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Anthonomus eugenii
Pest Report to support ranking of EU candidate priority pests

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1. Introduction to the report

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

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

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

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

The report has two appendices. Appendix A contains a host list created by amalgamating the host lists in the EPPO Global Database (EPPO, online) and the CABI Crop Protection Compendium (CABI, 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 *Anthonomus eugenii*, the following documents were used as key references: pest risk analyses (PRAs) by van der Gaag and Loomans (2013), rapid PRA by Baker et al. (2012), express PRA by JKI (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

Anthonomus eugenii Cano (Coleoptera: Curculionidae*)* (pepper weevil) is a single taxonomic entity.

The pepper weevil is an insect pest mainly of cultivated chilli and sweet pepper (*Capsicum* spp.) but it can also reproduce and feed on other *Solanum* species. Adult pepper weevils feed on fruit and leaf buds and lay eggs on flowers, buds and fruit. Larvae feed inside pepper pods (Riley and Sparks, 1995; Figure 1).

Males and females are attracted to volatiles from flowering and fruiting pepper plants, to pepper weevil-damaged plants, and to male-produced aggregation pheromone (Addesso et al., 2011). Early signs of infestation are small holes in flowers and immature fruits and small circular or oval holes (2-5 mm in diameter) in leaves which can be mistaken for other phytophagous damages, as in the case described by Costello and Gillespie (1993) where the signs observed in a Canadian greenhouse were initially attributed to slugs or caterpillars.

Females prefer young fruits for feeding and egg-laying, but they can also use flower buds, open flowers and mature fruits to lay eggs (Patrock and Schuster, 1992). A single egg is laid in feeding punctures. These holes are sealed with an anal secretion that serves as an “oviposition plug”. Females avoid laying eggs in buds where eggs have been laid before and distribute the eggs in a regular pattern over the young flowers and buds, the majority are laid around the calyx of the fruit (Addesso et al., 2007).

Larvae (maximum size: 6 mm) feed on seeds and other tissues inside the developing fruits, where they also pupate, and can be confused with other pests, e.g. with *Faustinus cubae* in the Americas (Capinera, 2008). Adult beetles (size: 2.5-3.5 mm) emerge from pupae (size: 2.5-3 mm) inside the fruits and may feed protected for several days inside before chewing a small exit hole (Costello and Gillespie, 1993; Capinera, 2008). The duration of the life cycle at 21 °C is of 21 days on average (Riley and Sparks, 1995).

The presence of *A. eugenii* can result in discoloured and deformed fruits, and more importantly, premature ripening and abscission of young fruits. Premature abscission is often a consequence of feeding and developing inside buds and fruits resulting in loss of production (Riley and Sparks, 1995).

2.2. Host plants

2.2.1. List of hosts

In addition to the primary host plants (*Capsicum annuum* and *C. frutescens*), several *Solanum* species, including *S. melongena* (aubergine) and some solanaceous weeds are also hosts. Pepper weevil adults can also feed on a wide range of solanaceous species, such as *Solanum tuberosum* (potato) and *S. esculentum* (tomato), but do not reproduce on them (Table 1).

Appendix A provides the full list of hosts.

2.2.2. Selection of hosts for the evaluation

Capsicum annuum (the sweet and chilli pepper) and *C. frutescens* (cayenne pepper) are the primary hosts for pepper weevil (EPPO datasheet, van der Gaag and Loomans 2013).

Table 1 Host plants of *Anthonomus eugenii* available in Europe (van der Gaag and Loomans, 2013)

Host plants: development and reproduction possible	**Feeding plants: food source for adults, no reproduction known**
Capsicum annuum	*Datura stramonium*
C. baccatum	*Petunia parviflora*
C. chinense	*Physalis pubescens*
C. frutescens	*Nicotiana alata*
C. pubescens	*Solanum lycopersicum*
Solanum americanum	*S. tuberosum*
S. carolinense	
S. elaeagnifolium	
S. melongena	
S. pseudocapsicum	
S. rantonettii	
S. rostratum	
S. nigrum	

2.2.3. Conclusions on the hosts selected for the evaluation

Capsicum annuum (the sweet and chilli pepper) and *C. frutescens* (cayenne pepper) were assessed for impact since they are the primary hosts. Other *Capsicum* species and several *Solanum* species, including *S. melongena*, were not assessed either because they are minor hosts or, as for potato and tomato, because no reproduction and therefore larval damage occurs.

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. *Anthonomus eugenii* is considered to have originated from Mexico and is now widely distributed in the southern states of North America, Central America, the Caribbean with occasional records further north and also in Hawaii and French Polynesia (Capinera, 2008; Ostojá-Starzewski et al., 2016).

It has been eradicated from Canadian greenhouses in 1992 and 2010 (Costello and Gillespie 1993; CFIA, online). In 2012 *A. eugenii* infestations were discovered in six Dutch glasshouses (NPPO NL 2012 and 2013). In 2013 *A. eugenii* was first found in Lazio Region of Italy in greenhouses and in open fields (Speranza, 2014).

Between January 2013 and April 2019, *A. eugenii* has been intercepted 57 times in the Netherlands, UK, France and Germany on fruit of *C. frutescens* mainly (but also *Capsicum chinense*, *Solanum melongena*, and *Capsicum* spp.) coming from Dominican Republic and Mexico (Europhyt annual and monthly reports[3]).

