PROC. ENTOMOL. SOC. WASH.
102(4), 2000, pp. 802–815

NEW HOST PLANT AND DISTRIBUTION RECORDS IN MEXICO FOR *ANASTREPHA* SPP., *TOXOTRYPANA CURVICAUDA* GERSTACKER, *RHAGOLETIS ZOQUI* BUSH, *RHAGOLETIS* SP., AND *HEXACHAETA* SP. (DIPTERA: TEPHRITIDAE)

MARTÍN ALUJA, JAIME PIÑERO, MAURILIO LÓPEZ, CÉSAR RUÍZ, ALBERTO ZÚÑIGA, ENRIQUE PIEDRA, FRANCISCO DÍAZ-FLEISCHER, AND JOHN SIVINSKI

(MA, JP, ML, CR, AZ, EP) Instituto de Ecología, A.C., Apartado Postal 63, C.P. 91000 Xalapa, Veracruz, México (MA, e-mail: alujam@ecologia.edu.mx); (FD-F) Departamento de Desarrollo de Métodos, Campaña Nacional Contra las Moscas de la Fruta, 2a Avenida Sur No. 5 (Altos), C.P. 30700 Tapachula, Chiapas, México; (JS) Center for Medical, Agricultural and Veterinary Entomology, USDA ARS, 1700 SW 23rd Drive, P.O. Box 14565, Gainesville, FL 32604, U.S.A.

Abstract.—We report the results of a nine-year study (1990–1998), aimed at determining the distribution of fruit flies (Diptera: Tephritidae) and identify their host plants in Veracruz, Mexico. Twenty *Anastrepha* species, *Toxotrypana curvicauda* and several unidentified *Hexachaeta* species were captured in McPhail traps. Among the 20 *Anastrepha* species, *A. limae, A. dentata,* and *A. canalis* are new records for Veracruz. Out of a total of 51 species of native, wild plants and exotic, cultivated plants collected in Veracruz, Mexico (representing 3,736 kg of fruit), 34 were infested by 13 *Anastrepha* species, 4 plants were infested by 4 *Rhagoletis* species, 2 plants were infested by *Toxotrypana curvicauda,* and one by an undescribed *Hexachaeta* species. Our observations include new host plant records for *Anastrepha hamata* (larvae feed only on seeds), *A. bahiensis, A. chiclayae, A. fraterculus, A. obliqua, T. curvicauda, Rhagoletis zoqui, R.* sp. and *Hexachaeta* sp. We present host plant data based on size of fruit and degree of infestation, provide information on local names and fruiting phenology, and discuss our findings in light of their practical implications and with respect to the zoogeography of Mexican fruit flies.

Resumen.—Reportamos los resultados de un estudio de nueve años (1990–1998), encaminado a determinar la distribución de moscas de la fruta (Diptera: Tephritidae) e identificar sus plantas hospederas en Veracruz, México. Veinte especies de *Anastrepha, Toxotrypana curvicauda* y varias especies no identificadas de *Hexachaeta* fueron capturadas en trampas McPhail. De estas especies *A. limae, A. dentata* y *A. canalis* representan nuevos reportes para Veracruz. De un total de 51 especies de plantas nativas (silvestres) y exóticas (cultivadas) colectadas en Veracruz, México (representando 3,736 kg de fruta), 34 fueron infestadas por 13 especies de *Anastrepha,* otras 4 por 4 especies de *Rhagoletis,* 2 por *Toxotrypana curvicauda* y una por una especie no descrita de *Hexachaeta.* Nuestras observaciones incluyen nuevas plantas hospederas para *Anastrepha hamata* (las larvas se alimentan sólo de semillas), *A. bahiensis, A. chiclayae, A. fraterculus, A. obliqua, T. curvicauda, Rhagoletis zoqui, R.* sp. y *Hexachaeta* sp. Presentamos información sobre plantas hospederas basada en el tamaño de fruto y grado de infestación, proporcionamos información acerca de nombres locales de los frutos, su fenología de fructificación y

discutimos nuestros descubrimientos en relación a sus implicaciones prácticas y con respecto a la zoogeografía de las moscas de la fruta presentes en México.

Key Words: *Anastrepha, Rhagoletis, Toxotrypana, Hexachaeta,* distribution, host plants, zoogeography

---

Flies in the genera *Anastrepha* Schiner, *Rhagoletis* Loew, *Toxotrypana* Gerstacker, and *Hexachaeta* Loew are widely distributed in the Neotropics (Norrbom et al. 1999). In *Anastrepha,* there are 197 described species distributed from the southern USA to northern Argentina (Aluja 1994, Norrbom et al. 2000). The host plants of *Anastrepha* were recently reviewed by Norrbom (2000) and Norrbom et al. (2000). These combined reports indicate that plant species in more than 75 families are used as hosts. For *Toxotrypana curvicauda* Gerstacker, host plants are restricted to two families only: Caricaceae and Asclepiadaceae. They include species such as *Carica papaya* L., *Carica cauliflora* Jacq., *Morrenia odorata* Lindl., and *Gonolobus sorodius* Gray. (Mason 1922, Castrejón-Ayala and Camino-Lavín 1991, Landolt 1994). For flies in the genus *Hexachaeta,* almost no host-plant data are available. This genus includes 25 described species and many undescribed species, and the few host plant reports available are predominantly plants in the family Moraceae (Norrbom et al. 1999).

Here, we report the results of a long-term study (nine years of year-round fruit collections and trapping activities) aimed at determining the distribution of the fruit fly genera *Anastrepha, Rhagoletis, Toxotrypana,* and *Hexachaeta* and identifying their host plants in the State of Veracruz, Mexico.

Materials and Methods

Study sites.—During nine years (1990–1998) we collected all wild or cultivated fruit (potential fruit fly hosts) we could find in 42 sites located in the state of Veracruz, Mexico. Two of these 42 sites are located in northern Veracruz (Morgadal and Alamo), one site is located in southern Veracruz (Los Tuxtlas), and the rest (39 sites) are located in central Veracruz. All study sites, their exact location (latitude, longitude) and altitude are described in Table 1.

Fruit sampling methods.—Ripe, and on occasion unripe, fruits of the plants listed in Table 2, were collected in areas with unperturbed and perturbed native vegetation, in backyard gardens, and in semicommercial and commercial orchards as described by Aluja et al. (1987). Samples were placed in plastic washbowls and transported to our laboratory in Xalapa, Veracruz, Mexico. There, samples were individually weighed and placed in plastic trays which in turn were placed over a plastic washbowl containing vermiculite as a pupation medium.

