima, *A. minuta* Stone, *A. tumida* Stone and *A. sp.* new species belonging to the *fraterculus* group.

1. *Anastrepha bezzii* Lima, 1934 (Fig. 2).

Examined material: (2♀, 5♂ IEXA) El Corte Chimalapa river, 21-XII-2006, 185 meters above sea level (masl), 16°55'21.3"N 94°34'45.2"O, E. Antonio-Hernández coll.

Distribution in Mexico: Chiapas, Oaxaca.

Continental distribution: Brazil, El Salvador, Guatemala, Mexico, Panama, Venezuela (Norrbom, 1991); Bolivia, Colombia (Rodríguez et al., 2018); Costa Rica (Jirón et al., 1988); Nicaragua (Niklaus-Ruiz and Basedow, 1997); Peru (Korytkowski and Ojeda, 1968).

Habitat: Tropical rainforest.

2. *Anastrepha furcata* Lima, 1934 (Fig. 3).

Examined material: (1♂ IEXA) Cerro Azul Chimalapa, 25-X-2002, 348 masl, 16°51'47.7"N 94°43'39.9"O, E. Antonio-Hernández coll; (1♀ IEXA) Rancho "El Zacatal" Chimalapa, 19-VIII-2007, 226 masl, 16°51'14.7"N 94°44'34.3"O, E. Antonio-Hernández coll; (2♂♂ IEXA) Cerro Azul Chimalapa, 17-VII-2007, 345 masl, 16°51'41.3"N 94°43'39.6"O, E. Antonio-Hernández coll; (1♀ IEXA) Rancho "El Zacatal" Chimalapa, 19-VIII-2007, 226 masl, 16°51'14.7"N 94°44'34.3"O, E. Antonio-Hernández coll; (1♀ IEXA) Cerro Azul Chimalapa, 15-VI-2008, 344 masl, 16°51'40.4"N 94°43'45.5"O, E. Antonio-Hernández coll; (1♂ IEXA) Cerro Azul Chimalapa, 15-VII-2008, 348 masl, 16°51'47.7"N 94°43'39.9"O, E. Antonio-Hernández coll; (1♀, 1♂ IEXA) Rancho "El Zacatal" Chimalapa, 15-VI-2008, 226 masl, 16°51'14.7"N 94°44'34.3"O, E. Antonio-Hernández coll; (1♀, 1♂ IEXA) Rancho "El Zacatal" Chimalapa, 06-VII-2008, 226 masl, 16°51'14.7"N 94°44'34.3"O, E. Antonio-Hernández coll; (1♀ USNM) Cerro Azul Chimalapa, 17-VI-2013, 341 masl, 16°51'40.7"N 94°43'44.6"O, E. Antonio-Hernández and A. Antonio-Ramos colls.

Distribution in Mexico: Oaxaca.

Continental distribution: Brazil, French Guiana, Panama (Norrbom et al., 1998); Colombia (Rodríguez et al., 2018); Peru (Mengual et al., 2017); Mexico (New record, in this paper).

Habitat: Tropical rainforest.

3. *Anastrepha minuta* Stone, 1942 (Fig. 4).

Examined material: (1♀ IEXA) Rancho "El Zacatal" Chimalapa, 25-VII-2007, 226 masl, 16°51'14.7"N 94°44'34.3"O, E. Antonio-Hernández coll; (1♀ IEXA) Rancho "El Zacatal" Chimalapa, 15-VI-2008, 226 masl, 16°51'14.7"N 94°44'34.3"O, E. Antonio-Hernández coll; (3♀♀ IEXA) Rancho "El Zacatal" Chimalapa, 06-VII-2008, 226 masl, 16°51'14.7"N 94°44'34.3"O, E. Antonio-Hernández coll; (1♀, 1♂ USNM) Cerro Azul Chimalapa, 27-VI-2013, 348 masl, 16°51'47.7"N 94°43'39.9"O, E. Antonio-Hernández and A. Antonio-Ramos colls.

Distribution in Mexico: Oaxaca, Veracruz.

Continental Distribution: Mexico (Hernández-Ortiz and Pérez-Alonso, 1993); Guatemala, Panama, Venezuela (Norrbom et al., 1998); Bolivia, Colombia (Rodríguez et al., 2018).

Habitat: Tropical rainforest.

4. *Anastrepha tumida* Stone, 1942 (Fig. 5).

