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Pest Risk Analysis for

Ceratothripoides brunneus and *C. claratris* (Thysanoptera: Thripidae)

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This risk assessment follows the EPPO Standard PM 5/5(1) *Decision-Support Scheme for an Express Pest Risk Analysis* (available at http://archives.eppo.int/EPPOStandards/pra.htm) and uses the terminology defined in ISPM 5 *Glossary of Phytosanitary Terms* (available at https://www.ippc.int/index.php). This document was first elaborated by an Expert Working Group and then reviewed by the Panel on Phytosanitary Measures and if relevant other EPPO bodies.

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Photos: *Ceratothripoides claratris* Courtesy: http://www.padil.gov.au

Based on this PRA, *Ceratothripoides brunneus* and *C. claratris* were added to the A1 Lists of pests recommended for regulation as quarantine pests in 2017.

Pest Risk Analysis for *Ceratothripoides brunneus* and *C. claratris* (Thysanoptera: Thripidae)

This PRA follows EPPO Standard PM 5/5 *Decision-Support Scheme for an Express Pest Risk Analysis*. It is a follow-up of the EPPO Study on Pest Risks Associated with the Import of Tomato Fruit (EPPO, 2015). Four PRAs for tomato pests were performed in parallel, in a new procedure by which they were prepared in a shorter time and reviewed together by one Expert Working Group. This implies among others that the final PRAs contain more uncertainties, which could not be resolved in the framework of this new procedure.

PRA area: *EPPO region*
Prepared by: EWG on PRAs for tomato
Date: 2015-12-07/11 (the PRA was further reviewed and amended by other EPPO bodies, see below)

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Prior to the EWG, the PRA was reviewed and comments provided by the following experts: Dr Sevgan Subramanian (ICIPE, Kenya), Bert Vierbergen (NPPO, The Netherlands).

Following the EWG, the PRA was further reviewed by Dom Collins (Defra, UK), Bruno Michel (Cirad, France). The following PRA core members also provided comments: Alan MacLeod (UK), Dirk Jan van der Gaag (The Netherlands), José Maria Guitian Castrillon (and colleagues; Spain), Silvija Pupelienė (and Henrikas Ostrauskas; Lithuania).
The Panel on Phytosanitary Measures considered the management options in 2016-11, 2017-03. The Pest Risk Management was reviewed by the EPPO Panel on Phytosanitary Measures between 2016-11 and 2017-03. EPPO Working Party on Phytosanitary Regulation and Council agreed that *Ceratothripoides brunneus* and *C. claratris* should be added to the A1 Lists of pests recommended for regulation as quarantine pests in 2017.

Summary of the Pest Risk Analysis for *Ceratothripoides brunneus* and *C. claratris* (Thysanoptera: Thripidae)

PRA area: *EPPO region*

Describe the endangered area: Both thrips species have the potential to establish in tomato crops in glasshouses and other protected conditions (screenhouses/ polytunnels), ***C. brunneus*** throughout the PRA area and ***C. claratris*** more likely in the southern part of the EPPO region.
Outdoors, ***C. brunneus*** could possibly establish in part of the EPPO region, which could not be defined precisely but would correspond to the parts of coastal areas of the Mediterranean where there is no frost and where humidity is high. In the long-term, populations are likely to maintain under protected conditions only if they can also survive outdoors. ***C. claratris*** is not expected to be able to establish outdoors in the EPPO region. Both species may establish transient populations outdoors.
Hosts at risk of economic impact are especially tomato, eggplant and capsicum, as well as cucurbits, and to a lesser extent some fabaceous crops.

Main conclusions

Overall assessment of risk: C. claratris is widely prevalent in Asia and is also present in East Africa. It is a major pest of tomato in Thailand and a vector of tospoviruses. *C. brunneus* is a widespread pest of solanaceous crops including tomato in Africa, and has been introduced to Asia and the Caribbean.
Likelihood of entry was considered moderate to high for both species on plants for planting, as well as for fruits of Solanaceae and others, and cut plant parts (flowers, leafy vegetables, herbs). For the latter pathways, the likelihood of entry was rated slightly lower for *C. claratris* than for *C. brunneus*. The probability of establishment differs (*C. claratis* is unlikely to establish outdoor in the PRA area), but they may cause outbreaks and transient populations under protected conditions in the EPPO region (where they may cause damage even in cases when they do not establish permanently, as for *T. palmi*). Both species are expected to have a moderate impact overall. They may both cause economic impact on Solanaceae, especially tomato, capsicum and eggplant, as well as cucurbits, and to a lesser extent on some fabaceous crops. *C. claratis* is vector of two tospoviruses (CaCV and TNRV). Spread will mainly be with traded commodities rather than natural spread.

Phytosanitary Measures to reduce the probability of entry: Risk management options were determined for plants for planting, fruit and cut parts of plant.

Phytosanitary risk for the *endangered area* (*Individual ratings for likelihood of entry and establishment, and for magnitude of spread and impact are provided in the document*)	High ☐	**Moderate** ☒	Low ☐
Level of uncertainty of assessment *(see Q 17 for the justification of the rating. Individual ratings of uncertainty of entry, establishment, spread and impact are provided in the document)*	**High for *C. claratris*** ☒	**Moderate for *C. brunneus*** ☒	Low ☐

Other recommendations: Raising awareness and inspection of luggage for travellers carrying fruits, cut flowers or plants for planting of main hosts

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Stage 1. Initiation

Reason for performing the PRA:

Ceratothripoides brunneus and *C. claratris* were identified during the EPPO Study on pests risks associated with the import of tomato fruit ('EPPO tomato study' hereafter; EPPO, 2015) and were later selected as priorities for PRA by the EPPO Panel on Phytosanitary Measures based on a number of criteria including its impact on tomato, biological criteria, consideration of entry and transfer from commodities to hosts at destination. *C. claratris* is widely prevalent in Asia and is also present in East Africa. It is a major pest of tomato in Thailand and a vector of tospoviruses. *C. brunneus* is a widespread pest of solanaceous crops including tomato in Africa, and has been introduced to Asia and the Caribbean.

PRA area: EPPO region (map at www.eppo.int).

Stage 2. Pest risk assessment

1. Taxonomy

Taxonomic classification. Order: Thysanoptera; Suborder: Terebrantia; Family: Thripidae; Subfamily: Thripinae; Genus: *Ceratothripoides*;

- **Species***:* *Ceratothripoides brunneus* Bagnall, 1918

Synonyms: *Physothrips marshalli* Bagnall, 1918; *Physothrips ventralis* Hood, 1918; *Taeniothrips ventralis* Priesner, 1952; *Taeniothrips brunneus* Mound, 1968

Note: *C. revelatus*, an African thrips, was recalled from synonymy with *C. brunneus* by Mound and Nickle (2009). Both species occur in Kenya and Uganda, but *C. revelatus* is not as widespread as *C. brunneus* (ICIPE, 2013a; Moritz et al., 2013).

- **Species**: *Ceratothripoides claratris* (Shumsher, 1946)

Synonyms: *Taeniothrips claratris* Shumsher, 1946; *Mycterothrips moultoni*, Seshadri and Ananthakrishnan, 1954; *Ceratothrips reticulatus* Reyes, 1994

Note: *C. claratris* is very similar to *C. cameroni*, which occurs in Africa and the Near East (Sudan, Nigeria, Saudi Arabia, Senegal) (Mound and Nickle, 2009), and it is unclear if they are different species or exhibit intraspecific variation. They differ only by colour and habitats (Mound and Nickle, 2009; Moritz et al., 2013). The paler specimens (*C. cameroni*) are commonly observed in more arid areas whereas the darker specimens (*C. claratris*) generally come from more humid areas (Mound and Nickle, 2009). *C. claratris* is also observed in the coastal and humid lake region of East Africa (Moritz et al., 2013). Mound and Nickle (2009) retain the two names because *C. claratris* is used for a form with economic significance. From the taxonomic point of view, there are currently two species. **This PRA considers only *C. claratris*, but some data on *C. cameroni* is provided as uncertainties where relevant.**

- **Common names**: seemingly none specific. Both are called 'tomato thrips' in some publications.

2. Pest overview

In surveys in Kenya, ***C. brunneus*** was the most dominant thrips species infesting tomato in the mid- and low altitude regions of Kenya, but above 2000 m the species was absent (Subramanian et al., 2009; ICIPE, 2009). It also infests other hosts (see section 7). ***C. claratris*** is the predominant tomato thrips in Thailand (Premachandra et al., 2005a; Ranamukhaarachchi & Wickramarachchi, 2007).

Life cycle. Thrips are small (1–2 mm in length), slender insects. Of the 5500 known thrips species, relatively few are serious crop pests and these are mainly members of the family Thripidae (Lewis, 1997). They affect plants by direct feeding, which may leave visible signs of damage, such as leaf silvering (Palmer et al., 1989). Like other Terebrantian thrips *C. brunneus* and *C. claratris* have six developmental stages: egg, first (L1) and second instar larvae (L2), prepupa, pupa and adult. Both sexual and asexual reproduction exist.

Comprehensive data on the biology of ***C. brunneus*** are not available (Macharia et al., 2015). Laboratory colonies of *C. brunneus* have been established on French beans pods at ICIPE and continuously reared for over 200 generations. In the field, feeding and oviposition by *C. brunneus* causes silvery lesions on the abaxial surface of the leaves and scaring on the fruit surface (S. Subramanian, pers. comm.).

