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Bactrocera dorsalis
Pest Report to support ranking of EU candidate priority pests

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1. Introduction to the report

This document is one of the 28 Pest Reports produced by the EFSA Working Group on EU Priority Pests under task 3 of the mandate M-2017-0136. It supports the corresponding Pest Datasheet published together on Zenodo[1] and applies the methodology described in the Methodology Report published on the EFSA Journal (EFSA, 2019).

This Pest Report has five sections. In addition to this introduction, a conclusion and references, there are two key sections, sections 2 and 3.

Section 2 first summarises the relevant information on the pest related to its biology and taxonomy. The second part of Section 2 provides a review of the host range and the hosts present in the EU in order to select the hosts that will be evaluated in the expert elicitations on yield and quality losses. The third part of Section 2 identifies the area of potential distribution in the EU based on the pest's current distribution and assessments of the area where hosts are present, the climate is suitable for establishment and transient populations may be present. The fourth part of Section 2 assesses the extent to which the presence of the pest in the EU is likely to result in increased treatments of plant protection products. The fifth part of section 2 reviews additional potential effects due to increases in mycotoxin contamination or the transmission of pathogens.

In Section 3, the expert elicitations that assess potential yield losses, quality losses, the spread rate and the time to detection are described in detail. For each elicitation, the general and specific assumptions are outlined, the parameters to be estimated are selected, the question is defined, the evidence is reviewed and uncertainties are identified. The elicited values for the five quantiles are then given and compared to a fitted distribution both in a table and with graphs to show more clearly, for example, the magnitude and distribution of uncertainty. A short conclusion is then provided.

The report has two appendices. Appendix A contains a host list created by amalgamating the host lists in the EPPO Global Database (EPPO, online) and the CABI Crop Protection Compendium (CABI, 2019). Appendix B provides a summary of the evidence used in the expert elicitations.

It should be noted that this report is based on information available up to the last day of the meeting[2] that the Priority Pests WG dedicated to the assessment of this specific pest. Therefore, more recent information has not been taken into account.

For *Bactrocera dorsalis*, the following documents were used as key references: EPPO/CABI datasheet (1996), the review by Clarke et al. (2005), the assessment by Biosecurity Australia (2009), the PRA by Castrillon et al. (2010), the cooperative eradication program by USDA (2017).

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[1] Open-access repository developed under the European OpenAIRE program and operated by CERN, https://about.zenodo.org/

[2] The minutes of the Working Group on EU Priority Pests are available at http://www.efsa.europa.eu/sites/default/files/wgs/plant-health/wg-plh-EU_Priority_pests.pdf

2. The biology, ecology and distribution of the pest

2.1. Summary of the biology and taxonomy

The Oriental fruit fly, *Bactrocera dorsalis* is a member of a species complex, the '*B. dorsalis* complex' which includes over 100 taxa, mainly endemic to south-east Asia (Schutze et al., 2015a). The '*dorsalis* complex' is one of the most destructive pest species complexes in global fruit production due to polyphagy, invasiveness, high reproductive potential, multivoltinism and continuous activity throughout the year. *Bactrocera dorsalis* formerly known as *Dacus dorsalis, Chaetodacus dorsalis, C. ferrugineus dorsalis, C. ferrugineus okinawanus, Strumeta dorsalis* (White and Elson-Harris, 1992), it was erroneously described as *B. invadens* (Drew et al., 2005) when first invaded Africa in 2003. Following a thorough revision it has recently synonymized with 3 other *Bactrocera* species (Schutze et al., 2015b): *B. invadens*, *B. papayae* and *B. philippinensis* (Schutze et al., 2015a). *Bactrocera dorsalis,* as a member of the '*dorsalis* complex', is a highly polyphagous pest with multiple overlapping generations and high intrinsic rate of increase (Stephens et al., 2007; Theron et al., 2017).

Adult morphology exhibits great variation among populations. Adults have a body length of about 8.0 mm, with mostly hyaline wings of approximately 7.3 mm in length. Body coloration is variable, with prominent yellow and dark brown to black markings on the thorax. Two horizontal black stripes and a longitudinal median stripe extending from the base of the third segment to the apex of the abdomen form a T-shaped pattern, but the pattern varies considerably. The ovipositor is very slender and sharply pointed (Weems et al., 1999).

2.2. Host plants

2.2.1. List of hosts

Hosts of the *B. dorsalis* species complex pertain to several plant families such as Anacardiaceae, Annonaceae, Clusiaceae, Lauraceae, Moraceae, Myrtaceae, Rutaceae, Sapotaceae, and Solanaceae, each with 15 or more known fruit fly host species (Clarke et al., 2005). Extreme polyphagy has been recorded for *B. papayae*, with 209 recorded larval hosts across 51 plant families and *B. dorsalis*, with 124 host species across 42 families (Clarke et al., 2005). For *B. invadens* a study on host preference is that conducted in Kenya by Rwomushana et al. (2008a).

Appendix A provides the full list of hosts.

2.2.2. Selection of hosts for the evaluation

The selection and grouping of hosts for the assessment of yield loss was carried out considering the major hosts listed in the EPPO Global Database (EPPO, online), the availability of production data in Eurostat and the supporting literature about quantitative records of yield losses.

Three categories of host have been considered

- exotic fruit: The host group of exotic fruit in Eurostat (category F2900- Other fruits from subtropical and tropical climate zones n.e.c.) includes *Mangifera indica* (mango), *Psidium guajava* (guava), *Carica papaya* (papaya), *Annona cherimola* (cherimoya), *Diaspyros kaki* (persimmon) and *Punica granatum* (pomegranate). Among those species, the following ones are among the most susceptible hosts of *B dorsalis* in the EU: avocado, mango, guava and papaya
- citrus: this category includes all the citrus species (*Citrus* spp.) grown in the EU

- peach: in this category both peaches and nectarines are included (*Prunus persica*)

2.2.3. Conclusions on the hosts selected for the evaluation

The complete list of hosts is produced by merging

- the list of host plants defined by EPPO (EPPO, online)
- the list of host species reported by CABI (CABI, 2019)

The hosts and group of hosts on which the impact is assessed are:

- exotic fruit
- citrus
- peach

2.3. Area of potential distribution

2.3.1. Area of current distribution

B. dorsalis originates from tropical areas, probably moving from Southeast China to Southeast Asia (Clarke et al., 2005; Wan et al., 2011; Shi et al., 2012), and not from Taiwan, as previously indicated by Hardy (1973). This pest dispersed over the last century to the Ryukyu Islands, Nauru, Pakistan, India, Nepal, Laos, Vietnam, Burma, Sri Lanka, Thailand, and Saipan Island (Clarke et al., 2005; Stephens et al., 2007; Wan et al., 2011, 2012; De Villiers et al., 2016). Outside Asia, it was found in the Commonwealth of the Northern Mariana Islands (1935), Hawaii (1945), Guam (1947), California and Florida (1960–1990), French Polynesia (1996), and Kenya (2003) (Fullaway, 1953; Lux et al., 2003; Aketarawong et al., 2007; Nakahara et al., 2008). During the last decades *B. dorsalis* has invaded and spread in the African continent (Lux et al., 2003), mainly prevailing in warm-humid lowland, cultivated and forestall areas, and has displaced other tephritids (Ekesi et al., 2006; Rwomushana et al., 2008a). Its area of distribution is expected to increase in the future due to its wide host range, climatic tolerance, high reproductive potential and spread capacity due to both natural dispersal and trade (Liu et al., 2018).

Figure 1 provides an overview of the current area of distribution of the pest. The first EU outbreak of *B dorsalis* has been notified in November 2018 from Campania region (Italy) (EPPO, online), where adults were detected using methyl eugenol baited traps (Nugnes et al., 2018).

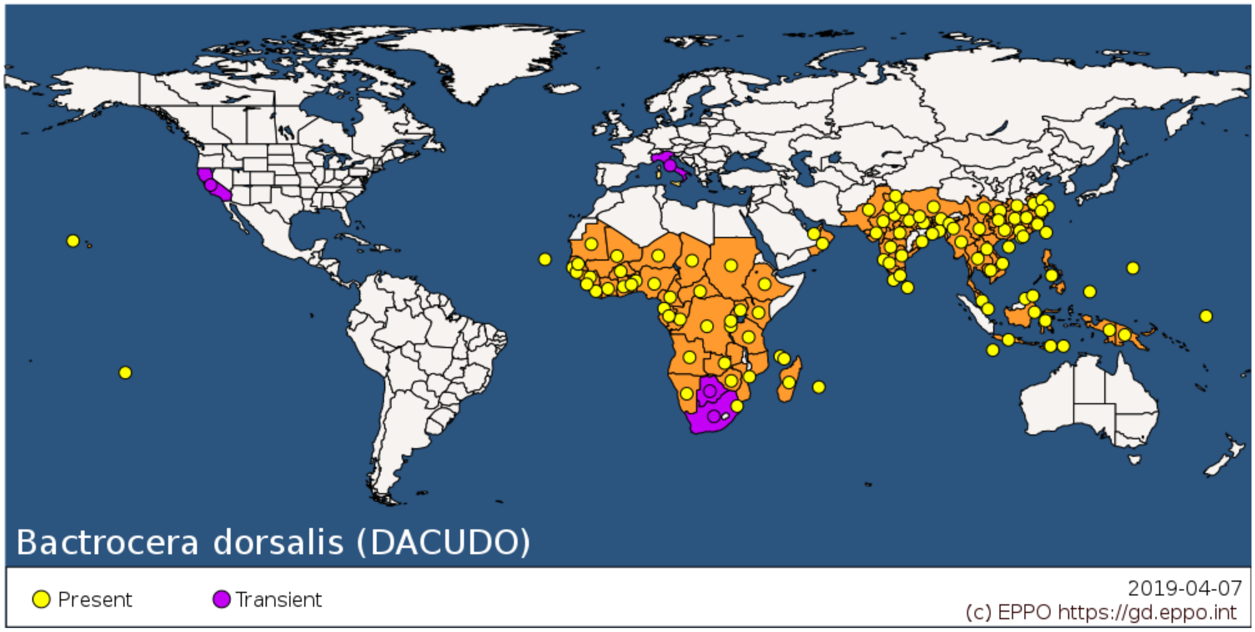

Figure 1 Distribution map of *Bactrocera dorsalis* from the EPPO Global Database accessed 01/04/2019, including also records of *B. invadens*, *B. papayae* and *B. philippinensis*.

