



Australian Government
Department of Agriculture,
Fisheries and Forestry

Draft report for a review of pest risk assessments for spider mites (Acari: Trombidiformes: Tetranychidae)

September 2023



© Commonwealth of Australia 2023

Ownership of intellectual property rights

Unless otherwise noted, copyright (and any other intellectual property rights) in this publication is owned by the Commonwealth of Australia (referred to as the Commonwealth).

Creative Commons licence

All material in this publication is licensed under a [Creative Commons Attribution 4.0 International Licence](https://creativecommons.org/licenses/by/4.0/) except content supplied by third parties, logos and the Commonwealth Coat of Arms.



Cataloguing data

This publication (and any material sourced from it) should be attributed as: DAFF 2023, *Draft report for a review of pest risk assessments for spider mites (Acari: Trombidiformes: Tetranychidae)*, Department of Agriculture, Fisheries and Forestry, Canberra, CC BY 4.0.

This publication is available at agriculture.gov.au/about/publications.

Department of Agriculture, Fisheries and Forestry

GPO Box 858 Canberra ACT 2601

Telephone: 1800 900 090

Web: agriculture.gov.au

Email: plantstakeholders@aff.gov.au

Disclaimer

The Australian Government acting through the Department of Agriculture, Fisheries and Forestry has exercised due care and skill in preparing and compiling the information and data in this publication. Notwithstanding, the Department of Agriculture, Fisheries and Forestry, its employees and advisers disclaim all liability, including liability for negligence and for any loss, damage, injury, expense or cost incurred by any person as a result of accessing, using or relying upon any of the information or data in this publication to the maximum extent permitted by law.

Acknowledgement of Country

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

Stakeholder submissions on draft reports

This draft report has been issued to give all interested parties an opportunity to comment on relevant technical biosecurity issues, with supporting rationale. A final report will then be produced taking into consideration any comments received.

Submissions should be sent to the Department of Agriculture, Fisheries and Forestry following the conditions specified within the related Biosecurity Advice, which is available at: agriculture.gov.au/biosecurity-trade/policy/risk-analysis/memos.

Cover image

Apple fruit infested by diapausing McDaniel spider mite, *Tetranychus mcdanieli* McGregor, © 2023 Wisconsin State University, E. Beers/Orchard Pest Management/<https://treefruit.wsu.edu/crop-protection/opm/>

Contents

Summary	v
Introduction.....	1
1.1 Initiation	1
1.2 Scope	1
1.3 Out of scope	1
1.4 Approach, method and structure for the review	1
1.5 Next steps.....	2
2 Taxonomy and biology	4
2.1 Taxonomy	4
2.2 Biology	4
3 Evaluation of previous assessments for spider mites	12
3.1 Introduction.....	12
3.2 Review of likelihood of entry	13
3.3 Review of likelihood of establishment	18
3.4 Review of likelihood of spread	19
3.5 Review of consequence assessments	23
4 Proposed ratings and potential implication of their application.....	35
4.1 Summary of previous and proposed ratings	35
4.2 Changes of URE resulting from the application of proposed ratings.....	36
4.3 Potential implication on pathways relevant to the 21 PRAs.....	36
5 Conclusion	43
Appendix A: Method for pest risk analysis	44
Appendix B: Summary of the ratings from the previous assessments of spider mites	57
Appendix C: Interception of spider mites on the fresh fruit pathways covered by the 21 PRAs.....	61
Appendix D: Comparison of previous and proposed ratings.....	64
Glossary, acronyms and abbreviations.....	69
References	72

Figures

Figure A.1 Decision rules for determining the impact score for each direct and indirect criterion, based on the <i>level of impact</i> and the <i>magnitude of impact</i>	52
---	----

Tables

Table 2.1 Average longevity of adult females in 5 species of <i>Tetranychus</i> at five temperatures.....	6
Table 2.2 Host comparison of spider mite species previously assessed by the department	10

Table 3.1 Tetranychid species assessed fully or partially in the respective PRA by the department ...	13
Table 3.3 Interception of spider mites on the fresh fruit pathways assessed in the 21 PRAs	15
Table 3.4 Host plant species, symptoms and damage of the 20 quarantine spider mite species previously assessed by the department.....	24
Table 4.1 Summary of previous ratings assigned in the 21 PRAs and proposed ratings in this review	35
Table A.1 Nomenclature of likelihoods	49
Table A.2 Matrix of rules for combining likelihoods	49
Table A.3 Decision rules for determining the overall consequence rating for each pest	53
Table A.4 Risk estimation matrix.....	53
Table B.1 Summary of the ratings in the previous assessments for spider mites	57
Table C.1 Interception of spider mites by Australia (2005-2021) on traded fruit commodity from country or region covered in the 21 finalised PRAs	61
Table D.1 Comparison of previous and proposed ratings for the likelihoods, overall consequences and unrestricted risk estimates	64
Table D.2 Changes of URE and URE outcome for spider mites on the specific pathways resulting from application of the proposed ratings	67

Summary

The Department of Agriculture, Fisheries and Forestry (this and all previous forms of the agency are henceforth referred to as 'the department') has been undertaking pest risk analysis (PRA) to consider market access requests for fresh fruit commodities for human consumption from trading partners for over two decades. Many of these PRAs included pest risk assessments for spider mites of the family Tetranychidae. The department has noted that in some PRAs different risk ratings were assigned to spider mites that share similar biological characteristics and are expected to pose similar biosecurity risks. The department has therefore initiated this review to examine and evaluate all these previous pest risk assessments for spider mites. The review will determine whether difference in these ratings are justified and, if not, to propose a way to address associated issues.

This report focuses on the review of all the previous pest risk assessments conducted by the department on species of Tetranychidae. Members of Tetranychidae are commonly referred to as spider mites or tetranychids, which are used interchangeably in this report.

The department has reviewed the biological characteristics of spider mites, particularly those previously assessed by the department, and confirms that they share a number of common biological characteristics relevant to biosecurity risk. On the basis of this, it could be expected that they would have similar likelihoods of entry, establishment and spread in Australia, and also to cause comparable consequences. As such, this review employs a method similar to the department's Group PRA approach, which is outlined in Section 1.4 and in Section A2.7 in Appendix A. The Group PRA approach has previously been used for three insect groups: thrips, (DAWR 2017a), mealybugs (DAWR 2019a) and scale insects (DAWE 2021).

The review includes information on the taxonomy and biology of Tetranychidae, and examination and evaluation of the previous likelihood and consequence assessments against scientific information. Australian interception data of spider mites on imported fresh fruit for human consumption are also presented and analysed against the previous assessments of likelihood of importation.

To date (August 2023), 21 species of Tetranychidae in 6 genera: *Amphitettranychus* (1 species), *Eotetranychus* (3 species), *Eutetranychus* (1 species), *Oligonychus* (6 species), *Panonychus* (1 species) and *Tetranychus* (9 species) have been assessed by the department in 21 finalised PRAs. All of these 21 PRAs were conducted on fresh fruit commodities for human consumption (Table B.1 in Appendix B and Table C.2 in Appendix C). One of the 21 assessed species is no longer a quarantine pest for Australia.

Through examination and evaluation of the supporting evidence presented in the 21 PRAs, Australian interception data and the latest scientific information, this review confirms that most of the ratings previously assigned in the 21 PRAs are appropriate. The review proposes, however, that some of the previously assigned ratings be adjusted to reflect evidence now available and/or aligned to reflect similar level of biosecurity risk posed by members of this pest group. Proposed changes to previously assigned ratings are explained and discussed in detail in Chapter 3. Comparisons of the previous ratings and the proposed ratings are presented in Chapter 4.

Outcomes from this draft report include the following proposals:

- Ratings for the likelihood of importation, which is pathway specific, for spider mite species in the 21 PRAs are appropriate, except for those species associated with stone fruit from the USA (Biosecurity Australia 2010b).
- Likelihood of importation for spider mite species associated with stonefruit from the USA be adjusted from 'Moderate' to 'High' due to interceptions of spider mites on this pathway.
- The likelihood of distribution of 'Moderate', as substantiated in Chapter 3, be consistently applied for all quarantine spider mite species previously assessed by the department in the 21 PRAs.
- An indicative likelihood of importation (pathway specific) of 'High' and an indicative likelihood of distribution (pathway and/or species specific) of 'Moderate' could be applied to all spider mite species in future assessments, unless there is information to suggest otherwise.
- Ratings for likelihood of establishment of 'High', likelihood of spread of 'High' and overall consequences of 'Low', as substantiated in Chapter 3, be consistently applied for all quarantine spider mite species previously assessed by the department in the 21 PRAs.
- These ratings for likelihood of establishment of 'High', likelihood of spread of 'High' and overall consequences of 'Low' could also be applied to other spider mite species in future assessments. The department recognises that there may be exceptions to the proposed ratings if counter evidence is available.

The application of the proposed ratings means that where the likelihood of importation is assessed as 'High', the unrestricted risk estimate (URE) would be 'Low', which does not achieve the appropriate level of protection (ALOP) for Australia and therefore specific risk management measures for spider mites are required. In cases where the likelihood of importation is assessed as 'moderate' or lower, the URE would be 'Very Low' or lower, which achieves the ALOP for Australia and therefore specific risk management measures for spider mites are not required.

It is also important to note that if a live quarantine spider mite species is intercepted on a consignment, remedial action will be required to manage the pest. This is because the interception of the pest is taken to indicate that the likelihood of importation for the pest is 'High', regardless of the assigned rating in the assessment.

The application of the proposed ratings would result in changes to the URE outcome for tetranychid species from achieving to not achieving the ALOP for Australia on 3 commodity/country pathways, and from not achieving to achieving the ALOP for Australia on 6 pathways. Implementation of these changes is not expected to have significant impact on the overall risk management measures for these pathways. This is because the pathways also require risk management measures for other pests, such as mealybugs and thrips, that are the same as the measures for spider mites.

For the remaining 12 pathways, the application of the proposed ratings would not result in changes to the URE outcome for tetranychid species, which remain as either not achieving the ALOP for Australia (11 pathways) or achieving the ALOP for Australia (1 pathway).

These changes and potential implication are presented in detail in Chapter 4. It is important to note that the department does not intend to implement any changes resulting from this review at this time. Following the finalisation of this review, implementation will be undertaken on a case-by-case basis for specific pathways in consultation with relevant stakeholders.

This draft report has been published on the department website to allow interested parties to provide comments and submissions within the specified consultation period. Next steps in the review process are outlined in Section 1.5.

Introduction

1.1 Initiation

This review of the previous pest risk assessments for spider mites was initiated by the department.

The department has been undertaking pest risk analysis (PRA) to consider market access requests for fresh fruit commodities from trading partners for over two decades. Many PRAs included pest risk assessments for spider mites. The department became aware that different risk ratings were assigned in previous pest risk assessments for spider mite pests that have similar biological characteristics and are therefore expected to pose similar biosecurity risks. The department thus considered it necessary to undertake a comprehensive review of all the previous pest risk assessments for spider mites to determine whether the risk ratings previously assigned are appropriate and, if not, propose a way to address associated issues.

1.2 Scope

The scope of this report is to review all the previous pest risk assessments for spider mites of the family Tetranychidae in the final PRAs on imports of fresh fruit commodities for human consumption.

1.3 Out of scope

This review excludes mite species in other families, such as the false spider mite family Tenuipalpidae and the predatory mite family Phytoseiidae, although these have also been assessed previously by the department in the final PRAs.

1.4 Approach, method and structure for the review

1.4.1 Group PRA approach

This review employs a method similar to the department's Group PRA approach. This approach has previously been used for three insect groups: thrips, (DAWR 2017a), mealybugs (DAWR 2019a) and scale insects (DAWE 2021).

The Group PRA approach is consistent with relevant international standards and requirements—including ISPM 2: *Framework for Pest Risk Analysis* (FAO 2019a), ISPM 11: *Pest Risk Analysis for Quarantine Pests* (FAO 2019c) and the SPS Agreement (WTO 1995). ISPM 2 states that 'Specific organisms may ... be analysed individually, or in groups where individual species share common biological characteristics.' This is the basis for the Group PRA approach in which organisms are grouped where they share common biological characteristics and are thus expected to pose a similar level of biosecurity risk.

Spider mites, as a pest group, share a number of common biological characteristics relevant to biosecurity risk. These characteristics include:

- small size and cryptic habits
- capacity for active and passive dispersal through crawling and/or aerial transfer
- plant feeding and predisposition to polyphagous behaviours
- ability to reproduce parthenogenetically as well as sexually

- frequent association with and transport on commodities in domestic and international commerce.

1.4.2 Method and structure of the review

The review starts by briefly discussing the taxonomy of Tetranychidae and providing biological information relevant to the pest risk assessment of spider mites (Chapter 2).

Chapter 3 reviews in detail the previous assessments and provides proposed ratings based on the examination and evaluation of:

- the supporting evidence provided in the previous assessments for the likelihood of entry (importation and distribution), of establishment and of spread, and for consequences. The supporting evidence is evaluated with respect to relevant factors listed in the department's method for PRA (Appendix A) and/or in ISPM 11 (FAO 2019c).
- the latest relevant scientific literature
- Australia's interception data for spider mites (Appendix C) – for likelihood of importation.

