Plant Protection Service
Ministry of Economic Affairs, Agriculture and Innovation

Pest Risk Analysis for *Thaumatotibia leucotreta*

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Plant Protection Service
Ministry of *Economic Affairs, Agriculture and Innovation*
P.O. BOX 9102
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Pest Risk Analysis for *Thaumatotibia leucotreta*

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PEST RISK ASSESSMENT
Thaumatotibia leucotreta

This Pest Risk Analyis (PRA) is based on the EPPO PRA scheme of 2009 (http://www.eppo.org).

Definition of terms/abbreviations used in this PRA

Pest arrival	Probability of pest association on particular commodity at import
Pest entry	Probability of pest arrival and transfer to suitable environment
Pest introduction	Probability of pest entry and permanent establishment
ICM	Integrated Crop Management
NPPO	National Plant Protection Organisation
NL	The Netherlands
CRI	Citrus Research International (South Africa)

1 What is the reason for performing the PRA?
The false codling moth, *Thaumatotibia leucotreta,* has been intercepted several times on roses, citrus and peppers from African countries. The organism is a polyphagous fruit- and nutborer and in 2009 an outbreak occurred in the Netherlands in a glasshouse of habanero peppers (*Capsicum chinense*).

2 Enter the name of the pest
Thaumatotibia leucotreta (Meyrick)
Syn: Cryptophlebia leucotreta

2A Indicate the type of the pest
The organism is a fruit- and nutborer

2B Indicate the taxonomic position
Taxonomic Tree

Class: Insecta
Order: Lepidoptera
Family: Tortricidae
Subfamily: Olethreutinae
Genus: Thaumatotibia
Species: Leucotreta (Meyrick)

3 Clearly define the PRA area
The Netherlands

4 Does a relevant earlier PRA exist?
A mini risk assessment for the US (Venette *et al.*, 2003) and pest response guidelines for the US (Stibick, 2006) are available.

5 Is the earlier PRA still entirely valid, or only partly valid (out of date, applied in different circumstances, for a similar but distinct pest, for another area with similar conditions)?
The information on biology, host plant range, geographic distribution and impact is up to date in Venette et al (2003) and Stibick (2006).
Updated pest management, pathway analysis and possible impact for glasshouses with suitable host plants is lacking.

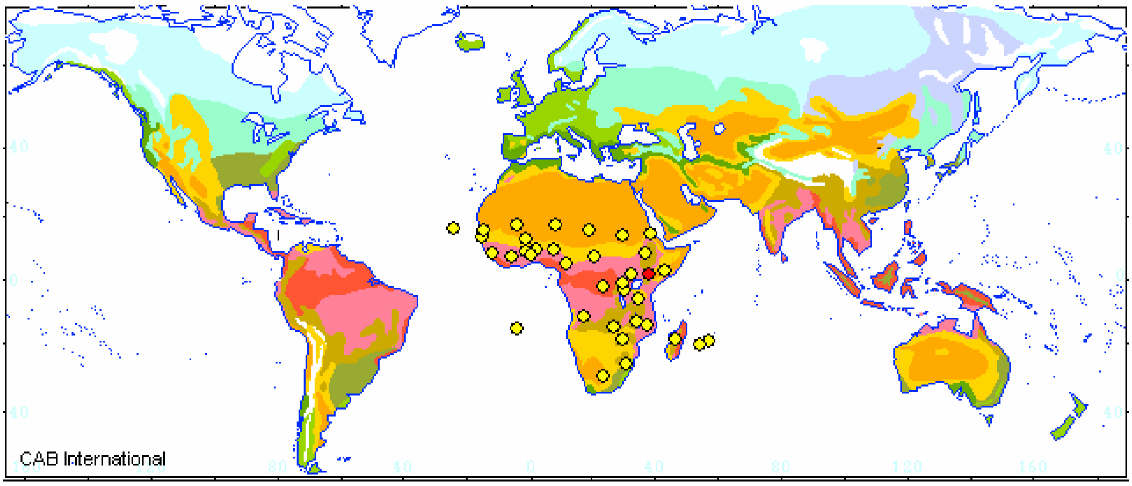
6 Specify the host plant species (for pests directly affecting plants) or suitable habitats (for non parasitic plants) present in the PRA area.

The organism is highly polyphagous and attacks over 70 plant species within 40 families. The larvae feed preferably on the pulp of fleshy fruits or other plant parts such as pods, seeds and bolls (Newton, 1998). The organism is not expected to establish sustainable populations in the field (see below). Therefore, only glasshouse crops are indicated here.

In the PRA area the following host plants are present (CBS, 2009):

Scientific name	Glasshouse Acreage in NL
Capsicum annuum (sweet pepper)	1.200 ha
Capsicum chinense (Chili pepper)	<20 ha
Solanum melongena (aubergine)	90 ha
Lycopersicon esculentum (tomato)	1.200 ha
Rosa	500 ha

7. Specify the pest distribution



Its area of distribution includes central and southern Africa and the islands in the Indian ocean and a restricted distribution and host association in Israel (EPPO PQR v4.6). The northern limit in Africa is at latitude 15 N (Couilloud,1994)

8. Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?
Yes

9. Even if the causal agent of particular symptoms has not yet been fully identified, has it been shown to produce consistent symptoms and to be transmissible?
-

10. Is the organism in its area of current distribution a known pest (or vector of a pest) of plants or plant products?
Yes, in Africa it is a pest of cotton, citrus, macadamias, avocadoes, stone fruit, grapes and maize (Couilloud, 1994; Newton, 1998; La Croix & Thindwa, 1986; Erichsen & Schoeman, 1992; Daiber, 1978).

11. Does the organism have intrinsic attributes that indicate that it could cause significant harm to plants?
Although the organism is capable of causing fruit decay and possible crop loss, it cannot cause vegetative damage to plants and in this regard will therefore not affect the health of the plant itself.

12 Does the pest occur in the PRA area?
No, there was an isolated outbreak in one glasshouse with chilli peppers in 2009.

13. Is the pest widely distributed in the PRA area?
No

14. Does at least one host-plant species (for pests directly affecting plants) or one suitable habitat (for non parasitic plants) occur in the PRA area (outdoors, in protected cultivation or both)?
Yes, see 6.

15. If a vector is the only means by which the pest can spread, is a vector present in the PRA area? (if a vector is not needed or is not the only means by which the pest can spread go to 16)
-

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, conditions in glasshouses in the PRA area are considered to be favourable for the organism.

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, potential damage is possible in suitable crops in glasshouses.

18. This pest could present a risk to the PRA area.
Yes

Section 2B: Pest Risk Assessment
Probability of introduction/spread and of potential economic consequences

1.1. Consider all relevant pathways and list them

(A) Consumer products of host plants of *T. leucotreta* imported from areas where the organism is present.
T. leucotreta is present in the following African countries: Angola, Benin, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Congo Democratic Republic, Côte d'Ivoire, Eritrea, Ethiopia, Gambia, Ghana, Kenya, Madagascar, Malawi, Mali, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Réunion, Saint Helena, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, and Zimbabwe (EPPO PQR, v4.6).

T. leucotreta is highly polyphagous and is reported from over 70 host plant species within 40 plant families. The larva is a borer and feeds preferably on the pulp of fleshy fruits or various parts of plants such as pods, seeds and bolls (Newton, 1998). Hence, the number of potential commodities on which *T. leucotreta* could be present is large. In Table 1 an overview is given of the import of *T. leucotreta* host plants into NL.

The organism is reported to induce economic losses in citrus, macadamia nuts, cotton and maize crops.

