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Journal
EFSA Journal, 21(10)

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Publication Date
2023-10-01

DOI
10.2903/j.efsa.2023.8107

Peer reviewed

SCIENTIFIC OPINION

efsa JOURNAL

ADOPTED: 28 April 2023

doi: 10.2903/j.efsa.2023.8107

Assessment of the probability of introduction of *Thaumatotibia leucotreta* into the European Union with import of cut roses

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Abstract

Following a request from the European Commission, the EFSA Panel on Plant Health performed a quantitative pest risk assessment to assess whether the import of cut roses provides a pathway for the introduction of *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae) into the EU. The assessment was limited to the entry and establishment steps. A pathway model was used to assess how many *T. leucotreta* individuals would survive and emerge as adults from commercial or household wastes in an EU NUTS2 region climatically suitable in a specific season. This pathway model for entry consisted of three components: a cut roses distribution model, a *T. leucotreta* developmental model and a waste model. Four scenarios of timing from initial disposal of the cut roses until waste treatment (3, 7, 14 and 28 days) were considered. The estimated median number of adults escaping per year from imported cut roses in all the climatically suitable NUTS2 regions of the EU varied from 49,867 (90% uncertainty between 5,298 and 234,393) up to 143,689 (90% uncertainty between 21,126 and 401,458) for the 3- and 28-day scenarios. Assuming that, on average, a successful mating will happen for every 435 escaping moths, the estimated median number of *T. leucotreta* mated females per year from imported cut roses in all the climatically suitable NUTS2 regions of the EU would vary from 115 (90% uncertainty between 12 and 538) up to 330 (90% uncertainty between 49 and 923) for the 3- and 28-day scenarios. Due to the extreme polyphagia of *T. leucotreta*, host availability will not be a limiting factor for establishment. Climatic suitability assessment, using a physiologically based demographic modelling approach, identified the coastline extending from the northwest of the Iberian Peninsula through the Mediterranean as area suitable for establishment of *T. leucotreta*. This assessment indicates that cut roses provide a pathway for the introduction of *T. leucotreta* into the EU.

Keywords: Africa, Israel, false codling moth, climate suitability, pathway model, quantitative assessment, waste management

Requestor: European Commission

Question number: EFSA-Q-2022-00033

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Declarations of interest: If you wish to access the declaration of interests of any expert contributing to an EFSA scientific assessment, please contact interestmanagement@efsa.europa.eu.

Acknowledgements: EFSA and the EFSA Plant Health Panel wishes to thank the Netherlands Food and Consumer Product Safety Authority (NVWA) for provision of data and information on cut roses import, particularly regarding the sampling and inspection procedures, the infestation rates and the development stage of intercepted *T. leucotreta* specimens; the Belgian Federal Agency for the Safety of the Food Chain (FAVV-AFSCA) for provision of data on interception and development stage of intercepted *Thaumatotibia leucotreta* specimens in cut roses import; the Kenya Plant Health Inspectorate Service (KEPHIS) for provision of report, data and information about *T. leucotreta* on cut roses and phytosanitary measures; the Ethiopian Agriculture Authority for provision of report on *T. leucotreta* on cut roses and phytosanitary measures; the Uganda Phytosanitary and Quarantine Inspection Service of the Ministry of Agriculture Animal Industry and Fisheries for provision of information on *T. leucotreta* on cut roses and phytosanitary measures. EFSA and the EFSA Plant Health Panel wish to thank the following for the support provided to this scientific output: Caterina Campese for her contribution to the systematic literature search on *T. leucotreta* distribution and the development of the Köppen–Geiger maps for *T. leucotreta*; Klara Nicova for her contribution on the collection and presentation of information and data on the waste management processes in the EU; Stella Papanastasiou for her contribution to the collection and analysis of data on *T. leucotreta* biology and occurrence from scientific literature and on *T. leucotreta* interceptions from the EUROPHYT and TRACES databases; Ewelina Czwienczek and Alzbeta Mikulova for their kind advice and precious support in the final editorial work.

Suggested citation: EFSA PLH Panel (EFSA Panel on Plant Health), Bragard, C., Baptista, P., Chatzivassiliou, E., Di Serio, F., Gonthier, P., Jaques Miret, J. A., Fejer Justesen, A., MacLeod, A., Magnusson, C. S., Navas-Cortes, J. A., Parnell, S., Potting, R., Reignault, P. L., Stefani, E., Thulke, H. H., 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. https://doi.org/10.2903/j.efsa.2023.8107

ISSN: 1831-4732

EUROPEAN FOOD SAFETY AUTHORITY

The EFSA Journal is a publication of the European Food Safety Authority, a European agency funded by the European Union.

Summary

Following a request from the European Commission on whether the importation of cut flowers of roses (*Rosa* sp.) into the EU could constitute a potential pathway for the introduction of *Thaumatotibia leucotreta* (Meyrick) (Lepidoptera: Tortricidae), the EFSA Panel on Plant Health performed a quantitative pest risk assessment limited to the entry and the establishment of *T. leucotreta*, the false codling moth. The assessment focused on the pathway of import of cut roses from the areas where *T. leucotreta* is known to occur and the likelihood of introduction (i.e. entry, including transfer, and establishment) in the EU.

This polyphagous insect pest (affecting more than 100 genera of host plants in more than 50 botanical families) occurs in sub-Saharan Africa and has spread to Israel. The pest is regularly intercepted on cut roses and other fresh produce imported into the EU from its areas of occurrence.

The area potentially suitable for the establishment of this pest in the EU was assessed using a climate matching approach according to Köppen–Geiger categories and a physiologically based demographic model (PBDM). The predictions of the PBDM were validated with the occurrence data from the areas of origin of the pest and from invaded areas.

T. leucotreta larvae on roses imported into the EU will be primarily affected by cold stress exacerbated by a lack of dormancy/diapause. The area of potential establishment includes the coastline extending from the northwest of the Iberian Peninsula through the Mediterranean. The estimated densities of populations in the EU do not reach the high population densities projected for East Africa. Other published models are in broad agreement with these predictions regarding the potential major areas at risk of establishment (which is related to the common use of data on temperature requirements of this pest).

Additional areas in the EU indicated as suitable with low population numbers are most likely associated with transient populations only. The main uncertainties about possible establishment in these areas are caused by the lack of developmental data at different temperatures. Besides outdoors establishment in regions climatically suitable, as stated by EPPO (2013), *T. leucotreta* could overwinter in greenhouses in other areas with horticultural production.

Considering entry, the pest has been frequently intercepted on cut roses and observational records exist of flying adults of the pest in a few locations in the EU. An entry pathway model was used to assess the probability of entry of *T. leucotreta*, considering different steps of the pathway, and to identify the uncertainties of the assessment. The model consisted of three components to determine the number of adults which would escape from cut roses imported from countries with reported occurrence of *T. leucotreta* (African countries and Israel):

- a cut roses distribution model which describes the proportion of the imported infested roses distributed to the NUTS2 regions in the EU with suitable climate;
- a developmental model that describes the proportion of *T. leucotreta* adults that would emerge from infested cut roses depending on the number of days after import into the EU;
- a waste model which describes the proportion of *T. leucotreta* adults that would survive and escape prior to different types of waste treatments.

The model estimates how many *T. leucotreta* individuals would survive and emerge as adults from commercial or household disposal of infested cut roses, in the EU NUTS2 regions where the establishment is estimated possible based on physiologically based demographic modelling. The number of *T. leucotreta* adults escaping from disposed cut roses per year and per season are calculated using trade and temperature data.

Four scenarios were considered, for the timespan from the initial disposal of the cut roses at the household until the waste treatment: 3, 7, 14 and 28 days.

According to model results, the median number of *T. leucotreta* adults escaping from imported cut roses in all the climatically suitable NUTS2 regions of the EU was estimated as 49,867 per year (90% uncertainty between 5,298 and 234,393) for the 3-day scenario of time from initial disposal of cut roses at the household until waste treatment, and as 143,689 per year (90% uncertainty between 21,126 and 401,458) for the 28-day scenario. The differences across the scenarios are due to the escapes from the regional waste management processes, whereas the escapes from the private compost remain constant across all scenarios.

Assuming as a realistic scenario that on average one of every 435 escaping *T. leucotreta* moths results in a successful mating, the estimated median number of *T. leucotreta* mated females per year from imported cut roses in all the climatically suitable NUTS2 regions of the EU would vary from

115 (90% uncertainty between 12 and 539) up to 330 (90% uncertainty between 49 and 923) for the 3- and 28-day scenarios, respectively. When analysing the results for the EU by seasons, the highest number of expected mated females is predicted in summer compared to the other seasons in the 14- and 28-day scenarios. In particular, for the 28-day scenario, the number of mated females in summer would be 185 (90% uncertainty between 28 and 480), contributing more than 50% of the total annual mated females. Factors like clustering of infestations in cut roses or spatial or temporal clustering of cut roses consumption in a particular residential area or during favourable times of the year would increase the probability of mating and transfer to suitable host.

With regard to host plants availability, the Panel agreed with EPPO (2013) on the wide availability of suitable hosts in the coastal areas of Southern Europe. A female of *T. leucotreta*, having an extremely wide range of plants suitable for oviposition and further larval development, will likely find suitable hosts for oviposition even during the winter in the areas climatically suitable. Due to the extreme polyphagia of *T. leucotreta* immature stages, host availability should not be a limiting factor for establishment in climatically suitable areas.

Overall, regular escape of pest insects on the territory of the EU is predicted but so far it has not led to outbreaks (other than few incursions) in the EU, possibly because of the relatively recent shift of pest pressure in Africa towards cut roses and the fact that much of the consumption of cut roses in the EU occurs in regions with lower climate suitability. However, observations of flying adults have been reported in the EU.

The outputs of this quantitative pest risk assessment indicate that cut roses provide a pathway for the introduction of *T. leucotreta* to the EU

The number of escaped adults of *T. leucotreta* with a possible mating partner, from the imported cut roses in the realistic clustering scenario, is predicted to be higher during summer than in the other seasons, particularly when the 14- and 28-day scenarios until waste treatment are considered. This seasonality is explained by the faster development of *T. leucotreta* in the warmer season.

Sensitivity analysis of the pathway model showed that the main uncertainties remain regarding: the infestation rate in the imported cut roses; and main parameters of the waste model, especially the proportion of waste privately composted and the timing between initial disposal of the cut roses in the household and the waste treatment in the public facilities.

To reduce the uncertainties, data collection and research are recommended on the following key topics: the ecology and biology of *T. leucotreta* in its natural environment and in cut rose production in Eastern Africa; the level of infestation and clustering of *T. leucotreta* in the cut roses consignments; the level of effectiveness of the export and import border inspections in detecting the different life stages of *T. leucotreta* in cut roses; the actual waste management processes at NUTS2 level in the EU, including the proportion of private composting and the timing between the initial waste disposal and the waste treatment.

Table of contents

1. Introduction

1.1. Background and terms of reference as provided by the requestor

1.1.1. Background

False codling moth (*Thaumatotibia leucotreta* [Meyrick]) is a moth species belonging to the family Tortricidae under the order of Lepidoptera. Larvae of the moth feed on a wide range of fruit, vegetable and other crops. It is not known to occur in the EU and it is regulated as a Union Quarantine Pest i.e., it is included in the annexes of Commission Implementing Regulation (EU) 2019/2072. It is also listed as a priority pest under Regulation (EU) 2019/1702. The pest is polyphagous and has a strong dispersal potential. The eggs and larvae of the pest are regularly intercepted on cut flowers of roses (*Rosa* sp.) imported into the EU from non-EU countries.

Cut flowers of roses (*Rosa* sp.) are included in Annex XI.A of Regulation (EU) 2019/2072 as a commodity that is subject to phytosanitary certificates. They are, however, not included among commodities for which special import requirements for *T. leucotreta* are required under Annex VII. of the aforesaid Regulation.

The reason for which EFSA is requested to prepare its scientific opinion is related to the inclusion of cut roses[1] in the system of reduced frequencies of physical checks during import plant health inspection (Regulation (EC) No 1756/2004). The inclusion in the system of cut roses imported from African countries (Kenya in particular), is put in question due to the number of interceptions of the pest.

Over the last few years, the number of interceptions of eggs and larvae of *T. leucotreta* in imported cut flowers of roses, especially from Kenya, has increased. It would be therefore helpful, if the risk of cut roses as a potential pathway for the introduction of the pest in the Union was clarified. This would complement the non-conclusive guidance on this potential pathway provided by the pest risk analysis carried out by EPPO in 2013 (modified in 2021),[2] and would guide the Commission and the Member States on further regulatory approach on the pest in the commodity.

1.1.2. Terms of reference (ToR)

EFSA is requested, pursuant to Article 29(1) of Regulation (EC) No 178/2002, to provide a scientific opinion in the field of plant health.

EFSA is requested to deliver an opinion whether the importation of cut flowers of roses (*Rosa* sp.) into the EU constitutes a potential pathway for the introduction of *Thaumatotibia leucotreta* (Meyrick). In order to reach that conclusion, EFSA shall take into account all relevant scientific and technical information, including data collected by Member States on interceptions of the pest in cut roses.

1.2. Interpretation of the terms of reference

The terms of reference specify that the requested opinion should address the probability of introduction, which is defined by the International Standard on Phytosanitary Measures ISPM No 5 (IPPC Secretariat, 2022) as the entry of a pest resulting in its establishment, thus including entry (including transfer) and establishment.

The assessment of spread and impact is therefore outside the scope of this mandate and not included in this opinion. The Panel therefore undertook a partial quantitative pest risk assessment, according to the principles laid down in its guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018), as it is limited to the steps of entry (including transfer) and establishment.

As the mandate focuses on the assessment of the probability of introduction with cut roses under current conditions, no additional scenario of risk reduction options is included.

This opinion only deals with the introduction of *T. leucotreta* (the false codling moth (FCM)) via the pathway of imported cut roses from countries where the pest occurs, i.e. African countries and Israel (as specified in the mandate background).

[1] Imported from specified countries of origin: Columbia, Ecuador, Ethiopia, Kenya, Tanzania, Zambia.
[2] https://gd.eppo.int/taxon/ARGPLE/documents

2. Data and methodologies

For this opinion, the following data were searched:

- Data on the EU import of cut roses from Africa and Israel;
- Data on the import volume and destinations of cut roses into the EU;
- Data on the waste treatment procedures in the EU;
- Data on *T. leucotreta* developmental biology in relation to temperature.

The assessment was based on a combination of literature review, interviews with hearing experts and Expert Knowledge Elicitation (EKE) with experts or Panel members and EFSA staff to assess quantities that could not be well identified from literature or databases alone (EFSA, 2014). To link pest entry with establishment potential, the distribution of infested plant material entering the EU was assessed using the NUTS 2 statistical regions of the EU as the spatial resolution.

Hearings with experts from the National Plant Protection Organisations (NPPO) of Kenya and Uganda took place on 10 November 2022. Experts presented the pest status of *T. leucotreta* on cut roses in Kenya and Uganda and the phytosanitary measures that are in place against *T. leucotreta* including their limitations. The NPPOs of Kenya and Ethiopia submitted a report about *T. leucotreta* pest status on cut roses in their countries and the respective phytosanitary measures along with their limitations. Upon request of the EFSA, the NPPO of Kenya (KEPHIS) sent additional information, on anonymised trapping data of *T. leucotreta* populations in and around six rose farms (KEPHIS, personal communication, 11 January 2023).

Information on the pest distribution was retrieved from the European and Mediterranean Plant Protection Organization (EPPO) Global Database (EPPO, online) and relevant literature.

Data on interceptions and outbreaks of the pest within the risk assessment area were searched in the EUROPHYT and TRACES databases.

Data on cut roses import sampling and inspection procedures, infestation rates and the development stage of intercepted *T. leucotreta* specimens were provided by the Netherlands Food and Consumer Product Safety Authority (NVWA) (NVWA, 2022. Development of *T. leucotreta* on cut roses, personal communication, 23 September 2022; NVWA, 2022. Development stage of intercepted *T. leucotreta* specimens, personal communication, 12 October 2022; NVWA, 2022. Infestation rates of consignments of cut-roses infested by *T. leucotreta*, personal communication, 12 October 2022).

Data on interception and development stage of intercepted *T. leucotreta* specimens in cut roses import were provided by the Belgian Federal Agency for the Safety of the Food Chain (FAVV-AFSCA) (FAVV-AFSCA, 2022. Reply to EFSA request of info on the FCM cut roses interceptions and checks in Belgium, personal communication, 25 January 2023).

2.1. Temporal and spatial scales

The cut roses pathway model calculates the flow per year, on average, over a period of 5 years (2022–2026).

The Köppen–Geiger climate classification used 30 years of climate data, 1981–2010. The Köppen–Geiger climate classification uses a $0.08 \times 0.08^\circ$ world grid.

The physiologically based demographic model (PBDM) (Gutierrez, 1996) uses 2000–2010 gridded temperature data with the scale of about $0.25^\circ \times 0.25^\circ$. The projected distribution and relative abundance map of *T. leucotreta* used the same resolution (Ruane et al., 2015; AgMERRA data, https://data.giss.nasa.gov/impacts/agmipcf/agmerra).

2.2. Data on *T. leucotreta* occurrence and interceptions

2.2.1. Occurrences of *T. leucotreta*

An extensive literature search for *T. leucotreta* global distribution was conducted in Web of Science (all databases, excluding Data Citation Index and Zoological Record) and Scopus on 12 May 2022 (Rossi et al., 2023; see Appendix D). The search string was based only on the scientific and English common name of the pest. No other keywords were used in order not to limit the retrieval of distribution data, often reported as secondary information. The review followed a two-step approach. The first step was based on the title and the abstract, while the second one was based on the full text. The search yielded 240 documents including information on pest distribution. From these documents, 751 records of the presence of *T. leucotreta* were extracted, out of which 516 were specific locations reporting geographic coordinates, or very small administrative units (e.g. small provinces) for which coordinates from Google Earth were used, and 235 were related to larger administrative units (Figure 1). The full description of the literature search methodology and the results is available in Rossi et al. (2023) (see Appendix D).

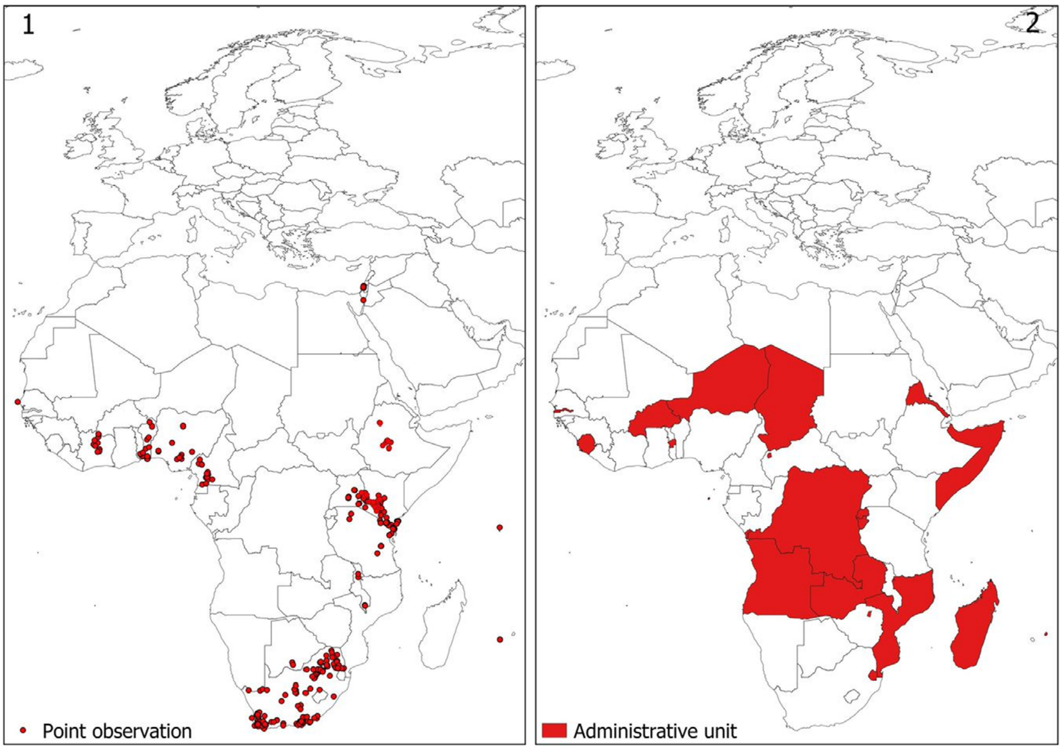


Figure 1: Observed distribution of *T. leucotreta*. The map on the left (1) shows point observations. The map on the right (2) shows observations at the administrative unit level, for the areas where point observations were not found (Rossi et al., 2023; Appendix D)

2.2.2. Interceptions of *T. leucotreta* in border inspections

The Panel searched for interceptions of *T. leucotreta* on any commodity from 1994 until 2022, in EUROPHYT (last accessed on 10 February 2023) and TRACES (accessed on 10 February 2023).

From 2014 to 2022, a total of 517 interceptions of *T. leucotreta* were found in the EU (Table 1). Most of the infested consignments were intercepted in the Netherlands, Belgium, France, Germany and Spain. In the same period, 261 interceptions were found in cut roses, with the majority of interceptions on cut roses in the Netherlands and Belgium and few interceptions from France and Germany (Table 2). No interceptions in cut roses were reported in any other EU Member State (MS) for the period 2014–2022; however, this can be explained by their limited trade in cut roses (see Figure 4).

From 2014 until January 2023, *T. leucotreta* was intercepted in 148 shipments of cut roses originating from Kenya, 84 shipments of cut roses from Uganda, 46 from Tanzania, 36 from Ethiopia, 20 from Zambia, 14 from Zimbabwe and 3 from Rwanda (Table 3). A peak in interceptions both in cut roses as well as in other consignments was recorded in 2021 (Table 4).

Live samples of egg and larval stages of *T. leucotreta* were repeatedly found during border inspections of cut roses from African countries conducted by the phytosanitary inspection services of the Netherlands (NVWA, 2022: Development stage of intercepted *Thaumatotibia leucotreta* specimens; personal communication, 12 October 2022; see Appendix A section A.7.1) and Belgium (FAVV-AFSCA, 2022: Reply to EFSA request of info on the FCM cut roses interceptions and checks in Belgium; personal communication, 25 January 2023; data not shown). In experiments conducted by the Dutch NPPO, *T. leucotreta* adults were bred from some of these larvae under simulated waste-bin conditions (NVWA 2022: Development of *Thaumatotibia leucotreta* on cut roses; personal communication, 23 September 2022).

Table 1: Annual interceptions of *T. leucotreta* on all commodities per EU MS, from 2014 until November 2022

Total interceptions	**Year**									
Country	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
Belgium		11	6	9	13	20	7	2	2	70
Bulgaria						2				2
Cyprus						1				1
France	7	6	7	7	4	3	1		4	39
Germany		3	5	1	2	2	1			14
Ireland		1								1
Italy	2									2
Lithuania				2						2
The Netherlands	23	16	21	13	48	43	48	79	69	360
Portugal	1			1		2				4
Spain	6	1	2	3						12
Sweden	1	3		2	1	2			1	10
Total	**40**	**41**	**41**	**37**	**68**	**77**	**57**	**81**	**76**	**517**

Table 2: Annual interceptions of *T. leucotreta* on cut roses per EU MS, from 2014 until November 2022

***Rosa* sp.**	**Year**									
Import country	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
Belgium					2	7	6	2		17
France									3	3
Germany						2	1			3
The Netherlands	1				29	25	43	79	61	238
Total	**1**	**0**	**0**	**0**	**31**	**34**	**50**	**81**	**61**	**261**

Table 3: Annual interceptions of *T. leucotreta* on cut roses per exporting Country, from 2014 until January 2023

***Rosa* sp.**	**Year**										
Exporting country	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023 (January)**	**Total**
Ethiopia	0	0	0	0	0	1	1	10	23	1	**36**
Kenya	0	0	0	0	37	39	9	44	18	1	**148**
Rwanda	0	0	0	0	0	1	2	0	0	0	**3**
Tanzania	0	0	0	0	33	12	1	0	0	0	**46**
Uganda	1	0	1	0	9	19	13	19	19	3	**84**
Zambia	0	0	0	0	4	4	0	9	2	1	**20**
Zimbabwe	0	0	0	0	13	0	0	0	1	0	**14**
Total	**1**	**0**	**1**	**0**	**96**	**76**	**26**	**82**	**63**	**6**	**351**

Table 4: Annual interceptions of *T. leucotreta* in the EU from 2014 until January 2023, in cut roses versus in all other commodities

Commodities	Year									
	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**Jan-23**	**Total**
***Rosa* sp.**	1	0	1	0	96	76	26	82	63	6	351
Other commodities	169	260	146	141	112	116	34	56	14	3	1,051
Total	**170**	**260**	**147**	**141**	**208**	**192**	**60**	**138**	**77**	**9**	**1,402**

2.2.3. Clustering of *T. leucotreta* in intercepted consignments

In the interception records of the Dutch NPPO some indications on clustered infestations of *T. leucotreta* in cut roses were given (NVWA, NVWA, 2022: Infestation rates of consignments of cut roses infested by *T. leucotreta*; personal communication, 12 October 2022). The Dutch NPPO reported, from all its imports of cut roses between January 2019 and September 2022, that 217 interceptions occurred, from which 77% of the samples had only one specimen, while 15% had two, and 8% had three specimens of *T. leucotreta*.

Neither the size of the consignment nor the sample size per consignment were recorded in the laboratory's database. As an approximation the Dutch NPPO assumed a median consignment size based on the import data for 2020 of 25,400 roses, which corresponds to a sample size of 400 roses according to the Dutch inspection rules (NVWA, 2022: Infestation rates of consignments of cut roses infested by *T. leucotreta*, personal communication, 12 October 2022, see also Appendix A Section A.7.2) (Table 5).

Table 5: Number of *T. leucotreta* specimens per sample in consignments of cut roses intercepted by the Dutch NPPO in the period January 2019–September 2022 (NVWA, 2022: Infestation rates of consignments of cut roses infested by *T. leucotreta*; personal communication, 12 October 2022)

Number of specimens per sample in infested consignments	Number of infested consignments		Total number of *T. leucotreta* specimens	
	Absolut	**Relative (% consignments)**	**Absolut**	**Relative (% specimens)**
1	167	77%	167	59%
2	32	15%	64	22%
3	18	8%	54	19%
4 or more	0	0%	0	0%
Total	217	100%	285	100%

Changing the view from consignments to specimens: 59% of the specimens were single individuals in the sample of the consignment, while 41% of the specimens were present as two or more insects per sample (= 22% + 19% + 0%; see Table 5 column on 'Relative [% specimens]'). Using the latter value, two scenarios on the clustering of two or more specimens of *T. leucotreta* in the imported consignments of cut roses were constructed:

Cluster scenario 1 (worst case): Looking at the 41% of the specimens having two or more insects per sample, it is assumed that at least two specimens:

- are on the same cut rose;
- have similar life stages (e.g. egg, early larva), develop in parallel and escape at a similar time in the same location.

The likelihood that one insect would have a possible mating partner in the same rose is at least:

$$\begin{aligned}&\text{Minimal likelihood for mating partner due to clustered infestation (within one rose)}\\&\quad = \text{Likelihood of multiple infestation per sample} \times \text{Likelihood of having a female}\\&\qquad \times \text{Likelihood of having a male}\\&\quad = 41\% \times 2/3 \times 1/3 = 9\%\end{aligned}$$

Where:

- Likelihood of multiple infestation per sample (41%) is derived from Table 5 and described above;
- Likelihood of having a female (2/3) and the likelihood of having a male (1/3) are derived from the sex ratio 2:1 of *T. leucotreta*, meaning two females per one male (Mkiga et al., 2019).

Hence, under this scenario, in total 9% of the insects will be females and will have a partner for mating in the same rose (i.e. at least one in every 11 *T. leucotreta*).

The **worst-case scenario** is not further elaborated, because the Panel considers it as unlikely referring to:

- the egg laying behaviour of the insect (according to COLEACP et al., 2020, the *T. leucotreta* female moth lays over 100 eggs at night, usually **singly** on flower petals or other parts of the rose bush);
- the lack of records from border inspections on multiple *T. leucotreta* specimens on a single cut rose. Although, according to COLEACP et al. (2020), generally only one to three larvae survive in each rose flower, there is no record so far of multiple *T. leucotreta* specimens on a single cut rose upon EU import border inspection.

Cluster scenario 2 (realistic case): Looking at the 41% of the specimens having two or more insects per sample, it is assumed that:

- Infested roses have no more than one *T. leucotreta* specimen per cut rose;
- Distribution of the cut roses is done in bunches of 10 cut roses;
- The specimens of *T. leucotreta* are uniformly distributed among the bunches of cut roses;
- The specimens of *T. leucotreta* in a bunch of cut roses have similar life stages (e.g. egg, early larvae), develop in parallel and escape at similar time in the same location from the bunch.

The likelihood that one insect would have a possible mating partner in the same bunch of 10 roses is at least:

$$\begin{aligned}&\text{Minimal likelihood for mating partner due to clustered infestation (within a bunch of 10 roses)}\\&= \text{Likelihood of multiple infestation per sample} \times \text{Likelihood of multiple infestation per bunch}\\&\quad \times \text{Likelihood of having a female} \times \text{Likelihood of having a male}\\&= 41\% \times 2.5\% \times 2/3 \times 1/3 = 0.23\%\end{aligned}$$

Where:

- Likelihood of multiple infestation per sample (41%) is derived from Table 5 and described above;
- Likelihood of multiple infestation per bunch (2.5%). A sample of 400 cut roses (as described above) has 40 bunches of 10 rose stems each; assuming that one bunch is infested with one insect, there is one out 40 possibilities for a second insect to infest the same bunch;
- Likelihood of having a female (2/3) and the likelihood of having a male (1/3) are derived from the sex ratio 2:1 of *T. leucotreta*, meaning two females per one male (Mkiga et al., 2019).

Hence, under this scenario, in total 0.23% of the insect will be females and will have a partner for mating in the same bunch of 10 roses (i.e. at least one in every 435 *T. leucotreta*).

This **realistic scenario** is further elaborated in the assessment, because it is representing typical market conditions and egg laying behaviour of the insect.

Clustered scenario 3 (best case): in Appendix A, Section A.1.4, the Panel has also estimated the average number of escaped *T. leucotreta* adults per 1 km radius in the residential areas of the NUTS2 regions within a 10-day period. This scenario could be interpreted as '**best case**', when no temporal or spatial clustering of the cut roses consumption occurs, and all escaping adults are homogeneously distributed within the residential area of a NUTS2 region throughout the year.

2.2.4. Records of *T. leucotreta* in the EU, the UK and USA

Since 1965, more than 30 adult specimens of *T. leucotreta* have been reported in the EU. Occasional records have been made in Finland (Karvonen, 1983), the UK (Knill-Jones, 1994; Langmaid, 1996; NBN atlas, 1997), Denmark and the Netherlands (Huisman and Koster, 2000), Sweden

(Svensson, 2002), France (Rogard, 2015), Czechia (Šumpich et al., 2021, 2022) and Belgium and Germany (Rennwald, 2022). Recordings consisted of a single adult specimen either found in private homes, likely imported as larvae with produce from Africa (oranges; FI: Karvonen, 1983; NL: Huisman and Koster, 2000; SE: Svensson, 2002; DE: Rennwald, 2022) or captured in light traps outdoors (the UK: Langmaid, 1996; NBN atlas, 1997; FR: Rogard, 2015; BE and DE: Rennwald, 2022). However, these were all isolated findings without any evidence of established populations.

Since 2009, three incursions[3] of *T. leucotreta* have been reported in Europe: In the Netherlands, one larva was found in a glasshouse on habanero peppers (*Capsicum chinense*) in 2009 (EPPO, 2010; Potting and van der Straten, 2011), and one larva and three adults on sweet peppers (*Capsicum annuum*) in 2013 (EPPO, 2014); and in Germany, one male was found in 2018 on a pheromone trap in a glasshouse producing sweet peppers (*C. annuum*) (EPPO, 2018). These incursions have been found near packaging facilities of imported fruits (the Netherlands) and near a supermarket waste container (Germany). No populations were established.

A single adult male was detected in a trap in California (USA) in 2008 (Gilligan et al., 2011), but, in spite of extensive surveys conducted for *T. leucotreta* throughout the state, no further detections of the pest occurred.

2.3. Entry

The process of pest introduction is defined by the IPPC (International Plant Protection Convention) as the entry of a pest resulting in its establishment[4] (IPPC Secretariat, 2022). Introduction can therefore be divided into the assessment of pest entry and the assessment of pest establishment, with the process of pest transfer to a host being the step that links entry to establishment.

Estimation of the number of *T. leucotreta* adults escaping from the cut roses imported from African countries into the EU was performed for the NUTS2 regions identified as suitable for establishment as described in Section 2.4.

To estimate the number of *T. leucotreta* adults that will escape from infested cut roses imported from countries with reported occurrence of *T. leucotreta*, a pathway model was used that consisted of three submodels: (i) a **rose distribution model** (Section 2.3.1) describing how the imported and infested roses are distributed into the NUTS2 regions in the EU area suitable for establishment, (ii) a **developmental model** (Section 2.3.2) describing the proportion of *T. leucotreta* adults emerging depending on the number of days after import into the EU and (iii) a **waste model** (Section 2.3.3) estimating which proportion of *T. leucotreta* will survive and escape different waste treatments. The last component was included because the life cycle of imported cut roses was assumed to end with cut roses being disposed. For the assessment of entry as estimated by the overall entry model (Section 2.3.4), and of potential establishment of *T. leucotreta*, it is therefore important to estimate the proportion of *T. leucotreta* that survives and escapes all possible waste treatments.

2.3.1. The cut roses distribution model

The average annual volume of cut roses imported into EU MS over the years 2011–2020 was 4,825 million stems. Most of the imported roses (91%) came from Africa and Israel (4,411 million stems). The remaining 9% (414 million stems) entered from the rest of the world, mainly Ecuador and Colombia, followed by the UK (Figure 2). The remaining countries contributed with only 1.5%. The EU countries on average exchanged 3,039 million stems among themselves. This includes trade of their own production and internal EU trade of imported cut roses from third countries.

[3] Definition of incursion (as per ISPM 5): 'An isolated population of a pest recently detected in an area, not known to be established, but expected to survive for the immediate future [ICPM, 2003]'.

[4] Establishment: Perpetuation, for the foreseeable future, of a pest within an area after entry (IPPC Secretariat, 2022).

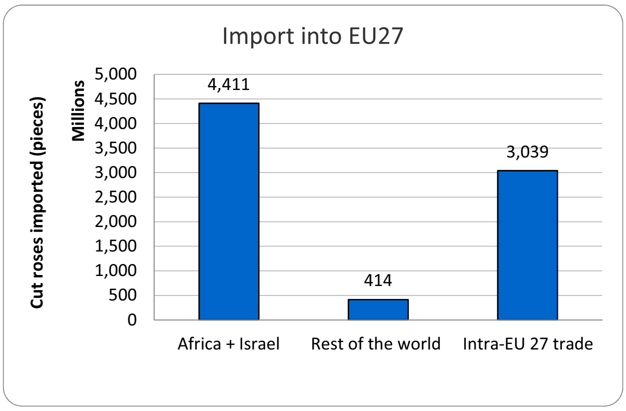


Figure 2: Trade in cut roses in the EU (average of 2011–2020)

The volume of cut roses imported into the EU has been relatively stable in period 2011–2020 (Figure 3), reaching a peak in 2016. The Covid-19 pandemic had only a marginal effect on the trade as indicated by the slight reduction in 2020.

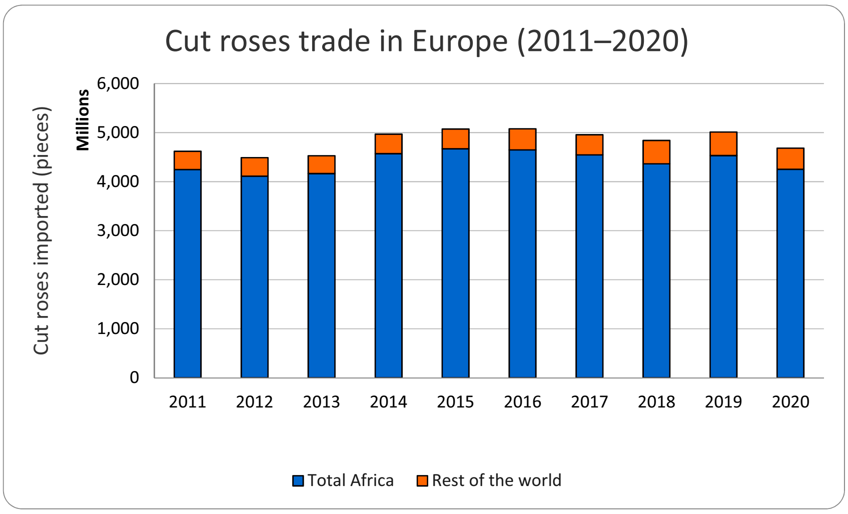


Figure 3: Trends in the EU of import of cut roses (2011–2020)

The imported roses are not distributed evenly through the EU. Most of the cut roses (on average 75.5%) enter the Netherlands, 15.0% enter Belgium, 6.1% enter Germany and only 3.4% enter the remaining 24 EU countries (Figure 4). However, the intra-EU trade complicates the calculations of the pathway model for the EU 27 MS, e.g. between 2015 and 2017 the import into Belgium was reduced, while that of the Netherlands was increased by a similar amount, indicating intra-EU trade relations between neighbouring countries. Due to the observed intra-EU trade relations, to limit the pathway model to the main intra-EU trade relations, some EU countries were therefore clustered for manageability of the pathway model calculations: 'The Netherlands/Belgium', 'Germany/Luxembourg', 'Spain/Portugal', 'Italy/Malta' and 'Greece/Cyprus'.

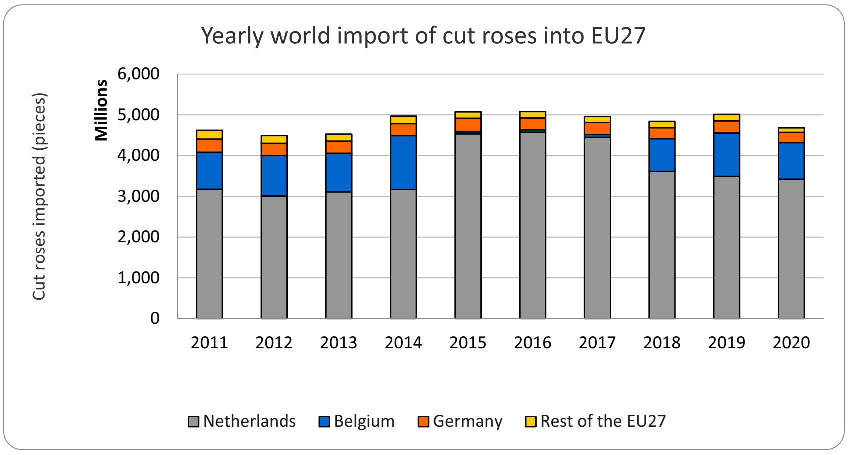


Figure 4: Distribution of cut roses imported by the EU (2011–2020)

The pathway of cut roses in the EU starts with entries mainly via airplane followed by repacking, auction, wholesalers and retail sales to the consumers (Figure 5).

All cut roses will finally end in the waste, differentiated by commercial waste in different countries, public waste and private compost.

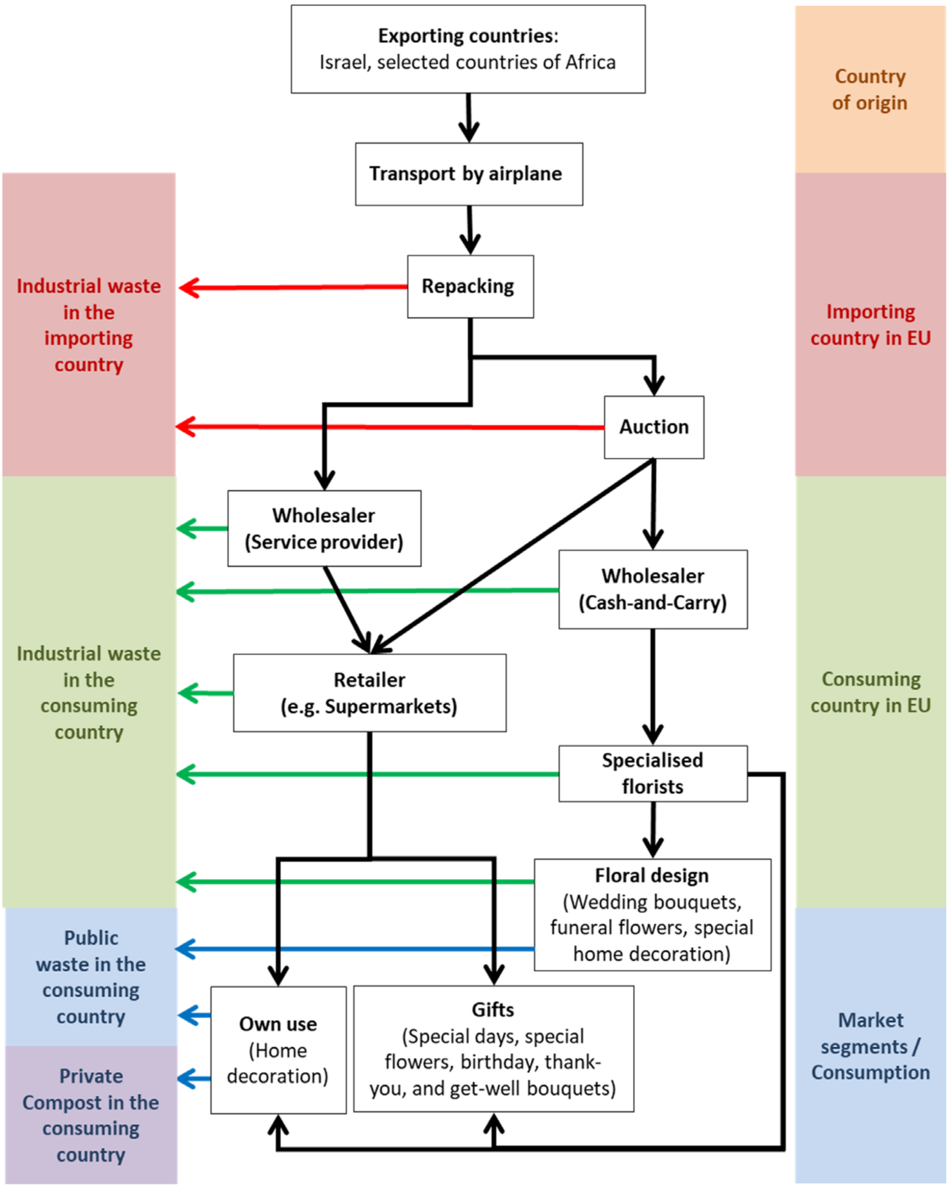


Figure 5: Pathway of cut roses from import to waste (adapted from CBI, 2017)

According to CBI (2017), the European cut flower market consists of two market channels: one focusing on specialised florists and the other on unspecialised retail (e.g. supermarkets). The main differences between the channels are the role of the flower auction and wholesalers, and the characteristics of the products.

Some of the imported cut roses are sold directly to high-end customers, but most are reserved for Dutch auctions, a major hub in the redistribution of cut flowers in the EU and worldwide. In 2020, in total 2,912 million stems were imported from African countries (CBS, 2022), 2,814 million stems were traded through Dutch auctions (Royal Flora Auctions, 2021). A minor part of cut roses consumed in the EU is produced in European greenhouses (the Netherlands 20.0%, Germany 0.4% and Belgium 0.2%). A large part (78.0%) of the cut rose stems auctioned in the Netherlands are imported from rose farms in Africa (Ethiopia 44.0%, Kenya 31.0%, Uganda 1.5% and others from Rwanda, Tanzania, Zimbabwe, Zambia and South Africa) (see Appendix A). Germany and France are the major intra-EU trade markets for auctioned roses (Rabobank, 2022). From the auction houses, cut roses are redistributed to various points of sale at retailers, any delay affects their vase life. Direct sales can drastically reduce the farm-to-vase time.

Due to missing precise information on the proportion of trade via specialised florists and supermarkets, the pathway model only distinguishes direct import into the consuming country/NUTS2 region, and re-exporting via European countries (indirect trade, see Figure 6).

The waste resulting from rejected roses by grading/repacking will end in the commercial waste of the consuming country or stays in the importing country. A diagram presenting the pathway model for the rose distribution model is outlined in Figure 6.

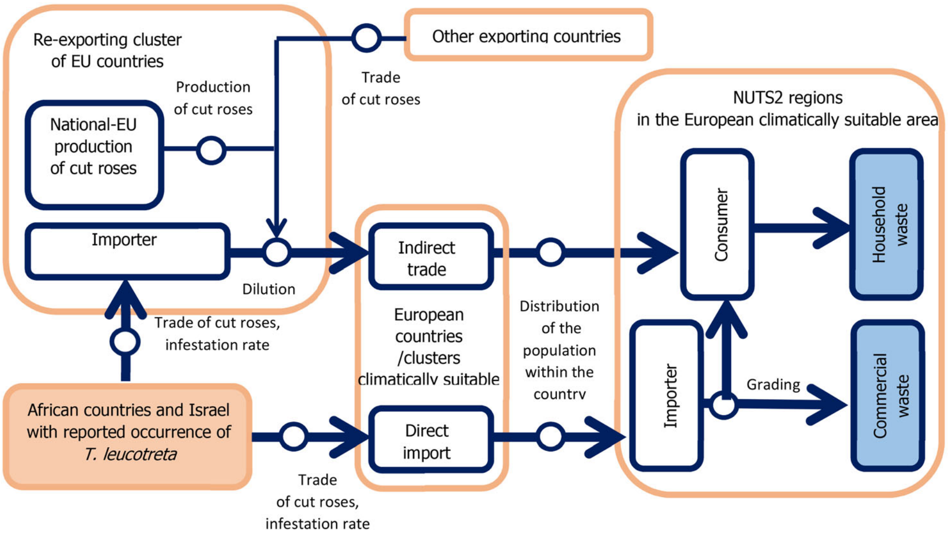


Figure 6: Pathway of cut roses from import to waste as conceptualised for the rose distribution model

The rose distribution model comprises two main pathways: 'direct' and 'indirect' import into the EU area climatically suitable. The latter one is further divided into two main clusters for intra-EU trade: 'The Netherlands/Belgium' and 'Germany/Luxembourg'.

1) **Direct import of cut roses from African countries and Israel**, with reported occurrence of *T. leucotreta* by a country with areas climatically suitable.
   For this pathway, the trade volume reported by Eurostat on national and monthly basis was considered in the model. To cover most of the trade between the countries within the areas climatically suitable, the following country clusters were established: (i) Spain and Portugal, (ii) Italy and Malta and (iii) Greece and Cyprus. In the model, it is assumed that the distribution within a cluster will follow the distribution of potential consumers, thus the distribution of the population within the countries/clusters. Different regional consumption habits are not considered.
   In this pathway, importers, including when applicable wholesalers and distribution centres, are in the NUTS2 region of consumption and it is assumed that they perform the necessary grading and repacking.
2) The cut roses **are imported by the Netherlands and Belgium and further traded 'intra-EU'** to the EU countries with areas climatically suitable.
   Because only the total trade volume between the Netherlands/Belgium and other EU flower consuming countries is reported to Eurostat, it is assumed that the imported cut roses (from Africa and Israel) will be equally diluted by other imports of cut roses, and the production in the Netherlands and Belgium. Preferences for the intra-EU re-trade of African cut roses are not considered.
   In this pathway, grading and repacking is assumed to be done in the Netherlands and Belgium, and then, the cut roses will go directly to retailers or specialised florist shops in the consuming countries.
   It is assumed that the national EU distribution will follow again the distribution of potential consumers, thus the distribution of the population within the cluster. Different regional consumption habits are not considered.

3) The cut roses **are imported by Germany and Luxembourg and further traded intra-EU** the countries with areas climatically suitable.
   For this pathway, the same assumptions made for re-exporting for the Netherlands and Belgium are valid (see Section 2 for details).

No other European cluster for the re-export of African roses is considered due to minor trade volumes. Due to the low infestation, the model further assumes that an infested rose contains one insect, and this could be in any life stage.

In all scenarios, the annual trade is further stratified by seasons: December–February, March–May, June–August, September–November; to reflect the different climatic condition per season (see developmental model).

The overall number of *T. leucotreta* individuals per season ending in commercial or household waste in a NUTS2 region climatically suitable in a specific season was therefore calculated as below. A description of the parameters used in the rose distribution model is presented in Table 6.

It is assumed that commercial waste only appears in the grading step at import or auction. Thus, for indirect import (intra-trade) via EU countries outside the EU climatically suitable areas (the EU climatically suitable area is indicated in the equations as the EU risk area, abbreviated as EURA), no commercial waste has to be considered. For the direct import, the number of *T. leucotreta* (FCM) entering a NUTS2 region in the EU climatically suitable area in a specific season ($\mathrm{FCM}_{\mathrm{commercial,\ NUTS2\ Season}}$) is calculated as:

$$\mathrm{FCM}_{\mathrm{commercial,\ NUTS2\ Season}} = \mathrm{Infestation}_{\mathrm{AF}} \times \mathrm{Trade}_{\mathrm{AF-EURA,\ Season}} \times \mathrm{Population}_{\mathrm{NUTS2/EURA}} \times \mathrm{Grading}$$

where $\mathrm{Trade}_{\mathrm{AF\text{-}EURA,\ Season}}$, $\mathrm{Infestation}_{\mathrm{AF}}$, $\mathrm{Population}_{\mathrm{NUTS2/EURA}}$ and Grading are the volume of direct import from Africa into a country cluster in a specific season, the infestation rate of African roses, the proportion of the population within a NUTS2 region climatically suitable (compared to the total population of the country cluster) and the proportion of roses deselected by grading due to quality problems or similar, respectively.

Because all roses will finally be wasted, the household waste consists in the EU climatically suitable areas of the marketed (not deselected during grading) roses, and the imported roses from the 'Dutch/Belgian' and 'German/Luxembourg' cluster.

$$\begin{aligned}\mathrm{FCM}_{\mathrm{household,\ NUTS2,\ Season}} = \mathrm{Infestation}_{\mathrm{AF}} \times (&\mathrm{Trade}_{\mathrm{AF-EURA,\ Season}} \times \mathrm{Population}_{\mathrm{NUTS2/EURA}} \times (1\text{–}\mathrm{Grading}) \\ &+ \mathrm{Trade}_{\mathrm{AF\rightarrow NLBE,\ Season}} \times \mathrm{Dilution}_{\mathrm{NLBE,\ Season}} \times \mathrm{Population}_{\mathrm{NUTS2/EURA}} \\ &+ \mathrm{Trade}_{\mathrm{AF\rightarrow DELU,\ Season}} \times \mathrm{Dilution}_{\mathrm{DELU,\ Season}} \times \mathrm{Population}_{\mathrm{NUTS2/EURA}}),\end{aligned}$$

Roses re-traded intra-EU are diluted by national production and by other imports into these clusters ('Dutch/Belgian' and 'German/Luxembourg' clusters). The dilution factor is calculated as proportion of African and Israelian roses in relation to the total amount of roses within the corresponding country cluster. The total amount of roses in a country cluster consists of import from Africa, other imports and own production. This assumes that all roses within an intra-EU trade cluster are mixed before intra-EU re-trade.

$$\mathrm{Dilution}_{\mathrm{NLBE,Season}} = \mathrm{Trade}_{\mathrm{AF\rightarrow NLBE,Season}} / (\mathrm{Trade}_{\mathrm{AF\rightarrow NLBE,Season}} + \mathrm{Trade}_{\mathrm{Others\rightarrow NLBE,Season}} + \mathrm{Production}_{\mathrm{NLBE,Season}})$$

$$\mathrm{Dilution}_{\mathrm{DELU,Season}} = \mathrm{Trade}_{\mathrm{AF\rightarrow DELU,Season}} / (\mathrm{Trade}_{\mathrm{AF\rightarrow DELU,Season}} + \mathrm{Trade}_{\mathrm{Others\rightarrow DELU,Season}} + \mathrm{Production}_{\mathrm{DELU,Season}})$$

Missing information on the cut rose production of Belgium and Luxembourg was extrapolated from the Dutch and German production and converted from the production area.

$$\mathrm{Production}_{\mathrm{NLBE,\ Season}} = \mathrm{Area}_{\mathrm{NL}} \times \mathrm{Extrapolation}_{\mathrm{NL\rightarrow NLBE}} \times \mathrm{Conversion}_{\mathrm{ha\rightarrow pcs}} \times \mathrm{Proportion}_{\mathrm{Season/Total}}$$

$$\mathrm{Production}_{\mathrm{DELU,\ Season}} = \mathrm{Area}_{\mathrm{DE}} \times \mathrm{Extrapolation}_{\mathrm{DE\rightarrow DELU}} \times \mathrm{Conversion}_{\mathrm{ha\rightarrow pcs}} \times \mathrm{Proportion}_{\mathrm{Season/Total}}$$

Table 6: Description and source of evidence for the parameters used in the rose distribution model

Parameter	Description	Source	Distribution
$FCM_{commercial,\ NUTS2,\ Season}$ $FCM_{household,\ NUTS2,\ Season}$	Number of *T. leucotreta* individuals ending in commercial or household waste in a NUTS2 region climatically suitable during a specific season	Calculated	
AF	African countries and Israel with reported occurrence of *T. leucotreta*	EPPO Global Database (Appendix A, Section A.2)	Strata
EURA	European countries/clusters with areas climatically suitable/under risk	Countries with at least one NUTS2 region with a climate suitability classification by the physiologically based demographic model above 0 (Appendix A, Section A.3)	Strata
NUTS2	NUTS2 regions climatically suitable	NUTS2 regions with at least one grid cell with a climate suitability classification by the physiologically based demographic model above 0 (Appendix A, Section A.3)	Strata
NLBE	Cluster of re-exporting countries: the Netherlands/Belgium	Annual trade of cut flowers from 2011 to 2020 (Appendix A, Section A.5)	Strata
DELU	Cluster of re-exporting countries: Germany/Luxembourg	Annual trade of cut flowers from 2011 to 2020 (Appendix A, Section A.6)	Strata
Season	Stratification by season: winter, spring, summer, autumn; or total		Strata
$Trade_{AF\text{-}EURA,\ Season}$	Direct trade of cut roses from AF to European climatically suitable countries/clusters (Unit: [pcs])	Eurostat monthly trade of cut roses (CN 03061100) in 2011–2020 (Appendix A, Section A.4)	NORMAL
$Population_{NUTS2/EURA}$	Proportion of the human population in the NUTS2 region climatically suitable in relation to the whole country or cluster (Unit: [−])	Eurostat population 1 January 2020 (Appendix A, Section A.4.2)	CONSTANT
Grading	Proportion of direct imported cut roses, which on average is discarded due to quality issues (Unit: [−])	Default value (Appendix A, Section A.4.4)	UNIFORM
$Trade_{AF\ NLBE,\ Season}$ $Trade_{AF\ DELU,\ Season}$	Trade of cut roses from AF to the European re-exporting clusters in a specific season (Unit: [pcs])	Eurostat monthly trade of cut roses (CN 03061100) in 2011–2020 (Appendix A, Sections A.5, A.6)	NORMAL
$Trade_{Others\ NLBE,\ Season}$ $Trade_{Others\ DELU,\ Season}$	Trade of cut roses from other countries to the European re-exporting clusters in a specific season (Unit: [pcs])	Eurostat monthly trade of cut roses (CN 03061100) in 2011–2020 (Appendix A, Sections A.5, A.6)	NORMAL
$Production_{NLBE,\ Season}$ $Production_{DELU,\ Season}$	Average production of cut roses in European re-exporting clusters in a specific season (Unit: [pcs])	Calculated	
$Area_{NL}$ $Area_{DE}$	Average, annual area for the production of cut roses in specific MS (Unit: [ha])	National statistics on cut roses production surface	CONSTANT

Parameter	Description	Source	Distribution
Extrapolation$_{NL\ NLBE}$ **Extrapolation$_{DE\ DELU}$**	Extrapolation from national production area to the area in a re-exporting cluster (Unit: [−])	Eurostat farm structure	CONSTANT
Conversion$_{ha\ pcs}$	Productivity of cut roses (Unit: [pcs/ha])	Productivity of different roses	CONSTANT
Proportion$_{Season/Total}$	Proportion of cut roses produced in the re-exporting clusters in a specific season compared to the annual production	Default value: equally distributed	CONSTANT
Dilution$_{NLBE,Season}$ **Dilution$_{DELU,Season}$**	Dilution of *T. leucotreta*-infested cut roses, imported from Africa and Israel, by other imports and own production in a specific re-exporting cluster and season (Unit: [−])	Calculated for scenarios without/with Intra-EU trade	UNIFORM
Infestation$_{AF}$	Average infestation rate of cut roses from AF (Unit: [−])	EKE question 2 (Appendix A, Section A.7)	GENERALBETA

2.3.2. The developmental model

The developmental model of *T. leucotreta* after entry into the EU (start at the border) estimates the number of *T. leucotreta* adults emerging in the importing country considering three sequential compartments:

A) Transport and storage under cold conditions. This compartment includes the handling after entry, cold transportation to the region for consumption, and cold storage there. After harvest and sorting on site in Africa, cut roses are stored in water at a temperature of 2–6°C. As a result, the moisture content is maintained. During transport by truck/trailer, a constant temperature of 4–6°C and humidity level (60–80%) is maintained to deliver the flowers to destinations in optimal condition (at 4°C ± 1°C, Flower Watch, 2011; Carrier Transicold, 2022). Temperatures, however, may fluctuate for short periods during handling (up to 8°C) and reloading (short periods up to 16°C) from storage into transport and from trucks into the aircraft cabin (Flower Watch, 2011; Carrier Transicold, 2022) Cut roses are mainly transported by air freight. A total turnover time from the grower up to and including the auction takes between 1 and 2 days by air transport (Flower Watch, 2011; Carrier Transicold, 2022). Upon arrival in Europe (mostly the Netherlands), the time from purchasing trade to the retailer takes a maximum of ~ 4 days at a temperature of 8°C ± 1°C, 75% RH.
During the whole chain from grower to retailer, a constant temperature of 8°C is assumed as a conservative (i.e. worst) scenario.
The duration of cut roses in this model compartment assumes a triangular distribution with parameters minimum, most likely and maximum equal to 1.0, 4.5 and 8.0 days, respectively, that adequately describe the uncertainty in the duration of transport. These values were also set considering the interest in keeping the transport time as short as possible by the flower industry. Additionally, the cold storage at the final place of sales to consumers is part of this compartment. It should be noted that even considering the extreme values for temperature and duration, transportation and cold storage do not support full development of *T. leucotreta*.

