APPROVED: 17 May 2019
Doi: 10.5281/zenodo.2789434

Conotrachelus nenuphar
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-2018-00389
Output number: EN-1647
Correspondence: alpha@efsa.europa.eu

Acknowledgements: EFSA wishes to acknowledge the contribution of Clement Akotsen-Mensah, Vicente Dalmau, Lluís Vila to the EKE and the review conducted by Josep Anton Jaques Miret.

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, 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 *Conotrachelus nenuphar*, the following documents were used as key references: pest categorisation of *Conotrachelus nenuphar* (EFSA PLH Panel, 2018).

[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

Conotrachelus nenuphar (Herbst) (Coleoptera: Curculionidae), the plum curculio, is a well-defined species. It is an oligophagous insect pest primarily of stone and pome fruit, feeding also on a range of other hosts mainly from the Rosaceae family (EPPO, 1996; CABI,2018).

There are two strains of *C. nenuphar* in its native range: a northern univoltine population and a southern multivoltine population (Zhang et al 2008, Selby 2014).

There is incompatibility between the two strainspreventing the production of viable offspring when mated (Zhang and Pfeiffer, 2008).

Depending on the climate and availability of hosts, *C. nenuphar* can have one to two generations per year: one in the northern part of its range (Canada and West-Virginia) and two from West Virginia southwards (Racette et al., 1992; Leskey 2008; EFSA PLH Panel, 2018).

The northern strain of *C. nenuphar* (Canada and north of Virginia) must diapause to become reproductively mature (obligate diapause) and has a single generation per year, with adults entering diapause in the late summer and early autumn before female reproductive features have developed. The southern strain (from West Virginia southwards) can develop a second or even, in rare cases, a third generation in a single season (facultative diapause) (Racette et al., 1992; EFSA PLH Panel, 2018).

The northern and southern strains of *C. nenuphar* are reproductively incompatible due to infection by *Wolbachia* spp. bacteria although there is some evidence of successful reproduction between the strains (Selby, 2014).

For the purposes of this impact assessment, this species is considered to consist of one genetically variable species with northern and southern strains capable of having one or more generations depending on climate.

Overwintered adults emerge in spring and early summer, from mid-April to early July and feed on tender shoots and twigs, flower buds and leaves of hosts to undergo maturation (Armstrong, 1958; Racette et al., 1992). After mating, females oviposit in young host fruit, eggs hatch in 4-7 days (Campbell et al., 1989). The feeding larvae cause the fruit to drop prematurely which enables the larvae to develop in the fallen and rotting fruit for 3-5 weeks depending on the host. Mature larvae eat their way out into the soil where they pupate at a depth of 1-8 cm (Racette et al., 1992). First-generation adults emerge from the beginning of July to August; they feed until mid-August and oviposit infrequently. In autumn *C. nenuphar* migrates to nearby woods where it overwinters in a thick layer of fallen leaves that provide shelter from desiccation (Lafleur et al., 1987). In spring, the pest migrates in the reverse direction and re-infests orchards or seeks new feeding sites (Lafleur and Hill, 1987).

During oviposition females chew small round holes in the skin of host fruit before depositing a single egg. After that the female makes a crescent-shaped wound in the skin of the fruit below the oviposition puncture (Eaton and Maccini, 2016). The wound prevents the fruit cells in the vicinity of the egg from developing normally and so protects the egg from being crushed within the swelling fruit.

Females can lay an average of 75 eggs (ranging from 100 to 500 eggs in their lifetime). The maximum oviposition rate is 25 eggs in 48 hours (Armstrong, 1958; Mampe and Neunzig, 1967; Deutch and Guedot 2018).

Larval development varies by fruit type. In apple and pear, the larvae that are most likely to survive and develop are those in the fruit that drop. Most of the larvae in hanging pome fruit are killed by the firmness of the developing fruit tissue. Therefore, for pome fruit the only injury to the fruit is often the crescent-shaped oviposition scar (Deutch and Guedot 2018).

In stone fruit, the larvae are able to feed internally and develop fully within the hanging fruit (Deutch and Guedot 2018).

Although adults can fly, the insect mainly moves between ground level and the host canopy by crawling. Above 20°C short distance flights are used to reach the canopy of host trees from within orchards and to return to the ground (Chen et al., 2006).

Adults are long lived under optimum conditions. A large percentage of those maturing the previous season survive throughout the next summer (Armstrong 1958).

2.2. Host plants

2.2.1. List of hosts

Conotrachelus nenuphar is known to affect stone and pome fruit but it also feeds on a range of other hosts mainly from the Rosaceae family. (EPPO 1996; CABI, 2018).

In a host preference field trial in West Virginia using mark-recapture of adults in orchards with a range of hosts carried out by Leskey and Wright (2007), *Prunus salicina* (Japanese plum) was the most preferred host followed by *P. domestica, P. persica, P. avium, P. cerasus, P. armeniaca, Malus domestica* and *Pyrus communis* respectively.

Malus domestica can also be widely affected in areas adjacent to *Prunus* spp. orchards or in areas where apples are more widely grown than peaches, for example north-eastern USA (Akotsen-Mensah, 2010).

Pears (*Pyrus communis*) are often scarred and deformed by the feeding and egg punctures of *C. nenuphar* but the larvae fail to develop in them (Armstrong, 1958).

Some soft fruit (e.g. *Ribes, Fragaria, Vaccinium*) and wild plants (e.g. *Crataegus*) are also considered as minor hosts (EPPO, online; CABI, 2018).

The plum curculio can easily adopt new hosts, because most of its hosts of economic importance are not native to the plum curculio's range, e.g., apple, peach, and pear (Quaintance and Jenne 1912, Maier 1990)

Appendix A provides the full list of hosts.

2.2.2. Selection of hosts for the evaluation

Major hosts highlighted by both EPPO (online) and CABI (2018) include *Prunus persica, P. domestica. Prunus americana, P. armeniaca, P. avium, P. cerasus* and *P. salicina* are also listed as main hosts by CABI. EPPO also lists *Hemerocallis lilioasphodelus* (Asphodelaceae) as a major host.

2.2.3. Conclusions on the hosts selected for the evaluation

Yield loss is assessed for two categories of host plants: (I) pome fruit and (II) stone fruit.

Prunus stone fruit is listed as major/main hosts by both CABI and EPPO. *C. nenuphar* is known to cause serious economic impact to apples and pears in north-eastern USA and Canada.

Within the two categories, yield loss is considered to be comparable between the different host species.

Hemerocallis lilioasphodelus* is not considered further in the assessment due to very limited evidence on the nature of the potential impact.

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 no outbreaks have yet been reported.