The organism has been intercepted on the following commodities:

Commodity	**Comments**
1. Citrus fruit	34 notifications in Europhyt, all origin South Africa. 40 interceptions by the NPPO of NL, not notified in Europhyt, all origin South Africa.
2. Capsicum fruit	4 interceptions by NPPO of NL, not notified in Europhyt, origin Uganda Many interceptions reported by USDA, several African countries, mainly airline passenger luggage, but also on consignments (Stibick, 2006)
3. Vitis fruit	4 interceptions reported by USDA, origin South Africa (Stibick, 2006)
4. Roses (cut flowers)	4 interceptions by NPPO of NL, not notified in Europhyt, origin Uganda, Ethiopia, Tanzania.
5. Others	Fortunella (1 interception by NPPO NL); Zea mays seeds, Cola seeds and Solanum spp. (mentioned in Stibick, 2006).

It should be noted that Capsicum fruit is not regulated in the EU and therefore not inspected. The reports in this table concern accidental findings. Therefore, the actual number of infested Capsicum consignments is unclear.
Based on the trade volume of the commodity, number of interceptions and outbreak, the following host plants will be considered in detail as pathway in this PRA:
Fruit: Citrus
Fruit: Capsicum
Cut flower: Roses

(B) Packaging material
In a PRA for the tomato leafminer *Tuta absoluta* (Lepidoptera), packaging material was considered as a pathway with a medium rating of entry (Potting, 2009). Several outbreaks in glasshouses in NL and 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. Growers sometimes get used (deposit) crates from auctions after delivery of their own produce. It is unknown if these import packaging materials could be a pathway for the organism. This pathway seems much less relevant than pathway A and is, therefore, not further considered in this PRA.

(C) Plants for Planting:
The only significant trade volume of plants for planting from African countries where *T. leucotreta* is present are cuttings. Cuttings are not a pathway, because the organism is only present in fruits.
Conclusion: The risk of introduction via plants for planting is considered very low and not further analysed in detail.

(D) Passenger luggage
Infested fruits and vegetables carried by airline passengers from countries where *T. leucotreta* is present can be an entry route. In the United States, 94% of the interceptions of the organism were from international airline passengers (Stibick, 2006). However, the probability that *T. leucotreta* will enter a commercial glasshouse from fruits or plants imported by private persons is estimated to be very low.
Conclusion: The risk of introduction via passenger luggage is considered very low and not further analysed in detail.

Table 1. NL Import data (2007+2008) of possible host plant commodities from African countries where *T. leucotreta* occurs (data from import database, NPPO of NL)

Plant species	Commodity	Countries of Origin	# Items	# Tonnes
1. Rosa	Cut Flowers	Kenya, Ethiopia, Uganda,Tanzania, Zimbabwe	7.129.323.615	
2. Citrus Total	Fruit	South Africa; Zimbabwe		648.563
3. Ficus	Plants for Planting	Uganda, Tanzania	2.944.430	
4. Vitis vinifera	Fruit	South Africa, Namibia		125.836
5. Hibiscus	Plants for Planting	Zimbabwe, Kenya, Uganda	1.344.921	
6. Yucca	Plants for Planting	South Africa	801.190	
7. Phaseolus	Vegetables	Tanzania, Senegal, Kenya, Sudan		53.610
8. Pennisetum	Plants for Planting	Tanzania, Kenya	296.691	
9. Prunus spp.	Fruit	South Africa		29.205
10. Persea americana	Fruit	South Africa, Kenya, Zimbabwe		16.837
11. Mangifera indica	Fruit	Mali, Ivory Coast, South Africa, Burkina Faso	21.326	
12. Lycopersicon esculentum	Vegetables	Senegal, Ethiopia, Kenya, Tanzania		3.734
13. Capsicum spp.	Vegetables	Zambia, South Africa, Senegal		42

Other minor import products (#items < 1000 or #tonnes < 3000)		
ANANAS	Fruit	Ivory Coast, Ghana, South Africa, Mauritius
CAMELLIA	Plants for planting	Kenya
CAPSICUM ANNUUM	Fruit	Kenya, Zimbabwe, Uganda, Tanzania, Senegal, Ethiopia
DIOSPYROS	Fruit	South Africa
LITCHI	Fruit	Madagascar, South Africa
LYCOPERSICON ESCULENTUM	Fruit	Senegal, Ethiopia, Kenya, Tanzania
PRUNUS ARMENIACA	Fruit	South Africa
PRUNUS DOMESTICA	Fruit	South Africa, Zimbabwe
PRUNUS PERSICA	Fruit	South Africa, Zimbabwe
SOLANUM MELONGENA	Fruit	Ghana, Ethiopia, Kenya, Mauritius, Tanzania, Uganda
SORGHUM	Seeds	South Africa
ZEA	Seeds	Kenya, Tanzania
ABUTILON	Plants for planting	Kenya, Ivory Coast

1.2. Estimate the number of relevant pathways, of different commodities, from different origins, to different end uses.
see 1.1

1.3. Select from the relevant pathways, using expert judgement, those which appear most important. If these pathways involve different origins and end uses, it is sufficient to consider only the realistic worst-case pathways. The following group of questions on pathways is then considered for each relevant pathway in turn, as appropriate, starting with the most important.

Pathway: Consumer products of host plants

**1.4. How likely is the pest to be associated with the pathway at origin taking into account factors such as the occurrence of suitable life stages of the pest,
the period of the year ?**

CITRUS: *T. leucotreta* is abundant and a serious pest of citrus in some growing regions in southern Africa, but it does not cause major economic crop loss of citrus in other parts of the region (CRI, pers comm.). Host suitability of citrus types varies from highly suitable for Navel oranges to unsuitable for lemons (Newton, 1998). Due to the association with fruit, *T. leucotreta* is subjected to intensive control measures in parts of southern Africa where it is abundant, with crop losses in recent times typically being contained at levels of 1% or less in such high abundance regions (CRI, pers. Comm.). Crop loss is cumulative across the growing season and fruit infestation closer to the point of ripening causes fruit to drop from the tree (Newton, 1998). Infested fruit that remain on the tree at harvest often display signs of infestation, facilitating cull during picking and packing and all citrus fruit for export is subjected to successive selection during picking and packhouse handling before packaging (CRI, pers. comm.). However, some fruit infestation remains less obvious at the point of harvest and may remain undetected during handling. Consequently, the organism has been intercepted in citrus from South Africa (see 1.1).
Rating: likely   Uncertainty: low

CAPSICUM: Capsicum species are reported as host for *T. leucotreta*. There are no specific reports on crop losses, but it is regularly present in *Capsicum chinensis* crops in Uganda (pers. comm. Vollebregt). The organism has occasionally been intercepted on capsicum from East and West Africa (see 1.1).
Rating: moderately likely   Uncertainty: low

ROSA: in East Africa there are large rose production companies and *T. leucotreta* is reported to be present, and common in Kenya (CABI, 2007). There is no information on the pest prevalence of *T. leucotreta*. *T. leucotreta* is not regarded to be a pest of roses (CRI, pers. comm.), but it is possible that roses may be a secondary host, when preferred hosts such as stonefruits are not available. The organism has been intercepted a few times on roses from East Africa (see 1.1).
Rating: Unlikely   Uncertainty: low

1.5. How likely is the concentration of the pest on the pathway at origin to be high, taking into account factors like cultivation practices, treatment of consignments?

Citrus
Concentration of the pest at origin is likely to be low:

> Given the variation in host suitability of different citrus types (from highly suitable to unsuitable) and variation in the pest status (from serious to no economic crop loss) across production regions, concentration of the pest on the pathway will also vary in intensity from potentially high to very low. Control programmes are applied as a matter of course, primarily to reduce the chance of infestation at harvest. This involves orchard sanitation and a range of registered control techniques (Moore & Kirkman, 2009), with special emphasis on insecticide application closer to harvest. As a matter of routine procedure, strict inspection for damaged and infested fruit is conducted at picking and packing, with the objective of removing infested fruit (CRI, pers. comm.).

