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Pest Risk Analysis for *Anthonomus eugenii*

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Netherlands Food and Consumer Product Safety Authority

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Abstract

The present Pest Risk Analysis was conducted after the finding of an outbreak of *Anthonomus eugenii* (pepper weevil) in a sweet pepper crop in the Netherlands in 2012. Official measures were taken to eradicate the pest. *A. eugenii* is present in Central America, the Caribbean, Mexico, USA and French Polynesia. Imports of fresh *Capsicum* and *Solanum* fruit from these regions and countries were identified as the most important pathways for introduction with *Capsicum* fruit being the most important one. *Capsicum* fruit has been imported since at least 1988 from countries where the pest is present. The import volume has not increased significantly since about 2000 and the probability of introduction has been assessed as "low" with a high uncertainty. Changes in handling of imported fruit, for example placing it in closer proximity to production facilities may significantly increase the probability of introduction. The pest can likely establish in greenhouses growing *Capsicum* fruit with short intercrop periods. Establishment in greenhouses growing *Solanum melongena* (egg plant) or Solanaceae pot plants is uncertain. *A. eugenii* may be able to establish outdoors in areas of southern Europe with mild winters which allow the presence of green host plants throughout the year. Transient populations may occur in *Capsicum* crops in areas where the pest cannot persist throughout the year. The impact in *Capsicum* fruit crops in protected cultivations has been assessed "major" with a medium uncertainty. In field-grown crops, the potential impact will depend on the chance that the pest can persist in the vicinity of the field in absence of the crop or the probability that the field becomes re-infested by human-assisted pathways. Once present in a greenhouse or field, the pest is difficult to control because of the hidden life stages, eggs, larvae, pupae and young adults are within the fruits. Application of insecticides to control the mature adults outside the fruits will disrupt existing integrated control systems. The impact for crops other than *Capsicum* fruit has been assessed to be minor with a medium uncertainty. Three options have been identified and evaluated to reduce the risk of introduction: import of *Capsicum* fruits only allowed (I) from Pest Free Areas or (II) Pest Free Production Places or sites or (III) after irradiation. Option III is currently not realistic because irradiated fresh fruit is prohibited in the EU. Less strict measures may be considered for fruits of *Solanum* because the probability of association of *A. eugenii* with fruits of *Solanum* is assessed to be much lower than with fruits of *Capsicum*.

Biology of the pest (short description)

The pepper weevil (*Anthonomus eugenii* Cano) is mainly an insect pest of cultivated chili and sweet pepper (*Capsicum* spp.) but can also reproduce on several *Solanum* spp. The pepper weevil lays eggs and feeds on and develops completely inside the floral buds and fruits of its hosts (Riley & Sparks, 1995; Photo 1; Fig. 1). The pepper weevil has a threshold and optimum temperature for development of about 10°C and 30°C, respectively (Toapanta et al., 2005). It takes the pepper weevil two weeks to complete its life-cycle in warm conditions (27°C), three weeks at ambient conditions (21°C) and 6 weeks in cool conditions (15°C). In subtropical areas, 5-8 generations per year may occur in a *Capsicum* crop. Multiple generations may develop in greenhouse conditions. The pepper weevil does not enter diapause, but does survive lower temperatures just above zero (Costello & Gillespie, 1993; Riley & King, 1994).

Photo 1. Pepper weevil developmental stages in sweet pepper: larva (left, maximum 6 mm), pupa (middle, 2.5-3 mm) and adult beetle (right, 2.5-3.5 mm) showing its characteristic hair pattern.

Photo 2. Symptoms of pepper weevil. Top: feeding punctures in flowers and egg laying scars in young fruit and fruit discolouration. Bottom: aborted fruits with dried calyx, emergence hole and damage inside fruit seed lists in young fruit due to feeding.

Males and females are attracted to volatiles from flowering and fruiting pepper plants, to pepper weevil-damaged crops, and to the presence of the male aggregation pheromones (Eller et al. 1994; Addesso & McAuslane 2009; Addesso et al., 2011). Adults feed on buds, flowers, fruits and leaves (Patrock & Schuster, 1992; Rodriguez-Leyva, 2006). 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 (EPPO, 1997). 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 & Schuster, 1992). In feeding punctures a single egg is laid and the holes are sealed with an anal secretion that serves as an "oviposition plug" (Elmore et al., 1934; Addesso et al., 2007). Females avoid laying eggs in buds were 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 feed on seeds and other tissue inside the developing fruits, where they also pupate (Costello & Gillespie, 1993; Elmore & Campbell, 1951; Capinera, 2008a). Adults eclose inside the fruits and may feed protected for several days inside before chewing a small exit hole. The presence of *A. eugenii* can result in discoloured and deformed fruits, and more importantly, premature ripening and abscission of young fruits (Photo 2). Premature abscission is often a consequence of feeding and developing inside buds and fruits resulting in loss of production (Rodriguez-Leyva, 2006). The pepper weevil has been implicated in the transmission of internal (*Alternaria* spp.) mould of peppers (Bruton et al., 1989).

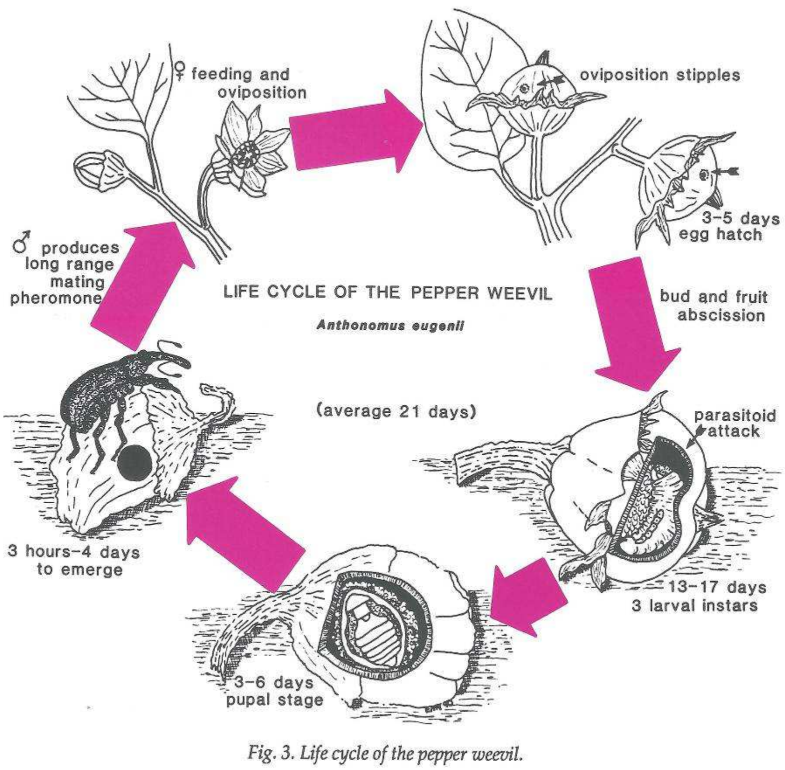

Fig. 1. Life-cycle of *Anthonomus eugenii* at 21°C (© Riley & Sparks, 1995, courtesy D. Riley).

Summary

Reason for performing the PRA and PRA area

The reason for performing the PRA was an outbreak of *Anthonomus eugenii* in a sweet pepper crop in a Dutch greenhouse confirmed by the NPPO of the Netherlands in July 2012. The PRA area is the European Union.

Distribution of *Anthonomus eugenii*

Continent	Country
Africa	Absent/not known to be present
Asia	Absent/not known to be present
Europe	Absent/not known to be present (eradicated from the Netherlands)
Americas	Belize, Canada[1], Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Jamaica, Mexico, Nicaraqua, Panama, Puerto Rico, USA
Oceania	French polynesia

[1] reported from greenhouses in 1992 and again in 2009-2010; current pest status uncertain

Area of potential establishment

Greenhouses. The pest can likely establish in greenhouses with a nearly continuous *Capsicum* fruit crop. *A. eugenii* can likely survive short intercrop periods in the greenhouse and in areas with mild winters (plant hardiness zone 10 and higher and the milder areas in hardiness zone 9), it may also be able to survive in the open after removal of the crop in the autumn/winter and re-enter the greenhouse in the spring. In warm areas where greenhouse crops are present from autumn to spring, *A. eugenii* may survive in the open during the summer if host plants are present (e.g. wild *Solanum* spp. or field-grown *Capsicum*). Establishment in greenhouses where *Solanum melongena* and Solanaceae pot plants are grown is uncertain.

Open field. *A. eugenii* may be able to establish in *Capsicum* fruit production areas outdoors in plant hardiness zone 10 and higher and the milder areas in zone 9 in southern EU which include roughly the Mediterranean coastal regions, the islands in the Mediterranean Sea, southern Portugal and the western half of Portugal. The limits of the potential area of distribution are uncertain. The presence of host plants throughout the year, e.g. wild *Solanum* spp. in absence of a *Capsicum* crop, seems a prerequisite for establishment and the absence or low prevalence of green and fruit carrying host plants during hot dry summers in the Mediterranean area might limit establishment. It is uncertain if *A. eugenii* can establish in wild *Solanum* vegetations; the presence of a *Capsicum* crop during at least part of the year might be needed for establishment. In areas where populations cannot persist, transient populations may occur by natural migration of the pest from infested greenhouses or by human assisted pathways.

Probability of introduction (entry and establishment)

Pathway 1: fruits of *Capsicum* spp.

The probability of entry along this pathway has been assessed as "low" (high uncertainty). Fruits of *Capsicum* spp. have been imported from countries where the pest is present at least since 1988. In the Netherlands, where an outbreak occurred in 2012, the annual import volume (from countries where *A. eugenii* is present) during 2006 – 2012 was approximately 3 times higher than during 1992 – 2005 but was similar to the years 1988 – 1991. The outbreak of *A. eugenii* in 2012 was the first one of this pest reported in the EU. For the whole EU, the import volume has increased since 1988 but not since about the last 10 years. The pest has been intercepted/found many times on fruits in North America and was recently intercepted/found on imported fruits in

Switzerland and the Netherlands. *A. eugenii* may regularly arrive with imported fruit in the EU as *Capsicum* fruit is currently not regular subject to phytosanitary import inspections. Transfer from infested fruit to a *Capsicum* crop seems, however, a relatively rare event. Assuming that transfer of the pest to a *Capsicum* crop will lead to an outbreak in the majority of cases, it is assessed that the pest may enter (including transfer to a place where it can establish) less than once in 10 years (corresponding to the rating level "low") assuming that the probability of entry has not recently increased and will not change significantly over time.

Pathway 2: fruits of *Solanum* spp.
The probability of entry along this pathway has been assessed as "low" (medium uncertainty). Although having the same rating level (the lowest in the range of rating levels provided), the probability of entry by import of fruit of *Solanum* spp. has been assessed to be lower than for pathway 1 because of the much lower probability of association of the pest with *Solanum* than *Capsicum* fruit.

Overall probability of introduction: "low" (high uncertainty). The uncertainty is high because the probability of introduction may recently have increased or may increase in the future if for example sorting and packing of imported fruit were to be carried out in (even) more proximity to pepper crops and/or if the import volume from areas where the pest is currently present would increase.

Note:
- Plants for planting of Solanaceae other than seeds are also a potential pathway. However, this pathway is currently closed by EU regulation.
- It is still unknown how *A. eugenii* has entered the Netherlands, leading to outbreaks in several greenhouses. No link has been found yet with import of fruits from countries where the pest is present. Pathways other than import of fruit, e.g. hitch-hiking with other products or human beings cannot be excluded.
- The pest might (incidentally) enter the EU by import of products other than *Capsicum* or *Solanum* fruit but the significance of such pathways is difficult to assess. The probability of association with other products is likely much lower. Large volumes of non-host plants are imported from Central America by boat. The long transport time also makes entry along that pathway less likely. Thus far, there are no reports of interceptions or findings of the pest which could be linked to products other than *Capsicum* or *Solanum* fruit.

Spread
A. eugenii can probably spread naturally during spring and summer in the largest part of the EU. The minimum temperature for flight is unknown but will probably be above 15°C. The pest can also be spread by human assistance, e.g. by internal trade of fruits and possibly also by trade of transplants, by contaminated clothes, machines etc. In general, conditions for natural spread will be more favourable in the warmer areas of the EU.

Potential consequences

Endangered area: the endangered area include all *Capsicum* crops in the EU. It is uncertain if *Solanum melongena* crops are part of the endangered area. They are possibly not endangered because *S. melongena* seems much less susceptible than *Capsicum* crops.

Economic impact: a "major" impact is expected for the production of *Capsicum* fruit in greenhouses with a medium uncertainty. There is uncertainty: in areas where *A. eugenii* cannot overwinter outdoors (which is the major part of the EU), the impact may be limited in time and place when growers are able to eradicate the pest from their greenhouses during the intercrop period which is usually during autumn/winter. This will be more likely to achieve for an isolated pepper-greenhouse than in high density greenhouse areas. In warmer areas in the EU where greenhouse crops are grown from autumn to spring, the pest may be able to survive the summer outdoors on wild host plants or field-grown peppers and the pest may be re-introduced into the greenhouse every new growing season. The impact for field-grown crops in areas where the pest cannot establish outdoors (the major part of the PRA-area) will probably be limited ("medium" impact) because only transient population can occur. However, if fields are located close to pepper greenhouses or there are other pathways by which the pest can be regularly introduced in these fields "major" impacts could occur. In the southernmost areas of the EU, the pest may be able to persist in the vicinity of pepper fields during the crop free period and "major" impacts may occur every year (high uncertainty).

Export markets: the impact of *Anthonomus eugenii* for export markets will largely depend on the measures importing countries may take. Thus, the impact is highly uncertain and may range from minor to major. Assuming that at least EPPO-countries outside the EU would require a PFPP this would at least lead to an increase in inspection costs and maybe some loss in export markets. Thus, a "medium" impact (some effects on market size are expected) seems most likely (medium uncertainty).

Environmental impact: "minimal" (medium uncertainty). The pest has not been reported to cause environmental damage even not from areas into it has been introduced. The pest may cause some damage in solanaceous garden plants and weeds but it is primarily known as a pest of *Capsicum* crops. There could be an indirect environmental effect due to an increased use of insecticides (this effect has not been included in the rating level).

Social impact: will be mainly related to the economic impact. Lower profit for companies due to infestations with the pest can lead to financial stress and in the worst case to bankruptcy.

Risk reduction options

Options to reduce the probability of introduction

Three options have been identified which will largely reduce the probability of introduction of *Anthonomus eugenii* with imports of fruits:

I Fruits of *Capsicum* spp. and *Solanum* spp. should originate from a pest free area;

II Fruits of *Capsicum* spp. and *Solanum* spp. should originate from a pest free production place or site;

III Fruits of *Capsicum* spp and *Solanum* spp. originating from areas where the pest is present should be irradiated at doses that renders the pest sterile (dose 400 Gy and possibly 150 Gy). This option is currently not realistic because irradiated fresh fruit is prohibited in the EU;

For EU-regulation, detailed requirements for fruits of *Capsicum* L. could be:

(a) the fruits originate in an area being free from *Anthonomus eugenii,*

or

(b) the fruits originate in a place or site of production that is officially monitored for presence of *Anthonomus eugenii* using appropriate monitoring methods,

and

in case of a finding of the pest, delivery is suspended until the responsible official body determines that appropriate measures have been taken and no sign of the pest has been observed at the place or site of production for a period of at least 30 days since the last finding.

Less strict measures may be considered for fruits of *Solanum* L. (e.g. visual inspections of consignments only) because the probability of association of *A. eugenii* with fruits of *Solanum* is assessed to be much lower than with fruits of *Capsicum*.

Contrary to fruit of *Solanum* spp., fruit of *Capsicum* spp. is currently not a regular subject to phytosanitary import inspections in the EU (phytosanitary import inspections of *Capsicum* fruit are not obliged in the EU). A small proportion of the consignments of sweet pepper (not chili pepper) is inspected for quality.

<u>Eradication after introduction</u>
Eradication from greenhouses can be achieved by removal of the crop and hygiene measures in areas where the pest cannot establish nor survive the intercrop period outdoors. Eradication will be more difficult in areas with a high density of greenhouses than in cases of more isolated greenhouses. In southern Europe, eradication may be difficult because temperatures will be more favourable for spread between greenhouses than in more northern areas and transient populations may occur outdoors during the summer period, the usual intercrop period.

Uncertainties
The main uncertainties in the present PRA are:

- The ability of *A. eugenii* to establish outdoors in southern EU and the limits of its potential area of distribution.
- Greenhouse cultivation in southern EU from spring to autumn: the ability of *A. eugenii* to survive summers outdoors on wild host plants and re-infest newly planted greenhouse crops in the autumn.
- Greenhouse cultivation in areas with cool summers and mild winters: the ability of *A. eugenii* to survive outdoors after removal of the *Capsicum* crop in the autumn/winter and re-infest the greenhouse in the spring.
- Wild *Solanum* spp. are known as alternative host in absence of a *Capsicum* crop; it is, however, uncertain if *A. eugenii* could persist over longer periods (i.e. establish) in absence of *Capsicum* spp.
- The possibility that solanaceous crops grown in greenhouses other than *Capsicum* spp. could act as a refuge for adults (e.g. tomato) or as an alternate host (e.g. egg plant) and contribute to the dispersal and establishment potential of *A. eugenii* in areas where the pest cannot establish outdoors.

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Methodology

The set-up of the present PRA follows partly the PRA-scheme of the European and Mediterranean Plant Protection Organisation (EPPO, http://www.eppo.org/). The present PRA scheme asks for:

- the host plants and pest distribution;
- the probability of entry (including transfer to a suitable place or habitat where the pest can establish) according to a 4-point qualitative scale (low, medium, high, very high; see explanation below);
- the area of potential establishment (description, no rating);
- the rate of spread once the pest has established (description, preferably with estimated distances, no rating);
- the probability of introduction (the probability that the pest enters and establishes according to a 4-point qualitative scale (the same scale as for the probability of entry).
- the economic, environmental and social impact according to a 5-point qualitative scale (minimal, minor, moderate, major, massive);
- the endangered area (description, no rating);
- the identification and evaluation of risk reduction options;
- the main uncertainties.

Rating guidance is provided in Annex I. For entry, a 4-point scale was used and not a 5-point scale as in the EPPO-scheme. In the present PRA-scheme, the rating levels corresponds with a quantitative interval while the EPPO-scheme has no rating guidance for "entry". It was considered that a 5-point scale would suggest a too high level of accuracy for the "entry-assessment". The information available to assess the probability of entry in PRAs is often very limited. The lowest rating level in the present PRA-scheme ("low") corresponds to an average of less than one entry in 10 years. In many cases, it is not considered possible to assess lower probabilities in a more accurate way (e.g. to make a difference between for example one entry in 10 – 25 years and one entry in less than 25 years). Also, the use of more narrow intervals for the three highest rating levels and to split them in four rating levels was not considered appropriate (see Annex I for the full rating guidance).

Similar to the EPPO-scheme, the level of uncertainty is rated according to a 3-point qualitative scale (low, medium and high). Adapted from IPPC definitions, low, medium and high uncertainty are defined as expressing 90, 50 and 35% confidence, respectively, that the score selected is the correct one (Mumford *et al*., 2010).

1. Pest Risk Initiation

1.1 What is the reason for performing the PRA?

In July 2012, a Dutch grower of sweet pepper, *Capsicum annuum*, contacted the NPPO of the Netherlands about observations of a population of beetles and damaged peppers. The NPPO of the Netherlands identified the beetles as *Anthonomus eugenii*, a pest which was not known from Europe. Based on a rapid risk assessment made by the Netherlands, it was decided to take emergency actions against the pest. It was also decided to make a more detailed PRA and to identify and evaluate risk reduction options. Initially, a PRA was conducted for the Netherlands (version 1.0, May 2013), which was adapted to cover the whole European Union (EU; version 2.0, June 2013).