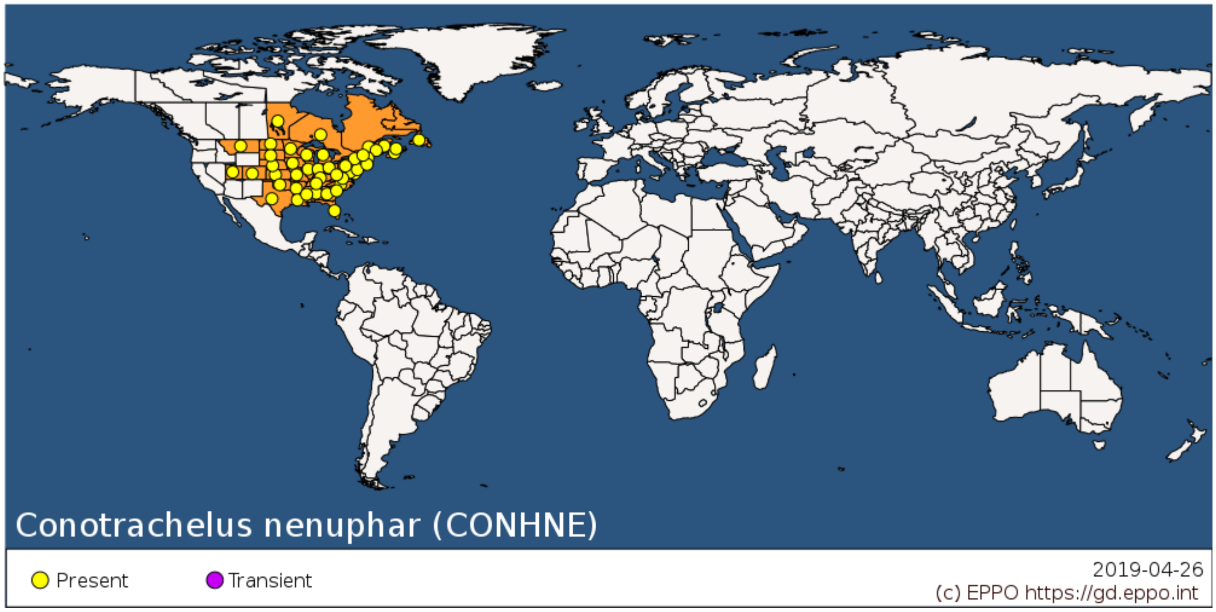

Figure 1 Distribution map of *Conotrachelus nenuphar* from the EPPO Global Database accessed 26/04/2019.

2.3.2. Area of potential establishment

Conotrachelus nenuphar is distributed across North America within a variety of Köppen-Geiger climate zones. The global Köppen-Geiger climate zones (Kottek et al., 2006) describe terrestrial climate in terms of average minimum winter temperatures and summer maxima, amount of precipitation and seasonality (rainfall pattern). In North America, *C. nenuphar* occurs in a number of zones such as Dfb (continental, uniform precipitation, warm summer) and Cfb (warm temperate, fully humid, warm summer). These climate zones also occur in the EU where hosts such as *Prunus* and *Malus* are grown (EFSA PLH Panel, 2018).

Lan et al. (2004) showed that the lower threshold temperatures for larval and pupal development were 11.1 and 8.7°C, respectively, with total thermal time requirements of 215.5 and 442.4 DD (degree days) to complete the corresponding stages in South-eastern United States.

Akotsen-Mensah et al. (2011) developed a day-degree phenology model linking accumulated temperature with weekly trap captures in Alabama peach orchards. The spring generation of adults peaked at 245 DD above 10°C after 1 January; the summer generation (July-August) of adults peaked at 1,105 DD and a late summer (September) generation peaked at 1,758 DD.

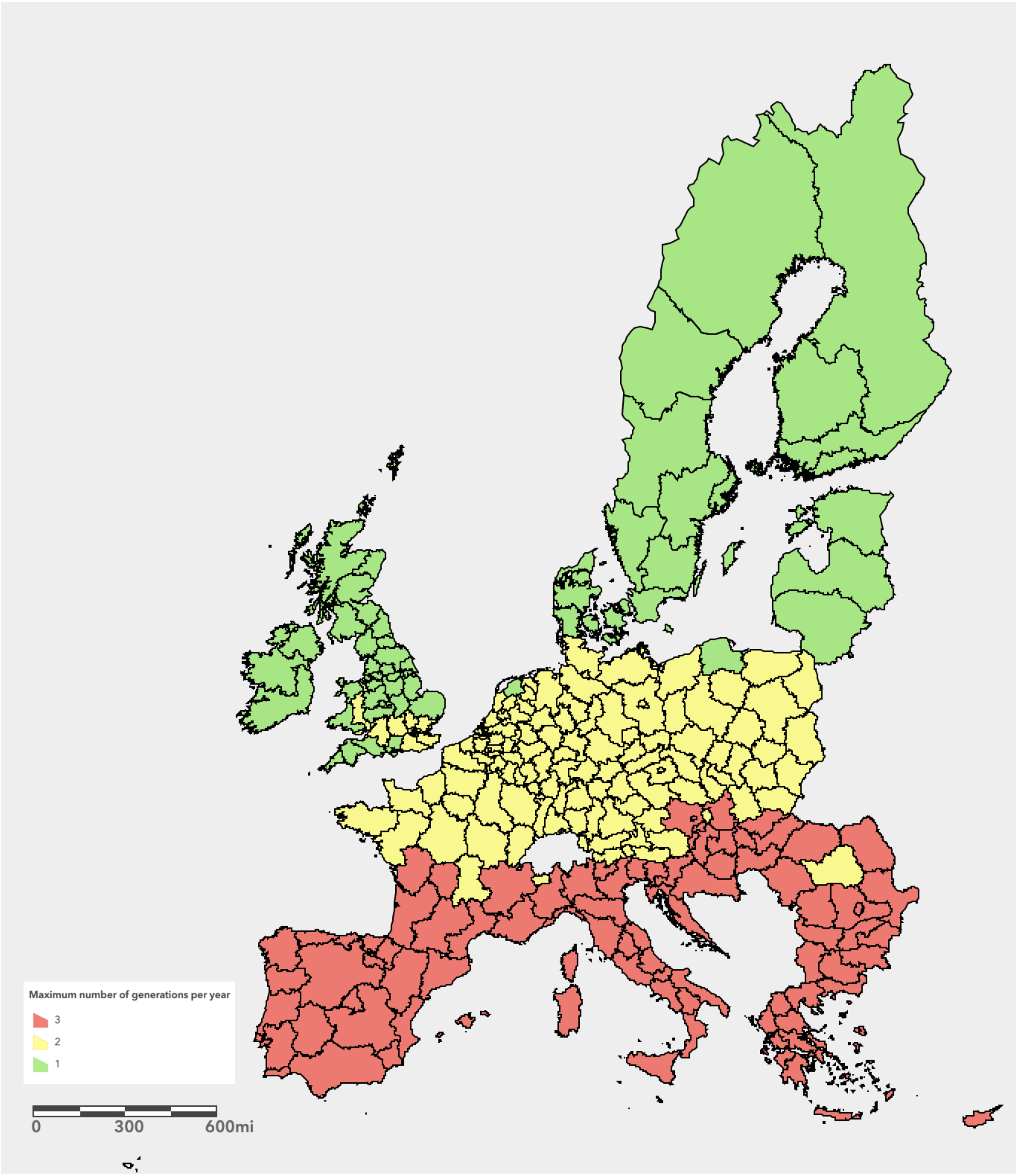

Figure 2 Area of potential establishment for *C. nenuphar* defined on the potential distribution of the pest in the EU NUTS2 regions based on number of generations and climate data from JRC (1998-2017). This link provides an online interactive version of the map that can be used to explore the data further: https://arcg.is/0bvyK0

2.3.3. Transient populations

Conotrachelus nenuphar 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

Host availability will not limit the potential area of distribution in Europe as pome and stone fruit are grown widely in all EU countries in commercial production and/or in private gardens. Several uncultivated species of both types of fruit are common and widespread.

