EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION
ORGANISATION EUROPEENNE ET MEDITERRANEENNE
POUR LA PROTECTION DES PLANTES

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This PRA document was modified in 2021 to clarify the phytosanitary measures recommended

Report of a Pest Risk Analysis for *Bactrocera invadens*

Taxonomic studies have synonymized *Bactrocera invadens* with *Bactrocera dorsalis* (Shultz *et a*l., 2016). The pest is now listed under this name on the EPPO A1 List. The content of the PRA report has not been changed.

This summary presents the main features of a pest risk analysis which has been conducted on the pest, according to EPPO Decision support scheme for quarantine pests.

Pest:	***Bactrocera invadens***
PRA area: The PRA area is the EPPO region (see map www.eppo.org).	
Assessors:	The Expert Working Group for PRA for *Bactrocera invadens*. A preliminary draft was prepared by José María Guitián Castrillón, Diana Catalan Ruescas and the EPPO Secretariat. This document was reviewed by an Expert Working Group composed of: Marc De Meyer[1], Denis Félicité Zulma[2], Catherine Guichard[2], Jose Maria Guitián Castrillon[3,] Alan MacLeod[4], Frédéric Plumelle[5], Serge Quilici[6], Nursen Üstün[7], Jean-François Vaysières[8] on 2009-12-07/10. [1]Royal Museum for Central Africa, Leuvensesteenweg 13, B-3080 Tervuren (BE) [2] Comité de Liaison Europe-Afrique- Caraïbes-Pacifique (COLEACP) [3] Tecnologias y Servicios Agrarios, S. A. - TRAGSATEC, C / Hnos. Garcia Noblejas, 37C. 2a Planta, 280037 Madrid (ES) [4] The Food and Environment Research Agency Sand Hutton, York YO41 1LZ (UK) [5] Plumelle Consulting (FR) [6] UMR "Peuplements Végétaux et Bio-agresseurs en Milieu Tropical", CIRAD Réunion (FR) [7] Plant Protection Research Institute, 35040, Bornova, Izmir (TR) [8] IITA-CIRAD / Biological Control Center for Africa, 08 B.P. 0932 Tri Postal Cotonou, Rép.du Bénin (BJ)
Date:	Expert Working Group 2009-12 Core member consultation 2010-05 Panel on Phytosanitary Measures conference call 2010-05-26
STAGE 1: INITIATION	
Reason for doing PRA:	Since 2003, a new fruit fly species, morphologically very similar to *B. dorsalis*, has been reported spreading rapidly throughout Sub Saharan Africa. This new pest is attacking cultivated and local tropical fruits (e.g. mangoes, guava, papaya, *Citrus* spp., etc.). It was described in 2005 and called *Bactrocera invadens* (Drew *et al*., 2005).
Taxonomic position of pest:	Diptera: Tephritidae

STAGE 2: PEST RISK ASSESSMENT

Probability of introduction

Entry

Geographical distribution:

B. invadens is believed to be native to Asia. Following the discovery of this species in Kenya in 2003, R. A. I. Drew (Brisbane, Australia) examined specimens collected in Sri Lanka in 1993 by K. Tsuruta (Yokohama, Japan) during his survey of the island. He found that *B.invadens* had previously been overlooked as unusual variants of several other species. This discovery confirms that the native range of *B. invadens* includes Sri Lanka, where it is not known to have any status as a pest.
The native range is likely to be larger than currently reported, since specimens may be misidentified as other representatives of the complex (de Meyer *et al*., 2009). It is not clear whether Buthan should be considered as part of the native area (de Meyer *et al*., 2009).

Asia: Bhutan, India, Sri Lanka.

Note: The species occurs in India, and it has been recorded for the first time in 2005 in Tamil Nadu in mango orchards, and it was particularly dominant in Chennai (Sithanantham *et al*., 2006).

Africa: Angola, Benin (first found 2004-06), Burkina Faso (2005-05), Burundi (2008-11), Cameroon (2004-08), Central African Republic (2008-08), Chad, Congo (2005-11), Comoros (2005-08), Côte d'Ivoire (2005-05), Democratic Republic of Congo, Equatorial Guinea, Ethiopia (2004-07), Gabon, Gambia (2005-06), Ghana (2004-11), Guinea (2005-05), Guinea-Bissau (2005-07), Kenya (2003-02), Liberia (2005-07), Mali (2005-06), Mauritania (2007-08), Mayotte (France) (2007-03), Mozambique (2007-07), Namibia (2008-10), Niger (2005-08), Nigeria (2003-11), Senegal (2004-06), Sierra Leone (2005-07), Sudan (2004-05), Tanzania (2003-07), Togo (2004-10), Uganda (2004-07), Zambia (2008).
Note: Its first place of discovery (i.e. Kenya) should not be assumed to be its point of entry into Africa, as it may have been overlooked in some areas.

Major host plants or habitats:

B. invadens is highly polyphagous, it has more than 40 known cultivated and wild hosts in Benin (Vayssières *et al*., 2009), and is expected to have as broad a host range as some other members in the *B. dorsalis* complex. All hosts are recorded from Africa; there are no data available on hosts within the native range of *B. invadens* in Asia (Mwatawala *et al.*, 2009).
Among major hosts are mango (*Mangifera indica*) and guava (*Psidium guajava*) (CABI, 2007), the list of major and minor hosts is presented in Appendix 1.

Which pathway(s) is the pest likely to be introduced on:

The EWG considered that *B. invadens* was likely to enter the PRA area with the following pathways

- Fruits of major hosts from countries where the pest occurs;
- Fruits of minor hosts from countries where the pest occurs;
- Plants for planting with growing medium attached from countries where the pest occurs;
- Fruits carried by passengers from countries where the pest occurs;
- Natural spread.

The information provided for pathways are based on the situation in Africa. Data

for the native region is missing.

Fruits from countries where the pest is known to occur

Fruits in trade infested with eggs, larvae and (rarely) pupae represent the most likely pathway, although it is unknown how *B. invadens* was introduced from Asia to Africa (EPPO, 2005). According to the Europhyt database (EU Member states only), 1291 consignments of fruits and vegetables infested with non-European Tephritidae were intercepted between 1993 and 2009, and 158 consignments infested with *Bactrocera* spp. were intercepted for the same period and the same commodities. These records may be underestimated, as in Roissy airport (France), the presence of non-European Tephritidae resulted in 273 notifications of non-compliance in 2009 alone. For 175 intercepted consignements, larvae were raised to the adult stage, among which 39 were identified as *B. invadens*. Additionally, French interceptions of *B. invadens* between 2007 and 2010 (as of May 2010) are as follows : 19 for 2010 from Cameroon and Togo; 39 in 2009 from Senegal, Mali, Kenya, Burkina-Faso, Côte d'Ivoire, Togo, Cameroon; 18 in 2008 from Cameroon, Côte d'Ivoire, Mali, Burkina-Faso, Senegal); 1 in 2007 from Cameroon (French NPPOs, pers. comm., 2010).
Switzerland has recently intercepted *B. invadens* on mango consignments from Cameroon (EPPO, 2009). Since 2006 the UK (Fera) have intercepted and detected it ten times; once in 2010 on *Psidium guajava* from Sri Lanka and nine times on Mango from Senegal (5), Gambia (2), Ghana (1) and Kenya (1).

B. invadens may infest many host plants (more than 40 host species recorded in Appendix 1), and this highly polyphagous species is being found on an increasing number of hosts; the current host list is not considered as definitive. Although more host plants are likely to be reported, they are probably of minor significance in international trade. The EWG considered that a distinction should be made between major hosts and minor hosts as risks of entry were perceived to be different.

The host fruits are divided into 2 categories called major and minor hosts.

Major hosts:

- a regular host that is usually relatively highly infested;
- a major host for which a large proportion of the samples is infested, number of flies emerging is often very high.

The following species are considered as major hosts:
Annona muricata (Sour sop), *Carica papaya, Chrysophyllum albidum, Citrus x paradisi* (grapefruit), *Citrus reticulata, Citrus sinensis, Citrus x tangelo, Diospyros montana, Eriobotrya japonica, Fortunella japonica, Fortunella margarita, Irvingia gabonensis, Mangifera indica, Psidium guava, Psidium littorale, Spondias cytherea, Spondias mombin, Terminalia catappa, Thevetia peruviana, Vitellaria paradoxa.*

Minor hosts

- an incidental host, with only one or a few records, usually with low infestation rate;
- a host that is used more regularly, but often with very low infestation rate. This can also be a host for which there are only few positive rearings, but with considerable numbers of flies emerging.