2.3.2. Area of potential establishment

Climatic conditions such as temperature, rainfall and relative humidity affect the survival, flight activity and population dynamics of *B. dorsalis*. Adults perform better in moist and high temperature conditions with an optimum range from 18-27°C (Adzim et al., 2016; Fletcher, 1987; Rwomushana et al., 2008b). The species can also be tolerant to dry climate and can be found in arid regions in terrestrial natural or semi-natural habitats (CABI, 2019).

The global distribution (Figure 1) of *B. dorsalis* is tropical or subtropical but recent outbreaks in the Cape Province of South Africa and Italy (Campania) suggest that it may also be able to establish in warm Mediterranean climates. Over the last two years detections have been reported in Austria but they are considered to stem from transient non established populations.

Potential distribution of *B. dorsalis* in South China has been predicted Using Maxent (Maximum Entropy) ecological niche model (Liu et al., 2011). CLIMEX model has also been used to assess the direction and magnitude of future invasions threats by *B. dorsalis* applying regional global climate model (GCM) (Stephens et al., 2007)..

De Villiers et al. (2016) reviewed the previous attempts to model the distribution of *B. dorsalis* and published their own projection of global potential distribution using the CLIMEX species distribution model with irrigation scenarios and climate change scenarios. We have used their baseline projection based on 1961-90 global climate and a composite irrigation scenario for the definition of the area of potential establishment of *B. dorsalis* (see Fig. 10).

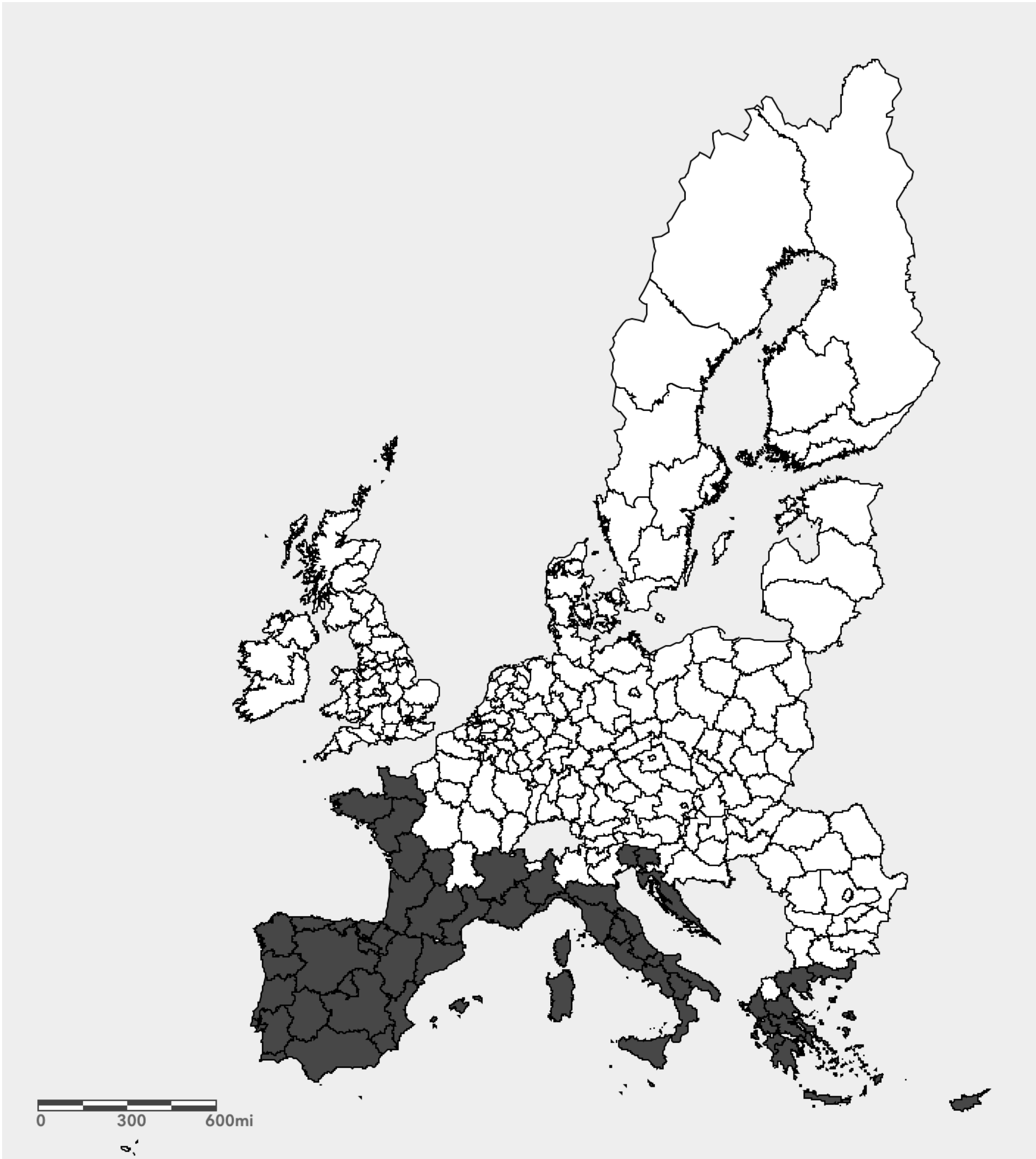

Figure 2 The potential distribution of the pest in the EU NUTS2 regions based on the scenarios established for assessing the impacts of the pest by the EFSA Working Group on EU Priority Pests (EFSA, 2019). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/KnPO

2.3.3. Transient populations

Bactrocera dorsalis is not expected to form transient populations in the EU (for "transient" see the definition in EFSA, 2019).

2.3.4. Conclusions on the area of potential distribution

The area of potential establishment of *B. dorsalis* is derived from the projection in De Villiers et al. (2016) based on 1961-90 global climate and a composite irrigation scenario. Fig. 10 shows that the potential distribution of *B. dorsalis* covers the Mediterranean coastal area of the Balkan peninsula and Italy, Southern Spain, Portugal and the Atlantic coast in France.

For the species transient population are not considered, therefore the assessment is limited to the area of potential establishment.

2.4. Expected change in the use of plant protection products

Organophosphorus and pyrethroid insecticides are widely used for the control of *B. dorsalis* in fruit orchards with a consecutive development of resistance to these chemicals. So far resistant populations have been recorded to trichlorphon (organophosphate), β-cypermethrin (pyrethroid) and avermectin (antibiotic insecticide) in China (Jin et al., 2011) and to fenitrothion, malathion and trichlorfon in wild populations in Taiwan (Hsu and Feng, 2000). Increased rates of resistance as well as synergistic and cross-resistance effects have been observed in laboratory trials for naled, trichlorfon, fenitrothion, fenthion, formothion, and malathion (organophosphates), methomyl (carbamate) and in cyfluthrin, cypermethrin, and fenvalerate (pyrethroids) (Hsu et al., 2004) and for spinosad (Hsu and Feng, 2006).

Additionally, "lure and kill" and "male annihilation" methods have been extensively used against the Oriental fruit fly. For example, Specialized Pheromone and Lure Application Technology (SPLAT - biologically inert materials used to control the release of semiochemicals and/or odours with or without pesticides) and methyl eugenol (ME: 4-allyl-1, 2-dimethoxybenzene-carboxylate) "attract-and-kill" sprayable formulations containing spinosad have been tested against other formulations in Hawaii (Vargas et al., 2008). Min-U-Gel formulations with ME were developed for spot applications in male annihilation programs in California for eradication of *B. dorsalis*. Min-U-Gel is a refined grade of attapulgite clay (anhydrous magnesium aluminium silicate) mixed with naled or malathion and ME to form a gel male annihilation formulation.

The Sterile Insect Technique (SIT) has been proposed against *B. dorsalis* (Steiner et al., 1970) but so far has not been widely adopted.

