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Pest categorisation of *Eotetranychus sexmaculatus*

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Abstract

The EFSA Panel on Plant Health performed a pest categorisation of *Eotetranychus sexmaculatus* (Acari: Tetranychidae), the six-spotted spider mite, for the EU. The mite is native to North America and has spread to Asia and Oceania. It is not known to occur in the EU. The species is not listed in Annex II of Commission Implementing Regulation (EU) 2019/2072. *E. sexmaculatus* feeds on more than 50 hosts in 20 botanical families and can be a serious pest of important crops in the EU such as citrus (*Citrus* spp.), avocado (*Persea americana*), grapevine (*Vitis* spp.) and ornamentals such as *Ficus* spp. and *Rosa* spp. In California and New Zealand, the mite can breed continuously on evergreen hosts such as avocados and citrus, growing slowly during the winter and faster during the summer. Dry weather conditions hamper its development. Plants for planting, fruit, cut branches and cut flowers provide potential pathways for entry into the EU. Some host plants for planting are prohibited from entering the EU while others require a phytosanitary certificate, as do cut branches and cut flowers. In the warmer parts of southern EU Member States, climatic conditions and host plant availability are conducive for establishment and spread. The introduction of *E. sexmaculatus* is expected to have an economic impact in the EU through the reduction in yield, quality and commercial value of citrus and avocado production. Additional damage on other host plants, including ornamentals, under EU environmental conditions and cropping practices cannot be ruled out. Phytosanitary measures are available to reduce the likelihood of entry and spread. *E. sexmaculatus* satisfies with no key uncertainties the criteria that are within the remit of EFSA to assess for it to be regarded as a potential Union quarantine pest.

Keywords: pest risk, plant health, plant pest, quarantine, six spotted spider mite, Tetranychidae

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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

Eotetranychus sexmaculatus is one of a number of pests listed in Annex 1B to the Terms of Reference (ToRs) 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

E. sexmaculatus was identified as a relevant pest during the commodity risk assessment of *Acer* spp. plants from New Zealand (EFSA PLH Panel, 2020). This pest categorisation was initiated as a result of that listing and subsequent discussion in PAFF, resulting in it being included in the current mandate. *E. sexmaculatus* was also listed in the alert list of the EU FP7 project DROPSA (Strategies to develop effective, innovative and practical approaches to protect major European fruit crops from pests and pathogens) for sweet orange and mandarin fruit.

2. Data and Methodologies

2.1. Data

2.1.1. Literature search

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

2.1.2. Database search

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

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

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

GenBank was searched to determine whether it contained any nucleotide sequences for *E. sexmaculatus* 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 *E. sexmaculatus*, following guiding principles and steps presented in EFSA guidance on quantitative pest risk assessment (EFSA PLH Panel, 2018), 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. While the Panel may quote impacts reported from areas where the pest occurs in monetary terms, the Panel will seek to express potential EU impacts in terms of yield and quality losses and not in monetary terms, in agreement with 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, *Eotetranychus sexmaculatus* is a defined species first described by Riley in 1890. However, there is variation in the description of the aedeagus which is a key diagnostic feature.

E. sexmaculatus (Riley) is a spider mite of the family Tetranychidae (Acari) first described by Riley from male specimens collected in citrus in the USA in 1890 and originally named *Tetranychus sexmaculatus* Riley. *Eotetranychus asiaticus* Ehara (1966), which had been originally described as a separate species, was synonymised under *E. sexmaculatus* by Ehara (1973), but later considered separate again based solely on aedeagal morphology (Seeman et al., 2017). Likewise, Seeman et al. (2017) renamed Australian specimens originally identified as *E. sexmaculatus* under *E. queenslandicus* Manson, 1967. Indeed, *E. asiaticus* and *E. queenslandicus* are almost identical to what is currently accepted to be *E. sexmaculatus*, differing only in the shape of the aedeagus, which is a key taxonomic feature for Tetranychidae. The multiple species of *Eotetranychus* that can be found on citrus and avocado (up to 13, including these three species), the misidentifications within the examined material of Pritchard and Baker (1955), coupled with the fact that McGregor (1950) and Pritchard and Baker (1955) in their revisions of tetranychid mites of America did not examine Riley's (1890) type specimens of *E. sexmaculatus*, means that the current concept of *E. sexmaculatus* may not match that of Riley (1890) (Seeman et al., 2017). For the purpose of this categorisation, *E. asiaticus, E. queenslandicus* and *E. sexmaculatus* are considered as different species. As a consequence, primary data on the biology of *E. sexmaculatus* in Australia will not be taken into account in this categorisation, as Seeman et al. (2017) concluded that this species is not present in that country. However, such a discrimination is not possible for *E. asiaticus* and primary data on the biology of *E. sexmaculatus* may not be genuine. This uncertainty, though, does not affect the conclusions of this categorisation. *E. sexmaculatus* is commonly known as six-spotted spider mite.

