EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION
ORGANISATION EUROPEENNE ET MEDITERRANEENNE POUR LA PROTECTION DES PLANTES

25-30309 (21-26630)

This PRA document was modified in 2021 to clarify the phytosanitary measures recommended, and in 2025 to add a note on the risk with import of cut roses.

Pest Risk Analysis for

Thaumatotibia leucotreta

September 2013

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This risk assessment follows the EPPO Standard PM 5/3(5) *Decision-support scheme for quarantine pests* (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 core members and by the Panel on Phytosanitary Measures and if relevant other EPPO bodies. It was finally approved by the Council in September 2013.

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25-30309 (21-26630, 20-25985, 13-19032, 13-18307, 12-18121)

Pest Risk Analysis for *Thaumatotibia leucotreta*

Fig. 1 Adult of *T. leucotreta* (courtesy Ms van der Straten)

Fig. 2 Larvae of *T. leucotreta* (courtesy Ms van der Straten)

Stage 2: Pest Risk Assessment Section A: Pest categorization
Stage 2: Pest Risk Assessment Section B: Probability of entry of a pest
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Stage 3: Pest Risk Management

Expert Working group for PRA for *T. leucotreta*:

Assessors	1st meeting 2011-11-29/12-02	2nd meeting 2012-06-25/28
Mr Baker, Food and Environment Research Agency, United Kingdom	X	X
Mr Baufeld, Julius Kühn Institut (JKI), Germany	X	X
Mr Guitián Castrillón,Tecnologías y Servicios Agrarios, S. A. (TRAGSATEC), Spain	X	X
Mr Hattingh, Citrus Research International, South Africa	X	
Mr Panagiotis, Benaki Phytopathological Institute, Greece	X	
Mr Sarto I Monteys, Servei de Sanitad Vegetal, Spain	X	
Ms van der Straten, Plant Protection Service, Netherlands	X	X
Ms Françoise Petter (EPPO Secretariat)	X	X

The PRA was further reviewed by 9 core members (José María Guitian Castrillón, Corinne Le Fay-Souloy, Dirk Jan van der Gaag, Alan MacLeod, Ernst Pfeilstetter, Gritta Schrader, Arild Sletten, Robert Steffek, Nursen Ustun) between the 2012-07-19 and 2012-09-10.
The risk assessment part was reviewed by the Panel on Phytosanitary Measures on 2012-10 and the pest risk management part on 2013-03.

Stage 1: Initiation

1.01 - Give the reason for performing the PRA

Identification of a single pest

1.02a - Name of the pest

Thaumatotibia leucotreta (Meyrick)

1.02b - Indicate the type of the pest

Arthropod

1.02d - Indicate the taxonomic position

Phylum: Arthropoda; Class: Insecta; Order: Lepidoptera; Family: Tortricidae; Tribe: Grapholitini; Species: *Thaumatotibia leucotreta*.

Common name False codling moth

Synonyms: *Cryptophlebia leucotreta*, *Argyroploce leucotreta*; note that the name *Cryptophlebia leucotreta* is still used in relatively recent publications.

1.03 - Clearly define the PRA area

EPPO member countries

1.04 - Does a relevant earlier PRA exist?

Yes

For the EPPO region

A PRA was performed by the British NPPO in 2002 (MacLeod, 2002)

A PRA was performed by the Spanish NPPO in 2006 (Sanjuan Carro, 2006)

A PRA was performed by the Dutch NPPO in 2010 (Potting & van der Straten, 2010)

A mini risk assessment for the US (Venette *et al.*, 2003) and pest response guidelines for the USA (USDA, 2010) are available.

Several pathway analyses have also been performed in the USA (Sullivan *et al*. 2010)

1.05 - Is the earlier PRA still entirely valid, or only partly valid (out of date, applied in different circumstances, for a similar but distinct pest, for another area with similar conditions)?

Not entirely valid

The PRA performed by the Dutch NPPO focuses on the Netherlands and only considers the risk for glasshouse production. The Spanish PRA is mostly focused on *Citrus*.

The UK PRA was a short PRA and a more detailed analysis is needed, the information on eradication of the pest in Israel is no longer valid (see question 1.07).

Information on biology, host plant range, geographic distribution and impact presented in these PRAs was evaluated and used in preparing the current PRA.

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

T. leucotreta is a polyphagous pest which can feed on many host plants present in the EPPO region.

An extensive literature review on host plants of *T. leucotreta* was undertaken. A list of currently known hosts is provided in Appendix 1. This includes remarks on the status of some of the recorded host plants, as for some of these (e.g. pear, tomato, pineapple) the EWG was not able to find sound references on their host status.

The list of the most relevant host plants to consider in this PRA is presented in Table 1. The selection of host is based on expert opinion taking into account the importance of the host in the PRA area, its host status (major or incidental) and the importance of the possible pathways (in terms of volume of imported commodities).

HOST PLANT	COMMON NAME	PLANT FAMILY
Capsicum spp.	Pepper	Solanaceae
Citrus reticulata & hybrids	Mandarin orange	Rutaceae
Citrus sinensis & hybrids	Orange	Rutaceae
Citrus paradisi	Grapefruit	Rutaceae
Gossypium spp.	Cotton	Malvaceae
Litchi chinensis	Litchi, Litchee	Sapindaceae
Macadamia spp.	Macadamia	Proteaceae
Mangifera indica	Mango	Anacardiaceae
Prunus persica	Peach	Rosaceae
Prunus persica var. nucipersica	Nectarine	Rosaceae
Persea americana	Avocado	Lauraceae
Psidium guajava	Guava	Myrtaceae
Punica granatum	Pomegranate	Lythraceae
Quercus robur	Oak	Fagaceae
Ricinus communis	Castor oil plant	Euphorbiaceae
Rosa sp.	Rose	Rosaceae
Solanum melongena	Eggplant	Solanaceae
Vitis vinifera	Grape	Viticeae
Zea mays	Maize	Poaceae

Table 1: most relevant hosts to consider in the PRA

There are no known reports of *T. leucotreta* being a pest of roses, however larvae of *T. leucotreta* have been detected several times by the NPPO of the Netherlands in buds of Rosa cut flowers originating from countries where the pest is present (M van der Straten, *pers. comm.*, 2011). Most of the larvae boring into the flowers were successfully reared to adults on Rosa (on buds as well as on single petals). From this information the EWG considered that Rosa is a host of *T. leucotreta*.

It should be noted that in *C. limon* (lemon) *and C. aurantiifolia* (lime), larval development is rarely if ever completed (Catling & Ashenborn, 1978; Newton, 1998) and these citrus species are therefore not considered as hosts.

Information on host switching is provided in the entry section (pathway 1 Fruits of Citrus sp.: *C. sinensis* (Orange), *C. reticulata* (Mandarin), *C. paradisi* (Grapefruit) question 2.10

1.07 - Specify the pest distribution for a pest initiated PRA, or the distribution of the pests identified in 2b for pathway initiated PRA

T. leucotreta is thought to originate from the Afrotropical region.

A distribution map is presented in Fig. 3.

EPPO region:

In Israel, it was first found in 1984 on macadamia nuts (a crop which is no longer grown for commercial purposes). In 2003, it was still present but with a limited distribution on cotton and castor bean which are minor crops for Israel (EPPO RS 2003/015). Recent information indicates that it is still found in the coastal area between Ashdod and Hadera (Opatowski, *pers. comm.* 2012).

In 2009, an incursion of *T. leucotreta* was detected in the Netherlands on glasshouse *Capsicum chinense*, and was subsequently eradicated (EPPO, 2010). The insect has also been occasionally noticed by lepidopterists in several Northern European countries such as the Netherlands (Huisman & Koster, 2000), Sweden (Svensson, 2002), Ireland (database of Irish Lepidoptera[1], see comment below) and the UK (Langmaid, 1996; Knill-Jones, 1994). However it is very unlikely that these moths came from established populations (Karnoven, 1983). Residency in Ireland recorded in the database of Irish Lepidoptera was confirmed to be erroneous (Ken Bond, *pers. comm.,* 2011).

Africa: Angola, Benin, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Congo (Democratic Republic of), Côte d'Ivoire, Eritrea, Ethiopia, Gambia, Ghana, Kenya, Madagascar, Malawi, Mali, Mauritius, Mozambique, Niger, Nigeria, Reunion, Rwanda, Saint Helena, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe.

Near East:
The pest has been intercepted in the USA in a consignment of Pomegranate from Saudi Arabia (Taylor, 1988) but there is no reference confirming the presence of the pest in this country.

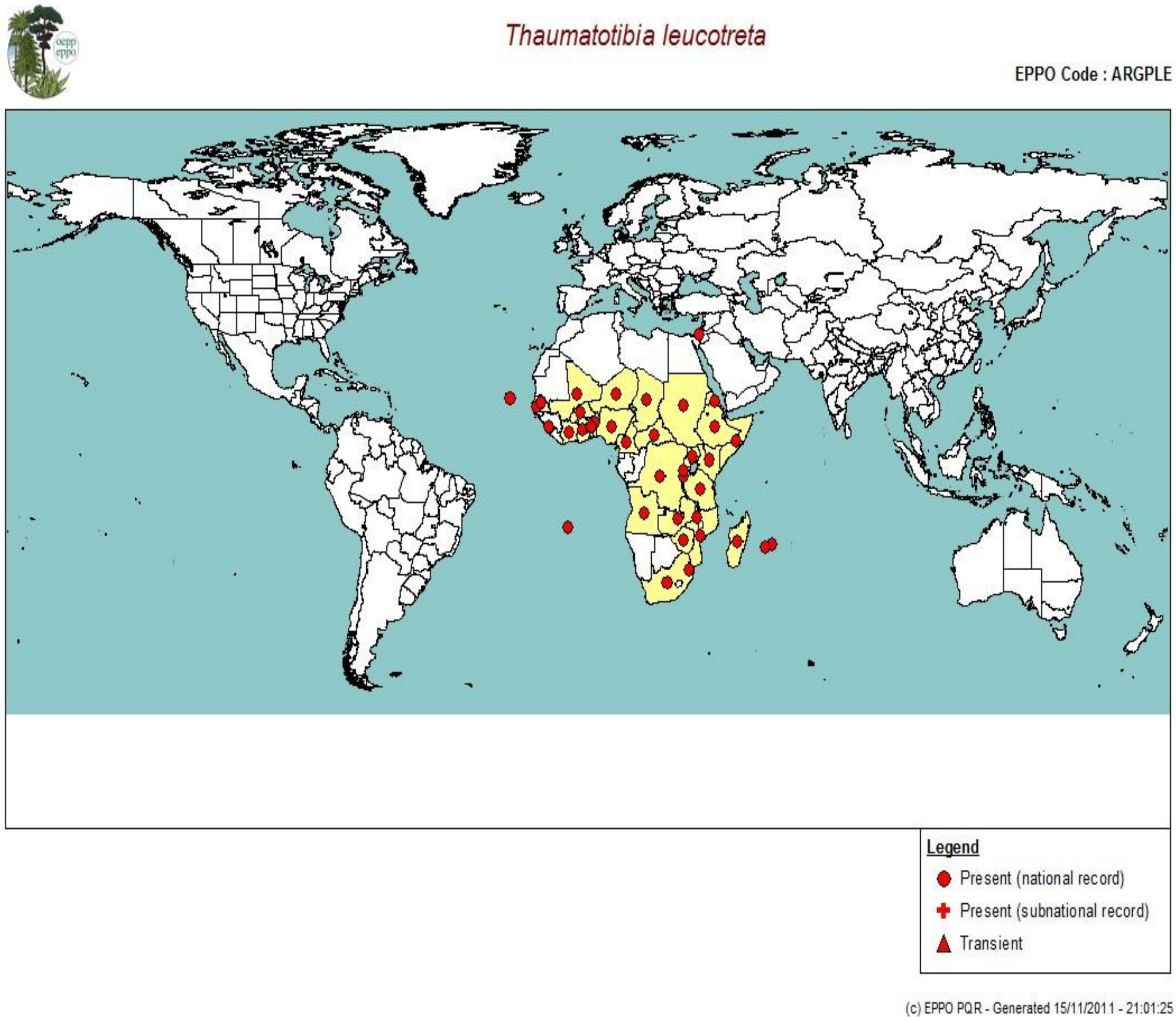

Fig. 3: Distribution map of *T. leucotreta* (PQR, 2011-11-15)

[1] www.npws.ie/publications/irishwildlifemanuals/IWM35.pdf

Stage 2: Pest Risk Assessment Section A: Pest categorization

1.08 - Does the name you have given for the organism correspond to a single taxonomic entity which can be adequately distinguished from other entities of the same rank?

Yes

The species name *leucotreta* was removed from the genus *Cryptophlebia* and placed in *Thaumatotibia* by Komai (1999). Although species of *Thaumatotibia* and *Cryptophlebia* are more or less similar externally they can be distinguished based on different morphological characters. This also applies to larval stages, though expert knowledge is needed. Details on taxonomy are available in Venette *et al*. (2003).

1.10 - Is the organism in its area of current distribution a known pest (or vector of a pest) of plants or plant products?

Yes (the organism is considered to be a pest)

Yes, in Africa it is a pest of cotton, citrus, macadamia nuts, avocado, stone fruit and maize (Couilloud, 1994; Newton, 1998; La Croix & Thindwa, 1986a; Erichsen & Schoeman, 1992; Daiber, 1978).

1.12 - Does the pest occur in the PRA area?

Yes

The pest has a limited distribution (see question 1.07).

1.13 - Is the pest widely distributed in the PRA area?

Not widely distributed

The pest has a limited distribution (see question 1.07).

1.14 - Does at least one host-plant species (for pests directly affecting plants) occur in the PRA area (outdoors, in protected cultivation or both)?

Yes

Citrus species (e.g. *C. sinensis* and *C. reticulata*), peach (*Prunus persica*) and pepper (*Capsicum* spp.) are cultivated in the EPPO region. It is also a pest of field crops such as maize (*Zea mays*) which is an important crop in EPPO countries. Cotton (*Gossypium hirsutum*) is also important for some EPPO countries.

1.15a - Is transmission by a vector the only means by which the pest can spread naturally?

No

Not relevant.

1.16 - Does the known area of current distribution of the pest include ecoclimatic conditions comparable with those of the PRA area or sufficiently similar for the pest to survive and thrive (consider also protected conditions)?

Yes

Protected conditions:
Conditions in glasshouses in the PRA area are considered to be favourable for the organism; at least one incursion is known in a greenhouse growing peppers in the Netherlands (Potting & van der Straten 2011).

Outdoor conditions:
Fig. 4 shows that climates similar to that found in the EPPO region are present in a limited part of South Africa. However, the EWG considered that a detailed analysis is needed to identify those areas where the pest will find suitable conditions for establishment outdoors.

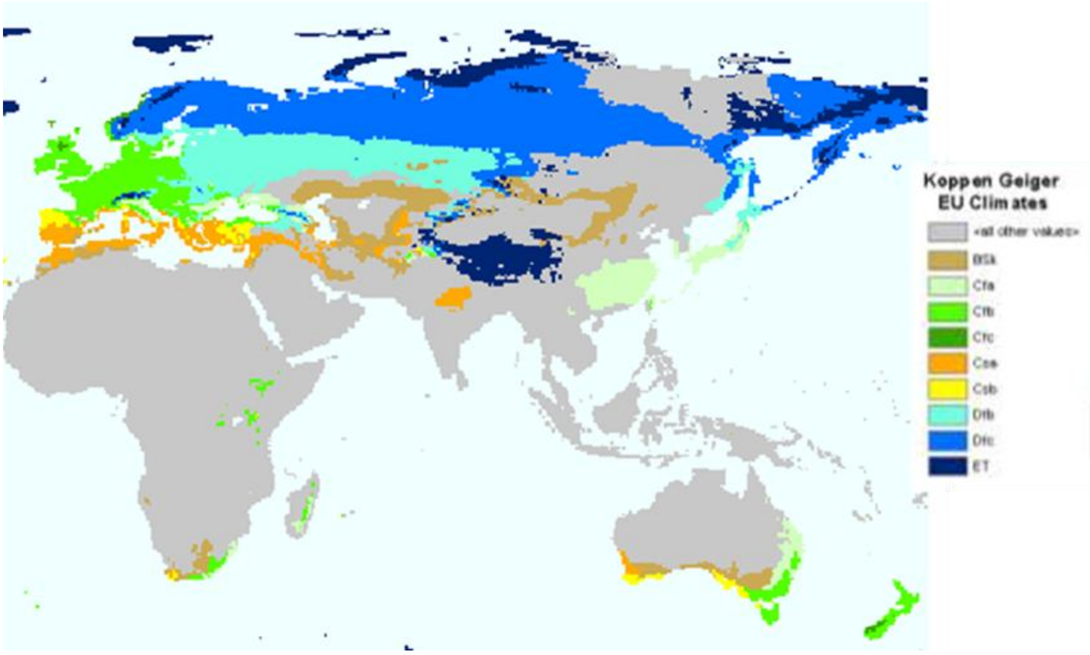

Fig.4: The updated Köppen-Geiger Climate Classification (Kottek *et al*. 2006) showing only the distribution of climates that occur in the EU

1.17 - With specific reference to the plant(s) or habitats which occur(s) in the PRA area, and the damage or loss caused by the pest in its area of current distribution, could the pest by itself, or acting as a vector, cause significant damage or loss to plants or other negative economic impacts (on the environment, on society, on export markets) through the effect on plant health in the PRA area?

Yes

T. leucotreta is a pest of economic importance to several crops, including: *Citrus* spp. (orange, mandarin, grapefruit), *Prunus persica* (peaches or nectarine), Zea mays (maize), *Litchi chinensis* (litchi), *Gossypium* spp. (cotton) and *Macadamia* spp. throughout sub-Saharan Africa, South Africa, and the islands of the Atlantic and Indian Oceans (Schwartz & Kok, 1976; Daiber 1979, 1980; La Croix & Thindwa, 1986a, b; Wysoki, 1986; Blomefield, 1989; Newton, 1989b; Newton & Crause, 1990; Silvie, 1993; Sétamou *et al.*, 1995; references cited in Venette *et al.* 2003).

Larval feeding and development can affect fruit development at any stage, causing premature ripening and fruit drop (Schwartz & Kok, 1976; USDA, 1984; Newton, 1988a, 1989a; Begemann & Schoeman, 1999).
T. leucotreta larvae are capable of developing in hard green fruit (Catling & Aschenborn, 1974). Once a fruit is damaged, it becomes vulnerable to fungal organisms and scavengers (Newton, 1989a).

Fig. 5: larvae of *T. leucotreta*
Source :
http://idtools.org/id/leps/tortai/Thaumatotibia_leucotreta.htm

Fig. 6: damaged fruits
Source :
http://idtools.org/id/leps/tortai/Thaumatotibia_leucotreta.htm

Some details on damage levels are provided below

- ***Citrus* spp.**

Fruit losses as a result of *T. leucotreta* attacks, range from below 2% to as high as 90% (Newton, 1998). 2% is the current fruit loss level in South Africa (Moore, *pers. comm.*, 2012). Some types of citrus are highly susceptible (for example Navel oranges), whereas others are not suitable hosts (lemons). In trials in navel orange orchards in the Eastern Transvaal Lowveld of South Africa, 7.8% yield losses were experienced in 1975-76, and 16.8% in 1976-77 when no control measures against *T. leucotreta* were implemented. This contrasts with 0.72% yield loss when a full spray programme was implemented (Schwartz, 1978).

- ***Prunus persica* (peach or nectarine)**

In the early 1970s *T. leucotreta* became a serious pest of peaches in the Transvaal, where peaches were grown near citrus, i.e. in the warmer peach-growing areas (Myburgh *et al.*, 1973). Economic losses are higher in late peach cultivars, and a mean percentage of infested fruits of 29% with a maximum of 55% are recorded (Daiber,1987).

- ***Macadamia* spp.**

T. leucotreta has caused significant yield losses (≥30%) to macadamia crops in Israel and South Africa (La Croix & Thindwa, 1986a; Wysoki, 1986).

- ***Capsicum* spp. (pepper)**

Damage on *Capsicum* spp. (pepper) is reported from Cape Verde and Senegal (e.g. Collingwood *et al.*, 1980; Bourdouxhe, 1982). Research in Senegal was initiated because of the increasing damage of *T. leucotreta* to both sweet and hot pepper. Fritsch (1988), in her study on the control of *T. leucotreta* with granulovirus in Cape Verde, recorded 70% of infested fruits in untreated Capsicum plants. Mück (1985) also reports *T. leucotreta* as the only relevant lepidopterous pest on Capsicum in Cape Verde, although it causes only minor damage. After the first meeting of the EWG, Mr Hattingh requested Mr Moore (IPM programme Manager Citrus Research International) to conduct an investigation on the pest status of *T. leucotreta* in *Capsicum* sp. in South Africa and Uganda (with particular reference to production in polytunnels). From this investigation Mr Moore concludes that *T. leucotreta “is rarely a pest of peppers”*. He also reports on an infestation recorded on *Capsicum* sp. in Uganda ‘(although the precise date is not known, it could have been in late 2009 coinciding with the Dutch interceptions). He reports that “*the outbreak lasted for about 6 weeks and disappeared*”. Contacts were taken with Dr Karungi (Makerere University, Uganda) who declared that “*its occurrence is sporadic and irregular, present in some areas but not in others. I have worked with hot pepper farmers in Central Uganda but it never came up.*”

Consequently damage on *Capsicum* sp. can occur but there is conflicting information on the level of damage that can occur.

- ***Gossypium* sp. (cotton)**

Cotton is an important crop in some EPPO member countries (in particular Uzbekistan, Turkey, Greece, Kazakhstan, Spain …).

In Ugandan cotton, *T. leucotreta* caused 20% loss of early sown varieties and 42-90% loss of late varieties (Byaruhanga 1977). Larval penetration of cotton bolls facilitates entry of other microorganisms that can rot and destroy the boll (Couilloud 1994).

Possible impact on export markets:

An incursion occurred in the Netherlands in 2009, that could be traced back to transfer from imported *Capsicum chinense* from Uganda, this incursion led to a temporary prohibition of export of *Capsicum* from the Netherlands to the USA.

This pest could present a phytosanitary risk to the PRA area.

1.18 - Summarize the main elements leading to this conclusion.

T. leucotreta is a polyphagous pest and many of its host plants are economically important crops in the EPPO region e.g. *Citrus* spp. (orange, mandarin, grapefruit), *Prunus persica* (peaches or nectarine), *Zea mays* (maize), *Capsicum* spp. (pepper) and *Gossypium* sp.. In its native area, it has been reported to cause economic damage, in particular on citrus and cotton. The suitability of climate for outdoor establishment needs to be studied in more detail.

Stage 2: Pest Risk Assessment Section B: Probability of entry of a pest

2.01a - Describe the relevant pathways

As explained in question 1.06, the EWG decided to focus on the following hosts:

HOST PLANT	COMMON NAME	PLANT FAMILY
Capsicum spp.	Pepper	Solanaceae
Citrus reticulata & hybrids	Mandarin orange	Rutaceae
Citrus sinensis & hybrids	Orange	Rutaceae
Citrus paradisi	Grapefruit	Rutaceae
Gossypium spp.	Cotton	Malvaceae
Litchi chinensis	Litchi, Litchee	Sapindaceae
Macadamia spp.	Macadamia	Proteaceae
Mangifera indica	Mango	Anacardiaceae
Persea americana	Avocado	Lauraceae
Prunus persica	Peach	Rosaceae
Prunus persica var. *nucipersica*	Nectarine	Rosaceae
Psidium guajava	Guava	Myrtaceae
Punica granatum	Pomegranate	Lythraceae
Quercus robur	Oak	Fagaceae
Ricinus communis	Castor oil plant	Euphorbiaceae
Rosa sp.	Rose	Rosaceae
Solanum melongena	Eggplant	Solanaceae
Vitis vinifera	Grape	Viticeae
Zea mays	Maize	Poaceae

Table 1: most relevant hosts to consider in the PRA

From this list the PRA considers in detail, those that:

- are a major (regular) host
- are exported to the PRA area in large quantities
- are not processed in a way that eliminates the risk of entry and
- have adequate data,

This represents the potential worst case current scenario, but it is important to note that other hosts could also present a pathway, especially if the volume imported into the PRA area would increase.

Consignments of fruits are the commodities which are most likely to be infested with eggs and larvae and represent the most likely pathway. In addition cut flowers of Rosa sp. have also been considered because the pest was detected in imported consignments (56 detections between 2004 and 2012, van der Straten *pers. comm.*, 2011).

Pathways considered as presenting the main risk of entry

The fruits of the two following host genera were considered for further detailed evaluation of the entry potential in the PRA:

Fruits of Citrus: *C. sinensis* (orange), *C. reticulata* (mandarin), *C. paradisi* (grapefruit)

Citrus fruits are considered as the main pathway for entry into the EPPO region. There is considerable variation in host suitability across these citrus species and furthermore across cultivars within these species (Newton, 1989 a,b; Newton & Anderson, 1985). Within *C. sinensis*, navel oranges are a preferred host and some cultivars are highly suitable (e.g. Palmer navel). Other cultivars in orchards adjacent to orchards with sensitive cultivars do not require control to avoid economic damage (e.g. Bahainina navel, Valencia oranges and also *C. sinensis*) and are not preferred hosts. Likewise within *C. paradisi* pigmented grapefruit are susceptible, but the Marsh Grapefruit cultivar is not susceptible. The vast majority of citrus exports from Africa to the PRA area originate from southern Africa (South Africa, Zimbabwe and Swaziland) with the bulk coming from South Africa (approximately 75% of the volume of citrus is imported into the region during the EPPO summer season which is counter seasonal to the northern hemisphere production of citrus). A sub-set of *Citrus* spp. i.e. *C. sinensis*, *C. paradisi* and *C. reticulata*, originating from southern Africa, is considered further in detail as "citrus".

Fruits of Pepper (*Capsicum* spp.)
Fruits of Capsicum sp. infested by *T. leucotreta* have been intercepted by the USDA (USDA-APHIS 2010), the UK (Malumphy & Robinson 2002, *pers. comm.* A. Koricynska, 2012) and the Netherlands (van der Straten *pers. comm.*, 2012). It is known from *Capsicum chinense* crops in Uganda (Vollebregt, *pers. comm.* cited in Potting & van der Straten 2011). It has also been found on *Capsicum* sp. in Senegal (Collingwood *et al.* 1980), Cape Verde (Fritsch, 1988) and South Africa (Hepburn, 2007). As already noted in question 1.17 for Capsicum, there are no data on difference in susceptibility to the pest in different species or varieties of *Capsicum*.

Fig. 7 Larvae in pepperfruit(courtesy Ms van der Straten)

The risk of entry presented by other fruits is summarized below. Although these have not been studied in detail in the entry section because of lack of data, the EWG agreed that they should be considered for management.

***Fruits of Prunus persica* (peach & nectarine)**
As explained later in the entry section for Citrus fruits, the pest is present all year round. However, regarding the likelihood of association with fruits, there seems to be a difference between *Prunus* spp. and *Citrus* spp.. Although Venette (2003) states that "*All stages of citrus and stone fruits are vulnerable to attack (Newton, 1988a)*" no specific reference to *Prunus* species is made in this article which states in the introduction that "*The wide range of some thirty-five recorded wild and cultivated host-plants, together with mild subtropical winters, ensure that the pest is an all-year-round threat in most citrus-producing areas of southern Africa. All stages of developing fruit can be attacked.*" It seems that 'all-year round threat' refers to citrus-producing areas and not specifically to *Prunus* sp.. Similarly, Venette (2003) quotes Catling & Aschenborn (1974) in a general way "Thaumatotibia leucotreta *larvae are capable of developing in hard green fruit*" however this reference is only about Citrus species. Daiber (1989) states that "*The climate in peach-growing areas is less suitable and peach crops are only susceptible for around 6 weeks per year. In many peach areas, damage by* Cryptophlebia leucotreta *is low and control unnecessary*" and "*At farm orchards early peaches are usually free FCM infestation, while late ones are infested*". Blomefield (1989) also mentions that "*The highest FCM infestation of 27,99% was recorded for a late peach cultivar; infestation of less than 1% was recorded for early cultivars*". As a conclusion, there is a difference in susceptibility within *Prunus* species and the late varieties are more likely to be associated with *T. leucotreta* than early ones.
Larvae damage stone fruits as they burrow into the fruit at the stem end and begin to feed around the stone. Infestations can be detected by the brown spots and dark brown frass (Daiber, 1976). Peaches become susceptible to damage about six weeks before harvest. There are no reports of the pest having been detected in consignments of peaches or nectarines imported in EPPO Countries (source report of notifications of non-compliance published in the EPPO Reporting Service). The pest is able to survive during transport and storage (see detailed entry section for Citrus).

The volume imported in tonnes by each EPPO country from countries where the pest is present in 2009 are presented in Appendix 2. The total volume is 5636 tonnes.
This volume represents 17 % of the total volume of imports of peaches and nectarines (i.e. 32 000 tonnes of fruits imported in EPPO countries in 2009 from all possible origins), the vast majority being imported from South Africa. Source: FAO Stats (accessed on 2011-12-05).

Fruits of *Punica granatum* (pomegranate)
T. leucotreta is recorded as one of the most serious pest of pomegranate in South Africa (Wohlfarter *et al*. 2010). If there is poor orchard sanitation, this pest can cause serious crop losses up to complete fruit loss (Wohlfarter *et al*. 2010). Unlike other fruits where usually only one larva per fruit is found, several larvae may be found in a pomegranate fruit. This is because of the fruit has compartments and the larvae are consequently separated. No data are available on the trade in this fruit in FAO stat but pomegranates are fruits increasing in popularity in the consumer markets of Western Europe (OTF, 2007).South Africa currently has "backyard" exports, but is gearing up for commercialization of production to increase exports, allowing them to fill the counter-season opportunity in Europe during the spring and early summer months (OTF, 2007). The EWG considered that although volumes are lower, since the fruit can be infested by several larvae, it presents a risk of entry similar to that posed with citrus fruits.

Other possible pathways for which the risk was evaluated as low and which are not considered for identification of management measures

1 Cut flowers of *Rosa* sp.:

Fig. 8: Damage in baby rose (Courtesy Ms van der Staten)

Fig. 9: Damage in rose (Courtesy Ms van der Staten)

Central East Africa is an important area for rose production and Europe is the most significant market for these countries. This trade is expected to increase further in the near future. 84 % of the total imports of *Rosa* cut flowers come from countries where *T. leucotreta* is present (source EUROSTAT consulted in 2011-11, data for the year 2009). Larvae of *T. leucotreta* have been detected by the NPPO of the Netherlands in buds of *Rosa* cut flowers originating from Ethiopia, Kenya, Malawi, Tanzania, Zambia, Zimbabwe and Uganda 107 times (2004– April 2013), with over 85% of the detections on imports from Uganda. However, taking into account the high import volumes compared to the number of detections, the percentage of infestations is considered very low.
Based on the detection of live larvae on imported consignments, the EWG concluded that *T. leucotreta* can arrive alive in the EPPO region.

The level of risk presented by this pathway is mainly dependent on the likelihood of transfer to a suitable host in the PRA area. The main mode of transport of roses to the PRA area is by plane. *Rosa* cut flowers should be precooled at 2°C to preserve quality and extend the vase life (UFO, 2003) and are

usually kept at temperatures that are not favourable to *T. leucotreta*. The shelf life of cut flowers is very short (1 to 2 weeks maximum) and the commodity will be transported to the end-consumer within a few days after arrival. The intended use of the commodity (flowers to be displayed indoors) makes direct contact with suitable hosts or habitats infrequent, although this is still possible. Risk of transfer to a suitable host is therefore higher when retailers or florists discard damaged flowers without proper disposal of waste. This may occur especially when imported consignments are repacked in packaging stations that are located in the vicinity of host production areas. If introduced larvae are able to pupate at waste disposal sites, emerging adults may be able to mate and fly and may reach nearby suitable crops, orchards or gardens.
At present *Rosa* is mainly imported by North-western European countries. Since the principal crops at risk for this pathway in Northern Europe are host plant species produced under glass (e.g. *Capsicum, Solanum melongena* and *Rosa*), the risk is limited to areas where repacking of imported cut flowers takes place in close proximity to production of these crops. However, most consignments of *Rosa* are directly distributed to the market, thus repacking concerns only low volumes. It should be noted that another lepidopteran species that is often present on roses from East Africa is *Helicoverpa armigera*. In a PRA for the European Union, Lammers & MacLeod (2007), concluded that the presence of *H. armigera* on consignments of consumer products (roses, beans) poses a very low risk of introduction to glasshouses (in northern Europe). The risk posed by *T. leucotreta* would be similar or slightly higher because its life cycle is shorter.

The north western European countries (in particular the Netherlands, Rikken, 2010) are the main providers of cut flowers for other European countries. Consequently, consignments imported are also distributed to other EPPO countries where *T. leucotreta* could establish outdoors. However, this also mainly concerns consignments intended for direct distribution to the end consumer. As noted above, transport time is short, and transport conditions are not favourable for the development of larvae. The volumes of trade are limited as mainly consignments from Uganda are infested so far. The chance under these circumstances of two adults developing simultaneously and mating is considered very low. Another aspect that decreases the chance of successful development of adults is the fact that the shelf life is short (1 to at most 2 weeks) compared to e.g. citrus fruits.

Given all the aspects reported above (in particular the low risk of transfer) the EWG considered the risk of *Rosa* cut flowers as a pathway as minor.

<u>2. Other fruits</u>

- *Litchi sinensis* (Litchi):

No data is available on the trade on this fruit in FAOSTAT. Litchi are imported in Europe from Madagascar and South Africa. The main destination of Litchis from Madagascar within the EPPO region is Europe with countries such as France, Germany, the Netherlands and Belgium.... The European countries are traditional markets. In 2009/2010 19 750 tonnes of litchis were exported from Madagascar (HTSPE, 2010). In 2009, 3833 tonnes were exported from South Africa to Europe.
Infestation on *L. sinensis* is assumed to be extremely low and this commodity is therefore not considered to be an important pathway.

- *Mangifera indica* (mango):

M. indica is being imported into the EPPO region in significant volumes. However, the only reported damage of *T. leucotreta* is from Zambia (Javaid, 1986) and concerns fruits grown in the wild. There was one finding reported in cultivated mangoes bought in a shop in Kenya (van der Straten, *pers. comm.*, 2012), but no records are known of detections of *T. leucotreta* in exported consignments.
T. leucotreta is not recorded in the booklet of the 16 most common pests that attack mango trees and their fruit in South Africa (de Villiers *et al.*, 2001). Infestation on *M. indica* is assumed to be rare and this commodity is therefore not considered to be an important pathway.

- *Persea americana* (avocado)

Grové *et al.* 2000 states that avocado is a poor host of *T. leucotreta*. When moths lay eggs on young fruits the caterpillars usually die and thus large caterpillars are seldom found, however, the caterpillars are able to develop if fruits are approaching maturity when infested (Grové *et al.*, 2010). This is also

mentioned in http://www.infonet-biovision.org/default/ct/205/crops#_1752_1446. Distinctive symptoms are not visible on avocado for the first 14 days after infestation and lesions are well defined six weeks after infestation indicating that visual inspection of recently infested fruits will not detect recent infestations (Grové et al, 2010). However, most avocados are harvested in a hard green state. From this it can be concluded that the pest is unlikely to be present on imported avocados.
Although trade exist from countries where the pest is present (in 2009, 39 499 tonnes from South Africa; 15 323 tonnes from Kenya, 31 798 tonnes from Israel representing 35% of the total imports, Source: FAOSTAT (accessed on 2011-12-08)), there are no reports of the pest having been detected in consignments of avocados (source report of notifications of non-compliance published in the EPPO Reporting Service). It should be noted that most EPPO countries do not have specific requirements for such fruits and these are not inspected on a regular basis. However the most important factor that reduces the risk of entry is that most avocados are harvested in a hard green state (see above).

- *Psidium guava* (Guava):

No data is available on the trade on this fruit in FAOSTAT. A limited survey conducted in the Netherlands showed that hardly any guava is imported from the area where *T. leucotreta* is present (I. Ribbens, Fruit and Vegetables Trade Association, NL, *pers. comm.*, 2011).

- *Quercus robur* (acorn)

Acorns are not being imported into the EPPO region and therefore are not considered as a pathway.

- *Ricinus communis (*ricinus)

Fruits of *Ricinus* are only imported into the EPPO-region after some sort of processing (for instance as castor oil). Unprocessed fruits are not imported into the EPPO region. *Ricinus* is therefore not considered as a pathway.

- *Solanum melongena* (aubergine):

Aubergine is being imported into e.g. the EU from several African countries and *T. leucotreta* has been detected occasionally on imported consignments of *Solanum melongena (pers. comm.* M. van der Straten for the interceptions NPPO the Netherlands & A. Koricynska for the interceptions NPPO of the UK, *pers. comm.,* 2012). This commodity is not considered to be an important pathway.

- *Vitis vinifera* (grape):

V. vinifera is being imported into the EPPO region in significant volumes. However, *T. leucotreta* has only been detected occasionally on grapes in the field and is considered a marginal host (Hattingh *pers. comm.* 2011). It has only incidentally been detected at pre-clearance inspections in consignments intended for the USA (J.P. Floyd, USDA, *pers. comm.,* 2011). This commodity is not considered to be an important pathway.

Fruits of other hosts are not imported into the EPPO region or only in limited volumes and are not further considered in the analysis.

3 Green parts of *Zea mays* (maize):
On maize, *T. leucotreta* has been reported laying eggs on the husk of the ear. Larvae damage maize by entering the ear from the husk through the silk channel (Stibick, 2006). Larvae can also be found in the stem (Reed, 1974). The risk of entry with maize is only with green parts and not with grain. Since there is no existing trade for green parts of maize (in particular sweet maize cobs) from areas where the pest is present, this pathway is not considered further in the PRA.

4. Plants for planting with growing medium attached (except seeds) from countries where the pest is known to occur
Since fruits on host plants can be infested with eggs or larvae, the main risk for entry is when fruits are present on the plants. Infestation of the growing media is possible when infested fruits fall on the surface allowing larvae to pupate. However, this will only happen with trees and shrubs that are old enough to bear fruits. The EWG considered that the infestation of growing media by pupae from nearby infested plants in a well-managed nursery is very unlikely, lowering the risk of plants for planting being

contaminated.

The importation of trees and shrubs with fruits is restricted in many countries in the EPPO region (e.g. in the EU, trees and shrubs imported from third countries other than European and Mediterranean countries should be free from fruits). Ornamental citrus, in particular *Citrus madurensis* (calamondin), are commonly traded as ornamental species and bear fruits. However the import of Citrus plants is prohibited for most EPPO countries and, in addition, the susceptibility of ornamental species is not known.
Although the introduction of plants for planting with fruits is a closed pathway, the situation could change. For instance, *Capsicum frutescens* with fruits is used as an ornamental plant (although it should be noted that this species cannot be imported by EU countries and some other EPPO countries because of the general prohibition applied to Solanaceae from non-Mediterranean countries).

5. Packaging material
In a PRA for the tomato leafminer *Tuta absoluta* (Lepidoptera: Gelechiidae), packaging material was considered as a pathway with a medium rating of entry (Potting, 2009). Several outbreaks in glasshouses in the Netherlands and the UK could be traced back to the introduction of contaminated packaging material. For *T. leucotreta*, there is a possibility that packaging material used at import may be contaminated with pupae of the organism. Re-usage of packaging material that has not been properly cleaned may represent a pathway. However most imports are in cardboard boxes and are usually not reused. Consequently this pathway is considered much less relevant than infested fruits and is, therefore, not further considered in this PRA.

6. Fruits carried by passengers
Fruits carried by passengers from countries where the pest occurs can also present a risk of entry but it is difficult to quantify due to lack of data. It should be noted that the importance of fruit carried by passengers as a pathway for pests such as fruit flies has been evaluated by Liebhold *et al*. (2006). The volumes concerned are considerably low compared to commercial imports and the fruits are intended for personal consumption thus lowering the risk. In addition unlike fruit flies only one larva is present in a fruit (with the exception of pomegranate). Details on transfer from fruits are given in pathway 1 question 2.10. Therefore this pathway is not further considered in the PRA.

Commodities which have been considered as presenting no risk because of processing

Macadamia nuts
Macadamia nuts are not a pathway as they are imported as a processed product. Macadamia nuts are vacuum packed at kernel moisture below 1.5%; larvae of *T. leucotreta* will die under such conditions.

Cotton lint
Green cotton bolls are the part of the cotton most likely to be infested with *T. leucotreta*. They are removed in the first step of the process. Furthermore, the process of removing lint from seeds includes mainly centrifuging and brushing under high temperatures to keep moisture at 6-7%, before packing the lint in pressed balls to protect it from contamination during transportation and storage. The pest is very unlikely to survive such a process.

Pathways not considered

Soil
Soil was not considered as a pathway because import is prohibited for most EPPO countries and secondly because this soil should originate from a fruit producing field this scenario did not seem realistic.

Natural spread
Natural spread from the countries where the pest is present is not a realistic pathway with the exception of the natural spread from Israel to neighbouring countries. However the pest is present there since 1983 and no spread has been reported.

Hitchhiking
There are no reports of hitchhiking for this species.

2.01b - List the relevant pathways that will be considered for entry and/or management. Some pathways may not be considered in detail in the entry section due to lack of data but will be considered in the management part.

- Fruits of *Citrus* sp.: *C. sinensis* (orange), *C. reticulata* (mandarin), *C. paradisi* (grapefruit)
- Fruits of *Capsicum* spp. (peppers)
- Fruits of *Prunus persica* (management only)
- Fruits of *Punica granatum* (management only)

- Pathway 1: **Fruits of *Citrus* sp.: *C. sinensis* (orange), *C. reticulata* (mandarin), *C. paradisi* (grapefruit)**

2.03 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account the biology of the pest?

Fruits originating from Israel: Unlikely*
Level of uncertainty: medium
Fruits originating from other origins Very likely
Level of uncertainty: low

Based on the biology of the pest the association is very likely.
The broad range of host plants, together with mild tropical and subtropical winters ensures that the pest is an all-year round threat to crops in most of its distribution (Newton, 1998). Consequently, suitable life stages of the pest are present when Citrus fruits are present and exported to the EPPO region (i.e. June to October).
Up to 16% of fruits infested with eggs have been noted in a study conducted from 1971 to 1979 in the Nelspruit area (Schwartz 1981 cited by Newton 1998).
There is considerable variation in abundance of the pest across the range of citrus production areas in southern Africa with the pest being highly abundant in some regions, whereas it is not considered a pest of economic importance and does not require control in other areas (S Moore, *pers. comm.*, 2012). In addition, as already mentioned in 2.01 there is a great variation across varieties of citrus as some are more susceptible than others.
The pest has been regularly detected between 2004 and 2010 on imported consignments in Spain and the Netherlands (for details see question 2.09).
The rating selected refers to a situation where fruits are of a susceptible variety.

Specific situation of Israel
The Expert Working Group rated this question Unlikely on the basis of the information provided by the Israeli NPPO that *T. leucotreta* is not associated with citrus fruits in this country and no specific treatments are carried out against this pest. It also noted that the pest has never been detected in imported consignments originating from Israel imported in the EPPO region, nor in the export inspection carried out in Israel for various destinations. However it should be noted that the Panel on Phytosanitary Measures in March 2013 considered that Israel should provide additional evidence and data to support the lower rating given.
Investigations were conducted in April 2014 to verify the identity of specimens collected in Israel. These have been confirmed as *T. leucotreta* by Ms van Straten (Dutch National Reference Center) and Mr Gilligan (Colorado State University, international expert on Tortricids) based on morphology and sequencing. As explained in this PRA there is no reference of host strain and further research would be needed to determine if such strain exist.

2.04 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account *current management* conditions?