Given that infested fruit tends to drop from the tree and infested fruit is mostly visible due to externally visible signs of decay associated with feeding damage, inspection of fruit during picking and packing is effective at reducing the occurrence of infested fruit (CRI, pers. comm.).
However, the cryptic nature of early stages of infestation, especially where larval penetration of the fruit has occurred inside the navel opening of the fruit, indicates that some infested fruit will remain undetected.

For citrus, the combination of these considerations indicates that the overall concentration is likely to be low to medium.

Capsicum
For Capsicum there is no information available on cultivation practices in Africa.

Rosa
The concentration of the pest at origin is likely to be low. There are no records of establishment and survival of the organism on roses (CRI, pers. comm.). It is possible that roses may be a secondary host, when preferred hosts such as stonefruits are not available.

1.6. How large is the volume of the movement along the pathway?

Import of citrus from African countries where *T. leucotreta* is present (data from EUROSTAT):

CITRUS (FRESH OR DRIED ORANGES)
Rating: massive Uncertainty: low

x100 kg	**Jan.-Dec. 2007**	**Jan.-Dec. 2008**
GHANA	-	1308
SOUTH AFRICA	1.815.966	1.966.977
ZIMBABWE	184.794	124.915

CAPSICUM (FRESH OR CHILLED FRUITS OF THE GENUS CAPSICUM OR PIMENTA)
Rating: moderate Uncertainty: low

x100 kg	**Jan.-Dec. 2007**	**Jan.-Dec. 2008**
ETHIOPIA	2.073	7
GHANA	45	2
KENYA	535	937
NIGERIA	1	0
UGANDA	2.888	2.574
SOUTH AFRICA	124	1.445
ZIMBABWE	1.252	1.901

ROSA
Rating: massive Uncertainty: low

x100 kg	**Jan.-Dec. 2007**	**Jan.-Dec. 2008**
ETHIOPIA	132.827	192.237
KENYA	534.094	585.578
TANZANIA	21.826	23.507
UGANDA	46.021	50.006
SOUTH AFRICA	73	129
ZIMBABWE	54.754	50.261

1.7. How frequent is the movement along the pathway?

In Table 2, the monthly import data for 2008 (EUROSTAT) are indicated for the main trade flows for Pepper (Uganda), Citrus (South Africa) and Roses (Kenya)
Roses are imported at high volume throughout the year.
Citrus is mainly imported in the period June-October.
Peppers are imported at very low volume throughout the year.

Table 2 Monthly import data (x100 kg; Eurostat)

PERIOD	Jan. 2008	Feb. 2008	Mar. 2008	Apr. 2008	May. 2008	Jun. 2008	Jul. 2008	Aug. 2008	Sep. 2008	Oct. 2008	Nov. 2008	Dec. 2008
PEPPER-UG	440	375	226	209	96	82	22	73	125	103	180	643
CITRUS-ZA	355				6192	115825	374770	602810	599794	260676	6555	
ROSES-KE	62480	71879	70819	65998	68663	55410	48828	49076	55075	62781	62902	62776

1.8. How likely is the pest to survive during transport/storage?

Rating: likely Uncertainty: low
The time between harvesting of both roses and peppers and arrival in NL is very short since most product is transported by air. The likelihood of survival under such conditions is high. Citrus fruit is shipped and transport time is mostly between two and three weeks. In those fruit where infestation was not obvious at the time of harvest and packing, decay will mostly develop in infested fruit during such shipping. *T. leucotreta* larvae show high levels of mortality in fruit that decays in storage. Furthermore, the obvious decay makes it very unlikely that such fruit will enter the distribution chain on arrival. However, given the volume of produce moved, some survival can be expected and indeed for all three commodities, living specimens of the organism have been intercepted at import. Occasionally adults are collected in North-western-Europe outdoors that are supposed to have developed from larvae imported with Citrus fruits (www.microlepidoptera.nl; Huisman, 2000; *Svensson, 2002; Langmaid, 1996;* Knill-Jones, 1994).

1.9. How likely is the pest to multiply/increase in prevalence during transport /storage?

Rating: very unlikely Uncertainty: low
CITRUS: consignments are transported by ship at 4.5°C or 11°C (fruit pulp temperature), depending on the colour of the fruit at the time of shipping. At these temperatures it would be impossible for any population build up or reproduction to take place. Daiber (1979a) determined that *T. leucotreta* eggs did not hatch at an average temperature of 10.6°C. Daiber (1979b) also determined the lower developmental threshold for the different life-stages to range from 11.6 to 12.5°C.

CAPSICUM & ROSA: consignments are transported by airfreight and arrive within a day.

1.10. How likely is the pest to survive or remain undetected during existing management procedures (including phytosanitary measures)?

Rating: likely Uncertainty: low
All three pathways: The organism has a hidden lifestyle and may be difficult to detect.
Larval entries in fruit take a few days to become visible. Therefore, larval entries that occur close to fruit harvest might not be detected at the time of export. However, as mentioned in 1.8, the time between harvesting of fruit and arrival in NL is often a few weeks. Infested fruit will begin to decay and symptoms of infestation (Newton, 1998) will therefore in all likelihood be clear by the time of importation. Therefore, although the pest may well survive in the fruit, its presence will be relatively easily detected. However, because *T. leucotreta* is not a quarantine pest, there are no targeted inspections and it is likely that the pest will survive the existing management procedures.

1.11. In the case of a commodity pathway, how widely is the commodity to be distributed throughout the PRA area?
Rating: very widely Uncertainty: low
All three pathways: commodities are end-consumer products and will be distributed quickly and widely throughout the PRA area.

1.12. In the case of a commodity pathway, do consignments arrive at a suitable time of year for pest establishment?
All three commodities arrive in the summer months (see 1.7). This overlaps with the potential occurrence of host plants outdoors.

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

CITRUS
The main route of introduction of citrus fruits to the PRA area is by ship. Consignments are temporarily stored in cooled stores in Rotterdam harbour. From there they are transported by truck to supermarkets throughout the country. At the point of entry the organism is usually present in the larval stage. Any eggs which may have survived handling during picking and packing will have died under shipping conditions. There is also no possibility that moths will emerge from infested citrus fruits, as pupation does not take place in fruit. Larvae need to exit fruit to pupate, a process which usually takes place in the soil (Newton, 1998). The progression of decay 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 the density of infested fruits at 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 introduction risk of this organism relative to fruit flies for example. Hence, the probability is very low that at least two moths of opposite sex emerge at the same place and time ~~and~~ to mate. This probability may be higher at places where discarded citrus fruits are assembled (e.g. waste containers at permanent fruit markets or auctions.
In the summer months escaped moths may be able to find suitable hosts outdoors, due to the polyphagous nature of the organism. However, it is apparent that whereas the species has a wide host range, very little host-switching occurs within a population (Stotter, 2009). Adult *T. leucotreta* also do not demonstrate high mobility over large distances under field conditions (Stotter, 2009). Furthermore, significant population build-up is unlikely due to sub-optimal climatic conditions in the PRA area. It is very unlikely that the density of mated female moths will be high enough in order to transfer from the place of emergence to a glasshouse with a suitable host plant. Incidental findings of moths in North Western Europe in the past (see 1.8) has never resulted in outbreaks.

Conclusion: The probability of transfer from citrus fruits to a glasshouse where it could temporarily establish is very low. Uncertainty: low.

CAPSICUM
In general, Capsicum fruit are end consumer products that arrive by aircraft and end up relatively quickly with the end consumer. Due to the dilution effect, as described above for citrus, it is unlikely that a significant number of moths will emerge, before the vegetables are discarded by the end consumer. However, this 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 eclosion of moths may occur. If consignments are cold-stored, then development of *T. leucotreta* will be retarded or halted and decay will develop, reducing the aforesaid risk.
In cases where consignments of vegetables are stored near production places with suitable host plants, there is a possibility that moths escaping from infested consignments may enter a suitable glasshouse,

mate and lay eggs. The risk that this event will occur is particularly high for companies that not only trade, but also have a production facility of the same commodity.
In NL there are a few companies that sort and pack vegetables from Africa and that also have a production facility within the same building. In 2009, there was an outbreak of *T. leucotreta* in the glasshouse adjacent to the storage room at one of these companies.

