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Pest categorisation of *Leucinodes orbonalis*

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Abstract

The EFSA Panel on Plant Health performed a pest categorisation of the eggplant fruit and shoot borer, *Leucinodes orbonalis* Guenée, (Lepidoptera: Crambidae), for the territory of the EU. *L. orbonalis* is a tropical and sub-tropical species native to Asia and Australia with India considered its centre of origin. Following taxonomic revision, literature reporting *L. orbonalis* from sub-Saharan Africa should be regarded as referring to members of a complex of other species of *Leucinodes* native to Africa and not as referring to *L. orbonalis*. *L. orbonalis* is not present in the EU and is not a regulated EU pest. *L. orbonalis* is a major pest of *Solanum melongena* (eggplant) in Asia where larvae feed within leaves, stems, shoots and fruits. Larvae can also feed on a range of other plants, mostly within Solanaceae although *L. orbonalis* is generally not reported as a pest of crops other than *S. melongena*. However, in recent years *L. orbonalis* has emerged as a pest of *Solanum tuberosum* in south-west India. In tropical areas there can be 10 generations per year if conditions are suitable. L. *orbonalis* has been intercepted 350 times in the EU from a range of Asian countries on a range of produce, mostly larvae in fruits of *S. melongena*. Biotic factors (host availability) and abiotic factors (climate suitability) suggest that some small areas of the EU could be suitable for establishment. Adult *L. orbonalis* can fly and the species could spread within the EU. The introduction of *L. orbonalis* into the EU would have an economic impact, most likely on *S. melongena* production, the magnitude of which is uncertain. Measures are available to prevent the entry of *L. orbonalis* into the EU. *L. orbonalis* satisfies the criteria that are within the remit of EFSA to assess for this species to be regarded as a potential Union quarantine pest.

Keywords: Aubergine, Brinjal fruit and shoot borer, Eggplant fruit borer, interceptions, pest risk, quarantine, *Solanum melongena*

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Table of contents

1. Introduction

1.1. Background and Terms of Reference as provided by the requestor

1.1.1. Background

The new Plant Health Regulation (EU) 2016/2031, on the protective measures against pests of plants, is applying from 14 December 2019. A focus on prevention and risk targeting is amongst the primary objectives of this legislation. Furthermore, conditions are laid down in this legislation for plant pests to qualify for listing as Union quarantine pests, protected zone quarantine pests or Union regulated non-quarantine pests. The lists of the EU regulated plant pests together with the associated import or internal movement requirements of commodities are included in Commission Implementing Regulation (EU) 2019/2072.

In line with the principles of the new plant health law, for a proactive approach, the European Commission with the Member States are discussing monthly the reports of the interceptions, together with data from horizon scanning for plant pests of concern of various sources. As outcome of those discussions, a number of plant pests of concern, not regulated in the EU, are identified, for which a risk assessment is needed to decide on potential EU regulation. *Leucinodes orbonalis* which was recently spilt into two species *Leucinodes orbonalis* and *Leucinodes pseudorbonalis, and Xanthomonas citri* pv. *viticola* are amongst the species identified during these discussions.

In the EU, a number of actions are already in place to mitigate the various multilevel effects of climate change. The aim is to avoid adverse changes to the environment and to ensure food security. As the success of plant pests to establish in an area, depends on various abiotic and biotic parameters, it is anticipated that climate change might affect the risk that certain plant pests pose. Parameters as temperature, humidity, CO_2 concentration and salinity of soil affect the survival and pathogenicity of a number of plant pests, as reported in the scientific literature. Changes in temperature, drought and salinity can affect also the geographic distribution of the hosts of plant pests, and as a consequence the plant pests' establishment.

There is therefore a need to develop further the quantitative risk assessment methodology followed for plant pests and consider including the effect of climate change in the assessment of the risk that plant pests pose to the EU.

1.1.2. Terms of Reference

In accordance with Article 29(1) of Regulation (EC) No 178/2002, the Commission asks EFSA to develop further the quantitative risk assessment (phase 1 and phase 2) methodology followed for plant pests, to include in the assessments the effect of climate change for plant pests. Such inclusion of climate change scenarios can benefit of the quantitative methodology with comparison of risk assessment scenarios which has been already developed by the EFSA PLH Panel and included in its Guidance on quantitative pest risk assessment. Examples of abiotic parameters affecting the biology of the pests and their hosts' distribution are given in the background. The aim of this methodological development is to enable risk projections in the future, with models taking into account the relevant critical parameters for spread, establishment and potential impact that are affected in a scenario of 'climate change'.

The risk assessments of *Leucinodes orbonalis, Leucinodes pseudorbonalis* and *Xanthomonas citri* pv. *viticola* can be used for the development of the methodology.

1.2. Interpretation of the Terms of Reference

EFSA PLH Panel has been requested to conduct a risk assessment for *Leucinodes orbonalis.* This document is the phase 1 component (pest categorisation) fulfilling the request. The purpose of the pest categorisation is to determine whether *L. orbonalis* fulfils the criteria of a regulated pest for the area of the EU excluding Ceuta, Melilla and the outermost regions of Member States referred to in Article 355(1) of the Treaty on the Functioning of the European Union (TFEU), other than Madeira and the Azores, and so inform European Commission decision-making as to its appropriateness for potential inclusion in the lists of pests of Commission Implementing Regulation (EU) 2019/ 2072.

If *L. orbonalis* fulfils the criteria to be potentially listed as a regulated pest, risk reduction options aimed to prevent entry will be identified. Consideration of climate change is beyond the scope of pest categorisation, but will follow in a separated phase 2 assessment, if *L. orbonalis* satisfies the criteria for quarantine pest (QP) status.

2. Data and methodologies

2.1. Data

2.1.1. Literature search

A literature search on *L. orbonalis* was conducted at the beginning of the categorisation in the ISI Web of Science bibliographic database, using the scientific name of the pest as search term. Papers relevant for the pest categorisation were reviewed, and further references and information were obtained from experts, as well as from citations within the references and grey literature.

2.1.2. Database search

Pest information, on host(s) and distribution, was retrieved from the European and Mediterranean Plant Protection Organization (EPPO) Global Database (EPPO, online), the CABI databases and scientific literature databases as referred above in section 2.1.1.

Data about the import of commodity types that could potentially provide a pathway for the pest to enter the EU and about the area of hosts grown in the EU were obtained from EUROSTAT (Statistical Office of the European Communities).

The Europhyt and TRACES databases were consulted for pest-specific notifications on interceptions and outbreaks. Europhyt is a web-based network run by the Directorate General for Health and Food Safety (DG SANTÉ) of the European Commission as a subproject of PHYSAN (Phyto-Sanitary Controls) specifically concerned with plant health information. TRACES is the European Commission's multilingual online platform for sanitary and phytosanitary certification required for the importation of animals, animal products, food and feed of non-animal origin and plants into the European Union, and the intra-EU trade and EU exports of animals and certain animal products. Up until May 2020, the Europhyt database managed notifications of interceptions of plants or plant products that do not comply with EU legislation, as well as notifications of plant pests detected in the territory of the Member States and the phytosanitary measures taken to eradicate or avoid their spread. The recording of interceptions switched from Europhyt Interceptions to TRACES in May 2020.

2.2. Methodologies

The Panel performed the pest categorisation for *L. orbonalis,* following guiding principles and steps presented in the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018), the EFSA guidance on the use of the weight of evidence approach in scientific assessments (EFSA Scientific Committee, 2017) and the International Standards for Phytosanitary Measures No. 11 (FAO, 2013) and No. 21 (FAO, 2004).

