Adopted: 23 May 2024

DOI: 10.2903/j.efsa.2024.8830

efsa JOURNAL

SCIENTIFIC OPINION

Pest categorisation of *Popillia quadriguttata*

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Abstract

The EFSA Panel on Plant Health performed a pest categorisation of *Popillia quadriguttata* (Coleoptera: Scarabaeidae), following a commodity risk assessment of bonsai *Pinus parviflora* grafted onto *P. thunbergii* from China, in which *P. quadriguttata* was identified as a pest of possible concern for the territory of the European Union. This is a univoltine polyphagous pest that occurs in eastern Asia from Vietnam northwards through eastern China and Taiwan, South Korea and into Far East Russia. Hosts include species of fruit trees within the genera *Malus* and *Prunus*, trees of forestry and environmental importance such as *Quercus* and *Ulmus*, shrubs such as *Wisteria*, soft fruit such as *Rubus*, grasses, including amenity turf and field crops such as potatoes, maize and soybean. Adults feed on host leaves, tender stems, flower buds, flowers and fruits; larvae feed on host roots. In northern China *P. quadriguttata* is a major pest of soybean; in South Korea, *P. quadriguttata* is one of the most serious insect pests of golf course turf. *P. quadriguttata* could enter the EU on various pathways including infested soil and growing media accompanying host plants for planning. Biotic factors (host availability) and abiotic factors (climate suitability) suggest that large parts of the EU would be suitable for establishment. Local spread would be mainly via natural dispersal of adults. Long distance spread would be facilitated by the movement of eggs, larvae and pupae infesting soil especially with plants for planting; adults could spread on plants for planting without soil. Economic and or environmental impacts would be expected on a range of plants if *P. quadriguttata* were to establish in the EU. Phytosanitary measures are available to reduce the likelihood of its introduction. *P. quadriguttata* satisfies all of the criteria that are within the remit of EFSA to assess for it to be regarded as a potential Union quarantine pest.

KEYWORDS

grubs, pest risk, plant health, plant pest, quarantine, scarab, turf pest

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. 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

Popillia quadriguttata is one of a number of pests relevant to Annex 1C of the Terms of Reference (ToR) to be subject to pest categorisation to determine whether it fulfils the criteria of a potential Union quarantine pest (QP) 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 QP, risk reduction options will be identified.

1.3 | Additional information

This pest categorisation was initiated following the commodity risk assessment of bonsai plants from China consisting of *Pinus* parviflora grafted onto *P. thunbergii* performed by EFSA (EFSA PLH Panel, 2022), in which *P. quadriguttata* was identified as a relevant non-regulated EU pest of possible concern, which could potentially enter the EU on bonsai plants.

2 | DATA AND METHODOLOGIES

2.1 | Data

2.1.1 | Literature search

A literature search on *Popillia quadriguttata* was conducted at the beginning of the categorisation in the ISI Web of Science and SCOPUS bibliographic databases, using the scientific name and synonyms of the pest as search terms (Appendix C). 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), scientific literature databases as referred above in Section 2.1.1.

Data about land cover and host production information 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 *P. quadriguttata* which could be used as a 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 *P. quadriguttata*, 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).

The criteria to be considered when categorising a pest as a potential Union 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 QP 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?

(Continues)

TABLE 1 (Continued)

Criterion of pest categorisation	Criterion in regulation (EU) 2016/2031 regarding union quarantine pest (article 3)
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, *Popillia quadriguttata* is a clearly defined insect species in the order Coleoptera (beetles), family Scarabaeidae (scarab beetles).

Popillia quadriguttata (Fabricius) (Coleoptera: Scarabaeidae) is a well-established species; it was originally described as *Trichius quadriguttata,* by Fabricius (1787). It has a number of synonyms such as *Popillia uchidai* Niijima and Kinoshita (see Appendix C for names used in the literature search). *P. quadriguttata* is very similar in appearance and habits to *P. japonica* Newman, commonly known as the Japanese beetle, with which it has been confused in literature (Chen et al., 2013; Lee et al., 2014), and which is currently present with restricted distribution in Italy (EPPO, online).

P. quadriguttata has the common name four-spotted beetle (Toepfer et al., 2014).

The EPPO code[1] (EPPO, 2019; Griessinger & Roy, 2015) for this species is: POPIQU (EPPO, online).

3.1.2 | Biology of the pest

In 2007, Lee et al. reported that little is known about the life cycle of *P. quadriguttata*. Later, Toepfer et al. (2014) summarised the life cycle but not in great detail. The life cycle of *P. quadriguttata* consists of four stages: egg, larva, pupa and adult. There is one generation per year with adults emerging in the summer (Toepfer et al., 2014). In South Korea, Kim et al. (2009) reported catching adults between mid-June and mid-September although this can vary, e.g. Lee et al. (2002) reported adults in South Korea over a shorter period, from late June to late July. Adults mate and eggs are laid in the soil during the summer. Larvae hatch from eggs in late summer or early autumn and develop through an unknown number of instars. Larvae overwinter and form pupae in the soil during late spring and early summer from which adults of the new generation emerge to complete the cycle (Toepfer et al., 2014).

3.1.3 | Host range/species affected

P. quadriguttata is a polyphagous pest. Adult hosts include species of fruit trees within the genera *Malus* and *Prunus*, and trees of forestry and environmental importance such as *Quercus* and *Ulmus*, shrubs such as *Wisteria*, soft fruit such as *Rubus* and field crops such as potatoes, maize and soybean. The larvae can feed on the roots of adult hosts but are more often reported to feed on the roots of a range of grasses (Chen et al., 2013; Kim et al., 2009; Toepfer et al., 2014).

Appendix A provides a comprehensive list of hosts.

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

3.1.4 | Intraspecific diversity

No intraspecific diversity has been described for this species.

3.1.5 | Detection and identification of the pest

Are detection and identification methods available for the pest?

Yes, floral and pheromone lures and traps can be used to detect the pest and conventional morphological methods can be used to identify it.

Symptoms

Noting that the biology of *P. quadriguttata* is reported to be similar to *P. japonica*, it is assumed that adults feed on host leaves and that when there are large numbers of adults, leaves can be skeletonised although this could not be confirmed in the available literature on *P. quadriguttata*. Chen et al. (2014) reported observing scars on soybean flowers, buds, immature leaves and shoots caused by adult *P. quadriguttata* feeding.

Wilting and reduced growth of hosts caused by damage to roots are potential symptoms. Discoloured grass patches, expanding over time, or the death of turf grass, can indicate the presence of *P. quadriguttata* larvae in the soil (Kim et al., 2009) although these are not diagnostic symptoms.

Detection

Adults can be detected by visual examination of green parts of host plants. Li et al. (1995) and Lee et al. (2007) found that adult *P. quadriguttata* were highly attracted to the lures used to attract *P. japonica*, the Japanese beetle, a closely related species. The lures, e.g. a floral lure (phenethyl propionate: eugenol: geraniol, 3:7:3) or a sex attractant [(*R*, *Z*)-5-(1-decenyl) dihydro-2(3*H*)-furanone] combined with the floral lure (Chen et al., 2013, 2014) are commercially available. Such lures could be used in warehouses and storage facilities where hosts are held.