Processing of larvae and pupae.—We inspected, on a daily basis, the pupation medium in the washbowls described above and collected all pupae and larvae. These were transferred to labeled, 500 ml plastic containers with vermiculite. All containers (one per sample) were kept in the laboratory at 26 ± 2°C and 60–70% RH until all adult flies had emerged from the pupae.

Trapping of adult flies.—Traps to survey adult flies were placed in Apazapan, Llano Grande, Monte Blanco, and Martínez de la Torre, Veracruz. With the exception of Martínez de la Torre, we worked in commercial mango orchards surrounded by patches of native vegetation, coffee plantations, and other orchards. In Martínez de la Torre we worked in a commercial grapefruit (*Citrus paradisi* Macfad.) orchard. At all sites we placed 16 McPhail traps baited with 250 ml

of a mixture of hydrolyzed protein, water, and borax in each orchard. In Apazapan we also placed 16 traps in a commercial chicozapote (*Manilkara zapota* [L.] P. Royen) orchard adjacent to the mango orchard. Bait preparation, and placement and service of traps are described in detail in Aluja et al. (1996).

Identification of adult flies and plants.—All flies emerging from puparia or caught in McPhail traps were identified at the Instituto de Ecología, A. C., by Vicente Hernández-Ortiz. Plants were dried, pressed, and identified by Carlos Durán, staff member of the IXAL herbarium at the Instituto de Ecología, A. C., in Xalapa, Veracruz. Voucher specimens of plants and insects not already represented in the permanent collections were kept in the IXAL herbarium and IXAL permanent insect collection. All plant names used here correspond to those listed in the USDA's GRIN online database (USDA 2000).

Results

Fruit sampling.—A total of 3,736 kg of fruit, representing 51 species from 22 plant families, was processed during this study (Table 2). Of these, 42 species from 17 families were found to be natural hosts of 13 *Anastrepha* species, 4 *Rhagoletis* species, *Toxotrypana curvicauda,* and an undescribed *Hexachaeta* species (Table 3). The fruiting phenology of all of these plant species is described in Table 4.

The more polyphagous species were *A. ludens* (Loew) (8 plant species attacked), followed by *A. obliqua* (Macquart) and *A. fraterculus* (Wiedemann) with 7 plant species attacked. In Apazapan we found *Myrciaria floribunda* (H. West ex Will.) O. Berg (Myrtaceae) simultaneously infested by three species of *Anastrepha*: *A. fraterculus, A. obliqua,* and *A. bahiensis* Lima (new host plant records for the latter two species). We were also able to confirm that *Terminalia catappa* L. (Combretaceae) is a natural (i.e., field-infested) host plant of *A. fraterculus* (first report in the State of Veracruz).

In contrast to the polyphagous *A. obliqua, A. ludens* and *A. fraterculus, A. aphelocentema* Stone and *A. alveata* Stone were monophagous species attacking *Pouteria hypoglauca* (Standley) Baehni (Sapotaceae) and *Ximenia americana* L. (Olacaceae), respectively. *Anastrepha hamata* (Loew) was an oligophagous species attacking seeds of both *Chrysophyllum mexicanum* Brandegee ex. Stand. and *Pouteria campechiana* (Kunth) Baehni fruits, belonging to the family Sapotaceae. *Rhagoletis zoqui* Bush, *R. pomonella* Walsh, *R. turpiniae* Hernández and *R.* sp. adults were obtained from *Juglans pyriformis* Liebm., *Crataegus mexicana* DC., *Turpinia insignis* (H.B. & K.) Tul., and *Solanum ionidium* Bitter, respectively. *Toxotrypana curvicauda* adults were obtained from *Gonolobus niger* (Cav.) R. Br. (Asclepiadaceae) fruits collected in the Llano Grande region. *Hexachaeta* sp. adults attacked *Trophis mexicana* (Liebm.) Bur. (Moraceae) fruits in the Monte Blanco region (details of all the above are in Table 5).

Infestation patterns (i.e., number of larvae per kg of fruit) are described in Table 5. Notably, the smaller, wild fruits were the most infested (Table 5, Fig. 1).

The highest infestation levels (larvae/kg of fruit) were found in *Spondias mombin* L., followed by *Ximenia americana* L. (fruits in the families Anacardiaceae and Olacaceae attacked by *A. obliqua* and *A. alveata,* respectively), while the lowest infestation levels were found in *Inga jinicuil* G. Don (Leguminoseae), infested by *A. distincta* Greene, followed by *Tabernaemontana alba* Mill. (Apocynaceae) attacked by *A. cordata* Aldrich (Table 5).

Trapping.—We captured 20 *Anastrepha* species in McPhail traps. Of these, 16 species were captured in Apazapan, 12 species in Llano Grande, 14 in Monte Blanco and 11 in Martínez de la Torre (Table 6). In the mango orchards, *A. obliqua* was by far the most abundant species, followed by *A. lu-*

Table 1. Study site locations.

No.	Study site	Northern latitude	Western longitude	Altitude (meters)
1	El Conchal	19°04′	96°06′	17
2	La Mancha	19°35′	96°22′	18
3	Cardel	19°22′	96°22′	31
4	Playa Azul	19°32′	96°23′	47
5	Playa Oriente	19°21′	96°19′	121
6	Paso de Ovejas	19°17′	96°26′	122
7	Morgadal (Poza Rica)	20°24′	97°21′	128
8	Alamo	22°55′	97°40′	180
9	Puente Nacional	19°19′	96°28′	198
10	Los Tuxtlas	18°25′	95°06′	200
11	Coyolar	19°17′	96°36′	228
12	El Aguaje	19°25′	96°36′	250
13	El Crucero	19°17′	96°35′	281
14	Actopan	19°30′	96°36′	311
15	Plan del Río	19°23′	96°39′	319
16	Rinconada	19°21′	96°33′	322
17	Apazapan	19°19′	96°42′	331
18	Martínez de la Torre	19°58′	96°47′	400
19	Emiliano Zapata	19°21′	96°33′	416
20	Cerro Gordo	19°25′	96°41′	559
21	Llano Grande	19°22′	96°53′	680
22	Corral Falso	19°27′	96°45′	744
23	San Pedro	19°24′	96°52′	904
24	Tejería	19°22′	96°56′	924
25	Miradores	19°28′	96°46′	966
26	Limones	19°20′	96°55′	1,021
27	Monte Blanco	19°23′	96°56′	1,026
28	Bella Esperanza	19°26′	96°52′	1,057
29	Vaquería	19°19′	96°57′	1,103
30	Coatepec	19°26′	96°57′	1,142
31	Xico	19°25′	97°00′	1,145
32	Teocelo	19°24′	96°58′	1,163
33	Jilotepec	19°37′	96°56′	1,292
34	Cosautlán	19°20′	96°59′	1,318
35	Texín	19°20′	97°01′	1,464
36	Xalapa	19°31′	96°54′	1,468
37	Amatla	19°19′	97°03′	1,478
38	El Diez	19°21′	97°01′	1,498
39	La Perla	19°19′	97°03′	1,578
40	El Arenal	19°19′	97°05′	1,649
41	Acajete	19°34′	96°59′	1,875
42	La Joya	19°37′	97°02′	2,004