The life cycle of ***C. claratris*** on tomato has been studied thoroughly (Murai et al., 2000; Rodmui, 2002 in Premachandra, 2004). The following features of the life cycle were observed on tomato: leaves are the most preferred plant part for both larvae and adults of *C. claratris*, but the species can also colonise flowers, stems and fruits (Murai et al., 2000; Rodmui, 2002 in Premachandra, 2004). Females (about 1 mm in length) insert their bean-shaped eggs (0.13 mm) into the plant tissue (leaves, stems and fruits). Newly laid eggs are pale white in colour. L1 (0.40 mm in length) starts to feed on the plant tissue after emergence. The L2 instar is about 0.8 mm in length (Rodmui, 2002 in Premachandra, 2004). Mature (late L2) larvae drop from the foliage to the soil or leaf litter, where they develop into the non-feeding and almost immobile prepupae and pupae with distinct wing pads. After emergence the adults resume feeding. Feeding of larvae and adults and oviposition by female *C. claratris* cause physical damage and severe infestations of tomato plants (Premachandra, 2004). Dark spots of excrement are often visible on the leaves. At high population densities, *C. claratris* also feed and oviposit on young fruits, causing malformation (Premachandra et al., 2005a).

Temperature requirements. Data on survival and performance of ***C. brunneus*** at different temperatures are not available. In a temperature range between 25 to 28°C, the total life cycle for *C. brunneus* ranged from 19 to 29 days, when reared on French beans. The egg, larval and pupal development ranged between 2-3, 4-6 and 3-5 days, respectively; adult longevity ranged from 10 to 15 days (S. Subramanian, pers. comm.). Although these biological data are preliminary, they are in line with those of *C. claratris* mentioned in Premachandra (2004).

Premachandra (2004) studied the effects of temperature on the development, reproduction and survival of ***C. claratris*** on tomatoes and found that pre-adult survival was greatest (95%) at 25 and 30°C, and lowest at 22°C. The total life cycle ranged from 8.8 days at 30°C to 19.5 days at 22°C. The lower thermal threshold for egg-to-adult development was estimated to be 16-18°C, and the optimum temperature was estimated at 32-33°C. At 40ºC, reproduction was not possible (Premachandra et al. 2004). The authors conclude that *C. claratris* is better adapted to high temperatures (30–35°C) than other important tropical thrips species such as *Thrips palmi* and *Scirtothrips dorsalis.*

Detection. There are no specific traps. Blue traps were more effective for both species, while yellow traps were not effective (Ranamukhaarachchi and Wickramarachchi, 2007; Muvea, 2011). Captures on coloured

sticky traps were not influenced by the addition of a synthetic flower volatile based kairomone, methyl isonicotinate (Muvea, 2011). Visual inspection is difficult as different life stages of thrips may remain undetected because of their small size and cryptic behaviour (Kirk, 1997): eggs are located in leaf tissues, larval instars and adults can feed in stems and fruits, whilst pupae are usually found on the (soil) substrate (Ullman et al., 1997).
Signs and symptoms of infestation. Infested plants show distortion of young leaves and fruits, yellow and brown speckled areas on leaves, silvered appearance of older leaves and dark spots of excrement the leaves. These symptoms are common to some other thrips species. Successful detection is linked to the intensity of sampling and is more difficult when there are only a few thrips in the consignments (EFSA, 2012).
In addition, *C. claratris* is known to be a vector of *Capsicum chlorosis virus* (CaCV) and *Tomato necrotic ringspot virus* (TNRV), and thus symptoms of virus infection may also be present (such as leaf chlorosis and necrosis).

Identification. Descriptions for morphological identification of species of the genus *Ceratothripoides* are provided in Mound and Nickle (2009) and Moritz et al. (2013). Articles on molecular methods are available (for *C. brunneus* Macharia et al., 2015; for *C. claratris*, Thakaew et al., 2011), but yet/currently these methods are not of use for practical identification at species level.

3. Is the pest a vector? ***C. brunneus*** **Yes** ☐ **No** ✓
C. claratris **Yes** ✓ **No** ☐

No evidence was found that ***C. brunneus*** is a vector, but experimental research is lacking. Note: only a limited proportion of thrips species (about 15 out of 5500) are recorded as tospovirus vectors. The mention of *C. brunneus* as vector in Sartiami and Mound (2013) is a misquotation of Mound and Nickle (2009) (which refers only to *C. claratris*).
C. claratris is a competent vector of *Capsicum chlorosis virus* (CaCV) (Premachandra et al. 2005b; Halaweh and Poehling, 2009), and the newly described *Tomato necrotic ringspot virus* (TNRV) (Chiemsombat et al., 2010; Seepiban et al., 2011).

4. Is a vector needed for pest entry or spread? **Yes** ☐ **No** ✓

5. Regulatory status of the pest

C. brunneus and *C. claratris* are not mentioned in the phytosanitary regulations of EPPO countries according to EPPO Global Database (at December 2015). A short PRA was carried out in the UK in 2003 (MacLeod et al., 2003).

C. brunneus is considered a quarantine pest for the USA according to USDA (2009) and for Japan (2014). Quarantine lists for a limited number of other non-EPPO countries were consulted and neither of these pests were found.

6. Distribution

Thrips of the genus *Ceratothripoides* belong to the Old World (Mound and Nickle, 2009). *C. brunneus* has been introduced to Asia and the Caribbean.

Table 1. Distribution of *C. brunneus* and *C. claratris*
All records are from EPPO Global Database, except where a reference is indicated. For EPPO Global Database records, references can be found in the database

Region	*C. brunneus*	*C. claratris*
EPPO region	**Absent**. See Note 1	**Absent**
Caribbean	**Cuba**, **Puerto Rico**, **Guadeloupe** *Unreliable record*: **Jamaica**. See Note 2	**Absent**. See Note 3
Africa	**Angola**, **Burundi**, **Cameroon**, **Congo**, **Côte d'Ivoire**, **Ethiopia**, **Ghana**, **Kenya**, **Mozambique**, **Nigeria**, **Sierra Leone**, **South Africa**, **Tanzania**, **Togo**, **Uganda**, **Zimbabwe**. *Absent, unreliable record*: **Gabon, Sao Tome.** See Note 4.	**Kenya**, **Tanzania**, **Uganda** (ICIPE, 2011 and 2013b; Moritz et al., 2013). See Note 5.

Region	*C. brunneus*	*C. claratris*
Asia	**Indonesia**, **Malaysia**. *Uncertain records*: **Thailand** (Sartiami and Mound, 2013), See Note 6 *Unreliable record:* **India**, **Singapore** (interception only; Masumoto et al., 2012). See Note 6 *Absent, invalid record*: **China** (Tibet) (Mirab-Balou and Tong, 2012– See Note 7).	**China** (Yunnan, Xie et al., 2012), **India** (Delhi, Maharashtra, Orissa, Tamil Nadu) **Thailand**, **Philippines**. *Uncertain records*: 'South East Asia (Nguyen et al., 2009). See Note 8. **Malaysia** (Premachandra and Borgemeister, 2006 – see Note 9) **Laos** (B. Michel, pers. comm. – see Note 10)
South America		*Uncertain record*: 'South America' (EFSA, 2012). See Note 11
Oceania	Uncertain record: **Australia** (Moritz et al., 2013). See Note 11	

Notes

1. Mound and Nickle (2009) mention a population studied from a greenhouse in the Netherlands (citing Mound & Azidah, 2009, which refers to specimens seen on *Ensete* in a glasshouse (Vierbergen, 1999). The infested *Ensete* plants were used in an experiment and an infestation of *C. brunneus* was found. The plants were destroyed at the end of the experiment (after four years); the pest was not found on other plants (PPS, 1998)
2. USCBP (2013) reports an interception on leaves in passenger luggage from Jamaica. No other record was found for Jamaica.
3. A record of *C. claratris* in Cuba (Suris and Rodriguez-Romero, 2009) was a misidentification of *C. brunneus* (Suris and Rodriguez-Romero, 2011, correcting the 2009 article).
4. Absent, unreliable records: Gabon **-** Frame and Durou (2001) pre-dates the recall from synonymy of *C. revelatus* and *C. brunneus*. It is not certain which species was found (*C. brunneus* or *C. revelatus*). Gabon is also not mentioned in Mound and Nickle (2009), but is in Moritz et al. (2013). Sao Tome – There are specimens in the collections of Cirad (France) (B. Michel, pers. comm.); however, it is not known if they pre-date the recall from synonymy of *C. revelatus* and *C. brunneus*.

5. Note. *C. cameroni* was reported from Sudan, Senegal, Nigeria, Saudi Arabia (Moritz et al., 2013; see section 1. Taxonomy).
6. Uncertain and unreliable records: Thailand, India, Singapore. Sartiami and Mound (2013) cites Mound and Nickle (2009) for Thailand, but the latter (as well as Mound and Azidah, 2009) do not refer to *C. brunneus* in Thailand. Peshin and Pimental (2014) mentions India (citing Nair, 1981), but the original source was not accessible and it is not listed in the updated checklist of Tyagi and Kumar (2015). Masumoto et al. (2012) mention interceptions from Singapore, but no specific record was found.
7. For China, Mirab-balou (2011) citing Zhang and Tong (1996) mentions Tibet. Mirab-balou and Tong (2012) later stated that this was described as *Pezothrips brunicornis*. No other record for *C. brunneus* in China was found.
8. Uncertain record: 'South East Asia' (Nguyen et al., 2009). No other records than those above were found. Loebenstein and Katis (2014) mention (referring to various publications), that "CaCV has since been detected associated with *C. claratris* in Thailand, China, Taiwan, India, and most recently Hawaii". The wording is ambiguous but the mention of *C. claratris* applies only to Thailand: the references for other countries refer only to CaCV (Kunkalikar et al., 2007 for India, Chen et al., 2007 for China, Zheng et al., 2008 for Taiwan, Melzer et al., 2014 for Hawaii) (*C. claratris* is separately reported in India and China – see table above). Chen et al. (2012) also mention that *C. claratris* was not found in Taiwan.
9. Malaysia. There is a record in Premachandra and Borgmeister (2006) citing Okajima, cited in Murai et al. (2000). However, Mound and Azideh (2009) note that no specimens have been seen from Malaysia.
10. Laos. There are specimens labelled as *C. claratris* in the collections of Cirad (France) (B. Michel, pers. comm.). No other record was found for Laos.
11. Uncertain records: 'South America'/*C. claratris* (EFSA, 2012); Australia/*C. brunneus* (Moritz et al., 2013). No record was found for South America or Australia.

