PRA template 3 (accidental introduction of potentially invasive species)

Pest Risk Analysis (PRA) for

Name of organism: *Anastrepha obliqua* (Macquart) (English name)

Territory: Turks & Caicos Islands   Assessment Number: 002/2020

Date: 13/03/2020   Version: 1

PRA type: accidental introduction

All sections should be completed. If not applicable indicate it

Part 1: Initiation

1.1 Summary of assessment results (max. 500 words)

Give a brief summary of the risks of introduction, establishment, spread, impact and overall risk. Fill this part in only after you have completed all the PRA template.

Anastrepha obliqua, a severe pest of Mango and other fruits belonging to the Anacardiaceae, is currently spreading throughout the Caribbean region. There is also the threat that the species will spread more globally throughout tropical and subtropical regions with a suitable climate.

The likelihood of entry into Turks and Caicos over the next few years is likely, because the territory imports mangoes from countries, which have *A. obliqua* and it is often difficult to detect the pest through inspection at the point of entry. It is likely that the pathway with the highest risk of accidentally introducing *A. obliqua* is the fruit trade with the Dominican Republic (DR) and other Caribbean or Central American sources of mango and other fruits. If prevention measures fail, establishment on Turks and Caicos is highly likely, due to very suitable environmental conditions combined with a fast potential spread (owing to the small size of the territory and a high self-dispersal capacity of the pest).

The main anticipated impact of *A. obliqua* invasion on Turks and Caicos is on agriculture, with a predicted loss of locally produced mangoes as well as sapodilla. At present these crops are not established in commercial quantities. Farmers, however, sell whatever fruits are produced themselves or to selected supermarkets. Environmental services may also be affected, to a small degree, due to the possible side effects of predicted pesticide use increase (in order to control *A. obliqua*). This also could result in an increased direct exposure to pesticides.

As no endemic or rare native Anacardiaceae occur on Turks and Caicos, the impact on the environment is predicted to be small, apart from a potential loss of agrobiodiversity in the area with predicted increased pesticide usage.

Biosecurity measures currently in place are likely to be insufficient to prevent the entry of *A. obliqua*. Pre-border restrictions (e.g. reliable phytosanitary measures and certificates regarding any imports from Dominican Republic and other Caribbean countries, where *A. obliqua* is already present) need to be reviewed and put in place. In addition, import permits need to be evaluated continuously based on current risk per country and pest alerts. Further and more detailed inspections at entry points should be encouraged, and additional measures to control the pest such as heat treatments or irradiation need to be considered. If the pest does become established on Turks and Caicos, further control measures should be put in place, including a suitable Integrated Pest Management (IPM) strategy to limit the required increased use of pesticides.

1.2 Assessor details

Institution/Department:
Name and Job Title:

Address:
Phone (office and/or mobile): Email:

Part 2: Background

2.1 Aim of assessment

This section is intended to put the new organism(s) in perspective of the wider activities having led to conducting this PRA (e.g. previous horizon scanning, recent alerts or interceptions); all technical/scientific words must be explained

Anastrepha obliqua is the most important fruit fly pest of mango (*Mangifera indica*) in the Neotropics and attacks a broad range of other fruits. It is widespread in Mexico, Central and South America and the West Indies. It is invasive in the Lesser Antilles and was temporarily established in Key West, Florida, USA. It should be considered a serious threat to other tropical parts of the world, particularly mango-producing regions. It is considered an A1 quarantine pest by EPPO. https://www.cabi.org/isc/datasheet/5659. The species is responsible for a high percentage damage to mangoes, given its preference for this fruit, as well as for fruits of the Anacardiaceae family, like jocote (*Spondias purpurea* L.) and cajá (*Spondias mombin* L.) (Zucchi, 1988 cited in Sa, de, et al. 2011).

2.2 Identity

Identify the organism as fully as possible

Scientific name (incl. taxonomic authority, date): *Anastrepha obliqua* (Macquart)

What is it? (max. 2 sentence description): *A. obliqua* is the most important fruit fly pest of mango in the Neotropics and attacks a broad range of other fruits.

English name(s): West Indian fruit fly; Antillean fruit fly

Family: Tephritidae

Synonyms: *Acrotoxa obliqua* (Macquart); *Anastrepha acidusa* Greene; *Anastrepha ethalea* Greene; *Anastrepha fraterculus* var. *ligata* Costa Lima; *Anastrepha fraterculus* var. *mombinpraeoptans* Seín; *Anastrepha mombinpraeoptans* Seín; *Anastrepha trinidadensis* Greene; *Tephritis obliqua* Macquart; *Trypeta obliqua* (Macquart)

Other taxonomic remarks: This species was first described by Macquart (1835) as *Tephritis obliqua*, although that name was confused and not recognized as pertaining to this species for many years. The species was also described as *Anastrepha fraterculus* var. *mombinpraeoptans* Seín, *Anastrepha fraterculus* var. *ligata* Lima, and *Anastrepha trinidadensis* Greene. Most records of *Anastrepha acidusa* (Walker) are misidentifications of this species.

2.3 Images of the species if available

If available, please provide pictures of different stages and habitats

Figure 1:

Figure 2:

2.4 Existence of PRAs for this species

Please indicate if PRAs for this species already exist and which target areas and climatic conditions these cover (for suggestions of websites to check see guidance notes (e.g. DoA Australia))

We couldn't find any PRA for this species covering specific regions or countries. However, a number of factsheets exist providing detailed information such as Weems et al. 2012: http://entnemdept.ufl.edu/creatures/fruit/tropical/west_indian_fruit_fly.htm and the datasheet for in the CABI Invasive Species Compendium: https://www.cabi.org/isc/datasheet/5659.

2.4 Biology/Ecology

Please provide background information relevant to your application covering the bullet points in box below whenever applicable; see also guidance notes

- Growth form and size: The adults of *A. obliqua* are easily separated from those of other tephritid genera by a simple wing venation character; vein M, the vein that reaches the wing margin just behind the wing apex, curves forwards before joining the wing margin. Furthermore, most *Anastrepha* spp. have a very characteristic wing pattern; the apical half of the wing has two inverted 'V'-shaped markings, one fitting within the other; and a stripe along the forward edge of the wing, which runs from near the wing base to about half-way along the wing length. Identification to species is more difficult. In particular, for positive identification it is essential to dissect the aculeus (the distal, piercing part of the ovipositor that is normally retracted into the oviscape) of a female specimen. *A. obliqua* adults are difficult to separate from those of *A. fraterculus, A. sororcula, A. zenildae, A turpiniae*, *A. suspensa* and several other species of the *fraterculus* group; if necessary, specimens should be referred to a specialist. The body is predominantly yellow to orange-brown, and the setae are red-brown to dark-brown. Head: yellow except ocellar tubercle brown. Facial carina, in profile, concave. Frons with three or more frontal setae, two orbital setae. Antenna not extended to ventral facial margin. Thorax: mostly yellow to orange-brown, with the following areas yellow to white and often contrasting: postpronotal lobe; single medial and paired sublateral vittae on scutum, the slender medial vitta extended nearly the full length of the scutum, slightly broadened posteriorly, ovoid; sublateral vitta extended from transverse suture almost to posterior margin, including intra-alar seta; scutellum; propleuron; dorsal margin of anepisternum; dorsal margin of katepisternum; katepimeron; and most of anatergite and katatergite. Area bordering scutoscutellar suture medially without dark-brown spot. Subscutellum without dark markings; mediotergite usually dark-brown laterally. Scutum entirely microtrichose or at most with small presutural, medial bare area. Wing: 5.7-7.5 mm long. Vein M strongly curved apically. Vein R2+3 nearly straight. Pattern mostly orange-brown and moderate-brown. C-band and S-band usually connected along vein R4+5, but sometimes separated; marginal hyaline spot (or end of band) present in cell r1 at apex of vein R4+5. S-band with middle section between costa and vein Cu1 largely yellow to orange with narrow brown margins, darkening distally; distal section of band moderately broad, well-separated from apex of vein M. V-band with distal arm complete and connected to proximal arm; proximal arm extended to vein R4+5, sometimes connected to S-band. Abdomen: tergites yellow to orange-brown, without dark-brown markings. Male terminalia: lateral surstylus moderately long, in posterior view slightly tapered, somewhat truncate apically. Phallus 2.3–2.7 mm long; ratio to mesonotum length 0.8-0.9. Glans with basolateral membranous lobe, mostly membranous medially, with isolated, T-shaped apical sclerite. Female terminalia: oviscape straight, 1.6-1.9 mm long; ratio to mesonotum length 0.53-0.61 mm. Dorsobasal scales of eversible membrane numerous, hook-like, in triangular pattern. Aculeus length 1.30-1.65 mm; tip 0.16-0.21 mm long, 0.08-0.12 mm wide, gradually tapering, but with slight constriction proximal to serrate part, distal 0.67-0.82 mm serrate. Three spermathecae ovoid.