1.2 Scientific name, taxonomy and type of pest

From the EPPO-datasheet (EPPO, 1997) with a few additions:

Name:	*Anthonomus eugenii* Cano
Synonyms:	*Anthonomus aeneotinctus* Champion
Taxonomic position:	Insecta: Coleoptera: Curculionidae
Common names:	Pepper weevil (English) Barrenillo del chile (Spanish) Paprikasnuitkever (Dutch)
Bayer computer code:	ANTHEU

1.3 PRA area

The risk assessment area is the European Union (EU).

1.4 Does a relevant earlier PRA exist?

The Canadian Food Inspection Agency has completed a Pest Categorisation for Canada of which a summary is available on the internet (CFIA, 2011). In 1993, the UK made a very short risk assessment ("Summary PRA") and in 1995 *A. eugenii* was added to the A1 list of the European and Mediterranean Plant Protection Organization (EPPO) and thus recommended for regulation by EPPO (EPPO, 2011). The NPPO of the Netherlands recently published a short risk assessment (Quick scan) of the pest on the internet (http://www.vwa.nl/onderwerpen/english/dossier/pest-risk-analysis/quickscans). The organism is currently not regulated in the EU. No other PRAs were found when this PRA was started (The UK finalized a rapid PRA in October 2012 available on http://www.fera.defra.gov.uk/.). A datasheet is available from EPPO (EPPO, 1997). Information from the Canadian Pest Categorisation and EPPO datasheet was used where relevant.

2. Pest Risk Assessment

2.1 Host plants and pest distribution

2.1.1 Specify all the host plant species (for pests directly affecting plants). Indicate the ones which are present in the PRA area.

Host plant species

Host plants utilized by pepper weevil for reproduction are confined to species within the genera *Capsicum* and *Solanum*, all in the family Solanaceae. *A. eugenii* prefers *Capsicum* spp., all of the five species of pepper grown as crops - *Capsicum annuum*, *C. frutescens, C. chinense*, *C. pubescens* or *C. baccatum* - are suitable for oviposition and development of the pepper weevil (Elmore et al., 1934; Wilson, 1986; Patrock & Schuster, 1992). However, it can also reproduce on several other *Solanum* spp. (Table 2.1). For example, reproduction on egg plant (*S. melongena*) is possible but the plant species is not very susceptible: "eggplant grown in proximity to pepper will sometimes be injured" (Capinera, 2011). Other solanaceous host plant species on which the pepper weevil can reproduce successfully are *Solanum americanum, S. axilifolium, S. carolinense, S. dimidiatum, S. elaeagnifolium, S. madrense, S. nodiflorum, S. nigrum, S. pseudocapsicum, S. pseudogracile, S. ptycanthum, S. rantonettii, S. rostratum, S. triquetrum and S. trydynamum* (Swezey, 1936; Nishida, 1945; Patrock & Schuster, 1992; Wilson, 1986; Rodriguez-Leyva, 2006; Torres-Ruíz & Rodríguez Leyva, 2012). It can be found on other species such as *S. umbelliferum*, *S. villosum* and *S. xanti* growing near pepper fields (Mau & Kessing, 1994). Furthermore, pepper weevil adults can feed on a wide range of solanaceous species, such as *Solanum tuberosum* (potato) and *S. esculentum* (tomato), but do not reproduce on them (Table 2.1). Reproduction on *S. tuberosum* can, however, not be 100% excluded as fruits have not been tested.

The Netherlands: host plant species grown indoors (greenhouses)

Sweet pepper (*Capsicum annuum*) is grown on about 1,400 ha (Table 2.2). In addition, there is a relatively small area with chili pepper (also *C. annuum*), probably about 30 – 35 ha (information from LTO Noord Glaskracht, 10th September 2012). Egg plant (*Solanum melongena*) is grown on about 100 ha (Table 2.2). In addition, several ornamental *Solanum* species are grown but at a relatively small scale, e.g. *S. jasminoides*, *S. rantonettii* and *S. pseudocapsicum*. It is uncertain if *A. eugenii* can reproduce on each of these ornamental *Solanum* species. Reproduction on *Solanum pseudocapsicum* is at least possible (Table 2.1). Also different *Capsicum* varieties are being cultivated as ornamental (pot and container) plants. Acreage of these ornamentals plants is presently unknown, but the total acreage of ornamental *Solanum* spp. is probably less than 100 ha.

The Netherlands: host plant species (reproduction possible) grown outdoors

Solanum nigrum (black nightshade) and *S. dulcamara* (bittersweet, climbing nightshade) are common weeds outdoors (www.soortenbank.nl; last access 30th August 2012). *S. nigrum* is known as a host plant on which *A. eugenii* can reproduce. Other native *Solanum* species are *Solanum physalifolium* and *S. triflorum*, but these species are rare. Ornamental *Solanum* species can be present in gardens, on patios and balconies.

Whole EU: host plant species (reproduction possible) in greenhouses and outdoors

In the EU, *Capsicum* fruit is grown on more than 120,000 ha and egg plant (aubergine) on more than 25,000 ha (Annex V). In northern and north-western Europe, *Capsicum* fruit is only or mainly grown in greenhouses while in other parts of the PRA area, *Capsicum* fruit is both grown in the open as in greenhouses (e.g. CAMIB, 2006; Fernández et al., 2005; Anonymous, 2013). About 25 *Solanum* species – annuals and perennials - wild and cultivated - are present in Europe; some cultivated species are locally naturalised, some are occasional casual (temporary resident) (Tutin et al., 2001; Celesti-Grapow et al., 2009). Several of these species are known host plants of *A.*

eugenii (Table 2.1) of which for example *S. nigrum and S. dulcamara* occur widespread (CABI, 2011). Other known hosts, such as *S. elaeagnifolium* and *S pseudocapsicum* have been introduced and are locally naturalised and ruderal in southern, central and/or eastern Europe at roadsides, waste places, river-banks, etc. in many habitats (Tutin et al., 2001; Celesti-Grapow et al., 2009).

2.1.2 Specify the pest distribution

A. eugenii probably originates in Mexico from where it has spread to many countries in Central America and southern states of the USA. Outbreaks have been reported from greenhouses in British Columbia (Canada) in 1992 but the pest was eradicated (EPPO, 2011). The pest was found again in greenhouses in Canada (Ontario) in 2009 and 2010; no statutory action was taken to eradicate the pest (CFIA, 2011). In Europe, the pest has been reported in greenhouses in the Netherlands in 2012 and subsequently eradicated (details provided in the present PRA). In 1997, USDA reported multiple interceptions of '*Anthonomus* sp.' from peppers (*Capsicum*) from Spain (Lightfield, 1997) but it was not clear which *Anthonomus* species was involved. *A. eugenii* is not known to be present in Spain. In 2012 and 2013, Spain and Portugal inspected sweet pepper production sites that had trade relationships with a company in the Netherlands where the pest had been found in 2012, but did not find the pest.

Table 2.1. Host plants of *Anthonomus eugenii* (Swezey, 1936; Nishida, 1945; Patrock & Schuster, 1992; Wilson, 1986; Rodriguez-Leyva, 2006; Torres-Ruíz & Rodríguez Leyva, 2012). Presence in Europe (W = western; S=southern, C=central) (Tutin et al., 2001; Celesti-Grapow et al., 2009).

Latin name	**Present in the European Union?**	**Host plants: reproduction possible**	**Host plants: food source for adults, no reproduction known**
Capsicum annuum	Commercial and hobby	X	
	(sweet pepper and chilipepper)	X	
Capsicum baccatum	Hobby (chilipepper)	X	
Capsicum chinense	Idem	X	
Capsicum frutescens	Idem	X	
Capsicum pubescens	Idem		
Solanum americanum	Cultivated, rare casual WSC Europe	X	
Solanum carolinense	Locally naturalised Italy	X	
Solanum dimidiatum	No	X	
Solanum elaeagnifolium	Locally naturalised S Europe	X	
Solanum melongena	Commercial and hobby (egg plant)	X	
Solanum nodiflorum	No	X	
Solanum pseudocapsicum	Pot plant, loc. naturalised SW Europe	X	
Solanum pseudogracile	No	X	
Solanum ptychanthum	No	X	
Solanum rantonettii	Yes (greenhouses, gardens)	X	
Solanum rostratum	Locally naturalised Italy	X	
Solanum triquetrum 1)	No	X	
Solanum axilifolium 2)	No	X	
Solanum madrense 2)	No	X	
Solanum nigrum 2)	Common weed (black nightshade)	X	
Solanum trydynamum 2)	No	X	
*Solanum tuberosum*1)	Commercial and hobby (potato)		X
Datura stramonium	Weed (jimsonweed)		X
Solanum lycopersicum	Commercial and hobby (tomato)		X
Nicotiana alata	Garden plant (sweet-scented tobacco)		X
Petunia parviflora	Garden plant (petunia)		X
Physalis pubescens	Hobby (husk tomato)		X

1)Fruits not tested, 2) No feeding observed

Table 2.2. The Netherlands: acreage and number of companies growing sweet pepper (*Capsicum annuum*) and egg plant (*Solanum melongena*) from 2008 – 2010 (LEI-CBS, 2011; http://statline.cbs.nl; last access 12th June 2013).

Year	Sweet pepper		Egg plant	
	Acreage (ha)	No. of companies	Acreage (ha)	No. of companies
2008	1184	370	97	59
2009	1331	347	95	54
2010	1403	322	104	53
2011	1357	-	101	-
2012	1313[1]	-	105[1]	-

[1] provisional data

Countries/states where *A. eugenii* has been reported from:

USA: there is some conflicting information about the distribution of *A. eugenii* in the USA. EPPO (2011) has listed 11 states where the pest is present: Arizona, California, Florida, Georgia, Hawaii, Louisiana, New Mexico, Texas, Virginia, North Carolina and South Carolina. Burke & Woodruff (1980) have mentioned records of *A. eugenii* in California, Arizona, Hawaii, Florida, Louisiana, Georgia, New Mexico, New Jersey and North Carolina and Diaz et al (2004) from Arkansas. Schultz & Kuhar (2008), however, have indicated that the pest is present in Florida, Texas and California and occasionally occurs in more northern locations with records available from New Mexico, Georgia, North Carolina and New Jersey. *A. eugenii* was detected in a sweet pepper field in Virginia Beach (Virginia) in summer 2007 (Schultz & Kuhar, 2008) but the pest was never detected again since that find (P. Schultz, Virginia Tech, pers. comm., 3-12-2012). Rodriguez-Leyva (2006) has stated "Presently, the pepper weevil is a pest in all pepper growing areas of the United States including North Carolina and New Jersey" referring to a paper from Burke & Woodruff (1980). According to Capinera (2011), "it is now found across the southernmost United States from Florida to California. Pepper weevil populations persist only where food plants are available throughout the year, largely limiting its economic pest status to the southernmost state in the USA. Because transplants are shipped northward each spring, however, pepper weevil sometimes occurs in more northern locations." Thus, persistent populations of *A. eugenii* may only be present in Florida, Texas and California while transient populations may occur in more northern states as illustrated by the finding of the pest in Virginia by Schultz & Kuhar (2008).

Central America and Caribbean: Belize, Costa Rica, Mexico, Nicaraqua, El Salvador, Guatemala, Honduras, Puerto Rico (EPPO, 2011), Dominican Republic (Muniappan et al., 2011), Jamaica, Panama (Rodriguez-Leyva, 2006)

Oceania: French Polynesia (Hammes & Putoa, 1986)

Canada: found in greenhouses in Ontario in 2009 and 2010; no statutory action was taken (CFIA, 2011). The current pest status in Canada is uncertain because no official measures are taken against the pest.

2.2 Probability of entry

2.2.1 Identification of pathways

Fruit of *Capsicum* spp.

A large proportion of the life cycle of *A. eugenii* takes place inside the fruits where larvae, pupae and young beetles can be present. Fruit is considered the main pathway by EPPO (1997): "*A. eugenii* can only spread over limited distances naturally, but is liable to be transported internationally in fruits of capsicums and possibly aubergines. This is presumably what has happened in Central America. Adults can survive prolonged cool conditions (2-5°C) for over 3 weeks and be transported as immatures in fresh fruits." The pathway "fruit of *Capsicum* spp." will be analysed in more detail below. This pathway does not include dried fruit because drying is expected to kill most life stages; eggs might survive but hatching and subsequent development of the larvae to an adult is unlikely to occur in dried fruit.

Fruits of *Solanum spp.*

See above: *A. eugenii* can reproduce on several *Solanum spp.* and, therefore, fruits of *Solanum* spp. may act as a pathway (EPPO, 1997). Fruit of *Solanum melongena* is being inspected at import and *Anthonomus eugenii* has been intercepted once (in the Netherlands in 1999; De Goffau, 2000). The pathway "fruit of *Solanum* spp." will be analysed in more detail below.

Plants for planting of Solanaceae, other than seeds

Import of plants for planting of Solanaceae is a potential pathway, but presently import of plants for planting of Solanaceae, other than seeds, is prohibited from most non-EU countries including those countries where the pest is known to be present (2000/29/EC). Illegal imports may occur but cannot be quantified. For these reasons, this pathway is not further analysed in the present PRA.

Plants for planting of non-hosts, non-agricultural products, visitors (hitch-hiking)

A. eugenii is unlikely to be associated with non-hosts (non-Solanaceae) and non-agricultural products. There is, however, a large import volume of plants from Central America. For example, 25 million plants of *Draceana*, 148 thousands of *Yucca* and 556 thousands of *Phoenix* plants were imported from Costa Rica into the Netherlands in 2011 (source: import database of the NPPO of the Netherlands). Transport can be by boat or by airplane. The larger volumes are generally transported by boat. Transport time per boat takes about 3 weeks and temperature during transport is probably around 15°C (information from importing companies). It is uncertain whether adults of *A. eugenii* can survive three weeks at 15°C without a host plant and would still have enough energy to fly to a host plant once arrived in the EU. Plants for planting are inspected at import and, thus far, *A. eugenii* has never been intercepted. Visitors from America might carry the pest in their clothes or hair and after visiting a greenhouse the pest may be transferred to a *Capsicum* crop. The likelihood of such an event seems low. The probability of entry is, therefore, assessed low for this pathway (hitch-hiking with non-hosts or humans) and the pathway is not further analysed (there are no data available which could lead to a more accurate assessment).

Passenger luggage/smuggling

Passengers may carry *Capsicum* and *Solanum* fruits. Interception data from the USA and also the Netherlands indicate that pest organisms are regularly present in passenger luggage (Caton & Griffin, 2006; nVWA, 2011). It is a potential pathway for *A. eugenii* but the probability of entry along this pathway is assessed to be much smaller than through commercial import. The number of individual peppers in luggage is likely to be small, the individual weevils unmated and the potential for them to find a mate and transfer to a greenhouse appears negligible unless greenhouse staff would carry peppers from infested areas. For this reason, and also because of lack of data on volumes brought in with passengers, this pathway is not further analysed. Smuggling of *Capsicum* plants may pose a higher risk than fruits carried by passengers especially if such plants were to be placed in commercial greenhouses. This could happen but because of lack data not further analysed in the present PRA.

Natural spread
Natural spread from America to Europe is not possible.

2.2.2 Analysis of pathways identified

Pathway 1: Fruits of *Capsicum* spp.

Probability of association
A large proportion of the life cycle takes place inside the fruits and eggs, larvae, pupae and young freshly emerged beetles can be present in *Capsicum* fruit. Percentages of infested fruits can be up to 100% (Riley & King, 1994; see also question 2.5.1). The percentage of infested fruits moving in trade will be much lower than percentage of infestation in the field because infested fruits usually drop and are not harvested. However, the pest has been found on fruits moving in trade. In a draft pathway-initiated PRA for *Capsicum* fruit from Jamaica the USDA (2012) reported 4 interceptions of *A. eugenii.* Import of *Capsicum* fruit from Jamaica into the USA started in the 1990s and was 71,000 kg in 1996 and 100,000 kg in 2011. In Canada, import of fresh peppers is the suspected pathway for greenhouse outbreaks in 1992 and 2009 (Costello & Gillespie, 1993; CFIA, 2011). Canada has intercepted the pest 4 times between 1958 and 1999 (once from Fiji on ship's stores). Between 2000 and 2012, Canada intercepted it 13 times. Interceptions were from Mexico and the U.S.A., all with *Capsicum* fruit (information from the CFIA, February 2012). In south New Jersey (USA), 65 weevils have recently been captured at non-farm locations on yellow stick traps; they were assumed to originate from infested fruit imported from the southern USA or Mexico (http://plant-pest-advisory.rutgers.edu/;last access 27th May 2013). Switzerland recently intercepted a larva of *A. eugenii* in *Capsicum frutescens* from the Dominican Republic (Europhyt, last access 8th April 2013) and in 2013, the Netherlands have detected *A. eugenii* in *Capsicum* fruit (chili pepper) from the Dominican Republic in 14 (sub)lots out of the 57 (sub)lots inspected until 24th June (Photo 3). Currently, fruit of *Capsicum* is not subject to regular phytosanitary inspections in the EU (Directive 2000/29/EC) and, therefore, *A. eugenii* may have regularly arrived in the EU without being noticed. No reports have been found that problems with *A. eugenii* recently have increased in exporting countries which could have lead to higher infestation percentages. The pest has been reported as a major problem in pepper production in southern USA, Mexico, Central America and several Caribbean islands since many years (e.g. Riley & King, 1994).

Photo 3. Infested pepper fruits detected during inspections in the Netherlands, origin Caribbean.

Import volume

Data sources. Import data are available from Eurostat for fresh and chilled fruits of the genus *Capsicum* and *Pimenta* (CN 070960) since 1988*.* Data are also available for "fresh or chilled sweet peppers" (CN 07096010) and for "fresh or chilled fruits of genus *Capsicum* or *Pimenta* excl. for industrial manufacture …, and sweet peppers" (CN 07096099). In addition, the number of pepper fruit consignments imported into the Netherlands was obtained from the Dutch customs for the years 2009 - 2011. The Eurostat data do not differentiate between chili pepper fruits (*Capsicum*) and fruits of the genus *Pimenta* (e.g. allspice) of which only the first one is a host for *A. eugenii*. The data from the Dutch customs also give a description of the product usually as "peppers" and sometimes as "fresh chili pepper". The description "fresh chili pepper" indicates fruit of the genus *Capsicum*. The description "peppers" also suggest that it concerns fruit of the genus *Capsicum*. Here, we assume that the majority of the import under CN-code 07096099) concerns fresh or chilled fruit of *Capsicum* spp. also because "Pimenta" (including allspice) seems to be mainly imported as dried or crushed or ground fruits in the USA from Mexico, Jamaica, Guatemala and Honduras (USAID, 2011) while the products under CN code 07096099 concerns "fresh and chilled fruits .." and are especially imported from the Dominican Republic (Figs 2.1-2.2). Also note that chili peppers from the genus *Capsicum* may be indicated as "pimento". Thus in this PRA, Eurostat import data under CN-code 07096099 are mainly or only assumed to be fresh or chilled fruit of *Capsicum* spp.

The Netherlands. Relatively low volumes of *Capsicum* fruit are imported from countries where *A. eugenii* is present. In 2011, about 150,000 kg was imported from these countries (Fig. 2.1a) whereas the total import volume of *Capsicum* fruit was approximately 116 million kg, with the majority being imported from Spain (44 million kg) and Israel (44 million kg). Fruit from countries where the pest is present is imported throughout the year (Table 2.3a).

The importation of *Capsicum* fruit into the Netherlands from countries where *A. eugenii* is present has varied between approximately 30,000 and 170,000 kg per year since 1988 (Fig. 2.1a). Mainly chili pepper is imported (Fig. 2.2a). The annual number of consignments ranged from 213 to 273 during 2009 – 2011 (data from Dutch customs, see also Annex II). The main suppliers are the Dominican Republic, USA and Mexico. The total import volume does not show a clear trend but the import volume from the Dominican Republic has increased from 0 to approximately 100,000 kg since 1991 (Fig. 2.1a). The annual import volume from 2006 – 2012 was approximately 3 times higher than from 1992 – 2005 but was similar to the years 1988 – 1991 (Fig. 2.1a).

Canada considers fresh peppers a high risk pathway for introduction of *A. eugenii* (CFIA, 2011). Canada imports much more *Capsicum* fruit from countries where the pest is present than the Netherlands (from 2008 – 2010, about 1250 times more in tonnes; data from FAOstat, item "chillies and peppers, green").

