APPROVED: 17 May 2019
Doi: 10.5281/zenodo.2787208

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

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Requestor: European Commission
Question number: EFSA-Q-2018-00384
Output number: EN-1642
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Acknowledgements: EFSA wishes to acknowledge the contribution of Elma Bali, Josep Anton Jaques Miret, Nikolaos Papadopoulos, Stella Papanastassiou to the EKE and the review conducted by Panagiotis Milonas.

European Food Safety Authority

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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, 2018). 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 zonata*, the following document was used as key references: EFSA, 2007.

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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

Bactrocera zonata (Saunders) is a single taxonomic entity. It is known as the peach fruit fly or the guava fruit fly and can also be found as *Bactrocera maculigera*, *Dacus zonatus*, *Dasyneura zonata* and *Rivellia persicae*, *Strumeta zonata* (EPPO, 2005; White and Elson-Harris, 1992). The peach fruit fly is a serious polyphagous pest that attacks more than 50 host plants, among which citrus, guavas, mangoes, peaches, and many vegetables (White and Elson-Harris, 1992). It is a non-diapausing, multivoltine species with an adult longevity ranging from 30-60 days and female fecundity of more than 500 eggs (Shehata et al., 2008). Adults are active throughout the year in their native area except for a short period in January and February. Overwintering occurs mostly in the larval or pupal stages. In juicy fruits, it causes the formation of resinous deposit in correspondence with the oviposition puncture. Hatched maggots penetrate into the host causing its deterioration.

2.2. Host plants

2.2.1. List of hosts

Bactrocera zonata has been recorded on over 50 cultivated and wild plant species, mainly those with fleshy fruits (EPPO, 2005). Its polyphagous habits allow *B. zonata* to find different hosts throughout the year, as observed for example in India, where females move from the ber fruits (*Zizyphus* spp.) infested in spring to peaches and loquats in May and June for oviposition, while during the rainy season, when the population density is highest, they attack mango, guava and citrus (Delrio and Cocco, 2012).

For a detailed host list refer to (EPPO, 2010), while Appendix A provides the full list of hosts according to the methodology proposed by EFSA (2019).

2.2.2. Selection of hosts for the evaluation

The selection and grouping of hosts for the assessment of yield loss was carried out by considering the major hosts listed in the EPPO Global Database (EPPO, online), the availability of production data in Eurostat and the supporting literature with quantitative records of yield losses. The main hosts of *B. zonata* are guava, mango and peach. Secondary hosts include apricot, fig, persimmon, cucurbits, pear and citrus. Three categories of host have been therefore considered for the assessment:

- 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 was produced by merging

- the list of host plants defined by EPPO (EPPO, online),
- the list of host species reported by CABI (CABI, 2018)

The hosts on which the impact is assessed are:

- exotic fruit;
- citrus;
- peach and nectarine.

2.3. Area of potential distribution

2.3.1. Area of current distribution

The peach fruit fly originates from South and South-East Asia (India, Indonesia, Laos, Sri Lanka, Thailand and Vietnam) and has been introduced into Bangladesh, Myanmar, Nepal, Pakistan, Saudi Arabia, Oman, Mauritius and Reunion Island. It is now present throughout Egypt, up to the borders of the Palestinian Territories (Gaza Strip) and Israel. Its presence has also been recorded recently in southern Iran, Lebanon, Libya but without location details (EPPO, 2019). The fly now seems to be established in Iraq as well (Khlaywi et al., 2017).

Experience in Egypt shows that *B. zonata* has already adapted to climatic conditions different to those in its area of origin. *Bactrocera zonata* has also been repeatedly detected in North America, California since 1989 (White and Elson-Harris, 1992; Papadopoulos et al., 2013).

Figure 1 provides an overview of the current area of distribution of the pest. In the EU no outbreaks have yet been reported.

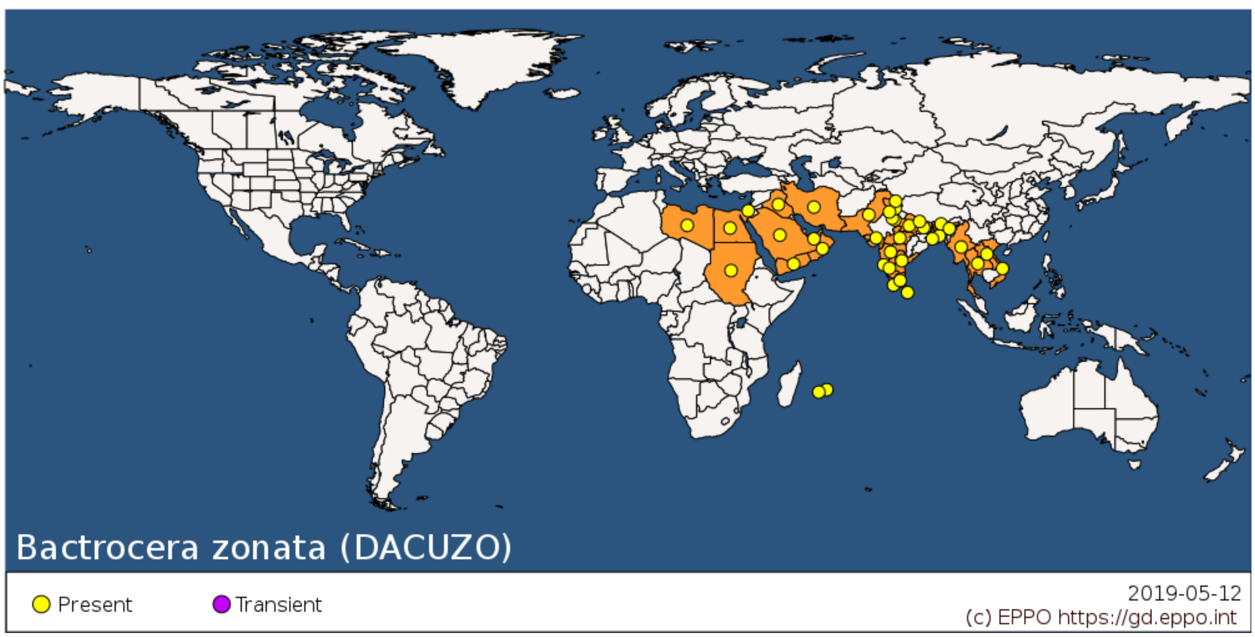

Figure 1 Distribution map of *Bactrocera zonata* from the EPPO Global Database accessed 12/05/2019.