Moderately likely
Level of uncertainty: Medium

There are many options available for the control of the pest, including chemical, biological, cultural

practices, mating disruption, attract and kill and the Sterile Insect Technique (Opoku-Debrah, 2008). Whereas the pest has developed resistance to some of the older chemistry (Hofmeyr & Pringle, 1998), these have been replaced with effective new generation chemistry options that have a favourable ecotoxicological profile (Appendix 3). Orchard sanitation remains an effective control option and the recent development of granulovirus products, mating disruption and the sterile insect technique all provide for effective and sustainable population management. However, since some of these options have only recently become available the full potential efficacy of these controls and combinations of treatments has probably not yet been reached. Furthermore the pest is not regulated as a quarantine pest by the major importers in the EPPO region, which implies that the intensity of control practices may be aimed at avoiding economic crop loss rather than strictly producing pest free consignments.
It should be noted that infestations *of T. leucotreta* occurring two weeks before harvest results in blemish, premature colour development, abscission and decay. Sorting of fruits is made during picking and packing: fruits showing signs of infestation are discarded but recent infestations will not be detected (Citrus Research International *pers. comm.* cited in the Dutch PRA 2010).

It should be noted that an audit was carried out by the European Commission Food and Veterinary Office in South Africa in June 2011. The objective of the audit was to evaluate the system of official controls and certification of citrus fruit for export to the European Union. This report states that:
"Following the high number of EUROPHYT notifications of interceptions, 21 in 2009, due to the presence of a non-listed pest, False Codling Moth (FCM), Thaumatotibia leucotreta *intercepted on citrus products originating from SA, which were reported mainly by Spain, the export control system has been upgraded. The PPECB inspection regime and CRI guidelines for producers have been revised to include FCM. In addition, a second check is carried out at the point of exit (port) for consignments destined to Spain. As a consequence of the new stricter control measures the number of interceptions has dropped to 2 in 2010."*
As noted in the report, the intensification of pre export inspection is for fruits exported to Spain but as noted in question 2.09 the pest continues to be detected in consignments exported to the Netherlands.

2.05 - Consider the volume of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this volume will support entry?

Very likely
Level of uncertainty: low

Import of *Citrus sinensis* (orange) from countries where *T. leucotreta* is present is significant, South Africa representing by far the main volumes imported in tonnes. The volumes imported in the EPPO countries in 2009 are presented in table 2 below.

reporter	Ghana	Israel	Kenya	Mozambique	South Africa	Swaziland	Zambia	Zimbabwe
Albania					52			
Algeria					185			
Austria					89			
Azerbaijan					18			
Belarus		157			2139			51
Belgium		226			21124			
Bulgaria					444			
Croatia		42			1459		2	64
Cyprus					83			
Denmark					1920			
Estonia					94			
Finland		5893			1281			

reporter	Ghana	Israel	Kenya	Mozambique	South Africa	Swaziland	Zambia	Zimbabwe
France		283			5883	24		
Germany					4504	5		
Greece					4626	5		48
Ireland		504			3582			318
Italy		454		46	33991	396		332
Jordan					1332			
Kazakhstan		114			5153			
Latvia					175			
Lithuania		156			2673	32		47
Malta					721			
Netherlands		489			145491*	7858		11454
Norway		849			4614	84		20
Portugal					7155	2		189
Romania					895	66		
Russian Federation		2569			24			
Serbia		380			1030	20		30
Slovenia		505			24			
Spain					30743	346		707
Sweden		4578			3693	18		
Switzerland		21			3544			
Turkey					155			156
Ukraine		159			14385			256
United Kingdom	2064	9762			64641	4230		477
Total	**2064**	**27141**	**0**	**46**	**367913**	**13086**	**2**	**14149**

* In 2009, 42 % of the oranges imported to the Netherlands were further distributed to other EU countries (mostly Spain) fruits are also exported to the Russian Federation Data retrieved from EUROSTAT (2012-07-12).

Table 2: Volumes in tonnes of *Citrus sinensis* (orange) imported in 2009 from countries where *T. leucotreta* is present (Source FAOSTAT). Only EPPO countries with imports are reported in the table

Data on exports from South Africa were provided by Mr Hattingh, these are presented below (note that there are differences between the figures in FAOSTAT and these data.

ORANGES	2008	2009	2010	2011
Northern Europe	268 292	192 366	230 965	199 101
Middle East	181 621	206 230	227 122	186 500
Russia	95 372	89 574	126 999	106 192
Far East	62 227	64 043	65 078	82 752
Southern Europe	105 254	71 660	85 755	70 311
United Kingdom	89 909	70 857	69 785	64 129
Asia	25 093	32 131	38 654	39 624

United States	34 659	27 170	34 037	36 866
North America (Canada)	24 283	21 040	21 757	24 165
Eastern Europe	14 296	13 830	14 451	10 885
Western Europe	1 459	2 836	24 717	9 581
Indian Ocean Island	6 208	5 102	5 309	6 344
Central Europe	3 809	3 011	3 691	4 172
Western Africa	2 199	1 782	3 331	2 914
Eastern Africa	1 568	2 818	2 247	1 697
Other		722	103	192
South America				143
Central Africa				81
Grand Total	**916 249**	**805 172**	**954 001**	**845 649**

Table 3 Volumes in tonnes export of oranges from South Africa (Hattingh *pers. comm.* 2011)

2.06 - Consider the frequency of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this frequency will support entry?

Likely
Level of uncertainty: low

The monthly import data for EU countries for 2010 (EUROSTAT) are indicated in Table 4 and Fig 10 for *Citrus sinensis* (orange) from Africa.
Citrus is mainly imported in the period June-October. The frequency of imports coincides with the presence of the pest in the area of origin and the period that is more likely to meet suitable conditions and find available hosts in the EPPO Region.

Country	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Ghana						960	1 440	960	960	480	480	1 440
Mozambique								435	2 757			
Nigeria									2	1		
Swaziland						974	16 283	31 467	44 572	2 367		
South africa	263		200		10 618	219 941	714 326	1 311 393	1 243 676	627 750	12 962	360
Zimbabwe							45 729	62 203	63 372	59 057	7 270	
Total	263	0	200	0	10 618	221 875	777 778	1 406 458	1 355 339	689 655	20 712	1 800

Table 4 Monthly imports (in 100 kg) of oranges from Africa to the EU countries in 2010 (source EUROSTAT)

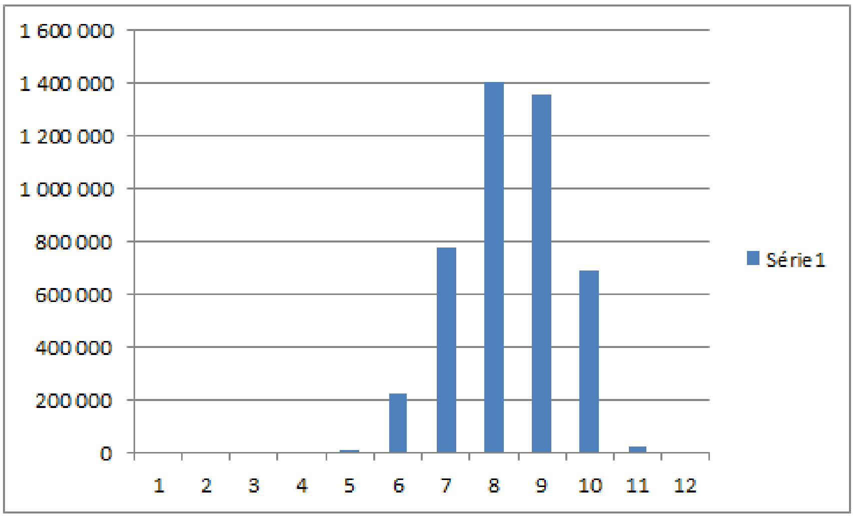

Fig. 10 Distribution of imported quantities (in 100 kg) per month in the year 2010 (source EUROSTAT)

2.07 - How likely is the pest to survive during transport or storage?

Likely

Level of uncertainty: medium

The pest has been regularly detected as larvae in imported consignments. This demonstrates that survival is possible during current transport conditions. Interception data show that, under current management practice, larvae are detected at all development stages (M. van der Straten *pers. comm.*, 2011).

The life stages of the pest likely to be present in consignments have a development threshold temperature of about 12°C (Daiber, 1979a, b and c). Storage and transport of the commodities at a temperature above this threshold will facilitate survival of the pest (Stotter & Terblanche 2009).

Citrus fruit that are infested with *T. leucotreta* larvae are prone to decay with resultant larval mortality as noted by Myburgh (1965) while trying to conduct large scale post-harvest treatments on *T. leucotreta* in citrus fruit and in artificial growth medium.

Citrus fruit is exported to parts of the PRA area under the following conditions:

Consignments are transported by ship, mostly with fruit pulp temperature in the range of 4 to 10°C (Transport Information Service http://www.tis-gdv.de/tis_e/ware/inhaltx.htm#6), but some consignments may occasionally be shipped at lower temperatures of 2.5°C and small quantities of grapefruit may on rare occasions be shipped at 16°C, with shipping times ranging from 12 to 18 days (R. Robinson, South African Perishable Products Export Control Board, *pers. comm.* 2011; and M. Brook, Citrus Growers Association of Southern Africa, *pers. comm.*, 2011). Myburgh (1965) demonstrated that whereas fairly high levels of larval mortality will ensue from shipping at the lower temperatures used (below 4.5°C), exposure to -0.55°C for 21 days is required to effect a Probit 9 level of mortality[2].

2.08 - How likely is the pest to multiply/increase in prevalence during transport or storage?

Very unlikely

Level of uncertainty: low

Considering the shipping temperatures referred to in 2.07, with the exception of the rare use of the 16°C, these temperatures are below the 12°C larval developmental threshold for *T. leucotreta* reported by Daiber (1979a).At these temperatures it would be impossible for an egg or larvae to complete its development up to the adult stage and newly developed pupae need ca. 40 days to develop into an adult at 16°C (estimated minimum period from Daiber 1979c).

2.09 - Under current inspection procedures how likely is the pest to enter the PRA area undetected?

Moderately likely

Level of uncertainty: medium

The pest has been regularly detected as larvae in imported consignments (see Table 5). However, larval entries into fruit take a few days to become visible, consequently fresh laid eggs or larval entries that

[2] Please note that the USDA treatment manual requires 24 days at -0.55°C or below.

occur close to fruit harvest are not easy to detect at the time of export.

At the time of import, infestations may not always be easily detected because:

- Transport conditions are not favourable to the pest development so larvae will not develop during transport.
- *T. leucotreta* is not a regulated pest and there are no targeted inspections other than those that are conducted for the detection of other pests such as *Guignardia citricarpa* and fruit flies (Tephritidae).

However, given shipping times and depending on transport temperature (see question 2.07) infested fruit may begin to decay (Newton, 1998) and in such case symptoms of infestation may be easier to detect by the time of importation.

Consequently the EWG considered that it is moderately likely that the pest may enter the PRA area undetected.

Table 5 below presents the notifications of non-compliance received at EPPO and reported interceptions by the NPPO the Netherlands regarding *T. leucotreta* between 2005 and 2011 (no notifications were received for the period 2000-2004).

Year	Citrus species	Reporting country/Origin	NO. of non-compliant consignments
2005	*Citrus* sp.	the Netherlands / South Africa	4
	Citrus reticulata	the Netherlands / South Africa	2
	Citrus sinensis	Spain/South Africa	15
		the Netherlands / South Africa	10
	Citrus x fortunella	the Netherlands / South Africa	1
2006	*Citrus* sp.	the Netherlands / South Africa	1
	Citrus reticulata	Spain/South Africa	1
	Citrus sinensis	Spain/South Africa	2
		the Netherlands / South Africa	6
2007	*Citrus reticulata*	Spain/South Africa	2
	Citrus paradisi	Spain/South Africa	2
	Citrus sinensis	Spain/South Africa	8
		the Netherlands / South Africa	4
		The Netherlands / Zimbabwe	1
2008	*Citrus paradisi*	Spain/South Africa	1
	Citrus sinensis	Spain/South Africa	2
		the Netherlands / South Africa	6
	Citrus paradisi	the Netherlands / South Africa	1
2009	*Citrus* sp.	the Netherlands / South Africa	1
	Citrus sinensis	Spain/South Africa	17
		the Netherlands / South Africa	4
		the Netherlands / Zimbabwe	1
	Citrus paradisi	Spain/South Africa	7
2010	*Citrus sinensis*	Spain/South Africa	3
		the Netherlands / South Africa	5
	Citrus paradisi	Spain/South Africa	1
		the Netherlands / South Africa	2
2011	*Citrus reticulata*	the Netherlands / South Africa	5
	Citrus sinensis	Spain/South Africa	4
		the Netherlands / South Africa	11
		Spain/Swaziland	2
	Citrus paradisi	Spain/South Africa	3
		the Netherlands / South Africa	7

Table 5 Notifications of non-compliance received at EPPO and reported interceptions by the NPPO of the

Netherlands and Spain regarding *T. leucotreta* between 2005 and 2011

The pest has been occasionally detected in imported consignments in the UK: 12 times between 1995 and 2010 (UK PRA, MacLeod, 2002). It has also been detected in imported fruits during an investigation in packinghouses located in the comunidad Valenciana between July 2004 and September 2005 (Tejedo *et al.*, 2006).

2.10 - How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?

Transfer from consignments intended for sorting and re-packing
Moderately likely
Level of uncertainty: Low

Transfer from consignments intended for retail
Unlikely
Level of uncertainty: medium

Summary:
Part of citrus consignments imported from countries where the pest is present is intended for sorting, re-packing and further distribution. These consignments are transported to warehouses which are often located near host growing areas. The probability of transfer from such consignments in Mediterranean countries is considered moderately likely, independently of the intended use because the main risk is posed by waste disposal in the proximity of susceptible crops or other wild hosts.

The probability of transfer from citrus fruit to glasshouses in Northern countries of the PRA area is generally considered low to very low, but in certain circumstances, like sorting of inferior quality fruits combined with improper waste disposal, probability of transfer is higher.

The main factor influencing the probability of transfer to a suitable host in all areas is the proper disposal of discarded fruits.

Citrus fruits are mainly transported by ship to the PRA area under cold conditions of between 4ºC and 10ºCalthough there are some exceptions depending on varieties (Transport Information Service, http://www.tis-gdv.de/tis_e/ware/inhaltx.htm#6). Consignments are temporarily stored in cold stores in harbour before being transported by refrigerated truck to handling/processing facilities or supermarkets scattered throughout the country. At the point of entry the organism is usually present in the larval stage. Any eggs which will have escaped detection during handling, picking and packing process are likely to have died under shipping conditions (Myburgh, 1965). Fruits are generally handled in a cold chain below the larval developmental threshold. In order to pupate larvae need to exit the fruit; pupation usually takes place in the soil (Newton, 1998). It should be noted that although pupation normally takes place in the soil, when a larva is due to pupate and no soil is available pupation can take place anyway. Successful pupation is mostly dependent on favourable temperature and humidity; when these conditions are met adults can develop.
The progression of decay of infested fruits during shipping, post-arrival storage and distribution, compounded by the dilution effect of an infested consignment from the point of entry via supermarkets to the end consumer, means that the proportion of infested fruits that may reach the end-consumer is very low. Furthermore, due to the cannibalistic nature of larvae, it is very seldom that more than one larva completes development in a single fruit (Catling & Aschenborn, 1978), greatly reducing the risk of introduction of this organism e.g. compared to fruit flies.

For the evaluation of the likelihood of transfer two types of consignments should be distinguished, 1) consignments that are handled for sorting/repacking/processing, 2) consignments intended for retail sale to the final consumers. The risk of transfer is different for these situations.

<u>Transfer in the case of consignments for sorting/repacking/processing</u>.

- Consignment intended for processing

EFSA (2007) reports that fruits and vegetables intended for processing (e.g. for juice, jam, etc.) are less subject to inspections, but the phytosanitary import regulation makes no such differentiation. As fruits and vegetables intended for processing are commonly of lower quality, they are therefore more susceptible to be infested. However, larvae will be destroyed during processing. If infested fruits are discarded before processing, the pest may survive if no effective waste disposal procedure is in place, particularly if they are discarded outdoors (see below).

- Consignment intended for sorting/repacking

In the Mediterranean part of the PRA area, part of citrus consignments from countries where the pest is present are imported for sorting, re-packing and further distribution. Sorting and packing facilities are located in the vicinity of Citrus fruit production areas thus ensuring host availability. During the sorting/repacking process, culled infested fruit may be discarded outdoors on compost piles. Mature larvae can exit the fruit and enter the soil to pupate. In such a situation, there is potential for mating pairs to occur close to suitable hosts. This may also happen to a lesser extent through the disposal of waste from retail centers within the Mediterranean coastal area. In such situations suitable host plants, including wild host plants such as *Ricinus communis* or *Quercus* spp., are likely to be present.

Host switching

In order to exploit these alternative hosts, *T. leucotreta* will have to switch hosts. Although a number of the host species recorded in the literature could not be verified (see Appendix 1) and known hosts are not attacked in some countries even if they are grown in close proximity to established populations (e.g. cotton and maize in South Africa, citrus in Israel), *T. leucotreta* is clearly a polyphagous species (see question 1.06). Such a "life system" strategy is common among species that live in spatially or temporally unstable habitats and have low mobility (Kennedy & Storer, 2000). *T. leucotreta*'s polyphagy can thus be considered as an adaptation to its low mobility coupled with its requirement for the continuous availability of fruit or flower buds that, for most species, are generally only present for short periods of time. However, Stotter (2009) found that in the Western Cape Province of South Africa acorns of *Quercus robur* provide an alternative host from November to March each year.

Although a variety of hosts may be suitable for development, it has been widely reported that, when given a choice, many insects tend to oviposit on the hosts they developed on and this behaviour is influenced by host availability (Cunningham & West, 2008; Coyle *et al.*, 2010). Oviposition preference may thus account for the different host ranges of *T. leucotreta* recorded in some countries, e.g. it has only been found on macadamia and *Ricinus communis* in Israel despite citrus orchards in close proximity (Opatowski, Israeli NPPO, *pers. comm.*, 2012, see also Q 3.01 pathway 1). Since there is no evidence of host strains for *T. leucotreta*, there is thus a risk that it is capable of attacking different host species in the absence of preferred species on entry to the PRA area. This conclusion is supported by the fact that it has been able to adapt to *Q. robur*, an alien species in South Africa, and larvae extracted from *Rosa* were found to be able to complete their development on citrus fruits (van der Straten, *pers. comm.*, 2012). In addition, Daiber (1987) showed that high levels of infestation in peaches only occur where alternative winter host plants, like wild hosts and citrus, are present.

In the northern part of the PRA area, citrus is imported either directly to retail outlets or is sorted and re-packed before being distributed (van der Straten, *pers. comm.* 2012). Some of these fruits may then be forwarded to the southern part of the PRA area. Where sorting and re-packing is undertaken in northern areas, moths that may emerge from infested fruits that have been discarded outdoors may also be able to find suitable hosts due to its polyphagous nature. Since adults of *T. leucotreta* cannot fly for long distances under field conditions (Stotter, 2009), it is very unlikely that mated female moths will be able to transfer from the place of emergence to a greenhouse with a suitable host plant. Incidental findings of moths in North Western Europe in the past have never resulted in establishment.

However, transfer cannot be completely excluded because in some cases in the Netherlands consignments of inferior quality, especially citrus, are sorted and upgraded to marketable quality by specialized companies. These consignments are stored under cold conditions, but the wastes are often disposed of in open containers that stay outside for several days (D. de Winter, KCB the Netherlands, *pers. comm.*, 2012). Several companies in the Netherlands involved in the business of sorting fruits are located within 600 m of greenhouses growing Capsicum (although adults *T. leucotreta* are not highly mobile under field conditions, some males have been trapped 1500 m from a citrus orchard (Stotter, 2009)).

The incursion in a green house in the Netherlands was probably caused by storage of peppers from Uganda in a room directly connected with the green house itself.

Transfer in the case of consignments intended for retail sale to the final consumers

The movement of infected fruit to markets/supermarkets and hence to consumers is likely to be another route for dispersal. Infested fruit could be discarded by the markets/supermarkets or the final consumer allowing emerging adults access to new crop areas (CABI, 2007).

When the infested fruits reach the final consumer, the species has greater possibilities to develop if the commodity is composted or garbage is not or is only irregularly collected as the pest may find suitable hosts in gardens. The increasing interest in composting of plant waste by the public increases this possibility. However, in general, it is supposed that trash would be incinerated or go to landfill.
The likelihood of infested fruit moving through the handling chain to the final consumer is reduced and smaller quantities of fruit are concentrated in one place at any one time. The result is a lower risk of mating pairs coinciding in time and space than with consignments intended for further handling/packing.

During and after the EWG the South African expert commented that trade from South Africa has a long history (100 years) and establishment of the pest in the Southern part of the EPPO region has not occurred so far.
Data on trade of citrus fruits from South Africa to Spain have been retrieved from EUROSTAT from 1992 and are presented in Fig. 11 below:

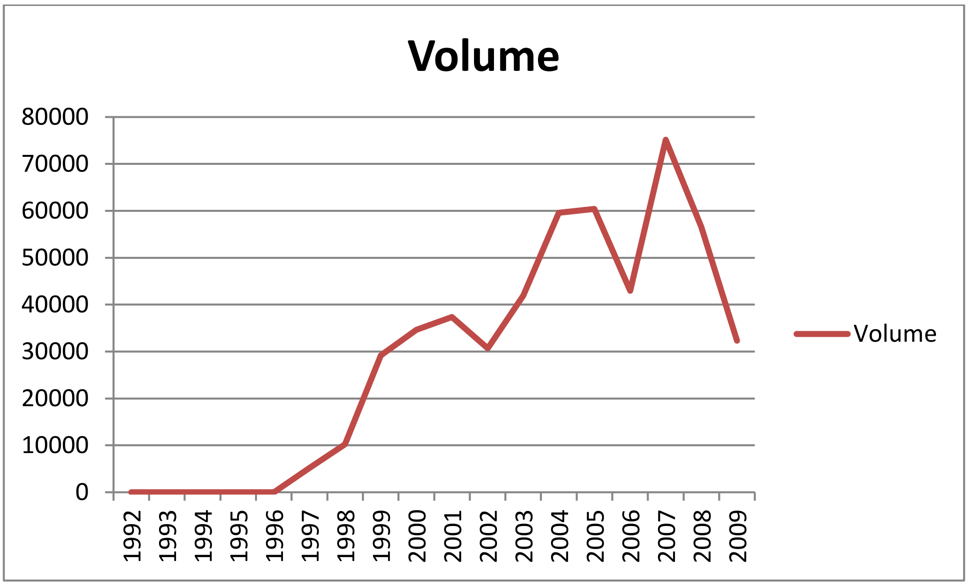

Fig.11 volumes in tonnes imported from South Africa to Spain between 1992 and 2009

Trade from South Africa to Spain only dates back to 1996 (the situation is similar for Italy). It is likely that traditional trade was mainly with northern Europe. So the risk can be considered as relatively recent for southern Europe.

2.11 - The probability of entry for the pathway should be described

Moderately likely
Level of uncertainty: Medium

C. *sinensis* (orange) *C. paradisi* (grapefruit) and *C. reticulata* (mandarines) fruits, the probability of entry is moderately likely for fruits intended for sorting and re-packing.

The association of the pest with the fruits taking into account management conditions is moderately likely with a medium uncertainty.
The probability of transfer is considered to be moderately likely when significant amounts of a particular commodity (e.g. a consignment) are stored for more than 1 week in the near vicinity of a production place, unless storage is at a low temperature (lower than around 12°C). The same goes for a situation

where waste of processed commodity is disposed under open conditions at temperatures above 12°C. The probability is lower for fruits for retail sale to the final consumers.

Fig 12,13 and 14 are respectively the results of the CAPRA visualizer for entry as well as the Matrix model.

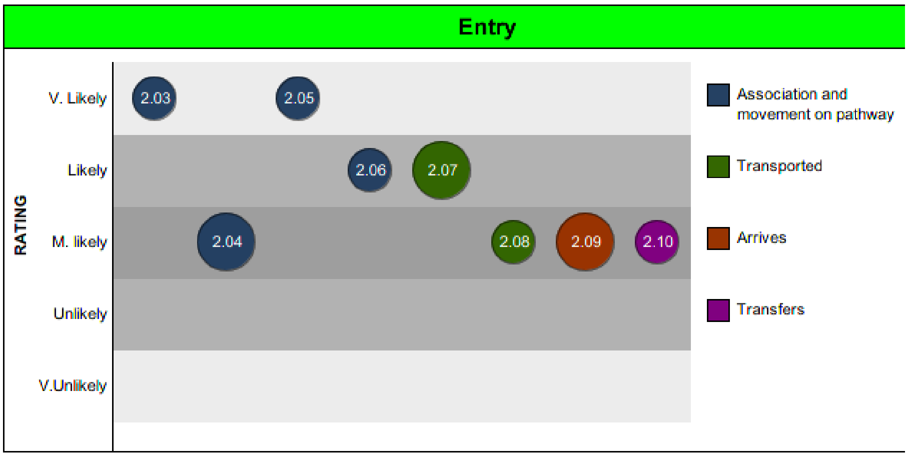

Fig. 12. Result of the CAPRA visualizer (visualization of the ratings and uncertainty for each question) for fruit consignments intended for sorting and re-packing

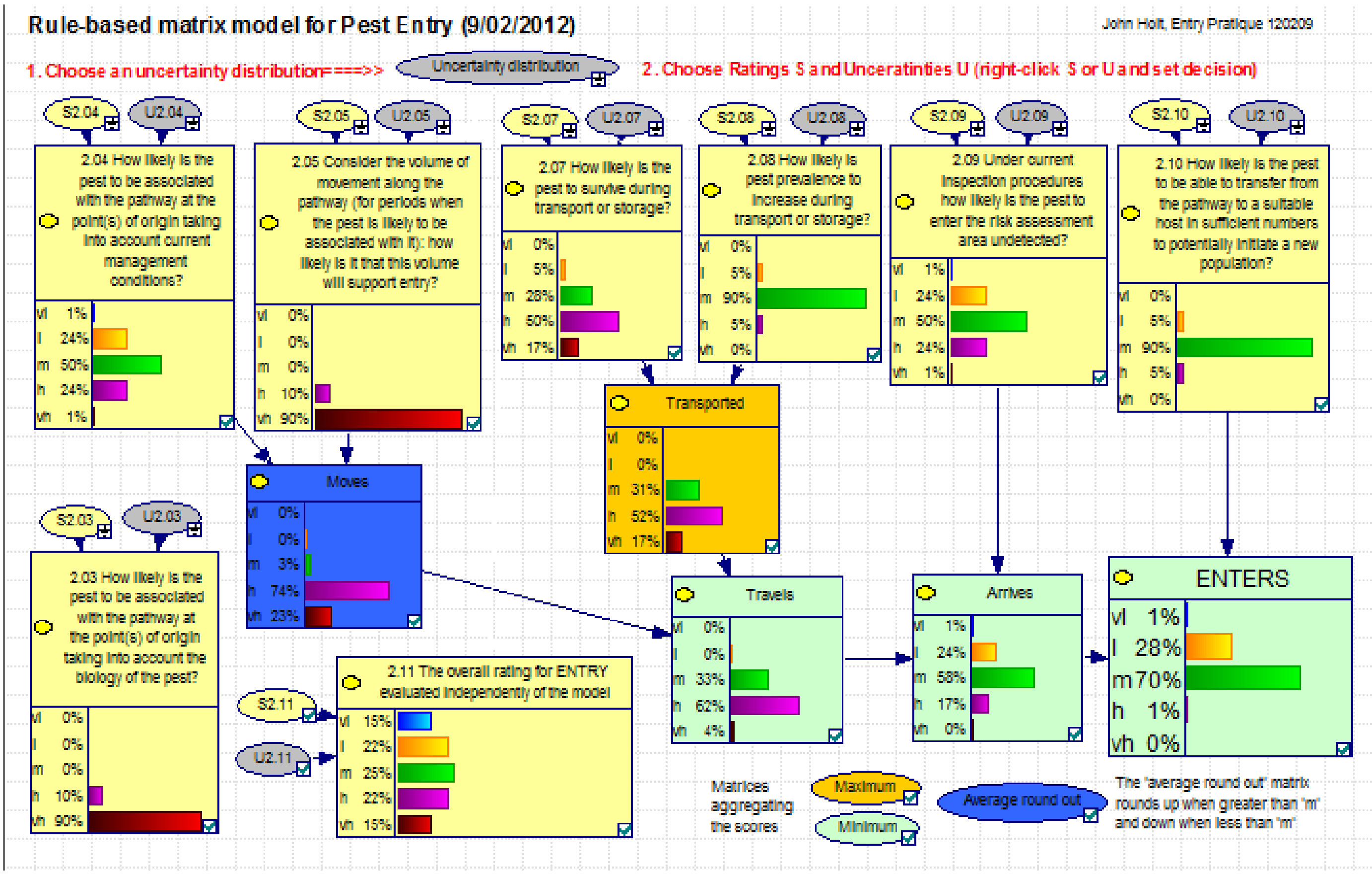

Fig. 13. Results of the Matrix model in CAPRA for the risk of entry for C. *sinensis* (orange) *C. paradisi* (grapefruit) and *C. reticulata* (mandarins) in fruit consignments intended for sorting and re-packing.

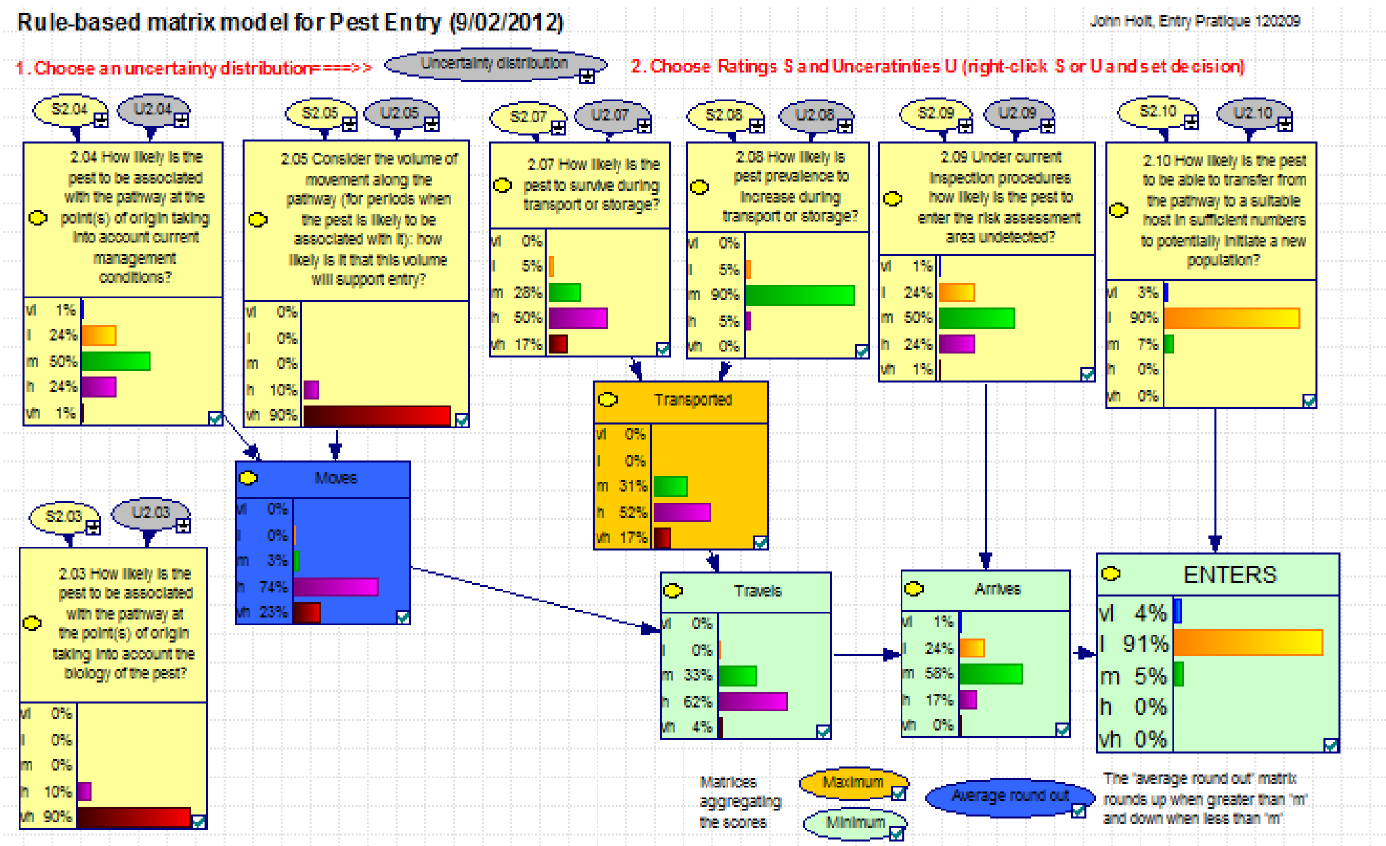

Fig. 14. Results of the Matrix model in CAPRA for the risk of entry for *C. sinensis* (orange) *C. paradisi* (grapefruit) and *C. reticulata* (mandarins) in fruit consignments intended for retail sale.

Fruits originating from Israel:
The probability of entry of *T. leucotreta* on *C. sinensis* (orange) *C. paradisi* (grapefruit) and *C. reticulata* (mandarines) fruits, is considered unlikely with a medium uncertainty because of the low probability of association with the pest. However it should be noted that the Panel on Phytosanitary Measures in March 2013 considered that Israel should provide additional evidence and data to support the lower rating given.

Pathway 2: **Fruits of *Capsicum* spp.**

2.03 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account the biology of the pest?

Capsicum originating from Israel*
Level of uncertainty: Medium
Other origin Likely
Level of uncertainty: Low

The broad range of host plants, together with mild tropical and subtropical winters ensures that the pest is an all-year round threat to crops in most of its distribution (Newton, 1998). Consequently, suitable life stages of the pest are present when Capsicum fruits are present and exported to the EPPO region as demonstrated by the detections of the pest in imported consignments. Based on biology the association is considered likely (see also next question).

*As for Citrus, the pest has never been recorded on Capsicum in Israel it is not present in the area where Capsicum are grown. The risk is considered unlikely with a medium uncertainty.

2.04 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account *current management* conditions?

Moderately likely
Level of uncertainty: high

There is no information available on the prevalence of the pest in pepper. Recent survey of the pest status of *T. leucotreta* on Capsicum commissioned by Citrus Research International suggests that it is not considered a pest of economic importance on Capsicum in South Africa and only of a sporadic nature in Uganda (Moore, unpublished report 2012). However information from a grower of *C. chinensis* (habanero pepper) from Uganda exporting this product to the Netherlands year round, suggests that the species is a common pest in his crop (Vollebregt *pers. comm.*, cited in Potting & van der Straten 2011).
The USDA reports many interceptions of *T. leucotreta* found on Capsicum (USDA-Aphis 2010) and incidental interceptions from Uganda are reported by the UK (Malumphy & Robinson 2002, A. Koricynska, *pers. comm.* 2012) and the Netherlands with regular detection in imported consignments from Uganda in 2013 (M. van der Straten, *pers. comm.*, 2012 & 2013). This shows that the current management measures are not preventing association. It should be noted that *Capsicum* is not currently regulated by the EU; interceptions are therefore accidental. As a result, there is no information on the percentage of infested consignments being imported in the EU.

The rating was consequently chosen at the middle point with high uncertainty due to the conflicting information gathered.

2.05 - Consider the volume of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this volume will support entry?

Unlikely
Level of uncertainty: Medium

The total volume of *Capsicum* spp. imported from countries where *T. leucotreta* is present equals 116 472 tonnes and the majority is imported from Israel. However the pest has never been recorded on Capsicum in Israel nor detected in imported consignments.
There are no detailed figures on the import of different species/types of capsicum. Also, since capsicum is not regulated, data on the percentage of consignments being infested are lacking. The rating unlikely reflects the low volume from infested countries excluding Israel.

2.06 - Consider the frequency of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this frequency will support entry?

Likely
Level of uncertainty: Medium

There are no detailed data on the import of different species and varieties of Capsicum.
Aggregated data of monthly Capsicum imports from countries where *T. leucotreta* is present are presented in Fig. 15. The trade is dominated by Capsicum from Israel that mainly occurs between December and April. When the Israeli imports are excluded (see Fig. 16), it can be seen that the monthly trade from other origins is relatively stable. This trade is primarily in chilli peppers.

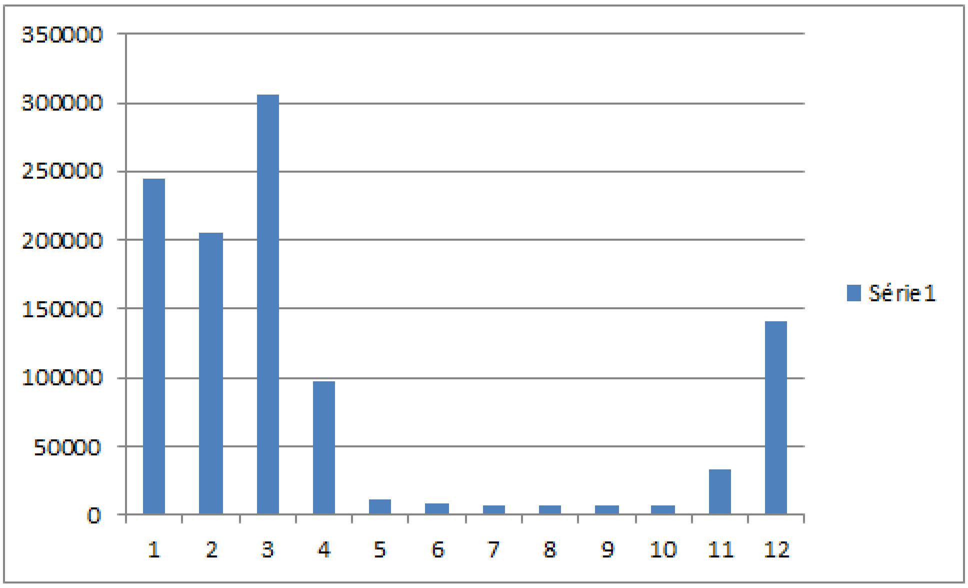

Fig. 15. Repartition of imports (in 100 kg) of *Capsicum* spp. to the EU countries throughout the year 2010

from countries where *T. leucotreta* is present (Source EUROSTAT)

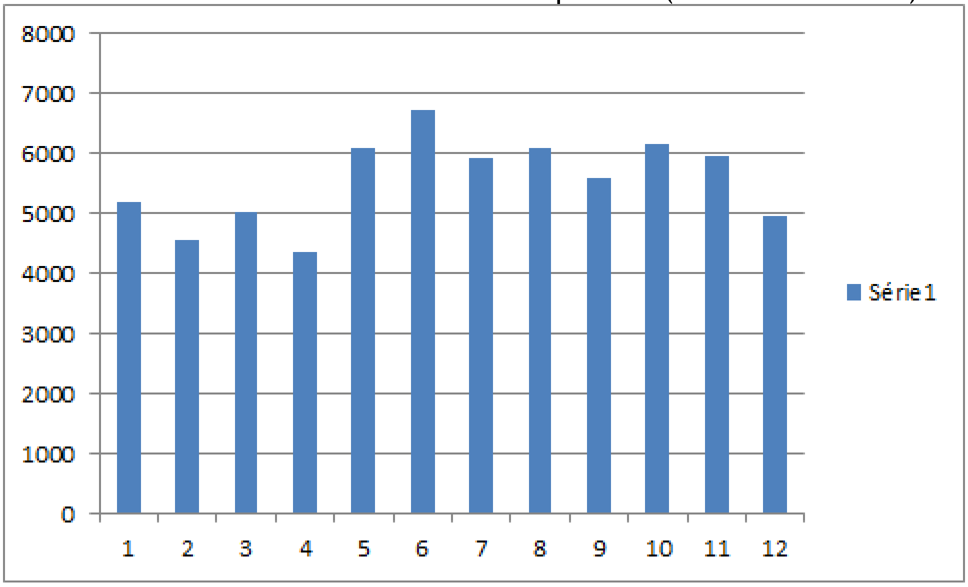

Fig. 16. Repartition of imports of *Capsicum* spp. (in 100 kg) to the EU countries throughout the year 2010 from countries where *T. leucotreta* is present excluding imports from Israel. (Source EUROSTAT)

2.07 - How likely is the pest to survive during transport or storage?

Very likely
Level of uncertainty: low

As the pest has been detected in imported consignments this demonstrates that survival is possible during transport. Consignments are transported by airfreight and arrive within a day.

The life stages of the pest likely to be present in consignments have a development threshold temperature of about 12°C (Daiber, 1979a, b and c). Storage and transport of the commodities at a temperature above this threshold will facilitate survival of the pest (Stotter & Terblanche 2009).

As stated for citrus fruits, Myburgh (1965) demonstrated that whereas fairly high levels of larval mortality will ensue from shipping below 4.5°C, exposure to -0.55°C for 21 days is required to effect a Probit 9 level of mortality. The EWG considered that these could also be considered valid for *Capsicum* spp.. However such temperature and time span are unsuitable for this commodity as they will damage the fruit.

According to Transport Information Service, favourable travel temperature range from 5 to 25°C (http://www.tis-gdv.de/tis_e/ware/gewuerze/paprika/paprika.htm#temperatur). Consequently the pest will be able to survive.

2.08 - How likely is the pest to multiply/increase in prevalence during transport or storage?

Very unlikely
Level of uncertainty: low

Consignments are transported by airfreight and arrive within a day.

2.09 - Under current inspection procedures how likely is the pest to enter the PRA area undetected?

Very likely
Level of uncertainty: low

Most EPPO Countries have no specific phytosanitary inspection procedures for Capsicum fruits which makes the pest very likely to enter undetected. If such inspection is performed, it would be moderately likely to enter undetected as the organism has a hidden lifestyle and may be difficult to detect.

Following entry, larval damage in fruit takes a few days to become visible. Therefore, larvae entering fruit close to the time of harvest are difficult to detect at the time of export.

No specific description of symptoms on Capsicum fruits exist but, as with other Lepidoptera borers, damage by *T. leucotreta* will consist of entrance holes, discoloration or distortion of fruit. This may be detected by visual inspection of the product. However, certain species e.g. *Capsicum chinense* have a "wrinkled/distorted" fruit shape (e.g. habanero peppers) and consequently infestations will be difficult to detect. Therefore *T. leucotreta* may remain undetected in some species of *Capsicum* spp. more than in others.

2.10 - How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?

Consignments of fruits for companies with combined trade and production

Moderately likely

Level of uncertainty: Medium

Consignments of fruits going directly to final consumer:

Unlikely

Level of uncertainty: Medium

Summary:
The transfer from capsicum fruits to a greenhouse where it could permanently establish is considered unlikely for the bulk of the trading flow that goes directly to the end consumer. The likelihood of transfer outdoors is also unlikely (as for Citrus fruits). The transfer to a glasshouse is considered moderately likely for combined trading and production companies of capsicum fruit.

For transfer to occur, a combination of events has to take place as illustrated in the different scenarios described below (from the most likely to the least likely to aid transfer):

- A mating pair may escape from storage places, market places (that trade in fruit) and houses and the mated female reaches suitable hosts.
- Infested fruits are discarded in a compost pile and some adults may hatch mate and find host plants.
- Infested fruit are thrown away; garbage is not collected regularly and the pest may escape, mate and reach host plants.

The probability of such events is not easy to evaluate and is highly dependent on local conditions.