The following species are considered as minor hosts:
Anacardium occidentale (Cashew), *Annona cherimola*, *Annona senegalensis*, *Annona squamosa (*sugar apple*), Averrhoa carambola* (star fruit), *Blighia* sp., *Capsicum annuum* (sweet pepper), *Capsicum frutescens* (chilli pepper), *Citrullus lanatus* (watermelon), *Citrus aurantium*, *Citrus grandis* (pomelo), *Citrus limon*, *Coffea arabica* (Arabica coffee) and *C. canephora* (Robusta coffee), *Cordia* sp. cf *myxa*, *Cordyla pinnata*, *Cucumis figarei*, *Cucumis* sp nr *metuliferus*, *Cucumis pepo*,*Cucumis sativus* (cucumber), *Cucurbita maxima*, *Cucurbita* spp. (pumpkins), *Flacourtia indica*, *Lycopersicon esculentum* (tomato), *Malus domestica* (apple), *Manilkara sapota* (bully tree), *Momordica cf trifoliata*, *Musa* spp. (banana), *Musa* x *paradisiaca*, *Persea americana* (avocado), *Prunus persica* (peach), *Sarcocephalus latifolius*, *Sclerocarya birrea*, *Solanum aethiopicum*, *Solanum anguivi*, *Solanum incanum*, *Solanum nigrum*, *Solanum sodomeum*, *Sorindeia madagascariensis*, *Strychnos mellodora*, *Sizygium cumini*, *Sizygium jambos*, *Sizygium malaccense* (Malay apple) and *Sizygium samarangense* and *Ziziphus mauritiana*.

- Plants for planting with growing medium attached from countries where the pest is known to occur

The main risk for plants for planting is when fruits are present on the plants. Fruits on host plants could be infested with eggs, larvae and (rarely) pupae of *Bactrocera invadens.*

The EWG noted that entry of planting material (trees and shrubs) with fruits attached from areas where the pest is currently present is prohibited by some phytosanitary legislation in the EPPO region (e.g. EU legislation), but considered that the situation could change (the pest could spread further or legislations could change).

Although the import of a plant species with fruit attached is restricted, pupae could be present in the growing media attached to the plants. This pathway was mentioned during EPPO ad hoc workshops on Pest Risk Analysis of non-European fruit flies in 1993 and 1994.

- Fruits carried by passengers

White & Elson-Harris (1992) report that many fruit fly outbreaks may be attributable to undetected imports of a few fruits in an airline passenger's baggage. This has also been recognized in later studies (Miller, 1997). Passengers could potentially bring back fruits from countries they visit that may be contaminated with *B. invadens*.

Passengers in cars, trains, ferries and buses between tropical Africa and the Mediterranean area are also a pathway.

Passengers bringing contaminated plants for planting are considered unlikely and are not considered further.

Other pathways not considered further in the PRA

- Natural spread

It is **unlikely** that *B. invadens* could enter the Mediterranean EPPO region by natural means in the near future.

- Fruits of hosts in mail

Fruits of hosts can be sent in mail either by individuals or by private companies. This pathway is not considered further as it is considered unlikely due to the price of sending fruit by mail. Nevertheless, whilst admittedly a minor pathway this does exist as Fera PHSI, UK intercepted 24 illegal imports of fruit in mail from July 2009 – April 2010, mainly *Malus* spp., *Citrus* spp. and *Mangifera indica* (Paul

Bartlett, pers comm., 2010).

- Cut branches with fruits used for ornamental purposes

On flower markets, cut branches with fruits such as *Coffea arabica* and *Coffea canephora* are a new niche, used for ornamental purposes. This has been observed in Rungis (D. Félicité-Zulma, pers. comm., 2009). This pathway is considered negligable.

- Hitchhiker on commodities

This is a theoretical pathway which has never been recorded. It is very unlikely that flying adults would hide in containers, they would usually rather fly away. This pathway is therefore considered very unlikely.

- Growing media in non host plants for planting

Pupae could be present in the growing media accompanying non host plants for planting which have been grown in the vicinity of contaminated hosts. This pathway is considered to be very unlikely.

- Soil as a commodity

Pupae could be present in soil imported as a commodity. This pathway is usually prohibited.

- Soil attached to machinery

Pupae could be present in the soil attached to machinery. This pathway has never been reported for Tephritidae and is considered very unlikely.

Establishment

Plants or habitats at risk in the PRA area:

B. invadens appears to be highly polyphagous as it counts more than 40 cultivated and wild hosts.

The main major hosts cultivated in the EPPO region are *Mangifera indica, Citrus* spp., *Psidium guajava,* and *Carica papaya.*

The main minor hosts cultivated in the EPPO region include: *Citrullus lanatus, Cucumis sativus, Capsicum annuum, Capsicum frutescens, Cucurbita* sp., *Lycopersicum esculentum, Malus domestica, Musa* spp., *Persea americana,* etc.

The total production area in hectares for fruit and vegetable hosts of *Bactrocera invadens* in the EPPO region and neighbouring countries for 2008 are shown below:

Country	**Producing area in ha in EPPO countries and potential members in 2008**
Malus domestica (Apples)	1 699 828
Persea americana (Avocados)	33 208
Musa spp. (Bananas)	88 071
Capsicum spp. (Chillies and peppers, green)	309 170
Citrus spp.	17 192
Cucumis sativus (Cucumbers & gherkins)	402 616
Mangifera indica, Garcinia mangostana (Mangoes, mangosteens) & *Psidium guava* (guavas)	135 031
Carica papaya (Papayas)	522
Prunus persica (Peaches & nectarines)	491 923
Cucurbita spp.& *Cucumis pepo* (Pumpkins, squash & gourds)	233 344

Lycopersicon esculentum (Tomatoes)	1 700 416
Citrullus lanatus (Watermelons)	784 872

Source: FAOSTAT.

Some of these species and many other hosts are used as ornamental plants in the EPPO region and can be planted in public and private gardens: *Anacardium occidentale, Eriobotrya japonica, Fortunella margarita,* etc. (see Appendix 1).

Moreover, *B. invadens* is currently enlarging its host range in Africa (see Appendix 1) (Vayssières *et al*., 2005), and it could also adapt to additional hosts (e.g. stone fruits such as peaches) when arriving in the EPPO region.

In the southern part of the EPPO region (particularly Citrus producing countries), major hosts (*Citrus* spp., *Mangifera indica,* etc.) and minor hosts (such as *Capsicum* spp., *Citrullus lanatus, Cucumis* spp., *Lycopersicum esculentum*, *Musa* spp.) are cultivated outdoors as crops. These species and other hosts might be used as ornamental plants in public and private gardens and along road sides.
Hosts are therefore present in cultivated fields and/or in gardens throughout the year and could allow *B. invadens* to complete several life cycles all year round.
For example in the Mediterranean area:
- from September till June, *Citrus* spp. are available,
- from July to November, mangoes are available,
- from May till September, fruits of other hosts are available.

Climatic similarity of present distribution with PRA area (or parts thereof):

Cold temperatures and low relative humidity are considered the most important abiotic parameters that would affect *B. invadens* establishment. Because the species continues to spread, the limits of its climatic tolerance are not yet precisely known. The hottest and most humid parts of the Mediterranean Basin, more or less corresponding to the citrus growing area, are considered to be the most at risk.

A climatic prediction analysis performed by Hurt & Takeuchi (2006) with NAPPFAST, concludes that entire African continent (including North Africa) has a high potential for the establishment of *B. invadens*. The model estimated the lowest number of generations per year in southern and northern parts of Africa (having a Mediterranean type climate); however, *B. invadens* is still predicted to have as many as 6 generations per year in those areas. For continental US, 0 to 5 generations were predicted (Hurt & Takeuchi, 2006).

According to a CLIMEX analysis, the countries of the Mediterranean basin that are considered to be particularly at risk (including non EPPO countries) from the establishement of *B. invadens* are: Algeria, Egypt, Jordan, Israel, Libya, Morocco, and Tunisia (Fig 1 & 2).