B) Retail and private home under climatisation. This compartment includes the provision to and the use of the flowers by the consumer.
Vase life at the consumer is aimed at a period of 7.0–10.0 days for imported cut roses (VBN, 2017; Harkema et al., 2017) and 2 weeks for locally produced cut roses (FloraNews, 2015), but can vary between 4.0 and 14.0 days (Yakimova et al., 1996; Ichimura et al., 2006) Hence, the duration of cut roses in this compartment was modelled assuming a triangular distribution with parameters minimum, most likely and maximum equal to 7.0, 10.5 and 14.0 days, respectively. Temperature in this compartment is assumed to be set to the ideal temperature values for human living and therefore modelled assuming it could adequately be described by a triangular distribution with parameters minimum, most likely and maximum equal to 18.0, 21.0 and 24.0°C, respectively.

C) Organic waste at ambient temperature. This compartment comprises the situation after waste disposal by the consumer. It is assumed that the temperatures are ambient according to the regional and seasonal situation. Due to missing information on the duration within this compartment, four scenarios for the time between waste disposal and waste treatment are constructed: 3, 7, 14 and 28 days (see the waste model in Section 2.3.3).

A diagram presenting the compartment model (time on the horizontal axis) for the developmental model is outlined in Figure 7.

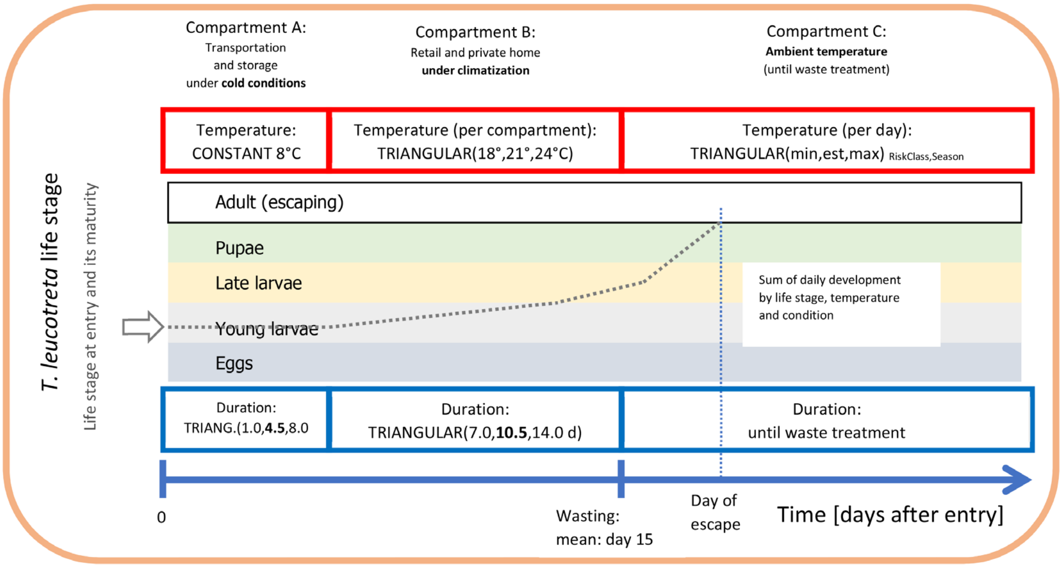


Figure 7: Visualisation of three phases of development after entry of cut roses. The blue axis at the bottom represents the time axis and three phases: (1) transport, (2) vase life, (3) post-waste disposal. The red boxes on top represent the assumed temperature during each phase, while the blue boxes at the bottom represent the duration. The dotted line in the middle of the graph indicates how larvae on the roses progress through their life stages during the three stages of the cut roses pathway, from production to waste.

The following simulation process was done using @RISK software version 7.6 (see Appendix C): An individual of *T. leucotreta* will enter the EU at a specific life stage. According to the temperature, the individual will develop each day a bit, additionally depending on a random component related to the insect and host conditions (see @RISK file data Appendices). Individuals will develop through successive life stages accordingly. When emerging from the pupae, the adult moth will escape the cut rose or waste. The day of escape was simulated for 10,000 *T. leucotreta* arriving in the EU. The simulation results in a profile of life stages for each day after entry, or the proportion of adults for a fixed day depending on the ambient temperatures for specific climate suitability classes and seasons. A description of the parameters used to inform the developmental model is presented in Table 7.

Table 7: Description and source of evidence for the parameters used in the developmental model

Parameter	Description	Source	Distribution
$\mathbf{ESC}_{\mathbf{time,\ xd,\ CSClass,\ Season}}$	Proportion of *T. leucotreta* which will escape the cut roses until x days (x = 3, 7, 14 or 28 days depending on the scenario) after initial disposal (at day 15) in a region of a specific climate suitability class and season	Calculated	
$\mathbf{Prop}_{\mathbf{Eggs}}$ $\mathbf{Prop}_{\mathbf{Young/all\ larvae}}$	Proportion of *T. leucotreta* life stages, when arriving at the border	EKE question 1a and 1b (Appendix A Section A.8)	GENERALBETA

Parameter	Description	Source	Distribution
Maturity	Level of maturity within a specific life stage, when arriving at the border	Uninformative on age	UNIFORM
$Develop_{LifeStage,Temp}$ Condition	Daily development of a specific life stage according to the temperature and a random component related to the insect and host conditions. Reciprocal of the duration of the specific life stage at a specific temperature. The condition is the position within a range of values	Scientific literature	TRIANGULAR with correlation of the life stages
$Temperature_{CompA}$ $Temperature_{CompB}$ $Temperature_{CompC}$	Temperature during the stay in a compartment. For compartments A and B, the temperature is assumed as constant, while for compartment C, the temperature may change every day	Default values for compartment A and B, seasonal weather data for 2001–2010 (at NUTS2 level)	TRIANGULAR
$Duration_{CompA}$ $Duration_{CompB}$	Duration of the stay in compartments A and B	Default values according to the objectives of the flower industry	TRIANGULAR

2.3.3. The waste model

The waste model estimates the proportion of *T. leucotreta* that survive and escape different waste treatments: private compost and the communal treatments (landfill, composting and incineration/anaerobic digestion). The proportion of each treatment is estimated for household and commercial (sorted vegetal) waste.

Because no data on the duration from initial disposal to waste treatment for normal household waste were available, and a dependence on local conditions is assumed, the calculations were done for four different times: treatment 3.0, 7.0, 14.0 and 28.0 days after initial disposal at the household.

To model the escape of *T. leucotreta* moths before the treatment of the waste, four scenarios for the collection of household waste are calculated:

- Scenario 1: Fast collection and treatment of household waste. In this scenario, treatment occurs 3 days after initial disposal (day 18 after entry). This is a 'best case' scenario where consumers would take their waste for collection on the same day that the cut roses were disposed of, and waste is also collected within 24 h and treated without delays.
- Scenario 2: Treatment occurs 7 days after initial waste disposal (day 22 after entry). This is for example the case where roses are kept for a few days in the waste bin at private consumers before being taken out for collection. The rest of the waste management chain runs smoothly with a possible 1- or 2-day delay between collection and treatment.
- Scenario 3: Treatment occurs after 14 days after initial disposal (day 29 after entry). This is a scenario assuming more severe delays, e.g. when roses are kept for a few days in the waste bin at the private consumer's before being taken out for collection. At the same time, there is a delay in either the waste collection or treatment, e.g. by intermediate storage.
- Scenario 4: Slow collection and treatment of household waste. In this scenario, treatment occurs 28 days after initial disposal (day 43 after entry). This should be regarded as the 'worst-case' scenario in which long delays occur and there is maximum opportunity for *T. leucotreta* adults to escape from waste. For example, the waste is not taken out for collection every week and/or there is a longer storage in the waste management chain before the treatment.

For the commercial waste, the Scenario 1 (3 days after initial disposal) is assumed. The pathway of the waste model is presented in Figure 8.

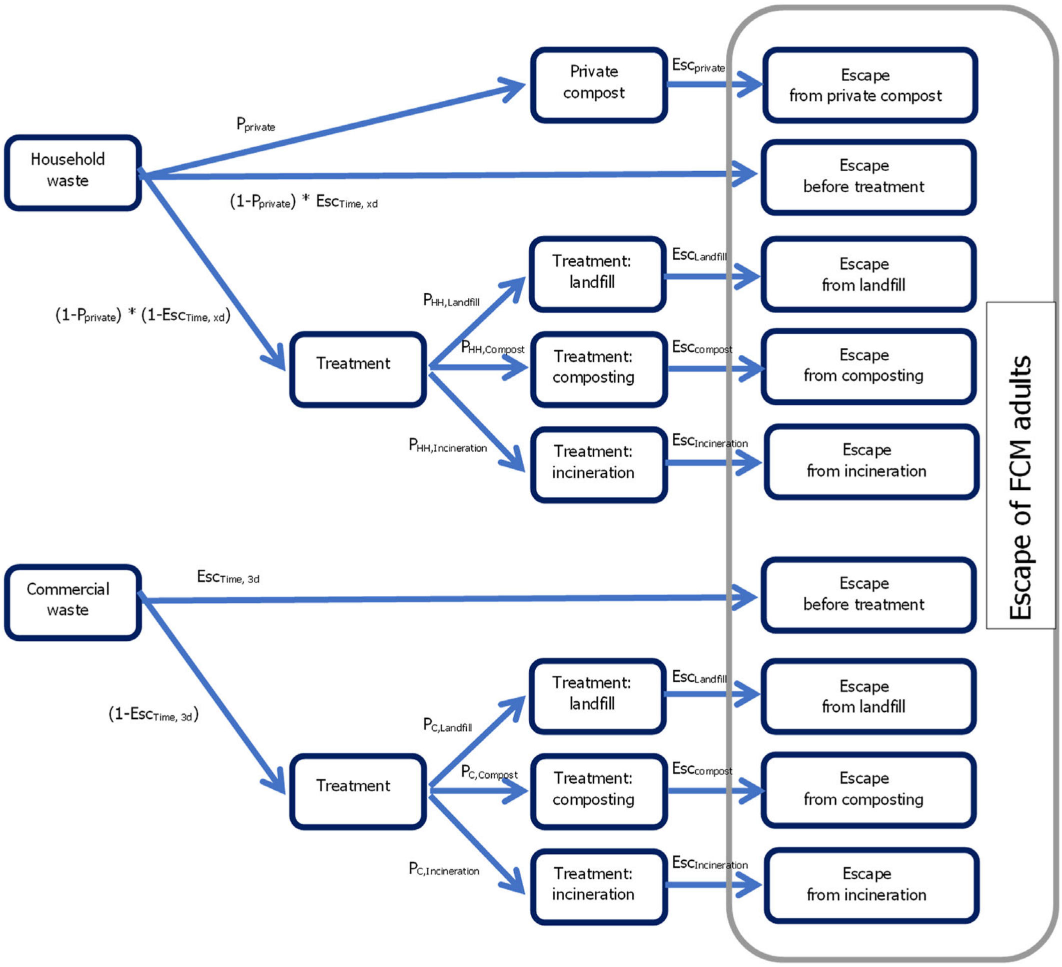


Figure 8: Pathway model for the waste management component (see text below, Table 8 and Appendix A for details)

The overall number of *T. leucotreta* individuals/year escaping from the household or commercial waste were therefore calculated as the escape from private compost, escape from household waste before the treatment and escape during the three types of treatment: landfill, composting or incineration.

$$\begin{aligned} ESC_{Household,\ NUTS2,\ Season} = {} & P_{private} \times ESC_{private} + (1\text{–}P_{private}) \times ESC_{time,\ xd,\ CSClass,\ Season} + (1\text{–}P_{private}) \\ & \times (1\text{–}ESC_{time,\ xd,\ CSClass,\ Season}) \times P_{HH,\ Landfill,\ country} \times ESC_{Landfill} + (1\text{–}P_{private}) \\ & \times (1\text{–}ESC_{time,\ xd,\ CSClass,\ Season}) \times P_{HH,\ Compostl,\ country} \times ESC_{Compost} + (1\text{–}P_{private}) \\ & \times (1\text{–}ESC_{time,\ xd,\ CSClass,\ Season}) \times P_{HH,\ Incineration,\ country} \times ESC_{Incineration} \end{aligned}$$

Additionally, *T. leucotreta* may escape the commercial waste. This may happen before the treatment (within 3 days after wasting), or during the different types of treatment.

$$\begin{aligned} ESC_{Commercial,\ NUTS2,\ Season} = {} & ESC_{time,\ 3d,\ CSClass,\ Season} + (1\text{–}ESC_{time,\ 3d,\ CSClass,\ Season}) \times P_{C,\ Landfill,\ country} \\ & \times ESC_{Landfill} + (1\text{–}ESC_{time,\ 3d,\ CSClass,\ Season}) \times P_{C,\ Compostl,\ country} \times ESC_{Compost} \\ & + (1\text{–}ESC_{time,\ 3d,\ CSClass,\ Season}) \times P_{C,\ Incineration,\ country} \times ESC_{Incineration} \end{aligned}$$

A description of the parameters used to inform the waste model is presented in Table 8.

Table 8: Description and source of evidence for the parameters used in the waste model

Parameter	Description	Source	Distribution
$ESC_{Household,\ NUTS2,\ Season}$	Proportion of *T. leucotreta*, which will escape the cut roses used at consumer level or household waste	Calculated	
$ESC_{Commercial,\ NUTS2,\ Season}$	Proportion of *T. leucotreta*, which will escape the commercial waste of cut roses	Calculated	
$P_{private}$	Proportion of household waste, which goes to private composting (not subjected to regional waste treatment)	EKE question 3 (Appendix A.9)	GENERALBETA
$ESC_{time,\ xd,\ CSClass,\ Season}$	Proportion of *T. leucotreta*, which will escape the cut roses until x days after initial disposal in a region of a specific climate suitability class (CSClass) and season	Calculated by the developmental model	
$P_{HH,Landfill,country}$ $P_{C,Landfill,country}$	Proportion of household (HH) or commercial (C) waste treated by 'landfill'	Eurostat waste treatment for household or vegetal waste (Appendix A.9.2 and A.9.3)	CONSTANT
$P_{HH,Compostl,country}$ $P_{C,Compostl,country}$	Proportion of household (HH) or commercial (C) waste treated by 'composting'	Eurostat waste treatment for household or vegetal waste (Appendix A.9.2 and A.9.3)	CONSTANT
$P_{HH,Incineration,country}$ $P_{C,Incineration,country}$	Proportion of household (HH) or commercial (C) waste treated by 'incineration or anaerobic digestion'	Eurostat waste treatment for household or vegetal waste (Appendix A.9.2 and A.9.3)	CONSTANT
$ESC_{private}$	Proportion of *T. leucotreta*, which will escape private compost	Conservative assumption	CONSTANT = 100%
$ESC_{Landfill}$	Proportion of *T. leucotreta*, which will escape waste treated by 'landfill'	EKE question 4a (Appendix A.9.4)	UNIFORM
$ESC_{Compost}$	Proportion of *T. leucotreta*, which will escape waste treated by 'composting'	EKE question 4b (Appendix A.9.4)	UNIFORM
$ESC_{Incineration}$	Proportion of *T. leucotreta*, which will escape waste treated by 'incineration or anaerobic digestion'	EKE question 4c (Appendix A.9.4)	CONSTANT = 0%

Waste treatments for both commercial and household waste include landfill, composting (and home composting), incineration or anaerobic digestion. A high variability in the proportions of waste treated by the different methods occurs across MSs, particularly in relation to the household waste (Figures 9 and 10).

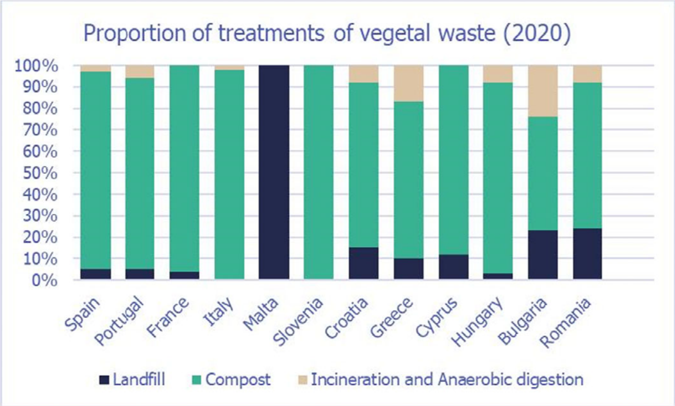


Figure 9: Proportion vegetal waste[5] treated as landfill, compost and incineration/anaerobic digestion in the European countries considered in the assessment

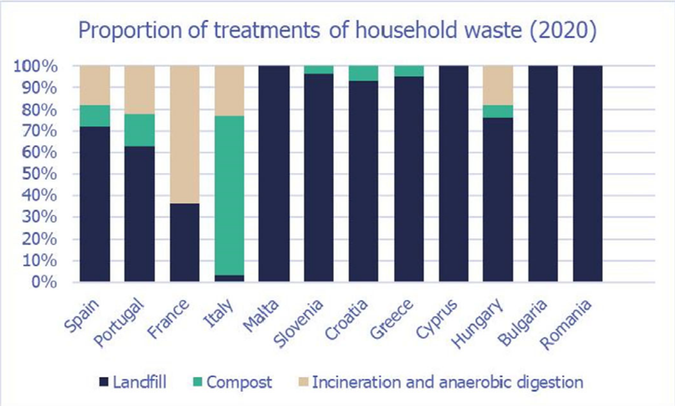


Figure 10: Proportion household waste treated as landfill, compost and incineration/anaerobic digestion in the European countries considered in the assessment

For each type of treatment, EKE was used to determine the proportion of *T. leucotreta* that survives and escapes the treatment. The main characteristics of the different treatments are described in Appendix A.9. This information was used as part of the evidence for the expert judgement on: (i) proportion of organic waste going to private composting (Appendix A section A.9), (ii) survival rate of *T. leucotreta* at landfill, during composting and incineration/anaerobic digestion (Appendix A Sections A.9.4, A.9.5 and A.9.6).

For the scope of the opinion, the following assumptions were made: (i) Public waste management is also applicable for cut roses wasted by private consumers and (ii) commercial waste of cut flowers will be handled as treatment of vegetal waste.

2.3.4. The overall entry model

The overall model for entry combines the three submodels and calculates the average number of *T. leucotreta* adults escaping from cut roses over all seasons according to the equation below.

To adjust for the natural mortality occurring during the development of the insect along the pathway, an overall mortality factor of 44–60% was introduced that reduced the total number of escaping adults.

Neither data nor information were found in the scientific and grey literature on the mortality of *T. leucotreta* in cut roses or in organic waste; however, in other commodities (sweet orange and sweet pepper, see Section 3.1.2), a larval mortality range was reported between 25% and 37%. Data or information on pupal mortality rate for *T. leucotreta* are also lacking; however, the Panel assumes that for

5 'Vegetal waste' comprises 'Green waste' and 'Vegetal waste of food production and products' according EU waste statistics (EC 2150/2002, amended EC 849/2002 Annex III).

T. leucotreta the pupal mortality and the larval mortality are comparable, as it is the case for other Tortricidae species (Milonas and Savopoulou-Soultani, 2000, Gutierrez et al., 2012). Therefore, as there are no data on mortality of *T. leucotreta* in cut roses and in organic waste and considering also that the temperature-dependent mortality remains low in the range of temperatures experienced by cut roses from entry to disposal (see Figure 16), a mortality rate between 25% (such as in sweet oranges) and 37% (sweet pepper) for developing larvae at 25.0 ± 2.0°C was used as a lower bound of the overall mortality for larvae in the cut roses pathway. Further assuming that the mortality range (25–37%) would be similar also for pupae, an overall mortality range of 44–60% from larvae to pupae was estimated and applied overall to the entry model results on the numbers of adult moths predicted to escape per year.

$$FCM_{Escape,\ NUTS2} = \left(1 - Mort_{natural}\right) \times \sum_{season} \left(FCM_{household,\ NUTS2,\ Season} \times ESC_{Household,\ NUTS2,\ Season} + FCM_{commercial,\ NUTS2,\ Season} \times ESC_{commercial,\ NUTS2,\ Season}\right)$$

Descriptions of the parameters used in the overall model are reported in Table 9.

Table 9: Description and source of evidence for the parameters used in the final model

Parameter	Description	Source	Distribution
$FCM_{Escape,\ NUTS2}$	Annual average number of *T. leucotreta* adults escaping from cut roses imported from AF (African countries with FCM occurrence and Israel) in a specific NUTS2 region		
$Mort_{natural}$	Natural developmental mortality	Observed larval mortality on other crops Extrapolation to pupae	UNIFORM
$FCM_{Commercial,\ NUTS2,\ Season}$ $FCM_{Household,\ NUTS2,\ Season}$	Number of FCM *T. leucotreta* individuals ending in commercial or household waste in a NUTS2 region climatically suitable in a specific season	Calculated in the distribution model	
$ESC_{Household,\ NUTS2,\ Season}$	Proportion of *T. leucotreta* which will escape the cut roses used at consumer level or household waste	Calculated in the waste model	
$ESC_{Commercial,\ NUTS2,\ Season}$	Proportion of *T. leucotreta* which will escape the commercial waste of cut roses	Calculated in the waste model	

Results of the overall model are expressed as average number of adult escapes per NUTS2 region with suitable climatic conditions for establishment.

To provide an interpretation of the results in terms of possible mating under different level of clustering, the results of the final model are also transformed to represent two scenarios:

- **Cluster Scenario 2**: Clustering in bunches of 10 roses as defined in Section 2.2.3. Under this scenario, a mating will happen for every 435 escaping *T. leucotreta* (No. mated $females_{NUTS2}$/year = $FCM_{Escape,\ NUTS2}$/435) (see results in Sections 3.4.1 and 3.4.2 and in Appendix A Sections A.1.2 and A.1.3).
- **Cluster scenario 3**: No temporal or spatial clustering and all escaping adults are homogeneously distributed within the residential area of a NUTS2 area and throughout a year. To this end, the average number of adult escapees is standardised to a circle of a 1-km radius (flying radius of *T. leucotreta* males), considering only the residential area of each NUTS2 regions during a time of 10 days (because the majority of eggs are laid within the first 10 days of female adult stage) (see results in Section 3.4.3 and in Appendix A Section A.1.4).

Results transformed as the number of mated females $_{NUTS2}$/year are presented for the EU and some selected NUTS2 regions as disaggregated values by season for all scenarios of time between waste disposal and waste treatment (i.e. 3, 7, 14 and 28 days).

To combine the uncertainties in the model parameter (expressed as distributions), the model is implemented in a Monte-Carlo simulation 10,000 times (using @RISK version 7.6) (see Appendix D).

2.3.5. Uncertainties of entry

Uncertainties on entry are generally quantitatively assessed in the model and in the EKE. Aspects not quantified and assumptions are described in Section 3.3. To identify the parameters of the pathway model driving most of the uncertainty on the output estimates, a sensitivity analysis was conducted on each scenario (3, 7, 14 and 28 days) by calculating the relative decomposition of R^2 from the calculated correlation coefficients between inputs and outputs.

2.4. Establishment

2.4.1. Climate suitability methodology

In the EPPO PRA for *T. leucotreta* (EPPO, 2013), a CLIMEX compare locations model was explored but then abandoned because of lack of knowledge on factors influencing winter survival and 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 recognising its uncertainty (as it was based on very few locations and there was uncertainty of the characteristics of the coldest winter that *T. leucotreta* could survive).

Other quantitative approaches to assess *T. leucotreta* establishment were found in literature but not all addressing the EU region (Table 10 below). The Panel used two approaches for assessing the area of potential establishment of *T. leucotreta*. The first is the Köppen–Geiger climate classification (MacLeod and Korycinska, 2019) matching climate categories in the EU with those in locations where *T. leucotreta* is known to occur in Africa and Israel (see Section 2.2.1 and Figure 1). The second is a physiologically based demographic model (hereinafter referred to as PBDM; Gutierrez, 1996).

In this document, the establishment is measured in terms of interannual average abundance of life stages of the pest, given entry. Establishment is interpreted as the similarity of predicted pest abundance (output of the PBD Model) for EU regions in comparison with after invasion locations that report establishment of the pest in newly invaded areas in South Africa and Israel (Giliomee and Riedl, 1998; Hofmeyr et al., 2015).

2.4.2. EPPO PRA

The EPPO PRA led to the following conclusions.

Based on the assumption that the capacity to survive cold stresses during the winter is the key climatic factor influencing the establishment in the EPPO region and the finding that, in the South African locations where *T. leucotreta* is known to occur with the minimum lowest winter temperature, maximum temperatures in the winter are up to 15–17°C, a simple rule was applied to estimate EPPO regions where the climate was suitable for *T. leucotreta*. As a result, according to the conclusions of EPPO (2013), not only the known distribution in South Africa and the Israeli coastal plain, but also parts of the Mediterranean coast in Europe (Spain, Italy [Sicily], Malta and Cyprus) and North Africa (Morocco, Algeria and Tunisia) together with Portugal, the Canary Islands, Azores and Jordan were shown to have temperatures above the threshold. It was deemed possible that *T. leucotreta* can establish in a wider area in the EU because of limited knowledge of *T. leucotreta* cold tolerance and the fact that recent climatic data suggest that the threshold is also likely to be exceeded in southern France, e.g. Corsica, and larger areas of southern Portugal, Greece (Crete), Spain and Italy. Based on this rule, in areas further north in Europe, conditions are too cold (low minimum temperatures below 0°C, or absolute/mean minimum temperatures in January, as low as 1–3°C) and not coupled by maximum temperatures within the 15–18°C range or warmer. However, up to about 55° of latitude north, sufficient degree days above the minimum development threshold of 12°C may accrue during warmer periods for *T. leucotreta* to complete at least one transient generation (EPPO, 2013).

2.4.3. Previous climate suitability assessments

Although the potential establishment range of *T. leucotreta* was assessed with different methodologies, the exploited data were similar and limited to development + fecundity (Daiber, 1979a, b,c) and cold stress data for certain life stages (Stotter and Terblanche, 2009). The methodologies differ from each other regarding whether the suitability was estimated based on observed presence or, by the predictive interpretation of the set of experimental data as drivers of the population development over generations (see Table 10).

Table 10: Methodological approaches to model climate and niche suitability of *T. leucotreta*

Model basis	Source	EU data
Host presence + pest occurrence + climate characteristics	EPPO (2013)	Yes, map
Pest occurrence + climate categories	(Köppen–Geiger) in this EFSA Scientific Opinion; Rossi et al. (2023)	Yes, map (Figure 23)
Pest occurrence + host presence	Venette et al. (2003)	None
Pest occurrence + degree-days + host presence	Li et al. (2022)	Yes, map (pers.comm, Figure 27)
Pest biology+Degree-day + cold stress (CLIMEX)	Barker and Coop (2019)	Yes, map (pers.comm)
Physiologically based demography	Gutierrez and Ponti (2013, 2023a,b)	Yes, map (Figure 25 and Figure 26)

2.4.4. Climate matching based on the Köppen–Geiger climate classification

The climate matching approach based on the Köppen–Geiger climate classification maps areas including climate types that fulfil two conditions: (i) the organism has been found to occur in them in its endemic range, (ii) the climate type occurs in EU. Thus, if the organism occurs in a climate type that does not occur in the EU, this climate is not mapped as a relevant climate for the assessment. The Panel used the implementation of Köppen–Geiger climate classification currently available in SCANClim (EFSA and Maiorano, 2022, published by the Institute for Veterinary Public Health of the University of Vienna (Kottek et al., 2006), for the period 1986–2010, rescaled after Rubel et al. (2017) (https://koeppen-geiger.vu-wien.ac.at/present.htm).

2.4.5. Physiologically based demographic model

The climate matching with Köppen–Geiger classification was difficult to interpret because one climate zone intersected with the occurrence data on the African continent to a small extent, which would add all middle and northern EU MS to the climatically suitable area for establishment. Therefore, the EU territory was assessed using a physiologically based demographic model (PBDM; see CASAS Global https://www.casasglobal.org/). This approach models the potential establishment of the pest from the physiological response of its developmental stages to daily weather, using daily climatic variables as input. The approach does not rely on occurrence records. The technique is taken from the literature with several applications to other pests (see e.g. Gutierrez and Ponti, 2013, 2023a,b).

PBDMs are based on the notion that analogous weather-driven submodels for resource acquisition and birth–death dynamics can be used to predict explicitly the biology and dynamics of heterotherm species across trophic levels (Gutierrez and Baumgärtner, 1984; Gutierrez, 1992, 1996; Gutierrez and Ponti, 2023b). When driven by site specific daily weather, PBDMs predict the phenology, age structure and abundance dynamics of the target species (e.g. an invasive insect herbivore) and as appropriate of interacting species in its food web (e.g. its host plant and natural enemies) across wide geographic areas (see Gutierrez et al., 2008, 2010).

The technical model documentation can be found in Appendix B of this scientific opinion. The model characteristics are summarised according to the POE protocol (Purpose, Overview, Evidence) (Grimm et al., 2020). **Purpose** of the PBD Model: a temperature-driven version of the PBDM (see Gutierrez and Ponti, 2013) was implemented to exploit local differences in climate on the scale of about $0.25^\circ \times 0.25^\circ$ for predicting the average annual level of the life stages of *T. leucotreta* in the EU, the Mediterranean Basin and Africa, using 10 consecutive years of daily maximum and minimum temperature values (years 2001–2010) as driver of daily *T. leucotreta* biology. **Overview**: The model describes the growth and survival of local pest populations (on a $0.25^\circ \times 0.25^\circ$ latitude/longitude grid resulting in horizontal resolution of about 25 km) based on interpreted temperature-dependent development, fecundity and mortality data available from the literature across all life stages of the pest (see Section 3.1). With daily resolution, the thermal biology data of the four developmental stages of *T. leucotreta* were summarised using biodemographic functions for development, fecundity and mortality (see Box 1 below and Appendix B). Biodemographic functions of *T. leucotreta* with available data are temperature-dependent developmental rates, per capita lifetime reproductive profiles and temperature-dependent mortality rates (see Section 3.1).

Box 1: Biodemographic functions used in the PBD model of *T. leucotreta*.

Oviposition profile on age x = days at 24°C times a scalar for the effects of temperature.

$$\text{eggs/female/day} = \frac{50a}{1.4^x} \cdot \left[\frac{36(T-10.3)}{1+1.75^{(T-28)}}/450\right] \text{for } 0.5 \leq x \leq 20 \text{ days}$$

Stage developmental rates on temperature (del_{stage})**:**

$$1/del_{egg} = {}^{0.0122(T-8.75)}\!/\!_{\left(1+4.25^{(T-38)}\right)}$$

$$1/del_{larvae} = {}^{0.0071(T-10.7)}\!/\!_{\left(1+5.25^{(T-33.5)}\right)}$$

$$1/del_{pupae} = {}^{0.0054(T-10.3)}\!/\!_{\left(1+5.25^{(T-33)}\right)}$$

Temperature (T) **dependent mortality rate:**

Polynomial mortality function for all stages (μ_{stage}):

$$0 \leq \mu_{E.L,P,A} = 0.0000000028T^6 - 0.0000003541T^5 + 0.0000169457T^4 - 0.0003689726T^3 + 0.0039554884T^2 - 0.0202175381T + 0.0808750603 < 1$$

Modification for larval temperature tolerance (τ; displacement of mortality curve)**:**

$$\text{if } T \geq 24^\circ\text{C then for } \tau \in [0, 4, 6^\circ\text{C}]$$

$$0 \leq \mu_L = 0.0000000028(T-\tau^6) - 0.0000003541(T-\tau)^5 + 0.0000169457(T-\tau)^4 - 0.0003689726(T-\tau)^3 + 0.0039554884(T-\tau)^2 - 0.0202175381(T-\tau) + 0.0808750603 < 1$$

Density-dependent predation mortality in eggs/pupae/adults (L_x)**:**

$$0 \leq L_x = \exp(-0.0001 \times \text{eggs/pupae/adult} \times \Delta t) \leq 1, \text{where } \Delta t = dd > 8.75^\circ\text{C}$$

Erlang parameters:

k_{egg} = k_{larvae} = k_{pupae} = 25 (age classes of each stage, see Appendix B)

k_{adult} = 15 (age classes of the adult stage, see Appendix B)

Mean developmental times (degree days > threshold):

eggs (86.1dd > 8.75°C)

larvae (148,8dd > 10.7°C)

pupae (185.2dd > 10.3°C)

adult females (191.8dd > 10.3°C)

Adult immigration rates ($adult_{immigration}$)

$$\text{if } T > 11^\circ\text{C then } adult_{immigration} = 0.00001 \times (0.5 + \text{random} \in [0, 1])$$

Sex ratio = 0.5

The growth and abundance of the pest at a geographic location emerge from the daily minimum and maximum temperature values (AgMERRA daily weather data; see Ruane et al., 2015) and a background density-dependent mortality term on all stages but larvae which are inside the rose bud.

Local population may go extinct during extended frost/cold periods. In the model, new introduction of adults at very low levels is immediately assumed when daily temperature, T, is above 11°C. The model is analysed in each spatial unit in discrete daily steps evaluating the life stage cohorts independently. The model output per 25 × 25 km spatial unit refers to the (average) number of pupae over 10 consecutive years of temperature data and pest population dynamics. For selected locations across the EU, the physiologically based pest abundance is shown by multi-annual time-series plots to understand qualitative differences on the prospective local population dynamics of the pest.

Evidence: The PBDM of *T. leucotreta* is adapted from an established modelling framework in support of QPRA of different pests and the modelling approach has repeatedly been validated with the occurrence or occurrence-based models of other pests (see e.g. Gutierrez and Ponti, 2013, 2023a,b). Likewise, the model output of the *T. leucotreta* version was assessed with the occurrence reports of indigenous and invasive *T. leucotreta* in Africa and Israel. The approach could predict positive densities of *T. leucotreta* for the regions with pest observations, in both indigenous and invaded locations (see Appendix B).

The model was modified to explore the impact of higher thermal tolerance of the larval stage when compared to the adult stage (see Box 1, modification for larval temperature tolerance). Literature provides strong indication of higher thermal tolerance of larvae (Uys, 2014; Terblanche et al., 2017), but data are not sufficiently detailed. Therefore, model scenarios were considered using different larval thermal tolerance. The displacement of larval temperature-dependent mortality curve by 4°C resp. 6°C facilitated the explanation of *T. leucotreta* occurrence records in western parts of Africa (Table 11 and Figure 11). However, the physiological aspect is of marginal relevance to predictions for EU climates, as the main constraint to *T. leucotreta* distribution in Europe is cold weather and the absence of dormancy in the pest (Terblanche et al., 2014).

Interestingly, the predicted population at 4°C and 6°C displacement of larval mortality keeps the original predictions for Kenya and Ethiopia nearly unchanged while the prediction for the southwest coastal areas of Africa increased. In summary, the *T. leucotreta* model including displacement of larval temperature-dependent mortality captures the distribution of *T. leucotreta* in Eastern parts of Africa (Kenya above the midpoint of the density range) and hotter regions such as Nigeria, Benin, Togo and Ghana (0.25–0.5 of the density range). In particular (and independent of the displacement scenario), the occurrences from South Africa, an invaded area of *T. leucotreta*, are captured in every detail of the ecological structure (Table 11 and Figure 11).

Table 11: Comparison of average number of pupae per year in the period 2001–2010, as projected by the PBDM model, under three scenarios of larval heat-stress mortality being displaced by 0°C, +4°C and 6°C. Percentages in brackets compare model predictions to observations

Continent/ Country	Number of *T. leucotreta* observations with geographical coordinates	No of *T. leucotreta* observations with predicted no pupae > 1 in scenario + 0	No of *T. leucotreta* observations with predicted no pupae > 1 in scenario +4°C	No of *T. leucotreta* observations with predicted no pupae > 1 in scenario +6°C
African continent	468	412 (88%)	446 (95%)	448 (96%)
Southern Africa	265	264 (99.6%)	265 (100%)	265 (100%)
Eastern Africa	123	112 (91%)	115 (93%)	115 (93%)
Western Africa	46	9 (19.6%)	41 (89%)	43 (93%)

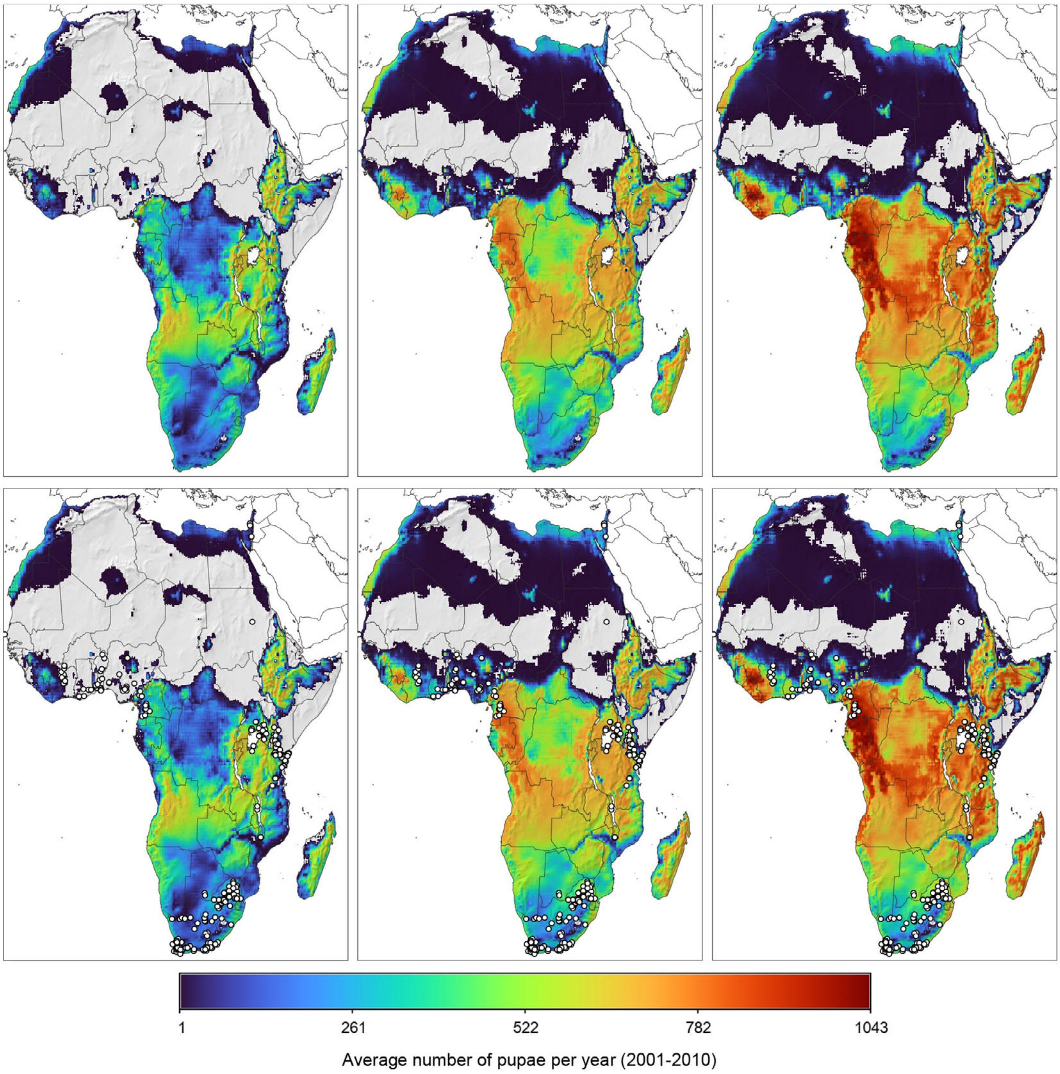


Figure 11: Maps of Africa with geographic distribution and relative abundance of *T. leucotreta* (average number of pupae during 2001–2010) as projected by the PBDM model shown for three scenarios of larval temperature-dependent mortality displacement by 0°C (left), 4°C (middle) and 6°C (right). The maps in the bottom row additionally show *T. leucotreta* occurrence records (white circles with black outline). In scenario 0°C, the predicted abundance is in the range of [1, 696] (left), with 4°C according to Terblanche et al. (2017) the range is [1, 828] (middle), and with 6°C according to Uys (2014) a range of [1, 1,043] average pupae per year (right) was predicted for the whole continent. The colour legend uses the turbo colour palette (Mikhailov, 2020) to maximise graphical inference (Reda and Szafir, 2021). The absolute minimum and maximum values of the colour scaling are equal for the three maps (i.e. 1–1043) to ease comparisons. PBDM simulations are mapped and analysed using GRASS (GRASS Development Team, 2022), a multipurpose open-source GIS (Neteler et al., 2012)

Limitations and assumptions: The biological data summarised from the literature and included in the PBDM for assessing establishment of *T. leucotreta*, enabled modelling temperature dependence of development, fecundity and mortality. These data, however, were generated from experiments designed for other purposes, such as developmental or quarantine studies, but not specifically addressing temperature-dependent population dynamics as would be most suitable for PBDM modelling.

Population dynamics in the model is driven by local daily temperature data intrinsically capturing altitude structure. Other dependencies of the pest on microclimatic parameters are not yet studied and quantitative data are unavailable. Nutritional and seasonal energy budget aspects are not included due to unavailable physiologically based data.

The model assumes that hosts for *T. leucotreta* are available year-round and would not limit the development of the pest. The assumption was motivated by the polyphagia of the pest and the wide distribution of hosts like tomato, maize, citrus, etc. in the areas climatically suitable for its establishment in the EU.

The predictions of the PBDM do not result from observational or studies in the field and do not include shelter from low temperature the pest may receive when inside a host subunit (e.g. fruit or pupae in soil). To average temperature-dependent population dynamics, local populations are maintained above a low minimum computational threshold by randomly adding a fraction of adults each day to each location (0.00001 adults/day per cell = per 625 km^2, equivalent to about one individual every 27 years). Hence, if local conditions favour population growth over the seasons/years, then the minimal density of stabilising (i.e. background) invasion does not have a quantitative impact on the output. True local extinction, however, cannot be inferred from the model results.

3. Assessment

The assessment of introduction of FCM into the EU via the pathway of imported cut roses has four chapters.

Pest biology, including thermal characteristics, is summarised in Section 3.1.

In Section 3.3, aspects not quantified for this QPRA are presented together with the main assumptions.

In Section 3.4, the Panel covers the entry and transfer of *T. leucotreta*, and discusses relevant aspects of the production, trade and use of the commodity (cut roses) that can act as a pathway.

In Section 3.5, the Panel covers the potential establishment of the pest in the EU and discusses climatic factors and host distribution.

3.1. Review of pest biology

A description of the biology of *T. leucotreta* is provided in the EFSA pest survey card (EFSA, 2020) with additional details in Adom and Fening (2021) and Mkiga et al. (2019). Here, we provide a summary overview with a focus on temperature-dependent developmental biology.

Immature stages of *T. leucotreta* include the egg, the larva (with five instars) and the pupa. After hatching, the first larval instar seeks a suitable host fruit for development, which may last a few hours before the larva penetrates the fruit (Kelly, 1914). Penetration of the host fruit is easier and faster through lesions or scars on the fruit surface (Daiber, 1979b). Each life stage exhibits different requirements in temperature for development (Boersma, 2018). The duration of larval development shows great variability and can last from 25 days in mature sweet oranges to 173 days in immature/maturing ones. However, in most cases, the larval developmental time of *T. leucotreta* recorded in sweet oranges, guavas and plums lasted from 50 to 70 days (reviewed in [Daiber, 1979b]). There are no detailed published data of *T. leucotreta* larvae on cut roses. Therefore, developmental data on artificial diet and other host fruits are reported.

3.1.1. Larval development in artificial media

In a set of laboratory experiments, the duration of larval development in artificial media was estimated and it was found to decrease as temperature increased from 12.1°C to 30.0°C (Table 12) (Daiber, 1979b, 1989). The lower temperature threshold for development was calculated at 11.6°C and a thermal constant of 156 day-degrees above the lower threshold is required for larval development. Shorter development times are observed in the first four larval instars, while the fifth instar before entering the prepupal stage takes significantly longer. Larval survival and development appear to be affected by the quality of the rearing medium (Daiber, 1979b).

Table 12: Developmental duration (in days) of *T. leucotreta* immatures developmental stages in artificial media under different temperatures (Daiber, 1979a,b,c; Daiber, 1989)

Temperature in °C	Egg	Larval	Pupae
10.9	22.0		
12.1		61.0	68.0
15.0		45.6	45.0

Temperature in °C	Egg	Larval	Pupae
15.3	14.0	39.0	
17.9	11.0	21.0	22.0
20.0	7.0	18.8	
21.2		14.0	15.0
23.8	6.0	12.0	15.0
25.0		11.6	
30.0	4.0	7.0	10.0
35.0	3.0	–	
40.0		–	

(–) = no development was observed; blank = not tested.

Unfortunately, there are limited detailed data on larval development for each larval instar across various temperatures. Using the data from Table 12, the total development time is estimated at different constant temperatures for egg to adult and for first-instar larva to adult. Using the composition of immature population of *T. leucotreta* (larval instars, prepupae and pupae) in artificial medium, under three different constant temperatures (15, 20 and 25°C), as reported by Daiber (1979a,b,c), the development time for the remaining larval instars to adult was estimated at 15, 20 and 25°C by deducting the number of days from oviposition until first appearance of the relevant instar larvae (Figures 12 and 13).

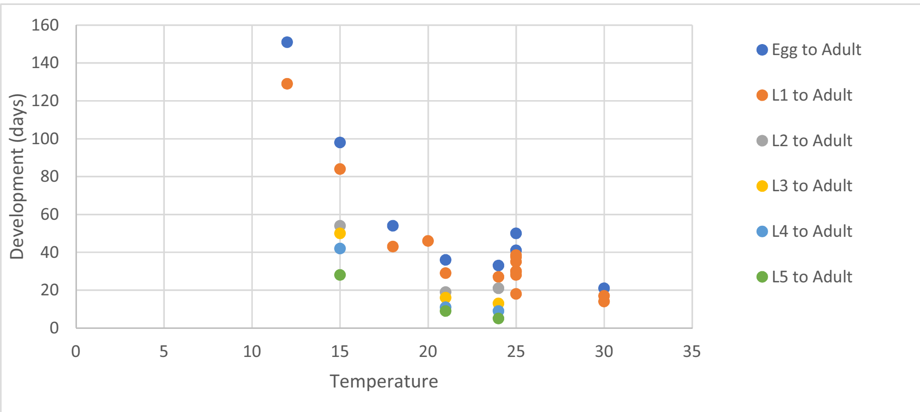


Figure 12: Total development time from egg to adult, L1 to adult and L2 to adult at different constant temperatures

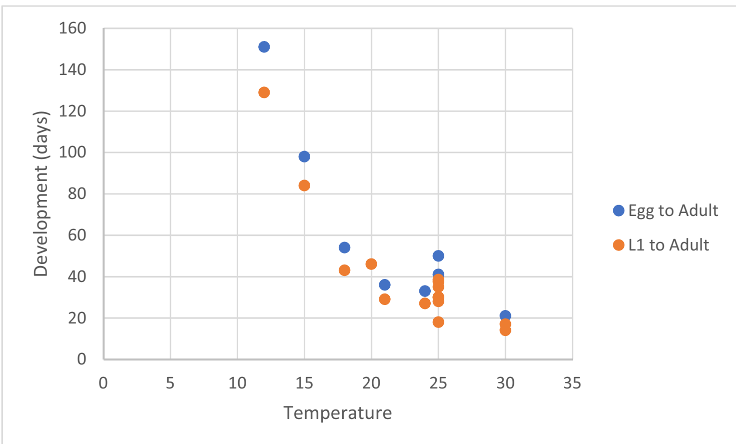


Figure 13: Total development time from egg to adult and from L1 to adult at different constant temperatures

3.1.2. Larval development in artificially infested fruits and vegetables

Larval development is affected by host fruit and rearing substrate. At 25.0 ± 2.0°C, larval development time was ~ 19 days on sweet oranges and 24 days on sweet pepper. Besides development time, survival is also affected by host fruit. Survival of developing larvae was estimated at 75% on sweet oranges and approximately at 63% on sweet pepper.

Larval survival and development time were also assessed in apples, pears, grapes and sweet oranges (De Jager, 2013). Total development time until adulthood was estimated at 50 days on pear and 41 days on sweet oranges (25°C). Apples proved to be an unviable host for *T. leucotreta*, with no fruit being penetrated, leading to no offspring.

In South Africa, natural infestation of peaches by *T. leucotreta* was investigated in commercial orchards and backyards of several areas (Pretoria, Rietondale, Silvertone, Hartbeespoortdam, Waterkloof). Low natural infestation (4%) of the late peach cultivar Keimoes was recorded in green and immature fruits. However, 20–30% of mature fruits, sampled during the week of harvesting, were found infested (Daiber, 1976).

Orange infestation was assessed in low, mid- and high-altitude areas of Kenya and Tanzania (25 orchards in each altitude, 300 fruit per orchard). In addition, okra, sweet peppers, chilli pepper and African eggplant (300 mature vegetables per species) were sampled from vegetable fields situated within 100 m from orange orchards. Fruit loss of up to 46% for sweet orange and 12% for solanaceous vegetables was reported in Kenya and Tanzania (Mkiga et al., 2019). Odanga et al. (2018) reported losses of more than 25% for avocado fruit produced in Taita hills and Mount Kilimanjaro of Kenya and Tanzania, respectively. Also, higher percentages of infestation were recorded in high and mid altitudes compared to low ones. African eggplant, okra, sweet and chilli pepper are grown throughout the year in irrigated fields which provide a continuous availability of host plants for this pest. In Kenya, maize, which is a favourable host for *T. leucotreta*, is widely cultivated in areas where greenhouses with cut roses occur. According to the NPPO of Ethiopia, *T. leucotreta* presence in greenhouses with roses is characterised as none to medium without further details. In Kenya, KEPHIS reports *T. leucotreta* prevalence from low to medium-high. *T. leucotreta* infestation is reported to be closely associated with crown galls affected by *Agrobacterium* spp. Farmers keep windows and doors open to reduce relative humidity to avoid grey mould, *Botrytis*, infections. However, windows often lack insect proof net, which allows entry of *T. leucotreta* adults in the greenhouse.

KEPHIS experts characterise *T. leucotreta* prevalence as high when adults trapped are > 20 without further details. KEPHIS provided trap capture data from a few farms without specifying their exact location. According to these scattered monitoring data provided by KEPHIS, *T. leucotreta* is persistent throughout the year in several locations where cut roses are grown both outside as well as inside the greenhouses. In these locations, outside catches were higher or comparable to those inside the greenhouse.

3.1.3. Thermal biology and population dynamics

Population dynamics of *T. leucotreta* life stages were predicted with the PBDM physiologically based population model (Appendix B; see e.g. Gutierrez and Ponti, 2013) that includes temperature-dependent development (Figure 14), fecundity (Figure 15) and mortality functions (Figure 16). These biodemographic functions are fitted to experimental data (Daiber, 1979a,b,c; Terblanche et al., 2014, 2017; Sections 3.1.1 and 3.1.2 of this opinion). Experimental data for *T. leucotreta* from South Africa report low- and high-temperature susceptibility and absence of diapause. *T. leucotreta* has adapted to a range of temperatures between 10°C and 35°C with the optimum near 24–25°C akin to that of a temperate species.

The biodemographic functions for the **development** of *T. leucotreta* are based on data of the four life stages (egg, larva, pupa and adult) (Figure 14).

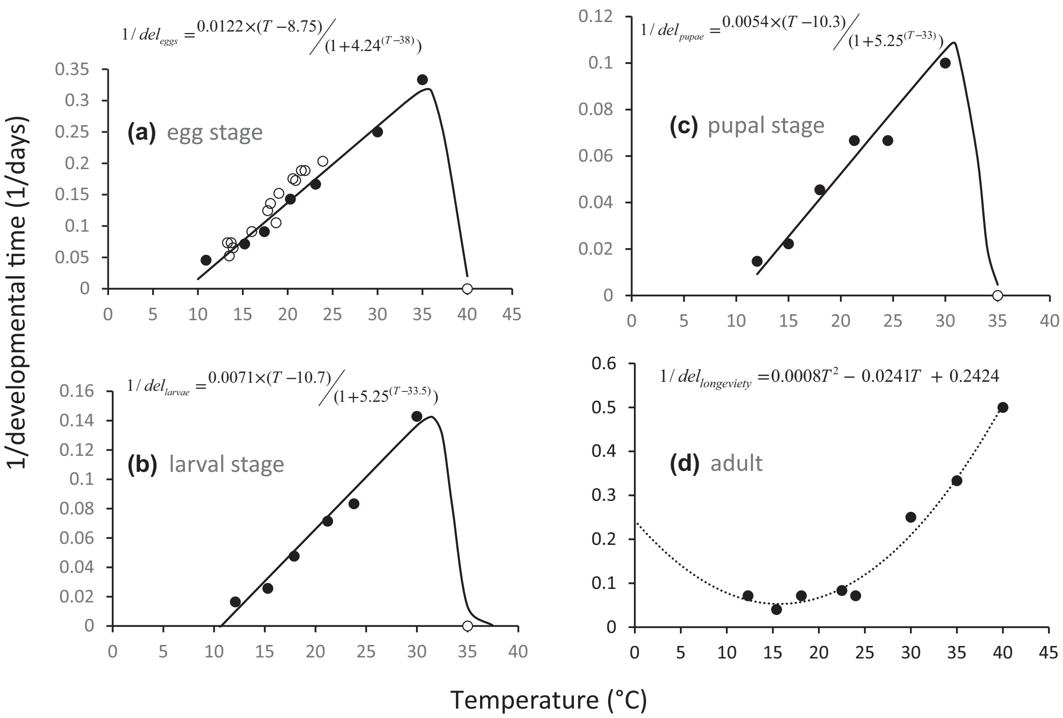


Figure 14: Development data applied in the model: (a) egg, (b) larval, (c) pupal and (d) adult stage. Experimental data on temperature dependence of development of the four life stages of *T. leucotreta*. Note that the data for adults are for adult longevity (i.e. the rate to final death) (Daiber 1979a,b,c, 1980)

The three-dimensional biodemographic function for **fecundity** used in the model combines data of the temperature-dependent number of eggs with the age-dependent oviposition rate profile. The product of the two functions is used to predict the oviposition rate [third dimension] at age (a) (second dimension) and temperature (T) [first dimension]. The left panel in Figure 15 is the age (a) specific oviposition profile at 24°C, while the right skewed function for total fecundity with a maximum of about 24°C in the right panel is the effect of temperature on oviposition. When normalised by dividing by maximum fecundity (i.e. 450), the latter function is used as a scalar of the age-specific profile (the rightmost half of the function in Figure 15).

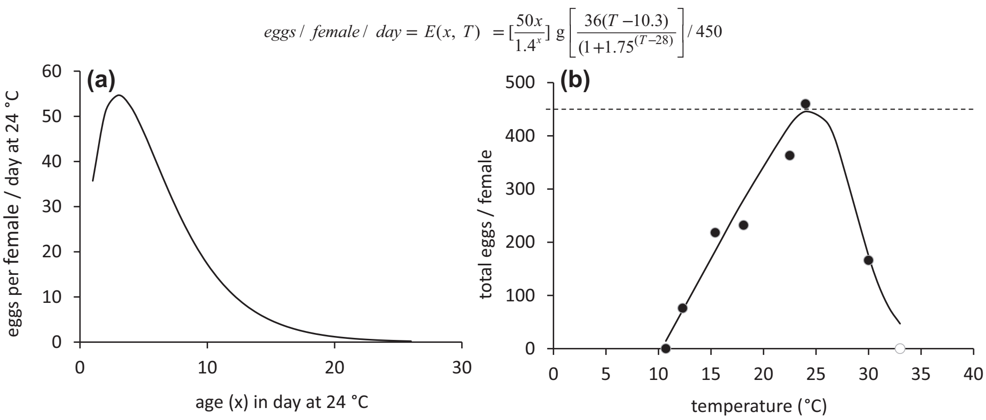


Figure 15: Fecundity functions used in the model. The left panel is the age specific per capita oviposition profile at 24°C. The effects of temperature on oviposition (right panel) showing a thermal threshold of 10.3°C with a maximum of 24°C and rapidly declining at higher temperatures with threshold about 33°C (Daiber (1980), see also Section 3.1 on biology)

Experimental high-temperature treatments had no significant effect on subsequent low-temperature survival of the insect Stotter and Terblanche (2009); therefore, individual data were combined over the temperature range of the model, assuming no effect if temperature changes between high and low or vice versa over short daily time scales. The biodemographic function for temperature-dependent daily **mortality** applied in the model for the *T. leucotreta* life stages is shown in Figure 16. It combines adult cold stress data (blue data points in Figure 16, Stotter and Terblanche, 2009), adult longevity data (brown data points in Figure 16; Daiber 1979a,b,c. see Figure 14) with larval data from Boardman et al. (2012, 2013) and Moore et al. (2022) (black data points in Figure 16).