Conclusion: The probability of transfer from capsicum fruits to a glasshouse where it could permanently establish is very low for the bulk of the trading flow that goes directly to the end consumer. The probability of transfer to a glasshouse is medium for combined trading and production companies of capsicum fruit.

ROSA
The main route of introduction of roses to the PRA area is by aircraft. The shelf life of cut flowers is very short and the commodity will be transported and end up at the end consumer within a few days after arrival. It is unlikely that a significant number of moths will emerge and mate before the cut flowers are discarded by the end consumer. There are no records of succesfull development of *T. leucotreta* on roses (CRI, pers. Comm.). Another lepidopteran species that is often present on roses from East Africa is *Helicoverpa armigera*. In a PRA (Lammers *et al.*, 2007), it was concluded that the presence of *H. armigera* on consignments of consumer products (roses, beans) does pose a very low risk of introduction to glasshouses.

Conclusion: The probability of transfer for the pathway roses is considered very low, because it is unlikely that larvae are able to develop into adults and that a significant number of mated females are able to find a glasshouse with suitable host plants.

1.14. In the case of a commodity pathway, how likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) to aid transfer to a suitable host or habitat?
see 1.13

1.15. Do other pathways need to be considered?
For the pathway Capsicum fruit the rating is medium in case there are trading companies that also have their own production facilities of Capsicum. In NL these combined companies also exist for Tomato and maybe for aubergine. It is unknown if these companies import vegetables from African countries where the pest occurs. Aubergine and tomato are mentioned as host plants for *T. leucotreta*, but no reports are available on pest prevalence. This may indicate that tomato and aubergine are secondary hosts and may not be an important pathway to consider. Therefore, these pathways are not analysed in this PRA.

Conclusion on the probability of entry.

Summary Pathway Analysis

Pathway	Prob. of Association	Trade volume	Prob. of arrival	Prob. of transfer[1]	Prob. of entry	Uncertainty
Citrus	medium	massive	High	very low	very low	low
Capsicum-A[2]	medium	medium	Medium	very low	very low	medium
Capsicum- B[2]	medium	very small	Medium	medium	medium	medium
Roses	low	massive	High	very low	very low	low

(1) The probability of transfer is considered to be high 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 11°C).
(2) Capsicum-A= trade goes directly to end-consumer (99% of Capsicum trade)
Capsicum-B= consignments are stored in the near vicinity of a production place.

1.16. Estimate the number of host plant species or suitable habitats in the PRA area.
See question 6.

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

Number of companies with glasshouses with potentially suitable host plants (CBS, 2009)

	2008		2009	
	Number	ha (total)	Number	ha (total)
Pepper	373	1184	348	1331
Tomato	404	1600	358	1628
Aubergine	60	96	55	94
Rosa	310	583	265	532

In general, these production places are concentrated in certain areas in NL.

Arable land: maize fields (maize cobs available July-Oct), very common.
Natural environment: Oak (*Quercus robur*), very common.

In the urban, semi-natural environment several fruit bearing host plants are present in gardens and parks.

1.18. If an alternate host or another species is needed to complete the life cycle or for a critical stage of the life cycle such as transmission (e.g. vectors), growth (e.g. root symbionts), reproduction (e.g. pollinators) or spread (e.g. seed dispersers), how likely is the pest to come in contact with such species?
Not applicable

1.19. How similar are the climatic conditions that would affect pest establishment, in the PRA area and in the current area of distribution?
Outside – LOW (uncertainty: low)
Borchert (2005) used the following parameters to predict establishment of *T. leucotreta* in US: 450 degree days per generation with minimum developmental temperature of 12 ˚C and upper developmental temperature of 40 ˚C. Cold stress parameters were 25 days with minimum daily temperature <-1 ˚C or 50 days or more with average daily temperature below 10 ˚C. Using these parameters with climatological data for the Netherlands (2001-2007) shows that the organism can survive for 1 generation in the summer months in the field. However, the cold stress factors do not allow for the organism to survive the winter conditions in the Netherlands.

Glasshouse – HIGH (uncertainty: low)
Mean temperature about 20 ˚C. Expected generation time (egg to adult) 7-8 weeks (Daiber, 1979, a, b & C). This assumes that the glasshouses are operated without interruption throughout the year, whereas in practice, facilities may experience temporary shut downs, particularly between production cycles in winter, which would make the environment unfavourable for survival.

1.20. How similar are other abiotic factors that would affect pest establishment, in the PRA area and in the current area of distribution?
No other abiotic factors seem important. The organism pupates outside the fruits on the ground.

1.21. If protected cultivation is important in the PRA area, how often has the pest been recorded on crops in protected cultivation elsewhere?
In Uganda *T. leucotreta* is reported to be present in glasshouses with *Capsicum chinensis* (pers. comm. T. Vollebregt, Dutch importer).

1.22. How likely is it that establishment will occur despite competition from existing species in the PRA area?
In general, competitive exclusion is very rare and is highly unlikely to prevent establishment. There are no other explicit fruitboring species present in vegetable production in NL glasshouses.

1.23. How likely is it that establishment will occur despite natural enemies already present in the PRA area?
In general, natural enemies are not able to completely eradicate or prevent establishment of a host species.

1.24. To what extent is the managed environment in the PRA area favourable for establishment?
Host plants such as pepper, tomato and aubergine are grown in monoculture in heated glasshouses. At a mean glasshouse temperature of 20 ˚C, the generation time is 7-8 weeks (Daiber, 1979a, b & c). The number of generations can be up to 6 per growing season (Newton, 1998).
It is uncertain if permanent establishment in glasshouses is possible. For permanent establishment in a glasshouse environment, the organism has to survive the period of crop removal and new crop initiation.

This seems unlikely for an organism that needs fruits to survive. In a pepper glasshouse a new culture starts in December and the first fruits are harvested in March the following year. This implies that a population that is present in a glasshouse at the end of the growing season (November) has to bridge a 'fruitless' period of at least 5-6 weeks within the same glasshouse (pers. comm. A. van der Linden, WUR-PPO). The organism has no diapause phase, but the pupal stage can last 4 weeks and the lifespan of adults is 3 weeks. Thus, there is a small probability that the organism can bridge the period without crop and settle on the new young crop. It is unlikely that the organism can have a successful generation cycle in the absence of fruits. Unlike *Leucinodes orbonalis,* where in the absence of fruits larvae may penetrate the stem (Van der Gaag *et al.*,2005), there is no evidence of this for *T. leucotreta* (CRI, pers. comm.). In the period of crop removal and initiation of new crop mated female moths may be induced to leave the glasshouse, because fruits are absent. However, dispersal to surrounding glasshouses with suitable host species is unlikely given the fact that windows remain closed in general in wintertime and outside night and day temperatures are generally too low for active flight.

1.25. How likely is it that existing pest management practice will fail to prevent establishment of the pest?
see 1.26

1.26. Based on its biological characteristics, how likely is it that the pest could survive eradication programmes in the PRA area?
Establishment of populations of *T. leucotreta* is only possible in heated glasshouses. The organism is difficult to control with insecticides, due to the hidden lifestyle of the larvae. Therefore, eradication may

be difficult during the growing season. However, eradication of populations in glasshouses seems feasible, given the fact that the period of crop removal and initiation of a new crop may be very critical for the population dynamics of the organism (see 1.24).

