SCIENTIFIC OPINION

efsa JOURNAL

ADOPTED: 30 March 2023

doi: 10.2903/j.efsa.2023.7998

Pest categorisation of *Solenopsis invicta*

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Abstract

The EFSA Panel on Plant Health performed a pest categorisation of *Solenopsis invicta* Butler (Hymenoptera: Formicidae) the red imported fire ant, for the EU territory. *S. invicta* is native to central South America and has spread to North and Central America, East Asia and Australia where it is recognised as a major invasive species causing serious environmental impacts to biodiversity and harming horticultural crops such as cabbage, eggplant and potatoes. It can girdle and kill young citrus trees. *S. invicta* is not listed as a Union quarantine pest in Annex II of Commission Implementing Regulation (EU) 2019/2072. However, the European Scientific Forum on Invasive Alien Species lists *S. invicta* as a species of Union concern (Commission Implementing Regulation (EU) 2022/1203). Like other ant species, *S. invicta* is a social insect commonly creating colonies in the soil. Long-distance spread in the Americas has been attributed to nests being carried in soil accompanying plants for planting, or simply in soil alone. *S. invicta* could enter the EU via conveyances carrying a wide range of goods if the conveyance is contaminated with soil or has been in close contact with soil, and with plants for planting in soil or growing media. Climatic conditions in large parts of the southern EU are suitable for establishment and spread would occur when mated females disperse to form new colonies. If *S. invicta* established in the EU, losses to horticultural crops would be expected in addition to losses to biodiversity. The impacts of *S. invicta* go beyond plant health with the ant attacking new-born, hatching, weak or sick animals. Stings can cause allergic reactions in humans and are a public health issue. However, such factors are outside the scope of a pest categorisation. *S. invicta* satisfies the criteria that are within the remit of EFSA to assess for it to be regarded as a potential Union quarantine pest.

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Keywords: invasive species, red imported fire ant, RIFA, pest risk, plant health, plant pest, quarantine

Requestor: European Commission

Question number: EFSA-Q-2022-00766

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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 wishes to acknowledge Oresteia Sfyra for her substantial contribution throughout the preparation of the scientific opinion, Alex Gobbi for coordinating the literature search and the climate suitability and Stella Papanastasiou and Malayka Picchi for performing the systematic literature search and extracting the distribution data.

Suggested citation: EFSA PLH Panel (EFSA Panel on Plant Health), Bragard C, Baptista P, Chatzivassiliou E, Di Serio F, Gonthier P, Jaques Miret JA, Justesen AF, Magnusson CS, Milonas P, Navas-Cortes JA, Parnell S, Potting R, Reignault PL, Stefani E, Thulke H-H, Van der Werf W, Vicent Civera A, Yuen J, Zappalà L, Grégoire J-C, Malumphy C, Kertesz V, Maiorano A and MacLeod A, 2023. Scientific Opinion on the pest categorisation of *Solenopsis invicta*. EFSA Journal 2023;21(5):7998, 26 pp. https://doi.org/10.2903/j.efsa.2023.7998

ISSN: 1831-4732

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

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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. Conditions are laid down in this legislation in order for 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 pests together with the associated import or internal movement requirements of commodities are included in Commission Implementing Regulation (EU) 2019/2072. Additionally, as stipulated in the Commission Implementing Regulation 2018/2019, certain commodities are provisionally prohibited to enter in the EU (high risk plants, HRP). EFSA is performing the risk assessment of the dossiers submitted by exporting to the EU countries of the HRP commodities, as stipulated in Commission Implementing Regulation 2018/2018. Furthermore, EFSA has evaluated a number of requests from exporting to the EU countries for derogations from specific EU import requirements.

In line with the principles of the new plant health law, the European Commission with the Member States are discussing monthly the reports of the interceptions and the outbreaks of pests notified by the Member States. Notifications of an imminent danger from pests that may fulfil the conditions for inclusion in the list of the Union quarantine pest are included. Furthermore, EFSA has been performing horizon scanning of media and literature.

As a follow-up of the above-mentioned activities (reporting of interceptions and outbreaks, HRP, derogation requests and horizon scanning), a number of pests of concern have been identified. EFSA is requested to provide scientific opinions for these pests, in view of their potential inclusion by the risk manager in the lists of Commission Implementing Regulation (EU) 2019/2072 and the inclusion of specific import requirements for relevant host commodities, when deemed necessary by the risk manager.

1.1.2. Terms of reference

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

EFSA is requested to deliver 53 pest categorisations for the pests listed in Annex 1A, 1B, 1D and 1E (for more details see mandate M-2021-00027 on the Open.EFSA portal). Additionally, EFSA is requested to perform pest categorisations for the pests so far not regulated in the EU, identified as pests potentially associated with a commodity in the commodity risk assessments of the HRP dossiers (Annex 1C; for more details see mandate M-2021-00027 on the Open.EFSA portal). Such pest categorisations are needed in the case where there are not available risk assessments for the EU.

When the pests of Annex 1A are qualifying as potential Union quarantine pests, EFSA should proceed to phase 2 risk assessment. The opinions should address entry pathways, spread, establishment, impact and include a risk reduction options analysis.

Additionally, EFSA is requested to develop further the quantitative methodology currently followed for risk assessment, in order to have the possibility to deliver an express risk assessment methodology. Such methodological development should take into account the EFSA Plant Health Panel Guidance on quantitative pest risk assessment and the experience obtained during its implementation for the Union candidate priority pests and for the likelihood of pest freedom at entry for the commodity risk assessment of High Risk Plants.

1.2. Interpretation of the Terms of Reference

Solenopsis invicta is one of a number of pests listed in Annex 1D to the Terms of Reference (ToR) to be subject to pest categorisation to determine whether it fulfils the criteria of a potential Union quarantine 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 EU decision making as to its appropriateness for potential inclusion in the lists of pests of Commission Implementing Regulation (EU) 2019/ 2072. If a pest fulfils the criteria to be potentially listed as a Union quarantine pest, risk reduction options will be identified.

1.3. Additional information

This pest categorisation was initiated as a result of media monitoring, PeMoScoring[1] (EFSA et al., 2022), and subsequent discussion at the Standing Committee on Plants, Animals, Food and Feed, resulting in it being included in the current mandate within the list of pests identified by horizon scanning and selected for pest categorisation.

2. Data and methodologies

2.1. Data

2.1.1. Literature search

A literature search on *S. invicta* 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 EPPO Global Database, 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 to TRACES in May 2020.

