APPROVED: 17 May 2019
Doi: 10.5281/zenodo.2789843

Thaumatotibia leucotreta
Pest Report to support ranking of EU candidate priority pests

EFSA (European Food Safety Authority),
Baker R, Gilioli G, Behring C, Candiani D, Gogin A, Kaluski T, Kinkar M, Mosbach-Schulz O, Neri FM, Preti S, Rosace MC, Siligato R, Stancanelli G and Tramontini S

Requestor: European Commission
Question number: EFSA-Q-2018-00403
Output number: EN-1656
Correspondence: alpha@efsa.europa.eu

Acknowledgements: EFSA wishes to acknowledge the contribution of Marja van der Straten to the EKE and the review conducted by Lucia Zappalà.

Table of Contents

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 *Thaumatotibia leucotreta*, the following documents were used as key references: pest risk assessments by NAPPFAST (2003), USDA APHIS (2010) and EPPO (2011 and 2013).

[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 false codling moth *Thaumatotibia leucotreta* (Tortricidae) is a single taxonomic entity. Its larvae feed primarily on the fruits of a wide range of crops (e.g. maize, pepper, citrus, and other exotic fruit). The moth is believed to be native to Sub-Saharan Africa and is adapted for warm climates (Stibick, 2006).

Under favourable conditions (warm and humid) up to five generations a year may be produced. Temperatures below 10°C greatly reduce survival rates, the moth cannot survive temperatures below 1°C (NAPPFAST, 2003).

The false codling moth has four life stages: egg, larva, pupa and adult. A single female moth can produce up to 800 eggs which are deposited on the surface of the host fruit throughout the adult's life. Once hatched from the eggs the larvae burrow into the host fruit pulp and begin to feed, moving further into the interior of the fruit as the larvae matures. This latest larval stage lasts from 12 to 67 days depending on weather conditions and only a few larvae may survive per fruit.

Upon maturity the larvae exit the fruit and drop to the ground where they enter the pupal stage in the soil. Adult males may live between 14 and 57 days, females between 16 and 70 days. The adults are inactive during the day and active only during some time of the night (Stibick, 2006).

2.2. Host plants

2.2.1. List of hosts

Thaumatotibia leucotreta is a polyphagous pest with more than 70 host plants. Important hosts include avocado (*Persea americana*), citrus (*Citrus* spp.), corn (*Zea mays*), cotton (*Gossypium* spp.), macadamia (*Macadamia* spp.), and peach and plum (*Prunus* spp.) (Stibick, 2006). Citrus is a preferred host with Navel oranges (*Citrus sinensis* L. Osbeck) being most vulnerable to *T. leucotreta* damage (Newton 1998;).

Appendix A provides the full list of hosts.

2.2.2. Selection of hosts for the evaluation

The list of the important hosts was reviewed selecting the most relevant to the EU in terms of agricultural production or its environmental role. The table below summarises the decision for each host/group of hosts.

Table 1: Host plants of *Thaumatotibia leucotreta* considered relevant for the EPPO PRA and their inclusion/exclusion from this assessment

Host plant	**Common name**	**Family**	**Reason for inclusion/exclusion**
Capsicum spp.	Pepper	Solanaceae	Included
Citrus reticulata & hybrids	Mandarin orange	Rutaceae	Included in Citrus group
Citrus sinensis & hybrids	Orange	Rutaceae	Included in Citrus group
Citrus paradisi	Grapefruit	Rutaceae	Included in Citrus group

Gossypium spp.	Cotton	Malvaceae	Not included
Litchi chinensis	Litchi, Litchee	Sapindaceae	Not important in the EU
Macadamia spp.	Macadamia	Proteaceae	Not important in the EU
Mangifera indica	Mango	Anacardiaceae	Damage is low
Persea americana	Avocado	Lauraceae	Included, together with guava (it belongs to the EUROSTAT category F2900: Annona, guava, lychee, mango, papaya, passion fruit, pineapple, dates, persimmons, pomegranate, etc.)
Prunus persica	Peach	Rosaceae	Included in peaches/nectarines group
Prunus persica var. nucipersica	Nectarine	Rosaceae	Included in peaches/nectarines group
Psidium guajava	Guava	Myrtaceae	Included, together with avocado (it belongs to the EUROSTAT category F2900: Annona, guava, lychee, mango, papaya, passion fruit, pineapple, dates, persimmons, pomegranate, etc.)
Punica granatum	Pomegranate	Lythraceae	Included in peaches/nectarines group (although it belongs to the EUROSTAT category F2900: Annona, guava, lychee, mango, papaya, passion fruit, pineapple, dates, persimmons, pomegranate, etc.)
Quercus robur	Oak	Fagaceae	Its main role is as a reservoir for the pest but the damage is expected to be limited, without reduction in seed and wood production.
Ricinus communis	Castor oil plant	Euphorbiaceae	Minor crop in the EU
Rosa sp.	Rose	Rosaceae	Not included
Solanum melongena	Eggplant	Solanaceae	Included in *Capsicum* spp. group
Vitis vinifera	Grape	Viticeae	Not included
Zea mays	Maize	Poaceae	Included, sweet corn and grain maize assessed separately

Groups of hosts for which EKE is done:

- *Citrus* spp.:
- *Capsicum* spp.
- *Prunus* spp.: Including peach, nectarine

Host species for which EKE is done:

- *Psidium guajava*
- *Punica granatum*
- *Persea americana*
- *Solanum melongena*
- *Zea mays*

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, 2019)
- the list of host species reported by CABI (CABI, 2019)

The hosts on which the impact is assessed are:

- *Citrus* spp., lemon and lime are not included, all the other citrus species and varieties are considered to have the same impact as that reported for Navel oranges
- *Prunus* spp. (peaches and nectarines)
- *Punica granatum*, the impact is considered to be the same as for peaches and nectarines
- *Psidium guajava* and *Persea americana* are assessed together
- *Capsicum* spp. and *Solanum melongena* are assessed together
- *Zea mays* (sweet corn and grain maize are assessed separately)

2.3. Area of potential distribution

2.3.1. Area of current distribution

Figure 1 provides an overview of the current area of distribution of the pest. In the EU, one male specimen has been caught in a trap in June 2018 during an official survey carried out in Saxony (EPPO, 2018).

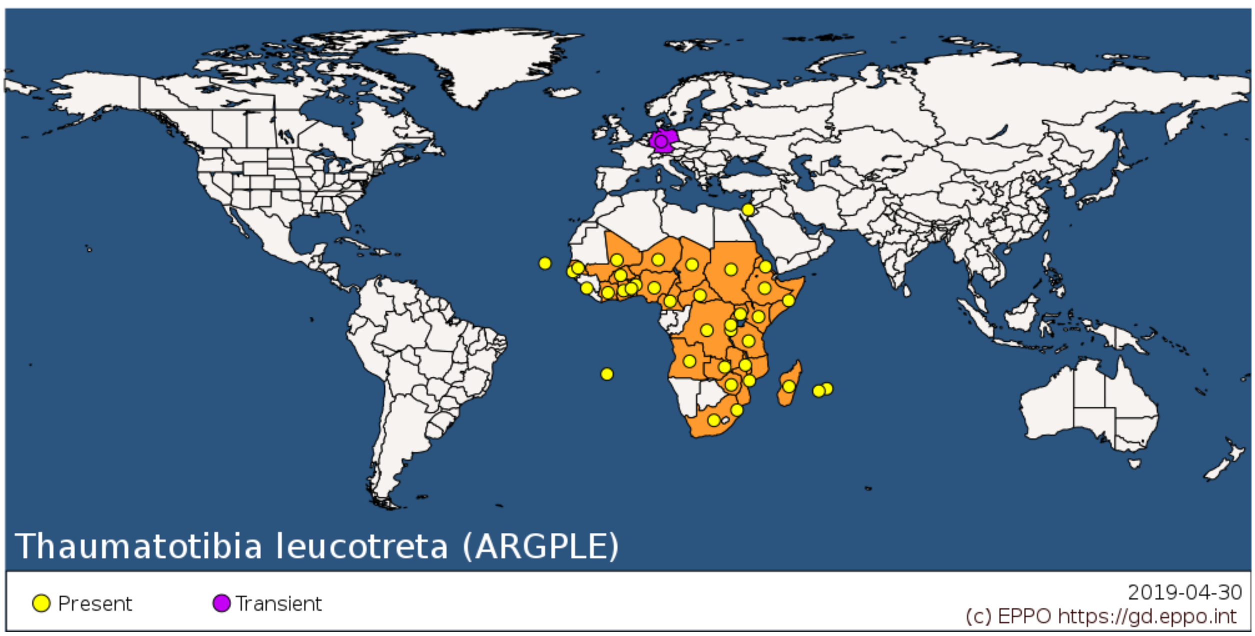

Figure 1 Distribution map of *Thaumatotibia leucotreta* from the EPPO Global Database accessed 30/04/2019.

2.3.2. Area of potential establishment

Climates in the area occupied by this pest can be characterized as tropical, dry or temperate (CABI, 2019). The currently reported global distribution of *T. leucotreta* suggests that the pest may be most closely associated with biomes that are generally classified as desert and xeric shrubland, tropical and subtropical grasslands, savannas, and shrubland; and tropical and subtropical moist broadleaf forest (Venette et al., 2003).

The analysis differs somewhat from the suggestion that the pest may be able to establish in areas where the average annual low temperature is >-10°C (NAPPFAST, 2003). However, without Warm locations for overwintering (e.g. greenhouses) this species cannot move very far north in the EU. More recently, both the PRATIQUE insect and mite thermal requirement database (Jarosik et al., 2011) and the Insect Development Database (NAPPFAST, 2011), based on Daiber's observations (summarised also by Venette et al., 2003) identified:

- 12°C as the minimum temperature for development
- 433 degree days (DD) as the heat sum over the summer growing season (growing degree days) to complete one generation (egg to egg)
- 40°C as the upper limit for development.

The indicated amount of degree days is widely available in the EU and is likely to allow transient populations to develop in the summer, as shown in EPPO (2013, Fig. 9, p. 112). In the same figure it can be observed that the potential number of generations is:

- one (assuming eggs are laid early in the summer) as far north as the Baltic coast of Sweden, Latvia and central England.
- up to 7 in southern coastal Mediterranean climates
- 4 or 5 in key citrus growing areas, such as Valencia
- 3-6 in the Canary Islands and the Azores (not shown).