In general, Capsicum fruit are consumer products that arrive by aircraft and end up relatively quickly with the end consumer. A dilution effect of an infested consignment from the point of entry via supermarkets to the end consumer means that the density of infested fruits at the end-consumer is very low. Due to this effect, it is unlikely that a significant number of moths will emerge, before the vegetables are discarded by the end consumer.
However, the dilution effect does not occur in cases where consignments are temporarily stored before trading continues. Under these circumstances it is possible that a significant number of larvae may exit fruit and seek the opportunity to pupate outside of the fruit. If they are successful, then moths may emerge. In cases where consignments of pepper are stored in facilities that are also production places with or near to suitable host plants, there is a possibility that moths escaping from infested consignments may mate and lay eggs. The risk that this event will occur is higher for companies that not only trade, but also have a production facility of the same commodity.
This is demonstrated by the incursion of *T. leucotreta* in a greenhouse in the Netherlands in 2009, caused by repacking of infested product imported from Uganda in a facility next to the greenhouse. In the Netherlands there are a few companies that sort and pack vegetables from Africa and that also have a production facility within the same building.
For a company that sorts and packs commodities, but has no production within the same building the risk is theoretically the same as described for citrus fruits. However, the volumes involved in such a process are much lower, lowering the chance of males and females developing at the same time.
In addition, if infested fruits are discarded before processing, the pest may survive if no effective waste disposal procedure is in place.

As *T. leucotreta* is a polyphagous pest, it may be able to find host plants in most of the PRA area (see pathway 1 for a more detailed explanation). However in the northern part of the PRA area, the pest will only find suitable conditions for transfer in summer (i.e. from May to October). It should be noted that peppers (esp. chilli peppers) may be re-exported from the northern to the southern part of the region. Transfer to a suitable host will be more likely in the southern part of the region.

2.11 - The probability of entry for the pathway should be described

Moderately likely

Level of uncertainty: Medium

The probability of entry with this pathway is considered moderately likely (in some part of the region the transfer may be more likely than others (in particular those where hosts plants are grown outdoors or facilities where imported product is handled in facilities together with production). The matrix model presented in Fig. 18 summarizes the risk as unlikely. However as transfer has already happened (incursion of *T. leucotreta* in a Dutch greenhouse), the EWG considered the overall probability as moderately likely.

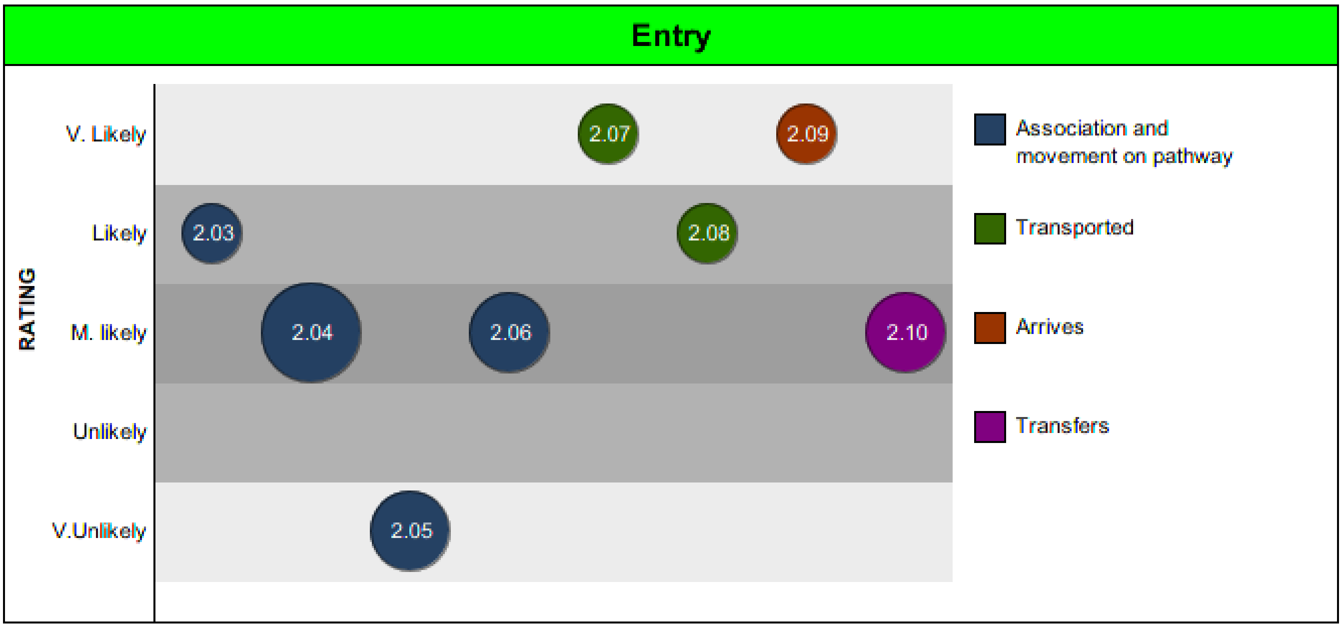

Fig. 17. Result of the CAPRA visualizer

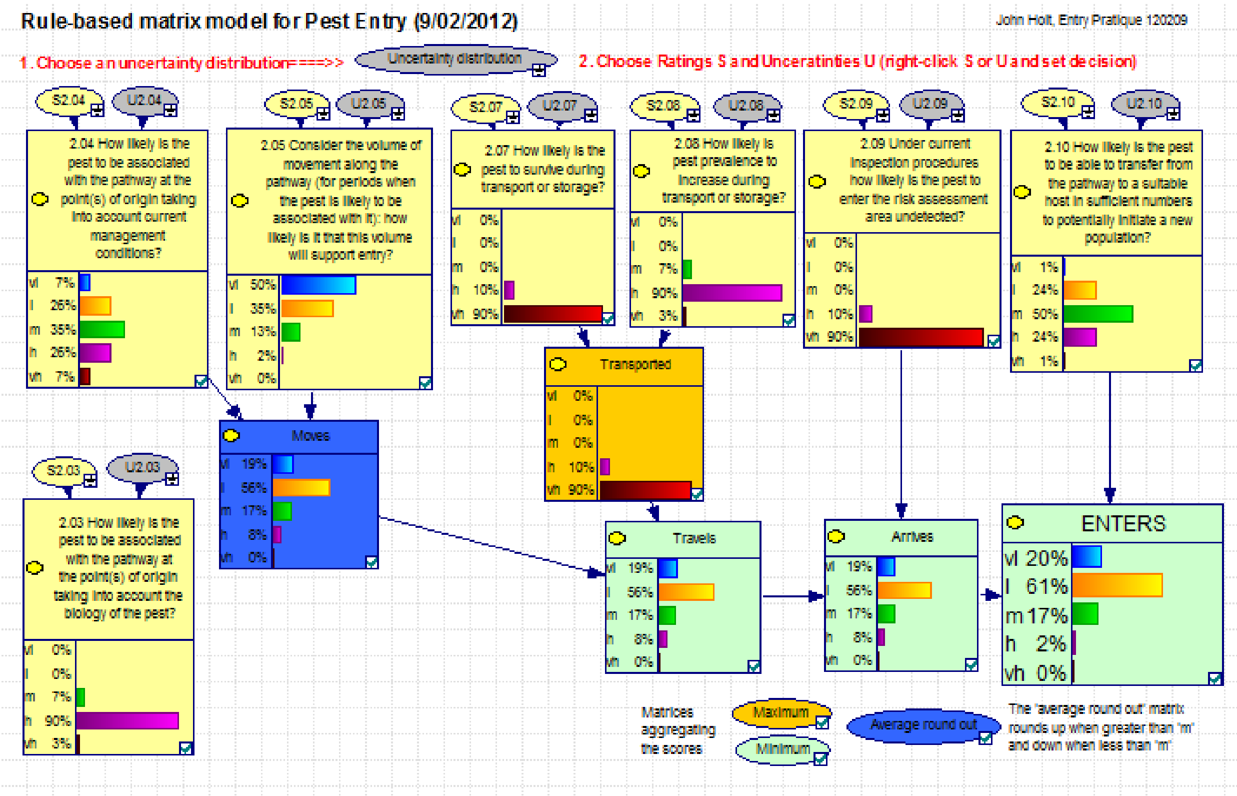

Fig. 18. Results of the Matrix model in CAPRA for the risk of entry for Capsicum spp.

2.13b - Describe the overall probability of entry taking into account the risk presented by different

pathways and estimate the overall likelihood of entry into the PRA area for this pest.

Moderately likely
Level of uncertainty: medium

The pest can be present on imported commodities but the risk of entry is mainly dependent on the success of transfer.

Stage 2: Pest Risk Assessment Section B: Probability of establishment

In the first part of the assessment of the probability of establishment, the ecological factors that influence the limits of the area of potential establishment and the suitability for establishment within this area have been selected. The result of the evaluation for the 7 factors to consider is presented in Table 6. For each question which was answered with a "yes", detailed information is provided after Table 6.

Factor	Is the factor likely to have an influence on the limits to the area of potential establishment?	Is the factor likely to have an influence on the suitability of the area of potential establishment?	Justification
Host plants and suitable habitat	Yes (see 3.01)	Yes (see 3.09)	
Alternate hosts and other essential species	No	No	*T. leucotreta* does not require another host or another essential species to complete its life cycle. However, it does require the availability of a continuous fruit supply.
Climatic suitability	Yes (see 3.03)	Yes (see 3.11)	
Other abiotic factors	No	No	*T. leucotreta* normally pupates in the soil and high soil moisture has been reported to be detrimental to survival (Daiber, 1979), but this factor can be considered to be a product of climate suitability
Competition and natural enemies	No	No	In African cotton and citrus crops many insect parasitoids (of the families Trichogrammatidae, Braconidae, Elasmidae and Ichneumonidae) have been recorded parasitising up to 10% of the eggs and 15% of the larvae (Glas,1991). The lower infestation rates in eastern Transvaal compared to Citrusdal in Western Cape Province are attributed to the wider parasitoid complex in the eastern Transvaal where it is native (it was introduced to Citrusdal in 1974 (Honiball (2004) quoted by Stotter (2009)). Newton (1998) noted that very high egg parasitism levels have occasionally been recorded but, summarising earlier work, concluded that "native parasitism does not play a regulatory role at the orchard level" and "larval parasitoids are apparently of lesser importance". Conversely more recent reports indicate naturally occurring egg and larval parasitoid control of up to 98% under field conditions in some southern African citrus production regions (S. Moore, Citrus Research International, *pers. comm.*, 2012). However it is unlikely that such levels of control will be achievable with more generalist tortricid insect parasitoids present in the EPPO region and therefore they are considered unlikely to affect the potential establishment of *T. leucotreta*.
The managed environment	Yes (see 3.06)	Yes (see 3.14 and 3.15)	
Protected cultivation	Yes (see 3.07)	Yes (see 3.16)	

Table 6. Evaluation of the ecological factors that influence the limits to the area of potential establishment and the suitability for establishment

Identification of the area of potential establishment (3.01 to 3.07)

Host plants and suitable habitats

3.01 - Identify and describe the area where the host plants or suitable habitats are present in the PRA area outside protected cultivation.

T. leucotreta is extremely polyphagous with over 70 hosts. Several of these are economically important crops in the EPPO region such as *Capsicum* (peppers), *Citrus reticulata* (and hybrids), *C. sinensis* (and hybrids), *Macadamia ternifolia* (macadamia nut), *Prunus persica* (peach), *Prunus persica var nucipersica* (nectarine), *Punica granatum* (pomegranate), and *Zea mays* (maize). See question 1.06 for more information on the host plants.
Most hosts occur primarily in the southern part of the EPPO region, but *Zea mays* (maize), *Rosa* sp. (rose), *Prunus domestica* (Plum, see Appendix 1 second table) and *Quercus robur* are found much further north. In Israel, *T. leucotreta* populations on macadamia nuts are sustained on the castor oil plant, *Ricinus communis* (Hamburger *et al*, 2001, Opatowski, Israeli NPPO, *pers. comm.*, 2011).

Climatic suitability

3.03 - Does all the area identified as being suitable for establishment in previous question(s) have a suitable climate for establishment?

No

Although hosts are more widespread in the EPPO Region, after careful study (see Appendix4), only areas near the Mediterranean coast in North Africa (Morocco, Algeria and Tunisia), the Near East (Israel and Jordan) and Europe (Spain, Italy (Sicily), Malta and Cyprus) together with Portugal, the Canary Islands and the Azores were shown clearly to be suitable climatically for *T. leucotreta*.

The species is native and widespread in sub-Saharan Africa and also occurs on islands in the Atlantic and Indian Oceans (Madagascar, St. Helena, Cape Verde, Mauritius and Reunion).

An outbreak on macadamia nuts in the coastal plain of Israel was found in November 1984 and attempts were made to eradicate it (Wysoki, 1986). However, Hamburger *et al*. (2001) noted that it was still present on macadamia nuts, cotton and castor bean (*Ricinus communis*) and that "the area of infestation where catches occur, approximately 60 km across, is in the center of the country". In 2003, the Israeli NPPO declared it to be "present, but of limited distribution, limited host range and subject to official control" (EPPO, 2003). The Israeli coastal plain has a Mediterranean climate and can therefore be considered as climatically suitable for establishment.

The suitability of the Mediterranean climate is also confirmed by its distribution in South Africa where it is present in all the citrus growing areas but it is particularly common in the Citrusdal area of Western Cape Province (Stotter, 2009) that has a dry Mediterranean climate.

Although this is strong evidence that the Mediterranean climate is suitable for *T. leucotreta,* it conflicts with Daiber (1989), quoted by Venette *et al*. (2003), who suggests that this pest may not perform well in Mediterranean climates and the biome comparison analysis by Venette *et al*. (2003) that did not predict establishment in the Mediterranean climates of California. However, the simple comparison of World Wildlife Fund biomes has been superseded by other methods and NAPPFAST day degree models now show that establishment is possible with 3-9 generations in California (Fig. 2-2 in USDA New Response Guidelines, 2007 and NAPPFAST, 2010 click on the link to access the NAPPFAST Map *T leucotreta*) and the recent Pareto risk map (Borchert, 2011, click on the link to access the Pareto risk map), that takes into account host distribution, shows the area around San Francisco and southern coastal areas to be particularly vulnerable.

The managed environment

3.06 - Is all the area identified as being suitable for establishment in previous questions likely to remain unchanged despite the management of the environment?

No

The limits to the distribution in the dry southern and eastern parts of the EPPO region will be expanded by irrigation and the use of natural lakes, riverbeds and other areas that retain winter rainfall.
However, the ameliorating effect of such surface water sources may have limited potential to alter the suitability of areas that experience hot dry extremes. Although other factors may play a role, this may

be the reason for the failure of the pest, despite protracted presence, to attain economic pest densities on citrus in hot dry production areas bordering the Limpopo River in northern South Africa (Hattingh, *pers. comm.* 2012).

Protected Cultivation

3.07 - Are the hosts grown in protected cultivation in the PRA area?

Yes

Of the hosts (see 1.06), Capsicum is widely grown in protected cultivation in the EPPO Region. *Rosa* sp. is another host that is commercially grown in several countries under protected cultivation. Ornamental Citrus plants are also grown under protected cultivation.

3.08 - By combining the cumulative responses to previous questions with the response to question 3.07, identify the part of the PRA area where the presence of host plants or suitable habitats and other factors favour the establishment of the pest.

Areas near the Mediterranean coast in North Africa (Morocco, Algeria and Tunisia), the Near East (Israel and Jordan) and Europe (Spain, Italy (Sicily), Malta, Cyprus and southern Greece) together with Portugal, the Canary Islands and the Azores where:

a) cool minimum night time winter temperatures greater than 1˚C are balanced by day time maximum temperatures that are up to 15-17˚C higher,
b) fruits of host plants (e.g. *Ricinus communis*) are available year-round. It should be noted that the pest can lay eggs on *Rosa* sp. as demonstrated by several detections in *Rosa* cut flowers from Uganda.
c) host plants are irrigated (or have naturally available water) to withstand the summer drought.

See Appendix 4 for maps of areas that are climatically suitable with and without deserts (Figs 5-8 in Appendix 4) and an explanation of the methods used.

Establishment year-round in protected cultivation, e.g. on Capsicum, outside this area is considered to be unlikely. However, since Capsicum is widely grown in protected cultivation over winter in southern Europe, this may enhance the area where the likelihood of successful overwintering is possible in southern Europe.

Suitability of the area of potential establishment (3.09-3.16)

Host plants and suitable habitats

3.09 - How likely is the distribution of hosts or suitable habitats in the area of potential establishment to favour establishment?

Likely

Level of uncertainty: Low

There are many host species, both wild and cultivated, in the Mediterranean area, especially close to the shores of the Mediterranean Sea. *T. leucotreta* is a polyphagous pest and may adapt to new hosts.

Wild *Ricinus communis* (the castor oil plant) "bears fruit most of the year" and sustains *T. leucotreta* populations in Israel when other host fruit (macadamia and cotton) are unavailable (Hamburger *et al.*, 2001). Different varieties and growth forms of *Ricinus communis* are very common in Mediterranean islands (such as Sicily, Sardinia, Crete and the Balearics) and North Africa, (Brundu *et al.*, 2003; Brundu *et al.*, 2004; Dal Cin D'Agata, 2009) where it is often invasive in riparian areas, such as temporary river watercourses and wetlands, agricultural and post-agricultural fields, ruderal areas and roadsides (Giuseppe Brundu, *pers. comm.*, 2011). It may also be grown as a crop.

Climatic suitability

3.11 - Based on the area of potential establishment already identified, how similar are the climatic conditions that would affect pest establishment to those in the current area of distribution?

Largely similar

Level of uncertainty: Medium

As noted in question 3.05, the detailed study on climatic suitability in the EPPO Region (see Appendix 4) showed that only areas near the Mediterranean coast in North Africa (Morocco, Algeria and Tunisia), the Near East (Israel and Jordan) and Europe (Spain, Italy (Sicily), Malta and Cyprus) together with Portugal, the Canary Islands and the Azores are climatically suitable for *T. leucotreta*. This area is largely climatically similar to the current area of distribution that includes the Israeli coastal plain. This area should be considered as a conservative estimate: (a) due to climate change (that now allows southern Greece to be included) and (b) the difficulty of estimating climatic responses and limitations in our knowledge of the distribution of the pest.

The managed environment

3.14 - How favourable for establishment is the managed environment in the area of potential establishment?

Very highly favourable
Level of uncertainty: Low

Crop production methods are similar to those in South Africa where *T. leucotreta* is an important pest. Conditions that favour the host, e.g. citrus grown outdoors and in protected cultivation (see question 3.07) are likely to favour the pest.

The following points should be noted and favour establishment:

- The time of the year that the relevant crop is grown and its phenology are congruent with the life cycle of the pest this has a positive influence on the establishment.
- Some hosts are grown under protected conditions
- Some hosts are perennial plants
- Irrigation has a positive influence on establishment (see question 3.08)
- The method of harvest has a positive influence on the establishment of the pest (leaving fruits on the trees and fallen fruits not collected will favour the pest).

3.15 - How likely is the pest to establish despite existing pest management practice?

Very likely
Level of uncertainty: Medium

CITRUS

Pest management practices for Citrus orchards

Few species requires control measures in citrus crops (see question 6.03). In all these cases, treatments carried out against those pests are unlikely to be fully effective against *T. leucotreta* because they are targeted to these species or timing is not optimal to control *T. leucotreta*.
Organic production will be more favourable for the establishment of *T. leucotreta* because less or no plant protection products are used.

Citrus orchards are sometimes not harvested for economic reasons and the orchards are temporarily abandoned. In such situations, no treatments to control pests are carried out and this may create favourable conditions for *T. leucotreta* to establish.

Pest management practices for citrus plants in private gardens in public parks or road sides

Domestic plants in public and private gardens and road sides are neither managed nor harvested, and are difficult to survey and inspect.
In public and private gardens and road sides, it is unlikely that individuals would use plant protection products. Moreover as *T. leucotreta* does not damage the plant, it is very unlikely that treatments are performed.
In urban areas in the European Union, the few active substances available to control Lepidoptera species cannot be used.
As a conclusion the pest is very likely to establish in citrus despite existing pest management practice.

CAPSICUM

On pepper crops, especially in protected cultivation, pest management targets arthropod virus vectors such as thrips and whiteflies and is mainly based on natural enemies. Plant protection products used for control are therefore very specific. Biological pest control is becoming more and more important in southern Europe. Biological control for pests in Almeria's fruit and vegetable sector grew in 2012 by 20,750 hectares, representing almost 80% of the greenhouse area. Pepper is the vegetable with the largest area treated with this method of cultivation, over 7,100 hectares. (source:http://www.freshplaza.com/news_detail.asp?id=97280).

Damage caused by Lepidoptera species are very sporadic, and consequently no targeted treatments against Lepidoptera species are usually carried out except in special circumstances (see details in question 6.04). In some parts of the PRA area growers may still regularly apply chemical insecticides against various other pests. The use of pyrethroids may be quite common in such situations and consequently may have an effect on *T. leucotreta* populations.
So, in the major pepper growing areas of Europe establishment of *T. leucotreta* will not be prevented by existing pest management practice.

PRUNUS
Prunus spp. are attacked by two important Lepidoptera species *Cydia molesta* in peaches and *Grapholita (Cydia) funebrana* in plums. Their biology and damage in terms of fruit tunnelling is similar to *T. leucotreta*. Control methods might have an effect but might not coincide with the seasonal phenology of *T. leucotreta* and therefore might not provide full control of *T. leucotreta*.

MAIZE
The effectiveness of control against *Sesamia nonagrioides* and *Ostrinia nubilalis* will depend on the timing of applications, which for a different species may lead to application in a different period and potentially to a more frequent need for application.
Recently, maize commercial margins are becoming very low and consequently no regular insecticide treatments are carried out in this crop.

So it is unlikely that existing management practices will prevent *T. leucotreta* from establishing in maize.

COTTON
Specialised pest control strategies are applied to cotton production. Pheromone mating disruption is applied for the control of *Pectinophora gossypiella*. Pest control is required for *Helicoverpa armigera* and *Earias insulana* and consequently when performed the pyrethroid treatments will have an effect on *T. leucotreta* populations. However, the cultivation of cotton in Europe is in a very critical situation due to the loss of commercial margins that reduce the capacity of the producers to use chemical treatments and implement new mating disruption techniques.
Consequently it will be very likely to establish despite existing pest management practice.

Protected Cultivation
3.16 - Is the pest likely to establish in protected cultivation in the PRA area?

Yes
Level of uncertainty: Low

T. leucotreta was detected in *Rosa* cut flowers that were grown in Uganda under protected conditions, showing that establishment of the pest in protected conditions is possible. *T. leucotreta* has also been able to mate and lay eggs in a Dutch *Capsicum* greenhouse.
However, in the current area of distribution continuous availability of fruits is a determining factor in the population build up. In the case of *Capsicum* under current cultivation practice in the PRA area, there is a period of 5 to 6 weeks without fruits being available; in the case of *Solanum melongena* this period is even longer. Alternative hosts are not available in the greenhouse (stems and flowers of these crops are unlikely to support development) and dispersal to surrounding greenhouses, that may offer alternative hosts, is unlikely because vents are closed in winter and temperatures are too low for flight (Potting and van der Straten, 2011). Furthermore, *T. leucotreta* lacks diapause that would enable it to bridge a period of unfavorable conditions. However *T. leucotreta* still may be able to survive without hosts for a longer period of time. For example the maximum pupal stage is 40 days in South-African wintertime and the adult longevity is 3 weeks (Newton, 1998)). Daiber (1979) showed that the duration of the pupal stage of females could be up to 60 days at 15°C, and at a constant temperature of 10,9°C one pupa survived even for 72 days. During the period between crops, which is wintertime in the Netherlands, the temperatures in the greenhouse are usually low (but not freezing). Thus, theoretically *T. leucotreta* is able to bridge this gap and can settle on the new young crop. However, at the moment of crop change, most of the population will be in the egg and larval stage, and only a part in the pupal stage. In a modern greenhouse with soilless cultivation pupation will mostly take place in the rockwool slabs or leaves on the ground. A large part of the population will therefore be removed at crop changing and

clearing. Only a small part of the population (in a pupal stage) will survive and by the time fruits on the new crop are developing again, it is likely that not enough adults will be present simultaneously to find a mate and build up a population (although this is highly depending on the size of the population at the moment of crop changing). Note: when cultivation is in soil instead of on rockwool larvae will pupate in the soil and will not be removed with the crop; the number of pupae that will be left behind and may be able to bridge the period without fruits will be higher in that case. This may also be the case if the rockwool slabs are not being removed at the clearing of the crop, but are being re-used for the next crop without being steam sterilized (steam sterilization will kill any pupae present).
In the case of the incursion in the Netherlands, eradication measures were taken before larvae could develop into adults but it can be assumed that one generation could have developed without intervention. Because of the eradication it is also not known whether the gap in between the old and new crop would have been bridged.

As noted in question 2.04, there is conflicting information on the economic importance of *T. leucotreta* on *Capsicum* grown in polytunnels in Uganda and S Moore (unpublished report, 2012) states that in South Africa no outbreaks of *T. leucotreta* in pepper produced in polytunnels have been reported even though the pest is present in the areas where pepper is produced. However, since this species has been recorded in Ugandan polytunnels, southern European polytunnels provide conditions suitable for development and the presence of protected *Capsicum* crops may enhance the likelihood of overwintering, increasing the area where establishment is possible, it is considered that *T. leucotreta* could establish in southern European polytunnels although the risk is lower than for the areas outdoors.

3.17 - How likely are the reproductive strategy of the pest and the duration of its life cycle to aid establishment?

Likely
Level of uncertainty: Low

This rating is based on the following information:

- Up to 5 generations per year have been recorded in South Africa (Daiber 1980), and up to 10 generations are possible in the lab (literature summarized by Venette *et al.*, 2003). The minimum generation time is approximately 30 days.
- Female fecundity can vary from 5-799 eggs with an average of 460 being laid at 25°C and 0.4 at 10°C (Daiber 1980).
- Pheromone attraction enhances the chance of mating.

3.18 - Is the pest highly adaptable?

No moderately adaptable or less
Level of uncertainty: Medium

The species is highly polyphagous. It is present throughout sub-Saharan Africa and in Israel and insecticide resistance may develop quickly. However, it has no diapause and its dependency on the continuous availability of specific host plant parts, mainly fruit, restricts establishment outdoors to areas where there are no lengthy cold periods and host plant material is always available.

3.19 - How widely has the pest established in new areas outside its original area of distribution?

Moderately widely
Level of uncertainty: Low

Large numbers of interceptions have been made in Europe and USA but new establishments are confined to:

- Israel since 1984 (Wysoki, 1986)
- Invaded Western Cape Province in 1974 (Giliomee & Riedl, 1998).

Using the CAPRA rating guidance, the pest is considered to be widely established (it has spread and established in 1 or 2 realms). Because establishment in the second realm concerns only one country (Israel) and, apart from this record, all other records are in the same realm, the EWG considered that the rating should be “moderately widely” and not “widely”.

3.20 - The overall probability of establishment should be described.

Likely

Level of uncertainty: Medium

The climate is suitable in part of the PRA area and hosts are present. The pest has already been introduced into Israel. Outdoors conditions are suitable in areas near the Mediterranean coast in North Africa (Morocco, Algeria and Tunisia), the Near East (Israel and Jordan) and Europe (Spain, Italy (Sicily), Malta, Cyprus and southern Greece), together with Portugal, the Canary Islands and the Azores.
Level of uncertainty: Medium (uncertainty of the climatic study)

Establishment is unlikely to moderately likely in protected cultivation where control of the pest is more likely to be effective including periods with no host production (stopping production during a given period).
Level of uncertainty: Low

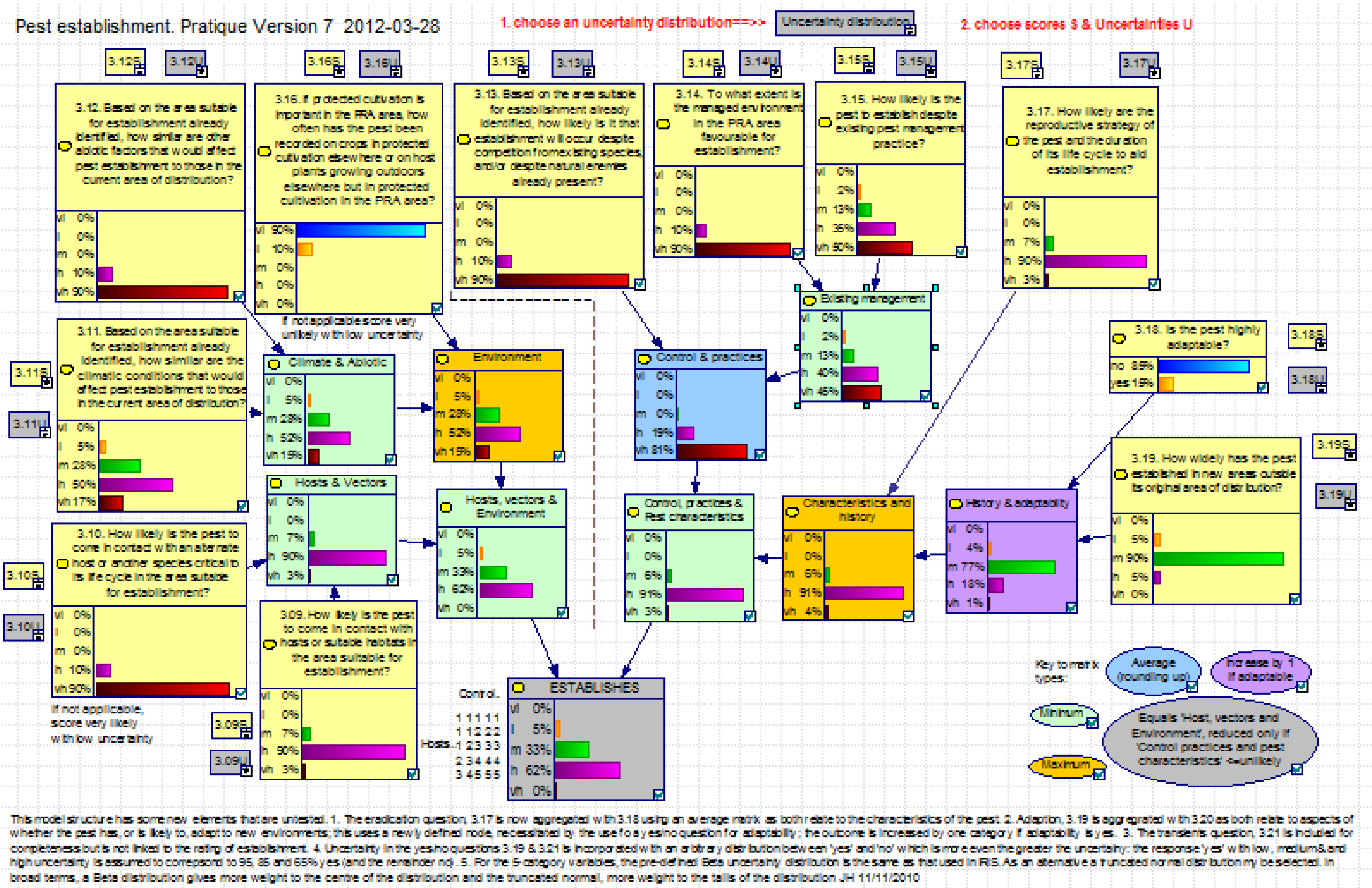

Fig. 19 results of the Matrix model in CAPRA for the probability of establishment.

Stage 2: Pest Risk Assessment Section B: Conclusion of introduction

Probability of entry:

Moderately likely
Level of uncertainty: Medium

Introduction of the pests in the PRA area is rated as moderately likely with a medium uncertainty (unlikely with a medium uncertainty for Citrus or Capsicum fruits originating from Israel). The pest can be present on imported commodities but the risk of entry is mainly dependent on the success of transfer.

Probability of establishment

Likely
Level of uncertainty: Medium

The climate is suitable in part of the PRA area and hosts present. The pest has already been introduced in Israel. Outdoors conditions are suitable in areas near the Mediterranean coast in North Africa (Morocco, Algeria and Tunisia), the Near East (Israel and Jordan) and Europe (Spain, Italy (Sicily), Malta, Cyprus and southern Greece), together with Portugal, the Canary Islands and the Azores.
Level of uncertainty: Medium (uncertainty of the climatic study)

Establishment is less likely in protected cultivation where control of the pest is more likely to be effective including periods with no host production (stopping production during a given period).
Level of uncertainty: Low

The risk of introduction can be considered as moderately likely with a medium uncertainty

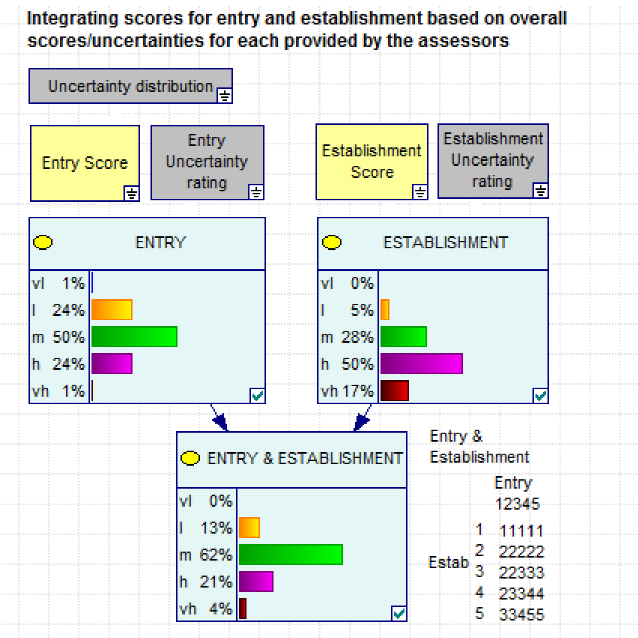

Fig 20 Combinations of scores according to the genie matrices **in CAPRA**

Stage 2: Pest Risk Assessment Section B: Probability of spread

4.01 - What is the most likely rate of spread by natural means (in the PRA area)?

Low rate of spread
Level of uncertainty: high

Information on natural spread capacity is scarce and depending on the authors the judgment on spread capacity is varying.

A study to assess the spatial and temporal distribution of males of *T. leucotreta* was conducted in the Citrusdal area (Stotter, 2009). Results showed that male *T. leucotreta* were mostly confined to citrus orchards, while most of those occurring outside orchards were close to such orchards, or close to identified alternative host plants. However, some male *T. leucotreta* were caught up to 1.5 kilometres from the nearest orchards, although only in small numbers.

Timm (2005) states that:

"T. *leucotreta* has been described as a poorly dispersing species on the basis of mark-recapture studies and general field observations (Newton, 1998). However, T leucotreta males have been found to respond to females more than a kilometre away (Omer-Cooper, 1939) and females were found to disperse up to 35 m away to lay their eggs on sentinel fruits placed in an effectively empty habitat of non-bearing trees (Schwartz, 1981). In this study, the only region in which significantly high levels of gene flow were calculated between populations was Retreat, the only urban area from which *T. leucotreta* samples were collected. It was not possible to distinguish between Retreat populations situated up to 6 km apart. It is therefore suggested that, like the closely related *C. pomonella* and *G. molesta*, *T. leucotreta* individuals may vary genetically in their capacity to disperse over long distances, which may be related to the habitat in which they are found (Mani & Wildbolz, 1977; Sziraki, 1979; Vickers *et al.*, 1985; Rothschild & Vickers, 1991; Schumacher *et al.*, 1997; Keil *et al.*, 2001). In orchards, where only short distance flights are required for *T. leucotreta* to reach another host plant, and where host plants are long-lived, the most successful ecological strategy for the moth would be to stay within the habitat. This would allow individuals to avoid the considerable risks associated with long-range dispersal, which includes the likelihood of not locating alternate resources and the increased probability of predation (Hardie *et al.*, 2001; Weisser, 2001). The same may not be relevant for *T. leucotreta* populations in urban environments, where the habitat is more variable than in orchards."

Based on this information, the EWG considered that the rate of spread was low.

4.02 - What is the most likely rate of spread by human assistance (in the PRA area)?

High rate of spread
Level of uncertainty: Low

Because commodities of host fruits are traded within the region the EWG considered that the rate of spread was high (but it should be noted that as for entry a transfer to suitable hosts needs to occur for the pest to establish further away).

4.03 - Describe the overall rate of spread

High rate of spread
Level of uncertainty: Medium

The rating for this question is the highest rating of the two previous questions.

4.04 - What is your best estimate of the time needed for the pest to reach its maximum extent in the PRA area?

The EWG was not able to provide a sound estimate.

4.05 - Based on your responses to questions 4.01, 4.02, and 4.04 while taking into account any current presence of the pest, what proportion of the area of potential establishment do you expect to have been invaded by the organism after 5 years?

No judgment could be made by the EWG
Level of uncertainty: High

Stage 2: Pest Risk Assessment Section B: Eradication, containment of the pest and transient populations

5.01 - Based on its biological characteristics, how likely is it that the pest could survive eradication programmes in the area of potential establishment?

Likely
Level of uncertainty: Medium

Eradication in protected conditions
In protected environment eradication is possible and likely with early detection and measures. There is evidence of this having been successfully undertaken in the Netherlands in 2009 (Potting & van der Straten, 2010)

Eradication outdoors
Eradication of a founder population in the outdoor environment is less likely, but potentially feasible provided there is early detection of the incursion, successful containment and rapid eradication action. The prospect of success is far greater if the founder population associates with a less suitable or less abundant host in a region where rapid population increase does not occur. An incursion of *T. leucotreta* was detected in Israel on macadamia nuts in 1984 (Wysoki, 1986), but attempts to eradicate it were unsuccessful since Hamburger *et al*. (2001) noted that it was still present on macadamia nuts, cotton and castor bean (*Ricinus communis*). In 2003, the Israel NPPO declared it to be "present, but of limited distribution, limited host range and subject to official control" (EPPO, 2003).
A wide range of effective control strategies have been developed in South Africa (e.g. Sterile Insect Technique, pheromone based mating disruption, pheromone based attract and kill products, virus products, new class chemistry with favourable ecotoxicology profiles and the mass release of egg parasitoids see Appendix 3 for further details) which could be included in eradication campaigns. Successful eradication under field conditions will however depend on rapid regulatory approval for the use of such measures, early pest detection and rapid implementation.

5.02 - Based on its biological characteristics, how likely is it that the pest will not be contained in case of an outbreak within the PRA area?

Likely outdoors
Unlikely under greenhouses
Level of uncertainty: medium

For outdoor production, defining the limit of the outbreak will not be easy, making containment difficult.
In protected environment containment will be possible.

5.03 - Are transient populations likely to occur in the PRA area through natural migration or entry through man's activities (including intentional release into the environment) or spread from established populations?

Yes
Level of uncertainty: low

Appendix 4 (Fig. 9) shows that there are sufficient degree days for the development of at least one generation of *T. leucotreta* (assuming eggs are laid early in the summer) as far north as the Baltic coast of Sweden, Latvia and central England, i.e. north to approximately latitude 55°N.

Stage 2: Pest Risk Assessment Section B: Assessment of potential economic consequences

***Warning:* In this section the evaluation mainly focuses on Citrus spp. Where information on other hosts is available, this is also provided.**

6.01 - How great a negative effect does the pest have on crop yield and/or quality of cultivated plants or on control costs within its current area of distribution?

Major
Level of uncertainty: Medium

T. leucotreta is a pest of economic importance to many crops throughout sub-Saharan Africa and the islands of the Atlantic and Indian Oceans (Schwartz & Kok, 1976; Daiber, 1979, 1980; La Croix & Thindwa 1986a, b; Wysoki, 1986; Blomefield, 1989; Newton, 1989b; Newton & Crause, 1990; Silvie, 1993; Sétamou *et al.*, 1995). However, the importance of damage recorded varies considerably across the distribution range and fruit type. For example, whereas *T. leucotreta* has been recorded as a pest of maize and cotton in the northern African part of the species' distribution range, it is not known as a pest of these crops in South Africa. *T. leucotreta* has been recorded as a pest of Macadamia in Israel but is not reported to attack Citrus (Opatowski, Israeli NPPO, *pers. comm.* 2012).

The rating selected represents the worst case scenario and the level of uncertainty shows the variation in damage recorded.

Reported Economic Damage on different crops

Crop*	**Comment**	**Reference**
Citrus reticulata & hybrids, *Citrus sinensis* & hybrids, *Citrus paradisi*	Whereas crop losses of 10-20% were reported in parts of South Africa in the past, current fruit losses are approximately 2%.	Glass, 1991 S. Moore, *pers. comm.*, 2012
Gossypium spp. cotton	Uganda, 20-90% loss	Couilloud, 1994; Reed, 1974
Zea mays maize	Economic damage reported from West Africa, 17-44% in combination with stem borers.	Ndemah & Schultess, 2002; Hell et al. 2000; CAB43
Macadamia spp. macadamia	South Africa, Israel, 30% or more loss	La Croix and Thindwa, 1986a; Wysoki et all, 1986
Prunus persica	South-Africa, 29-55% of infested fruits (mainly in late cultivars in warm conditions)	Blomefield, 1989; Daiber, 1978
Litchi chinensis Litchi	South Africa, 6%	Grové et al. 2004
Capsicum spp. Pepper	No figures on economic losses known. In field tests 70% of infested fruits have been reported in untreated plants (Senegal).	Fritsch, 1988
Punica granatum Pomegranate	*T. leucotreta* is recorded as one of the most serious pest of pomegranate in South Africa. If there is poor orchard sanitation, this pest can cause serious crop losses up to complete fruit loss.	Wohlfarter et al. 2010
Persea americana Avocado	Cosmetic damage to fruits, larvae are unable to complete development	Stibick, 2006

* For other relevant crops/host plants (see 1.06) no data on (economic) damage are available.

Table 7: Reported Economic Damage on different crops

Further details are provided below for some of these crops.

Effect on crop yield in citrus
In citrus in southern Africa, larval feeding and development can affect fruit development at any stage, causing premature ripening and fruit drop (Schwartz & Kok, 1976; USDA, 1984; Newton, 1988a, 1989a; Begemann & Schoeman, 1999). All stages of citrus are vulnerable to attack (Newton, 1988a). *T. leucotreta* larvae are capable of developing in hard green fruit (Catling & Aschenborn, 1974). Once a fruit is damaged, it becomes vulnerable to fungal organisms and scavengers (Newton, 1989a). A single larva can destroy an entire orange and the subsequent moth produced - in a few days, depending on temperature, could then lay more eggs leading to the build-up of large larval populations leading to the destruction of a large number of fruits. However, the degree of fruit damage can be highly variable from orchard to orchard and even between seasons (Begemann & Schoeman, 1999). It is one of the most important pests of citrus in certain parts of South Africa, and control measures are needed to avoid economic losses. In other parts it is not considered to cause economic crop losses.

In Israel, *T. leucotreta* has been present for more than 30 years, it was recorded as a pest of Macadamia but is not considered to be a pest of citrus. Contacts have been made with the Israeli NPPO to better understand the situation in Israel. Mr Opatowski (Israeli NPPO, *pers. comm.*, 2012) explained that traps are placed on the edges of citrus orchards and although *T. leucotreta* could be trapped, fruit infestations have never been detected in these orchards. In addition, orchard inspections are performed in the framework of fruit export to China and *T. leucotreta* has never been detected. Treatments programmes are in place but they do not target *T. leucotreta* and vary according to the growers. There is consequently no explanation that can be provided to explain the lack of damage on Citrus in Israel.. **This specific situation is recognized as a source of uncertainty in this PRA but the EWG considered that the PRA should consider the situation in South Africa to evaluate the risk.**

In an extensive survey of the most important phytophagous pests in South Africa, Moran (1983) ranked *T. leucotreta* as 33rd in pest status and 14th in lepidopteran pest status. However, later research conducted by Bell & McGeoch (1996) place *T. leucotreta* in 9th position in lepidopteran pest ratings.

