

South American Fruit Fly (suggested common name) *Anastrepha fraterculus* (Wiedemann) (Insecta: Diptera: Tephritidae)¹

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Introduction

Anastrepha fraterculus (Wiedemann) is an insect pest commonly referred to as the South American fruit fly, which occurs from the southern United States to Argentina (Figure 1). Recent research has revealed this species to be a complex of at least eight cryptic species (yet unnamed), currently described as morphotypes, rather than a single biological species (Hernández-Ortiz et al. 2004, 2012, 2015).



Figure 1. *Anastrepha fraterculus* (Wiedemann) female laying eggs in a peach.

Credits: Dori Nava, Embrapa Clima Temperado

Overall, the morphotypes in the complex are highly polyphagous with the potential to infest at least 110 host plants, including economically important fruit crops,

such as guava, citrus, and apples (Zucchi 2016). However, depending on their distribution, each fly morphotype may have its own host range, which is still unknown. Uncertainties around the taxonomic status of the complex represent a huge challenge to plant protection authorities (Hendrichs et al. 2015). Because of the economic importance of this group of flies, it is crucial to know which species within the complex are indeed insect pests in order for plant protection authorities to establish quarantine barriers and prevent the introduction of pest species across countries and spread within each country.

Synonymy

The suspicion that *Anastrepha fraterculus* was a complex of multiple species was initially raised by Stone in 1942. Subsequently, the status of cryptic species within *Anastrepha fraterculus* was confirmed by multiple lines of evidences, such as isozymes (enzymes with different amino acid sequences that catalyze the same reactions), karyotypes, molecular cytogenetics, morphometry, chemical profiles, and behavioral studies (Morgante et al. 1980; Steck 1991; Selivon and Perondini 1998; Smith-Caldas et al. 2001; Hernández-Ortiz et al. 2004, 2012, 2015, Selivon et al. 2005; Canal et al. 2015; Vera et al. 2006; Cáceres et al. 2009; Rull et al. 2013; Devescovi et al. 2014; Vanicková et al. 2015; Dias et al. 2016). These cryptic species of the *Anastrepha*

1. This document is EENY-696, one of a series of the Entomology and Nematology Department, UF/IFAS Extension. Original publication date December 2017. Visit the EDIS website at <http://edis.ifas.ufl.edu>. This document is also available on the Featured Creatures website at <http://entomology.ifas.ufl.edu/creatures>.

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fraterculus complex are often called morphotypes, representing groups of similar organisms.

Currently, eight morphotypes are recognized in the Neotropics as part of the nominal species *Anastrepha fraterculus*: Andean, Brazilian-1, Brazilian-2, Brazilian-3, Ecuadorian, Mexican, Peruvian, and Venezuelan morphotypes (Hernández-Ortiz et al. 2004, 2012, 2015). Those eight morphotypes are related to three distinct and directly unrelated phenotypic lineages, Andean, Brazilian, and Meso-Caribbean, suggesting the non-monophyly of the *Anastrepha fraterculus* complex (Hernández-Ortiz et al. 2015). However, to date, all phenotypes from the *Anastrepha fraterculus* complex remain named *Anastrepha fraterculus*.

The following synonyms for *Anastrepha fraterculus* are listed by the Integrated Taxonomic Information System (ITIS 2017):

Dacus fraterculus (Wiedemann 1830) (original designation)

Tephritis mellea (Walker 1837)

Trypeta unicolor (Loew 1862)

Anthomyia frutalis (Weyenbergh 1874)

Anastrepha peruviana (Townsend 1913)

Anastrepha braziliensis (Greene 1934)

Anastrepha costarukmanii (Capoor 1954)

Anastrepha scholae (Capoor 1955)

Anastrepha pseudofraterculus (Capoor 1955)

Anastrepha lambayecae (Korytkowski & Ojeda 1968)

Distribution

Species of the *Anastrepha fraterculus* complex are native to and most common in South America (Argentina, Brazil, Colombia, Ecuador, Peru, Venezuela), but can also be found in Central America (Guatemala, Panama) and North America (Mexico and the United States).

Description

Eggs

In general, the *Anastrepha fraterculus* eggs are creamy white, elongate, averaging 1.35 mm to 1.42 mm, have a conspicuous micropyle (opening for sperm entry) as well as

a short chorionic extension in the egg apex, and are bluntly rounded in the egg end (Figure 2) (Murillo and Jirón 1994; Selivon and Perondini 1998). Eggs from different morphotypes within the *Anastrepha fraterculus* complex may differ in length, position of the micropyle, structure of papilla, pattern of sculpturing of the chorion, size, and number of aepyles (respiratory channels) (Selivon et al. 1997; Selivon and Perondini 1998). Females deposit eggs inside the fruit through sclerotized ovipositors. The eggs hatch into larvae within two days.