The maps on climate suitability proposed by EPPO (2013, Fig. 7 p. 111) and in the current document (Figure 2) are based on a series of assumptions:

- the capacity to survive cold stresses during the winter is the key climatic factor influencing establishment in the EU
- where *T. leucotreta* is present in South Africa, at the locations with the lowest minimum winter temperatures, maximum temperatures are up to 15-17°C higher

The result obtained closely reflects the known distribution of *T. leucotreta* in South Africa. In the EU, Spain, Italy (Sicily and Sardinia), Malta, southern Greece and Cyprus together with Portugal, the Canary Islands and Azores are above the threshold.

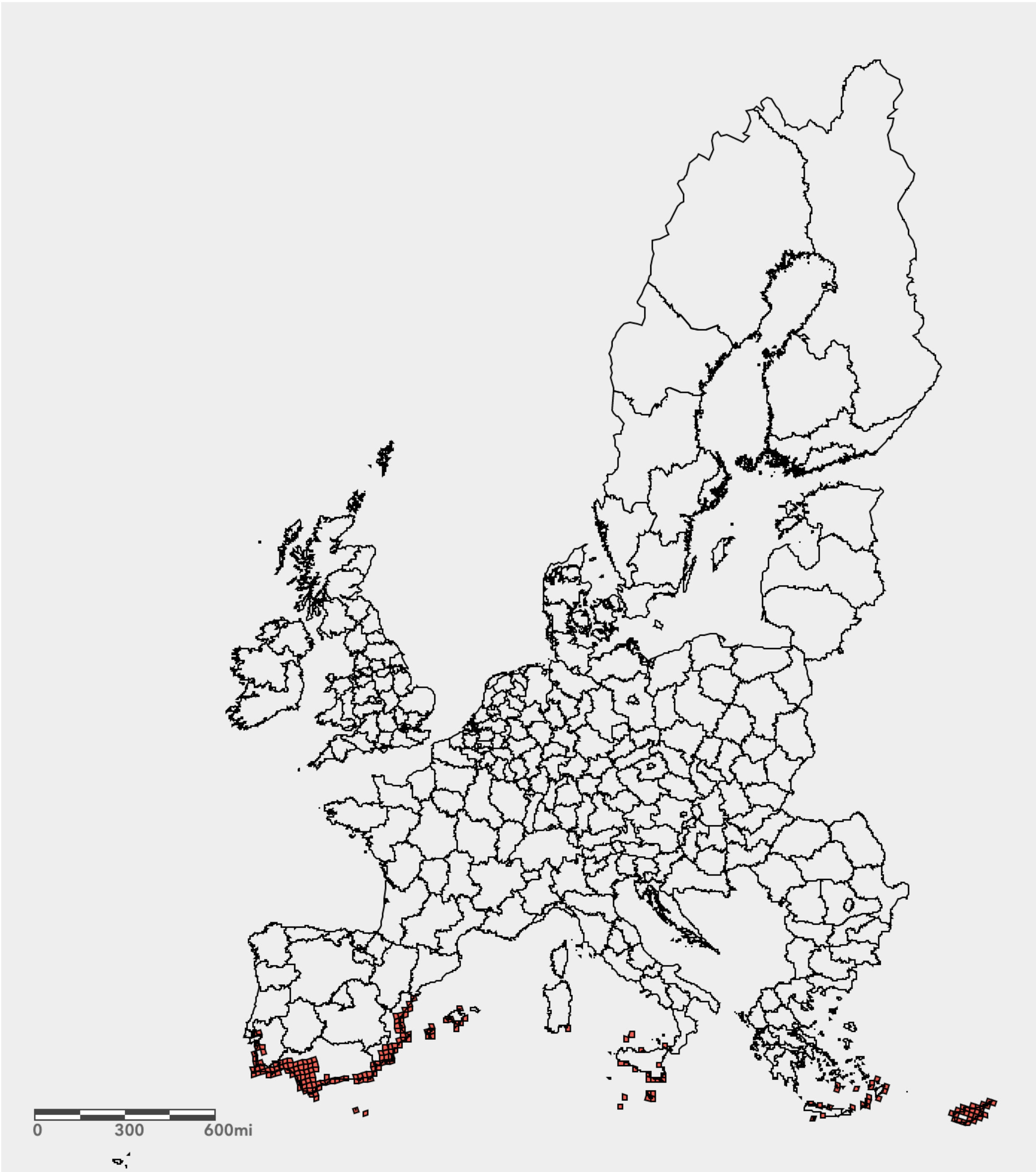

Figure 2 The areas of the EU that are climatically suitable for *T. leucotreta* based on the relationship between maximum and minimum temperatures in the coldest month (July for the southern hemisphere and January for the northern hemisphere) based on: Tmin >= 1°C and Tmax >=18°C, or Tmin >= 3°C and Tmax >= 15°C (following EPPO, 2013).

According to EPPO (2013) the suitable area could be even wider because of:

- the limited knowledge of *T. leucotreta* cold tolerance from the literature
- the limited capacity to infer cold tolerance from the distribution in South Africa due to the limited number of representative presence/absence locations and geographic features (the influence of Oceans)
- the relatively old climatic dataset (global mean 1961-90 climatology) used to build the maps: since then, the area of interest has warmed up
- the longer term and more recent Greek climatic weather station data, showing that parts of southern Greece, especially Crete, are above the threshold. According to EPPO (2013) a more comprehensive analysis of recent climatic data elsewhere is likely to show that the threshold could be exceeded in southern France, e.g. Corsica, and larger areas of southern Portugal, Spain and Italy.

North of this area, *T. leucotreta* may still have sufficient degree days for at least one transient generation to be completed.

In conclusion, the areas of highest risk can be considered to be those that have:

- winter max-min temperatures above the threshold,
- sufficient warmth for several generations to develop and
- continuously available fruit.

2.3.3. Transient populations

Thaumatotibia leucotreta 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

For the definition of the area of potential establishment overwintering capacity is considered to be the most important factor. The likelihood of winter survival is based on the relationship between maximum and minimum temperatures in the coldest month. The area of potential distribution includes parts of southern Spain, Italy (Sicily and Sardinia), Malta, southern Greece and Cyprus together with southern Portugal, and the Azores (Figure 3).

For this species transient populations are not taken into account and the assessment is limited to the area of potential establishment.

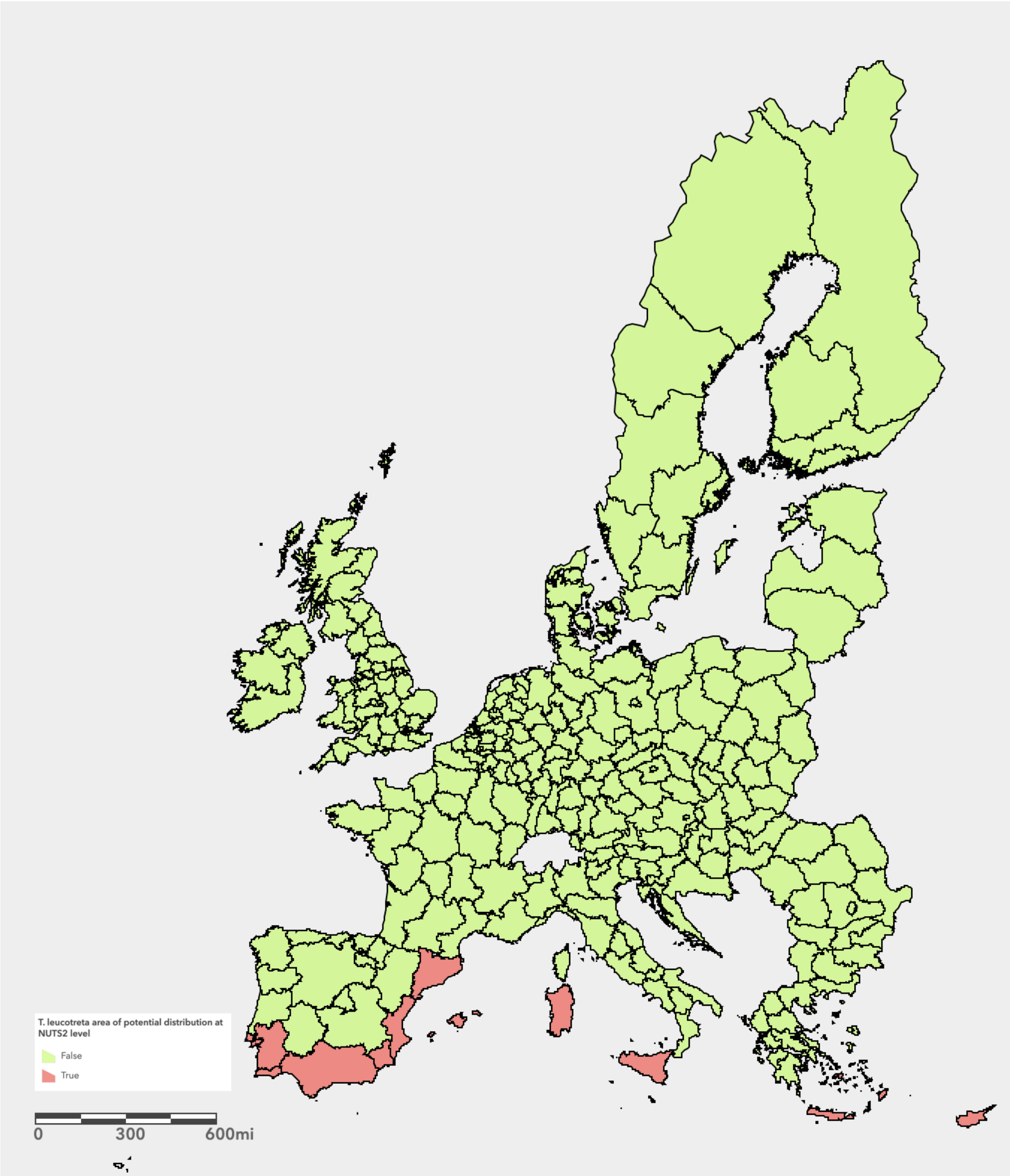

Figure 3 The potential distribution of the pest in the EU NUTS2 regions based on the scenarios established for assessing the impacts of the pest by the EFSA Working Group on EU Priority Pests (EFSA, 2019). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/1LWCaH .