Yellow bottle traps with chemical lures can also be used to capture adults (Chen et al., 2013).

Larvae can be detected by visual examination of roots in soil. Soil samples, e.g. from turf suspected of being infested, can be taken to detect larvae although detecting them can be difficult when populations are low (Lee et al., 2007).

Identification

Identification is not straightforward. The EPPO phytosanitary standard diagnostic protocol for *P. japonica* provides a key to the European families within the Superfamily Scarabaeoidea and enables the identification of the *Popillia* genus. However, no key to species is available and because the genus consists of more than 300 species, many from Africa and Asia, there is a chance of misidentifying some specimens (EPPO, 2016). Without a key to species of *Popillia*, it may be necessary to morphologically compare a specimen with the type species, or reference samples of *P. quadriguttata* to identify specimens to the species level.

A description of the type specimen of *Popillia uchidai* (now a synonym of *P. quadriguttata*) is provided in Niijima and Kinoshita (1923) (in German).

Egg: no description found.

Larvae: no description found but all scarabaeoids have oligopod scarabaeiform larvae, which are grub shaped and their bodies are curled to form a shape like the letter C.

Adult: oval-shaped, 8.0–11.0 mm long, metallic green with white spots on the side of the abdomen and brownish elytra (Dunlap et al., 2016).

There are two accessions in Genbank for *P. quadriguttata*; a partial sequence for 28S ribosomal RNA (Genbank ref KJ721911.1) and a partial sequence for 16S ribosomal RNA (Genbank ref KJ721848.1). Although these sequences could be used in molecular identification methods such methods have not yet been developed for the more than 300 species within the genus *Popillia*.

3.2 | Pest distribution

3.2.1 | Pest distribution outside the EU

P. quadriguttata occurs in eastern Asia from Vietnam northwards through eastern China and Taiwan, South Korea and into Far East Russia (Figure 1). Reed et al. (1991) reports *P. quadriguttata* to be the dominant species of scarab in Liaoning Province, which borders North Korea in north-east China. As such the species is quite likely to be present in North Korea but no data was found to confirm this.

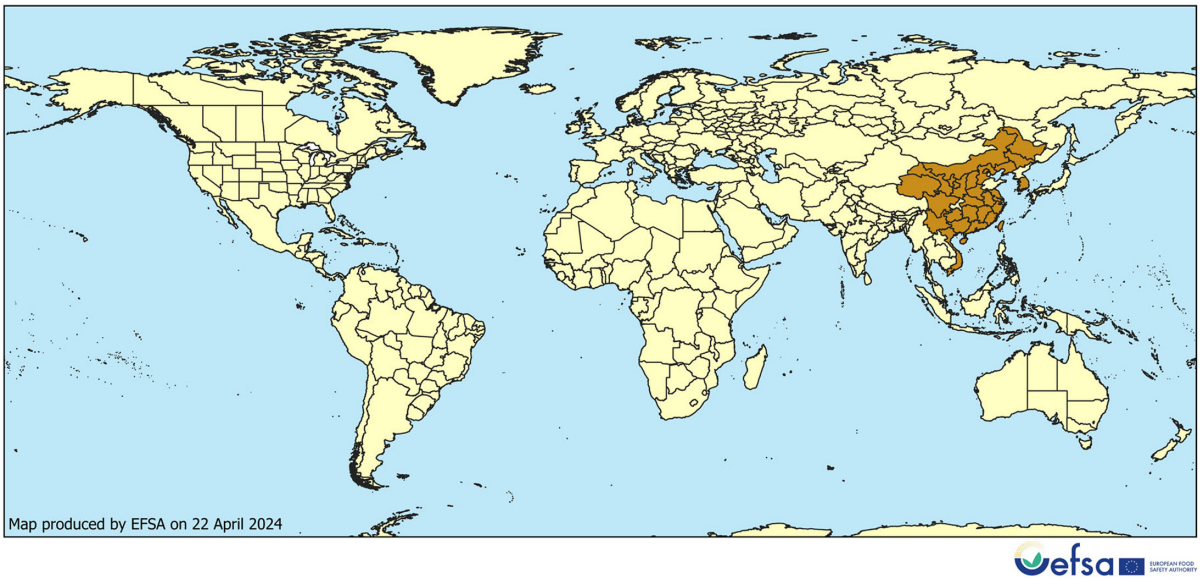

FIGURE 1 Global distribution of *Popillia quadriguttata* (Source: literature; for details see Appendix B).

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. *P. quadriguttata* is not known to be present in the EU.

3.3 | Regulatory status

3.3.1 | Commission Implementing Regulation 2019/2072

P. quadriguttata is not listed in Annex II of Commission Implementing Regulation (EU) 2019/2072, an implementing act of Regulation (EU) 2016/2031, or in any emergency plant health legislation.

3.3.2 | Hosts or species affected that are prohibited from entering the Union from third countries

EU phytosanitary legislation prohibits a number of *P. quadriguttata* hosts from entering the EU territory (Table 2 and the text below Table 2).

TABLE 2 List of plants, plant products and other objects that are *Popillia quadriguttata* 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**
2.	Plants of […] and *Quercus* L., with leaves, other than fruit and seeds	ex 0602 10 90 ex 0602 20 20 ex 0602 20 80 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 99 ex 0604 20 90 ex 1404 90 00	Third countries other than: Albania, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Canary Islands, Faeroe Islands, Georgia, Iceland, Liechtenstein, Moldova, Monaco, Montenegro, North Macedonia, Norway, Russia (only the following parts: Central Federal District (Tsentralny federalny okrug), Northwestern Federal District (Severo-Zapadny federalny okrug), Southern Federal District (Yuzhny federalny okrug), North Caucasian Federal District (Severo-Kavkazsky federalny okrug) and Volga Federal District (Privolzhsky federalny okrug)), San Marino, Serbia, Switzerland, Türkiye, Ukraine and the United Kingdom

TABLE 2 (Continued)