Figure 2. Egg morphology of *Anastrepha fraterculus* (Wiedemann), Brazilian-1, in comparison to other *Anastrepha* species. Credits: Vanessa Dias, University of Florida

Larvae

In order for *Anastrepha fraterculus* larvae to reach maturity, they must molt three times. Usually, the first instar occurs from 1 to 3 days old, the second instar from 4 to 6 days old, and the third instar (Figure 3) from 7 to 12 days old (Nieuwenhove and Ovruski 2011). The average body length of the third instar ranges from 8.77 mm to 10.02 mm across morphotypes (Canal et al. 2015). Several larval traits can be used to identify the different morphotypes within the *Anastrepha fraterculus* complex, particularly mandible shape, as shown in Figure 4 (Canal et al. 2015).



Figure 3. Ventral (top) and lateral (bottom) views of the *Anastrepha fraterculus* (Wiedemann) (Brazilian-1) third instar larvae. Credits: Vanessa Dias, University of Florida

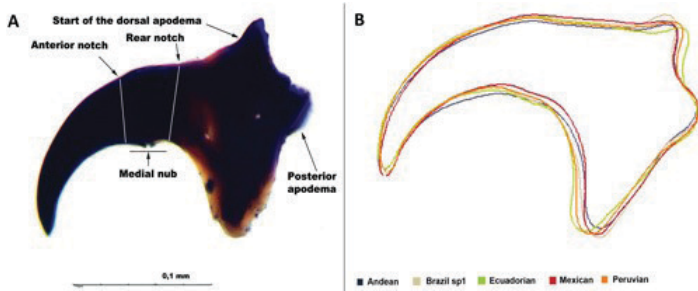


Figure 4. (A) Mouth hook of third instar larva from lateral view. (B) Estimated morphological differences in the shape of mouth hook of five morphotypes of the *Anastrepha fraterculus* (Wiedemann) complex. Credits: Canal et al. (2015), ZooKeys, open access under Creative Commons Attribution License (CC BY 4.0)

Pupae

The pupal stage is inert, but extremely important due to the intensive level of cellular differentiation. Pupae of the *Anastrepha fraterculus* complex are cylindrical and brownish, becoming darker when the insect is fully developed (Figure 5A), but still inside of the pupae as a pharate adult (Figure 5B). In nature, pupae can usually be found buried in the ground. Pupae hatch into adults within two to three weeks.

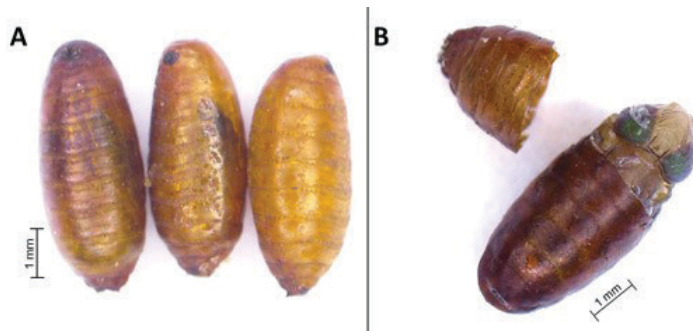


Figure 5. *Anastrepha fraterculus* (Wiedemann) pupae. (A) Pupae of different ages (note change in coloration as pupae age—older one on the left). (B) Puparium with a pharate adult (fully formed fly) inside. Credits: Vanessa Dias, University of Florida

Adults

The adults in the *Anastrepha fraterculus* complex are colorful, usually yellowish brown, ranging from 12 to 14 mm. Although they are highly variable, aspects of wings, genitalia (particularly female genitalia), and thorax (mesonotum) constitute important characteristics to identify the species within the complex (Hernández-Ortiz et al. 2004, 2012, 2015) (Figure 6). According to Greene (1934), *Anastrepha fraterculus* adults can be distinguished from other species of the genus by the shape of the ovipositor (females) and wing pattern. There is no sexual dimorphism, except in the sexual characteristics and size (females are usually larger than males) (Figure 7). For instance, one of the characteristics exclusive to females is the ovipositor, which can measure 2 mm long.

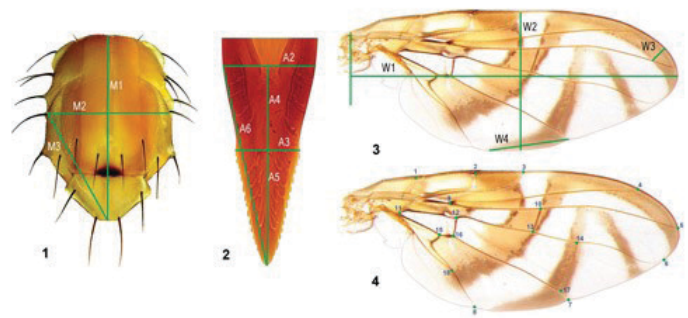


Figure 6. Morphological characteristics used to identify individuals from the *Anastrepha fraterculus* (Wiedemann) complex. 1. Thorax. 2. Aculeus tip (part of the ovipositor). 3 and 4. Multiple measurements from the wings.