Temperature and degree-day accumulation are considered to be the main factors determining the development of *C. nenuphar* and the number of generations per year (Figure 2).

Both strains of *C. nenuphar* are able to develop more than 1 generation per year. No significant differences in the overwintering potential of the two strains have been observed. The southern strain is also able to overwinter by facultative diapause (Akotsen-Mensah, 2019).

All areas of pome and stone fruit production in the EU are considered at risk.

2.4. Expected change in the use of plant protection products

Insecticide treatments against *C. nenuphar* are targeted to the adults during their maturation feeding or oviposition period, because the egg and the larval phases happen inside the fruit.

Insecticides used to control plum curculio are usually applied on a schedule that coincides with tree phenology and the oviposition cycle of *C. nenuphar*. Therefore, their effectiveness depends on the timing. Migration of adults to orchards from their overwintering sites starts at flowering. The treatments in US are usually performed at petal fall to ensure that bees are not affected.

Insecticides against *C. nenuphar* in apple orchards are applied up to three times: initially at petal fall to kill adults immigrating from sources outside the orchard (Chouinard et al., 1992). Usually at least one other insecticide spray is applied 10-14 days after petal fall, and a third application may be applied near the end of the curculio's oviposition period (Chouinard et at., 1992; Racette et al., 1992), if new fruit damage appears or if trap-based catches exceed 0.1 plum curculio adults/pyramid trap/week (Johnson et al., 2002; Blaauw et al., 2018).

A recent paper (Gökçe et al., 2018) mentions the risk of plum curculio developing resistance to the most applied insecticides.

The small number of predator and parasite species of the plum curculio are unable to provide an effective alternative to chemical insecticides in commercial orchards (Racette et al., 1992). Some entomopathogenic nematodes (*Steinernema* spp. and *Heterorhabditis* spp.) are virulent to ground-dwelling stages of *C. nenuphar* and may be incorporated into an integrated management programme. For example, *Steinernema riobrave* caused 85.0% to 97.3% control relative to the untreated check (Shapiro et al 2013).

The current application of PPPs in the EU

- For pome fruit, in Spain there can be 2 to 3 insecticide treatments (up to 5) per season. In the UK 4 treatments per season may be used. In areas of the EU the treatments for other pests would be later than petal fall. In areas where *Halyomorpha halys* is present and causes damage, e.g. in Italy, there has been a significant increase in insecticide use.
- For stone fruit the control is similar to pome fruit with 2 to 3 treatments per year. During petal fall there is usually treatment against thrips that could also be effective against plum curculio. The chemicals used in EU are effective against the pest.

In Europe, for the main pome fruit pests (e.g. *Cydia pomonella, Grapholita molesta, Diaspidiotus perniciosus*), any use of chemical control should be based on the proper use of traps and temperature-based models adapted to the local conditions. For spraying, selective insecticides (e.g. insect growth regulators) should be preferred to broad spectrum insecticides (e.g. organophosphates, pyrethroids) to reduce the risk posed to human health and the environment (FAO, 2017).

Insecticides alone are unlikely to be sufficient to provide long term control for the pest and integrated control measures will also need to be sought. Taking into account the initial phase of control after the introduction of plum curculio to Europe the most suitable PPP indicator is Case "C" and the category is "1" based on Table 2.

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

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

2.5. Additional potential effects

2.5.1. Mycotoxins

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

2.5.2. Capacity to transmit pathogens

The species is not known to vector any plant pathogens.

3. Expert Knowledge Elicitation report

3.1. 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

- *C. nenuphar* is assessed as one whole species without differentiating between the northern and southern strains: the potential of yield loss and damage to fruit is considered to be similar for both strains.
- Yield loss has been assessed for two different categories of host plants: (I) pome fruit and (II) stone fruit. Within the two categories yield loss is considered to be comparable for the different host species.
- The yield loss caused by plum curculio differs for stone and pome fruit: for stone fruit most of the damage is caused by the larvae feeding in the fruit, on pome fruit it is more by scarring due to oviposition.
- The assessment takes into account both orchards with conventional and with ecological farming practices.
- The pest prefers younger fruit, but this depends on availability/plant phenology. The 1st generation will attack more younger fruit than the 2nd generation.
- For some pome fruit the rapid development of the fruit may make it impossible for the larvae to develop inside the fruit.

3.1.1.3. Selection of the parameter(s) estimated

Yield loss comprises immature fruit drop, fruit rot due to larval feeding and the rejection of whole crops because of larval appearance. Fruit scarring and malformations due to oviposition are also considered as yield loss as this will greatly reduce the marketability

Quality loss has not been separately assessed since its considered that *C. nenuphar* damage will effectively make the fruit unmarketable as fresh fruit.

3.1.1.4. Defined question(s)

What is the percentage yield loss in pome fruit under the scenario assumptions in the area of the EU under assessment for *Conotrachelus nenuphar*, as defined in the Pest Report?

What is the percentage yield loss in stone fruit under the scenario assumptions in the area of the EU under assessment for *Conotrachelus nenuphar*, 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.

Some general points were made:

- More evidence is available on the yield loss on pome fruit and less about the impact on stone fruit.
- Evidence on the impact in the US could be expected to be similar in Europe.
- Host preference field trial by Leskey and Wright (2007)

3.1.1.6. *Uncertainties identified*

- The extent to which current control measures (e.g. insecticide treatments) in the EU against other pests would limit the impact by plum curculio.
- The variation in population abundance due to differences in climatic conditions across Europe and the availability of woodlands and wild hosts for overwintering in the vicinity of orchards.
- The preference for different host species and the susceptibility of different varieties grown in Europe to plum curculio.
- Differences in the potential impact of the northern and southern strain and areas where one or more than one generation per year are possible.
- The threshold for rejection of crops due to larval damage (more relevant for stone fruit).

3.1.2. Elicited values for yield loss on pome fruit

What is the percentage yield loss in pome fruit under the scenario assumptions in the area of the EU under assessment for *C. nenuphar*, as defined in the Pest Report?

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

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

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	1%	8%	15%	25%	50%

3.1.2.1. *Justification for the elicited values for yield loss on pome fruit*

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

The population abundance and density are high due to poor management of the orchards. It is also considered that there is greater availability of woodlands within a short flying distance of orchards where there are suitable overwintering habitats and wild *Prunus, Malus* and *Pyrus* hosts.

Two generations per year will increase the likelihood of crop damage.

Unmanaged and ecologically managed orchards where control measures have no or less effect, have more influence and contribute to overall population build-up.

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

Current insecticide treatments are more effective and also target *C. nenuphar* and this will limit the potential damage. Orchards are well managed with high standards of hygiene and overwintering habitats near orchards are less available. Pest population abundance might also be reduced by generalist predators already present in the EU.

One generation per year will reduce the likelihood of crop damage.

Even in untreated or ecologically managed orchards there will be a low impact due to host varieties that are less susceptible.

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

The main driver of the yield loss values is the uncertainty in the effectiveness of current control measures and insecticide treatments.