Biological control approaches include the use of parasitoid wasps (Hymenoptera: Braconidae). Some of the natural enemies that have extensively been used in a large-scale classical biocontrol program in Hawaii are *Diachasmimorpha longicaudata*, *Fopius vandenboschi* and *F. arisanus*. Since its establishment, *F. arisanus* has resulted in a dramatic reduction in fruit infestation in Hawaii through a high level of *B. dorsalis* parasitism (65%-70%), and it has remained the dominant parasitoid species (Vargas et al., 2012). Generic predators such as ground dwelling carabids, ants etc can also contribute to reduction of immature (larvae and pupae) population of B. *dorsalis*.

Entomopathogenic nematodes have been tested against *B. dorsalis* larvae in Benin with promising results (Godjo et al., 2018). The presence of some nematode species in mango orchards was confirmed but with low proportion of recovery. Field trials are required to confirm validity of this approach in the wild. Entomopathogenic nematodes, such as *Steinernema carpocapsae* have been tested in China as well with promising results (Lin et al., 2005; Liu et al., 2018).

The entomopathogenic fungi *Bauveria bassiana* has also been considered and field tests were found to be quite effective to control *B. dorsalis* (Liu et al., 2018; Pan et al., 2014).

In the EU a series of PPPs suitable against fruit flies are registered and can be used against *B. dorsalis* too. However, given the large number of hosts of this species, which includes vegetables, on which this pest could have a major impact, an increase in the use of PPPs is expected.

Due to the fact that effective treatments with plant protection products (PPPs) are currently available but an increase in their use would be expected in presence of this pest, the most suitable PPP indicator is Case "C" and the category is "1" based on Table 1.

Table 1: Expected changes in the use of Plant Protection Products (PPPs) following *Bactrocera dorsalis* establishment in the EU in relation to four cases (A-D) and three level score (0-2) for the expected change in the use of PPPs

Expected change in the use of PPPs	**Case**	**PPPs indicator**
PPPs effective against the pest are not available/feasible in the EU	A	0
PPPs applied against other pests in the risk assessment area are also effective against the pest, without increasing the amount/number of treatments	B	0
PPPs applied against other pests in the risk assessment area are also effective against the pest but only if the amount/number of treatments is increased	**C**	**1**
A significant increase in the use of PPPs is not sufficient to control the pest: only new integrated strategies combining different tactics are likely to be effective	D	2

2.5. Additional potential effects

2.5.1. Mycotoxins

The species is not known to be related to problems caused by mycotoxins.

2.5.2. Capacity to transmit pathogens

The species is not known to vector any plant pathogens.

3. Expert Knowledge Elicitation report

3.1. Proportion of yield and quality losses

3.1.1. Structured expert judgement

3.1.1.1. Generic scenario assumptions

All the generic scenario assumptions common to the assessments of all the priority pests are listed in the section 2.4.1.1 of the Methodology Report (EFSA, 2019).

3.1.1.2. Specific scenario assumptions

- Yield loss is assessed for groups of hosts: (I) exotic fruit (II) citrus and (III) peach.

3.1.1.3. Selection of the parameter(s) estimated

Yield loss in this case corresponds to the proportion of fruits lost due to premature dropping and to unmarketable fruits due to larval infestation at harvest.

The assessment of the yield losses is done by comparison with the EKE results of *Anastrepha ludens* and *B. zonata*.

The assessment on impact was conducted on the following hosts:

- Exotic fruit: *B. dorsalis* impact is expected to be higher than that caused by *A. ludens* and *B. zonata*
- Citrus
- Peach

Quality losses are not assessed because considered as full losses and included under the assessment of yield losses.

3.1.1.4. Defined question(s)

What is the percentage yield loss in exotic fruit under the scenario assumptions in the area of the EU under assessment for *Bactrocera dorsalis*, as defined in the Pest Report?

What is the percentage yield loss in citrus under the scenario assumptions in the area of the EU under assessment for *Bactrocera dorsalis*, as defined in the Pest Report?

What is the percentage yield loss in peach under the scenario assumptions in the area of the EU under assessment for *Bactrocera dorsalis*, as defined in the Pest Report?

3.1.1.5. Evidence selected

The experts reviewed the evidence obtained from the literature (see Table B.1 in Appendix B) selecting the data and references used as the key evidence for the EKE on impact.

A few general points were made:

Exotic fruit:

- Most interceptions of *B. dorsalis* from India are on mangos
- EU proportion of exotic fruit production: avocado (around 10,000 ha in Spain, 1,000 ha in Greece and 200 ha in Italy in 2018) (Piccione, 2018) > mango (around 5,000 ha in Spain and 100 ha in Italy in 2018) (Vincenzi and Speroni, 2018) >>> guava (still at a very initial phase in Spain and Sicily)
- Harvesting period: second half of August-end of October (Peláez, 2018)

Citrus:

- Rwomushana et al., 2008a
- Evidence from Africa supports that *B. dorsalis* can cause high damage in citrus

Peach:

- Wong et al. (1983) is considered the only relevant evidence for this category of hosts

3.1.1.6. Uncertainties identified

- Efficacy of control measures applied against *Ceratitis capitata* in controlling populations of *B. dorsalis*.
- Level of suitability of Mediterranean climatic conditions
- Difference in susceptibility of mango and avocado varieties
- Difference in harvesting time due to varieties (e.g. early vs late citrus varieties) and growing conditions (open field vs greenhouse for exotic fruit)

3.1.2. Elicited values for yield loss on exotic fruit

What is the percentage yield loss in exotic fruit under the scenario assumptions in the area of the EU under assessment for *Bactrocera dorsalis*, as defined in the Pest Report?

The five elicited values on yield loss on exotic fruit on which the group agreed are reported in the table below.

Table 2: The 5 elicited values on the yield loss (%) on exotic fruit

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	5%	12%	18%	25%	45%

3.1.2.1. Justification for the elicited values for yield loss on exotic fruit

Reasoning for a scenario which would lead to high yield loss (99th percentile / upper limit)

This scenario refers to condition in which (i) *C. capitata* control measures do not work, therefore the damage can be very high, (ii) the highly polyphagous habit of the pest facilitates the possibility to build up high density populations, (iii) infestation appears early in the season and it is difficult to be identified at the species level, (iv) early (harvest in August-September) and susceptible varieties (for example due to softer and/or thinner skins) are prevalent.

Comparison with *B. zonata*:

- *B. dorsalis* is known to be more destructive on mango than *B. zonata*
- *B. dorsalis* is adapted to climatic conditions that are more arid than those encountered in the Mediterranean area. Mediterranean conditions are more suitable to *B. zonata*

Comparison with *A. ludens*:

- the high yield loss would be comparable or a bit higher from *A. ludens*, although *B. dorsalis* is a strong flier and more aggressive than *A. ludens*, also better adapted to Mediterranean climatic conditions than *A. ludens*

Reasoning for a scenario which would lead to low yield loss (1st percentile / lower limit)

Treatment against *C. capitata* is more effective.

Mangos are a high value crop and grower are more aware on fruit flies.

Mediterranean conditions are not so suitable for *B. dorsalis*.

Prevalence of tolerant varieties (for example due to thicker skins) and late varieties (October-November).

Plants are grown in greenhouses.

Reasoning for a central scenario equally likely to over- or underestimate the yield loss (50th percentile / median)

Unlike *B. zonata*, damage is also caused on unripe fruit. Yield loss is expected to be little more than on *B. zonata* but not much. Compared to *A. ludens* this fruit fly will be more likely to build up bigger populations that would result in higher yield losses.

Climate suitability: *B. dorsalis* is well adapted to arid conditions, therefore the area where exotic fruits are grown (Southern Mediterranean zone) is very suitable to this pest. By comparison, *B. zonata*, which is more adapted to cooler climates, is expected to produce lower damages.

Mango are likely to be more prone to fruit flies' attacks than avocadoes, therefore although the impact on mangoes could be very high, the impact on the whole category of exotic fruit would remain limited.

Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile / interquartile range)

More certainty towards the median value.

3.1.2.2. *Estimation of the uncertainty distribution for yield loss on exotic fruit.*

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 3: Fitted values of the uncertainty distribution on the yield loss (%) on exotic fruit.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	5%					12%		18%		25%					45%
Fitted distribution	3.9%	5.1%	6.5%	8.3%	10.2%	12.2%	14.1%	17.8%	22.2%	25.0%	28.6%	32.8%	38.2%	43.2%	49.6%

Fitted distribution: Gamma (3.8581,0.050543), @RISK7.5

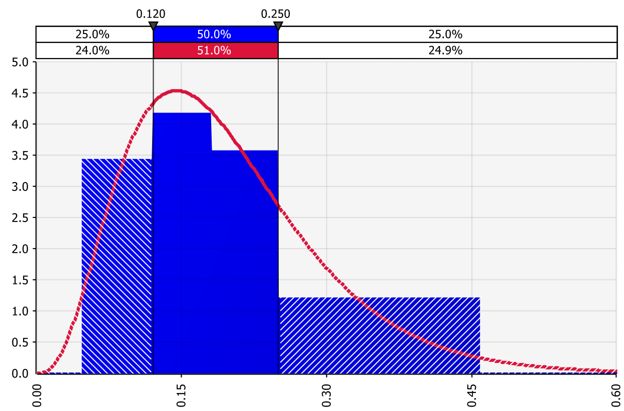

Figure 3 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on exotic fruit.