GenBank was searched to determine whether it contained any nucleotide sequences for *S. invicta* which could be used as reference material for molecular diagnosis. GenBank® (www.ncbi.nlm.nih.gov/genbank/) is a comprehensive publicly available database that as of August 2019 (release version 227) contained over 6.25 trillion base pairs from over 1.6 billion nucleotide sequences for 450,000 formally described species (Sayers et al., 2020).

2.2. Methodologies

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

[1] PeMoScoring is a ranking system that orders pests by risks posed to the EU and provide a tool to support risk managers in the decision of actions to take. It helps risk managers decide (i) whether further risk assessment, such as pest categorisation, is needed, (ii) whether EU surveillance and import control must be enforced for newly identified specific pests.

The criteria to be considered when categorising a pest as a potential Union quarantine pest (QP) is given in Regulation (EU) 2016/2031 Article 3 and Annex I, Section 1 of the 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. Whilst 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 quarantine pest status. Assessing social impact is outside the remit of the Panel.

Table 1: Pest categorisation criteria under evaluation, as derived from 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 clearly defined, 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 in a limited part of the EU or is it scarce, irregular, isolated or present infrequently? If so, the pest is considered to be not widely distributed.
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 for entry and spread.
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 (Section 3.6)	Are there measures available to prevent pest entry, establishment, spread or impacts?
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 clearly defined, or has it been shown to produce consistent symptoms and/or to be transmissible?

Yes. The identity of the species is established and *Solenopsis invicta* Buren is the accepted name.

Solenopsis invicta Buren, 1972 is an insect within the order Hymenoptera and family Formicidae. It was first described in 1916 as *Solenopsis saevissima wagneri*, a subspecies of *S. saevissima*, before being recognised as a separate species in 1972. *Solenopsis saevissima wagneri* is therefore a synonym.

S. invicta belongs to a clade of recently diverged taxa, including *Solenopsis richteri* and *Solenopsis geminata* (Ross et al., 2010; de Souza et al., 2014).

It is commonly known as the red imported fire ant, which in some literature is abbreviated to 'RIFA'.

The EPPO code[2] (Griessinger and Roy, 2015; EPPO, 2019) for this species is: SOLEIN (EPPO, online).

3.1.2. Biology of the pest

Like other ants, *S. invicta* are social insects that live in colonies. A *S. invicta* colony can consist of a single queen (monogyne colonies) or multiple queens (polygyne colonies) and thousands of worker ants and brood (the collective noun for eggs, larvae and pupae). Worker ants care and tend to the queen(s) and brood. A queen stays within the nest where she lays eggs. In the southern USA, eggs hatch after 8–10 days; larvae and pupae take 6–12 days and 9–16 days to develop, respectively. Most pupae develop into worker ants (sterile females). However, when a colony matures, typically 6–8 months after it was initiated, some pupae develop into winged males and females (Metcalf and Metcalf, 1993; Collins and Scheffrahn, 2016). A mature colony may produce 4,000 to 6,000 winged adults each year (Vinson, 1997). The winged adults leave the nest and fly in swarms to mate, then the mated females disperse to establish new colonies. Nuptial flights mostly occur in the spring and summer, 2 or 3 days after rain and when the temperature is between 24°C and 32°C (Morrill, 1974; Vinson, 1997). Males die soon after mating. Mated females seek out a suitable site for nesting, typically a few 100 m or, occasionally, a few kilometres from the nest they emerged from (Gunawardana, 2014). However, mated females are attracted to reflective surfaces and can land on cars, trains and other vehicles and can therefore spread hundreds of km from the natal colony (Vinson, 1997). Once a mated female has found a suitable site to nest, she will break off her wings and create a brood chamber in the soil where she will initially lay around 20 eggs. The females' wing muscles then break down to provide nutrients which she will use to feed the larvae that hatch from her first batch of eggs (Vinson and Sorenson, 1986); she feeds and cares for these larvae until they develop into workers (Collins and Scheffrahn, 2016). These first workers then begin tending to the adult female, which is now regarded as a queen. More eggs are laid by the queen and the workers begin to burrow in the soil, growing the chamber and nest and foraging for food for the queen. The workers care for the queen who focusses on laying more eggs to grow the colony. A queen can lay up to 1,500 eggs per day. Queens live for between 2 and 6 years (Collins and Scheffrahn, 2016).

Worker ants are polymorphic (i.e. come in different forms and sizes). The first workers in a new colony are the smallest workers, called minims. The slightly larger 'minors' develop later and live for up to 60 days, later 'media' workers live for up to 90 days whilst the biggest workers, called 'majors', live for up to 180 days. The tasks conducted by workers, such as tending the queen(s), grooming other adults, foraging and building the nest vary between size and age of each type of worker although there is overlap (Mirenda and Vinson, 1981). Individual worker ants cannot survive alone. A mature colony can contain up to 400,000 workers (Vinson, 1997) although most colonies are smaller with approximately 80,000 workers consisting of a mix of minor, media and major workers (Vinson and Sorenson, 1986).

The nest of a colony of *S. invicta* appears as a soil mound typically 125 cm in circumference and between approximately 40 and 90 cm high with a hard crust; there can be 60–250 mounds per hectare (Metcalf and Metcalf, 1993; Vinson, 1997) (Figure 2). The surface of a mound has no entrance or exit holes, the workers exit and enter the nest via tunnels that radiate out up to 30 m from the mound (Vinson, 1997). In infested areas, nests are usually found in sunny open areas and are common in disturbed and irrigated areas, such as on lawns and golf courses, in gardens, parks and along roadsides (Gunawardana, 2014).

3.1.3. Host range/species affected

Like many ant species, *S. invicta* is omnivorous and will eat almost any type of plant and animal material (Vinson and Sorensen, 1986). However, they generally feed on invertebrates (insects and other arthropods) which they sting and paralyse. They also feed on vertebrates (e.g. amphibians, birds, reptiles and mammals) as well as on young plants and seeds. They also harvest honeydew from Hemiptera (i.e. aphids, psyllids, scale insects and whiteflies). A study in Oklahoma by

[2] 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 harmonised system to facilitate the management of plant and pest names in computerised databases, as well as data exchange between IT systems (Griessinger and Roy, 2015; EPPO, 2019).

Vogt et al. (2002) revealed that whilst the majority of foraged items (i.e. food items collected by workers being returned to the nest) were arthropods, 15.7–17.2% of foraged items were (unspecified) plant seeds.