2.3.2. Area of potential establishment

The following studies are relevant to *B. zonata* potential establishment in the EU:

- EFSA (2007) commented on a qualitative Spanish PRA and concluded that further work was required to determine the area of southern Europe at risk of establishment with more precision based on, e.g. climatic comparisons with locations in northern Egypt, such as El Arish and

Alexandria, where the pest is common and on the use of the species distribution model (e.g., CLIMEX).

- CLIMEX maps projecting the potential global distribution of *B. zonata* based on 1961-90 gridded temperature and climate change scenarios were produced by Ni et al. (2012). Figure 4[3] in the original paper (pag. 179) shows that "suitable" and "optimal" values of the Ecoclimatic Index (EI) can be found along the whole Mediterranean coastline (except southern Turkey), central and southern Italy, central and southern Spain and throughout Portugal. More surprisingly, western France, particularly Brittany, is also shown with optimal EI values.
- Cobos-Suárez et al. (2010) also used CLIMEX, but with different variables, specifically to determine the potential distribution of *B. zonata* in Europe and the Mediterranean. Although the map presented in figure 1[4] of the original paper (pag. 108) needs to be redrawn so zero values can be seen more clearly, it is apparent that only the following areas are potentially suitable for establishment: Cyprus, the extreme south of mainland Greece and islands in the Aegean, the extreme south of Italy and Sicily, most of coastal southern and eastern Spain (except the north-east), and all of Portugal (except the north and north-east). A CLIMEX "match climates" model with an irrigation scenario, yielded similar results.

Although both CLIMEX models used the same 1961-90 climatic data, various reasons may account for the differences in the projected distribution:

- Ni et al. (2012) used a 12°C minimum threshold for development and a total of 380 degree days per generation based on a Reunion island population fed on artificial diet whereas Cobos-Suárez et al. (2010) used the 10°C and 323 degree day value obtained by Mohammed (2000) from an Egyptian population reared on guava.
- Both models used comparable cold stress temperature thresholds but Cobos-Suárez et al. (2010) added degree day cold stress parameters based on *Bactrocera tryoni.*
- Cobos-Suárez et al. (2010) did not use dry stress parameters, noting that it is often found in desert areas whereas Ni et al. (2012) applied dry stress to contain its distribution in Asia.

While criticisms can be made of both models, Cobos-Suarez et al. (2010) did use temperature threshold data from an Egyptian population, added degree day cold stress parameters and did not attempt to constrain the distribution using dry stress parameters. The resulting map (fig. 1 in Cobos-Suárez et al., 2010), showing only a potentially very southerly distribution for *B. zonata* in Europe where summer/winter temperatures are not too dissimilar from those in northern Egypt, is thus much more conservative than Ni et al. (2012) which projected the distribution as far north as north-western France.

However, the fundamental difficulty for both models with projecting *B. zonata* distribution into Europe is that there are no published data on its responses to cold temperatures and there is no clear northern limit to its distribution based on climate in the Mediterranean or in Asia that allows CLIMEX to be used to estimate cold stress parameters with any reliability. In the Mediterranean, it is still spreading and its

[3] Climatic suitability (EI) for the peach fruit fly, *B. zonata*, under the reference climate (1961–1990 averages) projected using CLIMEX (Ni et al., 2012).

[4] The potential distribution of *Bactrocera zonata* in Europe and in the Mediterranean Basin as predicted by CLIMEX. The degree of suitability of a location for permanent occupation is proportional to the indicated ecoclimatic index (EI) (Cobos-Suárez et al., 2010).

northerly limit is affected by the sea and areas of conflict. Frequent detections (almost every year for the last 8-9 years) have been reported in Austria but these are considered to stem from transient and not established populations. In Asia, it has been found in mountainous countries, such as Bhutan and Nepal, but there are huge temperature differences between the mountains and the valleys in these countries and the northerly limit further east in Vietnam has a tropical climate.

Since both CLIMEX models are unreliable in projecting the potential distribution in Europe because of their difficulty in estimating overwintering survival, we are left with making climatic comparisons between northern Egypt and southern Europe. The similarity of the map produced by the CLIMEX climate match algorithm (fig. 4 in Cobos-Suárez et al., 2010) and the full CLIMEX species distribution model (fig. 1 in Cobos-Suárez et al., 2010), albeit using station rather than gridded climate data gives more credence to the Cobos-Suarez et al. (2010) CLIMEX map. This is also supported by Figure 2 which compares monthly maximum and minimum temperature and rainfall at locations on the northern Egyptian coast (Alexandria and El Arish) with those in Cyprus (Nicosia), Greece (Heraklion and Athens), Sicily (Catania), southern Spain (Seville) and Nantes (north-western France) using data obtained from https://en.climate-data.org which models climate data worldwide from 1982-2012 weather data. The following table shows that, based on January and February mean minimum temperatures Nantes has a much colder winter than northern Egypt whereas the southern European locations, although cooler, are much more similar.

Table 1: Mean minimum January and February temperatures in degrees centigrade obtained from https://en.climate-data.org which models climate data worldwide from 1982-2012 weather data.

	January	February
Alexandria	9.8	10.4
El Arish	7.7	8.6
Nicosia	5.0	4.9
Heraklion	9.9	10.0
Athens	6.3	6.6
Catania	6.7	6.9
Seville	5.7	6.8
Nantes	2.2	2.3

Since the evidence from Nantes discredits Ni et al. (2012), an extreme southerly potential distribution, largely based on the area with an ecoclimatic index greater than zero in fig. 1 in Cobos-Suárez et al. (2010), was used as the area of potential establishment for the expert evaluations. In this area suitable hosts are commonly grown.

However, since the Cobos-Suarez et al., (2010) CLIMEX map contains errors and there is no clear basis for setting the limits to distribution based on ecoclimatic index thresholds, we have had to choose another method to define the area of potential distribution based on NUTS2 regions. This method has greater uncertainty because it is based on the area defined for another Tephritid species, *Anastrepha ludens*. Although this species has different temperature thresholds and degree days for development, its area of potential distribution is also considered to be only in the south of Europe.