The criteria to be considered when categorising a pest as a Union QP is given in Regulation (EU) 2016/2031 Article 3 and Annex 1 to this Regulation. Table 1 presents the Regulation (EU) 2016/2031 pest categorisation criteria on which the Panel bases its conclusions. In judging whether a criterion is met the Panel uses its best professional judgement (EFSA Scientific Committee, 2017) by integrating a range of evidence from a variety of sources (as presented above in Section 2.1) to reach an informed conclusion as to whether or not a criterion is satisfied.

The Panel's conclusions are formulated respecting its remit and particularly with regard to the principle of separation between risk assessment and risk management (EFSA founding regulation (EU) No 178/2002); therefore, instead of determining whether the pest is likely to have an unacceptable impact, deemed to be a risk management decision, the Panel will present a summary of the observed impacts in the areas where the pest occurs, and make a judgement about potential likely impacts in the EU. While the Panel may quote impacts reported from areas where the pest occurs in monetary terms, the Panel will seek to express potential EU impacts in terms of yield and quality losses and not in monetary terms, in agreement with the EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018). Article 3 (d) of Regulation (EU) 2016/2031 refers to unacceptable social impact as a criterion for QP status. Assessing social impact is outside the remit of the Panel.

Table 1: Pest categorisation criteria under evaluation, as defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorisation is shown in brackets in the first column)

Criterion of pest categorisation	Criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest (article 3)
Identity of the pest (Section 3.1)	Is the identity of the pest established, or has it been shown to produce consistent symptoms and to be transmissible?
Absence/ presence of the pest in the EU territory (Section 3.2)	Is the pest present in the EU territory? If present, is the pest widely distributed within the EU? Describe the pest distribution briefly
Regulatory status (Section 3.3)	If the pest is present in the EU but not widely distributed in the risk assessment area, it should be under official control or expected to be under official control in the near future.
Pest potential for entry, establishment and spread in the EU territory (Section 3.4)	Is the pest able to enter into, become established in, and spread within, the EU territory? If yes, briefly list the pathways
Potential for consequences in the EU territory (Section 3.5)	Would the pests' introduction have an economic or environmental impact on the EU territory?
Available measures (Specific import requirements) (Section 3.6)	Are there measures available to prevent the entry into the EU such that the likelihood of introduction becomes mitigated?
Conclusion of pest categorisation (Section 4)	A statement as to whether (1) all criteria assessed by EFSA above for consideration as a potential quarantine pest were met and (2) if not, which one(s) were not met.

3. Pest categorisation

3.1. Identity and biology of the pest

3.1.1. Identity and taxonomy

Is the identity of the pest established, or has it been shown to produce consistent symptoms and/or to be transmissible?

Yes. The identity of the species is established and *Leucinodes orbonalis* Guenée, 1854 is the accepted name and authority.

Leucinodes orbonalis is an insect in the family Crambidae (Order: Lepidoptera). *Pycnarmon discerptalis* (Hampson) is a junior synonym (EPPO GD). Its common English name is eggplant shoot and fruit borer or brinjal shoot and fruit borer. The EPPO code[1] for this species is: LEUIOR (EPPO, online).

The name *L. orbonalis* has been applied to species across Africa and for some interceptions from Africa but taxonomic studies of African *Leucinodes* indicated that true *L. orbonalis* are restricted to Asia (Hayden et al., 2013; Gilligan and Passoa, 2014; Mally et al., 2015; EFSA, PLH Panel, 2021). This pest categorisation focusses on literature reporting *L. orbonalis* in Asia and Australia.

3.1.2. Biology of the pest

Adult females lay eggs singly on the lower surface of young leaves, tender green stems, flower buds, or fruit calyces of hosts, primarily *Solanum melongena* (Alam et al., 2003). Individual females lay on average approximately 80 to 250 eggs. Most eggs (85%) are laid on the second night after female emergence although oviposition continues over two or three nights (Mannan et al., 2015a). Eggs usually hatch in 3 to 6 days depending on temperature. Within one hour of hatching larvae bore into the petioles and midribs of large leaves or young growing shoots, buds, flowers or fruit, entering from

[1] An EPPO code, formerly known as a Bayer code, is a unique identifier linked to the name of a plant or plant pest important in agriculture and plant protection. Codes are based on genus and species names. However, if a scientific name is changed the EPPO code remains the same. This provides a harmonized system to facilitate the management of plant and pest names in computerized databases, as well as data exchange between IT systems (Griessinger and Roy, 2015; EPPO, 2019).

under the calyx hence leaving no visible sign of infestation (Attygalle et al., 1988; Singh et al., 2019). Soon after boring into the plant, the larvae plug the entrance hole with excreta and remain concealed inside that particular plant part (Alam et al., 2006). Larval feeding creates tunnels within the host.

Regarding *S. melongena* with fruit, female *L. orbonalis* will lay eggs on fruit rather than leaves or stems and so there is a shift from larvae infesting leaves and shoots in young plants to infesting fruits in older plants (Mannan et al., 2015b). For example, in Rajastan (India), shoots are fed upon from early August until late October, peak incidence occurring in late August–early September, while fruits are fed upon from September until November (peak in October) (Choudhary et al., 2018). Further north in the state of West-Bengal, the pest is most active earlier between May and August with peak fruit damage in June (Ghosh and Senapati, 2009).

Multiple larvae can infest individual shoots and fruits. For example, Sultana et al. (2018) reported a mean of 1.1–4.4 larvae per shoot and between 1.3 and 5.0 larvae per fruit, depending on host (*S. melongena*) variety. There are five larval instars (Mannan et al., 2015a). Larval development takes 12–15 days during the summer and up to 22 days in the winter in South Asia (Alam et al., 2003). The final instar exits the host and drops to pupate on or just below the soil surface (Lal, 1975; Onekutu et al., 2013).

Adults emerge from pupae within 6 to 17 days depending on temperature (Alam et al., 2003). Emergence takes place at night, and 90% of mating occurs on the first night of adult emergence (Javed et al., 2017). Adult males live for approximately 3–5 days and females for 6–9 days (Mannan et al., 2015a).

In the warmest parts of India where *L. orbonalis* occurs there can be up to ten generations per year (Lall and Ahmad, 1965), further north, in Pakistan, there are five overlapping generations per year (Javed et al., 2017). In West Bengal, where *S. melongena* is grown year-round, spring-summer crops have higher numbers of *L. orbonalis* than autumn-winter crops (Koundinya et al., 2019). Where there is continuous development and overlapping generations, development from egg to adult takes from 17 to 44 days (Javed et al., 2017).

In the Kullu Valley of Himachal Pradesh (India) at altitudes between 1,200 and 2,000 m, *L. orbonalis* overwinters from October to April as pupae in the soil, or close to the soil surface, attached to host plants and can survive temperatures of –6.5°C although there is significant mortality (Lal, 1975).

Dhaliwal and Aggarwal (2021) examined the development of *L. orbonalis* under a range of fixed and variable temperatures to estimate minimum temperatures for development (T_{min}) and the thermal sum (K) for complete development for life stages and for overall development from egg to adult, estimating T_{min} to be 14.6°C with K 444.3° + days (DD) (Table 2). Islam et al. (2020) found that a thermal sum of 526.3 DD was necessary for development of female *L. orbonalis* from egg to adult; such a figure is within the ranges provided by Dhaliwal and Aggarwal (2021) (Table 2).