dens (Monte Blanco and Llano Grande) and *A. serpentina* (Wiedemann) (Apazapan). At Martínez de la Torre (citrus orchard), *A. ludens* was the most common *Anastrepha* species captured. All of these species are considered agricultural pests of economic importance in Mexico.

Many *Anastrepha* species of non-economic importance were also captured at all four trapping sites (e.g., *A. bicolor* [Stone], and *A. spatulata* Stone). In contrast, *A. bahiensis, A. dentata* (Stone), *A. robusta* Greene, and *A. zuelaniae* Stone were found only in Apazapan, while *A. canalis* Stone was captured only in Monte Blanco. Adults of *Hexachaeta* spp. were commonly cap-

Table 2. Plant species sampled in central Veracruz, Mexico, to determine their host status to the local tephritid fruit flies.

Plant family	Scientific name	Local common name	Locality code*
Anacardiaceae	*Mangifera indica* L.		1–9, 11–12, 14–15, 17, 19–21, 24, 27
	var. criollo	Mango corriente	
	var. manila	Mango manila	
	var. Kent	Mango petacon	
	Spondias mombin L.	Jobo	1–3, 5–6, 10, 16–17, 19–21, 23, 24, 27–28
	Spondias purpurea L.	Ciruelo tropical	1–6, 9–11, 13–17, 19–21, 23
	Spondias radlkoferi Donn. Sm.	Jobo Cimarron	24, 27
	Spondias sp.	Cundoria	5, 23, 25, 27
	Tapirira mexicana Marchand	Cacao silvestre	27, 30
Annonaceae	*Annona muricata* L.	Guanábana	5, 16–17
Apocynaceae	*Tabernaemontana alba* Mill.	Huevo de gato	10
Asclepiadaceae	*Gonolobus niger* (Cav.) R. Br.	Vaquitas	21, 27
Bombacaceae	*Quararibea funebris* (La Llave) Vischer	Canela	10
Caricaceae	*Carica papaya* L.	Papaya	8, 15, 17
Combretaceae	*Terminalia catappa* L.	Almendro	2, 5, 9, 16
Euphorbiaceae	*Ricinus communis* L.	Higuerilla	21
Guttiferae	*Mammea americana* L.	Zapote domingo	2
Juglandaceae	*Juglans pyriformis* Liebm.	Nogal	34, 36
Leguminoseae	*Inga jinicuil* G. Donht.	Jinicuil	21, 23, 24, 26, 27, 28–30, 34
	Inga spuria Humbl.	Chalahuite peludo	21, 24, 27
	Inga vera Willd.	Chalahuite	21, 24, 27
Malpighiaceae	*Byrsonima crassifolia* (L.) Kunth	Nanche	26, 32
Moraceae	*Trophis mexicana* (Liebm.) Bur.	Jobo Cimarron	27
	Brosimum alicastrum Sw.	Ramon (Ojite)	2, 13
Myrsinaceae	*Icacorea compressa* (Kunth) Standley	Capulin silvestre	27
Myrtaceae	*Myrciaria floribunda* (H. West ex Willd.) O. Berg	Guayabilla	17
	Psidium guajava L.	Guayaba	1–6, 9–17, 19–34, 36–40
	Psidium guineense Sw.	Guayaba acida	24
	Psidium sartorianum (O. Berg.) Nied.	Guayaba Tejon	6, 21, 27
	Syzygium jambos (L.) Alston	Pomarrosa	23, 24, 26–32, 36
Olacaceae	*Ximenia americana* L.	Ciruela de monte	16, 17, 21
Passifloraceae	*Bunchosia biocellata* Schlecht.	Granada de arbol	13
	Passiflora ciliata Aiton	Granada roja	27
	Passiflora edulis Sims.	Granada amarilla	27
	Passiflora edulis f. flavicarpa Deg.	Maracuyá	24, 27, 32
Rosaceae	*Cordia dodecandria* Sesse & Moc.	Copite	16
	Crataegus mexicana DC.	Tejocote	41, 42
	Eriobotrya japonica (Thunb.) Lindl.	Nispero	21, 24, 27, 32, 36
	Prunus persica (L.) Batsch	Durazno	21, 24, 27, 31, 36
Rutaceae	*Casimiroa edulis* La Llave & Lex.	Zapote Blanco	27, 36
	Citrus maxima (Burm.) Merr.	Pomelo	12, 16, 19
	Citrus reticulata Blanco	Mandarina	7, 16, 18
	Citrus paradisi Macfad.	Toronja	2, 18, 23, 25, 35
	Citrus sinensis (L.) Osbek		5, 6, 16, 18, 19, 21, 24, 26, 27, 29, 32, 34, 36
	var. valencia	Naranja Valencia	
	var. navel	Naranja Ombligona	

Table 2. Continued.

Plant family	Scientific name	Local common name	Locality code*
	Citrus aurantium L.	Naranja Cucha	1, 9, 14–16, 19–21, 23–25, 27, 28, 30, 31, 33, 40
Sapotaceae	*Bumelia spiniflora* A. DC.	Pionche	17
	Calocarpum mammosum (L.) P. Royen	Zapote Mamey	5, 21, 23, 24, 26, 27
	Chrysophyllum mexicanum Brandegee ex. Stand.	Zapote Niño	10
	Chrysophyllum cainito L.	Caimito	8
	Manilkara zapota (L.) P. Royen	Chico Zapote	14–17, 19
	Pouteria hypoglauca (Standl.) Baehni	Zapote calentura	2, 7
	Pouteria campechiana (Kunth) Baehni	Zapote Niño	27
Solanaceae	*Solanum ionidium* Bitter	Tomatillo	36
Staphyleaceae	*Turpinia insignis* (H.B. & K.) Tul.	Turpinia	36

* Places in which plant species were sampled. Numbers correspond to those presented in Table 1.

tured in McPhail traps in all four trapping sites. *Toxotrypana curvicauda* was captured only in Apazapan, Veracruz.