Chapter 4 discusses the proposed ratings in relation to potential implication of their application.

Chapter 5 provides conclusion for the report.

Appendix B summarises the ratings from previous assessments and Appendix D provides comparison between the ratings from previous assessments and the proposed ratings.

1.4.3 Explanations

Common names

Members of the mite family Tetranychidae are commonly referred to as spider mites or tetranychids, which are used interchangeably in this report.

Scientific names

Full scientific name, including the authority, is provided when it appears first time in the report, e.g. *Tetranychus urticae* Koch. When the same name appears subsequently in the report, no authority will be included, e.g. *Tetranychus urticae*. Also, the genus part of the specie name is, where appropriate, abbreviated, e.g. *T. urticae*, unless it is at the start of the sentence, first appearing in a paragraph or where it may result in confusion with another genus.

Table numbering

Tables are numbered sequentially with the chapter number or appendix letter, for example, Table 1.1 and Table 1.2 for tables in Chapter 1, and Table A.1 and Table A.2 for tables in Appendix A. Therefore, when the particular table is referred to with a letter, e.g. Table A.1, Table B.1, the cited table will be found in the relevant appendix.

1.5 Next steps

The department has notified registered stakeholders and the WTO Secretariat about the release of this draft report.

This draft report gives stakeholders an opportunity to comment on the department's review and to draw attention to any scientific, technical or other gaps in the data, or misinterpretations or errors. The department will consider submissions received on the draft report and may consult

further with stakeholders. The department will revise the report as appropriate, taking into account stakeholder comments, and then prepare a final report.

The final report will be published on the department's website with a notice advising stakeholders of the release. The department will also notify registered stakeholders and the WTO Secretariat about the release of the final report.

Should the proposed ratings in the final report result in changes to the URE outcome of specific pathways, implementation of any resultant changes will be undertaken on a case-by-case basis in consultation with relevant stakeholders.

2 Taxonomy and biology

2.1 Taxonomy

The family Tetranychidae includes over 1,300 species (Migeon & Dorkeld 2022) in around 70 genera, and is divided into two subfamilies: Bryobiinae and Tetranychinae (Krantz & Walter 2009). The family has commonly been referred to as ‘spider mites’ because some species in the subfamily Tetranychinae produce copious silken webbing (Walter & Proctor 2013). All tetranychid species assessed previously by the department belong to the subfamily Tetranychinae.

Tetranychidae is the most studied mite family in the subclass Acari due to the fact that many are important plant pests. Comprehensive knowledge on Tetranychidae has been summarised in a two-volume monograph edited by Helle and Sabelis (1985b) and Helle and Sabelis (1985a) titled: *Spider mites: their biology, natural enemies and control*. Vacante (2016) reviewed the main publications on the mites of economic plants, including Tetranychidae, after the monograph of Helle and Sabelis (1985b) and Helle and Sabelis (1985a).

2.2 Biology

Studies of tetranychid biology have concentrated on economically important species. General and specific biological information is available in books, including Jeppson, Keifer and Baker (1975), Helle and Sabelis (1985b), Helle and Sabelis (1985a) and Vacante (2016), and in journal articles. Carey and Bradley (1982) and Gotoh, Moriya and Nachman (2015) are examples of journal articles on the studies of specific species, including *Tetranychus kanzawai* Kishida, *T. pacificus* McGregor, *T. truncatus* Ehara, *T. turkestanii* (Ugarov & Nikolskii) and *T. urticae* Koch.

Information on the biology and behaviours of tetranychid mites is reviewed and summarised in this section.

2.2.1 Life cycle

The life cycle of spider mites includes five life stages: egg, larva, protonymph, deutonymph and adult (Crooker 1985; Jeppson, Keifer & Baker 1975).

Eggs laid by mature adult females are 110 – 150 µm in diameter, round to onion-like and have colours ranging from white to pale green, dark green, brown, orange and red (Crooker 1985).

After hatching from the eggs, the first immature stage (larva) has three pairs of legs. There are two nymphal stages: protonymph and deutonymph, both having four pairs of legs (Crooker 1985). The protonymph is slightly larger than the larva in size. Likewise, the deutonymph continues to grow and increase in size. Finally, the adults develop from the deutonymph stage. The adult is often red, brown, green or yellow in colour (Zhang 2008) and ranges from 200 to 900 µm in size (Migeon & Dorkeld 2022). Another life cycle begins when the newly emerged mature females lay new eggs.

There is an intervening period of quiescence following each of the three immature stages of larva, protonymph and deutonymph, during which moulting takes place (Crooker 1985). Carey and Bradley (1982) include the quiescent periods in their study of *Tetranychus pacificus*, *T. turkestanii* and *T. urticae* under 5 different temperatures. The study indicates that the

Taxonomy and biology

quiescent period can take about 30-40% of the total development time for larvae and can last longer than the active time for nymphs (Carey & Bradley 1982). At the end of each quiescence period, the subsequent life stages (protonymph, deutonymph and adult), emerge, respectively, from the exuvium (old skin) at eclosion (Crooker 1985).

2.2.2 Duration of life stages

The duration of each life stage depend on many factors, including species, temperature, humidity and host plants. The duration of the life stages has been included in many biological studies for important pest species.

Egg stage

The duration of the egg stage ranges from 3 to 10 days on average for most species (Crooker 1985). The key influencing factor is temperature and the duration can go beyond this range at higher or lower temperatures. For example, the egg stage of *T. urticae* was 3 days at 23.9°C and 21 days at 11.1°C in one study (Crooker 1985, and references therein) and 2.38 days at 32.5°C and 33.19 days at 11.5°C in another study (Crooker 1985, and references therein). The egg stage of *T. turkestani* lasted an average of 2.63 days at 29.4°C, 4.95 days at 23.8°C and 13.5 days at 15.5°C (Carey & Bradley 1982). The egg stage of *T. pacificus* was 2.58 days at 29°C, 4.41 days at 23.8°C and 11.91 days at 15.5°C (Carey & Bradley 1982).

Larval stage

The duration of larval development can be from one day to more than 10 days depending on the species and temperature. For example, larval development time of *T. urticae* reared in an insectary was one day at 22.8°C and 11 days at 12.5°C (Crooker 1985, and references therein). Carey and Bradley (1982) showed that average larval duration was about 1.4 days at 29.4°C for *T. urticae* and 5.6 days at 15.5°C for *T. turkestani*.

Nymphal stage

The development time of nymphs is also mainly depending on the temperature. For example, the duration of development of *T. urticae* ranged from one day at 23.3°C to 13 days at 9°C for protonymphs and 1 day at 23.4°C to 45 days at 4.3°C for deutonymphs (Crooker 1985, and references therein).

Adult stage

Adult longevity can range from one day to more than a month depending on the individual, species and mainly influenced by temperature. Carey and Bradley (1982) recorded adult longevity of three species under two different temperatures. For example, at 23.8°C adults of *T. turkestani* lived for 2–22 days with an average of about 12.46 days, those of *T. pacificus* lived for 6–19 days with an average of about 12.71 days. At 29.4°C, adults of *T. turkestani* lived for 3–18 days with an average of 8.79 days, while those of *T. pacificus* lived for 1–13 days with an average of about 8.91 days.

Gotoh, Moriya and Nachman (2015) recorded the average adult female life span of 5 species of *Tetranychus* under 5 different constant temperatures (Table 2.1). The shortest longevity was 5 days at 35°C for *T. phaselus* Ehara, while the longest was 42.4 days at 15°C for *T. ludeni* Zacher

Taxonomy and biology

(Table 2.1). The general trend from this study is that adult longevity decreases with an increase in temperature.

Table 2.1 Average longevity of adult females in 5 species of *Tetranychus* at five temperatures

Species	15°C (days)	20°C (days)	25°C (days)	30°C (days)	35°C (days)
<i>T. ludeni</i>	42.4	28.8	17.0	9.2	9.4
<i>T. phaselus</i>	29.1	34.5	25.9	10.3	5.0
<i>T. piercei</i>	31.1	18.6	16.9	11.7	7.7
<i>T. truncatus</i>	32.6	26.0	15.9	10.6	5.4
<i>T. urticae</i>	36.5	29.1	20.4	8.0	5.4

Source: Gotoh, Moriya and Nachman (2015)

Crooker (1985) noted that the optimum temperature for most rapid development is from 24°C to 29°C for most species of spider mites.

2.2.3 Reproduction

Spider mites can reproduce sexually and parthenogenetically. Sexual reproduction involves both males and females. Males emerge earlier than females. Average male developmental time was generally about 6–11% shorter than that of females of *T. pacificus*, *T. turkestanii* and *T. urticae* (Carey & Bradley 1982). Male deutonymphs mature first and then locate and remain near female deutonymphs and wait for the mature female to emerge (Crooker 1985). Copulation takes place almost immediately after the emergence of the mature female.

Parthenogenetic reproduction is common in spider mites. The most frequent type of pathogenesis is arrhenotoky, in which unfertilized eggs develop into males. Another type of parthenogenesis is thelytoky, in which unfertilized eggs develop into females. Thelytoky mostly occurs in the subfamily Bryobiinae. Helle and Pijnacker (1985: Table 1.2.3.1) listed parthenogenesis in Tetranychidae for 126 bisexual species: 17 species in 9 genera of Bryobiinae and 109 species in 14 genera of Tetranychinae.

The sex ratio of spider mites is considered to be genetically controlled and usually female biased: 1 male to approximately 3 females in many bisexual species (Helle & Pijnacker 1985, and references therein).

The life of a female can be divided into three phases: preoviposition, oviposition and postoviposition (Zhang 2003). Preoviposition is the time between the emergence of an adult female and the start of its egg laying and can be 12 hours to 5 days depending on temperature (Carey & Bradley 1982; Crooker 1985). Oviposition is from the female's first egg laying to its last egg laying, and is 10-15 days on average but can vary widely depending on species and environmental conditions (Crooker 1985). Oviposition can last for as long as for 40 days (Zhang 2003). Most species also have a post-oviposition phase – the time between the last egg laying and the death of the female, can average from 2.0 to 5.6 days, as for *T. bambusae* Wang & Ma, *T. piercei* McGregor and *T. truncatus* (Ullah, Gotoh & Lim 2014).

Females generally lay their eggs singly on the underside of leaves, as exemplified by the two-spotted mite *T. urticae*, but some species can lay eggs on the upper side of leaves, as observed for the oriental red mite, *Eutetranychus orientalis* (Klein) (Zhang 2008). For many economically

Taxonomy and biology

important species, a single female can lay an average of 5 or 6 eggs per day (Crooker 1985). However, in California, Carey and Bradley (1982) recorded an average maximum daily oviposition of 11.8 eggs/day for a single female of *T. turkestanii* and 8-10 eggs/day for that of *T. pacificus* and *T. urticae* in an experiment on cotton cotyledons under a constant temperature of 23.8°C and 50-65% relative humidity (RH). Maximum egg production generally occurs from day 5 to day 11, although some species, such as *T. turkestanii* and *T. urticae*, can still lay eggs erratically towards the end of their lives (Carey & Bradley 1982).

Total egg production for a single female also varies greatly from about 10 to several hundred depending on species, humidity, temperature, host and other factors (Crooker 1985; Fasulo 2009). Carey and Bradley (1982) reported that, at 23.8°C, the total number of eggs produced by a female ranged from 6 to 181 for *T. turkestanii*, 13 to 163 for *T. pacificus* and 16 to 166 for *T. urticae*. Ullah, Gotoh and Lim (2014: Table 6) summarised information from literature on total eggs per female for 12 species of *Tetranychus*, which ranged from an average of 12.1 to 200.5 per female on leaves of a variety of host plants at 23.8°C to 26°C.

2.2.4 Generations

The number of generations is influenced by the development time from egg to adult, which can vary between species and/or be influenced greatly by temperature, humidity, host plant and other factors (Crooker 1985).

According to Crooker (1985), the developmental time from egg to adult can be 6 to 10 days or more. Ullah, Gotoh and Lim (2014) tabled the results of life table parameters of 12 species of Tetranychidae on different host plants and held at constant temperature of 23.8°C to 26°C. The development time from egg to adult was around 9 to 10 days for most species but was between 7.4 days at 25°C on bean and 12.5 days at 24°C on mulberry for *T. truncatus*.

In the literature development time can also be reported as from egg to egg, which includes an additional 0.5 to 5 days for the time for the preoviposition phase.

As the development time from egg to adult can be relatively short, the mite populations can increase rapidly when conditions such as temperature, humidity and food plants are suitable, resulting in many generations per year. There can be several overlapping generations present in a season due to short development times of the immatures and the long life span of adults.