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

3.1.2. Biology of the pest

As with all tetranychids, *E. sexmaculatus* develops through five life stages: egg, larva, two nymphal stages (proto- and deutonymph) and adult (UC IPM, 2007). All life stages are mainly found on hosts leaves (DROPSA, 2016) but can also be found on petioles and peduncles (DPIRD, 2022). The mite overwinters on evergreen hosts such as avocados and citrus in all life cycle stages with large populations reported following colder winters (DPIRD, 2022). According to a review on this mite by DPIRD (2022), whether the mite can overwinter on deciduous host plants such as grapevines is not known. Tetranychidae usually have female-biased populations and reproduce by arrhenotokous parthenogenesis, with virgin females producing males only (Li et al., 2015). However, detailed information about this topic for *E. sexmaculatus* has not been found.

In New Zealand, Jamieson and Stevens (2007) determined the development, longevity and fecundity of *E. sexmaculatus* at six constant temperatures (10, 13, 18, 21, 25 and 30°C) on avocado leaf discs. No hatching occurred at 10°C, and egg development took from 23.9 to 5.3 days at 13°C and 30°C, respectively. Total developmental time (egg to adult) ranged from 29.6 to 11 days at 18°C and 30°C, respectively. Adults lived from 41.4 days at 18°C to 18.8 days at 30°C. Fecundity ranged from 6.9 to 20.9 eggs per female. The lower development threshold was estimated at 12.2°C and a thermal constant of 202.8 degree-days was necessary to complete development from egg to adult. In California (UC IPM, 2016), fecundity in avocados was estimated in the range of 25–40 eggs per female over a period of 10–20 days. Both in New Zealand and in California, the highest population densities on avocados occur in the spring and early summer. In Florida, numbers in citrus are higher in late winter–early spring (Beard, 2018).

According to Vacante (2010), the dynamics of *E. sexmaculatus* in citrus are adversely affected by dry weather conditions and its populations reach damaging densities only in humid coastal regions. *E. sexmaculatus* feeds on the undersides of leaves, seldom on fruits, which are affected when mite densities explode. Mite colonies feeding on the lower leaf surfaces produce yellow depressions which are covered by webbing produced by the mites. These areas on the upper surfaces become raised and yellowish. As the infestation increases, these areas converge and leaves become entirely yellow, distorted or misshapen, and drop prematurely.

Natural enemies play a key role on *E. sexmaculatus* dynamics and outbreaks have been related to disruption of biological control (Tomkins, 2002; UC IPM, 2016). According to Learmonth and Authority (2019), the predatory complex found in avocados in California includes generalist predators as phytoseiid mites (*Amblydromalus limonicus* (Garman & McGregor), *Euseius hibisci* (Chant), *Galendromus helveolus* (Chant) and *Typhlodromus rickeri* Chant), coccinellid beetles (*Stethorus punctum picipes* Casey) and thrips (*Scolothrips sexmaculatus* (Pergande)). Comparable functional groups of predators occur in avocados and citrus in the EU (Aguilar-Fenollosa et al., 2011; Jaques et al., 2015; Guzmán et al., 2016; Vela et al., 2017).

3.1.3. Host range/species affected

E. sexmaculatus is a polyphagous mite species. According to Migeon and Dorkeld (2022) and EPPO (online) (which consider *E. asiaticus* as synonym of *E. sexmaculatus*), this spider mite can feed on more than 50 plant species in more than 20 different families. A list of reported hosts can be found in Appendix A. These include cultivated plants like apples, avocados, grapes, citrus, peaches, raspberries, strawberries and tomatoes, and ornamentals, like *Euphorbia pulcherrima*, *Ficus retusa* and roses.

[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 (Griessinger and Roy, 2015; EPPO, 2019).

3.1.4. Intraspecific diversity

As noted in Section 3.1.1, *E. asiaticus*, *E. queenslandicus*, and *E. sexmaculatus* could refer to the same species (Seeman et al., 2017). Based solely on aedeagal morphology, these three species are considered as separate.

3.1.5. Detection and identification of the pest

Are detection and identification methods available for the pest?

Yes, detection and identification methods are available.

Detection

As typical of spider mites, *E. sexmaculatus* feeding on the abaxial leaf surface causes discoloration and eventually death of leaf tissues. As a consequence, the adaxial leaf surface becomes raised and chlorotic. As mite densities increase, these areas converge and leaves become entirely chlorotic and distorted. High-population densities may result in severe defoliation.

Description

According to UC IPM (2016), the oval adults are about 0.3 mm long. Their body is lemon yellow, often with about six dark blotches on the abdomen, although some individuals have no distinct spots. Females lay tiny, globular, pale greenish yellow to translucent or pearly white eggs, which have a slender projecting stalk. A full description of the adult male and female can be found in McGregor (1950).

Identification

The identification of *E. sexmaculatus* requires microscopic examination of slide-mounted adults and verification of the presence of key morphological characteristics, including the morphology of the aedeagus, which shows intraspecific variation (Seeman et al., 2017), as given by McGregor (1950).

Molecular techniques for species identification have not been published yet. GenBank, though, contains gene nucleotide sequences for *E. sexmaculatus* (Liang et al., 2020).