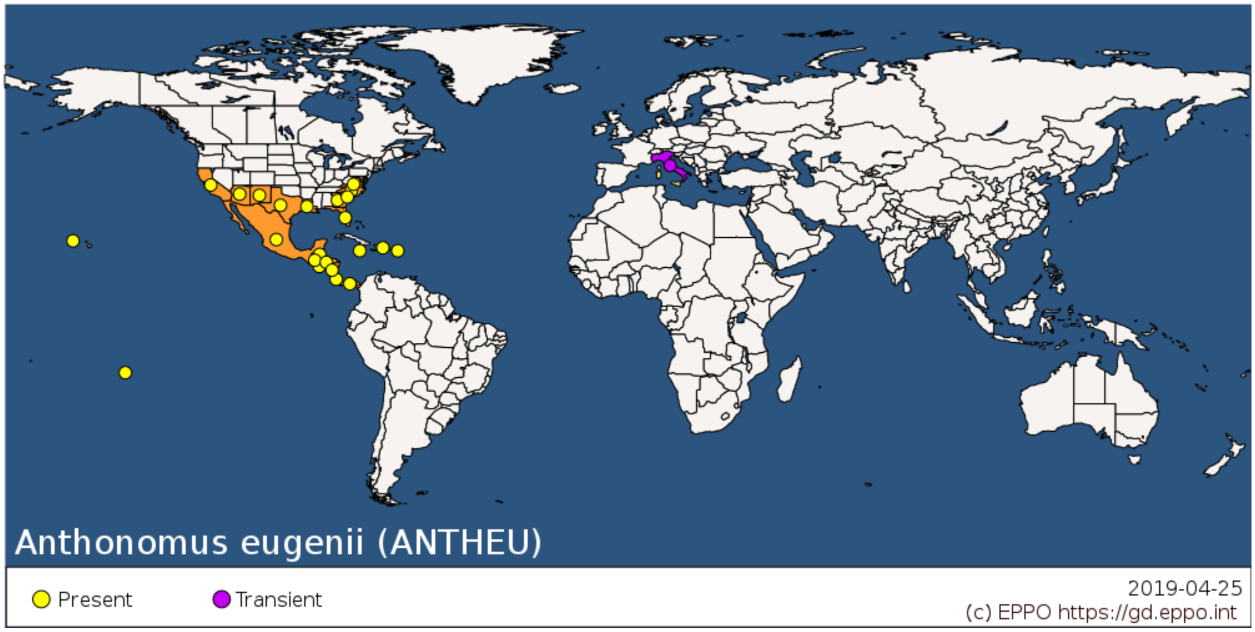

Figure 1 Distribution map of *Anthonomus eugenii* from the EPPO Global Database accessed 25/04/2019.

2.3.2. Area of potential establishment

The pepper weevil does not enter diapause, therefore the presence of host plants throughout the year is assumed to be a prerequisite for establishment outdoors and, in the absence of a *Capsicum* crop, wild *Solanum* spp. can serve as alternative host (Costello and Gillespie, 1993).

However, since green parts of *Capsicum* and *Solanum* spp. usually do not survive temperatures below 0°C, freezing temperatures are likely to be a limiting factor for establishment both because of direct effects on the pest and the availability of a food source. In northern and north-western Europe, *Capsicum* fruit is only or mainly grown in greenhouses while in southern Europe, *Capsicum* fruit is grown both in the open and in greenhouses.

It takes two weeks for the pepper weevil to complete its life-cycle in warm conditions (27℃), three weeks at 21℃ and six weeks in cool conditions (15℃). In subtropical areas, 5-8 generations per year may occur in a *Capsicum* crop.

In a laboratory experiment, adults died within 15 min when exposed to about -10°C (Costello and Gillespie, 1993). It is not known if adults can survive longer periods at milder freezing temperatures, especially when subjected to slowly decreasing temperatures as it usually happens in nature.

[3] EUROPHYT reports give monthly and annual overviews of interceptions made by the EU and Switzerland, of harmful organisms in imported plants and other objects. Available on: https://ec.europa.eu/food/plant/plant_health_biosecurity/europhyt/interceptions_en

Persistent populations of *A. eugenii* are known to be present in plant hardiness zones 10 and higher and milder parts within hardiness zone 9.

The pepper weevil has a lower threshold and optimum temperatures for development of about 10°C and 30°C, respectively. A lower developmental threshold of 9.6°C and a degree-day requirement of 256.4 for development from egg to adult has been identified (Toapanta et al., 2005). The accumulated number of degree days in the areas where persistent populations are present is probably at least 3,000 (van der Gaag and Loomans, 2013). Such high numbers of accumulated degree days are only reached in the southernmost parts of Europe (Figure 2).