2.2.5 Diapause

Diapause in spider mites was reviewed by Veerman (1985) and Vacante (2016). Diapause is defined as a genetically determined state of suppressed development, the expression of which may be controlled by environmental factors (Veerman 1985). It enables mites to survive periods of unfavourable environmental conditions, such as low winter temperature (hibernation) and/or summer heat or drought (aestivation) (Veerman 1985). Spider mites use eggs or adult females to go through diapause. Veerman (1985) listed the occurrence of diapause in 36 species of Tetranychidae, with 20 species employing the adult stage and 16 species using the egg stage for diapause. Of the 36 species, 31 were reported to undergo hibernal diapause, 2 aestival diapause, and 3 to have the capacity to undergo both hibernal and aestival diapause.

Nine of the 21 tetranychid species previously assessed by the department were included in the list by Veerman (1985), all of which undergo hibernal diapause: 7 species (*Amphitettranychus*

Taxonomy and biology

viennensis (as *Tetranychus viennensis*), *Oligonychus pratensis*, *Tetranychus canadensis*, *T. kanzawai*, *T. mcdanieli*, *T. pacificus* and *T. turkestanii*) diapause as adult females, and 2 species (*Oligonychus yothersi* and *Panonychus citri*) diapause as eggs.

2.2.6 Dispersal

Dispersal of spider mites has been comprehensively reviewed by Kennedy and Smitley (1985). Relevant information for spider mite dispersal is summarised here based on this review and the references cited therein, unless otherwise specifically indicated.

Spider mites have well-developed dispersal mechanisms enabling their populations to spread and exploit all parts of an individual host plant (intra-plant dispersal) as well as to spread over large areas and colonise widely separated plants (inter-plant dispersal).

Dispersal of spider mites is not a passive phenomenon and, in most instances, it actually involves behavioural response(s) to specific stimuli, such as high population density, deteriorating host plant conditions and/or presence of predators. Many of these behaviours appear to be common among the members of Tetranychidae.

Dispersal by crawling

Crawling is the common means for intra-plant dispersal and can also be important in inter-plant movement within a dense host patch or aggregation, where the individual plants intertwine in the aerial parts and over ground. For example, by crawling between plants, *Tetranychus urticae* populations invade maize fields from weeds growing around the field margins. Mites actively or passively dropping from plant foliage can also crawl on the soil surface. Crawling speed varies greatly depending on soil type, ranging from 5 cm to about 6 m per hour (Kennedy & Smitley 1985). Sabelis (1985) indicates that young females of *T. urticae* can easily walk several metres within a day.

At low population density, mite spread to unoccupied plant parts or other plants is largely by crawling. However, under high population density and plant damage, individuals undergo behaviour changes leading to dispersal from the plant. For *T. urticae*, the initiation of dispersal appears to be a phototactic response to food shortage and desiccation interacting with some unknown factors. The response is intensified under low humidity in the plant microclimate, resulting from extensive mite feeding on the foliage. This phototactic response results in mites moving upwards on plants, where they are presumably more exposed to air movements, facilitating aerial dispersal.

Dispersal by air

Aerial dispersal of mites has been well documented, with mites being captured at altitude as high as 3,048 m (10,000 feet) (Kennedy & Smitley 1985). Aerial dispersal is common in the Tetranychidae, involving at least two different behaviours: spinning downwards or raising the forelegs upright.

A number of spider mites can spin downwards from foliage on silk threads during periods of gentle breeze, which can break the silk threads and carry the mites aloft. Mites affix the threads to a substrate, hang from the thread in the air, and are carried off by the wind. This behaviour has been observed in species including *Eotetranychus sexmaculatus* (Riley), *Oligonychus punicae*

Taxonomy and biology

(Hirst), *O. ununguis* (Jacobi) and *Panonychus citri* McGregor. Species of *Tetranychus* may also disperse within a thick silk unit (about 5 – 10 cm), enclosing many live mites (Gerson 1986, and references therein). In greenhouses, mites may form silk ropes when leaving heavily infested plants. They complete the dispersal by initially concentrating at the upper plant apices to form a silken ball and then spinning threads by which individuals descend and drop. A single silken rope was observed to contain 1,350 protonymphs, 165 deutonymphs and 12 adult females of *Tetranychus* species (Gerson 1986, and references therein).

Aerial dispersal of *Tetranychus urticae* also involves raising the forelegs upright to assume a dispersal posture, as shown in Fig. 1.4.2.1 of Kennedy and Smitley (1985). This behaviour typically occurs after mites have concentrated at the upper portions of the plant and leaf apices. This posture is only manifest when both wind and light are present. However, the orientation is not dependent on wind direction, but is a negative phototactic response with mites orienting to face away from the light source, standing still and raising their forelegs. As a result, the mites face downward toward the ground from the plant stems and leaf edges with forelegs uplifted. This behaviour has been demonstrated to facilitate aerial dispersal of *T. urticae*. In the study, 50% of the adult females adopting this posture were carried aloft by a wind speed of 1.5 metres per second, in contrast to none of the mites in the normal standing posture were carried aloft. Aerial dispersal occurs most commonly as adult females, although the nymphal stages also adopt this behaviour. Adult males and larvae are rarely involved in aerial dispersal.

Aerial dispersal can occur throughout the period of population growth on plants, but greatest levels of aerial dispersal usually happen when the mite population is high and individuals have spread throughout all available foliage.

Dispersal by phoresy

There is a lack of research on phoresy in spider mites. It seems likely that some degree of phoretic dispersal does occur, although it may involve more serendipity than structured behaviour patterns. For example, when birds and large insects alight on plants/foilage heavily infested with spider mites, they are likely to pick up and carry some mites to the next visited plants. Animals brushing against heavily infested plants can potentially also pick up and subsequently transfer mites to other plants.

Dispersal by human activities

Spider mites can be spread by movement of infested plants and/or contaminated tools, machinery and workers clothes both within and between fields.

Long distance dispersal of spider mites is a result of trade activities or movement of infested plant material.

2.2.7 Host plants

Bolland, Gutierrez and Flechtmann (1998) provided a list of 3,600 host plant species belonging to 195 families in the '*World catalogue of the spider mite family (Acari: Tetranychidae)*'. The catalogue lists 1,189 tetranychid species. Krantz and Walter (2009) noted that members of the subfamily Bryobiinae commonly infest grasses and other lower-growing plants, while species of the subfamily Tetranychinae can feed on all higher plant groups.

Review of pest risk assessments of spider mites

Taxonomy and biology

Spider mite species can be monophagous – defined as feeding on one plant genus, oligophagous – feeding on two to 10 plant genera, polyphagous – feeding on 11 or more plant genera, or highly polyphagous – feeding on 50 or more plant families. For example, *T. turkestanii* has been recorded from 65 plant families (Migeon & Dorkeld 2022).

Table 2.2 provides a list of host plant ranges for the 21 spider mites species previously assessed by the department. There are 5 oligophagous, 14 polyphagous and 2 highly polyphagous species (Table 2.2) and none are monophagous. Overall, the host plant ranges of these mites vary from 5 – 271 species, 4 – 171 genera and 2 – 65 plant families.

Table 2.2 Host comparison of spider mite species previously assessed by the department

Spider mite species previously assessed by the department	Host families	Host genera	Host species	Description(a)
<i>Amphitetranychus viennensis</i>	14	30	70	Polyphagous
<i>Eotetranychus asiaticus</i> (now = <i>E. sexmaculatus</i>)	21	37	45	Polyphagous
<i>Eotetranychus geniculatus</i>	4	5	5	Oligophagous
<i>Eotetranychus smithi</i>	6	14	25	Polyphagous
<i>Eutetranychus palmatus</i>	2	4	6	Oligophagous
<i>Oligonychus afrasiaticus</i>	3	7	7	Oligophagous
<i>Oligonychus orthius</i>	4	8	10	Oligophagous
<i>Oligonychus pratensis</i>	10	58	77	Polyphagous
<i>Oligonychus punicae</i>	23	29	34	Polyphagous
<i>Oligonychus velascoi</i>	4	7	7	Oligophagous
<i>Oligonychus yothersi</i>	38	59	66	Polyphagous
<i>Panonychus citri</i> ^(WA)	39	70	113	Polyphagous
<i>Tetranychus canadensis</i>	27	52	67	Polyphagous
<i>Tetranychus kanzawai</i> ^(WA)	63	152	193	Highly polyphagous
<i>Tetranychus macfarlanei</i>	15	34	46	Polyphagous
<i>Tetranychus marianae</i> ^(WA)	26	74	105	Polyphagous
<i>Tetranychus mcdanieli</i>	10	13	15	Polyphagous
<i>Tetranychus pacificus</i>	25	44	54	Polyphagous
<i>Tetranychus piercei</i>	31	64	91	Polyphagous
<i>Tetranychus truncatus</i>	32	70	92	Polyphagous
<i>Tetranychus turkestanii</i>	65	171	271	Highly polyphagous

Sources: Migeon and Dorkeld (2022).

(a): oligophagous – feeding on two to 10 plant genera, polyphagous – feeding on 11 or more plant genera, highly polyphagous – feeding on 50 or more plant families. (WA): Regional quarantine pest for Western Australia.

A single plant species or genus may be attacked by many tetranychid species. For example, apple (*Malus* spp.) can be infested by 46 species (Migeon & Dorkeld 2022) and citrus by 60 species (Vacante 2009) of spider mites.

2.2.8 Feeding and symptoms

All spider mites are phytophagous. They feed by using their eversible stylophore to pierce the epidermis of the host plants (Jeppson, Keifer & Baker 1975). The stylophore is formed by the fusion of the cheliceral structure. The movable digits of the chelicerae are long, often whip-like and recurved proximally, and very suitable for piercing (Zhang 2003). Their feeding removes the contents of cells of palisade tissues, which are the cells just below the upper surface of leaves. Only the attacked cells are damaged and the adjacent cells and the elements of vascular leaf ribs remain unaffected. Therefore, the small punctures from piercing initially become light coloured and later appear as irregular white or greyish spots with prolonged exposure (Vacante 2009). The density of punctures has been observed as being as high as 873 feeding punctures/cm² for *Eutetranychus banksi* (McGregor) on leaves of Valencia orange (Vacante 2009, and references therein).

Spider mites mainly attack leaves of their host plants. However, they can also feed and develop on fruit. For example, *Panonychus citri* and species of *Eutetranychus* feed on both leaves and fruit of citrus (McMurtry 1985). *Eotetranychus yumensis* (McGregor) can readily develop on fruit as well as on leaves and *E. lewisi* (McGregor) is usually found on fruit of citrus (McMurtry 1985). *Oligonychus punicae* (Hirst) mainly feed on the upper leaf surface of avocado but can also feed on fruit in situations of heavy infestation (McMurtry 1985). Colonies of *Tetranychus urticae* develop on both leaves and fruit (Vacante 2009).

Mite attack can cause leaves to become yellowish, grey or yellow-brown, necrosis to form on young leaves, stalks and shoots, leaves to appear burnt or defoliate, fruit to drop, or even death of the whole plant (Vacante 2009; Zhang 2003). Webbing may remain on the plant as part of the symptoms for species that produce silk.

3 Evaluation of previous assessments for spider mites

3.1 Introduction

To date (August 2023), 21 species of Tetranychidae in 6 genera: *Amphitetranychus* (1 species), *Eotetranychus* (3 species), *Eutetranychus* (1 species), *Oligonychus* (6 species), *Panonychus* (1 species) and *Tetranychus* (9 species) have been assessed in 21 finalised PRAs. All of the 21 PRAs were conducted for market access requests for fresh fruit commodities for human consumption (Appendix B).

The 21 tetranychid species do not include the unidentified species of *Tetranychus* in mangosteen from Indonesia (DAFF 2012), nor *Panonychus ulmi* in the cherry from NZ to WA report (AFFA 2003). *Panonychus ulmi* is no longer a regional quarantine pest for WA (Government of Western Australia 2022) and the assessment of *P. ulmi* in that report was undertaken in a form of datasheet, which is not consistent with the current methodology used by the department.

The 21 PRAs that included pest risk assessments for tetranychid species were completed between 2005 and 2023 and can be divided into 2 groups: 5 PRAs with full pest risk assessments and 16 PRAs with partial pest risk assessments.

A full pest risk assessment provides ratings and supporting evidence for the likelihood of entry, likelihood of establishment and likelihood of spread and for the overall consequences.

A partial pest risk assessment provides a rating and supporting evidence for the likelihood of entry, but adopts the likelihood of establishment, likelihood of spread and the overall consequences from full pest risk assessments either for the same species, a different species in the same genus or a different species in a different genus.

The 5 full pest risk assessments together cover 11 species of Tetranychidae (Table 3.1). Three of the 5 full pest risk assessments each included an individual species: *Panonychus citri* in sweet orange from Italy (Biosecurity Australia 2005), *Amphitetranychus viennensis* in apple from China (Biosecurity Australia 2010a) and *Tetranychus kanzawai* in table grapes from China (Biosecurity Australia 2011a). Two of the 5 full pest risk assessments each included multiple species. The full pest risk assessment in the PRA for stone fruit from the USA covered 4 *Tetranychus* species – *Tetranychus canadensis* Mitrofanov, *T. mcdanieli* McGregor, *T. pacificus* McGregor and *T. turkestanii* (Ugarov & Nikolskii) (Biosecurity Australia 2010b). The full pest risk assessment in the PRA for banana from the Philippines covered 4 tetranychid species – *Oligonychus orthius* Rimando, *O. velascoi* Rimando, *Tetranychus marianae* McGregor and *T. piercei* (Biosecurity Australia 2008).