7. Host plants and their distribution in the PRA area

For both species, according to the information available, the main hosts recorded in the literature are Solanaceae, including *Solanum lycopersicum*, *S. melongena* and *Capsicum*, as well as hosts in the family Cucurbitaceae.

For ***C. brunneus***, although information is lacking on which species are breeding hosts (versus plants on which adults were merely found feeding), all Solanaceae and Cucurbitaceae species mentioned as hosts were kept in Table 2A below.

For ***C. claratris***, Steenken and Halaweh (2011) (experiments on host preference in glasshouses, with natural infestation of thrips from outside) provides data regarding the presence of larvae, and is the main source of information on hosts. In Thailand (Premachandra and Borgemeister, 2006; Steenken and Halaweh, 2011), high infestation levels were observed on tomato and eggplant, low levels on *Capsicum*, moderate infestations on Cucurbitaceae and low on Fabaceae.

For all other host species there are uncertainties on whether records relate to breeding hosts, or only to plants on which adults were found. Some studies indicate that records relate to collection of adults, other do not specify which life stages were collected. Where there was no indication on whether larvae have also been found on the species, they were included in uncertainties.

Table 2. Host plants

Hosts in **bold** are considered to be widely cultivated in the EPPO region.

Table 2A. Hosts of *C. brunneus*

HOSTS OF C. BRUNNEUS
Solanaceae
Solanum lycopersicum, ***Solanum melongena***, ***Capsicum*** (as 'capsicum and chillies'), 'African nightshade' (***Solanum villosum***, possibly others), 'African eggplant' (***Solanum aethiopicum***, possibly others), ***S. tuberosum*** (ICIPE, 2013; Moritz et al., 2013; S. Subramanian, pers. comm).
Other families
Cucurbitaceae. 'pumpkin' (***Cucurbita maxima***, possibly others), ***Citrullus lanatus*** (as 'watermelon'), 'Karela' (*Momordica charantia*), ***Cucumis melo*** (as 'melon') (ICIPE, 2013a; Moritz et al., 2013; S. Subramanian, pers. comm) Fabaceae: ***Phaseolus vulgaris*** (as 'French beans') (mentioned as host without details of life stage associated, but breeding in the lab obtained) (ICIPE, 2013a; Moritz et al., 2013, Machiara, 2015, S. Subramanian, pers. comm) Musaceae: *Ensete* (breeding host – Vierbergen, 1999; PPS, 1998) Lamiaceae: *Ocimum basilicum* (Azidah, 2011; intercepted as larvae in the Netherlands; NVWA, unpublished data)

Plants on which some life stages of *C. brunneus* were found (kept for relevant sections of this PRA)

- **Cases where adults were collected**

- In Malaysia, adults also collected from: Acanthaceae: *Asystasia*, *Thunbergia;* Apocynaceae: *Tabernaemontana*; Balsaminaceae: *Impatiens*; Fabaceae: *Vigna unguiculata;* Lamiaceae: *Orthosiphon, Salvia farinacea;* Malvaceae*: Hibiscus;* Myrtaceae: *Rhodomyrtus* (Azidah, 2011).
- In Indonesia, thrips were collected from Rosaceae: *Rosa* (Sartiami and Mound, 2013).

- **Uncertainty on which life stages were associated with the plants**

- Malvaceae: *Theobroma cacao* (Palmer et al. 1989; Mound and Kibby, 1998) 'commonly found on cocoa tree leaves'.
- Amaranthaceae: *Amaranthus*; Apiaceae: ***Daucus carota;*** Caricaceae: *Carica papaya*; Fabaceae: *Mucuna, Vigna unguiculata* (as cowpea); Malvaceae: *Gossypium* (as cotton); Musaceae: *Musa* (as banana);Passifloraceae: *Passiflora* (as passionfruit); Rubiaceae: *Coffea arabica* (as coffee); Theaceae: *Camellia sinensis;* Selaginallaceae: *Selaginella emmeliana* (as sweat), various weeds ('observed' in ICIPE, 2013a; also general mentions in Moritz et al., 2013).
- Malvaceae*: Hibiscus sinensis*, *Cola* (Mound and Nickle, 2009): at least in one case, referring to the collection of adults.

- Amaranthaceae : *Amaranthus hybridus*; Asteraceae: *Acanthospermum hispidum*; Brassicaceae: *Brassica. oleracea* var. *capitata*, *B. oleracea* var. *acephala*; Cleomaceae: *Cleome gynandra*; Poaceae: *Zea mays* (Machiara et al., 2015)
- Weeds including, Solanaceae: *Datura stramonium* (Machiara et al., 2015), *Solanum incanum*; Asteraceae: *Ageratum conyzoides, Bidens pilosa, Galinsoga parviflora, Sonchus oleracea Tithonia diversifolia*, (ICIPE, 2013a; Moritz et al., 2013)

- **From interceptions** (only if not mentioned in table above): Asteraceae: ***Chrysanthemum*** (Masumoto et al., 2012; NVWA, unpublished data), Orchidaceae: *Oncidium* (Masumoto et al., 2012). Plantaginaceae **-** *Veronica* (1 adult, Vierbergen, 2008; FERA, unpublished data), Cucurbitaceae - *Telfairia occidentalis* (FERA, unpublished data), *Momordica* vegetables (EPPO RS0809, EPPO RS 0511, ICIPE, 2009).

Other uncertainties for *C. brunneus* (plant species not covered further in this PRA)

- Rutaceae: ***Citrus*.** Two males were collected on *Citrus* in Puerto Rico (Mound and Nickle, 2009). Citrus is mentioned generally in Moritz et al. (2013). No other record of *Citrus* as a host was found. *Citrus* is not covered in this PRA.
- Malvaceae: **Gossypium.** Bournier (2002) was published before *C. revelatus* was recalled from synonymy with *C. brunneus;* also mentioned in Moritz et al. (2013).
- **'Orchid'** mentioned by Moritz et al. (2013), but record is unique and the host genus is not specified (see also interceptions below)

Table 2B. Hosts of *C. claratris*

HOSTS OF C. claratris
Solanaceae
S. lycopersicum, Solanum melongena, *Capsicum annuum, Nicotiana tabacum* (Steenken and Halaweh, 2011), *Solanum xanthocarpum* (Premachandra and Borgemeister, 2006), also ***Capsicum*** (ICIPE, 2013b; Moritz et al., 2013; S. Subramanian, pers. comm.).
Other families
Cucurbitaceae: ***Cucumis melo***, ***Cucumis sativus***, *Momordica charantia*, *Cucurbita moschata* **(**Steenken and Halaweh, 2011)**, *Citrullus lanatus*** (Premachandra and Borgemeister, 2006). Fabaceae: ***Phaseolus vulgaris, Pisum sativum***, *Vigna unguiculata*, *V. sinensis*, (Steenken and Halaweh, 2011; Premachandra and Borgemeister, 2006; ICIPE, 2013b; Moritz et al., 2013; S. Subramanian, pers. comm.). Asteraceae: ***Lactuca sativa*** (Steenken and Halaweh, 2011 – minor host, few larvae)

Uncertainties: plants on which some life stages of *C. claratris* were found (kept for relevant sections of this PRA)

- **Uncertainty on which life stages were associated with the plants**

- Amaryllidaceae: 'onion' (*Allium cepa*); 'African spiderplant' (Cleomaceae: *Cleome gynandra*); Poaceae: *Zea mays* (as 'maize')) (ICIPE, 2013b; Moritz et al., 2013; S. Subramanian, pers. comm.).
- Fabaceae: *Clitoria ternatea*. Premachandra and Borgemeister (2006) refer to a MSc thesis (Jangvitaya, 1993). It was not possible to check whether this is a host.
- Weeds: Solanaceae- *Solanum incanum* (ICIPE, 2013b), as well as Fabaceae - *Cassia angustifolia*, *Mimosa*; Asteraceae -*Vernonia popeana*; Amaranthaceae - *Amaranthus* (ICIPE, 2013b; Moritz et al., 2013).

Other uncertainties for *C. claratris* (not covered further in this PRA)

- Cucurbitaceae: *Luffa acutangula*. Premachandra and Borgemeister (2006) refer to a MSc thesis (Jangvitaya, 1993). It was not possible to check whether this is a host. In addition, in host preference studies, *Luffa acutangulata* is considered a doubtful host/non-host (uncertain because only few larvae were found but it was not clear if *C. claratris* or *T. palmi* was involved; CaCV was detected and both thrips species are vectors; Steenken and Halaweh, 2011).
- **Hosts of *C. cameroni*** (see Taxonomy). Fabaceae, Solanaceae (*Withania somnifera*: 3 females), Cucurbitaceae: *Citrullus lanatus* (Moritz et al., 2013), *Cucumis melo* (http://wetarcomdev.org/).

8. Pathways for entry

Both *C. brunneus* and *C. claratris* were recently found on continents outside their native range. Mound and Azidah (2009) presume that *C. brunneus* is transported with horticultural trade.