2.4. Expected change in the use of plant protection products

T. leucotreta larvae bore into the fruits within a couple of hours after hatching, therefore the only vulnerable stage is the egg both for chemical and biological (through egg-predators or egg-parasotoids) control.
Products targeted to other pests with phenology stages (at least partially) overlapping with *T. leucotreta* are more likely to be effective (e.g. chemical control of *Grapholita molesta* in Northern countries, where temperatures are colder).
Pheromone traps or mating disruption techniques used against other Lepidoptera pests are not expected to be effective against *T. leucotreta*, with some exceptions for the potential of these types of control techniques in *Citrus* and *Prunus* orchards targeted to *G. molesta*.
The absence of suitable hosts for a suitable period of time can have a good effect in eradicating or decreasing *T. leucotreta* populations, for example in the case of pepper grown as a protected crop in cooler climates, such as in the Netherlands, where very strict hygienic measures are taken during crop change.
Some examples of studies conducted on the control of *T. leucotreta* include*:*

- Cultural control: Van der Geest et al., 1991
- Biological control: Fritsch, 1988; Newton and Odendaal, 1990; Li and Bouwer, 2012
- Chemical control: Newton, 1987; Nepgen et al., 2018
- Pheromonal control: Hofmeyr and Burger, 1995.
- Temperature based control: Boardman et al., 2012, 2013 and 2017; Terblanche et al., 2014 and 2017; Boersma et al., 2018
- Sterile insect technique: Hofmeyr et al, 2016

In conclusion, based on the table below, this pest belongs to Case "D" and category "2", as an increase in the number of treatments is not expected to be sufficient to control *T. leucotreta* in most of the crops and more integrated strategies are required.

Table 2: Expected changes in the use of Plant Protection Products (PPPs) following *Thaumatotibia leucotreta* 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

Benin Hell et al., 2000 indicate a relationship between *T. leucotreta* presence and aflatoxins although the observations were collected in the presence of *S. calamitis*.

2.5.2. Capacity to transmit pathogens

The species is not known to vector any plant pathogens.

3. Expert Knowledge Elicitation report

3.1. 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

- For *Citrus* spp.:
  - The area of potential distribution includes only a part of the EU citrus production area
  - The navel cultivar appears to be the variety of citrus most heavily attacked by FCM
  - Grapefruits and mandarins are less susceptible, and larval development is rarely, if ever, completed in lemons and limes (EPPO, 2013), although, according to USDA APHIS (2010), mandarin and tangelo are both among the main hosts
  - Lemon and lime are not included in the citrus impact, while impact on all the other citrus species and varieties is assumed to be equivalent to the impact on Navel oranges
  - Current control options will not reduce the damage to citrus
  - Juice production is considered to be equivalent to a total loss
  - Quality loss is not included as the presence of the larvae cannot be detected and damaged fruit can only be observed after they are opened
- *Prunus* spp.:
  - Current control options could reduce the damage to *Prunus* (e.g. against *Grapholita molesta*)
- Pomegranate
  - Given the vulnerability of this species, the expected yield loss can be considered to be similar to peaches and nectarines
- Avocado and guava
  - These have been assessed together
- Maize
  - Considering the fact that this pest attacks only the cobs, the maize product for which the assessment is conducted is sweet corn for human consumption (80% of which is located in France). The available evidence on impacts on maize come from Africa where maize is used for human consumption and the data are therefore suitable for the assessment.
  - A cob is considered to be damaged when it is infested
- *Capsicum* spp. and eggplant

- The situation taken into account is southern Europe, where pepper is grown in open fields and in protected conditions (e.g. in tunnels) and the climatic conditions are most suitable in Europe
    - The situation differs from Southern Europe, since not all pests are present in Northern Europe
    - In northern Europe not all the pests in southern EU are present, in particular *Helicoverpa armigera*. Lepidoptera pests that are more or less common in *Capsicum* production in the Netherlands are *Chrysodeixis chalcites*, *Duponchelia fovealis*, *Clepsis spectrana* and *Cacoecimorpha pronubana*. Only *Duponchelia fovealis* is sometimes found boring into fruits, causing similar symptoms to FCM but mostly it is an external feeder, like the other species. So current control measures will generally be against larvae, not eggs, and will therefore have little effect
    - However, it was still decided to assume that the yield loss in protected cultivation (e.g. greenhouses) in central and northern Europe would be similar to that expected in Southern EU
    - Eggplants are included as damage can occur, although little or no quantitative data are available on the damage to eggplants
- Chemical control with insecticides is not very effective due to the difficulty of identifying the right timing and considering that larvae are protected by the fruit throughout their life. *Helicoverpa armigera* feeds in the fruit (while most of the Lepidoptera feed outside the fruit) but its life cycle is longer than *T. leucotreta* and therefore the control for the former is not expected to be very effective on the latter
- The penetration hole is enlarged by the mature larvae as they attempt to pupate and to leave the fruit. Frass will then be found on the damaged surface. Penetrated fruit take up to three to five weeks before they fall from the tree, while newly penetrated fruit pose a serious threat in the form of post-harvest decay, with the damage is not easily detected. Damage done to the fruit increases its vulnerability to scavengers and fungal infections (Hofmeyr 1998).

3.1.1.3. Selection of the parameter(s) estimated

The yield losses are caused by larval feeding and there take into account the effect of premature fruit dropping, rejected and not harvested fruit. In case of damage to cereals the impact is quantified in terms of reduction of harvested volumes.

3.1.1.4. Defined question(s)

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

What is the percentage yield loss in peach, nectarine and pomegranate production under the scenario assumptions in the area of the EU under assessment for *Thaumatotibia leucotreta*, as defined in the Pest Report?

What is the percentage yield loss in avocado and guava production under the scenario assumptions in the area of the EU under assessment for *Thaumatotibia leucotreta*, as defined in the Pest Report?

What is the percentage yield loss in sweet corn production under the scenario assumptions in the area of the EU under assessment for *Thaumatotibia leucotreta*, as defined in the Pest Report?

What is the percentage yield loss in maize production under the scenario assumptions in the area of the EU under assessment for *Thaumatotibia leucotreta*, as defined in the Pest Report?

What is the percentage yield loss in eggplant and pepper production under the scenario assumptions in the area of the EU under assessment for *Thaumatotibia leucotreta*, 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:

- Impacts have only been quantified on oranges
- Presence of parasitoids explain the limited damage in Transvaal, where the climate is also not fully comparable with that in Europe
- The 15% losses in avocado plantations in the Midlands in Tanzania from the paper by Odanga et al. 2018 is assumed to be the maximum damage that could occur in the most suitable EU climatic conditions
- Papers on impact to corn refer to maize for human consumption

3.1.1.6. Uncertainties identified

- Summary of aspects specific for *Citrus* spp
    - the preferences of the pest for the different citrus species (excluding lemon and lime) are not clear
    - Only data on Navel oranges are available

      Grapholita molesta and *Cryptoblabes gnidiella* are other citrus fruit boring Lepidoptera in the EU. The same chemical treatments that control those pests could also affect *T. leucotreta*, in case of the same timing, although the frequency of control on those pests is not known.
- Summary of aspects specific for *Prunus* spp. and pomegranate
    - Vulnerability of EU cultivars
- Summary of aspects specific for avocado and guava
    - Effect of cultural practices on EU production of avocado and guava
    - Uncertainty about potential effects of chemical control
- Summary of aspects specific for sweet corn
- Summary of aspects specific for grain maize
- Summary of aspects specific for *Capsicum* spp. and eggplant

3.1.2. Elicited values for yield losses on citrus

What is the percentage yield loss in citrus production under the scenario assumptions in the area of the EU under assessment for *T. leucotreta*, 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 3: The 5 elicited values on yield loss (%) on citrus

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	10%	20%	25%	35%	50%

3.1.2.1. 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)

Climate in the citrus production area is favourable, supporting up to 5 generations per year. Therefore, the damage increases during the same productive season. Early infestations will cause fruit drop. The value of 50% for the 99th percentile reflects the high uncertainty.

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

A mismatch occurs between time of fruit development and adult presence. The pest infests monocultural zones where only late citrus species or varieties are available.

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

The median value of 25% losses takes into account the fact that current agricultural practices and control measures applied in the EU on citrus plantations are not targeted to this pest or to other pests with similar biology.

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

The precision is mainly given by the confidence around the median and the uncertainty on the extreme values, in particular on the upper limit.

3.1.2.2. 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 4: Fitted values of the uncertainty distribution on citrus

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	10%					20%		25%		35%					50%
Fitted distribution	7.4%	9.5%	11.5%	14.1%	16.7%	19.3%	21.7%	26.2%	31%	33.8%	37.4%	41.2%	45.8%	49.8%	54.3%

Fitted distribution: BetaGeneral(4.5976,12.387,0,1), @RISK7.5

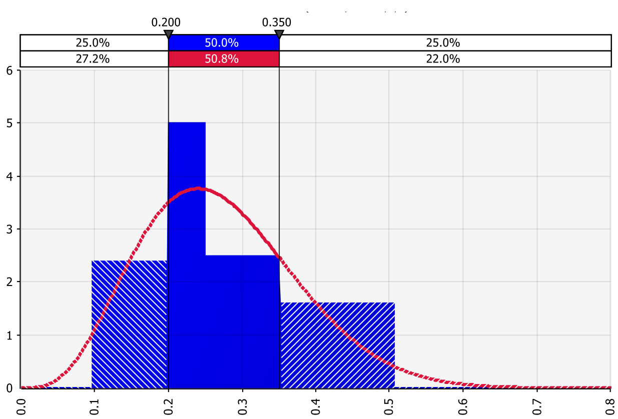

Figure 4 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on citrus.

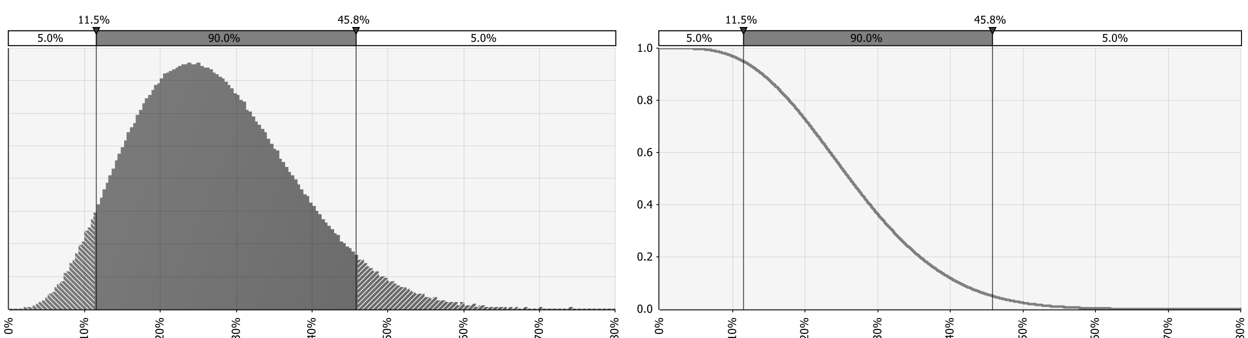

Figure 5 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on citrus.