Ten spider mite species were only assessed in partial pest risk assessments (Table 3.1). It is noted that a partial pest risk assessment was also undertaken for an unidentified species of *Tetranychus* in mangosteen from Indonesia (DAFF 2012) (Table 3.1). One of the 10 species, *Eotetranychus asiaticus* (now = *E. sexmaculatus*), is no longer a quarantine pest because it is now present in Australia (Dr Jenny Beard [Queensland Museum] 2022, pers comm., 31 August 2022).

Table 3.1 Tetranychid species assessed fully or partially in the respective PRA by the department

Species	Final PRA
Species with full pest risk assessments	
<i>Amphitetranychus viennensis</i> (a)	Apple from China (Biosecurity Australia 2010a)
<i>Oligonychus orthius</i> <i>Oligonychus velascoi</i>	Banana from Philippines (Biosecurity Australia 2008)
<i>Panonychus citri</i> ^(WA) (a)	Sweet orange from Italy (Biosecurity Australia 2005)
<i>Tetranychus canadensis</i>	Stonefruit from USA (Biosecurity Australia 2010b)
<i>Tetranychus kanzawai</i> ^(WA) (a)	Table grapes from China (Biosecurity Australia 2011a)
<i>Tetranychus marianae</i> ^(WA)	Banana from Philippines (Biosecurity Australia 2008)
<i>Tetranychus mcdanieli</i> (a) <i>Tetranychus pacificus</i> (a)	Stonefruit from USA (Biosecurity Australia 2010b)
<i>Tetranychus piercei</i>	Banana from Philippines (Biosecurity Australia 2008)
<i>Tetranychus turkestani</i> (a)	Stonefruit from USA (Biosecurity Australia 2010b)
Species with partial pest risk assessment(b)	
<i>Eotetranychus asiaticus</i> (now = <i>E. sexmaculatus</i>)(c) <i>Eotetranychus geniculatus</i> <i>Eotetranychus smithi</i>	Strawberry from Japan (DAWE 2020) Adopted ratings from apple from China (2010), table grapes from China (2011)
<i>Eutetranychus palmatus</i> <i>Oligonychus afrasiaticus</i> <i>Oligonychus pratensis</i>	Dates from Middle East and North Africa (DAWR 2019b) Adopted ratings from apple from China (2010), table grapes from China (2011)
<i>Oligonychus punicae</i> <i>Oligonychus yothersi</i>	Avocado from Chile (Department of Agriculture 2019) Adopted ratings from apple from China (2010), table grapes from China (2011)
<i>Tetranychus</i> sp.	Mangosteen from Indonesia (DAFF 2012) Adopted ratings from table grapes from China (2011)
<i>Tetranychus macfarlanei</i> <i>Tetranychus truncatus</i>	Okra from India (DAFF 2023b) Adopted ratings from stonefruit from USA (Biosecurity Australia 2010b)

(a): These species were also included in subsequent PRAs with partial pest risk assessments.

(b): These species were assessed in partial pest risk assessments where only likelihood of entry was assessed and ratings for the likelihood of establishment, likelihood of spread and the overall consequences were adopted from full pest risk assessments.

(c): *Eotetranychus asiaticus* was assessed in strawberry from Japan (DAWE 2020) and is now a junior synonym of *E. sexmaculatus*, which is no longer a quarantine pest as it is recognised as present in Australia (Dr Jenny Beard [Queensland Museum] 2022, pers comm., 31 August 2022).

(WA): Regional quarantine pest for Western Australia.

3.2 Review of likelihood of entry

Likelihood of entry is divided into likelihood of importation and likelihood of distribution.

3.2.1 Review of likelihood of importation

Likelihood of importation is assessed in a pathway specific manner because factors affecting the likelihood of importation of a pest may vary due to, for example, commodity type, the prevalence of the pest and commercial production practices in the exporting country/region. Therefore,

likelihood of importation has generally been assessed in all pest risk assessments, including in partial pest risk assessments.

Previous rating

Likelihood of importation has been assessed as 'Low', 'Moderate' or 'High' over the 21 PRAs (Appendix B). To determine if these ratings are still appropriate for each pathway, this review examines and evaluates the following information.

Evaluation of supporting evidence provided in the previous assessments

This review evaluates the supporting evidence for the assessed tetranychid species associated with each commodity/country pathway considered in the 21 PRAs and consider that the corresponding ratings for the likelihood of importation are appropriate unless suggested otherwise by later scientific information or Australian interception data.

Review of latest relevant scientific literature

Relevant scientific literature has been reviewed. To date, no published information has been found that would result in a change to the previous ratings for the likelihood of importation for the tetranychid species included in the 21 PRAs.

Analysis of Australia's interception data for spider mites

Australia maintains records of spider mites intercepted at the Australian border, which are considered relevant to the likelihood of importation. Following commencement of trade on a pathway, the pest interception data can be used as one of the indicators to verify whether the rating for the likelihood of importation assigned in the respective PRA is appropriate.

Interception of pests at the Australian border is based on Australia's sampling and inspection protocol, which requires that on-arrival inspection in Australia is conducted on 600 units randomly sampled from each homogeneous consignment. If no pests are detected, this sample size provides a confidence level of 95% that not more than 0.5% of the units in the consignment are infested. This implies that when pests are detected, the infestation level is likely to be 0.5% or higher.

Australian interception of spider mites on the fresh fruit pathways assessed in the 21 PRAs

This review focuses on the interception data for the specific fresh fruit pathways covered by the 21 PRAs that contained pest risk assessments for spider mites. Australian interception of spider mites from 2005 to 2021 on these pathways is detailed in Table C.2 and summarised in Table 3.3.

Review of pest risk assessments of spider mites
Evaluation of previous assessments for spider mites

Table 3.2 Interception of spider mites on the fresh fruit pathways assessed in the 21 PRAs

Fresh fruit pathways assessed in the 21 PRAs	Trade occurred (Yes/No)	Spider mites intercepted
Apple from China (Biosecurity Australia 2010a)	Yes	Yes
Stonefruit from the USA (Biosecurity Australia 2010b)	Yes	Yes
Strawberry from South Korea (DAWR 2017b)	Yes	Yes
Sweet orange from Italy (Biosecurity Australia 2005)	Yes	No
Table grapes from China (Biosecurity Australia 2011a)	Yes	No
Table grapes from South Korea (Biosecurity Australia 2011b)	Yes	No
Mangosteen from Indonesia (DAFF 2012)	Yes	No
Nectarine from China (DAWR 2016a)	Yes	No
Table grapes from Mexico (DAWR 2016c)	Yes	No
Avocado from Chile (Department of Agriculture 2019)	Yes	No
Strawberry from Japan (DAWE 2020)	Yes	No
Banana from the Philippines (Biosecurity Australia 2008)	No	N/A
Unshu mandarin from Japan (Biosecurity Australia 2009)	No	N/A
Table grapes from Japan (Department of Agriculture 2014)	No	N/A
Table grapes from India (DAWR 2016b)	No	N/A
Dates from MENA (DAWR 2019b)	No	N/A
Jujube from China (Department of Agriculture 2020)	No	N/A
Apple from the USA (DAFF 2022)	No	N/A
Melons from South Korea (DAFF 2023c)	No	N/A
Okra from India (DAFF 2023b)	No	N/A
Persian limes from Mexico (DAFF 2023a)	No	N/A

Of the pathways assessed in the 21 PRAs, trade has occurred on 11 pathways and spider mites were intercepted on 3 pathways: apple from China (Biosecurity Australia 2010a), stonefruit from the USA (Biosecurity Australia 2010b) and strawberry from South Korea (DAWR 2017b)

It is important to note that the majority of the intercepted specimens were not being identified to species level. Several factors contribute to this, including damage to specimens, life stage and sex of specimens, and/or importers opting for treatment of goods without requesting specimen identification. Thus, most intercepted specimens could only be identified to family or genus level and only 2 species (*Tetranychus mcdanieli* and *T. pacificus*) were identified from some samples associated with stonefruit from the USA.

Relevant information on each of these 3 pathways where spider mites were intercepted are presented.

Apple from China (Biosecurity Australia 2010a):

- Specimens of unidentified Tetranychidae have been intercepted on apples from China, although the assessed species *Amphitetranychus viennensis* was not specifically identified.
- Apart from *A. viennensis* being assessed as a quarantine pest on the pathway, 7 other species of Tetranychidae were categorised as associated with apple crops in China in the PRA. Of these 7 species, 3 are not quarantine pests for Australia (*Bryobia rubrioculus* (Scheuten), *Panonychus ulmi* and *Tetranychus urticae*), and 4 are quarantine pests but were assessed as unlikely to be on the apple fruit from China pathway (*Eotetranychus pruni* (Oudemans), *Eotetranychus* sp., *Tetranychus kanzawai* and *T. turkestani*).
- As the URE for *A. viennensis* on apple from China was assessed as 'Low' (Table C.2), which does not achieve the ALOP for Australia, measures are in place for this spider mite on this pathway.

Stonefruit from the USA (Biosecurity Australia 2010b):

- Two of the 4 assessed species (*Tetranychus mcdanieli* on peach and *Tetranychus pacificus* on nectarine) together with unidentified *Tetranychus* and unidentified Tetranychidae on nectarine, peach and plum have been intercepted from the USA.
- The 2 other assessed species, *Tetranychus canadensis* and *T. turkestani*, were not specifically identified among the intercepted specimens.
- Apart from the 4 assessed species, 8 other species of Tetranychidae were categorised as associated with stonefruit crops in the USA. Of the 8 species, 5 species are non-quarantine pests for Australia: *Bryobia rubrioculus*, *Oligonychus mangiferus* (Rahman & Sapro), *P. ulmi*, *T. neocaledonicus* (Andre) and *T. urticae*. The other 3 are quarantine species, *Eotetranychus carpini* (Oudemans), *E. pruni* (Oudemans) and *Panonychus citri*, but were categorised as unlikely to be on the stonefruit from the USA pathway.
- There have been no measures in place for spider mites on this pathway because the likelihood of importation for these spider mites was assessed as 'Moderate', resulting in their URE being 'Very Low', which achieves the ALOP for Australia (Table C.2).

Strawberry from South Korea (DAWR 2017b):

- *Tetranychus urticae*, unidentified *Tetranychus* and unidentified Tetranychidae have been intercepted on strawberry from South Korea.
- The assessed species *Tetranychus kanzawai* has not been specifically identified among the intercepted specimens.
- The only other species of Tetranychidae categorised as associated with strawberry in South Korea is *T. urticae*, a non-quarantine pest for Australia.
- As the URE for *T. kanzawai* on strawberries from Korea was assessed as 'Low' (Table C.2), which does not achieve the ALOP for Australia, measures are in place for *T. kanzawai* on this pathway.

Proposals for likelihood of importation

This review provides 3 proposals relevant to assessment of the likelihood of importation.

Proposal 1: The likelihood of importation for spider mites associated with stonefruit from USA is proposed to be adjusted from 'Moderate' to 'High'.

- This proposal is based on the fact that spider mites, including those species assessed in the PRA, have been intercepted on this pathway.

Proposal 2: The ratings for the likelihood of importation for spider mites associated with all other specific pathways assigned in the previous respective PRA are still appropriate and should be retained.

Proposal 3: An indicative likelihood of importation of 'High' could be applied to all tetranychid species in future assessments unless there is specific evidence to suggest otherwise.

- An indicative likelihood of importation of 'High' is consistent with the majority of the previous ratings (Table C.2).
- Measures for spider mites are in place for the pathways assessed as having likelihood of importation of 'High'. Spider mites have not been intercepted on most pathways where the likelihood of importation was assessed as 'High' (Table C.2), suggesting that these measures may have been effective.
- The proposed 'indicative' rating of 'High' for likelihood of importation means that, in future assessments, factors relevant to the likelihood of importation should be examined to determine whether the indicative rating can be verified. This approach is consistent with that applied to the Group PRAs for thrips, (DAWR 2017a), mealybugs (DAWR 2019a) and scale insects (DAWE 2021).

3.2.2 Review of likelihood of distribution

Previous rating

In the 21 PRAs, the likelihood of distribution was mostly assessed as 'Moderate', but was assessed as 'High' for *Oligonychus orthius*, *O. velascoi*, *Tetranychus marianae* and *T. piercei* in banana from the Philippines (Biosecurity Australia 2008), and as 'Low' for *Panonychus citri* in sweet orange from Italy (Biosecurity Australia 2005). The likelihood of distribution of 'Low' for *P. citri* was adopted for the same species in subsequent PRAs for Unshu mandarin from Japan (Biosecurity Australia 2009) and avocado from Chile (Department of Agriculture 2019).

Evaluation of supporting evidence provided in the previous assessments

The key factors considered for the likelihood of distribution are the dispersal ability of the pest to reach a host and the availability of the hosts in the environment.