Table 2: Important features of the life history strategy of *Leucinodes orbonalis*

Life stage	Phenology and relation to host	Minimum and maximum thresholds for development (T_{min}) and thermal sum (K) degree days from a variety of linear and non-linear development models reported by Dhaliwal and Aggarwal (2021)
Egg	Laid individually on leaves, stem, shoots and fruit, potentially all year round where there is overlapping generations.	Estimated T_{min} 8.9 to 9.5°C K 68.9 to 74.5 DD
Larva	Burrows into host and feeds internally. Entry hole blocked and difficult to detect. Can be found all year round where there is overlapping generations.	Estimated T_{min} 8.1 to 9.5°C Estimated K 253.8 to 280.5 DD
Pupa	Soil surface or just below the soil, can be attached to host plant. Pupae can overwinter.	Estimated T_{min} 10.7 to 14.0°C Estimated K 136.8 to 164.5 DD
Adult	Emerges at night, mates and lives for approximately 3 to 9 days.	Estimated T_{min} egg to adult 11.6 to 14.6°C Estimated K egg to adult 444.3 to 530.7 DD

3.1.3. Host range

Most literature focuses on eggplant, *S. melongena,* as the principal host. EPPO (GD) categorises *S. melongena* and *S. aethiopicum* as major hosts. Although *L. orbonalis* can develop on both potato and tomato plants, it is not commonly reported as a pest of these crops. Boopal et al. (2013) and Mannan et al. (2015a) successfully reared *L. orbonalis* larvae in the laboratory with larvae feeding on peeled potato tubers. Boopal et al. (2013) also raised larvae to adulthood with larvae developing in tomato fruit in laboratory conditions. Maureal et al. (1982) reported that 'even when tomato was planted in the immediate vicinity of eggplant [in the field], the borer was never observed to infest tomato fruits unless when subjected to hunger stress'. Hayden et al. (2013) notes that the stalks of potato are fed upon by larvae rather than potato tubers.

Alam et al. (2003) consider *L. orbonalis* as virtually monophagous, feeding principally on *S. melongena*; however, they recognise that tomato (*S. lycopersicum*) and potato (*S. tuberosum*) as well as the nightshades *S. nigrum* and *S. indicum* and turkey berry (*S. torvum*) have been reported as hosts. Lall and Ahmad (1965) report that *L. orbonalis* feeds on solanaceous weeds such as *S. nigrum* and *S. xanthocarpum* (= *S. virginianum*) when its preferred host, *S. melongena,* is not available. Note that all hosts reported by Alam et al. (2003) are Solanaceae. However, EPPO GD provides a more extensive list of hosts, including some which are not within the Solanaceae. Appendix A provides a list of host plants and plants reported as affected by *L. orbonalis,* as well as plants on which interceptions have occurred.

3.1.4. Intraspecific diversity

There are no reports of intraspecific variation within *L. orbonalis.*

3.1.5. Detection and identification of the pest

Are detection and identification methods available for the pest?
Yes, methods for detection and morphological and molecular methods for identification are available.

Symptoms

Larval feeding in stems inhibits the translocation of nutrients towards shoots causing infested plants to wither and droop; the growth of the plant and size and number of fruits can be significantly reduced (Latif et al., 2010). Larval feeding inside shoots results in progressive wilting of the young shoot resulting in a characteristic symptom called 'dead heart' (Alam et al., 2006). Feeding damage to the fruit is not always visible; if infested fruit are cut open larvae can be seen in tunnels. Exit holes in fruit can be seen when larvae have abandoned the fruit to pupate in the soil.

Detection

A variety of trap designs can be used to detect flying adults (Cork et al., 2003) and pheromone lures are available (Alam et al., 2003).

A key for the identification of microlepidoptera on Solanaceae by Hayden et al. (2013) is available online.

Description

A detailed description of the larva and adults is provided in Hayden et al. (2013) and by Mally et al. (2015).

Egg: flattened, elliptical, 0.5 mm diameter; creamy-white when laid changes to red before hatching (Alam et al., 2003).

Larva: Pink, covered with sparsely distributed hairs all over the body. Fully grown larva about 20 mm long (Hayden et al., 2013; Mally et al., 2015; Javed et al., 2017)

Pupa: white or beige becoming dark brown, oval (Mally et al., 2015).

Adult: white with pale brown or black spots at the back of the thorax and abdomen; wings are white with a pinkish or bluish tinge and are ringed with small hairs along the apical and anal margins; forewings have several black pale and light brown spots. 20–22 mm wingspan (Mally et al., 2015; Alam et al., 2003).

3.2. Pest distribution

3.2.1. Pest distribution outside the EU

L. orbonalis is a tropical and subtropical species native to Asia and Australia (Figure 1) with India thought to be its centre of origin (Karthika et al., 2019). Until Hayden et al. (2013) and Gilligan and Passoa (2014) reported that *L. orbonalis* was restricted to Asia, it was thought that *L. orbonalis* also occurred in sub-Saharan Africa. Literature previously reporting *L. orbonalis* from Africa should be regarded as referring to members of a complex of other species of *Leucinodes* native to Africa and not as referring to *L. orbonalis* (Mally et al., 2015; EFSA PLH Panel, 2021). Appendix A lists the global distribution based on EPPO Global Database.

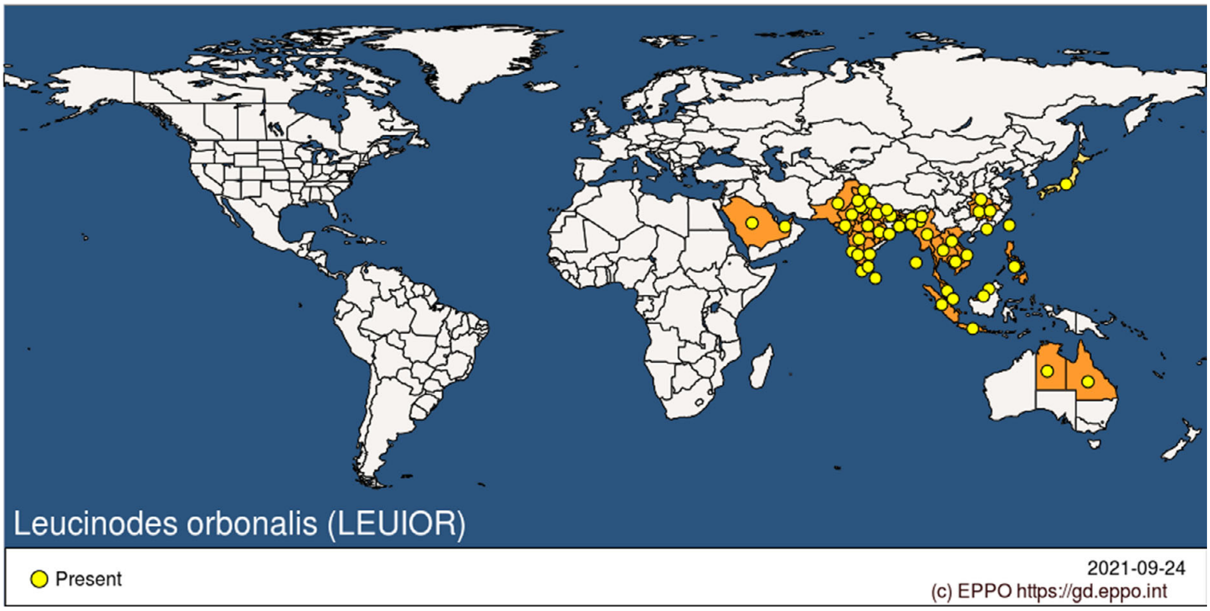

Figure 1: Global distribution of *Leucinodes orbonalis* (Source: EPPO Global Database accessed on 24/9/21)

3.2.2. Pest distribution in the EU

Is the pest present in the EU territory? If present, is the pest widely distributed within the EU?

No, *L. orbonalis* is not present in the EU.

3.3. Regulatory status

3.3.1. Commission Implementing Regulation 2019/2072

Leucinodes orbonalis is not listed in Annex II of Commission Implementing Regulation (EU) 2019/ 2072, an implementing act of Regulation (EU) 2016/2031.