Finding *S. invicta* on a plant does not necessarily indicate that the plant is a host; foraging workers may be searching for phytophagous arthropods on the plant on which to predate or harvest honeydew from.

Host plants reported in literature and compiled by Gunawardana (2014) are shown in Appendix A.

3.1.4. Intraspecific diversity

No subspecies or varieties have been described.

3.1.5. Detection and identification of the pest

Are detection and identification methods available for the pest?
Yes, nest mounds become visible in fields around 6 months after they begin to form. When disturbed, worker ants rush out to defend the nest and are easily seen.
Morphological keys and molecular methods are available to identify *S. invicta*.

Detection

Host plants attacked by workers can show a variety of symptoms such as wilting and dieback, stems of young hosts can be cut near the base. However, such symptoms are not specific to *S. invicta* and hence are not diagnostic. Ant mounds are visible to the naked eye. Undisturbed mounds on pasture-land can be 45 cm high or more (Gunawardana, 2014). However, *S. invicta* nests may occur in grassland areas where the mounds are flattened by mowing and are consequently less obvious.

Identification

Eggs are spherical to oval, approximately 0.03 mm in diameter and creamy white. They have an adhesive coating allowing them to stick together (Petralia and Vinson, 1979; Gunawardana, 2014).

There are four cream-coloured larval instars; first instar larvae are 0.27–0.42 mm long; second instar larvae are 0.42–0.57 mm long; third instar larvae are 0.59–0.91 mm long. Fourth instar larvae are 0.79–1.82 mm long. All are whitish grubs (Petralia and Vinson, 1979).

Pupae are creamy-white and become darker as they develop.

Worker adults are dark reddish-brown and black and have no wings. Workers range in size, minors are about 3 mm long whilst majors are up to 5 mm long (Vinson, 1997). Gunawardana (2014) lists the diagnostic features of workers.

Adult males: shiny and black with wings.

Queens: About 9 mm long, reddish-brown. Wings are removed after the nuptial flight (Gunawardana, 2014).

Keys based on morphological features can be used to identify *S. invicta*, e.g. Wojcik et al. (1976), Sarnat (2008) and Trager (1991). The minors of *S. invicta* can be difficult to distinguish morphologically from minors of related fire ants.

Molecular methods are available to identify *S. invicta* with over 400,000 accessions in Genbank.

Wurm et al. (2011) provide the whole genome from Roche 454 and Illumina sequencing.

Figure 1 shows an adult worker and Figure 2 a nest mound.

Figure 1: USDA APHIS PPQ – Red Imported Fire Ant (adult), © USDA APHIS PPQ, Bugwood.org
An adult worker (up to 5 mm long).

Figure 2: USDA APHIS PPQ – Red Imported Fire Ant mound, © USDA APHIS PPQ, Bugwood.org
A soil mound, indicating a nest is typically 125 cm in circumference and between approximately 40 and 90 cm high with a hard crust.

3.2. Pest distribution

3.2.1. Pest distribution outside the EU

S. invicta is a tropical and sub-tropical species native to central South America. It has spread to Central and North America and is now found in many Caribbean islands. It is also established in East Asia and Australia.

The ant was accidentally introduced into the southern United States in the early 20th century. Several papers suggest that the first introduction occurred in Mobile, Alabama, in the 1930s. However, Vinson (1997) suggests the first introduction actually occurred in 1918. Regardless of when the first introduction occurred, *S. invicta* now occupies much of the southern USA (Needleman et al., 2018). Figure 3 shows the global distribution of *S. invicta*. Appendix B provides details of the global distribution based on Gunawardana (2014) and the EPPO Global Database (EPPO, online).

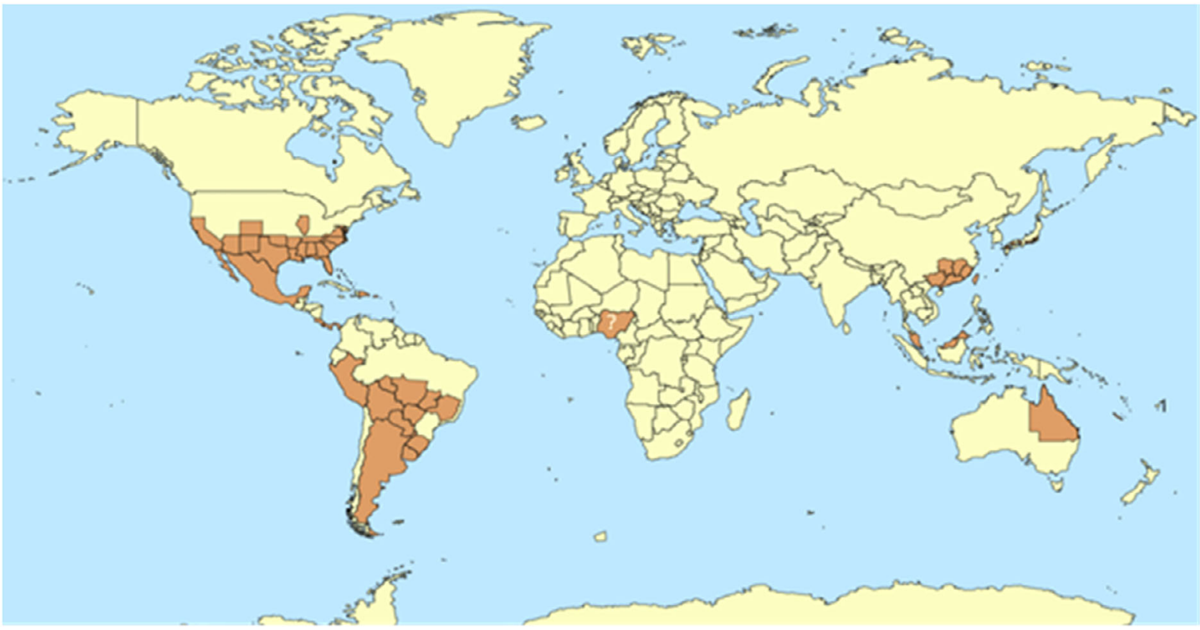

Figure 3: Global distribution of *Solenopsis invicta* (data source: EPPO Global Database accessed on 21/12/2022). Note that the occurrence of *S. invicta* in Nigera is considered unproven

There are reports of *S. invicta* from Nigeria (Njila and Hadi, 2015; Okoro and Cadmus, 2016; Akinmuleya and Oso, 2022), however, these are not accepted by the leading online database on ants (antweb.org), by a world-leading authority on ants, James Wetterer (pers. comm., March 2023), or consistent with recently published data (Chen et al., 2020; Jimoh et al., 2021). Therefore, the reported occurrence of *S. invicta* in Nigeria is considered unproven at present. Reports are highly likely to be a case of misidentification. *S. invicta* is often misidentified due to its very similar morphological features, ecology and stinging pain sensation with *S. geminata* and *S. richteri*. *S. geminata* is known to occur in West Africa (antweb.org).