3.2. Pest distribution

3.2.1. Pest distribution outside the EU

Based solely on aedeagal morphology of *E. asiaticus*, *E. queenslandicus*, and *E. sexmaculatus*, these species are considered as separate (Seeman et al., 2017). As a consequence, records from Australia are considered as misidentifications (correct species *E. queenslandicus*) and this country has been excluded from the global distribution of *E. sexmaculatus* (Figure 1). The list of countries where the pest is known to occur can be found in Appendix B and includes Bermuda, Cuba, US, and Peru in the Americas, China, India, Iraq, Japan, Korea, Taiwan and Vietnam in Asia and New Zealand and the US (Hawaii) in Oceania.

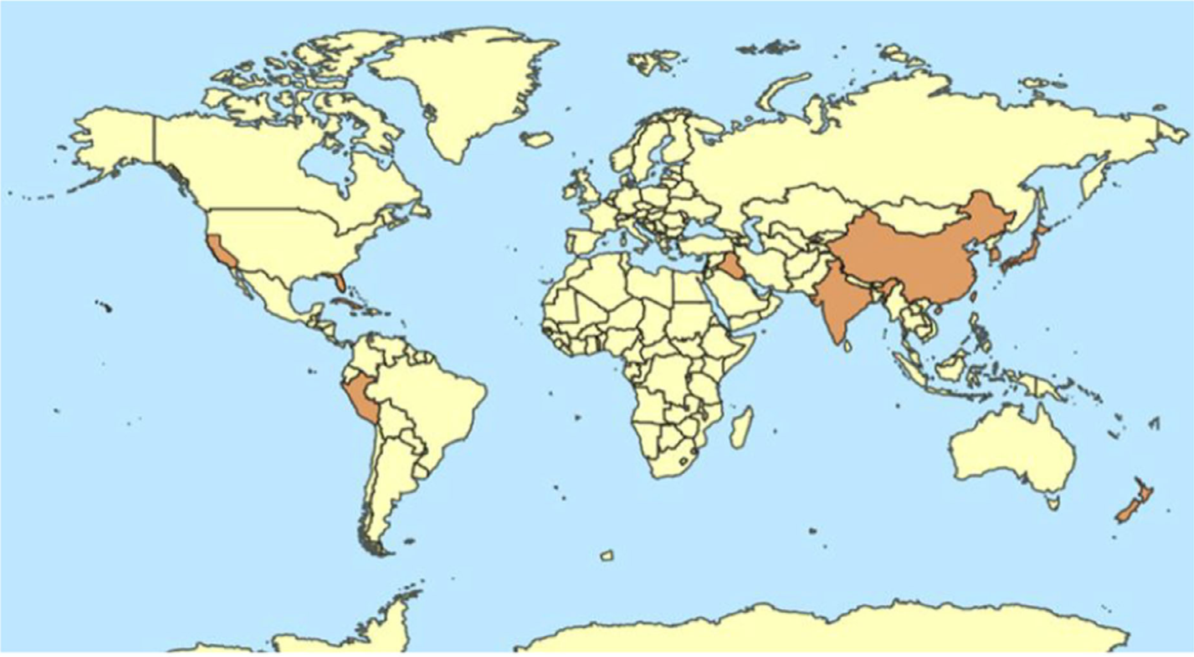

Figure 1: Global distribution of *Eotetranychus sexmaculatus* (Source: map produced from literature cited in this document)

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, *E. sexmaculatus* is not known to occur in the EU territory.

3.3. Regulatory status

3.3.1. Commission Implementing Regulation 2019/2072

E. sexmaculatus 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

Plants included in the host range of *E. sexmaculatus* whose introduction into the EU from certain third countries is prohibited are listed in Table 2.

Table 2: List of plants, plant products and other objects that are *Eotetranychus sexmaculatus* 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**
8.	Plants for planting of [. . .] *Malus Mill., Prunus L., [. . .].* *and Rosa* L., 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 *[. . .]*and their hybrids, and *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 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 (1) and United States other than Hawaii
10.	Plants of *Vitis* L., other than fruits	0602 10 10 0602 20 10 ex 0604 20 90 ex 1404 90 00	Third countries other than Switzerland
11.	Plants of *Citrus* L., [. . .] and their hybrids, 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
18,	Plants for planting of Solanaceae other than seeds and the plants covered by entries 15, 16 or 17	ex 0602 90 30 ex 0602 90 45 ex 0602 90 46 ex 0602 90 48 ex 0602 90 50 ex 0602 90 70 ex 0602 90 91 ex 0602 90 99	Third countries other than: 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

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**
			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

There is a temporary prohibition for HRPs (Regulation 2018/2019), some of which are *E. sexmaculatus* hosts (*Acer* L., *Diospyros* L., *Ficus carica* L., *Malus* Mill., *Persea* Mill., *Populus* L., *Prunus* L., *Robinia* L.,). Nevertheless, certain plants for planting of *Acer japonicum* Thunberg, *Acer palmatum* Thunberg and *Acer shirasawanum* Koidzumi, originating in New Zealand are exempt (Regulation (EU) 2020/1362).

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, the pest is able to enter into the EU territory. The main pathways are plants for planting, fruit, cut branches, and cut flowers.

Comment on plants for planting as a pathway.

Plants for planting could provide the main pathway for *E. sexmaculatus* to enter the EU (Table 3). However, current regulations prohibiting the import of many host plants for planting, make other regulated but not closed pathways (fruit, cut flowers and branches) also relevant.