3.1.3. Elicited values for yield losses on peaches/nectarines and pomegranate

What is the percentage yield loss in peach, nectarine and pomegranate production under the scenario assumptions in the area of the EU under assessment for *T. leucotreta*, as defined in the Pest Report?

The five elicited values on yield loss on peaches/nectarines and pomegranate on which the group agreed are reported in the table below.

Table 5: The 5 elicited values on yield loss (%) on peaches/nectarines and pomegranate

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	5%	13%	22%	30%	40%

3.1.3.1. Justification for the elicited values for yield loss on peaches/nectarines and pomegranate

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

Varieties on which damage was observed in South Africa are probably highly susceptible and in the current assessment the diversity of peach varieties is also taken into account.

Effective treatment of this pest with insecticides is not easy and therefore there is uncertainty concerning its effect.

The growing season of these crops is very suitable to the *T. leucotreta* life cycle, as fruit are available at the ideal time for laying eggs. In addition, if it is able to overwinter, the first generation will already produce high density populations.

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

Current treatments are effective against *T. leucotreta* infestations and some EU varieties are not very susceptible.

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

The control options are expected to have some effect.

The growing season of these crops is very suitable to the *T. leucotreta* life cycle, as fruit are available at the ideal time for laying eggs. In addition, if it is able to overwinter, the first generation will already produce high density populations. These same reasons applying to the upper quartile also support a high median value.

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

It is expected that the likelihood of values lower than the median are higher than those for values higher than median.

3.1.3.2. Estimation of the uncertainty distribution for yield loss

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 peaches/nectarines and pomegranate

Percentile	**1%**	**2.5%**	**5%**	**10%**	**17%**	**25%**	**33%**	**50%**	**67%**	**75%**	**83%**	**90%**	**95%**	**97.5%**	**99%**
Expert elicitation	5%					13%		22%		30%					40%
Fitted distribution	4.5%	6.0%	7.5%	9.5%	11.5%	13.5%	15.4%	19.1%	23.2%	25.7%	28.8%	32.3%	36.5%	40.2%	44.6%

Fitted distribution: BetaGeneral(3.883,15.367,0,1), @RISK7.5

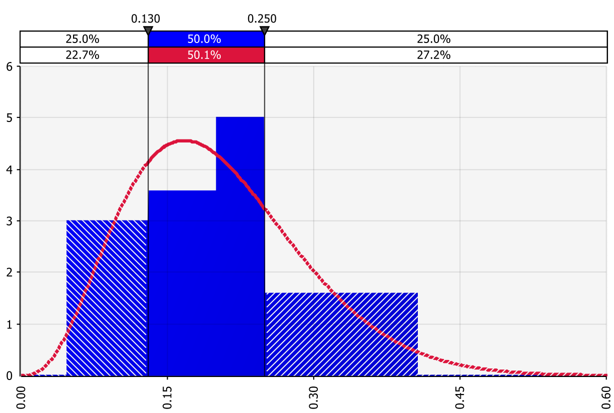

Figure 6 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on peaches/nectarines and pomegranate.

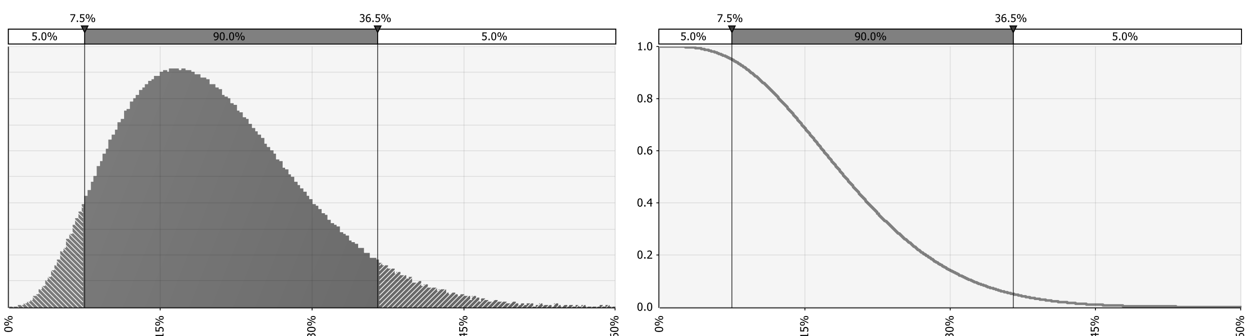

Figure 7 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on peaches/nectarines and pomegranate.

3.1.4. Elicited values for yield losses on avocado and guava

What is the percentage yield loss in avocado and guava production under the scenario assumptions in the area of the EU under assessment for *T. leucotreta*, as defined in the Pest Report?

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

Table 7: The 5 elicited values on yield loss (%) on avocado and guava

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	2%	6%	10%	15%	20%

3.1.4.1. Justification for the elicited values for yield loss on avocado and guava

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

Kilimanjaro is in the most favourable situation and probably more favourable than Mediterranean climate. In the Mediterranean growing areas, the temperature conditions are higher but, in the Kilimanjaro, more stable. However, control measures are not expected be effective.

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

It is not the most favoured host, but its location is in a very suitable climatic zone where many other potential host species are available.

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

No knowledge about effective treatments in the EU. Some of the larvae do not seem to be able to complete development on avocado.

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

Uncertainty is very high due to the absence of information on avocado and guava as FCM hosts.

3.1.4.2. *Estimation of the uncertainty distribution for yield loss on avocado and guava*

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 avocado and guava

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	2%					6%		10%		15%					20%
Fitted distribution	0.7%	1.3%	2.1%	3.3%	4.7%	6.2%	7.6%	10.3%	13.0%	14.5%	16.2%	17.7%	19.2%	20.1%	20.9%

Fitted distribution: BetaGeneral(1.5844,1.7639,0,0.22), @RISK7.5

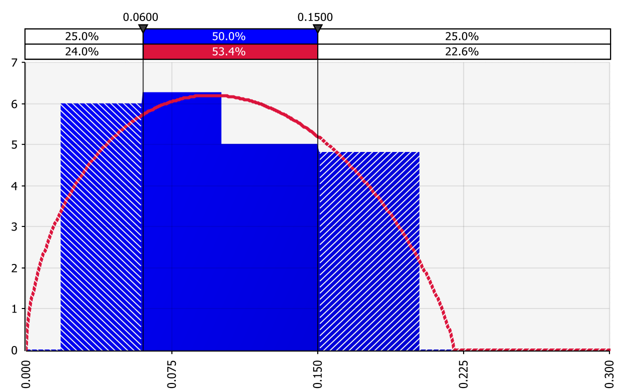

Figure 8 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on avocado and guava.

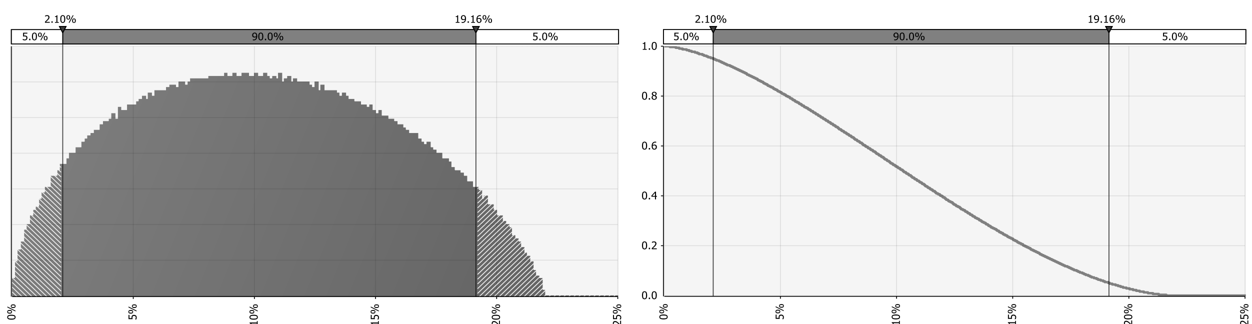

Figure 9 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on avocado and guava.

3.1.5. Elicited values for yield losses on sweet corn

What is the percentage yield loss in sweet corn production under the scenario assumptions in the area of the EU under assessment for *T. leucotreta*, as defined in the Pest Report?

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

Table 9: The 5 elicited values on yield loss (%) on sweet corn

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	5%	10%	15%	25%	40%

3.1.5.1. Justification for the elicited values for yield loss on sweet corn

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

Whenever a cob is attacked, the full cob is lost.

By comparison with avocado which is not a favourable host and with citrus which is not only a favoured host but is available even when other hosts aren't.

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

Maize is usually grown as a monoculture: an initial low-density population is expected, which slowly grows. Ploughing may have some effect in controlling *T. leucotreta* population.

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

Obtained by comparison with other host results, in particular citrus and avocado.

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

There is more confidence on values below the median.

3.1.5.2. Estimation of the uncertainty distribution for yield loss

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 sweet corn

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	5%					10%		15%		25%					40%
Fitted distribution	0.1%	0.3%	0.4%	0.7%	1.1%	1.5%	2.0%	3.0%	4.2%	4.9%	6.0%	7.2%	8.8%	10.2%	12.0%

Fitted distribution: BetaGeneral(2.4713,11.613,0,1), @RISK7.5

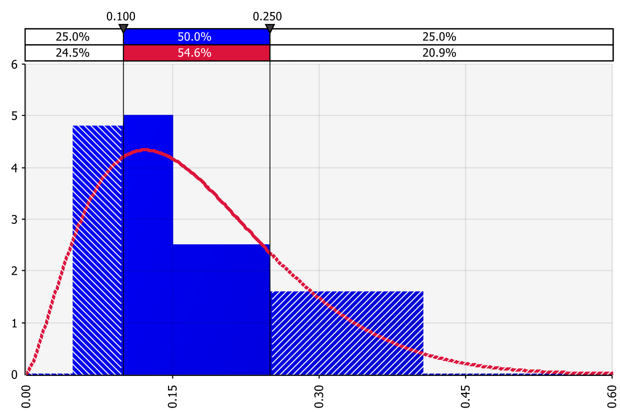

Figure 10 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on sweet corn.