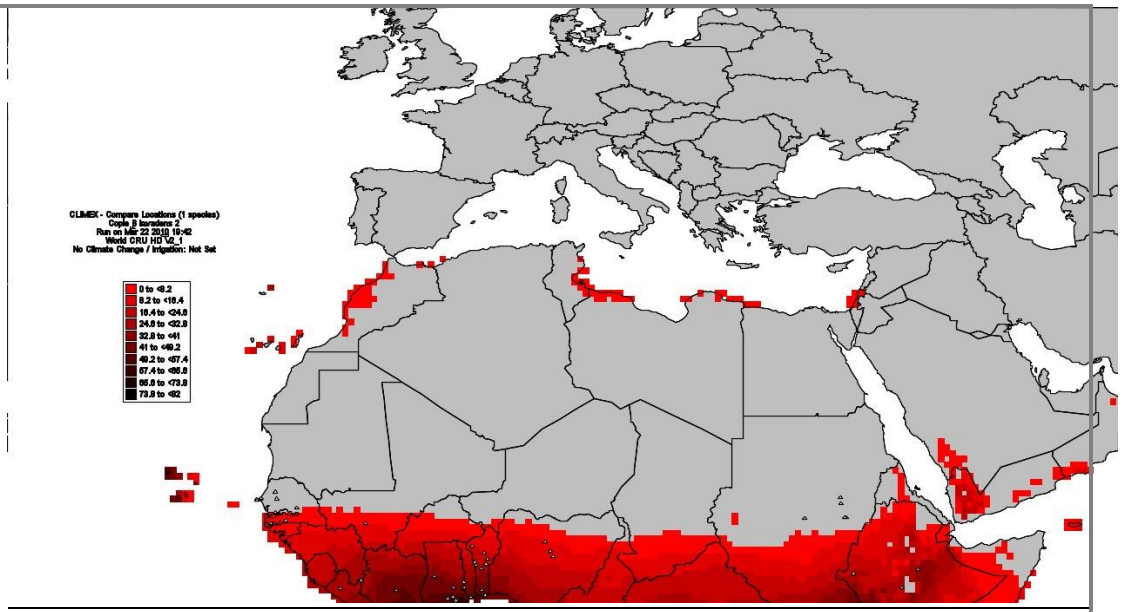


Figure 1: Potential distribution of *B. invadens* in the Mediterranean Basin (Ecoclimatic index) with CLIMEX

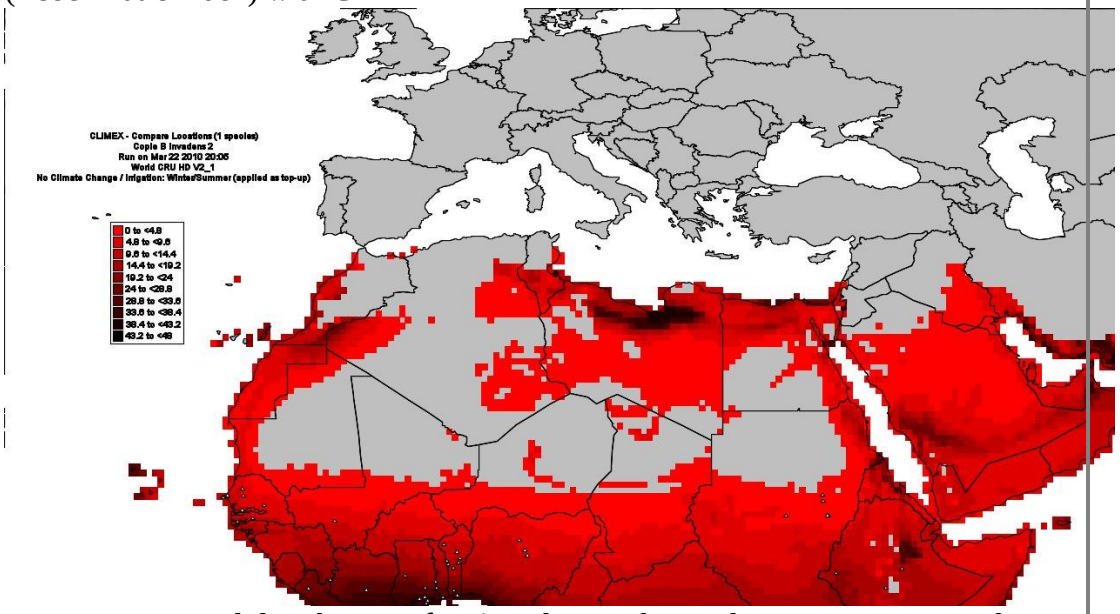


Figure 2: Potential distribution of *B. invadens* in the Mediterranean Basin with CLIMEX with irrigation scenario (Ecoclimatic index)

CLIMEX data also shows that establishment is not expected to occur in other Mediterranean countries although *B. invadens* could enter regularly with fruits and this may result in the occurrence of local transient populations. The species could develop up to 5 generations in Albania, France (Corsica), Cyprus, Croatia, Greece (Crete), Italy (Sardinia, Sicily), Lebanon, Portugal, Spain, Syria, Turkey (Fig 3). In comparison to Central Africa, the population build-up of these local transient populations is expected to be low. Spain is particularly at risk as the species could spread naturally if it became established in Morocco.

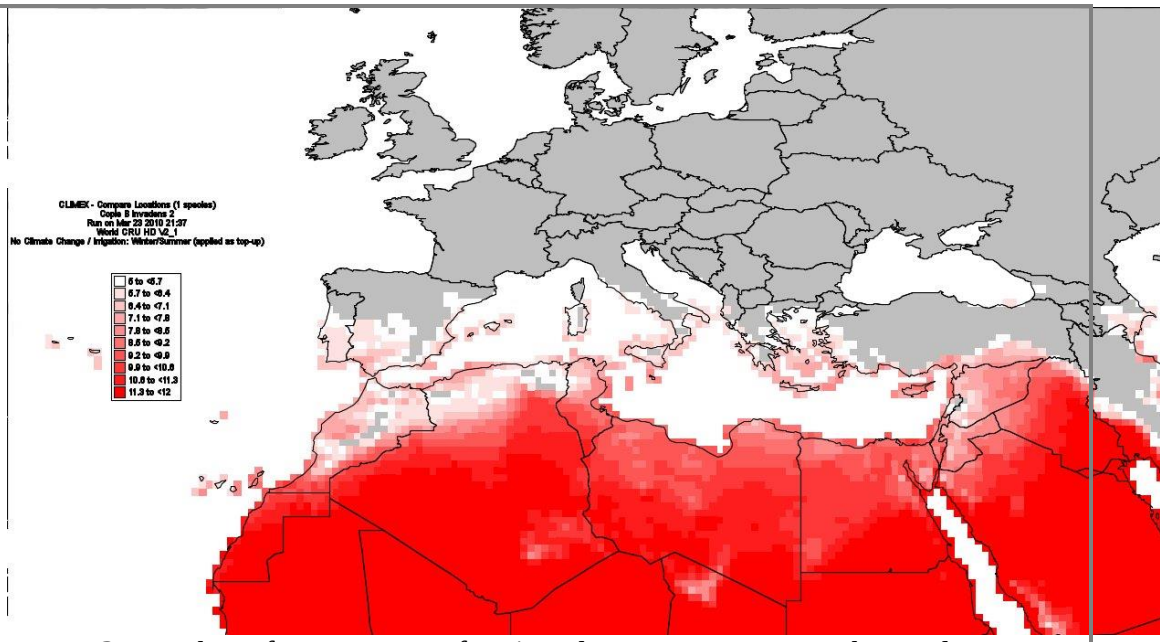


Figure 3: Number of generations of *B. invadens* superior to 5 in the Mediterranean Basin, with irrigation scenario

The tolerance of the species to cold temperatures and to dry conditions remain the two major uncertainties. The species could adapt to new conditions in the Mediterranean and have a wider distribution than the one described above.

The EPPO workshop on non-European fruit flies held in 1993 concluded that fruit flies are not considered to present a risk in glasshouse crops in Northern Europe. The EWG was unable to confirm this statement due to uncertainties concerning the range of authorized active ingredients under changing EU regulation or disruption of biological control practices in greenhouses. The risk of a greenhouse getting infested in Northern Europe by *B. invadens* remains very unlikely and is not considered further in the PRA. In the Southern region, the risk of glasshouses being infested is low, and very uncertain.

Characteristics (other than climatic) of the PRA area that would favour establishment:

Considering that the species spends most of its development phase inside fruits, abiotic factors other than climatic conditions are probably of minor importance for establishment.
There is no information on soil preference for the part of the life cycle of the species that is spent in the soil.

Which part of the PRA area is the endangered area:

The endangered area includes the horticultural and fruit-growing areas in Algeria, Egypt, Jordan, Israel, Libya, Morocco, and Tunisia.
In other Mediterranean countries, establishment is not expected to occur although *B. invadens* could enter regularly with fruits and this may result in the occurrence of local transient populations (see above), this area is consequently considered as part of the endangered area.
It also includes trees planted as amenity trees in private and public areas and home gardens.