  Immature Stages: It is very difficult, and in some cases impossible to identify larvae of *Anastrepha* species from morphological characteristics. The key by Steck et al. (1990) and the interactive key by Carroll et al. (2004) are the best tools for larval identification. Descriptions of *A. obliqua* larvae are provided by Berg (1979), Steck et al. (1990) and White and Elson-Harris (1994). White and Elson-Harris (1994) described the third-instar larva as follows: Larvae: medium-sized; 7.5-9.0 mm long; 1.4-1.8 mm wide. Head: stomal sensory organ rounded, only slightly protuberant, with two to three very small sensilla; 7-10 oral ridges; accessory plates small; mandible moderately to heavily sclerotised, with a large slender curved apical tooth. Thoracic and abdominal segments: T1 with a broad anterior band of 5-10 discontinuous rows of small, sharply pointed spinules; T2 and T3 with two to five rows of spinules. Dorsal spinules absent from A1-A8. Creeping welts on A1-A8 with 7-11 rows of stout spinules. A8 with large dorsal tubercles and stout sensilla; intermediate areas well-developed with obvious sensilla; ventral sensilla small, but well defined. Anterior spiracles: with 12-16 tubules. Posterior spiracles: spiracular slits about three times as long as broad, with heavily sclerotised, dark-brown rimae. Spiracular hairs in dorsal and ventral bundles of 10-16 stout hairs branched in apical third; lateral bundles of three to six hairs similarly branched. Anal area: lobes very large, protuberant, not grooved; surrounded by two to five discontinuous rows of small, sharp spinules. Egg: the eggs of *A. obliqua* bear a conspicuous lobe on the anterior (micropyle) end, which projects outside the fruit peel and is believed to aid in respiration (Murillo & Jiron, 1994). This lobe is lacking in related species, thus eggs inside the abdomens of gravid females can provide a useful diagnostic character for this species (source of information: https://www.cabi.org/isc/datasheet/5659).

- Habitat: Cultivated and agricultural land; managed forests, plantations and orchards; disturbed areas; urban/peri-urban areas; natural/semi-natural forests (source of information: https://www.cabi.org/isc/datasheet/5659).
- Lifecycle (e.g. reproduction and dispersal): The eggs are laid singly, below the skin of the host fruit. The larvae hatch within 3-12 days and feed for another 15-32 days. Pupariation is in the soil under the host plant and the adults emerge after 15-19 days (longer in cool conditions); the adults occur throughout the year (Christenson & Foote, 1960), with little seasonal variation (Hedström, 1993) (source of information: https://www.cabi.org/isc/datasheet/5659). The preoviposition period in Puerto Rico varies from about a week in summer up to two to three weeks in winter. Eggs are laid singly, generally in mature green fruits except for some varieties of mangoes which may be attacked when they are very small. The larval stage lasts 10 to 13 days in summer, slightly longer in winter, and the pupal stage occupies about the same length of time. Possibly six or seven generations develop annually (http://entnemdept.ufl.edu/creatures/fruit/tropical/west_indian_fruit_fly.htm).
- Hosts: The main native hosts are *Spondias* spp. (Anacardiaceae), but these are only of local interest. Mangoes (*Mangifera indica*), also Anacardiaceae, are the economically important host, on which the species has extended its range (Hernandez-Ortiz, 1992). *Citrus* spp. and guavas (*Psidium guajava*) are only occasional hosts. Like other *Anastrepha* spp., *A. obliqua* has been recorded incidentally on a wider range of fruits, both tropical and temperate, but these records are incidental occurrences, of no economic significance. In common with other polyphagous and difficult to identify species, many host records cannot be substantiated and only records confirmed by Norrbom and Kim (1988) or subsequent reliable sources have been accepted here. Post 1988 records include *Eugenia stipitata* (Couturier et al., 1996) (source of information: https://www.cabi.org/isc/datasheet/5659).
Listed hosts are: *Ampelocera hottlei* Ulmaceae; *Anacardium occidentale* (cashew nut) Anacardiaceae; *Averrhoa carambola* (carambola) Oxalidaceae; *Brosimum alicastrum* (breadnut) Moraceae; *Citrus* Rutaceae; *Citrus aurantium* (sour orange) Rutaceae; *Citrus limetta* (sweet lemon tree) Rutaceae; *Citrus sinensis* (navel orange) Rutaceae; *Citrus x paradisi* (grapefruit) Rutaceae; *Coffea arabica* (arabica coffee) Rubiaceae; *Diospyros ebenaster* (black sapote) Ebenaceae; *Eriobotrya japonica* (loquat) Rosaceae; *Malpighia glabra* (acerola) Malpighiaceae; *Mangifera indica* (mango) Anacardiaceae (main host); *Manilkara zapota* (sapodilla) Sapotaceae; *Passiflora quadrangularis* (giant granadilla) Passifloraceae; *Pouteria sapota* (mammey sapote) Sapotaceae; *Pouteria viridis* (green sapote) Sapotaceae; *Prunus dulcis* (almond) Rosaceae; *Prunus salicina* (Japanese plum) Rosaceae; *Psidium guajava* (guava) Myrtaceae; *Pyrus communis* (European pear) Rosaceae; *Spondias* (purple mombin) Anacardiaceae (main host); *Spondias dulcis* (otaheite apple) Anacardiaceae; *Spondias mombin* (hog plum) Anacardiaceae; *Spondias purpurea* (red mombin) Anacardiaceae; *Spondias tuberosa* Anacardiaceae; *Syzygium jambos* (rose apple) Myrtaceae; *Syzygium malaccense* (Malay apple) Myrtaceae; *Ziziphus joazeiro* Rhamnaceae (listed here as main host) (source of information: https://www.cabi.org/isc/datasheet/5659).
- Host specificity: Although recorded from a wide range of plants, little is known about the ability to fully develop and maintain populations on these plants. For example, the species can develop in grapefruit but shows much higher mortality rates in this species compared to other fruit flies (Mangan et al. 2011). Otherwise the species seems to be restricted to Anacardiaceae (*Mangifera* and *Spondias*) but also Rhamnaceae (*Ziziphus*).
- Associated pathogens, pests or parasites: see section on biological control below.
- Other: The adults of *A. obliqua* are difficult to separate from those of various other species of the *fraterculus* group, such as the *A. fraterculus* complex, *A. sororcula, A. zenildae*, *A. turpiniae* and *A. suspensa*. The females can be distinguished by the dimensions and shape of the aculeus, particularly its tip, which is two-thirds to three-fourths serrate. The adults lack the dark-brown spot on the scutoscutellar suture and lateral dark-brown mark on the subscutellum that are usually present in the above species. The larvae of *Anastrepha* are extremely difficult to identify and specialist help should be sought to confirm critical identifications. The third-instar larvae are very similar to those of *A. suspensa* and the *A. fraterculus* complex, and these species usually cannot be distinguished (Steck et al., 1990) (source of information: https://www.cabi.org/isc/datasheet/5659). More help for identification is provided by: http://entnemdept.ufl.edu/creatures/fruit/tropical/west_indian_fruit_fly.htm).