The rating for the likelihood of distribution of 'High' for spider mite species associated with banana from the Philippines (Biosecurity Australia 2008) appears to be overestimated. Circumstances in which mites may have difficulty reaching a susceptible host plant from the disposed banana waste material, exemplified by the statement '*....., spider mites would need to find a susceptible host in a short time or succumb to desiccation, starvation or other factors*' appears not to have been considered when a rating of 'High' was assigned.

The supporting evidence provided for the rating of 'Low' for *P. citri* in sweet orange from Italy (Biosecurity Australia 2005) appears to be underestimated. The 'Low' rating appears to have overlooked the ability of mites to crawl to reach nearby host plants. Also, *P. citri* is polyphagous, being reported on 113 species of host plants (Table 2.2), many of which are widely available in the PRA area.

In general, spider mites imported with fresh fruit would likely survive transportation, retail sale, and waste disposal. They are likely to enter the external environment through the disposal of waste by retailers and individual consumers.

When conditions at waste disposal deteriorate, it would stimulate the mites to disperse. Spider mites may disperse to host plants in 2 ways. Firstly, spider mites can reach a nearby host plant through their ability to crawl, as detailed under Section 2.2.6. Secondly, stimulated by the deteriorated condition, it is feasible that spider mites may initially crawl to a non-host plant and climb to the upper part of the plant, from where they could use the air currents to become airborne and reach a suitable host. It has been shown that, apart from passive dispersal by wind, the spider mites' dispersal behaviours can be proactive and include raising the forelegs upright for the wind to carry them (Kennedy & Smitley 1985). These mite pests are mostly polyphagous (Table 2.2) and a number of their hosts are species close to or at ground level, potentially in close proximity to disposed waste in backyards, roadsides and parks. Disposed waste would deteriorate quickly, so mites would have a limited timeframe to find a suitable host.

Overall, the evidence supports a rating of likelihood of distribution of 'Moderate', which considers the ability of spider mites to disperse by crawling and by air currents, as well as the wide availability of host plants in the PRA area, moderated by the factor of mites having a limited time to find a host.

Review of latest relevant scientific literature

Relevant scientific literature has been reviewed. To date, no information indicates that likelihood of distribution differs significantly among spider mite species assessed in the 21 PRAs.

Proposals for likelihood of distribution

This review provides 2 proposals relevant to assessment of the likelihood of distribution.

Proposal 1: A likelihood of distribution of 'Moderate' is considered to be appropriate for all 20 quarantine tetranychid species included in the 21 PRAs.

Proposal 2: An indicative likelihood of distribution of 'Moderate' could be applied to all tetranychid species in future assessments, unless there is specific evidence to indicate otherwise.

- The proposed indicative rating of 'Moderate' for likelihood of distribution means that, in future assessments, factors relevant to the likelihood of distribution should be examined to determine whether the indicative rating can be verified. This approach is consistent with that applied to the Group PRAs for thrips, (DAWR 2017a), mealybugs (DAWR 2019a) and scale insects (DAWE 2021).

3.3 Review of likelihood of establishment

Previous rating

The likelihood of establishment has been assessed consistently as 'High' for all species, except as 'Moderate' for *Panonychus citri* in the sweet orange from Italy PRA (Biosecurity Australia 2005). The 'Moderate' rating for *P. citri* was adopted for the same species in subsequent PRAs for Unshu mandarin from Japan (Biosecurity Australia 2009) and avocado from Chile (Department of Agriculture 2019).

Evaluation of supporting evidence provided in the previous assessments

This review considers that the evidence presented for the likelihood of establishment for *P. citri* supports a rating of 'High' instead of 'Moderate'. *Panonychus citri* is already established in

eastern Australia and being reported from many other countries (Migeon & Dorkeld 2022). *Panonychus citri* is polyphagous, being reported on 113 species of host plants (Table 2.2) and many of its host plants are widely available in Western Australia. In addition, *P. citri* has a short life cycle and its population can build up quickly when conditions are suitable (Vacante 2009). Thus, the likelihood of establishment of 'High' for *P. citri* is more appropriate, and also consistent with that of other species that share similar biological characteristics, assessed in other PRAs.

Review of latest relevant scientific literature

Relevant scientific literature has been reviewed. To date, no information suggests that likelihood of establishment differs significantly among spider mite species included in the 21 PRAs.

Proposals for likelihood of establishment

This review provides 2 proposals relevant to assessment of the likelihood of establishment.

Proposal 1: The likelihood of establishment of 'High' is appropriate for all 20 quarantine tetranychid species included in the 21 PRAs.

Proposal 2: A likelihood of establishment of 'High' could be applied to all tetranychid species in future assessments, unless there is specific evidence to indicate otherwise.

- The department recognises that there may be exceptions to the proposed ratings if counter evidence is available.

3.4 Review of likelihood of spread

Previous ratings

The likelihood of spread has been assessed as either 'Moderate' or 'High' in the 5 final PRAs containing full pest risk assessments for tetranychid species.

Likelihood of spread was rated as 'High' for *Oligonychus orthius*, *O. velascoi*, *Tetranychus marianae* and *T. piercei* in banana from the Philippines PRA (Biosecurity Australia 2008) and for *T. canadensis*, *T. mcdanieli*, *T. pacificus* and *T. turkestanii* in the stonefruit from the USA PRA (Biosecurity Australia 2010b).

A likelihood of spread of 'High' rating was adopted for *T. turkestanii* in the nectarine from China PRA (DAWR 2016a), for *T. mcdanieli*, *T. pacificus* and *T. turkestanii* in the apple from the USA PRA (DAFF 2022) and for *T. macfarlanei* and *T. truncatus* in the okra from India PRA (DAFF 2023b).

Likelihood of spread was assessed as 'Moderate' for *Panonychus citri* in the sweet orange from Italy PRA (Biosecurity Australia 2005), for *Amphitetranychus viennensis* in the apple from China PRA (Biosecurity Australia 2010a) and for *Tetranychus kanzawai* in the table grapes from China PRA (Biosecurity Australia 2011a).

A rating of 'Moderate' was adopted for the following species and PRAs:

- *Panonychus citri* in Unshu mandarin from Japan (Biosecurity Australia 2009) and avocado from Chile (Department of Agriculture 2019)
- *Tetranychus kanzawai* in table grapes from Japan (Department of Agriculture 2014), table grapes from South Korea (Biosecurity Australia 2011b), table grapes from India (DAWR 2016b), table grapes from Mexico (DAWR 2016c), strawberry from South Korea (DAWR 2017b), strawberry from Japan (DAWE 2020) and melons from South Korea (DAFF 2023c)

- *Amphitetranychus viennensis* in nectarine from China (DAWR 2016a), strawberry from Japan 2020 (DAWE 2020) and jujube from China 2020 (Department of Agriculture 2020)
- *Tetranychus* sp. in mangosteen from Indonesia (DAFF 2012)
- *Eutetranychus palmatus*, *Oligonychus afrasiaticus* and *O. pratensis* in dates from Middle East and North Africa (DAWR 2019b)
- *Oligonychus punicae* and *O. yothersi* in avocado from Chile (Department of Agriculture 2019)
- *Eotetranychus geniculatus* and *E. smithi* in strawberry from Japan 2020 (DAWE 2020).

Evaluation of supporting evidence provided in the previous assessments

Evaluation of the supporting evidence provided in the previous assessments shows:

- There is agreement across all the 5 PRAs that the natural and/or managed environment in the PRA area is suitable for the natural spread of spider mite pests.
- The assessments generally indicated that it would be difficult for spider mites to disperse across existing natural barriers unaided.
- The assessments generally concluded that spider mites have the potential for movement with commodity or conveyance.
- For intended use of the host commodities, some assessments in the PRAs mention fruit for human consumption, nursery stock and commercial crops.
- Consideration of vector is not applicable because spider mites do not require vectors for their spread.
- With regard to natural enemies, some assessments in the PRAs stated that natural enemies are unknown in the PRA area or if present, that their roles and effectiveness are unknown.
- Other information was also included in some assessments, such as the short generation time of spider mites, widespread host plant availability and ability of spider mites to diapause.

The review considers that there are no sufficient grounds to support the different ratings assigned for likelihood of spread for different spider mite species included in those 5 PRAs.

Review of latest relevant scientific literature

Relevant scientific literature has been reviewed. To date, no information suggests that likelihood of spread differs significantly among tetranychid species included in the 21 PRAs.

Further assessment of the likelihood of spread of spider mites

To determine an appropriate rating for likelihood of spread for tetranychid species, the review includes a further assessment against factors to be considered when assessing likelihood of spread (Section A2.2.3 in Appendix A). This assessment is based on the relevant scientific information currently available, following the department's Group PRA approach. The assessment is mainly focused on the 20 quarantine species included in the 21 PRAs.

The likelihood that tetranychid mites will spread within Australia, based on factors that affect the expansion of the geographic distribution of the pests is assessed as 'High'.

The likelihood of spread of 'High' for tetranychid mites is proposed because these mites can spread by natural means. The pests are generally polyphagous and their host plants have a variety of intended end uses. As such, spider mite pests can also be spread over long distances

via human-assisted movement, including trade, of infected plants or plant parts. Spider mite pests also have high fecundity and a short generation time.

The following information provides supporting evidence for this assessment.

Suitability of the natural and/or managed environment for natural spread of the pest

The mechanisms employed by spider mites for their natural spread are detailed under the description of biology (Section 2.2). Briefly, spider mites can disperse naturally by crawling and/or by air currents. Aerial dispersal is not necessarily passive, in most cases, spider mites can positively respond to dispersal stimuli, such as high population density and deteriorating conditions of their host plant, by climbing to the tip of the plant in preparation to be carried away to new host plants. These well-developed dispersal mechanisms enable mite populations to disperse to all parts of an individual host plant and/or to spread to over large areas and colonise widely separated plants.

The natural environment in Australia is suitable for the natural spread of spider mites. The same or similar environmental conditions to where spider mite pests currently occur are available throughout Australia, which contains tropical, subtropical, temperate and cool temperate regions (Bureau of Meteorology 2021).

Managed environments conducive to spread of spider mites are also available in Australia. For example, greenhouse and nursery environments can be suitable for aiding the spread of spider mites.

Presence of natural barriers

Natural barriers exist between different areas within Australia and/or within a particular state or territory. For example, long geographic distances arid areas, such as the Nullarbor Plain, exist between the east and the west of the continent and Bass Strait separates the mainland from Tasmania. Climatic differentials also occur between the north and the south. It would be difficult for spider mites to naturally disperse through their own activities from one such area to another without the assistance of wind dispersal and/or human activity, such as long distance transportation of infested plant material.

Potential for movement with commodities or conveyances

Spider mites are small and can be inconspicuous, and can easily be concealed in buds and leaf bases, under bracts and in the calyx of fruit, enabling mites to hide in plants and plant material. Spider mites can also contaminate farm machinery and farm workers' clothes. Movement of infested plant materials and contaminated items can spread mites between orchards, between nurseries and between different areas over large distances.

The polyphagous nature of the mite pests (Table 2.2) provides additional chance for them to be moved with commodities. Many species of Tetranychidae, such as *Tetranychus urticae*, are believed to have been introduced into new areas or regions through this means.

The small size and concealed habit enable spider mites on infested nursery stocks, including live plants, to be dispersed for long distance between different districts of a state/territory, and between states/territories, including overcoming natural barriers.

Intended use of the commodity

A variety of intended use of plants and plant parts derived from the large number of spider mite hosts is to be expected, including as fresh fruit and vegetables for human consumption, cut-flowers and foliage for decoration and ornamental purposes, cereal crops for human consumption, grains and fodder for animal feed and nursery stock for propagation and/or planting. Plants and plant parts, many of which are hosts of spider mites, are frequently moved around the country, and this assists the spread of eggs, nymphs and adults.

Potential vectors of the pest in the PRA area

Spider mites do not require a vector for their dispersal.

Potential natural enemies of the pest in the PRA area

Natural enemies of spider mites have been comprehensively reviewed in the book: *Spider mites: their biology, natural enemies and control* Volume 1B edited by Helle and Sabelis (1985a). The most important natural enemies are the predatory mites in the family Phytoseiidae. Some species of Phytoseiidae, such as *Phytoseiulus persimilis* Athias-Henriot, *Typhlodromus occidentalis* Nesbitt and *T. pyri* Scheuten, have been shown to be effective biocontrol agents for tetranychid pests and have been commercially produced. Other predatory mites in the families Stigmaeidae, Anystidae, Cheyletidae, and Erythraeidae can also feed on spider mites. In addition, spiders and insects such as ladybirds can also prey on spider mites. Some viruses and fungi have also been reported as natural pathogens for spider mites.

Members of these families or groups of natural enemies are present in Australia, but their impact on the spread of introduced spider mites in Australia is unknown. It can be anticipated that they are unlikely to have a significant impact on the spread of exotic spider mites because they can also use the local mites as food sources, and would not specifically target the introduced mite species.

For the reasons outlined, the likelihood that tetranychid mites will spread within Australia, based on factors that affect the expansion of the geographic distribution of the pests is assessed as 'High'.