POTENTIAL ECONOMIC CONSEQUENCES

How much economic impact does the pest have in its present

B. invadens is currently considered as one of the major pests in Africa (Mwatawala *et al.*, 2009). In general, *B. invadens* is displacing indigenous fruit flies in Africa (Ekesi *et al.*, 2006).
Quantitative data on crop losses are only available for mango and citrus species.

distribution:

Mangoes

CTA (2007) considers that because of attacks by *Ceratitis cosyra* and *Bactrocera invadens,* harvest losses on mangoes that are about 10% at the beginning of the growing season can reach 80% by the end of the season. Sampling of infested fruits at regular intervals during the mango season indicates that late cultivars are attacked much more than early ones.

In Western Africa, Vayssières *et al*. (2008) also found that for the cultivars Amélie (Gouverneur), Eldon, Dabschar, Kent, Smith, Keitt and Brooks together, losses stand at 15% in early April and exceed 69% in mid-June (the end of the mango season). Average losses were measured on 12 orchards in Borgou in Benin in 2005 and 2006 (see table 1).

Cultivars of mango	**Losses in % in 2005**	**Losses in % in 2006**	**Average losses in % for 2005 and 2006**
Gouverneur	14.8	15.8	15.3
Eldon	44.0	49.4	46.7
Amelioree	50.5	47.3	48.9
Dabschar	50.7	47.9	49.3
Kent	51.6	47.5	49.6
Smith	54.5	55.5	55.0
Keitt	62.8	60.8	61.8
Alphonse	65.0	64.2	64.6
Brooks	65.5	73.1	69.3

Table 1: losses on mango production in Benin expressed in percentages for different varieties for the years 2005 and 2006, experiment performed by JF Vayssières.

Losses attributed to Tephritidae had been extrapolated at the hectare scale on the basis of sampled mangoes and losses recorded on this sample. Losses were estimated to vary between 0.34 tonnes/ha, and 6.5 tonnes/ha (from 15% to 69%), depending on the cultivar (Vayssières *et al*., 2008).

Oviposition in the fruit can also lead to a number of pathogen attacks that can accelerate the damage to the fruit (Vayssières *et al*., 2008).

Citrus spp.

In Kenya, Rwamushana *et al*. (2008) reported heavy infestations on *Citrus limon, C. reticulata* and *C. sinensis.* It is extrapolated that heavy infestations could have impacts on the crop. The level of infestation depends on Citrus hosts as well as on the agro-ecological zone. In South Benin, from all citrus fruits sampled in 2008-2009, emerged fruit fly species were mostly *B. invadens* (98.3%) and the resulted damages depended on the locality and the *Citrus* species. In 2008, the recorded incidence on mandarin (*Citrus reticulata* Blanco) was 46.7% and 36.7% in orchards in Amoussa (Glo locality) and Monou (Sakété), respectively. On Tangelo (*Citrus x tangelo*), the incidence was 33.3% in the orchard in Amoussa. On sweet orange (*Citrus sinensis*) (cv Valencia) the incidence was 30.0%, 20.0%, 20.0% and 17.8% in orchards in Amoussa, Agban (Allada), Houéssou (Allada) and Monou, respectively. In terms of infestation rates (number of pupae per kg of fruit), on mandarin these were 25.6 and 22.4 in orchards in Monou and Amoussa, whereas in Tangelo these were 19.7 in the orchard in Amoussa. On sweet orange, the infestation rates were 8.7, 7.0, 5.3 and 3.0 in orchards in Amoussa, Monou, Agban and Houéssou respectively. This incidence level, due mostly to *B. invadens*, is an indication that, in South Benin, *B. invadens* is the most destructive and

economically important fruit fly in Citrus resulting in great yield losses (see table 2 for average losses for 2 years). As the crop is an important income provider for the producers and the country, a proper control method elaboration is urgently needed to reduce the yield losses, increase income and alleviate poverty.
In other countries such as Ghana, Guinea, Togo and Senegal the situation is similar to that in Benin and was sometimes even worse. In central Tanzania, *C. paradisi* seems to be the more heavily infested species.

	Guinean zone	**Sudanian zone**
***Citrus tangelo* (Tangelo)**	34%	?
***Citrus reticulata* (Mandarin)**	22%	6%
***Citrus sinensis* (Sweet orange)**	25%	12%
***Citrus x paradisii* (Grapefruit)**	?	10%

Table 2: performed losses assessments on *Citrus* species in Benin between November 2007 and November 2009 in the Guinean and the Sudanian zones. *Bactrocera invadens* causes about 90% of the damage observed. Results are expressed in percentages of losses of production, studies implemented by JF Vayssières *et al.* (unpublished data).

Describe damage to potential hosts in PRA area:

As is the case for other fruit flies, attacked fruit will usually show signs of oviposition punctures. Fruit with a high sugar content will exude a sugary liquid, which usually solidifies adjacent to the oviposition site.

Damage on Mangoes (CIRAD, 2008)

How much economic impact would the pest have in the PRA area:

In this section, no distinction is made between potential impacts for the areas where the species could establish, and where the species could be transient. After incidental introduction, transient populations could develop up to 5 generations per year. Impacts in areas where populations are only transient are expected to be lower as the populations would build up slowly, and damage would only be localized.

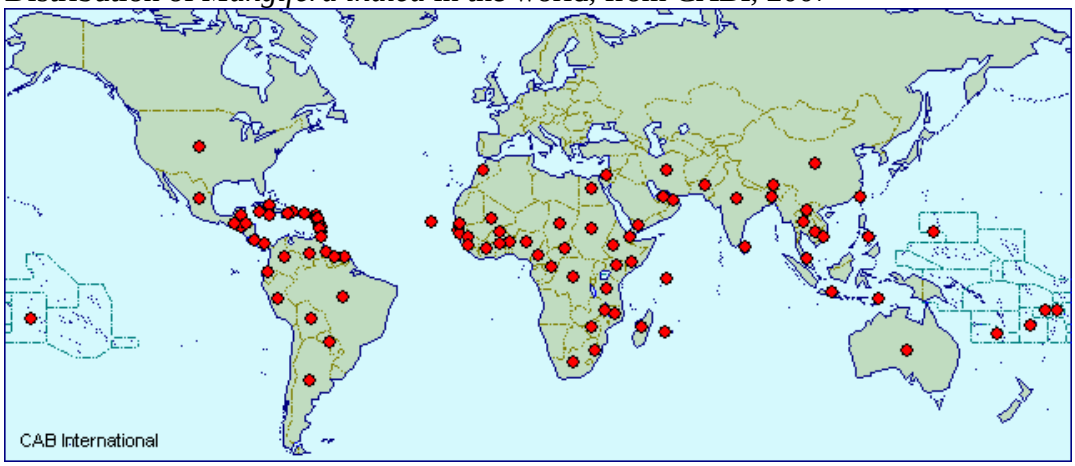
The countries in the endangered area produce 100% of bananas, mangoes, papayas, citrus and avocados that are produced in the EPPO region; almost 95% of peaches and nectarines; and nearly 80% of peppers and 75% of tomatoes.
According to EFSA (2007), the cooler conditions in the endangered area and the fact that there is better integrated pest management (IPM) practice and crop hygiene in orchards reduces the impacts compared with those recorded in the current range of the pest.
These figures do not include home-garden production, which could be substantial, but for which no information is available.

Major hosts

Mangifera indica

According to FAOSTAT, 37 852 tonnes of mango are cultivated in the EPPO region, mainly in Israel (37 827 tonnes) and Morocco (25 tonnes). This crop is not as important in the EPPO region as it is in most of Africa. The EWG noted that FAOSTAT does not report mango production in Spain, while such production occurs, particularly in the Canary Islands (JM Guitián Castrillón, pers. comm., 2009).