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**
8.	Plants for planting of *Chaenomeles* Ldl., […]., *Malus* Mill., *Prunus* L., *Pyrus* L. and […] other than dormant plants free from leaves, flowers and fruits	ex 0602 10 90 ex 0602 20 20 ex 0602 20 80 ex 0602 40 00 ex 0602 90 41 ex 0602 90 45 ex 0602 90 46 ex 0602 90 47 ex 0602 90 48 ex 0602 90 50 ex 0602 90 70 ex 0602 90 91 ex 0602 90 99	Third countries other than: Albania, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Canary Islands, Faeroe Islands, Georgia, Iceland, Liechtenstein, Moldova, Monaco, Montenegro, North Macedonia, Norway, Russia (only the following parts: Central Federal District (Tsentralny federalny okrug), Northwestern Federal District (Severo-Zapadny federalny okrug), Southern Federal District (Yuzhny federalny okrug), North Caucasian Federal District (Severo-Kavkazsky federalny okrug) and Volga Federal District (Privolzhsky federalny okrug)), San Marino, Serbia, Switzerland, Türkiye, Ukraine and the United Kingdom
9.	Plants for planting of […], *Malus* Mill., *Prunus* L. and *Pyrus* L. and their hybrids, and […], 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: Albania, Algeria, Andorra, Armenia, Australia, Azerbaijan, Belarus, Bosnia and Herzegovina, Canada, Canary Islands, Egypt, Faeroe Islands, Georgia, Iceland, Israel, Jordan, Lebanon, Libya, Liechtenstein, Moldova, Monaco, Montenegro, Morocco, New Zealand, North Macedonia, Norway, Russia (only the following parts: Central Federal District (Tsentralny federalny okrug), Northwestern Federal District (Severo-Zapadny federalny okrug), Southern Federal District (Yuzhny federalny okrug), North Caucasian Federal District (Severo-Kavkazsky federalny okrug) and Volga Federal District (Privolzhsky federalny okrug)), San Marino, Serbia, Switzerland, Syria, Tunisia, Türkiye, Ukraine, the United Kingdom and United States other than Hawaii
14.	Plants for planting of the family *Poaceae*, other than plants of ornamental perennial grasses of the subfamilies *Bambusoideae* and *Panicoideae* and of the genera *Buchloe*, *Bouteloua* Lag., *Calamagrostis*, *Cortaderia* Stapf., *Glyceria* R. Br., *Hakonechloa* Mak. ex Honda, *Hystrix*, *Molinia*, *Phalaris* L., *Shibataea*, *Spartina* Schreb., *Stipa* L. and *Uniola* L., other than seeds	ex 0602 90 50 ex 0602 90 91 ex 0602 90 99	Third countries other than: Albania, Algeria, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Canary Islands, Egypt, Faeroe Islands, Georgia, Iceland, Israel, Jordan, Lebanon, Libya, Liechtenstein, Moldova, Monaco, Montenegro, Morocco, North Macedonia, Norway, Russia (only the following parts: Central Federal District (Tsentralny federalny okrug), Northwestern Federal District (Severo-Zapadny federalny okrug), Southern Federal District (Yuzhny federalny okrug), North Caucasian Federal District (Severo-Kavkazsky federalny okrug) and Volga Federal District (Privolzhsky federalny okrug)), San Marino, Serbia, Switzerland, Syria, Tunisia, Türkiye, Ukraine and the United Kingdom
15.	Tubers of *Solanum tuberosum* L., seed potatoes	0701 10 00	Third countries other than Switzerland
16.	Plants for planting of stolon- or tuber-forming species of *Solanum* L. or their hybrids, other than those tubers of *Solanum tuberosum* L. as specified in entry 15	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: (a) Algeria, Egypt, Israel, Libya, Morocco, Syria, Switzerland, Tunisia and Türkiye, or (b) […]
18.	Plants for planting of *Solanaceae* other than seeds and the plants covered by entries 15, 16 or 17	ex 0602 10 90 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: Albania, Algeria, Andorra, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Canary Islands, Egypt, Faeroe Islands, Georgia, Iceland, Israel, Jordan, Lebanon, Libya, Liechtenstein, Moldova, Monaco, Montenegro, Morocco, North Macedonia, Norway, Russia (only the following parts: Central Federal District (Tsentralny federalny okrug), Northwestern Federal District (Severo-Zapadny federalny okrug), Southern Federal District (Yuzhny federalny okrug), North Caucasian Federal District (Severo-Kavkazsky federalny okrug) and Volga Federal District (Privolzhsky federalny okrug)), San Marino, Serbia, Switzerland, Syria, Tunisia, Türkiye, Ukraine and the United Kingdom

(Continues)

TABLE 2 (Continued)

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**
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

The following *P. quadriguttata* host genera are listed in Commission implementing regulation (EU) 2018/2019 as high-risk plants for planting, whose introduction into the Union is prohibited pending risk assessment other than as seeds, in vitro material, or naturally or artificially dwarfed woody plants:

- *Corylus*
- *Diospyros*
- *Ligustrum*
- *Malus*
- *Prunus*
- *Quercus*
- *Sorbus*
- *Tilia*
- *Ulmus*

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***.**

Comment on plants for planting as a pathway.

Yes, *P. quadriguttata* could enter the EU; pathways include infested soil and growing media accompanying host plants for planting (i.e. eggs, larvae and pupae); leaves and flowers on plants for planting, cut flowers and cut branches (i.e. adults) and hitchhiking adults, independent of host plants.

Potential pathways are summarised in Table 3.

TABLE 3 Potential pathways for *Popillia quadriguttata* into the EU.

Pathways (e.g. host/intended use/ source)	**Life stage**	**Relevant mitigations [e.g. prohibitions (Annex VI) within Implementing Regulation 2019/2072]**
Soil and growing media accompanying host plants for planting	Eggs, larvae and/or pupae	Existing legislation closes the soil pathway
Soil from tools and machinery	Eggs, larvae and/or pupae	Existing legislation closes the soil pathway
Plants for planting with foliage (excluding seeds)	Adults	Some hosts prohibited by Annex VI, others prohibited as High Risk Plants pending risk assessment
Cut flowers	Adults	
Hitchhiking independent of host plants	Adults	

Notifications of interceptions of harmful organisms began to be compiled in Europhyt in May 1994 and in TRACES in May 2020. As at 19 March 2024, there were 0 records of interception of *Popillia quadriguttata* in the Europhyt and TRACES databases.

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 large parts of the EU would be suitable for establishment.

Climatic mapping is the principal method for identifying areas that could provide suitable conditions for the establishment of a pest taking key abiotic factors into account (Baker, 2002). 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*

P. quadriguttata is a pest of a range of trees, shrubs, vegetable and field crops that are grown widely across the EU. It is also a pest of grasses. More than one third of the European agricultural area is grassland (Smit et al., 2008). Figure 2 shows agricultural grassland as a percentage of land cover across the EU at NUTS 2 resolution.