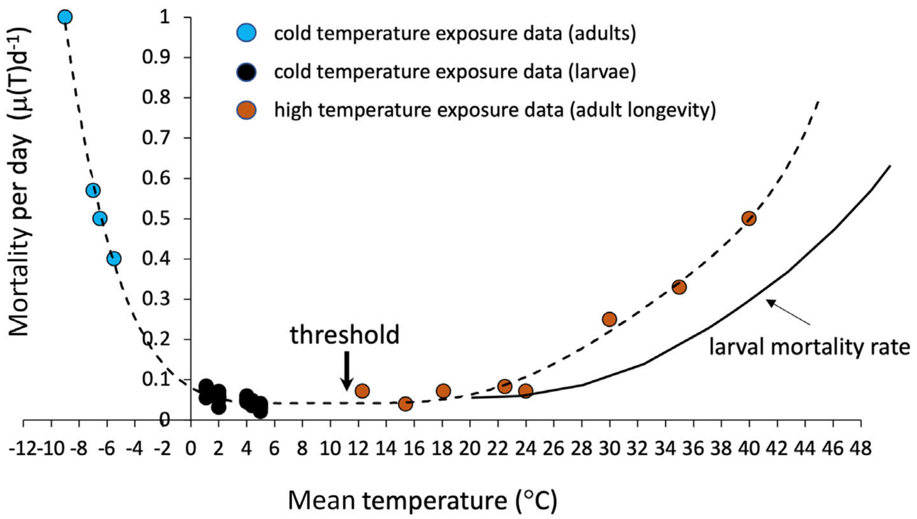


Figure 16: The biodemographic functions for larval and adult temperature-dependent mortality (source: Myburgh, 1965; Daiber, 1980; Boardman et al., 2012, 2013; Moore et al., 2016, 2022) with the 4°C displacement of larval mortality rates (see Terblanche et al., 2017) indicated as a solid line. Same mortality function was assumed for eggs and pupae (see, e.g. for other Tortricidae species: Milonas and Savopoulou-Soultani, 2000, Gutierrez et al., 2012)

The temperature-related mortality is assumed the same for the egg, pupal and adult stages, but non-systematic, survivorship data indicate the larval stage is more tolerant to high temperatures than the adult stage (Daiber, 1979a,b,c; Uys, 2014; Terblanche et al., 2017; and others). Although the thermal tolerance data by Terblanche et al. (2017) are insufficient to explicitly model the different patterns of larval mortality across temperatures, the data still suggest a 4°C displacement of the onset of increasing larval mortality versus those of adults above 24°C. With such displacement, the high-temperature mortality of larvae starts to increase above 28°C compared to 24°C for adults. A 6°C displacement of larval mortality rates was also implemented to account for even wider differences in high-temperature tolerance of larvae versus adults, as hinted in studies conducted by Uys (2014). In Figure 16, the 4°C displacement of larval mortality rates is indicated by the solid line. The prospective population dynamics of *T. leucotreta* were predicted for selected geographic locations in Europe, the Middle East and Africa (Figure 17, Table 13).

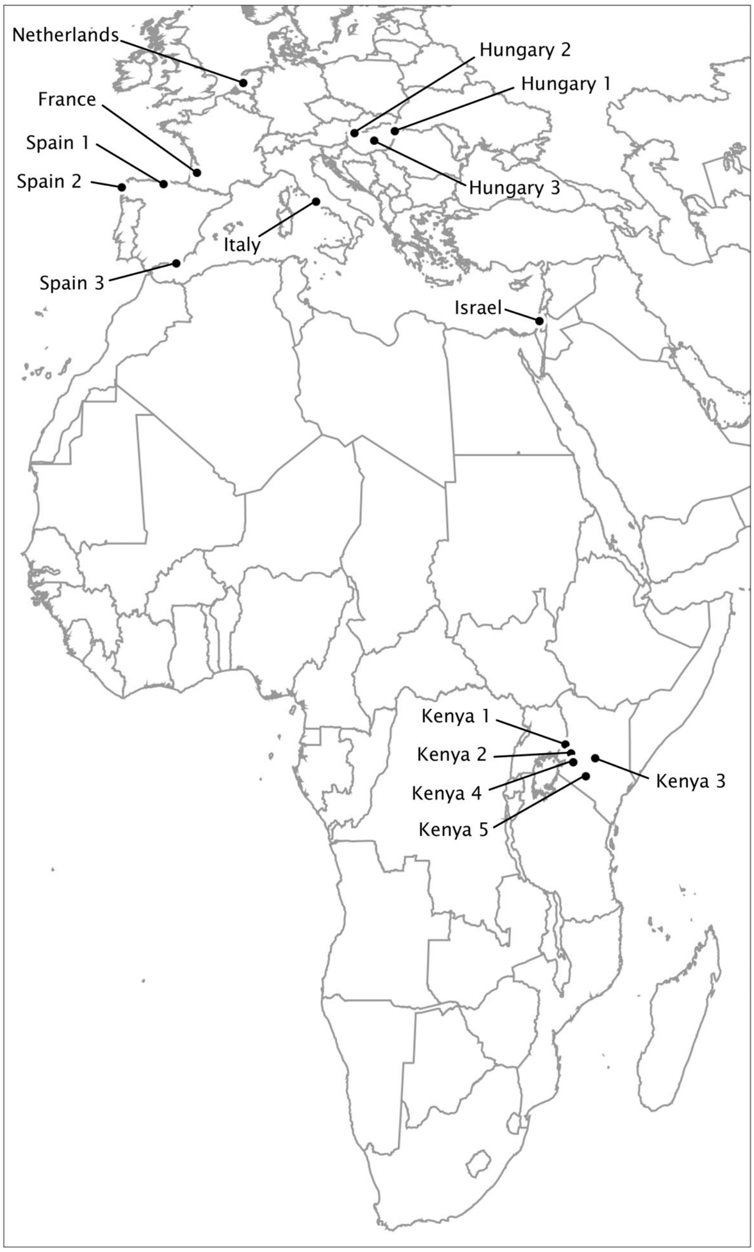


Figure 17: Map of selected geographic locations for which *T. leucotreta* stage-structured population dynamics are presented

Table 13: List of selected geographic locations for which *T. leucotreta* stage-structured population dynamics are presented in Figure 17

Label	Longitude (degrees E)	Latitude (degrees N)	Elevation (meters)	Köppen–Geiger classification
The Netherlands	4.869	52.229	–5.0	Cfb
Hungary 1	21.980	47.838	142.0	Cfb
Hungary 2	17.358	47.664	115.0	Cfb
Hungary 3	19.505	47.001	127.0	Cfb
France	–0.561	44.215	114.0	Cfb
Spain 1	–4.242	43.250	208.0	Cfb
Spain 2	–8.833	42.975	323.0	Csb
Italy	12.454	41.774	72.0	Csa

Label	Longitude (degrees E)	Latitude (degrees N)	Elevation (meters)	Köppen–Geiger classification
Spain 3	−2.725	36.722	46.0	BSh
Israel	34.880	32.164	67.0	Csa
Kenya 1	34.803	1.035	2017.0	Cfb
Kenya 2	35.341	0.398	2186.0	Cfb
Kenya 3	37.650	0.050	1596.0	Csb
Kenya 4	35.549	−0.236	2162.0	Cfb
Kenya 5	36.761	−1.238	1747.0	Cfb

The resulting time series show qualitative differences in the stage-structured population profile over time depending on the temperature characteristic of the location (Figure 18) using the same low initial values in the model. Note that the populations in Kenya grow to high levels but oscillate with changes in seasonal temperatures (Figure 18k–o). In highly unfavourable areas (Figure 18a–d), populations remain low due to random inputs in the model, and in intermediately favourable areas (coastal Israel, Figure 18j), the effects of seasonal cooler weather cause deep oscillations in the dynamics.

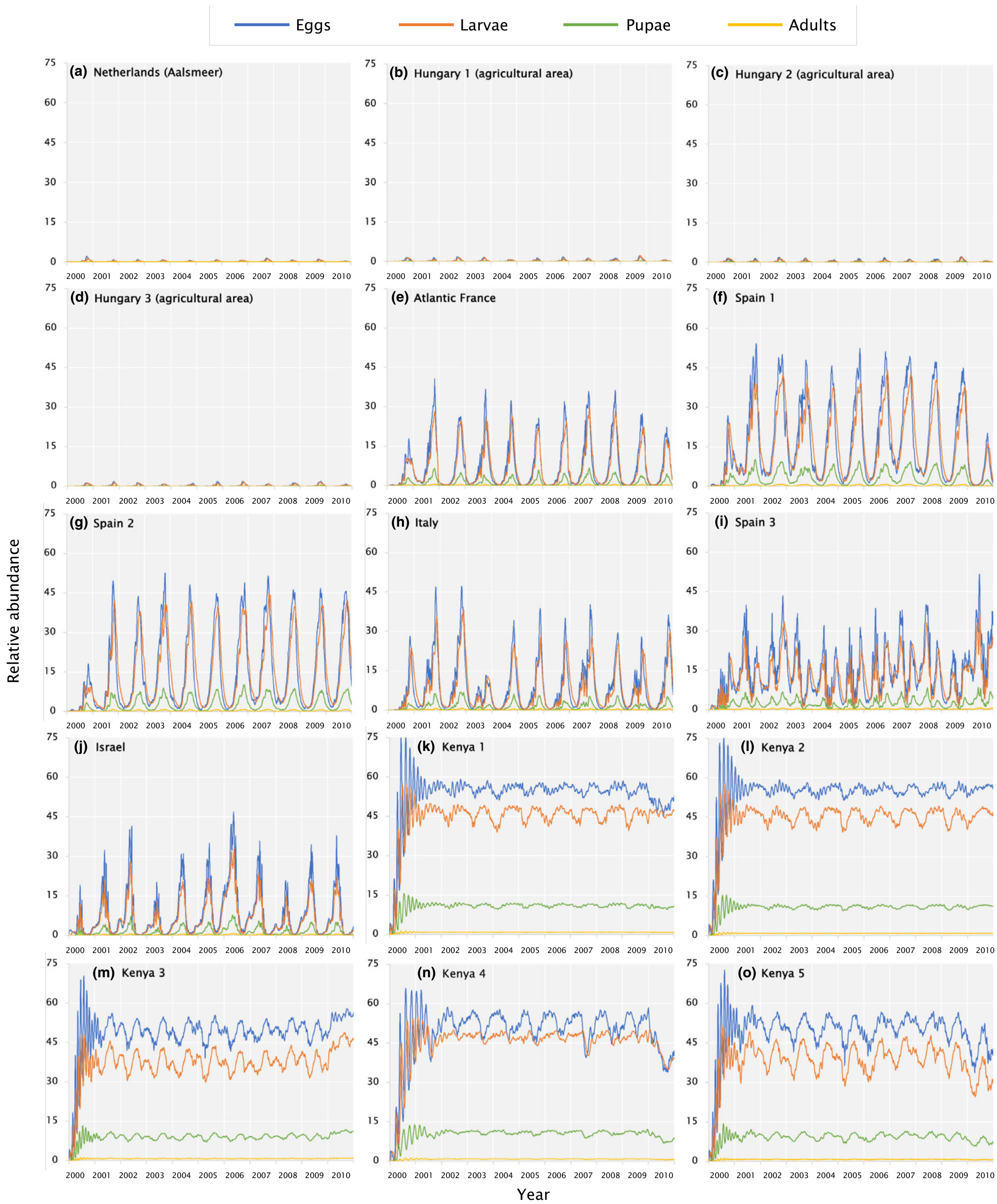


Figure 18: Population dynamics of *T. leucotreta* eggs (blue), larvae (orange), pupae (green) and adults (yellow) at selected locations for years 2000–2010. Plots in subfigures (a) to (o) are ordered so that the associated locations fall on a North to South gradient (see map of locations in Figure 17)

The predicted maps of establishment across EU MS, south-eastern Asia and Africa (see Section 3.5.2) are generated by averaging the population time series (Figure 18) over 10 years (2001–2010) as the mean abundance per cell per life stage of the insect. Only the pupal stage is shown in those figures (Section 3.5.2). Population dynamics for the first year of PBDM simulation (2000) are included in each plot of Figure 18 to show how the model equilibrates to local weather conditions but are not used for computing summary statistics (i.e. average pupae) shown on maps in Section 3.5.2.

PBDM simulations are mapped and analysed using GRASS (GRASS Development Team, 2022), a multi-purpose open-source GIS (Neteler et al., 2012).

3.2. Pest introduction

Pest introduction is the combination of entry (which includes transfer to hosts) and establishment.

In Section 3.3, the aspects not quantified in this opinion and the main assumptions are presented.

In Section 3.4, the Panel covers the entry and transfer of *T. leucotreta*, and discusses relevant aspects of the production, trade and use of the commodity (cut roses) that can act as a pathway.

Climatic factors and host distribution in the EU which can affect potential for establishment across are covered in Section 3.5.

3.3. Aspects not quantified and assumptions

Although a small but consistent percentage of cut flowers including cut roses is used for funerals and in cemeteries, the percentage varies among countries (5–13%, Rabobank, 2022) (see further below). This use is not specifically assessed in this scientific opinion, but it is covered by the different scenarios of the pathway model.

In line with EPPO (2013), it is assumed that *T. leucotreta*, being extremely polyphagous, will likely find suitable hosts for establishment outdoors in the climatically suitable areas.

Scenarios of possible changes in trade patterns or climate are not considered in this assessment.

Most common rose varieties are 'standard roses' developing one bloom per stem. There are, however, 'spray rose' varieties which develop multiple blooms per stem (typically three to seven flowers per stem). The pathway model assumes that one infested stem corresponds to one *T. leucotreta* insect. This is reasoned by the low level of infestation and the egg laying behaviour of *T. leucotreta*; however, spray rose varieties with multiple blooms per stem may not meet this assumption.

3.4. Entry into the EU where establishment is possible (NUTS2 resolution)

The Panel modelled the entry of *T. leucotreta* estimating the infestation level in cut roses imported into the EU, the trade flow and distribution into EU NUTS2 regions and the escape of *T. leucotreta* adults from the waste before and after waste treatment in the EU NUTS2 regions presenting areas suitable for the establishment of *T. leucotreta* (for methodology, see Section 2.3). NUTS2 regions were considered in the model when having at least one grid cell with at least 1 pupa per year (see Table 14 for the definition of the climate suitability classes and Figure 19).

Table 14: Definition of climate suitability classes in the pathway model

No. pupae/year per NUTS2 area	Climate suitability class	Interpretation	Colour
0	0	Not suitable	
1 ≤ × < 128	1	Low climate suitability	
128 ≤ × < 255	2		
255 ≤ × < 382	3		
382 ≤ × < 509	4	High climate suitability	

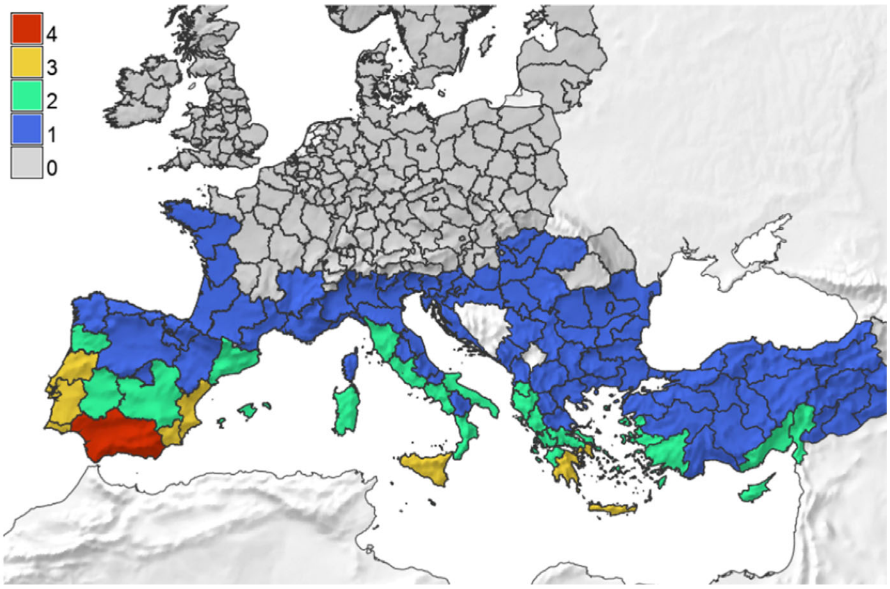


Figure 19: NUTS 2 regions in EU and some neighbouring countries, and their climate suitability classes according to the potential establishment of *T. leucotreta* based on the average number of pupae/year as estimated by the PBDM model. 0 = less than 1 pupae/year, 1 = between 1 and 128 pupae/year, 2 = between 128 and 255 pupae/year, 3 = between 255 and 382 pupae/year and 4 = between 382 and 509 pupae/year. Note: Kosovo and Bosnia and Herzegovina are not covered in the layer of NUTS 2 boundaries by Eurostat (year 2021; https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/nuts)

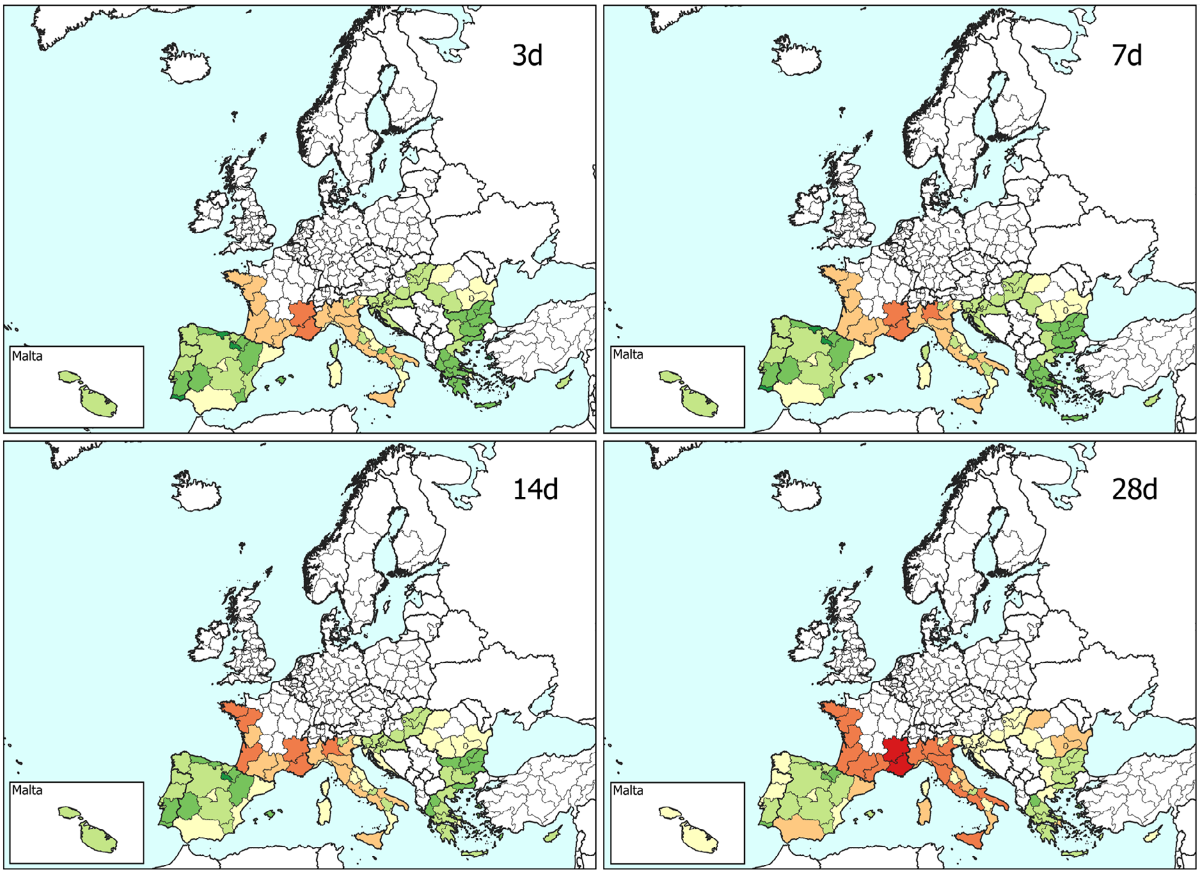
Considering the data included in the assessment, the regular escape of *T. leucotreta* adult insects in the territory of the EU is predicted as:

1) Average number of escaped adults per year per each NUTS2 (presented in Section 3.4.1);
2) Average number of escaped adults per year/(3.14 Km^2 × 10 days) in residential areas of each NUTS2 region (presented in Section 3.4.3 and in Appendix A Section A.1.4).

3.4.1. Results of the entry pathway model at NUTS2 level

Based on the outputs of the entry model, the median number of adults escaping from cut roses in all the climatically suitable areas of the EU is estimated to be 49,867 per year (90% uncertainty between 5,298 and 234,393) for the scenario of timing until waste treatment of 3 days and up to 143,689 per year (90% uncertainty between 21,126 and 401,458) for 28 days timing until waste treatment under the worst-case scenario (see Table A.1 in Appendix A). Results of the median number of escapes per year for the different climatically suitable NUTS2 regions are shown in log-scale in Figure 20 for the four considered scenarios of timing until waste treatment.

It has to be noted, however, that the differences across the scenarios are entirely due to the escapees from the regional waste management processes. In fact, considering that private composting is assumed not having a time gap between the initial disposal at household and the treatment, the escapees from the private compost remain constant across all scenarios. The detailed results (median) and 90% certainty intervals (P5 to P95) for each NUTS2 region in the climatically suitable NUTS2 regions of the EU are presented in Appendix A Section A.1 for the four considered scenarios of timing until waste treatment.



Legend:	**Total escapees** of *T. leucotreta* per year (a) [no adults/year]	**Total mated females** of *T. leucotreta* per year [1] (b = a/435) [no mated females/year]	**Years until first mated female** of *T. leucotreta* [1] (c = 1/b) [years]
(dark green)	1 - 32	0.002 - 0.07	14 - 435
(green)	32 - 100	0.07 - 0.2	4 - 14
(light green)	100 - 316	0.2 - 0.7	1.4 - 4
(light yellow)	316 - 1000	0.7 - 2.3	0.4 - 1.4
(light orange)	1000 - 3162	2.3 - 7.3	0.1 - 0.4
(orange)	3142 - 10000	7.2 - 23.0	0.04 - 0.1
(red)	10000 - 31623	23.0 - 72.7	0.01 - 0.04

[1]= Reasonable cluster scenario for bunches of 10 roses, see section 2.2.3 (Scenario 2). Every 435th escaped adult of *T. leucotreta* will be a female with mating partner in the same bunch of roses.

Figure 20: Maps of the European NUTS2 regions that are climatically suitable for *T. leucotreta* establishment showing the results of the pathway model for *T. leucotreta* in cut roses expressed in total number (log-scale) of *T. leucotreta* adults predicted to escape from the cut roses disposed per year and each NUTS2 region, under four different scenarios of timing from the initial disposal until the waste treatment of 3, 7, 14 and 28 days

In NUTS2 regions with higher climate suitability (i.e. within the climate suitability classes 3 and 4 of Table 14), and for a timing until waste treatment of 3 days, the median number of adults of *T. leucotreta* per year escaping from the cut roses varied from 1,510 for Sicily (Italy) to 506 for Attica (Greece), to 435 in Andalusia (southern Spain) and 257 in the Region of Valencia (eastern Spain) (see Table A.1 in Appendix A).

In some of the NUTS2 regions with lower climate suitability class (i.e. within the climate suitability class 1, see e.g. the blue areas in France in Figure 19), the estimated median number of adults escaping from cut roses was larger than in other more climatically suitable areas (e.g. Spain) (Figure 20), due to the large number of cut roses from Africa consumed in the region. This was the case for the Rhône-Alpes region (France) where the estimated median number of adults escaping from cut roses was 4,796 per year (Figure 20 and Table A.1 in Appendix A).

When the period until waste treatment becomes longer, the number of escapees increases, and this could become relevant in NUTS2 regions with higher climate suitability class. For example, for Andalusia (Spain), the median number of escapees per year increases from 435 (90% uncertainty between 42 and 2,498) to 1,848 (90% uncertainty between 269 and 5,440) when considering a time from initial disposal until waste treatment of 3 and 28 days, respectively. Similarly, in Sicily (Italy), the estimated median number of adults escaping from cut roses per year increased from 1,510 (90% uncertainty between 160 and 7,108) to 6,393 (90% uncertainty between 952 and 16,924) from scenario 3 to 28 days. Again, for Attica region (Greece), the estimated median number of escapees raised from 506 (90% uncertainty between 104 and 2,175) to 1,831 (90% uncertainty between 319 and 5,035) from scenario 3 to 28 days, respectively (Figure 20 and Table A.1 in Appendix A).

It should be noted that the period from the initial disposal at household level until the waste treatment remains a substantial source of uncertainty both within and between NUTS2 regions. For this reason, the Panel decided to follow a scenarios approach, ranging from the best-case scenario of 3 days timespan between disposal and treatment to the worst-case scenario of 28 days. The relative frequency of occurrence of the four scenarios in the real settings is, however, not known. The scenarios are expected to apply to individual communities or waste collection systems in a particular NUTS2, but the Panel does not expect that such scenarios will apply simultaneously in all NUTS2 in the same year.

Figure 20 also shows the predicted median number of mated females per year escaping from cut roses in the climatically suitable areas of the EU, under the **realistic scenario** that, on average, for every 435 escaping *T. leucotreta* adults a mating will occur (see Section 2.2.3). Under such scenario, the total estimated median number of *T. leucotreta* mated females per year from imported cut roses in all the climatically suitable NUTS2 regions of the EU would vary from 115 (90% uncertainty between 12 and 538) up to 330 (90% uncertainty between 49 and 923) for the 3- and 28-day scenarios, respectively (see Appendix A Table A.1.2 and Appendix D).

The number of years until the occurrence of the first mated female of *T. leucotreta* from imported infested cut roses in a climatically suitable NUTS2 region, varies from less than one up to few hundreds, depending on the NUTS2 region and on the scenario of timing from disposal until treatment (Figure 20). As observed above, when commenting the median number of *T. leucotreta* adults escape per NUTS2, many of these mated females will occur in NUTS2 regions only marginally suitable for the insect's establishment. However, under all the four scenarios of 3, 7, 14 and 28 days of timing until treatments, there are NUTS2 regions in the coastal areas of the Mediterranean and of the Iberian Peninsula where a mated female is predicted to result in less than 1 year.

Due to the polyphagous nature of *T. leucotreta*, host availability will not be a limiting factor (see also Section 3.4.5), while the likelihood for establishment may be limited by the climatic conditions (esp. winter cold) and other factors (e.g. natural enemies). It also has to be considered that the likelihood of mating will decrease with decreasing size of the flower bunch, but it will increase when several infested bunches would simultaneously occur during a suitable period (e.g. in the first 10 days of the female adult stage when the majority of eggs are laid [Daiber, 1980; Mkiga et al., 2019; EFSA, 2020]) within a suitable area (i.e. a radius of 1 km, flying radius of *T. leucotreta* males responding to females [EFSA, 2020]) (see also Sections 3.4.3 and 3.4.4).

3.4.2. Seasonality of predicted *T. leucotreta* escapes and matings from infested cut roses

The escape of adults of *T. leucotreta* is more likely, when the time between the initial disposal at the consumer household and the waste treatment is prolonged, especially 14 or 28 days. However, the effect is more pronounced when the temperatures induce faster development, especially in summer. In the 28-day scenario, the longer duration is sufficient to increase the number of escapes also in spring and autumn. To support the interpretation, a reasonable clustering scenario is assumed (see Section 2.3.3), namely the escape of females *T. leucotreta* with possible mating partner in a bunch of 10 roses. This is shown at EU level for all the climatically suitable NUTS2 regions in Table 15 and in Figure 21.

Table 15: Escape of *T. leucotreta* females with possible mating partner (median with 90% uncertainty range [P5–P95]) in a bunch of 10 cut roses (realistic scenario) in the EU climatically suitable areas during an average season over 10 years, for four scenarios on the timing between the initial disposal and waste treatment: 3, 7, 14 or 28 days

Season	Duration between initial disposal and waste treatment											
	3 days			7 days			14 days			28 days		
	Med	P5	P95	Med	P5	P95	Med	P5	P95	Med	P5	P95
Winter	**31**	3	148	**31**	3	148	**31**	3	148	**31**	3	148
Spring	**32**	3	153	**32**	3	153	**34**	4	155	**43**	6	170
Summer	**24**	3	112	**30**	4	121	**61**	9	177	**185**	28	480
Autumn	**27**	3	129	**28**	3	130	**32**	4	136	**56**	8	177

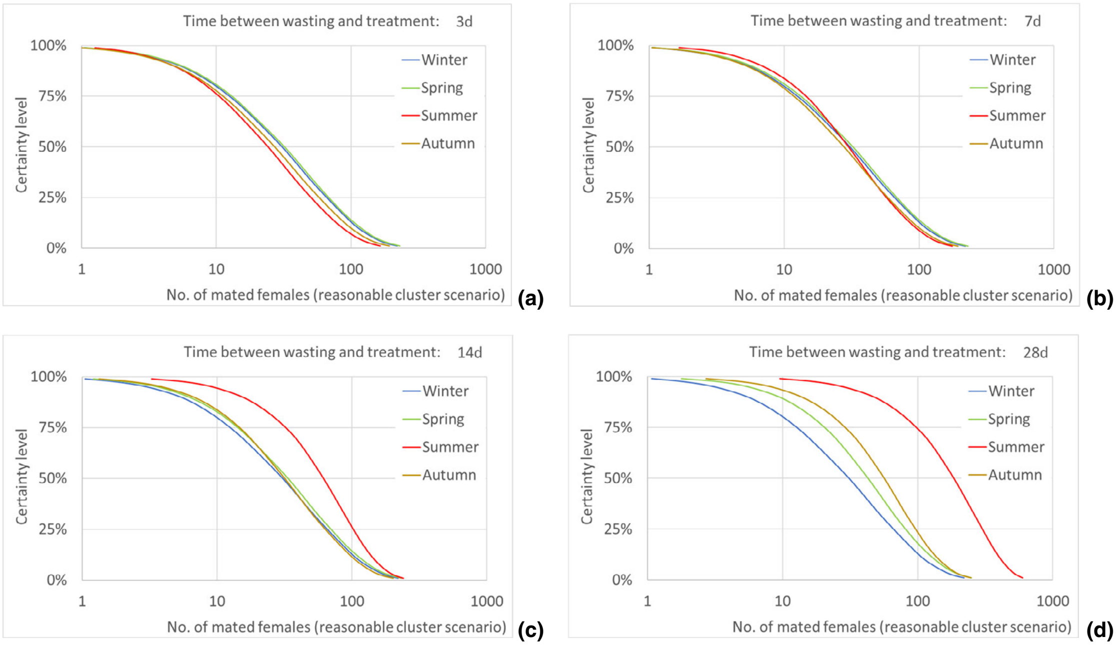


Figure 21: Escape of *T. leucotreta* females with possible mating partner in a bunch of 10 cut roses (realistic clustering scenario) during an average season over 10 years (blue line = winter, green = spring, red = summer and yellow = autumn) in the climatically suitable NUTS2 regions in the EU with certainty curves for different scenarios between initial wasting and waste treatment: (a) 3 days, (b) 7 days, (c) 14 days and (d) 28 days

Considering the results at the EU level, the highest estimated number of adults escapes and of mated females is predicted during the summer (Figure 21, Table 15). This is generally observed also in individual NUTS2 regions (see Appendix A: e.g. Rhone Alpes (FR), Andalusia (ES) and Sicily (IT)).

However, when considering individual NUTS2 regions, in specific regions, higher escape values may occur also in autumn, especially in the 28 days scenario (e.g. in Sicily (Figure 22) or in Andalusia [Appendix A Figure A.3]).

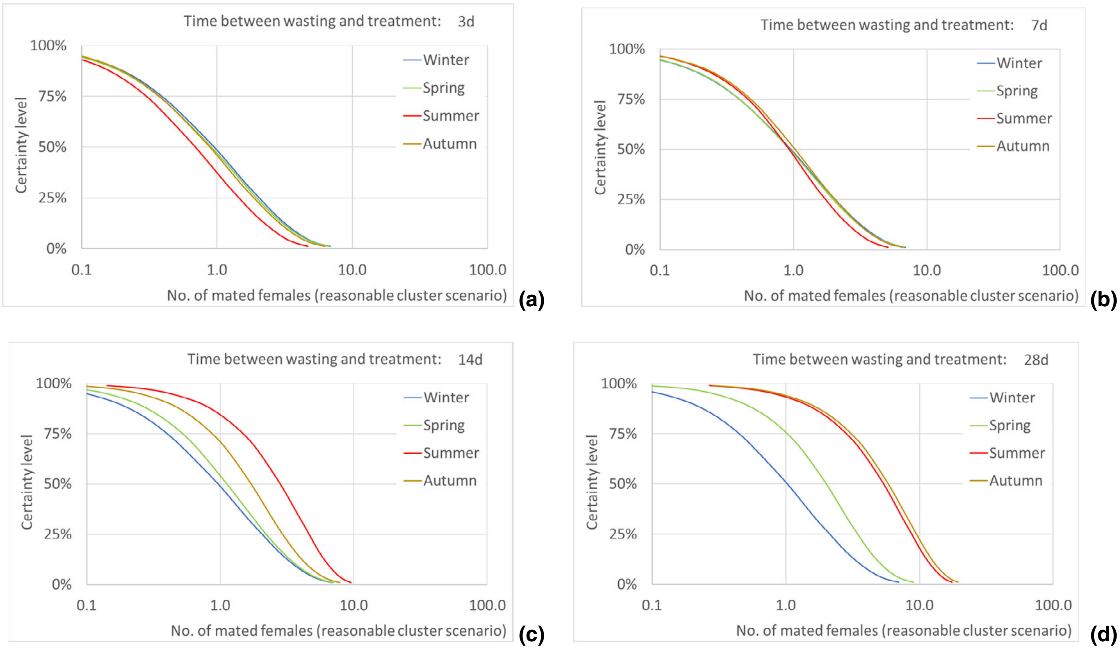


Figure 22: Escape of *T. leucotreta* females with possible mating partner in a bunch of 10 cut roses (realistic clustering scenario) during an average season over 10 years (blue line = winter, green = spring, red = summer and yellow = autumn) in Sicily (Italy) with certainty curves for different scenarios between initial wasting and waste treatment: (a) 3 days, (b) 7 days, (c) 14 days and (d) 28 days

3.4.3. Escape per circle of 1 km radius in the residential areas of the NUTS2 regions within 10 days (scenario 3)

The scenario 3 (see Section 2.2.3 and Appendix A Section A.1.4) assumes the complete absence of clustering of the infestation in the cut roses and the uniform distribution of disposed cut roses in the residential areas of each NUTS2 region. Under this scenario, on average more than one mated female (for the 95th percentile) is expected in summer under the 28 days waste treatment scenario in few NUTS 2 regions such as Corsica (France), Liguria and Sicily (Italy) and Malta. It should, however, be noted that these standardised values represent a uniform spatial and temporal distribution of insect escapes, but that such uniform distributions would be extremely unlikely to occur in reality. Hence, the details are reported in the Appendix A (Section A.1.4).

3.4.4. Spatial and temporal clustering of cut roses consumption

The Panel notes that an increase of the likelihood of *T. leucotreta* adults escaping and mating would also be expected in case of spatial or temporal clustering of cut roses consumption in a particular residential area or during a particular time of the year. Peaks of cut roses consumption are expected during the year, e.g. with peaks in Valentine's Day, Mother's Day and Easter. Spatial and temporal clustering may also occur due to ceremonies or cultural events (e.g. marriages, funerals, celebrations or festivals). However, data on such spatial and temporal clustering of cut roses are not available at NUTS2 level, and no adjustments to the calculations were made.

3.4.5. Host plants availability

With regard to host plants availability, in line with EPPO (2013), it is assumed that a female of *T. leucotreta*, having an extremely wide range of plants suitable for oviposition, will likely find suitable plants for oviposition even during the winter in the areas climatically suitable (see also Section 3.5). This is particularly true for the coastal areas of Southern Europe, where areas of intense horticulture occur close to highly urbanised regions and to natural Mediterranean evergreen vegetation. Citrus host plants are also widely used as ornamentals in urban areas and hence provide host fruits for oviposition.

3.4.6. Uncertainties affecting the assessment of entry

The key uncertainties on the entry assessment for *T. leucotreta* via the cut roses pathway regard:

- data on the prevalence in the environment and the level of infestation of *T. leucotreta* in the cut roses farms in the exporting countries;
- data on the abundance and clustering of *T. leucotreta* in single consignments of cut roses. Clustering could potentially increase the probability of entry by: (1) limiting the detection efficiency at the border; (2) increasing the likelihood of mating (and therefore the probability of transfer) when highly infested bouquets or consignments of cut roses are distributed in the same location and time;
- data on the effectiveness of the border inspections at export in the countries of origin in detecting the different life stages of *T. leucotreta* in cut roses, especially with regard to the details of the national procedures in place;
- data on the effectiveness of the border inspections at import in the EU MS in detecting the different life stages of *T. leucotreta* in cut roses;
- information on the practical implementation and timelines of the waste management processes in the EU Member States at NUTS2 level, particularly about: the private composting; the actual time between the initial waste disposal and the waste treatment in the EU MSs at NUTS2 level;
- lack of knowledge about development to adulthood of *T. leucotreta* in cut roses and in waste. These stages (e.g. during composting) might pose additional mortality (in addition to the overall mortality range already included in the pathway model). The Panel noted, however, that preliminary trials suggested that the complete development of *T. leucotreta* on cut roses in a simulated waste bin environment is possible (NVWA 2022: Development of *Thaumatotibia leucotreta* on cut roses; personal communication, 23 September 2022);
- there is a lack of information about spatial and temporal clustering of cut roses and their eventual disposal. For instance, one might infer that there is an increase of disposal of cut roses in the period after Valentine's Day, mother's day, Easter or other festivities.

Results of the sensitivity analysis of the pathway model using the contribution of each factor to total R^2 are shown in Table 16 below.

Table 16: Sensitivity analysis of the pathway model showing the contribution of each factor to total R^2 = 1

Uncertainty decomposition	Rel. decomposition of R^2			
	Total FCM (3 days)	**Total FCM (7 days)**	**Total FCM (14 days)**	**Total FCM (28 days)**
Infestation rate	50.7%	52.9%	63.4%	88.0%
Proportion private compost	47.8%	45.7%	34.8%	9.5%
Natural survival	1.1%	1.1%	1.4%	1.9%

From the relative decomposition of the R^2 (Table 16 and Appendix D), it emerges that the overall uncertainty in the output is mostly driven by the infestation rate and the relative proportion of waste treated as private compost; it has to be noted that the uncertainty of the proportion of private composting decreases as the time to treatment increases.

3.4.7. Conclusion on the assessment of entry

The Panel modelled the entry of *T. leucotreta* estimating the infestation level in cut roses imported into the EU, the trade flow and distribution into EU NUTS2 regions and the escape of *T. leucotreta* adults from the cut roses disposal before and after the waste treatment in the EU NUTS2 regions with areas climatically suitable for the establishment of *T. leucotreta*. Four scenarios, for the timespan from the initial disposal of the cut roses at the household until the waste treatment, were considered: 3, 7, 14 and 28 days.

According to model results, the median number of *T. leucotreta* adults escaping from imported cut roses in all the climatically suitable NUTS2 regions of the EU was estimated in 49,867 per year (90% uncertainty between 5,298 and 234,393) for the scenario of timing from initial disposal until waste treatment of 3 days and up to 143,689 per year (90% uncertainty between 21,126 and 401,458) for

28 days timing until waste treatment. The major differences across the scenarios are due to the escapes of adults across the regional waste management processes, whereas the escapes from the private compost remain constant across all scenarios.

In EU NUTS2 regions with higher climate suitability, for the scenario of 3 days until waste, the median number of *T. leucotreta* adults per year escaping from the cut roses varied from 1510 for Sicily (Italy) to 506 for Attica (Greece), to 435 in Andalusia (southern Spain) and 257 in the Region of Valencia (eastern Spain). In some EU NUTS2 regions with lower climate suitability, the estimated median number of adults escaping from cut roses was larger (e.g. in the Rhône-Alpes region in France) than in other more climatically suitable areas (e.g. in Spain) (Figure 20), due to the large number of cut roses from Africa consumed in the region.

When the period until waste treatment becomes longer, the number of escapes increases. For example, for Andalusia (Spain), the median number of escapes per year increased to 1,848 (90% uncertainty between 269 and 5,440) when the time from initial disposal until waste treatment was 28 days.

As evidenced by the sensitivity analysis in Table 16 and Appendix D, the uncertainties in the model outputs are mostly driven by the input parameters: (i) infestation rate and (ii) the relative proportion of waste treated as private compost while the contribution of the uncertainty in trade data and natural survival shown only marginal contribution.

Assuming as a realistic scenario that on average one in every 435 escaping *T. leucotreta* results in a mating, the estimated median number of *T. leucotreta* mated females per year from imported cut roses in all the climatically suitable NUTS2 regions of the EU would vary from 115 (90% uncertainty between 12 and 538) up to 330 (90% uncertainty between 49 and 923) for the 3- and 28-day scenarios, respectively. From the results disaggregated into seasons, in the EU a higher number of mated females are predicted in summer compared to the other seasons in the longer scenarios of 14 and 28 days until treatment. In particular, for the 28 days scenario, the number of mated females in summer would be 185 (90% uncertainty between 28 and 480), contributing more than 50% of the total annual mated females.

Factors like the clustering of infestation in the cut roses or the spatial or temporal clustering of cut roses consumption in a particular residential area or during particular times of the year would increase the number of mated females.

With regard to host plants availability, the Panel agreed with EPPO (2013) on the wide availability of suitable hosts in the coastal areas of Southern Europe. A female of *T. leucotreta*, being extremely polyphagous, would likely find suitable hosts for oviposition even during the winter in the climatically suitable areas.

3.5. Assessment of climatic factors and host distribution affecting establishment

Climatic mapping is the principal method for identifying areas that could provide suitable conditions for the establishment of a pest taking key abiotic factors into account (Baker, 2002). Climatic factors and availability of hosts are considered in the following sections.

3.5.1. Köppen–Geiger climate classification approach

Figure 23 shows the results of the Köppen–Geiger climate classification approach. It shows the climate types that are present in the EU and have also been associated with occurrences of FCM. Most of the observations occur under the semi-arid (BSk, BSk) and temperate dry (Csa, Csb) climates, while fewer observations, mainly clustered around the east side of Lake Victoria and on the coast of South Africa, fall under temperate wet climates (Cfa, Cfb, Cfc).

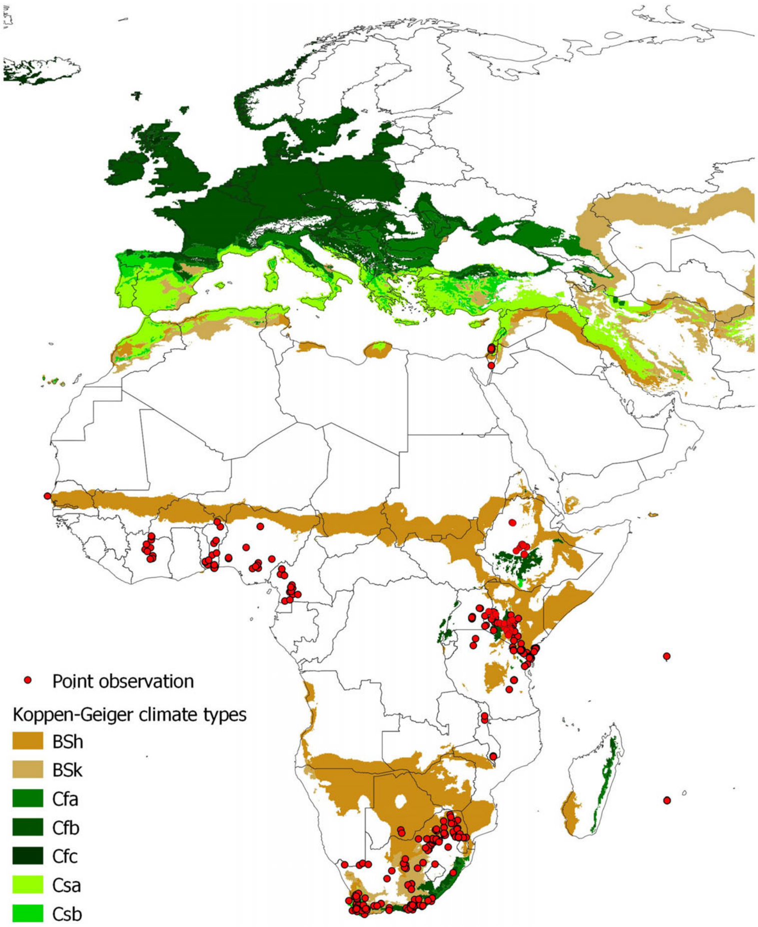


Figure 23: Climate suitability map of *T. leucotreta* for Europe and Africa, based on the Köppen–Geiger climate classification. Red dots indicate point observations of the pest (coordinates). Climates that are not present in the EU are not mapped. The legend shows the list of Köppen–Geiger climates occurring in the locations of observation

Figure 24 focuses on the location of observations in Southern Africa and Eastern Africa.

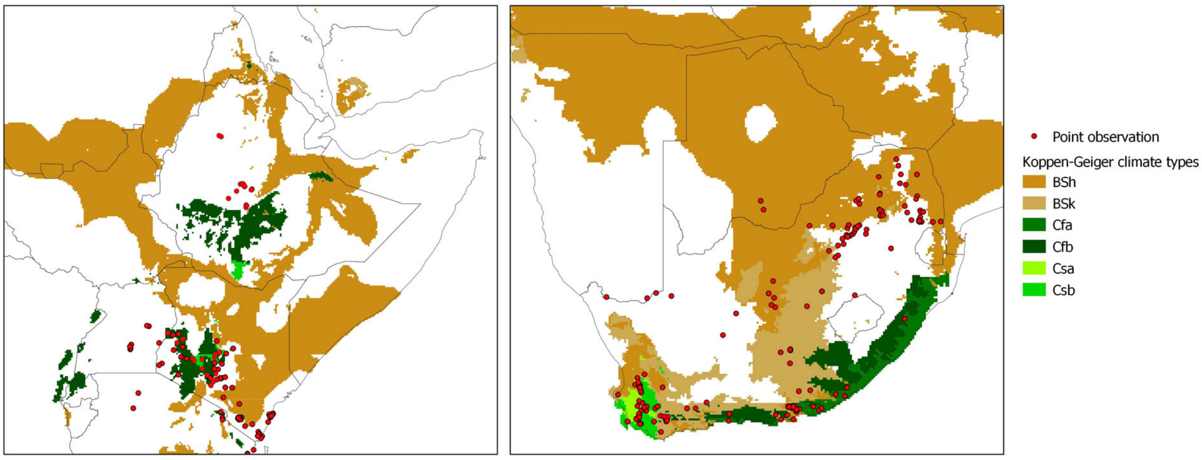


Figure 24: Climate suitability map of *T. leucotreta* for Eastern Africa, and South Africa, based on the Köppen–Geiger climate classification. Red dots indicate point observations of the pest (with coordinates). Climates not present in EU are not mapped. The legend shows the list of Köppen–Geiger climates occurring in the locations of observation

3.5.2. Physiologically based demographic model

The PBDM of *T. leucotreta* was applied to predict the average number of pupae for all 25 × 25 km cells in EU MS (see Figures 25 and 26) based on climate data of 2000–2010 (1990–2000 climate was additionally applied to balance the model dynamics). The outcome is presented as a colour map with colours referring to the average annually number of pupae in the cell. PBDM model predictions were mapped using the Turbo colour map (Mikhailov, 2020) to maximise graphical inference (see Reda and Szafir, 2021).

Predictions for EU MS are first displayed in maps encompassing Africa, south-west Asia and Europe to show the potential geographic distribution and relative abundance of *T. leucotreta* in the context of its wider native (sub-Saharan) and current invasive (South African and Israeli) distribution. Then, the focus moves to maps including Europe and the Mediterranean Basin for a more detailed assessment of *T. leucotreta* establishment risk in EU MS and neighbouring countries.

Using 4°C and 6°C temperature offset scenarios of increased larval tolerance to high temperatures (see Sections 2.4.5 and 3.1), *T. leucotreta* predicted population densities remain nearly unchanged for Kenya and Ethiopia, whereas increasing *T. leucotreta* densities are predicted in southwest Africa due to the increased larval tolerance to heat (Figure 25). The *T. leucotreta* model with larval heat tolerance displacement captures the distribution of *T. leucotreta* in eastern parts of Africa (note that Kenya remains above the midpoint of the density range) but marginally the infestations in South Africa (invaded areas) and hotter regions such as Nigeria, Benin, Togo and Ghana (0.25–0.50 of the pupal density range).

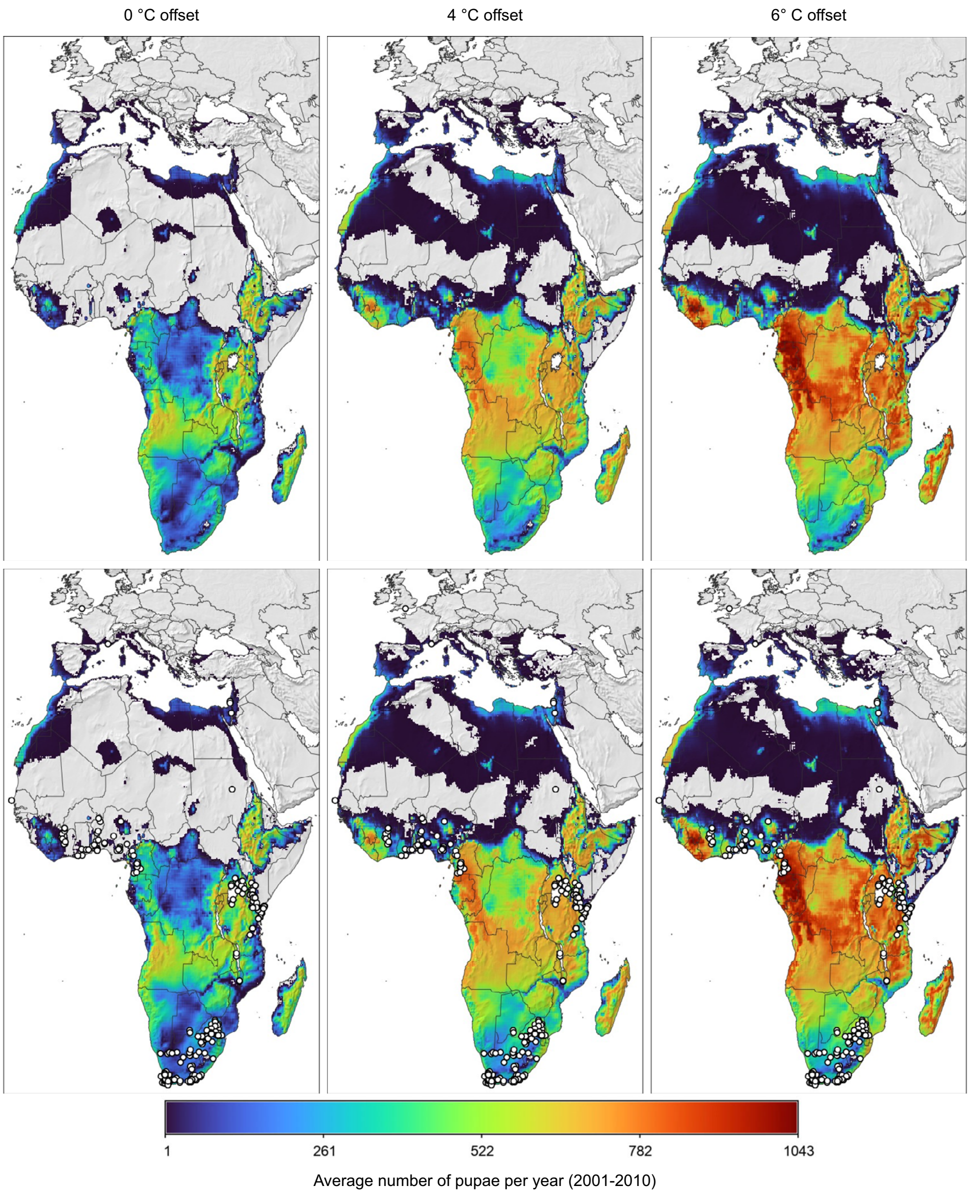


Figure 25: Maps showing average *T. leucotreta* pupal density in Europe, the Middle East and Africa for the period 2000–2010 (average number of pupae per year, as projected by the PBDM). Columns of maps show the effect of larval heat tolerance assuming displaced heat-stress mortality: left column without [data range (1, 696]), middle column with 4°C (Terblanche et al., 2017) [data range (1, 828)] and right column with 6°C (Uys, 2014) [data range (1, 1043)] displacement of larvae mortality relative to adults (heat tolerance of larvae increases left to right). The top versus bottom rows of maps differ only in that the bottom maps have *T. leucotreta* occurrence records superimposed (white circles with black outline). Note the model predicts infested areas from Gabon south to Angola with no records of *T. leucotreta*. The colour legend uses the turbo colour palette (Mikhailov, 2020) to maximise graphical inference (Reda and Szafir, 2021) and extends to the absolute minimum and maximum values across the three maps (i.e. 1–1043) to facilitate comparison between maps.

Restricting the attention to Europe, maps with 0, 4 and 6°C displacements for Europe and the Mediterranean Basin indicate little change in the underlying geographic distribution of *T. leucotreta*, but increased population densities in hotter areas such as Morocco, Egypt and Israel/Palestine. No areas show predicted *T. leucotreta* population densities as high as those of the occurrence data points in Kenya and Ethiopia, with maximum densities being ~ 40–50% lower. However, there are spots in

Europe which have shown predicted levels comparable with those in the Western Cape of South Africa (Figure 26) where the moth is considered naturalised (established although not indigenous) (Giliomee and Riedl, 1998; Hofmeyr et al., 2015).

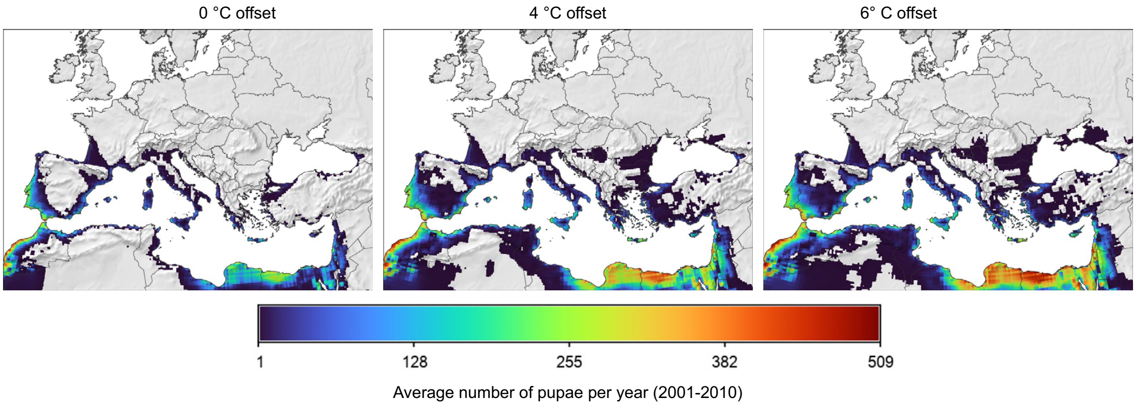


Figure 26: The predicted level of *T. leucotreta* establishment following entry into EU MS and the Mediterranean Basin (average number of pupae per year in the period 2001–2010, as projected by the PBDM model). The three columns of maps show the effect of different levels of heat tolerance. Left without [data range (1, 362)], middle with 4°C [data range (1, 467)] and right with 6°C [data range (1, 509)] displacement of larvae mortality relative to adults (cf. Figure 16). The colour legend uses the turbo colour rule (Mikhailov, 2020) to maximise graphical inference (Reda and Szafir, 2021) and extends to the absolute minimum and maximum values for Europe and the Mediterranean Basin across the three maps (i.e. 1–509)

Due to the cold limitations in large parts of the EU MS, the building of greater numbers of pupae over the 10 years of model analysis is prevented. The areas that have average pupae density like Israel (established invasion; Wysoki, 1986) are limited to the southern parts of the Mediterranean and Atlantic coastline of the EU (in particular in Portugal, Spain, Italy, Greece (i.e. Crete) and Cyprus).

For comparison, the abundance projection of the PBD is shown together for Africa and Europe (i.e. combining Figure 11 with predictions for Europe in Figure 25) but using the same colour code across the whole map. Indeed, in the southern part of the Iberian Peninsula, the model projects equal pupal abundance as shown in parts of South Africa where the moth has presence reports while being naturalised there. However, population densities predicted in native cooler subtropical areas of Africa (e.g. Kenya) are not predicted anywhere in the EU.