For ***C. brunneus***, there are many interception records. Interceptions on specific commodities are given in Table 4. Interceptions are mentioned in the USA (Mound and Nickle, 2009; 9 interceptions on various commodities), the Netherlands (13 interceptions in 2002-2015), and the UK (FERA, unpublished data, over 70 interceptions of adults between 1996-2015). *C. brunneus* has been intercepted, showing that detection is possible, probably because many EPPO countries have requirements targeting *T. palmi* on some host commodities (e.g. *S. melongena* or *Momordica*). However, not all possible origins of *Ceratothripoides brunneus* and *C. claratris* and commodities are inspected systematically for thrips.

For ***C. claratris***, only one interception is known (UK on *S. melongena*).

For both species, Solanaceae are major hosts, and were considered separately for the pathways. The pathways studied are identical for both species, but with different hosts: fruit (in the botanical sense, incl. vegetables), cut plant parts (flowers, herbs), and plants for planting. Plant species for each category, for each pest, are listed in Table 3.

In addition, pupae are normally found in the soil. If the population of thrips carried with commodities is in the late instar (L2), pupation can occur in paper cribs or paper tissues used in packaging; in the laboratory, thrips are allowed to pupate in filter paper sheets lining containers holding French beans (S. Subramanian, pers. comm.). This is similar to other thrips (e.g. packaging is mentioned for *Thrips palmi* in EPPO/CABI, 1997). Finally some of the commodities below may be transported by travellers in their luggage, and measures are considered in Section 16.

Table 3. Species or genera covered for different commodities

There are many hosts considered uncertain in section 7, because either only adults were reported, or the life stages observed are not specified. Relevant species were considered as uncertain hosts for the pathways 'fruit', but were fully covered in the pathways for plants and plant parts as they may carry (at least) adults.

Commodity	*C. brunneus*	*C. claratris*
Fruit of cultivated Solanaceae hosts	*Solanum lycopersicum*, *Solanum melongena*, *Solanum aethiopicum*, *Capsicum*, *Solanum villosum*, other 'African eggplant' and African nightshade.	*S. lycopersicum*, *S. melongena*, *Capsicum*
Fruit of cultivated hosts in other families	*Phaseolus vulgaris*, *Citrullus lanatus*, 'Karela' (*Momordica charantia*), 'pumpkin' (*Cucurbita maxima*), *Cucumis melo* (as melon) Hosts on which some life stages were found: *Carica papaya*, *Musa*, *Passiflora*, *Vigna unguiculata*, 'sweet pea', *Mucuna* sp., *Cola*	*Cucumis melo*, *Citrullus lanatus*, *Cucumis sativus*, *Cucurbita moschata*, *Momordica charantia*, *Phaseolus vulgaris*, *Pisum sativum*, *Vigna unguiculata*, *V. sinensis*
Cut plant parts (cut flowers, leafy vegetables, herbs)	Uncertain hosts on which some life stages were found: *Ocimum*, *Salvia*, *Rosa*, *Impatiens*, and other hosts that may be traded as cut plant parts From interceptions: *Chrysanthemum*, *Oncidium*, *Ocimum basilicum*, *Telfairia occidentalis*	Hosts: *Lactuca sativa* Uncertain hosts on which some life stages were found: *Clitoria ternatea* (flowers)
Plants for planting (except seeds) of cultivated hosts	Hosts in Table 2A, uncertain hosts on which at least adults were collected, species on which there have been interceptions	Hosts in Table 2B, uncertain hosts on which at least adults were collected, species on which there have been interceptions

A summary of the consideration of pathways is given in Table 4. For both species and all pathways, the following is taken into account:

- Both are recorded as feeding on various parts of plants and on fruits (at least on tomato).
- Both are expected to survive transport; *C. brunneus* has been intercepted alive on various commodities. However multiplication of both species in transit is considered unlikely, at least for fruit, because fruit are often transported under refrigeration (e.g. for ripe tomatoes 7-10°C, sometimes higher for less ripe stages;

EPPO, 2015). For fruit of other hosts, UK PI (2006) indicates an optimal transit temperature of 10°C for capsicum, watermelon, cucumber, 13-14°C for green bananas. The lowest temperature threshold for development of *C. claratris* (16-18°C, see section 2) is above the transport temperatures mentioned. Mortality of *C. claratris* was lowest for the pupal stage at temperatures tested between 22°C and 40°C (Premachandra, 2004). The effect of cooling on survival of *Ceratothripoides* is unknown.

- Transfer from all commodities to suitable hosts, resulting in establishment would be higher if the thrips are introduced into an area where they can survive outdoors.

Table 4. Consideration of pathways (refer to Table 3 for the exact coverage of pathways)

Packaging: If the population of the pest carried with commodities is in the late instar, pupation can occur in packaging (e.g. in paper tissue). Multiplication in transport is considered unlikely. If adults emerge from pupae, they may transfer to a host if the packaging is imported (or discarded) close to facilities where hosts are grown. *Likelihood of entry*: moderate, if imported (or discarded) close to production sites; *Uncertainty*: moderate.

Pathway/details	Fruit – Solanaceae	Fruit – others	Plants for planting (except seeds)	Cut plant parts (flowers, leafy vegetables, herbs)
Pathway prohibited in the PRA area?	No	No (uncertain host *Carica papaya* in Israel)	Partly. e.g. EU: Solanaceae; Uncertain host: *Rosa* (may only be imported when dormant, free from leaves, flowers and fruit)	No
Pathway subject to a plant health inspection at import?	Partly e.g. EU: *Capsicum*, *S. melongena* *S. lycopersicum*: recommended by EPPO	Partly e.g. EU: *Momordica* uncertain host *Passiflora.*	Most probably partly in many EPPO countries. e.g. EU: all	Partly e.g. EU: leafy vegetables *Ocimum* ; uncertain hosts: cut flowers of Orchidaceae, *Rosa*
Pest already intercepted?	Yes for *C. brunneus* – several interceptions, on *S. melongena* (UK: FERA, unpublished data; Netherlands: NVWA, unpublished data), *S. lycopersicon* (USA, USDA, 2009), *Solanum* (Netherlands, Vierbergen, pers. comm.) *C. claratris* – 1 interception on *S. melongena* (UK, FERA unpublished data).	Yes for *C. brunneus* – *Momordica charantia* (Germany, UK; EPPO RS0809, EPPO RS 0511, ICIPE, 2009); *Momordica* (UK, Netherlands, Vierbergen, pers. comm., FERA, pers. comm.) No records found for *C. claratris*	Yes for *C. brunneus:* - *Veronica* (Vierbergen, 2008; commodity not specified), *Chrysanthemum* (cuttings) (NVWA, unpublished data) - *Chrysanthemum* and *Oncidium* (Japan, Masumoto et al. (2012); it is not specified if plants for planting or cut flowers) - USA on leaves (commodity and plant not specified) (USCBP, 2013) No records found for *C. claratris*	Yes for *C. brunneus* *Ocimum basilicum, Veronica* (specified as produce so assume cut leaves); *Telfairia occidentalis* (specified as leaves, assumed for consumption) (UK, FERA, unpublished data) possibly others listed in ‘plants for planting’. No records found for *C. claratris*
Most likely stages that may be associated	Eggs on green parts of fruit (Premachandra et al. 2005a for *C. claratris*), larvae on fruit or green parts (e.g. calyx, stems). Both species also feed on fruit. Adults may be associated with fruit consignments, especially with green parts. Pupae and adults may also develop during storage/transport and hide in packaging material.	As for Solanaceae fruit, but no leaf parts attached, although thrips are possibly less likely to feed on fruit with a ‘hard’ peel	Eggs, larvae. Adults may also be associated with plant consignments. Pupae may be present in the soil accompanying the plants, and adults be formed during storage and transport.	Mostly eggs, larvae and adults.
Important factors for association with the pathway	Solanaceae are the main hosts.	Most of the species listed do not seem to be the preferred hosts, but infestations on Cucurbitaceae occur regularly. *Ceratothripoides* occur on green pods of Fabaceae as well. There	In the EU, current requirements on growing media accompanying plants aim to prevent the presence of harmful organisms in the soil or growing medium	The plants concerned are mentioned in the host lists, but there is no indication of their importance as hosts