Discussion

We discovered new host plants for *Anastrepha bahiensis, A. hamata* (2 plant species), *A. chiclayae* Greene, *A. fraterculus,* and most significantly, for the economically-important species, *A. obliqua.* New host plants are also reported for *Toxotrypana curvicauda, Rhagoletis zoqui, R.* sp. and *Hexachaeta* sp. We were further able to document, for the first time, the presence of *A. canalis, A. dentata,* and *A. limae* Stone in the State of Veracruz, Mexico.

Of the 17 species of *Anastrepha* reported by Hernández-Ortiz (1992) in the state of Veracruz, we found all in fruits, or captured in McPhail traps. In addition, we also found the previously unrecorded *A. alveata* (Piedra et al. 1993), *A. bicolor, A. canalis, A. dentata,* and *A. limae.*

Of the new records found for the genus *Anastrepha, A. hamata* stands out, not only because this is the first report of its host plants, but also because the larvae were found feeding only on seeds of two fruit species. Thus, this species is added to the list previously published by Hernández-Ortiz and Aluja (1993), in which *A. cordata, A. sagittata* (Stone), *A. pallens* Coquillett, *A. crebra* Stone, *A. anomala* Stone, and *A. pickeli* Lima are reported as seed-feeding species. We note however, that *A. cordata* and *A. crebra* also apparently feed in the mesocarp of fruits (Norrbom et al. 2000).

Anastrepha bahiensis, A. fraterculus, and *A. obliqua* were found simultaneously attacking the previously unreported host *Myrciaria floribunda* (local common name: Guayabilla) (Myrtaceae), in the Apazapan region. We wonder if these species are unable to recognize the host marking pheromone of their congeners or if the extremely scarce supply of alternative host plants during the time of year when this plant is in fruit, causes flies to oviposit in previously utilized and marked fruit (due to a large egg-load). For *A. fraterculus* and *A. obliqua,* it is relevant to mention that this plant can function as an alternative host from March until May. This could allow *A. fraterculus* to bridge the period when its previously reported hosts are unavailable (*Psidium* spp. prior to May, and *S. jambos* [L.] Alston from May to July). In the case of *Anastrepha obliqua,* we believe that this host could also serve as a "bridge" between the fruiting periods of two wild hosts (*Tapirira mexicana* Marchand, which locally bears fruits from September to November, and

Table 3. Native and exotic host plants that harbored fruit flies in Veracruz, Mexico, during our nine year study (1990–1998).

Fruit fly species	Common local name of host plant	Scientific name of host plant	Plant family
Anastrepha			
alveata	Ciruela de monte	*Ximenia americana*	Olacaceae
aphelocentema	Zapote calentura	*Pouteria hypoglauca*	Sapotaceae
bahiensis	Guayabilla*	*Myrciaria floribunda*	Myrtaceae
	Ramón or Ojite	*Brosimum alicastrum*	Moraceae
chiclayae	Granada amarilla	*Passiflora edulis*	Passifloraceae
	Granada roja	*Passiflora ciliata*	Passifloraceae
cordata	Huevo de gato	*Tabernaemontana alba*	Apocynaceae
crebra	Canela	*Quararibea funebris*	Bombacaceae
distincta	Jinicuil	*Inga jinicuil*	Leguminosae
	Chalahuite peludo	*Inga spuria*	Leguminosae
	Chalahuite	*Inga vera*	Leguminosae
fraterculus	Almendro**	*Terminalia catappa*	Combretaceae
	Guayabilla	*Myrciaria floribunda*	Myrtaceae
	Guayaba	*Psidium guajava*	Myrtaceae
	Guayaba ácida	*Psidium guineense*	Myrtaceae
	Guayaba tejón	*Psidium sartorianum*	Myrtaceae
	Pomarrosa	*Syzygium jambos*	Myrtaceae
	Durazno	*Prunus persica*	Rosaceae
hamata	Zapote Niño*	*Chrysophyllum mexicanum*	Sapotaceae
	Zapote Niño*	*Pouteria campechiana*	Sapotaceae
ludens	Mango cultivar Criollo cultivar Manila cultivar Kent	*Mangifera indica*	Anacardiaceae
	Durazno	*Prunus persica*	Rosaceae
	Zapote Blanco	*Casimiroa edulis*	Rutaceae
	Naranja cucha	*Citrus aurantium*	Rutaceae
	Pomelo	*Citrus maxima*	Rutaceae
	Toronja	*Citrus paradisi*	Rutaceae
	Mandarina	*Citrus reticulata*	Rutaceae
	Naranja dulce	*Citrus sinensis*	Rutaceae
obliqua	Mango var. Manila var. Kent var. Criollo	*Mangifera indica*	Anacardiaceae
	Ciruelo	*Spondias purpurea*	Anacardiaceae
	Cundoria	*Spondias* sp.	Anacardiaceae
	Jobo cimarrón	*Spondias radlkoferi*	Anacardiaceae
	Jobo	*Spondias mombin*	Anacardiaceae
	Cacao	*Tapirira mexicana*	Anacardiaceae
	Guayabilla*	*Myrciaria floribunda*	Myrtaceae
serpentina	Zapote mamey	*Calocarpum mammosum*	Sapotaceae
	Zapote niño	*Chrysophyllum mexicanum*	Sapotaceae
	Caimito	*Chrysophyllum cainito*	Sapotaceae
	Chico Zapote	*Manilkara zapota*	Sapotaceae
	Zapote calentura	*Pouteria hypoglauca*	Sapotaceae
striata	Guayaba	*Psidium guajava*	Myrtaceae
	Guayaba ácida	*Psidium guineense*	Myrtaceae
	Guayaba tejón	*Psidium sartorianum*	Myrtaceae

Table 3. Continued.

Fruit fly species	Common local name of host plant	Scientific name of host plant	Plant family
Rhagoletis			
pomonella	Tejocote	*Crataegus mexicana*	Rosaceae
turpiniae	Turpinia	*Turpinia insignis*	Staphyleaceae
sp.	Tomatillo	*Solanum iodinium*	Solanaceae
zoqui	Nogal	*Juglans pyriformis*	Junglandaceae
Hexachaeta			
(undescribed species)	Jobo Cimarrón*	*Trophis mexicana*	Moraceae
Toxotrypana			
curvicauda	Papaya	*Carica papaya*	Caricaceae
	Vaquitas*	*Gonolobus niger*	Asclepiadaceae

* First report for Mexico.
** First report for Veracruz State.