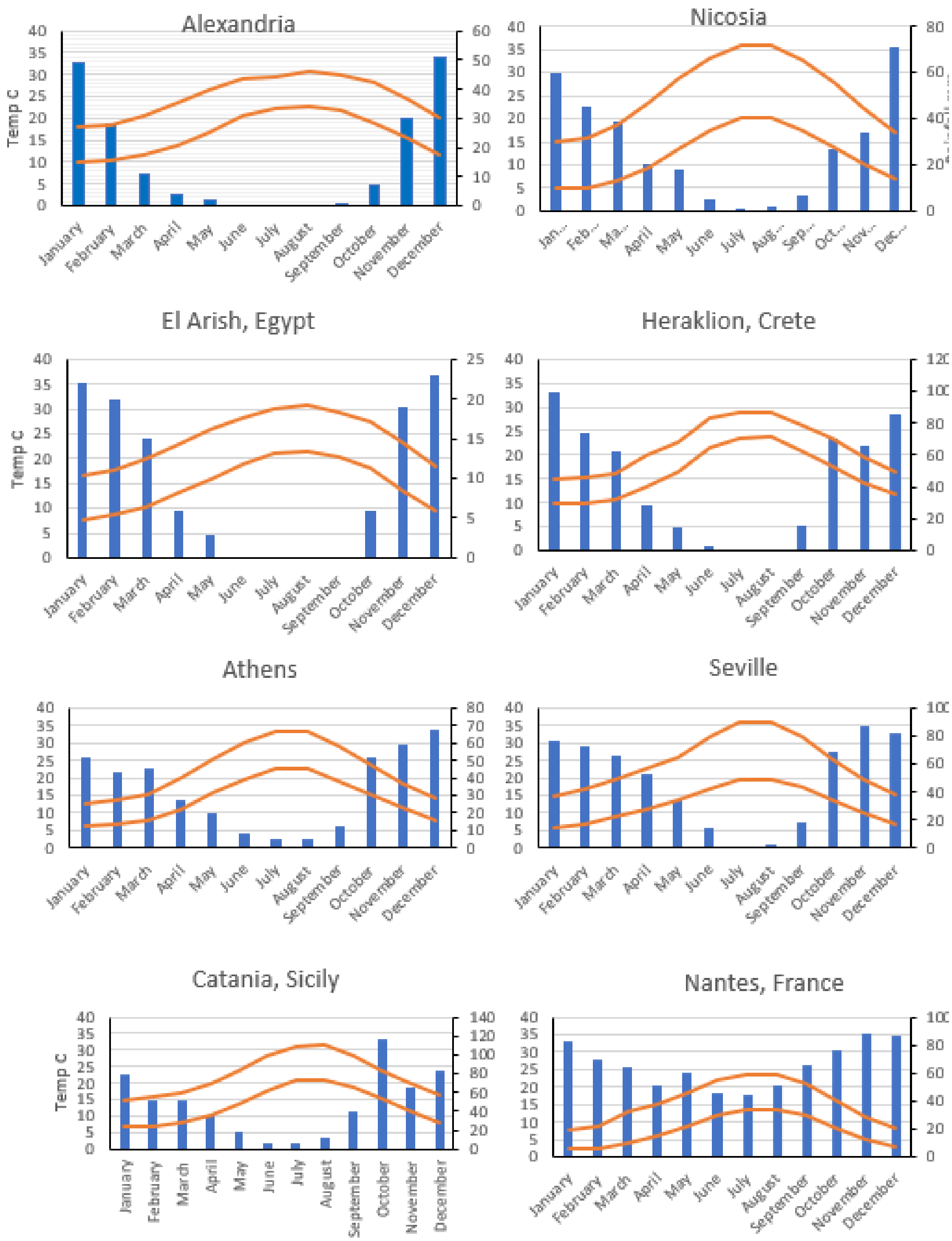

Figure 2 Mean minimum and maximum monthly temperatures (orange lines) in degrees centigrade and rainfall in mm for locations in Egypt and Europe obtained from https://en.climate-data.org which models climate data worldwide from 1982-2012 weather data.

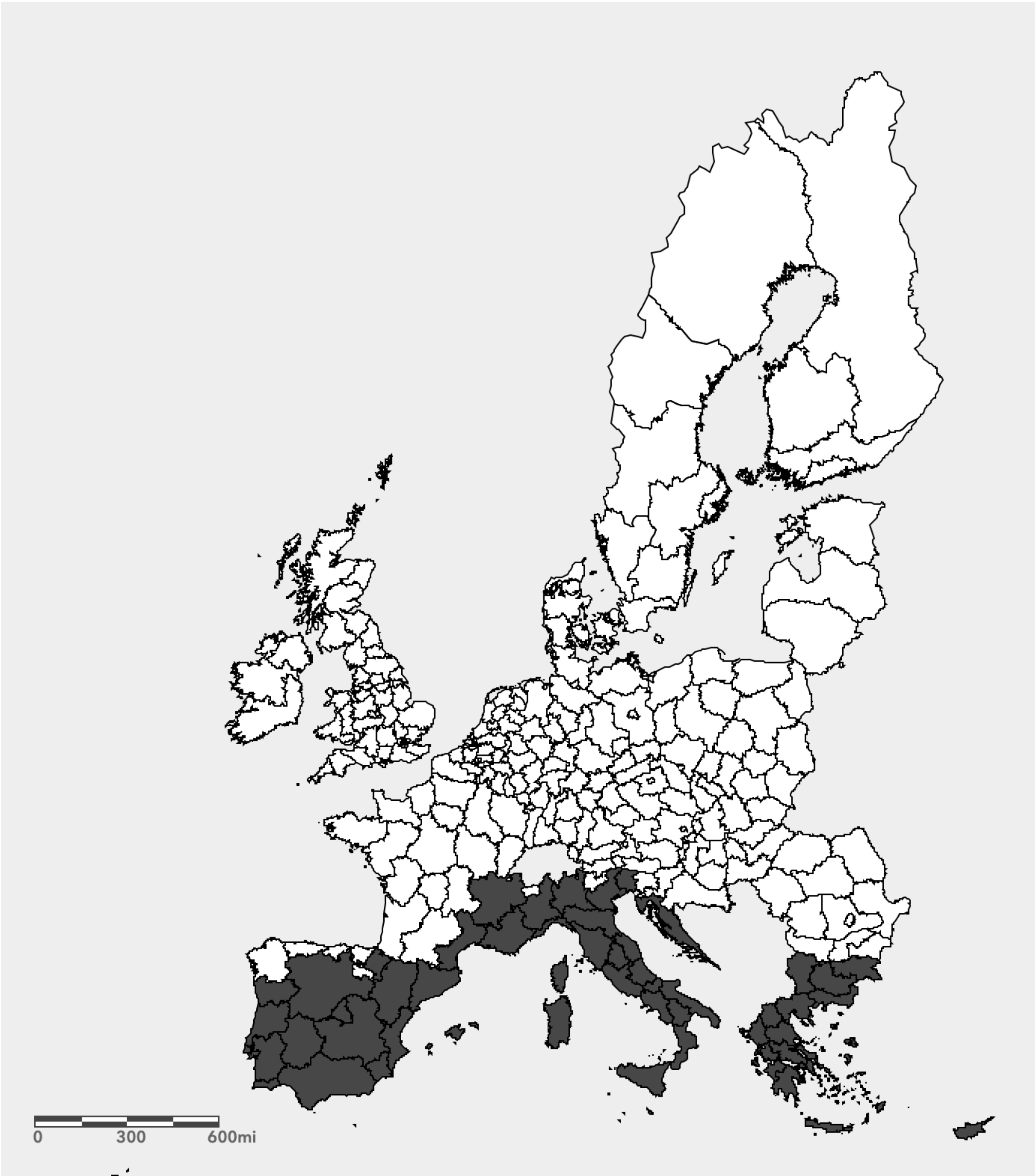

Figure 3 The potential distribution of the pest in the EU NUTS2 regions based on the scenarios established for assessing the impacts of the pest by the EFSA Working Group on EU Priority Pests (EFSA, 2019). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/0iTrvm.