Pome and stone fruit orchards in Europe are mainly conventionally managed and treated with insecticides. There are fewer organic orchards and untreated orchards, where higher yield losses could be expected due to the likelihood of inefficient control by natural enemies.

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

Highest uncertainty for 25% percentile. 75% percentile expresses more confidence in the median value.

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

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

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

Percentile	1%	2.5%	5%	10%	17%	25%	33%	50%	67%	75%	83%	90%	95%	97.5%	99%
Expert elicitation	1%					8%		15%		25%					50%
Fitted distribution	0.7%	1.4%	2.4%	4.0%	5.8%	8.1%	10.3 %	15.1 %	20.9 %	24.6 %	29.6 %	35.3 %	42.6 %	49.3 %	57.8 %

Fitted distribution: BetaGeneral(1.4918,6.9509,0,1), @RISK7.5

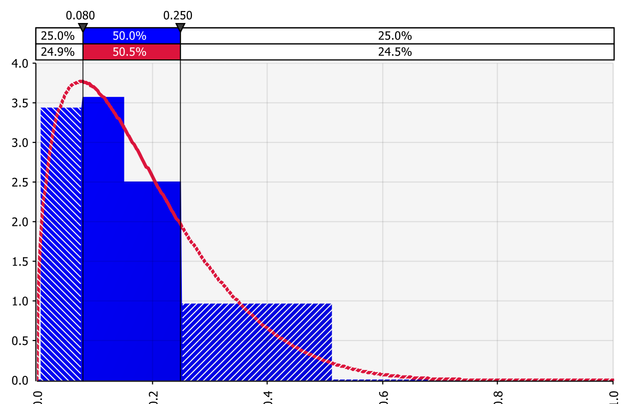

Figure 3 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on pome fruit.

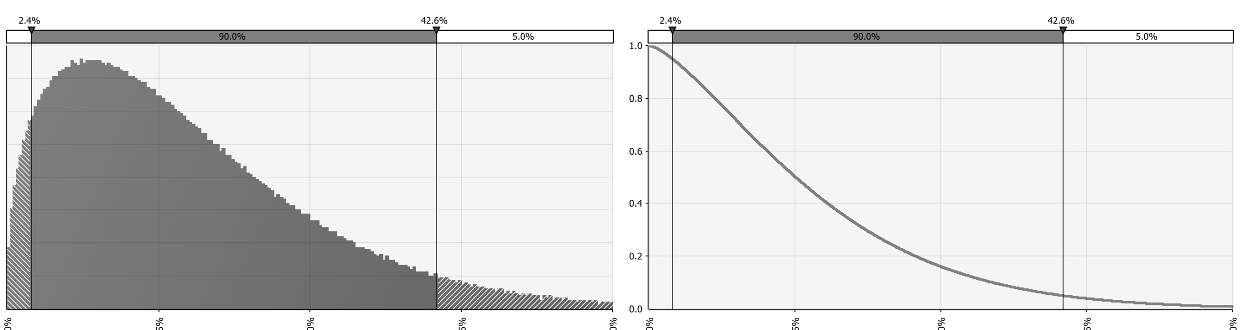

Figure 4 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on pome fruit.

3.1.3. Elicited values for yield loss on stone fruit

What is the percentage yield loss in stone fruit under the scenario assumptions in the area of the EU under assessment for *C. nenuphar*, as defined in the Pest Report?

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

Table 4: The 5 elicited values on yield loss (%) on stone fruit

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	1%	10%	20%	30%	55%

3.1.3.1. Justification for the elicited values for yield loss on stone fruit

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

The timing of insecticide treatments is very important, without an effective treatment the yield loss could be very high.

The population abundance and density are high with more availability of woodlands and suitable overwintering habitats near orchards where wild hosts may be present.

Peach and nectarine production is more concentrated in the southern European area, where the development of more than one generation per year is possible and can attack the same crop.

Rejection of crops due to internal larval presence and damage is more likely in stone fruit than in pome fruit (for which damage is mainly cosmetic with external scars formed by larval feeding).

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

Treatments against other pests are more effective (e.g. in Spain there is treatment against thrips during petal fall that would coincide with the migration of plum curculio into the orchards). The chemicals used are effective against the pest. Compared to pome fruit, there is a shorter time frame when the host and pest are both available.

The very limited evidence from literature would suggest that plum curculio would cause less yield loss for stone fruit compared to pome fruit.

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

Overall the potential yield loss by plum curculio on stone fruit is considered to be slightly higher compared to pome fruit mainly because stone fruit is the preferred host.

The effectiveness of control of pome and stone fruit could be considered similar.

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

Highest uncertainty for 25% percentile. 75% percentile expresses more confidence in the median value.

3.1.3.2. Estimation of the uncertainty distribution for yield loss on stone fruit

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

Table 5: Fitted values of the uncertainty distribution on the yield loss (%) on stone fruit

Percentile	**1%**	**2.5%**	**5%**	**10%**	**17%**	**25%**	**33%**	**50%**	**67%**	**75%**	**83%**	**90%**	**95%**	**97.5%**	**99%**
Expert elicitation	1%					10%		20%		30%					55%
Fitted distribution	1.1%	2.1%	3.3%	5.3%	7.7%	10.5%	13.3	19.1%	26.1%	30.5%	36.1%	42.3%	49.5%	55.8%	62.8%

Fitted distribution: BetaGeneral(1.5740,5.6390,0,1), @RISK7.5

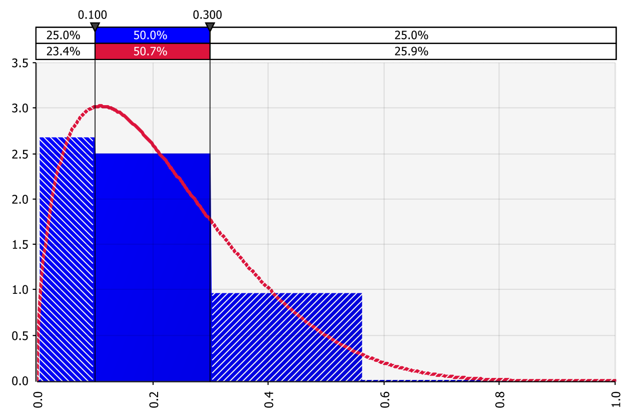

Figure 5 Comparison of judged values (histogram in blue) and fitted distribution (red line) for yield loss on stone fruit.

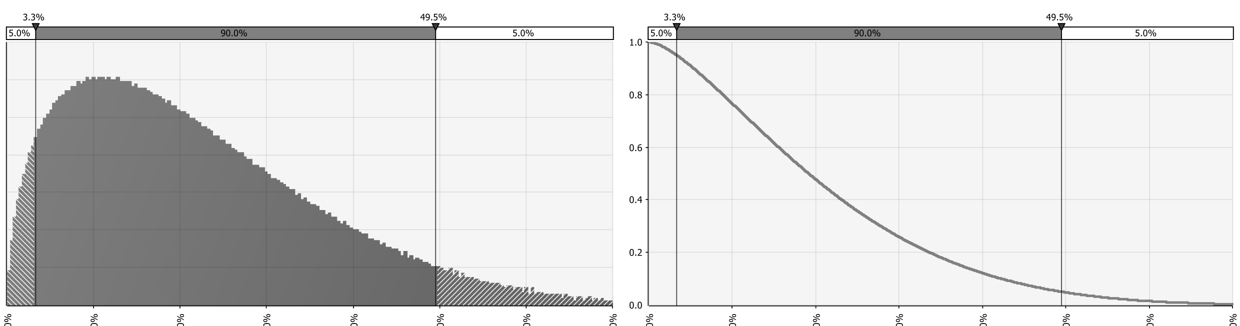

Figure 6 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for yield loss on stone fruit.