Potential pathways for the introduction of *E. sexmaculatus* into the EU are listed in Table 3.

Table 3: Potential pathways for *Eotetranychus sexmaculatus* into the EU

Pathways (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	All stages	Table 2 lists some plants for planting which are hosts of *E. sexmaculatus* and prohibited to import from third countries (Regulation 2019/2072, Annex VI). These include plants for planting of (. . .) *Prunus* and *Rosa* other than dormant plants free from leaves, flowers and fruits (8.), those of (. . .) *Prunus* L. [. . .] and their hybrids [...] other than seeds (9.), those of *Vitis* other than fruits (10), as well as those of *Citrus* L., [. . .] and their hybrids, other than fruits and seeds, and those of Solanaceae other than seeds. However, imports of plants for planting of *Prunus* and their hybrids from the USA other than Hawaii (*E. sexmaculatus* is known to occur in California, Florida and Hawaii) are permitted. There is a temporary prohibition for high-risk plants (Regulation 2018/2019), some of which are *E. sexmaculatus* hosts (*Acer* L., *Diospyros* L., *Ficus carica* L., *Malus* Mill., *Persea* Mill., *Populus* L., *Prunus* L., *Robinia* L.,). However, for certain *Acer* species the pathway exists (plants for planting of *A. japonicum* Thunberg, *A. palmatum* Thunberg and *A. shirasawanum* Koidzumi, originating in New Zealand, which require specific phytosanitary measures for their introduction into the EU (Regulation (EU) 2020/1362)). Plants for planting from third countries require a phytosanitary certificate (Regulation 2019/2072, Annex XI, Part A).

Pathways (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]
Fruit	All stages	Fruits of *Actinidia* Lindl., *Carica papaya* L., *Citrus* L. and their hybrids, *Diospyros* L., *Fragaria* L., *Malus* L., *Persea americana* Mill., *Prunus* L., *Psidium* L., *Punica granatum* L., *Vitis* L., and Solanaceae Juss., from third countries other than Switzerland require a phytosanitary certificate to import into the EU (2019/2072, Annex XI, Part A).
Cut branches	All stages	Cut branches from third countries require a phytosanitary certificate to import into the EU (2019/2072, Annex XI, Part A).
Cut flowers	All stages	Cut flowers from third countries require a phytosanitary certificate to import into the EU (2019/2072, Annex XI, Part A).

According to DROPSA (2016), *E. sexmaculatus* occurs mostly on leaves (Steven, 2004; González Fernández et al., 2010), but in severe infestations also on fruit (USDA, 1995). Therefore, pathways including either leaves or fruit (plants for planting, fruit, cut branches and cut flowers) provide plausible entry pathways for this mite.

The import of some host plants for planting of *E. sexmaculatus* from most third countries where it occurs is not permitted (Implementing Regulation 2019/2072, Annex VI: *Citrus* L., *Prunus* L., *Rosa L.* and *Vitis* L.). The main exception is *Prunus* plants for planting from the USA, which are permitted (Table 2). However, *Prunus* is prohibited according to the HRPs regulation (Regulation 2018/2019), which also includes some additional *E. sexmaculatus* hosts (*Acer* L., *Diospyros* L., *Ficus carica* L., *Malus* Mill., *Persea* Mill., *Populus* L., *Prunus* L., *Robinia* L.). Additionally, certain plants for planting of *Acer japonicum* Thunberg, *Acer palmatum* Thunberg and *Acer shirasawanum* Koidzumi, originating from New Zealand require specific phytosanitary measures for their introduction into the EU (Regulation (EU) 2020/1362). All the other known host plants for planting, fruit (Table 3), cut branches and cut flowers can be imported to the EU with a phytosanitary certificate (Implementing Regulation 2019/2072, Annex XI, Part A).

Notifications of interceptions of harmful organisms began to be compiled in Europhyt in May 1994 and in TRACES in May 2020. As of 12 December 2022, there were no records of interception of *E. sexmaculatus* in the TRACES database. Due to technical issues, it was not possible to access the Europhyt database. However, since *E. sexmaculatus* is not a quarantine pest, EU member states have no obligation to notify interceptions of the pest via Europhyt.

For the plants for planting entry pathway there are no uncertainties over the pests' ability to transfer to a suitable host following arrival into the EU. However, transfer for the remaining pathways is more uncertain. Uncertainties include the ability to find a mate and other Allee effects (effects causing reduced survival of new colonies with a reduced number of individuals) (Tobin et al., 2011) as well as the impact of EU native generalist predators comparable to those described in Section 3.1.2 (Table 4).