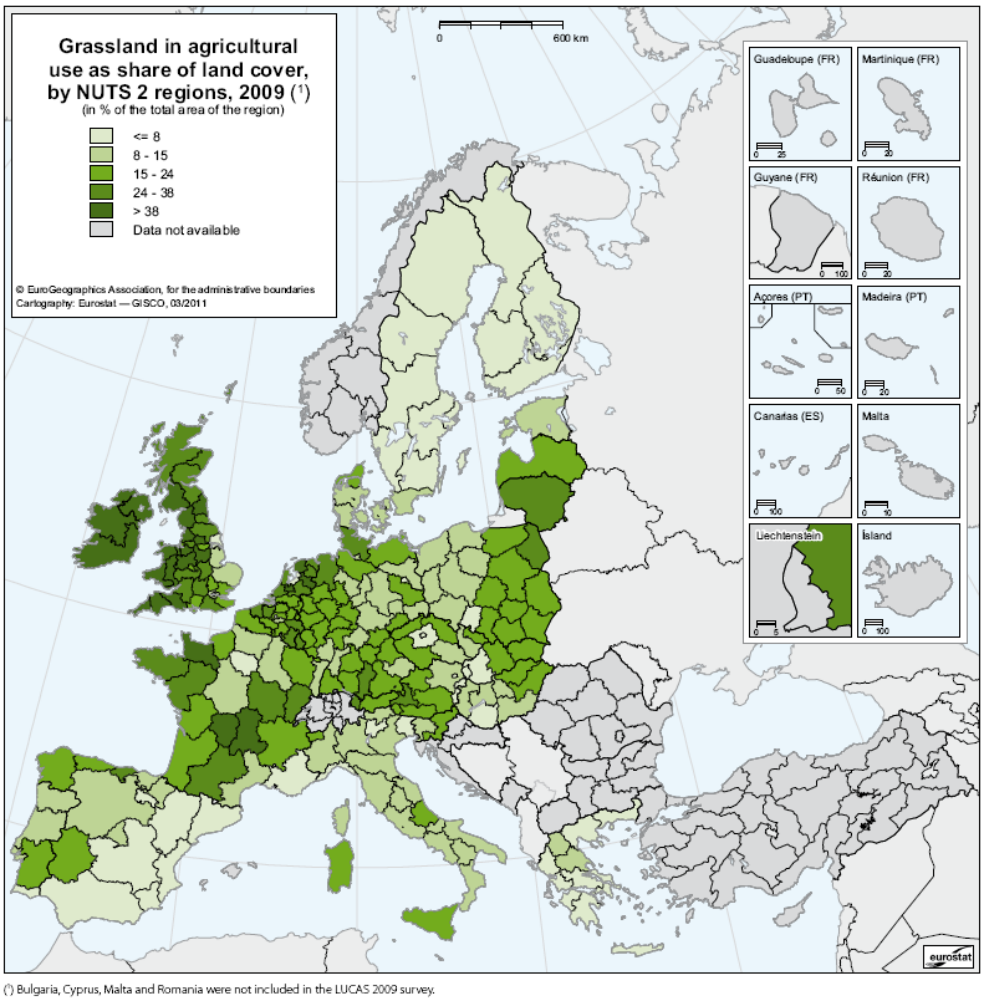

FIGURE 2 Grassland in agricultural use as share of land cover, by NUTS 2 regions (2009). *Source*: https://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:Land_cover_and_land_use_statistics_at_regional_level#Grasslands_maintain_Europe.E2.80.99s_livestock_farming

Golf courses can be found across the EU including climates suitable for *P. quadriguttata* establishment.
Table 4 shows the annual EU production area of selected crops on which *P. quadiguttata* can develop (2016–2023).

TABLE 4 EU area of examples of annual crops on which *Popillia quadiguttata* can develop (1000 ha). (Source: Eurostat apro_cpsh1).

Crop	2016	2017	2018	2019	2020	2021	2022	2023
Green maize	5847.2	5996.9	6100.0	6061.5	5985.9	6134.9	6210.4	6263.1
Potatoes	1602.4	1522.3	1525.9	1550.5	1601.2	1562.9	1603.7	1464.7
Soy	465.5	568.9	881.4	831.2	962.4	955.4	907.9	942.9

3.4.2.2 | *Climatic conditions affecting establishment*

P. quadriguttata is distributed across a wide range of Köppen–Geiger climate types (Kottek et al., 2006) in eastern Asia, including climate types which occur over wide areas of the EU (Figure 3). For example, climate type Cfb (temperate oceanic) which is found widely in central and northern EU countries and is represented in approximately 46% of EU 27 five arcmin grid cells (MacLeod & Korycinska, 2019).

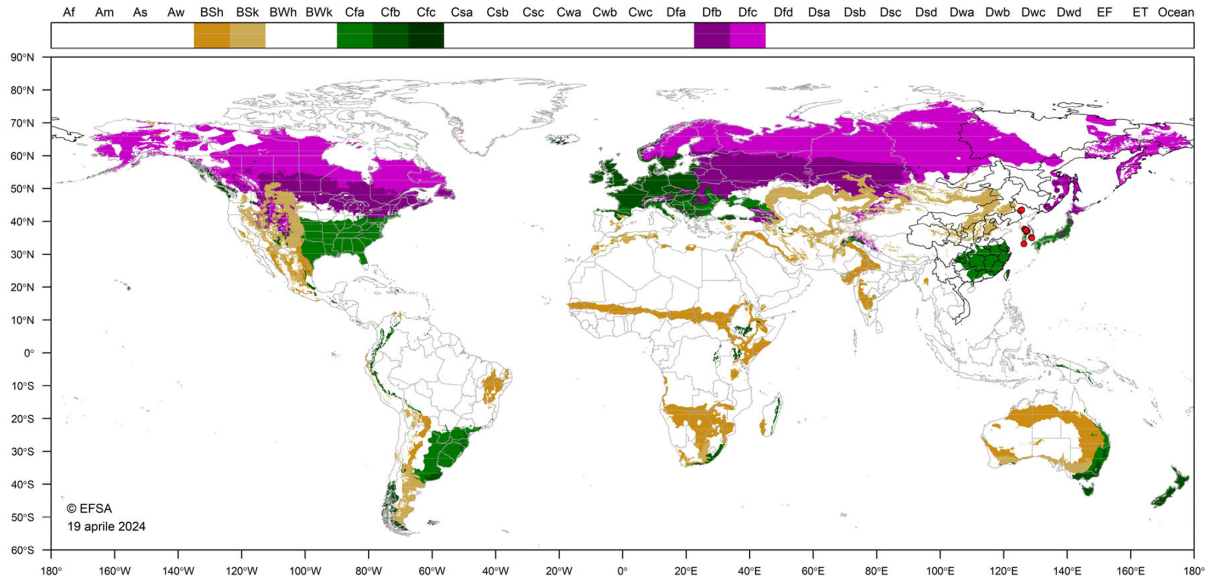

FIGURE 3 World distribution of Köppen–Geiger climate types that occur in the EU and which occur in countries where *Popillia quadriguttata* has been reported.

3.4.3 | Spread

Describe how the pest would be able to spread within the EU territory following establishment?

P. quadriguttata could spread following establishment. Local spread would be mainly via natural dispersal of adults. Long distance spread would be facilitated by the movement of eggs, larvae and pupae in soil, with or without plants for planting.

Comment on plants for planting as a mechanism of spread.

The trade in host plants for planting could facilitate the spread of *P. quadriguttata* within the EU if the plants were transported growing in soil contaminated with *P. quadriguttata* eggs, larvae or pupae. Adults could also be carried on larger plants for planting.