Proposal for the likelihood of spread

This review provides 2 proposals relevant to assessment of the likelihood of spread.

Proposal 1: The likelihood of spread of 'High' is appropriate for all 20 quarantine tetranychid species included in the 21 PRAs.

Proposal 2: The likelihood of spread of 'High' could be applied also to all other tetranychid species in future assessments, unless there is specific evidence to indicate otherwise.

- The department recognises that there may be exceptions to the proposed ratings if counter evidence is available.

3.5 Review of consequence assessments

3.5.1 Criteria for consequence assessment

The method for consequence assessment is detailed in Section A2.3 in Appendix A. In brief, the method indicates that consequence assessment is based on the consideration of the pest's effect on six criteria:

direct effect on

- i. plant life or health
- ii. other aspects of environment

indirect effect on

- iii. eradication and control
- iv. domestic trade
- v. international trade
- vi. non-commercial and environment.

The magnitude of the effect is represented by an impact score of A-G for each criterion.

The evidence provided and the scores assigned in the previous assessments are reviewed and evaluated under each of these 6 criteria.

3.5.2 Review of direct effect on plant life or health

Among the 6 criteria, the overall consequence rating relies heavily on the impact score given to the direct effect on plant life or health.

Previous impact score

The impact score for plant life or health was rated as either 'D' or 'E' in the 5 PRAs containing full pest risk assessments.

The impact score was rated as 'D' in 3 PRAs for 9 species: sweet orange from Italy (Biosecurity Australia 2005) for *Panonychus citri*, banana from the Philippines (Biosecurity Australia 2008) for *Oligonychus orthius*, *O. velascoi*, *Tetranychus marianae* and *T. piercei* and stonefruit from the USA (Biosecurity Australia 2010b) for *Tetranychus canadensis*, *T. mcdanieli*, *T. pacificus* and *T. turkestanii*.

The impact score of 'D' was adopted in subsequent PRAs for *P. citri* in Unshu mandarin from Japan (Biosecurity Australia 2009) and avocado from Chile (Department of Agriculture 2019), for *T. turkestanii* in nectarine from China (DAWR 2016a), for *T. mcdanieli*, *T. pacificus* and *T. turkestanii* in apple from the USA (DAFF 2022) and for *T. macfarlanei* and *T. truncatus* in okra from India (DAFF 2023b).

The impact score was rated as 'E' in 2 PRAs for 2 species: apple from China (Biosecurity Australia 2010a) for *Amphitetranychus viennensis* and table grapes from China (Biosecurity Australia 2011a) for *Tetranychus kanzawai*.

The impact score of 'E' was adopted in subsequent PRAs for:

- *Amphitetranychus viennensis* in nectarine from China (DAWR 2016a), strawberry from Japan 2020 (DAWE 2020) and jujube from China 2020 (Department of Agriculture 2020)
- *Tetranychus kanzawai* for table grapes from Japan (Department of Agriculture 2014), table grapes from South Korea (Biosecurity Australia 2011b), table grapes from India (DAWR 2016b), table grapes from Mexico (DAWR 2016c), strawberry from South Korea (DAWR 2017b), strawberry from Japan (DAWE 2020) and melons from South Korea (DAFF 2023c)
- *Tetranychus* sp. for mangosteen from Indonesia (DAFF 2012).
- *Eotetranychus geniculatus* and *E. smithi* in strawberry from Japan 2020 (DAWE 2020)
- *Eutetranychus palmatus*, *Oligonychus afrasiaticus* and *O. pratensis* in dates from Middle East and North Africa (DAWR 2019b)
- *Oligonychus punicae* and *O. yothersi* for avocado from Chile (Department of Agriculture 2019).

Evaluation of supporting evidence provided in the previous assessments

The evaluation of the supporting evidence presented in the 5 PRAs indicates that the evidence is similar across the different PRAs, and that there is insufficient information to support differences in the assigned impact score (of 'D' or 'E') among the different spider mite species. For example, the evidence presented in the stonefruit from the USA PRA for the score of 'D' for *T. canadensis*, *T. mcdanieli*, *T. pacificus* and *T. turkestanii*, is very similar to that presented in the table grapes from China PRA for the score of 'E' for *T. kanzawai*.

Review of relevant latest scientific literature

Relevant latest scientific literature has been reviewed. To date, no information suggests that the direct effect on plant life or health differs significantly among tetranychid species included in the 21 PRAs.

Further assessment of direct effect of spider mites on plant life or health

To determine an appropriate impact score for direct effect on plant life or health, the review includes a further assessment against factors to be considered when assessing direct effect of a pest on plant life or health. This assessment is based on information currently available, following the department's Group PRA approach. The assessment is mainly focused on the 20 quarantine species included in the 21 PRAs.

Known or potential host plants and type, amount and frequency of damage

The number of host plant species, examples of main host crops and typical symptoms and damage to host plants for the 20 quarantine tetranychid species previously assessed by the department is shown in Table 3.4. Further information on the feeding damage and symptoms caused by tetranychid mites is described in Section 2.2.8.

Table 3.3 Host plant species, symptoms and damage of the 20 quarantine spider mite species previously assessed by the department

Spider mite species	Host species(a)	Examples of 3 main host crops	Symptoms and damage
<i>Amphitetranychus viennensis</i>	70	Apple, pear, stonefruit	Leaves appearing yellowish grey, reducing number and size of buds, causing defoliation (Vacante 2009)

Review of pest risk assessments of spider mites
Evaluation of previous assessments for spider mites

Spider mite species	Host species(a)	Examples of 3 main host crops	Symptoms and damage
<i>Eotetranychus geniculatus</i>	5	Indian strawberry, strawberry, table grapes	Feeding on leaves, likely causing symptom and damage similar to other species of <i>Eotetranychus</i> (Vacante 2009)
<i>Eotetranychus smithi</i>	25	Apple, strawberry, table grapes	Feeding on leaves, likely causing symptom and damage similar to other species of <i>Eotetranychus</i> (Vacante 2009)
<i>Eutetranychus palmatus</i>	6	Cotton, dates, palm	Causing chlorotic scarring and blemishes on date fruit (Vacante 2009)
<i>Oligonychus afrasiaticus</i>	7	Dates, maize, sugarcane	Infesting pinnae and fruit of date palms, webbing covering dates so dust deposited in the webbing and thus the mite is also called date dust mite, infested dates becoming progressively drier and unsuitable for marketing and human consumption (Vacante 2009)
<i>Oligonychus orthius</i>	10	Banana, sorghum, sugarcane	Feeding on leaves and causing typical tetranychid damaging symptoms (Vacante 2009)
<i>Oligonychus pratensis</i>	77	Dates, sugarcane, wheat	Symptom and damage on coconut, dates, maize, sorghum, sugarcane, turf and wheat described in Vacante (2016), feeding on dates resulting in hardened, shrivelled, cracked and bronzed fruit
<i>Oligonychus punicae</i>	34	Avocado, mango, table grapes	Infesting lower and upper sides of leaves and fruit of avocado, leaves becoming brownish or bronzed and covered by whitish eggs and cast skins, causing partial defoliation (Vacante 2009)
<i>Oligonychus velascoi</i>	7	Banana, coconut, maize	Feeding on leaves and causing typical tetranychid damaging symptoms (Vacante 2009)
<i>Oligonychus yothersi</i>	66	Avocado, mango, table grapes	Symptom and damage on avocado, eucalyptus, coffee, and tea plant described in Vacante (2016), severe infestation causing bronzing on entire upper surface and part lower surface of avocado leaves and part defoliation.
<i>Panonychus citri</i>	113	Apple, citrus, stonefruit	Leaves with grey or silver appearance, green fruit becoming pale, mature fruit turning pale straw yellow, leaves and fruit dropping, twig dieback and large branches dying (Vacante 2009)
<i>Tetranychus canadensis</i>	67	Apple, cotton, stonefruit	Leaves turning rusty brown, causing leaves dropping, on barley hosts, leaves darkening initially, followed by yellowing, withering and sometimes crinkling, (Vacante 2009)
<i>Tetranychus kanzawai</i> ^(WA)	193	Grapes, Stonefruit, strawberry	Yellow spots on leaves, discoloration of bark and webbing on stems, effect on leaves, stems, fruit and also young tea shoots (Vacante 2009)
<i>Tetranychus macfarlanei</i>	46	Citrus, melons, okra	Causing leaves yellowish speckling, followed by leaf senescence and eventually falling (Vacante 2009)
<i>Tetranychus marianae</i> ^(WA)	105	Banana, cotton, tomato	Feeding on leaves, likely causing symptom and damage to other species of <i>Tetranychus</i> (Vacante 2009)
<i>Tetranychus mcdanieli</i>	15	Apple, citrus, stonefruit	Initially on ventral surface of leaves and reach upper surface later (Seeman & Beard 2005), causing typical tetranychid damaging symptoms (Vacante 2009)

Spider mite species	Host species(a)	Examples of 3 main host crops	Symptoms and damage
<i>Tetranychus pacificus</i>	54	Almond, grapes, stonefruit	Causing stippling on leaves, leaves turning brown and died, showing burning and bronzing appearance, resulting in defoliation and decreasing fruit maturity and quality (Vacante 2009)
<i>Tetranychus piercei</i>	91	Banana, capsicum, papaya	Infesting young leaves and shoots, yellow spots on leaves, leave burning, flowers and fruit dropping (Liu & Liu 1986)
<i>Tetranychus truncatus</i>	92	Cotton, melons, okra	Leaves speckling with yellow and bronze colours, infested cotton leaves showing yellowish spots and often associated with webbing on the lower leaf surface (Vacante 2009)
<i>Tetranychus turkestanii</i>	271	Apple, cotton, stonefruit	Feeding on lower surface of leaves and damage showing on the upper surface as necrotic areas, leaves dropping and plant death in high density, reducing cotton seed yields (Vacante 2009)

(a): Number of host plant species is based on Migeon and Dorkeld (2022). (WA): Regional pest for Western Australia.

Table 3.4 highlights that:

- all assessed species feed on and damage plants, all have multiple host plants including economically important crops
- all have host plants widely available in the PRA area
- all cause similar symptoms and damage – attacking leaves, shoots, stems and fruit, and causing leaf burning, defoliation and fruit dropping, or even plant death in high density.

Crop losses, in yield and quality

Tetranychid mites have caused damage and losses to crops in the countries where they occur. More than one hundred species of Tetranychidae are considered to be important pests, and about ten species are considered to be major pests (Migeon & Dorkeld 2022).

The species previously assessed by the department in the 21 PRAs have been reported as pests of many crops (Table 3.5). They all cause damage and yield losses to these crops, but there is generally a lack of information on the actual monetary loss caused by these mites.

Australia has significant primary industries with many host crops that are subject to attack by spider mites. For example, In 2017–2018, Australia’s annual gross value of production (GVP)—the value of production at the point of sale was \$4,266 million for horticulture, including apples, bananas, citrus, pears, stone fruit and table grapes and \$4,096 million for vegetables, including beans, capsicum, cucumbers, lettuce and tomatoes (ABS 2019). It is expected that the actual loss caused by a given pest would only be a portion and not the full extent of the GVP values for these industries.

Biotic factors and abiotic factors affecting damage and losses

The basic interactions between mites and their host plants are affected by both biotic and abiotic factors (Rabbinge 1985). These factors may influence the relationship between yield loss and mite population density.

Biotic factors include conditions of the host plants and the adaptability of the mite species. Nitrogen content and leaf age of the host plants are generally considered to be major biotic

factors. For example, nitrogen shortage can affect the fecundity and development of spider mites (Rabbinge 1985). However, in the modern crop system, there is generally no nitrogen shortage in crop leaves and maximal fecundities are normally reached (Rabbinge 1985).

Abiotic factors that can influence the mite population and thus affect the damage and yield losses include temperature, humidity, sunlight and wind. For example, high temperature and low humidity can increase the severity of damage by *Tetranychus pacificus* and water stress makes plants more susceptible to attack by *T. mcdanieli* (Vacante 2009). Suitable climatic conditions are available in Australia (Bureau of Meteorology 2021).

Rate of spread

The dispersal of spider mites is discussed in detail in Section 2.2. They have well-developed dispersal mechanisms enabling intra-plant dispersal and inter-plant dispersal over large areas (Kennedy & Smitley 1985). When the density of the population becomes high, and/or the host plant condition deteriorates, spider mites are able to initiate dispersal through crawling or by preparation for transport by wind.

Rate of reproduction

Species of Tetranychidae can reproduce both sexually and parthenogenetically. Parthenogenetic reproduction is common in spider mites.

Spider mites can develop from egg to adult in a short time period and are able to reproduce many and/or overlapping generations in a season because of the short development time of the immature stages and the long life span of adults, which can last for more than a month.

Spider mites have high fecundity. An individual female can lay 5 or 6 eggs daily on average and up to hundreds of eggs in total in their lifetime (Ullah, Gotoh & Lim 2014: Table 6). Thus, the mite populations can increase rapidly when conditions such as temperature, humidity and food plants are suitable. This could increase the damage to their host plants.