2.3.3. Transient populations

Bactrocera zonata 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 distribution is limited to central and southern Spain, central and southern Portugal, Madeira, the Azores, Italy, Malta, Greece and Cyprus (Figure 3). For this species, transient populations are not considered, and the assessment is limited to the area of potential establishment.

2.4. Expected change in the use of plant protection products

Current *B. zonata* control in Egypt is based primarily on applications of organophosphate insecticides, especially malathion, mixed with protein baits (El-Aw et al., 2008). In the same country, promising results were obtained with the bioinsecticide spinosad in bait applications (Delrio and Cocco, 2012). Spinosad-based control measures routinely taken against *C. capitata* in Israel could be effective against *B. zonata* since spinosad was highly toxic to the local population which at the same time showed a level of resistance to malathion (Gazit and Akiva, 2017). Nadeem et al., (2012) also tested the susceptibility of *B. zonata* populations in Pakistan, to some insecticides and showed that the pest has developed resistance against trichlorfon, malathion, bifenthrin, cyhalothrin and spinosad, while they still remained susceptible to methomyl.

Halawa et al., (2013) provide comparative results on the toxicity, biology and biochemical effects of a series of insecticides belonging to different chemical groups. Khan and Naveed (2017) indicate emamectin benzoate as an alternative to the most applied insecticides safer to beneficial organisms.

Other control measures include a combination of two techniques; the Male Annihilation Technique (MAT) and the Bait Application Technique (BAT) (Stonehouse et al., 2002; Al-Eryan et al., 2018).

Alternative products recently studied for the control of *B. zonata* are

- monoterpenes, (R)-camphor, (R)-carvone, and (1R,2S,5R)-menthol (El-Minshawy et al., 2018)
- leaf extracts of plants (i.e. *Cassia fistula*, *Datura alba*, *Azadirachta indica*, *Ocimum basilicum*, *Thevetia peruviana*, *Eucalyptus camaldulensis*) as sterilant and oviposition deterrents (Mahmoud and Shoeib, 2008; Ilyas et al., 2017)
- turmeric extract (Riaz et al., 2015).

Entomopathogenic nematodes can infect

- Adults: *Steinernema carpocapse*, *S. riobrave* and *Heterorhabditis bacteriophora* (Abbas et al., 2016; Soliman et al., 2014).
- Larvae before pupation: *Steinernema feltiae* and *Heterorhabditis marelatus* (Mahmoud et al., 2016; Saleh et al., 2018).
- Larvae and pupae for 6 cm soil depth: *Steinernema scapterisci*, whose efficacy can be increased with 2Gy gamma irradiation of nematode juveniles (Sayed et al., 2018).

According to the findings of a recent study by Gul et al., (2015), all tested entomopathogenic fungi (*Beauveria bassiana*, *Metarhizium anisopliae* and *Isaria fumosorosea*) proved to be successful for the management of *B. zonata* at larval and adult stages especially in the contact bioassay. *Metarhizium* *anisopliae* was found 1.61 times more effective than *B. bassiana* against *B. zonata* pupae (Soliman et al., 2014).

Diachasmimorpha longicaudata parasitoids species complex is mass-reared and used in augmentative releases against important fruit fly species in tropical and subtropical countries (Dashavant et al., 2018). Adults of the parasitoid Biosteres (Chilocaudatus) longicaudatus Ashmead emerged from fruit fly infested peach, pear, guava and Kinnow fruits in Punjab, India (Singh, 2012). Preliminary tests regarding the parasitization levels of *B. zonata* pupae by Aganaspis daci showed promising results and revealed 3 more parasitoid species infesting *B. zonata* in Egypt (El-Heneidy et al., 2016; Hosni et al., 2011).

Moreover, the performance of several predatory mites has been assessed when offered *B. zonata* eggs as an artificial diet (Momen et al., 2016; Momen et al., 2018).

In the EU a series of PPPs suitable against *B. zonata* is registered (i.e. methomyl, spinosad, malathion). However, given the large number of crops 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 2: Expected changes in the use of Plant Protection Products (PPPs) following *Bactrocera zonata* 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. dorsalis*.

The hosts considered for the assessment of impact are:

- Exotic fruit: *B. zonata* is expected to cause a lower impact than *B. dorsalis*
- Citrus
- Peach

Quality losses have not been 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 zonata*, 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 zonata*, 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 zonata*, 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:

- Based on the climate suitability maps, suitable climatic conditions are in central and southern Spain, central and southern Portugal, Madeira, the Azores, Italy, Malta, Greece and Cyprus.

- Adults are active throughout the year in their native area except for a short period in January and February.

Exotic fruit

- 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:

- EPPO, 2010
- Table 2 in Rwomushana et al. (2008)
- Evidence from Africa supports that 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. zonata*.
- 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 *B. zonata*, 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 3: 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 built 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. dorsalis*:

- *B. dorsalis* is known to be more destructive on mango than *B. zonata*.
- Mediterranean conditions are more suitable to *B. zonata* than to *B. dorsalis*.

Therefore, it is expected that the higher damage caused by *B. dorsalis* on mango is balanced by a lower adaptability of *B. dorsalis* to Mediterranean climate than *B. zonata*.

Comparison with *A. ludens*:

- the high yield loss would be comparable or a bit higher than those caused by *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 ideal to *B. zonata*.