2.5 What is the current distribution of the species

Consider: native range, history of introduction and invasion outside native range

A. obliqua is known from Mexico south to northern Argentina, and from most of the West Indies. Its original native range is obscure. It is the only species of *Anastrepha* widespread in both the West Indies and the mainland. Although commonly known as the West Indian fruit fly, the original range of *A. obliqua* in the Antilles is uncertain, and in at least some of the Lesser Antilles (Antigua and Barbuda, Barbados, Dominica, Grenada, Guadeloupe, Martinique, Montserrat, Netherlands Antilles, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines) it is an invasive species. It was originally described from Cuba and at least has long been present in the Greater Antilles. Its current distribution on the mainland and the Greater Antilles is presumed to be natural, but could have been affected by human activities (https://www.cabi.org/isc/datasheet/5659).
Within the Lesser Antilles, Kisliuk and Cooley (1933) reported it (as *Anastrepha acidusa*) from Dominica, Martinique, Nevis, St. Kitts, St. Lucia, Trinidad and the Virgin Islands. They reported *Anastrepha* larvae (presumably of *A. obliqua*), but did not rear adults from Guadeloupe. They did not find it in Antigua, the Bahamas, Barbados, and St. Vincent. A survey from 1988-1990 confirmed its presence in Dominica and St. Lucia. It has been present in Barbados since 2001, in Grenada since 2002, and in St. Vincent since 2002. White and Elson-Harris (1992) reported it from the Bahamas, but the basis for that record is unclear and it is probably erroneous as *A. obliqua* has not been collected in extensive trapping in the last decade of the 20th century. Reports of its introduction to Bermuda were erroneous (Woodley & Hilburn, 1994). It was established in southern Florida, USA (Key West) from 1930-1936 (McAlister, 1936), but there is no evidence of a breeding population being present since then (Steck, 2001). It has been trapped in California and Texas, USA, but is not established there (source of information: https://www.cabi.org/isc/datasheet/5659).

Part 3: Risk of accidental introduction, establishment and spread

3.1 Probability of entry/introduction

3.1.1 Has the species been introduced into other countries and/or have multiple introductions been reported

EPPO lists *A. obliqua* as an A1 quarantine pest (OEPP/EPPO, 1983) within the broad category 'non-European Trypetidae'; it is also of quarantine significance to APPPC, CPPC and NAPPO. For the recent introductions to any Caribbean Island, where the species is not native the cause of arrival is stated as accidental, presumably through transport of infested fruit (https://www.cabi.org/isc/datasheet/5659). *A. obliqua* has been proven to be invasive outside its native range and its invasiveness is considered to be high based on a broad native range, being abundant and a habitat generalist in its native range, and tolerating, or benefitting from, cultivation, browsing pressure, mutilation, fire etc. *A. obliqua* also has high reproductive potential and high genetic variability (https://www.cabi.org/isc/datasheet/5659).

3.1.2 Has the species been intercepted in the territory in the past Please, check existing interception data in the territory

For the past 5 years, there has been numerous confiscations of fruit fly larva in mangoes intercepted at the Providenciales International Airport as well as at the South Dock Port. The larvae were found in west Indian Cherries, Mangoes and guava. Most of the interception are found in mangoes shipped from Haiti, Dominican Republic and Jamaica (greater to lesser interception). Mango season begins around April to September and each year sees in excess on 5000kg of mangoes being confiscated for signs of fruit fly infestation (evidence of oviposition markings and the presence of larvae). Fruit fly larvae were reared in 2018 and 2019 respectively. The 2018 sample was taken from a mango with larvae from Haiti and 2019 sample was from mango originating from the Dominican Republic.

3.1.3 What are the likely pathways for the accidental introduction of the species?

Consider whether the species or some of its life-stages can easily be overlooked?

Crop production is the main cause for the pathways associated with *A. obliqua* with fruits, incl. pods (eggs; larvae; pupae) and growing medium accompanying plants (larvae; pupae) providing the substrate infected with various stages of the pest. In international trade, the major means of dispersal to previously uninfested areas is the transport of fruits containing live larvae. Globally, the most important fruits liable to carry *A. obliqua* are mango (*Mangifera indica*), and to a lesser extent *Citrus* spp. and guava (*Psidium guajava*) (https://www.cabi.org/isc/datasheet/5659). However, *A. obliqua* has a low likelihood of infesting *Citrus* spp., based on the scientific literature, APHIS interception records, and identification of larvae in fruits from Mexico intercepted by APHIS at Texas and California border stations between 2001-2004. APHIS concludes that there is a low likelihood of *Citrus* spp. being a host and *A. obliqua* being in the pathway of commercial *Citru*s spp. "Sweet orange, *Citrus sinensis*"; "grapefruit, *Citrus paradisi*"; "sweet lime, *Citrus aurantifolia*", and "sour orange, *Citrus aurantium*" should be removed as regulated hosts of *A. obliqua* for the USA (Hennessey & Miller 2004). However, considering its host range within the Caribbean, aside from the accidental import of the pest through imported mangoes, some local products such as jocote (red mombin, purple mombin, hog plum) (*Spondias purpurea* L.) and cajá (*Spondias mombin* L.) need to be considered as well. There is also a risk from the transport of puparia in soil or packaging with plants that have already fruited (https://www.cabi.org/isc/datasheet/5659).

Other likely pathways are:

- Aircraft: Immatures in fruit (long distance and local dispersal)
- Clothing, footwear and possessions: Fruit in case or handbag (long distance)
- Containers and packaging – wood: Of fruit cargo, in particular boxes and baskets (long distance)
- Vehicles: Aeroplanes and boats, with fruit cargo (long distance)
- Luggage: Immatures in fruit (long distance and local dispersal)
- Mail: Fruit in post (long distance)
- Plants or parts of plants: Immatures in fruit (long distance and local dispersal)
- Soil, sand and gravel: Risk of puparia in soil (long distance)

3.1.4 What is the probability of the pest being associated with the pathway(s) at origin?

Please give any information available about: prevalence of pest in the source area; occurrence of life stage able to associate with consignment; volume and frequency of movement along the pathway; seasonal timing; pest management procedures applied at place of origin; for definition of probability see guidance notes 3.1.

Globally, it is highly likely that the West Indian fruit fly is being transported internationally both accidentally and illegally (https://www.cabi.org/isc/datasheet/5659). The probability that the pest is associated with fruits imports into Turks and Caicos (TCI) is equally high. TCI imports mangoes and other fruits, which can be hosts to *A. obliqua*, such as West Indian cherries (*Malpighia emarginata*), guava (*Psidium guajava*), june plum /golden apple (*Spondias dulcis)* and *chayote* (*Spondias mombin*), from a number of countries already invaded by the pest or where the pest is considered to be native. A proportion of these imports are small consignments through small scale importers, sometimes bypassing regulated import channels. It can be assumed that some of these imports are from smallholder farms without adequate fruit fly management measures increasing the likelihood of infection. There are also large consignments of mangoes from Haiti and Dominican Republic that were accompanied by phytosanitary Certificates. Both countries have *Anastrepha* species present. Although symptoms caused by the pest are usually visible to the naked eye it is often difficult to detect infections through border inspections.