Examined material: (1♀USNM) Rancho “El Zacatal” Chimalapa, 24-VII-2013, 226 masl, 16°51'41.3"N 94°44'34.3"O, E. Antonio-Hernández and A. Antonio-Ramos colls.

Distribution in Mexico: Chiapas, Oaxaca.

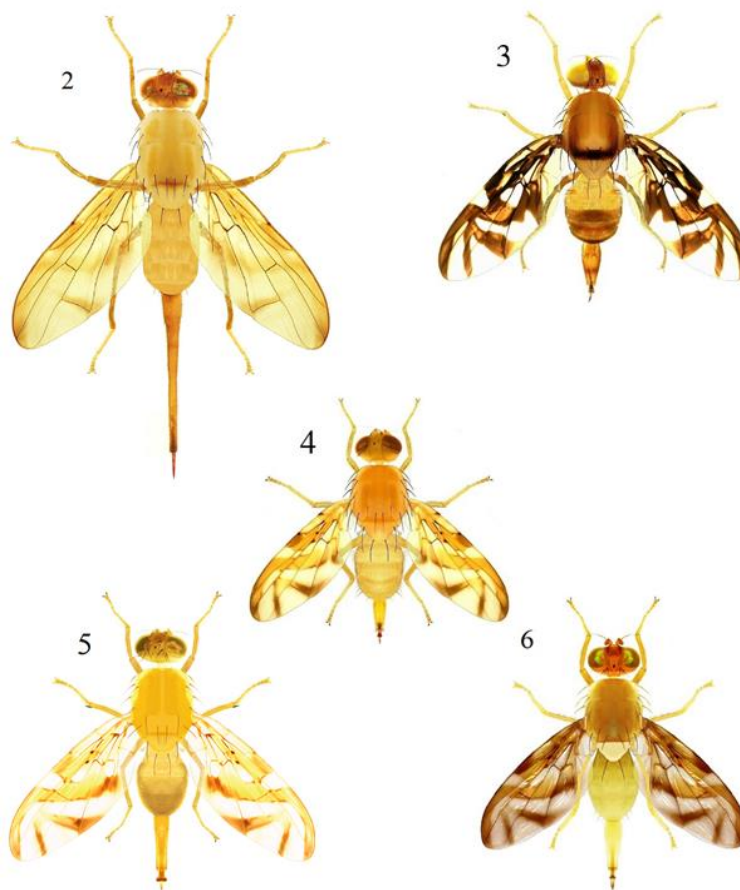
Continental distribution: Brasil (Uramoto et al., 1998); Colombia, Costa Rica, Ecuador, Mexico, Panama (Norrbom et al., 1998); Nicaragua (Niklaus-Ruiz and Basedow, 1997); Peru (Mengual et al., 2017).

Habitat: Tropical rainforest.

5. *Anastrepha* sp. new species, *fraterculus* group (Fig. 6).

Examined material: (2♀♀ IEXA) Arroyo Carrizal Chimalapa, 01-XI-2001, 241 masl, 16°46'50.6"N 94°09'29.0"O, E. Antonio-Hernández coll; (2♀♀IEXA) Rancho “El Zacatal” Chimalapa, 15-XI-2001, 226 masl, 16°51'14.7"N 94°44'34.3"O, E. Antonio-Hernández coll; (1♀IEXA) Arroyo Carrizal Chimalapa, 29-XI-2001, 241 masl, 16°46'50.6"N 94°49'29.0"O, E. Antonio-Hernández coll; (1♀IEXA) Arroyo Concha Chimalapa [Rancho San Antonio], 29-XI-2001, 233 masl, 16°49'24.9"N 94°47'04.2"O, E. Antonio-Hernández coll; (2♀♀IEXA) Arroyo Pita Chimalapa, 29-XI-2001, 230 masl, 16°49'48.9"N 94°45'44.5"O, E. Antonio-Hernández coll; (1♀USNM) Arroyo Carrizal Chimalapa, 23-VIII-2005, 247 masl, 16°46'51.5"N 94°49'30.2"O, E. Antonio-Hernández coll.

Distribution in Mexico: So far, the knowledge of the distribution of this species is only restricted to the tropical rainforest in Los Chimalapas, Oaxaca.



Figs. 2-6. New records of the genus *Anastrepha* in Oaxaca, dorsal view. 2) *A. bezzii* Lima; 3) *A. furcata* Lima; 4) *A. minuta* Stone; 5) *A. tumida* Stone; 6) *A. sp.* new species, *fraterculus* group.