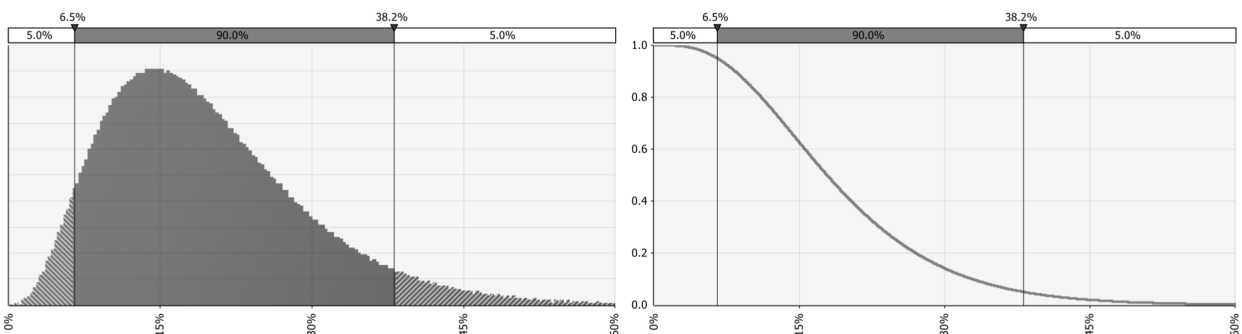

Figure 4 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on exotic fruit.

3.1.3. Elicited values for yield loss on citrus

What is the percentage yield loss in citrus under the scenario assumptions in the area of the EU under assessment for *Bactrocera dorsalis*, as defined in the Pest Report?

The five elicited values on yield loss on citrus on which the group agreed are reported in the table below.

Table 4: The 5 elicited values on the yield loss (%) on citrus

Percentile	1%	25%	50%	75%	99%
Expert elicitation	1%	5%	8%	15%	30%

3.1.3.1. Justification for the elicited values for yield loss on citrus

Reasoning for a scenario which would lead to high yield loss (99th percentile / upper limit)

Comparing with *A. ludens*, the pest is better adapted to the Mediterranean conditions and therefore more destructive than *A. ludens*.

Control measures against *C. capitata* are scarcely effective for *B. dorsalis*.

Being a highly polyphagous pest, it has great possibilities to build up high density populations in early growing season (early infestations).

Comparison with *B. zonata*: yield loss of *B. dorsalis* in citrus is expected to be little higher than of *B. zonata*.

As for *B. zonata*, citrus are expected to be less sensitive than mangoes, due to the different seasonality. Yield losses are more diluted compared to mangos because of late varieties of citrus and because citrus fruit are grown in winter, which is less suitable for *B. dorsalis*.

More damage is expected on early citrus species/varieties in presence of high-density starting populations of *B. dorsalis*.

Reasoning for a scenario which would lead to low yield loss (1st percentile / lower limit)

Treatment for *C. capitata* is effective for *B. dorsalis*. Late varieties of citrus during winter season would create dilution effect that will cause lower population build-up.

Less damage on late citrus species/varieties with low density of starting populations of *B. dorsalis*.

Reasoning for a central scenario equally likely to over- or underestimate the yield loss (50th percentile / median)

The median value of yield loss is given by the fact that Citrus is not the preferred host for *B. dorsalis*. Still this fruit fly is better adapted and could build larger populations than *A. ludens*.

The expected yield loss is similar to *B. zonata*, but a little bit higher.

Reasoning for a central scenario equally likely to over- or underestimate the yield loss (50th percentile / median)

More certainty towards the median in the lower range, more uncertainty in the upper range.

3.1.3.2. Estimation of the uncertainty distribution for yield loss on citrus.

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 5: Fitted values of the uncertainty distribution on the yield loss (%) on citrus.

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	1%					5%		8%		15%					30%
Fitted distributio n	0.6%	1.1%	1.6%	2.5%	3.5%	4.7%	5.9%	8.6%	11.9%	14.2%	17.2%	20.9%	25.7%	30.4%	36.4%

Fitted distribution: Gamma (1.7933,0.058291), @RISK7.5

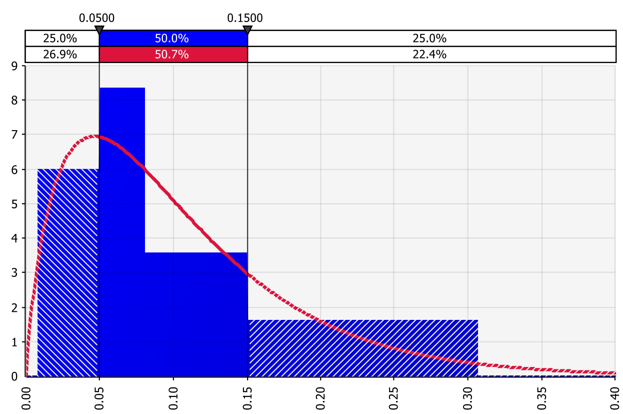

Figure 5 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on citrus.

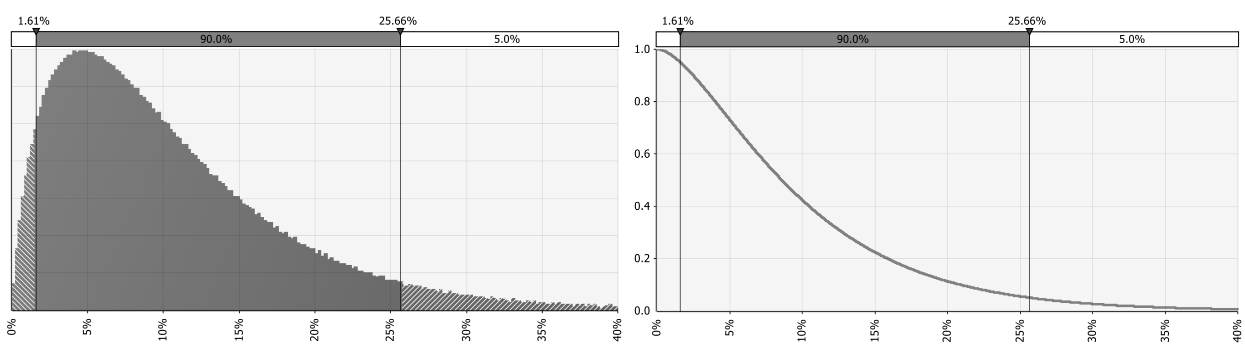

Figure 6 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on citrus.

3.1.4. Elicited values for yield loss on peach

What is the percentage yield loss in peach under the scenario assumptions in the area of the EU under assessment for *Bactrocera dorsalis*, as defined in the Pest Report?
The five elicited values on yield loss on peach on which the group agreed are reported in the table below.

Table 6: The 5 elicited values on the yield loss (%) on peach

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	1%	5%	9%	15%	35%

3.1.4.1. Justification for the elicited values for yield loss on peach

Reasoning for a scenario which would lead to high yield loss (99th percentile / upper limit)

C. capitata population abundance guides the timing of treatments. For *C. capitata* there would be two peaks of population, in summer and in autumn, following the availability of the hosts. High populations even in the early season. Control measures against *C. capitata* have less effect against *B. dorsalis*. Climatic conditions in Southern Europe are suitable for the pest.

Comparison with *B. zonata*: *B. zonata* is better adapted to Mediterranean conditions and more adapted to peach than *B. dorsalis*. Therefore, the impact of *B. dorsalis* is expected to be little lower than for *B. zonata*.

More damage on late varieties of peach is expected with high density of starting populations of *B. dorsalis*.

Reasoning for a scenario which would lead to low yield loss (1st percentile / lower limit)

Less damage on early varieties of peach (more frequent in Southern EU) with low density of starting populations of *B. dorsalis*. Treatment against *C. capitata* has more effect against *B. dorsalis*. Climatic conditions in Southern Europe are not so suitable for the pest.

Reasoning for a central scenario equally likely to over- or underestimate the yield loss (50th percentile / median)

Comparison with *B. zonata*- *B. zonata* is better adapted to Mediterranean conditions and more adapted to peach than *B. dorsalis*. Therefore, the impact of *B. dorsalis* is expected to be little lower than for *B. zonata*.

Populations and yield loss expected to be lower than on the exotic fruit.

Reasoning for a central scenario equally likely to over- or underestimate the yield loss (50th percentile / median)

High uncertainty on both sides of the median.

3.1.4.2. Estimation of the uncertainty distribution for yield loss on peach.

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 7: Fitted values of the uncertainty distribution on the yield loss (%) on peach.