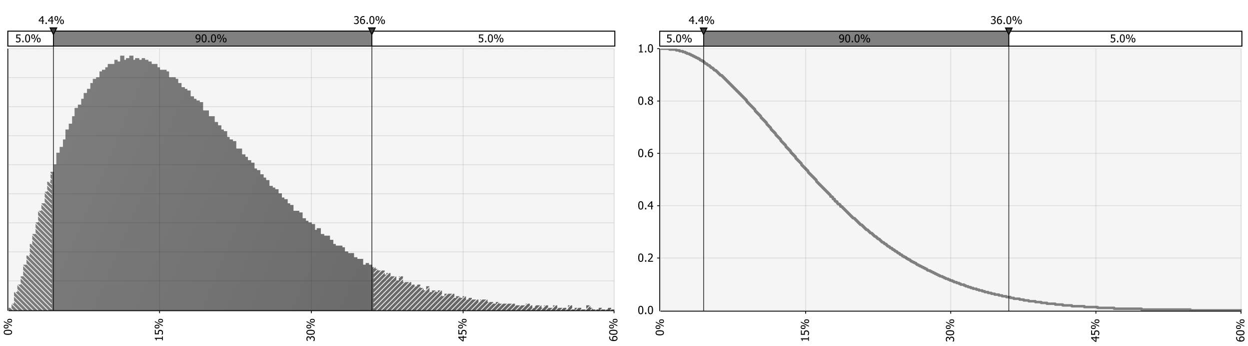

Figure 11 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on sweet corn.

3.1.6. Elicited values for yield losses on grain maize

What is the percentage yield loss in grain maize production under the scenario assumptions in the area of the EU under assessment for *T. leucotreta*, as defined in the Pest Report?

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

Table 11: The 5 elicited values on yield loss (%) on grain maize

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	0.5%	2%	3%	9%	15%

3.1.6.1. Justification for the elicited values for yield loss on grain maize

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

The estimation for the upper limit considers a situation where one third to one half of cobs are damaged.

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

The estimation for the lower limit refers to a situation where one tenth of cobs are damaged due to the fact that the population density is low with very few larvae per cob.

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

The media corresponds to the losses due to one fifth of cobs damaged.

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

As for the sweet corn, the curve is very flat.

3.1.6.2. Estimation of the uncertainty distribution for yield loss

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 grain maize

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	0.5%					2%		3%		9%					15%
Fitted distribution	0.5%	0.5%	0.5%	0.7%	0.9%	1.4%	2.1%	4.0%	6.8%	8.5%	10.4%	12.3%	13.9%	14.8%	15.4%

Fitted distribution: BetaGeneral(0.52993,1.1776,0.005,0.16), @RISK7.5

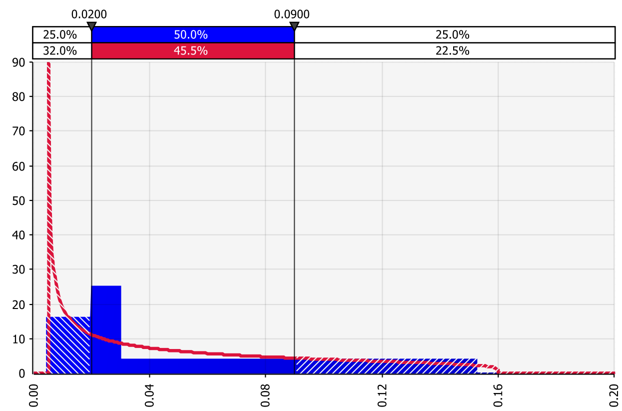

Figure 12 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on grain maize.

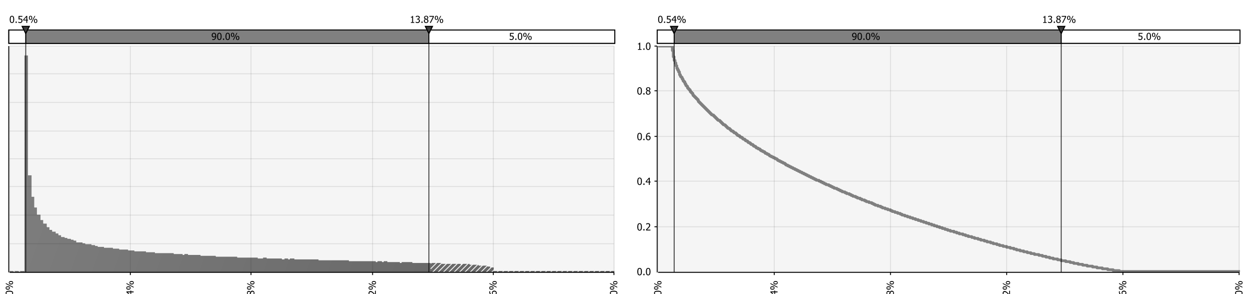

Figure 13 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on grain maize.

3.1.7. Elicited values for yield losses on *Capsicum* spp. and eggplant

What is the percentage yield loss in eggplant and pepper production under the scenario assumptions in the area of the EU under assessment for *T. leucotreta*, as defined in the Pest Report?

The five elicited values on yield loss on Capsicum spp. and eggplant on which the group agreed are reported in the table below.

Table 13: The 5 elicited values on yield loss (%) on *Capsicum* spp. and eggplant

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	2%	15%	25%	35%	60%

3.1.7.1. Justification for the elicited values for yield loss on Capsicum spp. and eggplant

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

High impacts are expected when the pest does not need to go into dormancy and is therefore able to build up high populations. Enough alternative hosts would be available to enhance the population. A period of the year when the temperatures are very favourable. The level of damage takes into account the absence of effective and well targeted control options.

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

It is in an area where the population of the pest will be quite low, due to the seasonality of pepper production (mainly in winter). There is an absence of alternative hosts. Good sanitation practices (removal of fallen fruits) occur.

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

The pest immediately attacks the fruit, without damaging the leaves, therefore its presence causes immediate damage, probably with more extreme effects than those observed on citrus, due to the fact that part of pepper production is in protected conditions, providing more favourable, warmer climate to the pest survival. On the other hand, the time period for the pest to attack the fruit is short. However, alternative hosts are available for most of the year.

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

Uncertainty is distributed on both sides of the curve, given the limited evidence available, but there is a certain level of confidence in the median.

3.1.7.2. Estimation of the uncertainty distribution for yield loss

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 14: Fitted values of the uncertainty distribution on *Capsicum* spp. and eggplant

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	2%					15%		25%		35%					60%
Fitted distribution	3.0%	4.6%	6.5%	9.2%	12.1%	15.4%	18.4%	24.4%	31.3%	35.4%	40.5%	46.2%	52.7%	58.3%	64.5%

Fitted distribution: BetaGeneral(2.2566,6.3142,0,1), @RISK7.5

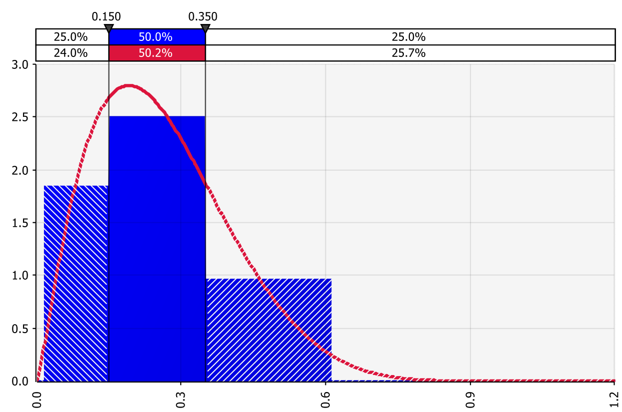

Figure 14 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on *Capsicum* spp. and eggplant.

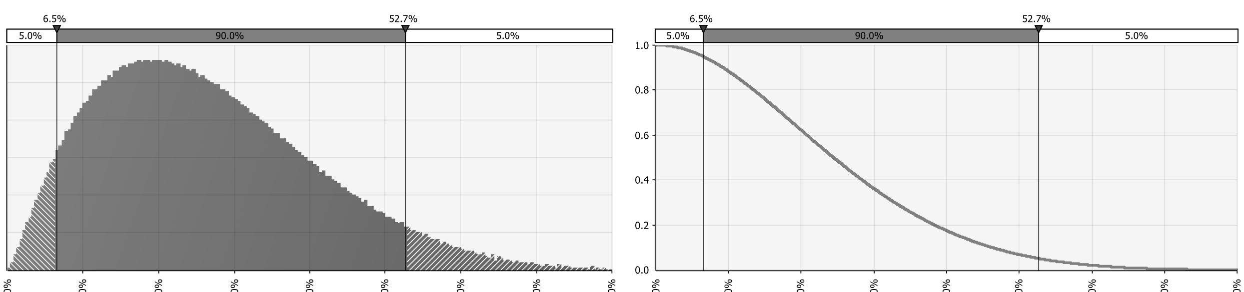

Figure 15 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on *Capsicum* spp. and eggplant.

3.1.8. Conclusions on yield and quality losses

Based on the general and specific scenario considered in this assessment, the percentage of yield losses is estimated to be

- 26.2% (with a 95% uncertainty range of 9.5-49.8%) on citrus
- 19.1% (with a 95% uncertainty range of 6.0-40.2%) on peaches/nectarines and pomegranate
- 10.3% (with a 95% uncertainty range of 1.3-20.1%) on avocado and guava
- 3% (with a 95% uncertainty range of 0.3-10.2%) on sweet corn
- 4% (with a 95% uncertainty range of 0.5-14.8%) on grain maize
- 24.4% (with a 95% uncertainty range of 4.6-58.3%) on *Capsicum* spp. and eggplant

Quality losses have not been included in the assessment because they are considered to be negligible compared to the 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

- Spread rate and time for detection are pest specific and independent from the host
- The spread in completely covered crops is not taken into account

3.2.1.3. Selection of the parameter(s) estimated

The spread rate has been assessed as the number of metres 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: m/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.

3.2.1.6. Uncertainties identified

- Only one single paper provides the spread rate for females
- Limited information on outbreaks from non-EU countries
- Information on spread by agricultural practices is missing

- *T. leucotreta* moves only when it has to (similar to *Cydia pomonella*), therefore even if alternative hosts are available the spread rate would remain low
- Information about *C. pomonella* taken into account: females can fly as far as males if needed

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: m/year)

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

Table 15: Summary of the 5 elicited values on spread rate (m/y)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	200	900	1,300	2,500	7,500

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)

- Wind in the Mediterranean area is an important factor, even when only normal coastal winds are considered; the moth will not fly in extreme events (strong winds, storms)
- They can fly up to 11 m favouring passive dispersal by wind (Schwartz, 1981)
- The females will fly as far as the males

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

- In this scenario fruits of host plant species are available all year close to the initial location
- During 1 year there can be up to 5 generations: and the exponential population growth curve would imply that there is some wider exploration of the environment, although the flights are not necessarily in one direction
- The contribution of the wind (passive movement), although this can be quite strong in the Mediterranean area, is not taken into account

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

- The typical Mediterranean situation under consideration would not favour very long distance flights
- Flying capacity estimates are based on other Tortricidae (e.g. *Cydia pomonella*) as a closely related species
- Population dynamics of the moth (in particular its oviposition strategy)

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

Few information and high uncertainty covered by a wide uncertainty range.