Distribution of *Mangifera indica* in the world, from CABI, 2007

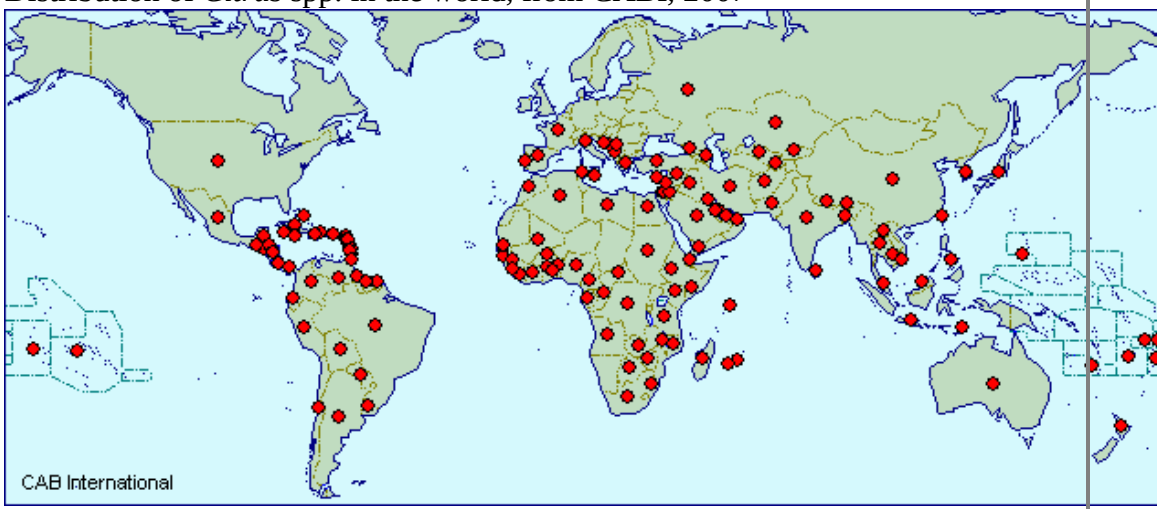


Legend: red dots indicate that the species is widespread

Citrus spp.

Citrus spp. is a major crop in the EPPO region and is produced all around the Mediterranean area (Morocco, Spain, Italy, Greece, Turkey, etc.). See table 1.

Distribution of *Citrus* spp. in the world, from CABI, 2007



Legend: red dots indicate that the species is widespread

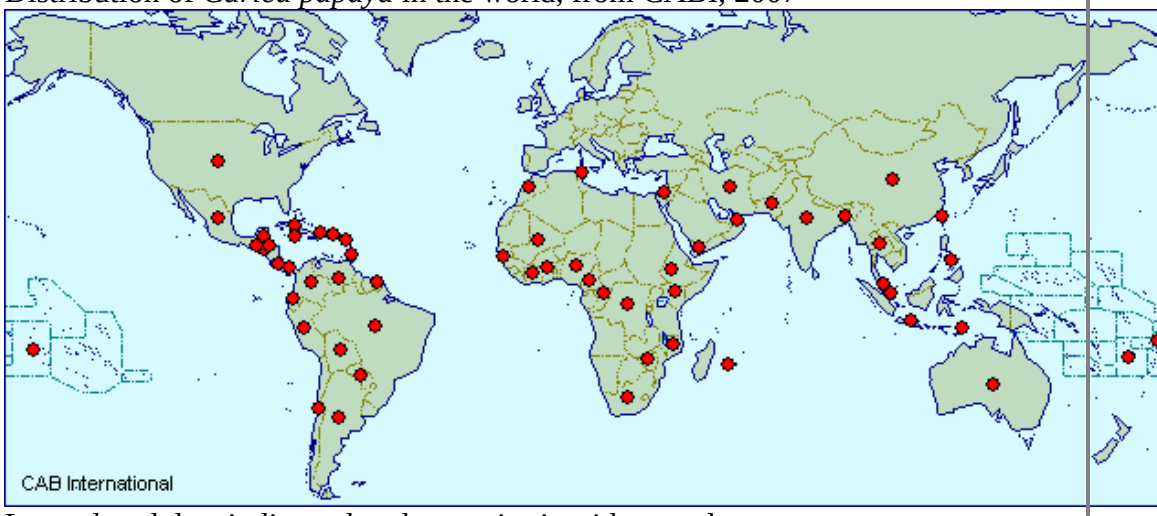
Carica papaya

In the EPPO region papayas are only produced in Israel, Morocco and Tunisia according to FAOSTAT. See table 1.

Commodity	**TOTAL produced in tonnes in 2007 in the EPPO region**
Citrus spp.	16 215 868
Carica papaya	425

Table 1: Production in tonnes of Citrus species and papayas in the EPPO region for 2007
Source: FAOSTAT. Details by country are available in Appendix 2.

Distribution of *Carica papaya* in the world, from CABI, 2007



Legend: red dots indicate that the species is widespread

The EWG considered that in the absence of control measures, the impact on major hosts (mango, citrus species and papayas) in the endangered area would be high.

Minor hosts
Impacts on minor hosts such as apples, watermelons, peaches and peppers are low in the current range of the species. The production in tonnes for 2007 in the EPPO region of crops at risk are provided in table 2.

Commodity	**Production in the EPPO region in tonnes in 2007**
Lycopersicon esculentum (Tomatoes)	36 593 790
Malus domestica (Apples)	18 888 307
Citrullus lanatus (Watermelon)	11 301 569
Cucumis sativus (Cucumbers & gherkins)	7 943 042
Capsicum spp. (Chillies and peppers, green)	5 626 987
Prunus persica (Peaches & nectarines)	5 307 329
Cucurbita spp.& *Cucumis pepo* (Pumpkins, squash & gourds)	3 839 177
Musa spp. (Bananas)	567 062
Persea americana (Avocados)	243 851

Table 2: Total tonnes of produced fruits and vegetables hosts of *Bactrocera invadens* in the EPPO region for 2007.
Source: FAOSTAT.

In addition to losses in crop yield, impact on exports are also expected.

CONCLUSIONS OF PEST RISK ASSESSMENT

Summarize the major factors	- many cultivated hosts are available in the Southern part of the EPPO region; - a succession of fruits from suitable hosts are available all year round;

that influence the acceptability of the risk from this pest:	- climatic conditions seem suitable in at least some parts of EPPO countries. - there are few active ingredients available to control tephritids, and the current management methods would not prevent the establishment of *B. invadens*; - eradication of the pest (outdoors) is very difficult without early detection and rapid emergency response; - *B. invadens*, as is the case for most tephritids, is characterized by a high fecundity and a short life cycle.
Estimate the probability of entry:	**Fruits of major and minor hosts** Major hosts such as *Mangifera indica* (mango), *Psidium guajava* (guava), *Carica papaya* (papaya) and *Citrus* spp. (citrus) represent a **likely pathway** for the entry of *B. invadens*. The concentration of the pest on these fruits is considered to be high. Uncertainty is low. Minor hosts such as *Capsicum annuum, Capsicum frutescens, Citrullus lanatus, Cucumis melo, Cucumis sativus, Cucurbita* sp., *Lycopersicum esculentum, Malus domestica, Musa* sp., *Persea americana* and *Prunus persica* (peach) represent a **moderately likely pathway.** The concentration of the pest on these fruits is considered to be lower than on major hosts. Uncertainty is low. **Plants for planting with growing media** The uncertainty on this pathway is high. It is **moderately likely** that plants for planting with fruits could provide a pathway for the entry of *B. invadens*, but it is currently a closed pathway for many EPPO countries. It is **unlikely** that plants for planting with growing media of hosts provide a pathway for the entry of *B. invadens*, entering as pupae in the growing media. Prohibition for plants of *Solanaceae, Citrus* spp. and *Fortunella* spp. when they are implemented by EPPO countries, prevent the entry of *B. invadens.* **Fruits carried by passengers** It is **moderately likely** that infested fruits carried by passengers provide a pathway of entry for *B. invadens.* **- Natural spread** It is **unlikely** that *B. invadens* could enter the Mediterranean EPPO region by natural means in the near future. It is to be noted that the establishment in any Mediterranean third country, or the Canary Islands would increase the risk of entry from all pathways, especially Citrus and tomato fruit imports and plants for planting (some current restrictions would no longer apply, e.g. no prohibition for *Solanaceae*).
Estimate the probability of establishment:	The countries of the Mediterranean basin that are considered to be particularly at risk (including non EPPO countries) because *B. invadens* could establish there are: Algeria, Egypt, Jordan, Israel, Libya, Morocco, and Tunisia. In other Mediterranean countries, establishment is not expected but *B. invadens* could enter regularly with fruits and this may result in the occurrence of local transient populations.