3.2.2. Pest distribution in the EU

Is the pest present in the EU territory? If present, is the pest in a limited part of the EU or is it scarce, irregular, isolated or present infrequently? If so, the pest is considered to be not widely distributed.

No. *S. invicta* is not known to occur in the EU territory.

3.3. Regulatory status

Regulation (EU) 1143/2014 aims to prevent the introduction, slow the spread and mitigate the impacts on biodiversity caused by invasive species of concern to EU members states. On the basis of a risk assessment that shows that *S. invicta* could establish and spread within the EU territory and have a significant adverse impact on biodiversity or related ecosystem services and may also have an adverse impact on human health or the economy (Kenis et al., 2017), the European Scientific Forum on Invasive Alien Species lists *S. invicta* as a species of Union concern (Commission Implementing Regulation (EU) 2022/1203). The regulation identifies plants for planting with growing media (CN code ex 0602) and soil and growing media (CN code ex 2530 90 00) as categories of goods generally associated with *S. invicta* and on which the ant could enter the EU.

3.3.1. Commission implementing regulation 2019/2072

S. invicta 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 or species affected that are prohibited from entering the union from third countries

A number of host plants are prohibited from entering the EU (Table 2).

Table 2: List of plants, plant products and other objects that are *Solenopsis invicta* hosts whose introduction into the Union from certain third countries is prohibited (Source: Commission Implementing Regulation (EU) 2019/2072, Annex VI) (The table is not necessarily comprehensive, other commodities not listed as hosts can also be associated with the pest)

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**
1.	Plants of [. . .] *Pinus* L., [. . .] other than fruit and seeds	ex 0602 20 20 ex 0602 20 80 ex 0602 90 41 ex 0602 90 45 ex 0602 90 46 ex 0602 90 47 ex 0602 90 50 ex 0602 90 70 ex 0602 90 99 ex 0604 20 20 ex 0604 20 40	Third countries other than [. . .]

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**
9.	Plants for planting of [. . .] *Fragaria* L., other than seeds	ex 0602 10 90 ex 0602 20 20 ex 0602 90 30 ex 0602 90 41 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 [. . .] Australia [. . .] Unites States other than Hawaii.
11.	Plants of *Citrus* L. [. . .] other than fruits and seeds	ex 0602 10 90 ex 0602 20 20 0602 20 30 ex 0602 20 80 ex 0602 90 45 ex 0602 90 46 ex 0602 90 47 ex 0602 90 50 ex 0602 90 70 ex 0602 90 91 ex 0602 90 99 ex 0604 20 90 ex 1404 90 00	All third countries
14.	Plants for planting of the family Poaceae, other than plants of ornamental perennial grasses of the subfamilies [. . .] Panicoideae and of the genera [. . .], other than seeds	ex 0602 90 50 ex 0602 90 91 ex 0602 90 99	Third countries other than [. . .]
15	Tubers of *Solanum tuberosum* L., seed potatoes	0701 10 00	Third countries other than Switzerland
18.	Plants for planting of Solanaceae other than seeds [. . .]	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
20.	Growing medium as such, other than soil, consisting in whole or in part of solid organic substances, other than that composed entirely of peat or fibre of *Cocos nucifera* L., previously not used for growing of plants or for any agricultural purposes	ex 2530 10 00 ex 2530 90 00 ex 2703 00 00 ex 3101 00 00 ex 3824 99 93	Third countries other than Switzerland

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, *S. invicta* could enter the EU via a wide variety of pathways. Mated females could enter alone as hitchhikers having been attracted to vehicles (see Section 3.1.2); colonies could be carried in contaminated soil or other growing media or in objects (such as shipping containers) that have been in contact with or close to contaminated soil.

Comment on plants for planting as a pathway.

Plants for planting with growing media could provide a major pathway for entry.

S. invicta is listed among '100 of the world's worst invasive alien species' (Lowe et al., 2000). Features such as their ability to spread as a hitchhiking species via international trade, their wide generalist nesting habits and frequent association with environmental disturbance facilitates expansion outside of their native range (Angulo et al., 2022). Among Hymenoptera, Formicidae (ants) are the family that is most intercepted (Turner et al., 2021). Globally most ant interceptions have been reported in Australia and New Zealand where plant health issues and environmental protection are well integrated into biosecurity systems (Turner et al., 2021). Greenberg and Kabashima (2013) note that *S. invicta* was apparently introduced into almond groves in California with beehives from Texas, when the bees were used for pollination of the almond crop. Table 3 lists potential pathways into the EU.

Table 3: Potential pathways for *Solenopsis invicta* into the EU 27

Pathways (Description, e.g. host/intended use/source)	Life stage	Relevant mitigations [e.g. prohibitions (Annex VI), special requirements (Annex VII) or phytosanitary certificates (Annex XI) within Implementing Regulation 2019/2072]
Plants for planting with growing media	Queen(s), workers, brood (i.e. eggs, larvae, pupae).	2019/2072 Annex VI prohibitions; Special requirements, Annex VII
Soil/growing media	Queen(s), workers, brood.	2019/2072 Annex VI prohibitions, Special requirements, Annex VII
Machinery and equipment (with soil attached) A specific example is honeybee hives (Greenberg and Kabashima, 2013)	Queen(s), workers, brood.	2019/2072 Special requirements Annex VII (e.g. 2. only for agricultural or forestry machinery and vehicles) For honeybee entry into the Union, specific animal health requirements are laid down in Commission Delegated Regulation (EU) 2020/692
Containers and wood packaging, especially if been in contact with soil	Queen(s), workers, brood.	ISPM 15 for wood packaging

In the EU, there were no notifications of interceptions of *S. invicta* in the Europhyt and TRACES databases (Note that because *S. invicta* is not a quarantine pest, member states are not obliged to notify findings to plant health authorities). Nevertheless, worker ants of *S. invicta* have been found during import inspections and a nest was found in the soil of *Ficus* plants imported into the Netherlands from the USA (Noordijk, 2010).