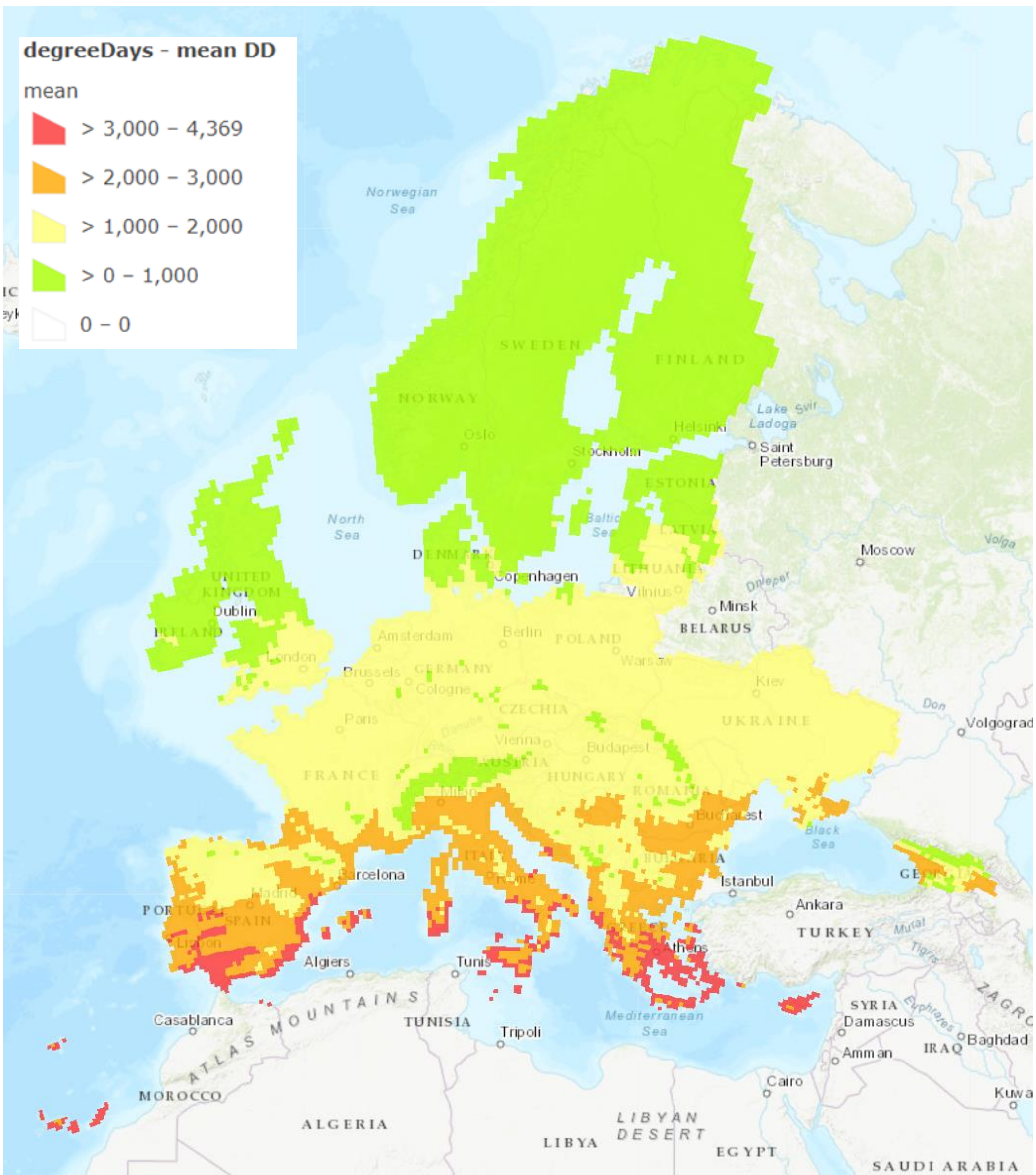

Figure 2 European map of temperature accumulation (Degree Days) based on a threshold of 9.6°C. Three thousand-degree days is considered to be the threshold for persistent year-round populations to occur in the EU.

2.3.3. Transient populations

Anthonomus eugenii 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 protected *Capsicum* crops throughout the EU and areas outdoors with over 3,000 annual degree days above a threshold of 9.6°C. This includes southern Spain, southern Portugal, Madeira, the Azores, southern Italy, Malta, southern Greece and Cyprus (Figure 3). For this species, transient populations are not considered, and the assessment is limited to the area of potential establishment.