DISCUSSION

It is evident that the five species mentioned in this paper have as typical habitat ecosystems associated with the tropical rainforest, and in some cases, the Isthmus of Tehuantepec is probably the northern limit of distribution on the continent of some *Anastrepha* species (e.g., *A. bezzii*, *A. furcata* and *A. tumida*), considering this is a region with a privileged geographical location, by virtue of it is located practically in the contact zone of the Neotropical and Nearctic biogeographic kingdoms (Pérez-García et al., 2001), and some physiographic subregions that integrate this region has great affinity with the ecosystems of Central and South America.

The tropical rainforests of southern Mexico (e.g., Los Tuxtlas in Veracruz, Los Chimalapas in Oaxaca and Lacandona in Chiapas) share in common some species that present a preferential distribution to South America (e.g., *A. bahiensis*, *A. cordata*, *A. crebra*, *A. minuta*, *A. tumida*) considering these ecosystems presented until a century ago a continuous distribution from the southeast of San Luis Potosí and north of Veracruz to the north and northeast of Chiapas (Rzedowski, 2006), which favored the dispersive displacement of these species. However, human dispersion in second half of the XIX and the first of the XX century, when the populations began to gradually expand to colonize the possible habitable regions in Mexico and the rest of the continent, as well as the alteration of ecosystems for agricultural purposes was a determining factor in the fragmentation of these forests, which led in different areas of the continent the formation of "ecological islands" represented in the current rainforests and which in turn in Mexico resulted in the isolation of various species of *Anastrepha* in the rainforests of the region of isthmus of Tehuantepec and other tropical forests of the country.

Some species associated with humid ecosystems of the tropical rainforests in Los Chimalapas (e.g., *A. bahiensis*, *A. bezzii*, *A. canalis*, *A. compressa*, *A. crebra*, *A. furcata*, *A. minuta*, *A. tumida* and *A. zuelaniae*) have a relatively wide distribution, due to all these species are found from the Isthmus of Tehuantepec to Panama, even *A. minuta* is distributed to Venezuela (Morales and González, 2007), and others, such as *A. bahiensis*, *A. bezzii*, *A. furcata* and *A. tumida*, present a distribution that extends to Brazil (Zucchi, 2008). These species, which generally present a predominant distribution to the south of the continent, were confined to these "ecological islands" in which them found the optimal elements for their subsistence and diversification, and the absence of some of them in intermediate areas between Mexico and South America, is due to elements which are directly related to the fragmentation and alteration of the ecosystems due to human activities.

Anastrepha bezzii it is a species belonging to the mucronota group (Norrbon, 1991), the specimens examined by the authors were collected in an ecosystem belonging to the tropical rainforest in the vicinity of the El Corte river in Los Chimalapas, its distribution in the Isthmus of Tehuantepec is closely related to humid ecosystems, although the constant deforestation of tropical forests in this region may be the cause of rare species such as *A. bezzii*, *A. barnesi*, *A. minuta* and *A. tumida* reduce their distribution areas or disappear from these ecosystems, within which it is probable that only their host plants are found. The discovery of this species in Los Chimalapas extends the knowledge of its distribution in approximately 300 kilometers to the northwest of the continent, due the only previous record in the country came from the Soconusco region in the state of Chiapas as *A. balloui* Stone (Aluja et al., 1987).

Anastrepha furcata along with *A. robusta* Greene and *A. cordata* Aldrich represent the three members of the robusta group in Mexico, the state of Oaxaca is to date the only place in the country where the three species have been reported jointly. The examined specimens in this work are

conspecific with specimens from Panama (subscutellum with dark brown dorsolateral mark), however it differs from Brazilian specimens, these last do not present dark brown mark in subscutellum according to Norrbom and Korytkowski (2009). The discovery of this species in the Isthmus of Tehuantepec represents the first record for Mexico, which extends the knowledge of its distribution in approximately 1600 kilometers to the northwest of the continent, previously the northernmost register for this species came from the province of Chiriqui, Panama (Norrbom and Korytkowski, 2009) and probably the Isthmus of Tehuantepec is the boreal end of its distribution on the continent, due to in ancient times, the humid rainforests of America were distributed continuously from Mexico to South America, and several species of *Anastrepha* and others genus of fruit flies found the optimal conditions for their dispersal to the Mesoamerican tropical rainforests. However, when these ecosystems were fragmented due to human actions, these taxa were isolated in these humid forests.