Credits: Hernández-Ortiz et al. (2015), ZooKeys, open access under Creative Commons Attribution License (CC BY 4.0)



Figure 7. Female (left) and male (right) of *Anastrepha fraterculus* (Wiedemann). Both specimens are from the Brazilian-1 morphotype. Credits: Vanessa Dias, University of Florida

Sexual behavior of these insects is complex, variable, and very interesting. Males from the *Anastrepha fraterculus* complex exhibit a lek mating system in which calling individuals get together on trees (usually under the leaves) to attract, court, and mate with receptive females (Morgante et al. 1983) (Figure 8).

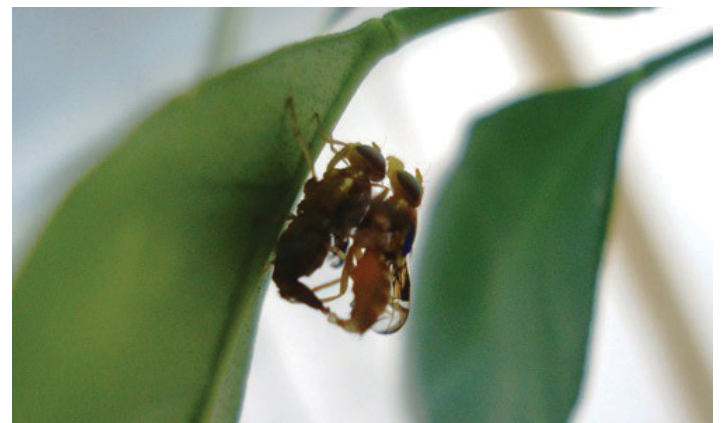


Figure 8. *Anastrepha fraterculus* (Wiedemann) mating. Credits: Vanessa Dias, University of Florida

Multiple signals, such as visual (symmetry of structures), acoustical (buzzing), and chemical (pheromones), are used by males to court females (Segura et al. 2007; Gomez-Cendra et al. 2011; Brizová et al. 2013; Dias et al. 2016) (Figure 9).



Figure 9. Male from the *Anastrepha fraterculus* (Wiedemann) complex releasing pheromone to attract females (see the abdomen tip of the male).

Credits: Vanessa Dias, University of Florida

Hosts

The species within the *Anastrepha fraterculus* complex infest at least 110 host plants, including several families, such as Anacardiaceae, Annonaceae, Myrtaceae, and many others (Zucchi 2016):

<i>Anacardium occidentale</i> , cashew	<i>Mangifera indica</i> , mango
<i>Andira humilis</i>	<i>Manilkara zapota</i> , sapodilla
<i>Annona crassiflora</i> , araticum do cerrado	<i>Marierea edulis</i>
<i>Annona rugulosa</i> , custard apple	<i>Mouriri acutiflora</i>
<i>Averrhoa carambola</i> , starfruit	<i>Mouriri glazioviana</i>
<i>Butia eriopatha</i> , woolly jelly palm	<i>Myrceugenia euosma</i>
<i>Byrsonima</i> , serrettes	<i>Myrcia aff. clauseniana</i>
<i>Campomanesia</i> spp., guavira, white guabiroba	<i>Myrciaria cauliflora</i> , Brazilian grapetree
<i>Carica papaya</i> , papaya	<i>Myrciaria jaboticaba</i> , Brazilian grapetree
<i>Celtis iguanaea</i> , Iguana hackberry	<i>Passiflora edulis</i> , passion fruit
<i>Chrysophyllum gonocarpum</i> , white star apple	<i>Picramnia</i> sp., bitterbush
<i>Cydonia oblonga</i> , common quince	<i>Plinia glomerata</i> , yellow jaboticaba
<i>Citrus aurantifolia</i> , key lime	<i>Plinia strigipes</i>
<i>Citrus aurantium</i> , bitter orange	<i>Pouteria caimito</i> , abiu
<i>Citrus limon</i> , lemon	<i>Pouteria gardneriana</i> , abuai
<i>Citrus maxima</i> , pomelo, jabong	<i>Pouteria ramiflora</i>
<i>Citrus reticulata</i> , tangerine	<i>Prunus avium</i> , wild cherry, sweet cherry, gean