Whole EU. For the whole EU, the import volume has increased since 1988 although the import volumes in 2004 and 2005 were relatively low and comparable to those in the 90's (Fig. 2.1b). The main supplier is the Dominican Republic, followed by Mexico and Nicaragua (Fig. 2.1b, Annex III). Mainly, chilli pepper is imported (Fig. 2.2b). The import volume is relatively small and accounts for 0.6% of the total import volume of *Capsicum* fruit. For chilli pepper alone this percentage is higher: 4.0% (Average values over 2008-2012; Table 2.3c).

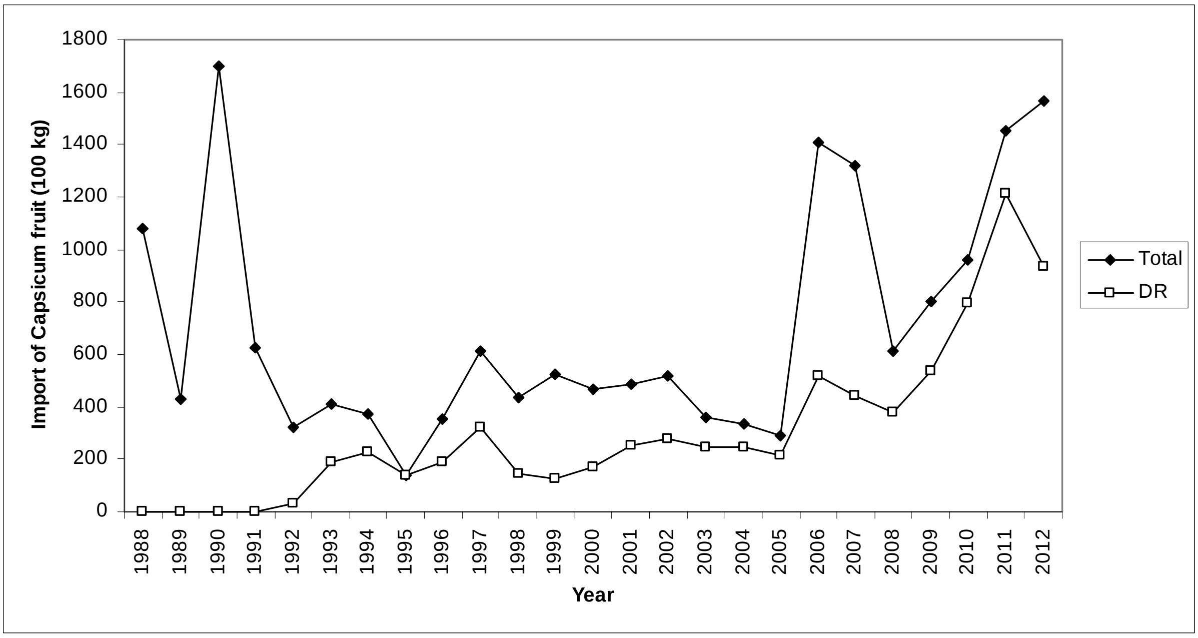

Fig. 2.1a. The Netherlands: import volume of fresh or chilled *Capsicum* fruit from 1988 to 2012 from countries (total) where *Anthonomus eugenii* is present and the Dominican Republic (DR). Data from Eurostat, CN 070960). CN 070960 also includes fresh or chilled fruits of the genus *Pimenta*; it is assumed that the import data include mainly *Capsicum* fruit (see also the text).

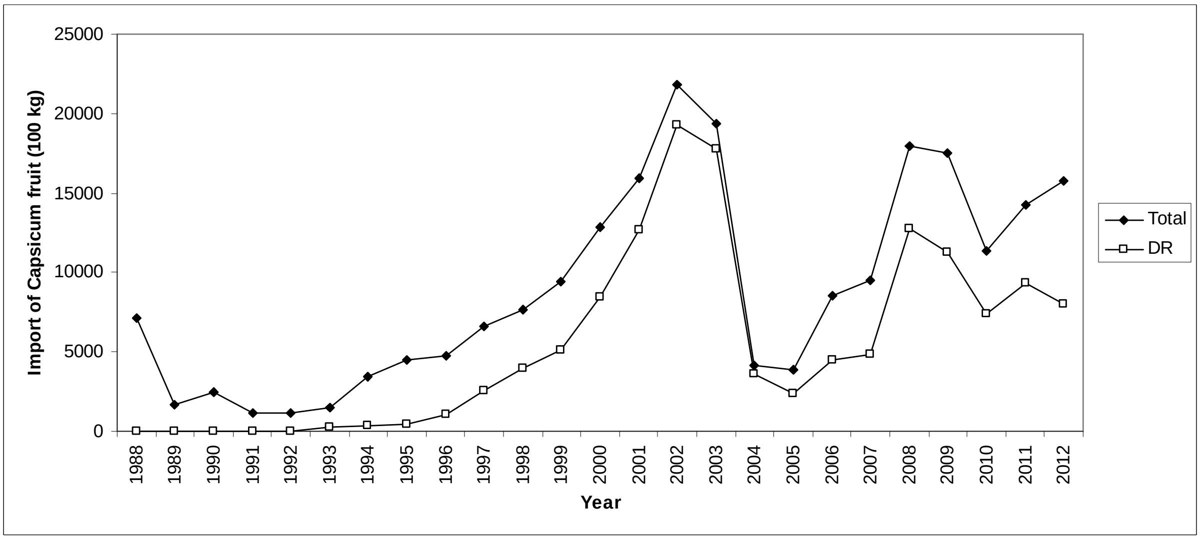

Fig. 2.1b. European Union: import volume of fresh or chilled *Capsicum* fruit from 1988 to 2012 from countries (total) where *Anthonomus eugenii* is present and the Dominican Republic (DR). Data from Eurostat (CN 07096010 & 07096099). CN 0709099 also includes fresh or chilled fruits of the genus *Pimenta*; it is assumed that the import data include mainly *Capsicum* fruit (see text).

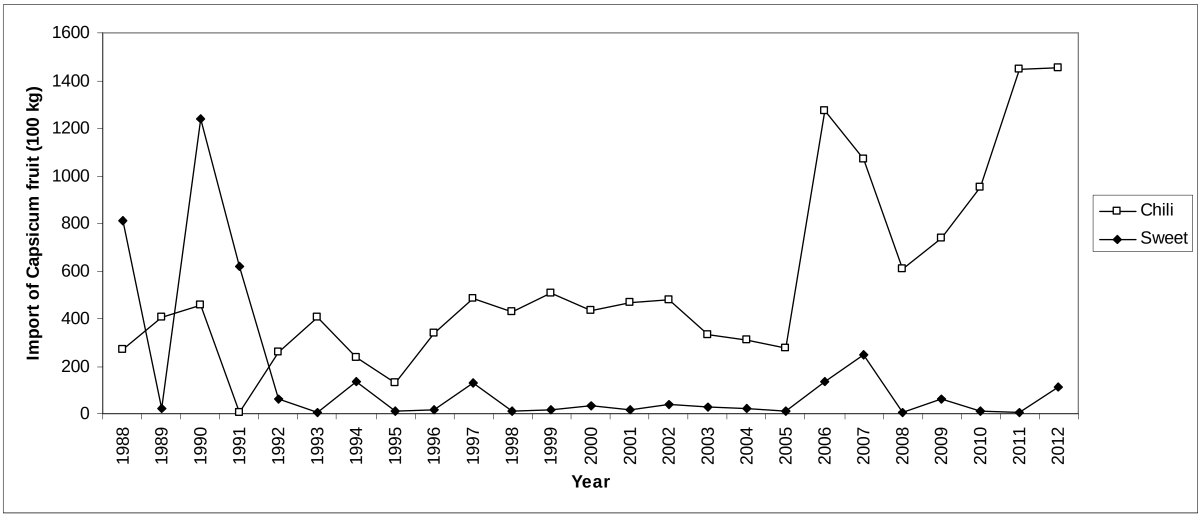

Fig. 2.2a. The Netherlands: import volume of fresh or chilled *Capsicum* fruit, chili pepper and sweet pepper, from 1988 to 2011 from countries where *Anthonomus eugenii* is present. Data from Eurostat, CN 07096010 (sweet pepper) and 07096099 (chili pepper). CN 07096099 also includes fresh or chilled fruits of the genus *Pimenta*; it is assumed that the import data include mainly *Capsicum* fruit (see text).

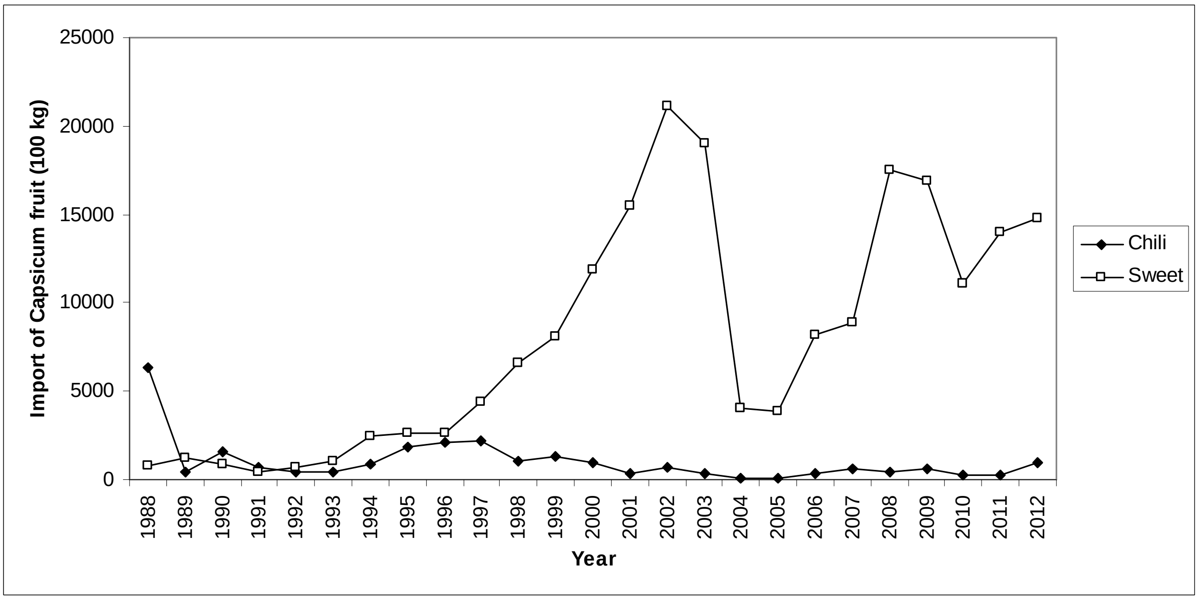

Fig. 2.2b. European Union: import volume of fresh or chilled *Capsicum* fruit, chili pepper and sweet pepper, from 1988 to 2011 from countries where *Anthonomus eugenii* is present. Data from Eurostat, CN 07096010 (sweet pepper) and 07096099 (chili pepper). CN 07096099 also includes fresh or chilled fruits of the genus *Pimenta*; it is assumed that the import data include mainly *Capsicum* fruit (see also the text).

Table 2.3a. The Netherlands: import volume of fresh or chilled *Capsicum* fruit (in 100 kg) per month from countries where *Anthonomus eugenii* is present into the Netherlands in 2010 and 2011 (Data from Eurostat, CN 070960). CN 070960 also includes fresh or chilled fruits of the genus *Pimenta*; it is assumed that the import data include mainly *Capsicum* fruit (see text)).

	Year	
Month	**2010**	**2011**
January	89	96
February	153	184
March	146	266
April	106	292
May	162	223
June	145	134
July	52	74
August	16	28
September	12	26
October	22	15
November	44	23
December	13	91

Table 2.3b. European Union: import volume of fresh or chilled *Capsicum* fruit (in 100 kg) per month from countries where *Anthonomus eugenii* is present into the EU in 2010 and 2011 (Data from Eurostat, CN 07096010 (sweet pepper) and 07096099 (chili pepper). CN 07096099 also includes fresh or chilled fruits of the genus *Pimenta*; it is assumed that the import data include mainly *Capsicum* fruit (see text)).

	Year	
Month	**2010**	**2011**
January	1132	1520
February	1134	1459
March	1286	1821
April	1239	2271
May	1793	2179
June	1144	1638
July	629	722
August	260	454
September	298	197
October	358	411
November	1079	666
December	935	939

Table 2.3c. European Union: import volume of *Capsicum* fruit (in 100 kg) into the EU, total and from countries where *Anthonomus eugenii* is present from 2008 – 2012 (Data from Eurostat, CN 07096010 (sweet pepper) and 07096099 (chili pepper). CN 07096099 also includes fresh or chilled fruits of the genus *Pimenta*; it is assumed that the import data include mainly *Capsicum* fruit (see text)).

	Total import volume from non-EU member states			**Import volume from countries where *A. eugenii* is present**		
year	**chili**	**sweet**	**total**	**sweet**	**chilli**	**total**
2008	384,000	2,182,444	2,566,444	17,517	404	17,921
2009	356,708	2,244,740	2,601,448	16,891	588	17,479
2010	381,900	2,125,357	2,507,257	11,127	227	11,354
2011	377,751	2,197,322	2,575,073	14,040	237	14,277
2012	390,421	2,077,892	2,468,313	14,771	959	15,730

Probability to survive transport
Fruit of *Capsicum* spp. from America to the Netherlands is transported by airplane (at about 4 – 10°C) and total transport time will be approximately 1 day (pers. comm. P. Verbaas, Frugi Venta, the Netherlands, 7th September 2012). Beetles can survive temperatures of 2°C for more than 100 days (Costello & Gillespie, 1993). It is expected that also the eggs, larvae and pupae survive such low temperatures. It is assumed that transport conditions from America to other EU member states will be similar.

Probability of transfer
The Netherlands. Generally, *Capsicum* fruit is transported from the airport (Schiphol) to a sorting/packing/distribution centre from where they are sold to retail companies or restaurants. It is also possible that *Capsicum* fruit growers sort and pack imported fruits in close proximity to their own crop. Some years ago, *Thaumatotibia leucotreta* was introduced (an subsequently eradicated) at a greenhouse company that also imported and packed fruits from Africa where *Thaumatotibia leucotreta* is present.

Available data from 2009 – 2011, indicate that *Capsicum* fruit from the Dominican Republic is usually transported to distribution centres located in cities and are (generally) not situated in close proximity to greenhouses. However, fruit from Mexico and USA appeared to be mainly destined for sorting and packing stations in the Westland area which is the main greenhouse area in the Netherlands (data from the Dutch customs 2009 - 2011; information from inspectors of the Netherlands, May 2013). From the sorting/packing stations located in greenhouse areas, beetles may be transferred to greenhouses with host plants, e.g. *Capsicum annuum* and *Solanum melongena*. The temperature inside sorting and packing stations is usually kept cool at 12°C or lower and *A. eugenii* is not expected to fly at such low temperatures (see 2.4.1., below: "Natural spread"). Transfer may, however, occur from discarded fruits or packaging material if they are placed outside the sorting station (e.g. in an open container). Fruits are imported throughout the year and the pest can likely move naturally outdoors during spring and summer. The pest could also be transferred by human activities, e.g. with packaging material (boxes/crates) from sorting facilities to greenhouses. In addition (although considered less likely), the pest may be transferred (e.g. by natural dispersal) from retail or consumer's places to greenhouses. The probability of transfer is assessed to be highest when the *Capsicum* fruit would be sorted and packed at companies that also produce *Capsicum* fruit.

Whole EU. Fruits arrive throughout the year (Table 2.3b) and the probability of transfer is assessed to be similar in a large part of the EU where *Capsicum* fruit is grown under protected conditions and where the pepper weevil is unlikely to establish outdoors (e.g. northern, north-western and central Europe). The probability of transfer is expected to be higher in southern Europe where the pest might be able to establish outdoors in some parts or where conditions are more favourable (higher temperatures) for natural dispersal (see also 2.3 "Area of potential establishment"). The probability of transfer will be highest in cases where imported fruit is sorted and packed in close proximity to greenhouses producing *Capsicum* fruit.

Pathway 2: Fruit of *Solanum* spp.

Probability of association
Anthonomus eugenii can reproduce on several *Solanum* spp. (Table 2.1). In the literature, *Solanum* spp. are mainly mentioned as alternative hosts in absence of a *Capsicum* crop (wild *Solanum* species near pepper fields) (e.g. Aguilar & Servin, 2000; Gordon-Mendoza et al, 1991; Patrock & Schuster, 1987). Import of *Solanum* fruits is mainly (or only) from the cultivated *S. melongena* (see below "Import volume"). Attacks on cultivated *Solanum melongena* has been mentioned in a few papers:

- "*Anthonomus eugenii*, Cano (pepper weevil) was found widely spread in Oahu, attacking various garden peppers [*Capsicum*] and the fruits of egg-plant [*Solanum melongena*] and *S. nigrum*." (Swezey, 1934);
- "Infests fruits of garden peppers and *Solanum nodiflorum*, also eggplant fruits to some extent" (Swezey, 1936);
- "They sometimes live on egg-plant [*Solanum melongena*]" (Elmore, 1942);
- "The only insects consistently found attacking flowers [of eggplant] were the pepper weevil, *Anthonomus eugenii* Cano (Coleoptera: Curculionidae), and the flower beetle, *Euphoria sepulcralis* (Fabricius) (Coleoptera: Scarabeidae) but their population levels were low" (Diaz et al., 2004);
- "..the pepper weevil was able to develop in eggplant (*S. melongena*) in the laboratory, but rarely is observed to attack this crop in the field" (Rodriquez-Leyva, 2006).
- "..eggplant grown in proximity to pepper will sometimes be injured" (Capinera, 2011).

Thus, *Solanum melongena* is clearly less attractive than *Capsicum* spp. for *A. eugenii* and the probability of association of the pest with import of fruit of *Solanum* spp. (mainly *S. melongena*) is assessed to be much lower than with fruit of *Capsicum* spp. The pest has been intercepted once on fruit of *Solanum melongena* by the NPPO of the Netherlands in 1999 (De Goffau, 2000). Other interceptions are not known to the assessors despite the fact that this kind of fruit has been imported from areas where the pest is present and has been subject to phytosanitary import inspections for many years.

Import volume

The Netherlands. Import of *Solanum* fruit from countries where the pest is present is mainly fruit of *S. melongena* from the Dominican Republic (Eurostat; import database of the NPPO of the Netherlands). The import volume from the Dominican Republic varied from 30,000 to approximately 180,000 kg per year between 1993 and 2011 (Fig. 2.3). The import volume is of the same order as the import volume of *Capsicum* fruit (see pathway 1). *S. melongena* fruit has also been imported in small quantities from Guatemala: 300 kg in 2009 and 700 kg in 2010 (Eurostat; data extracted September 2012). *Solanum melongena* fruit is imported throughout the year (Table 2.4).

Whole EU. Import of *Solanum melongena* fruit from countries where the pest is present is mainly from the Dominican Republic Fruit from which the import volume has increased from about 0 to 1.2 million kg between 1988 and 2012 (Annex IV; Fig. 2.3b).

Probability to survive transport

Transport conditions are the same as for fruit of *Capsicum* spp. (see above "pathway 1")

Probability of transfer

Destinations of imported *Solanum* fruit is not known to the assessors but they may also be sorted and packed at stations near greenhouses. See further above (pathway 1).