There were 13 interceptions of *Solenopsis* spp. in UK (England) between 1998 and 2023, mostly with fresh produce imported from South America, Caribbean, West Africa and Asia. Only one of these was confirmed as *S. invicta*, several live workers found in a shipping container whose last port of call was in West Africa. However, *S. invicta* is not known from Africa and the ants could have been in the container for some time having entered from another location.

3.4.2. Establishment

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

Yes, there are climate zones in the EU that match those found where *S. invicta* occurs. Recognising their generalist feeding habits the ants are opportunists and would make use of a very large array of plants and other food sources in these zones.

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

Multiple food sources for the pest are available throughout the EU. Hosts occur widely across the EU. Table 4 details the area of production of specified hosts although only a fraction of the crop areas will occur in regions climatically suitable for the establishment of *S. invicta* (see Section 3.4.2.2).

Table 4: EU area of crop production of hosts and plants affected by *Solenopsis invicta* (cultivation/harvested/production, thousand ha). Other hosts are also cultivated in the EU. Appendix B provides a list of hosts and plants affected. Source: Eurostat. https://ec.europa.eu/eurostat/databrowser/view/APRO_CPSH1

Crop	Code	2017	2018	2019	2020	2021	2022
Maize (grain maize and corn-cob mix)	C1500	8,271.6	8,259.5	8,917.6	9,215.2	9,247.0	8,934.2
Maize (green maize)	G3000	6,183.3	6,355.9	6,438.7	6,235.3	6,054.3	5,858.4
Sunflower	I 1120	4,311.6	4,025.7	4,337.8	4,396.7	4,368.7	5,153.6
Potatoes	R1000	1,601.2	1,562.9	1,603.7	1,462.8	1,404.1	1,354.9
Soya	I 1130	962.4	955.4	907.9	942.5	:	1,103.0
Citrus fruits	T0000	502.8	509.0	512.8	520.0	518.3	:
Sorghum	C1700	135.7	147.9	190.3	217.6	152.6	137.9
Strawberries	S0000	108.5	111.1	106.0	83.9	84.2	:
Cabbage	V1300	103.7	conf.	conf.	conf.	conf.	conf.
Clover (inc. mixtures)	G2910	:	:	:	:	:	:
Watermelons	V3520	76.5	73.7	74.5	64.5	68.0	:

: = no data; conf. = confidential.

3.4.2.2. Climatic conditions affecting establishment

The global Köppen-Geiger climate zones (Kottek et al., 2006) describe terrestrial climate in terms of average minimum winter temperatures and summer maxima, amount of precipitation and seasonality (rainfall pattern). *S. invicta* occurs in a range of climate zones in the Americas, Asia and Australia; its populations are limited by arid conditions and cold temperatures (Morrison et al., 2004). Some climatic zones in which *S. invicta* occurs are also found in the EU (Figure 4). For example, Mediterranean type climates, Csa and Csb, that occupy approximately 15% of all EU 27 five arcmin grid cells (MacLeod and Korycinska, 2018). Climate type Cfa (temperate, humid, sub-tropical) is found in large parts of the eastern United States and China and in parts of eastern Australia, where *S. invicta* also occurs and represents approximately 7% of EU 27 five arcmin grid cells.

Morrison et al. (2004) used a dynamic, ecophysiological model of colony growth together with minimum and maximum daily temperatures and precipitation data, to project the potential global distribution of *S. invicta*. The study suggested that areas of southern Europe, especially areas around the Mediterranean and Black seas, provided suitable conditions for establishment. Conditions further north into central and northern Europe were projected to be less suitable.

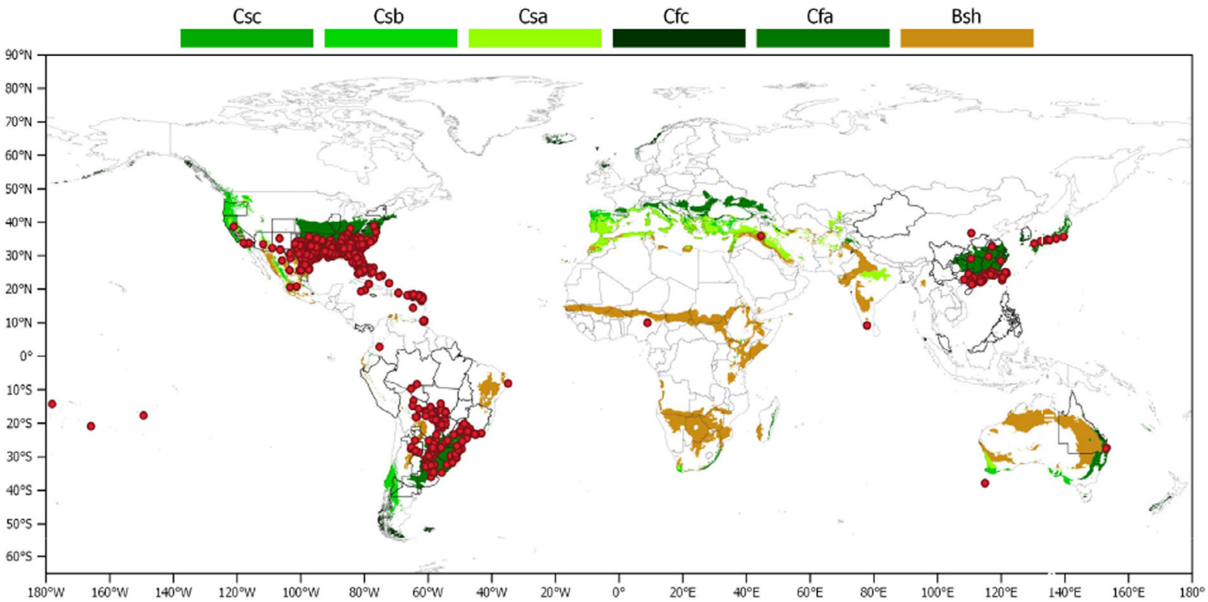

Figure 4: Distribution of selected Köppen–Geiger climate types that occur in the EU and in countries where *Solenopsis invicta* has been reported. Red dots mark point locations for *Solenopsis invicta* observations. The record from Africa (Nigeria) is unproven

3.4.3. Spread

Describe how the pest would be able to spread within the EU territory following establishment?
Spread would occur when new colonies are formed. Winged and sexually mature adults can fly; mated females disperse by flying and can move hundreds of meters before they settle to start a new colony. Mated females can land on vehicles and be carried many km before flying again to locate a nesting site. Nests could be transported with soil or with objects that have been in contact with soil.
Comment on plants for planting as a mechanism of spread.
All life stages could be transported on host plants for planting moved with soil or growing media.