3.1.4. Conclusions on yield and quality losses

Based on the general and specific scenarios considered in this assessment, the percentage yield loss in

- pome fruit is estimated to be 15% (with a 95% uncertainty range of 1.4-49.3%)
- stone fruit is estimated to be 19% (with a 95% uncertainty range of 2.1-55.8%)

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 is pest specific and independent from the host
- Natural spread is considered as an increase of the initial focus area of the population and not as the flight potential of the individual adults.
- Spread by human assistance is considered within one farm or production system.

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:

- Alston and Stark (2003) documents an outbreak in Utah which started in 1980. A survey in 2000 indicated that the pest is limited to a 50 square mile area. Since the outbreak is under quarantine control and it may have been moved by human interaction. Therefore, it does not give a good estimation on the potential of natural spread.

3.2.1.6. Uncertainties identified

- The overestimation of the results from the flight mill experiment
- The average size of orchards of pome and stone fruit in Europe

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

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	30	170	300	500	1000

3.2.2.1. *Justification for the elicited values of the spread rate*

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

The flight mill experiment gives an estimation of the maximum possible flight of an individual, however this is greatly overestimated.

Unassisted flight distances are small. The higher values expressed in the EKE reflect the potential human assisted spread within a farm, e.g. harvested fruits moved from field to packing houses, etc. The spread rate therefore depends on the size of the farms.

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

Adults mainly move by crawling on the ground and fly short distances only to reach tree canopy within orchards or overwintering sites. Natural spread is therefore limited to the distances between orchard trees and hibernation sites.

Low spread is foreseen when taking into account only natural spread when there is highly preferred host availability in the vicinity of overwintering areas.

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

The main driver of the assessment of maximum annual spread rate is the uncertainty of human assisted movement within the farm.

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

High uncertainty for 25% percentile.

75% percentile expresses more confidence in the median value, while taking into account the uncertainty in the average size of farms in Europe and thus local human-assisted spread.

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 7: 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	30					170		300		500					1000
Fitted distribution	17	32	52	85	124	169	213	306	419	490	583	692	827	952	1107

Fitted distribution: Weibull(1.4737,392.74), @RISK7.5

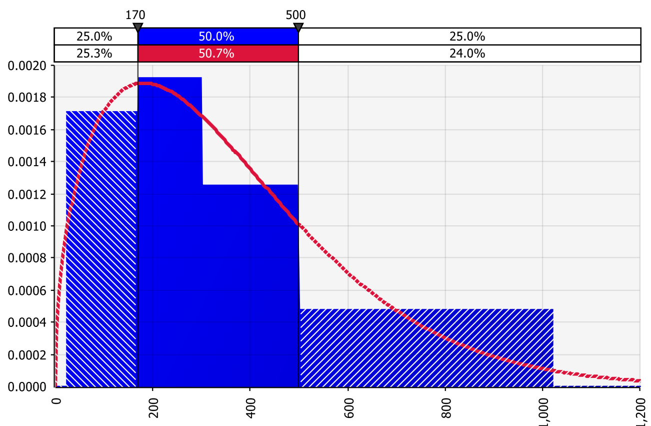

Figure 7 Comparison of judged values (histogram in blue) and fitted distribution (red line) for spread rate.

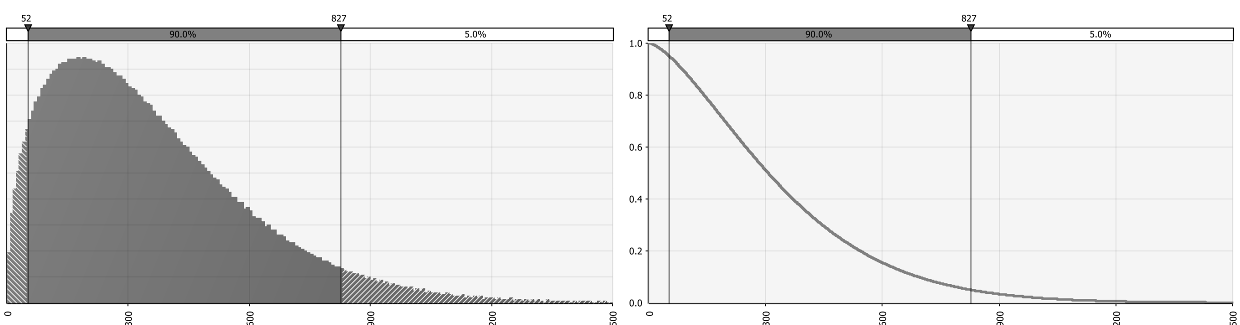

Figure 8 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for spread rate.

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 *C. nenuphar* is approximately 300 m (with a 95% uncertainty range of 32 – 952 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

- Time for detection is 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

- Adult traps for monitoring that are used in North America are specific for plum curculio. They are not used in Europe. The traps are time consuming to deploy and difficult to handle.
- The most reliable monitoring technique is the visual examination of fruitlets for the distinctive half-moon oviposition scars.
- Identification of *C. nenuphar* by morphological examination is limited to adult specimens because there are no adequate keys for the identification of eggs, larvae or pupae. Without careful examination, confusion can occur with native European Curculionidae.

3.3.1.6. Uncertainties identified

- The overall awareness about new and emerging pests
- The effectiveness of current control measures

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

Percentile	**1%**	**25%**	**50%**	**75%**	**99%**
Expert elicitation	7	14	20	30	40

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)

To the untrained eye, it is not very easy to distinguish the damage caused by plum curculio from that by oriental fruit moth (*Grapholita molesta*), codling moth (*Cydia pomonella*) and several other pests of stone and pome fruit.

For stone fruit you may need to wait until the adult emerges from the fruit to determine the species.

A longer time for detection of the pest would be caused if the initial population is low because it is located in orchards with several insecticide treatments per year during the adult flight period and in areas where there are few suitable overwintering sites in the vicinity. Outside commercial orchards, private gardens, wild hosts etc, even high densities will not be detected easily.

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

The outbreak is located inside a commercial orchard where control is ineffective and where technicians have better awareness of pests and are able to recognise a new threat.

The distinctive crescent-shaped oviposition damage on the fruit alerts orchard workers to the presence of the pest.

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

The median value is more skewed towards the lower values assuming that most fruit producers are highly experienced and advisors are aware of new pest threats.

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

The 25th and 75th percentile express high uncertainty for the lower and upper values.