Fruit losses as a result of *T. leucotreta* attacks, range from below 2% to as high as 90% (Newton, 1998). 2% is the current fruit loss level in South Africa (S. Moore, *pers. comm.*, 2012). Some types of citrus are highly susceptible (for example Navel oranges), whereas others are not suitable hosts (lemons). In trials in navel orange orchards in the Eastern Transvaal Lowveld of South Africa, 7.8% yield losses were experienced in 1975-76, and 16.8% in 1976-77 when no control measures against *T. leucotreta* were implemented. This contrasts with 0.72% yield loss when a full spray programme was implemented (Schwartz, 1978). In the Citrusdal area of Western Cape Province where infestations are often serious, crop losses of 10-20% were reported by Glas (1991). However, in eastern Transvaal, losses usually range from less than 1 to 3% due to a wider parasitoid complex exerting greater pressure on the pest population (Glas, 1991). The average percentage crop loss due to *T. leucotreta* was 1.6% in Navel oranges and 0.3% in Valencia oranges. In citrus orchards in South Africa, pheromone traps are used to facilitate decision making on pest control actions. In areas where the pest is serious, various treatments are routinely applied within an integrated pest management programme (Moore *et al.*, 2008). Where such control measures are initiated at the correct times, the pest populations can be effectively controlled at low population levels (Moore & Kirkman, 2009). In areas where it is a serious pest, losses are caused by reduction in yield, due to infested fruit dropping onto the ground, the cost of control measures, or due to post-harvest decay, owing to undetected infested fruit being packed and shipped (Kirkman, 2007). *T. leucotreta* has been reported to cause an annual loss of about ZAR 100 million (USD14 million i.e. 10.5 million EUR) to the South African citrus industry (Moore *et al.*, 2004)

Effect on crop yield on peaches
In the early 1970s *T. leucotreta* became a serious pest of peaches in the Transvaal, where peaches were grown near citrus, i.e. in the warmer peach-growing areas (Myburgh *et al.*, 1973). On the cooler Highveld the pest did very little damage; this could be due to the high altitude with cool nights although warm days. Daiber (1987) showed that high levels of infestation only occur where alternative winter host plants, like wild hosts and citrus, are present. These cause the presence of a substantial population of *T. leucotreta* at the beginning of the peach growing season. Without alternative winter hosts available, the population at the start of the growing season is small and population will not build up to levels that cause significant damage. Therefore economic losses are also highest in late peach cultivars, where Daiber (1987) recorded in his survey a mean percentage of infested fruits of 29% with a maximum of 55%.

6.02 - How great a negative effect is the pest likely to have on crop yield and/or quality of cultivated plants in the PRA area without any control measures?

Major
Level of uncertainty: Medium

T. leucotreta can permanently establish outside in only a relative small part of the PRA area. In other parts it can only establish in protected cultivations, while in unprotected conditions only one or two transient generations can develop. Similar losses as noted in 6.01 (i.e. 10-20% losses in Citrus) are expected in areas where permanent establishment will take place, including greenhouses, and several generations per year can develop. In other parts of the PRA area however, although several of the host plants are present, damage will be more limited than in the current area of distribution, due to the fact that only a few generations can develop or no generations at all.

In the Mediterranean area the level of damage will vary among the different crops but may be high in preferred hosts. Damage to citrus, pepper, *Prunus* (e.g. peach and nectarine), Cotton and Maize, among others, could be major in the absence of measures. The pest would cause a direct decrease in yield. In contrast to leaf feeding lepidopteran species, fruits harvested may be unmarketable due to low tolerance for quality defects and presence of larvae in fruit. In many EPPO countries (e.g. the Netherlands, Spain, United Kingdom) there is virtually a zero tolerance level for cosmetic damage for *Capsicum* fruits. However, given the variability in pest status across host types and production areas within the pests' current distribution range, there is a degree of uncertainty about the full extent of damage that can be expected. Nonetheless, if the pest does indeed associate with one or more of these crops as a preferred host the damage in the PRA area could be major.

6.03 - How great a negative effect is the pest likely to have on yield and/or quality of cultivated plants in the PRA area without any additional control measures?

Major
Level of uncertainty: Medium

Citrus crops

According to Jacas *et al*. (2010) key pests, that require the application of control measures most of the years because of economic damage in at least 50% of the countries producing Citrus in the Mediterranean countries include the medfly *Ceratitis capitata*, the California red scale *Aonidiella aurantii*, the citrus leafminer *Phyllocnistis citrella* and the citrus mealybug *Planococcus citri*.

Treatments focus on the control of these pests and biological control is used against other pests such as mites, whiteflies and other scale insects. In all these cases, treatments carried out against those pests are unlikely to be fully effective against *T. leucotreta* because they are targeted to these species or timing is not optimal to control *T. leucotreta*. In South Africa specific treatments and IPM programmes target *T. leucotreta* although all pests mentioned in the first paragraph are present in the country (PQR, 2012; CPC, 2012).

Existence of control measures on other Lepidoptera that could be efficient against T. leucotreta. Two Lepidoptera species are present on Citrus and have a similar number of generations per year: *Ectomyelois ceratoniae* and *Cryptoblabes gnidiella*. However, these are considered to be secondary pests and no specific treatments are usually required against these Lepidoptera. Control is mainly indirect, through the control of *Planococcus citri* before July. In fact, in “integrated production” (GAPs), no products are recommended against these pests.
According to the information provided by South African experts regarding control options (see 6.04), pyrethroids (deltametrine) are effective against *T. leucotreta* however their use is very restricted in citrus in order to preserve natural enemies. Consequently actual control measures are not expected to limit the negative effects of the pest.

In organic farming the effect is expected to be major as no existing control measures will be efficient against *T. leucotreta*.

In conclusion, without any additional control measures, the effect on yield and/or quality is likely to be major.

Pepper crops

Pepper (*Capsicum*) pest control, especially within greenhouses in Spain and other European countries, is targeting the control of virus (TSWV) vectors such as thrips (*Frankiniella occidentalis*) and whiteflies (*Trialeurodes vaporarium* and *Bemisia tabaci*) and is based on the release of natural enemies (especially *Orius* spp. and/or phytoseids depending on the strategies followed). Consequently, chemical products are avoided and only those that are highly compatible with natural enemies are used. For this reason, products used are very specific and since problems caused by Lepidoptera species are sporadic, few targeted treatments against Lepidoptera species are usually carried out. In some specific circumstances treatments with *Bacillus thuringensis* are made against *Spodoptera* species (*S. littoralis* and *S. exigua* and other noctuids: *Agrotis* spp., *Autographa gamma* and *Chrysodeixis chalcites)*. *Helicoverpa armigera* may be a problem in polytunnels in southern Europe and in such case plant protection products are used that may be efficient for *T. leucotreta* (Ucciero, *pers. comm.*, 2012). Natural enemies which are suitable for biological control include the egg parasite *Trichogramma evanescens* and the predatory bug *Podisus maculiventris*. A product based on *Spodoptera exigua* nuclear polyhedrosis virus is also available, which kills larvae in 3–6 days. No information is available regarding its efficiency against *T. leucotreta*.
Recent studies indicates that 100% of the total surface of Andalusia (8,578 ha) and Murcia (approximately 1,800 ha) is under biological control (Guittian Castrillon, *pers. comm.* based on information from Junta de Andalucia and Region de Murcia)

In the Netherlands, more than 95% of the pepper production companies apply Integrated Pest Management. IPM is based on pollination with bumblebees (*Bombus terrestris*) and pest management with biological control agents (parasitic wasps, predators and entomopathogenic nematodes). Biological control is applied against whiteflies, dipteran leaf-miners, mites and Lepidoptera. To avoid side effects of insecticide treatments on bumblebees and natural enemies, only a part of the available insecticides can be used in IPM (Biobest, 2009; Koppert, 2008). In the Netherlands, only Bt products (Turex, Xen Tari) and methoxyfenoxide (Runner) can be used against lepidopteran larvae without side-effects on beneficial agents. Although no data are available on efficacy of methoxyfenoxide for *T. leucotreta*, other active substances from this insect growth regulator class proved to be very effective in controlling field populations of the pest in South Africa, but protracted use resulted in the development of resistance to these insecticides (Hofmeyr & Pringle, 1998). The efficacy of Bt for the control of *T. leucotreta* is poor (S. Moore, CRI, unpublished data), probably due to the fact that larvae penetrate the fruit usually within 24 hr after eclosion of the egg (Kirkman, 2007).
Other insecticides, sometimes used against lepidoptera in glasshouse crops, are indoxacarb (Steward), spinosad (Tracer) and teflubenzuron (Nomolt). These products are generally avoided, because they disrupt the practice of pollination with bumblebees and biological control. Broad-spectrum insecticides, such as deltamethrin, cannot be used in integrated crop management, because no beneficial agents can be used for 2-3 months after application (Potting &van der Straten, 2011).

Prunus crops

Prunus spp. are primarily infested by two Lepidoptera species: *Grapholita molesta* in peaches and *Cydia funebrana* in plums. In parts of the PRA area, like Greece, *Anarsia lineatella* can be as important as *G. molesta*. Another important Lepidoptera pest is *Adoxophyes orana*. These species are very difficult to control. Mating disruption is one of the most effective techniques but will have no effect on *T. leucotreta*. When mating disruption is ineffective, treatments with chemical insecticides like Organo-phosphates, IGRs and pyrethroids, may be applied.
However, it is not known whether timing of application targeting common Lepidoptera pests on Prunus will coincide with the seasonal phenology of *T. leucotreta*.

Cotton crops

Cotton crops require special treatments and mating disruption techniques to control *Pectinophora gossypiella* especially in the areas where its incidence is important. Pyrethroids (alpha-cypermethrin, bifenthrin, cypermethrin, deltamethrin) are used to prevent oviposition of this pest and other lepidoptera species such as *Earias insulana* and might have an effect but the EWG could not evaluate as to whether timing of application is appropriate.
High population densities of *H. armigera* are usually associated with the use of broad-spectrum products

against other pests, with harmful effects on the populations of natural enemies. Consequently the use of pyrethroids in the crop is problematic and should be limited to situations where it is absolutely necessary.

Maize crops
In maize, the control of the corn borers, *Sesamia nonagrioides* and *Ostrinia nubilalis,* is based on chemical and cultural control. Specific monitoring is used to determine the optimum timing of treatment. In the case of *O. nubilalis*, chemical control is aimed at killing young larvae when they hatch and wander on the plant before they bore into the stem. In the case of *S. nonagrioides* the monitoring depends on the flight activity and in some EPPO countries, two spray treatments should be applied within 15-20 days around the peaks of flight activity. Against the second generation, one treatment should be applied at the peak of flight activity.
Resistant varieties (Bt varieties) are used at a limited scale within the PRA area. It is unknown whether *T. leucotreta* larvae could develop in GM varieties (Bt) in practice. Pyrethroid sprays in maize can be problematic since they may exacerbate the attack of mite species, especially *T. urticae*. Chemical control methods used against *S. nonagrioides* and *O. nubilalis* might have an effect on *T. leucotreta* because of the similarity of feeding behavior. However, the effectiveness of control will depend on the timing of applications, which for a different species may lead to application in a different period and potentially to a more frequent need for application. Recently, maize commercial margins are becoming very low and consequently no regular insecticide treatments are carried out in this crop. As an example, in Spain only some pyrethroids (cypermethrin and deltamethrin), organophosphates (chlorpyrifos and methyl- chlorpyrifos) and indoxacarb are registered.

In some EPPO countries, more and shallow stubble cultivation is used to control *O.nubilalis* in maize to avoid the use of insecticides. This will have no control effect on *T. leucotreta* as pupation usually takes place in soil (Newton, 1998)."
For the biological control of *O. nubilalis* in maize *Trichogramma evanescens* is successfully used. There is no data to show if this egg parasitoid is effective for the biological control of *T. leucotreta*. For the biological control of *T. leucotreta* usually *Trichogrammatoidea cryptophlebiae* is successfully used (Newton & Odendaal 1990).

So it is unlikely that control measures already in place for other pests will control *T. leucotreta*.
The level of uncertainty is medium as it was not possible to judge if timing of application for other pests will be appropriate to control *T. leucotreta*.

6.04 - How great a negative effect is the pest likely to have on yield and/or quality of cultivated plants in the PRA area when all potential measures legally available to the producer are applied, without phytosanitary measures?

Moderate
Level of uncertainty: Medium

Citrus:
A review of the control practices used for control of *T. leucotreta* on citrus in southern Africa is presented in Appendix 3 and includes a range of control options.

Evaluation of the control practices in place in South Africa for citrus orchards that are not currently in place in the PRA area and could be legally implemented in the EPPO region

- **Orchard sanitation:**

Orchard sanitation is an effective control strategy. Weekly removal of fruits effectively contributes towards the control of *T. leucotreta*. When fruits are collected weekly, it is estimated that 75% of the T. leucotreta population is removed (Moore & Kirkman, 2009).
However labour costs for sanitation are not affordable in crops such as citrus, cotton or *Prunus* sp. in many parts of the EPPO region. In the specific case of pepper cultivated in greenhouses, this technique is currently in place in some parts of the PRA area.

- Chemical control

Table 8 below summarizes the options available in South Africa and their availability in the European Union.

Control Type	Product	Active substance	European registration status
Chemical	Meothrin	Fenpropathrin	Active substance no longer approved in Europe
Chemical	Cypermethrin	Cypermethrin	Active substance approved in Europe under Commission Implementing Regulation 540/2011. Product authorizations exist for uses on citrus*.
Chemical	Alsystin	Triflumuron	Active substance approved in Europe under Commission Implementing Regulation 540/2011. Product authorizations exist for uses on citrus.
Chemical	Nomolt	Teflubenzuron	Active substance approved in Europe under Commission Implementing Regulation 540/2011. There do not appear to be authorizations for products for use on citrus at present.
Chemical	Delegate	Spinetoram	Active substance not approved in Europe at present. However, there is a decision pending based on a dossier that has been submitted to support this active substance.
Chemical	Coragen	Rynaxapyr	Rynaxapyr is a synonym of chlorantraniliprole, which is an active substance pending decisions based on a new supporting dossier in Europe. The current approval period has been extended while the review is being conducted. However, there do not appear to be authorizations for products for use on citrus at present.

* NB: Although authorizations exist for this use in Europe, the registration status will vary from country to country, depending on whether authorization for products has been commercially sought.

Table 8.: Options available in South Africa and their availability in the European Union

Insecticidal control options that are currently registered in EPPO countries and can be safely used in IPM are limited and their efficacy against *T. leucotreta* is unknown.
T. leucotreta has shown resistance to triflumuron.

The use of pyrethroids in some crops such as citrus or pepper can result in serious disruptions of the IPM programs currently in place. Because of their negative impact on natural enemies, pyrethroids are not recommended, in order to avoid high infestations caused by other pests. At least in the Netherlands and in Spain, more than 95% of the pepper production companies apply IPM (Potting & van der Straten, 2011; Guitián Castrillón, *pers. comm.* 2012).

Other active substances used in South Africa to control *T. leucotreta* would require regulatory approval before they can be used.

- Microbiological control and mating disruption:

The use of the virus and pheromone-based products for control needs registration and are not available so far. It was noted that they are promising because they can be readily incorporated into IPM.

- Sterile Insect Technique:

The Sterile Insect Technique is IPM compatible, is a very effective control option and is currently deployed on an increasing scale in southern Africa. This technique is not readily available in the EPPO region.

- Biological control:

Generalist biological control agents that attack lepidopteran eggs such as *Trichogramma* spp. are available in many EPPO countries (EPPO, 2011) but their efficacy against *T. leucotreta* is unknown. *Trichogrammatoidea cryptophlebiae* is used in South Africa but is not in the list of List of biological control agents widely used in the EPPO region (EPPO, 2011). There would be good prospects for classical biocontrol to target this pest, but prior authorisation would be required for the importation of exotic biocontrol agents.

Control of Capsicum

Data on incidence of *T. leucotreta* in *Capsicum* in countries where it is present is contradictory. Consequently it is uncertain what the population level of *T. leucotreta* in glasshouses would be in the PRA area.

No specific information of control methods could be found from the countries of origin and no specific IPM programs targeted to the pest are known. Consequently,it is difficult to predict which measures could be implemented. In any case due to the lack of products compatible with biological control in the PRA area the incidence will be similar as in 6.03 in the short term. The introduction of targeted products in the crop if registration can be achieved, such as the ones which seems very specific and more compatible with biological control, like rynaxapyr will probably control the pest in the medium term.
A temporary elimination of host material and exposure to adverse climatic conditions can be expected to be an effective and low cost means for eliminating a residual population at the end of a production cycle. However, such measure will be very difficult to implement in some parts of the Southern part of the PRA area. Indeed, to be efficient such measure should be implemented in winter and in all greenhouses at the same time whereas winter is the main producing season for pepper in this part of the PRA area.

6.05 - How great an increase in production costs (including control costs) is likely to be caused by the pest in the PRA area in the absence of phytosanitary measures?

Major
Level of uncertainty: Medium

Optimal control management strategies will need to be developed and will cause increased costs in terms of plant protection products, pheromones, equipment, labour (sanitation and cultural methods, monitoring, sorting of fruits). Control is likely to rely on increased application of insecticides until IPM programs are adjusted.

The actual cost is difficult to evaluate given uncertainty about the pest population levels that are likely to develop across production areas and host types given the variability within the pest's current distribution range (see question 6.1). However, it has previously been noted that *T. leucotreta* is a major pest of susceptible citrus types in Western Cape Province of South Africa that has a Mediterranean climate. Therefore, assuming that *T. leucotreta* were to become established in the field as a major pest of one or more of the major crops, the additional cost of control efforts required would be major. A wide range of control options have been developed to control the pest within its current distribution range. The costs would vary according to intensity of intervention required for an effective control. Only for monitoring purposes, each pheromone costs 2.29 € and has a duration of 6 weeks. Delta traps cost 2.5 €/unit and the gummed board that may be removed every 15 days costs 0.37 €/unit (data for Spain Guitián Castrillón, *pers. comm.*, 2012). The cost of IPM-compatible control strategies as used on citrus in southern Africa typically range from €60/ha/application for virus sprays, to €275/ha/year for Sterile Insect Technique. These controls need to be combined with crop sanitation (removal of infested fruits). Sanitation would be major cost item (due to labour costs) in some parts of the EPPO region.

6.06 - Based on the total market, i.e. the size of the domestic market plus any export market, for the plants and plant product(s) at risk, what will be the likely impact of a loss in export markets, e.g. as a result of trading partners imposing export bans from the PRA area?

Major
Level of uncertainty: Low

Exports from some Mediterranean countries are very important especially regarding fresh fruits of citrus, pepper and *Prunus* spp. among others (CIRAD, 2009; EUROSTATS, 2011). If the pest is introduced, trade of such products are likely to be affected. The presence of the pest in one country might have immediate effects on export markets and the detection of a single larva in fruits marked for export could result in the entire consignment being rejected (Moore, 2002; Hattingh, 2006). Effects on export markets may be in the form of a ban on the export of host fruits from the country where the pest becomes established. Bilateral agreements will need to be negotiated and agreed phytosanitary risk mitigation procedures should be implemented. Many fruits such as peppers do not tolerate a cold treatment and, as a consequence, specific treatments would need to be developed or a Systems Approach would need to be implemented usually resulting in additional costs. *T. leucotreta* is regarded as a high priority quarantine organism in the USA and is listed as a regulated pest in other countries, or recommended to be regulated by other RPPOs (see table 9).

RPPOs	APPPC	A1 list	1988
	COSAVE	A1 list	1992
	CPPC	A1 list	1990
	EPPO	Alert list	2011
	OIRSA	A1 list	1992
	PPPO	A1 list	1993
Individual countries	Argentina	A1 list	1995
	Brazil	A1 list	1992
	Chile	A1 list	1992
	Paraguay	A1 list	1992
	United States of America	Quarantine pest	1989
	Uruguay	A1 list	1992
	Israel	Quarantine pest	2009
	Jordan	Quarantine pest	2007
	New Zealand	Quarantine pest	2000

Table 9 Phytosanitary categorization of *T. leucotreta* (source PQR, 2012)

After the interception of an infested consignment of *Capsicum chinense* from the Netherlands in 2009, the USA prohibited the import of all Capsicum from this country. Third countries are important export markets for *Capsicum* in many EPPO countries (e.g. USA exportations from the Netherlands are worth EUR 35 million).
In addition, it should be noted that Japan regulates *T. leucotreta* on grapes (guidelines: phytosanitary requirements and working procedures for export of grapes from RSA to Japan).

6.07 - To what extent will direct impacts be borne by producers?

Moderate extent
Level of uncertainty: Low

Costs of plant protection products, monitoring and labour for pest control will be borne by the producers, however, prices will most likely increase and part of these costs will be bore by consumers (this situation occurred when when *Tuta absoluta* was introduced into the EU). It is also possible that some governments may partly cover the costs (e.g. development of IPM programmes, provision of pheromones) as has happened when *T. absoluta* was introduced into the EU.

6.08.0A - Do you consider that the question on the environmental impact caused by the pest within its current area of invasion can be answered?

T. leucotreta is a fruit borer and is mainly considered as a crop pest. No environmental impact is reported so the question cannot be answered.

6.08 - How important is the environmental impact caused by the pest within its current area of invasion?

Minor

Level of uncertainty: Medium

In Israel no environmental impact has been reported although the pest is present since 1984.

6.09 - How important is the environmental impact likely to be in the PRA area?

N/A

Level of uncertainty: Low

There are no reports that it is regarded as an organism harmful to the environment. Any environmental impact will be related to the frequency and the type of plant protection products needed to control it.

6.10 - How important is social damage caused by the pest within its current area of distribution?

Minor

Level of uncertainty: Low

In spite of the high losses there is no data on abandonments of fields. More labour force is required to implement cultural practices such as orchard sanitation.

6.11 - How important is the social damage likely to be in the PRA area?

Moderate

Level of uncertainty: Medium

During the first years of introduction and until IPM adapted strategies can be developed, high losses may cause abandonment of fields due to the low actual margins of some crops in some EPPO countries. It is difficult to judge if those would come back to production after IPM programme are developed.

As the responses to question 6.04 and 6.05 were "major" and the answers given to these questions do not have a high level of uncertainty, questions 6.12 to 6.14 were not considered.

6.15a - Describe the overall economic impact

Short term Major

Long term Moderate

Level of uncertainty: Medium

There is some uncertainty about the pest population levels that are likely to develop across production areas and host types given the variability occurring within the pest's current distribution range.

Assuming that *T. leucotreta* was to become established in one or more of the major crops, the economic impact would be major in the short term because of the cost of additional control measures and the loss of trade opportunities or the additional phytosanitary measures required to maintain trade. The impact will vary among the different crops depending on their respective IPM programs (basically whether pyrethroids are needed and regularly used or not in the crop due to the presence of other pests).

The long term impact is however considered to be moderate. IPM programs will need to be adjusted to incorporate T. leucotreta. The EPPO region can benefit from experience in South Africa to establish these programmes. Adjustments of control strategies could be achieved within a 5 years period (as happened with *T. absoluta)* and although costs of control will increase they are likely to be partly covered by consumers.

6.15b - With reference to the area of potential establishment identified in Q3.08, identify the area which at highest risk from economic, environmental and social impacts. Summarize the impact and indicate how these may change in future.

Major

Level of uncertainty: Medium

The whole area of potential establishment is at risk of short term major economic impact (long term moderate). Environmental and social impacts are likely to be minor.

Based on the analysis in Appendix 4, the areas of highest risk of establishment can be considered to be those that have: (a) winter max-min temperatures above the threshold (cool minimum night time winter temperatures greater than 1°C balanced by day time maximum temperatures that are 15-17°C higher), (b) sufficient warmth for several generations to develop (Figure 9 in Appendix 10 shows that up to 7 generations can develop) and (c) continuously available fruit. These areas include areas near the Mediterranean coast in North Africa (Morocco, Algeria and Tunisia) and Europe (Spain, Italy (Sicily), Malta Cyprus and southern Greece) together with Portugal, the Canary Islands, Azores and Jordan. It should be noted that the Israeli coastal plain is also included in the area of highest risk of establishment although as explained before *T. leucotreta* is not causing damage there (this could not be explained).

Crops of citrus, pepper, prunus and pomegranate are at highest risk. Areas where hosts are grown under protected cultivation are also at risk. In addition to commercial fruit crops, other wild hosts, such as *Ricinus communis*, are common in most of these areas.
As it is usually the case, organic crops are particularly at risk.
The economic impact is expected to be higher during the first years before IPM programs are adjusted provided that the registration of new products is carried out and proved to be effective and the Mating disruption techniques and SIT can be effectively implemented.

Stage 2: Pest Risk Assessment Section B: Degree of uncertainty

- Possible existence of host strains.
- List of hosts
- Association of the pest with the pathways taking into account current management measures
- Likelihood of the pest to enter the PRA area undetected
- Transfer from fruit or Rosa cut flowers to suitable habitats
- Volumes and frequency of import of Capsicum spp.
- Climatic suitability
- Establishment despite existing pest management procedures
- Adaptability of the pest
- Rate of spread of the pest (and consequently possibility of eradication and containment)
- Level of negative effect of the pest for some crops without measures and with measures.
- Pest management procedures for some hosts.

Regarding the specific situation in Israel information would be needed on

- what citrus varieties are grown near the Israeli populations on macadamia/Ricinus
- Information from the area where the pest is present concerning: pest distribution, the amount/locations etc of monitoring/trapping and the findings. Presence on other hosts, e.g. peach and capsicum, should also be investigated.
- can Israel provided a guarantee that Israeli citrus is not sorted/repacked?

Conclusion of the pest risk assessment

Probability of entry:

Moderately likely
Level of uncertainty: Medium

Introduction of the pests in the PRA area is rated as moderately likely with a medium uncertainty (unlikely with a medium uncertainty for Citrus or Capsicum fruits originating from Israel). The pest can be present on imported commodities but the risk of entry is mainly dependent on the success of transfer.

Probability of establishment

Likely
Level of uncertainty: medium

The climate is suitable in part of the PRA area and hosts present. The pest has already been introduced into Israel. Outdoors conditions are suitable in areas near the Mediterranean coast in North Africa (Morocco, Algeria and Tunisia), the Near East (Israel and Jordan) and Europe (Spain, Italy (Sicily), Malta, Cyprus and southern Greece), together with Portugal, the Canary Islands and the Azores.
Level of uncertainty: Medium (uncertainty of the climatic study)

Establishment is less likely in protected cultivation where control of the pest is more likely to be effective including periods with no host production (stopping production during a given period).
Level of uncertainty: Low

The risk of introduction can be considered as moderately likely with a medium uncertainty

Assessment of potential economic consequences

The whole area of potential establishment is at risk of short term major economic impact (long term moderate). Environmental and social impacts are likely to be minor.

Based on the analysis in Appendix 4, the areas of highest risk of establishment can be considered to be those that have: (a) winter max-min temperatures above the threshold (cool minimum night time winter temperatures greater than 1°C balanced by day time maximum temperatures that are 15-17°C higher), (b) sufficient warmth for several generations to develop (Figure 9 in Appendix 10 shows that up to 7 generations can develop) and (c) continuously available fruit. These areas include areas near the Mediterranean coast in North Africa (Morocco, Algeria and Tunisia) and Europe (Spain, Italy (Sicily), Malta Cyprus and southern Greece) together with Portugal, the Canary Islands, Azores and Jordan.

The pest presents a risk for the PRA area and management measures should be identified.

Stage 3: Pest Risk Management

7.01 - Is the risk identified in the Pest Risk Assessment stage for all pest/pathway combinations an acceptable risk?

No

The risk is not acceptable for areas near the Mediterranean coast in North Africa (Morocco, Algeria and Tunisia), the Near East (Israel and Jordan) and Europe (Spain, Italy (Sicily), Malta and Cyprus), together with Portugal, the Canary Islands and the Azores. The endangered area is predicted to be climatically suitable for *T. leucotreta* as it is largely similar to the Israeli coastal plain, which is part of the current area of distribution. There is also a risk for protected cultivation of hosts in the entire EPPO region.
All potential fruit pathways listed unbder 2.01a are considered together i.e.:

- Fruits of Citrus: *C. sinensis* (orange), *C. reticulata* (mandarin), *C. paradisi* (grapefruit)
- Fruits of *Capsicum* spp. (pepper)
- Fruits of *Prunus persica* (peach & nectarine)
- Fruits of *Punica granatum* (pomegranate)

7.02 - Is natural spread one of the pathways?

No

Natural spread from Israel to neighbouring EPPO countries was not considered as a likely pathway by the EWG. It was noted that the pest is present in Israel since 1984 but no spread is known to have occurred to neighbouring countries. This could be due to the presence of natural barriers such as desert.

7.03 - Is the pest already entering the PRA area by natural spread or likely to enter in the immediate future?

No

Fruits of *C. sinensis* (orange), *C. reticulata* (mandarin), *C. paradisi* (grapefruit)
Fruits of *Capsicum* spp. (pepper)
Fruits of *Prunus persica* (peach & nectarine)
Fruits of *Punica granatum* (pomegranate)

Comment:
The probability of entry with imports of fruit of *C. sinensis* (orange), *C. reticulata* (mandarin), *C. paradisi* (grapefruit) and *Capsicum* spp. from Israel is considered unlikely so for this origin measures could be less stringent; However it would be important that further information is provided by the Israeli NPPO.

7.06 - Is the pathway that is being considered a commodity of plants and plant products?

Yes

7.09 - If the pest is a plant, is it the commodity itself?

No (the pest is not a plant)

7.10 - Are there any existing phytosanitary measures applied on the pathway that could prevent the introduction of the pest?

No
Level of uncertainty: low

- **Fruits of *C. sinensis* (orange), *C. reticulata* (mandarin), *C. paradisi* (grapefruit)**

For countries that are following the EU regulations (Plant Health Directive 2000/29/EC, EU 2000), there are no specific requirements for *T. leucotreta*. For citrus Turkey follows a legislation similar to the EU legislation.
There are no targeted inspections of citrus other than those conducted for the detection of quarantine pests, such as *Xanthomonas campestris* (all strains pathogenic to *Citrus* spp.), *Cercospora angolensis*, *Guignardia citricarpa* and non-European Tephritidae (points 16.2, 16.3, 16.4 and 16.5 of Annex IVAI, Council Directive 2000/29/EC). Among the measures included in point 16.5 against non-European Tephritidae, the treatment option could have some effect on *T. leucotreta*. However, other options are

also possible which are not effective for *T. leucotreta* but usually preferred by exporters. Consequently it cannot be considered that measures against non-European Tephritidae will help preventing the introduction of the pest. Since a phytosanitary certificate is required, the consignment should be subjected to a visual inspection before export and infested consignments may be rejected for quality reasons.

Information available for other countries:

- Israel: import of citrus fruits is regulated and an import permit is required.
- Tunisia: import of citrus fruits is prohibited (Law No. 92/72 of 03.08.1992 on plant protection and orders for its application).
- Jordan: *T. leucotreta* is a regulated pest in Jordan (as *Cryptophlebia leucotreta) (source:* Quarantine List of Jordan (EPPO website http://www.eppo.int/ABOUT_EPPO/EPPO_MEMBERS/countries/animation/jordan.htm).
- Morocco: no specific requirements for the import of citrus fruits

- **Fruits of *Capsicum* spp.**

For countries that are following the EU regulations (Plant Health Directive 2000/29, EU 2000), there are no specific requirements for *T. leucotreta*. No phytosanitary certificate is requested consequently no systematic inspection is performed.

Information available for other countries:
In Israel import of fruits of *Capsicum* spp. is regulated and an import permit is required.
In Turkey a phytosanitary certificate is required to import all vegetables although there are no specific requirements for *T. leucotreta*. Since a phytosanitary certificate is required, the consignment should be subjected to a visual inspection before export and infested consignments may be rejected.

- **Fruits of *Prunus***

For countries that are following the EU regulations (Plant Health Directive 2000/29/EC, EU 2000), there are no specific requirements for *T. leucotreta*.
There are no targeted inspections of fruits of *Prunus* spp. other than those conducted for the detection of quarantine pests, such as *Monilinia fructicola*. Since a phytosanitary certificate is required, the consignment should be subjected to a visual inspection before export and infested consignments may be rejected for quality reasons.

Information available for other countries:
In Israel import of fruits of *Prunus* spp. is regulated and an import permit is required.
Tunisia: no specific requirements in place.

- **Fruits of *Punica granatum***

For countries that are following the EU regulations (Plant Health Directive 2000/29/EC, EU 2000), there are no specific requirements for *T. leucotreta*. No phytosanitary certificate is requested.
However in Turkey a phytosanitary certificate is required to import fruits and a moth *Virachola isocrates* is a regulated pest on fruits of *Punica granatum*. Since a phytosanitary certificate is required, the consignment should be subjected to a visual inspection before export and infested consignments may be rejected.

Options at the place of production

7.13 - Can the pest be reliably detected by visual inspection at the place of production?

Yes in a Systems Approach
Level of uncertainty: Low

Visual inspection at the place of production
Detailed information is available for citrus fruits only but is also valid for other fruits.
Detection by visual inspection at the place of production is possible as infested oranges show brown, sunken spots with larval holes bored in the center of the spot (Bradley *et al.* 1979) and infestations occurring two weeks before harvest result in blemish, premature colour development, abscission and

decay. However, recent infestations can be overlooked. Consequently visual inspection needs to be used within a Systems Approach, along with other measures such as trapping, cull sanitation analysis (i.e. cutting fallen fruits) and pre-harvest treatments.

7.14 - Can the pest be reliably detected by testing at the place of production?

No

Level of uncertainty: Low

Not relevant

7.15 - Can infestation of the commodity be reliably prevented by treatment of the crop?

Yes in a Systems Approach

Level of uncertainty: medium

In Citrus growing areas where the pest is serious, various treatments are routinely applied within an integrated pest management programme (Moore et al., 2008). Whereas the pest has developed resistance to triflumuron (Hofmeyr & Pringle, 1998), new insecticides from chemical groups that have favourable eco-toxicology profiles, such as spinetoram and rynaxapyr, have recently been registered. The following control options are currently registered and commercially available for *Citrus* spp. in Southern Africa (Moore & Hattingh, 2012):

Control Type	Product	Active Ingredient
Chemical	Meothrin	Fenpropathrin
	Cypermethrin	Cypermethrin
	Alsystin	Triflumuron
	Nomolt	Teflubenzuron
	Delegate	Spinetoram
	Coragen	Rynaxapyr
Microbial	Cryptogran	CrleGV
	Cryptex	CrleGV
Mating Disruption	Isomate	E7-12Ac, E8-12Ac, Z8/E8-12
	Checkmate FCM-F	E8-12Ac, Z8-12
Attract and Kill	Last Call FCM	E7-12Ac, E8-12Ac, Z8-12
Sterile Insect Technique	Sterile Insect Technique	Sterile FCM adult males
Biological	Egg parasitoid	*Trichogrammatoidea cryptophlebiae*

Where such control measures are initiated at the correct times, pest populations can be effectively controlled down to low population levels (Moore & Kirkman, 2009), but these measures will not eliminate the pest. Treatments of the crops are not sufficient as stand-alone measures, but could be used as part of a Systems Approach.
There are no data available about chemical treatments in other crops. Pyrethroids, that are potentially effective against the pest, are not often used in pepper crops and are known to have a potentially disruptive effect on natural enemies of other important pests.

7.16 - Can infestation of the commodity be reliably prevented by growing resistant cultivars?

No

Level of uncertainty: Low

Citrus species and cultivars may be more or less susceptible (or even not susceptible such as lemons and limes) but for those species that are considered to be suitable hosts, there are no known resistant cultivars; and in the absence of its preferred hosts, *T. leucotreta* might attack the less susceptible cultivars.

For other fruits, no difference in susceptibility to the pest in different species or cultivars is known.

7.17 - Can infestation of the commodity be reliably prevented by growing the crop in specified conditions (e.g. protected conditions such as screened greenhouses, physical isolation, sterilized growing medium, exclusion of running water, etc.)?

No for *Citrus*, *Prunus*, *Punica granatum*

Yes for Capsicum

Level of uncertainty: Low

It is not a realistic or viable option to produce fruits of *Citrus*, *Prunus*, *Punica granatum* in protected cultivation.

Fruits of *Capsicum* spp. can be grown under protected conditions with sufficient measures to exclude the pest. The vast majority of imports of *Capsicum* spp. into the EPPO region originate in Israel, where peppers are grown in large greenhouses in two main areas at the south of the country: West of Negev Desert and Arava Valley. It would be necessary to establish a monitoring system (e.g. a rate of baited traps per hectare inside the greenhouses and their immediate vicinity) to verify the absence of the pest.

7.18 - Can infestation of the commodity be reliably prevented by harvesting only at certain times of the year, at specific crop ages or growth stages?

No
Level of uncertainty: Low

T. leucotreta has continuous generations. Climate conditions and all-year round host availability ensure the presence of *T. leucotreta* when fruits are harvested and exported to the EPPO region.
Citrus spp. are mainly exported to the EPPO region from June to October, a period that coincides with favourable conditions for the pest in the area of origin. *Capsicum* spp. originating in Israel are mainly exported from November to April but *Capsicum* spp. exports from other countries where *T. leucotreta* is known to occur take place all-year round (see Q2.06).

7.19 - Can infestation of the commodity be reliably prevented by production in a certification scheme (i.e. official scheme for the production of healthy plants for planting)?

No
Level of uncertainty: low

Not relevant

7.20 - Based on your answer to question 4.01 (low rate of spread with high uncertainty), select the rate of spread.

Low rate of spread
Level of uncertainty: High

As stated in Q4.01, the EWG considered that the rate of spread is low. However, the uncertainty is high.

7.21 - The possible measure is: pest-free place of production or pest free area
Can this be reliably guaranteed?

Yes
Level of uncertainty: low

Pest free area (following ISPM 4):
-ISPM 4 outlines the requirements for the establishment of pest free areas (PFAs). The requirements of PFAs are discussed by defining three types:

- an entire country,
- an uninfested part of a country in which a limited infested area is present,
- an uninfested part of a country situated within a generally infested area.

The involved countries of origin where *T. leucotreta* is known to occur would fall into the second or the third category of PFAs. There are specific requirements for those types of PFAs which may include:

- Systems to establish freedom, including delimiting and detection surveys (which should include pheromone trapping).
- Phytosanitary measures to maintain freedom, including regulations on the movement of host material out of the infested area to the uninfested area.
- Checks to verify freedom, including on-going monitoring surveys.

Although pest prevalence varies significantly across the regions of Southern Africa, it occurs in all citrus-growing areas (Moore & Hattingh, 2012). The feasibility of the establishment of PFAs in the northern regions, such as Limpopo province, should be carefully evaluated.

Pest free place of production or pest free production site (ISPM 10)
ISPM 10 outlines the requirements for the establishment of pest-free places of production (PFPPs) and pest-free production sites (PFPSs). The suitability of this option is in particular dependent on the characteristics of the pest (point 2.2.1 of the ISPM). It was noted that one of the characteristics is that the natural spread of the pest is slow and over short distances. The EWG considered that this criterion was fulfilled and although the pest has many host plants, it was considered that this option could be appropriate because sensitive methods for detection exist. Pheromones have shown a high capacity of attraction (males attracted at distances up to 1.6 km) and are currently used to monitor pest population

in citrus orchards and to decide on treatments. In addition it was noted that such option was recently recommended for *Bactrocera invadens*[3] which has a higher spread capacity than *T. leucotreta*.

The measures required to determine a pest-free place of production are:

- absence of any detection in traps in places of production and the vicinity during a period to be determined:
  - (*OPTION a*) since the beginning of the last complete cycle of vegetation
  - *(OPTION b)* traps could be restricted to the seasons when hosts are present in the place of production and its vicinity.
- monitoring of traps should be done on a weekly basis and traps should be regularly serviced.
- sanitation with the removal of fallen fruits should be mandatory.
- in addition, examination to check absence of signs of the pest on the fruits before harvest at the place of production should take place under the authority of the NPPO.

Similar requirements apply to pest-free production sites.

The establishment of a buffer zone could be considered in areas of continuous presence of hosts or depending on pest prevalence in the area.
Depending on the pest prevalence in the area where the place of production/production site is located, preventive control measures may also be recommended (in particular if the pest is trapped in the buffer zone).

Options after harvest, at pre-clearance or during transport

7.22 - Can the pest be reliably detected by a visual inspection of a consignment at the time of export, during transport/storage or at import?

Yes in a Systems Approach
Level of uncertainty: Low

Typical damage symptoms on fruits of *Citrus* spp. and *Capsicum* spp. may be detected by visual inspection of the consignment. However, as *T. leucotreta* is an internal feeder, these symptoms are not always easy to detect, particularly if infestation takes place close to the time of harvest. Regarding inspection at import, an additional difficulty is that transport conditions are not favourable for pest development and low temperatures slow down the decay process of infested fruit. Destructive sampling (i.e. the sampled fruit being cut open in order to look for larvae) would increase the probability of the pest being detected.
Moreover, *T. leucotreta* may remain undetected in certain species of *Capsicum* spp., such as *Capsicum chinense*, which show an extremely variable fruit (e.g. distorted and variegated pods).
In conclusion, visual inspection of the consignment at the time of export/import is not reliable enough as a stand-alone measure but may well be considered as part of a Systems Approach.

7.23 - Can the pest be reliably detected by testing of the commodity (e.g. for pest plant, seeds in a consignment)?

No
Level of uncertainty: Low

not applicable

7.24 - Can the pest be effectively destroyed in the consignment by treatment (chemical, thermal, irradiation, physical)?

Yes as standalone measure for *Citrus* spp. and *Prunus persica fruit*
Level of uncertainty: Low

Cold treatment T107-k has been approved by USDA-APHIS for citrus against *T. leucotreta* and some fruit fly species (*Ceratitis rosa* and *Bactrocera invadens*). The treatment basically consists in a temperature of -0.55 °C (31 °F) or below for an exposure period of 24 days. It should be noted that Myburgh (1965) demonstrated that 21 days -0.55 °C is sufficient for probit 9 to be achieved.
Cold treatment T107-e has been authorized against *T. leucotreta* and several *Ceratitis* spp. (*C. capitata, C. quinaria* and *C. rosa*) for *Prunus persica* (nectarine, peach). In this treatment the temperature is the

[3] http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm select *Bactrocera invadens* PRA rep 10-16120

same than in T107-k (-0.55 ºC) but the exposure period is reduced to 22 days instead of 24. It should be noted that fruits mature quicker after such treatment.

There is no specific analogous cold treatment for *Capsicum* spp. as peppers are sensitive to chilling injury when stored below 7 ºC and symptoms can appear after a few days at 0 ºC. Methyl bromide fumigation (T101-a-3 MB at NAP — tarpaulin or chamber) is approved in the USA against internal pests, except fruit flies.

There is no information available for *P. granatum*.

Methyl bromide is a substance regulated under the Montreal Protocol, on substances that deplete the ozone layer. In the EU use of methyl bromide is no longer available according to Article 12 of the Ozone Regulation (Reg. (EC) No 1005/2009). However, the use for imports is permitted. Substitutes for this substance are still under study. Methyl bromide is not a long term alternative because its will be eventually phased out as well in other EPPO Member States that have signed the Montreal Protocol.

In conclusion, the pest is effectively destroyed by cold treatment in *Citrus* spp. and *Prunus persica*.

7.25 - Does the pest occur only on certain parts of the plant or plant products (e.g. bark, flowers), which can be removed without reducing the value of the consignment?

No
Level of uncertainty: Low

Not relevant

7.26 - Can infestation of the consignment be reliably prevented by handling and packing methods?

Yes in a Systems Approach
Level of uncertainty: low
Specific handling/packing methods in a Systems Approach

At picking, packing and sorting blemished fruits will be eliminated but recent infestation will not be detected.
Risk of infestation after harvest is very low. The pest is mostly active at night and picking operations are conducted in the day and fruits are then handled in a cold chain in closed packing houses. Fruits are transported in closed trucks (Hattingh pers. com, 2011)

Options that can be implemented after entry of consignments

7.27 - Can the pest be reliably detected during post-entry quarantine?