More information on the reproduction of spider mites is described in Section 2.2.

Summary of the assessment

The assessment undertaken in this review supports a consistent impact score for direct effect on plant life or health for all 20 quarantine spider mite species included in the 21 PRAs because:

- Most of these spider mite pests are polyphagous (Table 2.2).
- The types of their damage to plants are similar – attacking leaves, shoots, stems and fruit, causing leaf burning, defoliation and fruit dropping, or even death of the plant (Table 3.5).
- They are important pests of horticultural and agricultural crops, including the oligophagous species of *Eotetranychus*, *Eutetranychus* and *Oligonychus*. Some example crops include apple, banana, citrus, cotton, stonefruit, sugarcane and table grapes (Table 3.5).
- Similar biotic and abiotic factors affect the mite populations and the severity of their damage to host plants. These factors and conditions are available in Australia.
- These spider mites can initiate and spread quickly when the population density becomes high, and/or the host plant condition deteriorates.
- They have high fecundity and short generation time and thus can reproduce quickly when environmental conditions are suitable and food plants available.

The assessment considers an impact score of 'D' for the direct effect on plant life or health is appropriate for all 20 quarantine spider mite species included in the 21 PRAs. This is because the impact would be expected to threaten economic viability through a large decrease in production of infested crops at the local level. Damage caused by a spider mite includes weakening plant vigour to decrease yield and impacting the appearance of produce to reduce market value. The impact on plant industries is expected to be significant at the district level and of minor significance at the regional level because these industries within a state or territory are usually diverse in composition of hosts and physically dispersed.

An impact score of 'E' is considered to be overestimated, as this would indicate that the direct impact of a spider mite pest on plant life or health would be of major significance at the district level. A major significance at the district level means that the impact would be expected to threaten economic viability through a large decrease in production of infested crops at the district level and the damage is not expected to be reversible. A scenario of unreversible economic impact at a district level by a spider mite pest is considered to be unlikely.

In addition, it is noted that the impact score of 'D' proposed for spider mite pests is comparable to that of other arthropod groups assessed by the department, such as thrips (DAWR 2017a), mealybugs (DAWR 2019a) and scale insects (DAWE 2021). From a broad perspective, pests in these insect groups are considered to cause similar degrees of damage to plants to that caused by spider mite pests.

Proposal for the impact score for direct effect on plant life or health

This review provides 2 proposals relevant to the impact score for direct effect on plant life or health.

Proposal 1: The impact score of 'D' for the direct effect on plant life or health is appropriate for all 20 quarantine tetranychid species included in the 21 PRAs.

Proposal 2: An impact score of 'D' for the direct effect on plant life or health could be applied to all other tetranychid species in future assessments, unless there is specific evidence to indicate otherwise.

- Other tetranychid pests are also plant feeders and their host plants would include important economic crops, and they would cause similar damage to host plants by feeding on leaves, shoots, stems and fruit and can causing leaf burning, defoliation and fruit dropping, or even plant death.
- The department recognises that there may be exceptions to the proposed impact score if counter evidence is available.

3.5.3 Review of direct effect on other aspects of environment

The impact score for direct effect on other aspect of environment in the 5 PRAs containing full pest risk assessments was rated as 'B' for 7 species in 4 PRAs, i.e., sweet orange from Italy (Biosecurity Australia 2005), apple from China (Biosecurity Australia 2010a), table grapes from China (Biosecurity Australia 2011a) and stonefruit from the USA (Biosecurity Australia 2010b), and as 'D' for 4 species in 1 PRA, i.e., banana from the Philippines (Biosecurity Australia 2008).

Examination of the supporting evidence provided in the 5 PRAs and latest relevant scientific information indicates that there are no significant differences with respect to the direct effect of these different spider mite species on other aspects of environment.

The review considers an impact score of 'B' for direct effect on other aspects of environment is appropriate for all 20 quarantine tetranychid species included in the 21 PRAs. This is because a tetranychid pest may have a minor impact on native spider mites by competing for the same or similar resources locally with native species. It is not likely to cause reduction of keystone plant species, or plant species that are major components of ecosystems or significant reduction, displacement or elimination of other plant species.

The review considers the impact score of 'D' assigned for the 4 tetranychid species in banana from the Philippines (Biosecurity Australia 2008) to be overestimated. It is expected they may also have a minor impact on native spider mites by competing for the same or similar resources locally with native species, which should be assigned an impact score of 'B', similar to other tetranychid species considered in this review.

Proposal for the impact score for direct effect on other aspects of the environment

This review provides 2 proposals relevant to the impact score for direct effect on other aspects of the environment.

Proposal 1: An impact score of 'B' is appropriate for all 20 quarantine tetranychid species included in the 21 PRAs.

Proposal 2: An impact score of 'B' for the direct effect on other aspects of the environment could be applied to all other tetranychid pests in future assessments, unless there is specific evidence to indicate otherwise.

- The department recognises that there may be exceptions to the proposed impact score if counter evidence is available.

3.5.4 Review of indirect effect on eradication and control

The impact score for indirect effect on eradication and control were previously assessed as 'D', for all species except as 'C' for *Panonychus citri* in the sweet orange from Italy PRA.

In Australia, an exotic pest incursion will trigger an immediate response by Australian federal, state and territory governments and relevant industries, and there are costs involved with this response (Plant Health Australia 2020). The initial response includes consideration of the feasibility of eradication of the pest from Australia.

The difficulty of eradicating spider mite pests results from factors including their wide range of host plants, capacity for dispersal by wind and through spread on infested plant material and commodities, as well as the commonly delayed period to detection.

Once an exotic pest becomes established and eradication is not considered feasible, it is necessary to control and manage the pest on an ongoing basis. Control of spider mite pests usually involves cultural, physical, biological and chemical control methods. Chemical control is reserved for suppressing large pest population sizes when cultural, physical and/or biological measures become ineffective.

The presence of a new pest in any agricultural and horticultural cropping system will likely require initial investigation and ongoing additional research to determine what modifications to existing management regimes are required, and to evaluate their effectiveness. In Australia, such

research is often funded under shared government and industry arrangements and may take years to complete.

The review considers an impact score of 'D' is appropriate for all 20 quarantine tetranychid species included in the 21 PRAs. This is because the impact would be expected to threaten economic viability through a large increase in costs for containment, eradication and control at a local level. Containment and eradication activities are costly and would also cause significant disruption to agribusiness at the district level. The costs associated with the initial response to an incursion and ongoing control of the introduced pest, including any additional research requirement, would be expected to be of minor significance at the regional level.

The review considers the impact score of 'C' assigned for *P. citri* is underestimated. *Panonychus citri* is a pest of citrus and many other crops. It is polyphagous, being reported from 113 species of host plants. The measures and costs of eradication and/or control of *P. citri* would be similar to other exotic spider mites should the species be introduced to Western Australia. The supporting evidence on eradication and control described for all other species is also applicable to *P. citri*.

Proposal for the impact score for indirect effect on eradication and control

This review provides 2 proposals relevant to assessment of the impact score for indirect effect on eradication and control.

Proposal 1: An impact score of 'D' is appropriate for all 20 quarantine tetranychid species included in the 21 PRAs.

Proposal 2: An impact score of 'D' for the indirect effect on eradication and control could be applied to all other tetranychid pests in future assessments, unless there is specific evidence to indicate otherwise.

- The department recognises that there may be exceptions to the proposed impact score if counter evidence is available.

3.5.5 Review of indirect effect on domestic trade

The impact score for indirect effect on domestic trade was previously assessed as 'B' for *Panonychus citri* in sweet orange from Italy, as 'D' for *Amphitetanychus viennensis* in apple from China and as 'C' for the remaining 9 species in the other 3 PRAs.

All the supporting evidence for indirect effect on domestic trade provided in the 5 PRAs containing full pest risk assessments state that there would be effect on domestic trade if exotic spider mites were to be detected in Australia.

Australian states and territories have their own domestic biosecurity restrictions for pests of concern for their jurisdictions. An intergovernmental body has been established to ensure that the development of domestic market access conditions for plants and plant products in Australia is technically justified, coordinated and harmonised, and consistent with Australia's international import and export conditions and policies (Plant Health Australia 2019). When an exotic pest is detected and its distribution is limited in area, this body can restrict intra- and/or inter-state movement of affected commodities to prevent the pest's spread. Such a restriction would clearly impact on domestic trade. However, it is expected that such impact would be different between a regional quarantine pest for a state or territory and a national quarantine

pest for the whole of Australia. As a principle, an outbreak of a national quarantine pest could have a greater effect on domestic trade than a regional quarantine pest.

Of the 11 species assessed in the full pest risk assessments, 8 species are national quarantine pests and 3 species are regional quarantine pests.

The national quarantine pests are *Amphitetranynchus viennensis*, *Oligonychus orthius*, *O. velascoi*, *Tetranychus canadensis*, *T. mcdanieli*, *T. pacificus*, *T. piercei*, and *T. turkestanii*. If a national quarantine pest was detected in Australia, initially it would likely be restricted to a relatively small area. Quarantine measures would be enforced to prevent the movement of host material out of the incursion area for both intra-and inter-state trade.

The regional quarantine pests are *Panonychus citri*, *Tetranychus kanzawai* and *T. marianae*. These species are regional quarantine pest for Western Australia only as they are now present in the eastern Australia. If a regional quarantine pest was detected in the PRA area, the effect would likely be experienced only for intrastate trade and the economic impact would be limited to that state or territory. For example, if an outbreak of any of these 3 pests occurs in Western Australia, the effect on domestic trade would only be intrastate for different localities in that state.

The review considers the impact score of 'C' for indirect effect on domestic trade is appropriate for national quarantine tetranychid species. This is because the impact would be expected to threaten economic viability through a moderate reduction of trade or loss of domestic markets at the local level. Biosecurity measures would be enforced to prevent the movement of infested plant material out of the initial incursion area, which would have significant economic impacts on plant industries and business at the local level. The introduction of a new pest to a district would be likely to disrupt intra- and/or interstate trade due to biosecurity restrictions on the domestic movement of affected commodities. This would be expected to be of minor significance at the district level.

The review considers the impact score of 'B' for indirect effect on domestic trade is appropriate for regional quarantine tetranychid species. This is because the biosecurity restrictions would only be expected to have a minor impact for intrastate trade at the local level.

Proposal for the impact score for indirect effect on domestic trade

This review provides 4 proposals relevant to assessment of the impact score for indirect effect on domestic trade.

Proposal 1: An impact score of 'C' for indirect effect on domestic trade is appropriate for all national quarantine tetranychid species included in the 21 PRAs.

Proposal 2: The impact score of 'C' could be applied to other national quarantine tetranychid species in future assessments, unless there is specific evidence to indicate otherwise.

- The department recognises that there may be exceptions to the proposed impact score if counter evidence is available.

Proposal 3: An impact score of 'B' for indirect effect on domestic trade is appropriate for all regional quarantine tetranychid species included in the 21 PRAs.

Proposal 4: The impact score of 'B' for indirect effect on domestic trade could be applied to other regional quarantine tetranychid species in future assessments, unless there is specific evidence to indicate otherwise.

- It is noted that, in future assessments, it is probable some tetranychid mites may be regional quarantine pests for several states or territories and may warrant an impact score of 'C', as explained in Figure A.1.
- The department recognises that there may be exceptions to the proposed impact score if counter evidence is available.

3.5.6 Review of indirect effect on international trade

The impact score for indirect effect on international trade were assessed as 'C' for the 4 species in banana from Philippines and the 4 species in stonefruit from USA, and as 'D' for *Panonychus citri* in sweet orange from Italy, *Amphitetanychus viennensis* in apple from China and *Tetranychus kanzawai* in table grapes from China.

All the supporting evidence provided in the 5 PRAs states that there would be effect on international trade if exotic spider mites were to be present in commercial production areas in Australia but absent from the trading partners.

Many countries require phytosanitary measures to mitigate the risk posed by their tetranychid quarantine species. Australia is a significant exporter of agricultural and horticultural commodities, including hosts of tetranychid species. Should exotic tetranychid species become established on crops grown for export markets, Australia's trading partners may impose phytosanitary measures, typically inspection and treatment if spider mites are detected, resulting in additional export costs and/or disruption to the existing trade.

The review considers that the impact score of 'C' for the indirect effect on international trade is appropriate for all tetranychid species considered in this review. This is because the impact would be expected to threaten economic viability through a moderate reduction and/or disruption of trade and export markets at the local level and have a minor impact on affected industries at the district level. Resources would also be required to support affected industries in regaining market access or in implementing the additional phytosanitary measures.

The review considers the impact score of 'D' for the indirect effect on international trade to be overestimated. It is not expected that the establishment and spread of exotic spider mite species would have a significant impact on affected industries at the district level.

Proposal for the impact score for indirect effect on international trade

This review provides 2 proposals relevant to assessment of the impact score for indirect effect on international trade.

Proposal 1: An impact score of 'C' for indirect effect on international trade is proposed for all 20 quarantine tetranychid species included in the 21 PRAs.