Anastrepha minuta it is a rare and little-known species in Mexico, associated with humid ecosystems characteristic of the tropical rainforests, its presence in Los Chimalapas coincides with the rainy season of summer, mainly during the months of June and July. The few known specimens in the collections of Mexico come from the humid ecosystems of Los Tuxtlas, Veracruz (Hernández-Ortiz and Perez-Alonso, 1993) and Los Chimalapas, Oaxaca.

Anastrepha tumida is a rare species not assigned to any group, by virtue of their phylogenetic relationships unknown, few specimens of this species are known in Mexican collections, in the country the only previous report to this paper came from the Chajul reserve, in Montes Azules, in the state of Chiapas (Hernández-Ortiz, 1992), is undoubtedly a species closely related with humid ecosystems, its presence in Los Chimalapas extends the range of its distribution approximately 400 kilometers to the westward of the continent.

Anastrepha sp. this new species is placed within the fraterculus group in consideration of two of the three characters mentioned by Norrbom et al., (1999). 1.- subscutellum and/or mediotergite with dark lateral spots, and sometimes a spot in the scutoscuteellar suture (this last aspect is absent in this species). 2.- tip of the aculeus partially serrated and frequently with a constriction in the base of the sawn part. In the Steyskal's key (1977), this species runs to *Anastrepha obliqua* (Macquart), however, the size of the specimens and the length of the ov scape is greater than in *A. obliqua*, in addition, the shape of aculeus tip is acute nevertheless differs from *A. obliqua* in the serrations number (19-22 vs 9-12), aculeus length (2.2-2.4 vs 1.3-1.6) and shape of serrations (semi acute or slightly rounded vs totally acute in *A. obliqua*). It is interesting to mention that this species brings together the three cases of ecological oddities mentioned by Halffter and Ezcurra (1992), because it has only been found in Los Chimalapas (biogeographical rarity), its habitat is restricted to the humid tropical forest (habitat rarity) and in addition, only nine female specimens have been collected in little more than 20 years of systematic collections of fruit flies carried out by the senior author (demographic rarity) and the fact of being a new species for science it makes it exceptionally interesting.

Including the results of this paper, 27 species of the genus *Anastrepha* are reported for the state of Oaxaca: *A. acris* Stone, *A. alveata* Stone, *A. barnesi* Aldrich, *A. chichlayae* Greene, *A. distincta* Greene, *A. fraterculus* (Wiedemann), *A. leptozona* Hendel, *A. ludens* (Loew), *A. montei* Lima, *A. obliqua* (Macquart), *A. pallens* Coquillett, *A. robusta* Greene, *A. serpentina* (Wiedemann), *A. spatulata* Stone, *A. striata* Schiner (Hernández-Ortiz, 1992); *A. cordata* Aldrich (Hernández-Ortiz, 1999) without specifying the location; *A. bahiensis* Lima, *A. bicolor* (Stone), *A. canalis* Stone, *A. compressa* Stone, *A. crebra* Stone y *A. zuelaniae* Stone, in addition to *A. sp.*, (Antonio-Hernández, 2006), the latter turned

out to be a new species of the fraterculus group, which is mentioned in this paper; *A. bezzii* Lima, *A. furcata* Lima, *A. minuta* Stone and *A. tumida* Stone (in this paper). Except for *A. cordata*, the rest of the species have been recorded in the Isthmus of Tehuantepec.

Due to its rugged topography, variation of climates, as well as the ecological and orographic conditions, the Isthmus of Tehuantepec represents an area of extraordinary biological richness, due to the fact that this narrow strip of 215 kilometers wide (Coatzacoalcos, Veracruz-Puerto Estero, San Francisco del Mar, Oaxaca), located in the south of Mexico represents an important biological corridor for a great diversity of species of fruit flies of different genus.

This region is at the same time the only natural bridge that unites the dry forests, sub-humids forests and rainforests of Mexico, located between the Pacific and Atlantic Oceans, all these elements, make it is possible that taxa of Mesoamerican and South American origin coexist here, from humid tropical forests and dry forests, from warm environments located practically at sea level to temperate ecosystems at more than 1000 masl (Antonio-Hernández and García-Ramírez, 2018). Due to the conditions mentioned above, in this region there is an extraordinary diversity of fruit flies of the genus *Anastrepha*, not known elsewhere in Mexico.