1.27. How likely is the reproductive strategy of the pest and the duration of its life cycle to aid establishment?

Biological characteristics of *T. leucotreta* (20 °C, Daiber, 1979a, b & c):
Egg: 7 days
Larva: 21-22 days
Pupa: 26-28 days
Lifespan adult: 3 weeks in the lab; maximum of 2 weeks in the field.
It should be noted that the duration of the different life stages is temperature dependent, which is reflected in the wide variation in development times reported, e.g. up to 60 days for pupa and adults (Venette, 2003).

Five to six generations are reported in South African citrus orchards. The species has no diapause phase and must breed continuously to survive.
Oviposition activity is high between 20-25 °C, and very low at 10°C (Daiber, 1980). Females lay eggs singly on fruit and up to 800 eggs during their lifetime. Even in a heavily infested orchard, there will be an average of fewer than 2 eggs per fruit (considering only those fruit which have eggs on them) (Sean Moore, unpublished data). In addition, mortality of eggs and neonate larvae is very high. Larvae are cannibalistic, with infested fruit very seldom supporting more than one larva to completion of its development (Catling & Aschenborn, 1978). Adult moths do not disperse over great distances and field populations are generally highly localised. There are indications of strong host specificity at the population level which presents a barrier to host switching, thereby countering the apparent risk associated with the broad host range of the species (Timm, 2005; Stotter, 2009). These factors mean that the probability of a mating pair emerging from fruit and finding one another, mating and the female finding a suitable host is very small.

1.28. How likely are relatively small populations to become established?

Outdoors: unlikely (medium uncertainty)
Glasshouse: likely (medium uncertainty)
In the natural environment, the Allee effect may hamper the successful establishment of sustainable populations. Populations of a few emerged moths may have difficulties finding a mating partner and suitable host plants with fruits.
For glasshouses with a crop of a suitable host plant the above scenario is different, because host plants are abundant and moths emerge in a confined space.

1.29. How adaptable is the pest?

Rating: Moderate Uncertainty: medium
There are reports of development of resistance against chitin synthesis inhibitors (Hofmeyr & Pringle, 1998).
Polyphagous species sometimes develop strains or local populations which prefer specific host plants (Fox & Morrow, 1981; Futuyma & Peterson, 1985). Local populations of a polyphagous species can have a relatively narrow host range locally, or consist of host-specific sub-populations. In South Africa, a DNA analysis of field populations of *T. leucotreta* demonstrated that local populations could be recognized based on their DNA profile, indicating that there was little movement of genetic material between proximal populations (Timm, 2005). This is supported by the apparent preference for and even restriction to certain hosts in certain regions. For example, in Israel, *T. leucotreta* has been present since 1984, but there has been very little expansion of the host range beyond its original association with macadamias, and in Uganda it is a significant pest on cotton, whereas in South Africa its occurrence on cotton is minimal (CRI, pers. Comm.). Stotter (2009) found that whereas *T. leucotreta* was abundant in citrus production in the Citrusdal region, it had very limited association with alternative hosts and very

little (if any) shuttling took place between host plants and resource patches. This indicates the existence of behavioural barriers to host switching to 'new' hosts encountered in a new environment.

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

The only recorded case of introduction to and establishment in a new region is its introduction into Israel, where it has become exclusively a pest on macadamias (Wysoki, 1986) and has not spread in the Mediterranean region. The relatively weak invasiveness of this species is further reflected in the failure to expand its distribution despite the association with a wide range of crops that have been widely exported from Africa over protracted periods. For example, shipping routes between Africa and Europe have been operational for centuries and citrus fruit has been commercially exported from South Africa for more than a century.

The organism has been noticed several times by amateur lepidopterists in the Netherlands as a moth in 1998 and as larvae from rotting citrus fruits (microlepidoptera.nl), in Sweden (Svensson, 2002) and in the UK (Langmaid, 1996; Knill-Jones, 1994). It is highly unlikely that these moths came from established populations.

1.31. If establishment of the pest is very unlikely, how likely are transient populations to occur in the PRA area through natural migration or entry through man's activities (including intentional release into the environment)?

Not applicable

Conclusion on the probability of establishment

It is possible, but very unlikely, that transient populations could occur in the field during the summer months. Conditions in heated glasshouses offer conditions suitable for temporary survival of the organism, but the probability of permanent establishment is uncertain. There is no information available if the organism will be able to survive the period between two fruit bearing crops in a glasshouse.

1.32. How likely is the pest to spread rapidly in the PRA area by natural means?

The organism is regarded as a poor disperser. Although in South Africa it was able to disperse to uninfested citrus areas (Newton, 1998), this spread was over relative small distances and Timm *et al.* (2009) demonstrated significant genetic differences between all regional populations, even those from orchards very close to each other. This also indicates a low dispersal rate. Likewise, Stotter (2009) reported restricted movement of individuals under field conditions with very little, if any, shuttling between host resource patches. Potential natural spread would also be limited to summer months, when ambient night temperatures are high enough to enable dispersal outside.

Spread between glasshouses is unlikely to be significant. In general, movement from infested crops to unifested crops is only likely to occur when population densities are very high or when the crop is removed and adult moths are induced to disperse. It is uncertain if the organism is able to build-up high population densities in a glasshouse environment. Adults may leave a glasshouse when the crop is removed or repellent insecticides are used. However, this occurs in the winter months when glasshouse windows are closed and night temperatures do not favour outside dispersal.

1.33. How likely is the pest to spread rapidly in the PRA area by human assistance?

Spread between glasshouses is possible if infested material (fruited plants, fruits or packaging material) is transported.

Conclusion on the probability of introduction and spread

- The pest regularly arrives into the Netherlands via infested fruit (citrus and Capsicum) and cut flowers (roses) from Africa. However, the successful transfer from the place of arrival to a suitable place for reproduction and permanent establishment is very low. The organism is expected not to survive the winter period in the natural environment and whereas a population may arise within the protected environment inside glasshouses with suitable hosts, this is unlikely to result in permanent establishment in such a glasshouse. For the bulk of the trade flow of commodities (end-consumer products) from infested areas, there is a very low risk of introduction. However, incidental outbreaks and possible temporary populations in glasshouses is considered possible when imported commodities are stored and packed on the same premises. There are a few companies in the PRA area that combine import and production of peppers. In those cases there is a medium probability of temporary introduction.
- Both natural spread and human assisted spread are expected to be low in the PRA area. Therefore, it is likely that the pest can be contained within the PRA area.
- The overall probability of introduction is low for the bulk of the trade flow of roses, citrus and capsicum. With regard to this aspect, there are a lot of similarities with the PRA of *Leucinodes orbonalis* (van der Gaag et. al.,2005), an important fruitborer of aubergine. Also for this organism it was concluded that in order to transfer to a glasshouse production site, imported larvae would have to survive, develop and find a glasshouse with host plants. These successive events are very unlikely to happen.
- The probability of introduction is medium for companies that import capsicum from Africa and also have a production glasshouse adjacent to the storage room. There are only a few companies (<5) in NL that have these practices.
- For another organism associated with fruits, the leafmining moth *Tuta absoluta,* the PRA rated the probability of entry as high (Potting, 2009). The main reason for this high entry rating is that the possible presence and concentration of *T. absoluta* on consignments from infested areas within the EU was rated high. *T. absoluta* cannot only be present on fruits, but also on the green parts of vine tomatoes. In contrast to the main commodities for *T. leucotreta* (citrus, roses, peppers), there is a relatively large industry that imports and packs tomatoes from *T. aboluta* infested EU countries. The probability of spread from these packing companies is much higher for *T. absoluta* compared to *T. leucotreta*.

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

Rating: medium-high Uncertainty: low

T. leucotreta is one of the most important pests of citrus in certain parts of South Africa, whereas in other parts it is not considered to cause economic crop losses. Some types of citrus are highly susceptible (for example Navel oranges), whereas others are not suitable hosts (lemons). 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).
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 timeously, the pest populations can be effectively controlled at low population levels (Moore & Kirkman, 2008).