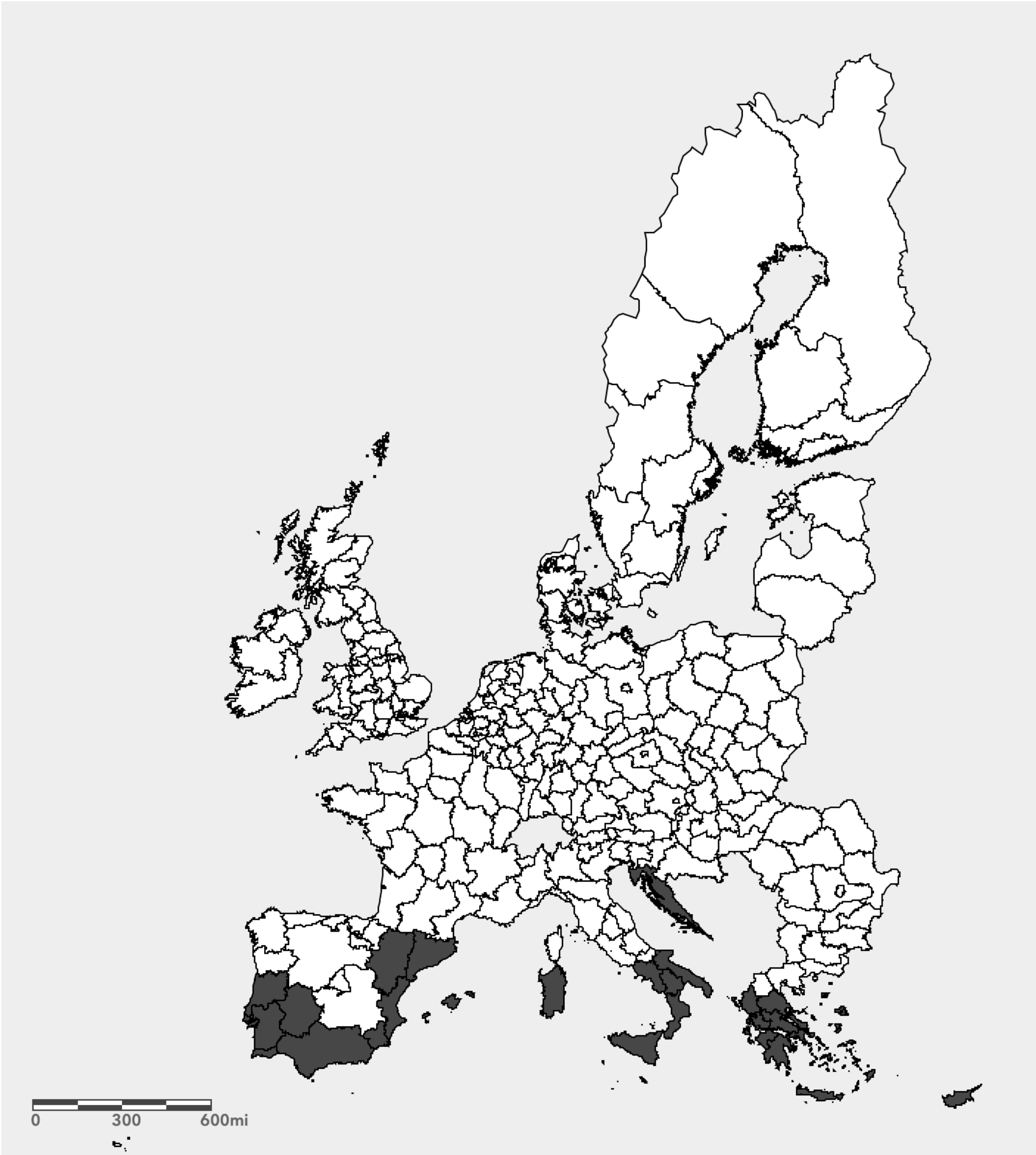

Figure 3 The potential distribution of the pest in the EU NUTS2 regions based on the scenarios established for assessing the impacts of the pest by the EFSA Working Group on EU Priority Pests (EFSA, 2019). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/1zO99G

2.4. Expected change in the use of plant protection products

Insecticides are generally not very effective against the pest because the larvae, pupae and the young freshly emerged adults are protected within the fruit. In Europe pest management in pepper crops, especially in protected cultivation, targets arthropod virus vectors, such as thrips and whiteflies and is mainly based on natural enemies. Plant protection products used for control are therefore very specific (EPPO, 2013).

Biological pest control is becoming more and more important in southern Europe. Biological control for pests in Almeria's fruit and vegetable sector grew in 2012 by 20,750 hectares, representing almost 80% of the greenhouse area. Pepper is the vegetable with the largest area treated with this pest control method, over 7,100 hectares (Fresh Plaza, 2012).

Weevils are difficult to control once an infestation has become established in the field. Early detection of adults is essential so that a properly timed insecticide application can be made to prevent further population increase. Fruit loss can reach 30 to 90% of the yield if treatment is not implemented (Riley and Sparks, 1995).

Ingerson-Mahar (2015) described that finding a pepper weevil is an urgent matter requiring immediate attention to prevent establishment. Unlike other insect pests, once established, spraying insecticide once or even twice over a short time period will not control it. Visible field infestations would require further insecticide applications.

Pest Management Strategic Plan for bell and non-bell Peppers in Delaware, Eastern Shore Maryland, and New Jersey (USA) lists insecticides used on pepper crops against *A. eugenii* and also mentions that weekly sprays are required to control it in pepper fields (Ghidiu et al., 2008):

- Pyrethroids:
  - bifenthrin (Brigade)
  - zeta-cypermethrin (Mustang MAX)
  - permethrin (sweet bell pepper type only)
  - lambda-cyhalothrin (Warrior)
  - gamma-cyhalothrin (Proaxis)
- Carbamate:
  - oxamyl (Vydate)
- Other active substances:
  - thiamethoxam (Actara)
  - acetamiprid (Assail)
  - cryolite (Kryocide)

Action thresholds of one adult per 400 terminal buds (Riley et al., 1992) or 1% of buds infested (Cartwright et al., 1990) have been suggested. A sequential sampling protocol was developed by Segarra-Carmona and Pantoja (1988).

In the EU, pepper is a crop that is efficiently protected with biocontrol for most of the pests. The adults would require additional treatments, and larvae even more. Their control would therefore cause a disruption in the biocontrol of other pests and increase attacks of other pests too, in particular thrips and whiteflies. An integrated management plan would therefore be required.

The most suitable PPP indicator is Case “D” and the category is “2” (based on Table 2) because increasing the amount of treatments to control the pest would not be feasible and IPM approaches need to be sought.

Table 2 Expected changes in the use of Plant Protection Products (PPPs) following *Anthonomus eugenii* 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 pepper weevil has been implicated in the transmission of internal mould of peppers *Alternaria* spp. (Bruton et al., 1989). *Alternaria* spp. is one of the most important genera of mycotoxigenic fungi (Milićević et al., 2010) and it can infect fruits also if their skin is injured (e.g. by insects) (Wall and Biles, 1993; Costa et al., 2019).

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

- Yield loss is mainly due to premature fruit drop but also from smaller fruit and discoloration and other damage that makes the fruit unmarketable
- An attacked fruit is likely to show damage due to the presence of *A. eugenii* larvae. Therefore all the attacked fruits are expected to be discarded from market as the pest damage will be sufficiently evident to make the fruit unmarketable
- When the infestation appears at the end of the production cycle and is not visible at the moment of harvest, the damage on the fruit is also not expected to be visible, therefore the quality of the product will not be affected by declassification
- When the infestation signs appear during the production cycle (e.g. malformations, discoloration, secondary infections) the presence of the pest is easy to recognise and therefore the fruit is not marketable
- Damage to sweet pepper and chili pepper is not distinguished; the assessment considers *Capsicum* spp. as a whole
- Assessment is carried out for the whole of the area of potential distribution, that is protected *Capsicum* crops throughout the EU and areas outdoors with over 3,000 annual degree days above a threshold of 9.6°C. This includes southern Spain, southern Portugal, Madeira, the Azores, southern Italy, Malta, southern Greece and Cyprus

3.1.1.3. Selection of the parameter(s) estimated

The impact of *A. eugenii* is assessed considering the long term average proportion (in %) of yield loss in pepper production, taking into account the current cropping practices for pepper production.