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. dorsalis*, damage is not caused on unripe fruit. Yield loss is expected to be little less than on *B. dorsalis* 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 4: 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 distributio n	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

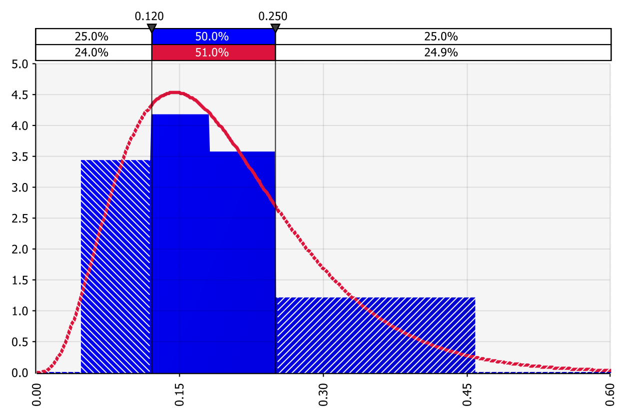

Figure 4 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on exotic fruit.

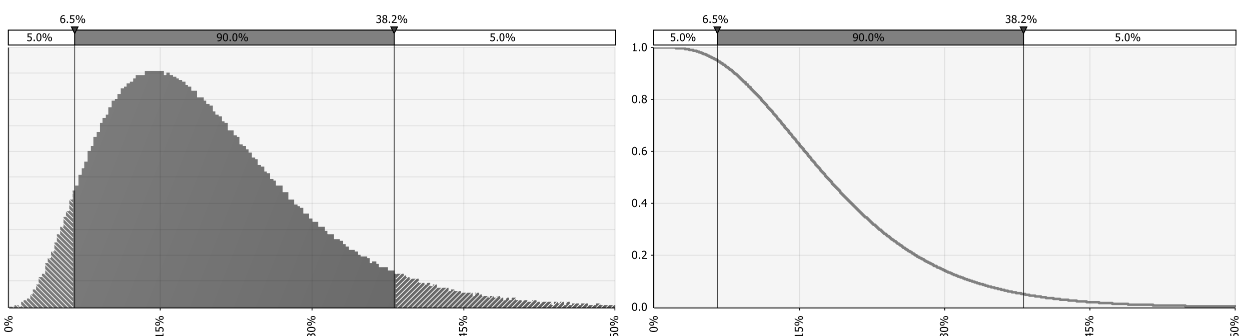

Figure 5 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on exotic fruit.

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 *B. zonata*, 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 5: 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. zonata*.

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

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

As for *B. dorsalis*, citrus are expected to be less sensitive than mangoes, due to the different seasonality.

More damage on early citrus species/varieties with high density of starting populations of *B. dorsalis*.

More diluted yield loss compared to mangos because of late varieties of citrus and because citrus fruit are grown in winter, which is less suitable for *B. zonata*.

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

Treatment for *C. capitata* is effective for *B. zonata*. 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. zonata*.

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. zonata*. Still this fruit fly is better adapted and could build higher populations than *A. ludens*.

The expected yield loss is similar to *B. dorsalis*, but a little bit lower.

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 6: 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

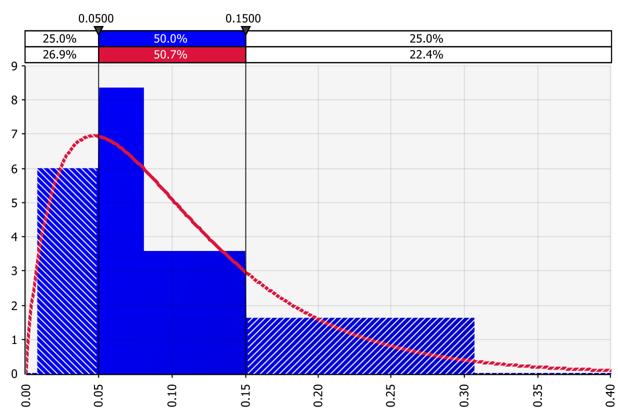

Figure 6 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on citrus.

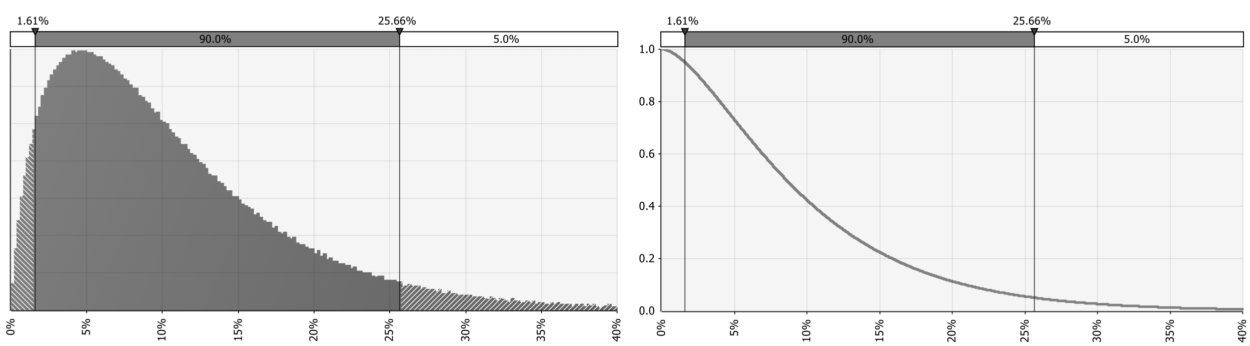

Figure 7 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on citrus.

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 *B. zonata*, 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 7: 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)

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. *C. capitata* population abundance guides the timing of treatments.

Control measures against *C. capitata* have less effect against *B. zonata*. Climatic conditions in Southern Europe are suitable for the pest.

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

More damage on late varieties of peach with high density of 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. zonata*. 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. dorsalis*- *B. zonata* is better adapted to Mediterranean conditions and more adapted to peach than *B. dorsalis*. Therefore the impact of *B. zonata* is expected to be little higher than for *B. dorsalis* .

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 8: 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 distributio n	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

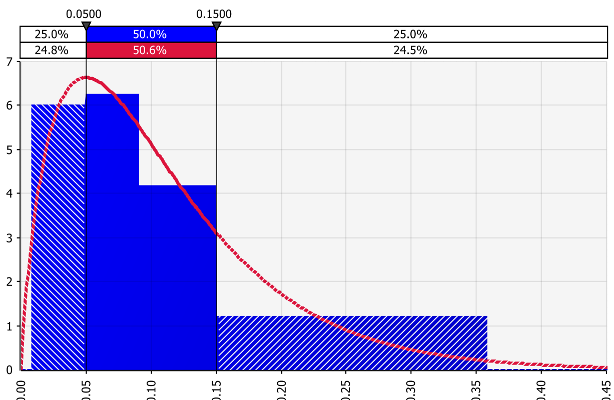

Figure 8 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on citrus.