Reported Economic damage.

Crop	**Notes**	**Reference**
Citrus	Whereas crop losses of 10-20% were reported in parts of South Africa in the past, with improved control strategies serious crop losses are now generally avoided.	(Van der Geest et al., 1991; CRI, pers. Comm.)

Cotton	Uganda, 20-90% loss	Couilloud, 1994. Venette et al., 2003
Maize	West Africa, 17-44% in combination with stemborers	Ndemah & Schultess, 2003; Hell et al. 2000; CAB43
Macadamia	South Africa, Israel (30% loss)	Venette et al. 2003
Stonefruits	Pyrus, Peach (28%)	Venette et al. 2003
Litchi	South Africa, 6%	Grove et al., 2004
Avocado	Cosmetic damage to fruits, larvae are unable to complete development	Stibick (2006)

2.2. How great a negative effect is the pest likely to have on crop yield and/or quality in the PRA area without any control measures?

CAPSICUM - Medium
In contrast to leaf feeding lepidopteran species, *T. leucotreta* directly attacks the fruits of capsicum. This may rapidly result in unacceptable levels of cosmetic damage. In NL there is virtual a zero tolerance level for cosmetic damage for capsicum fruits.
The production value of capsicum in NL is € 400 million (PT, 2007).

CITRUS - Low
There is no commercial production of citrus fruit in the PRA area. There are a few small companies that import and grow ornamental citrus plants.

ROSES - Low
The production value of Rosa in NL is € 700 million (PPO 2005-2006). Rosa is not considered a primary host plant for *T. leucotreta* and significant population build-up and damage is not expected because fruits are not present in rose production.

2.3. How easily can the pest be controlled in the PRA area without phytosanitary measures?

Rating: medium Uncertainty: medium

In the Netherlands, more than 95% of the pepper production companies apply Integrated Crop Management. ICM is based on pollination with bumblebees (*Bombus terrestris*) and pest management with biological control agents (parasitic wasps, predators and entomopathogenic nematodes). In Capsicum production, pollination with bumblebees is not necessary, but significantly enhances the quality of pepper fruits. It is applied by approx. 20% of the growers. Biological control is applied against whiteflies, dipteran leaf-miners, mites and Lepidoptera (see Table 3 for overview).
To avoid side effects of insecticide treatments on bumblebees and natural enemies, only a part of the available insecticides can be used in integrated crop management (Biobest, 2008; 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 (see Table 4). 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.

The larva bores into citrus fruit after a short period of time, usually within 24 hr (Kirkman, 2007). This implies that in order for an insecticide to be effective against *T. leucotreta* larvae, either timing of application must be accurate or the period of residual efficacy must be satisfactorily prolonged. The only available registered insecticides in the PRA area that could be used against *T. leucotreta* without disturbing ICM are methoxyfenoxide (Runner) and Bt-based products. Although no data are available on efficacy of Runner for *T. leucotreta*, other products from this insect growth regulator class of insecticides 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).

In South Africa, the most commonly used treatments in citrus production for control of *T. leucotreta* are a granulovirus (Cryptogran), followed by the pyrethroid (cypermethrin). Other products which are fairly widely used are Isomate (mating disruption), Last Call (attract and kill) and Meothrin (fenpropathrin) (S. Moore, CRI, pers. comm.). The use of the Sterile Insect Technique is also rapidly expanding. Other registered products in South Africa are triflumuron (Alsystin) and teflubenzuron (Nomolt). However, teflubenzuron cannot be used in ICM in NL and triflumuron is not registered for use in NL.

To keep the density of *T. leucotreta* as close to zero as possible, the following control techniques are applied/investigated in South Africa (Newton, 1989; Carpenter et al., 2007):

- Sterile Insect Technique (SIT): based on the mass production and release of sterilised moths that compete with the wild target population. Expensive method used for area wide control of insect pest. (Vreysen et al., 2007). In South Africa 1000 sterile adults/ha are released biweekly
- Granulovirus (CRYPTOGRAN & Cryptex): species specific virus formulation, registered and used in South Africa. Has no side effects on beneficial insects.
- Biological control with the egg parasitoid *Trichogrammatoidea cryptophlebiae*: based on mass production and release of the parasitoid. Relatively expensive technique and a relatively predictable egg-laying period of the host is necessary to be cost effective. Parasitoids used to be released commercially at 100 000 per ha. per season. This approach has not been employed for the last few years. However, two commercial insectaries are set to reintroduce this as an option.
- Pheromone: the pheromone of *T. leucotreta* is commercially available. It can be applied as a control technique in mating disruption (ISOMATE and CHECKMATE-FCM) and attract and kill (LAST CALL-FCM).
- Pyrethroids – Cypermethrin and Meothrin (fenpropathrin) – restricted to being used once, not later than four weeks before harvest.
- Triflumuron (Alsystin) and teflubenzuron (Nomolt): used to be relatively widely used and highly effective. However, resistance has developed to these products in certain areas after regular use for several years (Hofmeyr & Pringle, 1998).
- Orchard sanitation: Weekly removal of fruits effectively contributes towards the control of *T. leucotreta*. When fruits are collected weekly, it is estimated that 75% of the FCM population is removed (Moore & Kirkman, 2009).

Conclusion: Insecticidal control that is currently registered in NL and can be safely used in Integrated Crop Management is limited to Runner, although the efficacy against *T. leucotreta* is unknown. The use of CRYPTOGRAN and pheromone-based products are not registered, but are promising because they can be readily incorporated in ICM in NL. Biological control agents that attack lepidopteran eggs are available in NL. It is uncertain what the population level of *T. leucotreta* in NL glasshouses will be and if current ICM in NL practices are able to keep fruit damage below the economic threshold level. This relates to control of a *T. leucotreta* population within a glasshouse during a production cycle. The prospects for eradication of such a population at the end of a production cycle are good. A temporary elimination of host material and exposure to adverse climatic conditions can be expected to be an effective and low cost means of eliminating a residual population at the end of a production cycle.

TABLE 3. Overview of registered insecticides targeted against Lepidoptera in pepper production in the Netherlands, with an indication of side effects on beneficial agents. Side effects data from Biobest (2009), Koppert (2009).

Active ingredient	Target stage	Side Effects	Remarks

Name product			
Methoxyfenoxide *Runner*	Young larvae	Safe	Ecdysis
Indoxacarb *Steward*	Larva all stages	Medium	No information on effects on biological control agents Removal of Bumble bee colony for 3 days
Teflubenzeron *Nomolt*	Young larvae	Harmful	Benign to most biological agents Very harmful to Bumblebees
Spinosad *Tracer*	Larva	Medium	Medium effect on biological control agents Removal of Bumble bee colony for 3 days
Deltamethrin *Decis Micro/EC*	Larva, Adult	Very Harmful	8-12 weeks after application side effects on biological control agents Removal of Bumble bee colony for 1-2 days
Pyrethrin/ Piperonylbutoxide *Spruzit vlb.*	Larva / Adult	Very Harmful	Used for spot wise correction 8-12 weeks after application side effects on biological control agents Removal of Bumble bee colony for 3 days
Bacillus thuringiensis. *Turex 50 WP* *Xen Tari WG*	Young larvae	Safe	
Kernpolyedervirus *Spod-X*	Larvae	Safe	Specific virus-based product for *Spodoptera exigua*
Flubendiamide *Fame*	Larvae	Safe	Harmful to bees only

Table 4 Overview of biological control agents against various Lepidoptera applied in integrated pepper production in the Netherlands.