3.1.1.4. Defined question(s)

What is the percentage yield loss in pepper production under the scenario assumptions in the area of the EU under assessment for *Anthonomus eugenii*, 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.

- Segarra-Carmona and Pantoja (1988) estimated that economic damage commences with adult densities of 1 beetle per 100 plants
- Bottenberg and Lingren (1998) showed that a weekly catch of only one weevil per pheromone trap already corresponded to 8.3% fruit damage

- Examples on quality classes for pepper (United Nations, 2009)

3.1.1.6. Uncertainties identified

- Seasonal cycles of the pest
- Efficiency of infestations
- Survival of the crop break period on plant debris (also in greenhouses)
- Susceptibility of bell and chili pepper varieties and the proportion of yield loss due to the size difference of different fruit
- Compensation capacity of the pepper plants to produce more flowers when fruit drop is higher

3.1.2. Elicited values for yield losses

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

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

Table 3: The 5 elicited values on yield loss (%) on pepper

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	10%	30%	50%	65%	85%

3.1.2.1. Justification for the elicited values for yield loss on pepper

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

Milder climatic conditions during the winter and less seasonal variation with high or more stable pest populations already present early in the season. Higher yield losses in sites with production throughout the year. Less plant compensation with more tolerant varieties. Longer growth time of the fruit and therefore a longer period for infestation of the fruit. Proportion of late season production is higher. High weevil population densities coincide with the peak production season. Abundant alternative hosts are present in the vicinity of the crop. A greater proportion of production outdoors with homogeneous infestations.

The yield loss could be higher in places where there are abandoned production sites and wild hosts (e.g. *S. nigrum*) available acting as reservoirs for the pest.

When infestation level is very high the whole production will be unmarketable.

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

Tolerant varieties with a higher damage compensation capacity with more flowers produced. Low population surviving on wild *Solanum*, poor overwintering. Colder winters and climatic conditions, low population densities. More damage to the late season production than the early season. Normal fruit drop.

Wrong timing based only on a short period when fruit is available. Adult emergence coincides with more mature fruit development. Eggs laid in very small fruit do not favour population build-up. Late infestation

– the autumn crop may be heavily attacked but the main production period is early in the season. A higher proportion of greenhouse production with patchy infestations.

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

The pepper production is more evenly distributed throughout the year and there are no major peaks in the production. Therefore, the assumption is that since the pepper crop is available throughout the year (although growing more slowly during the winter), the pepper weevil population persists all year around and increases as soon as the temperature rises and the crop becomes more available.

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

High uncertainty for both 25% and 75% percentiles.

3.1.2.2. Estimation of the uncertainty distribution for yield loss on pepper

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 pepper

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	10%					30%		50%		65%					85%
Fitted distribution	9.2 %	11.3 %	14.2 %	19.0 %	24.7 %	31.1 %	37.1 %	48.6 %	59.9 %	65.8 %	71.9 %	77.2 %	81.7 %	84.3 %	86.2 %

Fitted distribution: BetaGeneral (2.1392,1.6113,0.45,1), @RISK7.5

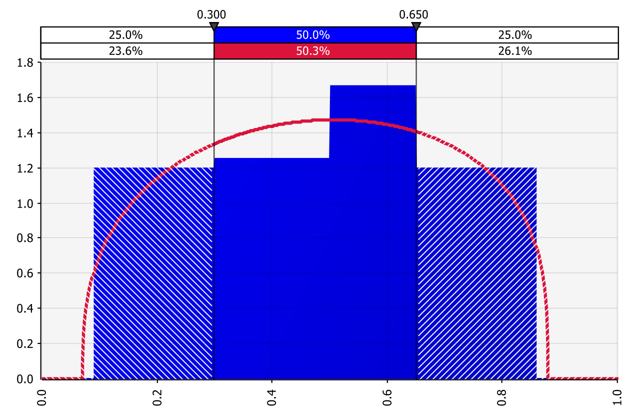

Figure 4 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on pepper.

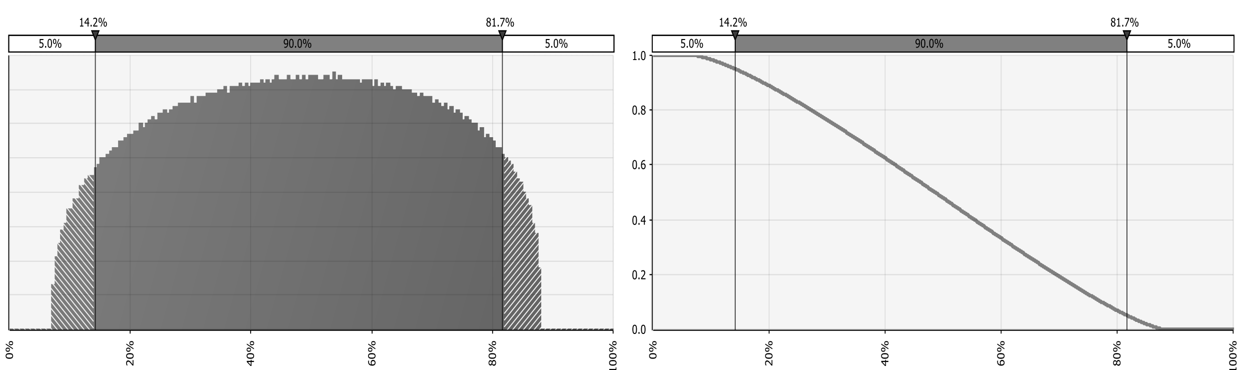

Figure 5 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on pepper.