	The uncertainty on the establishment of *B. invadens* in the southern EPPO region remains medium and is mainly associated with the suitability of climatic conditions.
Estimate the potential economic impact:	Both direct and indirect impact are expected to occur if the pest becomes established or to a lesser extent if transient population occur. Crops particularly at risk are *Mangifera indica*, *Citrus* spp. and *Carica papaya*, and there is an uncertainty on the potential impacts on other crops which are currently minor hosts in its current range: *Musa* spp., *Citrullus lanatus, Cucumis sativus, Capsicum* spp., *Cucurbita* spp., *Persea americana, Malus domestica, Lycopersicum esculentum*, etc. It is suspected that in the endangered area, peaches or other stone fruits could become major hosts. The overall uncertainty on the economic impact is considered medium to high.
Degree of uncertainty	The overall level of uncertainty is considered as medium to high. *Host species* *B. invadens* seems to have an increasing host range in Africa, and it is unknown whether it would adapt to alternative hosts (eg. stone fruits) present in the endangered area. There is no indication of the species' host range in its native range. *Climatic requirements* There is a lack of data on the limiting factors of the species (e.g. cold and drought resistance) and its ability to establish in temperate areas. *Spread capacity* There is no precise data available on the flight ability of *B. invadens*, and there is also an uncertainty on the succession of available hosts at different seasons in all parts of the endangered area. *Impact on crops* There is a major uncertainty on the potential impacts on the following crops in the endangered area: *Musa* spp., *Citrullus lanatus, Cucumis sativus*, *Capsicum* spp., *Cucurbita* spp., *Persea americana, Malus domestica, Lycopersicum esculentum*, stone fruits, etc. *Interceptions* No information is available for non EU EPPO countries, except for Switzerland *Adaptability* The potential adaptability of the pest is unknown. This includes the possibility of adaptation to protected cultivation, as several of the hosts are commonly grown in glasshouses in the EPPO region, whereas this is rarely the case in those areas where the pest is known to be present at this time.
OVERALL CONCLUSIONS	**The pest is an appropriate candidate for the management stage.**

STAGE 3: PEST RISK MANAGEMENT

IDENTIFICATION OF THE PATHWAYS

Pathways studied in the pest risk management	• Fruits of major and minor hosts from countries where the pest occurs • Plants for planting with growing medium attached • Fruits carried by passengers
Other pathways identified but not studied	(see entry part)

- **Pathway 1:** Fruits of major and minor hosts from countries where the pest is known to occur

Measures related to consignments:
For fruits originating from areas of low pest prevalence: post-harvest treatment

Measures related to the crop or to places of production:

1. **Fruits should originate in a pest free area** for fruit flies ISPM 26 *establishment of pest-free areas for fruit flies (Tephritidae)* should be followed.

    - **Areas of low pest prevalence**

2. **pest free places of production**
   The measures required to determine a free place of production are:
   - absence of any detection in Methyl Eugenol traps in places of production and the vicinity during a period to be determined:
   (*OPTION a*) since the beginning of the last complete cycle of vegetation/
   (OPTION b) Methyl Eugenol traps could be restricted to the seasons when susceptible hosts are present in the place of production and its vicinity.
   - A buffer zone adapted to the flying ability of the pest, the potential existence of natural barriers, and the presence of hosts should preferably be established. Such situations could occur in the sub Saharan area and in Mali. It should be noted that establishing a buffer zone is difficult due to the flying ability of the pest over long distances, and its polyphagy.
   - monitoring of traps should be done on a weekly basis under the authority of the NPPO.
   - sanitation with the removal of fallen fruits should be mandatory.
   - in addition, examination for absence of signs of the pest on the fruits before harvest at the place of production should take place under the authority of the NPPO.

    - **Areas other than areas of low pest prevalence**

3. **Systems Approach (ISPM no. 14)** Measures can be applied pre and post-harvest wherever the NPPO can oversee and ensure compliance[1]. Suggested measures against the fruit flies of concern are:

   Pre-harvest:

   Integrated Pest Management Measures (based on fruit fly monitoring around the production site, sanitation, male annihilation techniques, biocontrol, ploughing, agronomic practices, cultural practices, removal of reservoir hosts, bait station)
   Bagging of fruits when feasible

   Harvest:

   Harvest at earliest possible maturity level

   Post-harvest:

   Inspection of fruits before packing and sorting out injured fruits and proper disposal of

[1] These measures which are recommended by USDA (2006b) are considered much more effective in an area wide approach to pest management.

waste
Cold treatment for *Citrus* spp. and pome fruits (*Malus* sp., *Pyrus* sp.), or adequate treatment for other commodity.

4. **Pest-free place of production (with similar requirements as for areas of low pest prevalence) and adequate post-harvest treatment**

Possible impact on trade of these measures
Similar requirements are implemented in EPPO countries for exports to certain countries because of *Ceratitis capitata*.
Pest free areas
This option would affect imports of fruits from areas where the pest occurs, particularly Africa. Major exporters for the major hosts are mainly situated in Latin America, and importers in the EPPO region could find alternative sources there to substitute African origins.
Pest free place of production
This measure is difficult to implement. The management and maintenance of a buffer zone might increase the price of the fruits. There are few expected social or environmental consequences in EPPO countries, but it depends on the number of places of production that can be effectively implemented. A small number of possible places of production would have similar consequences as a pest free area.
Systems approach
The management at the place of production and post-harvest quarantine treatment might increase the price of the fruits. Fumigation with methyl bromide has a negative impact on the environment.

- **Pathway 2: Host plants for planting with growing media**

Measures related to consignments:
- Import of young plants (plants too young to fruit) or
- Import in a dormant stage or
- Removal of fruits 1 month prior to export
- Post-entry quarantine of the plants for planting with ME traps (see comment in Q 3.35)

Measures related to the crop or to places of production:
The plants should be grown
- Under protected conditions or
- Pest free place of production or
- Pest free area

Possible impact on trade of these measures
These measures are common measures for plants for planting.

Pathway 3: Host fruits carried by passengers
- the requirement of a phytosanitary certificate for passengers traveling with fruits
- prohibition on the carriage of host fruits
- publicity to enhance public awareness on pest risks.
- fines and incentives

Possible impact on trade of these measures
These measures have no impact on trade but could have an impact for the NPPOs of the countries concerned.

Other possible measures
Trapping is a particularly important method for the early detection of outbreaks and should be used as a component of the early warning systems within the PRA area. Methyl Eugenol traps could be used for monitoring the presence of this invasive pest. Many countries that are free of *Bactrocera* spp., e.g. certain States of the USA and New Zealand, maintain a grid of ME traps, at least in ports and airports

(CABI, 2007).
In case of any detection, a contingency plan aiming at eradication should be immediately implemented.
However, these measure would not guaranty the prevention of establishment of the pest.

EVALUATION OF THE MEASURES IDENTIFIED IN RELATION TO THE RISKS PRESENTED BY THE PATHWAYS

Degree of uncertainty	Uncertainties in the management part are: Efficacy of the treatments for *B. invadens* Efficacy of the option pest free place of production or of a systems approach as described, these are recommended on the basis of current practices.

CONCLUSION:
Recommendation for possible measures:
PC= Phytosanitary certificate, RC=Phytosanitary certificate of re-export

Pathway 1: **Fruits of hosts** ***(countries may wish to distinguish major and minor hosts as major host present a higher risk than minor hosts)***	PC and, if appropriate, RC - Pest free area Or *1 for fruits originating from areas of low pest prevalence* - Pest free place of production Or - Adequate post-harvest treatment (e.g. cold treatment for *Citrus* spp. or pome fruits) *2 for fruits originating from areas other than areas of low pest prevalence* - Pest-free place of production (with similar requirement as for areas of low pest prevalence) and adequate post-harvest Or - Systems approach (pre-harvest, harvest and post-harvest measures detailed above)

Pathway 2: Host fruits carried by passengers	The requirement of a phytosanitary certificate for passengers traveling with fruits Or Prohibition on the carriage of host fruits. Or Publicity to enhance public awareness on pest risks. Or Fines and incentives

Pathway 3: Host plants for planting with growing media	PC and, if appropriate, RC - Import of young plants (plants too young to fruit) Or - Import in a dormant stage Or - Removal of fruits 1 month prior to export Or - Production of the plants for planting in protected conditions Or - Post-entry quarantine of the plants for planting with ME traps (see comment in Q 3.35) Or - Plants produced in a pest free place of production Or - Plants produced in a pest free area

REFERENCES

CABI (2007) *Bactrocea invadens*. Crop Protection Compendium, 2007 Edition. Wallingford, UK: CAB International. www.cabicompendium.org/cpc.

CTA (2007) How to control the mango fruit fly? CTA Practical Guide Series, no 14. 7 p. http://naads.or.ug/manage/publications/170dochow%20to%20controll%20the%20mango%20fruit%20fly.pdf

de Meyer, M., Robertson, M.P., Mansell, M.W., Ekesi, S., Tsuruta, K., Mwaiko, W., Vayssières, J-F & Peterson A.T. (2009) Ecological niche and potential geographic distribution of the invasive fruit fly *Bactrocera invadens* (Diptera, Tephritidae). *Bulletin of Entomological Research* **27**, 1-14.