3.5.3. Uncertainties affecting the assessment of climatic suitability and presence of hosts in the risk assessment area

The most important uncertainty when assessing habitat suitability for establishment was that most data are about temperature dependence and all experimental data were produced for a different purpose than parameterising a quantitative pest risk assessment.

The literature on *T. leucotreta* is primarily from South Africa, where the pest is considered non-native. The data on its thermal biology were developed to inform quarantine procedures for the export of agricultural products and are based on stock colonies maintained at optimal non-fluctuating temperatures in the laboratory. This research focused on short period exposures of *T. leucotreta* life stages to cold and high temperatures for varying short periods of time (hours) to assess survival. While the data are useful for quarantine purposes, such data do not enable accurate evaluation of the potential of *T. leucotreta* natural populations to survive and establish in novel areas worldwide (e.g. Europe).

T. leucotreta developmental, mortality and reproductive rates are affected by temperature, moisture and host quality that vary in time and geographic space. Available data on the thermal biology for *T. leucotreta* development and survival were generally adequate in the favourable range (10–30°C) but were inadequate at low (< 10°C) and high (> 30°C) temperatures. This led to the development of a composite function for mortality that incorporated data from different life stages.

The niche model of *T. leucotreta* for Australia (Li et al., 2022) suggests a potentially inverse dependence of habitat suitability on precipitation in the driest quarter. There are no experimental data on this parameter (or what it means), and hence, it could not be included in the PBDM projections. Interestingly, Kenyan hearing experts did report '*T. leucotreta* is more prevalent at the onset of the rainy season'. Although the aspect of the *T. leucotreta* niche might be less relevant under precipitation regimes in EU territories, it likely could improve the validity of the PBDM model. It is therefore assumed important to consider precipitation with upcoming exposure experiments on the pest.

To refine the predictions of invasive risk of *T. leucotreta* following data should be assembled:

- experimental data on the effects of temperature on developmental and survival rates of all life stages, and the effects of temperature on oviposition profiles and life tables especially on cut roses;
- the effects of relative humidity (or vapour pressure deficit) on the survival of the life stages exposed to ambient conditions are required to refine temperature-dependent stage-specific survival rates, and reproduction by adult females;
- the genetic background of populations in areas of Africa with higher temperatures such as West Africa where *T. leucotreta* is also reported to occur.

There is generally a convincing agreement between model predictions and observation data. This argues for the validity of PBDM predictions that do not rely on occurrence data. Interestingly, another related approach produced a map comparable to that shown in Figure 26 (Barker and Coop, pers. Comm) using degree day patterns to predict cold stress-related exclusion areas and else predicting the multiplicity of generations given entry. The data of a third model projecting *T. leucotreta* habitat quality to the EU territory using MAXENT niche modelling plus degree day approach (see Figure 27, by courtesy of Li and McKirdy, personal communication, 13 January 2023) is in general agreement with Panel predictions. The predicted average pupal density above one (Figure 26) overlaps with the part of the inclusion area where Barker (personal communication, data not shown) predicts at least three generations per annum, while Li and McKirdy (Li and McKirdy, 2023, personal communication, 13 January 2023) project similar habitats along the Atlantic coast of the Iberian Peninsula and the Mediterranean coast of the EU (Figure 27).

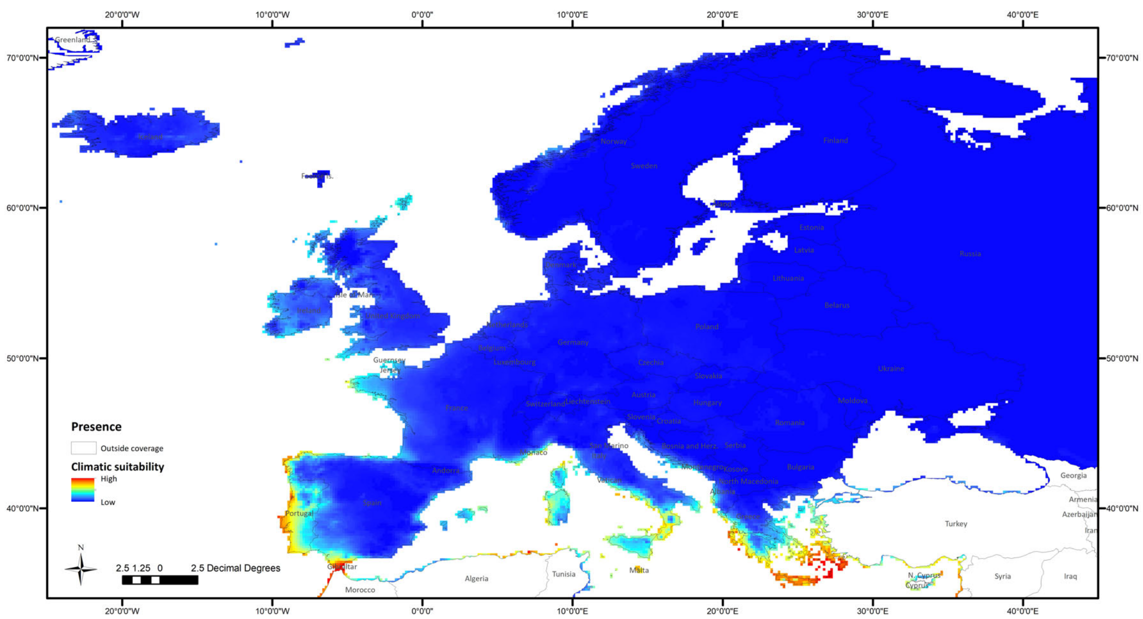


Figure 27: Climatic suitability map (with continued data) for the potential establishment of *T. leucotreta* in Europe, according to the species distribution model developed for Australia by Li et al. (2022). Personal communication by courtesy of Xingyu Li and Simon McKirdy, received by email on 13 January 2023

All three models are based on climate data with Li et al. (2022) additionally exploiting occurrence data. Hence, the PBD Model used here is confirmed by two independent model outcomes when extrapolating temperature-dependent *T. leucotreta* biology to local suitability for establishment and/or population growth.

The apparent difference between the PBDM and the two other approaches is regions north of the Pyrenees, Ireland and the UK. These areas were not excluded by the degree-day approach due to the absence of mortality during cold periods and yet predicted sufficient degree days for the development of up to two generations of *T. leucotreta* during favourable periods but tell little about the dynamics or the magnitude of the population. But the temporal cohesion of the degree-days is not considered and strongly influences the continuous development time in the PBD Model during cold periods. If the development days are not in a consecutive chain, fewer life cycles can be completed, resulting in lower average numbers of pupae. If the output of the PBD model was plotted for values below one, the apparent difference between models factually disappeared (data not shown).

It has to be noted that also the preliminary climate suitability assessment by EPPO (2013) projects similar climate suitability.

The uncertainty always remains as to whether other, yet unidentified climatic or ecological features might impact the temperature-dependent physiology and expand/contract the region of possible establishment. Hence, it is possible that the inclusion of other physiologically based determinants in the PBDM, such as those related to precipitation and humidity, for which no information is available, could further affect the estimated risk of establishment of the pest and the size of the risk area of establishment.

3.5.4. Conclusions on establishment

In summary, *T. leucotreta* larvae on African roses imported into the EU will be primarily affected by cold stress exacerbated by a lack of dormancy/diapause in the pest.

All model-based projections identify coastal areas with moderate temperatures (Mediterranean coasts, Iberian Atlantic coast, Pacific coast in USA and Australian coasts). These areas are characterised by limited cold periods of cool temperatures and by warm but not excessively hot summers.

The Mediterranean coastline and the western coast of the Iberian Peninsula are the main areas for potential establishment of *T. leucotreta* in the EU. Moreover, additional areas have the potential to host transient populations but not establishment due to limited population growth and discontinued winter survival outdoors preventing multiple generations.

As stated by EPPO (2013), *T. leucotreta* could overwinter in greenhouse in areas in cooler areas with intense horticultural production.

3.6. Overall uncertainty

The major sources of uncertainty identified in this assessment and for which data collection is recommended are:

- data on *T. leucotreta* infestation rate of cut roses in the country of origin and in consignments at export;
- data on the actual timing between the waste disposal at household and the waste treatments in the EU MSs at NUTS2 level;
- data on biology and ecology of *T. leucotreta* in natural environment and in cut roses in East Africa. In particular, there is a need to collect data used to estimate relevant parameters of the thermal biology of *T. leucotreta* originate from experiments carried out at constant temperatures using laboratory-reared specimens.

4. Conclusions

Following a request from the European Commission, the EFSA Panel on Plant Health performed a partial quantitative pest risk assessment of *T. leucotreta* for the EU, via the cut roses import pathway.

The area potentially suitable for establishment of the pest was assessed using the climate matching according to Köppen–Geiger categories and the physiologically based demographic model. The predictions of the PBDM were validated with the occurrence data from the areas of origin of the pest and recent invasion areas.

T. leucotreta larvae entering into the EU will suffer by cold stress exacerbated by a lack of dormancy/diapause in the pest, thus limiting the NUTS2 regions climatically suitable for establishment.

The area of potential establishment includes the coastline extending from the northwest of the Iberian Peninsula through the Mediterranean. However, the estimated population densities in the EU are not reaching the high population densities projected for *T. leucotreta*-native East Africa.

Additional areas in the EU, indicated as suitable but with low population numbers, are most likely associated with transient populations. Besides outdoor establishment in regions climatically suitable, as stated by EPPO (2013), *T. leucotreta* could overwinter in greenhouses in other areas with horticultural production.

Other published models are in broad agreement regarding the major areas at risk of establishment in the EU, which is related to the common use of data of temperature requirements for this pest.

The main uncertainties about possible establishment in the EU territory are caused by the lack of demographic studies at different temperatures and population studies in the cultivated and natural environment in the areas of pest distribution.

Considering entry, the pest has been frequently intercepted in cut roses and there are observational records of flying adults of the pest in a few locations in the EU.

The Panel modelled the entry of *T. leucotreta* estimating the infestation level in cut roses imported into the EU, the trade flow and distribution into EU NUTS2 regions, and the escape of *T. leucotreta* adults from the cut roses disposal before and after the waste treatment in the EU NUTS2 regions presenting areas climatically suitable for the establishment of *T. leucotreta*. Four scenarios, for the timespan from the initial disposal of the cut roses at the household until the waste treatment, were considered: 3, 7, 14 and 28 days.

According to model results, the median number of *T. leucotreta* adults escaping from imported cut roses in all the climatically suitable NUTS2 regions of the EU was estimated in 49,867 per year (90% uncertainty between 5,298 and 234,393) for the scenario of timing from initial disposal until waste treatment of 3 days and up to 143,689 per year (90% uncertainty between 21,126 and 401,458) for 28 days timing until waste treatment. The differences across the scenarios are due to the escapes across the regional waste management processes, whereas the escapes from the private compost remain constant across all scenarios. Assuming as a realistic scenario that, on average, for every 435 escaping *T. leucotreta* a mating would happen, the estimated median number of *T. leucotreta* mated females per year from imported cut roses in all the climatically suitable NUTS2 regions of the EU would vary from 115 (90% uncertainty between 12 and 538) up to 330 (90% uncertainty between 49 and 923) for the 3- and 28-day scenarios, respectively. From the results disaggregated into seasons, summer showed a higher number of expected mated females respect to the other seasons for the EU in the longer scenarios of 14 and 28 days until treatment. In particular, for the 28 days scenario, the mated females in summer would be 185 (90% uncertainty between 28 and 480), contributing to more than 50% of the total annual mated females. Factors like the clustering of the infestation in the cut roses or the spatial or temporal clustering of cut roses consumption in a particular residential area or in a particular time of the year would increase the probability of mating and transfer to suitable host.

With regard to host plants availability, the Panel agreed with EPPO (2013) on the wide availability of suitable hosts in the coastal areas of Southern Europe. A female of *T. leucotreta*, having an extremely wide range of suitable plants for oviposition, will likely find suitable plants for oviposition even during the winter in the areas climatically suitable. Due to the extreme polyphagia of *T. leucotreta* immature stages, host availability should not be a limiting factor for establishment in climatically suitable areas.

Overall, regular escape of pest insects on the territory of the EU is predicted through the cut roses but so far it has not led to outbreaks (other than few incursions) in the EU, possibly because of the relatively recent shift of pest pressure in Africa towards cut roses and of the fact that much of the cut roses consumption in the EU occurs in regions with less climate suitability. However, observations of flying adults have been reported in the EU.

The outputs of this quantitative pest risk assessment indicate that cut roses provide a pathway for the introduction of *T. leucotreta* to the EU.

Regarding the seasonality, the number of escaped adults of *T. leucotreta* with a possible mating partner from the imported cut roses in the realistic clustering scenario is predicted to be higher during summer, particularly when the 14- and 28-day scenarios until waste treatment are considered, due to the predicted faster development of *T. leucotreta* in the warmer season.

Sensitivity analysis of the pathway model showed that the main uncertainties remain regarding the infestation rate in the imported cut roses and main parameters of the waste model, especially the proportion of waste privately composted and the timing between initial disposal of the cut roses in the household and the waste treatment in the public facilities.

To reduce the uncertainties, data collection and research are recommended on the following key topics: the ecology and biology of *T. leucotreta* in its natural environment and in cut roses in Eastern Africa; the level of infestation and clustering of *T. leucotreta* in the cut roses consignments; the level of effectiveness of the export and import border inspections in detecting the different life stages of *T. leucotreta* in cut roses; the actual waste management processes at NUTS2 level in the EU, including the proportion of private composting and the timing between the initial waste disposal and the waste treatment.

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Abbreviations

CN	Combined Nomenclature (8-digit code building on HS codes to provide greater resolution)
CR	Certainty Range
DD	Degree Days
EI	Ecoclimatic index (an index of climatic suitability used by CLIMEX)
EKE	Expert Knowledge Elicitation
ENM	Ecological niche model

EPPO	European and Mediterranean Plant Protection Organisation
FAVV-AFSCA	Federaal Agentschap voor de Veiligheid van de Voedselketen- Agence Fédérale pour la Sécurité de la Chaîne Alimentaire (Federal Agency for the Safety of the Food Chain)
FCM	False Codling Moth
HS	Harmonised System (6-digit World Customs Organisation system to categorise goods)
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
KEPHIS	Kenya Plant Health Inspectorate Service
MS	Member State (of the EU)
NPPO	National Plant Protection Organisation
NUTS	Nomenclature Units for Territorial Statistics
NVWA	Nederlandse Voedsel- en Warenautoriteit (Netherlands Food and Consumer Product Safety Authority)
PBDM	Physiologically Based Demographic Model
PRA	Pest Risk Analysis
ToR	Terms of Reference

Appendix A – Pathway model on the entry of *Thaumatotibia leucotreta* via cut roses from Africa

A.1. Result table

The following table compares the annual escape of *Thaumatotibia leucotreta* by different waste collection scenarios: The timing from disposal by the consumer to waste treatment varies from 3, 7, 14 to 28 days.

Table A.1: Number of *Thaumatotibia leucotreta* adults escaping within a year from cut roses imported from Africa (including Israel) calculated by a pathway model for NUTS2 regions in the climatically suitable area of Europe. Results are stratified by four scenarios of timing from disposal at the consumer until the waste treatment, and given as median and 90% certainty interval (from P5 to P95)

Country	NUTS code	Label	Climate suitability class	Annual escape (3 days) (Adults/NUTS2)			Annual escape (7 days) (Adults/NUTS2)			Annual escape (14 days) (Adults/NUTS2)			Annual escape (28 days) (Adults/NUTS2)		
				P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95
Total		**Countries in the climatically suitable area**		5,298	**49,867**	234,393	6,059	**52,805**	238,832	9,431	**69,501**	264,975	21,126	**143,689**	401,458
Spain & Portugal	**ESPT**	**Spain and Portugal**		261	**2,794**	16,149	313	**2,994**	16,444	569	**4,408**	18,442	1,284	**8,883**	27,212
	ES11	Galicia	1	12	**137**	794	14	**142**	801	21	**173**	844	47	**333**	1,107
	ES12	Principado de Asturias	1	5	**52**	299	5	**54**	302	8	**65**	318	18	**126**	418
	ES13	Cantabria	1	3	**29**	171	3	**31**	173	4	**37**	182	10	**72**	239
	ES21	País Vasco	1	10	**111**	643	11	**115**	649	17	**140**	683	38	**270**	897
	ES22	Comunidad Foral de Navarra	1	3	**33**	193	3	**35**	195	5	**42**	205	11	**81**	269
	ES23	La Rioja	1	1	**16**	93	2	**17**	94	2	**20**	99	5	**39**	129
	ES24	Aragón	1	6	**67**	391	7	**70**	394	10	**85**	415	23	**164**	545
	ES30	Comunidad de Madrid	1	31	**342**	1,982	35	**355**	2,000	52	**432**	2,106	117	**832**	2,765
	ES41	Castilla y León	1	11	**122**	705	12	**126**	712	18	**154**	750	42	**296**	984
	ES42	Castilla-la Mancha	2	10	**104**	602	11	**110**	610	19	**154**	669	43	**300**	937
	ES43	Extremadura	2	5	**54**	312	6	**57**	317	10	**80**	347	22	**156**	487

Country	NUTS code	Label	Climate suitability class	Annual escape (3 days) (Adults/NUTS2)			Annual escape (7 days) (Adults/NUTS2)			Annual escape (14 days) (Adults/NUTS2)			Annual escape (28 days) (Adults/NUTS2)		
				P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95
	ES51	Cataluña	2	36	**389**	2,250	43	**412**	2,283	72	**575**	2,502	162	**1,121**	3,506
	ES52	Comunitat Valenciana	3	24	**257**	1,481	31	**283**	1,517	65	**481**	1,819	143	**989**	2,877
	ES53	Illes Balears	2	6	**62**	356	7	**65**	361	11	**91**	396	26	**177**	555
	ES61	Andalucía	4	42	**435**	2,498	54	**485**	2,574	116	**845**	3,131	269	**1,848**	5,440
	ES62	Región de Murcia	3	7	**77**	443	9	**85**	454	19	**144**	544	43	**296**	861
	ES63	Ciudad de Ceuta	3	0	**4**	25	1	**5**	25	1	**8**	30	2	**17**	48
	ES64	Ciudad de Melilla	2	0	**4**	25	0	**5**	25	1	**6**	28	2	**12**	39
	PT11	Norte	2	17	**182**	1,051	20	**193**	1,067	34	**269**	1,169	76	**524**	1,638
	PT15	Algarve	3	2	**22**	129	3	**25**	132	6	**42**	158	12	**86**	251
	PT16	Centro (PT)	3	11	**113**	653	14	**125**	669	29	**212**	802	63	**436**	1,268
	PT17	Área Metropolitana de Lisboa	3	14	**146**	843	18	**161**	863	37	**273**	1,035	81	**563**	1,637
	PT18	Alentejo	3	3	**36**	207	4	**40**	212	9	**67**	255	20	**139**	403
France	**FR**	**France**		2,302	**21,884**	104,347	2,581	**23,070**	105,876	3,865	**29,054**	114,867	8,831	**60,342**	171,723
	FRG0	Pays-de-la-Loire	1	288	**2,736**	13,048	323	**2,885**	13,239	483	**3,633**	14,363	1,104	**7,545**	21,473
	FRH0	Bretagne	1	253	**2,407**	11,476	284	**2,537**	11,645	425	**3,195**	12,633	971	**6,637**	18,887
	FRI1	Aquitaine	1	262	**2,493**	11,887	294	**2,628**	12,061	440	**3,310**	13,085	1,006	**6,874**	19,562
	FRI3	Poitou-Charentes	1	137	**1,300**	6,197	153	**1,370**	6,288	230	**1,726**	6,822	525	**3,584**	10,199
	FRJ1	Languedoc-Roussillon	1	216	**2,053**	9,789	242	**2,164**	9,933	363	**2,726**	10,776	829	**5,661**	16,110
	FRJ2	Midi-Pyrénées	1	233	**2,212**	10,549	261	**2,332**	10,703	391	**2,937**	11,612	893	**6,100**	17,360
	FRK2	Rhône-Alpes	1	505	**4,796**	22,868	566	**5,056**	23,203	847	**6,367**	25,174	1,935	**13,224**	37,634
	FRL0	Provence-Alpes-Côte d'Azur	1	383	**3,639**	17,351	429	**3,836**	17,605	643	**4,831**	19,100	1,468	**10,033**	28,554
	FRM0	Corse	1	26	**248**	1,182	29	**261**	1,199	44	**329**	1,301	100	**683**	1,945

Country	NUTS code	Label	Climate suitability class	Annual escape (3 days)			Annual escape (7 days)			Annual escape (14 days)			Annual escape (28 days)		
				(Adults/NUTS2)			(Adults/NUTS2)			(Adults/NUTS2)			(Adults/NUTS2)		
				P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95
Italy & Malta	**ITMT**	**Italy and Malta**		1,854	**18,232**	86,462	2,164	**19,409**	88,284	3,603	**26,401**	98,639	7,823	**54,231**	150,632
	ITC1	Piemonte	1	132	**1,316**	6,258	150	**1,380**	6,360	223	**1,706**	6,838	494	**3,463**	9,918
	ITC3	Liguria	1	47	**465**	2,213	53	**488**	2,249	79	**603**	2,418	175	**1,225**	3,508
	ITC4	Lombardia	1	308	**3,060**	14,556	349	**3,209**	14,793	519	**3,968**	15,904	1,150	**8,055**	23,070
	ITF1	Abruzzo	1	40	**395**	1,878	45	**414**	1,909	67	**512**	2,052	148	**1,039**	2,977
	ITF2	Molise	1	9	**92**	436	10	**96**	443	16	**119**	477	34	**241**	691
	ITF3	Campania	2	180	**1,754**	8,308	213	**1,883**	8,502	369	**2,697**	9,716	806	**5,539**	15,180
	ITF4	Puglia	2	125	**1,214**	5,750	148	**1,303**	5,884	256	**1,866**	6,724	558	**3,833**	10,506
	ITF5	Basilicata	1	17	**169**	803	19	**177**	816	29	**219**	877	63	**444**	1,273
	ITF6	Calabria	2	60	**582**	2,755	71	**624**	2,819	122	**894**	3,222	267	**1,837**	5,034
	ITG1	Sicilia	3	160	**1,510**	7,108	203	**1,686**	7,352	429	**2,981**	9,431	952	**6,393**	16,924
	ITG2	Sardegna	2	51	**495**	2,344	60	**531**	2,399	104	**761**	2,741	227	**1,563**	4,283
	ITH2	Provincia Autonoma di Trento	1	17	**166**	792	19	**175**	805	28	**216**	865	63	**438**	1,255
	ITH3	Veneto	1	150	**1,489**	7,082	170	**1,561**	7,198	253	**1,931**	7,738	559	**3,919**	11,225
	ITH4	Friuli-Venezia Giulia	1	37	**368**	1,751	42	**386**	1,779	62	**477**	1,913	138	**969**	2,775
	ITH5	Emilia-Romagna	1	137	**1,362**	6,480	155	**1,428**	6,585	231	**1,766**	7,080	512	**3,586**	10,270
	ITI1	Toscana	2	117	**1,134**	5,371	138	**1,217**	5,496	239	**1,743**	6,281	521	**3,581**	9,813
	ITI2	Umbria	1	27	**266**	1,263	30	**278**	1,284	45	**344**	1,380	100	**699**	2,002
	ITI3	Marche	1	46	**462**	2,196	53	**484**	2,231	78	**599**	2,399	173	**1,215**	3,480
	ITI4	Lazio	2	182	**1,768**	8,371	215	**1,897**	8,567	372	**2,717**	9,790	812	**5,581**	15,296
	MT00	Malta	2	17	**159**	750	20	**170**	767	34	**244**	876	73	**500**	1,368
Slovenia	**SI**	**Slovenia**		43	**437**	2,081	50	**460**	2,116	75	**584**	2,305	175	**1,214**	3,456
	SI03	Vzhodna Slovenija	1	23	**230**	1,092	26	**242**	1,110	39	**307**	1,210	92	**637**	1,814
	SI04		1	21	**208**	989	24	**219**	1,005	36	**278**	1,095	83	**577**	1,642

Country	NUTS code	Label	Climate suitability class	Annual escape (3 days) (Adults/NUTS2)			Annual escape (7 days) (Adults/NUTS2)			Annual escape (14 days) (Adults/NUTS2)			Annual escape (28 days) (Adults/NUTS2)		
				P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95
		Zahodna Slovenija													
Croatia	**HR**	**Croatia**		80	**857**	4,351	91	**907**	4,424	141	**1,171**	4,871	315	**2,414**	7,855
	HR02	Pannonian Croatia	1	21	**226**	1,148	24	**239**	1,167	37	**309**	1,285	83	**637**	2,072
	HR03	Adriatic Croatia	1	27	**287**	1,459	31	**304**	1,484	47	**393**	1,634	106	**810**	2,634
	HR05	City of Zagreb	1	16	**170**	862	18	**180**	876	28	**232**	965	62	**478**	1,555
	HR06	Northern Croatia	1	16	**174**	883	19	**184**	898	29	**238**	989	64	**490**	1,594
Greece & Cyprus		**Greece and Cyprus**		280	**1,517**	6,686	307	**1,625**	6,873	439	**2,382**	8,165	794	**4,673**	13,210
	EL30	Attiki	3	104	**506**	2,175	116	**555**	2,257	176	**916**	2,891	319	**1,831**	5,035
	EL41	Voreio Aigaio	2	5	**30**	132	6	**32**	135	8	**44**	155	14	**84**	242
	EL42	Notio Aigaio	2	8	**45**	200	9	**48**	204	12	**66**	235	21	**128**	367
	EL43	Kriti	3	18	**86**	370	20	**94**	384	30	**156**	492	54	**312**	857
	EL51	Anatoliki Makedonia, Thraki	1	12	**75**	342	13	**78**	347	16	**96**	377	29	**184**	558
	EL52	Kentriki Makedonia	1	36	**234**	1,070	39	**245**	1,084	50	**300**	1,178	92	**575**	1,744
	EL53	Dytiki Makedonia	1	5	**33**	151	6	**35**	153	7	**42**	166	13	**81**	247
	EL54	Ipeiros	2	8	**43**	192	8	**46**	196	11	**63**	226	21	**122**	352
	EL61	Thessalia	1	14	**89**	409	15	**93**	414	19	**115**	450	35	**220**	666
	EL62	Ionia Nisia	2	5	**26**	117	5	**28**	119	7	**39**	138	13	**75**	214
	EL63	Dytiki Ellada	2	15	**84**	374	16	**89**	383	22	**124**	441	40	**239**	687
	EL64	Sterea Ellada	2	13	**72**	320	14	**76**	327	19	**106**	376	34	**204**	587
	EL65	Peloponnisos	3	16	**77**	333	18	**85**	345	27	**140**	442	49	**280**	770
	CY00	Kypros	2	20	**115**	511	22	**122**	522	31	**169**	601	55	**326**	937

Country	NUTS code	Label	Climate suitability class	Annual escape (3 days) (Adults/NUTS2)			Annual escape (7 days) (Adults/NUTS2)			Annual escape (14 days) (Adults/NUTS2)			Annual escape (28 days) (Adults/NUTS2)		
				P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95
Hungary	**HU**	**Hungary**		88	**893**	4,286	100	**938**	4,361	156	**1,202**	4,746	368	**2,542**	7,298
	HU12	Pest	1	19	**194**	932	22	**204**	948	34	**261**	1,032	80	**553**	1,587
	HU23	Dél-Dunántúl	1	13	**131**	629	15	**138**	640	23	**176**	696	54	**373**	1,070
	HU31	Észak-Magyarország	1	16	**167**	804	19	**176**	818	29	**225**	890	69	**477**	1,369
	HU32	Észak-Alföld	1	21	**216**	1,037	24	**227**	1,055	38	**291**	1,148	89	**615**	1,765
	HU33	Dél-Alföld	1	18	**184**	885	21	**194**	900	32	**248**	980	76	**525**	1,506
Bulgaria	**BG**	**Bulgaria**		55	**421**	2,020	59	**442**	2,058	83	**559**	2,263	165	**1,123**	3,619
	BG31	Severozapaden	1	6	**44**	212	6	**46**	216	9	**59**	237	17	**118**	379
	BG32	Severen tsentralen	1	6	**47**	225	7	**49**	229	9	**62**	252	18	**125**	403
	BG33	Severoiztochen	1	7	**56**	269	8	**59**	274	11	**74**	301	22	**149**	481
	BG34	Yugoiztochen	1	8	**62**	298	9	**65**	303	12	**82**	333	24	**165**	533
	BG41	Yugozapaden	1	16	**127**	609	18	**133**	620	25	**168**	682	50	**338**	1,090
	BG42	Yuzhen tsentralen	1	11	**85**	409	12	**89**	416	17	**113**	458	33	**227**	732
Romania	**RO**	**Romania**		217	**2,212**	11,673	248	**2,350**	11,938	366	**3,071**	13,232	766	**6,265**	22,162
	RO11	Nord-Vest	1	40	**408**	2,150	46	**433**	2,199	67	**566**	2,437	141	**1,154**	4,082
	RO22	Sud-Est	1	37	**380**	2,006	43	**404**	2,052	63	**528**	2,274	132	**1,077**	3,809
	RO31	Sud - Muntenia	1	46	**464**	2,449	52	**493**	2,504	77	**644**	2,776	161	**1,314**	4,649
	RO32	Bucuresti - Ilfov	1	37	**371**	1,960	42	**395**	2,004	61	**516**	2,222	129	**1,052**	3,721
	RO41	Sud-Vest Oltenia	1	30	**306**	1,613	34	**325**	1,649	50	**424**	1,828	106	**865**	3,061
	RO42	Vest	1	28	**283**	1,495	32	**301**	1,529	47	**393**	1,695	98	**802**	2,839

A.1.1. Results for different wasting pathways

The following table explores the pathways of escape and compares the escape from private compost with the collected waste with different waste collection scenarios: The timing from disposal to waste treatment varies from 3, 7, 14 to 28 days.

Table A.2: Number of *Thaumatotibia leucotreta* adults escaping within a year from cut roses imported from Africa (including Israel) calculated by a pathway model for NUTS2 regions in the climatically suitable area of Europe. Results are stratified by waste treated by private compost and waste treated after communal collection with four scenarios of timing from disposal at the consumer until the waste treatment. Values are given as median and 90% certainty interval (from P5 to P95)

	NUTS code	Label	Climate suitability class	Annual escape from private compost (Adults/year)			Annual escape from collected waste (3 days) (Adults/year)			Annual escape from collected waste (7 days) (Adults/year)			Annual escape from collected waste (14 days) (Adults/year)			Annual escape from collected waste (28 days) (Adults/year)		
				P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95
Spain & Portugal	**ESPT**	**Spain and Portugal**																
	ES11	Galicia	1	12	**135**	791	0	**2**	5	1	**6**	17	5	**30**	84	24	**160**	451
	ES12	Principado de Asturias	1	4	**51**	298	0	**1**	2	0	**2**	6	2	**11**	32	9	**60**	170
	ES13	Cantabria	1	3	**29**	171	0	**0**	1	0	**1**	4	1	**6**	18	5	**35**	97
	ES21	País Vasco	1	10	**109**	641	0	**1**	4	1	**5**	14	4	**24**	68	20	**130**	365
	ES22	Comunidad Foral de Navarra	1	3	**33**	192	0	**0**	1	0	**2**	4	1	**7**	20	6	**39**	110
	ES23	La Rioja	1	1	**16**	93	0	**0**	1	0	**1**	2	1	**4**	10	3	**19**	53
	ES24	Aragón	1	6	**66**	390	0	**1**	2	1	**3**	8	2	**15**	41	12	**79**	222
	ES30	Comunidad de Madrid	1	29	**336**	1,976	1	**4**	11	3	**16**	43	12	**75**	210	60	**400**	1,126
	ES41	Castilla y León	1	10	**120**	703	0	**1**	4	1	**6**	15	4	**27**	75	22	**142**	401
	ES42	Castilla-la Mancha	2	9	**102**	599	0	**2**	4	1	**7**	19	6	**40**	112	25	**165**	459
	ES43	Extremadura	2	5	**53**	311	0	**1**	2	1	**4**	10	3	**21**	58	13	**86**	238
	ES51	Cataluña	2	33	**381**	2,241	2	**6**	17	5	**26**	71	23	**151**	418	93	**618**	1,717
	ES52	Comunitat Valenciana	3	22	**251**	1,473	1	**5**	14	5	**27**	72	28	**181**	501	96	**639**	1,764
	ES53	Illes Balears	2	5	**60**	355	0	**1**	3	1	**4**	11	4	**24**	66	15	**98**	272

	NUTS code	Label	Climate suitability class	Annual escape from private compost (Adults/year)			Annual escape from collected waste (3 days) (Adults/year)			Annual escape from collected waste (7 days) (Adults/year)			Annual escape from collected waste (14 days) (Adults/year)			Annual escape from collected waste (28 days) (Adults/year)		
				P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95
	ES61	Andalucía	4	37	**423**	2,483	3	**10**	27	9	**51**	138	52	**336**	931	187	**1,259**	3,530
	ES62	Región de Murcia	3	7	**75**	441	0	**2**	4	1	**8**	21	8	**54**	150	29	**191**	528
	ES63	Ciudad de Ceuta	3	0	**4**	25	0	**0**	0	0	**0**	1	0	**3**	8	2	**11**	29
	ES64	Ciudad de Melilla	2	0	**4**	25	0	**0**	0	0	**0**	1	0	**2**	5	1	**7**	19
	PT11	Norte	2	16	**178**	1,047	1	**3**	8	2	**12**	33	11	**70**	195	44	**289**	802
	PT15	Algarve	3	2	**22**	128	0	**0**	1	0	**2**	6	2	**16**	44	8	**56**	154
	PT16	Centro (PT)	3	10	**111**	649	1	**2**	6	2	**12**	32	12	**80**	221	43	**282**	778
	PT17	Área Metropolitana de Lisboa	3	12	**143**	838	1	**3**	8	3	**15**	41	16	**103**	285	55	**364**	1,004
	PT18	Alentejo	3	3	**35**	206	0	**1**	2	1	**4**	10	4	**25**	70	14	**90**	247
France	**FR**	**France**																
	FRG0	Pays-de-la-Loire	1	261	**2,689**	12,975	17	**46**	95	38	**164**	419	131	**783**	2,108	626	**4,161**	11,324
	FRH0	Bretagne	1	230	**2,365**	11,412	15	**40**	84	34	**144**	369	115	**689**	1,854	551	**3,660**	9,960
	FRI1	Aquitaine	1	238	**2,449**	11,820	15	**42**	87	35	**150**	382	119	**713**	1,920	571	**3,791**	10,316
	FRI3	Poitou-Charentes	1	124	**1,277**	6,163	8	**22**	45	18	**78**	199	62	**372**	1,001	297	**1,976**	5,379
	FRJ1	Languedoc-Roussillon	1	196	**2,017**	9,735	13	**34**	71	29	**123**	315	98	**588**	1,581	470	**3,122**	8,496
	FRJ2	Midi-Pyrénées	1	211	**2,174**	10,490	14	**37**	77	31	**133**	339	106	**633**	1,704	506	**3,364**	9,155
	FRK2	Rhône-Alpes	1	458	**4,712**	22,741	30	**80**	167	67	**288**	735	229	**1,373**	3,694	1,098	**7,293**	19,847
	FRL0	Provence-Alpes-Côte d'Azur	1	347	**3,575**	17,254	23	**61**	127	51	**218**	558	174	**1,041**	2,803	833	**5,534**	15,058
	FRM0	Corse	1	24	**244**	1,175	2	**4**	9	3	**15**	38	12	**71**	191	57	**377**	1,026
Italy & Malta	**ITMT**	**Italy and Malta**																
	ITC1	Piemonte	1	126	**1,298**	6,235	5	**15**	34	13	**68**	176	54	**341**	910	277	**1,833**	4,912
	ITC3	Liguria	1	44	**459**	2,205	2	**5**	12	5	**24**	62	19	**121**	322	98	**648**	1,737
	ITC4	Lombardia	1	292	**3,019**	14,503	11	**35**	80	30	**158**	409	125	**793**	2,117	643	**4,263**	11,426

	NUTS code	Label	Climate suitability class	Annual escape from private compost (Adults/year)			Annual escape from collected waste (3 days) (Adults/year)			Annual escape from collected waste (7 days) (Adults/year)			Annual escape from collected waste (14 days) (Adults/year)			Annual escape from collected waste (28 days) (Adults/year)		
				P5	**Median**	**P95**	**P5**	**Median**	**P95**	**P5**	**Median**	**P95**	**P5**	**Median**	**P95**	**P5**	**Median**	**P95**
	ITF1	Abruzzo	1	38	**390**	1,871	1	**5**	10	4	**20**	53	16	**102**	273	83	**550**	1,474
	ITF2	Molise	1	9	**90**	435	0	**1**	2	1	**5**	12	4	**24**	63	19	**128**	342
	ITF3	Campania	2	166	**1,720**	8,262	9	**29**	66	26	**135**	348	125	**802**	2,133	500	**3,310**	8,778
	ITF4	Puglia	2	115	**1,190**	5,718	7	**20**	45	18	**93**	241	87	**555**	1,476	346	**2,291**	6,075
	ITF5	Basilicata	1	16	**167**	800	1	**2**	4	2	**9**	23	7	**44**	117	35	**235**	630
	ITF6	Calabria	2	55	**570**	2,740	3	**10**	22	9	**45**	115	42	**266**	707	166	**1,097**	2,911
	ITG1	Sicilia	3	142	**1,468**	7,051	12	**36**	82	35	**182**	470	195	**1,257**	3,322	669	**4,432**	11,788
	ITG2	Sardegna	2	47	**485**	2,331	3	**8**	19	7	**38**	98	35	**226**	602	141	**934**	2,477
	ITH2	Provincia Autonoma di Trento	1	16	**164**	789	1	**2**	4	2	**9**	22	7	**43**	115	35	**232**	621
	ITH3	Veneto	1	142	**1,469**	7,057	5	**17**	39	15	**77**	199	61	**386**	1,030	313	**2,074**	5,559
	ITH4	Friuli-Venezia Giulia	1	35	**363**	1,745	1	**4**	10	4	**19**	49	15	**95**	255	77	**513**	1,374
	ITH5	Emilia-Romagna	1	130	**1,344**	6,457	5	**16**	36	14	**70**	182	56	**353**	942	286	**1,898**	5,087
	ITI1	Toscana	2	108	**1,112**	5,341	6	**19**	42	17	**87**	225	81	**518**	1,379	323	**2,140**	5,674
	ITI2	Umbria	1	25	**262**	1,259	1	**3**	7	3	**14**	35	11	**69**	184	56	**370**	991
	ITI3	Marche	1	44	**455**	2,188	2	**5**	12	5	**24**	62	19	**120**	319	97	**643**	1,724
	ITI4	Lazio	2	168	**1,733**	8,325	10	**29**	66	26	**136**	351	126	**808**	2,149	503	**3,335**	8,845
	MT00	Malta	2	15	**155**	744	1	**3**	8	3	**13**	33	12	**73**	193	45	**299**	792
Slovenia	**SI**	**Slovenia**																
	SI03	Vzhodna Slovenija	1	22	**226**	1,085	0	**3**	8	2	**13**	35	10	**65**	175	52	**352**	943
	SI04	Zahodna Slovenija	1	20	**205**	983	0	**2**	7	2	**12**	31	9	**59**	159	48	**319**	854

	NUTS code	Label	Climate suitability class	Annual escape from private compost (Adults/year)			Annual escape from collected waste (3 days) (Adults/year)			Annual escape from collected waste (7 days) (Adults/year)			Annual escape from collected waste (14 days) (Adults/year)			Annual escape from collected waste (28 days) (Adults/year)		
				P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95
Croatia	**HR**	**Croatia**																
	HR02	Pannonian Croatia	1	20	**222**	1,142	0	**3**	9	1	**13**	43	7	**64**	223	36	**344**	1,203
	HR03	Adriatic Croatia	1	26	**283**	1,452	0	**3**	11	2	**16**	55	9	**81**	284	46	**438**	1,530
	HR05	City of Zagreb	1	15	**167**	857	0	**2**	7	1	**10**	32	5	**48**	168	27	**258**	903
	HR06	Northern Croatia	1	16	**171**	879	0	**2**	7	1	**10**	33	5	**49**	172	28	**265**	926
Greece & Cyprus		**Greece and Cyprus**																
	EL30	Attiki	3	41	**431**	2,096	31	**71**	132	48	**113**	226	104	**408**	1,093	235	**1,264**	3,493
	EL41	Voreio Aigaio	2	3	**26**	129	1	**3**	6	2	**5**	9	4	**14**	38	9	**50**	144
	EL42	Notio Aigaio	2	4	**40**	195	2	**5**	9	3	**7**	14	6	**22**	58	14	**76**	217
	EL43	Kriti	3	7	**73**	357	5	**12**	22	8	**19**	38	18	**69**	186	40	**215**	595
	EL51	Anatoliki Makedonia, Thraki	1	7	**69**	336	2	**6**	11	3	**9**	18	6	**22**	60	17	**97**	293
	EL52	Kentriki Makedonia	1	21	**216**	1,049	7	**18**	34	10	**27**	55	19	**69**	187	53	**304**	916
	EL53	Dytiki Makedonia	1	3	**30**	148	1	**2**	5	1	**4**	8	3	**10**	26	7	**43**	130
	EL54	Ipeiros	2	4	**38**	187	2	**4**	8	3	**7**	14	6	**21**	55	13	**73**	208
	EL61	Thessalia	1	8	**82**	401	3	**7**	13	4	**10**	21	7	**27**	71	20	**116**	350
	EL62	Ionia Nisia	2	2	**23**	114	1	**3**	5	2	**4**	8	3	**13**	34	8	**45**	127
	EL63	Dytiki Ellada	2	7	**75**	365	4	**9**	16	5	**13**	27	11	**40**	108	26	**143**	407
	EL64	Sterea Ellada	2	6	**64**	312	3	**7**	14	5	**11**	23	9	**35**	92	22	**122**	348
	EL65	Peloponnisos	3	6	**66**	321	5	**11**	20	7	**17**	35	16	**62**	167	36	**193**	535
	CY00	Kypros	2	10	**102**	498	5	**12**	22	7	**18**	37	15	**55**	148	36	**195**	555
Hungary	**HU**	**Hungary**																
	HU12	Pest	1	18	**191**	928	0	**2**	6	2	**11**	31	9	**57**	157	46	**309**	849
	HU23	Dél-Dunántúl	1	12	**129**	626	0	**2**	4	1	**8**	21	6	**39**	106	31	**209**	572

	NUTS code	Label	Climate suitability class	Annual escape from private compost (Adults/year)			Annual escape from collected waste (3 days) (Adults/year)			Annual escape from collected waste (7 days) (Adults/year)			Annual escape from collected waste (14 days) (Adults/year)			Annual escape from collected waste (28 days) (Adults/year)		
				P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95	P5	Median	P95
	HU31	Észak-Magyarország	1	16	**165**	801	0	**2**	5	1	**10**	26	7	**50**	136	40	**267**	732
	HU32	Észak-Alföld	1	21	**213**	1,033	0	**3**	7	2	**12**	34	9	**64**	175	51	**344**	944
	HU33	Dél-Alföld	1	17	**182**	881	0	**2**	6	2	**11**	29	8	**55**	149	44	**294**	806
Bulgaria	**BG**	**Bulgaria**																
	BG31	Severozapaden	1	4	**42**	209	1	**2**	4	1	**4**	10	3	**13**	42	9	**64**	217
	BG32	Severen tsentralen	1	4	**44**	222	1	**2**	4	2	**4**	10	3	**14**	44	10	**68**	230
	BG33	Severoiztochen	1	5	**53**	265	1	**3**	5	2	**5**	12	4	**17**	53	11	**81**	275
	BG34	Yugoiztochen	1	6	**59**	294	1	**3**	6	2	**6**	13	4	**19**	59	13	**89**	305
	BG41	Yugozapaden	1	12	**120**	601	3	**6**	11	4	**11**	27	8	**38**	120	26	**183**	623
	BG42	Yuzhen tsentralen	1	8	**81**	404	2	**4**	8	3	**8**	18	6	**25**	80	17	**123**	418
Romania	**RO**	**Romania**																
	RO11	Nord-Vest	1	36	**400**	2,135	2	**7**	20	4	**25**	91	12	**118**	463	55	**624**	2,475
	RO22	Sud-Est	1	34	**373**	1,992	2	**7**	18	4	**23**	85	11	**110**	432	51	**582**	2,309
	RO31	Sud - Muntenia	1	42	**455**	2,432	2	**8**	22	5	**28**	103	14	**134**	527	63	**710**	2,819
	RO32	Bucuresti - Ilfov	1	33	**364**	1,946	2	**7**	18	4	**23**	83	11	**107**	422	50	**568**	2,256
	RO41	Sud-Vest Oltenia	1	27	**300**	1,601	2	**5**	15	3	**19**	68	9	**88**	347	41	**468**	1,856
	RO42	Vest	1	25	**278**	1,485	2	**5**	14	3	**17**	63	8	**82**	322	38	**434**	1,721

A.1.2. Results for the seasonal number of mated females

Escape of adults of *T. leucotreta* is more likely, when the time between initial disposal at the consumer and household waste treatment is prolonged, especially 14 or 28 days. But the effect is more pronounced, when the temperatures induce a faster development, which is especially in summer. In the scenario with 28d, the longer duration is also sufficient to increase the escape in spring and autumn. To support the interpretation, a reasonable clustering scenario is assumed (see Section 2.3.3), namely the escape of females *T. leucotreta* with possible mating partner in a bunch of 10 roses.

Table A.3: Average seasonal escape of females *T. leucotreta* with possible mating partner in a bunch of 10 roses (reasonable scenario) in the climatically suitable EU areas given for four scenarios on the timing between initial disposal and waste treatment: 3, 7, 14 or 28 days

Average escape	Duration between initial disposal and waste treatment											
	3 days			7 days			14 days			28 days		
Season	**Med**	**P5**	**P95**	**Med**	**P5**	**P95**	**Med**	**P5**	**P95**	**Med**	**P5**	**P95**
Winter	31	3	148	31	3	148	31	3	148	31	3	148
Spring	32	3	153	32	3	153	34	4	155	43	6	170
Summer	24	3	112	30	4	121	61	9	177	185	28	480
Autumn	27	3	129	28	3	130	32	4	136	56	8	177

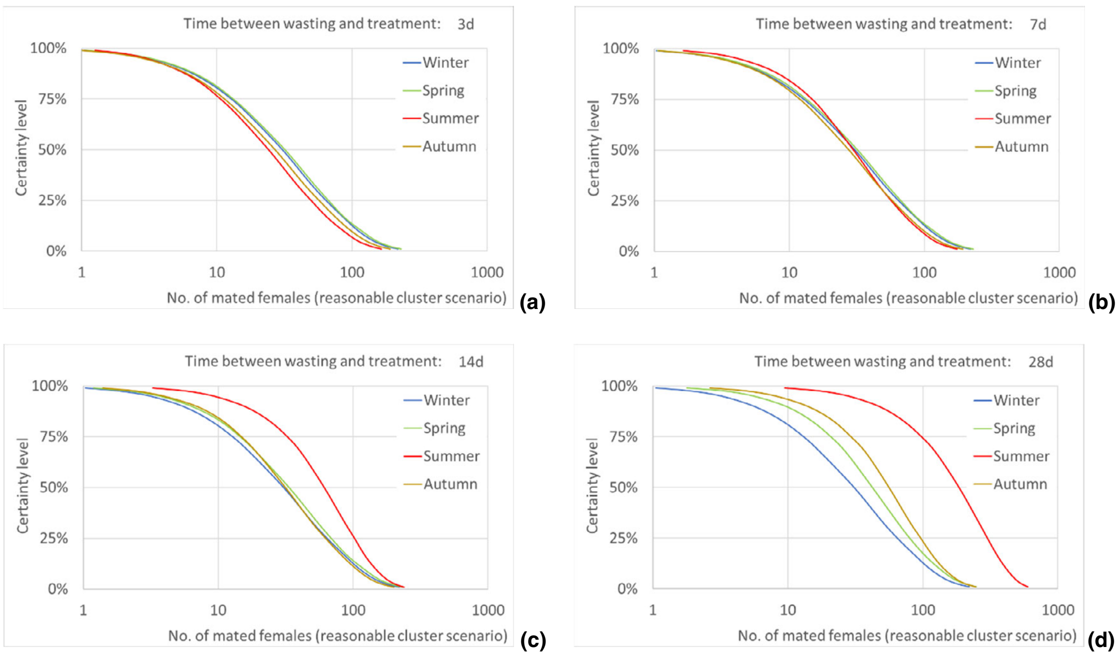

Figure A.1: Average seasonal number of female *T. leucotreta* with possible mating partner in a bunch of 10 roses (Reasonable clustering scenario) per season (blue line = winter, green = spring, red = summer and yellow = autumn) in the EU climatically suitable area with certainty curves for different scenarios between initial wasting and waste treatment: (a) 3 days, (b) 7 days, (c) 14 days and (d) 28 days

A.1.3. Results for the seasonal number of mated females for selected NUTS2 regions

Considering results at EU level, the highest estimated number of adults escapes and consequently also mating females occurs during summer (Figure A.1, Table A.3). When considering individual NUTS2 regions higher results may occur for specific regions (e.g. Andalusia [Figure A.3], Sicily [Figure A.4]) also in autumn esp. in the 28 days scenario.

A.1.3.1. Rhône-Alpes (France)

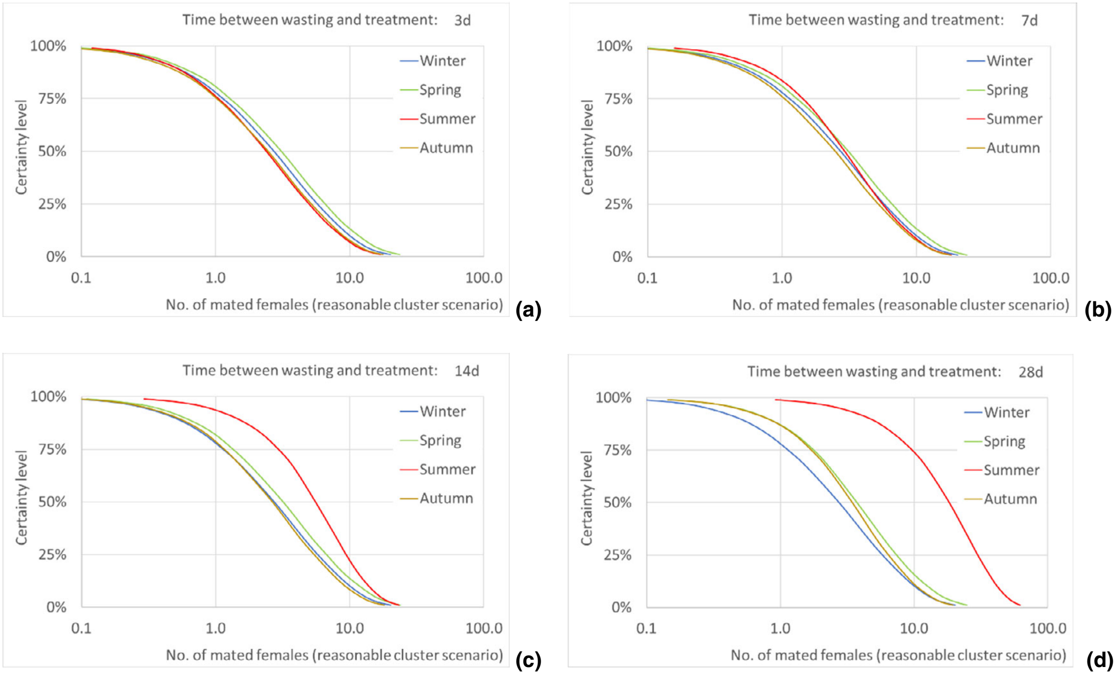

Figure A.2: Average seasonal number of female T. leucotreta with possible mating partner in a bunch of 10 roses (Reasonable clustering scenario) per season (blue line = winter, green = spring, red = summer and yellow = autumn) **in Rhône-Alpes (France)** with certainty curves for different scenarios between initial wasting and waste treatment: (a) 3 days, (b) 7 days, (c) 14 days and (d) 28 days

A.1.3.2. Andalusia (Spain)

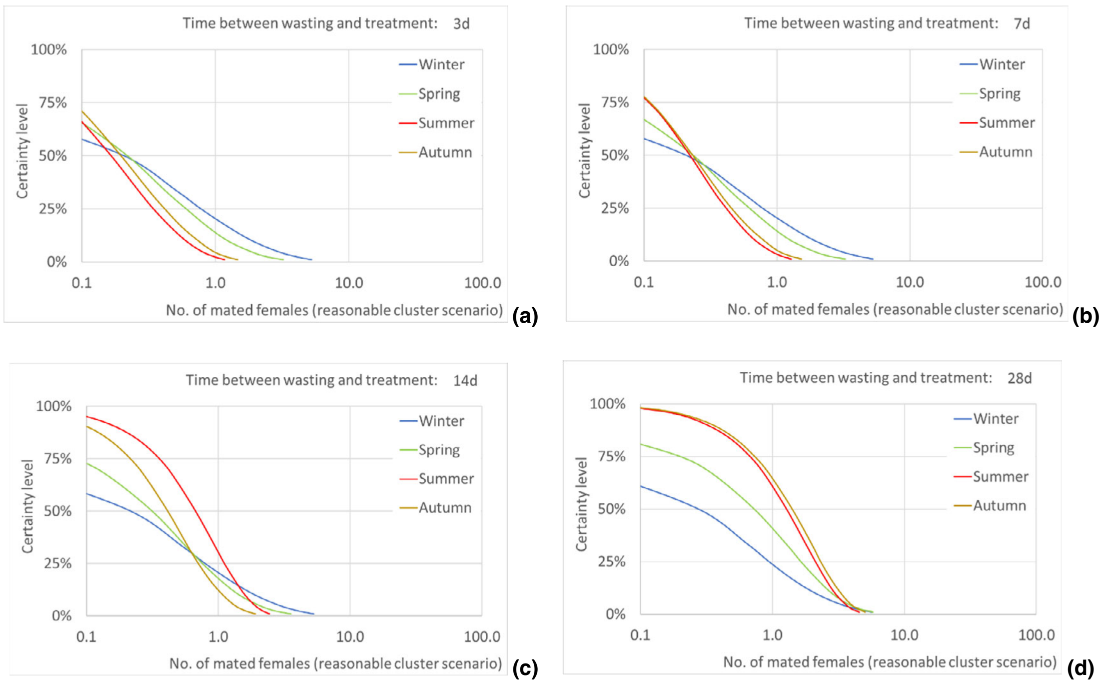

Figure A.3: Average seasonal number of female T. leucotreta with possible mating partner in a bunch of 10 roses (Reasonable clustering scenario) per season (blue line = winter, green = spring, red = summer and yellow = autumn) **in Andalusia (Spain)** with certainty curves for different scenarios between initial wasting and waste treatment: (a) 3 days, (b) 7 days, (c) 14 days and (d) 28 days

A.1.3.3. Sicily (Italy)

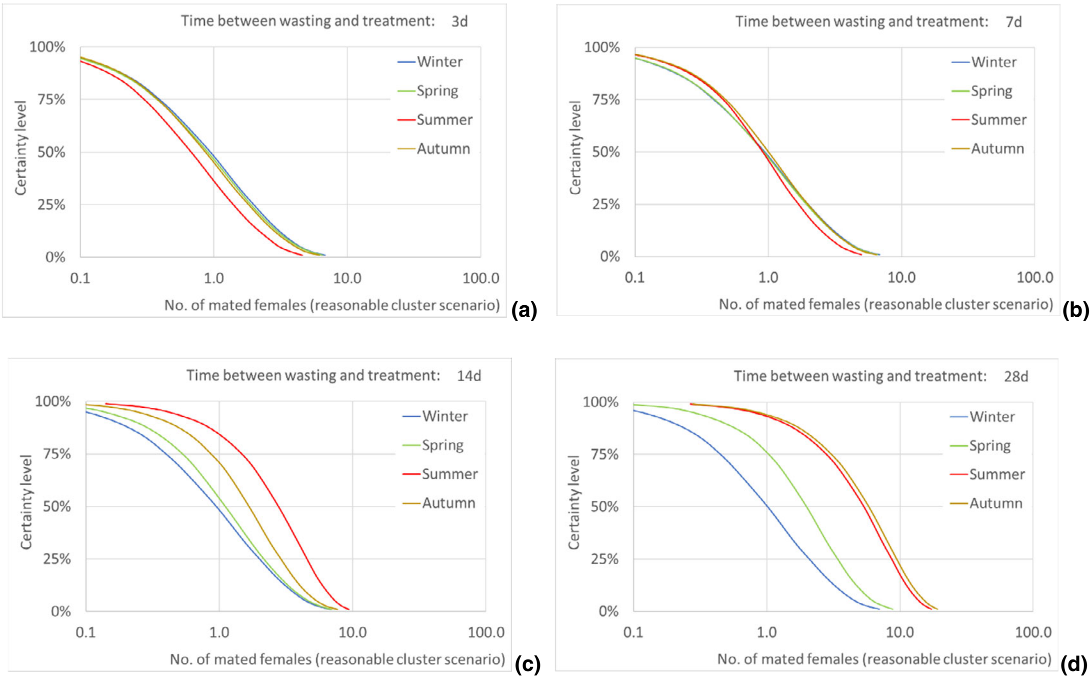

Figure A.4: Average seasonal number of female T. leucotreta with possible mating partner in a bunch of 10 roses (Reasonable clustering scenario) per season (blue line = winter, green = spring, red = summer and yellow = autumn) **in Sicily (Italy)** with certainty curves for different scenarios between initial wasting and waste treatment: (a) 3 days, (b) 7 days, (c) 14 days and (d) 28 days

A.1.4. Escape per 1 km circles in the residential areas of the NUTS2 regions within 10 days (scenario 3, opinion section 2.3.3)

The pathway model calculates the average annual number of *T. leucotreta* imported via cut roses from Africa (incl. Israel) and escaping to the environment in the different NUTS2 regions of the EU. NUTS2 regions with unfavourable climatic conditions for possible establishment are excluded. The spatial resolution assumes that the cut roses will be handled, used and wasted in residential areas. The temporal resolution considers trade and climatic conditions per season.