3.1.3. Conclusions on yield and quality losses

Based on the general and specific scenarios considered in this assessment, the percentage of yield losses is estimated to be about 49% (with a 95% uncertainty range of 11.3 - 84.3%).

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

- Movement and exchange of labourers between farms is not taken into account in the assessment of spread.
  It is most likely that the spread occurs inside only one farm or production unit
- Primary stimulus for spread would be created by the availability of hosts and the host volatiles
- The spread rate is based on the conditions in the area of potential distribution: protected crops and Southern Mediterranean Europe
- In the southern Mediterranean coastal area, 8 lifecycles per year could be expected

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.

One general point was made:

- weevils tend to fly when the temperature is high but the wind is not too high. The crop is vulnerable to wind and there will be structures, such as windbreaks, to break the wind. The adults would have to fly above the boundary layer for the wind to have an effect

3.2.1.6. Uncertainties identified

- Aggregation behavior
- Effect of wind

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 time to detection on which the group agreed are reported in the table below.

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

Percentile	1%	25%	50%	75%	99%
Expert elicitation	100	1,000	2,000	4,000	6,000

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)

High population densities will facilitate greater spread. The scenario when the longest distances of spread would occur would most probably be at the end of the first production period in early summer when the population densities are high and during the crop break period when transplanted crops that have not yet been infested are available. Environmental conditions for spread are favourable (high temperatures) stimulating high flight capacity.

The pest would have 8 generations per year, a patchy/scattered distribution of host plants outdoors (including private gardens) with high human assisted spread within the farm.

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

Pepper plants are available all year around (only a short period without the host) that will not create a stimulus to spread. The scenario takes into account not only situations where pepper crops are homogeneously distributed but also protected cultivation where the pest does not spread outside. Human assisted movement within a pepper field is a part of the low spread scenario and cannot be ignored. Good farm hygiene and management.

A. eugenii is not known to be a strong flier. Although females have to distribute the eggs, they are not likely to stay on the same plant.

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

There is a high uncertainty concerning whether, in one year, *A. eugenii* would stay on the same farm (production unit) or would spread further. Taken into account this uncertainty, a middle value of the expert estimations was given as the median.

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

There is high uncertainty for both the 25% and 75% percentile.

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 6: 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	100					1,000		2,000		4,000					6,000
Fitted distribution	95	119	173	313	545	890	1,285	2,201	3,276	3,876	4,524	5,088	5,550	5,802	5,968

Fitted distribution: BetaGeneral(0.73070,1.1181,85,6100), @RISK7.5

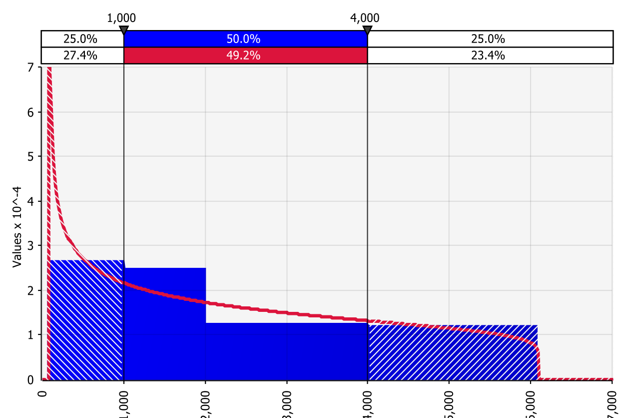

Figure 6 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

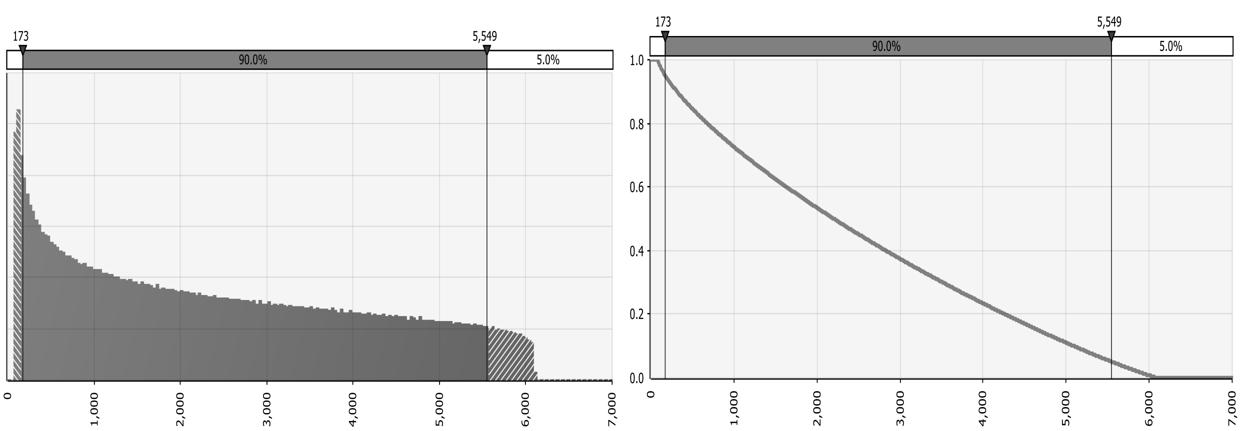

Figure 7 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

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 *A. eugenii* is about 2.2 km (with a 95% uncertainty range of 119 - 5,802 m).