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 16: Fitted values of the uncertainty distribution on the spread rate (m/y)

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	200					900		1,300		2,500					7,500
Fitted distribution	233	309	395	523	667	836	1,010	1,409	1,967	2,375	2,979	3,798	5,030	6,419	8,522

Fitted distribution: Lognorm(1900.8,1720.5), @RISK7.5

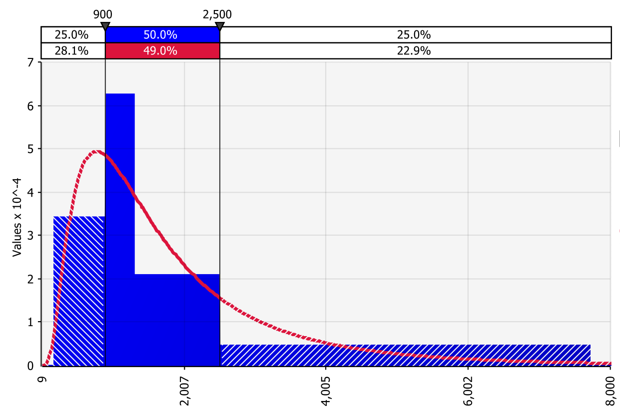

Figure 16 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

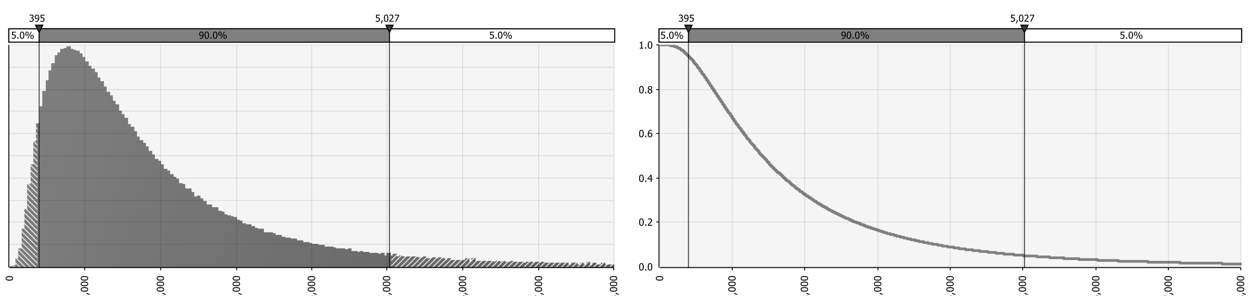

Figure 17 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

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 *T. leucotreta* is approximately 1,5 km (with a 95% uncertainty range of 300 m to 6.5 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

- Spread rate and time for detection are pest specific and independent from the host

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

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 time to detection.

3.3.1.6. Uncertainties identified

No main uncertainties were noted.

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 17: Summary of the 5 elicited values on time to detection (months)

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	4	15	24	28	36

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)

Outbreak starts in private gardens or natural environments. A small population not growing fast due to unfavourable climatic conditions. The symptoms are easily confused with those of other pests, particularly for Mediterranean countries where other similar phytophagous species are already present. It is not a pest that is expected to stay for a long time in natural environments and is expected to move quite quickly to crops, in particular to high value crops, where inspection activity is frequent. Therefore 3 years (corresponding to 10-15 reproductive cycles) is considered to be a reasonable maximum time period.

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

Traps are in use but are still rare in the assessment area and will not influence the time to detection. The morphological identification is straightforward and even in case of molecular tests the final identification requires just a few days. At least 1 generation is necessary for the impact to be visible. On Capsicum, identified after harvest depends on awareness.

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

Two years is considered to be a realistic time frame, taking into account suitable climatic conditions in Southern EU and increasing awareness of the biology and symptoms of this pest. A growing population is needed for detection. The population will grow quite fast and will be recognised most probably at harvest.

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

Confidence in the median value is due to the climatic conditions of Southern EU which should favour the survival and reproduction of the initial population.

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 18: 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	4					15		24		28					36
Fitted distribution	3.8	5.5	7.4	10.1	12.9	15.7	18.2	22.7	26.9	29.0	31.1	33.0	34.6	35.5	36.2

Fitted distribution: BetaGeneral(2.0145,1.4283,1,37), @RISK7.5

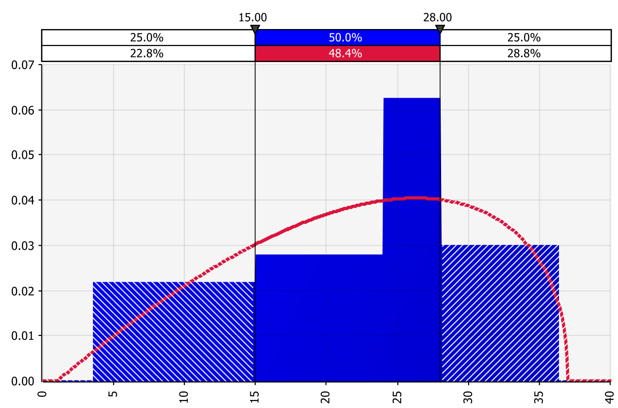

Figure 18 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection.

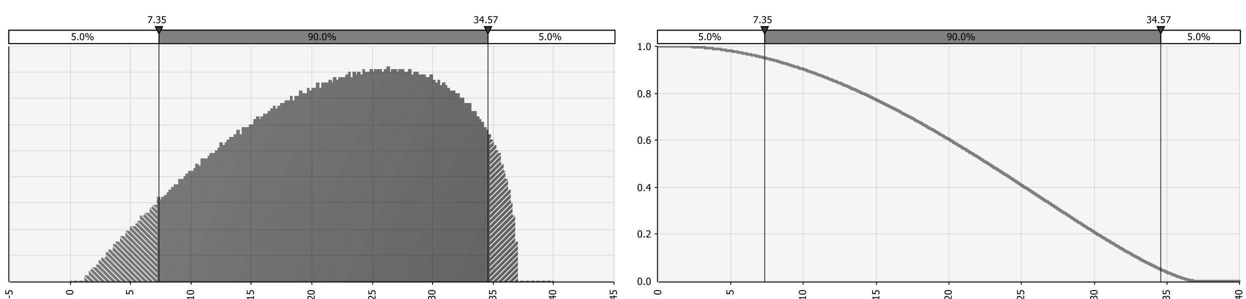

Figure 19 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection.

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 less than 2 years (with a 95% uncertainty range of 0.5-3 years).

4. Conclusions

Hosts selection

The complete list of hosts is produced by merging:

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

The hosts on which the impact is assessed are:

- *Citrus* spp., lemon and lime are not included, all the other citrus species and varieties are considered to have the same impact as that reported for Navel oranges
- *Prunus* spp. (peaches and nectarines)
- *Punica granatum*, the impact is considered to be the same as for peaches and nectarines
- *Psidium guajava* and *Persea americana* are assessed together
- *Capsicum* spp. and *Solanum melongena* are assessed together
- *Zea mays* (sweet corn and grain maize are assessed separately)

Area of potential distribution

For the definition of the area of potential establishment overwintering capacity is considered to be the most important factor. The likelihood of winter survival is based on the relationship between maximum and minimum temperatures in the coldest month. The area of potential distribution includes parts of southern Spain, Italy (Sicily and Sardinia), Malta, southern Greece and Cyprus together with southern Portugal, and the Azores.
For this species transient populations are not taken into account and the assessment is limited to the area of potential establishment.

Increased number of treatments

This pest belongs to Case "D" and category "2", as an increase in the number of treatments is not expected to be sufficient to control *T. leucotreta* in most of the crops and require more integrated strategies.

Yield and quality losses

Based on the general and specific scenario considered in this assessment, the percentage of yield losses is estimated to be

- 26.2% (with a 95% uncertainty range of 9.5-49.8%) on citrus

- 19.1% (with a 95% uncertainty range of 6.0-40.2%) on peaches/nectarines and pomegranate
- 10.3% (with a 95% uncertainty range of 1.3-20.1%) on avocado and guava
- 3% (with a 95% uncertainty range of 0.3-10.2%) on sweet corn
- 4% (with a 95% uncertainty range of 0.5-14.8%) on grain maize
- 24.4% (with a 95% uncertainty range of 4.6-58.3%) on *Capsicum* spp. and eggplant

Quality losses have not been included in the assessment because they are considered to be negligible compared to the 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 *T. leucotreta* is approximately 1.5 km (with a 95% uncertainty range of 300 m to 6.5 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 less than 2 years (with a 95% uncertainty range of 0.5-3 years).

5. References

Agboka K, Schulthess F, Tounoud AK, Tamòa M and Vidal S, 2013. The effect of leguminous cover crops and cowpea planted as border rows on maize ear borers with special reference to Mussidia nigrivenella Ragonot (Lepidoptera: Pyralidae). Crop Protection, 43, 72-78.

Begemann GJ and Schoeman AS, 1999. The phenology of *Helicoverpa armigera* (Hnbner) (Lepidoptera: Noctuidae), *Tortrix capensana* (Walker) and *Cryptophlebia leucotreta* (Meyrick) (Lepidoptera: Tortricidae) on citrus at Zebediela, South Africa. African Entomology, 7, 131-148.

Blomefield TL, 1989. Economic importance of false codling moth, *Cryptophlebia leucotreta*, and codling moth, *Cydia pomonella*, on peaches, nectarines and plums. Phytophylactica, 21, 435-436.

Boardman L, Grout TG and Terblanche JS 2012. False codling moth *Thaumatotibia leucotreta* (Lepidoptera, Tortricidae) larvae are chill-susceptible. Insect Science, 19, 315-328.

Boardman L, Sørensen JG and Terblanche JS, 2013. Physiological responses to fluctuating thermal and hydration regimes in the chill susceptible insect, *Thaumatotibia leucotreta*. Journal of Insect Physiology, 59, 781–794.

Boardman L, Sørensen JG, Grout TG and Terblanche JS, 2017. Molecular and physiological insights into the potential efficacy of CO_2-augmented postharvest cold treatments for false codling moth. Postharvest Biology and Technology, 132, 109-118.