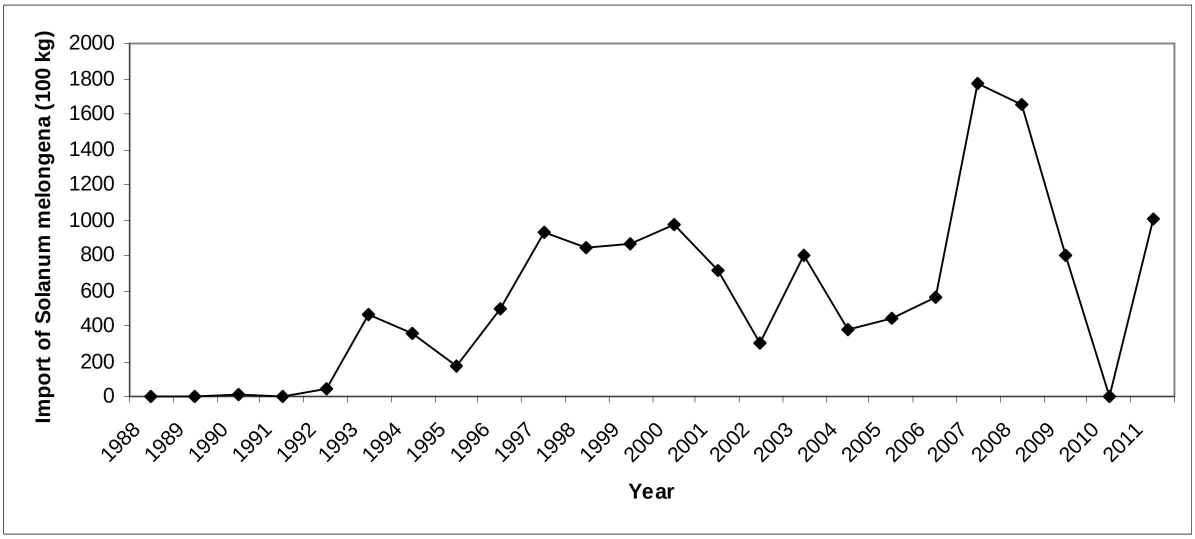

Fig. 2.3a. The Netherlands: import of fruit of *Solanum melongena* from the Dominican Republic from 1988 to 2012. Data from Eurostat (CN 070930).

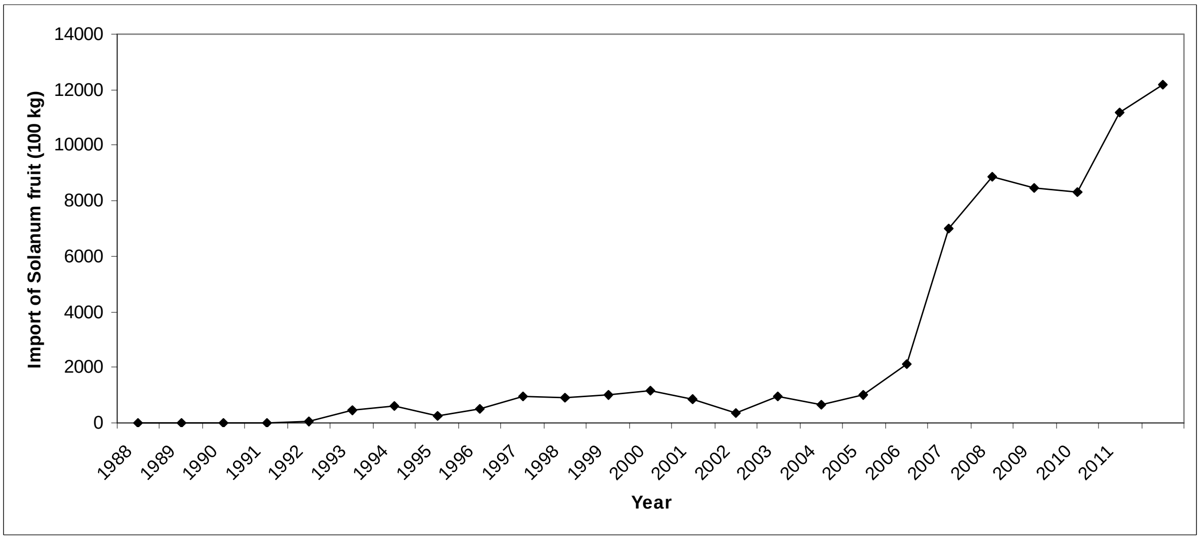

Fig. 2.3b. European Union: import of fruit of *Solanum melongena* from the Dominican Republic from 1988 to 2012. Data from Eurostat (CN 070930).

Table 2.4a. The Netherlands: import volume of *Solanum melongena* fruit (in 100 kg) per month from Dominican Republic in 2009 and 2011 (Data from Eurostat, CN 070930)

Month	Year	
	2009	**2011**
January	64	59
February	50	61
March	74	103
April	63	135
May	62	109
June	45	66
July	43	82
August	44	106
September	54	74
October	79	86
November	104	64
December	117	60

Table 2.4b. European Union: import volume of *Solanum melongena* fruit (in 100 kg) per month from Dominican Republic in 2009 - 2011 (Data from Eurostat, CN 070930)

Month	Year		
	2009	**2010**	**2011**
January	875	598	867
February	636	710	836
March	953	988	918
April	777	1024	836
May	549	987	1035
June	530	392	889
July	602	438	858
August	583	505	788
September	576	472	895
October	790	645	1042
November	784	699	955
December	822	868	1282

Conclusion on the probability of entry

Pathway 1: fruits of *Capsicum* spp.
Probability of entry: "low" with a high uncertainty.
Capsicum fruit from countries where the pest is present has been imported since at least 1988. The outbreak found in 2012 in the Netherlands was the first time the pest was reported from a crop in the EU. Thus, at least 24 years of importation without any known outbreak have succeeded before the first one was reported. The import volume has increased since 1988 but not since about 2000. In the Netherlands, import volumes in recent years were even similar to those around 1990. Assuming that transfer of the pest to a *Capsicum* crop will lead to an outbreak in the majority of cases these data suggest a low probability of entry (less than once in 10 years).

A low probability of entry is also suggested by information from Canada. Canada imports much more *Capsicum* fruit from countries where the pest is present than the Netherlands (from 2008 – 2010, about 1250 times more in tonnes) and packing sheds in Canada are often located in close proximity to greenhouse pepper production sites (CFIA, 2011; information provided by CFIA, 2012). The number of known introductions in greenhouses in Canada was two during the last 20 years (British Columbia and Ontario) although not each introduction may have been reported/detected as the pest has no official regulatory status in Canada.

The assessment, of a "low" probability of entry, is mainly based on the lack of previous outbreaks in the EU. The uncertainty is high because the probability of entry may have recently increased or may increase in the future. The probability of association with the pest might have changed but there are no data to verify this. Most critical for entry seems the transfer possibilities once infested fruit has arrived. Small changes in handling/packing of imported fruits may significantly alter the probability of entry. For example, one grower who decides to pack and sort *Capsicum* fruit from infested countries in a shed directly connected to a production site can strongly increase the probability of introduction from low to high or even very high. Therefore, it is emphasized that the probability of entry can strongly increase (or decrease) by change in handling practices (including change of locations where the fruit is sorted/packed) of imported fruit.

Pathway 2: fruits of *Solanum* spp.
Probability of entry: "low" with a medium uncertainty. Although having the same rating level (the lowest in the range of rating levels provided), the probability of entry by import of fruit of *Solanum* spp. has been assessed to be lower than for pathway 1 because of the much lower probability of association of the pest with *Solanum* than *Capsicum* fruit.

Overall probability of entry: "low" (high uncertainty).

Note
- It is still unknown how *A. eugenii* has entered the Netherlands which led to outbreaks in 6 greenhouses located close to each other. No link has been found yet with import of *Capsicum* or *Solanum* fruit from countries where the pest is present.
- The pest may (incidentally) enter the EU by import of products other than *Capsicum* or *Solanum* fruit but the significance of such pathways is difficult to assess. The probability of association to other products is much lower. Large volumes of non-host plants are imported from Central America by boat but the long transport time also makes entry along that pathway less likely. Thus far, there are no reports of interceptions or findings of the pest which could be linked to products other than *Capsicum* or *Solanum* fruit.

2.3 Area of potential establishment

2.3.1. Factors affecting the limits and suitability of the area of potential establishment

How widespread are host plants or suitable habitats in the PRA area?

The Netherlands
In 2011, about 1,400 ha *Capsicum* fruit crop (sweet pepper) and 100 ha *Solanum melongena* fruit crop were grown in greenhouses in the Netherlands (Table 2.1).

Sweet pepper is grown in greenhouses in the provinces of Zuid-Holland, Noord-Holland, Friesland, Noord-Brabant and Limburg (information from LTO Groeiservice, 10th September 2012). A high concentration of greenhouses is present in Westland (part of Zuid-Holland).

Ornamental *Solanum* spp. are also grown in greenhouses but on a limited scale (e.g. *Solanum jasminoides*, *S. rantonnettii* and *S. pseudocapsicum*). *A. eugenii* may also establish in these greenhouses. *S. rantonnettii* and *S. pseudocapsicum* have for example been reported as a host plant on which *A. eugenii* can reproduce (Table 2.1). Also, *Capsicum* pot plants are grown in greenhouses on which *A. eugenii* can reproduce.

Whole EU
Capsicum fruit (pepper) and *Solanum melongena* (egg plant) crops are grown in an area of more than 120,000 and 25,000 ha, respectively (Annex V). In northern and north-western Europe, *Capsicum* fruit is only or mainly grown in greenhouses while in other parts of the PRA area, *Capsicum* fruit is both grown in the open as in greenhouses (e.g. CAMIB, 2006; Fernández et al., 2005; Anonymous, 2013; Ecofaber, 2013). The presence of a pepper crop in relation to time of the year is discussed below ("Effect of management practices")

The presence of host plants throughout the year is probably a prerequisite for establishment outdoors and in absence of a *Capsicum* crop, wild *Solanum* spp. can serve as alternative host plants (e.g. Patrock & Schuster, 1987, 1992; Riley & King, 1994). Wild *Solanum* species such as *S. nigrum* and *dulcamara* are widespread in Europe (CABI, 2011) whereas the introduced *S. elaeagnifolium* has naturalised in the Mediterranean area. In addition, several *Solanum* spp. are grown as ornamental at commercial production sites and consumer's places (Table 2.1). The presence of wild *Solanum* species as affected by climate and season is discussed below ("suitability of climate").

A. eugenii has only been reported from *Capsicum* crops or *Solanum* spp. nearby and the presence of *Capsicum* sp. during at least part of the year might be a prerequisite for establishment. Patrock & Schuster (1987) found the highest number of adults on *Solanum americanum* following the moving of an infested *Capsicum* crop nearby after which the number of adults decreased. In a later study Patrock & Schuster (1992) found similar developmental times of *A. eugenii* in excised fruits of *C. annuum*, *C. frutescens*, *S. americanum* and *S. ptycanthum* and they discussed that wild *Solanum* spp. could support population increase and explained the decrease in the earlier report by a decrease in host plant availability during summer. Elmore (1934) stated "Weevils have been observed breeding in nightshade berries throughout the growing season, and their flight into pepper fields had some effect on the progress of infestations. Quantitative data to support this statement were, however, not presented. Thus, it remains uncertain if *A. eugenii* can establish in vegetation with wild *Solanum* spp. in absence of any *Capsicum* spp.

Suitability of climate (outdoors)

Anthonomus eugenii is a (sub)tropical pest. In the USA, *A. eugenii* seems only to persist throughout the year in (southern parts of) Texas, Florida and California (see above: 2.1.2). The presence of host plants throughout the year has been indicated as prerequisite for establishment because the pest is not known to enter a diapause (Riley & King, 1994; Capinera, 2011). In a laboratory experiment, adults died within 15 min when exposed to about -10°C (Costello & Gillespie, 1993). It is not known if adults can survive longer periods at milder freezing temperatures. However, green parts of *Capsicum* and *Solanum* spp. usually do not survive temperatures below 0°C and the plants die back in the autumn in the largest part of the PRA area. Thus, freezing temperatures are likely a limiting factor for establishment both because of direct effects on the pest and the availability of a food source. Persistent populations of *A. eugenii* are known to be present in plant hardiness zones 10 and higher (Annex VI: southern Florida and southern Texas and California). They may also be present in the milder parts within hardiness zone 9 (e.g. in more northern areas of Florida and Texas), but no reports have been found about the exact distribution of persistent populations in these states. It may also be difficult to determine when the pest can migrate in from milder areas. In hardiness zone 8 or lower, only transient populations seem to occur (see 2.1.2). For example, in Virginia (USA) the pest could not be found in pepper fields after the finding of the pest in the previous year (see 2.1.2). In the EU, plant hardiness zones 9 or higher are present in (parts of) Ireland, UK, Denmark and the Netherlands (western coastal areas in both countries) France (western and most southern part), Portugal, Spain, Italy, Greece, Malta and Cyprus (Fig. 2.4; Annex VI). In the Netherlands, *A. eugenii* is, however, unlikely to survive during winter because temperatures usually drop below 0°C in the entire country for at least several nights and wild *Solanum* spp. usually die away during winter (there may be exceptions during mild winters). The average number of days with temperatures below 0°C ranges from 25 to 70 days, being more than 45 days in the majority of the country (http://www.knmi.nl/klimatologie/; last access 29th May 2013). Thus, the upper limit of the potential area distribution of *A. eugenii* may be between hardiness 9 and 10. Incidentally, *A. eugenii* may survive in cooler areas because adults can survive inside buried pods as long as the pod remains unfrozen (pers. comm. D. Riley, University of Georgia, June 2013).

Not only winter temperature will determine the presence of green parts of host plants throughout the year but also precipitation. Except for river-banks, water-sides and irrigation canals, wild *Solanum* plants may die away during hot dry summers in parts of the Mediterranean area and regenerate or germinate from seeds in the autumn which could be a limiting factor for establishment of *A. eugenii* in these areas when no *Capsicum* crop is present. Water stress has been indicated to limit the presence of wild *Solanum* spp. during summer in Florida, and thereby affecting the survival potential of *A. eugenii* (Patrock & Schuster, 1987). There are, however, *Solanum* spp. (e.g. the perennials *S. linnaeaum* and *S. elaeagnifolium*) which are present in the Mediterranean area and are tolerant to drought (Wasserman et al., 1988 in EPPO, 2007; Lester et al., 2011); they flower and produce fruits during summer and could act as an alternative host on which *A. eugenii* could feed and reproduced until the next *Capsicum* crop is planted. *S. linnaeaum* (syn. *S. sodomeum*) is not know as a host of *A. eugenii* but could be one. Most likely, this plant species has never been exposed to *A. eugenii* because it is not known from America (Tutin et al., 2001; Lester et al., 2011).

Summer temperatures will also have a direct effect on the establishment potential of *A. eugenii*. The threshold temperature for development of the pest is about 10°C and the optimum temperature for development 30°C (Toapanta et al., 2005). The minimum temperature for flight is not known but may be above 15°C or even higher (see 2.4.1). Thus high temperatures will support population development. The accumulated number of degree days base 10°C in the areas where persistent populations are present is probably above 3,000 (Annex VII). Such high number of accumulated number of degree days are only reached in the eastern part of Cyprus, on Malta and very locally in southern

Spain (Fig. 2.5). Thus, although winter temperatures might allow for survival in more northern areas in the EU (e.g. coastal areas of Ireland, UK and France), it seems unlikely that *A. eugenii* can establish in the open field in those areas because summer temperatures are unfavourable for the pest and, maybe more important, *Capsicum* spp. are not grown in the open. The pest may, however, survive near pepper greenhouses in the open after removal on the crop in the autumn/winter and re-enter during spring when temperature increases and *A. eugenii* becomes more active. Climatic conditions in parts of southern EU (areas in plant hardiness zone 10 and possibly the milder areas in zone 9) are more likely to support persistent populations in the open field.

It was not considered useful to make a more detailed assessment of the potential area distribution by using for example CLIMEX (Sutherst et al., 2007) because of uncertainties about the exact distribution of persistent populations in the USA (see 2.1.2).

<u>How suitable are protected conditions for establishment?</u>
Protected conditions are likely suitable for establishment. The outbreaks in Canada and the Netherlands show that the pest can reproduce in *Capsicum* greenhouses. See also below "effect of management practices".

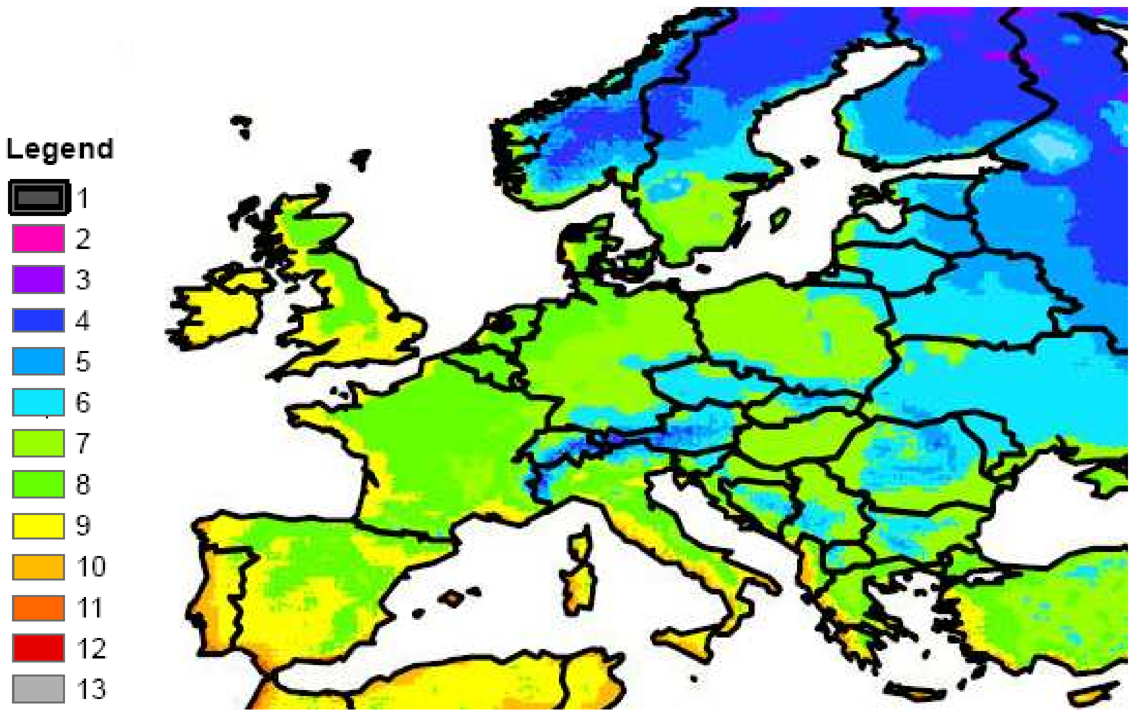

Fig. 2.4. Plant hardiness zones in Europe, excerpt from the world map shown in Annex VI. Source: http://www.nappfast.org/Plant_hardiness/2012/2012%20ph_index.htm

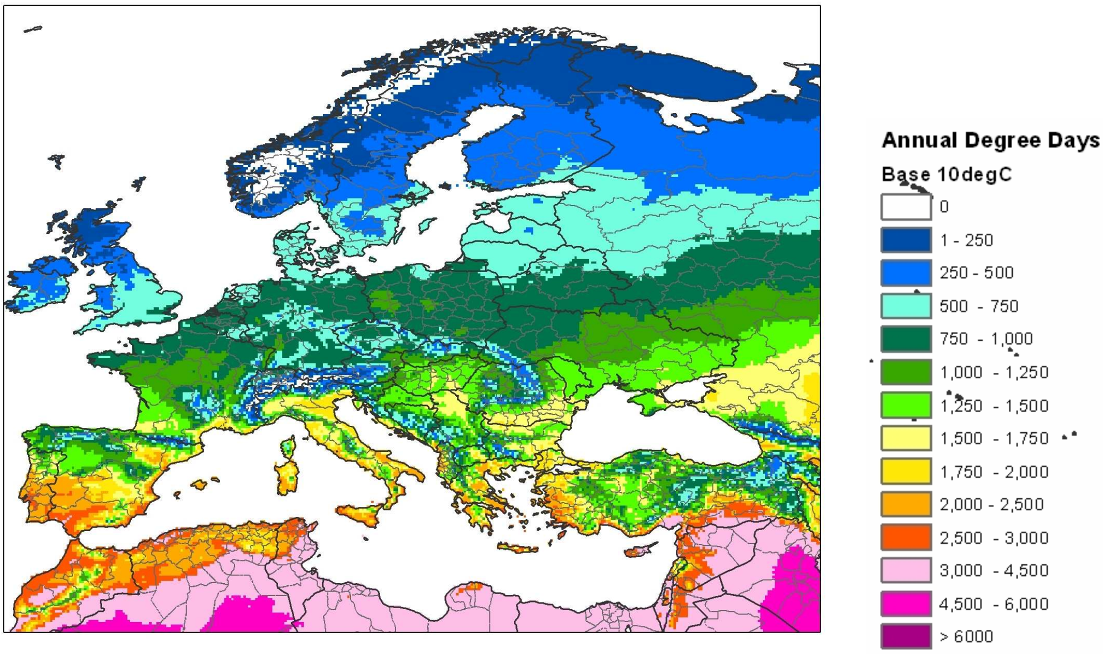

Fig. 2.5. European map of temperature accumulation (Degree Days) based on a threshold of 10°C using 1961-90 monthly average maximum and minimum temperatures taken from the 10 minute latitude and longitude Climatic Research Unit database (New et al., 2002). Maps were kindly provided by R. Baker, FERA, and previously used in the EFSA-project Prima Phacie (Macleod et al., 2012). Similar maps based on the same information but with different degree day intervals were published in 2002 and 2012 (Baker, 2002; Eyre et al., 2012).