Spondias purpurea L., available from April to June). Interestingly, *M. floribunda* is heavily preyed upon local mammals who eat practically every available fruit (trees bear fruit during the peak of the dry season and thus represent one of the few available food items for wildlife). Because of this, it is very difficult to find fruit in the field.

The presence of *A. fraterculus* in fruits of *Terminalia catappa* corroborates the previous report by Patiño (1989) working in Papantla and Gutiérrez Zamora, Veracruz. However, we find it noteworthy that it was never found infesting any of the several *Citrus* species we sampled.

Unfortunately, we were not able to rear *A. bicolor, A. canalis, A. dentata, A. limae, A. pallens, A. robusta, A. spatulata*, and *A. zuelaniae* from host fruits. These species were only captured in McPhail traps. However, Hernández-Ortiz (1992) pointed out that species belonging to the *dentata* group (e.g., *A. dentata*), *daciformis* group (e.g., *A. bicolor* and *A. pallens*) and *robusta* group (e.g., *A. robusta*) probably attack plants belonging to the family Sapotaceae. Future efforts at discovering their host plants should thus be directed to all wild species of this family. According to Stone (1939) and Baker et al. (1944), *A. pallens* attacks *Bumelia spiniflora* A. DC. (Sapotaceae), while Norrbom (1998) pointed out that it infests fruits of *Sideroxylon celastrinum* (Kunth) T.D. Pennington and *S. lanuginosa* Michx. (Sapotaceae). We note that Norrbom (1998) considers that *B. spiniflora* was likely misspelled (the correct name should be *B. spinosa* A.DC.). Should the latter be true, then *B. spiniflora* is a synonym of *S. celastrinum* (Norrbom 1998). *Anastrepha leptozona* Hendel was also not reared from any of the fruits collected. However, Aluja et al. (1987) found it in *Micropholis mexicana* Gilly ex Cronquist (Sapotaceae), in the state of Chiapas, and Norrbom and Kim (1988) report its occurrence in 6 plant families. Norrbom et al. (1999) also note that *A. zuelaniae, A. limae* and *A. canalis* are associated with plants in the families Flacourtiaceae, Passifloraceae and Staphylaceae, respectively.

In the Los Tuxtlas region, Hernández-Ortiz and Pérez Alonso (1993) reported the presence of 13 species of *Anastrepha.* Of these, they hypothesized that *A. crebra, A. minuta* and *Anastrepha* sp. (close to *A. perdita*) are apparently restricted in Mexico, to tropical, evergreen rain forests. Our results, indicating that these species are only present in the tropical decidous forests of central and northern Veracruz, lend support to this hypothesis.

For *Toxotrypana curvicauda,* our report corroborates the previous records of Mason

Table 4. Fruiting phenology of fruit fly host plants in Veracruz, Mexico.

Plant species	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Anastrepha host plants												
Brosimum alicastrum				X	X	X						
Calocarpum mammosum					X	X	X	X	X			
Casimiroa edulis					X	X	X					
Chrysophyllum mexicanum	X									X	X	X
Chrysophyllum cainito				X	X							
Citrus aurantium	X	X	X			X	X	X	X	X	X	X
Citrus maxima	X	X	X								X	X
Citrus paradisi	X	X								X	X	X
Citrus reticulata	X										X	X
Citrus sinensis	X	X	X							X	X	X
Inga jinicuil						X	X	X				
Inga spuria									X	X		
Inga vera									X	X		
Mangifera indica												
cultivar Criollo				X	X	X	X	X				
cultivar Manila			X	X	X	X	X	X	X			
cultivar Kent								X	X			
Manilkara zapota			X	X	X	X	X	X				
Myrciaria floribunda			X	X	X							
Passiflora edulis					X	X						
Passiflora ciliata						X						
Pouteria hypoglauca							X	X	X			
Pouteria campechiana	X	X								X	X	X
Prunus persica					X	X	X	X				
Psidium guajava												
0–500*	X	X			X	X	X	X	X	X	X	X
500–1,000*							X	X	X	X	X	
1,000–1,500*								X	X	X	X	
Psidium guineense	X	X							X	X	X	X
Psidium sartorianum	X	X								X	X	X
Quararibea funebris	X	X	X						X	X	X	X
Spondias purpurea				X	X	X	X					
Spondias mombin								X	X			
Spondias radlkoferi									X	X	X	
Spondias sp.								X	X	X		
Syzygium jambos					X	X	X					
Tabernaemontana alba						X	X	X	X	X	X	X
Tapirira mexicana										X	X	
Terminalia catappa						X	X	X	X	X	X	X
Ximenia americana				X	X	X						
Hexachaeta host plants												
Trophis mexicana					X	X						
Toxotrypana host plants												
Carica papaya			X	X	X	X	X	X	X	X		
Gonolobus niger	X	X	X									
Rhagoletis host plants												
Crataegus mexicana								X	X	X	X	
Juglans pyriformis							X	X	X	X		
Solanum ionidium							X	X				
Turpinia insignis							X	X				

* Meters above sea level.