Percentile	**1%**	**2.5%**	**5%**	**10%**	**17%**	**25%**	**33%**	**50%**	**67%**	**75%**	**83%**	**90%**	**95%**	**97.5%**	**99%**
Expert elicitation	1%					5%		9%		15%					35%
Fitted distribution	0.7%	1.2%	1.7%	2.7%	3.8%	5.0%	6.3%	9.1%	12.5%	14.9%	18.0%	21.8%	26.8%	31.6%	37.9%

Fitted distribution: Gamma (1.8322,0.059883), @RISK7.5

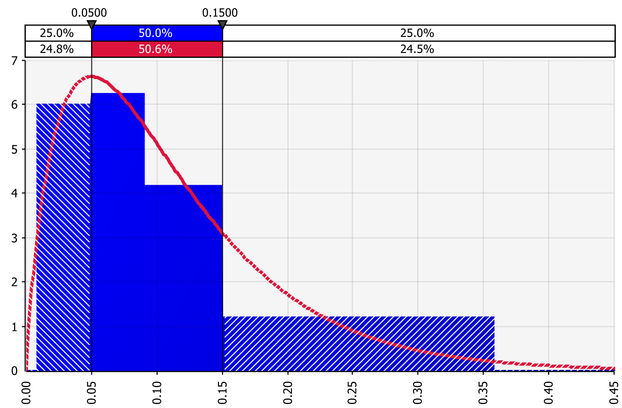

Figure 7 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on peach.

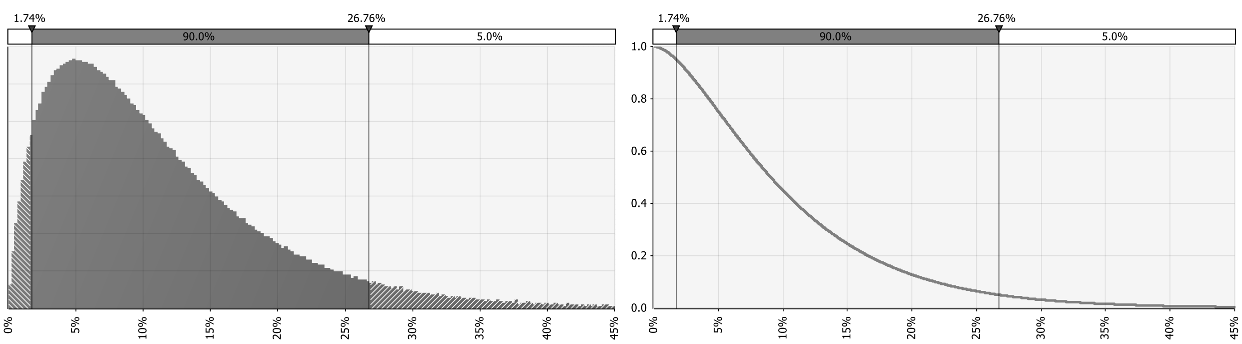

Figure 8 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on peach.

3.1.5. Conclusions on yield and quality losses

Based on the general and specific scenarios considered in this assessment, the proportion (in %) of yield losses (here with the meaning of proportion of fruits lost due to premature dropping and to unmarketable fruits due to larval infestation at harvest) is estimated to be

- 18% (with a 95% uncertainty range of 5-43%) on exotic fruit (in particular: avocado, mango, guava and papaya)
- 8.6% (with a 95% uncertainty range of 1-30%) on citrus
- 9% (with a 95% uncertainty range of 1-32%) on peach (including both peaches and nectarines)

Quality losses are not assessed because considered as full losses and included under the assessment of yield losses.

3.2. Spread rate

3.2.1. Structured expert judgement

3.2.1.1. Generic scenario assumptions

All the generic scenario assumptions common to the assessments of all the priority pests are listed in the section 2.4.2.1 of the Methodology Report (EFSA, 2019).

3.2.1.2. Specific scenario assumptions

- No shortage of suitable hosts
- Different host species won't influence the spread rate
- Hitchhiking is excluded as not confirmed to be a major component of spread

3.2.1.3. Selection of the parameter(s) estimated

- The isolated population not known to be established is a small population of adult females emerged all at the same time
- Spread rate from a low level population not in an invasion scenario
- The spread rate has been assessed as the number of kilometres per year

3.2.1.4. Defined question(s)

What is the spread rate in 1 year for an isolated focus within this scenario based on average European conditions? (units: km/year)

3.2.1.5. Evidence selected

The experts reviewed the evidence obtained from the literature (see Table B.2 in Appendix B) selecting the data and references used as the key evidence for the EKE on spread rate. A few general points were made:

- Data on movement at individual level and max distance travelled
- This species is a strong flier
- *B. dorsalis* is less adapted to dry climates than *B. zonata*
- Larger number of hosts than *B. zonata*

The spread rate of *B. dorsalis* and *B. zonata* has been assessed together. Despite the differences between the two species, their combination results in a similar distribution.

3.2.1.6. Uncertainties identified

- No information about population spread rate
-

3.2.2. Elicited values for the spread rate

What is the spread rate in 1 year for an isolated focus within this scenario based on average European conditions? (units: km/year)

The five elicited values on spread rate on which the group agreed are reported in the table below.

Table 8: The 5 elicited values on spread rate (km/y)

Percentile	1%	25%	50%	75%	99%
Expert elicitation	1	4	7	12	40

3.2.2.1. Justification for the elicited values of the spread rate

Reasoning for a scenario which would lead to wide spread (99th percentile / upper limit)

The upper value takes into account conditions for high active dispersal (e.g., patchy distribution of hosts) favourable winds, and development of 3 generations/year.

Reasoning for a scenario, which would lead to limited spread (1st percentile / lower limit)

The lower value of spread rate is justified by the release-recapture studies and the fact that adults would most probably find fruit available in the surroundings limiting the dispersal behaviour.

Reasoning for a central scenario, equally likely to over- or underestimate the spread (50th percentile / median)

The median value takes into account the fact that in Southern distribution there should be 2-3 generations, with 3-4 km/generation. In spite of being a strong flier, it will not disperse very much, given the likelihood of encountering suitable hosts in the surroundings, in the Mediterranean area. It is a tropical fly which goes though strong bottle necks during winter. This would cause a reduction in population density and therefore, in a small population, a lower spread capacity at the beginning of the season. Most of release-recapture studies observed 1-2 km distance/generation (doubled with two generations).

It is expected to spread a bit less than *B. zonata* due to its larger number of host species and its lower adaptation to Mediterranean (dry) climates.

Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile / interquartile range)

The precision is given by the fact that high uncertainty is present on the left side of the curve. More confidence on the median than on higher values on the right side of the curve.

3.2.2.2. Estimation of the uncertainty distribution for the spread rate

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 9: Fitted values of the uncertainty distribution on the spread rate (km/y)

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	1					4		7		12					40
Fitted distribution	1.1	1.4	1.8	2.5	3.2	4.0	4.9	7.0	9.9	12.0	15.2	19.7	26.4	34.1	45.9

Fitted distribution: Lognorm (9.6657,9.3259), @RISK7.5

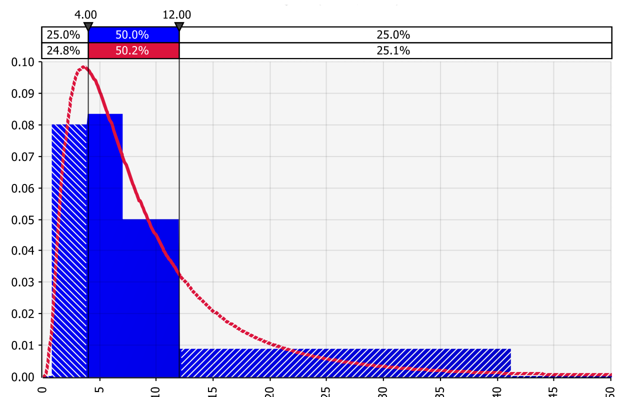

Figure 9 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

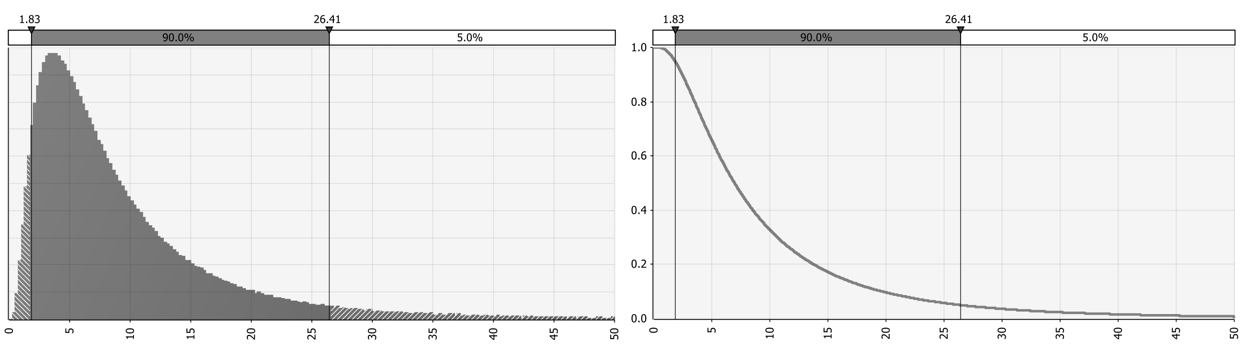

Figure 10 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

3.2.3. Conclusions on the spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *B. dorsalis* is 7 km (with a 95% uncertainty range of 1.4 – 34 km).