Effect of management practices

The Netherlands.

The period between two *Capsicum* fruit crops will be most critical for establishment. The period between 2 crops is usually about 2 weeks during which greenhouses are normally not heated and the average temperature will be around 10°C. Longer and shorter intercrop periods also exist. The period between planting and fruit setting is about 6-8 weeks for a sweet pepper and 4-6 weeks for a chili pepper crop. Adults can survive several weeks without food and longer in the presence of food source (Costello & Gillespie, 1993)[1]. Rodriguez-Leyva (2006) found survival times of females in the presence of a food source between 28 to 103 days with an average of 64.5 days at 27°C. Adults are, therefore, expected to survive and be able to deposit eggs on the fruits which are set about 2 months after removal of the former crop. There are currently no pesticides that may be used to disinfest an empty greenhouse. In Canada, a population of *A. eugenii* was found in a greenhouse in Ontario during the 2009 season and again in spring 2010 (CFIA, 2010) which suggested that the pest had survived the period between two crops although it cannot be excluded that the finding in 2010 was due to a new introduction from outside the greenhouses (e.g. through import of infested fruit).

[1] Costello & Gillespie (1993) found lower survival rates of adults in Petri dishes without a food source than in the presence of a food source at temperatures ranging from 2 – 27°C and concluded that the adults survived better in the presence of food. However, the effect of food at the lower temperatures was unclear because the adults were described as motionless with legs generally curled under the body. Apparently, the adults did not feed at the low temperatures although they survived longer in the presence of food. Maybe, the food source created a higher humidity which might have explained the longer survival times. Conditions in greenhouses may strongly deviate from those in the Petri-dish experiment and, therefore, the survival time in absence of food in greenhouses is highly uncertain.

For *Solanum melongena*, similar intercrop periods are used. *S. melongena* seems, however a much less attractive host plant (see above "host plants") and reproduction may be lower than on *Capsicum* spp. The probability that the pest will persist in the greenhouse after removal of the crop seems, therefore, lower than in case of a *Capsicum* fruit crop

During the intercrop period, adults may feed and survive on other greenhouse Solanaceous crops, like *Solanum lycopersicum* (tomato). There are about 1,600 ha of greenhouse tomatoes (http://statline.cbs.nl; last access 18-9-2012) and greenhouses with pepper and tomato fruit crops are often located in the same areas in the Netherlands. Thus, there is an uncertainty to which extent other Solanaceae crops could act as a refuge and contribute to the establishment potential of *A. eugenii* in the Netherlands.

A. eugenii may also reproduce on *Solanum* and *Capsicum* pot plants. However, these plants may only be grown during certain periods of the year and reproduction will only be possible when the pot plants bear fruit. These factors make greenhouses with pot plants less suitable for establishment than *Capsicum* fruit crops.

Whole EU
Conditions in greenhouses in member states in northern and north-western Europe will probably be quit similar to those in the Netherlands (see above) and a pepper crop may be present nearly all year round.

In areas in southern EU where peppers are produced in greenhouses from autumn to spring (e.g. Fernández et al., 2005; Anonymous, 2013), *A. eugenii* may survive in between two greenhouse crops in the open field, either on a field-grown pepper crop (if nearby) or on wild *Solanum* spp. In Florida, *A. eugenii* was found on *S. americanum* during summer after removal of infested *Capsicum* crops (Patrock & Schuster, 1987). Dry summers in the Mediterranean area may, however, limit the presence of green and fruit-carrying *Solanum* plants which may decrease the survival chances of the pest (see above "suitability of climate").

In some areas, both greenhouse and field-grown crops are present, for example in Puglia, Sicily, Campania, Calabria, Lazio and Veneto in Italy (Ecofaber, 2013). Establishment will be supported when greenhouse and field-grown crops overlap.

Effect of soil properties
Not relevant.

Effect of existing crop protection measures
Insecticides are generally not very effective against the pest because the larvae, pupae and the young freshly emerged adults are protected within the fruit. Also, *Capsicum* growers in at least part of the PRA area control pests in an integrated way by use of biological control agents (which are not effective against *A. eugenii*) and pesticides are only incidentally used. Thus, existing measures are not expected to prevent establishment of *A. eugenii*.

2.3.2. Reproductive strategy and transient populations

How likely can the pest establish starting from a low initial inoculum level/a few individuals? (take into account the reproductive strategy of the pest)
In principle, one fertilized female is sufficient to start a population. Mating usually takes place about 2 days after emergence, and may occur several times, but a female needs to mate just once to remain fertile for her entire life (Elmore et al., 1934). Parthenogenic reproduction is not known to occur.

How likely will transient populations occur?
In the largest part of the PRA area where establishment is unlikely to occur outdoors, transient populations may occur during the summer half year, for example on a field-grown *Capsicum* crop or on wild *Solanum* spp.

2.3.3 Description of the area of potential establishment

Protected cultivation: The pest can likely establish in greenhouses with a nearly continuous *Capsicum* fruit crop. In areas with mild winters, *A. eugenii* may be able to survive in the open after removal of the crop in the autumn/winter and re-enter the greenhouse in the spring. Establishment in greenhouses where *Solanum melongena* and Solanaceae pot plants are grown is uncertain. The pest can reproduce on *S. melongena* but *S. melongena* is a much less favourable host plant than *Capsicum* spp. For establishment in greenhouses with Solanaceae pot plants, the presence of fruits will be needed to allow reproduction. It is unknown if fruit-bearing Solanaceae pot plants are present in the same greenhouse throughout the year. It may concern specialties which are only produced during certain seasons. In areas in southern Europe where peppers are produced in greenhouses from autumn to spring, the pest may survive on wild host plants or on field-grown pepper during summer and may be re-introduced in the greenhouse in the autumn.

Outdoors: *A. eugenii* may be able to establish in *Capsicum* fruit production areas in the open in plant hardiness zone 10 and higher and the milder areas in zone 9 in southern EU which include roughly the Mediterranean coastal regions, the islands in the Mediterranean Sea, southern Portugal and the western half of Portugal. The limits of the potential area of distribution are uncertain. The presence of host plants throughout the year, e.g. wild *Solanum* spp. in absence of a *Capsicum* crop, seems a prerequisite for establishment and absence or low prevalence of green and fruit carrying host plants during hot dry summers in the Mediterranean area might limit establishment. It is uncertain if *A. eugenii* can establish in wild *Solanum* vegetations; the presence of a Capsicum crop during at least part of the year might be needed for establishment. In areas where populations cannot persist, transient populations may occur by natural migration of the pest from infested greenhouses or by human assisted pathways.

2.3.4 How often has the pest been introduced into new areas outside its original area of distribution? (specify the instances, if possible)

The origin of *A. eugenii* is probably Mexico from where it has been spread to many countries in Central America and southern states of the USA (EPPO, 1997; Rodriquez-Levy, 2006). It has been introduced into greenhouses in Canada in 1992 and 2009, presumably with import of *Capsicum* fruit (Costello & Gillespie, 1993; CFIA, 2011).

2.4 Spread

2.4.1 Natural spread
There are only few quantitative data available of natural dispersal distances of *A. eugenii.* The EPPO-datasheet (EPPO, 1997) states "*A. eugenii* can only spread over limited distances naturally" but no distances have been indicated. Riley (1990) studied dispersal of marked adults in a field in Florida. In that study marked adults were not detected at the farthest field margin (distance of about 50 m from the release point) until 2 week after the release. Only a small percentage of marked adults were recaptured and the author indicated that long range dispersal could have occurred without detection. It was observed that plant-to-plant flight occurred more frequently when air temperatures were higher.

Spread between greenhouses is probably possible especially when greenhouses with host plants are close to each other and when days are sunny and warm (temperatures above 20˚C). In Canada, two introductions have been reported, one from British Columbia in 1992 and one from Ontario (Costello & Gillespie, 1993; CFIA, 2011). In Ontario, several greenhouses were found infested. Also, in the Netherlands several (total of 6) greenhouses were found infested in 2012. These greenhouses were all in an area within a radius of approximately 1.5 km which suggested that the pest had spread naturally between greenhouses although spread by human assistance could not be excluded.

Temperature affects natural spread. The minimum temperature for flight of *A. eugenii* is not known. Threshold temperatures for flight of the related boll weevil (*A. grandis*) is about 15˚C (Fenton & Dunham, 1928; Jones & Sterling, 1979). Flight activity increases with temperature. In experiments of Jones & Sterling (1979) 50% of adults had initiated a flight at temperatures of 25.0 – 28.8˚C and 90% at temperatures of 25.7 – 35.0˚C depending on the adult population (adults were obtained from several sources and conditioned differently). The temperature threshold for walking of *A. grandis* averaged 2.6˚C in experiments by Jones & Sterling (1979). The threshold temperature for locomotor activity is higher for *A. eugenii.* Costello & Gillespie (1993) did not observe movement of adults placed at 10˚C: "Adults at 10˚C were generally found in a standing position, although significant movement was not seen until the dishes had warmed slightly at room temperature".

2.4.2 Spread by human assistance
The pest can be spread with infested fruits over long distances; this has presumably happened in Central and North America (EPPO, 1997; CFIA, 2011; see also the entry section). The pest may also be spread with contaminated clothes, packaging material, machines etc. although there are no data to substantiate this.

2.5 Probability of introduction
The probability of introduction is like the probability of entry assessed as "low" (less than one introduction in 10 years). The uncertainty of this assessment is high as already discussed in 2.2.2 (Probability of entry).

Conclusions on the area of potential establishment, probability of introduction (entry + establishment) and the probability and rate of spread

Area of potential establishment: The pest can likely establish in greenhouses with a nearly continuous *Capsicum* fruit crop. In areas with mild winters, *A. eugenii* may be able to survive in the open after removal of the crop in the autumn/winter and re-enter the greenhouse in the spring. Establishment in greenhouses where *Solanum melongena* and Solanaceae pot plants are grown is uncertain. *A. eugenii* may be able to establish in *Capsicum* fruit production areas in the open in plant hardiness zone 10 and higher and the milder areas in zone 9 in the southern EU. These are roughly the Mediterranean coastal regions, the islands in the Mediterranean Sea, southern Portugal and the western half of Portugal. The limits of the potential area of distribution are uncertain. The presence of host plants throughout the year, e.g. wild *Solanum* spp. in absence of a *Capsicum* crop, seems a prerequisite for establishment and absence or low prevalence of green and fruit carrying host plants during hot dry summers in the Mediterranean area might limit establishment. It is uncertain if *A. eugenii* can establish in wild *Solanum* vegetations; the presence of a Capsicum crop during at least part of the year might be needed for establishment. In areas where populations cannot persist, transient populations may occur by natural migration of the pest from infested greenhouses or by human assisted pathways.

Probability of introduction (entry + establishment): "low" (high uncertainty). An introduction event is expected to occur on an average less than once every 10 years. However, the probability of introduction can increase by various factors as already discussed in the entry section (see above).

Spread after introduction: natural spread is likely to occur in the field and between greenhouses located at short distances from each other (e.g. within one or maybe several kilometres from an infested greenhouse) during spring and summer when outdoor temperatures are above about 15˚C (exact threshold unknown and the threshold temperature for flight may be higher than 15°C). The pest can also be spread by human assistance (by handling and transport of infested fruits, clothes, machines etc.).

2.6 Potential consequences

Economic impact

2.6.1 What is the economic impact of the pest in its current area of distribution?
Riley & King (1994) have given an overview on yield losses due to *A. eugenii* reported in literature. In several papers yield losses reported varied from 33 – 50%. One paper reported a 100% infestation of fruits. In Florida, all pepper fields inspected in 1935 were infested. Riley & King (1994) estimated the average losses in four southern states in the USA due to *A. eugenii* at 10% despite control measures and also indicated that the losses in pepper production in Mexico were probably much higher. The pest is difficult to control because most life stages are protected within the fruit. Only the mature weevils can be controlled and insecticides are commonly applied at short intervals once buds begin to form (Capinera, 2011). Cartwright et al. (1990) reported that growers in the Rio Grande Valley of Texas (southern Texas, close to Mexico) rely on 8 – 15 insecticide sprays per season and insecticides are applied at 5-7-days intervals.

Outbreaks of the pest have occurred in Canadian greenhouses in the past (see also Q 2.1.2). Increase in control costs could be as much as 20-25%. Yield losses could be up to 40% if the pest was not detected and managed properly (Information from the CFIA, 10th October 2012). There is some production of peppers in greenhouses in countries where the pest is present (Table 2.5) but there are no data on yield losses from these countries. In a factsheet from Florida (Jovicich et al., 2012), *A. eugenii* is mentioned as one of the major arthropod pest in greenhouse peppers along with several other pests.

Attack of *Solanum melongena* (egg plant) has been mentioned in a few reports; yield losses have, however, not been reported (see Q. 2.2.2).

In conclusion: the economic impact of *A. eugenii* in its current area of distribution is "major" in *Capsicum* spp. (yield and/or quality losses are considerable, targeted measures are frequently needed and the treatment is costly). The uncertainty of this assessment is low. The economic impact in *Solanum* spp. in its current area of distribution is "minor" (medium uncertainty because hardly anything has been published about damage in *Solanum* crops).

Table 2.5. Acreage of greenhouse grown peppers (sweet peppers and chili peppers) in North America (Canada, Mexico, USA) in 2011

Country	Total acreage (ha) peppers	Greenhouse (ha) acreage
Canada	1,875	380
USA	30,000	25[1]
Mexico	150,000	775

Sources: Statistics Canada (CANSIM database; CANSIM (database) site: http://www5.statcan.gc.ca/cansim/home-accueil?lang=eng), Mexico (Agrifood and Fishery Information Service SIAP (http://www.siap.sagarpa.gob.mx) and USA (USA (Economic Research Service USDA http://www.ers.usda.gov/); [1] estimate 2009 based on http://agcensus.usda.gov and http://www.agalert.com/story/?id=589 (accessed: 2013-01-14)

2.6.2 What is the potential direct economic impact in the PRA area? *(without any control measures)*

Greenhouses
The outbreaks in Dutch greenhouses have shown that conditions are favourable for population development for at least part of the pepper production in the EU and without proper management yield losses may be severe (tens of per cent or even more) in

greenhouses when no control measures are taken (see 2.6.1) and the potential impact is assessed "massive" (medium uncertainty).

Open field
In field-grown pepper crops in southern EU, "massive" impacts may potentially occur if the pest is able to establish in the vicinity of these fields. For field-grown pepper in areas where *A. eugenii* cannot establish outdoors (the major part of the EU), the potential direct impact will be limited ("medium" impact): transient populations may occur in some years (medium uncertainty). However, if fields can regularly become re-infested for example by use of infested transplants or trade of infested peppers, the potential impact will increase.

2.6.3 Which control measures are available in the PRA area?

Monitoring methods: yellow sticky traps can be used (Riley & Schuster, 1994); pheromone traps are also available (Mellinger & Bottenberg, 2000). Mellinger & Bottenberg (2000) studied the efficacy of pheromone traps. The traps may attract beetles over several hundreds of metres in the absence of a *Capsicum* crop, but in the presence of crops with blooms and fruits weevils may be attracted from within a distance of 6-9 m only. This is because "pepper plants with blooms and fruit produce olfactory compounds that attract weevils, and therefore compete with the pheromone traps". More beetles were caught during crop destruction activities.

Insecticides: Eggs, larvae, pupae and young freshly emerged beetles present in the fruits cannot be controlled with insecticides. Only the adults outside the fruits can be controlled (Rodriguez-Leyva, 2006). Olson et al. (2012) provide a list of insecticides registered for use in pepper production in Florida. Insecticides recommended for use against *A. eugenii* and which also have a registration in the Netherlands in pepper production are mainly limited to the pyrethroids (deltamethrin) and neonicotinoids (thiacloprid and acetamiprid). These insecticides are also registered for egg plant (*Solanum melongena*) production. Some insecticides (azadirachtin, diflubenzuron) recommended for use by Olson et al. (2012) have a registration in other crops in the Netherlands (http://www.ctb-wageningen.nl/, last access 22nd August 2012). Azadirachtin showed variable effects in experiments (Seal & Schuster, 1995). Diflubenzuron decrease hatching of eggs of beetles which have come into contact with the insecticide.

Because, females lay eggs on several consecutive days, there will usually be several overlapping generations in a crop and insecticides should, therefore, be frequently, applied, e.g. at weekly interval. This will, however, disrupt existing biological control systems, pollination with bumble bees and also cause problems with harvest time of the fruits. In the Netherlands, the time between application and harvest of the fruits should be at least 1, 3 and 3 days for pesticides based on thiacloprid (Calypso), acetamiprid (Gazelle) and deltamethrin (e.g. Decis EC, Agrichem deltamethrin), respectively (http://www.ctb-wageningen.nl/, last access 22nd August 2012). In the Netherlands, pesticides are only available from two different groups (neonicotinoids and pyrethroids) and frequent application of these pesticides may lead to resistance of the pest against the pesticides. Control by insecticides may become more problematic in the future when the registration of some insecticides would be withdrawn or its use limited for example because of their high aquatic toxicity (Van der Linden et al., 2012). From 1st January 2014 on, deltamethrin may maximally be used 3 times during one cropping period in the Netherlands (http://www.ctb-wageningen.nl/, last access 28th May 2013). In other EU member states, more insecticides may be available but even in that case control remains problematic because of the cryptic nature of the immature stages as indicated above.

Biological control agents: Several natural enemies are known to prey or parasitize on larvae of the pepper weevil (Riley & King, 1994; Capinera 2008b, Rodriguez-Leyva et al., 2012), but generally these are not considered to be limiting factors for pepper weevil infestations in pepper crops. An external parasitoid, *Catolaccus hunteri*, attacking primarily third instars within flower buds and small fruit (Riley & Schuster, 1992) is often abundant in outdoor peppers. Augmentative weekly releases of this natural enemy reduced the appearance of pepper weevil infested fruits (Schuster, 2007), but releases are still experimental. Introduction of biological control agents in newly infested areas, such as Hawaii en California, resulted in some establishment, but no control success has been reported so far (Capinera, 2008b). Releases of biological control agents may be more successful in greenhouses than in the open field. Yet, at present little is known about the host efficiency and host specificity of *Catolaccus hunteri* and how successful it will be in a *Capsicum* greenhouse. In addition, an environmental risk assessment of such a natural enemy has to be made prior to any of such releases as a biological control agent, to evaluate potential non-target effects.

<u>Cultivation methods</u>: removal of (fallen) infested fruits will be one of the most effective measures. By removal and destruciton of all immature fruits, a large part of a population can be eliminated.

In areas where the pest cannot establish outdoors and the crop is removed during the winter period, *A. eugenii* populations can be strongly reduced and possibly even be eliminated from a greenhouse by application of insecticides against adults prior to removal of the crop and strict hygiene measures in between two crops to remove any plant residue that may harbour living stages of the pest and could act as food source for remaining adults. Pheromone traps in combination with heating the greenhouse to allow for adult flight could be used to check for absence of the pest before a new crop is planted. This approach will be less successful in areas where the pest can survive the crop free period outside the greenhouse and become re-introduced after planting of a new crop. To reduce the probability of re-introduction, insect screens can be placed in vents to reduce the risk of introductions by natural spread. This measure (insect screens) can require a large investment (Annex II). In the Netherlands, most greenhouses growing *Capsicum* fruit do currently not have insect screens.