3.3.2. Hosts of *Leucinodes orbonalis* that are prohibited from entering the Union from third countries

Table 3: List of plants, plant products and other objects that are *Leucinodes orbonalis* hosts whose introduction into the Union from certain third countries is prohibited (Source: Commission Implementing Regulation (EU) 2019/2072, Annex VI)

List of plants, plant products and other objects whose introduction into the Union from certain third countries is prohibited

	Description	CN Code	Third country, group of third countries or specific area of third country
15.	Tubers of *Solanum tuberosum*, seed potatoes	0701 10 00	Third countries other than Switzerland
16.	Plants for planting of stolon- or tuber-forming species of *Solanum* L.	ex 0601 10 90 ex 0601 20 90 ex 0602 90 50 ex 0602 90 70 ex 0602 90 91 ex 0602 90 99	Third countries other than Switzerland
17.	Tubers of species of *Solanum* L., and their hybrids, other than those specified in entries 15 and 16	ex 0601 10 90 ex 0601 20 90 0701 90 10 0701 90 50 0701 90 90	Third countries other than [...]
18.	Plants for planting of Solanaceae other than seeds and the plants covered by entries 15, 16 or 17.	ex 0602 90 30 ex 0602 90 45 ex 0602 90 46 ex 0602 90 48 ex 0602 90 50 ex 0602 90 70 ex 0602 90 91 ex 0602 90 99	Third countries other than [...]
19.	Soil as such consisting in part of solid organic substances	ex 2530 90 00 ex 3824 99 93	Third countries other than Switzerland

Note that potato tubers are only known as experimental hosts. In nature larvae feed and develop on above ground parts of *S. tuberosum*.

3.4. Entry, establishment and spread in the EU

3.4.1. Entry

Is the pest able to enter into the EU territory? If yes, identify and list the pathways.

Yes, *L. orbonalis* has been intercepted entering the EU 350 times from a range of Asian countries on a range of produce.

Comment on plants for planting as a pathway.

In principle, larvae could enter the EU on plants for planting given that eggs could be on leaves and larvae in stems and shoots; however, as Solanaceae from countries other than those in the Euro-Mediterranean area are prohibited entry into the EU, and *L. orbonalis* does not occur in the Euro-Mediterranean area, such pathways do not currently exist. There are no records of plants for planting being intercepted with *L. orbonalis.*

Regarding plants for planting as a pathway for spread within the EU; eggs could be carried on leaves and larvae in stems or shoots of host plants, especially *S. melongena*.

Table 4 lists potential pathways for the entry of *L. orbonalis* into the EU**.**

Table 4: Potential pathways for *Leucinodes orbonalis* into the EU 27

Pathways Description (e.g. host/intended use/source)	**Life stage**	**Relevant mitigations [e.g. prohibitions (Annex VI) or special requirements (Annex VII) within Implementing Regulation 2019/2072]**
Growing plants for planting of *Solanum melongena* and other Solanaceae, excluding seed	Eggs on leaves or stems, Larvae in leaves or stems, Pupae in soil could be attached to roots	Annex VI (18.) bans the introduction of plants for planting of Solanaceae other than seeds
Fresh produce, especially *Solanum melongena* and other Solanaceae	Larvae in fruits	Annex VII (68, 69 and 70) require statements that fruits are free from specified quarantine pests (*Neoleucinodes elegantalis*, *Thrips palmi* and *Keiferia lycopersicella*)
Soil/growing media	Pupa	Annex VI (19. & 20.) bans the introduction of soil and growing media as such into the Union from third countries other than Switzerland
Soil on machinery	Pupa	Annex VII (2.) Official statement that machinery or vehicles are cleaned and free from soil and plant debris

Notifications of interceptions of harmful organisms began to be compiled in Europhyt in May 1994 and in TRACES in May 2020. As at June 2021, there were 350 records of interceptions of *L. orbonalis* from Asian countries and nine interceptions of unspecified *Leucinodes* sp. in the Europhyt and TRACES databases (Appendix C). 92.8% of interceptions occur on *Solanum* species, the majority on *S. melongena* (Table 5). Interceptions on non-solanaceous plant material (7.2% of interceptions) may indicate hitchhiking rather than occurrence of the pest on true hosts. Records in TRACES and Europhyt of *L. orbonalis* from African countries are assumed to be interceptions of *L. pseudorbonalis* or other *Leucinodes* species (EFSA PLH Panel, 2021).

Table 5: Interceptions of *Leucinodes orbonalis* and *Leucinodes* sp.(1) from Asian countries

	Thailand	**Sri Lanka**	**India**	**Malaysia**	**Cambodia**	**Vietnam**	**Bangladesh**	**Pakistan**	**Laos**	**Japan**	**sum**
Solanum melongena	96	35	35	29	11	9	13	9	5	–	242
Solanum torvum	33	11	–	–	3	3	–	–	2	–	52
Other *Solanum* spp.(2)	8	24	2	–	–	3	–	1	1	–	39
Mangifera sp.	–	3	2	–	–	–	–	–	–	–	5
Momordica sp.	1	2	1	–	–	–	–	1	–	–	5
Ocimum sp.	4	–	–	–	–	–	–	–	–	–	4
Citrus hystrix	3	–	–	–	–	–	–	–	–	–	3
Psidium guajava	–	–	2	–	1	–	–	–	–	–	3
Capsicum annuum	–	–	–	–	–	–	–	–	–	1	1
Ipomoea aquatica	–	1	–	–	–	–	–	–	–	–	1
Murraya paniculata	–	1	–	–	–	–	–	–	–	–	1
Spondias dulcis	–	1	–	–	–	–	–	–	–	–	1
Vigna sp.	–	1	–	–	–	–	–	–	–	–	1
Unspecified	–	–	1	–	–	–	–	–	–	–	1
Sum	145	79	43	29	15	15	13	11	8	1	359

(1): Includes 9 *Leucinodes* not identified to species on *S. melongena* (ex. Sri Lanka × 3, ex Cambodia × 2, ex India × 1; on *S. torvum* ex Thailand × 1, on unspecified *Solanum* species ex Sri Lanka × 1, ex Vietnam × 1).

(2): Other *Solanum* species includes *S. aculeatissimum, S. aethiopicum, S. anguivi, S. stramoniifolium, S. undatum, S. virginianum* and unspecified species.

Table 5 shows that most interceptions have been recorded from *S. melongena*. However, there are limits regarding how interception data can be interpreted. A more meaningful analysis would be possible if the total number of consignments imported and inspected were available. Reports of interception should therefore be interpreted with caution if seeking to identify pathways most likely to carry particular pests (MacLeod, 2015).

Table 6 shows EU 27 annual imports of *S. melongena* from countries where *L. orbonalis* occurs.

Table 6: EU 27 annual imports of *Solanum melongena* (eggplant) from countries where *Leucinodes orbonalis* occurs (hundreds of kg) Source: Eurostat. Countries from which interceptions on *S. melongena* have occurred are marked(*)

	2016	2017	2018	2019	2020	5-year mean
Laos*	623.61	507.16	553.87	651.54	575.33	582.30
Thailand*	371.71	361.70	392.81	482.10	435.44	408.75
Vietnam*	439.72	375.63	338.35	307.70	38.43	299.97
Malaysia*	319.24	368.87	253.99	213.25	7.29	232.53
Cambodia*	6.81	10.77	13.77	37.58	140.51	41.89
Sri Lanka*	10.30	6.57	0.35	23.51	15.29	11.20
India*	13.83	4.45	–	15.61	3.25	7.43
Pakistan*	0.40	0	3.85	0.48	10.60	3.07
Indonesia	–	0	0.21	2.93	10.35	2.70
Japan*	0.24	1.24	0.53	1.94	0.38	0.87
Bangladesh*	0.15	1.05	–	–	–	0.24
Philippines	–	0	–	0.86	–	0.17
China	–	0	–	0.60	–	0.12
United Arab Emirates	–	0	–	0.10	–	0.02
Australia	–	0	–	–	–	0
Singapore	–	0	–	–	–	0
Taiwan	–	0	–	–	–	0

Appendix D provides EU 27 import data for some other *L. orbonalis* hosts.