Due to lack of detailed information on the temporal and local appearance of the insects, the model does not estimate the likelihood of establishment, esp. the proportion of females getting mated, the proportion of mated females finding a suitable host and the proportion of populations successful establishing in the new environment.

Instead in Section 2.2.3, a reasonable scenario of clustering in bunches of 10 roses is defined to interpret the data in view of possible mating. In this section, the average number of *T. leucotreta* adults escaping within a circle with radius 1 km (approximate flying distance to find mating partners) and the usual timespan for mating of 10 days is calculated. The parameter is stratified by NUTS2 regions and described as median estimate with an 90% certainty interval. Finally, the likelihood is calculated, that the average number of escaped insects is equal or higher 2.

Thus, this calculation could be interpreted as (scenario 3) 'best case scenario', when no temporal or spatial clustering happens and all escaping adults are homogeneously distributed within the residential area of a NUTS2 area and throughout a year.

Excluded are timely and spatial variations during a year or within the residential areas. These could be triggered by

- Clustered infestation of cut roses imported from Africa (incl. Israel): Infestation rates may vary between countries, production sites, production cycles and within a consignment. Therefore, single parts of a consignment may be free of *T. leucotreta*, while others shown a large proportion of infested roses, e.g. newly infested with eggs.

- Specific import patterns: While the average monthly import during a year is quite constant, will be an increase of imported roses to specific festivities, e.g. Valentine's day, Mother's day, etc.
- Collection points of private vegetal waste will lead to higher appearance of *T. leucotreta* adults during specific times and on specific locations.
- While the assessment focusses on the residential areas the final distribution of wasted roses in the environment depends from the local circumstances. Areas with isolated houses may have a higher density of private compost sites, while agglomerated housing (e.g. flats) may have larger waste collection sites. Also, intermediate storage of organic waste may lead to higher appearance of FCM adults on specific sites.

For a successful transfer, it has however to be considered that a certain number of adult insects need to emerge at the same time and at the same place, within a climatically suitable region and in presence of suitable host plants, for a successful mating and reproduction to happen.

T. leucotreta adult males may respond to calling females over a distance of 1.0 km and mated females in urban areas may spread at maximum 1.5 km to locate host plants. Such distances generally match the size of the waste treatment plants, which are concentrated in few geographical locations and on limited areas in each NUT2 region. However, based on the simulation results, the number of the estimated escaping adults is expected to be higher in the residential areas in respect to the waste treatment facilities. This is because most of the escapes are estimated to occur during private composting and in the time from the initial disposal by the consumer until the waste treatment. It should be considered that adults escaping during private composting or in the time from disposal until waste treatment may be scattered over a large area limiting their potential for successful mating and reproduction.

To assess the transfer to a suitable host of the *T. leucotreta* adults escaped from the cut roses pathway, the Panel considered that the adults life span for *T. leucotreta* is ca. 2 weeks (Mkiga et al., 2019), and the majority of eggs are laid within the first 10 days of female adult stage (Daiber, 1980; Mkiga et al., 2019; EFSA, 2020); the area covered by males responding to calling females would be a circle with radius of $\sim$ 1 km; given a sex ratio of approximately one male: two females, but at least one female and one male would be needed for a successful mating in a particular location; private gardens are mostly located in residential areas. Therefore, to provide an indication of the average number of adults escaping from cut roses that can mate within the flight distance reported for this species, the average number of adult escapes was also standardised to an area of 3.14 km^2 over 10 days in the residential area of each NUTS2 region. Results are shown in Table A.4 and Figure A.5 below.

Table A.4: Average density of *Thaumatotibia leucotreta* adults escaping within 10 days from cut roses imported from Africa (including Israel) per circle with a radius of 1 km (3.14 km^2) in the residential area. Area and duration allow females to find a mating partner. Results are stratified by four scenarios of timing from disposal at the consumer until the waste treatment. Values are given as median and 90% certainty interval (from P5 to P95)

	NUTS code	Label	Climate suitability class	Total escape of FCM per 3.14 km^2 and 10 days (3 days) (adults/[3.14 m^2 × 10 days])				Total escape of FCM per 3.14 km^2 and 10 days (7 days) (adults/[3.14 m^2 × 10 days])				Total escape of FCM per 3.14 km^2 and 10 days (14 days) (adults/[3.14 m^2 × 10 days])				Total escape of FCM per 3.14 km^2 and 10 days (28 days) (adults/[3.14 m^2 × 10 days])			
				P5	Median	P95	P (X ≥ 2)	P5	Median	P95	P (X ≥ 2)	P5	Median	P95	P (X ≥ 2)	P5	Median	P95	P(X ≥ 2)
Spain & Portugal	**ESPT**	**Spain and Portugal**																	
	ES11	Galicia	1	0.002	**0.018**	0.102	0.000%	0.002	**0.018**	0.103	0.000%	0.003	**0.022**	0.108	0.000%	0.006	**0.043**	0.142	0.000%
	ES12	Principado de Asturias	1	0.003	**0.031**	0.178	0.000%	0.003	**0.032**	0.179	0.000%	0.005	**0.039**	0.189	0.000%	0.010	**0.075**	0.248	0.000%
	ES13	Cantabria	1	0.002	**0.026**	0.149	0.000%	0.003	**0.027**	0.151	0.000%	0.004	**0.033**	0.159	0.000%	0.009	**0.063**	0.208	0.000%
	ES21	País Vasco	1	0.006	**0.063**	0.364	0.000%	0.006	**0.065**	0.368	0.000%	0.010	**0.079**	0.387	0.000%	0.022	**0.153**	0.508	0.000%
	ES22	Comunidad Foral de Navarra	1	0.006	**0.062**	0.358	0.000%	0.006	**0.064**	0.361	0.000%	0.009	**0.078**	0.380	0.000%	0.021	**0.150**	0.499	0.000%
	ES23	La Rioja	1	0.005	**0.052**	0.300	0.000%	0.005	**0.054**	0.303	0.000%	0.008	**0.065**	0.319	0.000%	0.018	**0.126**	0.418	0.000%
	ES24	Aragón	1	0.005	**0.055**	0.322	0.000%	0.006	**0.058**	0.324	0.000%	0.008	**0.070**	0.342	0.000%	0.019	**0.135**	0.449	0.000%
	ES30	Comunidad de Madrid	1	0.006	**0.068**	0.395	0.000%	0.007	**0.071**	0.398	0.000%	0.010	**0.086**	0.419	0.000%	0.023	**0.166**	0.551	0.000%
	ES41	Castilla y León	1	0.002	**0.024**	0.138	0.000%	0.002	**0.025**	0.139	0.000%	0.004	**0.030**	0.147	0.000%	0.008	**0.058**	0.192	0.000%
	ES42	Castilla-la Mancha	2	0.002	**0.019**	0.110	0.000%	0.002	**0.020**	0.112	0.000%	0.004	**0.028**	0.123	0.000%	0.008	**0.055**	0.172	0.000%
	ES43	Extremadura	2	0.002	**0.017**	0.097	0.000%	0.002	**0.018**	0.099	0.000%	0.003	**0.025**	0.108	0.000%	0.007	**0.048**	0.152	0.000%
	ES51	Cataluña	2	0.005	**0.056**	0.324	0.000%	0.006	**0.059**	0.329	0.000%	0.010	**0.083**	0.360	0.000%	0.023	**0.161**	0.505	0.000%
	ES52	Comunitat Valenciana	3	0.003	**0.032**	0.184	0.000%	0.004	**0.035**	0.188	0.000%	0.008	**0.060**	0.226	0.000%	0.018	**0.123**	0.357	0.000%
	ES53	Illes Balears	2	0.001	**0.013**	0.073	0.000%	0.001	**0.013**	0.074	0.000%	0.002	**0.019**	0.081	0.000%	0.005	**0.036**	0.113	0.000%
	ES61	Andalucía	4	0.004	**0.040**	0.229	0.000%	0.005	**0.044**	0.236	0.000%	0.011	**0.077**	0.287	0.000%	0.025	**0.169**	0.498	0.000%
	ES62	Región de Murcia	3	0.002	**0.021**	0.123	0.000%	0.003	**0.023**	0.126	0.000%	0.005	**0.040**	0.151	0.000%	0.012	**0.082**	0.238	0.000%
	ES63	Ciudad de Ceuta	3	0.002	**0.019**	0.108	0.000%	0.002	**0.021**	0.111	0.000%	0.005	**0.035**	0.133	0.000%	0.010	**0.072**	0.210	0.000%

	NUTS code	Label	Climate suitability class	Total escape of FCM per 3.14 km² and 10 days (3 days)				Total escape of FCM per 3.14 km² and 10 days (7 days)				Total escape of FCM per 3.14 km² and 10 days (14 days)				Total escape of FCM per 3.14 km² and 10 days (28 days)			
				(adults/[3.14 m² × 10 days])				(adults/[3.14 m² × 10 days])				(adults/[3.14 m² × 10 days])				(adults/[3.14 m² × 10 days])			
				P5	**Median**	**P95**	**P (X ≥ 2)**	**P5**	**Median**	**P95**	**P (X ≥ 2)**	**P5**	**Median**	**P95**	**P (X ≥ 2)**	**P5**	**Median**	**P95**	**P(X ≥ 2)**
	ES64	Ciudad de Melilla	2	0.002	**0.027**	0.155	0.000%	0.003	**0.028**	0.157	0.000%	0.005	**0.040**	0.172	0.000%	0.011	**0.077**	0.241	0.000%
	PT11	Norte	2	0.002	**0.024**	0.140	0.000%	0.003	**0.026**	0.142	0.000%	0.005	**0.036**	0.156	0.000%	0.010	**0.070**	0.218	0.000%
	PT15	Algarve	3	0.002	**0.017**	0.098	0.000%	0.002	**0.019**	0.100	0.000%	0.004	**0.032**	0.120	0.000%	0.009	**0.065**	0.190	0.000%
	PT16	Centro (PT)	3	0.001	**0.015**	0.084	0.000%	0.002	**0.016**	0.086	0.000%	0.004	**0.027**	0.103	0.000%	0.008	**0.056**	0.163	0.000%
	PT17	Área Metropolitana de Lisboa	3	0.005	**0.057**	0.325	0.000%	0.007	**0.062**	0.333	0.000%	0.014	**0.106**	0.399	0.000%	0.031	**0.217**	0.632	0.000%
	PT18	Alentejo	3	0.002	**0.016**	0.095	0.000%	0.002	**0.018**	0.097	0.000%	0.004	**0.031**	0.116	0.000%	0.009	**0.063**	0.184	0.000%
France	**FR**	**France**																	
	FRG0	Pays-de-la-Loire	1	0.013	**0.119**	0.570	0.000%	0.014	**0.126**	0.578	0.000%	0.021	**0.159**	0.627	0.000%	0.048	**0.329**	0.937	0.004%
	FRH0	Bretagne	1	0.011	**0.107**	0.508	0.000%	0.013	**0.112**	0.515	0.000%	0.019	**0.141**	0.559	0.000%	0.043	**0.294**	0.836	0.000%
	FRI1	Aquitaine	1	0.008	**0.077**	0.368	0.000%	0.009	**0.081**	0.374	0.000%	0.014	**0.103**	0.406	0.000%	0.031	**0.213**	0.606	0.000%
	FRI3	Poitou-Charentes	1	0.010	**0.098**	0.467	0.000%	0.012	**0.103**	0.474	0.000%	0.017	**0.130**	0.514	0.000%	0.040	**0.270**	0.768	0.000%
	FRJ1	Languedoc-Roussillon	1	0.017	**0.161**	0.768	0.003%	0.019	**0.170**	0.779	0.004%	0.028	**0.214**	0.845	0.005%	0.065	**0.444**	1.264	0.280%
	FRJ2	Midi-Pyrénées	1	0.011	**0.107**	0.510	0.000%	0.013	**0.113**	0.518	0.000%	0.019	**0.142**	0.562	0.000%	0.043	**0.295**	0.840	0.000%
	FRK2	Rhône-Alpes	1	0.018	**0.175**	0.832	0.006%	0.021	**0.184**	0.845	0.007%	0.031	**0.232**	0.916	0.017%	0.070	**0.481**	1.370	0.570%
	FRL0	Provence-Alpes-Côte d’Azur	1	0.016	**0.151**	0.722	0.002%	0.018	**0.160**	0.732	0.002%	0.027	**0.201**	0.794	0.003%	0.061	**0.417**	1.188	0.146%
	FRM0	Corse	1	0.029	**0.277**	1.322	0.859%	0.033	**0.292**	1.341	0.929%	0.049	**0.368**	1.455	1.371%	0.112	**0.764**	2.175	7.192%
Italy & Malta	**ITMT**	**Italy and Malta**																	
	ITC1	Piemonte	1	0.009	**0.088**	0.417	0.000%	0.010	**0.092**	0.424	0.000%	0.015	**0.114**	0.456	0.000%	0.033	**0.231**	0.661	0.000%
	ITC3	Liguria	1	0.025	**0.251**	1.192	0.482%	0.029	**0.263**	1.211	0.548%	0.042	**0.325**	1.302	0.755%	0.094	**0.659**	1.889	3.889%
	ITC4	Lombardia	1	0.019	**0.193**	0.918	0.014%	0.022	**0.202**	0.933	0.027%	0.033	**0.250**	1.003	0.066%	0.073	**0.508**	1.455	0.890%
	ITF1	Abruzzo	1	0.014	**0.135**	0.642	0.000%	0.015	**0.142**	0.653	0.000%	0.023	**0.175**	0.702	0.000%	0.051	**0.356**	1.018	0.008%
	ITF2	Molise	1	0.007	**0.072**	0.343	0.000%	0.008	**0.076**	0.348	0.000%	0.012	**0.093**	0.375	0.000%	0.027	**0.190**	0.543	0.000%

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				P5	**Median**	**P95**	**P (X ≥ 2)**	**P5**	**Median**	**P95**	**P (X ≥ 2)**	**P5**	**Median**	**P95**	**P (X ≥ 2)**	**P5**	**Median**	**P95**	**P(X ≥ 2)**
	ITF3	Campania	2	0.023	**0.225**	1.067	0.209%	0.027	**0.242**	1.092	0.255%	0.047	**0.346**	1.248	0.531%	0.104	**0.712**	1.950	4.395%
	ITF4	Puglia	2	0.020	**0.194**	0.919	0.014%	0.024	**0.208**	0.940	0.029%	0.041	**0.298**	1.074	0.131%	0.089	**0.612**	1.678	1.914%
	ITF5	Basilicata	1	0.011	**0.107**	0.508	0.000%	0.012	**0.112**	0.516	0.000%	0.018	**0.138**	0.555	0.000%	0.040	**0.281**	0.804	0.000%
	ITF6	Calabria	2	0.013	**0.126**	0.598	0.000%	0.015	**0.135**	0.612	0.000%	0.027	**0.194**	0.699	0.000%	0.058	**0.398**	1.092	0.018%
	ITG1	Sicilia	3	0.022	**0.206**	0.970	0.061%	0.028	**0.230**	1.004	0.086%	0.058	**0.407**	1.287	0.512%	0.130	**0.873**	2.310	9.502%
	ITG2	Sardegna	2	0.014	**0.141**	0.668	0.000%	0.017	**0.151**	0.684	0.000%	0.030	**0.217**	0.781	0.001%	0.065	**0.445**	1.221	0.103%
	ITH2	Provincia Autonoma di Trento	1	0.016	**0.161**	0.767	0.002%	0.018	**0.169**	0.780	0.002%	0.027	**0.209**	0.838	0.003%	0.061	**0.425**	1.216	0.172%
	ITH3	Veneto	1	0.012	**0.120**	0.572	0.000%	0.014	**0.126**	0.581	0.000%	0.020	**0.156**	0.625	0.000%	0.045	**0.317**	0.907	0.002%
	ITH4	Friuli-Venezia Giulia	1	0.007	**0.069**	0.331	0.000%	0.008	**0.073**	0.336	0.000%	0.012	**0.090**	0.361	0.000%	0.026	**0.183**	0.524	0.000%
	ITH5	Emilia-Romagna	1	0.007	**0.069**	0.326	0.000%	0.008	**0.072**	0.331	0.000%	0.012	**0.089**	0.356	0.000%	0.026	**0.180**	0.517	0.000%
	ITI1	Toscana	2	0.017	**0.163**	0.772	0.002%	0.020	**0.175**	0.790	0.002%	0.034	**0.250**	0.902	0.004%	0.075	**0.515**	1.410	0.537%
	ITI2	Umbria	1	0.008	**0.078**	0.370	0.000%	0.009	**0.081**	0.376	0.000%	0.013	**0.101**	0.404	0.000%	0.029	**0.205**	0.586	0.000%
	ITI3	Marche	1	0.013	**0.126**	0.598	0.000%	0.014	**0.132**	0.608	0.000%	0.021	**0.163**	0.654	0.000%	0.047	**0.331**	0.949	0.004%
	ITI4	Lazio	2	0.016	**0.152**	0.721	0.001%	0.019	**0.163**	0.738	0.001%	0.032	**0.234**	0.843	0.003%	0.070	**0.481**	1.317	0.294%
	MT00	Malta	2	0.026	**0.247**	1.168	0.403%	0.031	**0.265**	1.194	0.467%	0.053	**0.380**	1.364	0.906%	0.114	**0.778**	2.131	6.571%
Slovenia	**SI**	**Slovenia**																	
	SI03	Vzhodna Slovenija	1	0.007	**0.073**	0.346	0.000%	0.008	**0.077**	0.352	0.000%	0.012	**0.097**	0.384	0.000%	0.029	**0.202**	0.575	0.000%
	SI04	Zahodna Slovenija	1	0.012	**0.124**	0.591	0.000%	0.014	**0.131**	0.601	0.000%	0.021	**0.166**	0.654	0.000%	0.050	**0.345**	0.981	0.002%
Croatia	**HR**	**Croatia**																	
	HR02	Pannonian Croatia	1	0.006	**0.066**	0.337	0.000%	0.007	**0.070**	0.343	0.000%	0.011	**0.091**	0.377	0.000%	0.024	**0.187**	0.608	0.000%
	HR03	Adriatic Croatia	1	0.007	**0.079**	0.403	0.000%	0.008	**0.084**	0.410	0.000%	0.013	**0.108**	0.451	0.000%	0.029	**0.223**	0.727	0.000%
	HR05	City of Zagreb	1	0.008	**0.089**	0.450	0.000%	0.009	**0.094**	0.457	0.000%	0.015	**0.121**	0.503	0.000%	0.033	**0.249**	0.812	0.001%
	HR06	Northern Croatia	1	0.003	**0.033**	0.167	0.000%	0.004	**0.035**	0.170	0.000%	0.005	**0.045**	0.187	0.000%	0.012	**0.093**	0.302	0.000%

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				(adults/[3.14 m² × 10 days])				(adults/[3.14 m² × 10 days])				(adults/[3.14 m² × 10 days])				(adults/[3.14 m² × 10 days])			
				P5	**Median**	**P95**	**P (X ≥ 2)**	**P5**	**Median**	**P95**	**P (X ≥ 2)**	**P5**	**Median**	**P95**	**P (X ≥ 2)**	**P5**	**Median**	**P95**	**P(X ≥ 2)**
Greece & Cyprus		**Greece and Cyprus**																	
	EL30	Attiki	3	0.022	**0.108**	0.465	0.000%	0.025	**0.119**	0.483	0.000%	0.038	**0.196**	0.618	0.000%	0.068	**0.392**	1.076	0.010%
	EL41	Voreio Aigaio	2	0.007	**0.039**	0.174	0.000%	0.008	**0.042**	0.178	0.000%	0.010	**0.058**	0.205	0.000%	0.019	**0.111**	0.320	0.000%
	EL42	Notio Aigaio	2	0.003	**0.017**	0.077	0.000%	0.003	**0.019**	0.079	0.000%	0.005	**0.026**	0.091	0.000%	0.008	**0.049**	0.142	0.000%
	EL43	Kriti	3	0.013	**0.065**	0.281	0.000%	0.015	**0.072**	0.291	0.000%	0.023	**0.118**	0.373	0.000%	0.041	**0.236**	0.650	0.000%
	EL51	Anatoliki Makedonia, Thraki	1	0.004	**0.029**	0.132	0.000%	0.005	**0.030**	0.134	0.000%	0.006	**0.037**	0.145	0.000%	0.011	**0.071**	0.215	0.000%
	EL52	Kentriki Makedonia	1	0.011	**0.072**	0.331	0.000%	0.012	**0.076**	0.335	0.000%	0.015	**0.093**	0.364	0.000%	0.028	**0.178**	0.540	0.000%
	EL53	Dytiki Makedonia	1	0.007	**0.046**	0.210	0.000%	0.008	**0.048**	0.212	0.000%	0.010	**0.059**	0.230	0.000%	0.018	**0.113**	0.341	0.000%
	EL54	Ipeiros	2	0.013	**0.072**	0.321	0.000%	0.014	**0.077**	0.329	0.000%	0.019	**0.106**	0.378	0.000%	0.034	**0.205**	0.590	0.000%
	EL61	Thessalia	1	0.007	**0.044**	0.199	0.000%	0.007	**0.046**	0.202	0.000%	0.009	**0.056**	0.219	0.000%	0.017	**0.107**	0.325	0.000%
	EL62	Ionia Nisia	2	0.004	**0.023**	0.103	0.000%	0.004	**0.025**	0.105	0.000%	0.006	**0.034**	0.121	0.000%	0.011	**0.066**	0.189	0.000%
	EL63	Dytiki Ellada	2	0.011	**0.064**	0.284	0.000%	0.012	**0.068**	0.290	0.000%	0.017	**0.094**	0.334	0.000%	0.030	**0.181**	0.521	0.000%
	EL64	Sterea Ellada	2	0.007	**0.039**	0.172	0.000%	0.007	**0.041**	0.176	0.000%	0.010	**0.057**	0.203	0.000%	0.018	**0.110**	0.316	0.000%
	EL65	Peloponnisos	3	0.006	**0.029**	0.123	0.000%	0.007	**0.031**	0.128	0.000%	0.010	**0.052**	0.164	0.000%	0.018	**0.104**	0.285	0.000%
	CY00	Kypros	2	0.006	**0.035**	0.157	0.000%	0.007	**0.038**	0.160	0.000%	0.009	**0.052**	0.185	0.000%	0.017	**0.100**	0.288	0.000%
Hungary	**HU**	**Hungary**																	
	HU12	Pest	1	0.005	**0.052**	0.252	0.000%	0.006	0.055	0.256	0.000%	0.009	**0.071**	0.279	0.000%	0.022	**0.149**	0.429	0.000%
	HU23	Dél-Dunántúl	1	0.003	**0.033**	0.159	0.000%	0.004	0.035	0.162	0.000%	0.006	**0.045**	0.176	0.000%	0.014	**0.095**	0.271	0.000%
	HU31	Észak-Magyarország	1	0.005	**0.051**	0.245	0.000%	0.006	0.054	0.249	0.000%	0.009	**0.069**	0.271	0.000%	0.021	**0.145**	0.417	0.000%
	HU32	Észak-Alföld	1	0.005	**0.053**	0.255	0.000%	0.006	0.056	0.260	0.000%	0.009	**0.072**	0.283	0.000%	0.022	**0.152**	0.435	0.000%
	HU33	Dél-Alföld	1	0.003	**0.030**	0.143	0.000%	0.003	0.031	0.146	0.000%	0.005	**0.040**	0.159	0.000%	0.012	**0.085**	0.244	0.000%
Bulgaria	**BG**	**Bulgaria**																	
	BG31	Severozapaden	1	0.003	**0.021**	0.100	0.000%	0.003	**0.022**	0.102	0.000%	0.004	**0.028**	0.112	0.000%	0.008	**0.055**	0.179	0.000%
	BG32	Severen tsentralen	1	0.004	**0.031**	0.150	0.000%	0.004	**0.033**	0.152	0.000%	0.006	**0.041**	0.168	0.000%	0.012	**0.083**	0.268	0.000%

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				P5	Median	P95	P (X ≥ 2)	P5	Median	P95	P (X ≥ 2)	P5	Median	P95	P (X ≥ 2)	P5	Median	P95	P(X ≥ 2)
	BG33	Severoiztochen	1	0.002	**0.015**	0.074	0.000%	0.002	**0.016**	0.075	0.000%	0.003	**0.020**	0.083	0.000%	0.006	**0.041**	0.132	0.000%
	BG34	Yugoiztochen	1	0.006	**0.045**	0.218	0.000%	0.006	**0.048**	0.222	0.000%	0.009	**0.060**	0.244	0.000%	0.018	**0.121**	0.391	0.000%
	BG41	Yugozapaden	1	0.004	**0.032**	0.155	0.000%	0.005	**0.034**	0.158	0.000%	0.006	**0.043**	0.173	0.000%	0.013	**0.086**	0.277	0.000%
	BG42	Yuzhen tsentralen	1	0.004	**0.029**	0.138	0.000%	0.004	**0.030**	0.140	0.000%	0.006	**0.038**	0.154	0.000%	0.011	**0.077**	0.247	0.000%
Romania	**RO**	**Romania**																	
	RO11	Nord-Vest	1	0.008	**0.082**	0.431	0.000%	0.009	**0.087**	0.441	0.000%	0.014	**0.113**	0.489	0.000%	0.028	**0.231**	0.819	0.003%
	RO22	Sud-Est	1	0.009	**0.093**	0.493	0.000%	0.010	**0.099**	0.504	0.000%	0.015	**0.130**	0.559	0.000%	0.032	**0.265**	0.936	0.051%
	RO31	Sud - Muntenia	1	0.007	**0.069**	0.365	0.000%	0.008	**0.073**	0.373	0.000%	0.011	**0.096**	0.413	0.000%	0.024	**0.196**	0.692	0.000%
	RO32	Bucuresti – Ilfov	1	0.018	**0.179**	0.944	0.204%	0.020	**0.190**	0.966	0.221%	0.030	**0.248**	1.071	0.352%	0.062	**0.507**	1.793	3.266%
	RO41	Sud-Vest Oltenia	1	0.005	**0.048**	0.253	0.000%	0.005	**0.051**	0.259	0.000%	0.008	**0.067**	0.287	0.000%	0.017	**0.136**	0.480	0.000%
	RO42	Vest	1	0.005	**0.049**	0.259	0.000%	0.005	**0.052**	0.265	0.000%	0.008	**0.068**	0.294	0.000%	0.017	**0.139**	0.492	0.000%

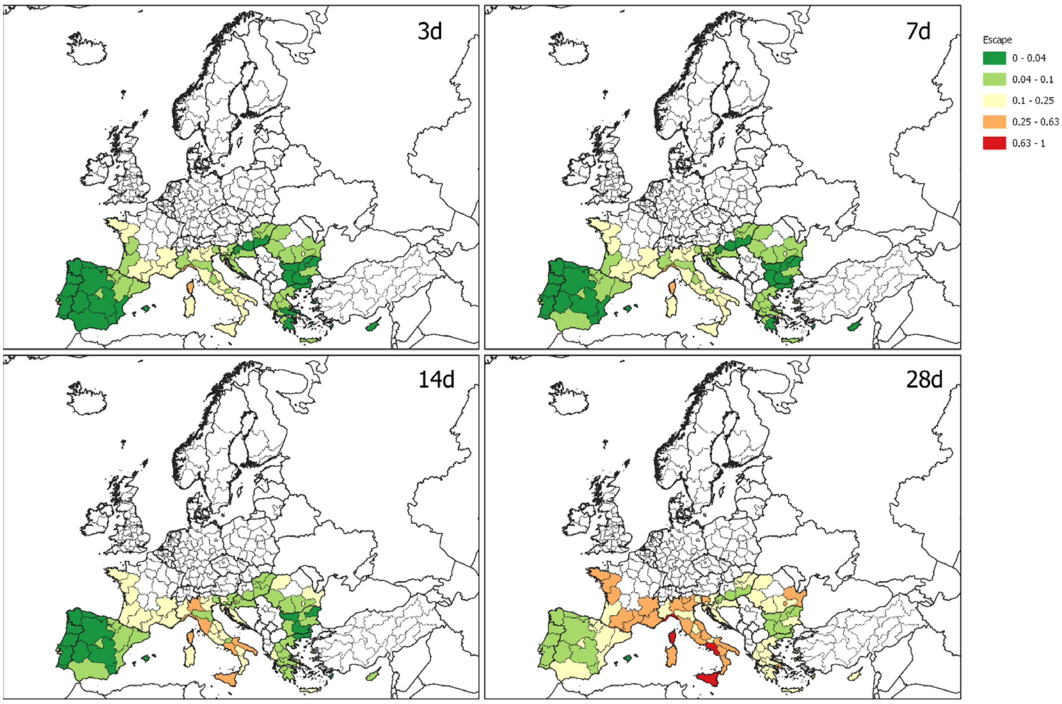

Figure A.5: Maps of the European NUTS2 regions that are climatically suitable for *T. leucotreta* establishment showing the estimated average numbers of *T. leucotreta* adult escapes standardised to an area of 3.14 km^2 over 10 days in the residential area of each NUTS2 region (log-scale). Results are presented for the four different scenarios of timing from the initial disposal until the waste treatment of 3, 7, 14 and 28 days

When the average numbers of adult escapes are standardised as discussed above in the residential area of each NUTS2 region, the highest values are observed in NUTS2 regions with high population densities in residential areas. For example, Corsica (France), Liguria (Italy) and Malta (Malta), which had a median of 23,948, 46,551 and 1,592 adult escapes per year, respectively, have the highest values when results are shown as average number of adult escapes standardised to an area of 3.14 km^2 over 10 days in the residential area. For Corsica, the values vary from 0.2737 (90% uncertainty between 0.029 and 1.286322) to 0.75064 (90% uncertainty between 0.112 and 2.14375) when considering a time from initial disposal until waste treatment of 3 and 28 days, respectively. Similarly, for Liguria, the values vary from 0.25146 (90% uncertainty between 0.025 and 1.15592) to 0.6509 (90% uncertainty between 0.094 and 1.88955) from scenario 3 to 28 days. For Malta, the values vary from 0.243 (90% uncertainty between 0.026 and 1.16832) to 0.77865 (90% uncertainty between 0.113 and 2.098131) from scenario 3 to 28 days. Also in this case, when the period until waste treatment becomes longer, the number of escapes increases.

Table A.5: Estimated number of *T. leucotreta* adults escaping from disposed infested cut roses in a 3.14-km^2 circle per decade in the residential areas of some example NUTS 2 regions

NUTS2 region	Time between disposal and waste treatment	Winter			Spring			Summer			Autumn		
		5th perc	Median	95th perc	5th perc	Median	95th perc	5th perc	Median	95th perc	5th perc	Median	95th perc
Andalusia	***3 days***	0.000	0.033	0.467	0.001	0.035	0.298	0.003	0.027	0.128	0.003	0.032	0.155
	7 days	0.000	0.033	0.468	0.001	0.037	0.303	0.005	0.036	0.144	0.005	0.038	0.164
	14 days	0.000	0.034	0.474	0.001	0.050	0.339	0.016	0.109	0.307	0.010	0.067	0.217
	28 days	0.000	0.044	0.516	0.002	0.116	0.602	0.031	0.206	0.571	0.034	0.226	0.624
Corse	***3 days***	0.028	0.280	1.351	0.032	0.317	1.583	0.030	0.245	1.152	0.025	0.280	1.351
	7 days	0.028	0.280	1.351	0.032	0.319	1.585	0.042	0.301	1.240	0.026	0.280	1.351
	14 days	0.028	0.280	1.351	0.034	0.326	1.597	0.087	0.571	1.730	0.029	0.280	1.351
	28 days	0.028	0.280	1.351	0.047	0.384	1.688	0.281	1.861	4.963	0.047	0.280	1.351
Liguria	***3 days***	0.028	0.279	1.335	0.026	0.265	1.296	0.021	0.197	0.922	0.025	0.253	1.215
	7 days	0.028	0.279	1.335	0.027	0.267	1.298	0.031	0.242	0.992	0.026	0.255	1.220
	14 days	0.028	0.279	1.335	0.028	0.273	1.307	0.068	0.465	1.388	0.068	0.465	1.388
	28 days	0.028	0.279	1.335	0.040	0.323	1.384	0.229	1.533	3.993	0.229	1.533	3.993
Sicily	***3 days***	0.023	0.226	1.082	0.022	0.216	1.052	0.019	0.164	0.754	0.023	0.211	0.993
	7 days	0.023	0.226	1.082	0.023	0.223	1.061	0.030	0.220	0.843	0.031	0.243	1.048
	14 days	0.023	0.229	1.087	0.033	0.267	1.131	0.100	0.671	1.787	0.059	0.405	1.313
	28 days	0.027	0.244	1.111	0.068	0.477	1.502	0.192	1.282	3.337	0.209	1.389	3.665
Malta	***3 days***	0.028	0.274	1.306	0.027	0.261	1.268	0.022	0.195	0.905	0.026	0.251	1.192
	7 days	0.028	0.274	1.306	0.027	0.265	1.274	0.033	0.250	0.993	0.029	0.263	1.213
	14 days	0.028	0.274	1.306	0.033	0.286	1.307	0.086	0.585	1.627	0.045	0.336	1.328
	28 days	0.029	0.275	1.309	0.054	0.398	1.487	0.231	1.543	4.016	0.113	0.771	2.151

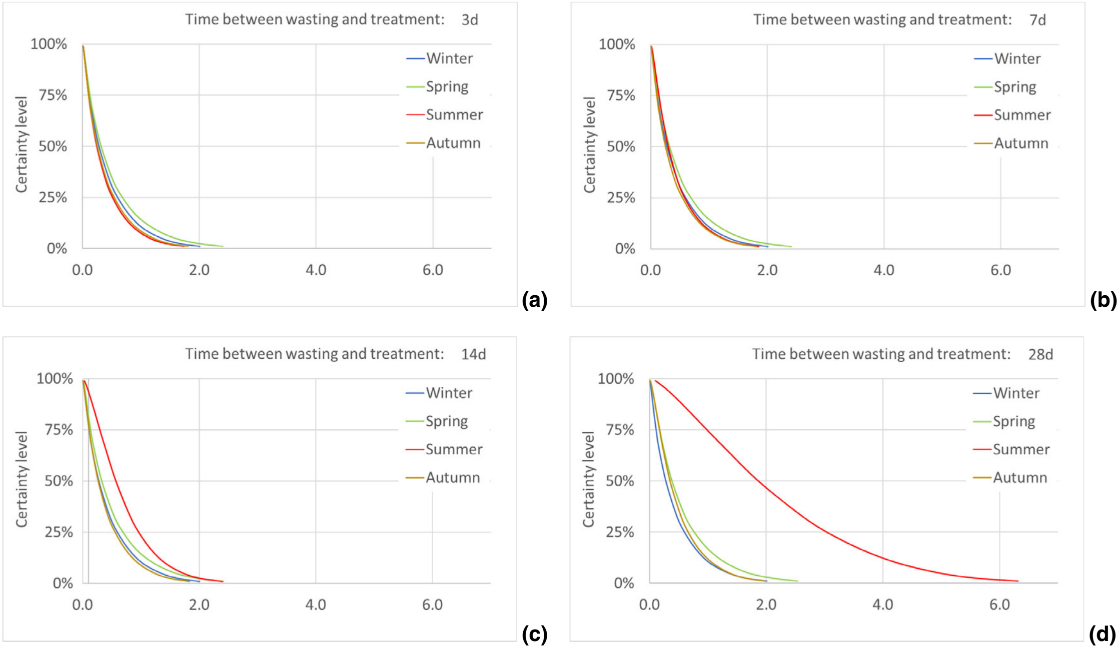

Figure A.6: Estimated number of *T. leucotreta* adults escaping from disposed infested cut roses in a 3.14-km^2 circle per 10 days in the residential areas of **Corsica (France)** with distribution functions for different scenarios between initial wasting and waste treatment: (a) 3 days, (b) 7 days, (c) 14 days and (d) 28 days

A.2. Pest status in Africa

The pathway model considers all African countries where *Thaumatotibia leucotreta* is reported as present according to EPPO. Israel is added to this list. Some countries do not export roses into the EU.

Table A.6: African countries and Israel with their status of *Thaumatotibia leucotreta* (in EPPO Global Database, Internet: https://gd.eppo.int/taxon/ARGPLE/distribution, accessed: 1 June 2022; Eurostat, EU trade since 1988 by HS2-4-6 and CN8, online, accessed on 4 October 2022)

Country	ISO Country code	Export of cut roses in 2011–2020 (Eurostat)	Status of *T. leucotreta* (EPPO)
Israel	IL	Yes	Present, restricted distribution
Angola	AO	Yes	Present, no details
Burkina Faso	BF	No	Present, no details
Burundi	BI	No	Present, no details
Benin	BJ	No	Present, no details
Rep.Democr. Congo	CD	No	Present, no details
Central African Republic	CF	No	Present, no details
Ivory Coast	CI	Yes	Present, no details
Cameroon	CM	No	Present, no details
Cape Verde	CV	No	Present, no details
Eritrea	ER	Yes	Present, no details
Ethiopia	ET	Yes	Present, no details
Ghana	GH	Yes	Present, no details
Gambia	GM	No	Present, no details
Kenya	KE	Yes	Present, no details
Madagascar	MG	No	Present, no details
Mali	ML	No	Present, no details

Country	ISO Country code	Export of cut roses in 2011–2020 (Eurostat)	Status of *T. leucotreta* (EPPO)
Mauritius	MU	Yes	Present, no details
Malawi	MW	Yes	Present, no details
Mozambique	MZ	No	Present, no details
Niger	NE	Yes	Present, no details
Nigeria	NG	Yes	Present, no details
Rwanda	RW	Yes	Present, no details
Sudan	SD	No	Present, no details
Sierra Leone	SL	No	Present, no details
Senegal	SN	No	Present, no details
Somalia	SO	No	Present, no details
Eswatini	SZ	Yes	Present, no details
Chad	TD	No	Present, no details
Togo	TG	No	Present, no details
Tanzania	TZ	Yes	Present, no details
Uganda	UG	Yes	Present, no details
South Africa	ZA	Yes	Present, no details
Zambia	ZM	Yes	Present, no details
Zimbabwe	ZW	Yes	Present, no details
Botswana	BW	No	No notification
Congo	CG	No	No notification
Algeria	DZ	No	No notification
Egypt	EG	Yes	No notification
Gabon	GA	No	No notification
Guinea	GN	No	No notification
Equatorial Guinea	GQ	No	No notification
Guinea-Bissau	GW	No	No notification
Comoros	KM	No	No notification
Liberia	LR	No	No notification
Lesotho	LS	No	No notification
Libya	LY	No	No notification
Morocco	MA	Yes	No notification
Mauritania	MR	No	No notification
Namibia	NA	Yes	No notification
Seychelles	SC	No	No notification
South Sudan	SS	No	No notification
Sao Tome and Principe	ST	No	No notification
Tunisia	TN	Yes	No notification

A.2.1. Export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel

Trade data for the years from 2011 to 2020 were used to estimate the average annual trade.

Table A.7: Average export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to EU ordered by the average annual volume [in pcs] (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, online, accessed on 4 October 2022)

Country	Average export 2011–2020 to Europe (EU27)	
	Absolute (roses, pcs)	**Relative (%)**
Total (selected countries of Africa and Israel)	4,411,137,386	100%
Kenya	2,406,079,285	54.55%
Ethiopia	1,486,976,887	33.71%
Uganda	238,429,156	5.41%
Zambia	150,072,433	3.40%
Zimbabwe	71,434,840	1.62%
Tanzania	48,774,537	1.11%
Rwanda	8,420,765	0.19%
South Africa	492,771	0.01%
Morocco	252,006	0.01%
Israel	127,714	0.00%
Eritrea	50,080	0.00%
Malawi	16,898	0.00%
Mauritius	4,796	0.00%
Côte d'Ivoire	1,484	0.00%
Egypt	1,085	0.00%
Nigeria	1,038	0.00%
Niger	558	0.00%
Namibia	528	0.00%
Eswatini	452	0.00%
Tunisia	52	0.00%
Angola	20	0.00%
Ghana	1	0.00%
Burkina Faso	0	0.00%
Burundi	0	0.00%
Benin	0	0.00%
Congo, Democratic Republic of	0	0.00%
Central African Republic	0	0.00%
Cameroon	0	0.00%
Cabo Verde	0	0.00%
Gambia	0	0.00%
Madagascar	0	0.00%
Mali	0	0.00%
Mozambique	0	0.00%
Sudan)	0	0.00%
Sierra Leone	0	0.00%
Senegal	0	0.00%
Somalia	0	0.00%
Chad	0	0.00%
Togo	0	0.00%

Main African countries with reported presence of *Thaumatotibia leucotreta* exporting cut roses to EU by their relative contributions are Kenya, Ethiopia, Uganda, Zambia and Zimbabwe.

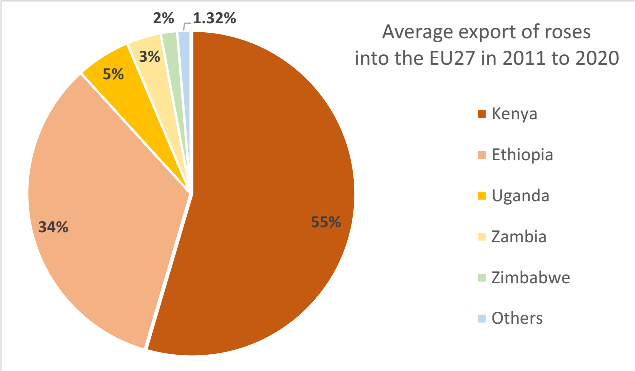

Figure A.7: Average relative export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to EU (Eurostat, EU trade since 1988 by HS2-4-6 and CN8 [DS-645593], CN 06031100, online, accessed on 4 October 2022)

A.3. Areas climatically suitable in Europe

The physiologically based demographic model (PBDM, see Appendix B) identified different climate suitability levels within the European Union by evaluating the potential of establishment of the pest from the physiological response of its developmental stages to climatic variables.

For the definition of the areas climatically suitable in Europe, the model version with the widest extension is used. This is the model with 6°C displacement of larvae mortality relative to adults.

The index for possible establishment ranges in Europe from 1 to 509 predicted pupae per year per NUTS2 region and was divided into four climate suitability classes using the quartiles.

Table A.8: Definition of climate suitability classes in the pathway model using quartiles of the climate suitability index (number of pupae per year per NUTS2 region) in the physiologically based demographic model (PBDM, see Appendix B)

No. pupae/year per NUTS2 region	Climate suitability class	Interpretation	Colour
0	0	Not suitable	(grey)
1 ≤ x < 128	1	Low climate suitability	(blue)
128 ≤ x < 255	2	↓	(teal)
255 ≤ x < 382	3		(yellow)
382 ≤ x < 509	4	High climate suitability	(red)

The physiologically based demographic model is calculated on a 25 × 25 km grid, while the pathway model uses NUTS2 regions for its spatial stratification. A NUTS2 region was assigned the maximum climate suitability class of the grid cell covered by the region. This gives following areas of different climate suitability classes.

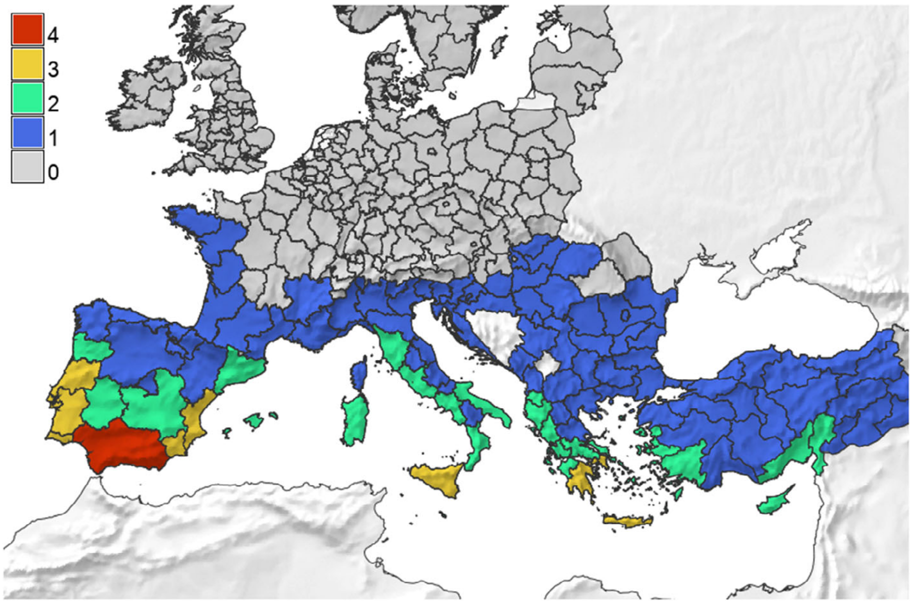

Figure A.8: NUTS 2 regions in EU and some neighbouring countries, and their climate suitability classes according to the potential establishment of *T. leucotreta* based on the average number of pupae/year as estimated by the physiologically based demographic model (PBDM, see Appendix B). 0 = less than 1 pupae/year, 1 = between 1 and 128 pupae/year, 2 = between 128 and 255 pupae/year, 3 = between 255 and 382 pupae/year and 4 = between 382 and 509 pupae/year. Note: Kosovo and Bosnia and Herzegovina are not covered in the layer of NUTS 2 boundaries by Eurostat (year 2021; https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/nuts)

The countries with areas climatically suitable are Portugal, Spain, France, Italy, Malta, Slovenia, Croatia, Greece, Cyprus, Hungary, Bulgaria, Romania.

Due to lacking data on the internal distribution of cut roses within these countries, the model assumes that the roses will be distributed to the NUTS2 regions proportional to the population of the regions.

A.3.1. Import of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to EU

The Netherlands, Belgium and Germany are the main importer of cut roses in Europe, but most of the roses will be re-exported to other European countries. Together, these three countries comprise more than 95% of the import from Africa.

Table A.9: Average annual import of cut roses from African countries with reported presence of FCM and from Israel to EU27 during 2011–2020 by importing country (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, online, accessed on 4 October 2022)

Country	Average annual import of cut roses from African countries with reported presence of FCM and from Israel to EU27	
	Absolute (roses, pcs)	Relative (%)
Total (selected countries of Africa and Israel)	4,411,137,386	100%
The Netherlands	3,376,807,643	76.55%
Belgium	710,493,824	16.11%
Germany	276,623,163	6.27%
Sweden	23,218,812	0.53%
France	**12,992,148**	**0.29%**
Italy	**3,324,573**	**0.08%**
Cyprus	**2,916,762**	**0.07%**

Country	Average annual import of cut roses from African countries with reported presence of FCM and from Israel to EU27	
	Absolute (roses, pcs)	Relative (%)
Ireland	1,661,139	0.04%
Greece	**1,082,122**	**0.02%**
Croatia	**569,584**	**0.01%**
Romania	**460,236**	**0.01%**
Bulgaria	**406,617**	**0.01%**
Spain	**232,484**	**0.01%**
Luxembourg	120,154	0.00%
Austria	95,904	0.00%
Czechia	74,929	0.00%
Slovenia	26,769	0.00%
Poland	10,880	0.00%
Malta	**8,229**	**0.00%**
Portugal	5,475	0.00%
Estonia	3,168	0.00%
Denmark	1,719	0.00%
Hungary	**672**	**0.00%**
Lithuania	206	0.00%
Finland	100	0.00%
Latvia	77	0.00%
Slovakia	0	0.00%

In bold: Countries in the climatically suitable area.

The model therefore considers two main pathways into the areas climatically suitable:

1) Direct import from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to EU countries in the area climatically suitable
2) Re-export of African roses from the Netherlands, Belgium and Germany to EU countries in the area climatically suitable

Re-export of fresh flowers happens usually within few days. Therefore, the model assumes, that re-export will only happens once. Nevertheless, the analysis of Intra-European trade showed that:

- Smaller countries (e.g. Portugal, Malta, Cyprus) in the area climatically suitable are substantially supplied by their neighbouring countries;
- Between the Netherlands and Belgium, a larger trade was recognised, which indicates additional trade exceeding the national consumption.

In both cases, it is likely that the trade figures represent more economic relations (e.g. used airports for import), than real trade flows. To adapt the model to this uncertainty, the countries were additionally clustered in EU regions with assumed closer economic relationships:

- The Netherland and Belgium (for re-export);
- Germany and Luxembourg (for re-export);
- Spain and Portugal (for import);
- Italy and Malta (for import);
- Greece and Cyprus (for import).

Possible re-export from countries outside the EU is not considered due to low market share of other countries.

A.4. Direct import from Africa to the area climatically suitable

The trade data were taken from Eurostat (Table 'EU trade since 1988 by HS2-4-6 and CN8' [DS-045409], downloaded on 24 January 2023 [Data update: 13 January 2023]) using the CN code 0603 11 00 for 'Fresh roses as cut flowers and flower buds of a kind suitable for bouquets or for ornamental purposes' (EC 2021/1832). The trade is retrieved in number of roses ('Supplementary quantity') on monthly values from December 2010 to November 2020.

In the analysis, seasons are aggregated and the mean and standard deviation of trade over the 10 years are calculated. Periods with missing values are not considered. Trade was assumed to be unsteady, if only the first years or only singular seasons are reported. In these cases, the direct trade, esp. to Slovenia, Croatia and Hungary, is assumed to be zero in the model.

Table A.10: Definition of seasons used in the temporal stratification of the pathway model.

Season	Months
Winter	December–February
Spring	March–May
Summer	June–August
Autumn	September–November

In total, 22 million cut roses are annually exported directly from Africa to European countries with areas climatically suitable. The average seasonal volume ranges from 4.4 million in summer to 6.1 million in spring.

Table A.11: Average direct import of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel into the countries of the EU with areas climatically suitable stratified by season (Eurostat, EU trade since 1988 by HS2-4-4-4-6 and CN8, CN 06031100, monthly statistics 12-4-2010-4-12.2020, online, accessed on 25 January 2023)

Season	Direct export of cut roses from African countries with FCM occurrence and from Israel to the EU areas climatically suitable									
	Average seasonal direct trade of cut roses [pcs]									
	Winter		Spring		Summer		Autumn		Annual	
Importer	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Spain & Portugal	106,573	51,173	101,610	52,522	15,344	16,381	78,777	44,764	305,426	83,625
France	2,960,189	1,800,901	3,879,806	2,364,787	2,974,537	1,836,849	2,902,042	2,101,205	12,925,290	3,869,307
Italy & Malta	1,407,232	1,065,589	802,466	421,035	267,157	239,740	865,456	558,681	3,423,925	1,210,909
Slovenia	0	0	0	0	0	0	0	0	0	0
Croatia	0	0	0	0	0	0	0	0	0	0
Greece & Cyprus	1,109,223	312,163	846,886	368,115	914,804	549,670	1,032,039	314,822	3,915,333	783,485
Hungary	0	0	0	0	0	0	0	0	0	0
Bulgaria	214,184	114,673	158,978	80,027	126,039	70,582	191,025	104,772	694,758	185,065
Romania	46,622	41,802	347,955	65,466	117,178	123,854	171,172	181,550	713,979	201,319
Sum	5,844,022		6,137,700		4,415,060		5,240,510		21,978,711	

To cover the annual variation in the model, each seasonal trade volume is included by a normal distribution with the specific mean and standard deviation. Negative values are set to zero.

A.4.1. Direct import from Africa and Israel to EU Member States climatically suitable

A.4.1.1. Direct import from Africa and Israel to Spain and Portugal

The following tables show the detailed annual direct trade from Africa and Israel to the European country clusters.

Table A.12: Average direct import of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Spain and Portugal stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Direct export of cut roses from African countries with FCM occurrence and from Israel to the EU area climatically suitable											
	Importer: Spain & Portugal											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	103,236	9,600	0	33,900	40,110	152,610	165,505	114,040	117,804	122,040	106,573	51,173
Spring	31,040	2,830	0	113,130	141,840	148,402	49,745	130,694	119,432	8,030	101,610	52,522
Summer	0	0	430	1,470	3,098	6,767	37,134	36,234	22,556	150	15,344	16,381
Autumn	0	340	750	37,704	90,035	91,020	62,432	157,974	91,453	20,820	78,777	44,764
Total	134,276	12,770	1,180	186,204	275,083	398,799	314,816	438,942	351,245	151,040		

A.4.1.2. Direct import from Africa and Israel to France

Table A.13: Average direct import of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to France stratified by season (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

	Direct export of cut roses from African countries with FCM occurrence and from Israel to the EUI area climatically suitable											
Season	**Importer: France**											
Year												
Winter	5,596,280	6,722,266	2,372,482	832,821	2,676,646	2,269,597	2,085,767	2,492,516	2,885,476	1,668,034	2,960,189	1,800,901
Spring	7,769,782	6,497,010	1,473,821	701,959	6,327,428	2,577,148	3,242,526	2,597,895	2,640,660	4,969,828	3,879,806	2,364,787
Sommer	7,631,084	3,577,815	1,619,495	1,842,012	3,059,671	2,501,320	1,810,309	1,842,665	1,851,521	4,009,477	2,974,537	1,836,849
Autumn	8,507,193	2,454,707	1,236,657	2,754,378	2,346,986	2,116,546	2,008,757	1,777,857	1,828,043	3,989,292	2,902,042	2,101,205
Total	29,504,339	19,251,798	6,702,455	6,131,170	14,410,731	9,464,611	9,147,359	8,710,933	9,205,700	14,636,631		

A.4.1.3. Direct import from Africa and Israel to Italy and Malta

Table A.14: Average direct import of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Italy and Malta stratified by season (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Direct export of cut roses from African countries with FCM occurrence and from Israel to EU area climatically suitable											
	Importer: Italy & Malta											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	962,803	1,000,999	476,860	824,850	907,680	977,375	1,053,155	1,398,230	4,074,650	2,395,720	1,407,232	1,065,589
Spring	680,097	620,297	291,020	525,926	681,050	649,800	900,270	1,198,090	1,797,566	680,539	802,466	421,035
Sommer	134,720	116,120	3,400	24,020	162,990	354,570	273,480	257,690	698,340	646,240	267,157	239,740
Autumn	451,580	319,570	307,005	470,580	857,562	596,810	773,409	1,493,048	1,813,864	1,571,135	865,456	558,681
Total	2,229,200	2,056,986	1,078,285	1,845,376	2,609,282	2,578,555	3,000,314	4,347,058	8,384,420	5,293,634		

A.4.1.4. Direct import from Africa and Israel to Slovenia

Table A.15: Average direct import of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Slovenia stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 122010-12.2020, online, accessed on 13 January 2023)

Season	Direct export of cut roses from African countries with FCM occurrence and from Israel to the EU area climatically suitable											
	Importer: Slovenia											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	0	0	0	0	0	0	0	0	0	0	0	0
Spring	0	0	0	0	0	0	0	0	0	0	0	0
Sommer	0	102,927	0	0	0	0	0	0	0	0	0	0
Autumn	0	164,759	0	0	0	0	0	0	0	0	0	0
Total	0	267,686	0	0	0	0	0	0	0	0		

A.4.1.5. Direct import from Africa and Israel to Croatia

Table A.16: Average direct import of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Croatia stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Direct export of cut roses from African countries with FCM occurrence and from Israel to the EU area climatically suitable											
	Importer: Croatia											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	863,030	540,730	416,740	0	0	0	0	0	0	0	0	0
Spring	828,155	750,534	568,232	0	0	0	0	0	0	0	0	0
Sommer	468,570	355,471	106,253	0	0	0	0	0	0	0	0	0
Autumn	548,090	404,730	0	0	0	0	0	0	0	0	0	0
Total	2,707,845	2,051,465	1,091,225	0	0	0	0	0	0	0		

A.4.1.6. Direct import from Africa and Israel to Greece and Cyprus

Table A.17: Average direct import of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Greece and Cyprus stratified by season. (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Direct export of cut roses from African countries with FCM occurrence and from Israel to the EU area climatically suitable											
	Importer: Greece & Cyprus											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	1,032,800	710,450	675,060	859,005	1,217,925	977,642	1,308,958	1,242,602	1,451,601	1,616,185	1,109,223	312,163
Spring	536,791	620,195	467,460	736,928	1,007,870	975,032	1,239,143	1,242,926	1,351,166	291,344	846,886	368,115
Summer	528,500	494,050	537,142	727,347	759,907	1,087,659	1,202,638	1,270,758	2,191,819	348,223	914,804	549,670
Autumn	746,336	609,610	692,124	960,376	1,014,232	1,208,207	1,367,877	1,403,582	1,472,738	845,310	1,032,039	314,822
Total	2,844,427	2,434,305	2,371,786	3,283,656	3,999,934	4,248,540	5,118,616	5,159,868	6,467,324	3,101,062		

A.4.1.7. Direct import from Africa and Israel to Hungary

Table A.18: Average direct import of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Hungary stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation. (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Direct export of cut roses from African countries with FCM occurrence and from Israel to the EU area climatically suitable											
	Importer: Croatia											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	0	0	0	0	0	0	0	0	0	0	0	0
Spring	0	0	0	0	0	0	0	0	0	0	0	0
Summer	0	0	0	0	0	0	0	0	0	0	0	0
Autumn	0	0	6,720	0	0	0	0	0	0	0	0	0
Total	0	0	6,720	0	0	0	0	0	0	0		

A.4.1.8. Direct import from Africa and Israel to Bulgaria

Table A.19: Average direct import of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Bulgaria stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation. (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Direct export of cut roses from African countries with FCM occurrence and from Israel to the EU area climatically suitable											
	Importer: Bulgaria											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	15,000	34,700	0	0	149,200	331,218	157,080	242,930	190,490	53,720	214,184	114,673
Spring	11,500	22,210	2,090	24,070	100,410	209,210	196,016	135,124	154,130	34,220	158,978	80,027
Summer	0	0	0	73,520	59,205	161,090	183,290	102,660	123,950	0	126,039	70,582
Autumn	26,880	0	0	124,085	85,608	222,440	295,616	178,250	173,210	4,390	191,025	104,772
Total				221,675	394,423	923,958	832,002	658,964	641,780	92,330		

A.4.1.9. Direct import from Africa and Israel to Romania

Table A.20: Average direct import of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Romania stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation. (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12–2010-12.2020, online, accessed on 13 January 2023)

Season	**Direct export of cut roses from African countries with FCM occurrence and from Israel to the EU area climatically suitable**											
	Importer: Romania											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	54,300	165,610	22,140	0	0	97,858	63,260	16,970	8,400	35,720	46,622	41,802
Spring	81,510	67,250	0	0	280	318,190	436,114	283,443	354,074	40,024	347,955	65,466
Summer	190,600	52,580	0	0	14,628	12,300	286,799	39,240	130,374	0	117,178	123,854
Autumn	245,975	109,400	0	0	124,450	45,430	408,375	13,970	216,911	0	171,172	181,550
Total	572,385	394,840	22,140	0	139,358	473,778	1,194,548	353,623	709,759	75,744		

A.4.2. Inner-national distribution of cut roses

No data on the further regional distribution of cut roses within the countries was available. Approximately the model takes the distribution of the population within the countries (clusters) as approximation for the distribution and consumption of cut roses. The resolution is set to NUTS2 level.