Pathway/details	Fruit – Solanaceae	Fruit – others	Plants for planting (except seeds)	Cut plant parts (flowers, leafy vegetables, herbs)
		have been interceptions (on *Momordica*) only for *C. brunneus.*	before transport (but pupae may be formed during transport and storage if mature larvae are present on the plants). The importance of most plants concerned as hosts is unknown.	
Survival during transport and storage	Likely	Likely	Likely. All life stages are likely to survive transport and storage.	Likely
Trade (*C. brunneus*) (from EPPO tomato study [EPPO, 2015] and incomplete data extracted from Eurostat 2014 for EU-28)	Data in EPPO (2015) indicate there have been imports in EPPO countries of **tomato** from South Africa, Kenya (& negligible amounts from Malaysia, Ethiopia) (EPPO, 2015). Data in Eurostat indicate there have been imports in the EU of **aubergine** from Kenya, South Africa, Cameroun, Cote d'Ivoire, Nigeria, Uganda, Ghana; ***Capsicum*** from Ghana, Uganda, Kenya; South Africa, Cameroun, Ivory Coast, Cuba, Ethiopia, Indonesia, Nigeria and Tanzania. No data were searched for other *Solanum* species.	Data in Eurostat indicate there have been imports in the EU of ***Cucurbita*** from South Africa, Ghana, Kenya, Uganda ; ***Cucumis sativus*** from Kenya, ***Cucumis melo*** from South Africa, Kenya, Uganda; ***Citrullus lanatus*** from South Africa, Cameroun, Nigeria, Uganda; ***Vigna*** and ***Phaseolus*** from Kenya Tanzania, Ethiopia, South Africa, Cote d'Ivoire, Uganda, Ghana, Nigeria. In the UK, *Momordica* is imported from Asia and Africa.	Data in Eurostat indicate some imports of ***Rosa*** plants from South Africa and Kenya. Plants for planting of Solanaceae are forbidden at least in the EU, and no data were found on import of other hosts (in particular vegetables)	Data in Eurostat indicate some imports of ***Chrysanthemum*** from South Africa and Kenya; ***Rosa*** from Kenya and Ethiopia.
Trade (*C. claratris*) (from EPPO tomato study [EPPO, 2015] and incomplete data extracted from Eurostat 2014 for EU-28)	Data in EPPO (2015) indicate there have been imports in EPPO of **tomato** from China, Thailand and Kenya. Data in Eurostat indicate there have been imports in the EU of **aubergine** from Kenya, India, Uganda and Thailand; ***Capsicum*** from India, Uganda, Kenya, China, Tanzania and Thailand.	Data in Eurostat indicate there have been imports in the EU of ***Cucurbita*** from India, Kenya, Uganda, Thailand ; ***Cucumis sativus*** from Kenya, India; ***Cucumis melo*** from Thailand, Kenya, Uganda, China*;* ***Citrullus lanatus*** from China, Philippines andThailand; ***Vigna*** and ***Phaseolus*** from Kenya, Tanzania, China, India and Uganda. In the UK, *Momordica* is imported from Asia and Africa.	Presumably low. Plants for planting of Solanaceae are forbidden in some countries (at least in the EU), and no data was sought on import of other hosts (in particular vegetables)	Likely to be very minor (flowers of *Clitoria ternata*)
Transfer to a host	Transfer is more likely if packing and handling facilities are located near production areas (but this is a known situation for at least tomato, pepper and eggplants), and private gardens with hosts. As solanaceous weeds are hosts, this increases the probability of transfer. Transfer with fruit directly provided to the consumer or used for processing is generally unlikely (the pest will be	See Solanaceae. No information is available on whether packing and handling facilities are located near production areas of hosts.	Plants for planting will be planted in favourable conditions for their development. Transfer to other hosts is very likely.	Transfer is less likely than for plants for planting, unless the cut plant parts are imported to facilities that also grow hosts

Pathway/details	Fruit – Solanaceae	Fruit – others	Plants for planting (except seeds)	Cut plant parts (flowers, leafy vegetables, herbs)
	destroyed at processing or discarded by the final consumer). However, there are circumstances for discarding fruit that may not eliminate the pest, such as domestic compost in private gardens, 'green bins', discarding prior to processing.			
Likelihood of entry: *C. brunneus*	Moderate-high if green parts attached Moderate otherwise	Moderate	High: moderate volumes. Except for Solanaceae and Cucurbitaceae other species are not main hosts, but this pathway has a higher likelihood of survival and transfer.	Moderate
Likelihood of entry: *C. claratris*	Moderate if green parts attached Moderate-low otherwise	Moderate-low	High	Moderate-low
Uncertainty	Moderate	Moderate	Moderate (volume of trade, association)	High (volume of trade, association)

Pathways considered unlikely (likelihood very low) and not considered further.

- **Soil or growing media from areas where *C. brunneus* and *C. claratris* occur.** Only pupae will be associated with soil. Soil associated with plants for planting of hosts is covered under the 'plants for planting' pathway. Regarding soil on its own, the importation of soil into many EPPO countries (at least the EU, Turkey and Israel) from countries where the pest occurs is forbidden. Finally, entry with soil associated with plants for planting of non-hosts is considered unlikely (pupae are presumably formed in the soil under host plants). **Uncertainty***:* low
- **Underground parts of hosts (potato tubers, carrots, onions).** Pupae may be associated with soil, and therefore with soil associated with these commodities. However, it is expected that only small amounts of soil would accompany these commodities. In addition, these are probably not main hosts. This pathway was considered unlikely. In addition, at least in the EU, while potatoes are subject to a prohibition from the origins concerned, onions would be destined only for consumption (*Allium cepa* for planting is prohibited). **Uncertainty**: low.
- **Hitch-hiking, natural spread.** There is no evidence that these could be pathways. **Uncertainty**: low
- **Seeds, tissue cultures, processed commodities made from hosts**: *C. brunneus* and *C. claratris* are not associated with those substrates.

The ratings of the likelihood of entry and the uncertainty are given in Table 4.

9. Likelihood of establishment outdoors in the PRA area

Host plants in the EPPO region

Some hosts that are common to *C. brunneus* and *C. claratris* are grown in the EPPO region, such as tomato (*S. lycopersicum*), eggplant *(S. melongena)*, peppers (*Capsicum)*, watermelon (*Citrullus lanatus)*, melon (*Cucumis melo*) and bean (*Phaseolus vulgaris)*. The main hosts (tomato, sweet peppers and eggplant) are grown commercially in the field or under protected conditions (glasshouse, tunnels, plastic) as well as in private gardens. Tomato is cultivated throughout the PRA area, whilst sweet pepper and eggplant have a more southern and eastern distribution (EPPO, 2014). Details on tomato are provided in the EPPO tomato study (EPPO, 2015). Many of the hosts or uncertain hosts (see Section 7) are major crops or widely grown in the EPPO region (such as cucumber (*Cucumis sativus*) or peas (*Pisum sativum*)).

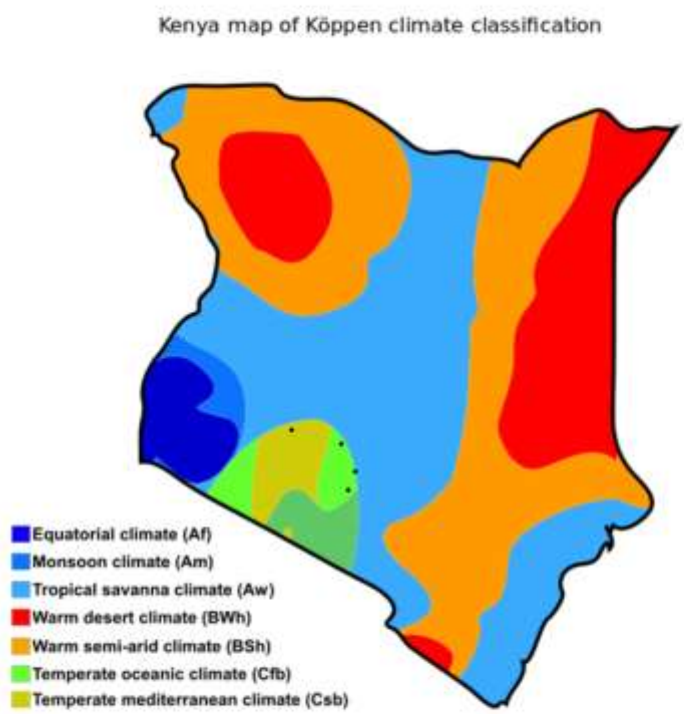
Host crops are present throughout the EPPO region. Some are more southerly than others (e.g *Citrullus lanatus*), and the production systems may vary (i.e. grown only in the field, only under glasshouse, or both).

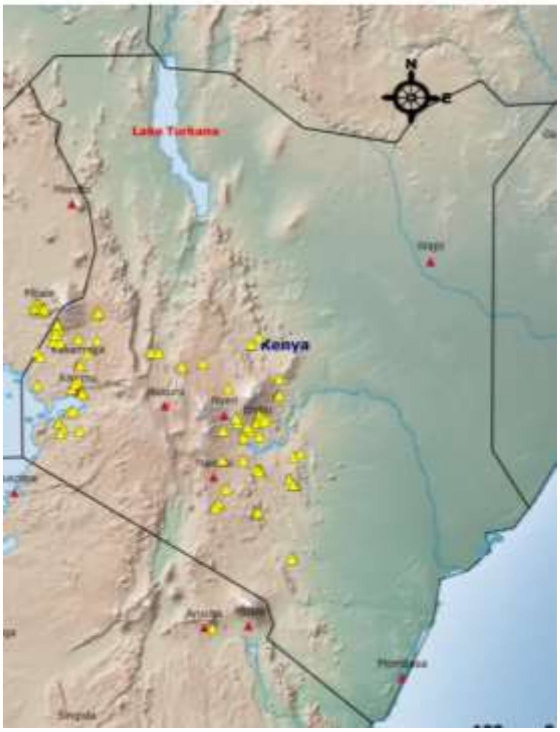
The abundance of host plants and the type of plants will influence the suitability of the area for establishment. In some parts of the PRA area, solanaceous hosts (possibly others) are grown all year round (e.g. at least North Africa, Turkey, and in greenhouses or tunnels elsewhere), which will favour establishment of the thrips. It is not considered likely that the existing management practices in the field will prevent establishment. Details of some management practices for tomato and eggplant are given in the PRA on *Keiferia lycopersicella* (EPPO, 2012).

Climatic conditions

According to the classification of Köppen Geiger (see map in Annex 1), *C. brunneus* and *C. claratris* occur mostly in countries of equatorial climates (such as Asia and the Caribbean; classes Af, Aw and Cwa). However the distributions of both species include countries with limited temperate climatic zones:

-*C. brunneus* is recorded from Ethiopia, Kenya, South Africa and Tanzania as well as Indonesia, each of which include small temperate climatic zones (class Cfb, oceanic climate which is widely present in the PRA area or Csb, warm-summer Mediterranean climate). Limited data is available to find out whether *C. brunneus* is present in such areas in these countries. The sites in Indonesia highlands in Johari (2015) are all considered to be of tropical climates (Af). The map provided by Moritz et al. (2013) for Kenya, Tanzania and Unganda show that although most sites where the pest is found are in tropical or equatorial climates, some survey sites where the pest was found in Kenya are located in temperate oceanic climate (Cfb), e.g. near Nairobi or Nyeri. In addition, Machiara et al. (2015) mention its presence in Nakuru and Kirinyaga which have a warm-summer Mediterranean climate (Csb). It should be noted that in these locations, average monthly temperatures would be 17°C-20°C and cool temperatures down to 8°C may occur but without frost, annual rainfall are about 900-1000 mm.