3.4.2. Establishment

Is the pest able to become established in the EU territory?

Yes, biotic factors (host availability) and abiotic factors (climate suitability) suggest that some areas of the EU would be suitable for establishment. However, the lack of EU outbreaks despite 350 previous interceptions suggests there is uncertainty around the ability of *L. orbonalis* to transfer to a host after arrival in the EU.

The warmest southern areas of the EU around the Mediterranean where there are very few days of frost each year and where hosts are grown both outdoors and in protected conditions would provide areas where establishment is most suitable; such areas could include parts of Cyprus, southern Greece, and southern Italy, Malta, southern Portugal and parts of coastal eastern Spain.

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). Availability of hosts is considered in Section 3.4.2.1. Climatic factors are considered in Section 3.4.2.2.

3.4.2.1. EU distribution of main host plants

While *L. orbonalis* is primarily regarded as a pest of *S. melongena*, it can feed on a number of crops and wild plants that grow in the EU (Table 7). In the EU *S. melongena* production is concentrated in Mediterranean countries and Romania, where it is produced both outdoors and indoors.

Table 7: Harvested area of some *Leucinodes orbonalis* hosts in EU 27, 2016–2020 (thousand ha). Source EUROSTAT (accessed 19/7/2021)

Crop	Code	2016	2017	2018	2019	2020
Potatoes (including seed potatoes)	R1000	1,550.51	1,601.18	1,562.85	1,607.36	1,660.31
Field peas	P1100	861.1	985.79	829.14	785.58	828.85
Tomatoes	V3100	246.80	240.87	239.55	235.14	236.46
Fresh peas	V5100	142.53	141.93	143.95	:	150.44
Peppers (*Capsicum*)	V3600	57.59	57.47	56.27	59.68	59.66
Eggplants	V3410	21.58	20.73	21.44	20.63	21.36
Beetroot	V4300	23.38	23.51	24.25	25.12	24.88

':' data not available.

Recognising that tomatoes and peppers are also hosts, and that *L. orbonalis* is a warmth loving organism, the EU27 area of production of tomatoes and peppers grown in greenhouses is shown in Table 8.

Table 8: Harvested area of greenhouse production for tomatoes and peppers, *Leucinodes orbonalis* hosts, in EU 27, 2016–2020 (thousand ha). Source EUROSTAT (accessed 13/8/2021)

Crop	Code	2016	2017	2018	2019	2020
Tomatoes	V3100s	41.97	40.90	41.72	39.48	39.00
Peppers (*Capsicum*)	V3600s	20.04	20.90	20.90	22.14	22.99

3.4.2.2. Climatic conditions affecting establishment

L. orbonalis is a pest found in tropical and subtropical countries in Asia; it is also found in Australia (Northern Territories and Queensland). Some climate types that occur in the EU are also found in tropical and sub-tropical countries where *L. orbonalis* occurs, for example Bsh, Bsk, Cfa and Csa (Figure 2). These climates are represented by approximately 18% of EU 27 five arcmin grid cells (MacLeod and Korycinska, 2018).

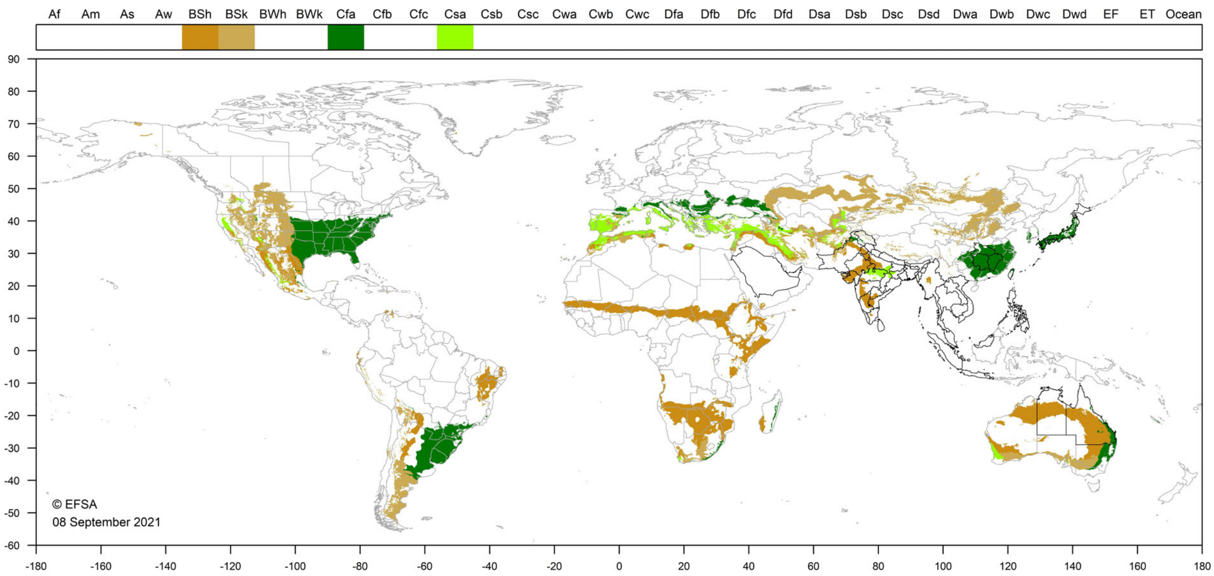

Figure 2: World distribution of four Köppen–Geiger climate types that occur in the EU and which occur in countries where *Leucinodes orbonalis* has been reported. (Countries where *L. orbonalis* occur are highlighted with black borders)

Numerous studies have examined the thermal biology of *L. orbonalis* and appear to draw a similar conclusion: that *L. orbonalis* is a warmth loving organism. Katiyar and Mukharji (1974) report that in the laboratory egg development was severely delayed at 15°C, with only one egg batch out of 15 hatching; development was fastest between 20°C and 25°C. Pupae held at 10°C did not develop.

Singh and Singh (2003) found that the highest levels of fecundity occurred when the average minimum temperature was more than 17°C and the average maximum temperature more than 27°C with average relative humidity more than 85%. Dhaliwal and Aggarwal (2021) estimate the threshold temperature for development from egg to adult to be 14.6 °C. Mall et al. (1992) report that 30°C and 70-90% RH were the most favourable conditions for *L. orbonalis* population growth in the field.

Although detailed studies on the thermal biology of *L. orbonalis* indicate a relatively high temperature threshold is required for complete development (approx. 15°C (Dhaliwal and Aggarwal, 2021)), Lal (1975) reports some *L. orbonalis* surviving as overwintering pupae at altitudes between 1,200 and 2,000 m where temperatures drop to −6.5°C during winter months although there is significant pupal mortality. Populations at such altitudes therefore appear to enter a diapause to survive unsuitable conditions whereas populations at lower altitudes are not reported to diapause and are found all year round. This gives rise to uncertainty as to the extent of potential establishment of *L. orbonalis* outdoors in the EU which may vary according to where *L. orbonalis* originates. i.e. *L. orbonalis* which can overwinter and survive −6.5 °C could potentially establish more widely in the EU than *L. orbonalis* which do not.

L. orbonalis does not appear to be a pest in greenhouses (van der Gaag and Stigter, 2005). However, should there be an introduction to a protected crop, it is possible that a population could develop. Temperatures in Dutch greenhouses growing *S. melongena* are usually between 20°C and 25°C and may exceed 30°C during warm periods (van der Gaag and Stigter, 2005). Such temperatures exceed the minimum required for development of *L. orbonalis* although whether populations would persist into the foreseeable future within glasshouses is uncertain given the careful management practices employed.