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REFERENCES

1. Aluja M., M. Cabrera, E. Ríos, J. Guillén, H. Celedonio, J. Hendrichs y P. Liedo, 1987. A survey of the economically important fruit flies (Diptera: Tephritidae) present in Chiapas and few other fruit growing regions in México. *Florida Entomologist*, 70(3): 320-329. DOI: 10.2307 / 3495065.
2. Antonio-Hernández E., 2006. Determinación de especies de moscas de la fruta del género *Anastrepha* Schiner (Diptera: Tephritidae) mediante trampeo y muestreo en cuatro areas del istmo de Tehuantepec, Oaxaca (Tesis Profesional, Instituto Tecnológico de Comitancillo).
3. Antonio-Hernández E. y M.J. García-Ramírez, 2017. Primer registro de *Anastrepha canalis* Stone, 1942 (Diptera: Tephritidae) en *Turpinia occidentalis* (Sw.) G. Don, 1832 (Staphyleaceae) en México. *Entomología Mexicana*, 4: 487-490.
4. Antonio-Hernández E. y M.J. García-Ramírez, 2018. Diversity of fruit flies of the genus *Anastrepha* Schiner (Diptera: Tephritidae) in the isthmus of Tehuantepec, Oaxaca, Mexico. In 10th International Symposium of Fruit Flies of Economic Importance 2018. Tapachula, Chiapas, México.
5. Antonio-Hernández E. y M.J. García-Ramírez. El género *Anastrepha* Schiner (Diptera: Tephritidae) y su diversidad en el istmo de Tehuantepec, Oaxaca (En preparación).

6. Halffter G. y E. Ezcurra, 1992. ¿Que es la biodiversidad? En: G. Halffter (Comp.), La diversidad biológica de Iberoamérica I. (Gonzalo Halffter comp.). Acta Zoológica Mexicana, Nueva Serie, volumen especial 1992. DOI: <https://doi.org/10.1017/S0266467400008051>
7. Hernández-Ortiz V., 1992. El género *Anastrepha* Schiner en México (Diptera: Tephritidae) taxonomía, distribución y sus plantas huéspedes. Instituto de Ecología, Xalapa, Veracruz.
8. Hernández-Ortiz V., 1999. Diptera. En: Deloya A.C.L. y J.E.G. Valenzuela (Eds.), Catálogo de insectos y ácaros plaga de los cultivos agrícolas de México. Sociedad Mexicana de Entomología, publicaciones especiales, México.
9. Hernández-Ortiz V. y R. Pérez-Alonso, 1993. The natural host plants of *Anastrepha* (Diptera: Tephritidae) in a tropical rain forest of México. Florida Entomologist, 76: 447-460. DOI: 10.2307/3495645
10. Korytkowski C. y D. Ojeda, 1968. Especies del género *Anastrepha* Schiner, 1868 en el Noroeste Peruano. Revista Peruana de Entomología, 11: 32-70.
11. INEGI (Instituto Nacional de Estadística Geografía e Informática). 1985. Carta topográfica Santo Domingo, Esc. 1: 50,000 E15C64 Oaxaca.
12. INEGI (Instituto Nacional de Estadística Geografía e Informática). 1987. Carta topográfica Niltepec, Esc 1: 50,000 E15C65 Oaxaca.
13. INEGI (Instituto Nacional de Estadística Geografía e Informática). 1988. Carta topográfica Guivicia, Esc. 1: 50,000 E15C54 Oaxaca.
14. INEGI (Instituto Nacional de Estadística Geografía e Informática). 1994. Carta topográfica Benito Juárez, Esc. 1:50,000 E15C66 Oaxaca.
15. INEGI (Instituto Nacional de Estadística Geografía e Informática). 2000. Carta topográfica Matías Romero, Esc. 1:50,000 E15C53 Oaxaca.
16. Jirón L.F., J. Soto-Manitui y A.L. Norrbom, 1988. A preliminary list of the fruit flies of the genus *Anastrepha* (Diptera: Tephritidae) in Costa Rica. Florida Entomologist, 71(2): 130-137. DOI: 10.2307/3495360
17. Malavasi A. 2009. Biología, ciclo de vida, relação com o hospedeiro, espécies importantes e biogeografía de tefritídeos. Em: Malavasi A y J. Virgínio (Eds.), Biología, monitoramento e controle de moscas-das-frutas: V curso internacional de capacitação em moscas-das-frutas, 21 a 29 de outubro de 2009. Biofábrica Moscamed Brasil, Juazeiro, Bahia, Brazil.
18. Márquez J., 2005. Técnicas de colecta y preservación de insectos. Boletín Sociedad Entomológica Aragonesa, 37: 385-408.
19. Mengual X., P. Kerr, A.L. Norrbom, N.B. Barr, M.L. Lewis, A.M. Stapelfeldt, S.J. Scheffer, P. Woods, M.S. Islam, C.A. Korytkowski, K. Uramoto, E.J. Rodriguez, D.B. Sutton, N. Nolasco, G.J. Steck y S. Gaimari, 2017. Phylogenetic relationships of the tribe Toxotrypanini (Diptera: Tephritidae) based on molecular characters. Molecular Phylogenetics and Evolution, 113: 84-112. DOI: <https://doi.org/10.1016/j.ympev.2017.05.011>