Table 4: Fresh fruits, which are hosts of *Eotetranychus sexmaculatus*, imported into the EU from countries where *the pest* is known to occur (quantity in 100 kg, Eurostat accessed on 23/11/2022)

Commodity	CN Code	2016	2017	2018	2019	2020
Kiwifruit	0810 50	1,818,089	1,548,306	1,915,485	1,806,506	1,972,001
Pawpaws 'papayas'	0807 20	514	421	501	592	173
Fresh or dried mandarins incl. tangerines and satsumas (excl. clementines)	0805 21	0	116,926	138,158	116,279	154,053
Persimmons	0810 70	178	0.3	6	1	805
Strawberries	0810 10 00	6,676	5,048	5,907	4,590	1,878
Apples	0808 10	764,824	756,928	985,550	728,840	764,327
Fresh or dried avocados	0804 40	1,245,065	1,353,580	2,011,812	1,584,644	2,132,132
Peaches, incl. nectarines	0809 30	24	11	146	1,325	62

Commodity	CN Code	2016	2017	2018	2019	2020
Fresh or dried guavas, mangoes and mangosteens	0804 50	812,402	903,942	1,210,501	1,104,930	1,278,371
Tomatoes	0702 00	15	9	13	47	35
Fresh grapes	0806 10	1,101,489	1,275,078	1,474,556	1,712,333	1,517,501

3.4.2. Establishment

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

Yes, both host availability and climatic conditions in the EU are conducive for the establishment of *E. sexmaculatus*. Regions in the warmer parts of southern EU MSs provide the most suitable conditions for establishment. Establishment may be possible in greenhouses in cooler areas.

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

E. sexmaculatus is a polyphagous species (see Appendix A). Many hosts are widely cultivated in the EU (i.e., tomatoes, strawberries, apples), while others are found in southern EU MSs only (i.e., avocados, citrus) (Table 5). Some hosts (*Acer* spp., *Rosa* spp., *Vitis* spp.) also occur in the EU in the wild. Therefore, host availability should not be a limit for the establishment of *E. sexmaculatus* in the EU.

Table 5: Harvested area of host plants of *Eotetranychus sexmaculatus* in the EU, 2016–2020 (1,000 ha). Source EUROSTAT (accessed on 27 November 2022)

Commodity	Code	2016	2017	2018	2019	2020
Grapes	W1000	3,136.15	3,133.32	3,135.50	3,155.20	3,145.71
Citrus fruits	T30000	519.01	502.84	508.99	512.83	519.98
Apples	F1110	505.66	504.61	506.27	491.08	484.63
Tomatoes	V3100	253.95	247.95	239.48	242.52	227.58
Peaches	F1210	156.39	154.06	150.80	144.78	137.07
Strawberries	S0000	103.78	103.76	106.42	101.16	83.92
Kiwis	F2200	43.79	43.83	44.20	44.18	44.83
Avocados	F2300	12.24	12.72	13.22	17.50	19.69

3.4.2.2. Climatic conditions affecting establishment

Figure 2 shows the world distribution of selected Köppen–Geiger climate types (Kottek et al., 2006) that occur in the EU and which occur in countries/states where *E. sexmaculatus* has been reported. However, Köppen–Geiger climate zones do not capture the number of frost days, which may further inform judgements about where in the EU *E. sexmaculatus* could establish. Appendix C shows the mean number of frost days each year on a global scale for the 30 year period 1988–2017, sourced from the Climatic Research Unit high resolution gridded dataset CRU TS v. 4.03 at 0.5° resolution (https://crudata.uea.ac.uk/cru/data/hrg/). A simple visual comparison of the red dots shown in Figure 2, marking precise locations of *E. sexmaculatus*, and Appendix C indicates that *E. sexmaculatus* occurs primarily in countries with few frost days (red colours in Appendix C). Appendix C indicates that the fewest frost days occur in southern Portugal, around the Mediterranean coast and islands in the Mediterranean. Recognising that the development threshold of this mite is 12.2°C (Jamieson and Stevens, 2007) we conclude that regions with the fewest frost days in the warmer parts of southern EU provide the most suitable conditions for establishment. Establishment may be possible in greenhouses in cooler areas.