<u>Conclusion on control measures</u>
Control measures currently available are:

- pheromone traps and yellow sticky traps for monitoring
- insecticides against adults during the crop period. Application of these insecticides will interfere with existing integrated pest management systems, pollination by bumble bees and harvest frequency because of the time interval required between insecticide application and harvesting (differences may exist between EU-member states in the availability of insecticides and use of integrated pest management systems).
- removal of infested (fallen) fruit during the crop period
- strict hygiene measures between two crops to reduce or even eliminate the pest from the greenhouse
- use of screens in the vents to prevent introduction by natural dispersal
- strict hygiene measures (people, machines, clean packaging material) to prevent any introduction by humans
- for companies that sort and pack fruits from other companies: only allow sorting and packaging of fruits at the production place originating from pest-free production places or sites.

2.6.4 What is the expected direct economic impact when the pest would become introduced? *(with the use of control measures)*

<u>*Capsicum fruit production*</u>
Once the pest is present in a *Capsicum* crop, the pest is difficult to control. Repeated application of insecticides will be necessary to control the pest and limit yield losses. These applications can disrupt existing integrated pest management systems. Below a more detailed impact assessment is given for the Netherlands (which may largely also apply to similar cropping systems in other EU member states) and a more general impact assessment for the whole EU.

The Netherlands. In the Netherlands, biological control agents are applied on about 95% of the total sweet pepper production area (http://statline.cbs.nl, last access 26th September 2012). The predator *Orius* sp. is used on about 90% of the total acreage and is sensitive to the insecticides which could be used against the pepper weevil, deltamethrin, thiacloprid and acetamiprid as discussed above (http://neveneffecten.koppert.nl/). Application of insecticides at a high frequency (e.g. weekly) will also make regular harvesting of fruits impossible which is normally 6 days a week during the summer period (see above 2.5.3). On the short term, the direct impact of the pest is, therefore, assessed to be major for individual companies (considerable yield losses, e.g. 5-10% may occur despite control measures and existing biological control systems will be disrupted). The pest can likely spread naturally between greenhouses especially because of the high density of greenhouses in the Netherlands in certain areas (e.g. Westland). *A. eugenii* may, however, not spread very rapidly. In 2012, six greenhouses were found infested, all located in an area within a radius of approximately 1.5 km. The pest might have been introduced into one of these greenhouses and the other 5 greenhouses might have been infested through natural dispersal of the pest. About 40 other greenhouses growing *Capsicum* fruit were present within a 2 km distance from the infested greenhouse but no infestation were found during surveys including the use of pheromone traps (see also stage 3 "Identification and evaluation of risk reduction options" for more details). Thus, after a first introduction the pest is expected to spread relatively slowly during summer when vents are open. The number of infested greenhouses is assumed to decrease after removal of the crop and start of a new crop (usually done in October – November) because growers generally take hygiene measure to get rid of pests and diseases during this period. In Canada, *A. eugenii* has successfully been eradicated from a greenhouse in British Columbia by voluntary measures (Costello & Gillespie, 1993; information from the CFIA, November 2012). Adults can, however, survive several weeks without food and no fumigants or insecticides are registered for use in empty greenhouses and, therefore, there is a risk that not all infestation sources will be eliminated by growers and greenhouses may become re-infested by natural dispersal during spring and summer. On the longer term (if eradication was not successful), growers may decide to invest in screens in the vents although the high costs for screens may limit this investment. Thus, yield losses may become more limited on the longer term because of more drastic measures to eliminate the pest from the greenhouse but at the same time production costs will increase due to these measures.

The total turnover of sweet pepper production was on an average about 370 million euro per year during 2007 – 2009 (Borgdorff & Schutter, 2010). Assuming an average yield loss of 1% due to invasion of *A. eugenii,* this would result in a loss of about 3.7 million euro per year (Annex II). If growers would choose for insect screens because of *A. eugenii*, this would require a large investment with annual costs estimated on 16 - 32 million euros per year (for existing and new greenhouses, respectively) for the total production area, about 1,400 ha (Annex II).

Whole EU. The expected direct impact for greenhouse crops is "major". However, in the northern half of the EU, growers may be able to eliminate the pest from their greenhouse during the intercrop period in winter time especially when the greenhouse is located far from other greenhouse pepper crops (i.e. not located in a greenhouse area). Eradication may, however, be difficult to achieve in dense greenhouse areas (see also "Surveillance, eradication, containment" in part 3 of the present PRA). In greenhouses in southern EU where a pepper crop is present from the autumn to the spring, *A. eugenii* can possibly survive outdoors during summer and re-infest the new crop in the autumn. In such a situation, the pest will be more difficult to control and considerable losses may occur despite control measures.

The expected impact in field-grown *Capsicum* crops will largely depend on the potential of *A. eugenii* to persist in the vicinity of the fields in absence of a crop or the probability that the field becomes infested through human assisted pathways (e.g. Riley & King, 1994). Severe losses ("major" impact) are expected in areas where the pest can survive during winter which may be possible in the southernmost areas of the EU (high uncertainty). In other areas, the impact will be limited ("medium" impact) because transient populations may only incidentally occur. However, if fields are located close to pepper greenhouses or there are other pathways by which the pest could regularly be re-introduced into these "major' impacts may occur.

Solanum melongena fruit production
A. eugenii is not known as an important pest of *S. melongena* (egg plant) in its current area of distribution (Q 2.5.1). Therefore, it is assessed that the pest will generally have a minor impact on egg plant production in the EU. However, *A. eugenii* may be more harmful in greenhouses with a monoculture of *S. melongena* than in field situations in its current area of distribution and, therefore, the uncertainty of this assessment is medium. Also, the lack of information on the impact of the pest on *S. melongena* fruit production in the area of current distribution adds to the uncertainty level.

Production of ornamentals of Solanaceae
Because Solanaceae ornamentals will usually only bear fruits during certain periods of the year, the pest may not be able to establish in commercial greenhouses or could be controlled or even eradicated by the application of insecticides (when flowers and fruits are not present, only adults will be present which can be controlled by insecticides). Generally, a minor impact is expected (medium uncertainty).

Conclusion.
A "major" impact is expected for the production of *Capsicum* fruit in greenhouses (medium uncertainty). In field-grown crops the impact may vary from "medium" to "major" largely depending on the potential of *A. eugenii* to persist in the vicinity of the fields in absence of a crop or the probability that the field becomes re-infested through human assisted pathways (high uncertainty). A "minor" impact is expected for *Solanum melongena* fruit production and the production of ornamentals of Solanaceae although incidentally larger impacts might occur (medium uncertainty).

Indirect economic impacts

2.6.5 To what extent will direct impacts be borne by producers

In general, the economic impact based on an assessment of expected yield losses and increase in production costs may overestimate the final economic impact. Yield losses will result in a lower production volume which may lead to higher prices (e.g. Soliman et al., 2010; 2012). Introduction of *A. eugenii* into the EU may lead to a (local) decrease of the production volume because of direct losses due to the pest. The production volume may also decrease due to increased production costs. Companies may stop or shift to the production of other crops because the production of *Capsicum* fruit is no longer economically profitable. This could (locally) lead to a decrease in production volume and some increase in prices. Thus, consumers may on the long term bear part of the costs of introduction of *A. eugenii* due to higher prices. In the Netherlands, the consumption of sweet pepper is relatively insensitive to price changes having a price elasticity between 0 and -1 (Van Berkum et al., 2003). Price changes due to the pepper weevil are, however, expected to be relatively low due to the open market and not be distinguishable from normal price fluctuations (see also Bremmer et al. (2012) for a decision tree to determine who experiences indirect economic impacts).

2.6.5 What is the expected impact on export markets for the PRA area?

Quarantine status outside the EU

A. eugenii is listed as a quarantine pest in East Africa, Argentina, Brazil, Chile, Paraguay, Uruguay, Jordan (EPPO, 2011) and Japan (NVWA, 2012). Note that this list of countries may not be complete and finding of the pest on EU produce may lead to measures by other countries as well. In such a case, (EPPO-)countries might follow the EPPO recommendation (EPPO, 1997) and only allow import of fruit originating from pest-free areas (PFA) or pest-free production places (PFPP).

Anthonomus eugenii is present in the USA and may be present in some greenhouses in Canada (see Q 2.2.1). However, the USA do not allow any living organisms on import commodities and presence of living specimen of *A. eugenii* on *Capsicum* fruit at the border may lead to rejection of the consignment (pers. comm. J. Roman, NVWA, 6th September 2012). On the other hand, Canada has recently decided not to regulate the pest although approximately 99 % of fresh, greenhouse-grown and field peppers are shipped to the USA (CFIA, 2011). Apparently, Canada does not expect any trade problems should the pest become established in Canadian greenhouses.

Export from the Netherlands

Among the countries where *A. eugenii* is known to be regulated, Japan is the largest importer of *Capsicum* fruit from the Netherlands (Table 2.6). Import of *Capsicum* fruit is generally prohibited in Japan but import is allowed under strict conditions (http://www.pps.go.jp/english/faq/index.html). There are presently about 35 Dutch production places which export to Japan under a specific regime (i.a. monitoring for *Ceratitis capitata*). The export to Japan has increased during recent years to nearly 6 million kg in 2011 (http://kcb.nl/columns/31/veel-paprika-naar-de-vs-en-japan; last access 6th September, 2012). Japan has currently no specific requirement concerning *Anthonomus eugenii* other than that consignments of *Capsicum* fruit should be free of the pest (pers. comm. M. Folkers, NVWA, 6th September 2012)).

The Netherlands export *Capsicum* fruit to at least three EPPO-members outside the EU: the Russian Federation, Norway and Switzerland (Table 2.6). Following the finding of *A. eugenii* in Dutch greenhouses, New Zealand (a non-EPPO country) has requested additional declarations of phytosanitary certificates accompanying *Capsicum* fruit from the Netherlands. The fruit have been sourced from a place of production free from *A. eugenii* or the fruit have been subjected to a treatment effective against *A. eugenii*. Until 11th September, New Zealand had imported 240 tons of *Capsicum* fruit from the Netherlands in 2012 (letter from the NPPO of New Zealand to the NPPO of the Netherlands, 11th September 2012).

Measures by importing countries could have large consequences for individual companies because the finding of one specimen at the company would make export to certain countries impossible. Also, inspection costs would increase for the companies to guarantee pest freedom of the production place or site.

Conclusions for the whole EU

Most *Capsicum* fruits produced within the EU are traded within the EU and a relative small volume is exported (Table 2.6b). The EPPO-countries the Russian Federation and Norway are important trade partners (Table 2.6b). If *A. eugenii* establishes in the EU and trade partners would require guarantees that the product is free of *A. eugenii* this would lead to an increase in inspection costs and possibly some loss of export market size. Thus, a "medium" impact seems most likely (medium uncertainty).

Table 2.6a. The Netherlands: trade and export volume of sweet pepper to EU and non-EU member states from 2008 – 2010, in 1000 kg (source: Borgdorff & Schutter, 2010; KCB, 7th September 2012).

Total/country	**2008**	**2009**	**2010**	**2011**
Total	301,644	330,164	320,613	317,655
Germany	109,605	127,728	121,431	115,305
UK	62,341	58,318	60,403	57,256
USA	10,418	15,557	18,641	20,916
Sweden	16,306	15,538	14,468	17,184
Russian Federation	12,235	13,888	8,782	5,164
France	9,459	10,285	8,571	9,074
Czech Republic	10,736	9,906	9,809	10,812
Poland	8,486	9,476	10,756	12,792
Norway	8,502	8,569	7,641	8,322
Denmark	7,324	7,982	8,674	8,162
Italy	4,539	6,993	6,740	9,027
Switzerland	5,676	6,546	6,934	6,979
Canada	4,882	5,552	1,804	45
Finland	4,509	4,972	4,361	5,133
Ireland	5,681	4,804	5,007	4,071
Japan	2,241	3,540	5,361	5,910
Austria	3,298	2,713	3,826	3,046
Belgium and Luxembourg	2,018	2,552	2,186	2,380
Other countries	13,388	15,245	15,218	16,077

Table 2.6b. Whole EU: trade and export volume of sweet and chili pepper (in 1000 kg) to EU and non-EU member states (total, Russian Federation and Norway) from 2008 – 2012 (data from Eurostat, extracted 28th May 2013, CN 07096010 (sweet pepper) and CN 07096099 (chilli pepper).

Total/country	**2008**	**2009**	**2010**	**2011**	**2012**
EU intra	975,293	1,055,111	1,029,340	1,117,371	1,088,860
EU extra (total)	104,897	116,55	118,603	131,489	146,284
Russian Federation	35,181	33,814	36,195	40,910	55,226
Norway	12,589	13,672	14,156	14,924	15,546

Environmental impact

2.6.6 What is the expected environmental impact in the PRA area?

A "minimal" impact on biodiversity and outdoor vegetation is expected (medium uncertainty). No environmental impact has been reported even not from areas into which the pest has been introduced. *A. eugenii* may cause some damage to wild *Solanum* spp. but it is primarily known as a pest of *Capsicum* crops. Introduction of *A. eugenii* is expected to lead to an increase of insecticide use and thereby to an increase of the impact of pesticides on the environment (Leendertse et al., 2011). If pesticides are used according to label instructions, the application should in principle not lead to unacceptable effects on the environment. Producers will, however, not be able to produce under a label for biologically or ecologically friendly produce if insecticides are (frequently) used.

Social impact

2.6.7 What is the expected social impact in the PRA area?

Social impact will mainly be related to the economic impact the pest can have for individual growers and for the sector as a whole and will not be discussed further (the economic impact has been discussed above).

Endangered area

2.6.8 What is the endangered area?

The endangered area includes all *Capsicum* crops in the EU. It is uncertain if *Solanum melongena* crops are part of the endangered area. They are possibly not endangered because *S. melongena* does not seem to be very susceptible (see 2.2.2 "Probability of entry – Pathway 1: Fruit of *Solanum* spp.").

Conclusions on impact

Endangered area: The endangered area includes all *Capsicum* crops in the EU. It is uncertain if *Solanum melongena* crops are part of the endangered area. They are possibly not endangered because *S. melongena* seems much less susceptible than *Capsicum* spp.

Economic impact: A "major" impact is expected for the production of *Capsicum* fruit in greenhouses with a medium uncertainty. There is uncertainty: in areas where *A. eugenii* cannot overwinter in the open (which is the major part of the EU), the impact may be limited in time and place when growers are able to eradicate the pest from their greenhouses during the intercrop period which is usually during autumn/winter. This will be more likely to achieve for an isolated pepper-greenhouse than in a greenhouse area. In warmer areas in the EU where greenhouse crops are grown from autumn to spring, the pest may be able to survive the summer outdoors on wild host plants or field-grown peppers and the pest may be re-introduced into the greenhouse every new growing season. The impact for field-grown crops in areas where the pest cannot establish outdoors (the major part of the PRA-area) will probably be limited ("medium" impact) because only transient population can occur. However, if fields are located close to pepper greenhouses or there are other pathways by which fields can become regularly re-infested "major" impacts could occur. In the warmer areas of southern EU, the pest may be able to persist in the vicinity of pepper fields during the crop free period and "major" impacts may occur every year (high uncertainty).

Export markets: the impact of *Anthonomus eugenii* for export markets will largely depend on the measures importing countries may take. Thus, the impact is highly uncertain and may range from minor to major. Assuming that at least EPPO-countries outside the EU would require a PFPP this would at least lead to an increase in inspection costs and maybe some loss in export markets. Thus, a "medium" impact (some effects on market size are expected) seems most likely (medium uncertainty).

Environmental impact: "minimal" (medium uncertainty). The pest has not been reported to cause environmental damage even not from areas into it has been introduced. The pest may cause some damage in solanaceous garden plants and weeds but it is primarily known as a pest of Capsicum crops. There could be an indirect environmental effect due to an increased use of insecticides (this effect has not been included in the rating level).

3. Identification and evaluation of risk reduction options

3.1 Indicate the pathway. "import of fruit of *Capsicum* spp." from areas where the pest is present.

3.2 Identification of risk reduction options

Table 3.1. overview of possible risk reduction options for the pathway "import of fruit of *Capsicum* spp."

Risk Reduction Option	Reduction of risk	Justification[1]
I. options at the place of production		
a. Detection of the pest at the place of production by inspection or testing	Yes	Low infestation levels are difficult to detect by visual inspection. Pheromone traps are available but are less efficient in a crop with flowers and fruits than in a vegetative crop.
b. Prevention of infestation of the commodity at the place of production: • use of resistant cultivars, • growing the crop in specified conditions (e.g. physical protection), • crop treatments, and/or • harvest at certain times of the year or growth stages	Yes: physical protection in combination with inspections	Resistant cultivars: not available Specified conditions: physical protection in combination with visual inspections and use of pheromone traps. Crop treatments: can reduce infestation. Harvest at certain times etc: not applicable, young and older fruits can be infested
c. Establishment and maintenance of a pest-free production site, pest- free production place or pest-free production area	Yes by physical protection	In Central America and the southern States of the US, the pest overwinters or oversummers on *Solanum* spp. around agricultural fields (e.g. Riley, 1990; Patrock & Schuster, 1992). The pest may spread over several kilometres and for crops grown in the open field maintenance of a pest free production place or site does not seem feasible.
II. options after harvest, at pre-clearance or during transport		
a. Detection of the pest in consignments by inspection or testing	Yes, but limited by sample size and weak symptoms	Fruits can be infested without apparent symptoms. The level of risk reduction is also limited by sample size.
b. Removal of the pest from the consignment by treatment or other phytosanitary procedures (remove certain parts of the plant or plant product, handling and packing methods)	No (no methods available)	No methods available.
III. options that can be implemented after entry of consignments		
a. Detection during post-entry quarantine	Not feasible	Short shelf-life of the product
b. Consider whether consignments that may be infested should be accepted without risk for certain end uses, limited distribution in the PRA area, or limited periods of entry, and can such limitations be applied in practice	Yes	Packing and sorting of fruits imported from areas where the pest is present outside greenhouse areas.
c. Effective measures that could be taken by the importing country (surveillance, eradication, containment) to prevent establishment and/or economic or other impacts	Yes	Outbreaks in greenhouses in areas where the pest cannot establish outdoors can be eradicated.

[1] a more detailed justification for those options which reduce the risk is given below.

I. options at the place of production

a. Inspection or testing

Very low infestation levels are difficult to detect by visual inspection. However, pheromone traps are available (PHEROCON AM NO-BAIT Traps and 4 PEW Dual Lure Sets (PEW-I & PEW-II): Trécé Inc. OK, USA) and are especially effective in absence of a *Capsicum* crop (e.g. before planting) and also before blooming (Mellinger & Bottenberg, 2000). Visual inspections in combination with pheromone traps can be used to optimize control measures and also to guarantee pest freedom of the production place or site (see below: "c. Pest free production area, place or site").

b. Prevention of infestation of the commodity at the place of production

Resistant cultivars: a few *Capsicum* cultivars have been reported with relatively low rates of infestation but there is no cultivar known to be resistant (Rodríguez-Leyva, 2006).

Crop treatments with insecticides that are effective against the beetles can reduce infestation but not eliminate them (Capinera, 2011).

Physical protection can guarantee pest freedom of the crop but monitoring will be needed (using pheromone traps and visual inspections) to make sure that the pest has not entered through accidental cracks or holes in the protection. In areas with a high prevalence of the pest, double doors may be needed to prevent introduction.

c. Pest-free production area, place or site

Maintenance of a pest-free production place or site in an area where the pest has established outdoors is difficult because *A. eugenii* can use wild *Solanum* species as alternative hosts (Riley, 1990; Rodriguez-Leyva, 2006). In such a situation, a pest-free production place or site may be obtained by complete physical protection in combination with monitoring (see above). Production places or sites may already be monitored before the planting date using pheromone traps because the traps are especially effective in absence of a *Capsicum* crop (Mellinger & Bottenberg, 2000).