Left: Map of Köppen climate on Kenya(https://en.wikipedia.org/wiki/Geography_of_Kenya#Climate) with dots corresponding to survey points of Moritz et al. (2013) and Machiara et al. (2015) where *C. brunneus* was found in Cfb and Csb climates.
Right: map of distribution of C. brunneus in Kenya from Moritz et al. (2013). Red triangles are major cities, Yellow triangles are where C. brunneus was found.

-*C. claratris* has been recorded in Kenya, Tanzania and Uganda but only in the hot and humid coastal regions and lake basin regions, and not in the temperate climatic zones (S. Subramanian, pers. comm.). *C. claratris* is referred to as a pest of hot and humid tropics (Nguyen et al., 2009), where it is a tomato pest both in the field and in protected conditions (Murai et al., 2000; Pramachandra & Borgemeister, 2006) and is adapted to high temperatures in the tropics (30-35°C).

Given the presence of ***C. brunneus*** in locations with a Cfb and Csb climates, it is considered that the pest may be able to establish in only part of the EPPO region (with a high uncertainty). Areas where frost occurs would not be suitable for the establishment of *C. brunneus*. Considering plant hardiness maps, the areas where hosts would be present all year round correspond to the coastal areas of the Mediterranean, but only the parts without frost and with high humidity would be suitable.
There are uncertainties (high) regarding the exact limits of the area of potential establishment, the role of humidity and the effect of irrigation in hot, dry areas in the south of the EPPO region. However, given the current distribution, it is likely that the pest require high humidity and high temperature. Thus, it would probably be unable to maintain populations year round in most parts of the region but it may form transient populations outdoors. Pest populations from areas where the climatic conditions are closer to those of the EPPO region have a higher likelihood of establishment than other populations. It should be noted that only one outbreak of *C. brunneus* has been reported in the EPPO region (see note 1 in section 6. Distribution) despite many interceptions especially in the Netherlands and the UK.

It is considered unlikely that ***C. claratris*** can establish outdoors in the EPPO region, but transient populations may occur.

C. brunneus

Coastal areas of the Mediterranean without frost and with high humidity (undefined)

Rating of the likelihood of establishment outdoors	*Low* ☐	*Moderate* ✓	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ✓	*High* ☐

Rest of the EPPO region

Rating of the likelihood of establishment outdoors	*Low* ✓	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ✓	*Moderate* ☐	*High* ☐

C. claratris

Whole EPPO region

Rating of the likelihood of establishment outdoors	*Low* ✓	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ✓	*Moderate* ☐	*High* ☐

10. Likelihood of establishment in protected conditions in the PRA area

Many hosts are grown under protected cultivation (e.g. under plastic, polytunnels, glasshouses) in the EPPO region, including *S. lycopersicum*, *S. melongena* and *Capsicum*. Indications on protected conditions in the EPPO region were provided for tomato and eggplant in the PRA on *K. lycopersicella* (EPPO, 2012).

C. brunneus was introduced with infested pot plants (*Ensete*) in the Netherlands, and was able to survive for at least four years in a greenhouse environment without pest management (Vierbergen, 1999 – see section 6). It is expected that *C. brunneus* may be able to establish in glasshouses in the EPPO region.

C. claratris is present in glasshouses in Thailand, which would imply conditions of high temperature and high humidity. Conditions may be appropriate in the EPPO region particularly the southern part, which may result at least in transient populations.

There is often a crop-free period in glasshouses, and establishment in protected conditions would be more likely if the pest can also find hosts and survive outdoors. Establishment of both species in glasshouses is unlikely if there is a sufficient crop-free period, and the growing medium is removed or treated to eliminate pupae, and the pest cannot survive outdoors.

C. brunneus

Whole EPPO region

Uncertainty: effect of existing pest management, lack of biological data

Rating of the likelihood of establishment in protected conditions	*Low* ☐	*Moderate* ✓	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ✓	*High* ☐

C. claratris

Southern part of the EPPO region

Rating of the likelihood of establishment in protected conditions	*Low* ☐	*Moderate* ✓	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ✓

Rest of the EPPO region

Rating of the likelihood of establishment in protected conditions	*Low* ✓	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ✓	*High* ☐

11. Spread in the PRA area

Both species are likely to spread naturally and through human-assisted pathways. There are a large number of commodities that may carry these thrips. The potential for natural spread is not known, although Premachandra et al. (2005a) mention that *C. claratris* may have a weak flying capacity. Thrips are amongst the weakest flying insects, and their actual flight speed varies depending on their size: from 10 cm/s for the smallest to 50 cm/s for the larger species (Lewis, 1997). However, thrips can be carried over large distances by winds exceeding their own flight speed (Mound, 1983; Pearsall and Myers, 2001). Initiation of thrips flight is affected by environmental factors such as high temperature, light and low wind speed (Lewis, 1997).

Thrips are also known to be readily carried on clothing (e.g. Sanderson, nd; for *Frankliniella occidentalis*) and this may allow spread at short distances. The spread would be highest if *C. brunneus* or *C. claratris* enter an area where they can survive outdoors and from which host commodities (fruit, plants for planting or cut flowers/herbs) are traded. Transport of host products within countries (e.g. markets, private use, passengers) may also play an important role. Considering that the establishment of *C. claratris* outdoors is considered unlikely, the magnitude of spread is expected to be lower than of *C. brunneus*.

Finally, the fact that many thrips species are present in the EPPO region, and that many species are not readily distinguished from each other, may cause difficulties and delays in identifying that a new species has become established, and may favour spread.

C. brunneus

Rating of the magnitude of spread	*Low* ☐	*Moderate* ✓	*High* ☐
Rating of uncertainty	*Low* ✓	*Moderate* ☐	*High* ☐

C. claratris

Uncertainty: suitability of the receptive environment, little evidence of moving in trade.

Rating of the magnitude of spread	*Low* ☐	*Moderate* ✓	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ✓	*High* ☐

12. Impact in the current area of distribution

Larvae and adults of both *Ceratothripoides* species cause direct damage, primarily on leaves and fruit, and to a lesser extent on stems by feeding (Premachandra et al. 2005a, Premachandra and Borgemeister, 2006, Biovision, 2012). Damage on flowers and buds is rare.

In a study on thrips species in four major tomato production areas in Kenya, ***C. brunneus*** was the predominant species in all areas (Macharia et al., 2015). Damage in Kenya and Uganda on tomato due to thrips (with *C. brunneus* as the dominant species) can be 'as high as 30%' (ICIPE, 2011 – there is no indication of which species caused the most damage). ICIPE (2009) note that earlier records mentioned *C. brunneus* only as occasional on tomato. *C. brunneus* also infests other solanaceous crops, such as African eggplant, African nightshade, *Capsicum* and eggplant (Moritz et al., 2013). In Indonesia (where it was introduced), damage by thrips on *C. annuum* in Jambi (by several species) reached 40%, with 10-100% reported elsewhere (Johari, 2015), but infestations by *C. brunneus* were only slight. *C. brunneus* is also infrequently observed on cucurbits such as pumpkin, watermelon and fabaceous crops such as cowpea, beans, French beans and sweet peas (Moritz et al., 2013), but no records on damage was found for these other crops. No indication of vector transmission was found.

Until 2000 (Murai et al, 2000), no records were known of ***C. claratris*** causing damage in tomato. Since then *C. claratris* has become one of the most destructive insect pests of tomato in Thailand (Panyasiri et al., 2007) and has caused significant yield losses in field and glasshouse tomatoes. On glasshouse tomatoes the abundance is much higher than in the field (Premachandra et al. 2004, Premachandra et al. 2005b). Oviposition on fruit causes deformation (Premachandra et al., 2005a). Indirect damage is caused by virus transmission (*Capsicum chlorosis virus*, Premachandra et al. 2005b), and the newly described *Tomato necrotic ringspot virus* (Seepiban et al., 2011). *C. claratris* is the predominant tomato thrips species in Thailand (Premachandra et al., 2005a; Ranamukhaarachchi & Wickramarachchi, 2007), especially in the Central plains area (Thakaew et al., 2011). No indication of damage was found for other Asian countries. In the humid coastal and lake regions of east Africa, *C. claratris* was commonly observed on solanaceous crops such as tomato, eggplant, capsicum and other solanaceous weeds (Moritz et al., 2013), but no indication of damage was found. No record on damage was found for other crops, such as cucurbits.

No mention of environmental or social impacts were found in the literature for either species.

Impact was rated as high due to reports of substantial damage on tomato from East Africa (***C. brunneus***) and on tomato from Thailand (***C. claratris***), through recognizing that data is lacking on damage elsewhere and on other hosts. Due to lack of quantitative data, there are many uncertainties and the same rating was applied to both species.

Uncertainty: impact on hosts other than tomato. Impact in countries where no information is available. For tomato, limited information from some countries and possible mixed thrips infestations.