3.3. Time to detection

3.3.1. Structured expert judgement

3.3.1.1. Generic scenario assumptions

All the generic scenario assumptions common to the assessments of all the priority pests are listed in the section 2.4.2.1 of the Methodology Report (EFSA, 2019).

3.3.1.2. Specific scenario assumptions

- Potential host fruits are available during the whole year
- More than 1 generation is needed to increase the population size up to a level that results detectable in a Med fly trap network)
- Time to detection for *B. dorsalis* and *B. zonata* are comparable

3.3.1.3. Selection of the parameter(s) estimated

The time for detection has been assessed as the number of months between the first event of pest transfer to a suitable host and its detection.

3.3.1.4. Defined question(s)

What is the time between the event of pest transfer to a suitable host and its first detection within this scenario based on average European conditions? (unit: months)

3.3.1.5. Evidence selected

- *Anastrepha ludens*' size is larger than *Bactrocera* and *Rhagoletis*
- There is survey activity against *Bactrocera*. The current survey national programs are in place and therefore the level of awareness is expected to be higher than for other invasive fruit flies
- Very few traps are used
- Females are likely to be found in Med fly and olive traps (as *Anastrepha*) but differently from *Anastrepha* they are not so visually distinguishable from EU fruit flies
- It could be trapped in orchards where *Ceratitis capitata* is controlled
- Specific attractants are available

3.3.1.6. *Uncertainties identified*

- Harmonization of survey national programs in terms of traps density, frequency of visits, selection of locations, etc.

3.3.2. Elicited values for the time to detection

What is the time between the event of pest transfer to a suitable host and its first detection within this scenario based on average European conditions? (unit: months)

The five elicited values on time to detection on which the group agreed are reported in the table below.

Table 10: The 5 elicited values on time to detection (months)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	6	16	20	40	60

3.3.2.1. *Justification for the elicited values of the time to detection*

Reasoning for a scenario which would lead to a long time for detection (99th percentile / upper limit)

Recent first EU outbreak of *B. dorsalis* could trigger stronger survey activity. It is easy to misclassify the pest but the expected impact is higher than *Anastrepha*.

The contribution of specific attractants is not taken into account in this scenario.

In Med fly traps the pest is likely overlooked.

Coexistence with Med flies in commercial orchards and connected control would keep the density of the population quite low increasing the difficulty of detecting individuals of this species.

Reasoning for a scenario which would lead to a short time for detection (1st percentile / lower limit)

Recent first EU outbreak of *B. dorsalis* could trigger stronger survey activity.

Higher awareness than for *A. ludens*. In addition, species from the genus *Bactrocera* are more aggressive therefore the lower value should be a bit lower than for *A. ludens* (i.e. *B. dorsalis* is detected earlier than *A. ludens*).

Reasoning for a central scenario, equally likely to over- or underestimate the time for detection (50th percentile / median)

The median is a bit lower than *A. ludens* due to the higher likelihood to detect *B. dorsalis* than *A. ludens*.

Reasoning for the precision of the judgement describing the remaining uncertainties (1st and 3rd quartile / interquartile range)

The uncertainty is on the lower part and it is unlikely to reach the 5 years due to presence of survey activity.

3.3.2.2. *Estimation of the uncertainty distribution for the time to detection*

The comparison between the fitted values of the uncertainty distribution and the values agreed by the group of experts is reported in the table below.

Table 11: Fitted values of the uncertainty distribution on the time to detection (months)

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	6					16		20		40					60
Fitted distribution	5.0	6.3	7.8	9.8	12.0	14.5	17.0	22.5	29.7	34.7	42.0	51.4	65.0	79.7	101.0

Fitted distribution: Lognorm (27.683,19.916), @RISK7.5

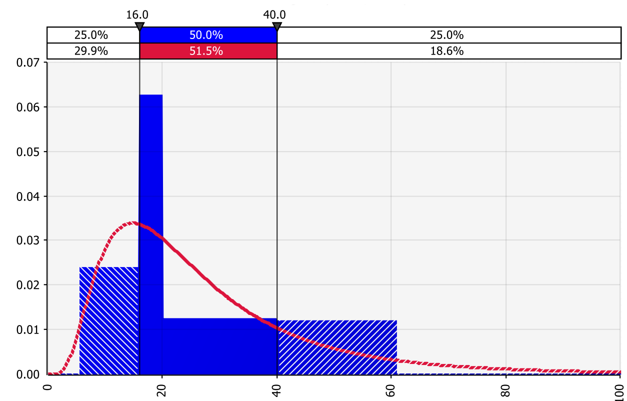

Figure 11 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection.

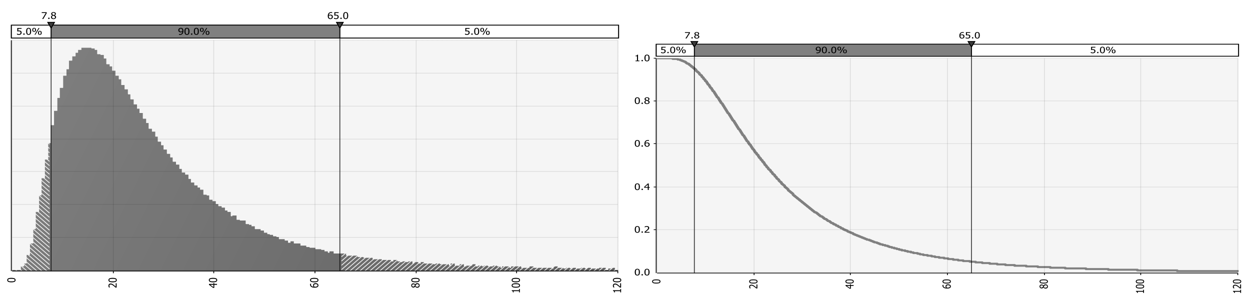

Figure 12 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection.

3.3.3. Conclusions on the time to detection

Based on the general and specific scenarios considered in this assessment, the time between the event of pest transfer to a suitable host and its detection is estimated to be almost 2 years (with a 95% uncertainty range of 0.5 – 6.5 years).

4. Conclusions

Hosts selection

The complete list of hosts is produced by merging

- the list of host plants defined by EPPO
- the list of host species reported by CABI

The hosts and group of hosts on which the impact is assessed are:

- exotic fruit
- citrus
- peach

Area of potential distribution

The area of potential establishment of *B. dorsalis* is derived from the projection in Villiers et al. (2016) based on 1961-90 global climate and a composite irrigation scenario. Fig. 10 shows that the potential distribution of *B. dorsalis* covers the Mediterranean coastal area of the Balkan peninsula and Italy, Southern Spain, Portugal and the Atlantic coast in France.

For *B. dorsalis* transient population are not considered, therefore the assessment is limited to the area of potential establishment.

Expected change in the use of plant protection products

Due to the fact that effective treatments with plant protection products (PPPs) are currently available but an increase in their use would be expected in presence of this pest, the most suitable PPP indicator is Case “C” and category “1”.

Yield and quality losses

Based on the general and specific scenarios considered in this assessment, the proportion (in %) of yield losses (here with the meaning of proportion of fruits lost due to premature dropping and to unmarketable fruits due to larval infestation at harvest) is estimated to be

- 18% (with a 95% uncertainty range of 5-43%) on exotic fruit (in particular: avocado, mango, guava and papaya)
- 8.6% (with a 95% uncertainty range of 1-30%) on citrus
- 9% (with a 95% uncertainty range of 1-32%) on peach (including both peaches and nectarines)

Quality losses are not assessed because considered as full losses and included under the assessment of yield losses.

Spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *B. dorsalis* is 7 km (with a 95% uncertainty range of 1.4 – 34 km).

Time for detection after entry

Based on the general and specific scenarios considered in this assessment, the time between the event of pest transfer to a suitable host and its detection is estimated to be almost 2 years (with a 95% uncertainty range of 0.5 – 6.5 years).

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Appendix A – CABI/EPPO host list

The following list, defined in the Methodology Report (EFSA, 2019) as the full list of host plants, is compiled merging the information from the most recent PRAs, the CABI Crop Protection Compendium and the EPPO Global Database. Hosts from the CABI list classified as 'Unknown', as well as hosts from the EPPO list classified as 'Alternate', 'Artificial', or 'Incidental' have been excluded from the list.