A specific requirement for a pest free production place or site (field or greenhouse compartment) within an area where *A. eugenii* is present or has recently been found (e.g. incursion or outbreak in an area previously known to be free of the pest) could be that the production site is monitored for presence of the pest using appropriate monitoring methods including visual inspections and pheromone traps and in case of a finding of the pest, delivery is suspended until the official responsible body determines that appropriate measures have been taken and the pest has not been observed for a period of at least 30 days since the last finding. The period of 30 days includes at least the duration of one life cycle at temperatures of about 20°C and higher (Toapanta et al., 2005). The risk could be further reduced by requiring periods longer than 30 days during which no sign of the pest may have been found. Such a period could even include a period prior to planting of the crop. The intensity and methodology of monitoring may be at least as important as the length of the monitoring period. Monitoring after the finding of the pest could include an increased rate of pheromone traps for the whole production site and especially near the place where the pest was found. In addition, visual inspections including cutting of any suspicious looking fruit could be intensified. The requirement of a pest free period before planting will further reduce the risk because the pheromone traps are more effective in absence of a *Capsicum* crop (see above). However, such very strict requirements can have major consequences even in situations where the risk is low, for example in cases where only a single beetle is found without any signs of further infestations.

II. options after harvest, at pre-clearance or during transport

a. Detection of the pest in consignments by inspection or testing
Infested *Capsicum* fruits can have apparent symptoms (Photos 2 and 3 at pages 4 and 17, respectively). However, a beetle has been found in a seemingly healthy sweet pepper fruit during the eradication actions in the Netherlands in 2012. Also, symptoms can be weaker at early stages (eggs and young larvae) than at later stages of infestation. Thus, not all infested pepper fruits may be detected during import inspections. The risk reduction level will also be limited by sample size. During import inspections, the NPPO of the Netherlands found for example infested fruits in 2 boxes while the pest could not be detected in 3 other boxes belonging to the same consignment.

b. Removal of the pest from the consignment by treatment or other phytosanitary procedures

Fumigation
No effective fumigation methods are known. Fumigation may not be very effective because larvae and the young beetles are protected within the fruits. Also note that the fumigant methyl bromide has adverse effects on the ozone layer and will be phased out in the future.

Irradiation
Dosages needed to kill the pest will probably decrease the quality of the fruits. Lower dosages could, however, be used for sterilization of the pest. The USA has, for example, approved low-dosage radiation which only sterilize insect pests and do not kill them: 150 Gy for tephritid fruit flies and 400 Gy for all insects pests except pupa and adult Lepidoptera. The method is, for example, used in the trade of eggplant fruit from Hawaii to USA mainland (Follett, 2009). Thus, 400 Gy will very likely be effective against *Anthonomus eugenii* and 150 Gy may already be sufficient based on data with other Curculionidae (Follett, 2009; Follett & Weinert, 2012; Hallman, 2011). Experimental studies would be needed to determine the minimum dose required to kill or sterilize *A. eugenii*.

The low dosages that render the pest sterile but do not kill it make it difficult for the importing country to check that the treatment has been effective. Certification of the irradiation facility and accompanying papers demonstrating that the proper dosage has been achieved will be important. The many interceptions of pests on solid wood packaging material despite the present of an official IPPC mark stating that it has been treated by heat or methyl bromide indicate a good control system will be important.

Irradiation at < 1,000 Gy has generally a minor effect on nutritional composition and sensory attributes of a wide range of crops including *Capsicum* fruit (Wall, 2008). However, dosages ≤ 400 Gy can have an effect on the quality of fruits of certain species and differences can occur between cultivars for example in citrus fruits (Wall, 2008). Dose-response studies (various cultivars of) *Capsicum* and egg plant fruit have not been found. However, both fruits of *Capsicum* spp. and *Solanum melongena* are thought to be tolerant to irradiation dosages of 400 Gy (pers. comm. P. Follett, USDA-ARS, 3rd October 2012). Thus far, low-dosage irradiation has not been implemented by the EU in the phytosanitary legislation and irradiation of fresh fruit is currently forbidden in the EU.

Heat treatment
A heat treatment is not possible: temperatures needed to kill the pest will also destroy the product.

Biological treatment
Not available

Conclusion
No treatments exist than can kill the pest in *Capsicum* fruit without negative effects on the fruit quality. However, low-dosage irradiation (400 Gy and possibly 150 Gy) that render the pest sterile and which probably does not significantly affect fruit quality would be effective. Irradiation of fresh fruit is currently prohibited in the EU.

III. options that can be implemented after entry of consignments

a. Detection during post-entry quarantine
Fruits could be stored at high temperatures to enable further development of the pest. Adults emerging from the fruits could be trapped using pheromones. However, this method is not feasible: fruit will lose its value during the post-entry quarantine period.

b. Certain end uses, limited distribution in the PRA area, or limited periods of entry
Measures could be taken to decrease the probability of transfer. Currently, part of the imported fruit is sorted and packed in areas where producers of *Capsicum* fruit are also present (e.g. in Westland, the Netherlands). The probability of natural transfer of the pest can be reduced when packing and sorting of fruits imported from areas where the pest is present takes place outside greenhouse areas. Hygiene measures could be taken to reduce the probability of transfer by human assistance from the packing/sorting facility to the production facilities (greenhouses). Screens could be placed in windows at the sorting and packing houses and any waste should be kept and transported in closed containers. Such measures will not reduce the probability of transfer from retail or consumer’s places.

c. Surveillance, eradication, containment
Early detection of an outbreak can be difficult because of the cryptic nature of the larvae. Pheromone traps are available but less effective in a crop that is blooming (Mellinger & Bottenberg, 2000). Outbreaks in greenhouses in areas where the pest cannot establish in nor survive the intercrop periods in the field can be eradicated by strict hygiene measures after removal of the crop (Costello & Gillespie, 1993). Eradication in an area with a high greenhouse density will be more difficult than in the case of an outbreak in an isolated greenhouse. In an area where greenhouses are located close to each other, the pest may have spread undetected to other greenhouses from where it can reinvade greenhouses from which it had formerly been eradicated. In the Netherlands but also in other countries in the EU (e.g. Almeria in Spain), many greenhouses are concentrated in a few areas and pepper but also tomato (on which adults might feed on and survive for some time) are major greenhouse crops. In the Netherlands for example, sweet pepper and tomato cover more than 25% of the total greenhouse area.

After the finding of *A. eugenii* in a greenhouse in the Netherlands, the following measures were applied to eradicate the pest from the greenhouse:

1. Intensive application of insecticides (pyrethroids and neonicotinoids), followed by
2. Removal and destruction of fruits which were not fully grown (including any fallen fruits and flower buds);
3. Removal of the crop. Insecticides were applied just before removal of the crop and the crop was removed during night to reduce the risk of spread of adults;
4. The crop was shredded and burnt or buried;
5. The greenhouse was cleaned from any crop residue;
6. The greenhouse was fumigated using dichlorvos (emergency registration);
7. A crop free period was required of 2 weeks with a minimal temperature of 20˚C. Intensive monitoring was required during this period using pheromone traps (10/ha).

This protocol was applied successfully on each of the six greenhouses that had been found infested and no weevils were captured during the 2 weeks crop free period after the application of dichlorvos. Additionally, a country-wide survey was conducted and in a zone of 2 – 2.5 km zone around the infested greenhouses all greenhouses growing

Capsicum spp., *Solanum melongena* or ornamental *Solanum* spp. were monitored using pheromone traps. Monitoring in this 2 – 2.5 km zone was conducted in the "old" crop, during the intercrop period (with obligatory heating to 20°C during at least 4 hours on at least 3 days) and in the "young" crop (most *Capsicum* fruit growers remove the "old" crop and plant a "new" crop in November-December). Thus far, no new infestations have been detected.

Thus experiences in British Columbia (Canada) and the Netherlands indicate that outbreaks in greenhouses can be eradicated at least in areas where the pest cannot establish nor survive the usual intercrop period in the open. In warmer areas in Europe, eradication may be much more difficult because temperatures will support natural dispersal during longer periods and the pest can possibly survive the usual intercrop period (summer) on wild *Solanum* spp. in the vicinity of the greenhouses.

In those areas where eradication is possible, the costs can be high especially when the crop has to be removed before the usual intercrop period. For individual greenhouses, the costs for eradication efforts will be much lower should the infested crop be removed and the greenhouse cleaned and disinfested during the usual intercrop period and harvest and sale of fruits from infested greenhouses would remain possible. This approach was successfully implemented in British Columbia (Canada) in the 1990s (Costello & Gillespie, 1993). In the Netherlands, pepper greenhouses can be located close to each other (e.g. Westland) and many greenhouses may become infested through natural or human assisted dispersal of weevils when an infested crop is present during the entire growing season (see above "2.4 spread"). On the other hand, crops are usually removed during November – December when outdoor temperatures normally will not allow for natural dispersal of weevils between greenhouses. This is making this period highly suitable for crop removal without posing a great risk for further spread. A well co-ordinated eradication effort could, therefore, result in total eradication when all greenhouses in the infested area implement sanitary measures during winter when natural dispersal is unlikely to occur. The more greenhouses are infested, the more difficult eradication, however, may be. This will especially be the case when infestations have not been detected before the crop is being removed. In such a case the grower may not take specific measures needed for eradication because the grower is not aware of the presence of the pest. It is also uncertain if Solanaceous crops other than *Capsicum* spp. (e.g. tomato) could act a refuge of adults and contribute to the dispersal and survival of the pest. Thus, in areas where the old crop is removed during winter when outdoor temperatures will not allow for natural spread, eradication may be achieved during the usual intercrop period but it may require a well co-ordinated action and intensive monitoring because the pest may have spread to many greenhouses during the growing season.

3.3 Selection of and conclusions on risk reduction options

Options to reduce the probability of introduction

Pathway 1: import of fruit of *Capsicum* spp.
Three options have been identified which largely reduce the probability of introduction. The impact and feasibility of these measures are evaluated here:

Option I: pest-free area (PFA)
Fruits of *Capsicum* spp. should originate from a pest free area. In practice, this could mean that import of *Capsicum* fruit from (most) countries in Central America and from southern USA where the pest is present would be prohibited. Currently, the import volume from these countries into the EU is relatively small, about 0.6% of the total import volume of *Capsicum* fruit (sweet pepper and chili pepper). For chili pepper alone these countries account for 4% of the import (average over 2008 – 2012; data from Eurostat CN codes 07096010 and 07096099).

Option II: pest-free production place or site (PFPP or site)
Fruits of *Capsicum* spp. should originate from a pest free production place or site. The pest free status of the production place or site should be ensured by intensive monitoring including visual inspection and the use of pheromone traps. Pheromone traps should already be placed in the field before the crop is planted and be present throughout the growing season. In areas where the pest has established outdoors complete physical protection will probably be needed to create a pest free production place or site. Physical protection may be too costly and the option "PFPP" may lead to a (large) reduction of the import volume of *Capsicum* fruit from Central America and the USA (like option I). There is, however, also production of *Capsicum* fruit in greenhouses and these sites may be kept free of *A. eugenii* with some additional investments and hygiene measures.

Option III: irradiation of the product
Irradiation at dosages (400 Gy and possibly 150 Gy) that render the pest sterile would be effective. This option (pre-shipment treatment) would increase the costs for the exporting country and may lead to price increases for the importing country. The method is, however, already used by various countries (Follett, 2009) and would not necessarily interfere with trade. Currently, irradiation is not mentioned as a phytosanitary measure in the EU-legislation (directive 2000/29/EC) although an approved method in a few non-European countries (Follett, 2009; Hallman, 2011). A reason for this may be that European consumers are reluctant to buy food which has been irradiated. At present, irradiation of fresh fruit (option III) is prohibited in the EU and, therefore, not considered a realistic option.

Options I and II are recommended by EPPO (1997). For EU-regulation, detailed requirements for fruits of *Capsicum* L. could be:

(a) the fruits originate in an area being free from *Anthonomus eugenii*,
or
(b) the fruits originate in a place or site of production that is officially monitored for presence of *Anthonomus eugenii* using appropriate monitoring methods,
and
in case of a finding of the pest, delivery is suspended until the responsible official body determines that appropriate measures have been taken and the pest has not been observed for a period of at least 30 days since the last finding.

Notes

- Regulation of *A. eugenii* will lead to inspection of consignments of fruit of *Capsicum* for presence of the pest. Contrary to fruit of *Solanum* spp., fruit of *Capsicum* spp. is currently not subject to phytosanitary inspections (i.e. not compulsary in the EU). A

small proportion of the consignments of sweet pepper is inspected for quality. There is currently no EU-regulation that requires inspection of chili peppers.
- If a pest-free area or pest-free production place or site were one of the requirements, this could lead to a strong decrease in import volume from countries where the pest is present.

Pathway 2: import of fruit of *Solanum* spp.
The options identified for pathway 1 "fruit of *Capsicum* spp." also apply to the pathway "fruit of *Solanum* spp.". No resistant *Solanum melongena* cultivars are known and visual inspection of consignments at the border will probably reduce the probability of introduction but not guarantee pest-freedom. However, less strict measures may be considered for fruits of *Solanum* L. because the probability of association of *A. eugenii* with fruits of *Solanum* is assessed to be much lower than for fruits of *Capsicum*. It may be that fruits of cultivated *Solanum* species are only incidentally attacked.

Conclusions on risk reduction options

Options to reduce the likelihood of introduction
Three options have been identified which will largely reduce the probability of introduction of *Anthonomus eugenii* with imports of fruits:
I Fruits of *Capsicum* spp. and *Solanum* spp. should originate from a pest-free area;
II Fruits of *Capsicum* spp. and *Solanum* spp. should originate from a pest-free production place or site as confirmed by monitoring with pheromone traps and visual inspections;
III Fruits of *Capsicium* spp and *Solanum* spp. originating from areas where the pest is present should be irradiated at dosages that render the pest sterile (dose 400 Gy and possibly 150 Gy). At present, this option is not realistic because fresh fruit and vegetables may not be irradiated nor marketed in the EU;

Specific requirements for fruits of *Capsicum* L. could be:
(a) the fruits originate in an area being free from *Anthonomus eugenii*,
or
(b) the fruits originate in a place or site of production that is officially monitored for presence of *Anthonomus eugenii* using appropriate monitoring methods,
and
in case of a finding of the pest, delivery is suspended until the responsible official body determines that appropriate measures have been taken and no sign of the pest has been observed for a period of at least 30 days since the last finding.

Less strict measures may be considered for fruits of *Solanum* L. (e.g. visual inspections of consignments only) because the probability of association of *A. eugenii* with fruits of *Solanum* is assessed to be much lower than with fruits of *Capsicum*.

Options I and II may lead to a (large) reduction of the import volume of fruits of *Capsicum* (and *Solanum*) spp. from Central American countries and the southern states of the USA where the pest has established outdoors. Pest-free production places or sites (option II) may be created in greenhouses although it could be difficult in areas with high pest prevalence.

Contrary to fruit of *Solanum* spp., fruit of *Capsicum* spp. is currently no regular subject to phytosanitary inspections. A small proportion of the consignments of sweet pepper (not chilli pepper) is inspected for quality.

If a pest-free area of pest-free production place or site were one of the requirements, this could lead to a strong decrease in import volume from countries where the pest is present.

4. Uncertainties

The main uncertainties in the present PRA are:

- The ability of *A. eugenii* to establish outdoors in southern EU and the limits of its potential area of distribution.
- Greenhouse cultivation in southern EU from spring to autumn: the ability of *A. eugenii* to survive summers outdoors on wild host plants and re-infest newly planted greenhouse crops in the autumn.
- Greenhouse cultivation in areas with cool summers and mild winters: the ability of *A. eugenii* to survive in the open after removal of the *Capsicum* crop in the autumn/winter and re-infest the greenhouse in the spring.
- Wild *Solanum* spp. are known as alternative host in absence of a *Capsicum* crop; it is, however, uncertain if *A. eugenii* could persist over longer periods (i.e. establish) in absence of *Capsicum* spp.
- The possibility that solanaceous crops grown in greenhouses other than *Capsicum* spp. could act as a refuge for adults (e.g. tomato) or as an alternate host (e.g. egg plant) and contribute to the dispersal and establishment potential of *A. eugenii* in areas where the pest cannot establish outdoors.

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Annex I: Rating guidance

Probability of entry (including transfer to a suitable host or habitat)

Rating level	Description
Low	On an average less than 1 “entry” in 10 years
Medium	On an average 1 “entry” per 5 – 10 years
High	On an average 1 “entry” per 2 – 4 years
Very high	On an average 1 or more “entries” per year

Establishment and probability if introduction

There is no rating for the probability of establishment but a description of the potential area of establishment is asked. The assessors should indicate where the pest can likely, possibly and/or may establish indicating a low, medium and high uncertainty, respectively.

A rating is asked for the probability of introduction (the probability of entry and establishment). For this the same rating levels and rating guidance as for the “probability of entry” is used (see above). The probability of introduction will depend on the probability of entry, the suitability of the environment for establishment and the biology of the pest (e.g. how likely the pest can establish starting from a low initial inoculum level/a few individuals).

Spread

No rating is asked but a description of the probability of spread and the rate of spread after introduction.

Impact

Rating guidance derived from the EPPO (European and Mediterranean Plant Protection Organisation) decision-support scheme for Pest Risk Analysis PM5/3(5) (http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm)

2.5.1 What is the economic impact of the pest in its current area of distribution?

Rating level	Description
Minimal	no yield and/or quality losses recorded.
Minor	yield and/or quality losses recorded but pest is fully controlled by non-targeted measures and control costs cannot be distinguished from normal plant protection costs.
Medium	yield and/or quality losses are limited, some targeted measures needed, but additional control costs are limited.
Major	yield and/or quality losses are considerable, targeted measures are frequently needed and the treatment is costly.
Massive	yield and/or quality losses are severe; high mortality of plants may also occur which can only be reduced by very expensive measures.

2.5.2 What is the potential direct economic impact in the PRA area? *(without any control measures)*

Rating level	Description
Minimal	no yield and/or quality losses are expected.
Minor	yield and/or quality losses are expected but they cannot be distinguished from normal variation
Medium	yield and/or quality losses are limited but they exceed normal variation, some targeted measures may be necessary
Major	yield and/or quality losses can be considerable, targeted measures may frequently be needed
Massive	yield and/or quality losses will be severe; and/or high mortality of plants is expected

2.5.4 What is the expected direct economic impact when the pest would become introduced? *(with the use of control measures)*

Rating level	Description
Minimal	no yield and/or quality losses expected
Minor	yield and/or quality losses are expected or cannot be distinguished from normal variation
Medium	yield and/or quality losses are limited
Major	yield and/or quality losses can be considerable
Massive	yield and/or quality losses will be severe; high mortality of plants is expected.

2.5.5 What is the expected impact on export markets for the PRA area?

Rating level	Description
Minimal	no effect on market size is expected
Minor	the effect on market size is negligible and cannot be distinguished from normal variation
Medium	some effects on market size are expected
Major	considerable effects on market size are expected
Massive	severe effects on market size are expected

2.5.6 What is the expected environmental impact in the PRA area?

No rating guidance.

2.5.7 What is the expected social impact in the PRA area?

The maximum rating level should be taken from "landscape effects" and "loss of employment"

Rating level	Description landscape effects
Minimal	damage to landscape has no consequences for landscape value
Minor	some plants which are not scene setting are damaged or die
Medium	some scene setting plants are damaged or die
Major	a substantial part of the scene setting plants are damaged or die
Massive	the majority of the scene setting plants die

Rating level	Description loss of employment
Minimal	no loss of employment due to economic impact occurs
Minor	some loss of employment due to economic impacts may occur, but cannot be distinguished from normal loss of employment
Medium	loss of employment due to economic impacts occurs to a limited extent
Major	considerable loss of employment and bankruptcy due to economic impacts occurs
Massive	due to economic impacts, the majority of the affected producers go bankrupt and their employees loose there job

Annex II NL- costs of introduction and phytosanitary measures

Introduction of *Anthonomus eugenii*: yield loss

The average annual turnover of Capsicum fruit production in the Netherlands was about 368 million euros from 2007 to 2009 (Table II.1). Assuming an average yield loss of 1% (e.g. a 5% yield loss on 20% of total crop acreage), the total yield loss would be about 3.7 million euros per year. Note that the costs for introduction may partly be borne by consumers due to an increase in prices of *Capsicum* fruit (see Q 2.2.2).