The population size on 1 January 2020 in European NUTS2 regions is taken from Eurostat (Table 'Population on 1 January by age, sex and NUTS 2 region' [DEMO_R_D2JAN], downloaded on 25 January 2023 [Version: 16 November 2022]). Missing data from Croatia were taken from the national CBS (podaci.dzs.hr/2022/en/29031, downloaded on 25 January 2023).

In the model only NUTS2 regions with climate suitability classes 1 to 4 are further considered.

A.4.2.1. NUTS2 regions climatically suitable in Spain and Portugal

Table A.21: List of NUTS2 regions of Spain and Portugal with their absolute and relative population, and climate suitability class (Eurostat 2022, table DEMO_R_D2JAN, total population on 1st January 2020, online, accessed on 25 January 2023)

NUTS code	Label	Population (–)	Proportion (%)	Climate suitability class FCM
ESPTT	**Spain and Portugal**	57,628,523	100.0%	
ES	**Spain**	47,332,614	82.1%	
ES11	Galicia	2,702,592	4.7%	1
ES12	Principado de Asturias	1,018,899	1.8%	1
ES13	Cantabria	582,388	1.0%	1
ES21	País Vasco	2,189,138	3.8%	1
ES22	Comunidad Foral de Navarra	656,509	1.1%	1
ES23	La Rioja	315,931	0.5%	1
ES24	Aragón	1,330,333	2.3%	1
ES30	Comunidad de Madrid	6,747,068	11.7%	1
ES41	Castilla y León	2,401,307	4.2%	1
ES42	Castilla-la Mancha	2,045,554	3.5%	2
ES43	Extremadura	1,061,979	1.8%	2
ES51	Cataluña	7,652,348	13.3%	2
ES52	Comunitat Valenciana	5,029,341	8.7%	3
ES53	Illes Balears	1,210,725	2.1%	2
ES61	Andalucía	8,478,083	14.7%	4
ES62	Región de Murcia	1,504,869	2.6%	3
ES63	Ciudad de Ceuta	84,085	0.1%	3
ES64	Ciudad de Melilla	84,473	0.1%	2
ES70	Canarias	2,236,992	3.9%	
PT	**Portugal**	10,295,909	17.9%	
PT11	Norte	3,575,338	6.2%	2
PT15	Algarve	438,406	0.8%	3
PT16	Centro (PT)	2,217,285	3.8%	3
PT17	Área Metropolitana de Lisboa	2,863,272	5.0%	3
PT18	Alentejo	704,558	1.2%	3
PT20	Região Autónoma dos Açores (PT)	242,796	0.4%	
PT30	Região Autónoma da Madeira (PT)	254,254	0.4%	

A.4.2.2. NUTS2 regions climatically suitable in France

Table A.22: List of NUTS2 regions of France with their absolute and relative population, and climate suitability class (Eurostat 2022, table DEMO_R_D2JAN, total population on 1st January 2020, online, accessed on 25 January 2023)

NUTS code	Label	Population	Proportion	Climate suitability class
		(–)	(%)	FCM
FR	France	67,320,216	100.0%	
FR10	Île de France	12,291,557	18.3%	0
FRB0	Centre - Val de Loire	2,565,726	3.8%	0
FRC1	Bourgogne	1,618,321	2.4%	0
FRC2	Franche-Comté	1,176,196	1.7%	0
FRD1	Basse-Normandie	1,463,606	2.2%	0
FRD2	Haute-Normandie	1,849,826	2.7%	0
FRE1	Nord-Pas-de-Calais	4,061,166	6.0%	0
FRE2	Picardie	1,926,629	2.9%	0
FRF1	Alsace	1,908,494	2.8%	0
FRF2	Champagne-Ardenne	1,311,830	1.9%	0
FRF3	Lorraine	2,315,678	3.4%	0
FRG0	Pays-de-la-Loire	3,818,421	5.7%	1
FRH0	Bretagne	3,358,524	5.0%	1
FRI1	Aquitaine	3,478,538	5.2%	1
FRI2	Limousin	726,253	1.1%	0
FRI3	Poitou-Charentes	1,813,633	2.7%	1
FRJ1	Languedoc-Roussillon	2,864,782	4.3%	1
FRJ2	Midi-Pyrénées	3,087,068	4.6%	1
FRK1	Auvergne	1,371,820	2.0%	0
FRK2	Rhône-Alpes	6,692,326	9.9%	1
FRL0	Provence-Alpes-Côte d'Azur	5,077,582	7.5%	1
FRM0	Corse	345,867	0.5%	1
FRY1	Guadeloupe	412,682	0.6%	
FRY2	Martinique	359,821	0.5%	
FRY3	Guyane	288,086	0.4%	
FRY4	La Réunion	856,858	1.3%	
FRY5	Mayotte	278,926	0.4%	
FRXX	Not regionalised/Unknown NUTS 2	0	0.0%	

A.4.2.3. NUTS2 regions climatically suitable in Italy and Malta

Table A.23: List of NUTS2 regions of Italy and Malta with their absolute and relative population, and climate suitability class (Eurostat 2022, table DEMO_R_D2JAN, total population on 1st January 2020, online, accessed on 25 January 2023)

NUTS code	Label	Population	Proportion	Climate suitability class
		(–)	(%)	FCM
ITMT	**Italy and Malta**	**60,156,052**	**100.0%**	
IT	**Italy**	**59,641,488**	**99.1%**	
ITC1	Piemonte	4,311,217	7.2%	1
ITC2	Valle d'Aosta/Vallée d'Aoste	125,034	0.2%	0
ITC3	Liguria	1,524,826	2.5%	1
ITC4	Lombardia	10,027,602	16.7%	1
ITF1	Abruzzo	1,293,941	2.2%	1

NUTS code	Label	Population	Proportion	Climate suitability class
		(–)	(%)	FCM
ITF2	Molise	300,516	0.5%	1
ITF3	Campania	5,712,143	9.5%	2
ITF4	Puglia	3,953,305	6.6%	2
ITF5	Basilicata	553,254	0.9%	1
ITF6	Calabria	1,894,110	3.1%	2
ITG1	Sicilia	4,875,290	8.1%	3
ITG2	Sardegna	1,611,621	2.7%	2
ITH1	Provincia Autonoma di Bolzano/Bozen	532,644	0.9%	0
ITH2	Provincia Autonoma di Trento	545,425	0.9%	1
ITH3	Veneto	4,879,133	8.1%	1
ITH4	Friuli-Venezia Giulia	1,206,216	2.0%	1
ITH5	Emilia-Romagna	4,464,119	7.4%	1
ITI1	Toscana	3,692,555	6.1%	2
ITI2	Umbria	870,165	1.4%	1
ITI3	Marche	1,512,672	2.5%	1
ITI4	Lazio	5,755,700	9.6%	2
MT	**Malta**	**514,564**	**0.9%**	
MT00	Malta	514,564	0.9%	2

A.4.2.4. NUTS2 regions climatically suitable in Slovenia

Table A.24: List of NUTS2 regions of Slovenia with their absolute and relative population, and climate suitability class (Eurostat 2022, table DEMO_R_D2JAN, total population on 1st January 2020, online, accessed on 25 January 2023)

NUTS code	Label	Population	Proportion	Climate suitability class
		(–)	(%)	FCM
SI	Slovenia	2,095,861	100.0%	
SI03	Vzhodna Slovenija	1,100,012	52.5%	1
SI04	Zahodna Slovenija	995,849	47.5%	1

A.4.2.5. NUTS2 regions climatically suitable in Croatia

Table A.25: List of NUTS2 regions of France with their absolute and relative population, and climate suitability class (Croatian CBS, 2022: Population estimate of Croatia in mid-2021, online: podaci.dzs.hr/2022/en/29031, accessed on 25 January 2023)

NUTS code	Label	Population	Proportion	Climate suitability class
		(–)	(%)	FCM
HR	Croatia	3,878,981	100.0%	
HR02	Pannonian Croatia	1,022,966	26.4%	1
HR03	Adriatic Croatia	1,300,810	33.5%	1
HR04	Continental Croatia			
HR05	City of Zagreb	768,054	19.8%	1
HR06	Northern Croatia	787,151	20.3%	1

A.4.2.6. NUTS2 regions climatically suitable in Greece and Cyprus

Table A.26: List of NUTS2 regions of Greece and Cyprus with their absolute and relative population, and climate suitability class (Eurostat 2022, table DEMO_R_D2JAN, total population on 1st January 2020, online, accessed on 25 January 2023)

NUTS code	Label	Population	Proportion	Climate suitability class
		(–)	(%)	FCM
ELCY	**Greece and Cyprus**	**11,606,570**	**100.0%**	
EL	**Greece**	**10,718,565**	**92.3%**	
EL30	Attiki	3,738,901	32.2%	3
EL41	Voreio Aigaio	229,516	2.0%	2
EL42	Notio Aigaio	347,512	3.0%	2
EL43	Kriti	636,504	5.5%	3
EL51	Anatoliki Makedonia, Thraki	598,613	5.2%	1
EL52	Kentriki Makedonia	1,872,102	16.1%	1
EL53	Dytiki Makedonia	264,670	2.3%	1
EL54	Ipeiros	333,265	2.9%	2
EL61	Thessalia	715,115	6.2%	1
EL62	Ionia Nisia	203,149	1.8%	2
EL63	Dytiki Ellada	651,065	5.6%	2
EL64	Sterea Ellada	556,002	4.8%	2
EL65	Peloponnisos	572,151	4.9%	3
CY	**Cyprus**	**888,005**	**7.7%**	
CY00	Kypros	888,005	7.7%	2

A.4.2.7. NUTS2 regions climatically suitable in Hungary

Table A.27: List of NUTS2 regions of Hungary with their absolute and relative population, and climate suitability class (Eurostat 2022, table DEMO_R_D2JAN, total population on 1 January 2020, online, accessed on 25 January 2023)

NUTS code	Label	Population	Proportion	Climate suitability class
		(–)	(%)	FCM
HU	**Hungary**	**9,769,526**	**100.0%**	
HU11	Budapest	1,750,216	17.9%	0
HU12	Pest	1,297,102	13.3%	1
HU21	Közép-Dunántúl	1,060,755	10.9%	0
HU22	Nyugat-Dunántúl	994,549	10.2%	0
HU23	Dél-Dunántúl	874,573	9.0%	1
HU31	Észak-Magyarország	1,118,577	11.4%	1
HU32	Észak-Alföld	1,442,660	14.8%	1
HU33	Dél-Alföld	1,231,094	12.6%	1
HUXX	Not regionalised/Unknown NUTS 2	0	0.0%	

A.4.2.8. NUTS2 regions climatically suitable in Bulgaria

Table A.28: List of NUTS2 regions of Bulgaria with their absolute and relative population, and climate suitability class (Eurostat 2022, table DEMO_R_D2JAN, total population on 1 January 2020, online, accessed on 25 January 2023)

NUTS code	Label	Population	Proportion	Climate suitability class
		(–)		FCM
BG	Bulgaria	6,951,482	100.0%	
BG31	Severozapaden	728,157	10.5%	1

NUTS code	Label	Population (–)	Proportion	Climate suitability class FCM
BG32	Severen tsentralen	773,450	11.1%	1
BG33	Severoiztochen	924,870	13.3%	1
BG34	Yugoiztochen	1,024,115	14.7%	1
BG41	Yugozapaden	2,094,260	30.1%	1
BG42	Yuzhen tsentralen	1,406,630	20.2%	1

A.4.2.9. NUTS2 regions climatically suitable in Romania

Table A.29: List of NUTS2 regions of Romania with their absolute and relative population, and climate suitability class (Eurostat 2022, table DEMO_R_D2JAN, total population on 1st January 2020, online, accessed on 25 January 2023)

NUTS code	Label	Population (–)	Proportion (%)	Climate suitability class FCM
RO	**Romania**	**19,328,838**	**100.0%**	
RO11	Nord-Vest	2,547,429	13.2%	1
RO12	Centru	2,314,826	12.0%	0
RO21	Nord-Est	3,184,215	16.5%	0
RO22	Sud-Est	2,377,101	12.3%	1
RO31	Sud - Muntenia	2,901,376	15.0%	1
RO32	Bucuresti - Ilfov	2,322,002	12.0%	1
RO41	Sud-Vest Oltenia	1,910,409	9.9%	1
RO42	Vest	1,771,480	9.2%	1

A.4.3. Area of NUTS2 regions climatically suitable

For the distribution of the escaping adults within a NUTS2 region the model focusses on the residential areas only.

Table A.30: Total and residential areas of NUTS2 region in the climatically suitable area of the EU (Eurostat, table LAN_USE_OVW, year: 2018, online, accessed on 20 February 2023)

Country	NUTS code	Area (km^2)	Residential area (km^2)
Spain & Portugal	**ESPT**		
	ES11	29,571	680
	ES12	10,601	147
	ES13	5,326	100
	ES21	7,229	154
	ES22	10,391	47
	ES23	5,045	27
	ES24	47,722	106
	ES30	8,031	438
	ES41	94,225	446
	ES42	79,458	475
	ES43	41,634	280
	ES51	32,110	606
	ES52	23,255	702
	ES53	4,990	428
	ES61	87,600	952

Country	NUTS code	Area (km^2)	Residential area (km^2)
	ES62	11,314	315
	ES63	20	20
	ES64	14	14
	PT11	21,287	655
	PT15	4,997	115
	PT16	28,200	680
	PT17	3,015	226
	PT18	31,604	191
France	**FR**		
	FRG0	32,376	1,998
	FRH0	27,471	1,971
	FRI1	41,804	2,814
	FRI3	25,967	1,158
	FRJ1	27,643	1,112
	FRJ2	45,603	1,803
	FRK2	44,962	2,396
	FRL0	31,839	2,097
	FRM0	8,726	78
Italy & Malta	**ITMT**		
	ITC1	25,387	1,308
	ITC3	5,416	162
	ITC4	23,864	1,383
	ITF1	10,833	255
	ITF2	4,461	111
	ITF3	13,670	679
	ITF4	19,541	546
	ITF5	10,073	138
	ITF6	15,222	402
	ITG1	25,833	639
	ITG2	24,100	306
	ITH2	6,207	90
	ITH3	18,407	1,080
	ITH4	7,862	462
	ITH5	22,453	1,734
	ITI1	22,988	607
	ITI2	8,464	298
	ITI3	9,401	320
	ITI4	17,232	1,013
	MT00	316	56
Slovenia	**SI**		
	SI03	12,433	275
	SI04	7,840	146
Croatia	**HR**		
	HR02	23,220	297
	HR03	24,705	316
	HR05	2,911	167
	HR06	8,028	461

Country	NUTS code	Area (km²)	Residential area (km²)
Greece & Cyprus			
	EL30	3,817	408
	EL41	3,848	66
	EL42	5,311	225
	EL43	8,346	115
	EL51	14,186	226
	EL52	18,838	282
	EL53	9,462	63
	EL54	9,152	52
	EL61	14,050	179
	EL62	2,301	99
	EL63	11,314	115
	EL64	15,560	162
	EL65	15,509	236
	CY00	9,253	284
Hungary	**HU**		
	HU12	6,391	323
	HU23	14,197	344
	HU31	13,426	286
	HU32	17,723	354
	HU33	18,336	538
Bulgaria	**BG**		
	BG31	19,068	185
	BG32	14,812	131
	BG33	14,648	317
	BG34	19,801	119
	BG41	20,301	343
	BG42	22,366	259
Romania	**RO**		
	RO11	34,160	435
	RO22	35,774	355
	RO31	34,467	586
	RO32	1,804	181
	RO41	29,206	556
	RO42	32,042	503

A.4.4. Grading

Cut roses entering the European market are mainly packed in cardboard boxes and will be sorted and re-packed into bunches of 10–20 stems directly after entering the EU. They need to comply with specific quality standards, which will be checked at the grading step. 'Products which do not meet the requirements for pre-treatment, minimum quality, bacteria content and ripeness are not traded and are destroyed if necessary.' (Dutch Centre for the Promotion of Imports from developing countries [CBI], 2017. Exporting roses to Europe. Updated: 13 June 2017. Internet: www.cbi.eu/market-information/cut-flowers-foliage/roses/europe; accessed on 3 February 2023. Because the grading is a responsibility of the trader, parts of the process can be already done at the country of origin (e.g. export of sorted and packed to bunches).

Due to the absence of further detailed information the model assumes a loss of 2–5% of flowers at grading. This margin is frequently accepted for trade of perishable products. The uncertainty on the average proportion is modelled by a Uniform distribution.

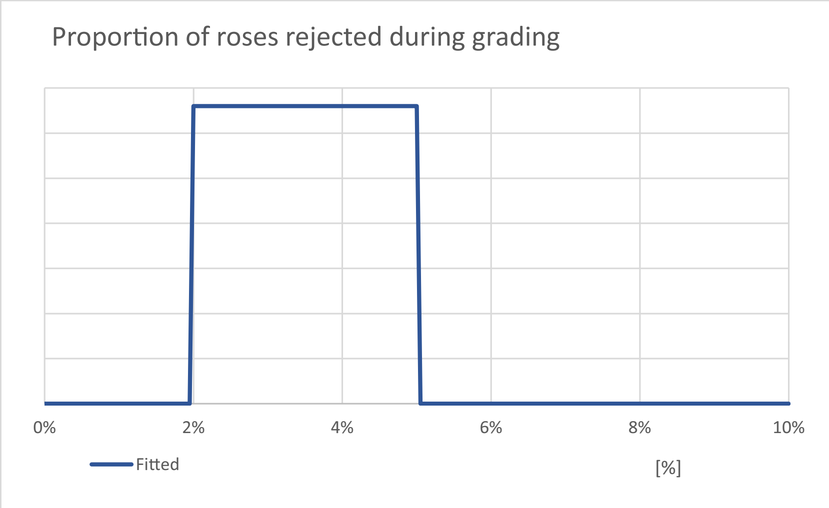

Figure A.9: Density function showing the uncertainty distribution of the proportion of cut roses rejected in grading step directly after import into the EU

It is assumed, that rejected flowers will be transferred into the commercial waste flow for vegetal waste.

A.5. Re-export by the Netherland and Belgium to the climatically suitable area

Also the data on Inner-European trade were taken from Eurostat (Table 'EU trade since 1988 by HS2-4-6 and CN8', accessed on 25 January 2023 [Data update: 13 January 2023]) using the CN code 0603 11 00 for 'Fresh roses as cut flowers and flower buds of a kind suitable for bouquets or for ornamental purposes' (EC 2021/1832). The trade is retrieved in number of roses ('Supplementary quantity') on monthly values from December 2010 to November 2020.

The export of cut roses from the Netherlands and Belgium to European countries with areas climatically suitable is on average 699 million per year. This is more than 30 times more than the direct import of these countries. The average seasonal volume ranges from 145 million in summer to 201 million in spring.

Table A.31: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel into the countries of the EU with areas climatically suitable via the Netherlands and Belgium stratified by season. (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses from the Netherlands and Belgium to the EU area climatically suitable									
	Average seasonal trade of cut roses [pcs]									
	Winter		Spring		Summer		Autumn		Annual	
Importer	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Spain & Portugal	9,456,896	15,986,293	7,960,316	7,132,380	4,474,421	830,011	5,454,526	1,044,759	30,554,150	13,884,949
France	112,100,482	12,025,162	128,525,842	26,247,886	93,037,573	13,036,657	99,774,668	11,094,109	433,439,048	33,492,424
Italy & Malta	46,911,375	4,777,377	45,665,516	7,625,087	32,624,136	3,111,446	42,758,330	4,478,807	167,958,860	10,451,179
Slovenia	921,748	201,786	1,212,569	158,102	871,427	84,731	1,098,204	137,442	4,103,953	302,651
Croatia	1,788,736	1,122,441	2,455,304	1,379,491	1,905,345	903,247	2,139,576	1,068,565	8,350,921	21,78,469
Greece & Cyprus	3,057,764	796,735	2,151,447	761,785	1,461,848	632,963	1,741,536	769,181	8,418,517	1,465,958
Hungary	3,372,167	718,415	4,101,544	1,031,021	3,096,897	497,899	3,206,296	530,643	13,776,885	1,449,223
Bulgaria	714,168	223,717	823,484	310,909	718,250	397,692	835,305	474,415	3,104,691	713,977
Romania	5,678,353	4,218,837	8,493,255	6,079,992	7,144,377	4,528,549	7,864,685	5,354,353	29,858,426	9,568,094
Sum	184,001,688		201,389,277		145,334,275		164,873,126		699,565,450	

To cover the annual variation in the model, each seasonal trade volume is included by a Normal distribution with the specific mean and standard deviation.

A.5.1.1. Export from the Netherlands and Belgium to Spain and Portugal

Table A.32: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Spain and Portugal via the Netherlands and Belgium stratified by season. (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses [pcs] from the Netherland and Belgium to the EU area climatically suitable											
	Importer: Spain and Portugal											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	54,922,392	5,652,691	4,688,797	3,626,780	4,709,680	4,094,909	4,601,809	3,546,874	4,525,384	4,199,646	9,456,896	15,986,293
Spring	9,570,556	7,305,652	5,183,524	5,084,602	5,337,739	27,603,086	4,911,252	4,860,443	6,892,104	2,854,199	7,960,316	7,132,380
Summer	6,418,915	4,438,117	3,529,361	3,876,374	4,371,803	4,466,202	4,193,624	3,792,502	5,253,900	4,403,415	4,474,421	830,011

Season	Export of cut roses [pcs] from the Netherland and Belgium to the EU area climatically suitable											
	Importer: Spain and Portugal											
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean	SD
Autumn	7,006,463	5,112,871	3,890,031	4,986,154	5,182,401	6,443,965	4,348,308	5,089,070	5,543,803	6,942,195	5,454,526	1,044,759
Total	77,918,326	22,509,331	17,291,713	17,573,910	19,601,623	42,608,162	18,054,993	17,288,889	22,215,191	18,399,455		

A.5.1.2. Export from the Netherlands and Belgium to France

Table A.33: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to France via the Netherlands and Belgium stratified by season. (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses (pcs) from the Netherland and Belgium to the EU climatically suitable area											
	Importer: France											
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean	SD
Winter	105,443,649	86,308,088	117,352,998	106,072,208	117,405,185	127,401,101	122,384,930	123,117,862	108,414,921	107,103,882	112,100,482	12,025,162
Spring	113,918,882	100,973,929	119,436,131	124,940,318	147,277,945	161,713,606	150,058,041	152,882,927	136,168,966	77,887,672	128,525,842	26,247,886
Summer	75,537,438	76,934,831	76,807,397	97,689,767	115,366,711	103,772,589	99,150,542	94,501,506	92,539,093 t	98,075,858	93,037,573	13,036,657
Autumn	85,667,581	91,630,564	90,743,824	107,298,307	116,508,744	110,497,034	101,204,375	106,755,003	103,342,089	84,099,161	99,774,668	11,094,109
Total	380,567,550	355,847,412	404,340,350	436,000,600	4,96,558,585	503,384,330	472,797,888	477,257,298	440,465,069	367,166,573		

A.5.1.3. Export from the Netherlands and Belgium to Italy and Malta

Table A.34: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Italy and Malta via the Netherlands and Belgium stratified by season. (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses (pcs) from the Netherland and Belgium to the EU area climatically suitable											
	Importer: Italy and Malta											
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean	SD
Winter	51,212,506	45,487,867	47,078,115	44,951,207	52,564,530	51,367,942	52,371,942	43,205,992	39,486,198	41,387,448	46,911,375	4,777,377
Spring	44,302,035	48,945,386	47,739,292	45,469,677	49,642,989	56,152,297	49,865,702	44,871,286	42,820,139	26,846,361	45,665,516	7,625,087
Summer	30,466,710	30,816,086	36,928,206	30,549,912	36,447,464	35,939,689	34,650,285	31,792,558	27,875,089	30,775,364	32,624,136	3,111,446

Season	Export of cut roses (pcs) from the Netherland and Belgium to the EU area climatically suitable Importer: Italy and Malta										
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean	SD
Autumn	40,818,457	43,150,536	43,413,959	44,613,784	44,566,565	48,417,493	45,930,981	41,741,261	31,535,713	43,394,554	42,758,330	4,478,807
Total	166,799,708	168,399,875	175,159,572	165,584,580	183,221,548	191,877,421	182,818,910	161,611,097	141,717,139	142,403,727		

A.5.1.4. Export from the Netherlands and Belgium to Slovenia

Table A.35: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Slovenia via the Netherlands and Belgium stratified by season. (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses (pcs) from the Netherland and Belgium to the EU area climatically suitable Importer: Slovenia											
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean	SD
Winter	1,005,363	942,239	892,867	860,816	759,867	726,592	855,575	791,601	942,687	1,439,872	921,748	201,786
And Spring	1,343,583	1,331,953	1,277,011	1,094,782	1,109,039	1,102,119	1,157,047	1,149,996	1,541,320	1,018,843	1,212,569	158,102
Summer	1,039,225	854,929	827,672	784,687	766,526	816,391	831,853	914,622	932,086	946,282	871,427	84,731
Autumn	1,213,301	1,125,320	1,058,102	966,095	961,370	1,077,297	983,052	1,056,319	1,123,349	1,417,831	1,098,204	137,442
Total	4,601,472	4,254,441	4,055,652	3,706,380	3,596,802	3,722,399	3,827,527	3,912,538	4,539,442	4,822,828		

A.5.1.5. Export from the Netherlands and Belgium to Croatia

Table A.36: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Croatia via the Netherlands and Belgium stratified by season. (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses (pcs) from the Netherland and Belgium to the EU area climatically suitable Importer: Croatia											
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean	SD
Winter	624,210	484,580	673,707	828,130	1,814,309	1,963,876	2,300,148	2,504,696	2,869,914	3,823,790	1,788,736	1,122,441
Spring	883,970	818,868	697,271	1,424,131	2,687,434	3,687,763	3,445,956	3,443,517	4,451,406	3,012,724	2,455,304	1,379,491
Summer	847,243	801,209	1,034,271	1,195,977	2,059,519	2,747,543	2,025,793	2,381,601	3,458,288	2,502,009	1,905,345	903,247

Season	Export of cut roses (pcs) from the Netherlands and Belgium to the EU area climatically suitable Importer: Croatia											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Autumn	750,690	791,794	1,012,756	1,689,809	2,200,260	2,857,706	2,166,501	3,055,162	3,848,748	3,022,336	2,139,576	1,068,565
Total	3,106,113	2,896,451	3,418,005	5,138,047	8,761,522	11,256,888	9,938,398	11,384,976	14,628,356	12,360,859		

A.5.1.6. Export from the Netherlands and Belgium to Greece and Cyprus

Table A.37: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Greece and Cyprus via the Netherlands and Belgium stratified by season (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses [pcs] from the Netherland and Belgium to the EU area climatically suitable Importer: Greece and Cyprus											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	3,058,945	3,155,845	1,948,872	1,918,740	2,374,786	2,932,047	3,720,640	3,381,805	3,720,117	4,365,838	3,057,764	796,735
Spring	2,332,618	2,483,458	1,222,767	973,875	1,936,915	2,265,068	2,369,365	2,949,135	3,454,441	1,526,823	2,151,447	761,785
Summer	849,296	835,480	713,876	972,249	1,457,777	1,443,578	1,853,957	2,118,312	2,635,520	1,738,431	1,461,848	632,963
Autumn	1,064,463	848,008	721,621	1,241,455	2,046,289	1,618,086	2,416,566	2,459,965	3,023,298	1,975,609	1,741,536	769,181
Total	7,305,322	7,322,791	4,607,136	5,106,319	7,815,767	8,258,779	10,360,528	10,909,217	12,833,376	9,606,701		

A.5.1.7. Export from the Netherlands and Belgium to Hungary

Table A.38: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Hungary via the Netherlands and Belgium stratified by season (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses [pcs] from the Netherlands and Belgium to the EU area climatically suitable Importer: Hungary											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	4,346,528	4,346,528	4,346,528	3,122,310	2,823,419	3,490,718	2,734,464	2,581,344	3,131,580	2,798,249	3,372,167	718,415
Spring	4,756,980	5,024,544	3,781,356	3,571,663	3,301,393	5,919,991	3,904,358	4,128,578	4,469,345	2,157,236	4,101,544	1,031,021
Summer	3,296,814	3,020,070	2,856,324	3,118,007	3,654,948	4,073,845	2,469,502	3,050,100	3,008,869	2,420,491	3,096,897	497,899

Season	Export of cut roses [pcs] from the Netherlands and Belgium to the EU area climatically suitable Importer: Hungary											
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean	SD
Autumn	3,787,750	2,740,039	3,101,069	3,191,286	3,843,916	3,395,119	2,470,416	3,802,608	3,310,171	2,420,583	3,206,296	530,643
Total	16,188,072	15,131,181	14,085,277	13,003,266	13,623,676	16,879,673	11,578,740	13,562,630	13,919,965	9,796,559		

A.5.1.8. Export from the Netherlands and Belgium to Bulgaria

Table A.39: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Bulgaria via the Netherlands and Belgium stratified by season. (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses [pcs] from the Netherlands and Belgium to the EU area climatically suitable Importer: Bulgaria											
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean	SD
Winter	701,933	686,740	538,284	418,049	606,632	553,377	643,998	1,133,920	829,972	1,028,770	714,168	223,717
Spring	719,991	522,810	705,171	472,013	623,786	749,185	837,847	1,128,000	1,511,261	964,776	823,484	310,909
Summer	457,355	355,147	389,682	329,470	477,217	645,155	1,444,716	922,922	1,266,157	894,682	718,250	397,692
Autumn	562,702	477,338	522,199	415,767	527,285	747,746	1,423,528	862,931	1,879,353	934,199	835,305	474,415
Total	2,441,981	2,042,035	2,155,336	1,635,299	2,234,920	2,695,463	4,350,089	4,047,773	5,486,743	3,822,427		

A.5.1.9. Export from the Netherlands and Belgium to Romania

Table A.40: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Romania via the Netherlands and Belgium stratified by season (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses [pcs] from the Netherland and Belgium to the EU area climatically suitable Importer: Romania											
Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean	SD
Winter	2,326,982	1,683,713	2,872,126	2,008,723	1,988,658	6,640,686	5,915,151	8,859,692	11,640,742	12,847,059	5,678,353	4,218,837
Spring	2,476,565	4,347,120	2,552,544	3,282,221	2,981,559	10,397,611	11,460,874	14,759,952	18,758,298	13,915,809	8,493,255	6,079,992
Summer	2,255,004	3,154,482	4,017,982	3,430,715	2,870,267	7,640,417	9,884,183	12,849,892	13,545,425	11,795,401	7,144,377	4,528,549

Season	Export of cut roses [pcs] from the Netherland and Belgium to the EU area climatically suitable Importer: Romania										
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Autumn	1,984,667	2,931,792	3,765,089	2,742,336	5,009,901	7,731,739	10,286,333	14,751,512	15,255,584	14,187,898	7,864,685	5,354,353
Total	9,043,218	12,117,107	13,207,741	11,463,995	12,850,385	32,410,453	37,546,541	51,221,048	59,200,049	52,746,167		

A.5.2. Dilution of African cut roses during re-export by the Netherlands and Belgium

The origin of the cut roses is not traced when these are being re-exported for intra-EU trade from the Netherlands and Belgium. A dilution may happen, when they are mixed with roses of other origins including the production in the Netherlands and Belgium itself.

To estimate the dilution, factor the model uses information on the import of cut roses from third countries outside the EU excluding the African import, and the total import of cut roses excluding the African import. The latter includes also import from other European countries.

While the Netherlands and Belgium imported on annual average 4,034 million cut roses from African FCM countries and 264 million from other third countries, the total import from Non-African FCM countries is 875 million roses (incl. intra-EU trade). The own production of cut roses in the Netherlands and Belgium is about 122 million.

A.5.2.1. Direct export of cut roses from African countries with FCM occurrence and from Israel to the Netherlands and Belgium

Table A.41: Average direct export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to the Netherlands and Belgium stratified by season (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Direct export of cut roses (pcs) from African countries with FCM occurrence and from Israel to the Netherlands and Belgium Exporter: African countries with reported occurrence of FCM and Israel											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	968,311,592	899,907,368	962,253,601	912,705,433	1,002,526,366	1,045,167,474	998,528,528	991,120,020	1,042,930,826	1,004,207,567	982,765,878	48,403,322
Spring	1,088,359,634	1,078,252,708	1,082,907,378	1,160,242,521	1,194,317,742	1,252,616,965	1,216,071,008	1,126,489,283	1,225,796,204	914,716,166	1,133,976,961	99,723,029
Summer	856,247,226	792,848,979	803,373,275	1,009,336,075	976,441,600	938,395,539	974,945,987	841,497,757	883,725,177	921,901,345	899,871,296	75,856,641
Autumn	931,377,554	948,755,946	981,919,812	1,027,628,033	1,081,044,981	1,035,893,806	1,030,055,155	1,052,462,689	1,036,091,544	1,052,989,797	1,017,821,932	48,156,920
Total	3,844,296,006	3,719,765,001	3,830,454,066	4,109,912,062	4,254,330,689	4,272,073,784	4,219,600,678	4,011,569,749	4,188,543,751	3,893,814,875	4,034,436,066	201,558,934

A.5.2.2. Export from Non-EU countries (different from African countries with FCM occurrence and Israel) to the Netherlands and Belgium

Table A.42: Average export of cut roses from countries outside the EU (excluding the African countries with reported presence of *Thaumatotibia leucotreta* and Israel) to the Netherlands and Belgium stratified by season (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses [pcs] from Non-EU countries (excluding African countries with FCM occurrence and Israel) to the Netherlands and Belgium											
	Exporter: All countries outside EU27 (2020) (excluding African countries with FCM occurrence and Israel)											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	57,219,395	62,838,666	55,824,054	68,010,189	70,661,224	79,576,154	66,049,118	71,153,040	81,133,470	95,954,508	70,841,982	12,106,589
Spring	52,810,406	59,368,783	55,656,894	61,398,802	65,396,635	76,929,861	67,769,557	87,204,694	90,357,076	58,271,159	67,516,387	13,117,814
Summer	39,467,290	44,117,164	42,493,733	46,854,560	51,622,219	54,417,987	52,111,798	66,038,031	68,913,177	67,884,829	53,392,079	10,842,946
Autumn	56,227,276	58,780,418	59,426,662	63,269,178	67,875,321	72,597,561	72,829,050	84,295,425	85,670,656	98,199,028	71,917,058	13,744,875
Total	205,724,367	225,105,031	213,401,343	239,532,729	255,555,399	283,521,563	258,759,523	308,691,190	326,074,379	320,309,524	263,667,505	44,181,183

A.5.2.3. Export from all countries (including EU countries; excluding African countries with FCM occurrence and Israel) to the Netherlands and Belgium

Table A.43: Average export of cut roses from all countries (including other EU countries; excluding African countries with reported presence of *Thaumatotibia leucotreta* and Israel) to the Netherlands and Belgium stratified by season (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses [pcs] from all countries (excluding African countries with FCM occurrence and Israel) to the Netherlands and Belgium											
	Exporter: All countries including EU27 (2020) (excluding African countries with FCM occurrence and Israel)											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	74,503,091	119,991,131	121,163,875	130,573,999	141,665,463	424,630,986	360,752,981	214,006,436	151,287,708	342,825,815	208,140,149	122,562,989
Spring	80,363,073	131,168,647	148,345,013	157,541,324	423,672,557	485,353,485	464,134,848	250,543,206	179,912,356	324,401,863	264,543,637	149,636,638
Summer	89,406,636	116,909,664	112,385,598	113,030,775	409,059,708	422,248,395	112,722,488	139,778,234	134,146,359	193,269,355	184,295,721	125,004,409
Autumn	122,573,769	129,665,466	138,068,493	136,168,094	421,034,045	425,570,306	136,623,353	172,469,809	150,816,977	342,363,256	217,535,357	126,040,423
Total	366,846,569	497,734,908	519,962,979	537,314,192	1,395,431,773	1,757,803,172	1,074,233,670	776,797,685	616,163,400	1,202,860,289	874,514,864	461,235,861

A.5.2.4. Own production of cut roses in the Netherlands and Belgium

The national statistical office of the Netherlands (CBS: opendata.cbs.nl/statline/) reports the area of cut roses production for certain years in open fields and glasshouses.

Table A.44: Production surface of cut roses in the Netherlands for specific years (Dutch CBS: opendata.cbs.nl/statline/ keyword: 'rozen', online, accessed on 21 March 2023)

Area of production of cut roses in the Netherlands				
Unit	**(ha)**			
Year	2010	2015	2020	Mean
Total	501	286	217	334

Similar data were not available for Belgium. Instead, the relation of area for all flower and ornamental production (Eurostat: Crops by classes of utilised agricultural area) in the Netherland and Belgium was used to estimate a factor of 111% to extrapolate from the area of the Netherland to the area of both, the Netherlands and Belgium.

Table A.45: Production surface of flowers and ornamentals of Belgium in comparison to the Netherlands for specific years (Eurostat: Crops by classes of utilised agricultural area [EF_LUS_ALLCROPS], online, accessed on 1 February 2023)

Area of production of flowers and ornamentals			
Unit	**(ha)**		
Year	2013	2016	Mean
The Netherlands	30,590	32,630	31,610
Belgium	1,510	5,270	3,390
Factor: Sum/NL	105%	116%	111%

To convert the production area into the number of produced cut roses a productivity of 200,000 roses/ha was used. The estimation was informed by productivity figures of different types of roses, flowers per plant and plants per ha. The reported data ranges roughly from 150,000 to 320,000.

The mean values were used to calculate the average, annual production of cut roses in the Netherland and Belgium:

$$\text{Production (NL + BE, pcs)} = \text{Area (NL)} \times \text{Extrapolation (NL + BE)} \times \text{Conversion (pcs/ha)}$$

$$122,261,130 \text{ pcs} = 553 \text{ ha} \times 111\% \times 200,000 \text{ pcs/ha}$$

Finally, the production is equally distributed on all four seasons (30,565,283 pcs/season), reasoned by a higher consumption in spring, but an assumed additional outdoor production in summer.

A.5.2.5. Dilution

For the calculation of the dilution rate two scenarios were assessed:

- In scenario 1 the Netherlands and Belgium get non-infested roses from other countries than the African countries with FCM occurrence and Israel, including the intra-EU trade, for re-export. This gives a higher dilution and low dilution factor (proportion of cut roses from African countries with FCM occurrence and Israel in re-export).
- In scenario 2 the intra-EU trade to the Netherlands and Belgium is not re-exported to further countries. This gives a lower dilution and higher dilution factor.

Table A.46: Calculation of the dilution factor in the Dutch/Belgian cluster using two scenarios (with or without intra-European trade)

Season	**Dilution of cut roses from African countries with occurrence of FCM and from Israel by other import and own production**							
	Scenario 1				**Scenario 2**			
	Import from African countries with FCM and Israel	**Other import (World+EU27)**	**Own production**	**Low dilution factor**	**Import from African countries with FCM and Israel**	**Other import (World, not EU)**	**Own production**	**High dilution factor**
	a	b1	c	a/(a + b1 + c)	a	b2	c	a/(a + b2 + c)
Winter	982,765,878	208,140,149	30,565,283	**80%**	982,765,878	70,841,982	30,565,283	**91%**
Spring	1,133,976,961	264,543,637	30,565,283	**79%**	1,133,976,961	67,516,387	30,565,283	**92%**
Summer	899,871,296	184,295,721	30,565,283	**81%**	899,871,296	53,392,079	30,565,283	**91%**
Autumn	1,017,821,932	217,535,357	30,565,283	**80%**	1,017,821,932	71,917,058	30,565,283	**91%**
Total	4,034,436,066	874,514,864	122,261,130		4,034,436,066	263,667,505	122,261,130	

In the model calculation a Uniform distribution between the low and high scenario is used to describe the uncertainty on the current proportion of cut roses from African countries with FCM occurrence and from Israel in re-export.

A.6. Re-export (intra-EU trade) from Germany and Luxembourg to the EU area climatically suitable

Also, the data on Inner-European trade were taken from Eurostat (Table 'EU trade since 1988 by HS2-4-6 and CN8' [DS-045409], downloaded on 24th January 2023 [Data update: 13 January 2023]) using the CN code 0603 11 00 for 'Fresh roses as cut flowers and flower buds of a kind suitable for bouquets or for ornamental purposes' (EC 2021/1832). The trade is retrieved in number of roses ('Supplementary quantity') on monthly values from December 2010 to November 2020.

The export of cut roses from Germany and Luxembourg to EU countries with areas climatically suitable is limited to France, Italy and Malta. It comprises 1.8 million cut flowers in total. The average seasonal volume ranges from 0.34 million in summer to 0.42 million in spring. For all other countries the trade is unsteady and assumed to be zero in the model.

Table A.47: Average re-export (intra-EU trade) of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel into the countries of the EU with areas climatically suitable via Germany and Luxembourg stratified by season (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	**Export of cut roses from Germany and Luxembourg to the EU area climatically suitable**									
	Average seasonal trade of cut roses (pcs)									
	Winter		**Spring**		**Summer**		**Autumn**		**Annual**	
Importer	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Spain & Portugal	0	0	167,808	97,037	0	0	0	0	169,461	93,508
France	175,465	187,776	235,545	242,386	131,374	142,615	567,938	1,284,961	1,440,994	979,315
Italy & Malta	155,077	250,723	177,537	298,559	123,696	302,040	157,018	370,555	856,180	454,646
Slovenia	0	0	0	0	0	0	0	0	0	0
Croatia	0	0	0	0	0	0	0	0	0	0
Greece & Cyprus	0	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	0	0	0	0
Sum	330,542		580,891		255,071		724,956		2,466,636	

To cover the annual variation in the model, each seasonal trade volume is included by a Normal distribution with the specific mean and standard deviation.

A.6.1.1. Export from Germany and Luxembourg to Spain and Portugal

Table A.48: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Spain and Portugal via Germany and Luxembourg stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	**Export of cut roses (pcs) from Germany and Luxembourg to the EU area climatically suitable**											
	Importer: Spain and Portugal											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	0	2,560	0	26,360	952,000	0	10	0	0	1	0	0
Spring	0	0	2	47,520	126,920	137,560	147,650	186,448	164,096	364,464	167,808	97,037
Summer	6,200	0	0	0	1	0	1	0	0	0	0	0

Season	Export of cut roses (pcs) from Germany and Luxembourg to the EU area climatically suitable Importer: Spain and Portugal											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Autumn	15	14	0	8,320	0	34,560	0	0	50	110,806	0	0
Total	6,215	2,574	2	82,200	1,078,921	172,120	147,661	186,448	164,146	475,271		

A.6.1.2. Export from Germany and Luxembourg to France

Table A.49: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to France via Germany and Luxembourg stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses [pcs] from Germany and Luxembourg to the EU area climatically suitable Importer: France											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	418,323	422,709	480,492	119,157	55,278	86,425	122,551	23,952	16,070	9,695	175,465	187,776
Spring	703,801	354,210	553,036	184,632	139,576	307,278	93,618	7,598	10,665	1,040	235,545	242,386
Summer	171,349	203,647	129,674	76,088	485,755	112,243	116,293	6,883	7,853	3,959	131,374	142,615
Autumn	448,670	547,480	146,687	129,470	4,186,056	133,551	73,318	4,272	3,707	6,167	567,938	1,284,961
Total	1,742,143	1,528,046	1,309,889	509,347	4,866,665	639,497	405,780	42,705	38,295	20,861		

A.6.1.3. Export from Germany and Luxembourg to Italy and Malta

Table A.50: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Italy and Malta via Germany and Luxembourg stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses (pcs) from Germany and Luxembourg to the EU area climatically suitable Importer: Italy and Malta											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	14,2173	18,132	116,884	2,616	90,308	180,388	2,024	260	157,418	840,569	155,077	250,723
Spring	47,981	5,907	52,842	2,149	2,050	21,883	45	488,427	255,100	898,987	177,537	298,559

Season	Export of cut roses (pcs) from Germany and Luxembourg to the EU area climatically suitable Importer: Italy and Malta											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Summer	19,213	3,149	17,411	3,186	2,299	133	4,591	3,493	222,278	961,210	123,696	302,040
Autumn	23,535	70,493	10,522	6,023	5,499	1,014	1,841	2	265,425	1,185,830	157,018	370,555
Total	232,902	97,681	197,659	13,974	100,156	203,418	8,501	492,182	900,221	3,886,596		

A.6.1.4. Export from Germany and Luxembourg to Slovenia

Table A.51: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Slovenia via Germany and Luxembourg stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses [pcs] from Germany and Luxembourg to the EU area climatically suitable Importer: Slovenia											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	8,462	10,390	9,320	9,240	2,280	0	0	3,150	0	0	0	0
Spring	16,380	22,754	1,600	18,230	600	0	2,110	0	4,225	0	0	0
Summer	1,050	10,940	7,500	480	0	0	0	0	817	1,340	0	0
Autumn	9,125	24,292	3,690	6,600	0	0	750	550	0	3,850	0	0
Total	35,017	68,376	22,110	34,550	2,880	0	2,860	3,700	5,042	5,190		

A.6.1.5. Export from Germany and Luxembourg to Croatia

Table A.52: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Croatia via Germany and Luxembourg stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses (pcs) from Germany and Luxembourg to the EU area climatically suitable Importer: Croatia											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	13,000	0	0	0	0	0	0	208,780	45,552	0	0	0
Spring	0	3,660	60	0	0	0	3,150	338,338	7,084	384	0	0

Season	Export of cut roses (pcs) from Germany and Luxembourg to the EU area climatically suitable											
	Importer: Croatia											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Summer	640	8,520	220	0	0	0	0	36,790	0	18,144	0	0
Autumn	0	0	0	0	0	0	0	171,964	0	33,180	0	0
Total	13,640	12,180	280	0	0	0	3,150	755,872	52,636	51,708		

A.6.1.6. Export from Germany and Luxembourg to Greece and Cyprus

Table A.53: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Greece and Cyprus via Germany and Luxembourg stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses (pcs) from Germany and Luxembourg to the EU area climatically suitable											
	Importer: Greece and Cyprus											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	22,225	100,193	0	0	0	0	0	0	0	12	0	0
Spring	8,080	25	0	0	0	0	0	0	0	0	0	0
Summer	200	25	0	0	0	0	0	0	0	0	0	0
Autumn	16,108	0	0	0	0	0	0	0	0	0	0	0
Total	46,613	100,243	0	0	0	0	0	0	0	12		

A.6.1.7. Export from Germany and Luxembourg to Hungary

Table A.54: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Hungary via Germany and Luxembourg stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses (pcs) from Germany and Luxembourg to the EU area climatically suitable											
	Importer: Hungary											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	2,360	25,832	0	0	0	0	0	0	0	0	0	0

Season	Export of cut roses (pcs) from Germany and Luxembourg to the EU area climatically suitable Importer: Hungary											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Spring	0	0	0	0	0	72,000	0	0	0	0	0	0
Summer	0	65,100	0	468	0	0	0	0	0	0	0	0
Autumn	0	200	14,378	0	0	0	0	0	0	0	0	0
Total	2,360	91,132	14,378	468	0	72,000	0	0	0	0		

A.6.1.8. Export from Germany and Luxembourg to Bulgaria

Table A.55: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Bulgaria via Germany and Luxembourg stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation. (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses (pcs) from Germany and Luxembourg to the EU area climatically suitable Importer: Bulgaria											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	48,785	14,600	0	0	0	1,000	6,886	0	0	0	0	0
Spring	39,160	0	0	0	0	0	0	0	0	0	0	0
Summer	17,375	0	0	0	0	0	0	0	314	0	0	0
Autumn	23,655	0	0	0	0	12,060	0	0	433	0	0	0
Total	128,975	14,600	0	0	0	13,060	6,886	0	747	0		

A.6.1.9. Export from Germany and Luxembourg to Romania

Table A.56: Average re-export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Romania via Germany and Luxembourg stratified by season. Cells marked in grey are not used to calculate the mean and standard deviation (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses [pcs] from Germany and Luxembourg to the EU area climatically suitable Importer: Romania											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	11,730	10,691	7,120	0	0	0	976,326	0	13,152	2,940	0	0
Spring	10,678	10,298	0	410	0	648,000	0	0	0	3,836	0	0

Season	Export of cut roses [pcs] from Germany and Luxembourg to the EU area climatically suitable Importer: Romania											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Summer	26,638	123,752	45,360	720	0	146,920	0	92,136	3,864	0	0	0
Autumn	50,540	140,532	0	340	0	2,298,240	233,280	110	0	2,926	0	0
Total	99,586	285,273	52,480	1,470	0	3,093,160	1,209,606	92,246	17,016	9,702		

A.6.2. Dilution of African cut roses during re-export by Germany and Luxembourg

Similar to the dilution in the Netherland and Belgium a corresponding factor was estimated for Germany and Luxembourg.

While Germany and Luxembourg imported on annual average 273 million cut roses from African countries with FCM occurrence and Israel and 19 million from other third countries, the total import from countries where FCM is absent is 1,110 million roses (including EU countries, esp. the Netherlands and Belgium). The own production of cut roses in the Germany and Luxembourg is about 61 million.

A.6.2.1. Direct export from African countries with FCM occurrence and Israel to Germany and Luxembourg

Table A.57: Average direct export of cut roses from African countries with reported presence of *Thaumatotibia leucotreta* and from Israel to Germany and Luxembourg stratified by season (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Direct export of cut roses [pcs] from African countries with FCM occurrence and from Israel to Germany and Luxembourg Exporter: African countries with reported occurrence of FCM and Israel											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	66,183,111	68,038,967	63,033,999	58,479,160	65,858,076	61,729,455	57,970,454	61,629,019	52,061,581	77,339,328	63,232,315	6,812,138
Spring	77,470,073	77,402,267	70,941,533	69,233,447	86,184,881	74,817,527	76,730,243	71,251,024	84,301,324	62,516,130	75,084,845	7,040,119
Summer	70,033,416	60,103,519	70,507,279	64,234,869	73,989,473	68,801,088	72,301,862	59,117,096	74,002,658	54,502,781	66,759,404	6,861,288
Autumn	72,468,416	63,139,415	70,172,519	69,192,138	79,131,192	67,404,126	72,521,837	60,642,306	67,804,899	55,741,864	67,821,871	6,654,630
Total	286,155,016	268,684,168	274,655,330	261,139,614	305,163,622	272,752,196	279,524,396	252,639,445	278,170,462	250,100,103	272,898,435	16,254,249

A.6.2.2. Export from the non-EU countries (different from African countries with FCM occurrence and Israel) to Germany and Luxembourg

Table A.58: Average export of cut roses from countries outside the EU (excluding the African countries with reported presence of *Thaumatotibia leucotreta* and Israel) to Germany and Luxembourg stratified by season (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses [pcs] from Non-EU countries (excluding African countries with FCM occurrence and Israel) to Germany and Luxembourg Exporter: All countries outside EU27 (2020) (excluding African countries with FCM occurrence and Israel)											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	10,381,450	8,329,155	6,366,583	7,355,775	5,769,171	4,104,950	4,112,952	3,661,479	2,858,588	2,395,018	5,533,512	2,581,063
Spring	8,805,197	7,412,268	7,106,249	7,435,264	6,223,055	3,571,263	4,144,927	3,761,527	3,110,066	1,285,485	5,285,530	2,427,199
Summer	6,051,951	4,883,054	4,743,628	6,279,209	4,236,482	3,236,675	2,875,200	2,620,271	1,870,404	894,182	3,769,106	1,769,923
Autumn	8,710,025	6,284,306	7,276,253	7,009,185	4,676,858	4,431,852	3,958,670	3,243,049	2,387,310	258,805	4,823,631	2,543,496
Total	33,948,623	26,908,783	25,492,713	28,079,433	20,905,566	15,344,740	15,091,749	13,286,326	10,226,368	4,833,490	19,411,779	9,137,744

A.6.2.3. Export from all countries (excluding African countries with FCM occurrence and Israel) to Germany and Luxembourg

Table A.59: Average export of cut roses from all countries (including other EU countries; excluding African countries with reported presence of *Thaumatotibia leucotreta* and Israel) to Germany and Luxembourg stratified by season (Eurostat, EU trade since 1988 by HS2-4-6 and CN8, CN 06031100, monthly statistics 12-2010-12.2020, online, accessed on 13 January 2023)

Season	Export of cut roses [pcs] from all countries (excluding African countries with FCM occurrence and Israel) to Germany and Luxembourg Exporter: All countries including EU27 (2020) (excluding African FCM countries and Israel)											
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean**	**SD**
Winter	200,069,796	212,226,199	193,216,213	254,689,631	252,022,490	236,711,711	299,011,853	275,433,513	274,884,677	267,031,911	246,529,799	35,252,866
Spring	238,094,718	278,311,529	275,137,340	312,314,358	306,767,513	366,977,231	343,313,811	341,755,120	332,460,379	313,978,686	310,911,069	38,416,344
Summer	209,282,507	235,277,209	233,861,580	345,111,859	256,121,346	324,539,694	295,690,036	286,419,206	311,857,411	284,226,411	278,238,726	43,732,132
Autumn	205,049,967	224,776,785	255,457,710	273,628,807	255,962,295	299,543,671	306,875,394	310,841,076	294,433,230	320,510,954	274,707,989	38,747,980
Total	852,496,988	950,591,722	957,672,843	1,185,744,655	1,070,873,644	1,227,772,307	1,244,891,094	1,214,448,915	1,213,635,697	1,185,747,962	1,110,387,583	142,065,164

A.6.2.4. Own production of cut roses in Germany

The national statistical office of Germany (DEStatis:Zierpflanzenanbau Report 2021, downloaded on 1 February 2023) reports the area of cut roses production for certain years.

Table A.60: Production surface of cut roses in Germany for specific years (DEStatis: Zierpflanzenanbau Report 2021, online, accessed on 1 February 2023)

Area of production of cut roses in Germany				
Unit	**(ha)**			
Year	2012	2017	2021	Mean
Total	354	323	234	304

Similar data were not available for Luxembourg. Instead, the relation of area for all flower and ornamental production (Eurostat: Crops by classes of utilised agricultural area) in Germany and Luxembourg was used. It reports in 2016 no additional production area in Luxembourg.

Table A.61: Production surface of flowers and ornamentals of Luxembourg in comparison to Germany for specific years (Eurostat: Crops by classes of utilised agricultural area [EF_LUS_ALLCROPS], online, accessed on 1 February 2023)

Area of production of flowers and ornamentals			
Unit	**[ha]**		
Year	2013	2016	Mean
Germany	7,710	7,640	7,675
Luxembourg		0	0
Factor: Sum/NL	100%	100%	100%

To convert the production area into the number of produced cut roses, a productivity of 200,000 roses/ha was used. The estimation was informed by productivity figures of different types of roses, flowers per plant and plants per ha. The reported data ranges roughly from 150,000 to 320,000.

The mean values were used to calculate the average, annual production of cut roses in the Germany and Luxembourg:

$$\text{Production (DELU, pcs)} = \text{Area (DE)} \times \text{Extrapolation (DELU)} \times \text{Conversion (pcs/ha)}$$

$$60,733,333 \text{ pcs} = 304 \text{ ha} \times 100\% \times 200,000 \text{ pcs/ha}$$

Finally, the production is equally distributed on all four seasons (15,183,333 pcs/season), reasoned by a higher consumption in spring, but an assumed additional outdoor production in summer.