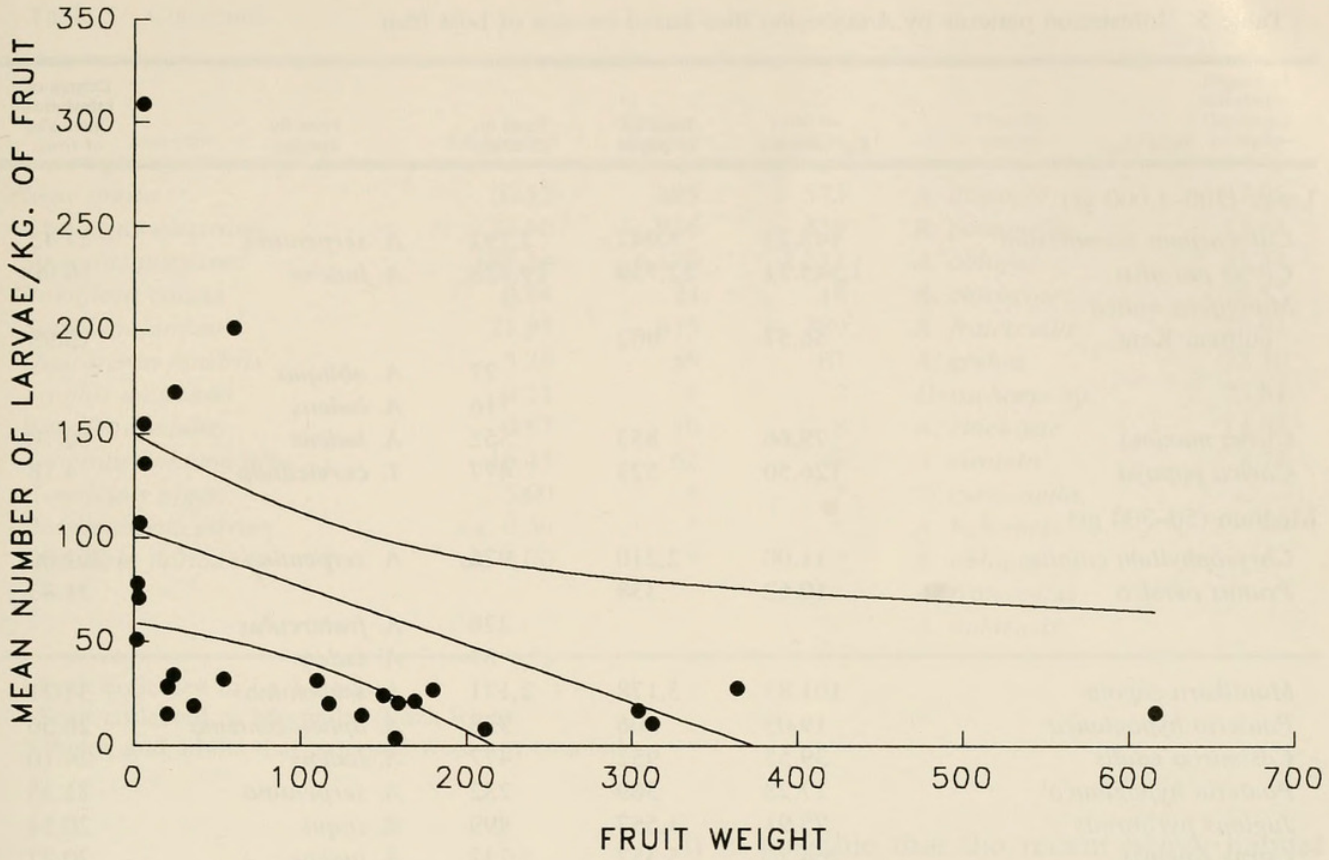

Fig. 1. Number of larvae per kilogram of fruit as influenced by size of fruit.

(1922), Castrejón-Ayala and Camino-Lavín (1991), and Landolt (1994), who pointed out that adults of this species feed mainly on fruits belonging to the families Caricaceae and Asclepiadaceae. Here we report this species infesting *Gonolobus niger,* a plant also belonging to the family Asclepiadaceae.

For *Hexachaeta* sp., we are the first to report its host plant as *Trophis mexicana.* This confirms that various species belonging to this fly genus develop in fruits of the Moraceae.

We are able to report a new host plant (*Juglans pyriformis*) for *R. zoqui.* The only other known host plant record for this fly species is *J. mollis* Engelm. (Bush 1966). Further, we also report for the first time that *Solanum ionidium* is a host plant of an undescribed species in the genus *Rhagoletis.* This adds further evidence about the importance of the family Solanaceae as hosts of this genus.

The polyphagy observed in *A. ludens* (8 plant species belonging to 3 families), *A. obliqua* (7 plant species belonging to 2 families) and *A. fraterculus* (7 species belonging to 4 families) has previously been discussed by Aluja et al. (1987) and Hernández-Ortiz and Aluja (1993). In our opinion, this polyphagy permits these four species to be abundant during practically the whole year. *Anastrepha bahiensis* was also found to be a polyphagous species, with larvae feeding on fruits belonging to two genera in two different families (*M. floribunda* [Myrtaceae] and *Brosimum alicastrum* Sw. [Moraceae]).

In contrast, some species in our study appeared to be monophagous. This is the case for *A. alveata* feeding on *Ximenia americana* (Olacaceae) (Piedra et al. 1993), and *A. aphelocentema* on *Pouteria hypoglauca* (Sapotaceae). *Anastrepha aphelocentema* was found only in the northern part of Veracruz (Papantla) (Patiño, 1989), in spite of the fact that this plant is also present in localites such as La Mancha, approximately 150 km away from Papantla. In La Mancha, fruits were attacked only by *A. serpentina.*

Table 5. Infestation patterns by *Anastrepha* flies based on size of host fruit.

Host plant	Kg. sampled	Total no. of pupae	Total no. of adults	Fruit fly species	Degree of infestation (larvae/kg of fruit)
Large (300–1,000 gr)					
Calocarpum mammosum	143.73	3,942	2,792	*A. serpentina*	27.43
Citrus paradisi	1,345.71	22,739	19,428	*A. ludens*	16.90
Mangifera indica cultivar Kent	56.57	902			15.95
			27	*A. obliqua*	
			716	*A. ludens*	
Citrus maxima	79.66	853	552	*A. ludens*	10.70
Carica papaya	126.50	529	477	*T. curvicauda*	4.18
Medium (50–300 gr)					
Chrysophyllum cainito	11.00	2,210	1,926	*A. serpentina*	201.00
Prunus persica	10.62	338			31.83
			228	*A. fraterculus*	
			37	*A. ludens*	
Manilkara zapota	101.83	3,178	2,171	*A. serpentina*	31.21
Pouteria hypoglauca[2]	19.05	506	328	*A. aphelocentema*	26.56
Casimiroa edulis	39.55	952	477	*A. ludens*	24.10
Pouteria hypoglauca[1]	17.28	369	232	*A. serpentina*	21.35
Juglans pyriformis	75.91	1,557	899	*R. zoqui*	20.51
Citrus sinensis	264.27	5,357	2,742	*A. ludens*	20.27
Citrus aurantium	669.29	13,513	8,525	*A. ludens*	20.20
Mangifera indica var. *criollo*	121.78	1,772			14.55
			20	*A. ludens*	
			995	*A. obliqua*	
Citrus reticulata	2.80	36	23	*A. ludens*	12.86
Chrysophyllum mexicanum	59.36	531	342	*A. hamata*	8.94
Mangifera indica var. *manila*	42.97	337			7.84
			58	*A. ludens*	
			222	*A. obliqua*	
Terminalia catappa	10.09	55	10	*A. fraterculus*	5.45
Inga jinicuil	22.38	77	64	*A. distincta*	3.44
Small (<50 gr)					
Spondias mombin	64.67	28,138	4,241	*A. obliqua*	435.10
Ximenia americana	16.08	4,960	2,082	*A. alveata*	308.46
Turpinia insignis	12.25	3,416	674	*R. turpiniae*	278.90
Psidium guajava	97.60	16,619			170.28
			4,879	*A. striata*	
			8,923	*A. fraterculus*	
Spondias sp.	29.20	4,514	2,155	*A. obliqua*	154.59
Inga vera	0.56	76	76	*A. distincta*	135.71
Psidium guineense	4.76	509			106.93
			73	*A. striata*	
			359	*A. fraterculus*	
Solanum ionidium	0.29	29	11	*R.* sp.	100.00
Psidium sartorianum	3.62	282			77.90
			47	*A. striata*	
			43	*A. fraterculus*	
Tapirira mexicana	14.93	1,060	325	*A. obliqua*	71.00
Spondias radlkoferi	7.57	384	131	*A. obliqua*	50.72