<i>Citrus sinensis</i> , orange or sweet orange	<i>Prunus domestica</i> , plum
<i>Coffea arabica</i> , common coffee	<i>Prunus mume</i> , Chinese plum, Japanese apricot
<i>Coffea canephora</i> , robusta coffee	<i>Prunus persica</i> , peach
<i>Cryptocarya aschersoniana</i>	<i>Prunus sellowii</i> , wild Brazilian peach
<i>Diatenopteryx sorbifolia</i>	<i>Prunus</i> sp., peach
<i>Diospyros kaki</i> , Japanese persimmon, kaki	<i>Psidium araca</i> , wild guava, Brazilian guava
<i>Eriobotrya japonica</i> , loquat	<i>Psidium cattleyanum</i> , strawberry guava
<i>Eugenia brasiliensis</i> , Brazil cherry	<i>Psidium guajava</i> , guava
<i>Eugenia dodoneifolia</i>	<i>Psidium guineense</i> , Brazilian guava, Castilian guava, sour guava, Guinea guava
<i>Eugenia gemminiflora</i>	<i>Psidium kennedyanum</i>
<i>Eugenia involucrata</i> , cherry of the Rio Grande	<i>Psidium myrtoides</i> , araçá-una
<i>Eugenia leitonii</i> , araçá piranga	<i>Psidium sellowiana</i>
<i>Eugenia platyphylla</i>	<i>Punica granatum</i> , pomegranate
<i>Eugenia platysema</i>	<i>Pyrus communis</i> , European pear
<i>Eugenia pyriformis</i> , uvaia	<i>Rollinia aff. sericea</i>
<i>Eugenia schomburgkii</i>	<i>Rollinia emarginata</i>
<i>Eugenia stipitata</i> , araçá, araçá-boi	<i>Rollinia laurifolia</i>
<i>Eugenia uniflora</i> , Surinam cherry	<i>Rollinia sericea</i> , araticum-alvadio
<i>Ficus carica</i> , fig	<i>Rubus</i> sp., raspberries, blackberries, dewberries
<i>Fortunella japonica</i> , round kumquat	<i>Rubus ulmifolius</i> , Elmleaf blackberry
<i>Fragaria ananassa</i> , strawberry	<i>Salacia campestris</i>
<i>Fragaria vesca</i> , strawberry	<i>Simaba guianensis</i>
<i>Garcinia brasiliensis</i> , bakupari	<i>Solanum</i> sp.
<i>Helicostylis</i> sp.	<i>Spondias dulcis</i> , ambarella, jew plum
<i>Inga edulis</i> , ice cream bean, monkey tail	<i>Spondias purpurea</i> , jocote
<i>Inga sellowiana</i> , ingá mirim, ingá da serra	<i>Spondias</i> sp., hog plums, Spanish plums
<i>Jacaratia heptaphylla</i>	<i>Stenocalyx dysentericus</i> , cagaita, cagaiteira
<i>Jambosia</i> sp., rose apple	<i>Syzygium aqueum</i> , watery rose apple
<i>Malpighia emarginata</i> , Barbados cherry	<i>Syzygium jambos</i> , rose apple cherry
<i>Malpighia glabra</i> , Barbados cherry	<i>Syzygium malaccense</i> , Malay rose apple
<i>Malpighia</i> sp., cherries	<i>Terminalia catappa</i> , Indian almond
<i>Malus domestica</i> , apple	<i>Vitis vinifera</i> , grapes
	<i>Ximenia americana</i> , tallow-wood

Economic Importance

Anastrepha fraterculus is an important pest in South America. For instance, attack by females from the Brazilian-1 morphotype to apple orchards in southern Brazil can result in economic losses estimated at US \$110 million (about 5% of the production or approximately 60,000 tons). In the same region, it is estimated that the losses in peaches can reach around 40% of the total production. Grapes can also be attacked, but the larvae cannot complete their development in grapes (Figure 10).



Figure 10. Damage to grapes caused by females of *Anastrepha fraterculus* (Wiedemann) complex.

Credits: Vanessa Dias, University of Florida

Management

Besides pesticides and toxic baits, more environmental friendly techniques can be applied to reduce the population of insects from the *Anastrepha fraterculus* complex. One of those approaches is the Sterile Insect Technique (SIT), a method of control based on the reduction of fertility in a target population through the mating of sterile males (released from the laboratory) and fertile females (wild females from the target pest population) (Lance and McInnis 2005).

The successful implementation of SIT programs depends on correctly understanding species boundaries within the *Anastrepha fraterculus* complex because sexual compatibility is a requirement for the success of the technique (Hendrichs et al. 2015). In addition, biological control and mating disruption are other promising strategies that can be used in integrated pest management programs to control *Anastrepha fraterculus* populations.

Acknowledgements

The authors would like to thank Vicente Hernández-Ortiz, Instituto de Ecología AC—Mexico, Nelson Canal, Universidad del Tolima—Colombia, and Silvana Caravantes, International Atomic Energy Agency, for

reviewing this article and contributing with helpful suggestions.

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