A.6.2.5. Dilution

For the calculation of the dilution rate, two scenarios were assessed:

- In scenario 1, Germany and Luxembourg get non-infested roses from other countries than the African countries with FCM occurrence and Israel, including the intra-EU trade, for re-export. This gives a higher dilution and low dilution factor (proportion of African countries with FCM occurrence and Israel in intra-EU trade re-export).
- In scenario 2, the intra-EU trade to Germany and Luxembourg is not re-exported to further countries. This gives a lower dilution and higher dilution factor.

Table A.62: Calculation of the dilution factor in the German/Luxembourg cluster using two scenarios (with or without intra-European trade)

Season	Dilution of cut roses from African countries with occurrence of FCM and Israel by other import and own production							
	Scenario 1				Scenario 2			
	Import from African countries with FCM and Israel	Other import (World+EU27)	Own production	Low dilution factor	Import from African countries with FCM and Israel	Other import (World, not EU)	Own production	High dilution factor
	a	b1	c	a/(a + b1 + c)	a	b2	c	a/(a + b2 + c)
Winter	63,232,315	246,529,799	15,183,333	19%	63,232,315	5,533,512	15,183,333	75%
Spring	75,084,845	310,911,069	15,183,333	19%	75,084,845	5,285,530	15,183,333	79%
Summer	66,759,404	278,238,726	15,183,333	19%	66,759,404	3,769,106	15,183,333	78%
Autumn	67,821,871	274,707,989	15,183,333	19%	67,821,871	4,823,631	15,183,333	77%
Total	272,898,435	1,110,387,583	60,733,333		272,898,435	19,411,779	60,733,333	

A.7. Infestation of cut roses at entry into the EU

A.7.1. Life stage of FCM at entry

The life stage at entry was assessed by Expert Knowledge Elicitation of two parameters:

- (Question 1a) the proportion of infested roses infested with eggs at border control;
- (Question 1b) the proportion of infested roses, which are not infested with eggs, but infested with young larvae (L1 or L2) at border control.

These life stages are difficult to detect. Especially early larval stages can only be detected by empty eggshells and entry holes.

It is assumed, that

- due to feeding damages and excrements the later larval stages (L3, L4 or L5) will be detected and sorted out at the place of origin;
- due to handling the pupae and adults are unlikely to be in imported cut flowers.

Following quantitative evidence was discussed during the EKE:

Cited from the Dutch report 'Development stage of intercepted *Thaumatotibia leucotreta* specimens' (NVWA, 2022: Development stage of intercepted *Thaumatotibia leucotreta* specimens; personal communication, 12 October 2022):

Results: *Life stages of intercepted specimens of Thaumatotibia leucotreta on cut roses were recorded by the NPPO for 452 specimens in the period 2015–2018 and for 190 specimens in the period 2019–2022. The table below provides an overview of the life stages detected on cut roses. The results are summarised for all origins. The table indicates that, after T. leucotreta was regulated as a quarantine species, there has been a clear shift in the interceptions towards younger life-stages. Since then, 50% of the interceptions concern eggs while the fraction of intercepted older larval stages (L2/L3 to L5) have decreased*.

Table A.63: Life-stages of intercepted specimens of *Thaumatotibia leucotreta* on cut roses as reported by the Dutch NPPO in the years 2015–2022 (NVWA, 2022: Development stage of intercepted *Thaumatotibia leucotreta* specimens; personal communication, 12 October 2022)

Intercepted life-stage	Roses (2015–2018) (n = 364)	Roses (2019–2022) (n = 190)
Eggs	54 (15%)	95 (50%)
L1	131 (36%)	28 (15%)
L1 or L2	–	33 (17%)
L2	85 (23%)	19 (10%)
L3	49 (13%)	7 (4%)
L4	33 (9%)	5 (3%)
L5	12 (3%)	3 (2%)

The table below provides an overview of the life stages detected at the entry points in the Netherlands on cut roses from the origins with most interceptions in in the period 2019–2022. For all origins, young life-stages predominate, although the fraction of eggs varies.

Table A.64: Life-stages of intercepted specimens of *Thaumatotibia leucotreta* on cut roses as reported by the Dutch NPPO in the years 2019–2022 from selected African countries (NVWA, 2022: Development stage of intercepted *Thaumatotibia leucotreta* specimens; personal communication, 12 October 2022)

Intercepted life-stage On cut roses	Ethiopia (2019–2022) (n = 38)	Kenya (2019–2022) (n = 36)	Uganda (2019–2022) (n = 88)
Eggs	8 (21%)	24 (67%)	41 (47%)
L1	3 (8%)	5 (13%)	18 (20%)

Intercepted life-stage	**Ethiopia (2019–2022)**	**Kenya (2019–2022)**	**Uganda (2019–2022)**
On cut roses	**(n = 38)**	**(n = 36)**	**(n = 88)**
L1 or L2	25 (66%)	4 (11%)	3 (3%)
L2	–	2 (6%)	15 (17%)
L3	2 (5%)	–	5 (6%)
L4	–	1 (3%)	3 (3%)
L5	–	–	3 (3%)

Under the assumption of continuous infestation of the roses in the countries of origin in time and pressure, the development time of the (immature) life stages can be used as proxy for the proportion of infestations. For the larval life stages (L1–L5), equal durations were assumed in the calculation.

Table A.65: Development time of FCM immatures developmental stages in artificial medium under different temperatures (Daiber 1979a,b,c, 1989). Proportion of eggs and portion of young larvae out of all larvae are calculated by EFSA

Temperature	FCM immatures developmental stages									Sum of different periods			Proportion of eggs		Proportion of young larvae (L1 + L2)	
	Egg	Larval							Pupae	Egg to pupa	Egg to larva	Larva to pupa	Rel. to E to P	Rel. to E to L	Rel. to L to P	Rel. to L
[°C]	Development duration [d]												[%]			
	E	L (Total)	L1	L1 + L2	L2	L3	L4	L5	P	E + L + P	E + L	L + P	E/(E + L + P)	E/(E + L)	0.4 L/ (L + P)	
10.9	22															assumed as 40%
12.1		61							68			129			19%	
15		45.6							45			90.6			20%	
15.3	14	39									53			26%		
17.9	11	21							22	54	32	43	20%	34%	20%	
20	7	18.8									25.8			27%		
21.2		14							15			29			19%	
23.8	6	12							15	33	18	27	18%	33%	18%	
25		11.6														
30	4	7							10	21	11	17	19%	36%	16%	
35	3															

The table also shows that the profile of life stages is not influenced by the temperature.
No infestations with pupae or adults were recognised by the Dutch border control. All countries include interception from non-African countries.
Combining the result of both elicitations gives the missing distribution of the later larval stages.

Table A.66: Intercepted life-stages of FCM on cut roses reported from the Netherlands (NVWA, 2022: Development stage of intercepted *Thaumatotibia leucotreta* specimens; personal communication, 12 October 2022). Proportion of eggs and portion of young larvae out of all larvae are calculated by the EFSA

Period	FCM immatures developmental stages									Sum of different periods			Proportion of eggs		Proportion of young larvae (L1 + L2)	
	Egg	Larval							Pupae	Egg to pupa	Egg to larva	Larva to pupa	Rel. to E to P	Rel. to E to L	Rel. to L to P	Rel. to L
	Number of interceptions [–]												[%]			
	E	L (Total)	L1	L1 + L2	L2	L3	L4	L5	P	E + L + P	E + L	L + P	E/(E + L + P)	E/(E + L)	(L1 + L2)/(L + P)	(L1 + L2)/L
Years (all countries)																
2019–2022	95	95	28	33	19	7	5	3			190			50%		84%
2015–2018	54	310	131		85	49	33	12			364			15%		
Countries (2019–2022)																
Ethiopia	8	30	3	25		2					38			21%		93%
Kenya	24	12	5	4	2		1				36			67%		92%
Uganda	41	47	18	3	15	5	3	3			88			47%		77%

Table A.67: Result report on EKE question 1a

Overview of the results of the Expert Knowledge Elicitation Question 1a															
Parameter	Proportion of infested roses, infested with eggs														
Stratification	Eggs out of all life stages														
Question	What is the proportion of infested roses infested with eggs at border control?														
Unit	[%], theoretical restriction: 0–100%														
Results	P1%	P2.5%	**P5%**	P10%	P16.7%	P25%	P33.3%	**P50%**	P66.7%	P75%	P83.3%	P90%	**P95%**	P97.5%	P99%
Elicited values	25					40		50		60					70
EKE results	25.0	26.6	28.7	32.1	35.8	39.8	43.5	50.3	56.7	59.8	63.1	65.8	68.0	69.2	70.1
Fitted distribution	BetaGeneral (1.5237, 1.2203, 23, 70.8)														

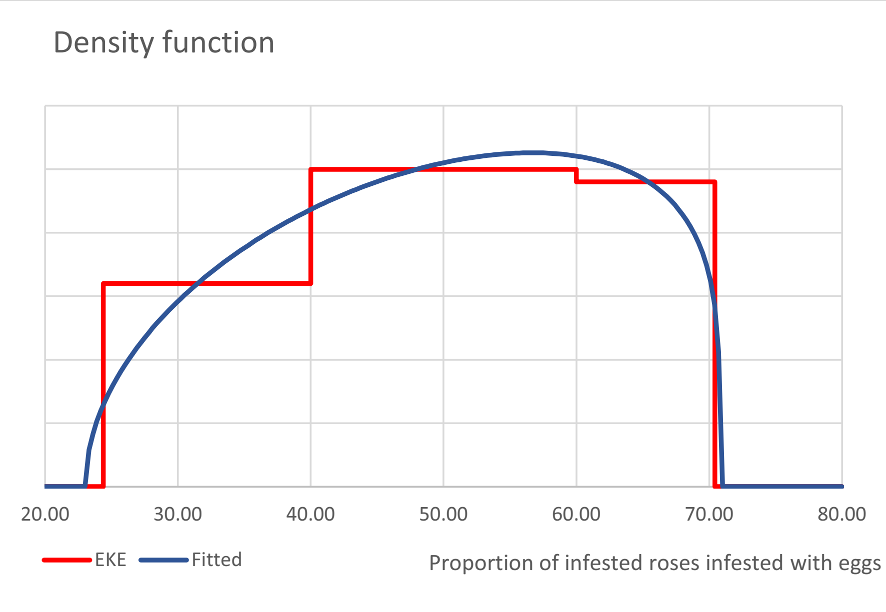

Figure (a): Comparison of elicited and fitted values/density function to describe the remaining uncertainties of the parameter

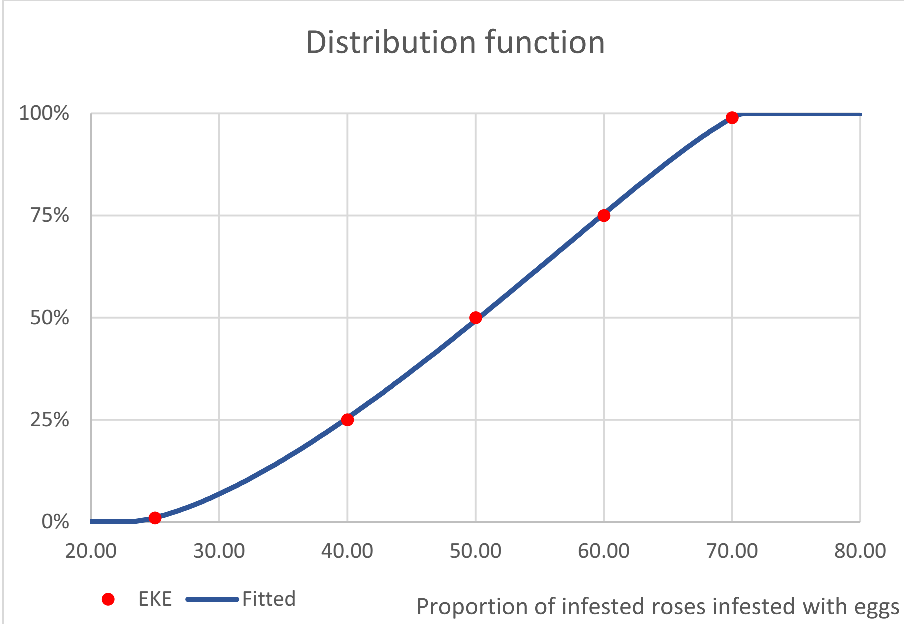

Figure (b): Cumulative distribution function (CDF) of the likelihood of the parameter

Summary of the evidence used for the evaluation	
• Developmental duration of FCM immature stages in artificial medium under different temperatures (Daiber 1979a,b,c, 1989) as proxi of infestation profiles of continuous infestations. • Information on duration and mortality especially of the different larval life stages (in general). • Intercepted life-stages of FCM on Roses reported from the Netherlands (NVWA, 2022: Development stage of intercepted *Thaumatotibia leucotreta* specimens; personal communication, 12 October 2022). • Information on the control procedures at border, esp. sampling procedures and time limitations • Pupae and adults are unlikely to be imported • Visual signs of infestations with different immature life stages of FCM on cut roses	
Main uncertainties	
• The influence of measures against FCM applied in the countries of origin on the profile • The effectiveness of grading cut roses and monitoring infestation rates before export in the countries of origin • The effectiveness of border controls in Europe, esp. regarding the determination of the abundance level	
Reasoning for a scenario which would lead to a reasonable high proportion	The **judgement on the upper limit** considers that • Measures in the country of origin may be more effective against older life stages • Grading procedures may fail to detect younger life stages, e.g. eggs, and let infested cut roses pass • Younger life stages, esp. eggs, are difficult to detect at border, and therefore underrepresented in the interception data
Reasoning for a scenario which would lead to a reasonable low proportion	The **judgement on the lower limit** considers that • Measures in the countries of origin may interrupt the life cycle and prevent new infestations • Earlier life stages have shorter durations and higher mortality • Specific training on FCM increases the detection of younger life stages, esp. eggs, in the country of origin
Fair estimate as judgement on the weighted evidence	The **judgement on the median** considers that • Slight tendency towards higher proportion of eggs (left-skewed). • Current data from NL show similar results
Precision of the judgement as description of remaining uncertainties	The **judgement on the interquartile range** considers that • High uncertainties above and below the median • Countries with less adequate measures may show a lower proportion of eggs • Countries with a more strict monitoring program may show a higher proportion of eggs
Experts	Antoon LOOMANS, Panos MILONAS, Klara NICOVA, Stella PAPANASTASIOU, Giuseppe STANCANELLI, Hans-Hermann THULKE
Facilitator/Reporter	Olaf MOSBACH-SCHULZ (facilitator)
Observers	na
Date and place of the EKE	Virtual meeting on 11 November 2022

Table A.68: Result report on EKE question 1b

Overview of the results of the Expert Knowledge Elicitation Question 1b															
Parameter	Proportion of roses infested with larvae, infested with young larvae														
Stratification	Young larvae (L1 + L2) out of all life stages without eggs														
Question	Taking only the infested roses, which are not infested with eggs. What is the proportion of these infested roses, infested with young larvae (L1 or L2) at border control?														
Unit	[%], theoretical restriction: 0–100%														
Results	P1%	P2.5%	**P5%**	P10%	P16.7%	P25%	P33.3%	**P50%**	P66.7%	P75%	P83.3%	P90%	**P95%**	P97.5%	P99%
Elicited values	40					55		70		75					85
EKE results	40.0	41.7	44.0	47.7	51.7	56.2	60.2	67.4	73.9	76.9	79.8	82.1	83.8	84.6	85.1
Fitted distribution	BetaGeneral (1.4356, 0.99332, 38.1, 85.4)														

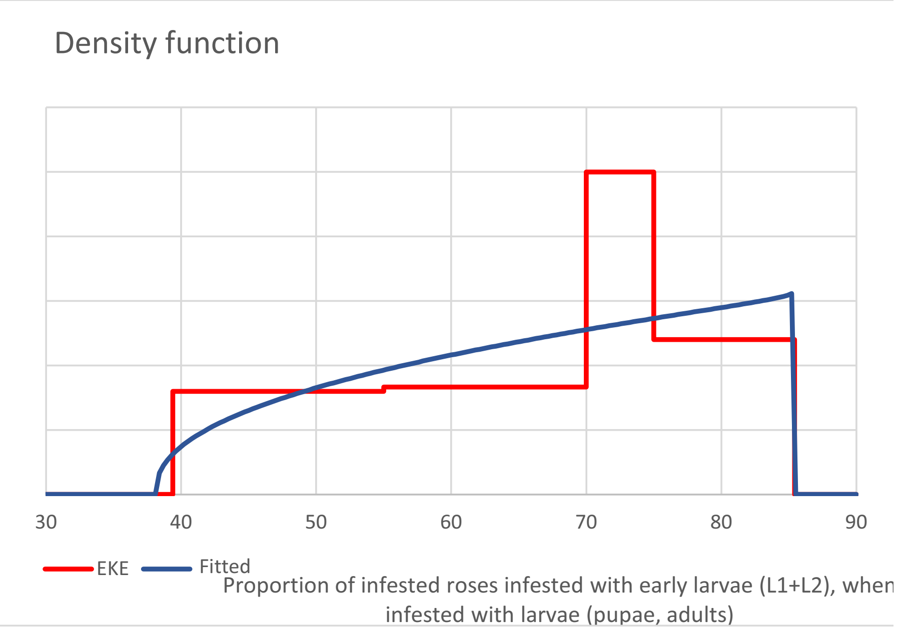

Figure (a): Comparison of elicited and fitted values/density function to describe the remaining uncertainties of the parameter

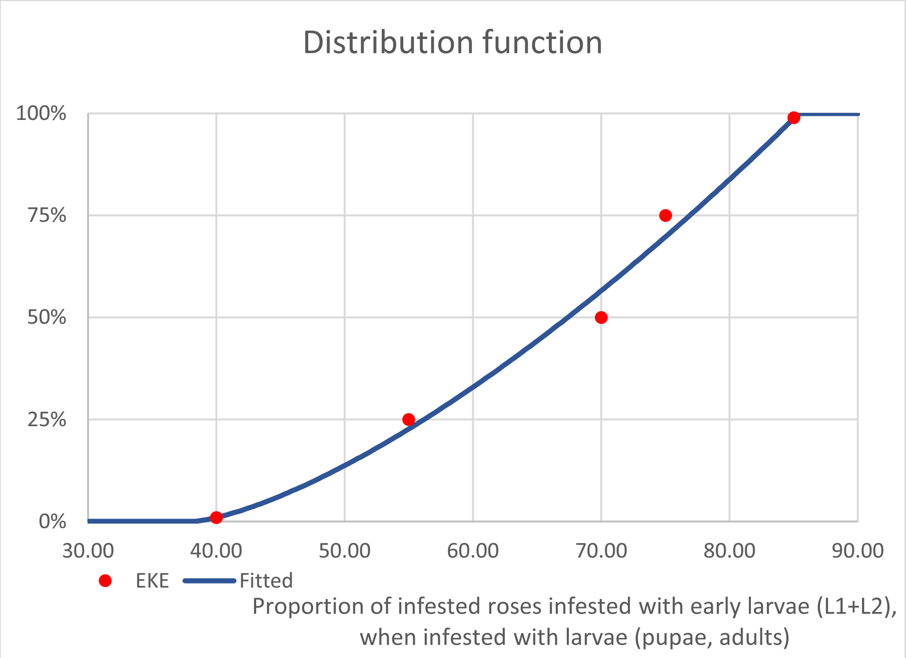

Figure (b): Cumulative distribution function (CDF) of the likelihood of the parameter

Summary of the evidence used for the evaluation	
• Developmental duration of FCM immature stages in artificial medium under different temperatures (Daiber 1979a,b,c, 1989) as proxi of infestation profiles of continuous infestations. • Information on duration and mortality especially of the different larval life stages (in general). • Intercepted life-stages of FCM on Roses reported from the Netherlands (***REF***). • Information on the control procedures at border, esp. sampling procedures and time limitations • Pupae and adults are unlikely to be imported • Visual signs of infestations with different immature life stages of FCM on cut roses	
Main uncertainties	
• The influence of measures against FCM applied in the countries of origin on the profile • The effectiveness of grading cut roses and monitoring infestation rates before export in the countries of origin • The effectiveness of border controls in Europe, esp. regarding the determination of the abundance level	
Reasoning for a scenario which would lead to a reasonable high proportion	The **judgement on the upper limit** considers that • Measures in the country of origin maybe more effective against older life stages • Grading procedures may fail to detect younger life stages, e.g. young larvae, and let infested cut roses pass • Young larvae are difficult to detect (only by empty eggshells, tiny, hidden entry holes) at border, and therefore underrepresented in the interception data • High proportions detected in recent data of the Dutch border
Reasoning for a scenario which would lead to a reasonable low proportion	The **judgement on the lower limit** considers that • Measures in the countries of origin may interrupt the life cycle and prevent new infestations • Earlier life stages have shorter durations and higher mortality • Older larvae might be overlooked (e.g. no eggshell) • Without measures younger larvae should represent a low proportion of all larvae.
Fair estimate as judgement on the weighted evidence	The **judgement on the median** considers that • Tendency towards higher proportion of young larvae (left-skewed). • Nevertheless, young larvae are not the only immature stage difficult to detect. • Older larvae would dominate in nature
Precision of the judgement as description of remaining uncertainties	The **judgement on the interquartile range** considers that • High uncertainties above and below the median • Developmental considerations suggest lower proportions • Current data show higher proportions • Measures (monitoring, control) in most countries are not very effective against younger stages

Experts	Antoon LOOMANS, Panos MILONAS, Klara NICOVA, Stella PAPANASTASIOU, Giuseppe STANCANELLI, Hans-Hermann THULKE
Facilitator/Reporter	Olaf MOSBACH-SCHULZ (facilitator)
Observers	na
Date and place of the EKE	Virtual meeting on 11 November 2022

Table A.69: Distribution of infestation of cut roses at the EU boarder with different immature life stages of FCM

Proportion at entry	Percentiles													
Life stages	P1%	P2.5%	**P5%**	P10%	P16.7%	P25%	P33.3%	**P50%**	P66.7%	P75%	P83.3%	P90%	**P95%**	P97.5%	P99%
Eggs	24.9%	26.5%	**28.7%**	32.0%	35.8%	39.8%	43.5%	**50.2%**	56.7%	59.8%	63.1%	65.8%	**68.0%**	69.2%	70.1%
L1 + L2	14.1%	15.3%	**17.6%**	20.4%	23.3%	25.2%	27.8%	**32.0%**	37.4%	40.5%	44.5%	48.2%	**53.0%**	55.9%	58.9%
L3 + L4 + L5	5.8%	6.4%	**7.0%**	8.2%	9.6%	11.1%	12.3%	**16.1%**	19.7%	21.7%	24.6%	27.9%	**31.6%**	33.9%	37.2%

At import cut flowers from Africa are mainly infested with eggs and young larvae.

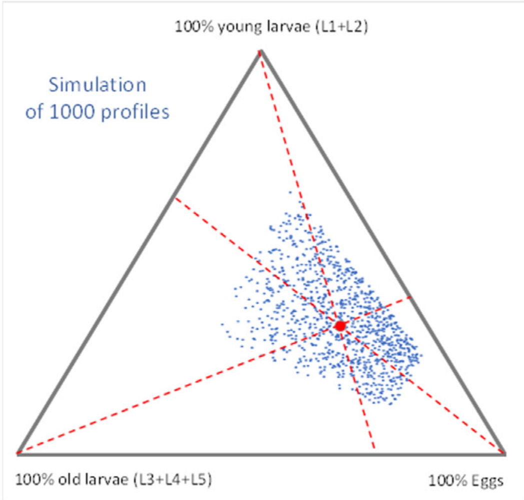

Figure A.10: Simulation of the profile of infestation of cut roses at the EU border with immature life stages of FCM (in a triangular diagram: Each corner represents a pure infestation with only one life stage)

A.7.2. Infestation rate

The infestation rate of cut roses from African countries with reported occurrence of FCM (incl. Israel) at entry into the EU was assessed by Expert Knowledge Elicitation:

- (Question 2) What is the proportion of cut roses (stems) imported from any African country, which are infested with any life stage of FCM directly after entering the EU for trade?

Following scenario was specified:

- Definition 'Infested rose' A rose is considered infested, if one or more specimens of FCM (at any life stage) is attached to the rose
- The infestation rate is assessed at time and place, when a consignment is entering Europe (place of control, e.g. airport, harbour) without any handling in Europe, e.g. grading, etc.
- It is assumed that the profile of immature life stages of FCM infestation follows the result of EKE question 1

Some quantitative evidence was discussed and reviewed for the EKE.

Inspection rate

For the Dutch border inspection, the applied inspection rate is known for the years 2018–2021 (NVWA, 2022: Data on inspection frequencies for cut roses 2018–2021; personal communication, 12 October 2022):

Table A.70: Inspection rate of consignments of cut roses from Ethiopia, Kenya, Tanzania and Zambia at the Dutch border between 2018 and 2021 (NVWA, 2022: Data on inspection frequencies for cut roses 2018–2021; personal communication, 12 October 2022)

Country of origin	Year	Consignments imported	No. of inspections	Inspection rate consignments		
		[no. cons.]	[no. cons.]	[% cons.]		
				Estimate	95%-CI[1]	
Ethiopia	2018	635	33	**5.20%**		
Ethiopia	2019	112	10	**8.93%**		
Ethiopia	2020	518	30	**5.79%**		
Ethiopia	2021	1,962	102	**5.20%**		
Ethiopia	2018–2021	3,227	175	**5.42%**	4.67%	6.26%

Country of origin	Year	Consignments imported [no. cons.]	No. of inspections [no. cons.]	Inspection rate consignments [% cons.] Estimate	95%-CI[1]	
Kenya	2018	58,335	4,019	**6.89%**		
Kenya	2019	52,892	5,732	**10.84%**		
Kenya	2020	42,273	5,439	**12.87%**		
Kenya	2021	38,030	4,589	**12.07%**		
Kenya	2018–2021	191,530	19,779	**10.33%**	10.19%	10.46%
Tanzania	2018	1,663	284	**17.08%**		
Tanzania	2019	871	371	**42.59%**		
Tanzania	2020	195	112	**57.44%**		
Tanzania	2021	0	0			
Tanzania	2018–2021	2,729	767	**28.11%**	26.42%	29.83%
Zambia	2018	727	82	**11.28%**		
Zambia	2019	616	70	**11.36%**		
Zambia	2020	405	37	**9.14%**		
Zambia	2021	337	57	**16.91%**		
Zambia	2018–2021	2,085	246	**11.80%**	10.44%	13.26%
All	2018–2021	199,571	20,967	**10.51%**	10.37%	10.64%

(1): Clopper–Pearson approximation (see below).

For the countries with reduced inspection rate, the average inspection rate ranges between countries from 5.42% (Ethiopia) to 28.11% (Tanzania) with an overall rate of 10.51% (90%CI: 10.37–10.64%). Esp. for Uganda all consignments are inspected.

Sample size

The Dutch NPPO (NVWA, 2022: Infestation rates of consignments of cut roses infested by *T. leucotreta*; personal communication, 12 October 2022) indicates '*The size of the infested consignments and sample size are not recorded in laboratory's database, so we cannot directly report the infestation rate of the inspected sample. However, we can provide an approximation of the infestation rate of T. leucotreta in intercepted consignments of cut roses. Based on import data from 2020, the median consignment weight of African roses is 635 kg. African roses a relatively light compared to European roses, being ca. 25 g per stem. This would amount to 25.400 roses in such a consignment. According to the inspection registry in the Netherlands, this would require a sample size of 400 inspected roses.*'

This is not confirmed by the import data from Eurostat, which indicates a four to five times larger weight of the consignments, and two times larger number of roses [as Eurostat assumes a standard weight of 50.7 g/rose [Conversion factor for unit mass, CNVF2016, CN 06031100, online)].

Table A.71: Size and weight of consignments from Ethiopia, Kenya, Tanzania and Zambia at the Dutch border between 2018 and 2021 using trade data from Eurostat (EU trade since 1988 by HS2-4-6 and CN8, online, accessed on 4 October 2022)

Country of origin		Import of cut roses of NL (Eurostat) [No. roses]	[100 kg]	Average consignment size[1] [No. roses /cons.]	[kg /cons.]
		50.7 g per rose			
Ethiopia	2018	772,833,741	391,826.71	1,217,061	61,705
Ethiopia	2019	643,991,752	326,503.82	5,749,926	291,521
Ethiopia	2020	874,588,023	443,416.13	1,688,394	85,602
Ethiopia	2021	840,201,265	425,982.04	428,237	21,712
Ethiopia	2018–2021	3,131,614,781	1,587,729	970,442	49,201

Country of origin		Import of cut roses of NL (Eurostat)		Average consignment size[1]	
		[No. roses]	[100 kg]	[No. roses /cons.]	[kg /cons.]
		50.7 g per rose			
Kenya	2018	2,091,366,487	1,060,322.81	35,851	1,818
Kenya	2019	2,153,153,091	1,091,648.62	40,708	2,064
Kenya	2020	1,840,848,751	933,310.32	43,547	2,208
Kenya	2021	2,017,377,550	1,022,810.42	53,047	2,689
Kenya	2018–2021	8,102,745,879	4,108,092	42,305	2,145
Tanzania	2018	45,025,113	22,827.73	27,075	1,373
Tanzania	2019	40,132,765	20,347.31	46,077	2,336
Tanzania	2020	15,263,161	7,738.42	78,273	3,968
Tanzania	2021				
Tanzania	2018–2021	100,421,039	50,913	36,798	1,866
Zambia	2018	85,761,147	43,480.90	117,966	5,981
Zambia	2019	83,997,625	42,586.80	136,360	6,913
Zambia	2020	102,281,036	51,856.49	252,546	12,804
Zambia	2021	97,089,926	49,224.59	288,101	14,607
Zambia	2018–2021	369,129,734	187,149	177,041	8,976
All	2018–2021	11,703,911,433	5,933,883	58,645	2,973

(1): Number of consignments as indicated by the Dutch NPPO (see Table A.68).

Again, the average consignment sizes are varying between the countries from 36,798 roses (Tanzania) to 970,442 roses (Ethiopia) with an average of 58,645 roses per consignment.

The Dutch report gives only few indications on the actual sample size: '*During import inspections in the Netherlands cut roses are inspected for the presence of T. leucotreta. The number of inspected roses is dependent on the size of the consignment and increases stepwise from 200 inspected roses in batches of 400–10,000 roses up to 1.200 inspected roses in batches of over 200,000 roses.*' (NVWA, 2022: Infestation rates of consignments of cut roses infested by *T. leucotreta*; personal communication, 12 October 2022).

By interpolation, we could assume following numbers of inspected roses.

Table A.72: Sample size of cut roses at the Dutch border control, interpolated in steps of 200 (NVWA, 2022: Infestation rates of consignments of cut-roses infested by *T. leucotreta*; personal communication, 12 October 2022. Note: the intermediate steps are calculated by EFSA)

Consignment size		Sample size
	[roses]	
From	to	
400	10,000	200
> 10,000	50,000	400
> 50,000	100,000	600
> 100,000	150,000	800
> 150,000	200,000	1,000
> 200,000		1,200

Infestation sample

The number of specimens within an infested sample is described in the Dutch report (NVWA, 2022: Infestation rates of consignments of cut-roses infested by *T. leucotreta*; personal communication, 12 October 2022) for all countries and years as in Table A.73 below.

Table A.73: Number of specimens per infested sample (n = 217 infested consignments in the period 2019–2022) as reported by the Dutch NPPO for all countries and years (NVWA, 2022: Infestation rates of consignments of cut-roses infested by *T. leucotreta*; personal communication, 12 October 2022)

Number of *T. leucotreta* specimens per consignment	Fraction of consignments (n = 217)
1	167 (77%)
2	32 (15%)
3	18 (8%)
4 or more	0 (0%)

Infestation per consignment

This would lead to following infestation rates within a consignment.

Table A.74: Estimated infestation rate (including the 95% confidence interval (CI)) dependent from the sample size and number of specimens detected

Consignment size		Sample size	Detected specimens											
[roses]			0 infested			1 infested			2 infested			3 infested		
From	To		Estimate	95%-CI[1]		Estimate	95%-CI[1]		Estimate	95%-CI[1]		Estimate	95%-CI[1]	
			Infestation rate [% roses]											
400	10,000	200	**0%**	0%	1.487%	**0.50%**	0.013%	2.75%	**1.00%**	0.12%	3.57%	**1.50%**	0.310%	4.32%
> 10,000	50,000	400	**0%**	0%	0.746%	**0.25%**	0.006%	1.38%	**0.50%**	0.06%	1.79%	**0.75%**	0.155%	2.18%
> 50,000	100,000	600	**0%**	0%	0.498%	**0.17%**	0.004%	0.93%	**0.33%**	0.04%	1.20%	**0.50%**	0.103%	1.45%
> 100,000	150,000	800	**0%**	0%	0.374%	**0.13%**	0.003%	0.69%	**0.25%**	0.03%	0.90%	**0.38%**	0.077%	1.09%
> 150,000	200,000	1,000	**0%**	0%	0.299%	**0.10%**	0.003%	0.56%	**0.20%**	0.02%	0.72%	**0.30%**	0.062%	0.87%
> 200,000		1,200	**0%**	0%	0.249%	**0.08%**	0.002%	0.46%	**0.17%**	0.02%	0.60%	**0.25%**	0.052%	0.73%

(1): Clopper–Pearson approximation (see below).

Table A.75: Calculation of the 95% confidence intervals for Binomial(N,p) distributed rates with the Clopper–Pearson approximation. The exponential approximation for full presence/absence is less conservative than Clopper–Pearson (minimal change)

Observation k out of N	Lower bound	Upper bound
0 < k < N	BETA.INV (0.025, k, N – k + 1)	BETA.INV (0.975, k + 1, N – k)
k = 0 (full absence in the sample)	0%	1-EXP(LN(0.05)/N) 'Upper 95% level'
k = N (full presence in the sample	EXP(LN(0.05)/N) 'Lower 95% level'	100%

Interception rate

Finally, the Dutch report gives the interceptions with FCM per country and year (NVWA, 2022: Data on inspection frequencies for cut roses 2018–2021; personal communication, 12 October 2022). This gives following interception rates (see Table A.76 below).

Table A.76: Estimated interception rate with *Thaumatotibia leucotreta* (including the 95% confidence interval [CI]) for selected African countries

Country of Origin	Year	No. inspections (No. cons.)	No. interceptions with FCM (No. cons.)	Interception rate Estimate (% cons.)	95%-CI[1] (% cons.)	(% cons.)
Ethiopia	2018	33	0	**0.00%**	0.00%	8.68%
Ethiopia	2019	10	0	**0.00%**	0.00%	25.89%
Ethiopia	2020	30	0	**0.00%**	0.00%	9.50%
Ethiopia	2021	102	8	**7.84%**	3.45%	14.87%
Ethiopia	2018–2021	175	8	**4.57%**	1.99%	8.81%
Kenya	2018	4,019	23	**0.57%**	0.36%	0.86%
Kenya	2019	5,732	40	**0.70%**	0.50%	0.95%
Kenya	2020	5,439	33	**0.61%**	0.42%	0.85%
Kenya	2021	4,589	40	**0.87%**	0.62%	1.19%
Kenya	2018–2021	19,779	136	**0.69%**	0.58%	0.81%
Tanzania	2018	284	14	**4.93%**	2.72%	8.13%
Tanzania	2019	371	13	**3.50%**	1.88%	5.92%
Tanzania	2020	112	3	**2.68%**	0.56%	7.63%
Tanzania	2021					
Tanzania	2018–2021	767	30	**3.91%**	2.65%	5.54%
Zambia	2018	82	4	**4.88%**	1.34%	12.02%
Zambia	2019	70	4	**5.71%**	1.58%	13.99%
Zambia	2020	37	1	**2.70%**	0.07%	14.16%
Zambia	2021	57	7	**12.28%**	5.08%	23.68%
Zambia	2018–2021	246	16	**6.50%**	3.76%	10.35%
All	2018–2021	20,967	190	**0.91%**	0.78%	1.04%

(1): Clopper–Pearson approximation (see above).

The average interception rate (at consignment level) varies by country from 0.69% (Kenia) to 6.5% (Zambia) with an overall average of 0.91% (95%-CI 0.78–1.04%).

Total infestation rate

To combine the different rates, a country-specific approach was done for the full period from 2018 to 2021. Because individual data on the consignment size were not available, all calculations are based on the country-specific average consignment size (according to Eurostat, see Table A.69).

The infestation rate within the inspected consignments is given by:

$$r_{inspected} = (1 - p_{intercepted}) \times r_{0\ specimens} + p_{intercepted}\ (q_{1\ spec} \times r_{1\ spec} + q_{2\ spec} \times r_{2\ spec} + q_{3\ spec} \times r_{3\ spec})$$

with

Abbr.	Description	Remarks
$r_{inspected}$	Infestation rate within the inspected consignments [% roses]	
$p_{intercepted}$	Proportion of intercepted consignments	Triangular (P2.5, est, P97.5)
$r_{0\ specimens}$	Detection limit according to the sample size	Uniform (0, P95)
$q_{k\ spec}$	Proportion of interceptions with k specimens	Constant
$r_{k\ spec}$	Infestation level of interceptions with k specimens	Triangular (P2.5, est, P97.5)

Table A.77: Schematic view on the infestation level

	Consignments checked at the EU border			
No of specimens	No FCM detected	1 specimen detected	2 specimens detected	3 specimens detected
Model assumption	Infestation assumed below the limit of detection	Estimated infestation, 95% CI calculated	Estimated infestation, 95% CI calculated	Estimated infestation, 95% CI calculated
Probabilistic model	Randomly selected between 0% and the LOD	Randomly selected from the 95%CI	Randomly selected from the 95%CI	Randomly selected from the 95%CI
	Merged according to the distribution of findings at the Dutch border			

The total infestation rate is assuming that intercepted consignments are not imported, but the not inspected have the same infestation level as the inspected ones:

$$r_{total} = [n \times (1 - u) \times r_{inspected} + n \times u \times (1 - p_{intercepted}) \times r_{0\ specimens}] / [n \times (1 - u) + n \times u \times (1 - p_{intercepted})]$$ with

Abbr.	Description	Remarks
r_{total}	Infestation rate within total import [% roses]	
n	Total import of roses [no. roses]	Uniform (min, max)
u	Inspection rate	Triangular (P2.5, est, P97.5)
$r_{inspected}$	Infestation rate within the inspected consignments [% roses]	Calculated
$p_{intercepted}$	Proportion of intercepted consignments	Triangular (P2.5, est, P97.5)
$r_{0\ specimens}$	Detection limit according to the sample size	Uniform (0, P95)

Table A.78: Schematic view on the final infestation level

	Consignments arriving at the EU border		
Level/result of the inspection	Not inspected	Checked without detection	Checked with detection
Model assumption	Infestation assumed to be similar to the inspected ones	Infestation assumed below the limit of detection	Rejected, not considered
Probabilistic model	See first scheme	Randomly selected between 0% and the LOD	
	Merged according to the distribution of controls and findings at the Dutch border		

Simulation results

Table A.79: Simulation of the overall infestation rate of cut roses imported to the Netherlands stratified by selected African countries

Parameter		Unit	Country				
			Ethiopia	**Kenya**	**Tanzania**	**Zambia**	**All countries**
Proportion of intercepted consignments		[% cons.]					
	Low (P2.5)		1.99%	0.58%	2.65%	3.76%	
	Est		4.57%	0.69%	3.91%	6.50%	
	High (P97.5)		8.81%	0.81%	5.54%	10.35%	
Average consignment size		[roses]	970,442	42,305	36,798	177,041	
Sample size		[roses]	1,200	400	400	1,000	
Detection limit according to the sample size		[%]					
	High (P95)		0.249%	0.746%	0.746%	0.299%	
Proportion of interceptions with 1 specimen		[%]					
	Constant		77%	77%	77%	77%	
Infestation level of interceptions with 1 specimen		[%]					
	Low (P2.5)		0.002%	0.006%	0.006%	0.003%	
	Est		0.083%	0.250%	0.250%	0.100%	
	High (P97.5)		0.463%	1.385%	1.385%	0.556%	
Proportion of interceptions with 2 specimens		[%]					
	Constant		15%	15%	15%	15%	
Infestation level of interceptions with 2 specimens		[%]					
	Low (P2.5)		0.020%	0.061%	0.061%	0.024%	
	Est		0.167%	0.500%	0.500%	0.200%	
	High (P97.5)		0.601%	1.794%	1.794%	0.721%	
Proportion of interceptions with 3 specimens		[%]					
	Constant		8%	8%	8%	8%	
Infestation level of interceptions with 3 specimens		[%]					
	Low (P2.5)		0.052%	0.155%	0.155%	0.062%	
	Est		0.250%	0.750%	0.750%	0.300%	
	High (P97.5)		0.729%	2.176%	2.176%	0.874%	

Parameter		Unit	Country				
			Ethiopia	Kenya	Tanzania	Zambia	All countries
Infestation rate within the inspected consignments		[%]					
	P01		0.011%	0.012%	0.030%	0.016%	
	P05		**0.024%**	**0.043%**	**0.065%**	**0.032%**	
	Median		**0.136%**	**0.395%**	**0.403%**	**0.165%**	
	P95		**0.248%**	**0.746%**	**0.743%**	**0.297%**	
	P99		0.260%	0.777%	0.776%	0.313%	
Total import of roses per year		[roses]					
	Min		643,991,752	1,840,848,751	15,263,161	83,997,625	
	Max		874,588,023	2,153,153,091	45,025,113	102,281,036	
Inspection rate		[% cons]					
	Low (P2.5)		4.67%	10.19%	26.42%	10.44%	
	Est		5.42%	10.33%	28.11%	11.80%	
	High (P97.5)		6.26%	10.46%	29.83%	13.26%	
Number of infested, imported roses per year		[roses]					
	P05		**173,520**	**855,344**	**15,748**	**28,193**	**2,134,881**
	Median		**1,021,268**	**7,868,961**	**108,735**	**151,369**	**9,162,766**
	P95		**1,917,593**	**14,902,594**	**262,553**	**276,725**	**16,284,936**
Number of imported roses per year		[roses]					
	P05		**653,680,625**	**1,855,131,767**	**16,563,332**	**84,219,119**	**2,688,766,359**
	Median		**757,116,193**	**1,995,552,436**	**29,810,984**	**92,374,548**	**2,874,815,411**
	P95		**860,638,364**	**2,136,040,972**	**43,034,339**	**100,521,627**	**3,061,979,365**
Infestation rate within total import		[%]					
	P01		0.011%	0.012%	0.025%	0.015%	0.041%
	P05		**0.023%**	**0.043%**	**0.058%**	**0.031%**	**0.074%**
	Median		**0.136%**	**0.394%**	**0.400%**	**0.164%**	**0.319%**
	P95		**0.248%**	**0.746%**	**0.744%**	**0.297%**	**0.564%**
	P99		0.260%	0.777%	0.775%	0.312%	0.599%
			Ethiopia	Kenya	Tanzania	Zambia	All countries

The infestation rate varies between the countries from 0.136% of the roses (Ethiopia) to 0.400% (Tanzania), with a trade-weighted average of 0.319% (90%-UI 0.074–0.564%).

Missing factors

- Variation in trade, incl. size of consignments, different sampling numbers.
- Detection level of visual inspection at border, esp. depending on the profile of life stages.
- Correctness of assumed representative sampling at border control with interpolated sample size.
- Calculations are done under the assumption that one specimen corresponds to one rose.
- Calculations are limited to four countries and import only to NL.
- Calculations are only for 4 years 2018–2021.

The simulated results and additional evidence were used to conduct an EKE on 12 December 2022 with following results.

Table A.80: Result report on EKE question 2

Overview of the results of the Expert Knowledge Elicitation Question 2															
Parameter	Infestation rate of cut roses imported from Africa at border														
Stratification	None (Total import from Africa)														
Question	What is the proportion of cut roses (stems) imported from any African country, which are infested with any life stage of FCM directly after entering the EU for trade?														
Unit	[%]														
Results	P1%	P2.5%	**P5%**	P10%	P16.7%	P25%	P33.3%	**P50%**	P66.7%	P75%	P83.3%	P90%	**P95%**	P97.5%	P99%
Elicited values	0.01%					0.12%		**0.20%**		0.35%					0.65%
EKE results	0.01%	0.02%	0.03%	0.05%	0.08%	0.11%	0.14%	0.21%	0.29%	0.34%	0.40%	0.46%	0.54%	0.59%	0.65%
Fitted distribution	BetaGeneral (1.3651, 3.4255, 0.000008, 0.00835)														

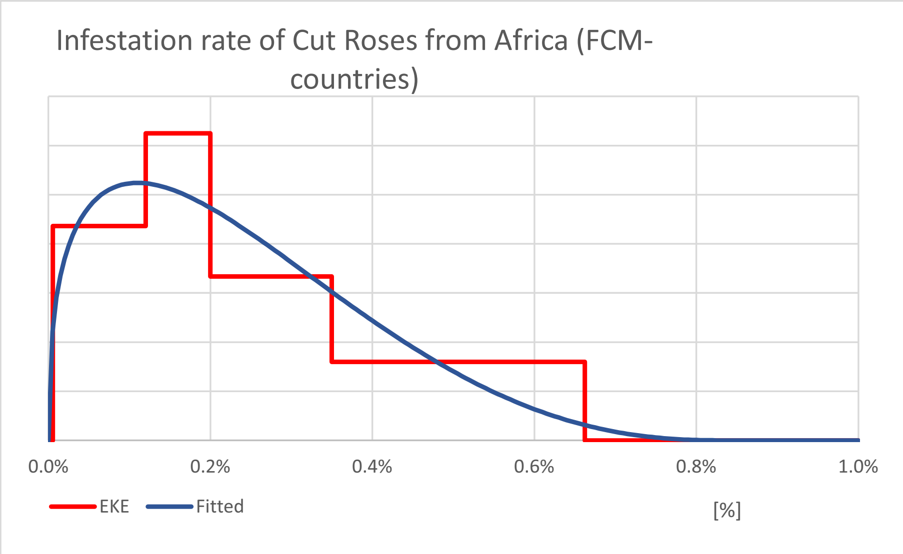

Figure (a): Comparison of elicited and fitted values/density function to describe the remaining uncertainties of the parameter

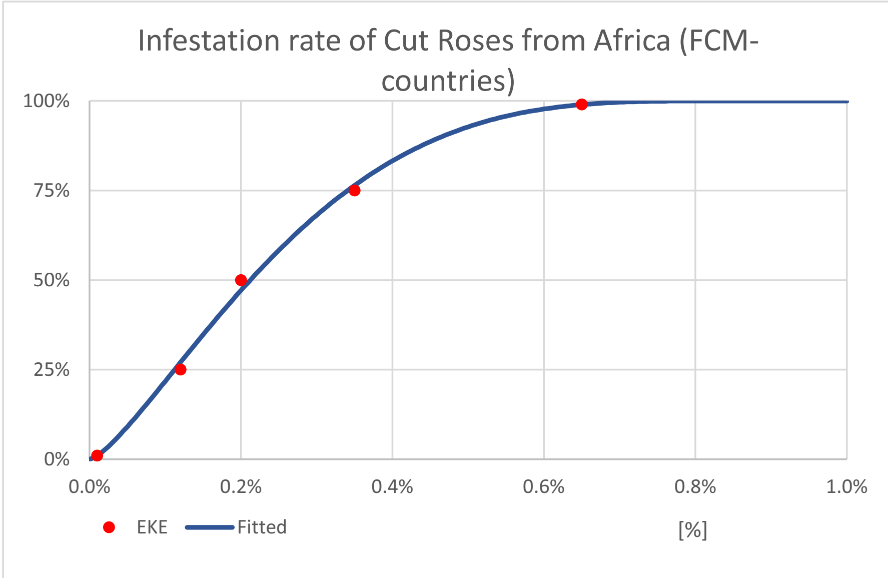

Figure (b): Cumulative distribution function (CDF) of the likelihood of the parameter

Summary of the evidence used for the evaluation

- Kenyan Systems Approach and working instructions indicate a control before export with a sample size of 700 roses/stems. This (700 stems per sample unit) would result in an 95% CI for the infestation rate of (0–0.43%)
- Interceptions recognised by the Dutch border control, including control density

Main uncertainties

- Variation in trade, incl. size of consignments, different sampling numbers
- Calculations are done under the assumption that one specimen corresponds to one rose
- Calculations are limited to four countries and import only to NL
- Calculations are only for 4 years 2018–2021
- Number of specimens per consignment is unclear, as control may stop after the first finding(s)
- The effectiveness of the border control is unclear, including the level of detection
- Clustering of infestations in a consignment is unclear

Reasoning for a scenario which would lead to a reasonable high proportion	The **judgement on the upper limit** considers that • Infestation is not clustered, but widespread in a consignment • High level of detection, low effectiveness of the border control, limited sampling, stop after first finding(s) • Non-rejected consignments are contaminated (up to the detection level) • More recent years have lower infestation rates
Reasoning for a scenario which would lead to a reasonable low proportion	The **judgement on the lower limit** considers that • Non-rejected consignments are free from FCM/low level of detection, high effectiveness of the border control • Smaller consignments have a higher inspection rate/other countries have complete inspection • Infestation is clustered, thus max. 3 specimens indicated low infestation rate • Multiple specimens per rose would lead to lower infestation rate • Recent years have higher infestation rates as the average
Fair estimate as judgement on the weighted evidence	The **judgement on the median** considers that • While high infestation rates cannot be excluded is the median infestation on the lower part of the range
Precision of the judgement as description of remaining uncertainties	The **judgement on the interquartile range** considers that • High uncertainty on infestation rates below the median • Medium uncertainty on infestation rates above the median
Experts	Antoon LOOMANS, Panos MILONAS, Klara NICOVA, Stella PAPANASTASIOU, Giuseppe STANCANELLI, Hans-Hermann THULKE
Facilitator/Reporter	Olaf MOSBACH-SCHULZ (facilitator)
Observers	na
Date and place of the EKE	Virtual meeting on 12 December 2022

A.7.2.1. Infestation rate estimated using a Poisson model

After the elicitation, the Panel reviewed the results and used a Poisson model to check the consistency of the elicited values.

The starting point were the observations from the Dutch NPPO on the number of specimens, when a sample indicates an interception (cp. Table A.73 [NVWA, 2022: Infestation rates of consignments of cut-roses infested by *T. leucotreta*; personal communication, 12 October 2022]). On infested samples (n = 400 cut roses with one or more specimens), the NPPO reported on average 1.31 specimens (Table A.81, 2nd column).

Table A.81: Number of specimens per infested sample (n = 217) as reported by the Dutch NPPO for all countries and years (nppo, 2022: Infestation rates of consignments of cut roses infested by *T. leucotreta*; personal communication, 12 October 2022) and as estimated by fitted Poisson distributions

No. specs. per sample	Observation Dutch NPPO	Fitted Poisson distribution	Fitted Poisson distribution	Fitted Poisson distribution bunch of 10 roses	Fitted Poisson distribution individual roses
	P(k ∣ X ≥ 1)	**P(k ∣ X ≥ 1)**	**P(k)**	**P(k)**	**P(k)**
Condition:	k ≥ 1, n = 400	k ≥ 1, n = 400	n = 400	n = 10	n = 1
k =		**mu_{400} = 0.57**	**mu_{400} = 0.57**	**mu_{10} = 0.01425**	**mu_{1} = 0.001425**
0	Not reported	Conditional distribution	57%	98.585%	99.858%
1	77%	74%	32%	1.405%	0.142%
2	15%	21%	9%	0.010%	0.000%
3	8%	4%	2%	0.000%	0.000%
4	0%	1%	0%	0.000%	0.000%
≥ 5	0%	0%	0%	0.000%	0.000%
Mean no. specs	1.31	1.31	0.57	0.0142	0.0014

Using the method of moments to fit a Poisson distribution to the observations under the condition of infested samples (k ≥ 1) leads to following equation:

$$1.31 = \mathrm{E}[\mathrm{Pois}(\mathrm{mu}|\mathrm{k} \geq 1)] = \mathrm{E}[\mathrm{Pois}(\mathrm{mu})]/\mathrm{Pois}(\mathrm{k} \geq 1, \mathrm{mu})$$

$$= \mathrm{mu}/(1\text{–}\exp(-\mathrm{mu}))$$

and results in a mean of the unconditional Poisson distribution of mu400 = 0.57 (Table A.81, 4th column). Assuming that the specimens are uniformly distributed inside the sample would lead to a Poisson distribution for individual roses (n = 1, Table A.81, 6th column) with a mean value of:

$$\mathrm{mu1} = \mathrm{mu400}/400 = 0.57/400 = 0.001425$$

The likelihood of infested roses (one or more specimens) can be calculated in this model as:

$$\mathrm{P}(\mathrm{k} \geq 1) = 1\text{–}\mathrm{P}(\mathrm{k} = 0) = 1\text{–}99.858\% = 0.142\%$$

which is consistent with the elicitation results.

A.8. FCM development after entry

The time to develop different life stages of FCM is reported in literature (see Section 3.1.1 of the opinion). For the developmental model, following times were taken to form TRIANGULAR distributions for the uncertainties.

Table A.82: Development times of young larvae (L1 and L2), mature larvae (L3–L5) and pupae according to the literature (Daiber (1979a,b,c, 1989), Schwartz (1981), interpolation of larval stages according Daiber (1979a,b,c))

Temperature	Development time [d]											
	Eggs			Young larvae (L1–L2)			Mature larvae (L3–L5)			Pupae		
	Min	Est	Max	Min	Est	Max	Min	Est	Max	Min	Est	Max
15	14.5	14.5	14.5	5.4	6.4	7.5	38.1	40.9	43.6	40.0	42.5	45.0
20	7.0	7.0	7.0	1.6	2.4	3.1	15.4	18.5	24.4	11.0	15.8	19.0
25	5.6	5.6	5.6	1.3	1.7	2.0	6.7	8.8	10.0	10.0	12.0	14.0
30	4.0	4.0	4.0	1.1	1.1	1.1	5.9	5.9	5.9	7.0	8.5	10.0

- No development is assumed below 8°C.
- The reciprocal value gives the developmental progress per day.
- Values for temperatures between the given temperatures were linearly interpolated.

A.8.1. Seasonal ambient temperatures in the climatically suitable area

To estimate the climatic situation in the different climate suitability classes, five European locations were selected, which represent the situation at the limits of the classes (see table below).

Table A.83: Average seasonal temperatures at selected locations in the years 2011–2020 given as median and first and third quartile. Weather data as used for the physiologically based demographic model (PBDM, see Appendix B)

Ambient temperatures	Location	Szeged (HU)			Archacon (FR)			Capo Vaticano (IT)			Cartagena (ES)			Fuengirola (ES)		
		Grey/Blue			Blue/Green			Green/Yellow			Yellow/Red			Red+		
	Season	P25	Median	P75	P25	Median	P75	P25	Median	P75	P25	Median	P75	P25	Median	P75
Q1	Winter	–2.0	1.3	4.3	5.0	7.5	10.0	8.5	10.4	11.8	10.6	12.0	13.4	12.3	13.5	14.7
Q2	Spring	8.7	12.4	16.1	11.2	13.4	16.0	12.8	15.1	17.8	14.9	17.0	19.0	15.1	17.0	19.1
Q3	Summer	19.2	21.7	24.2	19.1	20.8	22.6	23.3	25.2	26.9	24.2	25.5	26.8	23.1	24.7	26.2
Q4	Autumn	8.2	12.7	16.6	11.5	15.7	18.5	15.8	18.8	21.6	16.9	20.8	23.3	17.2	20.4	22.9

These led to following temperature ranges, which were used in the developmental model to estimate the escape of FCM at different days after entry:

Table A.84: Average seasonal temperatures of the climate suitability classes in the physiologically based demographic model (PBDM) in the years 2011–2020 as used in the developmental model

Climate suitability class	1			2			3			4		
Average temperature	Blue			Green			Yellow			Red		
	P01	Median	P99	P01	Median	P99	P01	Median	P99	P01	Median	P99
Winter	–2.0	4.4	10.0	5.0	8.9	11.8	8.5	11.2	13.4	10.6	12.7	14.7
Spring	8.7	12.9	16.0	11.2	14.3	17.8	12.8	16.0	19.0	14.9	17.0	19.1
Summer	19.2	21.3	22.6	19.1	23.0	26.9	23.3	25.3	26.8	24.2	25.1	26.2
Autumn	8.2	14.2	18.5	11.5	17.2	21.6	15.8	19.8	23.3	16.9	20.6	22.9

The detailed development over time is given by the profiles.