Table 5. Continued

Host plant	Kg. sampled	Total no. of pupae	Total no. of adults	Fruit fly species	Degree of infestation (larvae/kg of fruit)
Inga spuria	10.52	495	373	*A. distincta*	47.05
Crataegus mexicana	22.50	986	559	*R. pomonella*	43.83
Spondias purpurea	182.34	6,170	1,513	*A. obliqua*	33.84
Passiflora ciliata	0.84	24	18	*A. chiclayae*	28.57
Syzygium jambos	21.95	615	389	*A. fraterculus*	28.01
Quararibea funebris	3.26	89	67	*A. crebra*	27.30
Trophis mexicana	0.21	5	2	*Hexachaeta* sp.	23.81
Passiflora edulis	0.67	10	8	*A. chiclayae*	14.93
Tabernaemontana alba	16.43	62	49	*A. cordata*	3.77
Gonolobus niger	5.00	*	*	*T. curvicauda*	—
Brosimum alicastrum	ca. 0.30	*	*	*A. bahiensis*	—
Myrciaria floribunda	ca. 0.30	*	*	*A. obliqua* *A. fraterculus* *A. bahiensis*	—

[1] Fruit collected in La Mancha.
[2] Fruit collected in Morgadal (Poza Rica).
* Pupae and adults that emerged were not counted.

Table 6. Fruit fly species captured in McPhail traps in Central Veracruz, Mexico.

Fruit fly species	Apazapan	Llano Grande	Monte Blanco	M. de la Torre
A. alveata	X	X	X	
A. bahiensis	X			
A. bicolor	X	X	X	X
A. canalis			X	
A. chiclayae	X	X	X	X
A. cordata				X
A. dentata	X			
A. distincta	X	X	X	X
A. fraterculus	X	X	X	X
A. hamata	X		X	
A. leptozona		X	X	
A. limae		X	X	
A. ludens	X	X	X	X
A. obliqua	X	X	X	X
A. pallens	X			X
A. robusta	X			
A. serpentina	X	X	X	X
A. spatulata	X	X	X	X
A. striata	X	X	X	X
A. zuelaniae	X			
T. curvicauda	X			
Hexachaeta spp.	X	X	X	X

It is possible that the recent heavy habitat alteration caused local extinction of this species.

It is significant that in the Monte Blanco region (central Veracruz) fruits of *Pouteria campechiana* were attacked only by *A. hamata* (on seeds), whereas in Los Tuxtlas (southern part of the state), *Chrysophyllum mexicanum* fruits were attacked by both *A. serpentina* on pulp, and *A. hamata* on seeds. It is noteworthy that two species of *Anastrepha* can utilize the same host without competition. *Pouteria campechiana* seeds and pulp were also reported attacked by both *A. sagittata* and *A. serpentina,* respectively, by Baker et al. (1944). However, Aluja et al. (1987) reported only *A. serpentina* larvae feeding on pulp of *P. campechiana* fruits in the State of Chiapas (Mexico), but no trace of *A. sagittata.*

In other *Anastrepha* species, we found that their host plants belonged to multiple species of only one genus (stenophagous species). This was true for *A. distincta* in *Inga spuria* Humbl. and *I. vera* Willd. (Leguminoseae), for *A. striata* Schiner in *Psidium guajava* L., *P. guineense* Sw. and *P. sartorianum* (O. Berg) Nied. (Myrtaceae)

and for *A. chiclayae* in *Passiflora edulis* Sims. and *P. ciliata* Aiton (Passifloraceae). We also confirm that *A. serpentina* is an oligophagous species with larvae found feeding in four fruit species belonging to the Sapotaceae (see Hernández-Ortiz 1992). Interestingly, *A. hamata* was also found to be an oligophagous species (larvae feed on seeds of 2 plant species belonging to the Sapotaceae).

Even though trapping efforts were made in an extended region of central Veracruz, *A. dentata, A. robusta,* and *A. zuelaniae* were captured only in Apazapan, where the vegetation has been characterized as low deciduous forest. In contrast, adults of *A. canalis* were captured only in Monte Blanco, where the vegetation was originally comprised of montane cloud forest. *Anastrepha limae* was found in both Llano Grande and Monte Blanco. This suggests that the geographic distribution of some *Anastrepha* species is restricted to certain zones, possibly because their host plants are present only in these zones.

We also found that the timing of capture of certain monophagous species coincided with the fruiting periods of their host plants. For example, *A. hamata* and *A. alveata* adults were captured in McPhail traps almost exclusively when their host fruits were available (*P. campechiana* and *C. mexicanum,* and *X. americana,* respectively). In our opinion, this is probably due to an extraordinary capacity of adult survival for long periods of time. Under laboratory conditions, *A. alveata* adults can live up to 431 days (Aluja and Jácome, unpublished data). Such adult longevities probably allow adults to lay eggs in the fruits produced the following year. However, the locations where the adults of such species persist during most of the year are unknown.

Finally, our data on the relationship of fruit size and larval infestation levels represents further evidence that small, wild fruits are more heavily infested than larger, commercially grown fruits that were for the most part, recently (on an evolutionary scale) introduced to the Americas. This relationship was recently discussed by Aluja et al. (2000) who indicated that native flies have probably still not fully developed the ability to metabolize the toxic chemicals that these exotic plants contain. As a result, and despite the fact that females lay many eggs in them, few eggs hatch or most larvae die or develop poorly.