Introduction of *Anthonomus eugenii*: control costs

Control costs may increase due to introduction of *A. eugenii* but more importantly the pest's introduction will lead to disruption in existing biological control systems and will increase the probability that insects and mites develop resistance to pesticides. Frequent use of insecticides will also interfere with harvest frequency of fruits (see Q 2.2.2 in the PRA). Therefore, on the long term, companies may take more drastic measures to eradicate the pest from their greenhouse during the period of crop change. These measures might also include the use of screens in the vents. Estimates of costs for screens in vents have been estimated on €1,13 per m^2 per year for newly-built greenhouses and €2,26 for existing greenhouses http://www.infomil.nl/organisatie/milieumaatregelen/milieumaatregelen/@90338/insectengaas/; last access 18-09-2012) (according to the "BedrijvenInformatienetwerk" the costs are € 2,32 per per m^2 per year for existing greenhouses (BIN, LEI Wageningen UR, October, 2012). The costs for insect screens are significantly higher than the current costs for pest control which have been estimated on € 1,00 per m^2 (Vermeulen, 2008). The total acreage of *Capsicum* fruit production is about 1,400 ha (Table 2.2) and the total costs for insect screens (if used on the whole acreage) would be 16 – 32 million euros per year (for newly built and existing greenhouses, respectively). Insect screens will also contribute to the control of other pests and may reduce insecticide use 25 – 50%. (http://www.infomil.nl/organisatie/milieumaatregelen/milieumaatregelen/@90338/insectengaas/; last access 18-09-2012). However, insecticide use in the production of *Capsicum* fruit is currently low, approximately 2,5 kg per ha per year including *Bacillus thuringiensis* based insecticides (CBS, Statistics Netherlands) and, therefore, the reduction of control costs due to insect screens will be much lower than the increase in production costs due to the use of screens. Because of the high costs of insect screens it is not expected that many growers will invest in screens.

Table II.1. Acreage, number of companies and total turnover of sweet pepper production (Borgdorf & Schutter, 2010)

Year	Acreage (ha)	Number of companies	Total turnover in euro's
2007	1,187	401	441,600,000
2008	1,250	373	395,300,000
2009	1,331	348	266,600,000
Average			367,833,333

Import inspections of *Capsicum* fruit (inspections at the EU-border)

Contrary to fruit of *Solanum* spp., fruit of *Capsicum* spp. originating from non-EU countries is currently no subject to phytosanitary inspections. A low percentage of the consignments of sweet pepper are inspected for quality (chili pepper is not regularly inspected but may be subject to temporarily surveys). The majority of the import volume of *Capsicum* fruit is originating from countries from which 5% of the consignments are inspected for quality. These countries include Israel, Morocco, Turkey and Kenya from which about 98% of the total import volume originating in 2011, (http://kcb.nl/; last access 19th September 2012). The average annual number of consignments with *Capsicum* fruit from non-EU countries was 6,790 during the period 2009 – 2011 (Table II.2). If each of these consignments were to be inspected, the total inspection costs would be approximately 700 thousand euros (€ 100 per consignment). If *Capsicum* fruit were to be regulated only from countries where *A. eugenii* is present, the inspection costs would be much lower and may approximately be € 25,000 per year (250 consignments x €100/consignment) which is relatively high when compared with the total value of the imported consignments, about € 140,000 (Table II.3). If a pest-free area or pest-free production place or site were one of the requirements, this could lead to a strong decrease in import volume from countries where the pest is present and automatically lead to lower inspection costs (see also paragraph 3.3 in the PRA "Selection of and conclusions on risk reduction options").

Table II.2. Assessment of the total number of import consignments of fruit of *Capsicum* spp.

Year	**Import volume from non-EU countries**[1]	**Total number of consignments**[2]
2009	43,688,700	7,536
2010	36,955,400	6,790
2011	48,444,700	7,184
Average	43,029,600	6,790

[1] Volume in kg; data from Eurostat (CN 070960)
[2] Source: Dutch customs, November 2012

Table II.3. Number of import consignments of fruit of *Capsicum* spp. from countries where *Anthonomus eugenii* is present

Year	**Import volume**[1] **(kg)**	**Import value (euros)**[1]	**Total number of consignments**[2]
2009	73,300	153,205	246
2010	96,000	162,863	213
2011	145,200	289,386	273
Average	104,833	142,512	244

[1] From countries where *A. eugenii* is present. Import has been registered from Dominican Republic, Panama, Mexico and USA (Eurostat, data extracted July 2012).
[2] Source: Dutch customs

Costs of rejection of a consignment

The finding of *A. eugenii* will lead to rejection of the consignment and costs for the importer or exporter. However, if fruit is only imported from a pest-free area or pest-free production place or site (options I and II in the PRA) no or a very limited number of rejections are expected.

Annex III: Import data of *Capsicum* fruit from countries (in the region) where *Anthonomus eugenii* is present

EU-import quantity of *Capsicum* fruit in 100 kg. Source: Eurostat, data extracted 27.05.13. Product 07096010 (sweet pepper) and 07096099 (chili pepper)[1]

	USA		Costa Rica		Dominican Republic		Guatemala		Mexico		Panama		Belize	Hon duras	Jamaica		FrP[2]	Nic[3]	Cuba[4]	
Year	sweet	chili	sweet	chili	sweet	chili	sweet	chili	sweet	chili	sweet	chili	sweet	chili	sweet	chili	chili	chili	sweet	chili
1988	1,073	194	0	22	0	0	0	0	0	197	0	190	52	0	5214	159	0	0	0	0
1989	384	767	0	13	0	0	21	0	12	67	0	383	0	0	0	0	0	0	45	0
1990	1,607	369	0	6	0	25	0	0	0	9	11	412	0	0	8	29	0	0	0	0
1991	699	445	0	24	0	0	0	0	0	0	0	5	0	0	9	3	0	0	0	0
1992	383	405	0	42	5	32	0	0	0	17	0	194	0	0	0	6	0	0	48	0
1993	440	536	1	119	0	231	0	12	0	42	0	127	0	0	0	0	0	0	0	0
1994	911	1,869	0	5	5	358	0	100	0	174	0	0	0	0	0	0	0	0	0	0
1995	1,747	2,047	0	39	21	396	0	0	10	175	0	0	0	0	11	4	0	0	46	0
1996	1,640	1,349	11	74	1	1,044	101	26	23	108	0	0	0	0	0	61	0	0	296	0
1997	1,836	1,663	0	5	23	2,495	0	0	6	172	0	0	0	0	100	59	0	0	241	22
1998	923	1,732	3	3	3	3,961	0	0	120	740	0	0	0	0	0	133	0	0	46	19
1999	1,202	2,629	0	7	14	5,134	0	3	20	283	0	0	0	0	50	41	5	0	1	0
2000	898	2,547	0	0	14	8,413	3	559	97	256	0	0	0	0	0	101	0	0	0	0
2001	394	2086	0	0	0	12,706	0	193	0	389	0	0	0	0	0	149	0	0	0	0
2002	692	1,032	0	0	0	19,291	0	198	9	564	0	0	0	0	0	0	0	0	0	10
2003	215	767	0	0	26	17,758	0	355	18	10	0	0	0	0	113	76	0	0	0	7
2004	85	347	0	9	21	3,572	0	0	0	84	0	0	0	0	0	42	0	0	0	15
2005	23	956	0	0	13	2,332	0	0	0	363	0	0	0	0	0	1	0	181	19	1
2006	0	1,340	0	136	242	4,285	0	0	91	1,382	39	0	0	11	0	10	0	935	0	59
2007	243	1,500	62	44	51	4,824	0	9	130	1,104	112	0	0	6	0	23	0	1,159	0	261
2008	55	1,307	0	0	264	12,460	0	0	85	1,229	0	0	0	0	0	948	0	1,495	0	78
2009	52	1,681	0	0	536	10,771	0	70	0	1,884	0	58	0	0	0	647	0	1,714	0	66
2010	0	645	0	0	214	7,163	0	47	0	2,042	7	60	0	88	0	234	0	846	6	2
2011	21	455	0	0	208	9,115	0	0	6	2,244	0	0	0	35	2	91	0	2,097	0	3
2012	0	600	0	0	670	7,332	0	190	289	4,624	0	0	0	323	0	6	0	1,611	0	85

[1] CN 07096099 also includes fresh or chilled fruits of the genus Pimenta; it is assumed that the import data include mainly *Capsicum* fruit (chilli pepper) (see Question 2.2.2 in the PRA)

[2] FrP: French Polynesia

[3] Nic: Nicaragua

[4] Pest not reported from Cuba, but present in nearby countries

Annex IV: Import data of *Solanum melongena* fruit from countries (in the region) where *A. eugenii* is present

EU-Import quantity in 100 kg. Source: Eurostat, data extracted 27.05.13. Product 07093000 (aubergines)

Year	USA	Costa Rica	Dominican Republic	Guatemala	Mexico	Panama	Cuba[1]	Honduras	Jamaica	Total
1988	53	0	0	0	0	29	0	0	163	245
1989	1086	0	22	8	0	3	0	0	277	1,396
1990	89	0	16	0	113	23	0	0	0	241
1991	33	0	0	0	0	0	0	0	0	33
1992	63	0	45	0	0	0	0	0	0	108
1993	191	0	466	0	0	0	0	0	0	657
1994	3	0	622	0	0	0	0	0	0	625
1995	40	9	230	0	0	0	0	0	0	279
1996	32	0	496	0	0	0	0	0	22	550
1997	31	0	948	0	0	0	0	0	0	979
1998	30	0	923	0	86	0	0	0	0	1,039
1999	105	0	992	0	0	0	0	0	0	1,097
2000	0	0	1,138	0	0	0	0	0	0	1,138
2001	1	0	866	0	0	0	0	0	0	867
2002	0	1	337	0	0	0	0	0	0	338
2003	0	0	961	0	0	0	0	0	0	961
2004	0	0	653	0	0	0	1	0	0	654
2005	0	0	985	0	0	0	1	0	0	986
2006	18	0	2,139	0	0	0	0	0	7	2,164
2007	0	0	6,976	0	0	0	18	0	0	6,994
2008	0	0	8,850	0	0	0	1	0	0	8,851
2009	0	0	8,477	3	0	0	0	0	0	8,480
2010	0	0	8,326	7	0	0	0	0	0	8,333
2011	0	0	11,201	0	0	0	0	0	0	11,201
2012	44	0	12,206	0	0	0	0	20	0	12,270

[1] Pest not reported from Cuba, but present in nearby countries

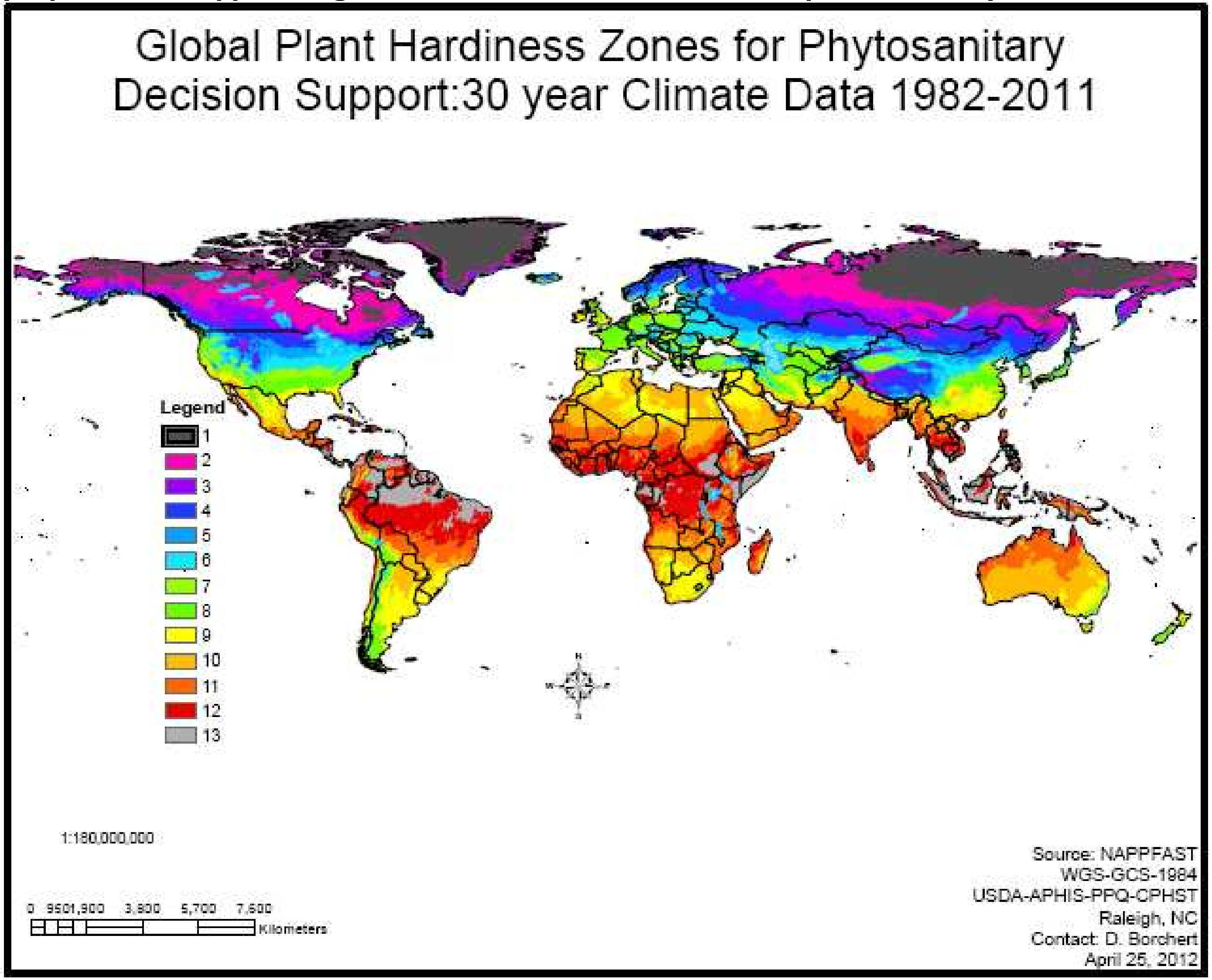
ANNEX V: Pepper and aubergine, area harvested in the EU and Switzerland (ha)

Source: FAOSTAT (http://faostat.fao.org/site/339/default.aspx)
Data extracted 27th and 28th May 2013

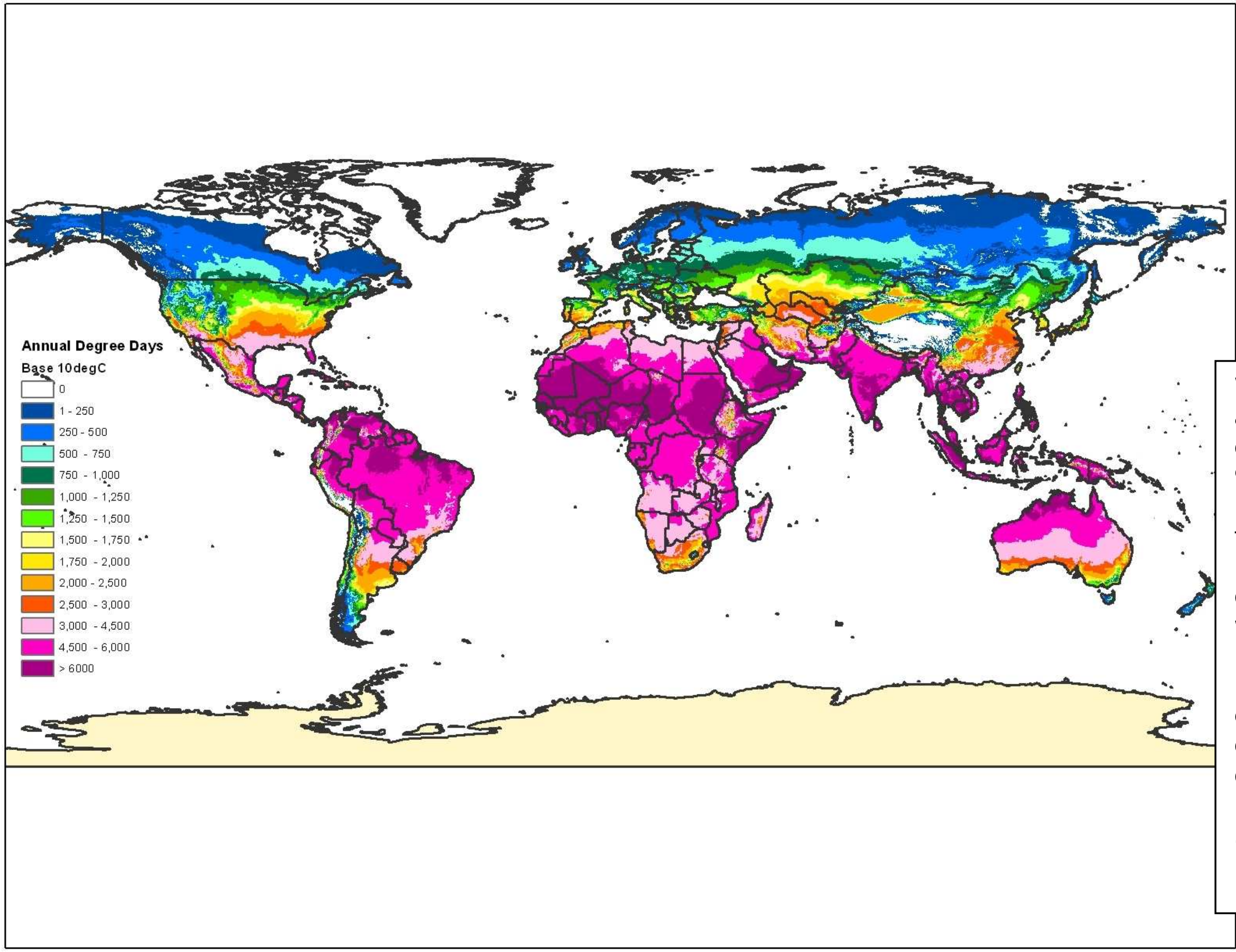
Country	Chili and pepper, green		Chili and pepper, dry		Aubergines	
Austria	163				6	
Belgium	87	*			22	
Bulgaria	4,620		312	Im	347	
Cyprus	21				21	
Czech Republic	263	Im	4525			
Denmark						
Estonia						
Finland	6					
France	624				711	
Germany	43					
Greece	3,600		118	Im	2500	
Hungary	2,668		2,125	Im	52	
Ireland						
Italy	10,327				9423	
Latvia						
Lithuania					996	Im
Luxembourg						
Malta					24	Im
Netherlands	1357				101	
Poland						
Portugal	239	Im			349	Im
Romania	20,001		54,403	Im	10,020	
Slovakia	1740	Im				
Slovenia	139		274	Im		
Spain	16,887		2,341	Im	3268	
Sweden						
Switzerland	17					
United Kingdom	72					
TOTAL	62,874		64,098		27,840	

* = Unofficial figure | [ ] = Official data | F = FAO estimate | Im = FAO data based on imputation methodology

ANNEX VI: World hardiness zones
(http://www.nappfast.org/Plant_hardiness/2012/2012%20ph_index.htm)



ANNEX VII: Annual number of degree days base 10°C



World map of temperature accumulation (Degree Days) based on a threshold of 10°C using 1961-90 monthly average maximum and minimum temperatures taken from the 10 minute latitude and longitude Climatic Research Unit database (New et al., 2002). Maps were kindly provided by R. Baker, FERA, and previously used in the EFSA-project Prima Phacie (Macleod et al., 2012). Similar maps based on the same information but with different degree day intervals were published in 2002 and 2012 (Baker, 2002; Eyre et al., 2012).