P. quadriguttata could spread naturally within the EU. Adults can fly and Lee et al. (2007) reported most flight activity occurred between mid-day and 4:00 pm. The authors also cited Chinese literature reporting that adults were not active at night and were not attracted to light (references in Lee et al., 2007). Larvae in the soil would not spread naturally very far but could be distributed widely within the EU, e.g. via plants for planting.

It is worth noting that the closely related *P. japonica* has been established in the Azores (Portugal) since the early 1970s. It has also been introduced into Italy, being first found in the north of Italy in July 2014. In June 2017 it was found in southern Switzerland in a canton close to the Italian national park where P. japonica occurs (EPPO, online).

3.5 | Impacts

Would the pests' introduction have an economic or environmental impact on the EU territory?

Yes. As a polyphagous pest feeding on agricultural, horticultural and ornamental crops, as well as fruit trees, grown in the EU, *P. quadriguttata* is expected to have an economic impact were it to establish in the EU. Larvae can feed on the roots of nursery stock, girdling the roots, severely stunting or killing host plants and can cause serious damage to grass turf.

P. quadriguttata is polyphagous (Section 3.1.3, Appendix A) and is amongst the most important scarab pests of cultivated crops, including maize, soybean, vegetables (including potatoes (Toepfer et al., 2014)) and fruit in East-Asia (Chen et al., 2013, 2014 and references therein), and is notably a pest of horticultural crops throughout Korea and China (Lee et al., 2002; Sang, 1979). Both adults and larvae cause damage through feeding activity. Adults feed on host leaves, tender stems, flower buds, flowers and fruit; larvae feed on host roots. Larval damage to roots leads to yield losses and can cause host mortality, especially in young plants, seedlings and nursery stock (Toepfer et al., 2014).

In China *P. quadriguttata* can cause substantial damage to fruit trees, ornamental, horticultural and agricultural crops. For example, Chen et al. (2014) cites Chinese literature that reports *P. quadriguttata* causing annual yield losses of 1% in Chinese soybean, equating to losses of between ~ 150,000 and 180,000 tonnes per year.

In South Korea, *P. quadriguttata* is the dominant, and one of the most serious, insect pests of golf course turf (Chen et al., 2013; Kim et al., 2009). Larvae feed heavily on grass roots (Lee et al., 2007; Reed et al., 1991) creating large patches of dead and dying grass on courses; such damage is compounded by birds such as magpies that dig-up turf, causing secondary serious damage to courses, when searching for larvae to eat (Lee et al., 2007).

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. Existing measures prohibit the entry of soil and some host plants into the EU as plants for planting (see Section 3.3). Additional measures are also available (see below).

3.6.1 | Identification of potential additional measures

Phytosanitary measures (prohibitions) are currently applied to some *P. quadriguttata* hosts but not in relation specifically to *P. quadriguttata*. Several key hosts are prohibited from entering the EU as plants for planting (see Section 3.3.2). As a pest that spends the majority of its life in the soil, the prohibition of soil from third countries not belonging to continental Europe assists in inhibiting the entry of *P. quadriguttata* into the EU both in soil (alone) and with host plants for planting that had been grown in soil (the soil would need to be removed and plants imported either bare rooted or in new media).

Additional potential risk reduction options and supporting measures are shown in Sections 3.6.1.1 and 3.6.1.2.

3.6.1.1 | *Additional potential risk reduction options*

Potential additional control measures are listed in Table 5.

TABLE 5 Selected control measures (a full list is available in EFSA PLH Panel, 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	• Plant or plant product comes from country officially free from pest, • Pest free area, • Pest free place of production (e.g. place of production and its immediate vicinity is free from pest over an appropriate time period, e.g. since the beginning of the last complete cycle of vegetation, or past 2 or 3 cycles). • Pest free production site	Entry/Spread
Growing plants in isolation	As a pest that is so polyphagous, it will be difficult to grow plants outdoors that are isolated from other potential hosts. However, if plants can be grown in physical protection, e.g. within a secure/insect proof glasshouse then some protection can be provided	Entry/Spread
Managed growing conditions	Mass trapping (30 traps per hectare) can reduce adult abundance by 72% and in combination with a chemical lure can reduce adult abundance by 90% (Chen et al., 2014)	Entry/Spread
Use of resistant and tolerant plant species/varieties	Field trials and laboratory assays have revealed significant variation in susceptibility of *Betula* spp., *Glycine max*, *Tilia* spp. and *Ulmus* spp. to the related species *P. japonica* (Potter & Held, 2002). It is possible that plants resistant or tolerant to *P. japonica* could also be resistant or tolerant to *P. quadriguttata*	Entry/Establishment/Impact
Roguing and pruning	Roguing is defined as the removal of infested plants and/or uninfested host plants in a delimited area, whereas pruning is defined as the removal of infested plant parts only without affecting the viability of the plant	Entry/Spread/Impact
Biological control and behavioural manipulation	In laboratory trials the entomopathogenic nematode *Heterorhabditis bacteriophora* provided 95% mortality against *P. quadriguttata* larvae; when applied at a rate of 2.24×10^9 infective juvenile nematodes ha^{-1} on a golf course infested by *P. quadriguttata* and two other species of scarab, scarab larval numbers were reduced by 39% compared to samples from control areas (Choi et al., 2006) Mass trapping using a chemical lure could be useful in monitoring and eradication of *P. quadriguttata* in Europe (Chen et al., 2013; Chen et al., 2014)	Impact
Chemical treatments on crops including reproductive material	In the US, insecticides have been applied to the foliage and flowers of susceptible plants to target and manage adults of the closely related pest *P. japonica* (Potter & Held, 2002). It is possible that the same insecticides could be effective against *P. quadriguttata*. However, Chen et al. (2013) reports *P. quadriguttata* is resistant to unspecified insecticides	Entry/Establishment/Impact
Chemical treatments on consignments or during processing	Use of chemical compounds that may be applied to plants or to plant products after harvest, during process or packaging operations and storage The treatments addressed under this measure are: a. fumigation; b. spraying/dipping pesticides; c. surface disinfectants; d. process additives; e. protective compounds	Entry/Spread
Physical treatments on consignments or during processing	This measure deals with the following categories of physical treatments: irradiation/ionisation; mechanical cleaning (brushing, washing); sorting and grading, and; removal of plant parts (e.g. debarking wood). It does not address: heat and cold treatment, or roguing and pruning Brushing and washing could help remove eggs, larvae and pupae from root vegetables but no literature to support this view was found	Entry/Spread
Cleaning and disinfection of facilities, tools and machinery	This category covers physical and chemical cleaning and disinfection of facilities, tools, machinery, transport means, facilities and other accessories (e.g. boxes, pots, pallets, palox, supports, hand tools). The measures addressed are washing, sweeping and fumigation Infested soil could carry eggs, larvae and pupae so should be cleaned from tools and machinery. Adults are known to hitchhike and so could be transported, e.g. in packing boxes. Cleaning the packaging (boxes) may help	Entry/Spread
Limits on soil	• Plants, plant products 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; • Consignment or lot does not contain more than 1% by net weight of soil and growing medium	Entry/Spread