No
Level of uncertainty: Low

Not practical for fruits.

7.28 - Could consignments that may be infested 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
Level of uncertainty: Medium

Limited end uses is a possible option for fruits intended for processing
When fruits are intended for processing, it could be possible to accept infested consignments. However to be allowed this requires that:

- transport to the processing company is done under official control and
- fruits are handled in a cold chain (below 11°C) and
- appropriate waste disposal is guaranteed.

Limited distribution in the PRA area (under a bilateral agreement) is a possible option but will be difficult to implement in practice.

The unfavourable climatic conditions of Northern EPPO Member countries outdoors reduce the risk of pest establishment, as winter temperatures are too low to allow the survival of *T. leucotreta*. However, the risk for these countries cannot be neglected after the recent incursion in a greenhouse growing peppers in the Netherlands (Potting & van der Straten, 2011). The probability of transfer to a glasshouse was rated 'moderately likely' for combined trading and production companies of fruit of *Capsicum* spp. The risk of transfer from the Citrus fruit pathway to a greenhouse production unit was considered very low as well as the risk to establish transient populations because the main hosts are not present in this part of the region.
It should also be noted that limiting the distribution of fruits in the EU is not possible given that fruits can be moved freely within the Community. Thus, even when the fruits are exported to the Northern EU countries, there is no guarantee that they will not be moved to the Southern part of the region.

Limited periods of entry is not an option for most fruits as they are imported in counter season when conditions are suitable for establishment.
Approximately 75% of the volume of *Citrus* spp. is imported into the EPPO region during the summer season (June to October) which is counter seasonal to the northern hemisphere production of citrus. In this period, *T. leucotreta* is likely to meet suitable conditions and find available hosts.
Regarding *Capsicum* spp., consignments arrive nearly all-year round.

7.29 - Are there effective measures that could be taken in the importing country (surveillance, eradication, containment) to prevent establishment and/or economic or other impacts?

No

Level of uncertainty: Medium

Surveillance could be put in place near points of entry and in areas where hosts are grown but it would be difficult to prevent establishment due to the wide range of hosts attacked by *T. leucotreta* and extensive surface that will need to be surveyed.

In the Northern EPPO Member countries where the pest cannot survive outdoors in winter, measures could be taken in the importing country. This would require the separation of trade and production flows (separated facilities for imported consignments and for growing peppers) and a good surveillance system including trapping at packing houses. Eradication is considered possible in greenhouses in that part of the PRA area (see Q5.01).

7.30 - Have any measures been identified during the present analysis that will reduce the risk of introduction of the pest?

For fruits of *C. sinensis* (orange), *C. reticulata* (mandarin), *C. paradisi* (grapefruit), *Prunus persica* (peach & nectarine) the measures provided in table 10 can reduce the risk of introduction of the pest:

Q.	Standalone	Systems Approach	Possible Measure	Uncertainty
7.13		X	visual inspection at the place of production	Low
7.15		X	specified treatment of the crop	Low
7.20	X		pest-free place of production, pest-free production site or pest-free area	Low
7.22		X	visual inspection of the consignment	Low
7.24	X		specified treatment of the consignment	Low
7.26		X	specific handling/packing methods	Low
7.28	X		import of the consignment under special licence/permit and specified restrictions	medium

Table 10. Options for fruits of *C. sinensis* (orange), *C. reticulata* (mandarin), *C. paradisi* (grapefruit), *Prunus persica* (peach & nectarine)

Fruits of Capsicum & *Punica granatum* (pomegranate)

Q.	Standalone	Systems Approach	Possible Measure	Uncertainty
7.13		X	visual inspection at the place of production	Low
7.15		X	specified treatment of the crop	Low
7.17	X		specified growing conditions of the crop **only for Capsicum**	Low
7.20	X		pest-free place of production, pest-free place of production or pest-free area	Low
7.22		X	visual inspection of the consignment	Low
7.26		X	specific handling/packing methods	Low
7.28	X		import of the consignment under special licence/permit and specified restrictions	medium

Table 11 options for Fruits of Capsicum (peppers) and *Punica granatum* (pomegranate)

In the northern EPPO Member countries where the pest cannot survive outdoors in winter, measures could be taken in the importing country (provided that no movement of fruits to suitable areas can be guaranteed).

7.31 - Does each of the individual measures identified reduce the risk to an acceptable level?

No
Level of uncertainty: low

Some measures are not sufficient on their own.
The following measures reduce the risk to an acceptable level on their own:
- pest-free area
- pest-free place of production/pest-free production site
- appropriate post-harvest treatment cold treatment
- import under a special license for a specific end use.

7.32 - For those measures that do not reduce the risk to an acceptable level, can two or more measures be combined to reduce the risk to an acceptable level?

Yes
Level of uncertainty: high

Measures can be combined in a Systems Approaches as follows:
- In the crop trapping programme, visual inspection of fruits in the orchard and culls, sanitation of fruits and pest control.
- Visual examination at harvest and during handling/packing of the consignment, and visual inspection at export.

The efficacy of such Systems Approach is not known and would require bilateral discussions with the exporting countries to evaluate if these can be accepted.

7.34 - Estimate to what extent the measures (or combination of measures) being considered interfere with international trade.

fruits of *C. sinensis* (orange), *C. reticulata* (mandarin), *C. paradisi* (grapefruit), *Prunus persica* (peach & nectarine) and *Punica granatum* (pomegranate)
The measures are expected to interfere with citrus trade because *T. leucotret*a is not currently a regulated pest for most EPPO countries (except Jordan). Mr Hattingh (expert from South Africa who attended the 1st meeting of the EWG) provided a study conducted by the Citrus Growers Association of Southern Africa. This evaluation is presented for information in Appendix 5.
The EWG considered that:
Establishing a pest-free area or pest-free place of production may not always be possible in countries where the pest occurs.

Cold treatment T107-k (-0.55 °C; 24 days) and T107-e (-0.55 °C; 22 days) is a requirement for some countries such as the USA. However, there are limitations regarding capacities in exporting countries to perform this treatment for larger volumes (see Appendix 5).

A Systems Approach may provide an alternative to the measures above but would require bilateral discussions with the exporting countries to be able to judge on the efficacy.

A judgment is difficult to be made for other fruits but imported volumes are lower.

Fruits of *Capsicum* spp.
Measures may interfere with trade because the pathway is currently unregulated in most EPPO Member countries. Growing *Capsicum* spp. under protected conditions is common; however, additional measures will be needed. Pest-free areas may not be feasible for most of the exporting countries. Other options such as pest-free place of production or Systems Approach are common measures in trade but are not required so far.

Level of uncertainty of this answer: low

7.35 - Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences.

The measures proposed at origin would have costs related to physical isolation of greenhouses, monitoring and control to the crop and consignment.

T. leucotreta could be difficult to eradicate or contain if introduced in the citrus and horticultural-growing areas of the Mediterranean Basin.

Measures regarding safe disposal of wastes to be implemented in the PRA area would have a cost for the processing and packing companies concerned. Separation of packing and production would also have a cost.

Level of uncertainty of this answer: low

7.36 - Have measures (or combination of measures) been identified that reduce the risk for this pathway, and do not unduly interfere with international trade, are cost-effective and have no undesirable social or environmental consequences?

Yes

7.41 - Consider the relative importance of the pathways identified in the conclusion to the entry section of the pest risk assessment

The pathways in order of importance are

- Fruits of *C. sinensis (*orange*), C. reticulata (*mandarin*), C. paradisi (*grapefruit*).*
- Fruits of *Punica granatum* (pomegranate)
- Fruits of Capsicum spp. (pepper)
- Fruits of *Prunus persica (*peach & nectarine*)*

For rationales, see question 2.01a.

7.42 - All the measures or combination of measures identified as being appropriate for each pathway or for the commodity can be considered for inclusion in phytosanitary regulations in order to offer a choice of different measures to trading partners. Data requirements for surveillance and monitoring to be provided by the exporting country should be specified.

7.43 - In addition to the measure(s) selected to be applied by the exporting country, a phytosanitary certificate (PC) may be required for certain commodities. The PC is an attestation by the exporting country that the requirements of the importing country have been fulfilled. In certain circumstances, an additional declaration on the PC may be needed (see EPPO Standard PM 1/1(2) Use of phytosanitary certificates).

7.45 - Summarize the conclusions of the Pest Risk Management stage.
List all potential management options.

	Citrus	*Prunus*	*Capsicum*	*Punica granatum*
pest free area	X	X	X	X
pest free place of production	X	X	X	X
specified growing conditions (under greenhouse)	No	No	X	No
appropriate post-harvest treatment cold treatment	X	X	No (fruit cold sensitive)	No (no data)
import under a special license for a specific end use	X	X	X	X
Measures can be combined in a Systems Approaches as follows: • In the crop trapping programme, visual inspection of fruits in the crop and culls, sanitation of fruits and pest control. • Visual inspection at harvest, during handling/packing and at export. *Would require bilateral discussions with the exporting countries.*	X	X	X	X

Table 12 Summary of management options

Uncertainties.

- Efficacy of the Systems Approach this should be negotiated based on information provided by the exporting country.
- Efficacy of the treatments in the field
- Rate of spread, need and size of the buffer zone.
- Feasibility of the establishment of PFAs in certain areas regions,
- Efficacy of cold treatment for *Punica granatum*

Remark: In 2023, an EFSA assessment of the probability of introduction of *Thaumatotibia leucotreta* into the European Union with import of cut roses was performed (EFSA PLH, 2023). Following this assessment, the Panel on Phytosanitary Measures (2024-10) noted that EPPO member countries may decide to regulate this additional pathway to achieve a higher level of protection.

References

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

Bell JC & McGeoch MA (1996) An evaluation of the pest status and research conducted on phytophagous Lepidoptera on cultivated plants in South Africa. African Entomology 4: 161-170.

Biobest (2009) http://www.biobest.be/neveneffecten/3/3/

Blomefield TL (1989) Economic importance of false codling moth *Cryptophlebia leucotreta* and codling moth, Cydia pomonella, on peaches, nectarines and plums. Phytophylactica, 21(4): 435-436.

Borchert D (2005) *Thaumatotibia leucotreta* (meyr.) False Codling Moth: Estimation of generation potential, area of potential establishment and host commodity distribution. USDA/APHIS/PPQ/ /PERAL, 6 pp (DRAFT).

Borchert D (2011) Pareto Risk Map *Thaumatotibia* (*Cryptophlebia*) *leucotreta*, False Codling Moth. 1 p. http://www.nappfast.org/caps_pests/maps/Pareto/Thaumatotibia%20leucotreta%20Pareto%20Map.pdf

Brundu G, CamardaI & Satta V (2003) A methodological approach for mapping alien plants in Sardinia (Italy). – pp. 41-62 in: Child, LE, Brock JH, Brundu G, Prach K, Pyšek P,Wade M & Williamson M (eds.), Plant Invasions: Ecological Threats and Management Solutions. – Leiden.

Brundu G, Camarda I, Hulme PE, Vilà M, Troumbis A, Traveset A, Moragues E & Suhes CM (2004) Comparative analysis of the abundance and distribution of alien plants on Mediterranean islands. In: Arianoutsou, M. & Papanastasis, V. (eds.), Ecology, Conservation and Management of Mediterranean Climate Ecosystems. Proceedings 10th MEDECOS Conference, 25 April - 1 May 2004, Rhodes, Greece. Millipress, Rotterdam, (124) 9 pp.

Byaruhanga EK (1977) Manipulation of sowing dates of cotton for the control of Crypotphlebia leuctreta (Meyrick). pp. 73-75, Proceedings of the 1st E.A. Conference on Entomology and Pest Control. East African Literature, Nairobi, Kenya.

CABI (2003) Crop protection compendium: global module. Commonwealth Agricultural Bureau International, Wallingford, UK.

CABI (2007) CABI Crop protection compendium: global module. Commonwealth Agricultural Bureau International, Wallingford, UK.

Catling HD & Aschenborn H (1974) Population studies of the false codling moth, *Cryptophlebia leucotreta* Meyrick, on citrus in the Transvaal. Phytophylactica, 6:31-38.

Catling HD & Ashenborn H (1978) False codling moth (*C. leucotreta* Meyr. In Citrus pests in the republic of South Africa (ed. E.C.G Bedford), pp. 1165-170 Science Bulletin Department of Agricultural Technical Services Republic of South Africa N°391).

Collingwood EF, Bourdouxhe L & Diouf (1980). Rapport des essais pesticides. I: Insecticides. Centre pour le développement horticole (Dakar, Sénégal). 39 p.

Couilloud R (1994) *Cryptophlebia leucotreta* (Meyrick) (Lepidoptera: Tortricidae). In: Matthews, G. A. & Tunstall, J.P. (eds.) Insect Pests of Cotton, CAB International, pp.207-213.

Coyle DR, Clark KE, Raffa KF & Johnson SN (2010) Prior host feeding experience influences ovipositional but not feeding preference in a polyphagous pest. Entomologia Experimentalis et Applicata, 138: 137-145.

Csurhes SM & Kriticos D (1994) *Gleditsia triacanthos* L. (Caesalpiniaceae), another thorny, exotic fodder tree gone wild. Plant Protection Quarterly, 9, 101-105.

Cunningham JP & West SA (2008) How host plant variability influences the advantages of learning: A theoretical model for oviposition behavior in Lepidoptera. Journal of Theoretical Biology, 251: 404-410.

Daiber CC (1976) A survey of the False Codling Moth (*Cryptophlebia leucotreta* (Meyr.) in peach orchards. Phytophylactica 8: 97-102.

Daiber CC (1978) Insecticidal control of false codling moth (Cryptophlebia leucotreta Meyr.) in peaches. Phytophylactica 8: 109-110.

Daiber CC (1979a) A study of the biology of the false codling moth [*Cryptophlebia leucotreta* (Meyr.)]: the egg. Phytophylactica 11: 129-132.

Daiber CC (1979b) A study of the biology of the false codling moth [*Cryptophlebia leucotreta* (Meyr.)]: The larva. Phytophylactica 11: 141-144.

Daiber CC (1979c) A study of the biology of the false codling moth [*Cryptophlebia leucotreta* (Meyr.)]: The cocoon. Phytophylactica 11: 151-157.

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

Daiber CC (1989 The false codling moth, *Cryptophlebia leucotreta* (Meyr.) (Lepidoptera, Tortricidae), in Southern Africa J. Plant Dis. Protect., 96: pp. 71–80.

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

Dal Cin D'Agata C, Skoula M & Brundu G (2009) A preliminary inventory of the alien flora of Crete (Greece). - Bocconea 23 : 301-315.

EFSA PLH (2023) EFSA Panel on Plant Health, Bragard C, Baptista P, Chatzivassiliou E, Di Serio F, Gonthier P, Jaques Miret JA, Fejer Justesen A, MacLeod A, Magnusson CS, Navas-Cortes JA, Parnell S, Potting R, Reignault PL, Stefani E, Thulke HH, Vicent Civera A, Van der Werf W, Yuen J, Milonas P (2023) Assessment of the probability of introduction of *Thaumatotibia leucotreta* into the European Union with import of cut roses. *EFSA Journal* **21(10)**, 1–166. Available at https://doi.org/10.2903/j.efsa.2023.8107

EPPO (2010). EPPO Reporting Service 2010/013 Isolated finding of *Thaumatotibia (Cryptophlebia) leucotreta* on *Capsicum chinensis* in the Netherlands http://archives.eppo.int/EPPOReporting/2010/Rse-1001.pdf

EPPO (2011). EPPO Standards on Safe use of Biological Control - PM 6/3 - Version 2011 List of biological control agents widely used in the EPPO region.
http://archives.eppo.int/EPPOStandards/biocontrol_web/bio_list.htm#biolist

EPPO PQR (2012), EPPO database on quarantine pests v4.6
http://www.eppo.org/DATABASES/databases.htm

Erichsen, C & Schoeman AS (1992). Economic losses due to insect pests on avocado fruit in the Nelspruit/Hazyview region of South Africa during 1991. *South African Avocado Growers' Association Yearbook* 15: 49-54.

EUROSTAT, EU Statistics database,
http://epp.eurostat.ec.europa.eu/portal/page/portal/external_trade/data/database

EPPO (2003) Reporting Service 015. Status of *Thaumetotibia (Cryptophlebia) leucotreta* in Israel http://archives.eppo.int/EPPOReporting/2003/Rse-0302.pdf

Eyre D, Baker RHA, Brunel S, Dupin M, Jarosik V, Kriticos DJ, Makowski D, Pergl J, Reynaud P, Robinet C & Worner S (2012). Rating and mapping the suitability of the climate for pest risk analysis. *EPPO Bulletin* 42, 48–55

FAOSTATs (accessed on 2011-12-05).

Fritsch E (1988). Biologische Bekämpfung des Falschen Apfelwicklers, *Cryptophlebia leucotreta* (Meyrick) (Lep., Tortricidae), mit Granuloseviren. Mitt. Dtsch. Ges. Allg. Angew. Ent. 6, 280-283.

Giliomee JH & Riedl H (1998) A century of codling moth control in South Africa I. Historical Perspective Journal of South African Society of Horticultural Science 8: 27-31.

Glas M (1991). Tortricids in miscellaneous crops. In: van der Geest, van Luis, eds. Tortricoid Pests, Their Biology, Natural Enemies and Control. World Crop Pests: 5. UK: Elsevier.

Grové T Steyn WP & Beer MS de (2000) Host status of Hass avocado fruit for the false codling moth, *Cryptophlebia leucotreta* (Meyrick) (Lepidoptera: Tortricidae) South African Avocado Growers' Association Yearbook 2000. 23:99-102

Grové T, Steyn WP & Beer MS de (2004). *Cryptophlebia* species (Lepidoptera: Tortricidae). South African Litchi Growers' Association Yearbook. 2004. 16: 52-59.

Grové T, De Beer MS & Joubert PH (2010). Developing a Systems Approach for *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae) on 'Hass' Avocado in South Africa.

Gunn D (1921) The false codling moth (*Argyroploce leucotreta* Meyr.). Union of South African Pretoria. Department of Agriculture Science Bulletin, 21: 1-28. The Government Printing and Stationary Office, Pretoria, South Africa.

Hamburger M, Zarabi L, Weiss M, Argaman Q, Kuslitzky W & Klein K (2001) False codling moth (*Cryptophlebia leucotreta*) in Israel. Phytoparasitica, 29(1): 84-84.

Hardie J, Gibson G & Wyatt TD (2001). Insect behaviours associated with resource finding. In: Insect movement: mechanismens and consequences. Woiwod, I. P., Reynolds, D. R. & Thomas, C. D. (eds.). CABI Publishing, UK, pp. 87-109.

Hattingh V (2006) Citrus Research International (CRI) Group Annual Research Report. South Africa, p. 1-10.

Hell K, Cardwell KF, Setamou M & Schulthess F (2000). Influence of insect infestation on aflatoxin contamination of stored maize in four agroecological regions in Benin. African Entomology. 2000. 8: 2, 169-177.

Hepburn C (2007) Composition and phenology of insect pests of Capsicum (Solanaceae) cultivated in the Makana District, Eastern Cape Province, South Africa. master of science of Rhodes university. 202 pp.

Hill DS (1987) Agricultural Insect Pests of Temperature Regions and their Control. Cambridge University Press. Cambridge.

Hofmeyr JH & Pringle KL (1998) Resistance of the False Codling Moth to the chitin synthesis inhibitor, triflumuron. African Entomology 6: 373-375.

HTSPE (2010) Suivi de la campagne 2009-2010 de commercialisation du litchi de Madagascar sur les marchés européens, http://ctht.org/litchis/camp0910/Rapfinallit0910a.pdf

Huisman H & Koster S (2000) New and interesting Microlepidoptera from The Netherlands in particular from the years 1997 and 1998 (Lepidoptera). Entomologische Berichten 60(11): 193-216.

Jacas JA, Karamaouna F, Vercher R & Zappalà L (2010) Citrus Pest Management in the Northern Mediterranean Basin (Spain, Italy And Greece) Integrated Management of Plant Pests and Diseases, Volume 5, Part 1, 3-27, DOI: 10.1007/978-90-481-8606-8_1.

Javaid I (1986). Causes of damage to some wild mango fruit trees in Zambia. International Pest Control, 28(4): 98-99.

Karnoven J (1983) *Cryptophlebia leucotreta* imported into Finland (Lepidoptera, Tortricidae). Notulae Entomologicae 63: 94.

Keil S, Gu H & Dorn S (2001) Response of *Cydia pomonella* to selection on mobility:laboratory evaluation and field verification. Ecological Entomology 26: 495-501.

Kennedy GG & Storer NP (2000) Life systems of polyphagous arthropod pests in temporally unstable cropping systems. Annual Review of Entomology, 45:467-493.

Kirkman W (2007) Understanding and improving the residual efficacy of the *Cryptophlebia leucotreta* granulovirus (CRYPTOGRAN). MSc Thesis, Rhodes University, Grahamstown, South Africa.

Kirkman W & Moore S (2007). A study of alternative hosts for the false codling moth, *Thaumatotibia leucotreta* in the Eastern Cape. SA Fruit Journal (apr/may): 33-38.

Knill-Jones SA (1994) Two species of micro-lepidoptera new to the Isle of Wight. Entomologist's Record & Journal of Variation 106(5-6): 114.

Komai F (1999) A taxonomic review of the genus Grapholita and allied genera (Lepidoptera: Tortricidae) in the Palaearctic region. Entomologica. Scandinavica. Suppl., 55: 1-226.

Koppert (2008) http://neveneffecten.koppert.nl/

Kottek M, Grieser J, Beck C, Rudolf B & Rubel F (2006) World Map of the Köppen-Geiger climate classification Meteorologische Zeitschrift, Vol. 15, No. 3, 259-263.

La Croix EAS & Thindwa HZ (1986a) Macadamia pests in Malawi. III. The major pests. The biology of bugs and borers. Tropical Pest Management 32(1): 11-20.

La Croix E & Thindwa H (1986b) Macadamia pests in Malawi. IV. Control of bugs and borers. Tropical Pest Management 32: 120-125.

Lammers W & MacLeod A (2007) Pest Risk assessment of *Helicoverpa armigera*. NPPO of the Netherlands. http://www.minlnv.nl/portal/page?_pageid=142,2268041&_dad=portal&_schema=PORTAL&p_file_id=18429

Langmaid JR (1996) *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae) and *Cryptophlebia leucotreta* (Meyrick) (Lepidoptera: Tortricidae) at m.v. light in Hampshire. Entomologist's Gazette. 47(1): 50.

Liebhold AM, Work TT, McCullough DG & Cavey JF (2006) Airline Baggage as a Pathway for Alien Insect Species Invading the United States, American Entomologist. 53(1): 48-54.

MacLeod A (2002) Pest Risk Analysis for *Crytpophlebia leucotreta* (unpublished document), Fera.

Malumphy C & Robinson J (2002) Lepidopterous larvae intercepted on imported produce of fresh bean, pea, okra, sweet pepper, aubergine and tomato fruit in England and Wales between 1970 and 2000. Entomol. Gaz. 53: 191–202.

Mani E & Wildbolz T (1977) The dispersal of male codling moths (*Laspeyresia pomonella* L.) in the Upper Rhine Valley. Zeitschrift für Angewandte Entomologie, 83, 1-4, 161-168.

Moore SD (2002) The development and evaluation of *Cryptophlebia leucotreta* granulovirus (CrleGV) as a biological control agent for the management of false codling moth, *Cryptophlebia leucotreta*, on citrus. PhD Thesis, Rhodes University: 311 pp.

Moore SD, Pittaway T, Bouwer G & Fourie JG (2004). Evaluation of *Helicoverpa armigera* Nucleopolyhedrovisus (HearNPV) for control of *Helicoverpa armigera* (Lepidoptera: Noctuidae) on citrus in South Africa. Biocontrol Science and Technology 14: 239-250.

Moore SD, Grout TG, Hattingh V & Hofmeyr JH (2008) Thresholds and guidelines for intervention against citrus pests. South African Fruit Journal, Aug/Sep 2008, pp. 77-81.

Moore SD & Kirkman W (2009) Citrus orchard sanitation with emphasis on false colding moth control. South African Fruit Journal, Dec/Jan 2009, 57-60.

Moran VC (1983) The phytophagous insects and mites of cultivated plants in South Africa: patterns and pest status. Journal of Applied Ecology 20: 439-450.

Myburgh AC (1965) Low temperature sterilization of false codling moth, *Argyroploce leucotreta* Meyr. in export citrus. Journal of the Entomological Society of Southern Africa 28:277-285.

Myburgh AC, Whitehead VB & Daiber CC (1973) Pests of deciduous fruit, grapes and miscellaneous other horticultural crops in South Africa. — Rep. S. Afr. Dept. Agric. Tech. Serv. Ent. Mem. 27, 1-38.

NAPPFAST (2011) Insect Development Database http://www.nappfast.org/databases/Insect%20Development%20Datatbase%20for%20Web-%20Final%20without%20links.xls

Ndemah R & Schulthess F (2002) Yield of maize in relation to natural field infestations and damage by lepidopteran borers in the forest and forest/savanna transition zones of Cameroon. Insect Science and its Application. 22: 3, 183-192.

Newton PJ (1988) Inversely density-dependent egg parasitism in patchy distributions of the citrus pest *Cryptophlebia leucotreta* (Lepidoptera: Tortricidae) and its agricultural efficiency. Journal of Applied Ecology, 25(1): 145-162.

Newton PJ (1989a) The influence of citrus fruit condition on egg laying by the false codling moth, *Cryptophlebia leucotreta*. Entomologia Experimentalis et Applicata 52: 113-117.

Newton P (1989b). Combinations of applications of a chitin synthises inhibitor and inundaitve releases of egg parasitoids against the false codling moth, *Crytophplebia leucotreta* (Meyrick) (Lepidoptera: Tortricidae), on citrus. Bulletin of Entomological Research 79: 507-519.

Newton PJ (1998) False Codling Moth, *Cryptophlebia leucotreta* (Meyrick). In: Citrus pests in the Republic of South Africa, Eds Bedford et al., pp.192-200.

Newton PJ & Anderson T (1985). Crop loss due to false codling moth, *Cryptophlebia leucotreta* (Meyr.) (Lepidoptera: Tortricidae), and other factors, on different navel orange selections at Citrusdal. Information Bulletin, Citrus and Subtropical Fruit Research Institute, South Africa, 159: 22-24.

Newton PJ & Crause C (1990) Oviposition on *Litchi chinensis* by *Cryptophlebia* species (Lepidoptera: Tortricidae). Phytophylactica, 22(3): 365-367.

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

Opoku-Debrah JK (2008). Geographic variation in the susceptibility of false codling moth Thaumatotibia leucotreta, populations to a ganulovirus (CrleGV-SA). Submitted in fulfilment of the requirements for the degree of Master of Technology Agriculture (Research) at the Nelson Mandela Metropolitan University. 238 pp.

OTF (2007) Pomegranates Albanian Export Opportunities to Europe and the Region, http://greenmarket.al/web/pub/albania_pomegranate_market_opportunities_12_19_21_1.pdf

Potting RPJ (2009) Pest Risk Analyis Tuta absoluta, NPPO The Netherlands, http://www.vwa.nl/onderwerpen/english/dossier/pest-risk-analysis/evaluation-of-pest-risks

Potting RPJ & van der Straten M (2011) Pest Risk Analysis for *Thaumatotibia leucotreta*. Version 5, Februar 2011, 27 pp.

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

Rikken (2010) CTB, le Marché Européen des fleurs et plantes equitables et durables. Link to the report

Rothschild GHL & Vickers RA (1991) Biology, ecology and control of the oriental fruit moth. In World crop pest: Tortricid pests. Van der Geest, L. P. S. & Evanhuis, H. H. (eds.) Elevier, Amsterdam, pp. 389-413.

Sanjuan Carro E (2006). Pest Risk Assessment for *Thaumatotibia leucotreta*. MINISTERIO DE AGRICULTURA, PESCAY ALIMENTACION. 32 pp.

Schumacher P, Weber DC, Hagger C & Dorn S (1997) Heritability of flight distance for *Cydia pomonella*. Entomologia Experimentalis et Applicata 85: 169-175.

Schwartz A & Kok (1976) Cold sterlization and fumigation for the control of false codling moth, *Cryptophlebia leucotreta* Meyr., and fruit flies, *Ceratitis spp.*, in export cirtrus fruit. Journal of the Entomological Society of South Africa 39: 261-266.

Schwartz A (1981) 'n Bydrae tot die biologie en beheer van die valskodlingmot *Cryptophlebia leucotreta* (Lepidoptera: Eucosmidae) op nawels. Ph. D. thesis, University of Stellenbosch. 280 pp. Cited by Newton 1998.

Silvie P (1993) New information on *Mussidia nigrivenella* Ragonot (Lepidoptera: Pyralidae) in Togo. Insect Science and its Application, 14(5): 643-649.

Stibick J (2006) New pest response guidelines: False codling moth *Thaumatotibia leucotreta*. USDAAPHIS-PPQ. [http://www.aphis.usda.gov/import_export/plants/manuals/emergency/downloads/nprgfcm.pdf]

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

Stotter RL & Terblanche JS (2009) Low-temperature tolerance of false codling moth *Thaumatotibia leucotreta* (Meyrick)(Lepidoptera:Tortricidae) in South Africa Journal of Thermal Biology34 pp 320–325

Sutherst RW & Maywald G (2005). A climate-model of the red imported fire ant, *Solenopsis invicta* Buren (Hymenoptera: Formicidae): implications for invasion of new regions, particularly Oceania. Environmental Entomology, 34, 317- 335.

Sziraki G (1979) Dispersion and movement activity of the oriental fruit moth *Grapholita molesta* (Busck) in large-scale orchards. Acta Phytopathologia Academiae Hungaricae 14: 209-228.

Svensson I (2002) Remarkable records of Microlepidoptera in Sweden during 2001; Entomologisk Tidskrift. 123(1-2): 1-11.

Taylor RS (1988) Pathway study for USDA, not published internal document (attached to Lightfield letter).

Tejedo V, Llorens JM & García-Marí F (2006) Citrus phytosanitary survey project in the Comunidad Valenciana. II: Packinghouses and commercial outbuildings. Bulletin OILB/SROP, 29: 3, 161.

Timm AE (2005) Morphological and molecular studies of Tortricid moths of economic importance to the South African fruit industry, PhD dissertation, University of Stellenbosch.

UFO SUPPLIES (2003) Post-Harvest treatments of cut flowers Aalsmeer NL www.UFOsupplies.nl (click here for the article)

USDA (2010) New pest response guidelines: false codling moth *Thaumatotibia leucotreta*. U.S. Department of Agriculture, Animal Plant Health Inspection Service, Plant Protection and Quarantine, Emergency and Domestic Programs, Riverdale, Maryland. http://www.aphis.usda.gov/import_export/plants/manuals/online_manuals.shtml [accessed February 20, 2012].

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

Venette R, Davis CEE, DaCosta M, Heisler H & Larson M (2003) Mini Risk Assessment: False codling moth, *Thaumatotibia* (=*Cryptophlebia*) *leucotreta* (Meyrick) [Lepidoptera: Tortricidae]. University of Minnesota, Department of Entomology, CAPS PRA. 1-30 pp. [http://www.aphis.usda.gov/ppq/ep/pestdetection/pra/tleucotretapra.pdf#search=%22tleucotretapra.pdf%22]

Vickers RA, Rothschild GHL & Jones EL (1985) Control of the oriental fruit moth, *Cydia molesta* (Busek) (Lepidoptera: Tortricidae), at a district level by mating disruption with synthetic female pheromone. Bulletin of Entomological Research, 75: 625-634.

Vreysen MJB, Robinson AS & Hendrichs J (2007) Area-wide control of insect pests, Springer, 789 pp.

Watt MS, Kriticos DJ, Alcaraz S, Brown AV & Leriche A (2009) The hosts and potential geographic range of Dothistroma needle blight. Forest Ecology and Management, 257, 1505-1519.

Weisser WW (2001) Predation and the evolution of dispersal. In: Insect movement: mechanisms and consequences. Woiwod, I. P., Reynolds, D. R. & Thomas, C. D. (eds.). CABI Publishing, UK, pp. 261-280.

Wohlfarter M, Giliomee JH & Venter E (2010) A survey of the arthropod pests associated with commercial pomegranates, *Punica granatum* (Lythraceae), in South Africa. African Entomology, 18(1): 192-199.

Wysoki M (1986) New records of lepidopterous pests of macadamia in Israel. Phytoparasitica 14: 2.

de Villiers EA, van den Berg MA & Joubert PH (2001) Mango Pests and Diseases in South Africa. ARC-Institute for Tropical and Subtropical Crops. 70 pp.

Appendix 1: *Thaumatotibia leucotreta* host plant list

Introduction

The compiled host plant list is a result of a thorough review of sources that report on the host plants of *T. leucotreta*. Host plant lists in previous works on *T.leucotreta* (PRA's, guidelines, and many others) often appear to be copies of host plants listed by others, with original, verified, sources often missing. Among the most cited general authors are the following:

- **Bradley *et al*. 1979**: book on British Tortricid moths. Lists several host plants with no specific literature references. No original research or observations.
- **CABI (2000).** Crop Protection Compendium. CAB International, Wallingford, UK.
- **Carter, D.J. (1984).** Pest Lepidoptera of Europe with special reference to the British Isles. Series Entomologica (Dordrecht) 31, 1–431.
- **Couilloud 1988**: lists a total of 77 food plants, including fruits, vegetables and trees of economic importance.
- **Pearson 1958***:* book on pests of cotton in Tropical Africa. The host plants of *T. leucotreta* are listed with general references to Ford 1934, Gunn 1921 and Tothill 1940. No original research or observations.
- **Komai 1999**: a taxonomic review on Palaearctic *Grapholita* and related species. No original research or observations.
- **Hill 1975 / 1983**(revised edition): general book on tropical pests. It lists host plants with no specific literature sources. No original research or observations.
- **Newton 1998**: an overview of pests on Citrus in South Africa. It mentions several other host plants of *T. leucotreta* with references to other authors. No original research or observations.
- **Pinhey 1975:** book on Moths of Southern-Africa. Lists major host plants with no literature references. No original research or observations.
- **Schwartz 1981**: a review Ph. D. thesis: lists host plants with general reference to other authors (among them Pearson 1958 and Hill 1975*)*. No original research or observations.
- **Venette et al 2003**: a Mini Pest Risk Analysis listing host plants with reference to other articles. No original research or observations.
- **Van der Geest,1991**. Tortricids in miscellaneous crops. In: van der Geest, L.P.S. and Evenhuis, H.H. (eds). Tortricid pests, their biology, natural enemies and control. World Crop Pests. Volume 5. (Amsterdam, The Netherlands: Elsevier Science Publishers), pp. 563–577.
- **USDA (United States Department of Agriculture). 2010**. New pest response guidelines: false codling moth Thaumatotibia leucotreta. U.S. Department of Agriculture, Animal Plant Health Inspection Service, Plant Protection and Quarantine, Emergency and Domestic Programs, Riverdale, Maryland. http://www. aphis.usda.gov/import_export/plants/manuals/online_manuals.shtml

The list

The list we present here aims to include as much as possible only reliable and original records of *T. leucotreta* host plants, based on:
(a) Literature sources that clearly indicate *T. leucotreta* was found feeding on the specified host plant, as a result of rearing and/or original research carried out by the article's author(s).
(b) Specimens collected in the field within the host plant or on interceptions from international trade that were identified to species level by expert identifiers.

As already host plant status itself is not always evident, determination whether a host plant is a preferred/major or a secondary/minor host is even more disputable. Therefore the EWG has decided to split the many reported host plants into two groups. One (Table I) with host plants of *T.leucotreta* considered relevant for the EPPO PRA, based on the expert opinion of the EWG; the other including other reported host plants (Table II).

Notes on in-/exclusion of relevant plants as host of *T. leucotreta*

In some references we found host plants cited, that can be relevant for the PRA, *if* their host plant status is correct. Here we give an account of the findings on these plants and substantiate why we have included or excluded them from the list presented here.

1.*C. lemon*:
In lemon, and lime, larval development is rarely if ever completed (Catling & Ashenborn, 1978; Newton, 1998) and are therefore not considered as hosts.

2. Pears (*Pyrus)*
Three references were found:
- Timm (2005, 2007), in the introductions of both papers, cites apples and pears as host plants with references to Blomefield 1989 and Newton 1998. In both latter articles however, apples and pears are not mentioned as host plants for *T. leucotreta*. Therefore we consider these references erroneous. Also table 9.1 (Timm 2005) lists Pears as "host". In this case the column header "host" refers to adults being collected in a trap in an orchard growing pears; no larvae were collected from these pears. There is no proof that these adults are associated with the pears in this orchard.
  (Citing apples seems also erroneous: it can't be found in any other source).
- The PRA from the Netherlands mentions at question 2.1 damage on ***Pyrus*** Peach (28%) with a reference to Venette, 2003. *Pyrus* is a type-error, which should have been *Prunus*.
- Germany reported the interception of larvae of *T. leucotreta* on pears from South Africa in April 2007. Later they concluded the identity of such larvae was uncertain (rearing to the adult stage for verification also failed) (*pers. comm.* P. Baufeld).

We consider *Pyrus* not as a host plant.

3. Pineapple (*Ananas comosus*).
Pineapple was quoted as *T. leucotreta* host plant in Pinhey (1975) from Angola, "according to Investig. Cientif. Agron.". This source was unavailable to us.
Graham Petty, an entomologist working on pineapples in South Africa for about 40 years did however never encounter this pest attacking this fruit (*pers. comm.* S.Moore). He did also not list it as a pest of pineapple in Petty, 2005 (Petty, D.J., Sterling, G.R. & Bartholomew, D.P., 2005. Pests of pineapple (Chapter 6).*in*: eds J.E. Pena, J.L. Sharp & M. Wysoki. Tropical Pests and Pollinators: Biology, Economic importance, Natural enemies and Control. 157 pp.).
Other sources seem to be lacking, therefore, for now, we do not consider pineapple a host plant.

4. Avocado (Persea americana).
Grové *et al.* (2000) indicated *T. leucotreta* is not using avocado as a host plant since larvae die in the first instar and do not penetrate the flesh, staying only under the skin. Other authors (du Toit *et al.*1979; Erichsen & Schoeman 1992; Joubert & du Toit 1993) mentioned economic damage because of lesions on avocado's skin, but did not mention avocado as a *T. leucotreta* host plant proper. It is generally accepted that *T. leucotreta* can infest avocado and it was therefore included in the list for further evaluation in particular as a pathway.

5. Okra (*Abelmoschus esculentus*)
Muck, 1985, lists in the introduction of his study *T. leucotreta* as one of the pests found on Okra in Cape Verde; however le basis of this record is not clear. In USDA_Aphis_new_guidelines Okra (1983) okra is considered a major host (just a common citation); one hint for rearing on okra (Vreysen *et al.* 2007) and one interception from Whittle (1984). In the document "Importation of okra from Ghana into the entire US (USDA, 2007)" interceptions are reported of *Cryptophlebia* sp. on okra *of any origin* (7) as well as interceptions from Ghana on *all commodities* (>1000) but there is no specific data in this document to support that these interception refer to *T. leucotreta* (syn. *Cryptophlebia leucotreta)* on okra.
Okra is included in the list, but the host plant status is poorly supported.

6. Beans (*Phaseolus* sp)
Venette, 2003, lists *Phaseolus sp.* as host plant (no specific reference mentioned). In the USDA New pest response guidelines..T. leucotreta (2010) it has been specified to *Phaseolus lunatus*. The original source of this record has not been found, nor other sources so far. Therefore *Phaseolus lunatus* has been included in the list (with unverified host status), but *Phaseolus sp.* has been excluded.

7. Tomato (*Lycopersicum esculentum*)
Both Venette, 2003, and the later USDA New pest response guidelines, 2010, list tomato as a host, but no other references can be found. Reliable support for the host plant status is therefore missing and tomato is not included in the list.

8. Ricinus (*Ricinus communis*)
Kirkman & Moore (2007) quoted *Ricinus communis* as an alternative host for *T. leucotreta* in South Africa. This was however not found in the field, but only at tests in the laboratory where neonate larvae were placed onto the fruit and successfully developed (*pers. comm.* Moore, 2012); in field surveys it was never found.
Valle y March, 1972, however positively identified *T. leucotreta* larvae on Ricinus in field surveys in Mozambique, and also Muck, 1985, lists it, although the bases for that is unclear (see Okra). Further *T. leucotreta* on Ricinus is known from Israel (Wysoki et al, 1986). Ricinus is therefore included in the list.