Boersma N, Boardman L, Gilbert M and Terblanche JS, 2018. Sex-dependent thermal history influences cold tolerance, longevity and fecundity in false codling moth *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae). Agricultural and Forest Entomology, 20, 41-50.

Buadu EJ, Gounou S, Cardwell KF, Mochiah B, Botchey M, Darkwa E, and Schulthess F, 2002. Distribution and relative importance of insect pests and diseases of maize in southern Ghana. African Plant Protection, 8, 11 pp.

CABI (Centre for Agriculture and Bioscience International), 2019. Datasheet report for *Thaumatotibia leucotreta* (false codling moth). Crop Protection Compendium. Last modified 11 January 2019. Available online: https://www.cabi.org/isc/datasheet/6904

Daiber C, 1980. A study of the biology of the false codling moth *Cryptophlebia leucotreta* (Meyr.): the adult and generations during the year. Phytophylactica, 12, 187-193.

Daiber C, 1976. A survey of the false codling moth (*Cryptophlebia leucotreta* Meyr.) in peach orchards. Phytophylactica, 8, 97-102.

Daiber KC, 1989. The false codling moth, *Cryptophlebia leucotreta* (Meyr.) (Lepidoptera: Tortricidae), in southern Africa. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz, 96, 71-80.

Djieto-Lordon C, Heumou C R, Elono Azang PS, Alene CD, Ngueng AC and Ngassam P, 2014. Assessment of pest insects of *Capsicum annuum* L.1753 (Solanaceae) in a cultivation cycle in Yaoundé. International Journal of Biological and Chemical Sciences, 8, 621-632.

EFSA (European Food Safety Authority), Baker R, Gilioli G, Behring C, Candiani D, Gogin A, Kaluski T, Kinkar M, Mosbach-Schulz O, Neri FM, Siligato R, Stancanelli G and Tramontini S, 2019. Scientific report on the methodology applied by EFSA to provide a quantitative assessment of pest-related criteria required to rank candidate priority pests as defined by Regulation (EU) 2016/2031. EFSA Journal 2019;17(5):5731, 64 pp. https://doi.org/10.2903/j.efsa.2019.5731

EPPO (European and Mediterranean Plant Protection Organization), 2018. Incursion of *Thaumatotibia leucotreta* in Germany. Available online: https://gd.eppo.int/reporting/article-6354 [Accessed: 27 May 2019]

EPPO (European and Mediterranean Plant Protection Organization), online. EPPO Global Database. Available online: https://www.eppo.int/ [Accessed: 27 May 2019]

EPPO (European and Mediterranean Plant Protection Organization), 2019. *Thaumatotibia leucotreta* (ARGPLE). EPPO Global Database. Available online: https://gd.eppo.int/taxon/ARGPLE/hosts [Accessed: 27 May 2019]

EPPO (European and Mediterranean Plant Protection Organization), 2011. Report of a pest risk analysis for *Thaumatotibia leucotreta.* Available online: https://gd.eppo.int/taxon/ARGPLE/documents

EPPO (European and Mediterranean Plant Protection Organization), 2013. Pest risk analysis for *Thaumatotibia leucotreta*. Available online: https://gd.eppo.int/taxon/ARGPLE/documents

Fritsch E, 1988. Biological control of the false codling moth, *Cryptophlebia leucotreta* (Meyrick) (Lep., Tortricidae), with a granulosis virus. Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie, 6, 280-283.

Gounou S and Schulthess F, 2006. Effect of traditional rice/maize intercropping on population densities, crop damage and parasitism of stem-borers in the Ivory Coast. African Plant Protection, 12, 93–102.

Hell K, Cardwell KF, Setamou M and Schulthess F, 2000. Influence of insect infestation on aflatoxin contamination of stored maize in four agroecological regions in Benin. African Entomology, 8, 169-177.

Hofmeyr JH, 1998. Production guidelines for the control of false codling moth *Cryptophlebia leucotreta* (Meyrick), on citrus produced for potential export to the USA. In: Grout, T.G. et al. Integrated Production Guidelines for Export Citrus. Volume 3. Integrated Pest and Disease Management. Citrus Research International (CRI), Nelspruit.

Hofmeyr JH and Burger BV, 1995. Controlled-release pheromone dispenser for use in traps to monitor flight activity of false codling moth. Journal of Chemical Ecology, 21, 355-363.

Hofmeyr H, Hofmeyr M and Slabbert K, 2016. Postharvest phytosanitary disinfestation of *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae) in citrus fruit: Tolerance of eggs and larvae to ionizing radiation. Florida Entomologist, 99, 48-53.

Jarosik V, Honek A, Magarey RD and Skuhrovec J, 2011. Developmental database for phenology models: related insect and mite species have similar thermal requirements. Journal of Economical Entomology, 104, 1870-1876.

Li H and Bouwer G, 2012. The larvicidal activity of *Bacillus thuringiensis* Cry proteins against *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae). Crop Protection 32, 47-53.

NAPPFAST (North-Carolina-State-University/Animal-and-Plant-Health-Inspection-Service Plant Pest Forecasting System), Borchert DM, Magarey RD, Fowler GA, 2003. Pest assessment: false codling moth, *Cryptophlebia leucotreta* (Meyrick), (Lepidoptera: Tortricidae).

NAPPFAST (North-Carolina-State-University/Animal-and-Plant-Health-Inspection-Service Plant Pest Forecasting System), 2011. Insect Development Database.

Ndemah R, Schulthess F, Poehling M and Borgemeister C, 2001a. Spatial dynamics of lepidopterous pests on *Zea mays* (L.) and *Pennisetum purpureum* (Moench) in the forest zone of Cameroon and their implications of sampling schemes. Journal of Applied Entomology, 125, 507-514.

Ndemah R, Schulthess F, Korie S, Borgemeister C and Cardwell KF, 2001b. Distribution, relative importance and effect of lepidopterous borers on maize yields in the forest zone and mid-altitude of Cameroon. Journal of Economical Entomology, 94, 1434-1444.

Nepgen ES, Moore SD and Hill MP, 2018. Integrating chemical control with sterile insect releases in an integrated pest management programme for T*haumatotibia leucotreta*, Journal of Applied Entomology, 142, 421–427.

Newton PJ, 1987. Efficacy of chitin synthesis inhibitors and synthetic pyrethroids against *Cryptophlebia leucotreta* (Lepidoptera: Tortricidae) on citrus in South Africa. Phtophylactica 19, 95-97.

Newton PJ, 1988. Inversely density-dependent egg parasitism in patchy distributions of the Citrus pest*Cryptophlebia leucotreta* (lepidoptera: tortricidae) and its agricultural efficiency. Journal of Applied Ecology, 25, 145-162.

Newton PJ, and Odendaal WJ, 1990. Commercial inundative releases of *Trichogrammatoidea cryptophlebiae* (Hym: Trichogrammatidae) against *Cryptophlebia leucotreta* (Lepidoptera: Tortricidae) in Citrus. Entomophaga, 35, 545-556.

Newton P and Crause C, 1990. Oviposition on *Litchi chinensis* by *Cryptophlebia* species (Lepidoptera: Tortricidae). Phytophylactica, 22, 365-367.

Newton PJ, 1998. False codling moth *Cryptophlebia leucotreta* (Meyrick). In: Citrus pests in the Republic of South Africa. E.C.G. Bedford, M.A. van den Berg and E.A. de Villiers. (eds.) Dynamic Ad, Nelspruit, South Africa, 192-200.

Omer-Cooper J, 1939. Remarks on false codling moth. Rhodes University, Grahamstown. Mimeograph, p.17.

Odanga JJ, Mohamed S, Mwalusepo S, Olubayo F, Nyankanga R, Khamis F, Rwomushana I, Johansson T and Ekesi S, 2018. Spatial distribution of *Bactrocera dorsalis* and *Thaumatotibia leucotreta* in smallholder avocado orchards along altitudinal gradient of Taita Hills and Mount Kilimanjaro. Insects, 9, 71, 11 pp. doi:10.3390/insects9020071

Reed W, 1974. The false codling moth, *Cryptophlebia leucotreta* Meyr. (Lepidoptera: Olethreutidae) as a pest of cotton in Uganda. Cotton Growing Review, 51, 213-225.

Schulthess F, Bosque-Pérez N and Gounou S, 1991. Sampling lepidopterous pests on maize in West Africa. Bulletin of Entomological Research, 81, 297-301.

Schwartz A, 1981. 'n Bydrae tot die biologie en beheer van die valskodlingmot *Cryptophlebia leucotreta* (Lepidoptera: Eucosmidae) op nawels. PhD Thesis, University of Stellenbosch, 280 pp.

Stibick J, 2006. New pest response guidelines: false codling moth *Thaumatoibia leucotreta*. USDA-APHIS-PPQ-Emergency and Domestic Programs, Riverside, Maryland.

Stotter RL, 2009. Spatial and temporal distribution of false codling moth across landscapes in the Citrusdal area (Western Cape Province, South Africa). MSc Thesis, University of Stellenbosch, 101 pp.

Sullivan M, 2007. CPHST Pest Datasheet for *Thaumatotibia leucotreta*. USDA-APHISPPQ-CPHST. Revised January 2014, 16 pp.

Terblanche JS, de Jager Z, Boardman L and Addison P, 2014. Physiological traits suggest limited diapause response in false codling moth *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae). Journal of Applied Entomology, 138, 683-691.

Terblanche JS, Mitchell KA, Uys W, Short C and Boardman L, 2017. Thermal limits to survival and activity in two life-stages of false codling moth *Thaumatotibia leucotreta* (Lepidoptera, Tortricidae). Physiological Entomology, 42, 379–388.

Timm AE, 2005. Morphological and molecular studies of Tortricid moths of economic importance to the South African fruit industry. PhD Thesis, University of Stellenbosch, 127 pp.

USDA (United States Department of Agriculture) APHIS (Animal and Plant Health Inspection Service), 2010. New pest response guidelines: false codling moth *Thaumatotibia leucotreta*. Available online: http://www.aphis.usda.gov/import_export/plants/manuals/online_manuals.shtml

Van der Geest LPS, Wearing CH and Dugdale JS, 1991. Tortricids in miscellaneous crops, in: Van der Geest and Evenhuis, HH, Tortricid pests, their biology, natural enemies and control. World Crop Pests Volume 5, Amsterdam, Elsevier, pp. 563-577.

Venette RC, Davis CEE, DaCosta M, Heisler H and Larson M, 2003. Mini Risk Assessment False codling moth, *Thaumatotibia* (=C*ryptophlebia*) *leucotreta* (Meyrick) [Lepidoptera: Tortricidae]. CAPS PRA, University of Minnesota, Department of Entomology, CAPS PRA. 1-30 pp.