On tomato (C. brunneus* and *C. claratris)

Rating of the magnitude of impact in the current area of distribution	*Low* ☐	*Moderate* ☐	*High* ✓
Rating of uncertainty	*Low* ☐	*Moderate* ✓	*High* ☐

On other crops (C. brunneus* and *C. claratris)

Rating of the magnitude of impact in the current area of distribution	*Low* ✓	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ✓

13. Potential impact in the PRA area

Will impacts be largely the same as in the current area of distribution? **No**

Damage is expected to be lower as climatic conditions outdoor are not optimal. Both species could cause direct damage to crops indoors. There is an uncertainty on whether they would survive periods without the crop. Specific control measures will be needed. IPM strategies are widely used in the EPPO region, and may have to be modified to include *Ceratothripoides* species. There are already several thrips attacking host species in the EPPO region, but control measures may not be applied throughout the region or at times suitable to control *C. brunneus* and *C. claratris*. For example, *F. occidentalis* is mainly controlled with IPM programmes based on the use of natural enemies, which may not be efficient against other thrips species (although thrips predators are often generalists). In addition, at least *C. claratris* is a vector of viruses not known to be present in the EPPO region. Both species may cause loss of harvest, increase in production costs, disruption of IPM programmes and of small productions, and have an impact on external markets as well as on the large trade of hosts fruit and plants (incl. cut flowers/herbs) within the EPPO region.

No environmental impact is expected, apart if pesticide applications increase. Social impacts are expected to be minor overall, possibly major locally.

On tomato (indoors for C. claratris and C. brunneus, and in areas outdoors where C. brunneus can establish)

Rating of the magnitude of impact in the area of potential establishment	*Low* ☐	*Moderate* ✓	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ✓

On other crops

Rating of the magnitude of impact in the area of potential establishment	*Low* ✓	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* ☐	*High* ✓

14. Identification of the endangered area

Both thrips species have the potential to establish in glasshouses and other protected conditions (screenhouses/ polytunnels), ***C. brunneus*** throughout the PRA area and ***C. claratris*** more likely in the southern part of the EPPO region.
Outdoors, ***C. brunneus*** could possibly establish in part of the EPPO region, which could not be defined precisely but would correspond to the parts of coastal areas of the Mediterranean where there is no frost and where humidity is high. In the long-term, populations are likely to maintain under protected conditions only if they can also survive outdoors. ***C. claratris*** is not expected to be able to establish outdoors in the EPPO region.

In addition, both species may establish transient populations outdoors.
Hosts at risk of economic impact are especially tomato, eggplant and capsicum, as well as cucurbits, and to a lesser extent some fabaceous crops.

15. Overall assessment of risk

C. brunneus and *C. claratris* share some elements of this risk assessment. Entry was considered possible (with varying likelihood and uncertainties for both species on different pathways – see Table 4 in section 8) for both species on plants for planting, as well as for fruits of Solanaceae and others, and cut plant parts (flowers, leafy vegetables, herbs). For the latter pathways, the likelihood of entry was rated slightly lower for *C. claratris* than for *C. brunneus*. The risk of establishment differs (see below), but they may cause outbreaks and transient populations under protected conditions in the EPPO region (where they may cause damage if they do not establish permanently, as for *T. palmi*). Both species are expected to have a moderate impact overall. They may both cause economic impact on Solanaceae, especially tomato, capsicum and eggplant, as well as cucurbits, and to a lesser extent on some fabaceous crops. Spread will mainly be with traded commodities rather than natural spread.

C. brunneus and *C. claratris* differ for other components of the risk.

C. brunneus possibly has a more temperate distribution, and is present at higher altitudes in some tropical countries, and may be able to establish outdoors in part of the EPPO region. Due to lack of data, this area could not be defined precisely, but taking into account its current distribution and plant hardiness, this may correspond to the parts of coastal areas of the Mediterranean where there is no frost and where humidity is high. There are relatively frequent records of interceptions of *C. brunneus* on various commodities, but fewer reports of damage where it occurs. It is not known as a vector of plant viruses.

C. claratris is a more tropical species with requirements for high temperature and humidity. It is not likely to establish outdoors in the EPPO region. In protected conditions, it is more likely to establish in the southern part of the region. There is only one known record of interception of *C. claratris*. It has greatly increased in importance in Thailand in the past 15 years, but reasons are not known. It is vector of two tospoviruses, CaCV and TNRV. It is not known why *C. claratris* is intercepted very infrequently (it may simply be because trade of its host commodities from Thailand has not been important so far; or it may be linked to its inability to be associated with commodities and survive transport). Finally, there are still unresolved taxonomic issues as it is not clear whether *C. claratris* and *C. cameroni* are the same species (which would expand the distribution of the pest in Africa).

Phytosanitary measures were elaborated for plants for planting, fruit and cut parts of plant.

Stage 3. Pest risk management

16. Phytosanitary measures

Measures were considered for all pathways identified in section 8, i.e. fruit, plants for planting and cut flowers/herbs (see Table 3 in section 8 for hosts covered for each thrips and pathway, noting uncertainties on hosts or their importance), as well as entry with travellers carrying host commodities from countries where the thrips occur. Measures are considered to apply to both species. Annex 2 summarizes the consideration of measures. Measures regarding packaging are not detailed in Annex 2, but combined below with those for the different commodities.

Possible pathways ***(in order of importance)***	**Measures identified (see details in Annex 2)**
Plants for planting (except seeds and tubers) of cultivated hosts Note: for many EPPO countries, the import of Solanaceae plants for planting is prohibited, but not other important host plants	Phytosanitary certificate and: - Pest Free Area (with survey, trapping and identification of thrips) + appropriate packing/handling methods to avoid infestation during transport Or - Pest free site/place of production under complete physical isolation (following EPPO Standard PM 5/8)+ appropriate packing/handling methods to avoid infestation during transport In all cases above: - Only new packaging should be used at origin, and packaging should be destroyed or safely disposed of at import.
Fruit of cultivated hosts	Phytosanitary certificate and: - Pest Free Area (with survey, trapping and identification of thrips), Or - Pest free site/place of production under complete physical isolation (following EPPO Standard PM 5/8) Or - Systems approach (on the basis of bilateral agreement): Growing under glasshouse + monitoring and treatment at the place of production + good agricultural practices + inspection at packing Or - Import only in winter, for direct consumption (only in countries where the pest cannot establish outdoors) Or - Surveillance in the importing country + separation of trade flows (only in countries where the pest cannot establish outdoors, on the basis of bilateral agreement) In all cases above: - Only new packaging should be used at origin, and packaging should be destroyed or safely disposed of at import.
Cut flowers and herbs of cultivated hosts	Phytosanitary certificate and: - Pest Free Area (with survey, trapping and identification of thrips) + appropriate packing/handling methods to avoid infestation during transport Or - Pest free site/place of production under complete physical isolation (following EPPO Standard PM 5/8) + appropriate packing/handling methods to avoid infestation during transport Or - Systems approach (on the basis of bilateral agreement): Growing under glasshouse + monitoring and treatment at the place of production + good agricultural practices + inspection at packing + appropriate handling/ packing methods to avoid infestation, at the production site and during transport) Or - Import only in winter, for direct consumption for areas (only in countries where the pest cannot establish outdoors) Or - Surveillance in the importing country + separation of trade flows (only in countries where the pest cannot establish outdoors, on the basis of bilateral agreement) In all cases above: - Only new packaging should be used at origin, and packaging should be destroyed or safely disposed of at import.

Travellers carrying fruits, cut flowers and herbs, or plants for planting of main hosts	Raising awareness and inspection of luggage

Eradication and containment. Eradication of similar species, e.g. *Thrips palmi*, has been conducted in several EPPO countries (e.g. EPPO Standard PM10/15(1) *Disinfestation of production site against Thrips palmi*), and it is likely that similar eradication programmes could be applied to *C. brunneus* or *C. claratris*. The highest chance of eradication would be for an introduction under protected conditions in an area where *C. brunneus* and *C. claratris* cannot survive outdoors. However, any eradication plan is costly, and it is considered here that introduction should rather be prevented.

Due to the nature of this PRA (short), it is not possible to provide detailed requirements for eradication and containment.

17. Uncertainty

The main uncertainties are as follows (for both species if not mentioned otherwise):

- taxonomy: for *C. claratris*, whether *C. cameroni* is the same species. If they are the same species, are they all biologically the same, or is there one population/metapopulation that has changed, leading to the emergence of *C. claratris* as a pest in Thailand?
- biology/ecology (temperature and humidity requirements, survival at low temperatures)
- current distributions (including infranational distribution in countries with limited temperate areas)
- exact host range
- extent of damage caused on the different hosts, also where introduced.
- capacity of spread of *C. claratris*, and why it is not been found in trade (unlike *C. brunneus*).

18. Remarks

None.