3.1.5 What is the probability of the pest surviving during transport?

Consider: speed and conditions of transport; duration and vulnerability of life cycle; previous interceptions of the pest; prevalence of pest; commercial procedures during transport (e.g. refrigeration)

No detailed information is currently available, but the species must be able to survive average transport conditions for its hosts as its high invasiveness has proven. It can be assumed that the time scale of survival is similar to the survival rate of the transported fruits. No information on mortality during refrigerated transport is available, but *A. obliqua* has been intercepted in France on mangoes from Mexico (https://www.cabi.org/isc/datasheet/5659).

3.1.6 What is the probability of the pest evading existing biosecurity procedures? **Consider:** inspection methods and quality control; certification schemes; chemical treatment

Although symptoms can be spotted with the naked eye it is thought that that the species is difficult to identify/detect as a commodity contaminant (https://www.cabi.org/isc/datasheet/5659).

3.1.7 What is the probability of transfer from entry point to a suitable host or habitat? **Consider:** dispersal mechanisms, including vectors; number of destinations; proximity to suitable hosts; seasonality

There is evidence that the adults of *Anastrepha* spp. can fly as far as 135 km (Fletcher, 1989) and therefore spread from the entry point to any mango tree present on the island where the entry point is located within TCI (https://www.cabi.org/isc/datasheet/5659). Spread to other islands over this distance is possible but less likely. Although individual flies can cover apparently large distances the mean dispersal is generally much shorter and is estimated for *A. obliqua* as 70 to 90 m (Utges et al., 2013). Results from the same study give a median survival time for *A. obliqua* flies released seven days after emergence as 4.5 days (i.e. 11.5 days after emergence) (Utges et al., 2013).

Summary probability of accidental introduction ~~entry~~

Probability of introduction in next 10 years	Very unlikely ☐	Unlikely ☐	Moderately likely ☐	Likely☒	Very likely ☐
Confidence	High confidence ☒	Medium confidence ☐	Low confidence ☐		

3.2 Probability of establishment

3.2.1 Does the territory provide suitable climatic and habitat conditions for the species to **survive** and **reproduce** under natural conditions unassisted or without human interference (e.g. cultivation, gardens)? **Consider:** climate similarity between the species global range and the PRA area, availability of the habitat conditions required by the species based on its behaviour elsewhere; identify/name specifically the climate/habitat it might survive? Which land-cover? Justify why and provide landmarks as examples; for definition of human interference see guidance notes 3.2.1

- Survival: *A. obliqua* is likely to survive in most parts of TCI all year round
- Reproduction (self-sustaining population): The organism may multiply both outdoors and indoors in all parts of TCI all year round. Recently, *A. obliqua* has spread over a wide geographical area in a very short time period, indicating a high ability to reproduce under a relatively wide range of climatic conditions.

3.2.2 How likely can the species survive and reproduce indoors or in similar habitats (e.g. polytunnels, gardens, urban area)? **Consider:** availability of the habitat conditions required by the species based on its behaviour elsewhere; identify/name specifically the conditions it might survive?

- Survival: Survival under indoor conditions is likely but not of significant concern for TCI where the host species are not grown under cover.
- Reproduction (self-sustaining population): Reproduction under indoor conditions is likely but not of significant concern for TCI where the host species are not grown under cover.

3.2.3 (**only for pests and diseases**) If hosts or vectors are required, are these available in the PRA area? **Consider:** abundance of hosts and alternate hosts or vectors and how these are distributed in the PRA area; geographic proximity of hosts to pathway destinations; presence of other suitable species that could be new hosts; compare the known distribution of the pest with ecoclimatic zones in the PRA area; soil factors for soilborne pests; survival strategies; survival in protected cultivation

n.a.

Summary probability of establishment

Probability of establishment in the wild	Very unlikely ☐	Unlikely ☐	Moderately likely ☐	Likely ☐	Very likely ☒
Confidence	High confidence ☒	Medium confidence ☐	Low confidence ☐		

3.3 Probability of spread

3.3.1 What is the potential spread in the territory? **Consider:** rate and distance of spread elsewhere; natural barriers in PRA area, the occurrence of a dispersal vector or commodity; see also guidance notes 3.3.1

- Self-dispersal: There is evidence that the adults of *Anastrepha* spp. can fly as far as 135 km (Fletcher, 1989) and therefore natural movement is an important means of spread (https://www.cabi.org/isc/datasheet/5659).
- Direct transport by humans: Transport of infected fruits is highly likely
- Transport via vehicles (e.g. boat, cars, including tyres): There is a risk from the transport of puparia in soil or packaging with plants that have already fruited (https://www.cabi.org/isc/datasheet/5659). However, this is less likely compared with the transport of infected fruits.
- Wind drift or via driftwood: Yes, via wind drift
- Water: No
- Transport via animals (e.g. berries digested by birds, seeds stuck to wool, etc.): Unlikely
- Transport with vectors: No
- Other: None recognised at this stage
- How rapidly would the organism spread by natural means? See self-dispersal

Summary probability of spread

How quickly can the species spread (excluding deliberately assisted by humans)	Less than 10 m/year. Can't occupy suitable habitats within next 100 years Very slowly ☐	Between 10 and 100 m per year. Suitable habitats are likely to be occupied between 50 and 100 years Slowly ☐	Between 100 and 500 m per year. Suitable habitats are likely to be occupied between 50 and 100 years Moderate pace ☐	> 500 m per year Can occupy suitable habits throughout the territory within 5 to 20 years Quickly ☐	Can occupy suitable habits throughout the territory within 5 years Very quickly ☒
Confidence	High confidence ☒	Medium confidence ☐	Low confidence ☐		

Part 4: Economic and environmental risks

It is important to look at the potential magnitude of the consequences, and to look at distribution effects (who bears risks). Consider potential maximum impact.

Please, **complete this section referencing supporting material**. Please, cite the material in the text and provide a description of where the information in the application has been sourced in the list of references (e.g. from in-house research, independent research, technical literature, community or other consultation, and provide that information with this application). If the information available is scarce, include information about related species (e.g. same genus or family) clearly indicating that it does not correspond to the organism being assessed.

4.1 Risks recorded from outside the territory, which are applicable to the territory

4.1.1 Is the species listed in the following Plant Protection organizations and Invasive lists and if so, what is its status?

America
COSAVE: yes/no; not able to open website
NAPPO: yes/~~no;~~ it is of quarantine significance to NAPPO
OIRSA: ~~yes~~/no
Europe
EPPO: yes/~~no;~~ EPPO lists *A. obliqua* as an A1 quarantine pest (OEPP/EPPO, 1983) within the broad category 'non-European Trypetidae';
EC Plant Health Directive (Council Directive 2000/29/EC): yes/no
Africa
ARC: yes/no; website not fully functional
Others:
CABI CPC: full data sheet
CABI ISC: full data sheet
GISD: no
Other organizations relevant for the territory (e.g. regional, national…): *A. obliqua* it is of quarantine significance to APPPC and CPPC

4.1.2 Is there any negative impact of the species on the economy, environment or public health recorded from any parts of its current distribution? Please provide a summary of the available information

Anastrepha spp. are the most serious fruit fly pests in the tropical Americas (Norrbom & Foote, 1989), with the possible exception of the introduced *Ceratitis capitata* (EPPO/CABI, 1996). *A. obliqua* is recorded from *Citrus* spp., but they are not important hosts (Enkerlin et al., 1989). *A. obliqua* mainly attacks mangoes (*Mangifera indica*) and other Anacardiaceae (Whervin, 1974, https://www.cabi.org/isc/datasheet/5659). The West Indian fruit fly is the main fruit fly species that attacks mango fruits in commercial orchards at low altitudes in Mexico (Aluja et al., 1987, 1996). Here, this fly has the second greatest economic impact among all species belonging to the *Anastrepha* genus (Reyes et al., 2000). In summary, *A. obliqua* is considered to be one of the most important pests throughout the Americas. With the potential to spread much further globally, enhanced quarantine and monitoring measures should be implemented in areas that are projected to be suitable for the establishment of the pest under current and future climatic conditions (Fu et al., 2013).