Small to large colonies can be transported in soil with plants for planting and nursery rootstock; the movement of road construction equipment, pipelines and electrical and telecommunication lines can also facilitate movement of nests (Vinson, 1997). Following the introduction of *S. invicta* into Alabama, Gunawardana (2014) states that the ant spread westward at approximately 198 km per year.

When a nest is disturbed, worker ants will move brood (eggs, larvae and pupae) and the queen(s) to another location a few meters away and build a new nest. Workers can also detect rising water levels and will respond by creating rafts of ants consisting of workers and queen(s). Such rafts can float and be carried on flood water resulting in local movement (Collins, 1992).

3.5. Impacts

Would the pests' introduction have an economic or environmental impact on the EU territory?
Yes, *S. invicta* is a major invasive species. Losses to horticultural crops would be expected in addition to negative environmental impacts such as losses to biodiversity.

S. invicta is listed among '100 of the world's worst invasive alien species' (Lowe et al., 2000) because of the wide variety and magnitude of its impacts. Pimentel et al. (2005) estimated that in the USA *S. invicta* has an annual impact of US$ 1 billion per year due to losses and management costs. Angulo et al. (2022) examined 1,342 records reported between 1930 and 2020 of potential (i.e. expected or predicted) or incurred (i.e. actual) economic impacts, attributed to 12 ant species in 27 countries. Potential costs totalled US$ 40.98 billion and actual costs totalled US$ 10.95 billion. 80% of total costs were associated with *S. invicta* and *Wasmannia auropunctata* in the USA and Australia. Aoyama et al. (2020) estimated the economic impact that could occur if *S. invicta* spread throughout the Okinawa Prefecture in Japan; costs to agriculture, households, recreation and tourism, local infrastructure and government intervention were estimated to be approximately 44 billion yen (approximately € 315 million) per year.

Impacts on plants. *S. invicta* tunnels through roots and tubers and feeds on plants, fruit and seeds (Stewart and Vinson, 1991). It can be a serious agricultural pest of cabbage (*Brassica oleracea* var *capitata*), collard greens (*B. oleracea* var. *viridis*), eggplant (*Solanum melongena*) and potatoes (*S. tuberosum*) feeding on their tender stems just below the soil surface when young plants (Metcalf and Metcalf, 1993). Adams et al. (1988) reported a 45% loss in marketable yield from a commercial potato field in Florida due to *S. invicta* infestation. Losses were due to lower overall yield and culling harvested tubers that had been damaged by *S. invicta*. Also in Florida, Banks et al. (1991) reported *S. invicta* building nests close to citrus trees that were between 1 and 4 years old. Workers chewed at the bark and cambium to obtain sap and often girdled a tree, killing it. Worker ants also chewed new growth at the tips of branches and fed on flowers and developing fruit, lowering yield. Plant feeding can increase during dry or drought conditions when other food items are less abundant (Gunawardana, 2014).

As well as causing direct damage to plants, *S. invicta* facilitates damage to plants through the mutualistic relationships the species has with hemipteran plant pests (e.g. aphids, psyllids, scale insects and whiteflies). The ants consume the sugary honeydew produced by these pests whilst protecting them from natural enemies. For example, Zhou et al. (2013) reported higher mealybug densities on hibiscus plants tended by *S. invicta* compared to mealybug densities on hibiscus plants that were not attended by the ants. The difference in mealybug density was due to the lower number of mealybug predators and parasites on plants with *S. invicta*.

Plant viruses have been detected in *S. invicta* (Xavier et al., 2021). However, whether *S. invicta* can vector such viruses is uncertain.

The hard nest mounds of *S. invicta* can damage agricultural equipment and interfere with harvesting of crops (Metcalf and Metcalf, 1993) in effect, reducing yield.

Impacts to the biotic environment. In a literature review of over 400 primary research papers that reported the ecological effects of invasive alien insects, Kenis et al. (2009) reported that 18% of the papers focused on *S. invicta*; most publications reported effects on native biodiversity at a population or community level. *S. invicta* can displace native ant species (Wilder et al., 2013); this can affect higher trophic levels and impact on birds, reptiles and amphibians (Allen et al., 2017; Angulo et al., 2022). In the south-western USA, the tortoise *Gopherus polyphemus* creates burrows and is an important ecological engineer; the burrows create habitat for 360 other species and the tortoise is regarded as a keystone species. *S. invicta* attack newly hatched tortoises and can reduce invertebrate abundance, species richness and diversity in the burrows (Epperson et al., 2021). *S. invicta* can reduce the numbers of springtails, earwigs, beetles and thrips in agroecosystems (Wickings and Ruberson, 2011).

Impacts to the abiotic environment. Nest building and foraging activities of *S. invicta* affect the physical and chemical properties of the soils through structural modifications and nutrient accumulation (Lafleur et al., 2005).

The impacts of invasive ants go beyond the factors normally considered in a pest categorisation. For interest, examples of such impacts include:

- Attacks on new-born, hatching, weak or sick animals that can cause their death. *S. invicta* can attack vulnerable animals and sting in and around the eyes, (can lead to blindness) and around the mouth and nose (can lead to swelling and suffocation) (Queensland Government, 2022).
- *S. invicta* can forage on farm animal food and water, stinging the animals that the food and water is intended for. The animals then avoid the food and water and starve or become dehydrated (Queensland Government, 2022).
- *S. invicta* can impact on human health; allergic reactions to *S. invicta* stings are a serious public health problem (Xu et al., 2012).
- Nests and tunnels created by *S. invicta* in urban areas can undermine pavements and damage cables and wires damaging human infrastructure (Lard et al., 2002).

3.6. Available measures and their limitations

> *Are there measures available to prevent pest entry, establishment, spread or impacts such that the risk becomes mitigated?*
>
> **Yes**, measures are available to reduce the likelihood of entry and establishment and to limit the magnitude of spread and impacts.

Annex VI of 2019/2072 prohibits the introduction of some plants for planting and soil from many third countries, including countries where *S. invicta* occurs. Such measures reduce the likelihood of entry (see Section 3.3.2). However, as a species capable of being introduced via conveyances contaminated by soil, such as shipping containers, *S. invicta* could enter the EU on pathways not generally included in plant health regulations.

3.6.1. Identification of potential additional measures

Potential additional control measures are listed in Table 5.