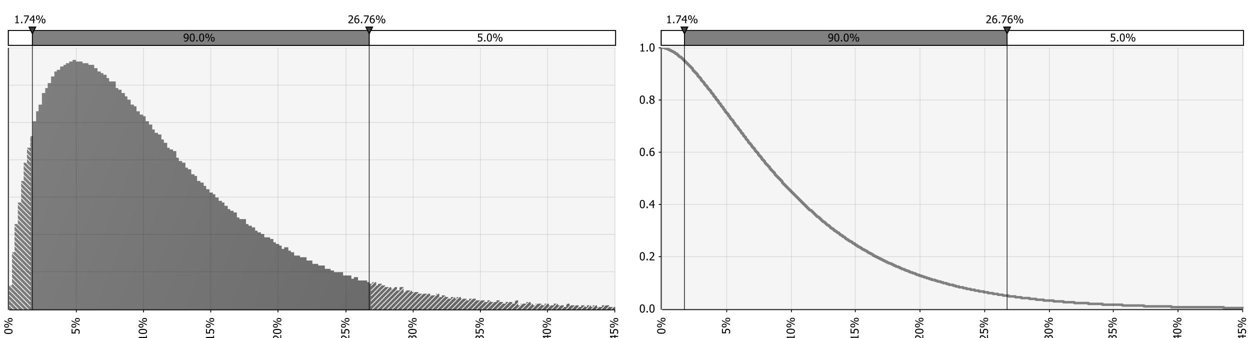

Figure 9 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on citrus.

3.1.5. Conclusions on yield and quality losses

Based on the general and specific scenario 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 spread rate has been assessed as the number of kilometres per year, taking into account that:

- 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.

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:

- Adults are strong fliers and can actively move many kilometres searching for hosts for oviposition and passively by means of winds (Delrio and Cocco, 2012).
- The maximum distance travelled during individual moments is considered
- This species is a strong flier
- *B. zonata* is more adapted to dry climates than *B. dorsalis*
- Lower number of hosts than *B. dorsalis*

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
- No observations on dispersal in conditions of hosts availability
- Role of hitchhiking as a component of local spread

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 9: 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 won't disperse very much, given the likelihood of encountering suitable hosts in the surroundings, in the Mediterranean area. It is a tropical fly which goes through strong bottle necks during winter. This would cause a reduction in population density and therefore in a small population and therefore lower spread capacity at the beginning of the season. Most of release-recapture studies observed 1-2 km distance/generation (therefore the double with two generations).

It is expected to spread a bit more than *B. dorsalis* due to its lower number of host species and its better 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 10: 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					4
Fitted distributio n	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

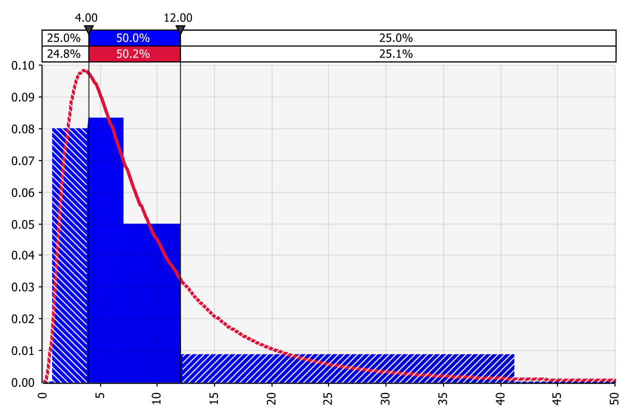

Figure 10 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

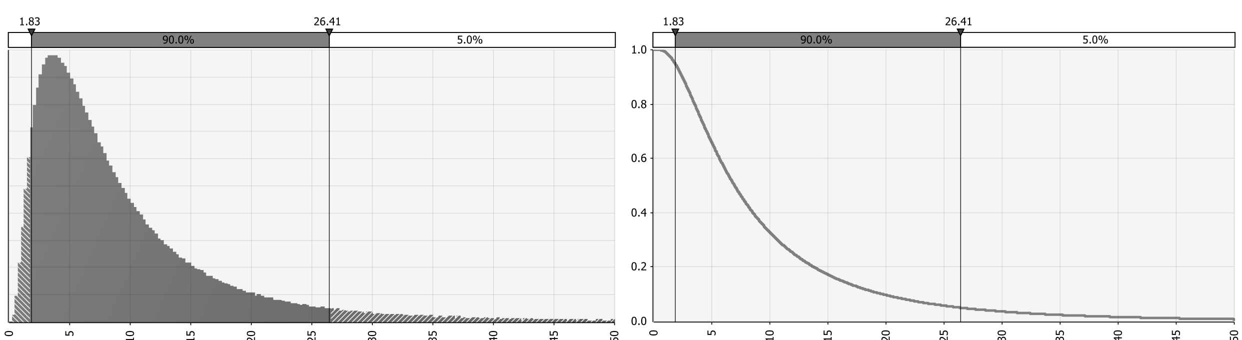

Figure 11 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

3.2.3. Conclusions on the spread rate

Based on the general and specific scenario considered in this assessment, the maximum distance expected to be covered in one year by *B. zonata* is 7 km (with a 95% uncertainty range of 1.4-34.1 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. zonata* and *B. dorsalis* 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

- *A. 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 attractant is 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 11: 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)

It is easy to misclassify the pest, but the expected impact is higher than *A. ludens*.

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.

The awareness about *B. zonata* is expected to be higher 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 for *A. ludens* due to the higher likelihood to detect it compared to *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 12: 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

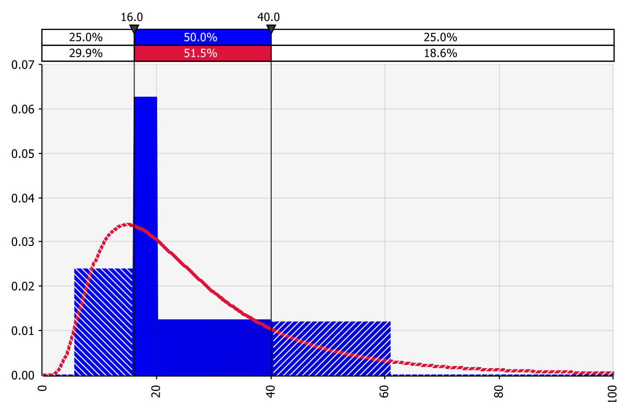

Figure 12 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection.