4.2 Economic and socioeconomic effects

4.2.1 Could the species have any negative effect on economic activities in the territory? Please include any information about specific assessments from areas outside the PRA area including experiences with closely related species with relevance for the area of interest (**consider:** reduction in crop yield or quality; reduction in prices or demand, including export markets; increase in production costs (including costs of control); vectoring of other pests of economic importance; extent of phytosanitary regulations imposed by importing countries)

- Agriculture: yes Invasion by *A. obliqua* to TCI can be predicted to impact on the local production of mangoes and related fruits. Although there are no mango plantations on any of the islands some residents have one or two mango trees on their property. It is currently not a popular plant on islands thus the large importation of the fruits. Sapadilla is grown on the Island of North Caicos which does not have a main port. Persons/ cargo going to North Caicos have to pass through Providenciales (the main ports) then cross by ferry or Grand Turk (the Capital) by aircraft. Apart from reduced yield the quality of produced fruits would deteriorate significantly and such fruits would lack marketability. De-fruiting of trees will result in growers not having fruits for consumption or whatever means of fruit utilisation. Measures to control *A. obliqua* cause additional costs. Conducting fruit fly surveillance will be costly and very time consuming. Residents will also have to give permission for fruit fly traps to be placed on their properties where host trees are present.
- Livestock: no
- Fisheries: no
- Aquaculture: no
- Forestry: no
- Tourism: no
- Recreational potential: no

- Infrastructure: no
- Employment rates: yes; people employed in production, marketing and sale of locally produced mangoes and other fruits are at risk of losing their jobs and livelihoods. Also, persons who make their living from the sale of imported regulated articles including mangoes may experience reduced income due to restriction that are placed on the importation of mangoes.
- Other: not at this stage

4.2.2 Are there any risks of impacts on cultural valuable species, habitats, landscapes, practices or other values? Please include any information about specific assessments from areas outside the PRA area including experiences with closely related species with relevance for the area of interest

- Competition with or impact on cultural valuable species: no
- Impact on historically valuable practices: no
- Change of landscape: no
- Value of landscape for recreation: no
- Other: not at this stage

Summary economic and socioeconomic impacts

Make sure the summary score is well linked with the information reported above so the scoring is fully justified (for more information risk levels see guidance notes)

Risk of socioeconomic impact	Very small ☐	Small ☐	Medium ☐	Large ☒	Very large ☐
Confidence	High confidence ☒	Medium confidence ☐	Low confidence ☐		

4.3 Impact on public health

4.3.1 Could there be any impact on public health? **Consider:** Can the species be disease-causing or be a parasite, or be a vector or reservoir for human diseases?

There could be some impact on public health to increased exposure to an increased use of pesticides to control the pest.

Summary public health impact

Risk of impact on public health	Very small ☐	Small ☒	Medium ☐	Large ☐	Very large ☐
Confidence	High confidence ☒	Medium confidence ☐	Low confidence ☐		

4.4 Impact on animal health

Could there be any impact on animal health? **Consider:** Can the species be disease-causing or be a parasite, or be a vector or reservoir for animals?

no

Summary animal health impact

Risk of impact on animal health	Very small ☒	Small ☐	Medium ☐	Large ☐	Very large ☐
Confidence	High confidence ☒	Medium confidence ☐	Low confidence ☐		

4.5. Environmental and ecosystem effects

4.5.1 Are there any threats to native or endemic species? Indicate direct effects on native species; note any aspects related to pollination of native species should be covered in the following question (**consider**: threat to endangered species; impact on keystone species; changed community structure; hybridization with native species)

There is no record of native species that can be affected by the *A. obliqua*.

4.5.2 What is the level of potential negative impact on ecosystem services in the PRA area? (**consider**: provisioning services (freshwater, wood and fibre, fuel); regulating services (soil formation, natural hazards, water and air quality); cultural services (aesthetic, educational, recreational, spiritual); supporting services (nutrient cycling, habitat stability; pollination) see also guidance notes 4.5.2

Although an introduced population of *A. obliqua* may have some follow-on effects on other species (e.g. additional prey for native or invasive insectivores) overall these can be considered negligible. Equally, impacts on agrobiodiversity and/or water supplies through increased use of pesticides to control *A. obliqua*.are most likely negligible since the number of mango trees on the islands in very small- just a few residents have a mango tree.

Summary environmental impact

Risk of environmental impact	Very small ☐	Small ☒	Medium ☒	Large ☐	Very large ☐
Confidence	High confidence ☐	Medium confidence ☒	Low confidence ☒		

Part 5: Pest risk management

5.1 Prevention

5.1.1 Which measures **already** in place are suitable to minimise the risk of introduction and establishment **Consider**: inspection of commodities; trapping, disrupting specific pathways, etc.

- **Pre-border:** Although *A. obliqua* is difficult to identify/detect in the field (https://www.cabi.org/isc/datasheet/5659), importers have to inspect mangoes and other fruits prior to shipment and issue phytosanitary certificates. However, passengers with smaller quantities do not get fruits inspected before importing. There are unaccompanied bags and commercial quantities of mangoes that are transported by air and the pre- border checks are uncertain (particularly from Haiti, Dominican Republic and Jamaica to a lesser extent)
- **At the border:** Attacked fruit can show signs of oviposition punctures, but these, or any other symptoms of damage, are often difficult to detect in the early stages of infestation. Much damage may occur inside the fruit before external symptoms are seen, often as networks of tunnels accompanied by rotting. Very sweet fruits may produce a sugary exudate. The adults of *A. obliqua* are difficult to separate from those of various other species of the *fraterculus* group. The females can be distinguished by the dimensions and shape of the aculeus, particularly its tip, which is two-thirds to three-fourths serrate. The adults lack the dark-brown spot on the scutoscutellar suture and lateral dark-brown mark on the subscutellum that are usually present in the above species. The larvae of *Anastrepha* are extremely difficult to identify and specialist help should be sought to confirm critical identifications. More help for identification is provided by: http://entnemdept.ufl.edu/creatures/fruit/tropical/west_indian_fruit_fly.htm
  Fruits are examined for signs of oviposition markings, exit holes (larvae may have emerged) or signs of larva on fruits or in/on the containers. Ripe and green fruits are cut open just beneath the skin to look for the presence of larvae or feeding tunnels. At present, there are no active trapping programmes in place. There is only active inspection process at the borders. Fruits showing signs of oviposition marking, exit holes or the presence of larvae on the fruit or container are confiscated, destroyed and buried.
- **Post-border:** Away from the border inspection is not done presently due to shortage of human resources

5.1.2 Which measures **not yet** in place are suitable to minimise the risk of introduction and establishment **Consider**: inspection of commodities; trapping, disrupting specific pathways, etc.