Biocontrol agent	**Group**	**Target**	***T. leucotreta* as target**
Steinernema carpocapsae	parasitic nematode	larvae in soil and on leaf	unknown
Hypoaspis aculeifer/ H. miles	Predatory mite	Soil insects, including Duponchelia fovealis	No
Macrolophus caliginosus	Predatory mite	Lepidoptera eggs	plausible
Trichogramma brassicae	Parasitoid	Lepidoptera eggs	No, but other species available
Chrysoperla carnea	Lacewing	Lepidoptera eggs	plausible

2.4. How great an increase in production costs (including control costs) is likely to be caused by the pest in the PRA area?

Production costs of crops grown under protected conditions (mainly sweet pepper) will probably increase due to an increase in pesticide applications and a disruption of the integrated control strategies. Yields may be lower due to damage caused by the pest organism and labour costs may increase, as damaged fruits will have to be removed.

2.5. How great a reduction in consumer demand is the pest likely to cause in the PRA area?

Rating: low **Uncertainty: low**

No effects on consumer demand are expected. Damaged fruits are sorted out

2.6. How important is environmental damage caused by the pest within its current area of distribution?
Rating: very low Uncertainty: low
T. leucotreta is present on many wild host plants (Kirkman & Moore, 2007). There are no reports that it is regarded as an organism harmful to the environment.

2.7. How important is the environmental damage likely to be in the PRA area Rating: low Uncertainty: low
See 2.6. It is expected that *T. leucotreta* is unable to establish sustainable populations in the natural environment.

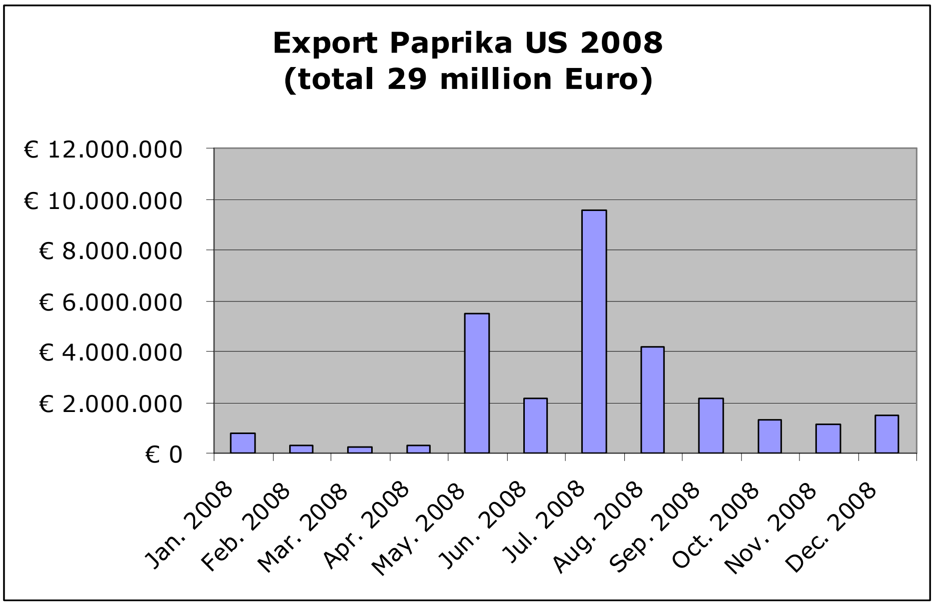
2.8. How important is social damage caused by the pest within its current area of distribution?
Rating: low Uncertainty: low
There are no records of social damage.

2.9. How important is the social damage likely to be in the PRA area?
Rating: low Uncertainty: low
See 2.5 and 2.7

2.10. How likely is the presence of the pest in the PRA area to cause losses in export markets?
Rating: high Uncertainty: low

T. leucotreta is regarded as a high priority quarantine organism in the US. After the interception of an infested consignment of *Capsicum chinensis* from NL in 2009, the US prohibited the import of all Capsicum from NL.
The US is an important export market for Capsicum from NL (€ 35 million).
The impact will be lower if only companies that trade with US have to guarantee, with a systems approach, that their export products are free from harmful organisms, as is already in place for *Duponchelia fovealis* in capsicum.

Export data Capsicum NL to US (Eurostat data)



Export data of NL capsicum

Bron: PT / KCB	2005 Hoev. x 1.000 kg	2005 in %	2006 Hoev. x 1.000 kg	2006 in %	2007 Hoev. x 1.000 kg	2007 in %	2008 Hoev. x 1.000 kg	2008 in %
Paprika totaal	**312.087**	**100**	**286.419**	**100**	**288.683**	**100**	**301.644**	**100**
Duitsland	117.135	38	117.033	41	112.622	39	109.605	36
Ver.Koninkrijk	62.871	20	54.645	19	57.459	20	62.341	21
Zweden	15.796	5	15.183	5	15.969	6	16.306	5
Rusland	10.905	3	11.361	4	11.583	4	12.235	4
Tsjechië	9.332	3	7.090	2	6.799	2	10.736	4
VS van Amerika	21.249	7	17.119	6	10.660	4	10.418	3
Frankrijk	9.728	3	6.688	2	9.693	3	9.459	3
Noorwegen	6.733	2	6.937	2	7.609	3	8.502	3
Polen	4.728	2	3.016	1	4.435	2	8.486	3
Denemarken	8.004	3	8.107	3	8.248	3	7.324	2
Ierland	4.627	1	3.944	1	4.821	2	5.681	2
Zwitserland	5.161	2	4.850	2	5.680	2	5.676	2
Canada	6.578	2	5.015	2	4.357	2	4.882	2
Italië	4.953	2	3.127	1	4.764	2	4.539	2
Finland	3.289	1	2.678	1	4.100	1	4.509	1
Oostenrijk	3.375	1	3.511	1	3.341	1	3.298	1
Japan	5.106	2	4.741	2	3.416	1	2.241	1
overige landen	12.519	4	11.373	4	13.128	5	15.406	5

CONCLUSIONS

Endangered area

- *Thaumatotibia leucotreta* is a polyphagous fruitborer. Glasshouses with roses, pepper, tomato and aubergine are at risk. Rose, tomato and aubergine are minor host plants. Only the risk for pepper production is considered in detail in this PRA.

Probability of introduction: low

- The most important pathways are citrus fruits, roses and capsicum fruits from African countries where *T. leucotreta* is present.
- There is a large trade volume of citrus and *T. leucotreta* is occasionally intercepted at import in Rotterdam harbour. The probability of transfer from infested citrus fruits to glasshouses with suitable host plants is very low. There is no spatial association between citrus trade and vegetable production in glasshouses.
- There is a large trade volume of roses from Africa and *T. leucotreta* has been intercepted several times. The probability of transfer from infested roses to glasshouses with suitable host plants is very low. There is no spatial association between the rose trade chain and vegetable production in glasshouses.
- There is a moderate trade volume of Capsicum from Africa and *T. leucotreta* has been intercepted several times. The probability of transfer from capsicum fruits to a glasshouse where it could establish is very low for the bulk of the trading flow that goes directly to the end consumer. The probability of transfer to a glasshouse is medium for combined trading and production companies of capsicum. There are a few (<5) companies in NL with this medium risk profile.

Probability of establishment: outside-low, glasshouse-medium

- In the natural environment, it is possible but unlikely that during the summer transient field populations may occur on suitable host plants with fruits. However, the organism is not expected to survive the winter conditions outside.
- In heated glasshouses establishment is possible and the number of generations can be up to 6-7 per growing season. Because *T. leucotreta* probably needs fruits to survive, the probability seems low that the organism will be able to survive the period between two fruit bearing crops in a glasshouse, making permanent establishment unlikely and eradication achievable.

Economic impact
Direct impact: potentially medium (medium uncertainty)
Indirect impact: potentially high (low uncertainty)

- If no specific control measures are applied against the organism, damage to pepper production can be high, because the organism attacks the fruits, which may induce unacceptable levels of cosmetic damage.
- The organism is difficult to control with insecticides. The additional potential economic impact due to disruption of biological control and pollination may be high (uncertain). The efficacy of currently available ICM-compatible treatments is untested and other ICM-compatible treatments that are used to control the pest in South Africa are not presently registered for use in NL.
- If the organism establishes in NL glasshouses this may have an effect on export of products that are suitable host plants for *T. leucotreta*, such as roses, peppers, tomato and aubergine.