Genus	Species epithet
Adenanthera	*pavonina*
Afzelia	*xylocarpa*
Alangium	*chinense*
Alangium	*salviifolium*
Alpinia	*mutica*
Anacardium	*occidentale*
Annona	
Annona	*cherimola*
Annona	*glabra*
Annona	*macroprophyllata*
Annona	*montana*
Annona	*muricata*
Annona	*reticulata*
Annona	*senegalensis*
Annona	*squamosa*
Antidesma	*ghaesembilla*
Aporosa	*villosa*
Ardisia	*crenata*
Areca	*catechu*
Arenga	*pinnata*
Arenga	*westerhoutii*
Artabotrys	*siamensis*
Artocarpus	*altilis*
Artocarpus	*elasticus*
Artocarpus	*heterophyllus*
Artocarpus	*integer*
Artocarpus	*lacucha*
Artocarpus	*lanceifolius*
Artocarpus	*nitidus*
Artocarpus	*odoratissimus*
Artocarpus	*rigidus*
Artocarpus	*sericicarpus*
Averrhoa	*bilimbi*
Averrhoa	*carambola*
Azadirachta	*excelsa*
Baccaurea	*motleyana*
Baccaurea	*racemosa*

Baccaurea	*ramiflora*
Balakata	*baccata*
Barringtonia	*edulis*
Blighia	*sapida*
Borassus	*flabellifer*
Bouea	*macrophylla*
Bouea	*oppositifolia*
Breonia	*chinensis*
Breynia	*racemosa*
Bridelia	*stipularis*
Callicarpa	*longifolia*
Calophyllum	*inophyllum*
Cananga	*odorata*
Capparis	*sepiaria*
Capsicum	
Capsicum	*annuum*
Capsicum	*frutescens*
Careya	*arborea*
Carica	*papaya*
Carissa	*carandas*
Carissa	*spinarum*
Caryota	*mitis*
Casimiroa	*edulis*
Castanopsis	
Celtis	*tetranda*
Chionanthus	*parkinsonii*
Chrysophyllum	*albidum*
Chrysophyllum	*cainito*
Chukrasia	*tabularis*
Cissus	*repens*
Citrofortunella	*mitis*
Citrullus	*colocynthis*
Citrullus	*lanatus*
Citrus	
Citrus	*aurantiifolia*
Citrus	*aurantium*
Citrus	*hystrix*
Citrus	*jambhiri*
Citrus	*latifolia*
Citrus	*limon*
Citrus	*maxima*
Citrus	*paradisi*
Citrus	*reticulata*
Citrus	*sinensis*
Citrus	*swinglei*
Citrus	*tangelo*
Clausena	*lansium*
Coccinia	*grandis*
Coffea	

Coffea	*arabica*
Coffea	*canephora*
Cordia	*alba*
Cordia	*myxa*
Cordia	*sinensis*
Cordyla	*africana*
Crinum	*asiaticum*
Cucumis	*ficifolius*
Cucumis	*melo*
Cucumis	*sativus*
Cucurbita	*maxima*
Cucurbita	*pepo*
Desmos	*chinensis*
Dillenia	*obovata*
Dimocarpus	*longan*
Diospyros	
Diospyros	*areolata*
Diospyros	*blancoi*
Diospyros	*castanea*
Diospyros	*diepenhorstii*
Diospyros	*kaki*
Diospyros	*malabarica*
Diospyros	*mollis*
Diospyros	*montana*
Diospyros	*roxburghii*
Dovyalis	*hebecarpa*
Dracaena	*steudneri*
Ehretia	*microphylla*
Elaeocarpus	*hygrophilus*
Eriobotrya	*japonica*
Erycibe	*subspicata*
Eugenia	*reinwardtiana*
Eugenia	*uniflora*
Excoecaria	*agallocha*
Fagraea	*ceilanica*
Fibraurea	*tinctoria*
Ficus	*auriculata*
Ficus	*benjamina*
Ficus	*chartacea*
Ficus	*fistulosa*
Ficus	*hirta*
Ficus	*hispida*
Ficus	*microcarpa*
Ficus	*obpyramidiata*
Ficus	*ottoniifolia*
Ficus	*racemosa*
Ficus	*religiosa*
Ficus	*sycomorus*
Flacourtia	*indica*

Flacourtia	*rukam*
Flueggea	*virosa*
Fortunella	
Fortunella	*japonica*
Fortunella	*margarita*
Fruit	*trees*
Garcinia	*atroviridis*
Garcinia	*cowa*
Garcinia	*dioica*
Garcinia	*dulcis*
Garcinia	*griffithii*
Garcinia	*hombroniana*
Garcinia	*mangostana*
Garcinia	*mannii*
Garcinia	*prainiana*
Garcinia	*speciosa*
Garcinia	*xanthochymus*
Garuga	*floribunda*
Glochidion	*littorale*
Glycosmis	*pentaphylla*
Gmelina	*elliptica*
Gmelina	*philippensis*
Gymnopetalum	*scabrum*
Hanguana	*malayana*
Heynea	*trijuga*
Holigarna	*kurzii*
Hylocereus	*undatus*
Inocarpus	*fagifer*
Irvingia	*gabonensis*
Irvingia	*malayana*
Ixora	*javanica*
Ixora	*macrothyrsa*
Knema	*globularia*
Lagenaria	*siceraria*
Landolphia	
Lansium	*domesticum*
Lepisanthes	*fruticosa*
Lepisanthes	*rubiginosa*
Lepisanthes	*tetraphylla*
Litsea	*glutinosa*
Litsea	*salicifolia*
Maclura	*cochinchinensis*
Maerua	*duchesnei*
Malpighia	*emarginata*
Malpighia	*glabra*
Malus	
Malus	*domestica*
Mammea	*siamensis*
Mangifera	*caesia*

Mangifera	*foetida*
Mangifera	*griffithii*
Mangifera	*indica*
Mangifera	*laurina*
Mangifera	*odorata*
Manilkara	*zapota*
Merremia	*vitifolia*
Microcos	*tomentosa*
Mimusops	*elengi*
Mitrephora	*teysmannii*
Momordica	*charantia*
Morinda	*citrifolia*
Morinda	*coreia*
Morinda	*umbellata*
Morus	*alba*
Morus	*nigra*
Muntingia	*calabura*
Murraya	*paniculata*
Musa	
Musa	*acuminata*
Musa	*balbisiana*
Musa	*paradisiaca*
Musa	*troglodytarum*
Myrciaria	*cauliflora*
Myxopyrum	*smilacifolium*
Nauclea	*latifolia*
Nauclea	*orientalis*
Neonauclea	*purpurea*
Nephelium	*lappaceum*
Ochreinauclea	*maingayi*
Ochrosia	
Palaquium	
Palaquium	*maingayi*
Parinari	*anamense*
Parkia	*speciosa*
Passiflora	*edulis*
Passiflora	*foetida*
Passiflora	*laurifolia*
Passiflora	*quadrangularis*
Passiflora	*suberosa*
Pereskia	*grandifolia*
Persea	*americana*
Phaseolus	*vulgaris*
Physalis	*angulata*
Piper	*nigrum*
Planchonella	
Planchonella	*duclitan*
Polyalthea	*longifolia*
Polyalthia	*simiarum*

Pometia	*pinnata*
Poncirus	*trifoliata*
Poupartia	*birrea*
Pouteria	*caimito*
Pouteria	*campechiana*
Premna	*serratifolia*
Prunus	*armeniaca*
Prunus	*avium*
Prunus	*cerasus*
Prunus	*domestica*
Prunus	*dulcis*
Prunus	*mume*
Prunus	*persica*
Prunus	*salicina*
Psidium	*cattleianum*
Psidium	*guajava*
Psidium	*littorale*
Punica	*granatum*
Pyrus	
Pyrus	*communis*
Pyrus	*pyrifolia*
Rhizophora	
Rhodomyrtus	*tomentosa*
Rollinia	*pulchrinervis*
Saba	*senegalensis*
Sambucus	*javanica*
Sandoricum	*koetjape*
Sauropus	*androgynus*
Schoepfia	*fragrans*
Sclerocarya	*birrea*
Shirakiopsis	*indica*
Siphonodon	
Solanum	*aethiopicum*
Solanum	*americanum*
Solanum	*anguivi*
Solanum	*capsicoides*
Solanum	*hazenii*
Solanum	*incanum*
Solanum	*linnaeanum*
Solanum	*lycopersicum*
Solanum	*melongena*
Solanum	*nigrum*
Solanum	*rudepannum*
Solanum	*sodomeum*
Solanum	*stramoniifolium*
Solanum	*torvum*
Solanum	*trilobatum*
Sorindeia	*madagascariensis*
Spondias	

Spondias	*dulcis*
Spondias	*mombin*
Spondias	*pinnata*
Spondias	*purpurea*
Streblus	*asper*
Strychnos	
Strychnos	*mellodora*
Syzygium	*aqueum*
Syzygium	*aromaticum*
Syzygium	*borneense*
Syzygium	*cumini*
Syzygium	*formosanum*
Syzygium	*grande*
Syzygium	*jambos*
Syzygium	*lineatum*
Syzygium	*malaccense*
Syzygium	*megacarpum*
Syzygium	*nervosum*
Syzygium	*samarangense*
Terminalia	*arenicola*
Terminalia	*catappa*
Terminalia	*citrina*
Theobroma	*cacao*
Thevetia	*peruviana*
Trichosanthes	*ovigera*
Triphasia	*trifolia*
Uvaria	*cordata*
Uvaria	*grandiflora*
Veitchia	*merrillii*
Vitellaria	*paradoxa*
Vitis	*vinifera*
Willughbeia	*edulis*
Xanthophyllum	*flavescens*
Ximenia	*americana*
Zehneria	*wallichii*
Ziziphus	*jujuba*
Ziziphus	*mauritiana*
Ziziphus	*nummularia*
Ziziphus	*oenoplia*

Appendix B – Evidence tables

B.1 Summary on the evidence supporting the elicitation of yield and quality losses