Drew RAI, Tsuruta K & White IM (2005) A new species of pest fruit fly (Diptera: Tephritidae: Dacinae) from Sri Lanka and Africa. *African Entomology*, 13, 149-154.

EFSA (2007) Opinion of the Scientific Panel on Plant Health on the Pest Risk Analysis made by Spain on *Bactrocera zonata*. *The EFSA Journal* **467**: 1-25.

Ekesi S, Nderitu PW & Rwomushana I (2006) Field infestation, life history and demographic parameters of the fruit fly *Bactrocera invadens* (Diptera: Tephritidae) in Africa. *Bulletin of Entomological Research* **96**, 379–386.

EPPO (2005) EPPO RS 2005/085: *Bactrocera invadens* a new invasive species of fruit fly: addition to the EPPO Alert List. *EPPO Reporting Service* No. 6. Paris, France: EPPO.

EPPO (2009) Reporting Service. EPPO report on notifications of non-compliance (2009/056, 2009/100, 2009/121, 2009/144, 2009/183, 2009/201).

FAOSTAT Website http://faostat.fao.org/

Hurt C & Takeuchi Y (2006) *Bactrocera invadens* (Drew *et al.*, 2005): Known information on biology, hosts, and distribution. USDA-APHIS-PPQ-CPHST-PERAL 24pp. Raleigh, NC. Unpublished report.

Mwatawala MW, De Meyer M, Makundi RH & Maerere P (2006) Seasonality and host utilization of the invasive fruit fly, *Bactrocera invadens* (Dipt., Tephritidae) in central Tanzania. *Journal of Applied Entomology* **130**, 530–537.

Mwatawala M, De Meyer M, Makundi R & Maerere A (2009) Host range and distribution of fruit-infesting pestiferous fruit flies (Diptera, Tephritidae) in selected areas of Central Tanzania. *Bulletin of Entomological Research* **99**(1), 1-13.

Rwomushana I, Ekesi S, Gordon I & Ogol CKPO (2008) Host plants and host plant preference studies for *Bactrocera invadens* (Diptera: Tephritidae) in Kenya, a new invasive fruit fly species in Africa. *Annals of the Entomological Society of America* **101**, 331-340.

Sithanantham S, Selvaraj P, Boopathi T (2006) The fruit fly *Bactrocera invadens* (Tephritidae: Diptera) new to India. *Pestology* **33**(9), 36-37.

Vayssières JF, Goergen G, Lokossou O, Dossa P & Akponon C (2005) A new *Bactrocera* species in Benin among mango fruit fly (Diptera: Tephritidae) species. *Fruits* **60**, 371-377.

Vayssières JF, Korie S, Coulibaly T, Temple L, Boueyi S (2008) The mango tree in northern Benin (1): cultivar inventory, yield assessment, early infested stages of mangos and economic loss due to the fruit fly (Diptera Tephritidae). *Fruits*, **63** (6), 335-348.

Vayssières JF, Sinzogan A, Abandonon A (2009) Range of cultivated and wild host plants of the main mango fruit fly species in Benin. Regional Fruit Fly Control Project in West Africa (WAFFI). Leaflet 8. 4 p.

White IM, Elson-Harris MM (19992) Fruit flies of economic significance: their identification and bionomics. CABI. UK. Wallingford. 601 p.

Appendix 1

Recorded hosts of *Bactrocera invadens*

Major and minor recorded hosts of *Bactrocera invadens* are listed below.
Legend:
+ : an accidental host, only one or a few records. Usually with low infestation rate
++: a host that is used more regular but often with very low infestation rate (as we observed in avocado or in most Citrus for example). Also sometimes host for which there are only a few positive rearings but with considerable numbers of flies emerging
+++: a regular host that is usually relatively highly infested
++++: major host. Large proportion of the samples is infested, number of flies emerging is often very high.

The following species are considered **major hosts** because in at least one area they have been recorded either as:
- a regular host that is usually relatively highly infested
- a major host for which a large proportion of the samples is infested, number of flies emerging is often very high.

Species	**Family**	**Common name**	**Reference(s)**	**Region E : East W : West**	**Information***	**Use**
Annona muricata	Annonaceae	Sour sop	Vayssières *et al.*, 2009 ; Ekesi *et al*., 2006; Mwatawala *et al.*, 2006; Rwomushana *et al*., 2008; Mwatawala *et al.*, 2009	E&W	++ in N Benin, +++ in S Benin ++ in Tz + in Kenya	Ornament, RHS plant finder, 2004
Carica papaya	Caricaceae	papaya	Drew *et al*., 2005; Vayssières *et al.*, 2005 ; Vayssières *et al*., 2009	W	+++ in S Benin + in Tz (unpubl data)	Crop, Eurostat; Ornament, RHS plant finder, 2004
Chrysophyllum albidum	Sapotaceae	African or white star apple	Vayssières et al., 2005; Vayssières et al., 2009	W	+++ in N&S Benin	/
Citrus x paradisi	Rutaceae	grapefruit	Vayssières *et al*., 2009; Mwatawala *et al*., 2006; Mwatawala *et al.*, 2009	E&W	+ in N Benin ++/+++ in tz	Crop, Eurostat; Ornament, RHS plant finder, 2004
Citrus reticulata	Rutaceae	Mandarin, tangerine	Vayssières *et al.*, 2005; Vayssières *et al*., 2009; Mwatawala *et al*., 2006; Rwomushana *et al*., 2008;Mwatawala *et al*., 2009	E&W	+ in N Benin, +++ in S Benin ++ in Tz ++ in Kenya	Crop, Eurostat; Ornament, RHS plant finder, 2004
Citrus sinensis	Rutaceae	sweet orange	Vayssières *et al*., 2005; Vayssières *et al*., 2009; Mwatawala *et al*., 2006; Rwomushana *et al*., 2008; Mwatawala *et al*., 2009	E&W	++ in N Benin, +++ in S Benin ++ in Tz ++ in Kenya	Ornament, RHS plant finder, 2004
Citrus x tangelo	Rutaceae	tangelo	Vayssières et al., 2009;	W	++++ in S Benin	Crop, Eurostat; Ornament, RHS plant finder, 2004

Diospyros montana	Ebenaceae	mountain persimmon	Vayssières *et al*., 2005; Vayssières *et al*., 2009	W	+++ in S Benin	/
Eriobotrya japonica	Rosaceae	loquat	Mwatawala *et al*., 2006; Mwatawala *et al*., 2009	E	++++ in Tz	Ornament, RHS plant finder, 2004
Fortunella japonica	Rutaceae	kumquat	JY Rey, pers. comm., 2009 in Senegal	W	++++ in Senegal	
Fortunella margarita	Rutaceae	kumquat	Mwatawala *et al*., 2009 JY Rey, pers. comm., 2009 in Senegal	E&W	+++ in Tz ++++ in Senegal	Ornament, RHS plant finder, 2004
Irvingia gabonensis	Irvingiaceae	African wild mango	Vayssières *et al.*, 2009	W	+++ in N Benin, ++++ in S Benin	/
Mangifera indica	Anacardiaceae	mango	Drew *et al*., 2005; Vayssières *et al*., 2005; Vayssières *et al*., 2009 ; Rwomushana *et al*., 2008; Mwatawala *et al*., 2009	E&W	++++ in N & S Benin ++++ in Tz ++++ in Kenya	PPP index
Psidium guajava	Myrtaceae	guava	Drew *et al*., 2005; Vayssières *et al*., 2005; Vayssières *et al*., 2009; Ekesi *et al*., 2006; Mwatawala *et al*., 2006; Rwomushana *et al*., 2008; Mwatawala *et al*., 2009	E&W	++++ in N Benin ++++ in Tz +++ in Kenya	Crop, Eurostat; Ornament, RHS plant finder, 2004
Psidium littorale	Myrtaceae	strawberry guava	Mwatawala *et al*., 2009	E	++++ in Tz	Ornament, RHS plant finder, 2004
Spondias cytherea	Anacardiaceae	jew plum	Mwatawala *et al*., 2006; Mwatawala *et al*., 2009	E	+++ in Tz	PPP index
Spondias mombin	Anacardiaceae	tropical plum	Vayssières *et al.*, 2009 IITA, unpublished data	W	+++ N Benin	/
Terminalia catappa	Combretaceae	tropical almond	Vayssières *et al*., 2009; Ekesi *et al*., 2006; Rwomushana *et al*., 2008; Mwatawala *et al*., 2009	E&W	++++ in S Benin ++++ in Tz ++++ in Kenya	PPP index
Thevetia peruviana	Apocynaceae	lucky nut	Mwatawala *et al*., 2009	E	+++ in Tz	Ornament, RHS plant finder, 2004
Vitellaria paradoxa	Sapotaceae	sheanut	Vayssières *et al*., 2009	W	++++ in N Benin	/

The following species are considered **minor hosts** as they are recorded either as:
- an incidental host, with only one or a few records. Usually with low infestation rate;
- a host that is used more regularly, but often with very low infestation rate. This can also be a host for which there are only few positive rearings, but with considerable numbers of flies emerging.