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 9: 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	7					14		20		30					40
Fitted distribution	6.4	6.8	7.6	9.1	11.1	13.5	16.0	21.0	26.4	29.3	32.4	35.1	37.5	38.9	40

Fitted distribution: BetaGeneral(1.0704,1.3290,6,41), @RISK7.5

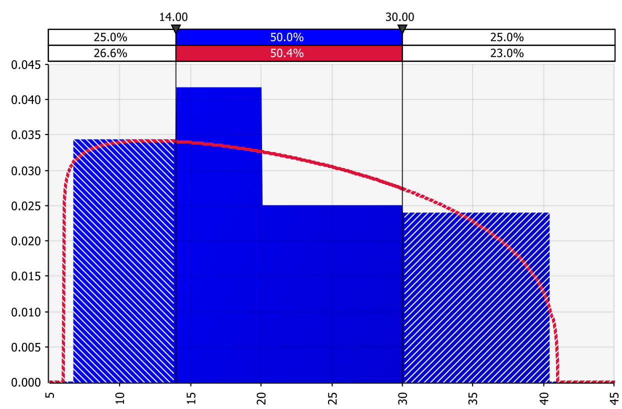

Figure 9 Comparison of judged values (histogram in blue) and fitted distribution (red line) for time to detection.

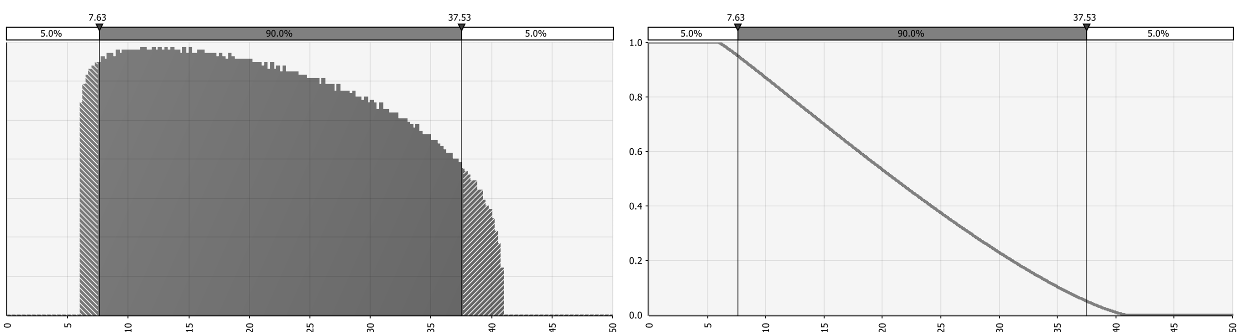

Figure 10 Fitted density function to describe the uncertainties with 90% uncertainty interval (left) and fitted descending distribution function showing the likelihood (y-axis) that a given proportion (x-axis) maybe exceeded (right) for time to detection.

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 21 months (with a 95% uncertainty range of 6.8 – 38.9 months).

4. Conclusions

Hosts selection

Yield loss is assessed for two categories of host plants: (I) pome fruit and (II) stone fruit.

Prunus stone fruit is listed as major/main hosts by both CABI and EPPO. *C. nenuphar* is known to cause serious economic impact to apples and pears in north-eastern USA and Canada.

Within the two categories, yield loss is considered to be comparable between the different host species.

Hemerocallis lilioasphodelus is not considered further in the assessment due to very limited evidence on the nature of the potential impact.

Area of potential distribution

Host availability will not limit the potential area of distribution in Europe as pome and stone fruit are grown widely in all EU countries in commercial production and/or in private gardens. Several uncultivated species of both types of fruit are common and widespread.

Temperature and degree-day accumulation are considered to be the main factors determining the development of *C. nenuphar* and the number of generations per year.

Both strains of *C. nenuphar* are able to develop more than 1 generation per year. No significant differences in the overwintering potential of the two strains have been observed. The southern strain is also able to overwinter by facultative diapause (Akotsen-Mensah, 2019).

All areas of pome and stone fruit production in the EU are considered at risk.

Expected change in the use of plant protection products

Insecticides alone are unlikely to be sufficient to provide long term control for the pest and integrated control measures will also need to be sought. Taking into account the initial phase of control after the introduction of plum curculio to Europe the most suitable PPP indicator is Case "C" and the category is "1".

Yield loss

Based on the general and specific scenarios considered in this assessment, the percentage yield loss in

- pome fruit is estimated to be 15% (with a 95% uncertainty range of 1.4-49.3%)
- stone fruit is estimated to be 19% (with a 95% uncertainty range of 2.1-55.8%)

Spread rate

Based on the general and specific scenarios considered in this assessment, the maximum distance expected to be covered in one year by *C. nenuphar* is approximately 300 m (with a 95% uncertainty range of 32 – 952 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 21 months (with a 95% uncertainty range of 6.8 – 38.9 months).

5. References

Akotsen-Mensah C, 2010. Ecology and Management of Plum Curculio, *Conotrachelus nenuphar* (Coleoptera: Curculionidae) in Alabama Peaches. PhD thesis, Auburn University, Alabama August 9, 2010.

Akotsen-Mensah C, Boozer RT, Appel AG and Fadamiro HY, 2011. Seasonal occurrence and development of degree-day models for predicting activity of *Conotrachelus nenuphar* (Coleoptera: Curculionidae) in Alabama peaches. Annals of the Entomological Society of America, 104, 192–201.

Akotsen-Mensah C, 2019. Dr. Clement Akotsen-Mensah, Research Fellow and Resident Entomologist, Forest and Horticultural Crops Research Centre, University of Ghana, personal communication at the Priority Pests WG meeting of 29 March 2019.

Alston DG and Stark A, 2003. Plum curculio biology, host range, distribution, and control in Utah Final Report. Department of Biology, Utah State University (USU). Available online: http://jenny.tfrec.wsu.edu/wtfrc/PDFfinalReports/2003FinalReports/AppleEntomology/Alston2000.pdf

Armstrong T, 1958. Life history and ecology of the plum curculio (*Conotrachelus nenuphar* Hbst. [Coleoptera: Curculionidae]) in the Niagara peninsula, Ontario. Canadian Entomologist, 90, 8-17.

Blaauw B, Brannen P, Bellinger B, Lockwood D and Ritchie D, 2018. Southeastern peach, nectarine and plum pest management and culture guide. Bulletin 1171, University of Georgia in cooperation with Fort Valley State University, USDA. Available online: http://extension.uga.edu/publications/detail.html?number=B1171&title=Southeastern%20Peach,%20Nectarine,%20and%20Plum%20Pest%20Management%20and%20Culture%20Guide

CABI (Centre for Agriculture and Bioscience International), 2018. *Conotrachelus nenuphar* (plum curculio). CABI Invasive Species Compendium. Last modified 27 September 2018. Available online: https://www.cabi.org/isc/datasheet/15164.

Campbell JM, Sarazin MJ and Lyons DB, 1989. Canadian beetles (Coleoptera) injurious to crops, ornamentals, stored products, and buildings. Agriculture Canada Publication 1826, Canadian Government Publishing centre, Ottawa, 491 pp.

Chen H, Kaufmann C and Scherm H, 2006. Laboratory evaluation of flight performance of the plum curculio (Coleoptera: Curculionidae). Journal of Economic Entomology, 99(6), 2065 -2071.

Chouinard G, Hill SB, Vincent C and Barthakur NN, 1992. Border-row sprays for control of the plum curculio in apple orchards: behavioral study. Journal of Economic Entomology, 85(4), 1307-1317.

Clark MS and Gage SH, 1997. Relationship between fruit yield and damage by codling moth and plum curculio in a biologically-managed apple orchard. The Great Lakes Entomologist, 30, 161-168.