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

- In the assessment area (the southern Mediterranean coastal areas), 8 lifecycles per year could be expected

3.3.1.3. Selection of the parameter(s) estimated

The time for detection has been assessed as the number of years 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

- Duration of the life cycle

3.3.1.6. Uncertainties identified

- The overall awareness of new and emerging pests

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

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	6	12	18	24	30

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)

The scenario with high values considers that detection will happen only after the outbreak has already spread to several production units. Growers would be reluctant to officially notify the outbreak.

Low population density. Less sensitive hosts. Low impact.

There are conditions that would make it difficult to recognise the infestation (fruit loss due to drought or heat stress). Similar damage from native pests (*Duponchelia fovealis*) could also make it more difficult to recognise the outbreak. Climatic conditions do not favour development and it will take longer time for the population to build up and low spread of the pest. Insecticide applications against *Duponchelia* would have some effect against the adults of *A. eugenii*.

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

It will still take a few (3-4) generations for the population to build up so that the impact could be detectable. There would be a higher accumulation of several symptoms that will alarm the growers. Growers have a high awareness of pests of peppers: they recognize them quickly and send them to the laboratory.

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

There is high uncertainty whether on average there would be recognition of the outbreak during the first or the second production cycle.

In the average case there is high possibility that the symptoms would not accumulate and could be therefore overlooked. However, after a few years, high population densities (from a high number of generations per year) would develop so that the impact will be detected.

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

Maximum uncertainty also for the 25% and 75% percentile.

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 8: 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					12		18		24					30
Fitted distribution	5.9	6.4	7.1	8.4	10.1	12.1	14.1	17.9	21.9	23.9	26.0	27.8	29.2	30.0	30.5

Fitted distribution: BetaGeneral(1.1410,1.1822,5.5000,31), @RISK7.5

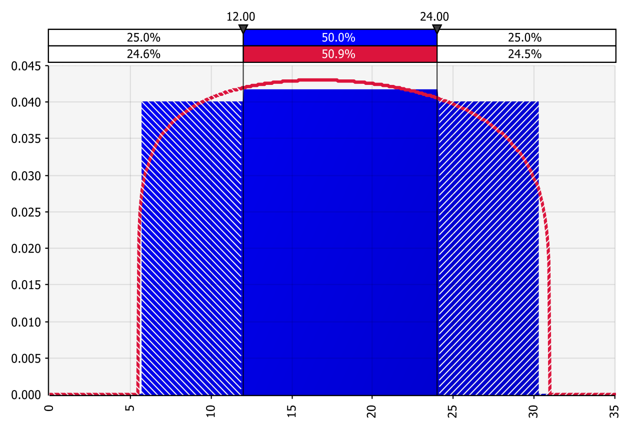

Figure 8 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection.

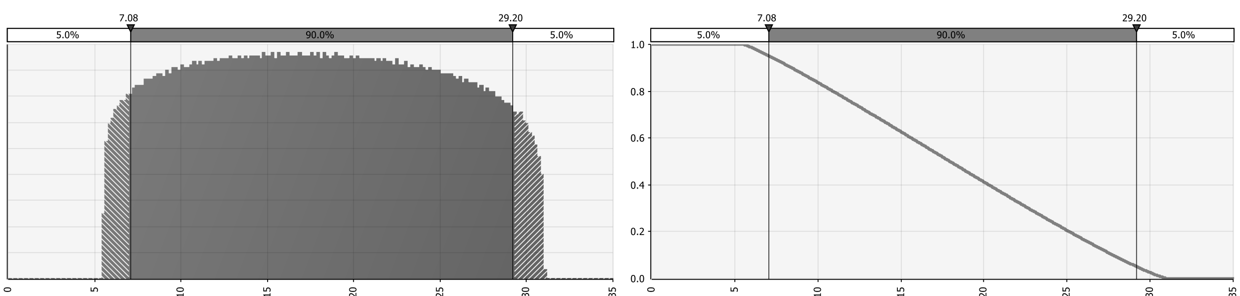

Figure 9 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection.

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 1.5 years (with a 95% uncertainty range of 6.4-30 months).

4. Conclusions

Hosts selection

Capsicum annuum (the sweet and chilli pepper) and *C. frutescens* (cayenne pepper) were assessed for impact since they are the primary hosts. Other *Capsicum* species and several *Solanum* species, including *S. melongena*, were not assessed either because they are minor hosts or, as for potato and tomato, because no reproduction and therefore larval damage occurs.

Area of potential distribution

The area of potential distribution is protected *Capsicum* crops throughout the EU and areas outdoors with over 3,000 annual degree days above a threshold of 9.6°C. This includes southern Spain, southern Portugal, Madeira, the Azores, southern Italy, Malta, southern 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

The most suitable PPP indicator is Case "D" and the category is "2" because increasing the amount of treatments to control the pest would not be feasible and IPM approaches need to be sought.

Yield and quality losses

Based on the general and specific scenarios considered in this assessment, the percentage of yield losses is estimated to be about 49% (with a 95% uncertainty range of 11.3 - 84.3%).

Spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *A. eugenii* is about 2.2 km (with a 95% uncertainty range of 119 - 5,802 m).

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 1.5 years (with a 95% uncertainty range of 6.4-30 months).