Uncertainties of Pest Risk Analysis

Section of PRA	**Uncertainty**	**Information needed**
Establishment	If the organism will be able to survive the period between two fruit bearing crops in a glasshouse.	
Economic impact	It is uncertain if *T. leucotreta* can be sufficiently suppressed without disrupting ICM – strategies that are commonly used at pepper production sites.	Efficacy of available biological agents against the organism. Range of effective insecticides and frequency of use in relation to disruption of ICM.
Entry	How common the practice is to re-use packaging material from packing stations that are at risk.	

REFERENCES

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

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

CABI (2007) CABI Crop Compendium.

Carpenter, J., Bloem, S. & Hofmeyr, H., 2007. Area-wide control tactics for the False Codling Moth, *Thaumatotibia leucotreta*. In: Vreysen et al (eds) Area-wide control of insect pests, Springer, pp 351-360.

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

CBS, 2009. Centraal Bureau voor Statistiek, Statline, http://statline.cbs.nl/StatWeb.

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.

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

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

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

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

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

Erichsen, C. & Schoeman, A.S. 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

Fox, L.R. & Morrow, P.A. 1981. Specialization: species property or local phenomenon ? Science 211: 887-893.

Futuyma, D.J. & Peterson, S.C. 1985. Genetic variation in the use of resources by insects. Annu. Rev. Entomol. 30: 217-230.

Grove, T, Steyn, W. P. & Beer, M. S. de. 2004. *Cryptophlebia* species (Lepidoptera: Tortricidae). South African Litchi Growers' Association Yearbook. 2004. 16: 52-59.

Hell, K. Cardwell, K. F., 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

Hofmeyr, J.H. & Pringle, K.L. 1998. Resistance of the False Codling Moth to the chitin synthesis inhibitor, triflumuron. African Entomology 6: 373-375.

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

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

Koppert (2009) http://neveneffecten.koppert.nl/

La Croix, E.A.S. & Thindwa, H.Z. 1986. Macadamia pests in Malawi. III. The major pests. The biology of bugs and borers. *Tropical Pest Management* 32(1): 11-20.

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

Moore, S.D., Grout, T.G., Hattingh, V. & Hofmeyr, J.H. 2008. Thresholds and guidelines for intervention against citrus pests. *South African Fruit Journal*, Aug/Sep 2008, pp. 77-81.

Moore, S.D. & Kirkman, W. 2008. Citrus orchard sanitation with emphasis on false colding moth control. *South African Fruit Journal*, Dec/Jan 2009, 57-60.

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. 2002. 22: 3, 183-192.

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

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

Stibick, J. 2006. New pest response guidelines: False codling moth *Thaumatotibia leucotreta*. USDA-APHIS-PPQ. [http://www.aphis.usda.gov/import_export/plants/manuals/emergency/downloads/nprg-fcm.pdf]

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

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

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

Van der Gaag, D. & Stigter, H. 2005. Pest Risk Analysis *Leucinodes orbonalis*. NPPO The Netherlands, http://www.minlnv.nl/portal/page?_pageid=142,2268041&_dad=portal&_schema=PORTAL&p_file_id=14186

Van der Geest, L.P.S., Wearing, C.H. & Dugdale, J.S. 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.C. et al. 2003. Mini Risk assessment, False codling moth *Thaumatotibia leucotreta*. Univ. Minnesota, Department of Entomology, CAPS PRA: 1-30.

Vreysen, M.J.B., Robinson, A.S. & Hendrichs, J. Area-wide control of insect pests, Springer, 789 pp.

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

ANNEX I

Host plant range of *T. leucotreta*. Tables taken from Kirkman (2007).

Table 1.1. Cultivated plants which have been recorded as hosts of *Thaumatotibia leucotreta* (Daiber, 1980; Newton, 1998; Pinhey, 1975; Vennette *et al*, 2003).

Common Name	Species
Avocado	*Persea americana*
Apricot	*Prunus armeniciata*
Banana	*Musa paradisiacal*
Bean	*Phaseolus* spp.
Cacao	*Theobroma cacao*
Citrus	*Citrus sinensis, Citrus* spp.
Coffee	*Coffea arabica, Coffea* spp.
Cola	*Cola nitida*
Corn	*Zea mays*
Cotton	*Gossypium hirsutum*
Grape	*Vitis* spp.
Guava	*Psidium guajava*
Litchi	*Litchi chinensis*
Loquat	*Eribotrya japonica*
Macadamia nut	*Macadamia ternifolia*
Mango	*Mangifera indica*
Olive	*Olea europaea* subsp. *Europaea*
Pepper/pimento	*Capsicum* spp.
Persimmon	*Diospyros* spp.
Plum	*Prunus* spp.
Pineapple	*Ananas comosus*
Pomegranate	*Punica granatum*
Sorghum	*Sorghum* spp.
Tea*	*Camellia sinensis*

*Doubtful host association considering the plants biology.

Table 1.2. Wild plants which have been recorded as hosts of *Thaumatotibia leucotreta* (Schwartz, 1981; Venette *et al*, 2003), although some of these are doubtful hosts considering the plants' biology (CRI, pers. Comm..)..

Common Name	Species
Bur weed	*Triumfeta spp.*
Bluebush	*Diospyros lycoides*
Bloubos	*Royena pallens*
Boerboon	*Schotia afra*
Buffalo thorn	*Zizyphus mucronata*
Carambola	*Averrhoa carambola*
Castorbean	*Ricinus communis*
Chayote	*Sechium edule*

Cowpea	*Vigna unguiculata, Vigna* spp.
Custard apple	*Annona reticulata*
Elephant grass	*Pennisetum purpureum*
English Walnut	*Juglans regia*
Governors plum	*Flacourtia indica*
Indian mallow	*Abutilon hybridium*
Jakkalsbessie	*Diospyros mespiliformis*
Jujube	*Zizyphus jujuba*
Jute	*Abutilon* spp.
(Wild) Kaffir plum	*Harpephyllum caffrum*
Kapok/copal	*Ceiba pentranda*
Kei apple	*Dovyalis caffra*
Khat	*Catha edulis*
Kudu-berry	*Psuedolachnostylis maprouneifolia*
Lima bean	*Phaseolus lunatus*
Mallow	*Hibiscus* spp.
Mangosteen	*Garcinia mangostana*
Marula	*Sclerocarya caffra, Sclerocarya birrea*
Monkey pod	*Cassia petersiana*
Oak	*Quercus* spp.
Okra	*Ablemoschus esculentus*
Peacock flower	*Caesalpinia pulcherrima*
Pride of De Kaap	*Bauhinia galpini*
Raasblaar	*Combretum zeyheri*
Red milkwood	*Mimusops zeyheri*
Rooibos / Bushwillow	*Combretum apiculatum*
Sida	*Sida* spp.
Snot apple	*Azanza garckeana*
Stamvrugte	*Chrysophyllum palismontanum*
Sodom apple	*Calotropis procera*
Soursop	*Annona muricata*
Stemfruit	*Englerophytum magaliesmontanum*
Surinam cherry	*Eugenia uniflora*
Suurpruim / large sour plum	*Ximenia caffra*
Water-bessie	*Syzygium cordatum*
Wag'n'bietjie	*Capparis tomentosa*
Weeping boerboon	*Scotia brachypetala*
Wild fig	*Ficus capensis*
Wild medlar	*Vangueria infausta*
Wing bean	*Xeroderris stuhlmannii*
Yellow-wood berries	*Podocarpus falcatus*
Yellow-wood, real	*Podocarpus latifolius*