Deutsch A and Guédot C, 2018. A4160 Plum Curculio. University of Wisconsin-Extension. Available online: https://learningstore.uwex.edu/Assets/pdfs/A4160.pdf

Eaton AT and Maccini R, 2016. Plum curculio. Pest factsheet 5, University of New Hampshire Cooperative Extension. Available online: https://extension.unh.edu/resources/files/Resource002799_Rep4154.pdf

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

EFSA PLH Panel (EFSA Plant Health Panel), Bragard C, Dehnen-Schmutz K, Di Serio F, Gonthier P, Jacques M-A, Jaques Miret JA, Justesen AF, Magnusson CS, Milonas P, Navas-Cortes JA, Parnell S, Potting R, Reignault PL, Thulke HH, Van der Werf W, Vicent Civera A, Yuen J, Zappalà L, Czwienczek E and MacLeod A, 2018. Scientific opinion on the pest categorisation of *Conotrachelus nenuphar*. EFSA Journal 2018;16(10):5437, 29 pp. https://doi.org/10.2903/j.efsa.2018.5437

EPPO (European and Mediterranean Plant Protection Organization), 1996. EPPO datasheet *Conotrachelus nenuphar*. In: Smith IM, McNamara DG, Scott PR and Holderness M. Quarantine pests for Europe. 2nd Edition. CABI/EPPO, Wallingford, 1425 pp .

EPPO (European and Mediterranean Plant Protection Organization), online. EPPO Global Database. Available online: https://www.eppo.int/ [Accessed: 22 May 2019]

FAO (Food and Agriculture Organization of the United Nations), 1995. ISPM (International standards for phytosanitary measures) No 27. Diagnostic protocols for regulated pests DP 28: *Conotrachelus nenuphar.* Available online: https://www.ippc.int/static/media/files/publication/en/2018/09/DP_28_2018_Cnenuphar_2018-09-21.pdf

FAO (Food and Agriculture Organization of the United Nations), 2017. Integrated pest management of major pests and diseases in eastern Europe and the Caucasus. Available online: http://www.fao.org/3/a-i5475e.pdf

Glass EH and Lienk SE, 1971. Apple insect and mite populations developing after discontinuance of insecticides: 10-year record. Journal of Economic Entomology, 64, 23-26.

Gökçe A, Bingham GV and Whalon ME, 2018. Impact of long-lasting insecticide-incorporated screens on Colorado potato beetle and plum curculio. Turkish Journal of Agriculture and Forest, 42, 38-44.

Johnson Jr DT, Mulder PG, McCraw BD, Lewis BA, Jervis B, Carroll B and McCleod PJ, 2002. Trapping plum curculio *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae) in the southern United States. Environmental Entomology, 31, 1259–1267.

Kottek M, Grieser J, Beck C, Rudolf B and Rubel F, 2006. World map of the Koppen-Geiger climate classification updated. Meteorologische Zeitschrift, 15, 259–263.

Lafleur G and Hill SB, 1987. Spring migration, within-orchard dispersal, and apple-tree preference of plum curculio (Coleoptera: Curculionidae) in southern Quebec. Journal of Economic Entomology, 80, 1175–1187.

Lafleur G, Hill SB and Vincent C, 1987. Fall migration, hibernation site selection, and associated winter mortality of plum curculio (Coleoptera: Curculionidae) in a Quebec apple orchard. Journal of Economic Entomology, 80, 1152–1172.

Lan Z and Scherm H, 2003. Reduced midseason pesticide program for control of scab and plum curculio in peach. Plant Disease, 87, 699-706.

Lan Z, Scherm H and Horton DL, 2004. Temperature-dependent development and prediction of emergence of the summer generation of plum curculio (Coleoptera: Curculionidae) in the southeastern United States. Environmental Entomology, 33(2), 174-181.

Leskey CT, 2008. Reproductive development of female plum curculio (Coleoptera: Curculionidae) in the Mid-Atlantic: presence of multivoltine populations. Journal of Entomological Science, 43(2), 208-216.

Leskey CT and Wright SE, 2007. Host preference of the plum curculio. The Netherlands Entomological Society, 123, 217–227.

Maier CT, 1990. Native and exotic rosaceous hosts of apple, plum, and quince curculio (Coleoptera: Curculionidae) in the northeastern United States. Journal of Economic Entomology, 83, 1327–1332.

Mampe CD and Neunzig HH, 1967. The biology, parasitism and population sampling of the plum curculio on blueberry in North Carolina. Journal of Economic Entomology, 60, 807–812.

Myers CT, Leskey TC and Forsline PL, 2007. Susceptibility of fruit from diverse apple and crabapple germplasm to attack by plum curculio (Coleoptera: Curculionidae). Journal of Economic Entomology, 100, 1663-1671.

Piñero JC and Prokopy RJ, 2006. Temporal dynamics of plum curculio, *Conotrachelus nenuphar* (Herbst.) (Coleoptera: Curculionidae), Immigration into an apple orchard in massachusetts. Environmental Entomology, 35, 413-422.

Quaintance AL and Jenne EL, 1912. The plum curculio. USDA Bureau of Entomology: Bulletin No. 103. Available online: https://archive.org/stream/plumcurculio103quai/plumcurculio103quai_djvu.txt

Racette G, Chouinard G, Vincent C and Hill SB, 1992. Ecology and management of plum curculio, *Conotrachelus nenuphar* [Coleoptera: Curculionidae], in apple orchards. Phytoprotection, 73, 85-100.

Shapiro-Ilan DI, Wright SE, Tuttle AF, Cooley DR and Leskey TC, 2013. Using entomopathogenic nematodes for biological control of plum curculio, *Conotrachelus nenuphar*: Effects of irrigation and species in apple orchards. Biological Control, 67, 123–129.

Selby RD, 2014. Modeling the phenology and monitoring the activity of the plum curculio *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae) with novel methods and technology. PhD thesis, Michigan State University, 110 pp.

Vincent C and Hanley J, 1997. Measure of agreement between experts on apple damage assessment. Phytoprotection, 78, 11-16.

Vincent C and Roy M, 1992. Entomological limits to biological control programs in Québec apple orchards. Acta Phytopathologica et Entomologica Hungarica, 27, 649-657.

Vincent C, Chouinard G and Hill SB, 1999. Progress in plum curculio management: a review. Agriculture, Ecosystems and Environment, 73, 167-175.

Williams MA, Strang JG, Bessin RT, Law D, Scott D, Wilson N, Witt S and Archbold DD, 2015. An assessment of organic apple production in Kentucky. Hortechnology, 25, 154-161.

Wise JC, VanWoerkom AH and Gut LJ, 2015. Plum curculio control in sweet cherry, 2014. Arthropod Management Tests, 1–1.

Wise JC, VanWoerkom AH and Gut LJ, 2016. Control of oriental fruit moth and plum curculio in peach, 2015. Arthropod Management Tests, 1–1.

Wise JC, VanWoerkom AH and Gut LJ, 2017. Plum curculio control in sweet cherry, 2016. Arthropod Management Tests, 1–2.

Zhang X and Pfeiffer DG, 2008. Evaluation of reproductive compatibility of interstrain matings among plum curculio populations in the eastern United States. Population Ecology, 37(5), 1208-1213.