- **Pre-border:** Prior to shipment, consignments of fruits of *Citrus* spp., mango (*Mangifera indica*) and guava (*Psidium guajava*) from countries where *A. obliqua* occurs should be inspected for symptoms of infestation. Those suspected should be cut open in order to look for larvae (https://www.cabi.org/isc/datasheet/5659).
  EPPO (OEPP/EPPO, 1990) recommends that such fruits should come from an area where *A. obliqua* does not occur or from a place of production found free from the pest by regular inspection for 3 months prior to harvest. Fruits may also be treated in transit by cold treatment (for example, 13, 15 or 17 days at 0.5, 1 or 1.5°C, respectively) or, for certain types of fruits, by vapour heat (for example, keeping at 43°C for 4-6 h) (USDA, 1994), or by hot water immersion (Nascimento et al., 1992; Thomas and Mangan, 1995) or forced hot air quarantine treatment. The efficiency of a hot-air quarantine treatment for mangoes against *A. obliqua* (EPPO A1 pest) was investigated in Texas, US. Mangoes infested by larvae of the pest were subjected to a forced hot air treatment with a running air temperature of 50°C at a speed of 0,4 m3s-1. The mangoes were heated until the seed surface temperature reached 48°C. No surviving larvae of the pest were found after this treatment and probit 9 (99,9968% mortality) was achieved (Mangan & Ingle, 1992). The hot air treatment did not affect quality and appearance of the treated mangoes (Mangan & Ingle, 1992). Ethylene dibromide was previously widely used as a fumigant, but is now generally withdrawn because of its carcinogenicity (https://www.cabi.org/isc/datasheet/5659).
  Irradiation can be used as a quarantine treatment against fruit flies, in particular against *A. ludens* and *A. obliqua* (both EPPO A1 quarantine pests) on citrus. The currently accepted criterion to assess the efficacy of irradiation as a quarantine treatment of fruit flies is prevention of adult emergence, as insects are not killed in a reasonable amount of time at the doses allowed on fresh commodities (≤ 1kGy). Irradiation would generally be applied after fruit packing. Packed fruits such as citrus are likely to stay at ambient conditions for a few days before being irradiated, allowing third instars to emerge and pupate within the packaging. As pupae are more tolerant to irradiation than eggs and larvae, studies were done in USA to determine the tolerance of these immature stages (feeding third instar, pupariation to pharate adult) of *A. ludens* and *A. obliqua* in grapefruit. According to their results, the authors recommended that grapefruit should not remain at ambient temperature (~25°C) for more than 2 or 3 days before being irradiated (Hallman & Worley, 1999).
  Plants of host species transported with roots from countries where *A. obliqua* occurs should be free from soil, or the soil should be treated against puparia, and should not carry fruits. Importation of such plants may be prohibited (https://www.cabi.org/isc/datasheet/5659).
- **At the border:** No male lures have yet been identified for *Anastrepha* spp. However, they are captured by traps emitting ammonia and it is likely that traps already set for other species such as *Rhagoletis cerasi* may attract *Anastrepha* spp. McPhail traps are usually used for the capture of *Anastrepha* spp. (Drew, 1982) and possible baits are ammonium acetate (Hedström and Jimenez, 1988), casein hydrolysate (Sharp, 1987) and torula yeast (Hedström and Jiron, 1985). The number of traps required per unit area is high; in a release and recapture test, Calkins et al. (1984) placed 18 traps per 0.4 ha and only recovered about 13% of the released flies (source: https://www.cabi.org/isc/datasheet/5659).
  Some studies have shown that egg morphology can be used to separate closely related species found in host fruits (Murillo and Jiron, 1994). The larvae of some species may also be differentiated using cuticular hydrocarbons (Sutton and Carlson, 1993). Neither method has yet been generalized for application outside of very specific circumstances (https://www.cabi.org/isc/datasheet/5659).
- **Post-border:** Trapping near local mango trees could be established using the same methods as described under 'at the border' above. Regular inspection of locally produced mangoes can help to detect the occurrence of the pest at an early stage.

Summary efficacy of current prevention measures from 5.1.1

Probability of prevention measures being effective	Very unlikely ☐	Unlikely ☐	Moderately likely ☒	Likely ☐	Very likely ☐
Confidence	High confidence ☐	Medium confidence ☒	Low confidence ☐		

Summary efficacy of proposed prevention measures from 5.1.2

Probability of suitable future prevention measures being effective	Very unlikely ☐	Unlikely ☐	Moderately likely ☐	Likely ☒	Very likely ☐
Confidence	High confidence ☐	Medium confidence ☒	Low confidence ☐		

5.2 Control

5.2.1 What existing control measures available in the territory for the control of other pests can provide adequate control to mitigate the risks described above? **Consider:** cultural practices e.g. irrigation, planting, harvesting methods etc.; pest control programmes; natural enemies; please link to effectiveness, practicality, costs, negative consequences and acceptability

- **Eradication:**
- **Containment to prevent further spread:**
- **Mechanical/chemical control:**
- **Biological control:**
- **Other** (provide additional information): McPhail traps and torula yeast are available. Howeber, biosecurity staff do not have the man power to actively and consistently set, monitor and service the traps. De-fruiting of trees with fruits showing signs of infestation or the presence of the *Anastrepha*.

5.2.2 What additional control measures currently not available in the territory can provide adequate control to mitigate the risks described above? **Consider:** cultural practices e.g. irrigation, planting, harvesting methods etc.; pest control programmes; natural enemies; please link to effectiveness, practicality, costs, negative consequences and acceptability

- **Eradication:** *A. obliqua* was first discovered in Florida in 1930. As a result of that discovery, a large fruit fly survey and eradication campaign was conducted from 1930 until 1936. Eradication actions began in 1934 and included widespread fruit removal and destruction, and biweekly insecticidal sprays. During this time, numerous *A. obliqua* specimens were collected, all from Key West. There is no confirmed evidence of the presence of *A. obliqua* in Florida since 1935. Apparently, the control actions of 1931–1936 indeed eradicated this pest from Florida, as no adult *A. obliqua* has been detected again in the field, despite the presence of many thousands of fruit fly detection trap surveys that have been run throughout the Keys and peninsular Florida continuously and year-round since 1956 (Steck 2001, cited in Weems et al. 2012; http://entnemdept.ufl.edu/creatures/fruit/tropical/west_indian_fruit_fly.htm).
- **Containment to prevent further spread:** The same approach as used for eradication could be applied.
- **Mechanical/chemical control:** Control can be considerably aided by good cultural practices, for example, by gathering all fallen and infected host fruits and destroying them, and by the selection of suitable varieties (Jiron, 1996). Insecticidal protection is possible by using a cover spray or a bait spray. Malathion is the usual choice of insecticide for fruit fly control and this is usually combined with protein hydrolysate to form a bait spray (Roessler, 1989). Practical details are given by Bateman (1982). Bait sprays work on the principle that both male and female tephritids are strongly attracted to a protein source from which ammonia emanates. Bait sprays have the advantage over cover sprays that they can be applied as a spot treatment so that the flies are attracted to the insecticide and there is minimal impact on natural enemies. The use of natural plant substances, such as a leaf infusion of *Piper auritum* combined with gathering fallen fruit resulted in local eradication (Perales-Segovia et al., 1996). Many baits have been evaluated including those based on yeasts (Fragenas et al., 1996), borated hydrolysed protein and yeast (Jiron & Soto-Manitiu, 1989), human urine (Hedström, 1988) and molasses (Hedström & Jiron, 1985). The longevity of some baits was compared by Malo (1992, cited in https://www.cabi.org/isc/datasheet/5659).
- **Biological control:** Several braconid larval parasitoids are recorded but their impact appears low, for example, *Biosteres longicaudatus* in 2.7% of larvae (Borge and Basedow, 1997). For further information, see Ohashi et al. (1997).