TABLE 5 (Continued)

Control measure/risk reduction option (Blue underline = Zenodo doc, Blue = WIP)	RRO summary	Risk element targeted (entry/establishment/spread/impact)
Soil treatment	Eggs, larvae and pupae develop in the soil and efforts targeting the soil could be considered. In the USA, large amounts of pesticides are applied to grassland to manage the related pest *P. japonica* (USDA/APHIS, 2015)	Entry/Establishment/Impact
Waste management	Consignments intercepted with *P. quadriguttata* should be disposed of appropriately	Establishment/Spread
Heat and cold treatments	Controlled temperature treatments aim to kill or inactivate pests without causing any unacceptable prejudice to the treated material itself. The measures addressed here are: autoclaving; steam; hot water; hot air; cold treatment Heat and cold treatments can often be effective against insects but no data regarding the thermal tolerance of this species was found in the literature hence designing and specifying a treatment regime would not seem appropriate	Entry/Spread
Conditions of transport	Specific requirements for mode and timing of transport of commodities to prevent escape of the pest and/or contamination. a. physical protection of consignment b. timing of transport/trade	Entry/Spread
Controlled atmosphere	Treatment of plants by storage in a modified atmosphere (including modified humidity, O_2, CO_2, temperature, pressure)	Entry/Spread (via commodity)
Post-entry quarantine and other restrictions of movement in the importing country	This measure covers post-entry quarantine (PEQ) of relevant commodities; temporal, spatial and end-use restrictions in the importing country for import of relevant commodities; Prohibition of import of relevant commodities into the domestic country 'Relevant commodities' are plants, plant parts and other materials that may carry pests, either as infection, infestation, or contamination	Establishment/Spread

3.6.1.2 | *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, 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	ISPM 5 (FAO, 2023) defines inspection 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 The effectiveness of sampling and subsequent inspection to detect pests may be enhanced by including trapping and luring techniques	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 (FAO, 2008), 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	According to ISPM 5 (FAO, 2023), a phytosanitary certificate and a plant passport are official paper documents or their official electronic equivalents, consistent with the model certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements: a) export certificate (import) b) plant passport (EU internal trade)	Entry/Spread

(Continues)

TABLE 6 (Continued)

Supporting measure (Blue underline = Zenodo doc, Blue = WIP)	Summary	Risk element targeted (entry/establishment/spread/impact)
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	Entry/Spread
Certification of reproductive material (voluntary/official)	Plants come from within an approved propagation scheme and are certified pest free (level of infestation) following testing; Used to mitigate against pests that are included in a certification scheme	Entry/Spread
Delimitation of Buffer zones	ISPM 5 (FAO, 2023) defines a buffer zone as 'an area surrounding or adjacent to an area officially delimited for phytosanitary purposes in order to minimize 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'. 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
Surveillance	Surveillance to guarantee that plants and produce originate from a Pest Free Area could be an option	Spread

3.6.1.3 | *Biological or technical factors limiting the effectiveness of measures*

- If a *Popillia* species is intercepted from Asia, the difficulty in identifying *P. quadriguttata* means that any action may be delayed if a precise diagnosis is required.
- Chen et al. (2013) reports *P. quadriguttata* is resistant to chemicals but does not state which ones.
- Eggs, larvae and pupae develop underground/in soil and are difficult to detect.
- Adults can disperse by flight.
- The pest feeds on many plants.
- Hosts are widely available throughout the EU.

3.7 | Uncertainty

No key uncertainties have been identified.

4 | CONCLUSIONS

P. quadriguttata satisfies all of the criteria that are within the remit of EFSA to assess for it to be regarded as a potential Union QP (Table 7).

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)	*Popillia quadriguttata* is a clearly defined insect species in the order Coleoptera, family Scarabaeidae	None
Absence/presence of the pest in the EU (Section 3.2)	*P. quadriguttata* is not known to be present in the EU	None
Pest potential for entry, establishment and spread in the EU (Section 3.4)	*P. quadriguttata* could enter the EU on various pathways including infested soil and growing media accompanying host plants for planning, cut flowers and cut branches and potentially hitchhiking, independent of host plants. Biotic factors (host availability) and abiotic factors (climate suitability) suggest that large parts of the EU would be suitable for establishment. Local spread would be mainly via natural dispersal of adults. Long distance spread would be facilitated by the movement of eggs, larvae and pupae in soil, with or without plants for planting	None

TABLE 7 (Continued)

Criterion of pest categorisation	Panel's conclusions against criterion in regulation (EU) 2016/2031 regarding union quarantine pest	Key uncertainties
Potential for consequences in the EU (Section 3.5)	As a polyphagous pest feeding on agricultural, horticultural and ornamental crops, as well as fruit trees, grown in the EU, *P. quadriguttata* is expected to have an economic impact were it to establish in the EU. Larvae can feed on the roots of nursery stock, girdling the roots, severely stunting or killing host plants and can cause severe damage to grass turf	None
Available measures (Section 3.6)	Existing phytosanitary measures prohibit the entry of soil and some host plants into the EU. Additional measures are also available	None
Conclusion (Section 4)	*P. quadriguttata* satisfies all of the criteria that are within the remit of EFSA to assess for it to be regarded as a potential Union quarantine pest	None
Aspects of assessment to focus on/ scenarios to address in future if appropriate:		

GLOSSARY

Containment (of a pest)	Application of phytosanitary measures in and around an infested area to prevent spread of a pest (FAO, 2023).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO, 2023).
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, 2023).
Eradication (of a pest)	Application of phytosanitary measures to eliminate a pest from an area (FAO, 2023).
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO, 2023).
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 & 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, 2023).
Pathway	Any means that allows the entry or spread of a pest (FAO, 2023).
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, 2023).
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, 2023).
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, 2023).

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
PZ	Protected Zone
TFEU	Treaty on the Functioning of the European Union
ToR	Terms of Reference

ACKNOWLEDGMENTS

EFSA wishes to acknowledge the contribution of Malayka Picchi to this opinion for performing the climate suitability exercise.

CONFLICT 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.

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EFSA-Q-2024-00042

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How to cite this article: EFSA PLH Panel (EFSA Panel on Plant Health), Bragard, C., Baptista, P., Chatzivassiliou, E., Di Serio, F., Gonthier, P., Jaques Miret, J. A., Justesen, A. F., Magnusson, C. S., Milonas, P., Navas-Cortes, J. A., Parnell, S., Potting, R., Reignault, P. L., Stefani, E., Thulke, H.-H., Van der Werf, W., Vicent Civera, A., Yuen, J., … MacLeod, A. (2024). Pest categorisation of *Popillia quadriguttata*. *EFSA Journal*, *22*(6), e8830. https://doi.org/10.2903/j.efsa.2024.8830

APPENDIX A

Popillia quadriguttata host plants/species affected

In the conventional scientific literature, no conifers were found to be reported as hosts of *P. quadriguttata*. However, the Chinese dossier evaluated by EFSA (EFSA PLH Panel, 2022) states that *P. quadriguttata* is a pest of *P. parviflora*. Therefore, the EFSA PLH Panel cannot exclude *P. parviflora* as a host.