Zhang X, Tu Z, Luckhart S and Pfeiffer DG, 2008. Genetic diversity of plum curculio (Coleoptera: Curculionidae) among geographical populations in the eastern United States. Annals of Entomological Society of America, 101(5), 824-832.

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**
Amelanchier	*arborea*
Amelanchier	*canadensis*
Crataegus	
Cydonia	*oblonga*
Diospyros	*kaki*
Fragaria	*ananassa*
Hemerocallis	
Hemerocallis	*lilioasphodelus*
Malus	
Malus	*domestica*
Prunus	
Prunus	*alleghaniensis*
Prunus	*americana*
Prunus	*armeniaca*
Prunus	*avium*
Prunus	*cerasus*
Prunus	*domestica*
Prunus	*japonica*
Prunus	*maritima*
Prunus	*mexicana*
Prunus	*nigra*
Prunus	*pensylvanica*
Prunus	*persica*
Prunus	*pumila*
Prunus	*salicina*
Prunus	*serotina*
Prunus	*virginiana*
Pyrus	
Pyrus	*communis*
Ribes	
Ribes	*uva*
Sorbus	*aucuparia*
Vaccinium	
Vaccinium	*corymbosum*
Vaccinium	*stamineum*
Vitis	*rotundifolia*
Vitis	*vinifera*

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
	Incidence	***Severity***	***Losses***		
Malus spp.			Damage ranged from 1%-46% and average 15%	New York, 10-year period when insecticide use was discontinued in a 1-acre apple orchard.	Glass and Lienk, 1971
Malus spp.			Average 70% of inspected fruit was bearing insect damage (min 43%, max 88%)	Pesticide free orchard Quebec (1986-1989) Damage was assessed from apples at the end of the physiological fruit drop. 100 apples were picked randomly from each of 5 different sections of the orchard.	Chouinard et al., 1992 (Table 6)
Malus spp.			Average 47,6% of apples showing damage, (max 85%)	Apple orchard in Quebec without insecticide treatments. 1000 apples examined every year at harvest for 13 years.	Vincent and Roy, 1992 (Table 3)
Malus spp.			Average of 56% of apples were damaged (24-83%)	Biologically managed orchard in southwestern Michigan. During 8 years (1988-1995), 5 apples were collected during harvest from each tree for damage assessment.	Clark and Gage, 1997
Malus spp.			Mean % of fruit damaged by PC: in 2005 0-19.17%. In 2006 mid-season 0.5-11.33%. In 2006 late season 23.33-79.75%.	In Geneva, NY 2005-2006. Without pesticide treatments. Assessment of the susceptibility of a different Malus accessions. In 2005 one mid-season assessment. 70 fruit per tree from each accession were visually examined; most accessions had at least two replicate trees. In 2006 assessments were conducted once in the mid-season (20 June) and later in the season (9 August), to account for damage caused by long-living adults and possibly by a second summer generation. 100 fruit per tree	Myers et al., 2007
Malus spp.			Apples with insect injuries was 9.5-31.4% of the whole yield	Organically grown apple orchard 2011-2013 in Kentucky US. Damage varied among varieties- Redfree, Crimson Crisp and Enterprise.	Williams et al., 2015
Prunus avium			16-19.5% of fruit had pest stings	Untreated check plot (evaluated mid-June)	Wise et al., 2015
Prunus persica			3,5 and 32% of fruit damage incidence in peach orchard in 1999 and 2000 respectively	Control plot, without insecticide treatment	Lan and Scherm, 2003
Prunus persica			10.8% (mean) of fruit had	Untreated check plot (evaluated mid-July)	Wise et al.,

			stings		2016
Prunus cerasus			31.8-36% of fruit had pest stings	Untreated check plot (evaluated in June)	Wise et al., 2017

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

Spread	**Additional information**	**Reference**	**Uncertainty**
Adults showed a net rate of spread of up to 3m per day.		Lafleur et al., 1987	
Between May and August adults moved from outside rows of an apple orchard towards the center. Mean distance of dispersion was 15.3 m (26.5 if only those who moved were taken into account). Greatest distance covered was 129 m in 28 days (142 m in 45 days) and fastest speed of dispersion was 67 m in 6 days.	Many of the recaptured adults were recovered from the same tree that they were first found on. Accomplished mainly by walking	Lafleur and Hill, 1987	
Although *C. nenuphar* may have been present in Utah since 1980, a survey in 2000 indicates the pest is limited to a 50 square mile area.		Alston and Stark, 2003	The outbreak is under quarantine control
Total distance travelled within 24 h ranged from 0.3 to 8093 m (median, 122.7 m), Total flight time from 0.5 to 466.5 min (median, 23.5 min), Maximum uninterrupted flight time from 0.5 to 115.5 min (median,2.0 min)		Chen et al., 2006	Flight mill experiments are artificial and in general, the insect is an infrequent flier
Trapping has indicated that immigration in orchards of Massachusetts, USA can last for 51 to 85 days		Piñero and Prokopy, 2006	
8.25-35.71 m (from 6 April to 28 October)	Table 1 shows the different mean distances travelled by adults in different habitats, during a release-recapture study	Leskey and Wright, 2007	

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

Reference	**Case**	**Results / evidence**	**Limitation / uncertainties**
Racette et al., 1992	Detection method	Enzymes released by larvae feeding in fruit cause the fruit to drop prematurely, e.g. in apples before the fruit reaches 3 cm diameter	
FAO, 1995	Detection method	Identification of *C. nenuphar* by morphological examination is limited to adult specimens because there are no adequate keys for the identification of eggs, larvae or pupae	
Johnson et al., 2002	Detection method	Several methods have been used to detect adult *C. nenuphar* in orchards: beating and shaking branches and collecting adults that are dislodged and fall onto white sheets under the branches, using green painted sticky-coated ping pong balls, pitfall traps, pyramid traps, screen traps and sticky-trunk bands	
Eaton and Maccini, 2016	Detection method	If the presence of *C. nenuphar* is expected, hosts at the outer edges of orchards should be monitored regularly during the period of flowering up to petal fall for feeding or egg laying punctures on young fruit.	
Armstrong, 1958	Pest biology	The time spent inside the fruit (combining the egg and larval periods) varied from 13 to 49 days, the majority falling within the range 17 to 22 days	
Armstrong, 1958	Pest biology	Development from final instar larva to adult takes 32 to 45 days, the extremes being 21 and 81 days	
Campbell et al., 1989	Pest biology	At mean daily temperatures of 19.3ºC to 23.3ºC, eggs take 4 to 7 days to hatch. At a constant 27.8ºC eggs hatch in just under 3 days	
Campbell et al., 1989	Pest biology	At mean daily temperatures of 19.3ºC to 23.3ºC, eggs take 4 to 7 days to hatch. At a constant 27.8ºC eggs hatch in just under 3 days	
Armstrong, 1958	Pest/host combination	Multiple eggs can be laid in a single host fruit, for example in a heavily infested apricot orchard reported up to 13 larvae per fruit.	
Vincent and Hanley, 1997	Pest/host combination	Average agreement of 71.8 on the damage of *C. nenuphar.*	Four teams of experts individually estimated the damage of 200 apples at harvest.
Vincent et al., 1999	Pest/host combination	Within an apple orchard, a plum curculio population released from insecticide control efforts is capable of returning to levels causing major economic damage within three years	