Table 5: Selected control measures (a full list is available in EFSA PLH Panel et al., 2018) for pest entry/establishment/spread/impact in relation to currently unregulated hosts and pathways. Control measures are measures that have a direct effect on pest abundance

Control measure/Risk reduction option (Blue underline = Zenodo doc, Blue = WIP)	RRO summary	Risk element targeted (entry/establishment/spread/impact)
Require pest freedom	Pest free production site, area, place or production	Entry/Spread
Managed growing conditions	Tillage can destroy ant mounds but worker ants may survive and relocate, taking the queen(s) and brood to build a new nest elsewhere; excavation and physical removal of a nest can reduce population size but workers, queen(s) and brood may escape during excavation to start another colony (Collins, 1992).	Impact
Biological control and behavioural manipulation	In the USA classical biocontrol has been partially successful using species of parasitic flies (Diptera: Phoridae) such as *Pseudacteon curvatus* Borgmeier from Argentina (Graham et al., 2003).	Spread/Impact
Chemical treatments on crops including reproductive material	A variety of chemical treatments, including drenches, granules, aerosols, fumigants and baits are used in USA to destroy nests (Collins, 1992) chemical options have included abamectin and spinosad (Greenberg and Kabashima, 2013).	Establishment/Impact
Cleaning and disinfection of facilities, tools and machinery	Prior to their export machinery and vehicles which have been operated for agricultural or forestry purposes are cleaned and free from soil and plant debris. Cleaning of containers would be helpful.	Entry/Spread
Limits on soil	• Plants, plant products and other pathway agents (e.g. used farm machinery) to be free from soil or growing medium; • Growing medium is pest free e.g. the growing medium is free from soil and organic matter and had not been previously used for growing plants or for any other agricultural purposes, or was composed entirely of peat or fibre, or was subjected to effective fumigation or heat treatment or subjected to effective systems approach to ensure freedom from pests.	Entry/Spread

Control measure/Risk reduction option (Blue underline = Zenodo doc, Blue = WIP)	RRO summary	Risk element targeted (entry/establishment/ spread/impact)
Soil treatment	Collins (1992) reports use of fumigants against nests/mounds.	Entry/Establishment/Spread

3.6.1.1. Additional supporting measures

Potential additional supporting measures are listed in Table 6.

Table 6: Selected supporting measures (a full list is available in EFSA PLH Panel et al., 2018) in relation to currently unregulated hosts and pathways. Supporting measures are organisational measures or procedures supporting the choice of appropriate risk reduction options that do not directly affect pest abundance

Supporting measure (Blue underline = Zenodo doc, Blue = WIP)	Summary	Risk element targeted (entry/ establishment/ spread/impact)
Inspection and trapping	Inspection is defined as the official visual examination of plants, plant products or other regulated articles to determine if pests are present or to determine compliance with phytosanitary regulations (ISPM 5). The effectiveness of sampling and subsequent inspection to detect pests may be enhanced by including trapping and luring techniques.	Entry/ Establishment/ Spread
Laboratory testing	Examination, other than visual, to determine if pests are present using official diagnostic protocols. Diagnostic protocols describe the minimum requirements for reliable diagnosis of regulated pests.	Entry/Spread
Sampling	According to ISPM 31, it is usually not feasible to inspect entire consignments, so phytosanitary inspection is performed mainly on samples obtained from a consignment. It is noted that the sampling concepts presented in this standard may also apply to other phytosanitary procedures, notably selection of units for testing. For inspection, testing and/or surveillance purposes the sample may be taken according to a statistically based or a non-statistical sampling methodology.	Entry/Spread
Phytosanitary certificate and plant passport	An official paper document or its official electronic equivalent, consistent with the model certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements (ISPM 5) a) export certificate (import) b) plant passport (EU internal trade)	Entry/Spread
Certified and approved premises	Mandatory/voluntary certification/approval of premises is a process including a set of procedures and of actions implemented by producers, conditioners and traders contributing to ensure the phytosanitary compliance of consignments. It can be a part of a larger system maintained by the NPPO in order to guarantee the fulfilment of plant health requirements of plants and plant products intended for trade. Key property of certified or approved premises is the traceability of activities and tasks (and their components) inherent the pursued phytosanitary objective. Traceability aims to provide access to all trustful pieces of information that may help to prove the compliance of consignments with phytosanitary requirements of importing countries.	

Supporting measure (Blue underline = Zenodo doc, Blue = WIP)	Summary	Risk element targeted (entry/ establishment/ spread/impact)
Delimitation of Buffer zones	ISPM 5 defines a buffer zone as 'an area surrounding or adjacent to an area officially delimited for phytosanitary purposes in order to minimise the probability of spread of the target pest into or out of the delimited area, and subject to phytosanitary or other control measures, if appropriate' (ISPM 5). The objectives for delimiting a buffer zone can be to prevent spread from the outbreak area and to maintain a pest free production place (PFPP), site (PFPS) or area (PFA).	Spread/Impact
Surveillance	Surveillance to guarantee that plants and produce originate from a Pest Free Area could be an option.	Spread/Impact

3.7. Uncertainty

There is a substantial amount of literature on *S.invicta* and no key uncertainties were identified.

4. Conclusions

S. invicta satisfies the criteria that are within the remit of EFSA to assess for it to be regarded as a potential Union quarantine pest. Table 7 provides a summary of the PLH Panel conclusions.

Table 7: The Panel's conclusions on the pest categorisation criteria 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	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 *Solenopsis invicta* Buren is the accepted name and authority.	None
Absence/presence of the pest in the EU (Section 3.2)	*Solenopsis invicta* is not known to occur in the EU territory	None
Pest potential for entry, establishment and spread in the EU (Section 3.4)	*Solenopsis invicta* could enter the EU via a wide variety of pathways. Colonies could be carried in contaminated soil with plants for planting or with a range of conveyances if contaminated with soil. Climatic conditions in large parts of the southern EU are suitable for establishment and spread would occur when mated females disperse to form a new colony.	None
Potential for consequences in the EU (Section 3.5)	*Solenopsis invicta* is a major invasive species. Losses to horticultural crops would be expected in addition to negative environmental impacts such as losses to biodiversity.	None
Available measures (Section 3.6)	Annex VI of 2019/2072 prohibits the introduction of some host plants and soil; the European Scientific Forum on Invasive Alien Species lists *S. invicta* as a species of Union concern (Commission Implementing Regulation (EU) 2022/ 1203).	None
Conclusion (Section 4)	*Solenopsis invicta* satisfies the criteria that are within the remit of EFSA to assess for it to be regarded as a potential Union quarantine pest.	
Aspects of assessment to focus on/scenarios to address in future if appropriate:		

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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
PAFF	Standing Committee on Plants, Animals, Food and Feed (PAFF Committee)
PLH	EFSA Panel on Plant Health
PZ	Protected Zone
SEM	Scanning electron microscopy
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, 2021)
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO, 2021)

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, 2021)
Eradication (of a pest)	Application of phytosanitary measures to eliminate a pest from an area (FAO, 2021)
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2021)
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.
Hitchhiker	An organism sheltering or transported accidentally via inanimate pathways including with machinery, shipping containers and vehicles; such organisms are also known as contaminating pests or stowaways (Toy and Newfield, 2010).
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, 2021)
Pathway	Any means that allows the entry or spread of a pest (FAO, 2021)
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, 2021)
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, 2021)
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, 2021)

Appendix A – *Solenopsis invicta* host plants/species affected

Source: CABI Invasive species compendium (Gunawardana, 2014; CABI, 2022) and literature.