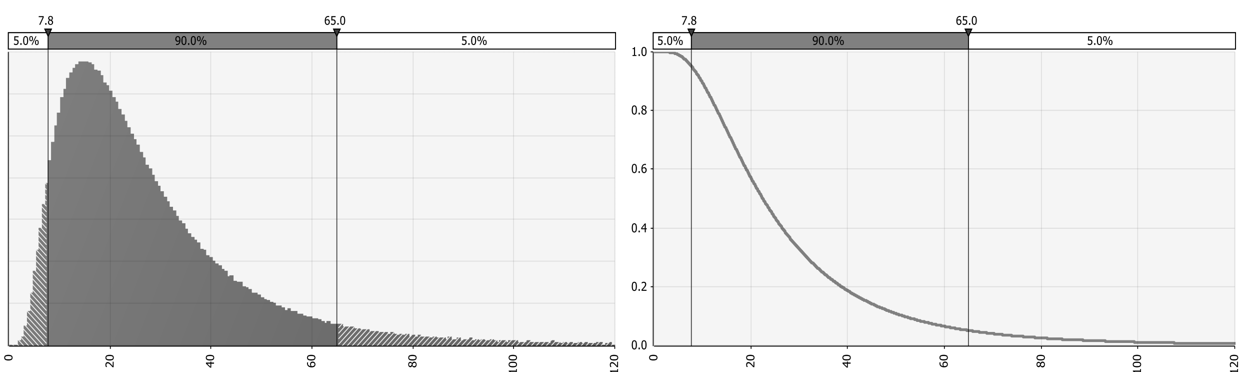

Figure 13 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection.

3.3.3. Conclusions on time to detection

Based on the general and specific scenario 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 was produced by merging

- the list of host plants defined by EPPO (EPPO, online),
- the list of host species reported by CABI (CABI, 2018)

The hosts on which the impact is assessed are:

- exotic fruit;
- citrus;
- peach and nectarine.

Area of potential distribution

The area of potential distribution is limited to central and southern Spain, central and southern Portugal, Madeira, the Azores, Italy, Malta, Greece and Cyprus. For this species, transient populations are not considered, and 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 scenario 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 scenario considered in this assessment, the maximum distance expected to be covered in one year by *B. zonata* is 7 km (with a 95% uncertainty range of 1.4-34.1 km).

Time for detection after entry

Based on the general and specific scenario 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**
Aegle	*marmelos*
Annona	*squamosa*
Careya	*arborea*
Carica	*papaya*
Citrus	
Cydonia	*oblonga*
Ficus	*carica*
Fruit	*trees*
Grewia	*asiatica*
Luffa	
Malus	*domestica*
Mangifera	*indica*
Momordica	*charantia*
Phoenix	*dactylifera*
Prunus	*armeniaca*
Prunus	*persica*
Psidium	*guajava*
Punica	*granatum*
Solanum	*tuberosum*
Terminalia	*catappa*

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***			
Citrus			7.5% (loss estimate in % of harvested fruit)	Pakistan	Stonehouse et al., 1998	Damage caused by the fruit fly complex *B. dorsalis, B. cucurbitae, B. zonata*: not possible to distinguish the damage caused by *B. zonata* only
Navel orange	15.5 %			2002-2003, Fayoum Governorate (Egypt),	Delrio and Cocco 2012	
Grapefruit	10.0 %			2002-2003, Fayoum Governorate (Egypt),	Delrio and Cocco 2012	
Mandarin	8.7%			2002-2003, Fayoum Governorate (Egypt),	Delrio and Cocco 2012	
Sour orange	5.7%			2002-2003, Fayoum Governorate (Egypt),	Delrio and Cocco 2012	
Lemon	0.6%			2002-2003, Fayoum Governorate (Egypt),	Delrio and Cocco 2012	
Valencia orange	0.6%			2002-2003, Fayoum Governorate (Egypt),	Delrio and Cocco 2012	
Guava (*Psidium guajava*) and Mango (*Mangifera indica*)			*B. correcta*, *B. dorsalis* and *B. zonata* damage to an extent of 60 to 80%		Das et al., 2017 citing Jalaluddin et al., 1999	Combined infestation of 3 *Bactrocera* species

Mango	Percentage of the infested fruits			2012-2014 randomized complete block design with five treatments and a control treatment	Khosravi et al., 2018	Not clear if they differentiate between *B. zonata* and other fruit flies
Guava (*Psidium guajava*)	50-55% infestation in summer			Pakistan	Syed et al., 1970; Awad et al., 2014	Probably all coming from a single source of information
Guava	2.28 pupae (of which 1.1 unemerged) 1.45 adults			Pakistan, average infestation per fruit	Stonehouse, 1997	
Mango (*Mangifera indica*)	9% infestation by *B. zonata*		15%	Pakistan	Stonehouse et al., 1998	Damage caused by the fruit fly complex *B. dorsalis, B. cucurbitae, B. zonata*: not possible to distinguish the damage caused by *B. zonata* only
Guava (*Psidium guajava*)	11-80% infestation by *B. zonata*		35%	Pakistan	Stonehouse et al., 1998	Damage caused by the fruit fly complex *B. dorsalis, B. cucurbitae, B. zonata*: not possible to distinguish the damage caused by *B. zonata* only
Peach (*Prunus persica*)			30%	Pakistan	Stonehouse et al., 1998	Damage caused by the fruit fly complex *B. dorsalis, B. cucurbitae, B. zonata*: not possible to distinguish the damage caused by *B. zonata* only
Apricot			15%	Pakistan	Stonehouseet al., 1998	Damage caused by the fruit fly complex *B. dorsalis, B. cucurbitae, B. zonata*: not possible to distinguish the damage caused by *B. zonata* only
Plum			35%	Pakistan	Stonehouse et al., 1998	Damage caused by the fruit fly complex *B. dorsalis, B. cucurbitae, B. zonata*: not possible to distinguish the damage caused by *B. zonata* only
Persimmon	11% infestation by *B. zonata*		40%	Pakistan	Stonehouse et al., 1998	Damage caused by the fruit fly complex *B. dorsalis, B. cucurbitae, B. zonata*: not possible to distinguish the damage caused by *B. zonata* only
Mango (*Mangifera indica*),	108.33 pupae/500 g,	Deformity rate 1.53%			El-Gendy, 2017	Experiment under laboratory conditions, forced infestation