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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**
Capsicum	
Capsicum	*annuum*
Capsicum	*frutescens*
Solanum	
Solanum	*melongena*

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**	**Uncertainty**
	Incidence	***Severity***	***Losses***			
Pepper			The first 2 pickings yielded an average of 84 fruits/plot. During the 3rd and 4th pickings the pepper weevil infestation appeared and yield decreased to 48 fruits/plot for the 3rd picking and to none for the 4th picking. Premature falling of fruits of the order of 74 and 68 per plot were observed for the 3rd and 4th pickings, respectively.	Occurrence of pepper weevil in Puerto Rico in 1982. Sixty plots, each with 80 plants/plot, were surveyed to evaluate insect damage and measure losses. Damage observed only on pepper.	Abreu and Cruz, 1985	
Cubanelle pepper			Percent of aborted fruit per planting (control): 82.1% and 93.6%.	Puerto Rico (Isabela Agricultural Experiment Substation) September 1985 to June 1986. 2 plantings, 4 different spray regimes (weekly, 0,1 ET 0,5 ET and Control)	Segarra-Carmona and Pantoja, 1988	
Pepper			Premature fruit drop and can result in significant crop losses of up to 50 percent. Often, entire pepper fields must be ploughed under because too few fruit are left to harvest, and the infestation poses a threat to later pepper plantings. Up to 90 percent fruit loss has been measured in experimental plots infested early in the season and left untreated.		Riley and Sparks, 1995	
Pepper			With high pepper weevil population, 19 to about 90% of the fruits in the uncontrolled check displayed internal damage.	Insecticide tests in laboratory and field against the pepper weevil. West-Central and South Florida.	Seal and Schuster, 1995	Maybe overestimation compared with open field conditions

Pepper (chili)			Mean % of pepper weevil infested fruits varied from 3,6 to 40,1% among different chili pepper varieties. Also stated in the text that in severe cases of infestation, 70-90% of small buds and flowers of pepper can be infested.	3 studies in commercial fields in Homestead, Florida.	Seal and Bondori, 1999	
Pepper			It has caused yield losses of 5% to 80% on farms in New Jersey since 2004.	New Jersey	Ghidiu et al., 2008	
Pepper			Destructive sampling of harvested peppers resulted in 30% infested fruit on 13 August, and 35% infested fruit on 27 August.	First Record of Pepper Weevil Infestation in Virginia 2007	Schultz and Kuhar, 2008	
Pepper			Recorded crop losses due to this pest varied from 30% to 90%; and chemical control did not always lead to reduced infestations so that often crops were abandoned because of concerns of shipping infested fruit to markets.		García-Nevárez, 2012 (in spanish)	
Pepper			2013 was the most devastating year for pepper weevil damage in the state's history. At least 25 fields were infested throughout southern New Jersey and one farm abandoned fields early because of disease and pepper weevil pressure. Another farmer estimated a 25% yield loss.	New Jersey	Ingerson-Mahar, 2015	

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

Spread	Additional information	Reference
	(Figure 10, page 11) Progress of pepper weevil infestation from 0 up to 70% of infested buds happened between mid-August to early October. Percentages were calculated from counts of infested and uninfested buds in representative 1/3-acre plots in two fields.	Elmore, 1934
Spread within 1,5 km radius	In the Netherlands total of 6 greenhouses were found infested in 2012 which all were in an area within 1.5 km. Spread by human assistance could not be excluded.	van der Gaag and Loomans, 2013
1,5 miles	Observations in 2013 and 2014 suggest that pepper weevils can fly as far as 1,5 miles and may be aided in their dispersal by prevailing winds and storm fronts.	Ingerson-Mahar et al., 2015

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

Reference	Case	Results / evidence	Limitation / uncertainties
Detection methods			
Rodriguez-Leyva, 2006	Visual symptoms	The presence of A. eugenii can result in discoloured and deformed fruits, and more importantly, premature ripening and abscission of young fruits.	
Capinera, 2008	Visual symptoms	Early signs of infestation are small holes in flowers and immature fruits and small circular or oval holes (2-5 mm in diameter) in leaves which can be mistaken for slug or caterpillar damage.	
Ghidiu et al., 2008	Visual symptoms	Damage can be detected by puncture wounds from feeding or egg-laying on the buds and/ or premature dropping of flowers, bud and small pods, however, this is much more difficult to detect once picking has begun.	
Whitney King et al., 2008	Trapping	Pheromone traps are available for use with pepper weevil and can help monitor for the presence of the weevil.	The traps require maintenance and many other species of insects are attracted to the yellow sticky cards used for the trap. Currently available pheromones attract several species of weevils and the person inspecting the traps should have a hand lens in order to be able to identify the weevil properly.
Long, 2017	Trapping	Pheromone baited sticky traps are effective in attracting and capturing adults of pepper weevil that may be present in a pepper field and these traps are easy to use. Vigilant monitoring is the first and best line of defense against pepper weevil infestations.	
Ingerson-Mahar, 2015	Trapping	Some fields become widely infested before the first weevil is trapped. Placement of the traps is critical; they should be placed in high traffic, disturbed areas such as around the packinghouse and on the borders of fields.	
Coudriet and Kishaba, 1988		Pheromones emitted by live males are effective and specific.	
Biology of the pest			
Riley and Sparks, 1995		Pepper weevils disperse slowly through pepper fields early in the season, which can result in localized clumps of weevils and their damage. The clumped pattern of pepper weevil infestation in the field makes scouting more difficult.	
Riley and Sparks, 1995		Generation time 2 to 6 weeks Generation per year- 5 to 8 Longevity of adults- 3 months average with food Oviposition period- 1 month average Fecundity- average 340 eggs per adult	

		Oviposition rate – average 6 eggs per day	
Host conditions during the period of potential detection			
Riley and Sparks, 1995		Normally, pepper weevil infestations occur along field borders. This can be determined by examining the height of the plants. Where the weevils have been active the longest, there will be fewer fruit on the plants so that more energy goes into plant growth rather than fruit production.	