Table I. Host plants of *T. leucotreta* considered relevant for the EPPO PRA

HOST PLANT	COMMON NAME	PLANT FAMILY	REFERENCE (a.o.)*	LOCATION
Capsicum	Pepper	Solanaceae	Collingwood *et al.*, 1981	Senegal
			Fritsch, 1988	Cape Verde
			Infestations found sporadically and irregularly (pers.comm. Karungi, 2012)	Uganda
			One outbreak of 6 weeks in polytunnel (pers.comm. Moore, 2012)	Uganda
			Incidental in open field (pers.comm. Moore, 2012; pers.comm. Booysens in Hepburn, 2007)	South Africa
			Interceptions in the Netherlands (pers.comm. van der Straten, 2011)	Uganda
			Incursion in a green house in the Netherlands (Potting, 2010)	Netherlands/Uganda
			Interceptions in the United Kingdom (Malumphy, 2002 & Korycinska, pers. comm, 2011)	Uganda, Zambia, Ghana
			Interceptions in the USA (USDA-Aphis-PPQ, 2010)	Africa
Citrus paradisi	Grapefruit	Rutaceae	Interceptions in Spain (Guitian Castrillon, pers. comm, 2011)	South Africa
			Interceptions in the Netherlands (pers.comm. van der Straten, 2011)	
Citrus reticulata & hybrids	Mandarin orange	Rutaceae	Interceptions in the Netherlands (pers.comm. van der Straten, 2011)	South Africa
Citrus sinensis & hybrids	Orange	Rutaceae	Stofberg 1954	South Africa
			Newton 1988, 1989, 1990,	South Africa

Table I. Host plants of *T. leucotreta* considered relevant for the EPPO PRA				
HOST PLANT	**COMMON NAME**	**PLANT FAMILY**	**REFERENCE (a.o.)***	**LOCATION**
			1998	
			Begemann & Schoeman 1999	South Africa
			Stotter, 2009	South Africa
			Interceptions in Spain (Guitian Castrillon, pers. comm, 2011)	South Africa, Swaziland
			Interceptions in the United Kingdom (Malumphy, 2002 & Korycinska, pers. comm, 2011)	South Africa
			Interceptions in the Netherlands (pers.comm. van der Straten, 2011)	South-Africa, Zimbabwe
Gossypium spp	Cotton	Malvaceae	Pomeroy, 1925	Nigeria
			Angelini & Houiller, 1955	Ivory Coast
			Reed 1974	Uganda
			Silvie, 1990, 1993	Togo
			Hamburger *et al*. 2001	Israel
Litchi chinensis	Litchi, Litchee	Sapindaceae	Newton & Crause 1990	South Africa
			Grové *et al*. 2000, 2002, 2004	
Macadamia ternuifolia	Macadamia	Proteaceae	Wysoki 1986	Israel
			Wysoki *et al*. 1986	
			Hamburger *et al*. 2001	
M. integrifolia / M. tetraphylla hybrid	Macadamia	Proteaceae	la Croix & Thindwa 1986a	Malawi
			la Croix 1990	
			Chambers *et al*. 1995	
			Ching'oma 2001	
Mangifera indica	Mango	Anacardiaceae	Javaid 1986	Zambia
			Detection in the Netherlands in fruits from a shop in Kenya (pers.comm. van der Straten, 2011)	Kenya?
Persea americana	Avocado	Lauraceae	Hargreaves, 1933	Sierra Leone
			Muck, 1985	Cape Verde
			du Toit *et al*. 1979	South Africa
			Erichsen & Schoeman 1992	South Africa
			Grové *et al*. 2000	South Africa
Prunus persica	Peach	Rosaceae	Blomefield 1989	South Africa
			Daiber, 1976	
Prunus persica var. nucipersica	Nectarine	Rosaceae	Blomefield 1989	South Africa
Psidium guajava	Guava	Myrtaceae	Villiers, 1978	South Africa

Table I. Host plants of *T. leucotreta* considered relevant for the EPPO PRA				
HOST PLANT	**COMMON NAME**	**PLANT FAMILY**	**REFERENCE (a.o.)***	**LOCATION**
			Newton 1988	
			Stotter, 2009	
Punica granatum	Pomegranate	Lythraceae	Wohlfarter *et al*. 2010	South Africa
Quercus robur	Oak	Fagaceae	Anderson 1986	South Africa
			Stotter, 2009	
Ricinus communis	Ricinus	Euphorbiaceae	*Muck, 1985 (thesis, introduction lists lepidoptera pests found in the field)*	Cape Verde
			Valle-y-March, 1972	Mozambique
			Hamburger *et al*. 2001	Israel
Rosa sp	Rose	Rosaceae	Interceptions in the Netherlands, in buds (pers.comm. van der Straten, 2011)	Africa, mainly Uganda
Solanum melongena	Eggplant	Solanaceae	Interceptions in the USA (USDA-Aphis-PPQ, 2010)	Africa
			Interceptions in the United Kingdom (Malumphy, 2002 & Korycinska, pers. comm, 2011)	Ivory Coast
			Interceptions in the Netherlands (pers.comm. van der Straten, 2011)	Uganda
Vitis vinifera	Grape	Vitaceae	Interception by USDA-Aphis (pre-clearance, *pers. comm.* J. Floyd, 2011))	South Africa
			Hattingh, *pers. comm.*, 2011	
Zea mays	Maize	Poaceae	Reed 1974	Uganda
			Moyal & Tran 1989	Ivory Coast
			Silvie, 1990	Togo
			Schulthess *et al*. 1991	Benin & Nigeria
			Songa *et al*. 2001, 2002	Kenya
			Buadu *et al*. 2002	Ghana
			Ndemah & Schulthess 2002	Cameroon
*** Table I: Of host plants with many references, only a subset is included**				

Table II. Other plants reported as host plants of *T. leucotreta*				
HOST PLANT	**COMMON NAME**	**PLANT FAMILY**	**REFERENCE ***	**LOCATION**
Abelmoschus esculentus	Okra	Malvaceae	*Muck, 1985*	Cape Verde

Table II. Other plants reported as host plants of *T. leucotreta*				
HOST PLANT	COMMON NAME	PLANT FAMILY	REFERENCE *	LOCATION
			(thesis, introduction lists lepidoptera pests found in the field)	
Abutilon spp.	Mallow	Malvaceae	*USDA-Aphis, 2010*	???
Afrocarpus falcatus	-	Podocarpaceae	Brown *et al.* in preparation	Kenya
Albuca sp.	-	Asparagaceae	Kirkman & Moore 2007	South Africa
Allophylus ferrugineus var. *ferrugineus*	-	Sapindaceae	Brown *et al.* in preparation	Kenya
Annona senegalensis	Wild custard apple (Eng.) ; Muembe (Venda language); Wilde vla-apple (Afr.)	Annonaceae	Stofberg 1939	South Africa
Aristolochia albida	-	Aristolochiaceae	Brown *et al.* in preparation	Kenya
Asparagus crassicladus	Asparagus	Asparagaceae	Kirkman & Moore 2007	South Africa
Averrhoa carambola	Carambola	Oxalidaceae	Grové *et al.* 2000	South Africa
Blighia unijugata	-	Sapindaceae	Brown *et al.* in preparation	Kenya
Butryospermum parkii	Butterseed	Sapotaceae	*USDA-Aphis, 2010*	???
Calotropis procera	Apple of Sodom	Asclepiadaceae	*Hill, 1983, not original*	???
Camellia sinensis	Tea	Theaceae	*Bradley et al. 1979, not original*	???
Ceiba pentandra	Kapok ceiba	Malvaceae	*USDA-Aphis, 2010*	???
Chaetacme aristata	-	Ulmaceae	Brown *et al.* in preparation	Kenya
Chrysophyllum albidum	-	Sapotaceae	Brown *et al.* in preparation	Kenya

Table II. Other plants reported as host plants of *T. leucotreta*				
HOST PLANT	**COMMON NAME**	**PLANT FAMILY**	**REFERENCE ***	**LOCATION**
Chrysophyllum cainito	Star apple	Sapotaceae	Interceptions UK (pers.comm. C. Malumphy & A.Korycinska 2011)	Nigeria
Chrysophyllum magalis-montanum	-	Sapotaceae	*Gunn, 1921 (not original?)*	???
Chrysophyllum viridifolium	-	Sapotaceae	Brown *et al.* in preparation	Kenya
Citrus aurantiifolia	Lemon	Rutaceae	*USDA-Aphis, 2010*	???
Citrus limon	Lemon	Rutaceae	*USDA-Aphis, 2010*	???
Coffea arabica	Coffee	Rubiaceae	*Pinhey, 1975 ("according to Investig. Cientif. Agron.")*	Angola
			Brown *et al.* in preparation	Kenya
Cola minor	-	Stericulaceae	Brown *et al.* in preparation	Kenya
Combretum apiculatum	Red bushwillow	Combretaceae	*Gunn, 1921 (not original?)*	???
Combretum zeyheri	Large fruited bushwillow	Combretaceae	*Gunn, 1921 (not original?)*	???
Crassula ovata	-	Crassulaceae	Kirkman & Moore 2007	South Africa
Croton sylvaticus	-	Euphorbiaceae	Brown *et al.* in preparation	Kenya
Cyphomandra betacea	Tree tomato	Solanaceae	*USDA-Aphis, 2010*	???
Deinbollia borbonica	-	Sapindaceae	Brown *et al.* in preparation	Kenya
Diospyros mespiliformis	the Jackalberry (also known as	Ebenaceae	Stofberg 1939	South Africa

Table II. Other plants reported as host plants of *T. leucotreta*				
HOST PLANT	**COMMON NAME**	**PLANT FAMILY**	**REFERENCE ***	**LOCATION**
	African Ebony and by its Afrikaans name *jakkalsbessie*)			
Diospyros kaki	Japanese Persimmon	Ebenaceae	Giliomee 2004	South Africa
Drypetes natalensis var. *leiogyna*	-	Euphorbiaceae	Brown *et al.* in preparation	Kenya
Eriobotrya japonica	Loquat	Rosaceae	Brown *et al.* in preparation	Kenya
Ficus ssp	Wild figs	Rutaceae	*Hill, 1983, not original*	???
Flacourtia indica	-	Salicaceae	*Venette, 2003*	???
Grewia tephrodermis	-	Tiliaceae	Brown *et al.* in preparation	Kenya
Guettarda speciosa	-	Rubiaceae	Brown *et al.* in preparation	Kenya
Harpephyllum caffrum	Wild plum	Anacardiaceae	Williers 1979	South Africa
Hibiscus spp.	Hibiscus	Malvaceae	*USDA-Aphis, 2010*	???
Hirtella zanzibarica subsp. *zanzibarica*	-	Chrysobalanaceae	Brown *et al.* in preparation	Kenya
Juglans spp.	Walnut	Juglandaceae	*Gunn, 1921 (not original?)*	???
Landolphia sp.	-	Apocynaceae	Brown *et al.* in preparation	Kenya
Lecaniodiscus fraxinifolius subsp. *scasselattii*	-	Sapindaceae	Brown *et al.* in preparation	Kenya
Lepisanthes senegalensis	-	Sapindaceae	Brown *et al.* in preparation	Kenya
Lettowianthus stellatus	-	Annonaceae	Brown *et al.* in preparation	Kenya
Mimusops bagshawei	-	Sapotaceae	Brown *et al.*	Kenya

Table II. Other plants reported as host plants of *T. leucotreta*				
HOST PLANT	**COMMON NAME**	**PLANT FAMILY**	**REFERENCE ***	**LOCATION**
			in preparation	
Mimusops obtusifolia	-	Sapotaceae	Brown *et al.* in preparation	Kenya
Monodora grandidieri	-	Annonaceae	Brown *et al.* in preparation	Kenya
Musa paradisiaca var. *sapientum*	Banana	Musaceae	*USDA-Aphis, 2010*	???
Ochna mossambicensis	-	Ochnaceae	Brown *et al.* in preparation	Kenya
Olea europaea	Olives	Oleaceae	*Gunn, 1921 (not original?)*	???
Opuntia ficus-indica	-	Cactaceae	Kirkman & Moore 2007	South Africa
Pappea capensis	-	Sapindaceae	Brown *et al.* in preparation	Kenya
Passiflora sp.	-	Passifloraceae	Kirkman & Moore 2007	South Africa
Phaseolus lunatus	Lima bean	Fabaceae	*Venette, 2003*	???
Physalis spp.	Ground Cherry	Solanaceae	*USDA-Aphis, 2010*	???
Podocarpus falcata	Outeniqua yellowwood	Podocarpaceae	*Gunn, 1921 (not original?)*	???
Prunus armeniaca	Apricot	Rosaceae	*USDA-Aphis, 2010*	???
Prunus spp.	Cherries (All)	Rosaceae	*USDA-Aphis, 2010*	???
Prunus domestica	Plum	Rosaceae	Blomefield 1989 Interceptions UK (pers.comm. C. Malumphy & A.Korycinska 2011)	South Africa
Pseudolachnostylis maprounaefolia	-	Phyllanthaceae	*USDA-Aphis, 2010*	???

Table II. Other plants reported as host plants of *T. leucotreta*				
HOST PLANT	**COMMON NAME**	**PLANT FAMILY**	**REFERENCE ***	**LOCATION**
Rourea minor	-	Connaraceae	Brown *et al.* in preparation	Kenya
Royena pallens	-	Ebenaceae	*Gunn, 1921 (not original?)*	???
Saccharum officinarum	Sugarcane	Poaceae	Komai 1999, not original!	??
Salacia elegans	-	Celastraceae	Brown *et al.* in preparation	Kenya
Salacia leptoclada	-	Celastraceae	Brown *et al.* in preparation	Kenya
Schotia sp	Wild bean tree	Fabaceae	*USDA-Aphis, 2010*	???
Schotia speciosa	-	Fabaceae	*Gunn, 1921*	
Schotia afra	-	Fabaceae	Kirkman & Moore 2007	South Africa
Sclerocarya birrea subsp. *caffra*	Wild marvolanut	Anacardiaceae	*Gunn, 1921*	???
Sida sp.	Jute, Sidas	Malvaceae	*USDA-Aphis, 2010*	???
Solanum tomentosum	No common name found	Solanaceae	Kirkman & Moore 2007	South Africa
Sorghum vulgare	Sorghum	Poaceae	Reed 1974	Uganda
Stephania abyssinica var. *abyssinica*	-	Menispermaceae	Brown *et al.* in preparation	Kenya
Synsepalum dulciticum	Miraculous berry	Sapotaceae	*USDA-Aphis, 2010*	???
Syzygium cordatum	water berry, waterbessie, umdoni waterberry, umdoni, waterwood, waterhout, monhlo, montlho, umcozi, muthwa, muhlwa, mutu, umswi, umjome	Myrtaceae	Stofberg 1939	South Africa
			Brown *et al.* in preparation	Kenya
Syzygium jambos	Malabar Plum, *champakka, chom pu* or *chom-phu.*	Myrtaceae	*USDA-Aphis, 2010*	???

Table II. Other plants reported as host plants of *T. leucotreta*

HOST PLANT	COMMON NAME	PLANT FAMILY	REFERENCE *	LOCATION
Theobroma cacao	Cacao	Malvaceae	*Venette, 2003*	???
Triumfetta spp.	Triumfetta, Burrbark	Malvaceae	*USDA-Aphis, 2010*	???
Vangueria infausta	Vanguria	Rubiaceae	*Gunn, 1921*	???
Vigna unguiculata	Cowpea	Fabaceae	*USDA-Aphis, 2010*	???
Ximenia caffra	Large sourplum (Eng.); Grootsuurpruim (Afr.); umThunduluka-obmvu (Zulu); Morokologa (Northern Sotho)	Olacaceae	*Gunn, 1921*	???
			Stofberg 1939	South Africa
			Brown *et al.* in preparation	Kenya
Yucca spp.	Yucca	Agavaceae	*USDA-Aphis, 2010*	???
Zanha golungensis	-	Sapindaceae	Brown *et al.* in preparation	Kenya
Ziziphus mauritiana	-	Rhamnaceae	Brown *et al.* in preparation	Kenya
Ziziphus mucronata	Buffalo thorn	Rhamnaceae	*USDA-Aphis, 2010*	???

*** Table II: The host status of certain plants, indicated with references written in italics and highlighted in grey, are unclear or even doubtful. These host plants are cited in either review articles or books, or previous PRAs dealing totally or partly with FCM, but original sources are lacking (original sources contain own research or observations by the author(s), reporting unambiguously a particular plant as a host plant for FCM; original sources can also be identifications done by experts).**
Because of the high uncertainty on their host plant status the EWG has decided not to consider these as host plants of relevance.

Appendix 2 :Imports of *Prunus persica* (Peaches and Nectarine) from Countries where the pest is present (Tonnes in 2009)

Country	Israel	Kenya	Mauritius	Saudi Arabia	Senegal	South Africa	Zimbabwe
Albania							
Algeria						5	
Austria							
Azerbaijan						2	
Belarus						1	
Belgium	23					63	
Bulgaria							
Croatia						1	
Cyprus	194					15	
Denmark							
Estonia							
Finland							
France	8		1			101	
Germany						35	
Greece	56						
Hungary							
Ireland							
Italy	22					21	
Jordan						13	
Kazakhstan						2	
Latvia							
Lithuania							
Luxembourg							
Malta							
Morocco						6	
Netherlands						878	
Norway						12	
Poland							
Portugal						24	
Romania							
Serbia						0	
Slovakia							
Slovenia	17						
Spain						13	
Sweden							
Switzerland						3	
Tunisia							
Turkey						2	
Ukraine						2	
United Kingdom	57					4059	
	377	0	1	0	0	5258	0

Appendix3

9 January 2012

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Pre-harvest Control Options for False Codling Moth in Citrus in Southern Africa

Introduction

Development and evaluation of pre-harvest control measures for false codling moth (FCM) on citrus in southern Africa date back to 1926 (Hepburn & Bishop, 1954). This report only includes assessment of those control measures which are currently available. Literature reports varying levels of success with different control measures. In order to correctly understand and interpret this, one firstly needs to understand the range of different needs and requirements for FCM control measures. Firstly, different citrus types have differing susceptibility to FCM. Navel oranges are the most susceptible citrus type, followed by some mandarin and grapefruit types, with most Valencias and white grapefruit seldom being subject to serious attack while lemons and limes are not considered to be a suitable host (Gunn, 1921; Newton, 1998; Moore, 2011a). Lemons have always been considered to not be susceptible (Gunn, 1921; Moore, 2011a). Although FCM occurs in all citrus production areas of southern Africa, pest pressure varies dramatically across these regions and is generally less abundant in the far northern regions (Moore, 2011a), to the extent that FCM is not considered an economically important pest of citrus in the hot and dry northern Limpopo province of South Africa. Consequently, control requirements and the relative success with the different control measures differ from region to region and citrus type to citrus type.

It is important to understand that in practice none of these control measures should be measured in isolation. The efficacy of control measures for FCM on citrus in southern Africa have in the past been described as deficient (eg Schwartz, 1975; Newton, 1998; Stotter, 2009). However, an assessment of this criticism reveals certain important trends: a) conclusions are invariably drawn from experiences in regions of high pest pressure and on highly susceptible citrus types (obviously this is where the majority of the trial work has been conducted and where any negative experiences would be observed); b) poor results can often be attributed to deficiencies in the application of the treatments; c) such statements often are made as general comments, without supporting data, in the introduction to an alternative technique, which is the subject of the paper. Importantly, a) several new and effective control measures for FCM have been introduced since the earlier articles criticising control measures were published, b) comprehensive FCM management is now practiced by virtually all citrus growers in southern Africa, which was far from the case in the past, c) FCM control has become far more sophisticated than was previously the case, meaning that no single control measure is ever used in isolation. The level of control achieved is therefore the sum of the efficacy of all the measures used. For example, if a grower is applying orchard sanitation, parasitoid conservation (or augmentation), virus sprays and mating disruption, his control could be say 80%, on top of 70%, on top of 70%, on top of 75%. Together this would provide control of more than 99%. Even if each technique only gave 50% control, overall reduction in FCM would be almost 95%.

Control options currently registered and commercially available

Control Type	**Product**	**Active ingredient**
Chemical	Meothrin	Fenpropathrin
	Cypermethrin	Cypermethrin
	Alsystin	Triflumuron
	Nomolt	Teflubenzuron

	Delegate	Spinetoram
	Coragen	Rynaxapyr
Microbial	Cryptogran	CrleGV
	Cryptex	CrleGV
Mating Disruption	Isomate	E7-12Ac, E8-12Ac, Z8/E8-12
	Checkmate FCM-F	E8-12Ac, Z8-12
Attract and Kill	Last Call FCM	E7-12Ac, E8-12Ac, Z8-12
Sterile Insect Technique	Sterile Insect Technique	Sterile FCM adult males
Biological	Egg parasitoid	*Trichogrammatoidea cryptophlebiae*

Chemical control

In laboratory trials Hofmeyr (1983a) demonstrated that synthetic pyrethroids were effective as ovicides, larvicides and oviposition inhibiters. Of six pyrethroids tested, cypermethrin proved to be the most effective. In one trial, field weathered residues of cypermethrin remained effective in preventing fruit damage for up to 20 weeks, after artificial infestation with eggs; 100% of untreated fruit were damaged. In field trials two synthetic pyrethroids, cypermethrin and deltamethrin, applied two to three months before harvest, reduced fruit drop by an average of 90% (Hofmeyr, 1983b). However, because of the potentially disruptive effect that pyrethroids would have on natural enemies of other important pests, they were not registered for control of FCM on citrus until after the turn of the millennium (Hendrik Hofmeyr, personal communication).

Residues of Alsystin, field weathered for 75 days, caused up to 85.4% egg mortality (Hofmeyr, 1984). Alsystin was more effective than was Nomolt. In field trials, FCM-induced fruit drop from Navel orange trees was greatly reduced with a single application, either in February or in March (Hofmeyr, 1984). Newton (1987) conducted field trials in which he showed the same two IGRs to work marginally better than did the two pyrethroids, cypermethrin and deltamethrin. Alsystin reduced fruit loss by up to 86.4%. Hofmeyr & Hofmeyr (1991) later reported regularly obtaining in excess of 90% control, with up to 97.6% reduction in infestation. These IGRs (Alsystin and Nomolt) were the first products to be registered for the control of FCM on citrus. In some regions, FCM has developed resistance to Alsystin, after six to seven seasons of regular usage (Hofmeyr & Pringle, 1998).

In 2011 two new chemical insecticides were registered for use against FCM: Delegate and Coragen. These two products appear to have comparable efficacy, usually reducing FCM infestation by between 50 and 60% if applied correctly (Moore & Kirkman, 2011b). However, Stotter (2011) recorded up to 75% reduction with Delegate and Kirkman et al (2010) recorded 68.3% reduction. Furthermore, these products are from chemical groups that have highly favourable eco-toxicology profiles. making them compatible with IPM strategies and suitable for the widespread establishment of acceptable residue tolerances.

Microbial control

Two granuloviruses, Cryptogran and Cryptex, are registered. When applied correctly (i.e. correct timing relative to host life-stage, correct time of day, adequate coverage, addition of correct adjuvants) FCM control has been recorded for up to 17 weeks with a single application, with an average of 70% reduction in infestation over that time (Moore et al, 2004). Up to 87% reduction in FCM infestation has been recorded in field trials on Navel oranges with a single application of Cryptogran (Kirkman et al, 2008).

Mating disruption

During 1999, the first mating disruption product for FCMcontrol was registered for use on citrus (Quant, BASF). A few years later, Isomate was registered. It was initially registered to be applied in November and February. However, further trials showed markedly improved efficacy with earlier application (October and January) (Nico Hanekom, UAP, personal communication). Two trials conducted by CRI in Navel orange orchards in 2002 revealed a 55% (in an orchard with high pressure) and a 75% (in an orchard with low pressure) reduction in FCM infestation from December to the end of April (Hofmeyr & Hofmeyr, 2002). However, more importantly, this reduction was 86% and 95% respectively for the last evaluation before harvest. Another mating disruption product, Checkmate FCM-F, which is a spray-applied capsule suspension, does not seem to be quite as effective (Moore & Kirkman, 2010, 2011a).

Attract and Kill

The only Attract and Kill product on the market for control of FCM on citrus in southern Africa is Last Call FCM (Insect Science, South Africa). CRI trials indicate inferior efficacy to mating disruption (Hofmeyr & Hofmeyr, 2002). However, this was against fairly high FCM pressure. By all accounts, efficacy is better in low-pressure FCM regions.

Orchard sanitation

All infested fruit, both on the trees and on the ground, is collected regularly (at least weekly) and destroyed (Hepburn, 1947). Stofberg (1954) found that a programme of regular sanitation could save between 24 and 60 fruit per tree from FCM infestation. Moore & Kirkman (2008) demonstrated that weekly orchard sanitation conducted from December to June could remove an average of 75% of FCM larvae infesting fruit.

Biological control

Newton & Odendaal (1990) showed that inundative releases of *Trichogrammatoidea cryptophlebiae* egg parasitoids could reduce FCM larval population size by almost 60% during a second consecutive release season. This was a result of weekly releases of an average of more than 3 million parasitoids per hectare for an average of 31 weeks and would therefore be impractical and unaffordable. Years later Moore and colleagues demonstrated that augmentative releases of the parasitoid on a monthly basis, at between 25000 and 250000 parasitoids per hectare per season, could reduce FCM infestation by up to 60% (Moore & Fourie, 1999; Moore & Richards, 2000, 2001 & 2002; Moore & Hattingh, 2004). However, results were variable, almost certainly being strongly influenced by environmental conditions, particularly chemical spray regimes. More importantly than this, where undisrupted, egg parasitism from naturally occurring parasitoids reached between 80 and 100%, causing anything from 67% reduction in FCM infestation in Navel oranges from December to harvest (around May) or even total elimination of FCM infestation by harvest (Moore & Fourie, 1999; Moore & Richards, 2000, 2001 & 2002). This emphasises the importance of conserving the parasitoid through judicious use of pesticides within an IPM programme.

Currently, commercial mass rearing and releasing of *T. cryptophlebiae* is being conducted by Du Roi IPM and Vital Bugs (Letsitele, South Africa), at a release rate of 100000 parasitoids per hectare per season.

Sterile Insect Technique

The principle of the sterile insect technique (SIT) is to flood citrus orchards with large numbers of partially sterile moths at a ratio of at least 10 sterile to 1 wild male moth. The result will be that the probability of a wild female moth mating with a sterile male moth will be significantly greater than the probability of it mating with a wild male moth. A field trial conducted in 35 ha Navel orange orchards in Citrusdal achieved a 94% reduction in infestation (Hofmeyr & Hofmeyr, 2006). Two subsequent trials conducted in the Eastern Cape and Limpopo both achieved higher than 80% reduction in infestation of Navel and Valencia oranges and grapefruit (Hofmeyr & Hofmeyr, 2010; Moore, 2011b). The technique was commercialised by Xsit (Pty) Ltd in 2007 and is now being conducted over more than 4500 ha of citrus in the Western Cape and more than 2000 ha in the Eastern Cape, with good success (Stotter, 2011).

References

Gunn, D. 1921. The False Codling Moth (*Argyroploce leucotreta* Meyr.). *Science Bulletin, Department of Agriculture and Forestry, Union of South Africa* 21:1-28.

Hepburn, G.A. 1947. Insect pests of citrus in the eastern districts of the Cape Province: I - False codling moth. *Citrus Grower* 162: 9 - 11.

Hepburn, G.A. & Bishop, H.J. 1954. The insect pests of citrus in South Africa. *Union of South Africa Department of Agriculture Bulletin* No. 333 (Entomology Series No. 41): 15-22.

Hofmeyr, J.H. 1983a. Valskodlingmot: Evaluering van die kunsmatige piretroïdes se doeltreffendheid teen verskillende ontwikkelingstadia. *Citrus and Sub-Tropical Fruit Journal* 599: 5 - 7, 10 & 11.

Hofmeyr, J.H. 1983b. Valskodlingmot: vermindering van oesverliese met behulp van kunsmatige piretroides. *Citrus and Sub-Tropical Fruit Journal* 600: 4-6.

Hofmeyr, J.H. 1984. Valskodlingmot: Evaluasie van groei-inhibeerders in laboratorium-en veldproewe. *Citrus and Sub-Tropical Fruit Journal* 601: 4-9.

Hofmeyr, JH & Hofmeyr, M. 2006. Bestryding van valskodlingmot deur middel van steiriele insekloslatings. *Citrus Research International Annual Research Report 2006*, pp 22-41.

Hofmeyr, JH & Hofmeyr, M. 2010. Bestryding van valskodlingmot deur middel van steiriele insekloslatings. *Citrus Research International Annual Research Report 2009-10*, pp 11-20.

Hofmeyr, JH & Hofmeyr, M. 2002. Evaluasie van die paringsontwrigter Isomate vir die kommersiële bestryding van valskoldingmot op nawelbome. *Citrus Research International Annual Research Report 2002*, pp 68-74.

Hofmeyr, JH & Hofmeyr, M. 1991. *Navorsingsverslag oor navorsing gedoen in die tydperk Januarie 1987 tot Oktober 1991*. Outspan International, 195 pp.

Hofmeyr, J.H. & Pringle, K.L. 1998. Resistance of false codling moth, *Cryptophlebia leucotreta* (Meyrick) (Lepidoptera: Tortricidae), to the chitin synthesis inhibitor, triflumuron. *African Entomology* 6(2): 373-375.

Kirkman, W., Moore, S.D & Honiball, S. 2008. Investigating and improving the field persistence of Cryptogran. *Citrus Research International Annual Research Report 2008*, pp 60-82.

Kirkman, W, Moore, SD & Keeton, K. 2010. Investigating and improving field persistence of Cryptogran. *Citrus Research International Annual Research Report 2010*, pp 21-30.

Moore, SD. 2011a. False codling moth (Chapter 3). In: *Citrus Research International Integrated Pest Management Guidelines Volume III* (Ed: TG Grout), Part 9, pp 1-9.

Moore, SD. 2011b. Regional rollout of SIT for FCM. *Citrus Research International Annual Research Report 2010-11*, pp 13-27.

Moore, S.D. and Fourie, J.G. 1999. Assessment and development of the augmentation technique for FCM control with the parasitoid *Trichogrammatoidea cryptophlebiae*. *Outspan Citrus Centre Annual Research Report 1999*, pp. 51-58.

Moore, SD & Hattingh, V. 2004. Augmentation of natural enemies for control of citrus pests in South Africa: A guide for growers. *SA Fruit Journal* 3(4): 45-47, 51, 53.

Moore, SD & Kirkman, W. 2008. Citrus orchard sanitation with emphasis on false colding moth control. *South African Fruit Journal*, 7(6): 57-60.

Moore, SD & Kirkman, W. 2010. Evaluation of Checkmate FCM-F for the control of false codling moth. *Citrus Research International Annual Research Report 2009-10*, pp 91-96.

Moore, SD & Kirkman, W. 2011a. Evaluation of Checkmate FCM-F for the control of false codling moth. *Citrus Research International Annual Research Report 2010-11*, pp 91-96.

Moore, SD & Kirkman, W. 2011b. The efficacy of Coragen for control of false codling moth in the Eastern Cape. *Citrus Research International Annual Research Report 2010-11*, pp 58-59

Moore, SD, Kirkman, W & Stephen, P. 2004. CRYPTOGRAN: A virus for the biological control of false codling moth. *SA Fruit Journal* 3(6): 35-39.

Moore, S.D. & Richards, G.I. 2000. Assessment and development of the augmentation technique for FCM control with the parasitoid *Trichogrammatoidea cryptophlebiae*. In: *Citrus Research International Annual Research Report 2000*, pp. 23-29.

Moore, S.D. & Richards, G.I. 2001. Assessment and development of the augmentation technique for FCM control with the parasitoid *Trichogrammatoidea cryptophlebiae*. In: *Citrus Research International Annual Research Report 2001*, pp. 68-74.

Moore, SD & Richards, GI. 2002. Assessment and development of the augmentation technique for FCM control with the parasitoid *Trichogrammatoidea cryptophlebiae*. In: *Citrus Research International Annual Research Report 2002*, pp 51-57.

Newton, P.J. 1987. Efficacy of chitin synthesis inhibitors and synthetic pyrethroids against *Cryptophlebia leucotreta* (Lepidoptera: Tortricidae) on citrus in South Africa. *Phtophylactica* 19: 95-97.
Newton, P.J. 1998. False codling moth *Cryptophlebia leucotreta* (Meyrick). In: *Citrus pests in the Republic of South Africa*. E.C.G. Bedford, M.A. van den Berg & E.A. de Villiers. (eds.) Dynamic Ad, Nelspruit, South Africa.
Newton, P.J. & Odendaal, W.J. 1990. Commercial inundative releases of *Trichogrammatoidea cryptophlebiae* (Hym: Trichogrammatidae) against *Cryptophlebia leucotreta* (Lepidoptera: Tortricidae) in Citrus. *Entomophaga* 35(4): 545 - 556.
Schwartz, A. 1975. Is daar hoop om valskodlingmot onder die knie te kry? *The Citrus and Sub-Tropical Fruit Journal*, October 1975: 15 & 21.
Stofberg, F.J. 1954. False codling moth of citrus. *Farming in South Africa*, June 1954: 273-276.
Stotter, RL. 2009. Spatial and temporal distribution of false codling moth across landscapes in the Citrusdal area (Western Cape Province, South Africa). MSc thesis, University of Stellenbosch, 101 pp.
Stotter, RL. 2011. Monitoring the efficacy of Sterile Insect Technique to control false codling moth in the Citrusdal area (Western Cape Province, South Africa). *CitrusResearch International Annual Research Report 2010-11*, pp 39-56.

Appendix 4

Thaumatotibia leucotreta (FCM): climatic suitability in the EPPO Region

A. Introduction

This appendix describes how the climatic suitability of the EPPO Region has been assessed to help:

- define the area of potential establishment (Q3.08)
- assess climatic suitability in the area of potential establishment (Q3.11)
- assess the likelihood of transient populations (Q5.03)
- define the area at highest risk (Q6.15b)

It was decided to undertake a more detailed investigation than a visual comparison of global climate zones as provided by Capra to attempt to map the area of climatic suitability.

We therefore followed the decision support scheme (DSS) for climatic mapping (Eyre *et al.*, 2012) prepared by the EU PRATIQUE project to:

- ensure that climatic mapping for FCM in the EPPO region is appropriate and feasible
- assemble information on the pest's climatic responses
- determine the pest location categories

Section B shows how we used the PRATIQUE climatic mapping DSS. Section C describes the approach adopted and the conclusions are provided in section D.

B. The PRATIQUE Climatic Mapping Decision Support Scheme (DSS)

Answers are provided for the false codling moth (**FCM**), *Thaumatotibia leucotreta,* in the text boxes

"Based on the area of potential establishment already identified, how similar are the climatic conditions that would affect pest establishment to those in the current area of distribution?"
(Question 3.11 in the risk assessment section)
not similar, slightly similar, moderately similar, **largely similar,** completely similar

FCM: Largely similar

Level of uncertainty:	Low	**Medium**	High

FCM: Medium

Stage 1: "Is it appropriate to map climatic suitability?"
B1.1 Based on the response to Question 3.11, is there low uncertainty that the climate in the area suitable for establishment is completely or largely similar to the climate where the pest is currently present?

Note: Answer "yes" if the climate is completely or largely similar to areas where the pest is already present, especially if it is widespread and abundant. This is particularly likely to be true if the species is present and common in a neighbouring country with a similar climate or the climatic responses of the pest and the host species that occur in the PRA area are known to be very similar. Climatic mapping may also not be required if the PRA area has a relatively uniform climate or the pest is known to be able to adapt to a very wide range of climatic conditions. For example, pests that are widespread and common in one area with a Mediterranean climate, e.g. California, are likely to find at least part of other areas with a Mediterranean climate, e.g. in Europe, climatically suitable for establishment. The global and regional maps of Köppen-Geiger climate zones, hardiness zones and growing degree days can be used to help answer this question (see guidance on answering question 3.11 in the main qualitative scheme).

If Yes: Mapping climatic suitability may not be needed unless it is important to highlight areas where the climate is particularly suitable, e.g. to identify the endangered area.
Provide a justification for not mapping climatic suitability & Return to the PRA Scheme

If No or there is a need to highlight areas where the climate is particularly suitable:
Mapping may be appropriate
Provide a justification &Go to Question 1.2

FCM: NO
Although FCM is present in the coastal plain of Israel, further investigation is needed to identify other areas that are climatically suitable.

B1.2 Based on the response to Question 3.11, is there low uncertainty that the climate in the area suitable for establishment is not similar or slightly similar to the climate where the pest is currently present?

Note: Answer "yes" if the climate is not similar or slightly similar to areas where the pest is already present, e.g. a pest with a tropical distribution that has never been found in protected conditions being assessed for a PRA area with a temperate climate. This is particularly likely to be true if the climatic responses of the pest and the potential host species that occur in the PRA area are known to be very different. Even if the climate is very unsuitable, climatic risk mapping methods may still be employed to identify areas where transient populations might occur.
This question is particularly relevant if, in the categorisation stage of the PRA, you have answered UNCERTAIN to question 1.16: "Does the known area of current distribution of the pest include ecoclimatic conditions comparable with those of the PRA area or sufficiently similar for the pest to survive and thrive (consider also protected conditions)?"

If Yes: climatic mapping can be used to confirm such a conclusion but the time and effort required may not be appropriate if the evidence is very clear.
Provide a justification for not mapping climatic suitability & Return to the PRA Scheme

If No: Mapping may be appropriate
Provide a justification &Go to Question 1.3

FCM: NO
FCM presence in the coastal plain of Israel indicates that some parts of the PRA area are highly suitable climatically.

B1.3 Does the species spend a large part of its life cycle experiencing climatic conditions significantly different to those measured at weather stations?

Note: Consider situations where climate, as measured at weather stations, is likely to be dissimilar to the microclimate inhabited by the species because it undertakes much of its life cycle in protected or irrigated cultivation, submerged aquatic habitats, the soil, thick woody plant tissue or vectors. In such microhabitats, the microclimate may still be influenced by the external climate but daily and seasonal conditions are less likely to vary. For example, mound-building ants may experience constant temperatures which are approximately the same as daily average air temperatures (Sutherst & Maywald, 2005).The survival of species overwintering on the soil surface may be greater in areas with predictable snow cover that insulates the ground from extreme temperature minima. Arthropods may exhibit behavioural thermoregulation, e.g. by moving to more favourable microhabitats, aggregating into colonies or forming structures such as silken webs. Some organisms have stages in their life cycle when the climate has little influence, e.g. resistant fungal spores and insects in winter or summer diapause.

If Yes: climatic mapping may be irrelevant or the results may be difficult to interpret
Provide a justification for not mapping climatic suitability & Return to the PRA Scheme

If No OR Uncertain: Mapping may be appropriate
Provide a justification &Go to Question 1.4

FCM: NO
The larval stage is protected within the fruit and the pupal stage may be in the soil but climate will still play a role in influencing survival.

B1.4 Are the climatic limits to the distribution very unclear or very difficult to infer because the distribution of the pest is very poorly known, the pest is known to be spreading very rapidly or its distribution is extremely dependent on the distribution of factors other than climatic conditions?
Note: The distribution of the pest may be very poorly known if there are very few unambiguous current records in scientific databases and the literature. Factors other than climatic conditions that can significantly affect distribution include, for example, the presence of hosts, specific habitats, vectors, geographical barriers (such as the sea or mountains), competitors, natural enemies, pest or crop management measures, e.g. irrigation. In such situations, climatic mapping may only indicate the minimum area likely to be climatically suitable for the pest at risk and interpretation of the risk maps may therefore be problematic.

If Yes: climatic mapping may provide results that are difficult to interpret
Provide a justification for not mapping climatic suitability & Return to the PRA Scheme

If No OR Uncertain: Mapping is likely to be appropriate
Provide a justification &Go to 1.5

FCM: NO
The species distribution is fairly well known in sub-Saharan Africa. However, in the south-west of South Africa (Western Cape) the species is not considered to be native, there are only a few location records, and the southernmost limits to its distribution are set by the Indian and Atlantic Oceans. In addition, for year-round survival, the species needs fruit to be continuously available (although the species is polyphagous and can be found on nuts (acorns) in the Cape).

B1.5 Decide whether to model and map climatic suitability
If your answers have led you to this point, modelling and mapping climatic suitability is likely to be appropriate. Take into account the following notes and:
GO TO STAGE 2

Stage 2: What type of organism is being assessed and what are the key climatic factors limiting its distribution?

Please fill in the following two tables based on the type of organism and the importance of the climatic factors that will affect its distribution in the PRA area. If the climatic factors listed in the second table are incomplete, too broad or relate to a different time period, additional factors can be added (as "Other"). In Stage 3, the availability of the key climatic factors limiting distribution is assessed in more detail.

Arthropod	Nematode	Plant	Virus or Viroid	Bacteria	Fungus & Fungal-Like Organisms	Other
✓						

Climatic Factor	Note	Rating	FCM *Thaumatotibia leucotreta*
Winter Temperature)	*Consider whether the species distribution is known to be limited by minimum winter temperatures and whether the species can survive low temperatures by diapausing or forming cold-resistant stages (e.g. spores, pupae, seeds and bulbs.*	+++	Without the capacity for diapause, FCM will be particularly vulnerable to continuous cold conditions but may be able to survive in areas where there are large diurnal fluctuations. Temperatures below 0°C for 2-3 days can kill eggs (Daiber, 1979a). Under field conditions oviposition was limited to the early night time period and essentially ceased at a temperature between 15°C to 10°C (Daiber, 1979d). Daiber (1979a) states that in South Africa FCM is well adapted to warm areas where for example citrus is grown and poorly adapted to colder areas where for example peaches are grown. Likewise Daiber 1978 concludes that "low temperatures are a strong factor limiting *T. leucotreta* numbers".
Summer Temperature	*Consider whether the species distribution is known to be limited by summer temperatures, particularly whether it may be difficult for it to complete its life cycle due to insufficient degree days above its minimum temperature threshold. Temperature maxima may be limiting in some areas.*	+	Both the PRATIQUE insect and mite thermal requirement database (Jarosik *et al*, unpublished) and the Insect Development Database (NAPPFAST, 2011) interpret Daiber's extensive work (summarised by Venette *et al.*, 2003) and show the minimum temperature for development to be 12°C and the heat sum over the summer growing season (growing degree days) for FCM to complete one generation (egg to egg) to be 433. This amount of degree days is widely available in the PRA area and is likely to allow transient populations to develop in the summer. The upper limit for development is given at 40°C.
Rainfall	*Rainfall is particularly likely to be critical for pathogen infection and plant survival (with indirect effects on insect populations). Extreme rainfall events may affect invertebrate populations.*	-	In the drier areas, its crop hosts are irrigated. Very young larvae may be washed off before they burrow into the fruit. Cold temperatures and heavy rainfall can kill eggs (Daiber, 1979a)
Humidity	*Humidity plays a particularly important role in pathogen life cycles. For invertebrates and plants, humidity may also significantly affect survival depending on the ambient temperature. Invertebrates can avoid desiccation by diapausing, pathogens by forming drought resistant spores, and plants by using seeds, bulbs or*	-	Newton (1988) states that humidity causes mortality for eggs and young instars in the lab. Daiber (1979a & c) states that low humidity is detrimental to egg and pupal survival. However, FCM can survive hot dry summers in the Cape and cold dry winters in the high veld of Transvaal, suggesting that whereas

Climatic Factor	Note	Rating	FCM *Thaumatotibia leucotreta*
	losing their leaves.		it may influence abundance, overall this parameter is not critical for survival.
Leaf Wetness	*Leaf wetness duration is particularly important for infection by foliar plant pathogens.*	-	Not relevant
Soil or substrate temperatures	*Consider how much of the life cycle is spent in the soil or other substrates (e.g. aquatic habitats or thick woody plant tissue – see Stage 1 question 1.3). Soil temperatures may be correlated with average daily air temperatures depending on soil depth, plant cover, type, moisture, drainage, etc.*	-	Daiber (1979c) reports that FCM pupae in soil are sensitive to temperatures below 11°C.
Soil or substrate moisture	*Soil moisture is likely to be particularly important for plants. Pathogen and invertebrate life cycles may also be affected through their plant host.*	++	FCM requires host plants that will not tolerate soil moisture below permanent wilting point for prolonged periods. This will prevent it from persisting in xeric environments unless irrigation is practised. FCM pupates in the soil, pupae are intolerant of high soil moisture conditions (Schwartz 1981) and under field conditions in South Africa wet winters have been reported to result in population suppression (Gunn 1921, Ford 1938, Daiber 1979c).
Other (please specify)	*Other abiotic factors include, e.g. solar radiation, snow cover and late spring frosts.*	-	

Rating	Description
-	Climatic factor not directly relevant to species distribution
+	Minor factor determining species distribution
++	Important factor determining species distribution
+++	Critical factor determining species distribution

Stage 3: How much information is available on the key climatic factors affecting distribution?

Climatic Factor	Known?	Uncertainty	FCM *Thaumatotibia leucotreta*
Temperature: minimum threshold for development	++	low	The minimum threshold for development is interpreted to be 12ºC by (Jarosik *et al*, in press) and the Insect Development Database (NAPPFAST, 2011) based on Daiber's extensive work (summarised by Venette *et al*., 2003).
Temperature: optimum for development	+	medium	
Temperature: maximum threshold for development	++	low	The upper development limit is given as 40ºC. No lethal hot temperature is recorded.
Temperature: degree days to complete life cycle	++	low	The egg to adult development time is given as 405 and the egg to egg development time as 433 degree days by the insect development databases noted above.
Temperature minimum survival	+	medium	Temperatures below 0˚C for 2-3 days can kill eggs (Daiber, 1979a). Myburgh (1965) demonstrated high levels of larval mortality after protracted exposure to 1.1˚C and probit 9 level mortality after exposure to -0.5˚C for 21 days.
Rainfall: minimum annual total	N/A		
Relative Humidity optimum	N/A		
Leaf Wetness duration	N/A		
Soil temperature	N/A		
Soil moisture	++	High	FCM requires host plants that will not tolerate soil moisture below permanent wilting point for prolonged periods. This will prevent it from persisting in xeric environments unless irrigation is practised. High levels of soil moisture are detrimental to larval survival (Schwartz 1981).
Other	N/A		

Note:
The ability to apply climatic modelling and mapping programs for a particular species depends on the extent to which its climatic responses for development and survival:

- can be inferred from its current distribution.
- are available from field or laboratory experiments;
- can be calculated or inferred from field studies at known locations where climatic factors have been recorded;

Even for the very few species that have known climatic responses obtained from experiments in the laboratory, evidence from field studies and knowledge of their current distribution are still important because

- Climate factors may limit the distribution of a species indirectly.. For example, *Dothistroma pini* is a plant pathogen that forms cold tolerant spores that can be safely stored at -80 °C, but it's poleward range appears limited by the ability of its host plants to tolerate temperatures below -30 °C (Watt *et al*. 2009)
- laboratory experiments, often conducted under constant temperatures, cannot emulate field conditions in which temperature and other climatic variables fluctuate and interact.
- the laboratory data may have been generated from small sample sizes and the genetic composition of the populations may be different from the potential invaders considered by the PRA.