Species	Family	Common name	Reference(s)	Region E : East W : West	Information*	Use
Anacardium occidentale	Anacardiaceae	cashew	Vayssières *et al*., 2005; Vayssières *et al*., 2009	W	++ in North Benin + in Tz (unpubl data)	PPP index
Annona cherimola	Annonaceae	cherimoya	Rwomushana *et al*., 2008; Mwatawala et al., 2009 ;	E	++ in Tz +++ in Kenya	Ornament, RHS plant finder, 2004
Annona senegalensis	Annonaceae	Wild custard apple	Vayssières *et al*., 2009	W	+ in N Benin	PPP index
Annona squamosa	Annonaceae	sugar apple	Rwomushana *et al*., 2008	E	+ in Kenya	PPP index
Averrhoa carambola	Oxalidaceae	starfruit	Vayssières *et al*., 2009	W	+ in N Benin, ++ in S Benin + in Tz (unpubl data; single record)	PPP index
Blighia spp.	Sapindaceae		IITA, unpublished data	W	+ in Benin	?
Capsicum annuum	Solanaceae	Sweet pepper	Vayssières *et al.*, 2005	W	- in Tz	Crop, Eurostat; Ornament, RHS plant finder, 2004
Capsicum frutescens	Solanaceae	chili pepper	Vayssières *et al*., 2009	W	+ in N Benin	Ornament, RHS plant finder, 2004
Citrullus lanatus	Cucurbitaceae	watermelon	Mwatawala *et al*., 2006; Mwatawala *et al*., 2009	E	++ in Tz	Crop, Eurostat;
Citrus aurantium	Rutaceae	Sour orange	IITA, unpublished data	W	+ in Benin	PPP index
Citrus grandis	Rutaceae	pomelo	Mwatawala *et al.*, 2009	E	+ in Tz	Crop, Eurostat;
Citrus limon (=C. limonum)	Rutaceae	lemon	Ekesi *et al.*, 2006; Mwatawala *et al.*, 2006; Rwomushana *et al.*, 2008 Mwatawala *et al.*, 2009	E	++ in Tz ++ in Kenya	Crop, Eurostat; Ornament, RHS plant finder, 2004
Coffea arabica	Rubiaceae	arabica coffee		E	+ in Tz (unpubl data)	PPP index
Coffea canephora	Rubiaceae	robusta coffee	Mwatawala *et al*., 2009	E	+ in Tz	PPP index
Cordia sp. cf *myxa*	Boraginaceae	Assyrian plum	Rwomushana *et al*., 2008	E	+ in Kenya	?
Cordyla pinnata	Caesalpiniaceae	Cayor pear tree	Vayssières *et al*., 2009	W	+ in N Benin	/
Cucumis figarei	Cucurbitaceae	hyena's watermelon	Mwatawala *et al*., 2006; Mwatawala *et al*., 2009	E	+ in Tz	/
Cucumis sp nr metuliferus	Cucurbitaceae			E	+ in Tz	?
Cucumis pepo	Cucurbitaceae	gourd	IITA, unpublished data	W	+ in Benin	Crop, Eurostat;

Cucumis sativus	Cucurbitaceae	cucumber	Mwatawala *et al*., 2006; Mwatawala *et al*., 2009	E	+ in Tz	Crop, Eurostat; PPP index
Cucurbita maxima	Cucurbitaceae		IITA, unpublished data	W	+ in Benin	Crop, Eurostat;
Cucurbita spp.	Cucurbitaceae	pumpkin	Mwatawala *et al*., 2009	E	+ in Tz	Crop, Eurostat;
Flacourtia indica	Flacourtiaceae	governor's plum	Mwatawala *et al*., 2006; Mwatawala *et al*., 2009	E	+/++ in Tz	PPP index
Lycopersicon esculentum	Solanaceae	tomato	Vayssières *et al*., 2009; Ekesi *et al*., 2006; Rwomushana *et al*., 2008	E&W	+ in N Benin + in Tz + in Kenya	Crop, Eurostat;
Malus domestica	Rosaceae	apple	Mwatawala *et al*., 2009	E	+ in Tz	Ornament, RHS plant finder, 2004
Manilkara zapota	Sapotaceae	Bully tree	Vayssières *et al*., 2009;	W	++ in S Benin	PPP index
Momordica cf trifoliata	Cucurbitaceae			E	+ in Tz	Ornament, RHS plant finder, 2004
Musa sp. AAA	Musaceae	banana	Vayssières *et al*., 2009; Ekesi *et al*., 2006; Rwomushana *et al*., 2008	E&W	+ in S Benin + in Tz (unpubl data) ++ in Kenya	Ornament, RHS plant finder, 2004
Musa x *paradisiaca*	Musaceae		IITA, unpublished data	W	+ in Benin	Ornament, RHS plant finder, 2004
Persea americana	Lauraceae	avocado	Vayssières *et al*., 2009; Ekesi *et al*., 2006; Mwatawala *et al*., 2006; Mwatawala *et al*., 2009	E&W	+ in S Benin +/++ in Tz	Crop, Eurostat;
Prunus persica	Rosaceae	peach	Mwatawala *et al*., 2006; Mwatawala *et al*., 2009	W&S	+ in Tz	Crop, Eurostat; Ornament, RHS plant finder, 2004
Sarcocephalus latifolius	Rubiaceae	African peach	Vayssières *et al*., 2009;	W	+ in Benin	/
Sclerocarya birrea	Anacardiaceae	marula plum	Ekesi *et al*., 2006; Rwomushana *et al*., 2008; Mwatawala *et al*., 2009; Vayssières *et al*., 2009	E&W	++ in N&S Benin ++ in Tz ++ in Kenya	PPP index
Solanum aethiopicum	Solanaceae	African eggplant	Mwatawala *et al*., 2009	E	+/++ in Tz	/
Solanum anguivi	Solanaceae	African eggplant		E	+ in Tz (unpubl data)	/
Solanum incanum	Solanaceae			E	+ in Tz (unpubl data)	PPP index
Solanum nigrum	Solanaceae	Black nightshade		E	+ in Tz (unpubl data)	PPP index
Solanum sodomeum	Solanaceae	Sodom apple		E	+ in Tz (unpubl data)	/

Sorindeia madagascariensis	Anacardiaceae	sondriry	Rwomushana *et al*., 2008	E	+ in Kenya	/
Strychnos mellodora	Strychnaceae	monkey orange	NPPO of South Africa	S	Not sure whether actually record from S; could be based on record from Kenya	/
Syzigium cumini	Myrtaceae	jambolan	Mwatawala *et al*., 2009	E	++ in Tz	
Syzygium jambos	Myrtaceae	rose apple		E	+ in Tz (unpubl data)	Ornament, RHS plant finder, 2004
Sizygium malaccense	Myrtaceae	Malay apple	IITA, unpublished data	W	+ in Benin	PPP index
Syzygium samarangense	Myrtaceae	Java apple	Vayssières *et al*., 2009	W	+ in S Benin	/
Ziziphus mauritiana		Indian jujube	Vayssières pers. comm. 2009		+ in N-Benin	

In North and South Benin, only hosts for which there are quantitative data and repetitions are mentioned in Vayssières *et al*., 2009.
For Kenya, data have been taken from Rwomushana *et al*., 2008

Hosts to be confirmed

Species	**Family**	**Common name**	**Reference(s)**	**Use**
Diospyros kaki	Ebenaceae	Japanese persimmon	IITA, unpublished data	Ornament, RHS plant finder, 2004
Dracaena steudneri	Dracaenaceae		IITA, unpublished data	Ornament, RHS plant finder, 2004
Ficus sycomorus	Moraceae	wild fig	IITA, unpublished data	/
Garcinia mannii	Clusiaceae	chewing stick	IITA, unpublished data	/
Landolphia sp.	Apocynaceae		IITA, unpublished data	/
Mareua duchesnei	Capparaceae		IITA, unpublished data	/

IITA, unpublished data
http://www.africamuseum.be/fruitfly/AfroAsia.htm

NPPO of South Africa
http://www.nda.agric.za/docs/NPPOZA/pest_alert_information.htm