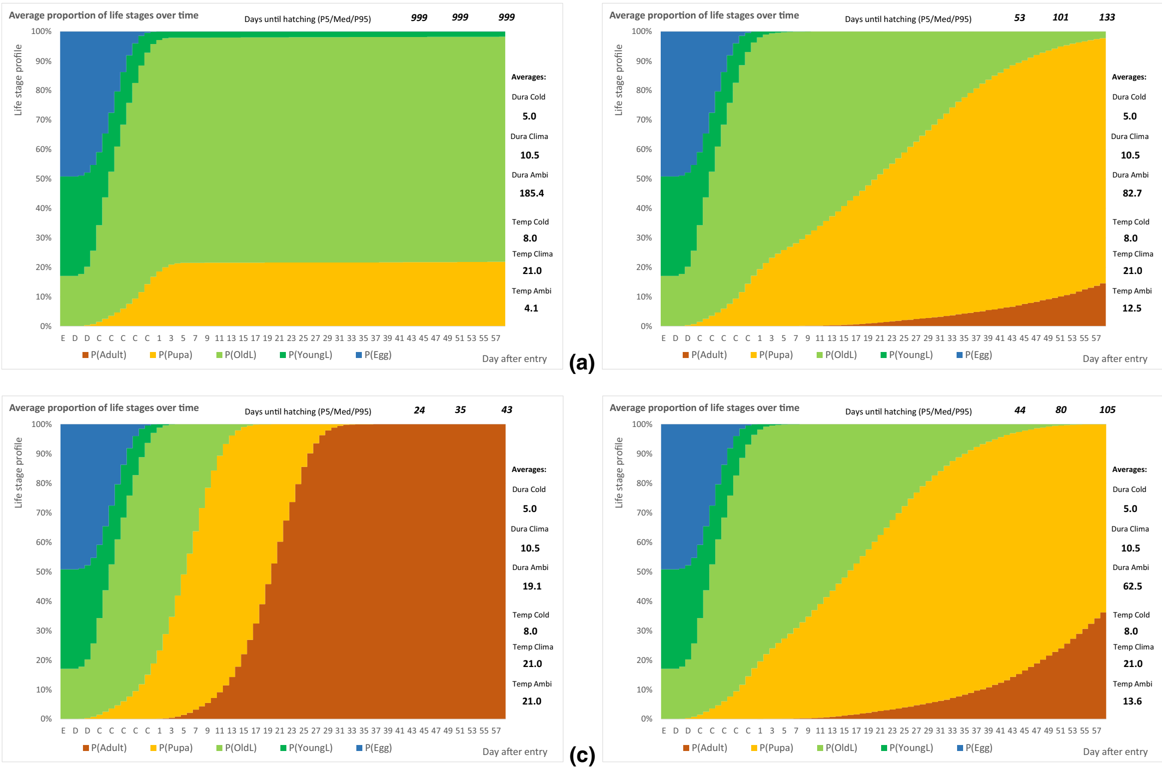

Figure A.11: Average proportion of different life stages (blue = eggs, dark green = L1–L2, light green = L3–L5, yellow = pupae, red = adults) of *Thaumatotibia leucotreta* by day (horizontal axis) starting with entering the EU (E), distribution in cooled conditions (D), consumption in climatised environment (C) and days after wasting by the consumer. Results by the developmental model are given for NUTS2 regions in climate suitability class 1 for winter (a), spring (b), summer (c) and autumn (d)

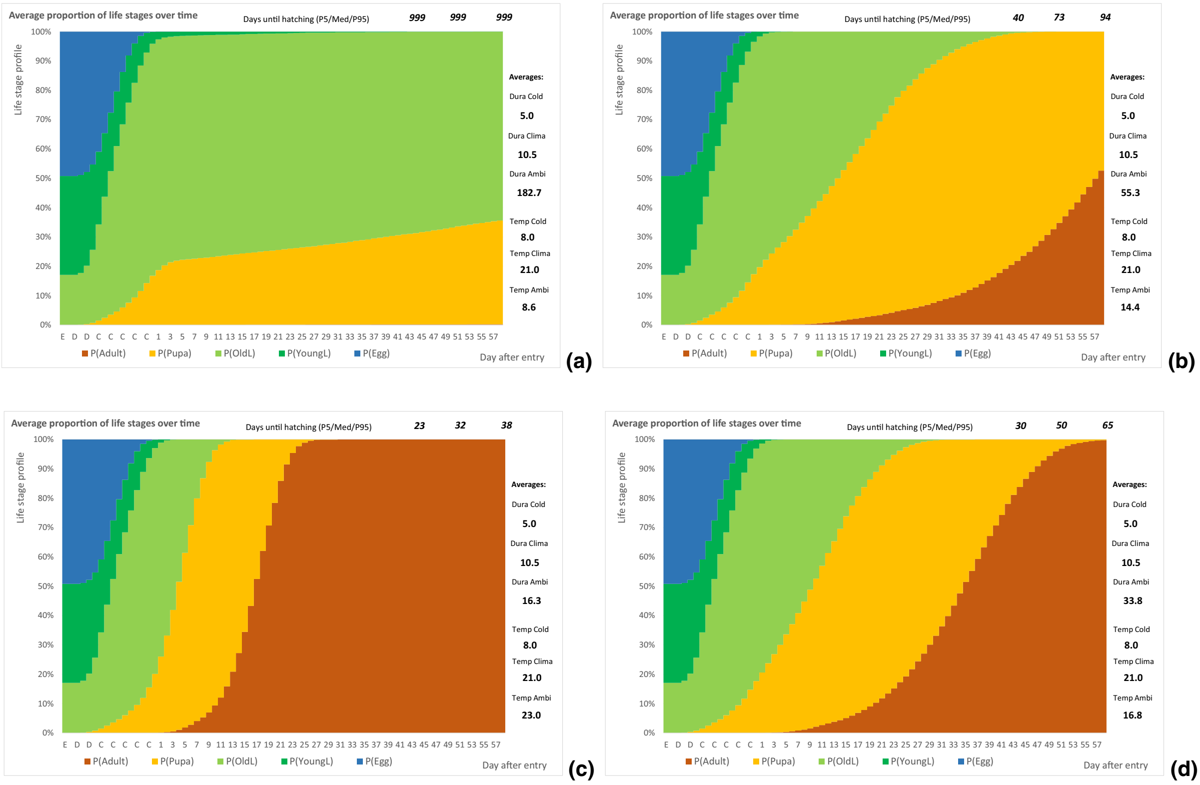

Figure A.12: Average proportion of different life stages (blue = eggs, dark green = L1–L2, light green = L3–L5, yellow = pupae, red = adults) of *Thaumatotibia leucotreta* by day (horizontal axis) starting with entering the EU (E), distribution in cooled conditions (D), consumption in climatised environment (C) and days after wasting by the consumer. Results by the developmental model are given for NUTS2 regions in climate suitability class 2 for winter (a), spring (b), summer (c) and autumn (d)

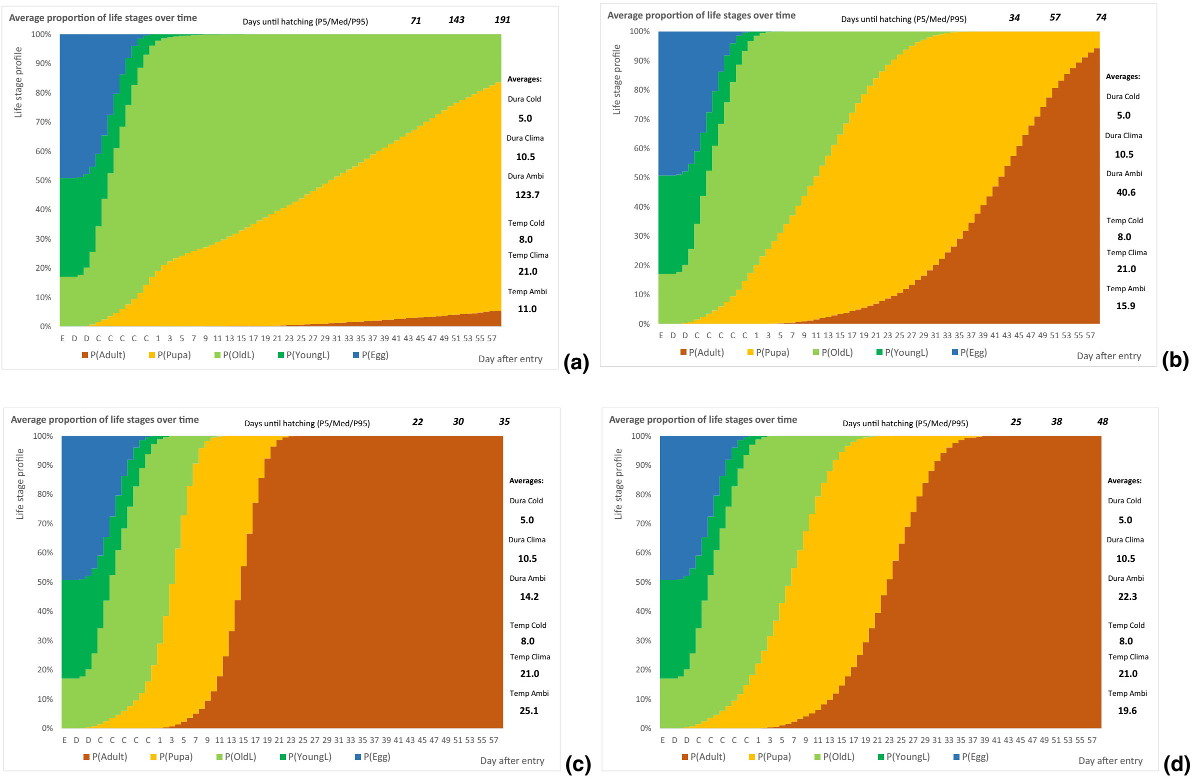

Figure A.13: Average proportion of different life stages (blue = eggs, dark green = L1–L2, light green = L3–L5, yellow = pupae, red = adults) of *Thaumatotibia leucotreta* by day (horizontal axis) starting with entering the EU (E), distribution in cooled conditions (D), consumption in climatised environment (C) and days after wasting by the consumer. Results by the developmental model are given for NUTS2 regions in climate suitability class 3 for winter (a), spring (b), summer (c) and autumn (d)

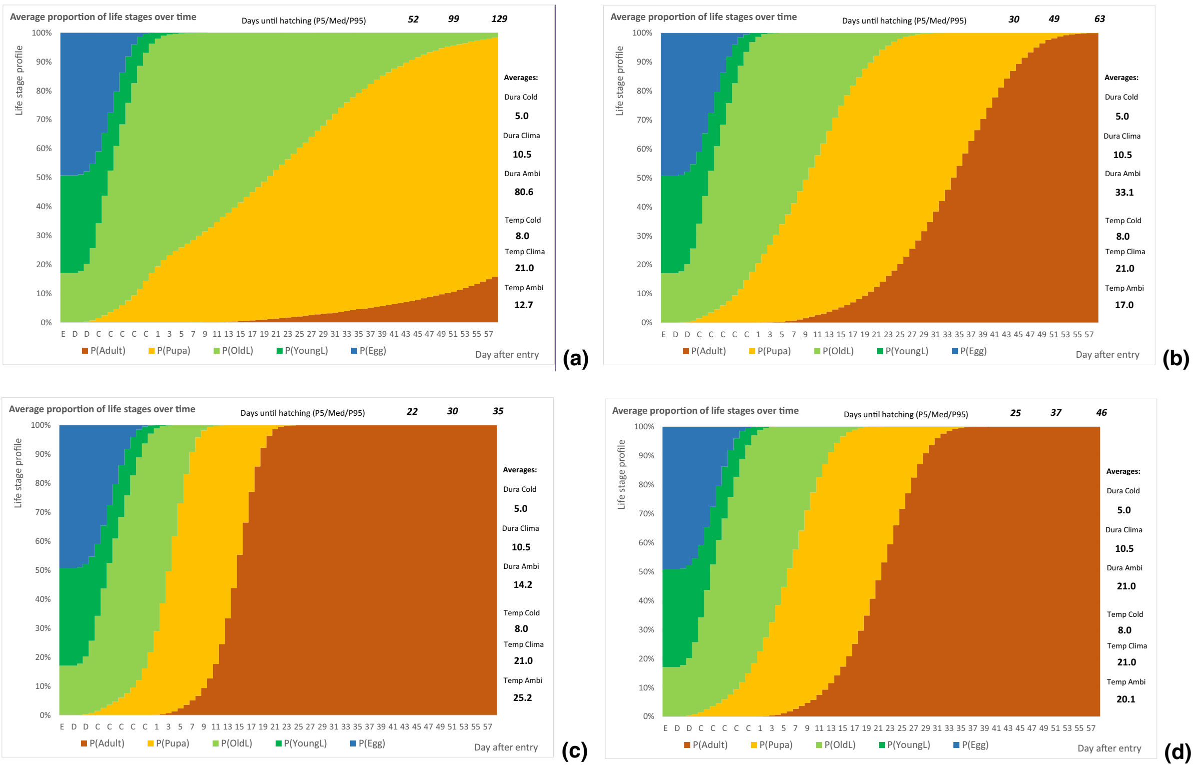

Figure A.14: Average proportion of different life stages (blue = eggs, dark green = L1–L2, light green = L3–L5, yellow = pupae, red = adults) of *Thaumatotibia leucotreta* by day (horizontal axis) starting with entering the EU (E), distribution in cooled conditions (D), consumption in climatised environment (C) and days after wasting by the consumer. Results by the developmental model are given for NUTS2 regions in climate suitability class 4 for winter (a), spring (b), summer (c) and autumn (d)

A.8.2. Proportion of insects developing to adults before the waste treatment

The waste model includes the proportion of adults, which will escape the cut rose, before it is treated by different forms of waste treatment. This proportion is influenced by the development time of *Thaumatotibia leucotreta*, esp. the temperatures in the compartments B (climatised) and C (ambient temperatures, depending on the season), and the time between initial disposal by the consumer and the waste treatment. Because of lacking information on the duration between disposal and treatment, four scenarios are defined: 3 days, 7 days, 14 days and 28 days. 3 days can be seen as best case, while 28 days is a reasonable worst case.

For the calculation, a mean time of 15 days until initial disposal wasting was used.

Table A.85: Definition of different scenarios for the time between initial disposal and waste treatment

	Treatment	
	Days after entry	**Days after initial disposal**
Scenario 1	18 days	3 days
Scenario 2	22 days	7 days
Scenario 3	29 days	14 days
Scenario 4	43 days	28 days
Scenario 5[1]	71 days	56 days

(1): Scenario 5 was calculated but disregarded as worst-case scenario.

Which resulted in following escape rates of FCM adults before the waste treatment.

Table A.86: Median seasonal proportion of escaping adults before the waste treatment for four scenarios of the time between initial disposal and waste treatment

Proportion adults		**Season**	**Time between initial disposal and waste treatment**				
Climate suitability class			**3 days**	**7 days**	**14 days**	**28 days**	**56 days**
1	Blue	Winter	0.05%	0.05%	0.05%	0.05%	0.05%
		Spring	0.05%	0.11%	0.39%	2.67%	13.1%
		Summer	0.43%	3.22%	17.8%	96.3%	100%
		Autumn	0.05%	0.20%	0.94%	4.98%	32.4%
2	Green	Winter	0.05%	0.05%	0.05%	0.12%	0.27%
		Spring	0.08%	0.26%	1.29%	6.44%	47.1%
		Summer	0.53%	4.06%	27.2%	99.9%	100%
		Autumn	0.16%	0.82%	4.38%	27.0%	99.5%
3	Yellow	Winter	0.05%	0.07%	0.21%	0.97%	5.12%
		Spring	0.09%	0.46%	2.95%	15.1%	91.2%
		Summer	0.73%	5.05%	43.9%	100%	100%
		Autumn	0.33%	2.33%	11.9%	79.4%	100%
4	Red	Winter	0.05%	0.12%	0.38%	2.82%	14.1%
		Spring	0.16%	0.82%	4.62%	28.5%	99.9%
		Summer	0.73%	5.09%	43.9%	100%	100%
		Autumn	0.37%	2.65%	14.2%	87.2%	100%

Natural mortality of the life stages is assumed (see Section A.9) during the time until the waste treatment. This includes a stable host suitability, and no 'specific' treatment of the disposed waste before the commercial waste treatment.

A.9. Waste treatment in the climatically suitable area

The main characteristics of the different treatments for the organic fraction of solid waste (landfill, composting, anaerobic digestion and incineration) are briefly described in this section. This information was used as part of the evidence for the expert judgement on: (i) Proportion of organic waste going to private composting (A.9.1), (ii) Survival rate of FCM at landfill (A.9.4), composting (A.9.5) and anaerobic digestion and incineration (A.9.6).

Landfill

According to the Landfill Directive (LD) (1999/31/EC, 2018/850/EC) landfill is defined as: 'a waste disposal site for the deposit of the waste onto or into land (i.e. underground)'. The definition does not include (i) facilities where waste is unloaded in preparation for further transport for recovery, treatment or disposal elsewhere, (ii) storage of waste prior to recovery or treatment for a period less than 3 years as a general rule or (iii) storage of waste prior to disposal for a period less than 1 year.

Landfilling is considered as the least preferable option by the EU Waste Framework Directive (WFD) (2008/98/EC 2018/851/CE) and should be limited to the necessary minimum. Landfilling of bio-waste is explicitly addressed in the LD which requires Member States (MS) to adopt national strategies for the progressive reduction of biodegradable municipal waste (BMW) going to landfill by means of in particular, recycling, composting, biogas production or material/energy recovery. According to the LD, by 2035, all MS should reduce the amount of municipal waste sent to landfill to 10% or less of the total municipal waste generated. As reported by the European Environment Agency (EEA), implementation of these directives so far resulted in a decrease in the landfill rate (waste sent to landfill as a proportion of waste generated) from 23% to 16% between 2010 and 2020 in EU-27 and an overall 27.5% reduction of the total amount of waste sent to landfill in the same period. However, it should be noted that the municipal waste landfill rates are highly variable across MS with differences ranging from close to 0 to 90% (EEA) https://www.eea.europa.eu/ims/diversion-of-waste-from-landfill).

In article 6(a) of LD, it is specified that only waste that has been subjected to a pretreatment to reduce the volume or hazardous nature, facilitate its handling or enhance recovery may be placed into landfill. The Biodegradable municipal waste (BMW) going to landfill as part of the municipal solid waste (MSW) is therefore assumed to follow the typical landfilling operations for non-hazardous waste involving: (1) waste dumping at the working face, (2) waste spreading, shredding and compaction and (3) waste covering (Chandrappa and Das, 2012).

Upon arrival at the landfill site, MSW is generally compacted using bulldozers or other compaction vehicle to spread the waste evenly and optimise the usable landfill space. The densely compacted waste should then be covered with at least 15 cm of soil or other approved material at the end of the working day to reduce odours, prevent dispersion of the waste and deter scavengers. Once the landfill has reached the permitted height, a final cover consisting of an engineered barrier of clay, soil or other materials to seal in the waste is constructed and laid over the whole landfill (Boase, 1999, Chen et al., 2011).

Industrial composting

Composting, defined as '*the controlled biological decomposition of organic material in the presence of air to form a humus-like material*'. (EEA, online) involves % of the separately collected bio-waste in Europe and consists of four main phases: (1) Reception and preparation (sorting, shredding, homogenising), (2) Aerobic degradation, (3) Maturation and (4) Finalisation (size classification, removal of impurities) with the las two steps not always involved (EC, 2018).

Most common industrial composting methods are (i) windrow, an outdoor composting system consisting in piles of compost that are aerated either manually or mechanically turning the piles; (ii) aerated static pile (ASP), a system that makes use of forced aeration to push or pull air through the pile core and (iii) in-vessel composting, a system where the waste is enclosed in vessels or containers and environmental conditions are strictly controlled by the waste management facilities (Lim et al., 2017). A combination of the composting systems is also possible, e.g. the waste can first spend short time in in-vessel for fast degradation followed by continuous degradation and stabilisation in a windrow (Lim et al., 2017).

Composting is a microbiological process facilitated by bacteria and fungi and under controlled conditions, it proceeds through three phases: (i) the mesophilic phase, normally lasting for a couple of days and normally reaching about 45°C, (ii) the thermophilic phase, characterised by an increase in the temperature up to about 70°C and lasting from a few days to several months (depending on the size of the system and the composition of the initial substrate) and, finally, (iii) a cooling and maturation phase (Nikoloudakis et al., 2018; Palaniveloo et al., 2020). The maturation time strongly depends on the conditions during composting and can take as long as 6–12 months (Chen et al., 2011) or as short as 14–21 days (Raabe, 2001).

Home composting

While the industrial composting is a well-defined process taking place under controlled conditions in authorised plants, home composting is a gardening practise, carried out by citizens on a voluntary basis not entailing specific permits or obligations. No precise definition exists for home composting; the practice is normally understood as a cooler aerobic breakdown of domestic organic waste (dumping, feeding, etc.). The composting typically takes place in small-scale composters and by 'slow-stack' treatment methods (European bioplastics, 2015), for this reason, home composting is normally done by garden owners that can use the final product (i.e. the compost) as a fertiliser. Temperatures reached during home composting are generally lower than those reached in industrial settings, normally not controlled and following much more fluctuating pattern (Colón et al., 2010, Tatàno et al., 2015).

Due to the general lack of regulatory drivers to promote home composting at European level and the domestic nature of the practice, there is a substantial lack of data in terms of prevalence and volume of organic waste treated as home composting. A number of MS promote home composting as a strategy to reduce the amount of biodegradable waste going to landfill, but the uptake of this practice remains challenging to estimate and absence of harmonised collection of information makes country-level data difficult to compare. For example, a proportion ranging from 5% to 10% of the households are reportedly active in home composting in the Netherlands while it seems that about 14% of the household waste treated biologically in 2012 was home composted in Sweden (Sulewski et al., 2021). Again, the statistical office of Slovenia reported 48% of people having a home composting system in 2015 (Žitnik and Vidic, 2016) while in Italy, the national aggregated value for the amount of waste destined for home composting in 2020 was 3.8% of the separately collected organic waste (ISPRA, 2021). Based on 2012 aggregate data from Austria, Denmark, Estonia, Finland, Germany, Ireland, Sweden and the UK, Stenmarck et al. estimated a home composting rate of 8% of the total household food waste (Stenmarck et al., 2016).

Anaerobic digestion

Anaerobic digestion (AD) is another decomposition process mediated by bacteria. It consists in a series of biochemical reactions where bacteria break down the organic matter of any substrate into a gaseous mixture (CH_4, CO_2, H_2, H_2S, etc.) in the absence of free oxygen. To ensure anaerobic environment, AD occurs in a closed tank or vessel, often called digester (Uddin and Wright, 2022).

The biochemical AD reactions can be divided into four distinct stages: (i) hydrolysis, (ii) acidogenesis, (iii) acetogenesis and (iv) methanogenesis (Uddin and Wright, 2022). The methanogenesis stage is anaerobic; therefore, the digesters are covered to ensure anaerobic conditions (Uddin and Wright, 2022). Common feedstock for AD (the biodegradable biomass materials used in AD) includes agricultural waste (including livestock manure), industrial agronomic residues and the organic fraction of municipal solid waste. Co-digestion of different substrates is often used to avoid nutrient imbalances/process inhibition (Uddin and Wright, 2022). In order to enhance the performance of the AD processes, a range of mechanical, chemical, physical or thermal pretreatments can be used (alone or in combination) to enable the cell constituents of the organic matter to become easily available to microorganisms for biogas production (Uddin and Wright, 2022). Final products of AD are the biogas and the digestate, which is the unconverted substrate normally used as a soil fertiliser.

Optimal operating temperature ranges for AD are 55–60°C and 35–40°C for digestion operated by thermophilic and mesophilic methanogenic bacteria, respectively (Uddin and Wright, 2022). The average residence time of the substrate in the digester varies with the amount/type of substrate itself and the operating temperature (Uddin and Wright, 2022); typical retention times are in the range of 10–40 days and 12–14 days for mesophilic and thermophilic digesters, respectively (Verma, 2002, Monnet, 2004).

Incineration

In general, any incineration facility will incorporate the following processes: waste storage and handling, pretreatment and waste preparation, combustion, air pollution control and residue (ash) handling (NRC, 2000).

In practice, the incoming waste is usually tipped from collection vehicles into reception chambers where non-combustible objects are removed before the transfer into a concrete waterproof storage chamber (Boase, 1999; Neuwahl et al., 2019). The whole delivery area may be enclosed to limit the odour, noise and emissions from the waste (Neuwahl et al., 2019). The storage chambers usually have a capacity of 3–5 days of plant operational throughput; however, this is dependent on local factors and the specific nature of the waste (Neuwahl et al., 2019). During combustion, the reaction temperature ranges from 800°C to 1,450°C.

A.9.1. Proportion of private compost

Table A87: Result report on EKE question 3

Overview of the results of the Expert Knowledge Elicitation Question 3															
Parameter	Proportion of organic waste going to private composting														
Stratification	Countries in the climatically suitable area/only one average of the climatically suitable area														
Question	Compared to the waste counted in the statistics of Eurostat, what additional proportion of organic waste is going to private composting?														
Unit	[%], theoretical restriction: 0–100%														
Results	P1%	P2.5%	**P5%**	P10%	P16.7%	P25%	P33.3%	**P50%**	P66.7%	P75%	P83.3%	P90%	**P95%**	P97.5%	P99%
Elicited values	2%					8%		**13%**		25%					40%
EKE results	2.0%	2.2%	2.6%	3.6%	5.1%	7.1%	9.4%	14%	21%	24%	28%	32%	36%	38%	40%
Fitted distribution	BetaGeneral (0.85283, 1.555, 0.0188, 0.425)														

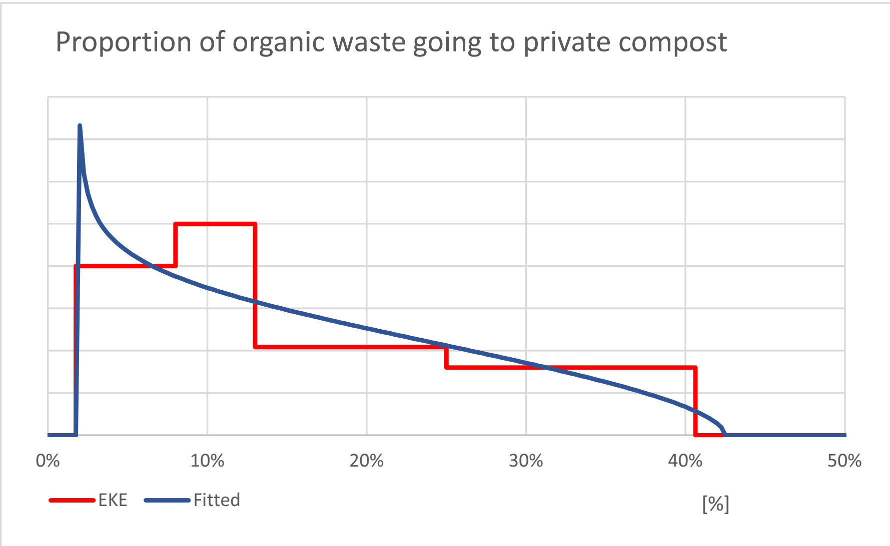

Figure (a): Comparison of elicited and fitted values/density function to describe the remaining uncertainties of the parameter

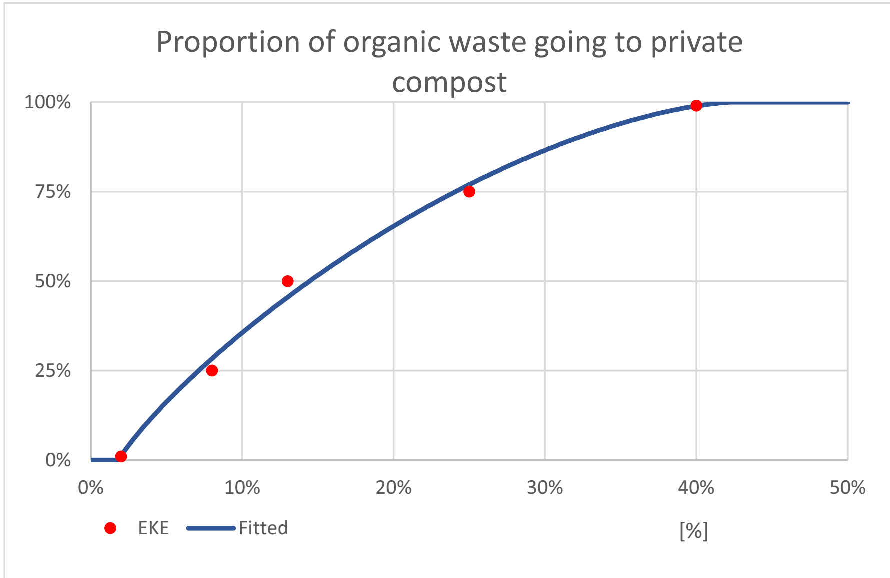

Figure (b): Cumulative distribution function (CDF) of the likelihood of the parameter

Summary of the evidence used for the evaluation	
• Literature on home composting (e.g. see: Colón et al., 2010; Tatàno et al., 2015; Stenmarck et al., 2016; Žitnik and Vidic, 2016; ISPRA, 2021; Sulewski et al., 2021)	
Main uncertainties	
• Lack of data on volumes of organic waste treated as home composting and on conditions of home composting	
Reasoning for a scenario which would lead to a reasonable high proportion	The **judgement on the upper limit** considers that • Level of population living in houses (50%)/High rate of private compost in a survey/Complete organic part going to private compost • Slovenia is an example for a high rate 48% of private compost, but high proportion of living in houses
Reasoning for a scenario which would lead to a reasonable low proportion	The **judgement on the lower limit** considers that • It is above 0%, because it includes all kind of disposal of organic waste (dumping, feeding, etc.), not only composted waste • 24% of population is living in rural areas
Fair estimate as judgement on the weighted evidence	The **judgement on the median** considers that • Statistics from 5 countries mainly Northern/Western EU shows about 8%, for the countries of the climatically suitable area the home composting will be higher • High part of the population living in rural areas • It includes all kind of disposal of organic waste (dumping, feeding, etc.), not only composted waste
Precision of the judgement as description of remaining uncertainties	The **judgement on the interquartile range** considers that • High uncertain on both sides of the median value
Experts	Antoon LOOMANS, Panos MILONAS, Klara NICOVA, Giuseppe STANCANELLI, Hans-Hermann THULKE
Facilitator/Reporter	Olaf MOSBACH-SCHULZ (facilitator)
Observers	na
Date and place of the EKE	Virtual meeting on 9 January 2023

A.9.2. Proportion of treatments of commercial waste in the climatically suitable area

Eurostat reports the treatment of waste by waste category, hazardousness and waste management operations (Eurostat table: ENV_WASTRT (WST_OPER) in tonnes. The model uses most recent data of 2020 on 'Vegetal waste' to calculate the relative proportions:

- Landfill consists of 'Disposal – landfill (D1, D5, D12)'; 'Disposal – Other (D2-D4, D6-D7)'; and 'Recovery – backfilling'
- Compost consists of 'Recovery – recycling'
- Incineration, anaerobic digestion consist of 'Disposal – incineration (D10)'; and 'Recovery – Energy recovery (R1)'.

Hence, the model assumes, that in commercial situations the wasted cut flowers are only mixed with other vegetal waste.

Table A.88: Proportion of different types of waste treatments of commercial waste per country in the EU climatically suitable area (Eurostat, ENV_WASTRT (WST_OPER), 2020, online, downloaded on 1 February 2023)

Treatment	Country in the climatically suitable area											
	Spain	Portugal	France	Italy	Malta	Slovenia	Croatia	Greece	Cyprus	Hungary	Bulgaria	Romania
	Proportion of different treatments of commercial waste [%]											
Landfill	5%	5%	4%	0%	100%	0%	15%	10%	12%	3%	23%	24%
Compost	92%	89%	96%	98%	0%	100%	77%	73%	88%	88%	53%	68%
Incineration	3%	6%	0%	2%	0%	0%	8%	17%	0%	8%	24%	8%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

A.9.3. Proportion of treatments of household waste in the climatically suitable area

As proxy for the proportion of different treatments of household waste, the model uses the same classification of Eurostat on household waste. Because the category 'Recovery – recycling' comprises several possibilities of recycling, this approach assumes similar recycling rates for all kind of household waste.

Table A.89: Proportion of different types of waste treatments of household waste per country in the EU climatically suitable area (Eurostat, ENV_WASTRT (WST_OPER), 2020, online, downloaded on 1 February 2023)

Treatment	Country in the climatically suitable area											
	Spain	Portugal	France	Italy	Malta	Slovenia	Croatia	Greece	Cyprus	Hungary	Bulgaria	Romania
	Proportion of different treatments of household waste [%]											
Landfill	72%	63%	36%	3%	100%	96%	93%	95%	100%	77%	100%	100%
Compost	10%	15%	0%	74%	0%	4%	7%	5%	0%	6%	0%	0%
Incineration	18%	22%	64%	23%	0%	0%	0%	0%	0%	18%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

A.9.4. Result Survival rate of FCM at landfill

Table A.90: report on EKE question 4a

Overview of the results of the Expert Knowledge Elicitation Question 4a															
Parameter	Survival rate of FCM in household waste going to landfill														
Stratification															
Question	Assuming infestation of cut roses at the beginning of the waste treatment with later larval stages and pupae. What is the proportion of FCM which will develop to an adult and escape the waste treatment (landfill)?														
Unit	[Escape out of 10,000]														
Results	P1%	P2.5%	**P5%**	P10%	P16.7%	P25%	P33.3%	**P50%**	P66.7%	P75%	P83.3%	P90%	**P95%**	P97.5%	P99%
Elicited values	0														10
EKE results	0.1	0.3	0.5	1.0	1.7	2.5	3.4	5.1	6.7	7.6	8.4	9.1	9.6	9.8	10.0
Fitted distribution	Uniform (0, 0.00101)														

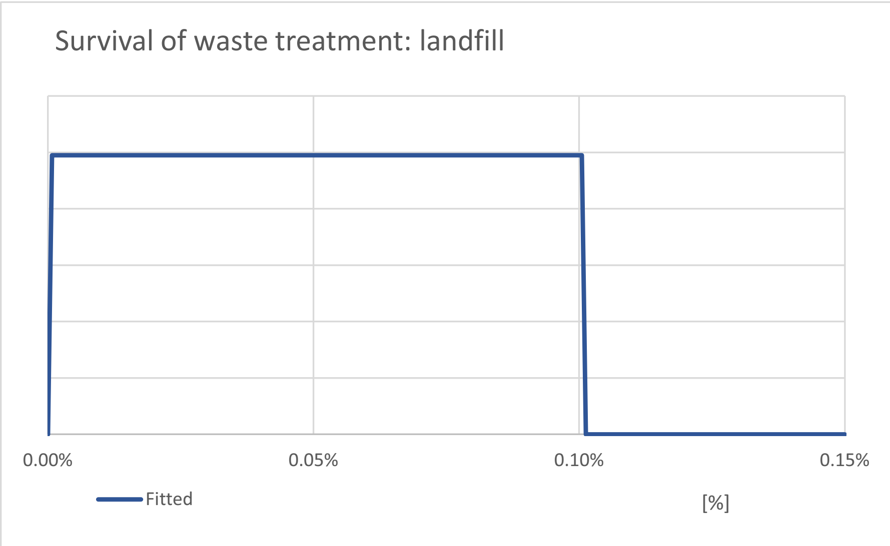

Figure (a): Comparison of elicited and fitted values/density function to describe the remaining uncertainties of the parameter

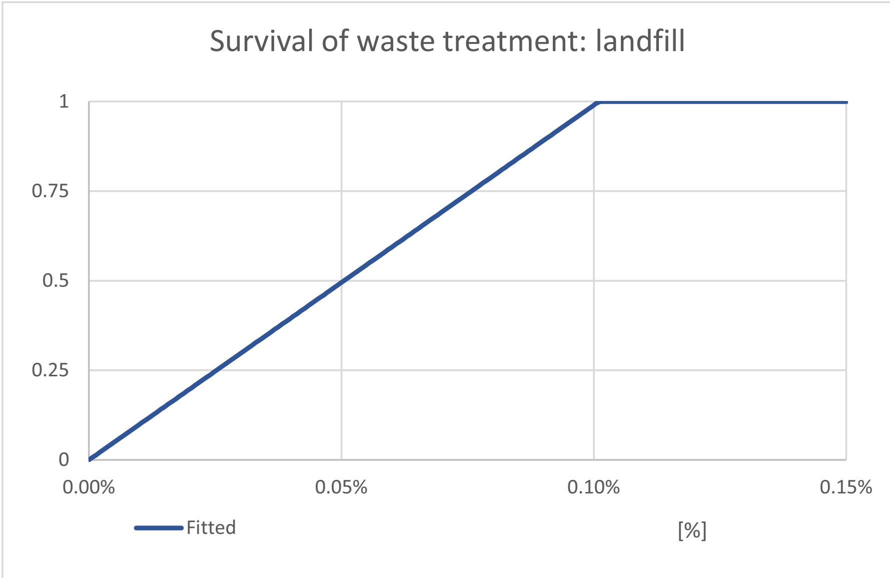

Figure (b): Cumulative distribution function (CDF) of the likelihood of the parameter

Summary of the evidence used for the evaluation	
• Literature on effects of waste treatments on insects, e.g. Soderstrom et al. (1990), Ali Ahmed et al. (2007), Baughman et al. (2015), Love et al. (2019) • Conditions of regular landfill	
Main uncertainties	
• Possibility of larvae to move in soil, effect of land cover • Effect of compaction, pressure esp. on pupae	
Reasoning for a scenario which would lead to a reasonable high proportion	The **judgement on the upper limit** considers that • *Thaumatotibia leucotreta* in late pupa stage • Escape before covering with new soil, waste • No effect on compaction (cp. Love et al. 2019) • Only deep burying (thicker than 46 cm) is effective • In parts of landfill, which is not regularly treated by covering, etc.
Reasoning for a scenario which would lead to a reasonable low proportion	The **judgement on the lower limit** considers that • Regular procedure of landfill • Treatment with compaction and coverage is effective to inhibit escape • Coverage thicker than possible movement of larvae, e.g. 5 cm vertically
Fair estimate as judgement on the weighted evidence	The **judgement on the median** considers that • Due to missing knowledge on implemented landfill processes maximum uncertainties in the credible range (L–U)
Precision of the judgement as description of remaining uncertainties	The **judgement on the interquartile range** considers that • Due to missing knowledge on implemented landfill processes maximum uncertainties in the credible range (L–U)
Experts	Antoon LOOMANS, Panos MILONAS, Klara NICOVA, Stella PAPANASTASIOU, Giuseppe STANCANELLI, Hans-Hermann THULKE
Facilitator/Reporter	Olaf MOSBACH-SCHULZ (facilitator)
Observers	Na
Date and place of the EKE	Virtual meeting on 9 January 2023

A.9.5. Survival rate of FCM at composting

Table A.91: Result report on EKE question 4b

Overview of the results of the Expert Knowledge Elicitation Question 4b															
Parameter	Survival rate of FCM in household waste going to compost														
Stratification															
Question	Assuming infestation of cut roses at the beginning of the waste treatment with later larval stages and pupae. What is the proportion of FCM which will develop to an adult and escape the waste treatment (compost)?														
Unit	[Escape out of 10,000]														
Results	P1%	P2.5%	**P5%**	P10%	P16.7%	P25%	P33.3%	**P50%**	P66.7%	P75%	P83.3%	P90%	**P95%**	P97.5%	P99%
Elicited values	0														1
EKE results	0.01	0.03	0.05	0.10	0.17	0.25	0.34	0.51	0.67	0.76	0.84	0.91	0.96	0.98	1.00
Fitted distribution															

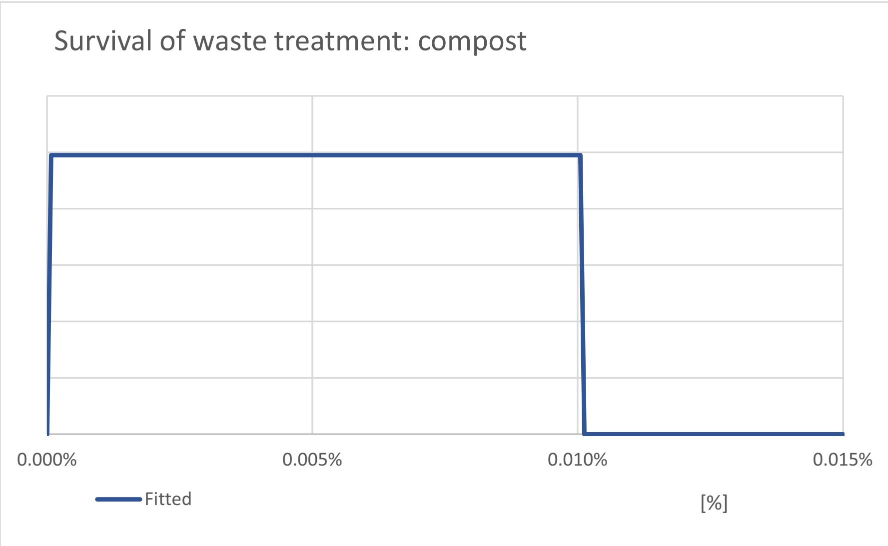

Figure (a): Comparison of elicited and fitted values/density function to describe the remaining uncertainties of the parameter

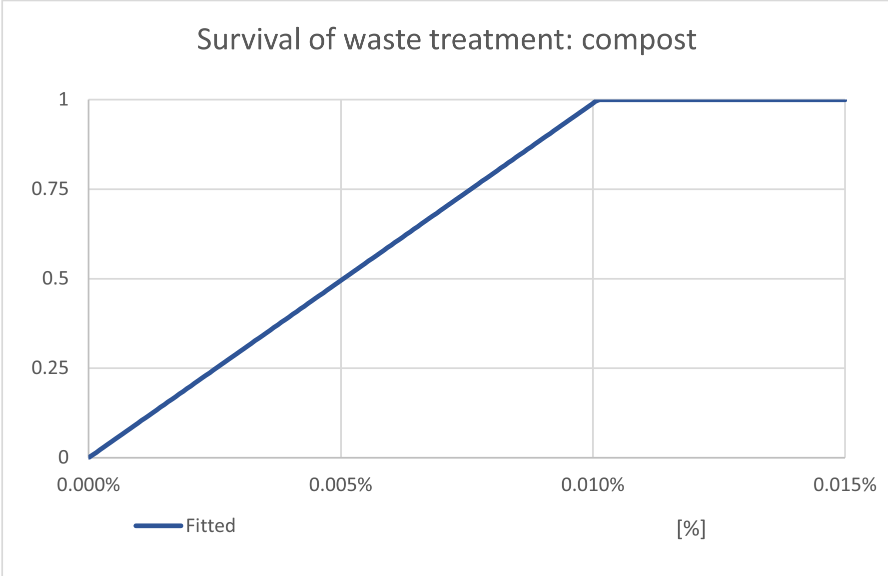

Figure (b): Cumulative distribution function (CDF) of the likelihood of the parameter

Summary of the evidence used for the evaluation	
• Literature on effects of waste treatments on insects, e.g. Soderstrom et al. (1990), Ali Ahmed et al. (2007), Baughman et al. (2015), Love et al. (2019) • Conditions of regular composting, incl. timing, turn of piles and soil cover with clean soil	
Main uncertainties	
• Possibility of larvae to move in soil, effect of soil cover • Effect of lower temperatures, existence of temperature profiles of the pile with lower temperatures, existence of incorrect turn of the piles	
Reasoning for a scenario which would lead to a reasonable high proportion	The **judgement on the upper limit** considers that • *Thaumatotibia leucotreta* in late pupa stage • Parts of the piles with insufficient temperatures (below 45°C) • Short duration of the heat treatment • In parts of pile, which is not regular turned, or with too low temperatures.
Reasoning for a scenario which would lead to a reasonable low proportion	The **judgement on the lower limit** considers that • Regular procedure of composting • Treatment with heat and coverage is effective to kill the eggs, larvae and pupae; and/or inhibit escape • Coverage thicker than possible movement of larvae, e.g. 5 cm vertically
Fair estimate as judgement on the weighted evidence	The **judgement on the median** considers that • Due to missing knowledge on implemented landfill processes maximum uncertainties in the credible range (L–U)
Precision of the judgement as description of remaining uncertainties	The **judgement on the interquartile range** considers that • Due to missing knowledge on implemented landfill processes maximum uncertainties in the credible range (L–U)
Experts	Antoon LOOMANS, Panos MILONAS, Klara NICOVA, Stella PAPANASTASIOU, Giuseppe STANCANELLI, Hans-Hermann THULKE
Facilitator/Reporter	Olaf MOSBACH-SCHULZ (facilitator)
Observers	na
Date and place of the EKE	Virtual meeting on 9 January 2023

A.9.6. Survival rate of FCM at incineration and anaerobic digestion

Table A.92: Result report on EKE question 4c

Overview of the results of the Expert Knowledge Elicitation Question 4c															
Parameter	Survival rate of FCM in household waste going to incineration or anaerobic digestion														
Stratification															
Question	Assuming infestation of cut roses at the beginning of the waste treatment with later larval stages and pupae. What is the proportion of FCM which will develop to an adult and escape the waste treatment (incineration or anaerobic digestion)?														
Unit	[Escape out of 10,000]														
Results	P1%	P2.5%	**P5%**	P10%	P16.7%	P25%	P33.3%	**P50%**	P66.7%	P75%	P83.3%	P90%	**P95%**	P97.5%	P99%
Elicited values	0														0
EKE results	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fitted distribution	Constant(0)														

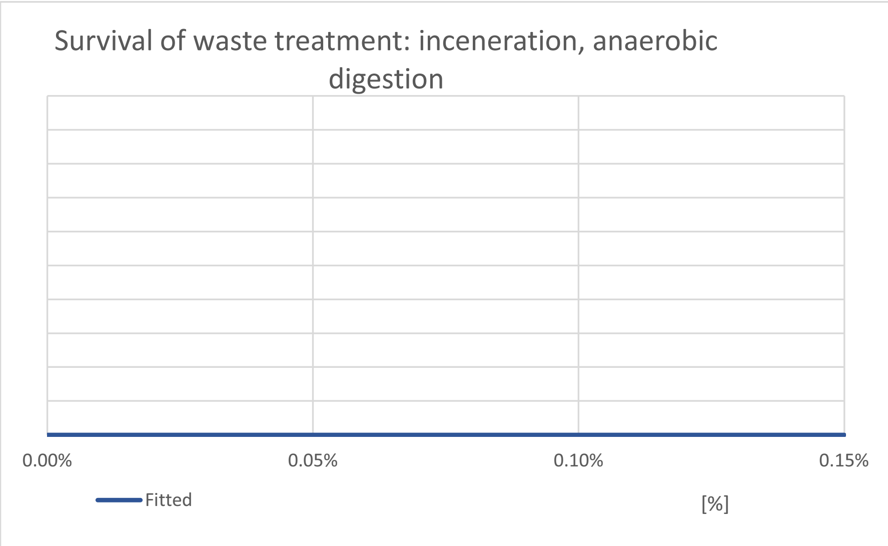

Figure (a): Comparison of elicited and fitted values/density function to describe the remaining uncertainties of the parameter

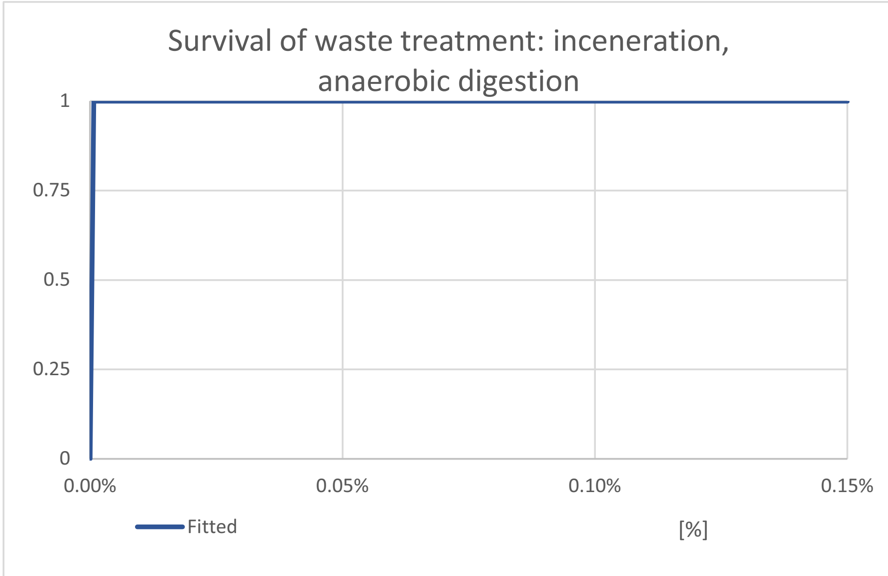

Figure (b): Cumulative distribution function (CDF) of the likelihood of the parameter

Summary of the evidence used for the evaluation	
• Literature on effects of waste treatments on insects, e.g. Soderstrom et al (1990), Ali Ahmed et al. (2007), Baughman et al. (2015), Love et al (2019) • Conditions of regular incineration/anaerobic digestion, esp. fermentation, heat treatment and exchange of atmosphere (higher CO_2)	
Main uncertainties	
• Effect of lower temperatures, duration and completeness of fermentation • Due to the closure of the process, it is considered as process with 100% mortality	
Reasoning for a scenario which would lead to a reasonable high proportion	The **judgement on the upper limit** considers that • Material is complete fermented or burned, same as low value
Reasoning for a scenario which would lead to a reasonable low proportion	The **judgement on the lower limit** considers that • Regular procedure of incineration, or anaerobic digestion, incl. high temperatures, exchanged atmosphere, complete closure • Treatment is effective to kill the eggs, larvae and pupae; and/or inhibit escape
Fair estimate as judgement on the weighted evidence	The **judgement on the median** considers that • Complete 100% mortality
Precision of the judgement as description of remaining uncertainties	The **judgement on the interquartile range** considers that • No uncertainties
Experts	Antoon LOOMANS, Panos MILONAS, Klara NICOVA, Stella PAPANASTASIOU, Giuseppe STANCANELLI, Hans-Hermann THULKE
Facilitator/Reporter	Olaf MOSBACH-SCHULZ (facilitator)
Observers	na
Date and place of the EKE	Virtual meeting on 9 January 2023

A.10. Natural developmental mortality

Finally, the number of escaped insects is corrected by a factor taking into account the mortality during the development of the larval and pupal stage. Numbers were taken from the reported mortality of larvae in citrus fruits between 25% and 37%. Assuming a similar natural mortality for the pupa stage gives an overall developmental mortality between 44% and 60%.

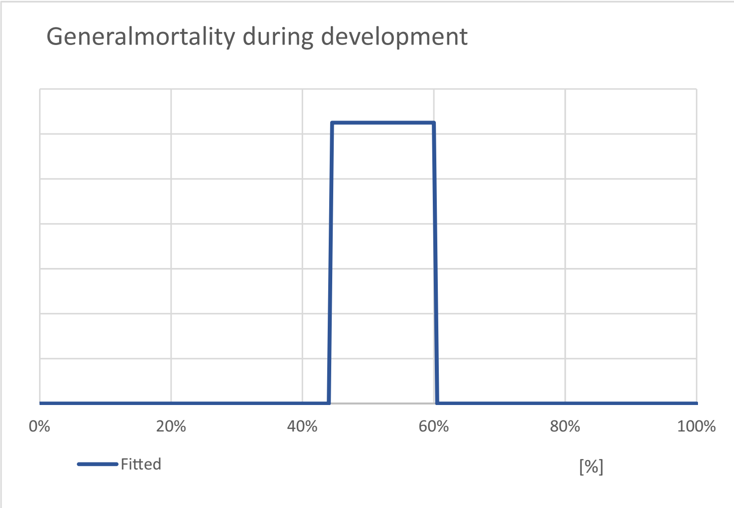

Figure A.15: Density function showing the uncertainty distribution of the mortality during natural development of *Thaumatotibia leucotreta*

Appendix B – PBDM modelling of temperature-driven dynamics of FCM *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae), the false codling moth

Assessing the EU suitability for establishment of the exotic false codling moth (*Thaumatotibia leucotreta*) was a major part of the quantitative assessment of whether the importation of cut roses from East Africa provides a potential pathway for pest introduction in the EU. To determine this, a mechanistic temperature-driven physiologically based demographic modelling (PBDM) was developed. The approach explicitly incorporates the mathematical description of the observed thermal biology of the pest to assess the phenology and dynamics of *T. leucotreta* populations in its native African range and its prospective range in the EU and the Mediterranean Basin.

Various modelling methods have been used to assess the suitability for potential establishment of pest species: *Ecological niche models* (ENMs) and **physiologically based demographic models (PBDMs)** are referenced in this text. **ENMs** characterise the ecological niche of *T. leucotreta* using aggregate weather and other factors in areas where the species has been recorded and use the model to predict the potential geographic range of the species in novel areas. The main advantage of ENM approaches is their relative simplicity to implement and low biological data requirements and, may provide an unbiased first screening of the potential range of invasive pests in new areas. The **PBDM** is used to capture the biology of *T. leucotreta* to predict prospectively its dynamics and distribution across vast geographic regions independent of occurrence records.

In its simplest form, the PBDM captures the time-varying response of *T. leucotreta* to thermal variables as biodemographic functions (BDFs). The available data on the effects of temperature on *T. leucotreta* developmental rate, reproduction and mortality are illustrated in Box 1 and Section 3.1 of the opinion. These BDFs are imbedded in temperature-driven population dynamics models and used to assess the EU suitability for potential establishment of *T. leucotreta*.

Age-structured dynamics models that have been used to model the population dynamics of invasive species include the Manetsch (1976), Vansickle (1977) and forward Fokker-Planck partial differential equation models (Buffoni and Pasquali, 2007). These models capture distributed maturation times of cohort members as observed in nature. The models also can imbed the time–temperature varying dynamics of holometabolous insect species having distinct stages: egg (e.g. e = eggs), larval (l), pupal (p) and adults (a) in an age specific manner. Individuals enter the first age class, say as an egg and develop through the life stages at temperature-dependent rates exiting from the final age class, or via mortality from any age or stage.

The time invariant distributed-maturation-time demographic model (Manetsch, 1976) was used here to capture the dynamics of *T. leucotreta*. Absent extrinsic mortality, the theoretical distribution of cohort developmental times can be approximated using k age categories (i.e. Erlang parameter $k = \Delta^2/\mathrm{var}$), where var is the variance of average physiological developmental time D. The general form of the time invariant model is given for the ith of k age classes of a stage (left superscript s) with initial density in each age class ${}^{s}N_i(t_0)$ $(i = 1, 2, \ldots, k)$. Using the notation of Di Cola et al. (1999, page 523) and ignoring the stage superscript, the age class dynamics is as follows:

$$\frac{dN_i}{dt} = \frac{k \cdot \Delta_x}{\Delta}[N_{i-1}(t) - N_i(t)] - \mu_i(t)N_i(t), \quad (1)$$

where $\Delta_x(T(t)) = (1/\mathrm{del}(T)) \times \Delta$ is the change in physiological age at time t and temperature T (see text Box 1), and $\mu_i(\cdot, t)$ is the net proportional loss rate that may be (+, −) and includes age-specific components such as death rates, density-dependent capacity-related mortality and net immigration. In terms of flux, $n_i(t) = N_i(t)\nu_i(t)$ where $\nu_i(t) = \frac{k}{\Delta}\Delta_x(T(t))$, and

$$\frac{d}{dt}\left[\frac{\Delta}{k}n_i(t)\right] = n_{i-1}(t) - n_i(t) - \mu_i(t)n_i(t)\frac{\Delta}{k} \quad (2)$$

The density of the stage population at time t is ${}^{s}N(t) = \sum_{i=1}^{k} {}^{s}N_i(t)$.

Potential total births $b_0(t)$ are the sum of adults' (stage A in ${}^{A}k$ age classes) times the age specific reproduction $\left(\sum_{x=1}^{{}^{A}k} f(x, T_{opt}) \times {}^{A}N_i(x, t)\right)$ corrected for sex ratio (sr) and J limiting factors $(0 \leq f_j < 1)$ such as temperature, relative humidity, nutrition with only temperature used in the *T. leucotreta* assessment:

$$b_0(t) = sr \times \prod_{j}^{J} \phi_j(t) \times \sum_{x=1}^{k} f(x, T_{opt}) \cdot N_i(x, t). \quad (3)$$

The $b_0(t)$ individuals enter the youngest age class (k = 1) of the first developmental stage, with forward flows (ageing) occurring between age classes and between stages, and adults exit as deaths latest at maximum adult age ($i = {}^{A}k$).

The numerical solution and the computations for the time invariant and time varying dynamics of the pest (and possibly any species in all trophic levels) are made with the same few lines of computer code (*c.f.* Abkin and Wolf, 1976; see Gutierrez, 1996, p. 157–159). Because of non-linearities and the time varying nature, the model can only be evaluated numerically.

Regional analysis

The regional analysis of the geographic distribution and abundance of a species occurred as follows: (i) run the model using daily weather data (observed or climate model data) across all lattice cell in the landscape across all years, (ii) compute means, standard deviation and coefficient of variation for annual summary variables in each lattice cell and (iii) map the geo-referenced data using GIS (e.g. GRASS, see Neteler et al., 2012).

Appendix C – Compartment model for FCM development in EU

The compartment model for *Thaumatotibia leucotreta* (Lepidoptera: Tortricidae) development in the EU is available in Excel format in the Supporting publication to this Scientific opinion.

Appendix D – Cut roses pathway model for import from Africa

The cut roses pathway model from Africa is available in Excel format in the Supporting publication to this Scientific opinion.

Appendix E – EFSA Climate Suitability Analysis of *Thaumatotibia leucotreta*

The EFSA Climate Suitability Analysis report is available on the Zenodo platform: https://doi.org/10.5281/zenodo.7648499 and it shall be cited as:

Rossi Eugenio, Campese Caterina, Maiorano Andrea, Picchi Malayka, Papanastassiou Stella, Muñoz Guajardo Irene and Stancanelli Giuseppe. (2023). EFSA Climate Suitability Analysis of *Thaumatotibia leucotreta*. Zenodo. https://doi.org/10.5281/zenodo.7648499