A.1 | CULTIVATED HOSTS

Host name	Plant family	Common name	Reference
Acalypha australis	Euphorbiaceae	Three-seeded copperleaf	Lee et al. (2002)
Amorpha fruticosa	Fabaceae	Bastard indigo	Lee et al. (2002)
Artemisia princeps var. *orientalis*	Asteraceae	Japanese mugwort	Lee et al. (2002)
Chloris virgata	Poaceae	Feather-top chloris	Lee et al. (2002)
Corylus heterophylla var. thunbergia	Corylaceae	Japanese hazel	Lee et al. (2002)
Dioscorea septemloba	Dioscoreaceae	–	Lee et al. (2002)
Glycine max	Fabaceae	Soybean	Lee et al. (2002)
Helicteres angustifolia	Malvaceae	Kang-chih-ma	Lee et al. (2002)
Lespedeza cyrtobotrys	Fabaceae	Bush lespedeza	Lee et al. (2002)
Ligustrum obtusifolium	Oleaceae	Border privet	Lee et al. (2002)
Lindera erythrocarpa	Lauraceae	–	Lee et al. (2002)
Lysimachia burystachis	Primulaceae	–	Lee et al. (2002)
Malus pumila var. dulcissima	Rosaceae	–	Lee et al. (2002)
Persicaria senticosa	Polygonaceae	–	Lee et al. (2002)
Prunus sangentii	Rosaceae	Sargent's cherry	Lee et al. (2002)
Pteridium aquilinum	Dennstaedtiaceae	Bracken fern	Lee et al. (2002)
Pyrus spp.	Rosaceae	–	Lee et al. (2002)
Quercus serrata	Fagaceae	Gland-bearing oak	Lee et al. (2002)
Rhapontica uniflora	Asteraceae	–	Lee et al. (2002)
Rubus parvifolius	Rosaceae	Japanese raspberry	Lee et al. (2002)
Salix koreansis	Salicaceae	–	Lee et al. (2002)
Solanum lyratum	Solanaceae	–	Lee et al. (2002)
Ulmus pumila	Ulmaceae	Dwarf Asiatic elm	Lee et al. (2002)
Wistaria floribunda	Fabaceae	Japanese wisteria	Lee et al. (2002)
Zanthoxylum spp.	Rutaceae	–	Lee et al. (2002)
Zea mays	Poaceae	Maize	Lee et al. (2002)

A.2 | ARTIFICIAL/EXPERIMENTAL HOSTS

Binomial name	Plant family	Common name	Reference
Amelanchier asiatica	Rosaceae	Asian serviceberry	Lee et al. (2002)
Chaenomeles lagenaria	Rosaceae	Common flowering quince	Lee et al. (2002)
Chionanthus retusa	Oleaceae	Chinese fringe tree	Lee et al. (2002)
Cleyera japonica	Pentaphylacaceae	Japanese cleyera	Lee et al. (2002)
Diospyros kaki	Ebenaceae	Kaki, persimmon	Lee et al. (2002)
Diospyros lotus	Ebenaceae	Caucasian persimmon	Lee et al. (2002)
Euonymus alata	Celastraceae	Burning bush	Lee et al. (2002)
Hibiscus syriacus	Malvaceae	Syrian hibiscus	Lee et al. (2002)
Ilex crenata	Aquifoliaceae	Box-leaved holly	Lee et al. (2002)
Ilex rotunda	Aquifoliaceae	Kurogane holly, round-leaf holly	Lee et al. (2002)
Liriodendron tulipifera	Magnoliaceae	American whitewood, white poplar	Lee et al. (2002)
Platanus orientalis	Platanaceae	Chenar tree, oriental plane	Lee et al. (2002)
Prunus davidiana	Rosaceae	David's peach	Lee et al. (2002)

(Continued)

Binomial name	Plant family	Common name	Reference
Prunus mume	Rosaceae	Japanese apricot	Lee et al. (2002)
Prunus salicina	Rosaceae	Chinese plum, Japanese plum	Lee et al. (2002)
Punica granatum	Lythraceae	Pomegranate	Lee et al. (2002)
Pyracantha angustifolia	Rosaceae	Narrow-leaf firethorn	Lee et al. (2002)
Pyrus ussuriensis var. *mecrostipes*	Rosaceae	Siberian pear	Lee et al. (2002)
Sophora japonica	Fabaceae	Japanese pagoda tree	Lee et al. (2002)
Sorbus lommixta	Rosaceae	–	Lee et al. (2002)
Quercus aliena	Fagaceae	Japanese white oak	Lee et al. (2002)
Styrax japonicus	Styracaceae	Japanese snowbell	Lee et al. (2002)
Symplocos chinensis for. *pilosa*	Symplocaceae	Asiatic sweet-leaf	Lee et al. (2002)
Thea sinensis	Theaceae	Tea plant	Lee et al. (2002)
Tilia mandshurica	Malvaceae	Manchurian linden	Lee et al. (2002)
Ulmus parvifolia	Ulmaceae	Chinese elm	Lee et al. (2002)
Viburnum awabuki	Adoxaceae	Awabuki viburnum	Lee et al. (2002)
Viburnum sargentii	Adoxaceae	Chinese redbud	Lee et al. (2002)
Vitis coignetiae	Vitaceae	Crimson glory vine	Lee et al. (2002)
Zizyphus jujuba var. *inermis*	Rhamnaceae	Chinese date	Lee et al. (2002)

A.3 | PLANTS PROVIDED TO *POPILLIA QUADRIGUTTATA* BUT NO FEEDING WAS RECORDED (LEE ET AL., 2002) SUGGESTING THAT THE PLANTS ARE NOT HOSTS

Family	Binomial name	Common name	Ref
Adoxaceae	*Viburnum dilatatum*	Linden viburnum	1
Aquifoliaceae	*Ilex integra*	Mochi	1
Araliaceae	*Acanthopanax sessiliflorus*	–	1
Caprifoliaceae	*Weigela subsessilis*	–	1
Fabaceae	*Albizia julibrissin*	Persian acacia	1
	Caragana sinica	–	1
	Cercis chinensis	Chinese redbud	1
Fagaceae	*Castanopsis cuspidate* var. *siebolidii*	Japanese chinquapin	1
	Quercus acuta	Japanese evergreen oak	1
	Quercus myrsinifolia	Bamboo-leaved oak	1
Garryaceae	*Aucuba japonica* for. *variegata*	Japanese laurel	1
Hamamelidaceae	*Distylium racemosum*	Isu tree	1
Lamiaceae	*Vitex negundo var. incisa*	Common flowering quince	1
Lauraceae	*Cinnamomum camphora*	Camphor	1
	Lindera glauca	Grey-blue spicebush	1
	Machilus thunbergia	Makko	1
	Neolitsea sericea	–	1
Magnoliaceae	*Magnolia kobus*	Northern Japanese magnolia	1
	Magnolia liliiflora	Lily magnolia	1
	Magnolia sieboldii	Oyama magnolia	1
Moraceae	*Ficus carica*	Common fig	1
Oleaceae	*Abeliophyllum distichum*	Korean abeleaf	1
	Forsythia koreana	–	1
	Forsythia ovata	Early forsythia	1
	Fraxinus mandshurica	Japanese ash, Manchurian ash	1
	Osmanthus asiaticus var. aurantiacus	–	1
	Osmanthus fragrans	Fragrant olive, sweet olive	1
	Osmanthus heterophyllus	Chinese holly	1
Rhamnaceae	*Rhamnella franguloides*	–	1