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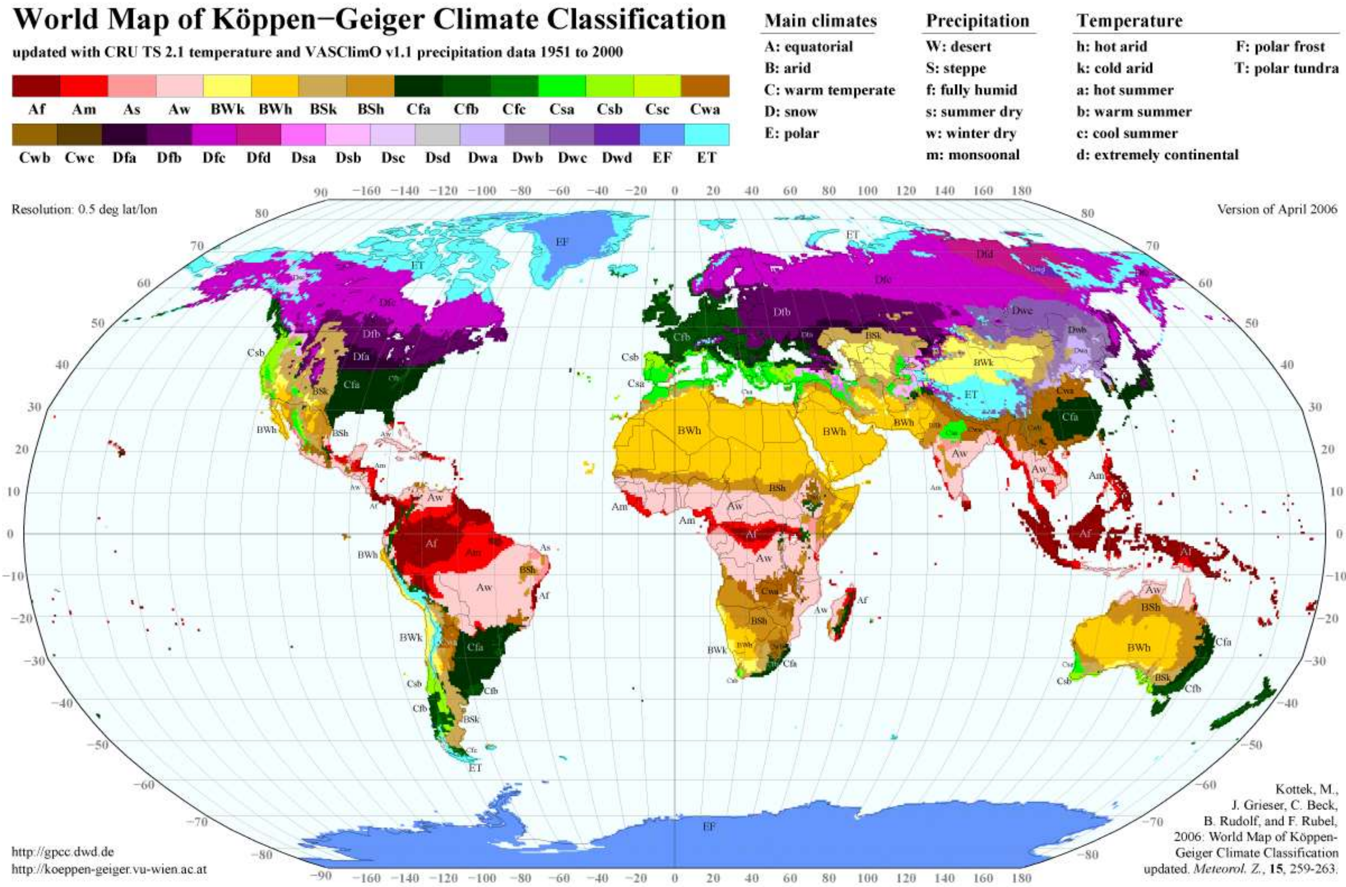
Annex 1


World Map of Köppen−Geiger Climate Classification
updated with CRU TS 2.1 temperature and VASClimO v1.1 precipitation data 1951 to 2000
Af Am As Aw BWk BWh BSk BSh Cfa Cfb Cfc Csa Csb Csc Cwa
Cwb Cwc Dfa Dfb Dfc Dfd Dsa Dsb Dsc Dsd Dwa Dwb Dwc Dwd EF ET
Main climates
A: equatorial
B: arid
C: warm temperate
D: snow
E: polar
Precipitation
W: desert
S: steppe
f: fully humid
s: summer dry
w: winter dry
m: monsoonal
Temperature
h: hot arid
k: cold arid
a: hot summer
b: warm summer
c: cool summer
d: extremely continental
F: polar frost
T: polar tundra
Resolution: 0.5 deg lat/lon
Version of April 2006
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Annex 2. Consideration of pest risk management options

The table below summarizes the consideration of possible measures for the different pathways (based on EPPO Standard PM 5/3). When a measure is considered appropriate, it is noted "yes", or "not alone" if it should be combined with other measures in a systems approach. "No" indicates that a measure is not considered appropriate. A short justification is included.
Measures are considered to apply to both *C. brunneus* and *C. claratris*.

Option	Plants for planting (except seeds and tubers)	Fruit (Solanaceae)	Fruit (others)	Cut flowers/ herbs
Existing measures in EPPO countries	Partly: Prohibition existing on import of Solanaceae plants for planting into the EU and other countries but other hosts are not regulated (e.g. Cucurbitaceae)	No. The existing measures are not sufficient to prevent the risk of entry of the pest (at the scale of the whole EPPO region)		
Options at the place of production				
Visual inspection at place of production	Not alone. Thrips are minute and difficult to see. Unlikely to detect low infestation levels or early infestation, or eggs. Trapping (sticky traps) available, but not specific, and identification of thrips is difficult (especially larval stages)			
Testing at place of production	No. Not relevant.			
Treatment of crop	Not alone Not reliable to guarantee pest freedom. It may be used in combination with others in a systems approach			
Resistant cultivars	No. Not relevant.			
Growing the crop in in glasshouses/ screenhouses	Yes (+ handling/packing preventing infestation) but difficult to implement in practice This would require complete physical isolation with stringent measures (following EPPO Standard PM 5/8) due to the size of the thrips. Screenhouses should have an appropriate mesh size (100µm). It is difficult to implement in practice because of the temperature and humidity in the tropics, and the difficulty to have appropriate ventilation in such screenhouses. The pest is very mobile, and additional requirements should be applied for growing media (to make sure that it is free from pupae). Plants for planting and cut flowers/herbs should be appropriately packaged/handled to avoid infestation during transport out of the physical isolation for trade.			
Specified age of plant, growth stage or time of year of harvest	No. Thrips infest seedlings as well as plants bearing fruit			
Produced in a certification scheme	No. Not relevant for an insect.			
Pest free production site	Only growing under complete physical isolation but may not be practical (see above)			
Pest free place of production	Not alone if not under complete physical isolation. According to ISPM 10 *Requirements for the establishment of pest free places of production and pest free production sites*, it will require in particular, use of pest free planting material, clean growing medium, trapping and regular inspection. Note: Place of production freedom (not under complete physical isolation) is an option for *T. palmi* in the EU Directive 2000/29. Freedom should be confirmed by official inspections carried out at least monthly during the three months prior to export. However, the Panel on Phytosanitary Measures considered that a PFPP outdoors would not provide a suitable level of protection for this pest.			

Option	Plants for planting (except seeds and tubers)	Fruit (Solanaceae)	Fruit (others)	Cut flowers/ herbs
Pest free area	Yes PFA as described in ISPM 4. It will require the use of traps. Because those are not specific, specialized identification capacities should be available. Pest-free seedlings should be used. There should be control on movement of all host fruit and plants, other hosts, equipment and packaging, etc. in and out of the area. Plants for planting and cut flowers/herbs should be appropriately packaged/handled to avoid infestation during transport out of the PFA. Note: this is an option for *T. palmi* in the EU for plants for planting and some cut flowers and fruit.			
Options after harvest, at pre-clearance or during transport				
Visual inspection of consignment	No. Eggs may also be present, and pupae in the growing medium	Not alone. Interceptions at import inspection are reported for thrips (incl. *C. brunneus*), but there is a likelihood of not detecting low infestation levels or early infestation. Inspection at import is a standalone measure in the EU for *T. palmi* on some fruit/cut flowers («Cut flowers of Orchidaceae and fruits of *Momordica* L. and *Solanum melongena* L: Official statement that the cut flowers and the fruits immediately prior to their export, have been officially inspected and found free from *Thrips palmi »)*. Berlese funnel should be used, and sufficient identification capabilities should be available.		
Testing of commodity	No. Not relevant.			
Treatment of the consignment	No. This is an option for *T. palmi* in the EU (in combination with inspection immediately prior to export) but the EWG considered that there are no available treatments for consignment.	No. No treatment was found for fruit.		
Pest only on certain parts of plant/plant product, which can be removed	No. The thrips may be present on leaves, stems and fruit. For fruit, ensuring absence of green parts will reduce the risk, but not eliminate the thrips completely.			
Prevention of infestation by packing/handling method	Not alone Commodities may already be infested. Only new packaging should be used. For plants for planting and cut plant parts, suitable packing/handling methods should be used to prevent infestation during transport. It is considered unlikely that the pest will infest fruits after harvest.			
Options that can be implemented after entry of consignments				
Post-entry quarantine	Not alone. Possible in theory for small consignment of high value plants in the framework of bilateral agreements (but may not be practical/cost-effective). (no data to decide	Not relevant		

Option	Plants for planting (except seeds and tubers)	Fruit (Solanaceae)	Fruit (others)	Cut flowers/ herbs
	on length, but should allow the development of at least 1 generation with regular inspections)			
Limited distribution of consignments in time and/or space or limited use	No. Not applicable for plants as the intended use is for planting.	Yes, but it may be difficult to implement in practice as it is not always possible to be sure of the final destination of a consignment. Consignments may be imported when temperatures are cold for immediate processing or direct consumption, where the pests cannot survive outdoors. However, there is limited knowledge on the conditions under which they may survive outdoors. Immediate processing of the fruit and destruction of the waste (e.g. burning, deep burial) is possible, but it is not practical and difficult to control in practice. Adults that have emerged during transport might also escape.		Yes, but it may be difficult to implement in practice as it is not always possible to be sure of the final destination of a consignment. Cut flowers and herbs would normally be used indoors, and the risk of transfer should therefore be low in areas where the pest cannot survive outdoors. However, the exact limit of this area is not known.
Only surveillance and eradication in the importing country	No	Yes, but it may be difficult to implement in practice. Only possible in individual EPPO countries in the northern part where the pest cannot establish outdoors. In the part of the EPPO region where the pest cannot establish outdoors (not precisely defined), infested consignments could in theory be imported. This would require the separation of trade and production flows (separate facilities for imported consignments and for growing hosts) and a good surveillance system (although this will be challenging as there are no species-specific traps). Eradication is considered possible in greenhouses in that part of the PRA area. This would be possible only as long as the trade volumes are very low.		