The following control agents have been used for the control of *A. obliqua* in the past (including area and target crop (source: https://www.cabi.org/isc/datasheet/5659):

- *Aceratoneuromyia indica* (Dominica, Citrus)
- *Biosteres longicaudatus* (Dominica, Citrus)
- *Doryctobracon areolatus* (Dominica; Honduras, Citrus, Spondias)
- *Doryctobracon crawfordi* (Dominica, Citrus)
- *Doryctobracon trinidadensis* (Dominica, Citrus)
- *Opius bellus* (Dominica, Citrus)
- *Pachycrepoideus vindemmiae* (Dominica, Citrus)
- *Utetes anastrephae* (no further information available)

- **Other** (provide additional information): Whenever possible prevention and eradication of small founder populations should be given priority as all methods currently available for control are costly and need to be applied indefinitely (exception biological control).

Summary efficacy of current control measures from 5.2.1

Probability of control measures being effective	Very unlikely ☒	Unlikely ☐	Moderately likely ☐	Likely ☐	Very likely ☐
Confidence	High confidence ☒	Medium confidence ☐	Low confidence ☐		

Summary efficacy of proposed control measures from 5.2.2

Probability of suitable future control measures being effective	Very unlikely ☐	Unlikely ☐	Moderately likely ☒	Likely ☐	Very likely ☐
Confidence	High confidence ☐	Medium confidence ☒	Low confidence ☐		

Other information

Add here any further information you wish to include in this application including if there are any ethical considerations that you are aware of in relation to your application

Is there a need for a more detailed PRA or for more detailed analysis of particular sections of the PRA? (For completion by the Biosecurity group only!)

No ☒ Yes ☐

References and information sources consulted

Aluja, M., Cabrera, M., Rıos, E., Guillen, J., Celedonio, H., Hendrichs, J., Liedo, P. (1987) A survey of the economically important fruit flies (Diptera: Tephritidae) present in Chiapas and a few other fruit growing regions in Mexico. - Florida Entomologist, 70: 320–328.

Aluja, M., Birke, A. (1993) Habitat Use by Adults of *Anastrepha obliqua* (Diptera: Tephritidae) in a Mixed Mango and Tropical Plum Orchard. – Annals of the entomological society of America, 86 (6): 799-812.

Aluja, M., Celedonio-Hurtado, H., Liedo, P., Cabrera, M., Castillo, F., Guille´n, J., Rı´os, E. (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.

Berg, G.H. (1979) Pictorial key to fruit fly larvae of the family Tephritidae. - Organismo Internacional Regional de Sanidad Agropecuaria. San Salvador El Salvador, 36 pp.

Borge, M.N.R., Basedow, T. (1997) A survey on the occurrence and flight periods of fruit fly species (Diptera: Tephritidae) in a fruit growing area in southwest Nicaragua, 1994/95. - Bulletin of Entomological Research, 87 (4): 405-412.

Calkins, C.O., Schroeder, W.J., Chambers, D.L. (1984) Probability of detecting Caribbean fruit fly, *Anastrepha suspensa* (Loew) (Diptera: Tephritidae), populations with McPhail traps. - Journal of Economic Entomology, 77 (1): 198-201.

Carroll, L. E., A. L. Norrbom, M. J. Dallwitz, and F. C. Thompson. 2004. Pest fruit flies of the world – larvae. Version: 8th December 2006. http://delta–intkey.com.

Christenson, L.D., Foote, R.H. (1960) Biology of fruit flies. - Annual Review of Entomology, 5: 171-192.

Couturier, G., Tanchiva, E., Gonzales, J. Cardenas, R., Inga, H. (1996) Observations preliminaires sur les insectes nuisibles a l'araza (Eugenia stipitata Mc Vaugh, Myrtaceae), nouvelle culture fruitiere an Amazonie. - Fruits Paris, 51: 229-239.

Drew, R.A.I. (1982) Fruit fly collecting. - In: Drew, R.A.I., Hooper, G.H.S., Bateman, M.A. (eds.) Economic Fruit Flies of the South Pacific Region, 2nd edition. - Brisbane, Australia: Queensland Department of Primary Industries, 129-139.

Enkerlin, D., Garcia, R.L., Lopez, M.F. (1989) Pest status; Mexico, Central and South America. - In: Robinson, A.S., Hooper, G. (eds.) Fruit Flies; Their Biology, Natural Enemies and Control. - World Crop Pests, 3(3A):83-90. Amsterdam, Netherlands: Elsevier.

EPPO - Data Sheets on Quarantine Pests: *Anastrepha obliqua*. Prepared by CABI and EPPO for the EU under Contract 90/399003.

EPPO (2014) EPPO Global database (available online). - Paris, France: EPPO. https://gd.eppo.int/

EPPO/CABI (1996) *Ceratitis capitata*. - In: Quarantine pests for Europe. 2nd edition (Ed. by Smith, I.M.; McNamara, D.G.; Scott, P.R.; Holderness, M.). CAB International, Wallingford, UK.

Fletcher, B.S. (1989) Ecology; movements of tephritid fruit flies. - In: Robinson, A.S., Hooper, G., (eds.) Fruit Flies; Their Biology, Natural Enemies and Control. - World Crop Pests, 3(B). Amsterdam, Netherlands: Elsevier, 209-219.

Fragenas, N.N., Gonzalez, E.T., Hernandez, J. de la, Casares, R., Lander, E. (1996) Elaboracion y evaluacion de atrayentes para la mosca del mango *Anastrepha obliqua* (Macquart) (Diptera: Tephritidae). - Boletin de Entomologia Venezolana, 11: 19-25.

Fu, L., Li, Z-H., Huang, G-S., Wu, X-X., Ni, W-L., Qü, W-W. (2013) The current and future potential geographic range of West Indian fruit fly, *Anastrepha obliqua* (Diptera: Tephritidae). - Insect Science, 21 (2); DOI: 10.1111/1744-7917.12018.

Hallman, G.J.; Worley, J.W. (1999) Gamma radiation doses to prevent adult emergence from immatures of Mexican and West Indian fruit flies (Diptera: Tephritidae). - Journal of Economic Entomology, 85: 1859-1864.

Hedström, I. (1988) Use of a natural substance in the capture of fruit flies of the genus *Anastrepha* Schiner (Diptera: Tephritidae). - Revista de Biologia Tropical, 36 (2A): 269-272.

Hedström, I. (1993) Population dynamics and host relationships of Neotropical fruit flies (Diptera: Tephritidae) in seasonal and non-seasonal environments. - International Journal of Pest Management, 39 (4): 400-410.

Hedström, I., Jimenez, J. (1988) Field evaluation of attractants in the capture of *Anastrepha* spp. (Diptera, Tephritidae), pests of fruit trees in tropical America. II. Ammonium acetate and torula with sodium borate. - Revista Brasileira de Entomologia, 32 (2): 319-322.

Hedström, I., Jirón, L.F. (1985) Field evaluation of attractants in the trapping of *Anastrepha* spp. (Diptera, Tephritidae), pests of fruit trees in tropical America. I. Molasses and torula yeast. - Revista Brasileira de Entomologia, 29 (3/4): 515-520.

Hennessey, M., Miller, C.E. (2004) Host Status of *Citrus* spp. for *Anastrepha obliqua* (Diptera: Tephritidae) https://www.aphis.usda.gov/plant_health/plant_pest_info/fruit_flies/downloads/obliquahosts112904.pdf

Hernandez-Ortiz, V. (1992) El género Anastrepha en México. Taxonomfa, distribución y sus plantas huéspedes. - Xalapa, Mexico: Instituto de Ecologia.