Rating	**Description**
N/A	Climatic factor not directly relevant to species distribution
-	No information
+	Very little data or high uncertainty on climatic responses. Information often inferred from field studies or related species.
++	Data from one study or from more than one study but with no clear consensus.
+++	Information based on detailed experiments consistently supported by more than one study.

Uncertainty	**Description**
low	Low Uncertainty
medium	Medium Uncertainty
high	High Uncertainty

Stage 4: What category of location data is available?

Select one or more of the following location data categories.

[The table has been filled in for FCM *Thaumatotibia leucotreta.]*

N	Pest location data category	*Notes*	Implications for modelling	Category Choice	FCM *Thaumatotibia leucotreta*
1	**Native range locations only**	*This category refers to situations where the distribution in its native range is well known but the species may not have invaded new areas or locations in the new areas are unknown.*	The native range of a species represents its *realised* niche, which may be more climatically conservative that its*fundamental* niche. A species' realised niche includes the negative effects of its natural enemies, which can reduce its population growth rate and reduce its ability to persist in marginal habitats. For models built using only the native range, the data should be considered to be conservative unless supported by ecophysiological data that indicate that it is persisting in all areas that it can tolerate. Natural enemies include parasites, parasitoids, predators and competitors affecting the pest or its host(s).		
2	**Native plus exotic range locations**	*In this category, the distribution of the species in both the native and invaded region is well known.*	Where we have knowledge of a species in its native and its exotic range, we may be able to detect evidence of climatic range expansion due to release from the effects of its natural enemies. This effect is most likely to be observed when and where climatic resources are most abundant. We can be most confident that we are seeing a species expressing its full range of climatic tolerance where it has spread in an exotic range without encountering geographic dispersal barriers and its distribution appears to be at dynamic equilibrium. The	✓	Exotic range includes, Western Cape Province, South Africa and the Israeli coastal plain. The residency record for Ireland was found to be incorrect.

N	Pest location data category	*Notes*	Implications for modelling	Category Choice	FCM *Thaumatotibia leucotreta*
			resulting distribution may still be conservative, but this is the best field-based data that we can usually draw upon.		
3	**Locations biased to the periphery of the range**	*The periphery of the range is similar to the zone of occasional abundance defined by Hill (1987[4]) where climatic conditions are less suitable, e.g. cooler or drier, with greater variation in suitability than in the centre of its range. Here, the population may be kept low by climatic conditions and the pest only rarely causes significant damage.*	Peripherally-biased species distribution data will not affect those techniques that utilise the outer ranges of a species climatic tolerances to describe its range. This includes the climate envelope models (e.g. Bioclim and Habitat) and the niche models (CLIMEX Compare Locations). Floramap will probably indicate the core suitability appropriately. Other regression-based models will tend to under-represent the risk in the core suitability area and over-represent it in the marginally suitable habitat.		
4	**Locations biased to the centre of the range**	*The centre of the range is similar to the (endemic) zone of natural abundance (Hill, 1987) where the pest is always present often at high density. Here climatic conditions are relatively*	All models that rely solely upon the species distribution data to infer climate suitability will underestimate its potential distribution. Models built using ecophysiological observations can use the distribution data as a fuzzy validation. CLIMEX Compare Locations can still use climate responses and some knowledge of biology to estimate the range periphery.	✓	There is a greater amount of information on locations where FCM is present in damaging population densities in South Africa.

[4]Hill DS (1987) Agricultural Insect Pests of Temperature Regions and their Control.Cambridge University Press.Cambridge. Page 21

N	Pest location data category	*Notes*	Implications for modelling	Category Choice	FCM *Thaumatotibia leucotreta*
		favourable and the species is regularly a pest of some importance.			
5	**Few location data points**	*The pest has been recorded at only a few locations.*	All models that rely solely upon the species distribution data to infer climate suitability will underestimate its potential distribution. Models built using ecophysiological observations can use the distribution data as a fuzzy validation. CLIMEX Compare Locations can still use climate responses and some knowledge of biology to estimate the range periphery.		
6	**Very few location data points**	*The pest has been recorded at very few locations.*	All models that rely solely upon the species distribution data to infer climate suitability will underestimate its potential distribution. Models built using ecophysiological observations can use the distribution data as a fuzzy validation, CLIMEX Compare Locations can still use climate responses and some knowledge of biology to estimate the range periphery. Climate similarity (e.g. CLIMEX Match Climates and Domain) and Climate Envelope models (Bioclim and Envelope Score) may usefully indicate broad geographic areas of concern. These results should be considered as conservative if high thresholds are used. Using low thresholds with climate similarity and envelope models should be avoided, as it is just as likely to include false positive locations as it is to infill suitable locations (Csurhes & Kriticos 1994)		
7	**Erroneous locations**	*It is known that the list of pest locations*	Erroneous locations have the potential to significantly bias the results of the climatic		

N	Pest location data category	*Notes*	Implications for modelling	Category Choice	FCM *Thaumatotibia leucotreta*
	included	*includes some that are erroneous but these cannot be directly identified and deleted.*	modelling, resulting in a model that overstates the geographic risk. Ideally, location records should be scrutinised to check that they represent an established population, although this is not always easy or possible. Few models provide useful diagnostic techniques to identify climatic outliers in the species distribution data. Diva GIS provides a set of graphical tools to visualise climatic outliers. CLIMEX Compare Locations confronts the modeller with the challenge of fitting outlying points with biologically reasonable climatic response functions. The outputs of phenology models could be checked for locations when a location point appears unreasonable. If a distribution point requires unreasonable parameter values, a range of techniques are available to explore whether this is due to geocoding error, a favourable land use overcoming climatic limitations or another factor.		
8	**Locations influenced by land use (e.g. irrigation practices) and other non-climatic factors**	*The distribution is influenced by non-climatic factors apart from host distribution (see Stage 1, question 1.4). Host distribution is considered in category 10. It includes situations where the pest distribution is constrained by*	Models built solely using distribution data may overstate the geographic risk, if the non-climatic range-influencing factor is promoting the species' persistence in a location. If the land use is also present in the PRA area in a similar climate then this may be an appropriate indication of risk. Reviewing the biology and ecology of the pest species should provide an indication of whether or not land use factors will be important. It is possible to model the distribution with and without the presence of the land use factor. Models that include consideration of ecophysiological data may	✓	Limits in South Africa are influenced by the Atlantic and Indian Oceans.

N	Pest location data category	*Notes*	Implications for modelling	Category Choice	FCM *Thaumatotibia leucotreta*
		major geographical features, e.g. mountain ranges and the sea, and expanded by crop management measures such as irrigation.	identify these outliers, enabling their effect to be gauged (e.g. CLIMEX Compare Locations). Where this type of effect is suspected, the land use should be confirmed through other sources (e.g. by contacting local experts or consulting land use datasets), or by using a model to simulate its effect (e.g. the irrigation scenario in CLIMEX Compare Locations or a temperature modification scenario in a phenology model). Southern hemisphere distributions for terrestrial species may be constrained by a lack of land extending into high latitudes. Competition (e.g. from species in the same genus) may preclude a species from expressing its full climatic range potential in areas where the natural enemies are not present. In this case, all models that rely solely upon the species distribution data to infer climate suitability will underestimate its potential distribution. Regression-based models will usually provide conservative results when trained on location data affected by this form of bias. Models informed by ecophysiological observations may identify and overcome this problem. The problem may become apparent if the model requires parameter values that are excessively conservative for the organism type being considered.		
9	**Locations influenced by seasonal invasion**	*The locations include some points from areas where the species is only transient (not*	Models may overstate the risk if ephemeral (transient) distribution records are treated as if they represented established populations. Suspicious points may be identified by considering ecophysiological	✓	It has been recorded in Northern Europe, e.g. the UK and Ireland, but these are considered to be transients.

N	Pest location data category	*Notes*	Implications for modelling	Category Choice	FCM *Thaumatotibia leucotreta*
		established) and its presence is dependent on seasonal invasion.	data. If the species needs to survive excessively stressful climatic conditions through part of the year at a location and it has no obvious resting stage (e.g. pupa or seed) or refugia in the vicinity and there is a likely source population within a reasonable dispersal distance then it may be likely that the record represents a transient population.		
10	**Distribution constrained by hosts**	*The pest's current distribution is limited to areas where the host is present despite other areas being known to be climatically suitable.*	All models that rely solely upon species distribution data to infer climate suitability will underestimate its potential distribution. Producing a map of host and pest distribution may help to determine whether this is a factor. Models may also underestimate the pest risk if other hosts are present in the PRA area, and they are able to inhabit a wider climatic range than the host in the training dataset. A requirement for biological reasonability in parameters may overcome this problem.	✓	Limits are also determined by the presence of fruit all year round.
11	**Regional distribution data only**	*Precise location data based on latitudes and longitudes (or named locations from which latitudes and longitudes can be derived) are unavailable and the distribution is only available at the regional (state, province, department,*	Fuzzy input data can be used to inform a similarly fuzzy estimate of pest risk. Be aware that country records can both over-estimate, as well as underestimate risk if a country is not noted as being inhabited by a species because its presence is of insufficient consequence or it has insufficient scientific infrastructure, etc.		

N	Pest location data category	*Notes*	Implications for modelling	Category Choice	FCM *Thaumatotibia leucotreta*
		county, etc) level.			
12	**Locations influenced by climate change**	*The location dataset includes data from areas that have only recently become suitable due to climate change. Where historical data are available, it is possible that climatic conditions are no longer suitable at these locations.*	A mismatch of climate data and distribution records can result in either over- or under-estimating pest risk. Modellers should carefully consider the effect of recent range expansion or contraction due perhaps to climatic warming, and the effect that this may have on the perceived pest risk. The time period represented by the climatic dataset used in modelling will influence the model predictions.		
13	**Location category unknown**	*Location data are available but cannot be assigned to categories 1-12 because too little is known about what they represent.*	Extreme caution should be exercised with using these data.		

Stage 5: Based on the type of organism, the information available on its climatic responses and the availability of location data, *how well is each climatic mapping method likely to perform in assessing current and future pest risk*?

Objectives of Stage 5:
In this stage, the likely performance of each climatic mapping method is compared based on the information summarised in Stages 2-4. Armed with this knowledge, risk assessors should be able to judge how well each model is likely to perform for the pest and for the area being studied and then make an appropriate selection taking into account other more general attributes of each model, e.g. usability and functionality.

B5.1 Summarise the information obtained in Stages 2-4 in the following table:

Organism	Limiting climate factor	Limiting climate factor responses known?	Location Data Category
Arthropod	Summer temperature sum Winter temperature minima Soil moisture	+++ + ++	2. Native plus exotic locations 4. Locations biased to the centre of the range 8. Locations influenced by land use (and other non-climatic)factors 9. Locations influenced by seasonal invasion 10. Distribution constrained by hosts

B5.2 Refer to the Table in Annex 2C of the PRATIQUE Decision Support Scheme that provides a summary of model performance based on climate response information and location data.

This table does not indicate whether one model is better than another in estimating potential distribution. It compares the susceptibility of each modelling system to problems that can arise from different input data quality issues. It is intended as a cautionary guide to alert the assessor to data quality issues that can arise with using each model system. It is important to note that, in practice, input data may suffer from more than one type of bias or data quality issue at the same time.The assessor should be vigilant to these issues and seek to understand the behaviour of the selected modelling system sufficiently well as to understand signs that the input data may be suffering from biases. Some modelling systems provide information tools to identify such problems.

B5.3 Refer to the Table in Annex 2D of the PRATIQUE Decision Support Scheme which provides general information on the differences and similarities of each climate risk modelling and mapping method

The similarities and differences are described for each of the following headings:

Functionality, e.g.:

- *whether climate data are included*
- *the number of climatic variables*
- *the time step*
- *ability to modify parameter variables*

Ease of use, e.g.:

- *complexity*
- *training requirements*
- *availability*
- *cost*
- *speed*

Quality assurance and user confidence, e.g.:

- *sensitivity analysis and outlier identification*
- *relationship between model methodology and known biological/ecological processes*

Appropriateness for location data categories, e.g.:

- *locations biased to the range periphery*
- *few data.*

B5.4 Choose your Climatic Mapping Method

Although a CLIMEX compare locations model was explored for FCM, this was abandoned because:

- too little is known about the factors influencing winter survival
- the distribution in South Africa is too strongly influenced by, the presence of the sea and the requirement for a continuous food (fruit) supply to make it easy to infer the areas that are at the climatic limits of its distribution

A simple rule based on diurnal temperatures (based on the difference between weekly maxima and minima) was adopted although it is recognised that:

- this is based on very few locations (though these are considered to include the extremes in South Africa)
- since we are uncertain of the characteristics of the coldest winter that FCM can survive, this rule may identify only a minimum area of potential establishment when extrapolated to the EPPO Region

C. Mapping the Climatic Suitability of the EPPO Region for *Thaumatotibia leucotreta* (FCM).

C1 Summary of the key information influencing the mapping of climatic suitability of the EPPO Region for FCM

The following information is particularly relevant to the analysis;

- FCM is established in Israel confirming that at least part of the EPPO Region is climatically suitable
- FCM can be assumed to be capable of establishing in Mediterranean climates (with cool wet winters and hot dry summers) because it is present in:
    - The coastal plain of Israel between Hadera and Ashdod (Wysoki 1986), Hamburger *et al.* (2001) and Opatowski personal communication)
    - Western Cape Province (South Africa), particularly in Citrusdal (Stotter, 2009), but also at Stellenbosch, Swellendam and Knysna.
- FCM's native range in South Africa is primarily in areas with a non-Mediterranean climate (wet summers and dry winters) that is particularly cool in the high veld area near Pretoria (Rustenburg and Lyttelton) where peach is the primary host. Reports from field studies in South Africa indicate that the species is well adapted to warm areas where for example citrus is grown and poorly adapted to colder areas where for example peaches are grown (Daiber 1979a). Likewise Daiber (1978) concludes that "low temperatures are a strong factor limiting *T. leucotreta* numbers".
-
- Our knowledge of FCM's capacity to survive cold weather in a wet Mediterranean winter is limited because (a) the Atlantic and Indian Oceans prevent us from knowing whether FCM could survive further south and (b) we only have a few confirmed locations for Western Cape Province.
- Our knowledge of FCM's capacity to survive cold weather in a dry high veld winter is limited because the cold limits to its distribution in the high veld are not well known.
- Although FCM has a relatively high overall minimum threshold of development (12°C), it has a short life cycle (433 degree days) (Jarosik & IPD).
- No diapause has been observed and overlapping generations occur (x – y per year)
- The species requires the presence of continuous fruit to maintain its life cycle but the pupal stage has been observed to last for a maximum of 72 days (Daiber, 1979c)

- The hosts favoured by this species are primarily those that are vulnerable to very low temperatures.
- Apart from just after egg hatch, the larval stage is inside the fruit and buffered from external temperatures. Eggs and adults are most exposed to climatic extremes. Pupae are primarily found in the upper layers of soil (Daiber,1979)
- Some information on cold temperature survival is available (Daiber,1979a-d) but this is difficult to extrapolate to field conditions

Based on this information, it has been assumed that:

- climatic suitability in the EPPO region will be primarily dependent on its capacity for surviving the coolest period of the year.
- Rainfall and humidity will be much less important than temperature for overwintering survival
- Without the capacity for diapause, FCM will be particularly vulnerable to continuous cold conditions but may be able to survive in areas where there are large diurnal fluctuations
- In many areas where conditions will be too cold (or fruit unavailable) for overwintering, more than one generation may be possible during the summer allowing transient populations to occur (as suggested by moth trap catches in, e.g. the UK).
- High levels of soil moisture may also play a role in making some areas less suitable for establishment, but we considered low temperature to be more widely restrictive, with areas that may be unsuitable due to high soil moisture already being restricted by low temperatures.

C2 Methods

In order to determine the most appropriate method for delimiting the area that is climatically suitable for FCM we first examined the climatic conditions in Israel and at the limits to its distribution in South Africa.

We adopted the following approach:

(i) Identify where FCM occurs in South Africa and assess its abundance, focussing on the locations where it experiences the coolest climatic conditions in winter

(ii) Use the 1961-90 mean monthly minimum and maximum temperature interpolated to 10 minutes of latitude and longitude (New *et al.*,) and the similar Climond database loaded into CLIMEX (Kriticos *et al*) to represent the climate at the locations in South Africa and Israel where FCM is present

(iii) Compare the climates at the different locations by plotting them on the same graph ensuring that winter temperatures in northern and southern hemispheres coincide.

(iv) Compare minimum and maximum temperatures during the winter and the difference between the two variables at each location and determine whether a common pattern can be observed.

(v) Based on the evidence from (iv), decide whether predictions of climatic suitability can be based on an arithmetic rule extrapolated from the climatic data comparisons taking into account climatic response data in the literature.

Using the NAPPFAST program, Borchert (2005) in Stibick (2006) mapped two potential exclusion layers existing of 25 and 50 or more days where minimum daily temperature is below -1°C (30.2°F) and average daily temperature is below 10°C (50°F) but we did not follow this approach because the derivation of these parameters was not explained.

C3 Results

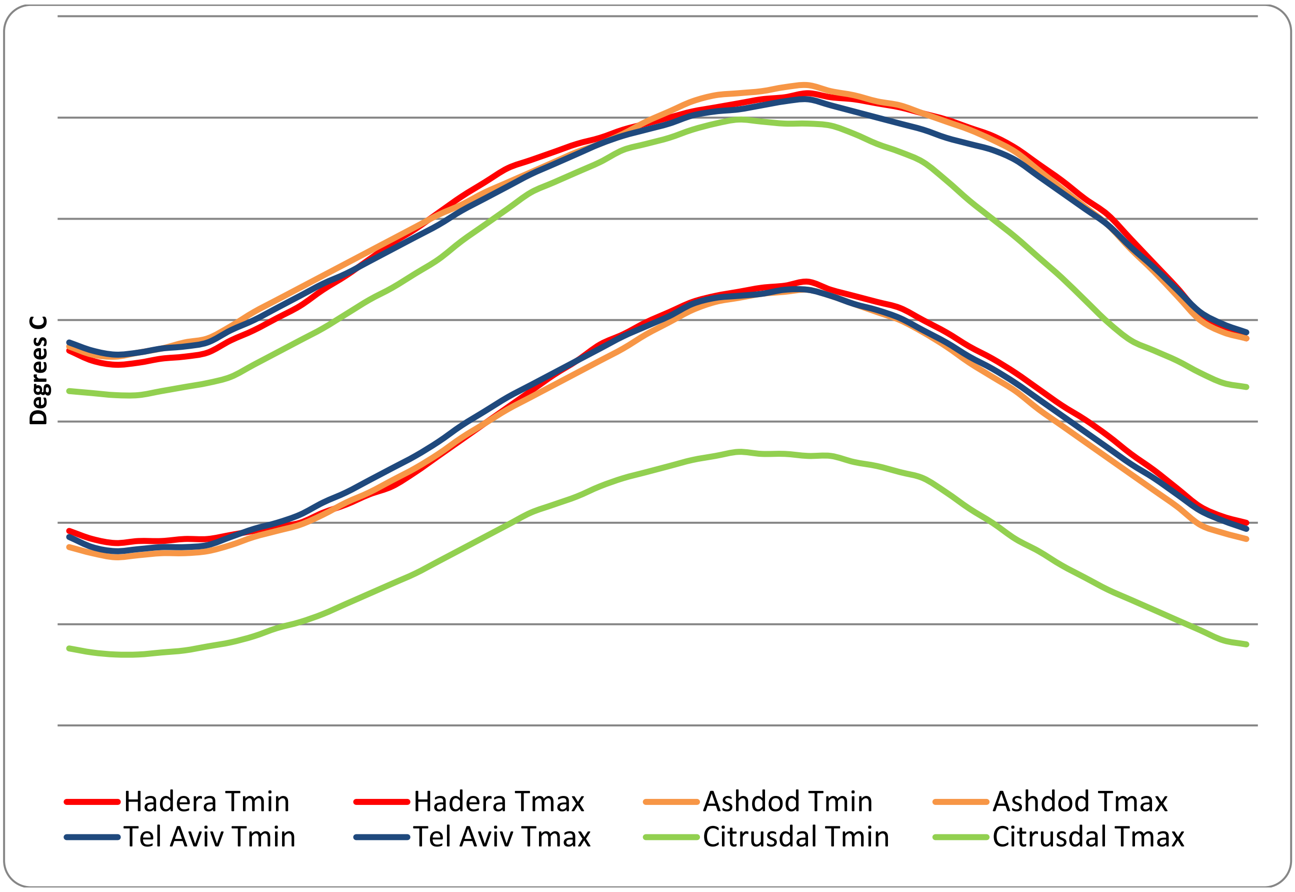

Fig. 1: Comparison of Maximum and Minimum Temperatures for grid cells representative of Citrusdal (South Africa) and Hadera, Ashdod and Tel Aviv (Israel) (1961-90 CliMond Database extracted from CLIMEX to give weekly data). The South African data have been switched so the winters coincide.

Fig. 1 shows that:

- maximum and minimum temperatures in the Israeli coastal plain at Hadera, Ashdod and Tel Aviv (between the two locations) are very similar and data from one location can be used to represent climate in the area where the pest occurs
- Citrusdal has slightly lower maximum temperatures than the Israeli locations year round
- Citrusdal has much cooler minimum temperatures than the Israeli locations year round.
- both Citrusdal and the Israeli locations have considerable differences between the maximum and minimum temperatures throughout the year. For Citrusdal the difference is greater in summer (17˚C) than in winter (13˚C). The Israeli locations have a difference of 10˚C throughout the year.
- the differences between maximum and minimum reflect a substantial diurnal temperature range that is likely to be of particular importance in overwintering survival. The biological relevance of this diurnal range is considered to be linked to the relatively high threshold temperatures for flight and especially egg laying, that is restricted to the early night time and is constrained by a temperature threshold of between 15˚C and 10˚C (Daiber 1980).

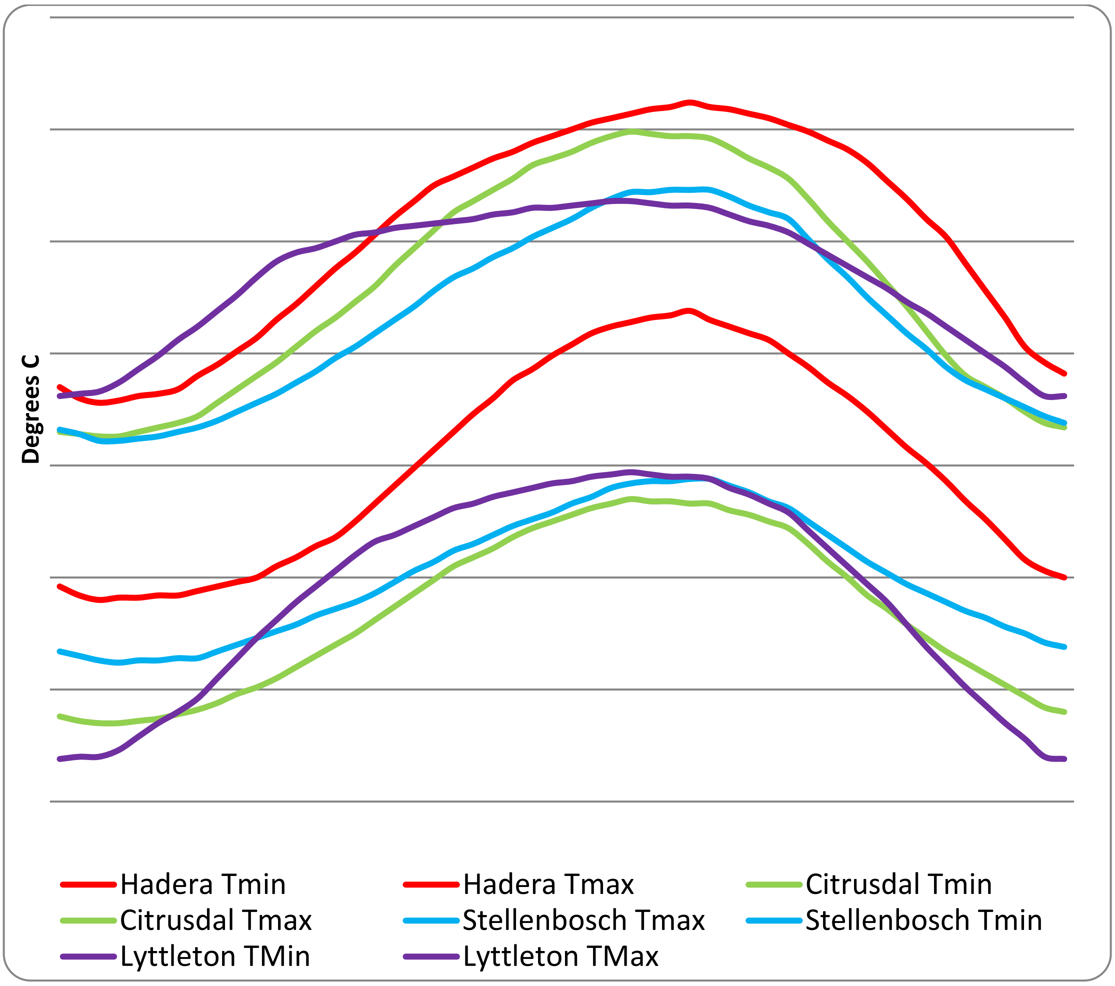

Fig. 2: Comparison of Maximum and Minimum Temperatures for grid cells representative of Citrusdal, Stellenbosch & Lyttleton (South Africa) and Hadera (Israel) (1961-90 CliMond Database extracted from CLIMEX to give weekly data). The South African data have been switched so the winters coincide.

Fig. 2 shows that:

- the South African locations, selected to be representative of FCM locations in the Western Cape (Citrusdal and Stellenbosch) and the coldest location where FCM has been recorded on the high veld (Lyttleton), all have much colder winter minima than on the Israeli coastal plain (Hadera)
- the winter minima at the South African locations coincide with maxima that are up to 15 degrees higher.
- the South African location with the lowest minimum temperature of approximately 3°C (Lyttleton) has the highest diurnal range and the highest maximum temperature (approximately 18°C).
- theSouth African locations with warmer minimum temperatures of approximately 4-7°C (Citrusdal and Stellenbosch) have a smaller diurnal range and lower maximum temperatures (approximately 16°C.

Assuming these locations are representative, this implies that the colder the minimum temperature, the higher the maximum temperature and the greater the diurnal temperature needs to be for overwintering survival.

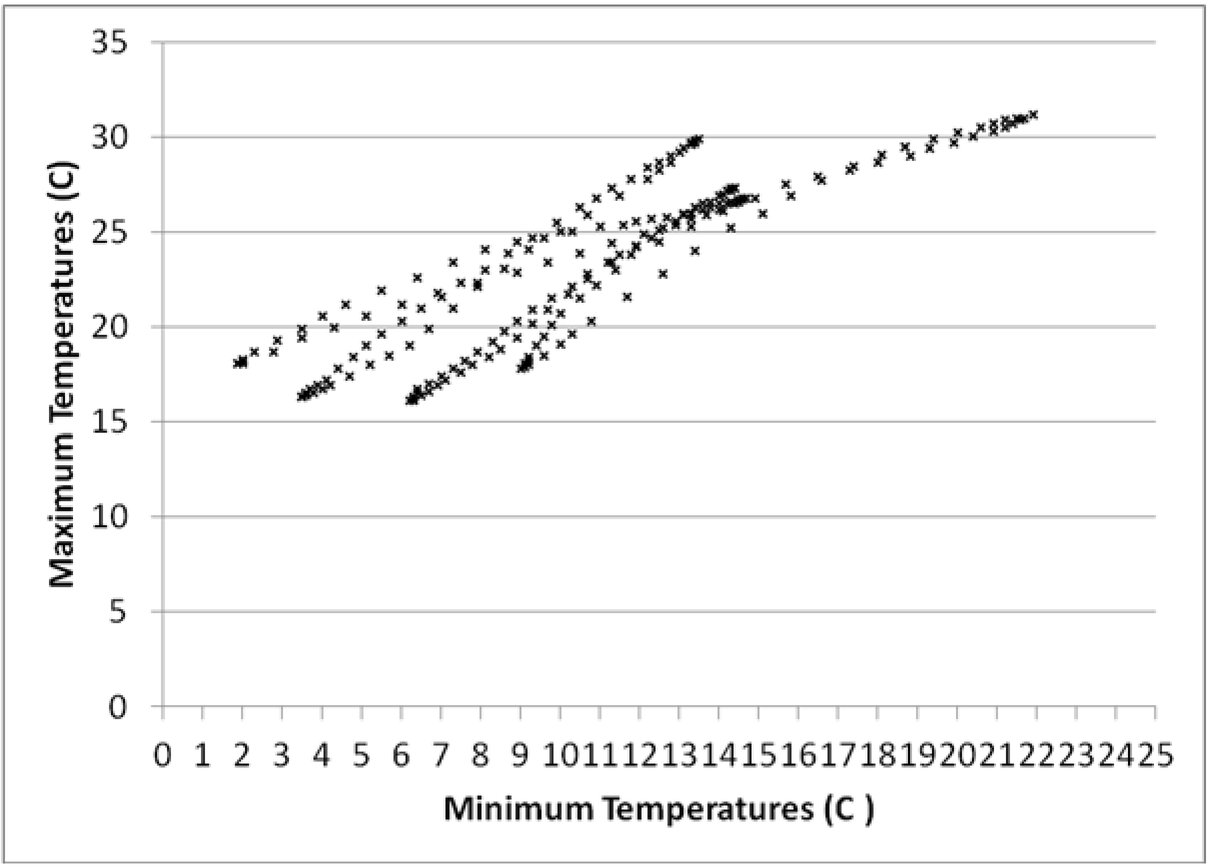

Fig. 3 Scatter plot of minimum and maximum temperatures for grid cells representative of Hadera (Israel), Citrusdal, Stellenbosch and Lyttleton (South Africa) (1961-90 CliMond Database extracted from CLIMEX to give weekly data)

Fig. 3 shows the relationship between minimum and maximum temperature at locations in Israel, the Western Cape and the high veld (South Africa).

Since the lower the minimum, the higher the maximum temperature during the coolest time of the year, it was decided to see whether a simple rule based on this graph might help explain the climatic limits to the distribution in South Africa and therefore help predict the limits in the EPPO Region. The following rule was used:

- Tmin >= 1°C and Tmax >= 18°C
- Tmin >= 3°C and Tmax >= 15°C

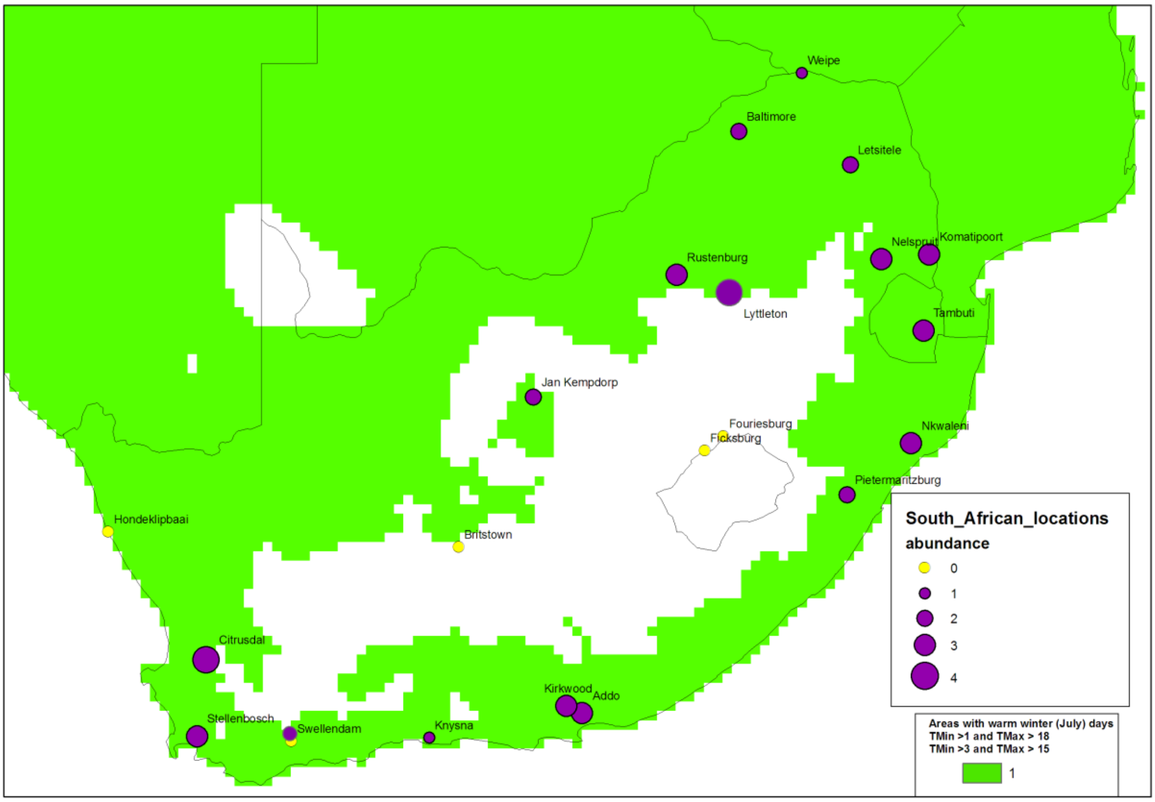

Fig. 4 Abundance of FCM at different locations in South Africa and the areas that are climatically suitable based on the relationship between maximum and minimum temperatures in the coldest month (July): Tmin >= 1°C and Tmax >= 18°C, or Tmin >= 3°C and Tmax >= 15°C

Fig. 4 shows that FCM only occurs where cold nights in July are followed by days which are up to 15-17°C warmer. The distribution, as obtained from the literature and by direct contact with workers in the field, is greatly influenced by the location of hosts and the areas surveyed.

Since this rule provides an area that corresponds well to the distribution in South Africa, we decided to apply it to the rest of the EPPO region.

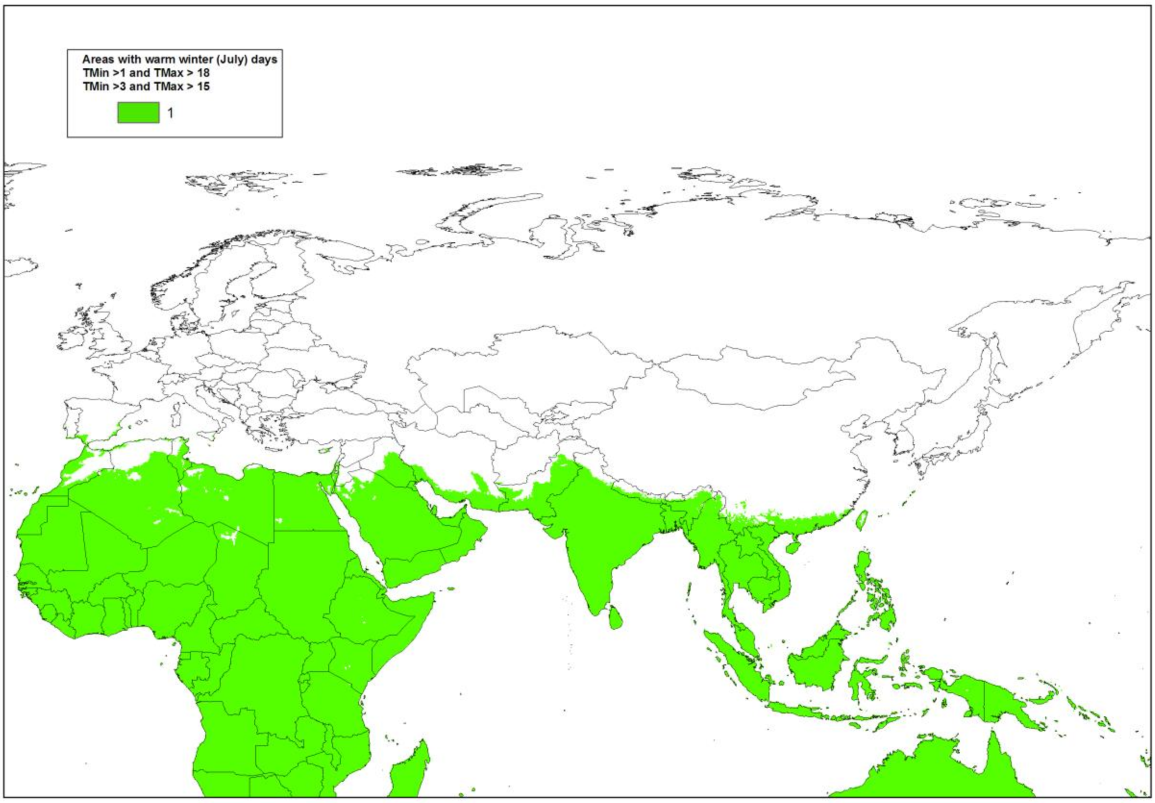

Fig. 5 The areas of the EPPO Region that are climatically suitable for FCM based on the relationship between maximum and minimum temperatures in the coldest month (July for the southern hemisphere and January for the northern hemisphere) based on: Tmin >= 1°C and Tmax >= 18°C, or Tmin >= 3°C and Tmax >= 15°C

Table 1 The number of 10 minute latitude x 10 minute longitude grid cells that are climatically suitable for FCM in the countries of the EPPO region

Country	**Number of Grid Cells**	**Area**
Algeria	6386	177.4
Cyprus	11	0.3
Israel	57	1.6
Italy	4	0.1
Jordan	29	0.8
Malta	1	0.0
Morocco	708	19.7
Portugal	15	0.4
Spain	122	3.4
Tunisia	394	10.9

However, most of these grid cells are in the deserts of Algeria, Morocco and Tunisia so Fig. 6 was prepared.

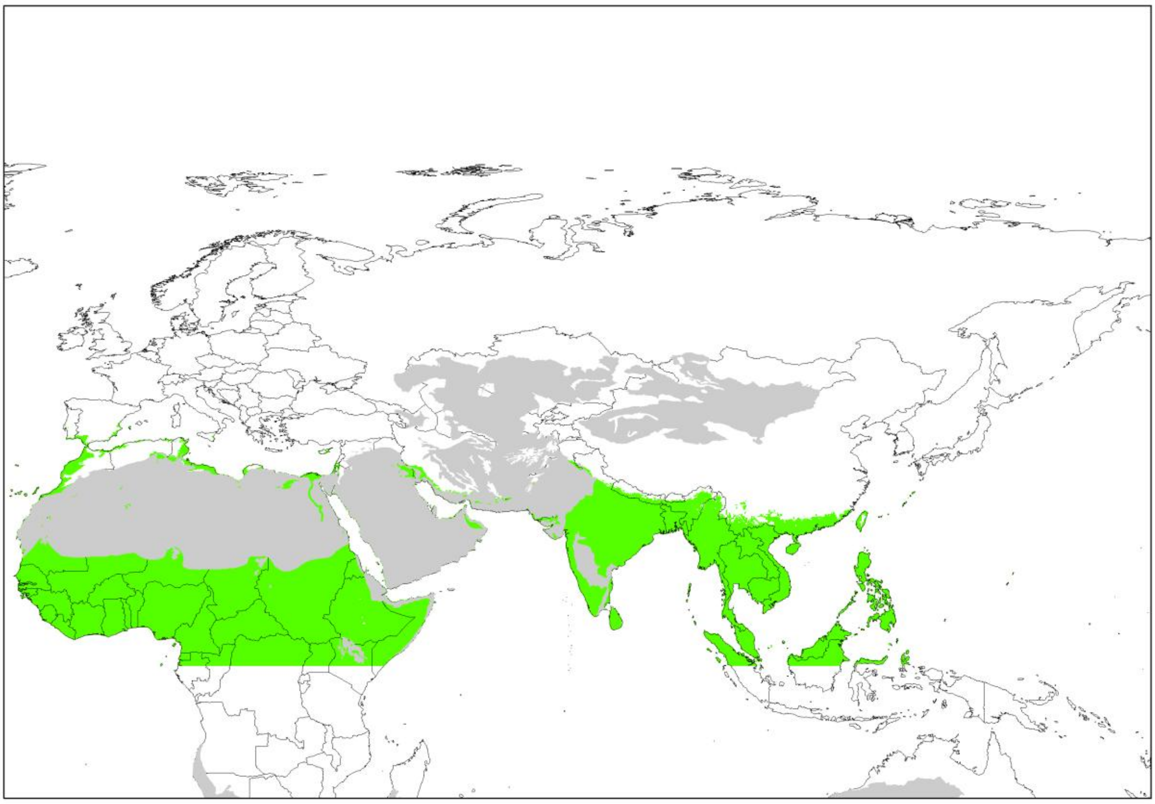

Fig. 6 The non-desert areas that are climatically suitable for FCM based on the relationship between maximum and minimum temperatures in the coldest month (July for the southern hemisphere and January for the northern hemisphere) based on: Tmin >= 1°C and Tmax >= 18°C, or Tmin >= 3°C and Tmax >= 15°C

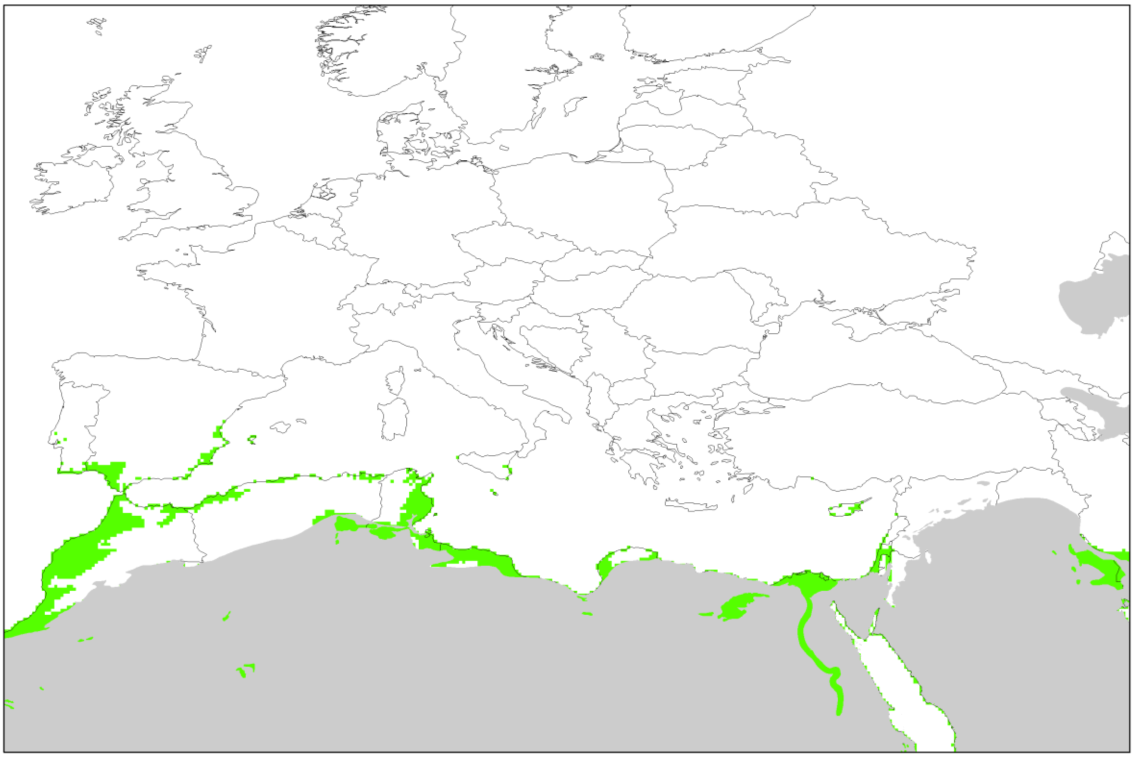

Fig. 7 The non-desert areas of the EU, North Africa and near East that are climatically suitable for FCM based on the relationship between maximum and minimum temperatures in the coldest month (July for the southern hemisphere and January for the northern hemisphere) based on: Tmin >= 1˚C and Tmax >= 18˚C, or Tmin >= 3˚C and Tmax >= 15˚C

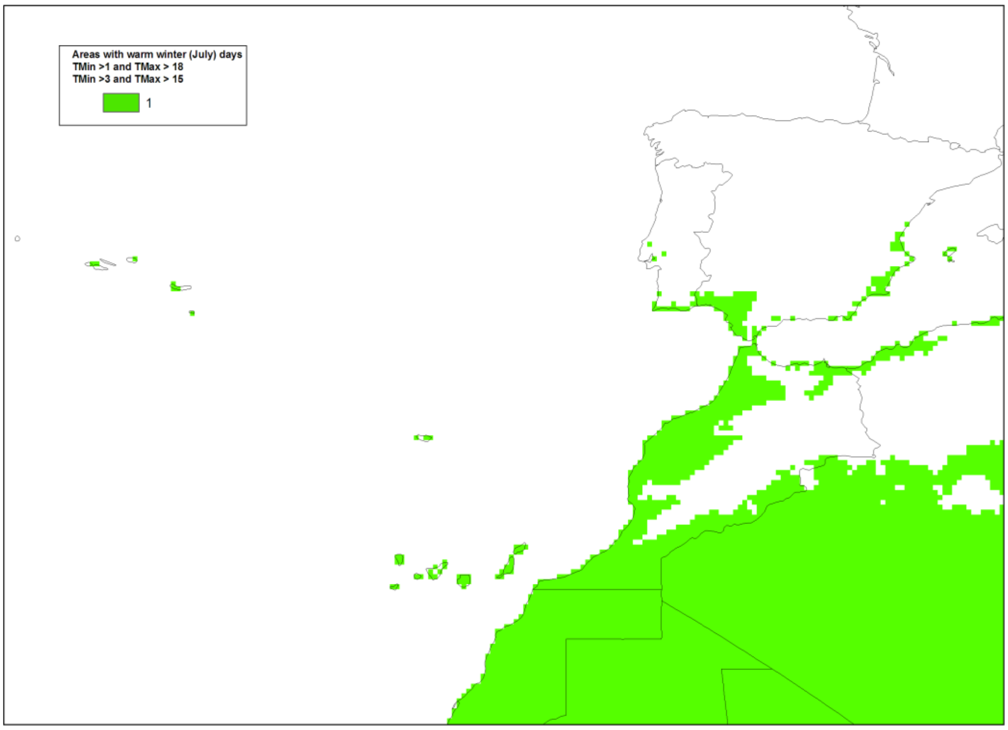

Fig. 8 The western area of the EU and North Africa (highlighting the Canary Islands and the Azores) that are climatically suitable for FCM based on the relationship between maximum and minimum temperatures in the coldest month (July for the southern hemisphere and January for the northern hemisphere) based on: Tmin >= 1˚C and Tmax >= 18˚C, or Tmin >= 3˚C and Tmax >= 15˚C

Figs. 5-8 show that the rule that requires low minimum temperatures above 1°C to be coupled with maxima that are 17°C higher and low minimum temperatures above 3°C to be coupled with maxima that are 15°C higher provides grid cells suitable for FCM overwintering in Portugal (and the Azores), Spain (and the Canary Islands), Italy (Sicily), Cyprus, Israel, Jordan, Morocco, Algeria and Tunisia within the EPPO Region. The Israeli locations for FCM are completely within this area.