Hamawy apricot (*Prunus armeniaca*),	103.33 pupae/500 g,	Deformity rate 4.19%			El-Gendy, 2017	Experiment under laboratory conditions, forced infestation
Florida prince peach (*Prunus persica*),	55.33 pupae/500 g,	Deformity rate 0%			El-Gendy, 2017	Experiment under laboratory conditions, forced infestation
Hollywood plum (*Prunus persica*),	44.00 pupae/500 g,	Deformity rate 0%			El-Gendy, 2017	Experiment under laboratory conditions, forced infestation
Balady apple (*Malus domestica*)	14.66 pupae/500 g.	Deformity rate 0%			El-Gendy, 2017	Experiment under laboratory conditions, forced infestation
Okra	38.33 pupae/500 g,	Deformity rate 1.71%			El-Gendy, 2017	Experiment under laboratory conditions, forced infestation
Pepper	33.33 pupae/500 g,	Deformity rate 0%			El-Gendy, 2017	Experiment under laboratory conditions, forced infestation
Eggplant	25.33 pupae/500 g,	Deformity rate 0%			El-Gendy, 2017	Experiment under laboratory conditions, forced infestation
Tomato	11.33 pupae/500 g.	Deformity rate 0%			El-Gendy, 2017	Experiment under laboratory conditions, forced infestation
Squash	25.66 pupae/500 g,	Deformity rate 0%			El-Gendy, 2017	Experiment under laboratory conditions, forced infestation
Cucumber	0	Deformity rate 0%		No pupae were obtained from Amera cucumber (*Cucumis sativus)* fruits	El-Gendy, 2017	Experiment under laboratory conditions, forced infestation
Peach	12→ 30% on fruit on the trees 15.4→20% on peach fruits falling under the trees			no treatments Al-Mounifeya Governorate, Egypt	Hanafy and El-Sayed, 2013	
Peach (*Prunus persica*), Apricot (*Prunus armeniaca*), Guava (*Psidium guajava*) and Figs (*Ficus carica*)			25 to 100%	India	Sharma et al., 2015	Not possible to distinguish the specific damage for each host

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

Spread	Additional information	Reference	Uncertainty
	e.g. country where the experiment was conducted		Any observation concerning the provided evidence
Male flies were recaptured in lure traps placed in various directions and distances up to 25 miles from the release point irrespective of host plants. The maximum reported is 40 km	Tandojam, Pakistan	Qureshi et al., 1974, Table 2 pag. 204	
up to 100 m from the release point and only 4% at a distance between 150m and 200m from the release point	Mauritius	Sookar et al., 2014	After 4 days males untreated and treated with *B. bassiana* was 76% and 81%, respectively; 90% of the recovered sterile flies from both groups

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

Category of factors	case	Evidence	Additional information	Reference	Uncertainties
Detection methods	Visual symptoms	Attacked fruits usually show signs of oviposition punctures. Fruits with high sugar content, such as peaches, exude a sugary liquid, which usually solidifies adjacent to the oviposition site.		EPPO, 2015	
Detection methods	Reliability	Males are attracted to methyl eugenol-baited traps (Jackson or Steiner traps, though Jackson traps are preferable). Various dispensers and impregnation mediums have been tested Males are also attracted to Raspberry essence and GF-120 though significantly less than to ME		Bagheri et al., 2017; EPPO, 2005; Singh, 2012 Ahmad andBegum, 2017	

	Identificatio n	Morphological identification with a binocular microscope is the recommended diagnostic method based on adult features. Identification at larvae stage may be challenging.	Magnification 910 for adult to 9200 for larva and aculeus.	EPPO, 2013; White andElson-Harris, 1992	A reliable identification can only be performed on an adult specimen
	Official procedures				
Biology of the pest	Pest life cycle	*B. zonata* is a non-diapausing, polyphagous, multivoltine species. Adults are active throughout the year in their native area except for a short period in January and February. Overwintering occurs mostly in the larval or pupal stages.	can complete 3-9 annual generations in different areas of its geographical range	Delrio and Cocco, 2012	
Biology of the pest	Pest life cycle	The adults appear by the end of March and start mating. The mated females insert their eggs into the fruit skin (in groups of 3 to 9 eggs) and the larvae hatch within 1.5 to 3 days. Larvae upon hatching start eating and caving on the fruit and might remain close together in feeding until nearly full grown. Then the larvae leave fruits and preferably pupate in the soil (optimum depth 5-10 cm) and after pupation adults emerge. Adult emergence occurs profusely in the morning (usually between 9-11 a.m.) and more infrequently during cool weather. Adult population flight activity peaks in September coinciding with mango ripening period in Tehran, Iran.		Bagheri et al., 2017; Qureshi et al., 1974; Shehata et al., 2008; CABI, 2018	
Biology of the pest	Pest life cycle	Duration of incubation of eggs and larvae (17.8, 11.5, 8.7 days) Duration of pupae stage (19.3, 13.2,8.2 days)	Field conditions 19 days, 13.6 days	Abu-Ragheef and Al-Jassany, 2018	Biological aspects are related to temperature (20±2, 25±2, 30±2 ° C)
Biology of the pest	Pest life cycle	Pre egg laying time (23.9, 16.4, 10.8 days) Egg laying time (43.6, 32.8, 26.4 days)	Field conditions 22.3 days, 29 days	Abu-Ragheef and Al-Jassany, 2018	Biological aspects are related to temperature (20±2, 25±2, 30±2 ° C)
Biology of the pest	Pest life cycle	duration of immature stages under different temperatures		Ali, 2016	

Biology of the pest	Pest reproductio n	High reproductive potential (as many as 564 eggs in a lifetime),		CABI, 2018	
Biology of the pest	Feeding and flying behaviour	Adults of *B. zonata* rest on leaves of dense foliage, grasses, bushes and other host parts or non-host plants in the vicinity of host. During the warmer hours of the day they disperse and fly actively	Adult tephritid fruit flies are often found on the host plant and feeding on pollen, nectar, rotting plant debris, or honeydew.	CABI, 2018	
Biology of the pest	Lifespan	Longevity of adults was determined for both female and male; the female had an average of 43.55 ± 3.46 days with a range of 38 - 49 days, while, the longevity of male lasted 38.5 ± 3.67days of average with a range of 33 - 44 day		(Mohamed, 2012)	
Biology of the pest	Infestation progress	The hatched larvae feed and grow inside the host be destroying the mesocarp		CABI, 2018	
Biology of the pest	Population density	The lowest level of means captured males of flies were through January- February and increased gradually to reach a peak in March – May, then populations declined in June - July but increased to reach a peak in August reaching another peak in September.	Pakistan	Qureshi et al., 1974	
Host conditions during the period of potential detection	Effects on symptom expression	Attacked fruits usually show signs of oviposition punctures. Fruits with high sugar content, such as peaches, exude a sugary liquid, which usually solidifies adjacent to the oviposition site.		EPPO, 2005	