Acknowledgments

We thank Jesús Reyes Flores for having encouraged us to do this study, Vicente Hernández-Ortiz for identifying all fly species reported here, and Isabel Jácome, Anita Sánchez, Braulio Córdoba, Guadalupe Trujillo, Gloria Lagunes, and Anabel Dávila (all Instituto de Ecología, A.C., Xalapa, Veracruz, Mexico) for technical assistance. We also thank Leticia Lagunes, Pedro Córdoba, Augusto Martínez, Faustino Cabrera and the Bigurra-Armida family for allowing us to collect fruits and install McPhail traps in their orchards. Thanks are also due to Carlos Durán, and Sergio Avendaño (Herbarium IXAL, Instituto de Ecología, A.C.) for identifying plant material and to Diana Pérez-Staples for reviewing an early version of the manuscript. Useful critical reviews were also made by A.L. Norrbom and an anonymous referee. Partial financial support was provided by the Consejo Nacional de Ciencia y Tecnología (CONACyT) (Grant D111-903537), the Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) (Grant FB325/H296/96), the United States Department of Agriculture-Agricultural Research Service (Agreement 58-6615-3-025), the Sistema Regional de Investigación del Golfo de México (SIGOLFO) (Grant 96-01-003-V) and the Campaña Nacional Contra las Moscas de la Fruta Mexico Secretaría de Agricultura, Ganadería y Desarrollo Rural—Instituto Interamericano de Cooperación para la Agricultura (SAGAR-IICA).

Literature Cited

Aluja, M. 1994. Bionomics and Management of *Anastrepha.* Annual Review of Entomology 39: 151–174.

Aluja, M., J. Piñero, I. Jácome, F. Díaz-Fleischer, and J. Sivinski. 2000. Behavior of flies in the genus *Anastrepha* (Trypetinae: Toxotrypanini), pp. 375–406. *In* Aluja, M. and A.L. Norrbom, eds., Fruit Flies (Diptera: Tephritidae): Phylogeny and Evolution of Behavior. Boca Raton, FL, USA. CRC Press, 944 pp.

Aluja, M., J. Guillén, G. de la Rosa, M. Cabrera, H. Celedonio-Hurtado, P. Liedo, and J. Hendrichs. 1987. Natural host plant survey of the economically important fruit flies (Diptera: Tephritidae) of Chiapas, Mexico. Florida Entomologist 70: 329–338.

Aluja, M., H. Celedonio-Hurtado, P. Liedo, M. Cabrera, E. Castillo, J. Guillén, and E. Ríos. 1996. Seasonal population fluctuations and ecological implications for management of *Anastrepha* fruit flies (Diptera: Tephritidae) in commercial mango orchards in Southern Mexico. Journal of Economic Entomology 89: 654–667.

Baker, A. C., A. C. Stone, C. C. Plummer, and M. McPhail. 1944. A review of studies on the Mexican fruit fly and related Mexican species. USDA-APHIS Miscellaneous Publication No. 531. 154 pp.

Bush, G. L. 1966. The taxonomy, cytology, and evolution of the genus *Rhagoletis* in North America (Diptera: Tephritidae). Bulletin of the Museum of Comparative Zoology (Harvard University) 134: 431–562.

Castrejón-Ayala, F. and M. Camino-Lavín. 1991. New host plant record for *Toxotrypana curvicauda* (Diptera: Tephritidae). Florida Entomologist 74: 466.

Hernández-Ortiz, V. 1992. El género *Anastrepha* Schiner en México (Diptera: Tephritidae). Taxonomía, distribución y sus plantas hospederas. Instituto de Ecología Publ. No. 33, Xalapa, Veracruz, México, 162 pp.

Hernández-Ortiz, V. and M. Aluja. 1993. Listado de especies del genero neotropical *Anastrepha* (Diptera: Tephritidae) con notas sobre su distribución y plantas hospederas. Folia Entomológica Mexicana 88: 89–105.

Hernández-Ortiz, V. and R. Pérez-Alonso. 1993. The natural host plants of *Anastrepha* (Diptera: Tephritidae) in a tropical rain forest of Mexico. Florida Entomologist 76: 447–460.

Landolt, P. J. 1994. Mating frequency of the papaya fruit fly (Diptera: Tephritidae) with and without host fruit. Florida Entomologist 77: 305–312.

Mason, A. C. 1922. Biology of the papaya fruit fly *Toxotrypana curvicauda* in Florida. U.S. Department of Agriculture Bulletin No. 1081, 10 pp.

Norrbom, A. L. 1998. A revision of the *Anastrepha daciformis* species group (Diptera: Tephritidae). Proceedings of the Entomological Society of Washington 100: 160–192.

———. 2000. Host plant database for *Anastrepha* and *Toxotrypana* (Diptera: Tephritidae: Toxotrypanini), Diptera Data Dissemination Disk 2.

Norrbom, A. L. and K. C. Kim. 1988. A list of the reported host plants of the species of *Anastrepha* (Diptera: Tephritidae). USDA-APHIS Miscellaneous Publication No. 81-52, 114 pp.

Norrbom, A., L. E. Carroll, F. C. Thompson, I. M. White, and A. Freidberg. 1999. Systematic Database of Names, pp. 65–251. *In* Thompson, F. C., ed., Fruit Fly Expert Identification System and Systematic Information Database. Myia 9, 524 pp.

Norrbom, A., R. A. Zucchi and V. Hernández-Ortiz. 2000. Phylogeny of the Genera *Anastrepha* and *Toxotrypana* (Trypetinae: Toxotrypanini) Based on Morphology. pp. 343–362. *In* Aluja, M. and A. Norrbom, eds., Fruit Flies (Diptera: Tephritidae): Phylogeny and Evolution of Behavior. CRC Press. Boca Raton, Florida, 944 p.

Patiño, J. 1989. Determinación de las especies de *Anastrepha* Schiner (Diptera: Tephritidae) en frutales y cítricos de Papantla y Gutiérrez Zamora, Veracruz, Bsc. Thesis, Universidad Veracruzana, Tuxpan, Veracruz, México.

Piedra, E., A. Zúñiga, and M. Aluja. 1993. New host plant and parasitoid record in Mexico for *Anastrepha alveata* Stone (Diptera: Tephritidae) Proceedings of the Entomological Society of Washington 95: 127.

Stone, A. 1939. A new genus of Trypetidae near *Anastrepha* (Diptera). Journal of the Washington Academy of Science 29: 340–350.

USDA, ARS. 2000. National Genetic Resources Program. *Germoplasm Resources Information Network—(GRIN).* [Online Database] National Germplasm Resources Laboratory, Beltsville, Maryland.