Jirón, L.F., Soto-Manitiu, J. (1989) Field evaluation of attractant substances on the catch of Anastrepha spp. (Diptera: Tephritidae), pest of fruit in tropical America. III. Borated hydrolysed protein and borated torula yeast. - Revista Brasileira de Entomologia, 33 (2): 353-356.

Kisliuk, M., Cooley, D.E. (1933) Fruit-fly survey in the West Indies, Brazil, Uruguay, Chile, and Peru. - Department of Agriculture, Plant Quarantine Service Regulatory Announcements, 227-243.

Malo, E.A. (1992) Effect of bait decomposition time on capture of *Anastrepha* fruit flies. - Florida Entomologist, 75 (2): 272-274.

Mangan, R.L., Thomas, D.B., Moreno, A.T., Robacker, D. (2011) Grapefruit as a host for the West Indian fruit fly (Diptera: Tephritidae). – J. Econ. Entomol.,104 (1): 54-62.

Mangan, R.L.; Ingle, S.J. (1992) Forced hot-air quarantine treatment for mangoes infested with West Indian fruit fly (Diptera: Tephritidae). - Journal of Economic Entomology, 85: 1859-1864. https://gd.eppo.int/reporting/article-4795

McAlister, Jr, L.C. (1936) Observations on the West Indian Fruit Fly at Key West in 1932-33. - Journal of Economic Entomology, 29 (2): 440-445.

Murillo, T., Jiron, L.F. (1994) Egg morphology of *Anastrepha obliqua* and some comparative aspects with eggs of *Anastrepha fraterculus* (Diptera, Tephritidae). - Florida Entomol., 77: 342-348.

Nascimento, A.S., Malavasi, A., Morgante, J.A., Duarte, A.L.A. (1992) Hot-water immersion treatment for mangoes infested with *Anastrepha fraterculus, A. obliqua*, and *Ceratitis capitata* (Diptera: Tephritidae) in Brazil. - Journal of Economic Entomology, 85 (2): 456-460.

Norrbom, A.L., Kim, K.C. (1988) A list of the reported host plants of the species of *Anastrepha* (Diptera: Tephritidae). - Hyattsville, MD, USA: US Dept. Agric., Animal and Plant Health Inspection Service, Plant Protection and Quarantine.

OEPP/EPPO (1983) Data sheets on quarantine organisms No. 41, Trypetidae (non-European). - Bulletin OEPP/EPPO Bulletin 13, (1).

Perales-Segovia, C., Bravo-Mojica, H., Leyva-Vazquez, J.L., Martinez-Garza, A. (1996) Sustancias vegetales para el control de moscas de la fruta. - Agrociencia, 30: 411-415.

Reyes F. J., Santiago M. G. and Hernandez M. P. (2000) The Mexican fruit fly eradication programme, pp. 377–380. In Area-Wide Control of Fruit Flies and Other Insect Pests. - Proceedings of the

5th International Symposium on Fruit Flies of Economic Importance, 28 May–5 June 1998, Penang, Malaysia (edited by K. H. Tan). Penerbit Universiti Sains Malaysia, Pulau Penang.

Rössler, Y. (1989) Control; insecticides; insecticidal bait and cover sprays. - In: Robinson, A.S., Hooper, G. (eds.) Fruit Flies. Their Biology, Natural Enemies and Control. - World Crop Pests 3(B). Amsterdam, Netherlands: Elsevier, 329-336.

Sa, de, R.F., Castellani, da, M.A., Ribeiro, A.E.L., Perezmaluf, R., Moreira, A.A., Nagamoto, N.S., Nascimento, do, A.S. (2012) Faunal analysis of the species *Anastrepha* in the fruit growing complex Gavião River, Bahia, Brazil. - Bulletin of Insectology, 65 (1): 37-42.

Segarra-Carmona, A. E., Torres-Rivera, C. N., Escudero, J., Ortiz, A. A., Acevedo Alfaro, J., & González Figueroa, W. (1988). Bacteria associated with the West Indian fruit fly *Anastrepha obliqua* (Macquart) (Diptera: Tephritidae). - The Journal of Agriculture of the University of Puerto Rico, 72 (3): 489-490. https://revistas.upr.edu/index.php/jaupr/article/view/6879

Sharp, J.L. (1987) Laboratory and field experiments to improve enzymatic casein hydrolysate as an arrestant and attractant for Caribbean fruit fly, *Anastrepha suspensa* (Diptera: Tephritidae). - Florida Entomologist, 70 (2): 225-233.

Steck, G.J., (2001) Concerning the occurrence of *Anastrepha obliqua* (Diptera: Tephritidae) in Florida. Florida Entomologist, 84 (2): 320-321.

Steck, G.J., Carroll, L.E., Celedonio-Hurtado, H., Guillen-Aguilar, J. (1990) Methods for identification of *Anastrepha* larvae (Diptera: Tephritidae), and key to 13 species. -Proceedings of the Entomological Society of Washington, 92 (2): 333-346.

Thomas, D.B., Mangan, R.L. (1995) Morbidity of the pupal stage of the Mexican and West Indian fruit flies (Diptera: Tephritidae) induced by hot-water immersion in the larval stage. - Florida Entomologist, 78 (2): 235-246.

USDA, 1994. Treatment manual. - Frederick, USA: USDA/APHIS.

Utges, M.E., Vilardi, J.C., Oropeza, A., Toledo, J., Liedo, P. (2013) Pre-release diet effect on field survival and dispersal of *Anastrepha ludens* and *Anastrepha obliqua* (Diptera: Tephritidae). - J. Appl. Entomol., 137, (Suppl. 1): 163–177.

Weems, H. V., Heppner, J.B., Steck, G.J., Fasulo, T.R. (2012) West Indian Fruit Fly, *Anastrepha obliqua* (Macquart) - (Insecta: Diptera: Tephritidae). - EENY-198, Entomology and Nematology Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. - http://entomology.ifas.ufl.edu/creatures.

Whervin, L.W. van (1974) Some fruitflies (Tephritidae) in Jamaica. - PANS, 20 (1): 11-19.

White, I.M., Elson-Harris, M.M. (1992) Fruit flies of economic significance: their identification and bionomics. - Wallingford, UK: CAB International, xii + 601 pp.

Woodley, N.E. (Hilburn, D.J. (1994) The Diptera of Bermuda. - Contributions of the American Entomological Institute, 28 (2): 64 pp.

Zucchi, R.A. (2000) Espécies de Anastrepha, sinonímias, plantas hospedeiras e parasitóides. - In: Moscasdas-frutas de importância econômica no Brasil – conhecimento básico e aplicado (Malavasi, A., Zucchi, R.A., eds.) - Holos, Ribeirão Preto, SP, Brazil, pp. 41-48.

Appendices and referenced material (if any) and glossary (if required)

In case this is an application made for the deliberate introduction of a species/commodity it is recommended that you contact a member of the biosecurity group as early in the application process as possible. Biosecurity can assist you with any questions you have during the preparation of your application including providing advice on any consultation requirements.

Unless otherwise indicated, all sections of this form must be completed for the application to be formally received and assessed. If a section is not relevant to your application, please provide a comprehensive explanation why this does not apply.

Commercially sensitive information must be included in an appendix to this form and be identified as confidential. If you consider any information to be commercially sensitive, please show this in the relevant section of this form and cross reference to where that information is located in the confidential appendix.

Any information you supply to biosecurity prior to formal lodgement of your application will not be publicly released. Following formal lodgement of your application any information in the body of this application form and any non-confidential appendices will become publicly available.