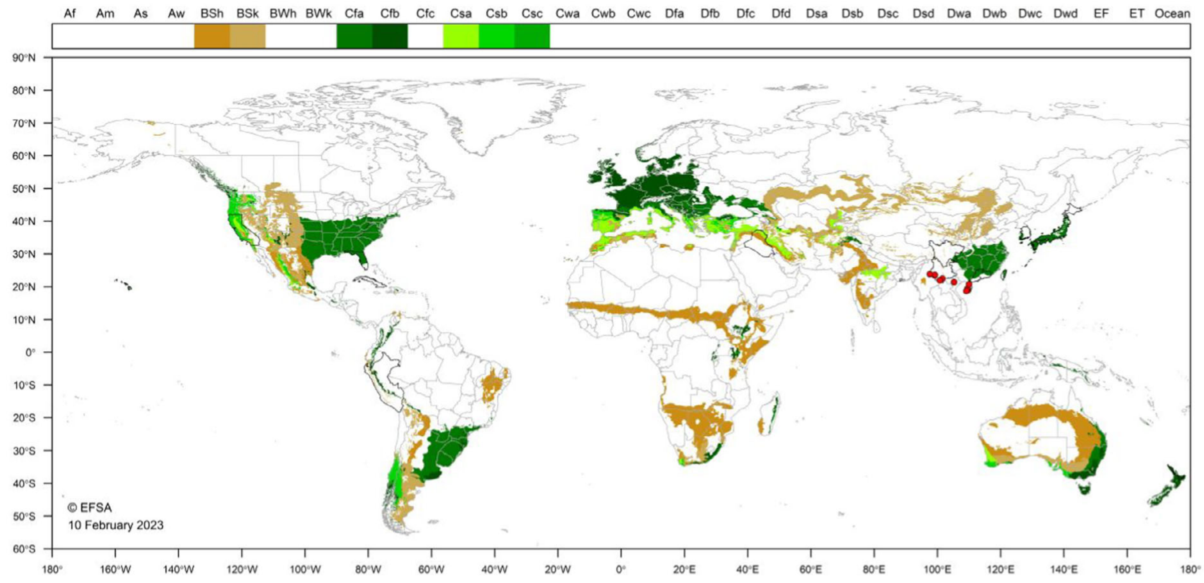

Figure 2: World distribution of selected Köppen–Geiger climate types that occur in the EU and which occur in sites where *Eotetranychus sexmaculatus* has been reported. Red dots indicate point locations of *E. sexmaculatus* for which geographical coordinates are available

3.4.3. Spread

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

Spider mites active spread is mostly by crawling to leaves within the same plant or neighbouring plants. Therefore, natural spread will occur locally and relatively slowly. However, passive spread by wind (including ballooning specimens), rain or animals could cover longer distances with uncertain success. Human-assisted movement of plant material (especially infested plants for planting) but also infested gear, would provide a more successful long distance spread mechanism.

Comment on plants for planting as a mechanism of spread.

Plants for planting would provide the most successful long distance spread mechanism for *E. sexmaculatus*.

According to EFSA commodity risk assessment of *Acer* spp. plants from New Zealand (EFSA PLH Panel, 2020), *E. sexmaculatus* can be passively spread by wind (by ballooning: producing silk threads and climbing up to plant tips), rain, animals and birds (DROPSA, 2016). The review produced by DPIRD (2022) also includes passive movement with equipment, machinery, and workers' clothing. Spider mites can actively crawl to leaves within the same plant or neighbouring touching plants.

3.5. Impacts

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

Yes, the introduction of *E. sexmaculatus* into the EU could result in an economic impact on avocado and citrus production.

E. sexmaculatus can be a serious pest of avocados in New Zealand and in California, especially in foggy coastal areas (Jamieson and Stevens, 2007; UC IPM, 2016), citrus (Li et al., 1997; Vacante, 2010), plumeria (Yang and Lin, 1983) and rubber trees in South-East Asia (Liang et al., 2020). According to Vacante (2010), *E. sexmaculatus* is a major pest of citrus in China, Hawaii, Korea, India, Iraq, Japan, Korea, New Zealand, Taiwan and the USA. Outbreaks have been frequently observed after disruption of natural biological control, for instance after application of non-selective pesticides targeting other pests (Tomkins, 2002; UC IPM, 2016).

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, although the existing phytosanitary measures identified in Section 3.3.2 do not specifically target *E. sexmaculatus*, they mitigate the likelihood of its entry into, establishment and spread within the EU.

3.6.1. Identification of potential additional measures

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

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 6.

Table 6: 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 a country officially free from pest, a pest free area, a pest free place of production, or a pest free production site	Entry/Spread
Growing plants in isolation	Nursery plants could be produced in an insect proof place of production with complete physical isolation	Entry/Spread/Impact
Use of resistant and tolerant plant species/varieties	Resistant plants are used to restrict the growth and development of a specified pest and/or the damage they cause when compared to susceptible plant varieties under similar environmental conditions and pest pressure. Mite-resistant rubber tree (*Hevea brasiliensis*) germplasms have been used in China (Liang et al., 2020)	Entry/Establishment/Spread/Impact
Biological control and behavioural manipulation	Augmentative and conservation biological control exploiting phytoseiid predatory mites and other predatory microarthropods have been used against *E. sexmaculatus* (see Section 3.1.2) (Jamieson and Stevens, 2007; UC IPM, 2016)	Spread/Impact
Chemical treatments on crops including reproductive material	Chemical control has been used against *E. sexmaculatus* in avocados (Jamieson and Stevens, 2007; UC IPM, 2016) and citrus (UC IPM, 2016)	Impact
Physical treatments on consignments or during processing	Brushing and washing, sorting and grading and removal of plant parts (e.g. leaves) at storehouse is a common postharvest practice for citrus and other fruit	Entry/Spread
Cleaning and disinfection of facilities, tools and machinery	Washing at storehouse is a common postharvest practice for citrus and other fruit. The 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) should be used in nurseries and storehouses.	Entry/Spread

3.6.1.2. Additional supporting measures

Potential additional supporting measures are listed in Table 7.

Table 7: 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	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/Impact
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
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/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/Impact
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/Impact

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
Surveillance	Surveillance to guarantee that plants and produce originate from a Pest Free Area could be an option.	Entry/Establishment/ Impact

3.6.1.3. Biological or technical factors limiting the effectiveness of measures

- *E. sexmaculatus* may be difficult to detect where low populations occur.
- *E. sexmaculatus* is polyphagous, making the inspections of all consignments containing hosts from countries where the pest occurs difficult and opening the possibility that the pest enters with non-regulated host species.
- *E. sexmaculatus* populations are most probably female-biased, therefore adult males, which are required for identification may be difficult to find in a sample.