3.4.3. Spread

Describe how the pest would be able to spread within the EU territory following establishment?
Adult *L. orbonalis* can fly and could spread within the EU. They are not known to be migratory.
Comment on plants for planting as a mechanism of spread.
Regarding plants for planting as a pathway for spread within the EU; eggs could be carried on leaves and larvae in stems or shoots of host plants, especially *S. melongena*.

L. orbonalis is a free-living organism and adults can fly. Some Crambidae are known to be strongly migratory and can sustain long flights over bodies of water, e.g. *Cnaphalocrocis medinalis* (Fu et al., 2014). Unfortunately, no information on the dispersal ability of adult *L. orbonalis* could be found. If *L. orbonalis* was a migratory species reports of such behaviour should have been evident within the literature given the economic importance of *L. orbonalis* in Asia. Recognising that no evidence for migration was found, the Panel assumes that *L. orbonalis* is not a migratory species. Nevertheless, adults would be expected to disperse during night flights, perhaps flying hundreds or even thousands of meters. For comparison, adult female European corn borer, *Ostrinia nubilalis,* also a member of the Crambidae, have been measured flying 3.1 km during a single flight in laboratory studies (Dorhout et al., 2008).

3.5. Impacts

Would the pests' introduction have an economic or environmental impact on the EU territory?
Yes, the introduction of *L. orbonalis* into the EU would have an economic impact, most likely on *S. melongena* production.

L. orbonalis is thought to be the most serious pest of *S. melongena* in Asia and is a limiting factor to its production (Ahmad et al., 2018; Akter et al., 2018). Early generations of *L. orbonalis* that feed on the leaves or developing shoots of *S. melongena* can cause leaves to drop; larval feeding inside shoots results in wilting of the young shoots. The damaged shoots ultimately drop off, resulting in fewer flowers and so loss of fruit, lowering yield. While new shoots may grow the resulting fruit will be smaller (Hossain et al., 2013; Baidoo et al., 2018). Later generations whose larvae burrow into fruit make them unsuitable for consumption (Attygalle et al., 1988) and prevent the fruit from being marketed resulting in economic yield loss (Alam et al., 2003, 2006; Mainali, 2014; Singh et al., 2019). Larval burrowing into *S. melongena* provides access for pathogens and secondary infection by bacteria causing rotting of fruits and further deteriorates the quality of fruits (Javed et al., 2017).

Estimates of loss or damage caused by *L. orbonalis* vary considerably. Mall et al. (1992) reported average yield losses of 13% (consisting of 8 to 111 kg/ha lost if the unconsumable part of the fruit was removed and the reminder of the fruit was kept, up to 46 to 380 kg/ha if all fruit with any damage was rejected); Mehto et al. (1983) reported yield reductions ranging from 50% to 60% and Patnaik (2000) reported that damage to fruit ranges from 48% to 86%.

High relative humidity and heavy rainfall favour outbreaks of *L. orbonalis* hence there is greater abundance of *L. orbonalis* during the monsoon season (Ghosh and Senapati, 2009).

Although *L. orbonalis* is a serious pest of *S. melongena* in tropical and sub-tropical Asia with most impact occurring during the monsoon season, such conditions do not occur in the EU. Whilst feeding damage would cause losses in production, the magnitude of losses in the EU is not expected be as high as in Asia.

Natikar and Balikai (2018) reported that *L. orbonalis* had become the most destructive pest of potatoes (*S. tuberosum*) in Karnataka (southern India) causing heavy yield losses in recent years. Surveys within 20 villages during 2016/17 revealed up to 22.3% of shoots were infested during the vegetative growing stage.

No reports of *L. orbonalis* damage to crops in Queensland and Northern Territory (Australia) were found during the preparation of this pest categorisation. The lack of reports from Australia, where growing conditions could be more similar to southern and Mediterranean Europe might indicate that *L. orbonalis* does not cause noticeable impact. Biotic factors (e.g. presence of natural enemies) could also be responsible for lowering impacts in Australia.

3.6. Available measures and/or potential specific import requirements and limits of mitigation measures

Are there measures available to prevent the entry into the EU (and spread for pests already present) such that the risk becomes mitigated?

Yes, solanaceous plants for planting (other than seed) are prohibited from entering the EU from third countries (Section 3.3.2). Host produce such as *S. melongena* fruit require a phytosanitary certificate so must be inspected prior to export. If *L. orbonalis* were listed as an EU QP, consignments could not be exported to the EU if *L. orbonalis* was detected. Fruit could be sourced from areas free of *L. orbonalis* (see Section 3.6.1).

3.6.1. Identification of potential additional measures

Phytosanitary measures (prohibitions) are currently applied to some host plants for planting (see Section 3.3.2).

Potential control measures on hosts that are imported are listed in Table 9.

Table 9: Selected control measures (a full list is available in EFSA PLH Panel, 2018) for pest entry (and spread when applicable) in relation to currently unregulated hosts and pathways

Special requirements summary (with hyperlink to information sheet if available)	Potential control measure summary
Pest freedom	Used to mitigate likelihood of infestation by specified pest at origin, hence to mitigate entry. Host produce should be free of *L. orbonalis.*
Managed growing conditions	Cultural practices, including crop rotation, solarisation, or sanitation could be used to reduce field densities of *L. orbonalis*. Used to mitigate likelihood of infestation at origin
Growing plants in isolation	Used to mitigate likelihood of infestation by specified pest in vicinity of growing site Growing hosts under protective netting or similar to prevent infestation would help.
Certification of reproductive material (voluntary/official)	Used to mitigate pests that are included in a certification scheme
Chemical treatments on crops including reproductive material	Used to mitigate likelihood of infestation of pests susceptible to chemical treatments - chemicals already widely used resulting in development of pesticide resistance.
Inspections	Used to mitigate likelihood of infestation by specified pest at origin,
Physical treatments on consignments or during processing	Used to mitigate likelihood of infestation of pests susceptible to physical treatments
Heat and cold treatments	Used to mitigate likelihood of infestation of pests susceptible to physical treatments
Controlled atmosphere	Used to mitigate likelihood of infestation of pests susceptible to modified atmosphere (usually applied during transport) hence to mitigate entry
Conditions of transport	Used to mitigate likelihood of entry of pests that could otherwise infest material post-production
Phytosanitary certificate and plant passport	Used to attest which of the above requirements have been applied. If *Leucinodes orbonalis* becomes an EU quarantine pest, a phytosanitary certificate could only be issued if the consignment was found free of the pest.

3.6.1.1. Biological or technical factors limiting the effectiveness of measures to prevent the entry of the pest

- Internal feeding in fruit with entry holes sealed make infested fruit difficult to detect unless cut open.
- Resistance to pesticides has developed within *L. orbonalis* (Ayam et al., 2016; Shirale et al., 2017; Kariyanna et al., 2020) driven by the frequent application of pesticides (e.g. there can be between 56 and 180 applications during the *S. melongena* growing season; Chakraborti and Senapati, 2016).

3.7. Uncertainty

The lack of EU outbreaks despite 350 previous interceptions suggests there is uncertainty around the ability of *L. orbonalis* to transfer to a host in a suitable environment after arrival in the EU.

There are uncertainties about the precise environmental limitations within which *L. orbonalis* can survive. This raises uncertainty around the area of the EU where establishment may be possible. Several papers report multiple generations per year in tropical and subtropical conditions with a threshold for development from egg to adult of around 15°C. However, a single report of *L. orbonalis* occurring at altitudes between 1,200 and 2,000 m where temperatures drop to –6.5°C during winter months suggests a much wider potential tolerance for cooler climates.

There is uncertainty over the magnitude of potential losses to EU hosts should *L. orbonalis* establish in the EU.

Most literature focusses on the impact on eggplant, however, Natikar and Balikai (2018) report that serious damage has been recorded on potatoes in south-west India, suggesting *L. orbonalis* is emerging as a pest on another crop. Whether *L. orbonalis* would also cause serious damage to potatoes in the EU is uncertain.