Susceptibility	**Infestation**	**Symptoms**	**Impact**	**Additional information**	**Reference**	**Uncertainties**
	Incidence	***Severity***	***Losses***			
Mango (*Mangifera indica*)			16 - 40% yield loss	Heavy rainfall zone of south Gujarat, India untreated	Patel et al., 2013	
Mango (*Mangifera indica*)	19% and 17% of collected mangoes were infested from *B. invadens* in 2006, 2007 respectively	172/360 control mangoes where infested and yielded 3480 pupae in total – 181 *B. invadens* 30 treated mangoes yielded 8 *B. invadens* females	Combined losses caused by *C. cosyra* and *B. invadens* reached 48% in untreated orchards and 8.3% in treated with GF-120 orchards	Benin, West Africa	Vayssieres et al., 2009	
Mango (*Mangifera indica*)	1.5 – 76.3% field infestation in different sites in Kenya		Over 80% of mango fruits were infested with both *C. cosyra* and *B. invadens* with 91% of the total collected pupae belonging to *B. invadens*	Nguruman, Kenya	Ekesi et al., 2006	
	Guinean zone *Citrus tangelo* (Tangelo) 34% Citrus reticulata (Mandarin) 22% *Citrus sinensis* (Sweet orange) 25% *Citrus x paradisii*	Sudanian zone Mandarin 6% Sweet orange 12% Grapefruit 10%	About 90% (2 years)	South Benin	Castrillon et al., 2010	Excluded: emerged fruit fly species were mostly *B. invadens* (98.3%)
Exotic fruit, citrus fruit			High infestations levels	Tanzania	Mwatawala et al., 2009	

Mango (*Mangifera indica*) Guava (*Psidium guajava*)		from 5 to 80% and from 10 to 80%	Mango: 1-86% Guava: 19-80%	India	Verghese et al., 2002	
Mango (*Mangifera indica*)			up to 97 flies per kg of fruit	Benin	Ekesi et al., 2006	Excluded: *B. dorsalis/ Ceratitis cosyra*. Highest numbers of *B. invadens* were collected at low elevations, while *C. cosyra* appeared to dominate at high elevations
Mango (*Mangifera indica*)			Loss averages varied globally from 12% (4 to 8 April) to 50% (27 to 30 June). Thus, losses for Eldon varied from 14% (4 to 8 April) to 57% (13 to 17 June); for Kent from 9% to 42% for the same periods; for Smith from 10% to 57%; for Brooks from 11% to 54% and, for Dabschar, from 11% to 45%.		Vayssières et al., 2005	Excluded: all the mango fruit flies
Guava (*Psidium guajava*)			80% loss in guava fruit production		Ahmad and Begum, 2017; Kafi, 1986	
Dragonfruit (Hylocereus undatus)	2 fruits 14 fruits	14 pupae 84 pupae	2,3 per kg infested fruit 16,3 per kg infested fruit	11/14/07 49 fruits 13kg 11/12/08 50 fruits 15,5kg	McQuate, 2010	Excluded
Mango		5.5%- 58% pupae emerging			Salmah et al., 2017	
					Wong et al., 1983	
Citrus, mango, guava, apricot, pomegranate, peach, plum, etc			Table 4: overall percentage loss estimates for some important crops caused by fruit flies in Pakistan	Pakistan	Stonehouse et al., 1998	Excluded: Loss estimates refer to overall losses caused by fruit flies that are present in the

						respective areas of Pakistan (*B. dorsalis*, *B. zonata* and *B. cucurbitae*)
Plum	Table 2 (p. 664) Mean percentage infestation in the absence of controls: 23%				Stonehouse et al., 2002	Identification inferred from trap catches although no adults were reared.
Mango	Table 2: level of infestation by B. invadens and Ceratitis cosyra at different locations. Infestation rates ranged from 3.0 to 97.2 flies per kg of fruit.			Kenya *"In most locations, B. invadens frequently shared the same mango fruit with Ceratitis cosyra (Walker); therefore the number of C. cosyra that emerged from collected fruits is also presented* *Highest numbers of B. invadens were collected at low elevations, while C. cosyra appeared to dominate at high elevations. […] In general, in the highlands (elevation > 1500 m) fruit infestation from B. invadens did not exceed 5 flies per kg of mangoes."*	Ekesi et al., 2006	
Citrus, mango, guava, etc. (for a total of 14 plant species and eight families - (both cultivated and wild host plants)	Table 2: *B. invadens* infestation. % infested fruit, number of adults (total and per kg of fruits) *Bactrocera invadens* was reared from a total collection of 3,913 fruit			Observations from three provinces of Kenya (from a range of habitats by surveys carried out at the Coast, Eastern, and Rift Valley provinces of Kenya) from December 2004 to April 2006	Rwomushana et al., 2008a	

B.2 Summary on the evidence supporting the elicitation of the spread rate

Spread	Additional information	Reference	Uncertainty
Thirty adults were captured at distances over 2 km, ranging from 2.63–11.39 km.	Puna, Hawaii	Froerer et al., 2010	Short-distance movement (<0.5 km) occurred for over 2 weeks, long-distance movement occurred within a short period of time after a release (<4 days).
Adult build up and movement from guava native areas to papaya cultivated areas	Kauai, Hawaiian Islands	Vargas et al., 1989	
Immature adults are able to disperse over at least 60 km to find fresh food resources and breeding substrates. Large numbers usually move into fruiting areas when the fruit begins to ripen, and they may leave when the bearing season ends. Long distances are covered in flight. One marked male has recovered 24 miles from its release point		Fletcher, 1987; Liu and Ye, 2007; Steiner, 1957	
Long distance dispersal has occurred for *B. dorsalis* population using mountain pass and prevailing air currents. Fruit flies are able to disperse more than 250 km with the wind along narrow passes	Between Ailao and Hengduan mountains, Yunnan Province, China	Liu et al., 2007	Uncertainty about confirmation that these values refer to natural spread only (possibility to exclude human assisted component of spread)
far as 50 km		Pieterse et al., 2017; Shi et al., 2005	
250 km by wind dispersal	It is thus plausible that the high gene flows measured between Jinghong and Huanian are partly caused by passive wind dispersion of the fly.	Shi et al., 2005	unpublished data
		Chen et al., 2015	Not added due to artificial conditions of observations
Nine of 3000 marked males, released at Haha lima, ca. 50 km from Chichi lima, were caught by 3 traps set on Chichi Jima.		Iwahashi, 1979	

B.3 Summary on the evidence supporting the elicitation of the time to detection

Category of factors	**case**	**Evidence**	**Additional information**	**Reference**	**Uncertainties**
	Visual symptoms	Small discoloured patches on the fruit skin, developed from punctures or stings made by the female through egg-laying. Infested immature fruit becomes distorted, callused and usually drop, while mature fruit develop a water soaked appearance. The larval tunnels provide entry points for bacteria and fungi that cause the fruit to rot.			Symptoms are similar to those caused by endemic fruit flies
	Visual symptoms	Attacked fruit usually show signs of oviposition punctures. Fruit with a high sugar content, such as peaches, exude a sugary liquid, which solidifies adjacent to the oviposition site.		UF page	
Detection methods	Reliability	Adult trapping with male lure is extensively used. Male- specific attractant is methyl eugenol (ME) with a range of 1 km and effectiveness of approx. 2 weeks. Detection is usually performed with standard Jackson trap with liquid ME on cotton wick and naled, malathion, dichlorvos, spinosad (or other insecticide). Other broad range lures include GF-120 fruit fly bait and torula yeast Females were attracted to 8 components and to a blend of them	3-Methyl-1-butanol, Ethyl butanoate, Butyl acetate, 2-Methylpyrazine, 3-Methylbutyl acetate, 2,5-Dimethylpyrazine, Benzaldehyde, Ethyl hexanoate	Odanga et al., 2018; Vargas et al., 2003; Vargas et al., 2010; Vargas et al., 2000 Biasazin et al., 2018	Attractiveness of female *B. dorsalis* was more pronounced in laboratory conditions. No significant differences were observed in relation to control traps in the field
Biology of the pest	Pest life cycle	Life expectancy 75.1 and 86.4 day for females and males respectively Net fecundity 794.6 eggs per female Net reproductive rate 273.0 Intrinsic rate of increase 0.113			
	Pest life cycle	Females lay their eggs below the skin of the host fruit, hatching takes place within 1-3 days and the larvae feed for approximately 9-35 days. This species development ceases in temperatures below 13°C. Pupae drop on the soil and pupate under the host plant. Adults emerge within 1-2 weeks and can be active throughout the year (Christenson and Foote, 1960).			

		The adults are best able to survive low temperatures, with a normal torpor threshold of 7°C, dropping as low as 2°C in winter.			
	Pest life cycle	Table 1: Mean oviposition period, fecundity and longevity		Yu-Bing Huang et al., 2016	
	Pest life cycle	Table 2: mean duration of different life stages egg: .1.52 days instars: 1^{st} 2.12 days, 2^{nd} 2.2 days, 3^{rd} 4.22 days puparia: 11.22 days adults with food: males 87.83, females 104.12 adults without food: males 1.54, females 1.62		Vanitha et al., 2017	