3.7. Uncertainty

The main source of uncertainty regards the taxonomic status of *Eotetranychus asiaticus, E. queenslandicus* and *E. sexmaculatus*, which could constitute one single taxon, and their geographical distribution. However, this is not a key uncertainty likely to change the conclusion.

4. Conclusions

E. sexmaculatus satisfies with no key uncertainties the criteria that are within the remit of EFSA to assess for it to be regarded as a potential Union quarantine pest (Table 8).

Table 8: 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)	*Eotetranychus sexmaculatus* is a defined species first described by Riley in 1890. However, there is variation in the description of the aedeagus, which is a key diagnostic feature.	None
Absence/presence of the pest in the EU (Section 3.2)	*E. sexmaculatus* is not known to occur in the EU territory.	None
Pest potential for entry, establishment and spread in the EU (Section 3.4)	*E. sexmaculatus* is able to enter into, become established in, and spread within the EU territory. The main entry pathways are plants for planting, fruit, cut branches, and cut flowers. Infested plants for planting provide most probably also the main spread pathway. Establishment is possible in the warmest parts of southern EU MSs where there are few frost days.	None
Potential for consequences in the EU (Section 3.5)	The introduction of *E. sexmaculatus* into the EU could result in an economic impact on avocado and citrus production.	None

Criterion of pest categorisation	Panel's conclusions against criterion in Regulation (EU) 2016/2031 regarding Union quarantine pest	Key uncertainties
Available measures (Section 3.6)	Existing phytosanitary measures not specifically targeting *E. sexmaculatus* could mitigate the likelihood of its entry into, establishment and spread within the EU of this mite. Additional measures are available and listed in the main body of this categorisation.	None
Conclusion (Section 4)	*E. sexmaculatus* satisfies with no key uncertainties 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:	Studies aimed at clarifying the taxonomic status of *Eotetranychus asiaticus, E. queenslandicus* and *E. sexmaculatus* and their worldwide distribution would be instrumental to refine the conclusions of this categorisation.	

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Abbreviations

EPPO	European and Mediterranean Plant Protection Organization
FAO	Food and Agriculture Organization
HRP	high-risk plant
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

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 – *Eotetranychus sexmaculatus* host plants/species affected