(Continues)

(Continued)

Family	Binomial name	Common name	Ref
Rosaceae	*Malus sieholdii*	–	1
	Photinia glabra	–	1
	Prunus persica	Peach	1
	Prunus tomentosa	Nanking cherry	1
Sabiaceae	*Meliosma myriantha*	–	1
Sapindaceae	*Acer buergerianum*	Trident maple	2
	Acer triflorum	Rough-barked maple	1
	Sapindus mukorossi	Chinese soapberry	1
Staphyleaceae	*Euscaphis japonica*	Korean sweetheart tree	1
Theaceae	*Camellia japonica*	Japanese camellia	1
Thymelaeaceae	*Edzeworthia papyrifera*	–	1

Key to references: 1 = Lee et al. (2002); 2 = Lee et al. (2002) citing Chung (1983).

APPENDIX B

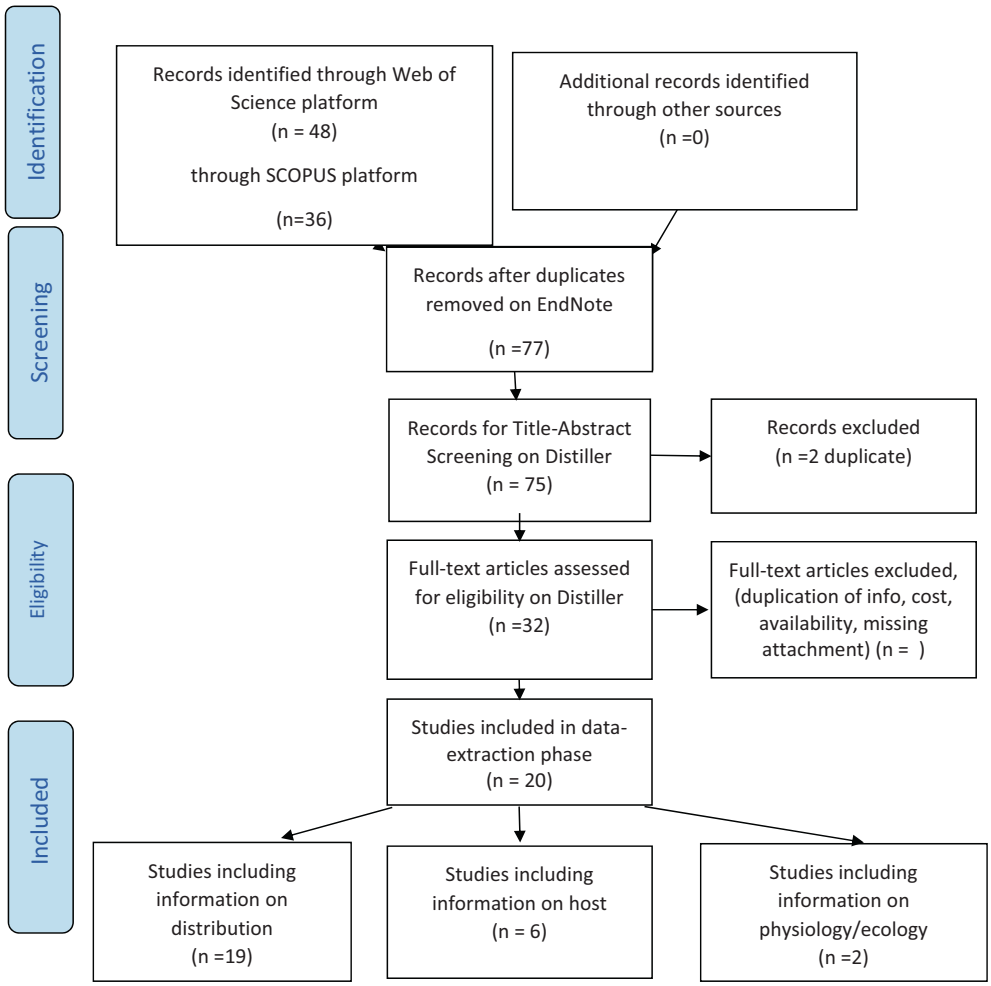
Distribution of *Popillia quadriguttata*

Distribution records based on literature as indicated in the table.

Region	Country	Sub-national (e.g. state)	References
Asia	China	Anhui	Catalogue of Life (online)
		Beijing	Catalogue of Life (online)
		Fujian	Catalogue of Life (online)
		Gansu	Catalogue of Life (online)
		Guangdong	Catalogue of Life (online)
		Guangxi	Catalogue of Life (online)
		Guizhou	Chen et al. (2014)
		Hebei	Catalogue of Life (online)
		Heilongjiang	Catalogue of Life (online)
		Henan	Chen et al. (2014)
		Hubei	Catalogue of Life (online)
		Hunan	Catalogue of Life (online)
		Jiangsu	Catalogue of Life (online)
		Jiangxi	Catalogue of Life (online)
		Jilin	Chen et al. (2014)
		Liaoning	Chen et al. (2014)
		Nei Mongol	Catalogue of Life (online)
		Ningxia	Catalogue of Life (online)
		Qinghai	Catalogue of Life (online)
		Shaanxi	Catalogue of Life (online)
		Shanghai	Catalogue of Life (online)
		Shanxi	Chen et al. (2014)
		Sichuan	Catalogue of Life (online)
		Yunan	Chen et al. (2014)
		Zhejiang	Catalogue of Life (online)
	Republic of Korea		Chen et al. (2014)
	Russia	Russia Far East	Catalogue of Life (online)
	Taiwan		Chen et al. (2014)
	Vietnam		Chen et al. (2014)

APPENDIX C

PRISMA 2009 Flow Diagram
Name of the Pest: *Popillia quadriguttata*
Date of the search: 21 February 2024
Approved Literature Search String: ("*Popillia quadriguttata*" OR "*Popillia uchidai*" OR "*P.quadriguttata*" OR "P.*uchidai*" OR "*Trichius biguttatus*" OR "*Popillia bogdanowi*" OR "*Popillia castanoptera*" OR "*Popillia chinensis*" OR "*Popillia dichroa*" OR "*Popillia frivaldszkyi*" OR "*Popillia purpurarescens*" OR "*Popillia ruficollis*" OR "*Popillia sordida*" OR "*Popillia straminipennis*").



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097
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