Host name	Common name	Reference
Brassica oleracea var. *capitata*	Cabbage	Gunawardana, 2014
Brassica oleracea var. *viridis*	Collard greens	Metcalf and Metcalf, 1993
Abelmoschus esculentus	Okra	Gunawardana, 2014
Arachis hypogaea	Groundnut/peanut	Gunawardana, 2014
Carya illinoinensis	Pecan	Gunawardana, 2014
Citrullus lanatus	Watermelon	Gunawardana, 2014
Citrus		Gunawardana, 2014
Cucumis sativus	Cucumber	Gunawardana, 2014
Cynodon dactylon	Bermuda grass	Gunawardana, 2014
Fragaria ananassa	Strawberry	Gunawardana, 2014
Glycine max	Soyanbean	Gunawardana, 2014
Helianthus annuus	Sunflower	Gunawardana, 2014
Ipomoea batatas	Sweet potato	Gunawardana, 2014
Medicago falcata	Yellow alfalfa	Gunawardana, 2014
Pinus	Pines	Gunawardana, 2014
Solanum melongena	Aubergine	Gunawardana, 2014
Solanum tuberosum	Potato	Metcalf and Metcalf, 1993
Sorghum bicolor	Sorghum	Gunawardana, 2014
*Stenotaphrum secundatum**	Buffalo grass	Gunawardana, 2014
Trifolium	Clovers	Gunawardana, 2014
Zea mays	Maize	Gunawardana, 2014

* in subfamily Panicoideae, so can be imported into the EU (see Table 2).

Appendix B – Distribution of *Solenopsis invicta*

Distribution records based on the EPPO Global Database (EPPO, online) and scientific literature.

Region	Country	Sub-national (e.g. State)	Status	Refs
North America	Mexico		Present, no details	1,2
	United States of America		Present, restricted distribution	1,2
		Alabama	Present, widespread	1,2
		Arizona	Present, no details	1,2
		Arkansas	Present, restricted distribution	1,2
		California	Present, no details	1,2
		Colorado	Present, no details	1,2
		Florida	Present, widespread	1,2
		Georgia	Present, widespread	1,2
		Illinois	Present, no details	1,2
		Louisiana	Present, widespread	1,2
		Maryland	Present, no details	1,2
		Mississippi	Present, widespread	1,2
		New Mexico	Present, restricted distribution	1,2
		North Carolina	Present, restricted distribution	1,2
		Oklahoma	Present, restricted distribution	1,2
		South Carolina	Present, widespread	1,2
		Tennessee	Present, restricted distribution	1,2
		Texas	Present, restricted distribution	1,2
		Virginia	Present, no details	1,2
	Puerto Rico		Present, widespread	1,2
Central America & Caribbean	Anguilla		Present, no details	2
	Antigua and Barbuda		Present, no details	1,2
	Aruba		Present, no details	6
	Bahamas		Present, no details	1,2
	Cayman Islands		Present, no details	2
	Costa Rica		Present, no details	1,2
	Dominican Republic		Present, no details	2
	Jamaica			6
	Monserrat		Present, no details	2
	Nevis			7
	Panama		Present, no details	1,2
	Saint Kitts and Nevis		Present, no details	2
	Sint Maarten		Present, no details	2
	Trinidad and Tobago		Present, no details	1,2
	Turks and Caicos Islands		Present, no details	1,2
	Virgin Islands (British)		Present, no details	1,2
	Virgin Islands (US)		Present, no details	1,2

Region	Country	Sub-national (e.g. State)	Status	Refs
South America	Argentina		Present, restricted distribution	1,2
	Bolivia		Present, no details	2
	Brazil		Present, restricted distribution	1,2
		Goias	Present, no details	2
		Mato Grosso	Present, no details	1,2
		Mato Grosso do Sul	Present, no details	1,2
		Minas Gerais	Present, no details	2
		Rio Grande do Sul	Present, no details	1,2
		Rondonia	Present, no details	1,2
		Sao Paulo	Present, no details	1,2
	Paraguay		Present, restricted distribution	1,2
	Peru		Present, no details	2
	Uruguay		Present, no details	2
Africa	Nigeria		Unproven	3,4,5
Asia	China		Present, restricted distribution	1,2
		Aomen (Macau)	Present, no details	1,2
		Fujian	Present, no details	1,2
		Guangdong	Present, no details	1,2
		Guangxi	Present, no details	1,2
		Hunan	Present, no details	1,2
		Jiangsi	Present, no details	2
		Xianggang (Hong Kong)	Present, no details	1,2
	Japan			
		Aichi	Present, no details	8
		Fukuoka	Present, no details	8
		Hiroshima	Present, no details	8
		Hyogo	Present, no details	8
		Tokyo	Present, no details	8
		Kobe	Present, no details	9
	India			10
	Indonesia			11
	Iraq	Erbil		12
	Malaysia		Present, no details	2
	Singapore		Present, no details	2
	Taiwan		Present, no details	1,2
Oceania	Australia	Queensland	Present, restricted distribution	1,2
	French Polynesia			13

References
1 = EPPO Global Database (EPPO, online)
2 = CABI Invasive species compendium (CABI, 2022)
3 = Njila and Hadi (2015)
4 = Okoro and Cadmus (2016)
5 = Akinmuleya and Oso (2022)
6 = Valles et al. (2015)
7 = Wetterer and Davis (2010)
8 = Fukano and Soga (2019)

9 = Liu et al. (2020)
10 = Wylie et al. (2020)
11 = Mufti et al. (2020)
12 = Mustafa et al. (2014)
13 = Angulo et al. (2022)