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**
Abelmoschus	*esculentus*
Abutilon	*hybrids*
Abutilon	*hybridum*
Acca	*sellowiana*
Ananas	*comosus*
Annona	*muricata*
Averrhoa	*carambola*
Camellia	*japonica*
Camellia	*sinensis*
Capsicum	
Capsicum	*annuum*
Capsicum	*chinense*
Ceiba	*pentandra*
Citrus	
Citrus	*limon*
Citrus	*paradisi*
Citrus	*reticulata*
Citrus	*sinensis*
Coffea	*arabica*
Coffee	*arabica*
Diospyros	*kaki*
Eriobotrya	*japonica*
Gossypium	
Gossypium	*hirsutum*
Juglans	*regia*
Litchi	*chinensis*
Macadamia	*integrifolia*
Macadamia	*ternifolia*
Mangifera	*indica*
Musa	*paradisiaca*
Olea	*europaea*
Persea	*americana*
Phaseolus	
Prunus	*persica*
Psidium	*cattleianum*
Psidium	*friedrichsthalianum*
Psidium	*guajava*
Punica	*granatum*
Quercus	
Quercus	*robur*
Ricinus	*communis*

Rosa	
Solanum	*melongena*
Sorghum	
Sorghum	*bicolor*
Syzygium	*paniculatum*
Syzygium	*samarangense*
Theobroma	*cacao*
Vigna	*unguiculata*
Vitis	
Vitis	*vinifera*
Zea	*mays*

Appendix B – Evidence tables

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

Susceptibility	Infection	Symptoms	Impact	Additional information	Reference	Uncertainties
	Incidence	***Severity***	***Losses***			
Avocado			Average percentage of infested fruit was: • 9% in Highland area (1500–1799 masl) • 14% in the Midland area (1200–1499 masl) • 20% in the Lowland area (900–1199 masl)	2 small/scale avocado orchards (Taita Hills Kenya and Mount Kilimanjaro Tanzania). Without any control measures	Odanga et al., 2018	
Pepper	70% of infested fruits in untreated Capsicum plants.		In a test on sweet pepper in the untreated plot, at harvest time 52,2% of the fruits was infested by late stage larvae, 18,9% by early stage larvae and in 2,2% of the fruits dead larvae were found. 26,7% of the fruits was undamaged.	Capo Verde	Fritsch, 1988	
Pepper			Loss of harvest due to *Cryptophlebia leucotreta* on red and sweet peppers is between 13 and 16% of total yield loss.		Dijeto-Lordon et al., 2014	

Citrus			7.8% yield losses were experienced in 1975-76, and 16.8% in 1976-77 when no control measures against *T. leucotreta* were implemented. This contrasts with 0.72% yield loss when a full spray programme was implemented	Data from Transvaal, without control measures	Schwartz, 1981	Uncertainty of data extrapolation from Transvaal to Mediterranean climate
Citrus			In the Citrusdal area of the western Cape Province, prevailing losses ranged from 10 to 20% of the total crop. In the eastern Transvaal, where losses ranged from < 1 % up to 3 % of total crop, orchards were chosen on the experimental farm of the Citrus and Subtropical Fruit Research Institut		Newton 1988	
Citrus			Losses in orchards ranged from 1.0 to 10.1% on navels in the Rustenburg area (North-Wesst Province) from 1982 to 1985; from 2.5 to 19.4% in Citrusdal; and from 1.4 to 3.4 in Nelspruit	without control measures	Newton 1998	
Citrus			Losses were generally 20-30% of the total fruit drop in the Rustenburg and Nelspuit area and considerably higher (up to 90% at times) in the Citrusdal farms		Newton 1998	

Citrus			1.6% loss in Navels and 0.3% in Valencias According to a regression between moth catches and Navel fruit loss, a weekly average of 10 males trap-1 22 ha-1 of trees per week resulted in a loss of 0.53 cartons of fruit ha-1 week-1 four weeks later.	South Africa Highest single incidence of Navel fruit loss occurred in December and Valencia fruit loss in July	Begemann and Schoeman, 1999	
Citrus			2% is the current fruit loss level in South Africa		EPPO, 2013	
Maize		Incidence of 44% of cobs containing larvae. About 20% of examined cobs contained larvae (Table 1) Larvae can also be found in the stem			Reed, 1974	
Maize	In the forest zone, the percentage of infested plants [P(I)] was high during both years and seasons (Table 1), with seasonal means across locations of 56.5- 63.5%. In almost all locations, *B. fusca* and *E. saccharina* were the most common species, accounting for _80% of all borers in almost all locations, followed by the ear borers *M. nigrivenella* and *C. leucotreta* (Table 1). In the mid-altitude, P(I) was lower than in the forest (Table 1) with seasonal means across locations of 21 - 43%. *B. fusca* was the predominant species, except in Bali where an unknown *Chilo*-like species was the most prevalent during both the Þrst and second seasons. Across the zone, *S.*	In the forest zone, ear and stem damage signifcantly reduced ear weight, whereas in the mid-altitude only stem tunneling was signicant		Cameroon:	Ndemah et al., 2001a	No clear data on damage: also. forestry area may influence the results.

	calamistis and the ear borers *M. nigrivenella* and *C. leucotreta* were of equal importance, whereas *E. saccharina* was completely absent.					
Maize	*T. leucotreta* was found, but population densities far lower than other Lepidopterous maize borers. (ecological zones identified as high disease and pest pressure areas for maize in western Africa)			Southern Ghana surveys between 1996 and 1998	Buadu et al, 2002	
Maize	Of all lepidopterous larvae found in maize *T. leucotreta* comprised 3.1% in early season and 11.1% in late season. During the late season, *C. leucotreta* densities were twice as high in intercropped (with rice) maize than in monocropped maize (comprising 3.7 and 33.9% in early and late season respectively).			southern Ivory Coast in 1995	Gounou and Schulthess, 2006	Percentage of species on corn related to other species. No clear data on damage of *T.leucotreta*
Maize		*T. leucotreta* has been reported laying eggs on the husk of the ear. Larvae damage maize by entering the ear from the husk through the silk channel			Stibick, 2006	
Maize	During both seasons, numbers of feeding days by Sesamia calamistis were higher than those of Mussidia nigrivenella, while E. saccharina and *Thaumatotibia leucotreta* were less common.			Benin	Agboka et al., 2013	Data on damage only on Mussidia nigrivella, other pests grouped together

Peach			Average percentage of infested fruit was up to 20% for early peach cultivars and up to 55% for late cultivars	5 orchards in and near Pretoria, South Africa	Daiber 1976	
Peach	The highest infestation (27.99%) was recorded on a late peach cultivar (Malherbe). Infestations of <1% were recorded on early cultivars (the peach Flordabella, the nectarine Independence and the plum Santa Rosa).		28% loss in a late peach crop	South Africa	Blomefield, 1989	

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

Spread	**Additional information**	**Reference**	**Uncertainties**
T leucotreta males have been found to respond to females more than 1 kilometre away		Omer-Cooper, 1939	Original paper not available The only evidence given is about males
Females were found to disperse up to 35 m away to lay their eggs on sentinel fruits placed in an effectively empty habitat of non-bearing trees		Schwartz, 1981	The experimental design didn't measure longer flights therefore the provided information is not relevant to the assessment.
	T. leucotreta has been described as a poorly dispersing species	Newton, 1998	Too general
	T. leucotreta individuals may vary genetically in their capacity to disperse over long distances, which may be related to the habitat in which they are found	Timm, 2005	
few males found up to 1.5 kilometres from the nearest orchards	Studies conducted in the Citrusdal area showed that male *T. leucotreta* were mostly confined to citrus orchards, while most of those occurring outside orchards were close to such orchards, or close to identified alternative host plants.	Stotter, 2009	The only evidence given is about males

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

Category of factors	Evidence	Reference
Biology of the pest	The female moth lays 100-400 eggs by night, usually singly on the bolls or fruits of the plant. When full grown the larva descends to the ground on a silken thread and spins a tough silken cocoon in the soil or amongst debris. The development time for each stage varies considerably with temperature, details are given by Daiber 1980 who states that in South Africa five generations per year could be achieved by the moth. There is no diapause.	Daiber, 1980
Detection methods	Visual inspections of plant materials may be used to detect eggs, larvae, and adults of *T. leucotreta*. Eggs will commonly be found on fruits, foliage, and occasionally on branches but they are laid singly and are difficult to detect.	USDA APHIS, 2010
Detection methods	On citrus fruits and other fleshy hosts, dissections are needed to detect larvae; larvae are likely to be found in the pulp. Infested fruits may be on or off the tree.	Sullivan, 2014
Detection methods	In cotton, older larvae may be found in open bolls and cotton seed. Occasionally adults may be observed on the trunk and leaves of trees in infested orchards	Sullivan, 2014
Detection methods	For field crops such as corn, the whole plant is the recommended sample unit	Venette et al., 2003
Detectability	As *T. leucotreta* is primarily a fruit feeder, crops of cotton grown close to fruit trees may be less affected. In areas with a prolonged dry season the moth, which needs a continual source of food, is less likely to reach pest proportions, conversely irrigation allows populations to build up to levels which cause damage.	Van der Geest, 1991
Identification	*Thaumatotibia leucotreta* can be confused with many *Cydia* spp. including *C. pomonella* (codling moth) because of similar appearance and damage, however, unlike codling moth its host range does not include apples, pears or quince ().	Sullivan, 2014
Identification	“In West Africa, *T. leucotreta* is often found in conjunction with *Mussidia nigrevenella*,” however they can be distinguished by close examination of morphological characters.	CABI, 2019
Identification	In South Africa, there is also an overlapping host range for *T. leucotreta*, *T. batrachopa* and *Cydia peltastica*, particularly on litchi and macadamia.	Venette et al., 2003; USDA APHIS, 2010
Symptoms	In peaches - Larvae damage stone fruits as they burrow into the fruit at the stem end and begin to feed around the stone. Infestation can be identified by the brown spots and dark brown frass.	Sullivan, 2014
Symptoms	An infested orange shows brown, sunken spots with larval holes bored in the center of the spot	Venette et al., 2003
Symptoms	Damage to corn is caused from larvae entering the ear from the husk through the silk channel	Ndemah et al., 2001b
Symptoms	On cotton, larvae penetrate cotton bolls, and their presence is often characterized by the occurrence of a filamentous waxy secretion protruding from the entry hole.	EPPO, 2013