20. Morales P. y E. González, 2007. El género *Anastrepha* Schiner y su importancia económica en frutales de Venezuela. En: V. Hernández-Ortiz (Ed.), Moscas de la fruta en Latinoamérica (Diptera: Tephritidae): Diversidad, biología y manejo. S y G editores, Distrito Federal, México.
21. Niklaus-Ruiz B. y T. Basedow, 1997. A survey on the occurrence and flight periods of fruit flies species (Diptera: Tephritidae) in a fruit growing area in Southwest Nicaragua, 1994/95. Bulletin of Entomological Research, 87: 405-412.
22. Norrbom A., 1991. The species of *Anastrepha* (Diptera: Tephritidae) with a grandis-type wing pattern. Proceedings of the Entomological Society of Washington, 93(1): 101-124. DOI: <https://doi.org/10.4039/tce.2012.13>
23. Norrbom A., L.E. Carroll, F.C. Thompson, I.M. White y A. Freidberg, 1998. Systematic database of names. En: F.C. Thompson (Ed.), Fruit fly expert identification system and systematic information database, 9: 65-251. DOI: https://doi.org/10.1007/978-1-4757-2278-9_1
24. Norrbom A., R. Zucchi y V. Hernández-Ortiz, 1999. Phylogeny of the genus *Anastrepha* and *Toxotrypana* (Trypetinae: Toxotrypanini) based on morphology. En: Aluja M. y A.L. Norrbom (Eds.), Fruit flies (Tephritidae): Phylogeny and evolution of behaviour. CR Press, USA.
25. Norrbom A.L. y C.A. Korytkowski, 2009. A revision of the *Anastrepha robusta* species group (Diptera: Tephritidae). Zootaxa, 2182: 1-91. DOI: <https://doi.org/10.4039/tce.2012.13>
26. Pérez-García E.A., J. Meave y C. Gallardo, 2001. Vegetación y flora de la región de Nizanda, Istmo de Tehuantepec, Oaxaca, México. Acta Botánica Mexicana, 56: 19-88. DOI: <https://doi.org/10.21829/abm56.2001.879>
27. Rodríguez C.P.A., A.L. Norrbom, E. Arévalo, F. Balseiro, P.A. Díaz, M.C. Benítez, J. Gallego, M.I. Cruz, J.M. Montes, E.J. Rodríguez, G. J. Steck, D. B. Sutton, E. Quisberth, J.J. Lagrava y F. Colque, 2018. New records of *Anastrepha* (Diptera: Tephritidae) primarily from Colombia. Zootaxa, 4390(1): 001-063. DOI: <http://dx.doi.org/10.11646/zootaxa.4390.1.1>
28. Rzedowski J., 2006. Vegetación de México. Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, México.
29. Steyskal G.C., 1977. Pictorial key to species of the genus *Anastrepha* (Diptera: Tephritidae). Entomological Society of Washington, Washington.
30. Uramoto K., N.A. Canal y R.A. Zucchi, 1998. New records of *Anastrepha* species (Diptera, Tephritidae) in Brazil. En: V International Symposium on Fruit Flies of Economic Importance, 1998, Penang, 1998. p. 19.
31. Zucchi R.A., 2008. *Anastrepha* species their host plants and parasitoids <http://www.lea.esalq.usp.br/anastrepha/> (accesado en mayo 11, 2018).

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