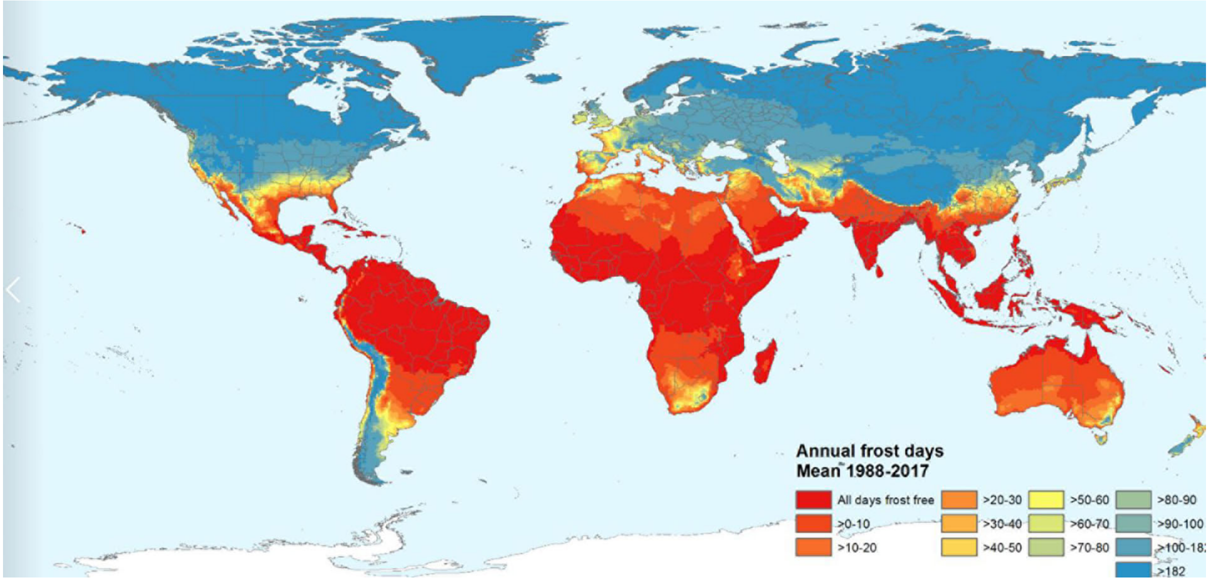
Host status	Host name	Plant family	Common name	Reference
Cultivated hosts	*Acer* spp.	Sapindaceae	–	DROPSA (2016)
	Acer pseudoplatanus	Sapindaceae	Sycamore	McGregor (1950)
	Actinidia deliciosa	Actinidiaceae	Kiwifruit	DROPSA (2016)
	Azalea	Ericaceae	–	DROPSA (2016)
	Broussonetia papyrifera	Moraceae	Common paper mulberry	Migeon and Dorkeld (2022)
	Carica papaya	Caricaceae	Papaya	DROPSA (2016)
	Ceratonia siliqua	Fabaceae	Locust tree	McGregor (1950)
	Cinnamomum camphora	Lauraceae	Camphor tree	Pritchard and Baker (1955)
	Cinnamomum javanicum	Lauraceae	–	Saito et al. (2016)
	Citrus spp.	Rutaceae	–	DROPSA (2016)
	Citrus × *aurantium*	Rutaceae	Bitter lemon	Pritchard and Baker (1955)
	Citrus limon	Rutaceae	Lemon	DROPSA (2016)
	Citrus maxima	Rutaceae	Pummelo	DROPSA (2016)
	Citrus reticulata	Rutaceae	Mandarin	DROPSA (2016)
	Citrus sinensis	Rutaceae	Sweet orange	DROPSA (2016)
	Clausena lansium	Rutaceae	Wampee	Migeon and Dorkeld (2022)
	Diospyros kaki	Ebenaceae	Chinese persimmon	DROPSA (2016)
	Euphorbia pulcherrima	Euphorbiaceae	Poinsettia	Migeon and Dorkeld (2022)
	Ficus	Moraceae	–	DROPSA (2016)
	Ficus erecta	Moraceae	–	Ehara (1966)
	Ficus hispida	Moraceae	–	Migeon and Dorkeld (2022)
	Ficus retusa	Moraceae	–	Migeon and Dorkeld (2022)
	Fragaria x ananassa	Rosaceae	Strawberry	DROPSA (2016)
	Hevea brasiliensis	Euphorbiaceae	Brazilian rubber tree	DROPSA (2016)
	Hydrangea sp.	Hydrangeaceae	–	Migeon and Dorkeld (2022)
	Litsea glutinosa	Lauraceae	Indian laurel	Migeon and Dorkeld (2022)
	Malus domestica	Rosaceae	Apple	DROPSA (2016)
	Morus	Moraceae	–	DROPSA (2016)
	Oxalis corniculata	Oxalidaceae	Creeping oxalis	Migeon and Dorkeld (2022)
	Paulownia tomentosa	Paulowniaceae	Foxglove tree	Pritchard and Baker (1955)
	Persea americana	Lauraceae	Avocado	DROPSA (2016)
	Phaseolus	Fabaceae	–	DROPSA (2016)
	Platanus	Platanaceae	–	DROPSA (2016)
	Populus	Salicaceae	–	DROPSA (2016)
	Prunus	Rosaceae	–	DROPSA (2016)
	Prunus domestica	Rosaceae	European plum	Garrett and Haramoto (1967)
	Prunus mume	Rosaceae	Japanese apricot	Gupta and Gupta (1994)
	Prunus persica	Rosaceae	Peach	DROPSA (2016)
	Psidium guajava	Myrtaceae	Guava	DROPSA (2016)
	Pyracantha	Rosaceae	–	DROPSA (2016)
	Rhapis excelsa	Arecaceae	Large lady palm	Migeon and Dorkeld (2022)
	Rhododendron	Ericaceae	–	DROPSA (2016)
	Robinia pseudoacacia	Fabaceae	Locust tree	Migeon and Dorkeld (2022)

Host status	Host name	Plant family	Common name	Reference
	Rosa	Rosaceae	–	DROPSA (2016)
	Rubus	Rosaceae	–	DROPSA (2016)
	Sassafras albidum	Lauraceae	Common sassafras	McGregor (1950)
	Solanum lycopersicum	Solanaceae	Tomato	DROPSA (2016)
	Ternstroemia gymnanthera	Pentaphylacaceae	Japanese cleyera	Gotoh et al. (2003)
	Vitis vinifera	Vitaceae	Grapevine	DROPSA (2016)

Appendix B – Distribution of Eotetranychus sexmaculatus

Region	Country	Sub-national (e.g. State)	Status	Reference
North America	Bermuda		Present, no details	DROPSA (2016)
	USA	California	Present, no details	DROPSA (2016)
		Florida	Present, no details	DROPSA (2016)
Caribbean	Cuba		Present, no details	DROPSA (2016)
South America	Peru		Present, no details	DROPSA (2016)
Asia	China		Present, no details	DROPSA (2016)
		Guangdong	Present, no details	Liu et al. (2022)
		Hainan	Present, no details	Liu et al. (2022)
		Sichuan	Present, no details	Tna (1986)
		Yunnan	Present, no details	Liu et al. (2022)
	India		Present, no details	DROPSA (2016)
	Japan		Present, no details	DROPSA (2016)
	Iraq		Present, no details	DROPSA (2016)
	Korea (Republic)		Present, no details	DROPSA (2016)
	Taiwan		Present, no details	Ehara (1999)
	Vietnam	Hanoi	Present, no details	Nie et al. (2020)
Oceania	New Zealand		Present, no details	DROPSA (2016)
	USA	Hawaii	Present, no details	Garrett and Haramoto (1967)

Appendix C – Annual frost days



Source: Climatic Research Unit high resolution gridded dataset CRU TS v. 4.03 at 0.5° resolution (https://crudata.uea.ac.uk/cru/data/hrg/)).