There is some uncertainty regarding non-Solanaceae as hosts given lack of reports in the literature and evidence being based on the interceptions which may be the result of hitchhiking.

4. Conclusions

L. orbonalis satisfies the criteria that are within the remit of EFSA to assess for this species to be regarded as a potential Union QP. Table 10 provides a summary of the PLH Panel conclusions.

Table 10: The Panel's conclusions on the pest categorization criteria defined in Regulation (EU) 2016/2031 on protective measures against pests of plants (the number of the relevant sections of the pest categorization is shown in brackets in the first column)

Criterion of pest categorisation	Panel's conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest	Key uncertainties
Identity of the pest (Section 3.1)	The identity of the species is established and *Leucinodes orbonalis* Guenée, 1854 is the accepted name and authority.	Taxonomic revision means literature reporting *L. orbonalis* from Africa should be disregarded.
Absence/presence of the pest in the EU (Section 3.2)	*L. orbonalis* is not present in the EU. It is a tropical and sub-tropical species occurring in Asia and Australia.	
Regulatory status (Section 3.3)	*L. orbonalis* is not a regulated EU pest.	
Pest potential for entry, establishment and spread in the EU (Section 3.4)	*L. orbonalis* can enter the EU, it has been intercepted 350 times from a range of Asian countries on a range of produce, mostly larvae in fruits of *Solanum melongena* (eggplants). Biotic factors (host availability) and abiotic factors (climate suitability) suggest that some areas of the EU would be suitable for establishment. Adult *L. orbonalis* can fly and the species could spread within the EU.	
Potential for consequences in the EU (Section 3.5)	The introduction of *L. orbonalis* into the EU could have an economic impact, most likely on *S. melongena* production.	Magnitude of impact is uncertain
Available measures (Section 3.6)	Measures are available to prevent the entry, establishment and spread of *L. orbonalis* into and within the EU. For example: Solanaceous plants for planting (other than seed) are already prohibited from entering the EU and host produce require a phytosanitary certificate so must be inspected prior to export	
Conclusion (Section 4)	*L. orbonalis* satisfies the criteria that are within the remit of EFSA to assess for this species to be regarded as a potential Union quarantine pest.	
Aspects of assessment to focus on/scenarios to address in future if appropriate:	Suggest focus on likelihood of pest transfer following entry to the EU; environmental conditions for establishment, potential overwintering in the EU, the number of generations possible per year and synchrony with hosts to aid evaluation of impacts.	

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Abbreviations

EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures
MS	Member State
PLH	EFSA Panel on Plant Health
QP	quarantine pest
TFEU	Treaty on the Functioning of the European Union
ToR	Terms of Reference

Glossary

Containment (of a pest)	Application of phytosanitary measures in and around an infested area to prevent spread of a pest (FAO, 2018).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO, 2018).
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO, 2018).
Eradication (of a pest)	Application of phytosanitary measures to eliminate a pest from an area (FAO, 2018).
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2018).
Greenhouse	A walk-in, static, closed place of crop production with a usually translucent outer shell, which allows controlled exchange of material and energy with the surroundings and prevents release of plant protection products (PPPs) into the environment.
Impact (of a pest)	The impact of the pest on the crop output and quality and on the environment in the occupied spatial units.
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO, 2018).
Pathway	Any means that allows the entry or spread of a pest (FAO, 2018).

Phytosanitary measures	Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO, 2018).
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO, 2018).
Risk reduction option (RRO)	A measure acting on pest introduction and/or pest spread and/or the magnitude of the biological impact of the pest should the pest be present. A RRO may become a phytosanitary measure, action or procedure according to the decision of the risk manager.
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO, 2018).

Appendix A – *Leucinodes orbonalis* host plants and plants affected

Source: EPPO Global Database (EPPO online) + indicates major host

Host status	Host name	Plant family	Common name	Reference
Cultivated hosts	*Solanum aethiopicum* +	Solanaceae	Bitter tomato	
	Solanum melongena +	"	Eggplant/aubergine	
	Solanum torvum	"	Pea eggplant	Interception data
	Capsicum annuum	"	Sweet pepper	
	Physalis minima	"	Wild cape gooseberry	
	Physalis peruviana	"	Goldenberry	
	Solanum aculeatissimum	"	Dutch eggplant	
	Solanum anguivi	"		
	Solanum erianthum	"	Velvet nightshade	
	Solanum lycopersicum	"	Tomato	
	Solanum macrocarpon	"	African eggplant	
	Solanum mammosum	"	Nipplefruit	
	Solanum myriacanthum	"		
	Solanum stramoniifolium	"		Interception data
	Solanum tuberosum	"	Potato	
	Solanum undatum	"		Interception data
	Solanum virginianum	"		Interception data
	Beta vulgaris	Amaranthaceae	Beet	
	Mangifera indica	Anacardiaceae	Mango	
	Spondias dulcis	"	Amberella	Interception data
	Ipomoea batatas	Convolvulaceae	Sweet potato	
	Ipomoea aquatica	"		Interception data
	Momordica sp.	Cucurbitaceae	Bitter melon	Interception data
	Pisum sativum	Fabaceae	Pea	
	Vigna sp.	"	A bean	Interception data
	Ocimum sp.	Lamiaceae	Basil	Interception data
	Psidium guajava	Myrtaceae	Guava	Interception data
	Murraya paniculata	Rutaceae	Orange jasmine	Interception data
	Citrus hystrix	"	Thai lime	Interception data
Wild weed hosts	*Solanum nigrum*	Solanaceae	Black nightshade	
	Solanum viarum	"	Tropical soda apple	
Artificial / experimental host	*Solanum tuberosum* (peeled tubers)	"	potato	Boopal et al. (2013), Mannan et al. (2015a)

Appendix B – Distribution of *Leucinodes orbonalis*

Distribution records based on EPPO Global Database (EPPO, online).