Some locations, particularly those in southern Greece are very close to the threshold. Crete is covered by 22 grid cells and four of these have maximum temperatures greater than 14°C coupled with minimum temperatures between 7.8°C and 8.3°C. These data are interpolated averages for 1961-90 (mid-point 1975). Longer-term and more recent station data from Crete, Rhodes and the Peloponnese exceed the threshold. Thus the Hellenic National Meteorological Service[5] gives Heraklion, the principal town in Crete, a January 1955-1997 minimum average temperature of 9°C and a maximum of 15.3°C. In January 2011, the values were 9.9°C and 15.7°C for Heraklion.[6] Five other Crete weather stations, one on the Island of Rhodes and one the Greek mainland also have January 1955-1997 monthly averages that exceed the threshold:

- Chania (Crete): 9.2°C and 15.8°C
- Ierapetra (Crete): 8.9°C and 16.1°C
- Kalamata (southern Peloponnese): 5.7°C and 15.3°C
- Rethymno (Crete): 9.5°C and 15.5°C
- Rodos (Rhodes): 8.8°C and 15.1°C
- Sitia (Crete): 9.4°C and 15.3°C
- Tympaki (Crete): 7.5°C and 15.9°C

To explore the potential for transient populations to develop in summer the number of possible generations was also calculated and mapped.

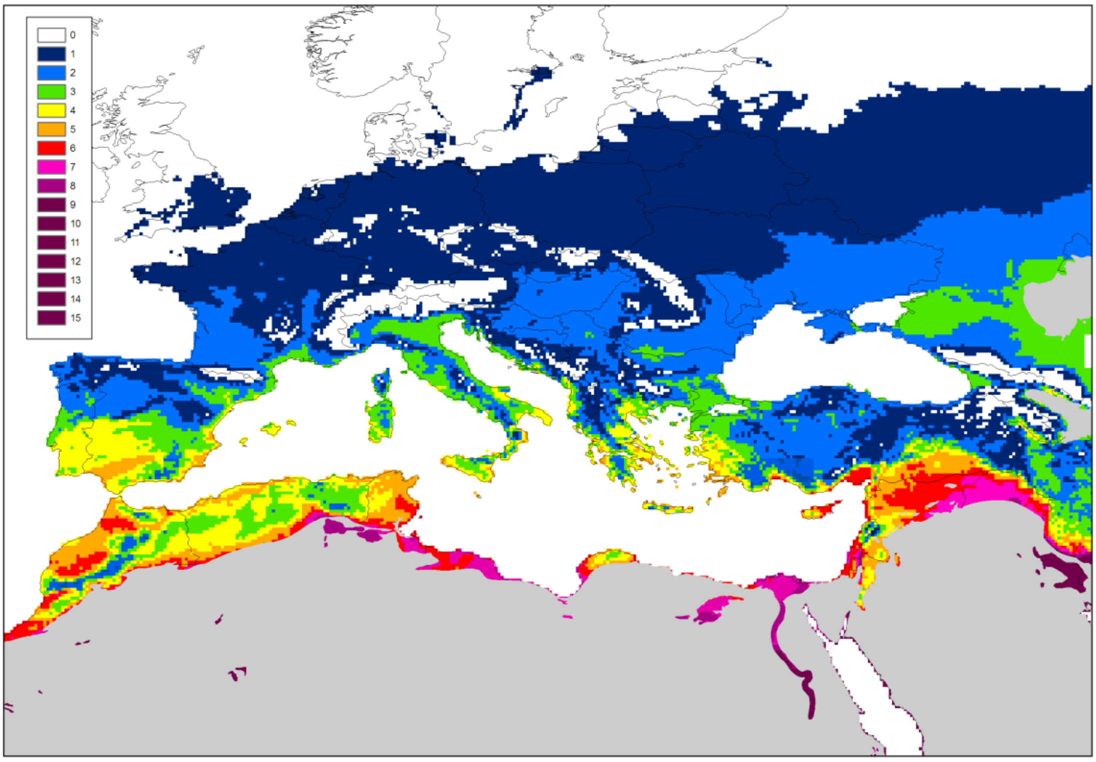

Fig. 9 The number of generations for FCM possible in the EU, North Africa and the Near East based on a minimum development threshold of 12°C and the number of degree days required for each generation of 433.

[5] http://www.hnms.gr/hnms/english/climatology/climatology_region_diagrams_html?dr_city=Heraklion
[6] http://www.hnms.gr/hnms/english/climatology/climatology_html

Fig. 9 shows that one generation (assuming eggs are laid early in the summer) is possible as far north as the Baltic coast of Sweden, Latvia and central England. In southern coastal Mediterranean climates, up to 7 generations may be possible. In key citrus growing areas, such as Valencia 5 generations may be possible. In the Canary Islands and the Azores (not pictured), 3-6 generations are possible.

D. Conclusions

Based on the assumption that the capacity to survive cold stresses during the winter is the key climatic factor influencing establishment in the EPPO region and the finding that, at the South African FCM locations with the lowest minimum winter temperatures, maximum temperatures are up to 15-17°C higher, we applied a simple rule to grid cells in Africa and the EPPO region at 10 minutes of latitude x 10 minutes of longitude. The resulting maps closely mirrored the known distribution in South Africa. In the EPPO Region, not only the Israeli coastal plain were FCM is established but also areas near the Mediterranean coast in North Africa (Morocco, Algeria and Tunisia) and Europe (Spain, Italy (Sicily), Malta and Cyprus) together with Portugal, the Canary Islands, Azores and Jordan were also shown to be above the threshold.

Although we conclude that these areas of the EPPO Region are climatically suitable for FCM, it is also possible that FCM can establish in a wider area because:

- we only have a limited knowledge of FCM's cold tolerance from the literature
- we only have a limited capacity to infer cold tolerance from the distribution in South Africa because of the limited number of representative presence/absence locations and geographic features (the Oceans)
- the EPPO region has warmed up since the global mean 1961-90 climatology used for the analysis and to make the maps.
- Longer term and more recent Greek climatic weather station data show that parts of southern Greece, especially Crete, are above the threshold. A more comprehensive analysis of recent climatic data elsewhere is likely to show that the threshold is also likely to be exceeded in southern Turkey, southern France, e.g. Corsica, and larger areas of southern Portugal, Spain and Italy.

North of this area, assuming this rule remains valid, outdoors, conditions are too cold (very low minimum temperatures) or cool minimum temperatures in January (as low as 1-3°C) are not coupled by maximum temperatures that are 15-18°Cor warmer. In these areas, up to about 55° of latitude north, FCM may still have sufficient degree days above the minimum development threshold 12°C for at least one transient generation to be completed.

The areas of highest risk can be considered to be those that have: (a) winter max-min temperatures above the threshold, (b) sufficient warmth for several generations to develop and (c) continuously available fruit.

References

Daiber, 1979a. A study of the false codling moth [*Cryptophlebia leucotreta* Meyr.]: the egg. Phytopylactica 11:129-132.
Daiber, 1979b A study of the false codling moth [*Cryptophlebia leucotreta* Meyr.]: the coccoon. Phytopylactica 11:151-157
Daiber, 1979c A study of the false codling moth [*Cryptophlebia leucotreta* Meyr.]: the larva. Phytopylactica 11:144-157
Daiber, 1979d. A study of the false codling moth [*Cryptophlebia leucotreta* Meyr.]: the adult and generations during the year. Phytophylactica 12: 187-193.
Eyre, D., Baker, R.H.A., Brunel, S., Dupin, M., Jarosik, V., Kriticos, D.J., Makowski, D., Pergl, J., Reynaud, P., Robinet, C. & Worner, S. 2012. Rating and mapping the suitability of the climate for pest risk analysis. *EPPO Bulletin* 42, 48–55
Jarosik *et al* 2011. Insect and mite thermal requirement database PRATIQUE (unpublished).
NAPPFAST 2011. Insect Development Database http://www.nappfast.org/databases/Insect%20Development%20Datatbase%20for%20Web-%20Final%20without%20links.xls

An Assessment of the Supply Side Economic Impact of Potential Phytosanitary Regulations on Trade in Potential Host Pathway Commodities of False Codling Moth with Emphasis on European Union Supply of Citrus Fruit from Southern Africa

This is a supporting document for question 7.34 stating the position of the South African Citrus Growers Association.

Compiled by
Paul Hardman, Industry Affairs Manager
Citrus Growers Association of Southern Africa

20th December 2011

Executive Summary

The European and Mediterranean Plant Protection Organisation (EPPO) is currently undertaking a Pest Risk Assessment (PRA) for False Codling Moth (FCM), that may lead to a recommendation to EPPO member countries to introduce additional FCM-specific regulations for imports of potential host pathway commodities. FCM is endemic to sub-Saharan Africa and has a broad host range that includes many types of fresh produce produced in Africa and exported to EPPO member countries, especially fruit exported to the European Union (EU) member countries. Large quantities of citrus fruit are produced in southern Africa and exported to EU countries. This assessment investigates the economic impact of a few selected potential control options for export of citrus fruit (oranges, grapefruit and mandarins) from southern Africa to EU-member countries. It is recognised that this scope is limited, but the availability of relevant information for this focus area facilitates an assessment of the potential impact that can be extrapolated more broadly. The assessment has focussed on the following broad control options: cold sterilisation, a systems approach and market segregation.

Mandatory EU-wide imposition of cold sterilisation is not a feasible option for three main reasons. Firstly, it would result in the immediately exclusion of cold sensitive citrus varieties (satsumas and grapefruit), resulting in an immediate collapse in the satsuma industry, and increase the incidence of chilling injury in all citrus types (annual losses of approximately **€134 million**). Secondly, there is insufficient pre-cooling capacity to feasibly handle the volumes exported to the EU on an annual basis. The cost of building such facilities is estimated at **€45 million**. Human resources to manage the cold sterilisation process within country of origin official inspection services are insufficient. Thirdly, the additional operational costs associated with cold sterilisation would amount to approximately **€24 million** per annum. The losses and costs combined would preclude continued profitable export of citrus fruit from Africa to the EU.

A systems approach would require significant intensification of monitoring and control practices to manage FCM at the orchard level. Intensified FCM monitoring, orchard sanitation and the added chemical control options will increase the costs to producers by **€30.75 million** annually. The roll out of a systems approach will also require significant human resources to administer and monitor the system. Such resources are currently insufficient and would need to be built up over time. The extra costs of a systems approach applied to all citrus exports to the EU would impact upon profit margins to the extent that continued economic viability of such trade is unlikely.

Of the three options considered here, market segregation represents the only economically viable option for trade given that a high proportion of citrus fruit from southern Africa is destined for northern Europe and that the primary potential risk area is assumed to be the southern EU member countries. Although this would still have material economic implications (**€1.88 million** annually plus some unquantified additional costs) it would avoid the devastating implications of the other two options considered.

Although no attempt has been made to quantify the economic impact of other key considerations that might be expected to come into play with the first two measures considered these impacts are also expected to be significant. Certainly the impact on socio-economic and environmental aspects in southern Africa will be massive. Citrus market dynamics within the EU, particularly retail trade, will be massively disrupted. Given the major role played by southern Africa in the European summer citrus season, the economic impact on various components of the value chain within Europe will be massive.

The disruption of the EU citrus trade will also have a tremendous knock-on effect on citrus trade globally. The impact on other southern hemisphere citrus industries is expected to be substantial. The impacts are expected to extend globally to the citrus-processing sector and to have a direct knock on impact on the counter-seasonal northern hemisphere citrus producing industries. Southern African citrus (oranges, grapefruit and mandarins) has been the focus of this assessment but it is anticipated that similar impacts would also be experienced in other potential host pathway trade from Africa as a whole.

The ultimate conclusion of this assessment is that all three potential measures will have dire consequences for the southern African citrus industry and African agriculture more widely. The first two options will be devastating for the African production base, will have major impact within Europe and the impact will extend on a wide international scale. The impact of the third option is expected to have a significantly reduced impact relative to the other two options.

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1. Introduction

The European and Mediterranean Plant Protection Organisation (EPPO) is currently undertaking a Pest Risk Assessment (PRA) for False Codling Moth (FCM). Through this PRA process there may be recommendations to regulate the import of potential host pathway commodities into certain EPPO member countries. It is relevant to review the potential impact on affected industries when considering recommending the imposition of trade regulations. This paper presents data showing the potential impact of some risk-mitigation regulatory mechanisms that may be considered.

Although a range of potential host plant pathways for FCM are exported from Africa to the EPPO region, this assessment focuses on the export of citrus fruit (orange, grapefruit and mandarin-types) from southern Africa to the EU member countries. Citrus is considered in detail because oranges, grapefruit and mandarin types are considered suitable hosts for FCM and are exported in large quantities from Africa (southern Africa in particular) to the EU (approx. 500 000 – 600 000 tonnes annually)[7]. Nevertheless the same principles and practical implications associated with citrus from southern Africa would be of similar magnitude for other traded potential host pathway commodities.

Background information is provided around African/EU trade as it stands today (Section 2) and key statistics of the southern African (South Africa, Swaziland and Zimbabwe) citrus industry (Section 3). This is followed by a description of some potential EU regulatory measures that may be under consideration (Section 4). These are then each analyzed in greater detail in Section 5, 6 and 7. Further key concerns and implications are addressed in Section 8.

2. Africa/EU trade in potential host pathway material

The European Union (EU) is the single biggest market for horticultural agricultural goods produced in Africa. To provide a sense of the volume and value of this trade, Table 1 summarizes some key commodities that are potentially associated with FCM and are exported to the EU. These commodities are sourced from countries across Africa.

Current trade in these goods is valued at **€0.77 – 0.84 billion per annum.** The extent to which trade is ultimately disrupted will depend on which additional risk-mitigating measures are introduced and how practical and feasible it will be to implement these regulations in the countries of production.

Table 1: Volume and Value of commodities across Africa annually exported to the EU

Category	Volume (x 1000 tonnes)	FOB Value (€m)
Avocado	37 – 54	€22 - €25
Citrus (excl. lemons and limes)	500 – 600	€250 - €270
Flowers (roses)	0.7-0.8	€190 - €200
Green beans	12	€26 - €29
Mangos	37 – 55	€22 - €33
Peppers	6-7	€11 - €14
Persimmons	5 – 6	€1.9 - €2.3
Pomegranates	4-6	€3 - €4
Stone fruit (peaches, plums, apricots)	40-45	€30 - €35
Table grapes	150-160	€210 - €230
Total		**€765 - €842**

Sources: Food and Agricultural Organization, www.fao.org; Perishable Products Export Control Board, December 2011.

[7] Lemons and limes are excluded from the assessment as they are widely considered as unsuitable host plant material for FCM.

3. Focus on southern African citrus industry

The southern African (South Africa, Zimbabwe & Swaziland) citrus industry's annual production is approx. 1.9 million tonnes of which approx. 1.3 million tonnes (or 60-70 percent) are exported. In total 58 000 citrus hectares are in production (38 820ha oranges, 8 978ha grapefruit and 4 960ha mandarins).

South Africa is the second largest exporter of citrus globally and citrus is the largest agricultural export commodity from the region. The citrus industry plays a key role in the overall composition of the broader agricultural sector and is significant to the overall success of the South Africa Government's Rural Development Plans and job creation initiatives.

Commercial export of citrus from southern Africa to the EU dates back to 1910 and the EU remains the single largest market for southern African oranges, grapefruit and mandarin-types (45.4 percent of exports). The next largest importer is the Russian Federation at 12.1 percent of exports.

4. Some potential regulatory measures selected for impact assessment

To estimate the economic impact of potential regulatory measures it is appropriate to identify and describe them. A general and broad understanding of the measures is used, although some variation from this "typical" measure is possible.

4.1. Cold sterilisation

Disinfestation for FCM typically involves in-transit (in ship or container) cold sterilisation of citrus fruit for 22 days at -0.6 degrees Celsius. Pre-cooling of the fruit at specialised land-side facilities is essential. Cold sterilisation requires intensive monitoring and management.

4.2. Systems approach leading to consignment freedom from FCM

A systems approach caters for varying (intensifying) degrees of intervention based on the demographics and concentration of the pest along the production and handling chain. The systems approach is considered to consist of various pest management practices at the place of production in combination with systematic selection/grading across harvesting and packing, through to sample inspections of the final packed product. Consideration is given to the pest prevalence (pest pressure) at a particular site (orchard or production unit), region and country to determine the corresponding pest control and inspection intensity relevant for that site and region. For the purpose of this exercise it has been assumed that only the achievement of pest-free consignments would be a potentially feasible goal.

4.3. Market segregation within the EU

Market segregation is the delineation of sensitive areas within the importing region where establishment of the pest is considered to be a high risk. Regulations are restricted to the introduction of host pathway material into such sensitive regions, but enabling trade to continue with other areas.

5. Implications of FCM cold sterilisation

The introduction of cold sterilisation on shipments of oranges, grapefruits and mandarins will firstly have an impact on the fruit itself (horticultural implications) and secondly, will bring about considerable changes to how the fruit must be handled through the cold chain (logistic implications). These aspects are discussed below. The impact assessment is based on the assumption of mandatory cold treatment being applicable to all orange, grapefruit and mandarin exports from southern Africa to the entire EU.

5.1. Sensitivity of citrus fruit to cold sterilisation

5.1.1. Exclusion of sensitive varieties

Experience has shown that some varieties are simply not able to withstand the rigors of cold sterilisation, meaning their automatic exclusion from any future citrus marketing campaigns to the EU. Satsuma and Grapefruit (particularly white) are the most sensitive to chilling injury and would not be considered suitable to put through a cold sterilisation protocol. Effectively this would terminate current trade for satsumas and grapefruit of approximately **€90 million** annually.

This disruption to trade is particularly disconcerting with regard to satsumas given the high proportion sent to "non-sensitive" regions within the EU. During 2010, 21 702 pallets of satsuma were exported to the United Kingdom (14 318) and northern Europe (7 028), accounting for 98.3 percent of all southern African satsuma exports to Europe. Satsuma exports to the EU constitute 75 percent of the southern African satsuma industry's global exports. Given this level of reliance on export to the EU, this disruption would inevitably result in complete collapse of the southern African satsuma industry.

5.1.2. Chilling injury to fruit
The incidence of chilling injury on citrus fruit increases enormously with the application of cold sterilisation. At "normal" shipping temperatures (3-11 degrees Celsius) to EU almost zero chilling injury occurs, with chilling injury generally only associated with cases of cooling equipment failure. It is estimated that mandatory cold sterilisation would result in the incidence of chilling injury increasing to between 15-30 percent, depending on the variety[8].

There are three main problems with increased chilling injury. The first is the obvious reduction in marketable fruit. In addition to the total exclusion of satsumas and grapefruit, this loss is expected to be about 43 000 pallets (or 11 percent of Valencia, Navel, Clementine and Mandarin fruit collectively). The second problem is that the remaining fruit is of general decreased quality, which attracts a lower price. It has been assumed that this change in value will range from between -5 and -10 percent of current value.

The third major problem is that the damaged fruit needs to be sorted from the marketable portion of fruit, a process that can only be done by re-packing the fruit. Estimates of the cost of repacking are approximately €14-€28 per pallet or €5m-€10m per annum. Nevertheless, regardless of the cost, it is unlikely that the process of re-packing such large volumes of fruit would be at all feasible due to inadequacy of current capacity of re-packing facilities in northern Europe.

As shown in Table 2 losses of approximately **€134 million** per annum would result due to the introduction of cold sterilisation. Additional costs of **€5-€10 million**per annum for re-packing could also be expected.

Table 2: Export citrus volumes to EU, average values, and possible impact of cold sterilisation

	Exports and Avg Values			Introduction of Cold Sterilisation					
	2011 Exports	Price	Value	Chilling Injury Damage	Available for Sale	Reduction in Value	Price	Value	Lost Value
Variety	Pallets	€/Pallet	€m	%	Pallets	%	€/Pallet	€m	€m
Clementine	20 277	893	**18.1**	5%	19 263	-5%	848	**16.3**	**1.8**
Mandarins	14 769	1 233	**18.2**	5%	14 031	-5%	1 171	**16.4**	**1.8**
Satsumas	21 934	850	**18.6**	100%	-	-	-	**-**	**18.6**
Red Grapefruit	113 748	600	**68.2**	100%	-	-	-	**-**	**68.2**
White Grapefruit	8 473	570	**4.8**	100%	-	-	-	**-**	**4.8**
Navels	120 739	683	**82.4**	20%	96 591	-5%	648	**62.6**	**19.8**
Valencia	237 727	648	**153.9**	8%	219 897	-5%	615	**135.3**	**18.7**

8 Chilling injury estimates are based on discussion with post-harvest fruit quality specialist Dr Paul Cronje, Citrus Research International, December 2011. Both evidence from comparative trials under controlled research conditions and the feedback from monitoring of cold sterilization in practice were considered.

Total	537 667		364.4		349 782			230.7	133.7

Source: Perishable Products Export Control Board, December 2011. Piet Smit, Cedarpak Sitrus Bpk, December 2011. Peter Nicholson, Alicedale Farm, December 2011.

5.2. Logistical feasibility of cold sterilisation

By looking at existing capacity and an assessment of what would be required, it is clear that cold sterilisation is not a practically feasible option for current volumes of citrus fruit exported to the EU. Particular details are provided here around pre-cooling capacity, shipping implications and administration and inspections implications. Annex 1 summarises key data used in this section. Satsuma and grapefruit volumes have been excluded from the calculation given their entire exclusion from the EU citrus campaign as discussed above.

It is relevant that prior to 2009 various bottlenecks and delays in the export citrus supply chain were identified as a key challenge facing the southern African citrus industry, leading to the appointment of a Logistics Project Coordinator. Despite the provision of resources to address these concerns[9], many of these logistics problems persist today, highlighting the inability of such a large supply chain to rapidly adjust to major changes.

5.2.1. Pre-cooling capacity

With current cooling facility capacity, the total number of additional pallets that could feasibly be cooled in a season is 70 000. EU volumes exceed this current capacity by a further 323 696 pallets. Clearly in the short-term cold sterilisation of such a large number of additional pallets would not be feasible. Longer-term it is conceivable that additional capacity could be introduced through the installation of additional forced-air cooling facilities. To handle 323 696 pallets an additional 21 580 slots would need to be created. This would cost approximately €19.6 million[10]. Including the cost of land, this figure increases to**€45 million**.

5.2.2. Shipping implications

Durban port is the busiest port in Africa, and handles approximately 60 percent of citrus exports. Some of the current bottlenecks faced by the citrus supply chain relate to overall congestion of this port. Minimising the impact of the congestion requires a great deal of coordination and anticipation. Introduction of a cold sterilisation component adds to the complexity of the logistics process, making planning and execution much more difficult.
The current systems used to plan and implement shipments have also not been tested with a significantly larger volume of citrus.

It has been assumed that sufficient container boxes and conventional ships would be available from around the world to handle the volume that would undergo the cold treatment, and this would not represent a constraint.

5.2.3. Administration and inspection services

Country of origin official inspection services would have to monitor the cold treatment protocol. In southern Africa the requisite official manpower to do this is not available. It will require major enhancement of the manpower capacity with associated training requirements to gear up for this. By implication it will not be possible to administer the increased cold treatment volume in the short term. The cost of upgrading the manpower facilities has not been calculated.

5.3. Additional costs associated with cold sterilisation

Besides the massive infrastructure and capacity costs that would be required to apply cold treatment to all citrus exported to the EU, supply chain costs will increase drastically. To estimate these particular costs it is assumed for now that sufficient capacity is already available

[9] Citrus Growers Association of Southern Africa appointed a Logistic Project Coordinator in 2009.

[10] Capital requirements to establish cold storage capacity were based on prior discussions with developers of a cold store facility in Durban, South Africa, during 2008 plus provision made for inflation (CPIX = between 5-8 percent from 2008 to 2010).

to handle the EU fruit, including the cost of capital used to finance such infrastructure development. Again Annex 1 summarizes the details of cold sterilisation costs.

5.3.1. Cold store handling costs

Cold stores handling costs will increase to cover the added energy bill linked to pre-cooling the fruitand the fact that fruit must now be stored for longer at the facility before it reaches its target temperature. This component will add **€11.9 million** to supply chain costs annually.

5.3.2. Shipping costs

Two modes of shipping are used to export citrus from southern Africa to the EU, namely conventional (or break-bulk) and container shipping. Approximately 70 percent is shipped via containers. The key problem, irrespective of the mode, is that sailing time to the EU is shorter than 22 days, which means arrangements must be made to either handle the fruit landside (in the case of containers) or incur demurrage (sailing slow, in the case of conventional shipping). Assuming the shipping ratio of conventional to container remains 30:70 the additional shipping costs alone will be **€10.4 million** annually.

5.3.3. Administration

Based on the current cost of administering and managing other small scale cold treatment protocols it has been estimated that these costs for the EU programme will add another **€1.3 million** annually.

5.4. Summary of additional cold sterilisation costs

New pre-cooling facilities to handle the additional volume of citrus to the EU in a cold sterilisation protocol will require infrastructure expenditure of **€45 million** (including land purchase). Assuming it was actually possible to put this additional infrastructure in place, or that the current volumes of citrus could be handled with existing infrastructure, the total additional cost burden of cold sterilisation will be approximately **€23.7 million** per year. Given the reduced value of product due to chilling injury (Table 2), this cost constitutes 10 percent of value. Average profit margins at farm gate are generally less than 7.5 percent. **The implication is therefore that export of citrus to the EU from Africa will cease to be profitable.**

Table 3: Summary of additional costs associated with cold sterilisation for fruit destined for the EU.

Investments	€ Million
Total Additional Pre-cooling Facilities	**€ 45**
Annual Costs	
Additional Handling	€ 11.9 pa
Additional Shipping - Conventional	€ 4.9 pa
Additional Shipping - Container	€ 5.5 pa
Additional Administration	€ 1.3 pa
Total Additional Costs (annually)	**€ 23.7 pa**

6. Systems approach

Following a systems approach to achieve production of FCM-free consignments of export citrus will require highly intensified on-farm control practices. This section illustrates estimates of changes from current approaches and the cost implications of those additional practices. See Annex 2 for calculation details.

6.1. Current practices to manage FCM given prevailing FCM EU regulations

6.1.1. Monitoring

Monitoring FCM populations in the orchards forms a key component of any FCM management strategy. This management practice currently costs producers approximately €4.5 million annually. It is estimated that the intensity of monitoring required in a systems approach will approximately double, costing an additional **€4.5 million** per annum.

6.1.2. Control options

At present producers employ a range of alternative and partially interchangeable sets of control measures for FCM, including sanitation, mating disruption, virus sprays, attract & kill sprays, pesticide sprays and sterile insect technique (SIT). It is estimated that on average across southern Africa, two approaches are followed by most growers.

6.2. Additional control options required under a systems approach

6.2.1. Additional chemical control options

On consultation with entomologists working in the southern African citrus industry it was estimated that on average at least an additional two chemical approaches will need to be applied. The precise combination used by each producer depends on location, pest pressure, efficacy, cost consideration and the degree to which Integrated Pest Management is followed.

Given the high degree of variability in the approach to FCM management on farm and even orchard level, it is extremely difficult to determine the typical costs per hectare at the national level. Therefore to estimate the overall change in costs, a simpler method has been adopted here, although it is accepted that some accuracy is lost. Annex 2 lists each control option and summarizes costs.

The cost per hectare of each approach is used to determine the average cost per hectare across the different control options – a typical cost of employing any one control option. Both the cost of materials and the associated application costs (fuel, labour, etc) are included in the calculation. A typical cost of employing any one control option was estimated to be R2 260 per hectare per season.

It is assumed that on average two options are deployed (R4 412 per hectare) at present. Using the information provided by the consulted entomologists it is further assumed that on average an additional two options will need to be added. Since there are approximately 52 000 hectares that will require increased control, the total increase will be R2 260 x 2 x 52 000 = R283 million **(€21.7 million)** per year.

6.2.2. Additional orchard sanitation

Again entomologists working in the southern African citrus industry were consulted to estimate the additional orchard sanitation that might be followed under a systems approach. It was believed that doubling the current level of orchard sanitation would probably be necessary (i.e. instead of passing through an orchard once a week the frequency of this task would need to increase to twice weekly). Doubling orchard sanitation would increase production costs by **€4.6 million** per annum.

6.3. Administration and inspection services

A systems approach will require increased monitoring from country of origin official inspection services. In southern Africa the requisite official manpower to do this is currently not available. It will require major enhancement of the manpower capacity with associated training requirements to gear up for this. By implication it will not be possible to administer immediate roll out of a systems approach across the whole production base. The cost of upgrading the manpower facilities has not been calculated. The additional recurrent cost of intensified inspection services has also not been calculated.

6.4. Summary of additional FCM monitoring and control options

Additional FCM monitoring will increase the cost of citrus production by €4.5 million per annum. The intensified chemical control practices and orchard sanitation required to implement a systems approach are estimated to annually cost an additional €21.7 million and €4.6 million respectively. Therefore total production costs will increase by **€30.75 million** annually to effectively implement the systems approach.

Current exports to the EU are valued at approximately €364 million per annum. The above additional costs for monitoring and control of FCM of €30.75 million represent about 7 percent of this value alone. Given that profit margins at farm gate are generally less than 7.5 percent, **the implication is therefore that it is highly unlikely that export of citrus to the EU from Africa will continue to be profitable.**

7. EU Market Segregation

7.1. Imports into northern, central and eastern Europe

From Table 4, below, it is clear that over 83 percent of citrus volume exported to the EU in 2011 was shipped directly to northern, central and eastern Europe. For mandarins this ratio is significantly higher, with more than 98 percent being shipped directly to regions outside southern Europe. It is likely that a small proportion of this fruit may move south to the southern EU member countries. Conversely, a significant proportion of the fruit that is shipped directly to southern EU countries is not for sale in these southern markets. Much of this fruit enters the southern ports to take advantage of the efficiencies inherent in the distribution networks that have been developed there to handle locally produced fruit. Consequently much of this fruit does not remain in these southern countries, but is distributed into northern EU countries. It is estimated that approximately 50 percent of this fruit is distributed out of these southern countries, and consequently over 90 percent of total southern African citrus is destined for the non-risk parts of the market.

Table 4: Summary of citrus volumes exported from southern Africa to the EU, 2011

Product	Northern, central, eastern EU (incl UK)	Southern EU	EU Total
2011 Exports (Pallets)			
Grapefruit	104 431	17 791	**122 222**
Oranges	287 849	70 311	**358 160**
Mandarins	55 872	1 109	**56 981**
Total	**448 152**	**89 211**	**537 463**
2011 Exports (%)			
Product	%	%	%
Grapefruit	85.4%	14.6%	**100.0%**
Oranges	80.4%	19.6%	**100.0%**
Mandarins	98.1%	1.9%	**100.0%**
Total	**83.4%**	**16.6%**	

Source: Perishable Products Export Control Board, December 2011.

7.2. Risk mitigation in combination with market segregation

The key motivation for shipping fruit via the southern entry ports into the EU is economic in nature and arises out of lower logistics costs of getting fruit to market by making use of the distribution networks established in these regions for handling locally produced fruit in the counter season of northern hemisphere production. The diversion of 50 percent of these imports to northern ports will have cost implications for both the southern African producers and the handling and distribution networks operating from these southern countries, from which the produce will be excluded. These costs have not been calculated, but will certainly be insignificant in comparison with the EU-wide application of cold sterilisation and systems approach considered above.

The added costs of cold treatment or a systems approach would then be limited to approximately 8 percent of the current EU exports that are indeed destined for the southern member countries. Closer consideration of the more costly option of cold treatment indicates that with such market segregation, there would be no need to create additional pre-cooling facilities to handle 8 percent of the EU volume so capital costs can be avoided, but additional cold store handling costs (approximately **€0.95 million**) and shipping costs (approximately **€0.83 million**) would be incurred. Based on current administration costs for small scale cold sterilisation programmes the additional costs of monitoring the programme by country of origin official inspection services is estimated to be **€0.1 million** annually. The total additional cost would be **€1.88 million** annually. Alternatively, the addition of a systems approach to 8 percent of the EU volume, assuming that this can be achieved with intensified controls applied to only 5 percent of the production base (due to selective use of production from lower pest pressure areas), would add a cost of **€1.54 million** annually.

7.3. Benefits and costs of market segregation

In Table 2 above (section 5) it is estimated that the combined value of oranges, grapefruit and mandarins exported to the EU is approximately €364 million annually. If market segregation was applied, an estimated 92 percent of fruit, valued at €335 million would then continue entering the EU market with little disruption. Approximately €29m per annum of current trade would be disrupted and attract additional costs of approximately €1.9 million per annum. These figures are probably underestimated given that approximately 50 percent of the fruit now entering the southern ports will be diverted to northern ports and incur additional expenses, but this remains an enormous improvement on the devastating consequences of the other two options considered.

It is currently a legislative requirement that all citrus fruit imported into the EU contains a declaration of country of origin up to the point of final sale. It would seem to be relatively simple to include legislative qualification of this declaration in terms of permissible area for distribution and sale.

8. Additional key considerations

This section introduces a range of other important aspects relevant in considering implications of possible regulatory options.

8.1. Implications for the southern African citrus industry and international citrus trade

Table 5 shows that southern Africa supplies 78 percent of oranges and 95 percent of grapefruit to the EU during summer months (i.e. from southern hemisphere sources). In 2011 the EU market accounted for 46 percent of southern African citrus exports. Global citrus trade is highly sensitive to supply and demand forces. Attempts to divert significant portions of this volume to other world markets will unavoidably result in collapse of such other markets, with the result that other southern hemisphere citrus exporting countries will also be impacted (e.g. Argentina, Uruguay, Chile, Peru and Australia).

Table 5: Summary of citrus volumes exported from southern Africa to the EU, 2011

	Orange	Mandarins	Grapefruit
SHAFFE	553 128	148 762	135 548
Southern Africa	78%	39%	95%

Source: Southern Hemisphere Association of Fresh Fruit Exporters (SHAFFE), 2011.

It is commonly recognised that market conditions created by over-supply of markets in one half of the year carry over to the counter-seasonal supply, so the northern hemisphere citrus exporting countries will also be impacted by the knock-on effects. The world orange and grapefruit juice prices are less seasonally defined than the fresh fruit market, so the knock-on effect of a massive diversion of fruit from the southern hemisphere fresh fruit season to processing will have a global impact on juice pricing, with knock-on implications for major juice industries such as Florida and Brazil.

8.2. Other exports from Africa

Considering the massive impact of the first two regulatory options on the southern African citrus industry, it can reasonably be assumed that the impact on other smaller and more vulnerable African fresh produce export industries will be no less. Certainly the socio-economic implications of such disruption will only be more acutely felt in other parts of Africa.

8.3. Socio-economic considerations

60 000 permanent employees are dependent on a livelihood from working on southern African citrus farms and another 40 000 jobs are created during the harvest period (mainly April to September) at packing facilities. It is estimated that these jobs help workers support on average four dependents each, or 500 000 people in total. Citrus operations are generally located in rural areas and therefore contribute significantly to the stability and prosperity of outlying regions. Additional downstream jobs (in trucking, logistics, cold storage, shipping, etc) are estimated to add another 5 000 jobs (25 000 with dependents). A large proportion of the South African citrus industry is based in three of the poorest provinces (Eastern Cape, Mpumalanga and Limpopo), where entire communities depend on the citrus export industry. There is little prospect for work opportunities in agriculture or other industries outside the citrus industry with the South African unemployment rate at between 24-35 percent. The situation is even more dire in production regions of Zimbabwe and Swaziland. It is obvious that the implications of major disruption to southern Africa citrus export opportunities will have far reaching and devastating regional socio-economic impact.

8.4. Environmental considerations

An initiative to estimate the average carbon footprint, and therefore contribution to climate change, linked to the production and export of citrus fruit was launched in 2009. Although there is insufficient data to draw any reliable conclusions at this point (sample size is still too small) it is clear that the energy demand required to power the additional pre-cooling facilities for cold sterilisation would be significant. South Africa has a coal-based energy generating system and any additional carbon emissions linked to electricity generation is a concern. More ammonia will also be needed at the cooling facilities, adding to the environmental impact of cold sterilisation.

More orchard sprays to control FCM will also impact on the environment. Besides the larger amount of pesticide and chemicals introduced into the environment, more water and fossil-fuels (energy) will be required to apply these chemicals.

8.5. Implications for citrus trade value chain within the EU

This paper has largely considered the supply-side economic implications. However, the loss of citrus trade, as contemplated with the first two potential regulatory options considered, will also have severe economic impacts within Europe. As a broad average, 40 to 50 percent of the value of the product (based on sales price) is retained within Europe. Considering that the southern African supply represents approximately 80 percent of Europe's summer supply of oranges, grapefruit and mandarins, the impact of loss of this trade on retailers, product receivers, handling facilities, distributors, transport agents and various other service providers in Europe, including shipping lines, will be considerable.

Business relationships have been developed over many years and it will not be easy to switch to new suppliers without considerable adjustments. Factors associated with supply into European chain stores include Good Agricultural Practice certification status, Good Manufacturing Practice certification status, ethical trade status, adherence to retailer plant protection product usage and residue requirements to name a few. Typically these factors evolve over long periods and it takes producers years to become certified. Consequently, severe disruption of the southern African supply base will inevitably result in consumer supply shortages for several years.

9. Conclusion

This assessment has considered cold sterilisation, a systems approach and market segregation as three broad strategies that might potentially be considered to regulate trade in potential host pathway commodities of FCM, with the emphasis on EU supply of oranges, grapefruit and mandarins from Southern Africa.

EU-wide application of cold sterilisation is not a feasible option for a three main reasons. Firstly, it would immediately result in the exclusion of satsuma and grapefruit trade to the EU. The satsuma industry would immediately collapse and the grapefruit trade would be massively impacted upon, both within the EU and globally. Cold sterilisation would also increase the incidence of chilling injury in all citrus types, further adding to losses, taking total losses to approximately €134 million per annum.

Secondly, there is currently insufficient pre-cooling capacity to feasibly handle the volumes exported to the EU on an annual basis. Costs of €45 million would be associated with the creation of capacity to pre-cool 323 696 more pallets. Cold sterilisation for 22 days would mean sailing times would increase from the average sailing time of between 14-18 days making it extremely impractical to handle the annual EU citrus supply. More volume requiring cold sterilisation would compound existing congestion problems in southern African ports. Current insufficient human resources to manage the cold sterilisation process within country of origin official inspection services will need to be addressed, something that would take time. Thirdly, the ongoing costs of applying cold sterilisation would make it infeasible. The combined additional costs from cold store handling, shipping and administration are estimated to be €24 million annually. Total losses and additional costs would be **€158 million** annually, plus additional infrastructure costs of **€45 million**. These costs far exceed profit margins precluding continuation of profitable export of citrus fruit from southern Africa to the EU.

A systems approach would require a significant intensification of monitoring and control practices at the orchard level to manage FCM, which would add to the cost of production. Intensified orchard monitoring and control actions would cost an additional **€31 million** annually. The roll out of a systems approach would also require significant human resources to administer and monitor the system, which is currently insufficient and would need to be built up in time. Given current farm gate profit margins it is highly unlikely that continued supply of the EU market from Africa would remain viable.

EU market segregation is clearly the least disruptive and the only economically viable option of those considered. Given the high proportion of citrus fruit from southern Africa that is destined for non-risk portions of the EU this would seem to be most appropriate.

Although likely to be significant, no attempt has been made to quantify the economic impact of other key considerations that might be expected to come into play with the introduction of phytosanitary measures on potential FCM host pathway material exported to the EU. Certainly global citrus trade would be destabilized by the first two options considered, potentially causing massive losses in these markets due to knock-on effects. The impact would also extend to the northern hemisphere supply countries given that knock-on effects would likely carry over into their traditional supply windows. Citrus market dynamics at the retail level within the EU would also be severely disrupted. Global orange and grapefruit juice prices would also likely decline as more volume is diverted away from the fresh fruit market and into the processing industry.

The impact on socio-economic aspects in southern Africa would be massive as many small communities, in mainly outlying areas, depend on the citrus industry for their livelihoods. They face bleak prospects outside the citrus industry.

The ultimate conclusion of this assessment is that all three potential measures to regulate the trade in host pathway material for FCM into the EU would have severe consequences for the southern African citrus industry. Market segregation represents the only feasible option. Oranges, grapefruit and mandarins to the EU from southern Africa have been the focus of this assessment, but it is anticipated that similar and greater impacts would also be experienced in other potential host pathway industries across Africa.