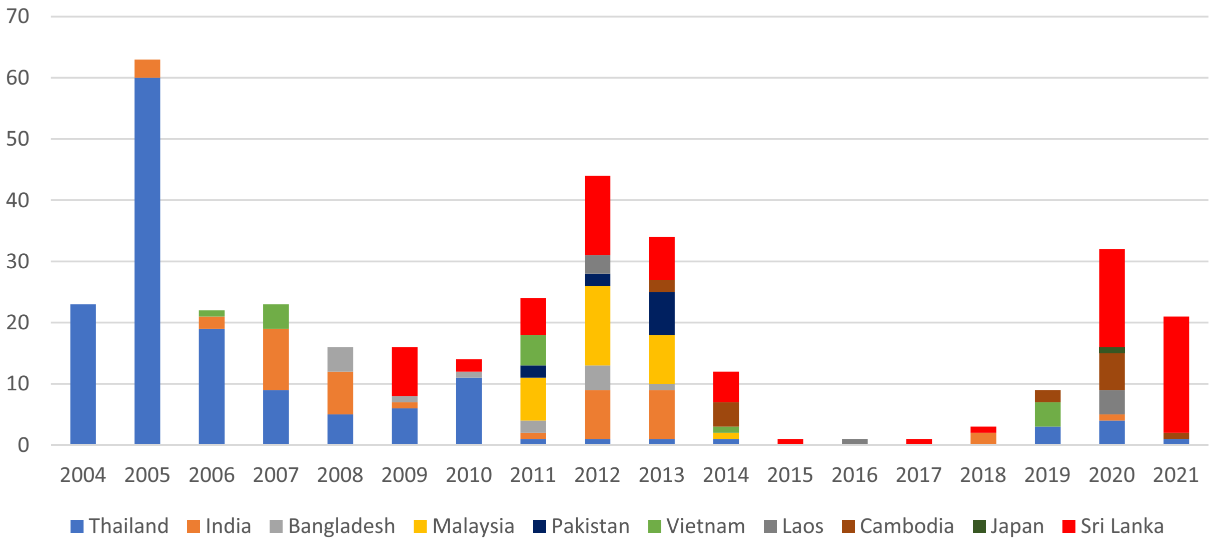
Region	Country	Sub-national (e.g. State)	Status
EU (27)	Denmark		Absent, intercepted only
	Netherlands		Absent, intercepted only
Other Europe	UK		Absent, has been found in the past but not established (Higgott, 2009)
Africa	Burundi		Absent, invalid record
	Cameroon		Absent, invalid record
	Congo, DRC		Absent, misidentification of taxonomy
	Congo		Absent, invalid record
	Côte d'Ivoire		Absent, invalid record
	Ethiopia		Absent, invalid record
	Ghana		Absent, invalid record
	Kenya		Absent, invalid record
	Lesotho		Absent, invalid record
	Malawi		Absent, invalid record
	Mozambique		Absent, invalid record
	Nigeria		Absent, invalid record
	Rwanda		Absent, invalid record
	Sao Tome and Principe		Absent, invalid record
	Sierra Leone		Absent, invalid record
	Somalia		Absent, invalid record
	South Africa		Absent, invalid record
	Tanzania		Absent, invalid record
	Uganda		Absent, invalid record
	Zambia		Absent, invalid record
Asia	Bangladesh		Present, widespread
	Brunei Darussalam		Present, no details
	Cambodia		Present, no details
	China		Present, restricted distribution
		Guangdong	Zhang et al. (2010) in CABI, online
		Hubei	Present, no details
		Hunan	Present, no details
		Jiangsu	Present, Widespread (CABI, online)
		Jiangxi	Present, no details
		Xianggang (Hong Kong)	Present, no details
	India		Present, widespread
		Andaman and Nicobar Islands	Present, no details
		Andhra Pradesh	Present, no details
		Assam	Present, widespread
		Bihar	Present, no details
		Chhattisgarh	Present, no details
		Delhi	Present, no details
		Goa	Present, no details
		Gujarat	Present, no details
		Haryana	Present, no details
		Himachal Pradesh	Present, no details

Region	Country	Sub-national (e.g. State)	Status
		Jammu and Kashmir	Present, no details
		Jharkhand	Chang JianCheng et al. (2016) in CABI, online
		Karnataka	Present, no details
		Kerala	Present, no details
		Madhya Pradesh	Present, no details
		Maharashtra	Present, no details
		Manipur	Present, no details
		Meghalaya	Present, no details
		Nagaland	Present, no details
		Odisha	Present, no details
		Punjab	Present, no details
		Rajasthan	Present, no details
		Tamil Nadu	Present, no details
		Tripura	Present, no details
		Uttarakhand	Present, no details
		Uttar Pradesh	Present, no details
		West Bengal	Present, no details
	Indonesia		Present, restricted distribution
		Java	Present, no details
		Sumatra	Present, no details
	Japan		Present, no details
	Laos		Present, no details
	Malaysia		Present, no details
		Sarawak	Present, no details
		West	Present, no details
	Myanmar		Present, no details
	Nepal		Present, no details
	Pakistan		Present, no details
	Philippines		Present, no details
	Saudi Arabia		Present, no details
	Singapore		Present, no details
	Sri Lanka		Present, no details
	Taiwan		Present, no details
	Thailand		Present, no details
	United Arab Emirates		Present, no details
	Vietnam		Present, restricted distribution
Oceania	Australia		Present, restricted distribution
		Queensland	Present, no details
		Northern Territory	Present, no details

Appendix C – Interception data through time

EU Interceptions of *Leucinodes orbonalis* (350 records) and *Leucinodes* sp. (9 records) from Asia; Jan 2004 to June 2021

Year	Bangladesh	Cambodia	India	Japan	Laos	Malaysia	Pakistan	Sri Lanka	Thailand	Vietnam	Sum
2004	–	–	–	–	–	–	–	–	23	–	23
2005	–	–	3	–	–	–	–	–	60	–	63
2006	–	–	2	–	–	–	–	–	19	1	22
2007	–	–	10	–	–	–	–	–	9	4	23
2008	4	–	7	–	–	–	–	–	5	–	16
2009	1	–	1	–	–	–	–	8	6	–	16
2010	1	–	–	–	–	–	–	2	11	–	14
2011	2	–	1	–	–	7	2	6	1	5	24
2012	4	–	8	–	3	13	2	13	1	–	44
2013	1	2	8	–	–	8	7	7	1	–	34
2014	–	4	–	–	–	1	–	5	1	1	12
2015	–	–	–	–	–	–	–	1	–	–	1
2016	–	–	–	–	1	–	–	–	–	–	1
2017	–	–	–	–	–	–	–	1	–	–	1
2018	–	–	2	–	–	–	–	1	–	–	3
2019	–	2	–	–	–	–	–	–	3	4	9
2020	–	6	1	1	4	–	–	16	4	–	32
2021	–	1	–	–	–	–	–	19	1	–	21
Sum	**13**	**15**	**43**	**1**	**8**	**29**	**11**	**79**	**145**	**15**	**359**



Appendix D – Import data into EU 27

(Eurostat accessed on 20/7/2021)

Fresh or chilled aubergines 'eggplants' (CN code: 07093000) (Hundreds of kg)

Country	2016	2017	2018	2019	2020
Laos	623.61	507.16	553.87	651.54	575.33
Thailand	371.71	361.70	392.81	482.10	435.44
Viet Nam	439.72	375.63	338.35	307.70	38.43
Malaysia	319.24	368.87	253.99	213.25	7.29
Sri Lanka	10.30	6.57	0.35	23.51	15.29
India	13.83	4.45	–	15.61	3.25
Pakistan	0.40	0	3.85	0.48	10.60
Indonesia	–	0	0.21	2.93	10.35
Japan	0.24	1.24	0.53	1.94	0.38
Bangladesh	0.15	1.05	–	–	–
Philippines	–	0	–	0.86	–
China	–	0	–	0.60	–
United Arab Emirates	–	0	–	0.10	–

Tomatoes (CN code: 0702) (Hundreds of kg)

Country	2016	2017	2018	2019	2020
Japan	13.75	8.98	13.31	45.67	34.37
United Arab Emirates	–	0.00	–	3.77	–
Australia	–	0.00	–	2.52	–
Thailand	0.08	0.08	0.08	0.02	0.02
Viet Nam	0.03	0.06	–	–	–
India	–	0.00	–	0.01	–

Fresh or chilled sweet peppers (CN code: 07096010) (Hundreds of kg)

Country	2016	2017	2018	2019	2020
Japan	13.75	8.98	13.31	45.67	34.37
United Arab Emirates	–	0.00	–	3.77	–
Australia	–	0.00	–	2.52	–
Thailand	0.08	0.08	0.08	0.02	0.02
Viet Nam	0.03	0.06	–	–	–
India	–	0.00	–	0.01	–

Fresh or chilled peas (CN code: 070810) (Hundreds of kg)

Country	2016	2017	2018	2019	2020
China	924.42	757.01	1442.82	1580.7	1780.75
Thailand	100.19	74.31	87.9	153.74	85.36
Pakistan	7.9	19.28	9.07	19.08	19.89
Australia	0	0	–	–	71.76
India	4.55	16.14	0.74	1.5	22
Bangladesh	2.25	5.8	–	–	3.95
Laos	1.32	0.01	–	–	6.13
Japan	0.13	0.07	4.48	0.01	0.02
Nepal	–	0.5	–	–	1.92

Country	2016	2017	2018	2019	2020
Cambodia	–	0	–	1.73	0.04
United Arab Emirates	–	0	–	1.4	–
Viet Nam	0.02	0	–	0.19	0.55
Sri Lanka	–	0.48	–	–	0.05