Proposal 2: An impact score of 'C' for the indirect effect on international trade could be applied to all other tetranychid pests in future assessments, unless there is specific evidence to indicate otherwise.

- The department recognises that there may be exceptions to the proposed impact score if counter evidence is available.

3.5.7 Review of indirect effect on non-commercial and environment

The impact score for indirect effect on non-commercial and environmental was assessed as 'B' for all 11 tetranychid species in all the 5 PRAs. The supporting evidence basically states that the impact would be of minor significance at the local level, resulting from potential for spray drift by the additional use of pesticides for controlling of exotic pests.

Spray drift of pesticide application can result in soil toxicity, runoff and water system contamination (APVMA 2008; NSW DPI 2012). The Australian Pesticides and Veterinary Medicines Authority (APVMA) defines spray drift as the physical movement of spray droplets (and their dried remnants) through the air from the nozzle to any off-target site at the time of application or soon thereafter (APVMA 2008). Spray drift has been implicated with the decline of some butterflies in Australia (Sands & New 2002). Soil toxicity in agricultural systems is reported in the USA to inhibit germination and lead to elevated pesticide residues in plants (Dalvi & Salunkhe 1975), possibly leading to issues with maximum residue limits (MRLs) and saleability of crops. Runoff and leaching may affect biodiversity in aquatic ecosystems (NSW DPI 2012).

The review considers the impact score of 'B' for indirect effect on non-commercial and environment is appropriate for all 20 quarantine tetranychid species included in the 21 PRAs.

Proposal for the impact score for indirect effect on non-commercial and environmental

This review provides 2 proposals relevant to assessment of the impact score for indirect effect on non-commercial and environmental.

Proposal 1: An impact score of 'B' for the indirect effect on the non-commercial and environmental is appropriate for all 20 quarantine tetranychid species included in the 21 PRAs.

Proposal 2: An impact score of 'B' for the indirect effect on the non-commercial and environmental could be applied to all other tetranychid pests in future assessments, unless there is specific evidence to indicate otherwise.

- The department recognises that there may be exceptions to the proposed impact score if counter evidence is available.

3.5.8 Overall consequences

Proposal for the overall consequences rating

This review provides 2 proposals relevant to overall consequences.

Proposal 1: An overall consequences of 'Low' is appropriate for all 20 quarantine tetranychid species included in the 21 PRAs.

- The proposed overall consequences of 'Low' is based on the impact scores of 'D' proposed for the direct effect on 'Plant life or health' and for the indirect effect on 'Eradication and control'. The overall consequences rating is determined using the decision rules described in Table A.3, that is, where the consequences of a pest with respect to one or more criteria having an impact score of 'D', the overall consequence rating is estimated to be 'Low'.

Proposal 2: An overall consequences of 'Low' could be applied to all other tetranychid pests in future assessments, unless there is specific evidence to indicate otherwise.

- The department recognises that there may be exceptions to the proposed impact score if counter evidence is available.

4 Proposed ratings and potential implication of their application

This chapter summarises information on proposed ratings in comparison with previous ratings assigned in the 21 PRAs (Section 4.1, Table D.1) and discusses the potential implication from the application of the proposed ratings (Section 4.2, Table D.2).

4.1 Summary of previous and proposed ratings

Previous ratings assigned in the 21 PRAs and ratings proposed in this review are summarised in Table 4.1 and details are provided in Table D.1.

Table 4.1 Summary of previous ratings assigned in the 21 PRAs and proposed ratings in this review

Likelihood or consequences	Previous ratings in the 21 PRAs	Proposed ratings in this review
Likelihood of importation	Low, Moderate or High (pathway specific)	<ol style="list-style-type: none"> 1. Maintain previous ratings assigned in the PRAs, except for stonefruit from USA (a) 2. 'High' for stonefruit from USA 3. 'High' (indicative, pathway specific) for all tetranychid species in future assessments (b)
Likelihood of distribution	Low, Moderate or High (pathway and/or species specific)	<ol style="list-style-type: none"> 1. 'Moderate' for all 20 quarantine tetranychid species included in the 21 PRAs 2. 'Moderate' (indicative, pathway and/or species specific) for all tetranychid species in future assessments (c)
Likelihood of establishment	Moderate or High	<ol style="list-style-type: none"> 1. 'High' for all 20 quarantine tetranychid species included in the 21 PRAs 2. 'High' for all other tetranychid species in future assessments, unless there is specific evidence to indicate otherwise
Likelihood of spread	Moderate or High	<ol style="list-style-type: none"> 1. 'High' for all 20 quarantine tetranychid species included in the 21 PRAs 2. 'High' for all other tetranychid species in future assessments, unless there is specific evidence to indicate otherwise
Overall consequences	Low or Moderate	<ol style="list-style-type: none"> 1. 'Low' for all 20 quarantine tetranychid species included in the 21 PRAs 2. 'Low' for all other tetranychid species in future assessments, unless there is specific evidence to indicate otherwise

(a): For tetranychid species associated with a pathway where the rating of likelihood of importation has previously been assessed as 'Moderate' or lower and the species is subsequently intercepted on the pathway, the indicative rating of 'High' can be applied to the species on that pathway.

(b): Likelihood of importation of 'High' is proposed as an indicative rating for all other tetranychid mite species in future assessments, unless there is information to suggest otherwise. This means in future assessments, factors relevant to the likelihood of importation should be examined to determine whether or not the indicative likelihood of 'High' can be verified, following the application of Group PRAs, as explained in Section A2.7 of Appendix A and exemplified in the latest PRA reports.

(c): Likelihood of distribution of 'Moderate' is proposed as an indicative rating for all other tetranychid mite species in future assessments, unless there is information to suggest otherwise. This means in future assessments, factors relevant to the likelihood of distribution should be examined to determine whether the indicative likelihood of 'Moderate' can be verified, following the application of Group PRAs, as explained in Section A2.7 of Appendix A and exemplified in the latest PRA reports.

Proposed ratings for the likelihoods of entry, establishment and spread and the overall consequences as well as the resulting UREs for the 20 quarantine tetranychid species included in the 21 PRAs are compared with the previous ratings in Table D.1. The URE is determined by combining the estimates of the likelihood of entry, establishment and spread with the overall consequence rating by using the risk estimation matrix of Table A.4.

4.2 Changes of URE resulting from the application of proposed ratings

The application of the proposed ratings would result in changes to the URE for tetranychid species associated with some commodity/country pathways (Table D.2). A pest's URE determines whether or not its risk achieves the ALOP for Australia. The URE of 'Very Low' or lower achieves the ALOP for Australia (Table A.4), and therefore specific risk management measures for the tetranychid species are not required for the pathway. The URE of 'Low' or higher does not achieve the ALOP for Australia (Table A.4), and therefore specific risk management measures for the tetranychid species are required for the pathway. Thus, changes to the URE can result in changes to the URE outcome, i.e., the risk of the pest changing from achieving the ALOP for Australia (URE of 'Very Low' or 'Negligible') to not achieving the ALOP for Australia (URE of 'Low', 'Moderate', 'High' or 'Extreme'), or *vice versa*.

The URE outcome from the application of proposed ratings for tetranychid species on the pathways relevant to the 21 PRAs are summarised in Table D.2. As the likelihood of entry is pathway and/or species specific, consequently, the same tetranychid species may have different UREs on different pathways. Likewise, the different tetranychid species on the same pathway may have different UREs.

The application of the proposed ratings (Table D.1) means that, where the likelihood of importation is assessed as 'High' for spider mite species on a particular pathway, the URE would be 'Low', which does not achieve the ALOP for Australia and risk management measures for those species will be required for that pathway. Where the likelihood of importation is assessed as 'Moderate' or lower for spider mite species on a specific pathway, the resultant URE would be 'Very Low' or 'Negligible', which achieves the ALOP for Australia and risk management measures for those species will not be required for that pathway.

4.3 Potential implication on pathways relevant to the 21 PRAs

Of the 21 PRAs, trade has occurred for only 11 commodity/country pathways (Table D.2).

This section discusses the potential implication for individual commodity/country pathways relevant to the 21 PRAs when the proposed ratings are applied.

At this stage, the department does not intend to implement changes resulting from this review. Following the finalisation of this review, implementation will be undertaken on a case-by-case basis for specific pathway in consultation with relevant stakeholders.

These pathways are discussed under 3 categories:

- i. pathways with URE outcome for spider mites changed from achieving to not achieving the ALOP for Australia (section 4.3.1)
- ii. pathways with URE outcome for spider mites changed from not achieving to achieving the ALOP for Australia (section 4.3.2)

- iii. pathways with URE outcome for spider mites unchanged (i.e., remaining as either achieving or not achieving the ALOP for Australia) (section 4.3.3)

It is noted that some pathways have more than one URE outcome for different spider mite species on the same pathway, i.e. with some species having URE outcome achieving ALOP for Australia and others having URE outcome not achieving ALOP for Australia.

4.3.1 Pathways with URE outcome for spider mites changed from achieving to not achieving the ALOP for Australia

A change of the URE outcome from achieving to not achieving the ALOP for Australia will require specific risk management measures for tetranychid species associated with the respective commodity/country pathways. Risk management measures for tetranychid mites include inspection and remedial action if the pests are detected. These measures are the same as those for mites in other families and for insect groups such as mealybugs and thrips.

The 3 commodity/country pathways for which the URE outcome of associated tetranychid species will change from achieving to not achieving the ALOP for Australia as a result of the application of the proposed ratings include sweet orange from Italy, Unshu mandarin from Japan and stonefruit from the USA (Table D.2).

Sweet orange from Italy and Unshu mandarin from Japan

There has been some trade for sweet orange from Italy but no trade as yet for Unshu mandarin from Japan.

Panonychus citri is assessed as being associated with the pathways of sweet orange from Italy and Unshu mandarin from Japan. The URE and URE outcome for *P. citri* on these pathways would be changed from previous 'Very Low', which achieves the ALOP for Australia, to 'Low', which does not achieve the ALOP for Australia. These changes in URE and URE outcome result from the changes of rating for likelihood of distribution from 'Low' to 'Moderate', likelihood of establishment from 'Moderate' to 'High' and likelihood of spread from 'Moderate' to 'High' (Table D.1).

As a result, specific risk management measures would be introduced on these pathways for *P. citri*. However, this introduction is not expected to impact on the overall measures for these pathways. This is because both these pathways already have requisite risk management measures in place for other pests, such as mealybugs, other mites and thrips, that are the same as the measures that would be required for *P. citri*.

Stonefruit from the USA

There has been substantial trade on this pathway.

Tetranychus canadensis, *T. mcdanieli*, *T. pacificus* and *T. turkestanii* are assessed as being associated with the stonefruit from the USA pathway. The URE and URE outcome for these 4 tetranychid species on this pathway would be changed from 'Very Low', which achieves the ALOP for Australia, to 'Low', which does not achieve the ALOP for Australia (Table D.1). These changes in URE and URE outcome result from the change of rating for likelihood of importation from 'Moderate' to 'High' due to the fact that at least two of these species have been intercepted on this pathway (Table C.2).

As a result, specific risk management measures would be introduced on this pathway for *T. canadensis*, *T. mcdanieli*, *T. pacificus* and *T. turkestanii*. However, this introduction is not expected to impact on the overall measures for this pathway. This is because the pathway already has requisite risk management measures in place for other pests, such as mealybugs and thrips, that are the same as the measures that would be required for these spider mite species.

4.3.2 Pathways with URE outcome for spider mites changed from not achieving to achieving the ALOP for Australia

A change of the URE outcome from not achieving to achieving the ALOP for Australia will require specific risk management measures for tetranychid species being removed from the respective commodity/country pathways.

The 6 commodity/country pathways for which the URE outcome of associated tetranychid species will change from not achieving to achieving the ALOP for Australia as a result of the application of the proposed ratings include: table grapes, strawberry and melon from South Korea, nectarine and jujube from China, and strawberry from Japan (Table D.2).

Table grapes, strawberry and melon from South Korea

There has been a substantial volume of trade for table grapes and limited trade for strawberry from South Korea. There has been no trade as yet for melons from South Korea.

Tetranychus kanzawai is assessed as being associated with the table grapes, strawberry and melon from South Korea pathways. The URE and URE outcome for *T. kanzawai* on these pathways would be changed from 'Low', which does not achieve the ALOP for Australia, to 'Very Low', which achieves the ALOP for Australia. The changes in URE and URE outcome result from the change of the overall consequences from 'Moderate' to 'Low', even though the likelihood of spread would be raised from 'Moderate' to 'High' (Table D.1).

As a result, specific risk management measures would be removed from these 3 pathways for *T. kanzawai*. However, this removal is not expected to impact on the overall measures for these pathways. This is because the pathways still requires risk management measures for other pests, such as mealybugs and/or thrips, that are the same measures as those required for *T. kanzawai*.

As explained in note (a) under Table 4.1, future detection of *T. kanzawai* on these pathways will trigger the change in its likelihood of importation from 'Moderate' to 'High', resulting in the URE be changed from 'Very Low' to 'Low' and the measures be re-introduced.

Nectarine from China

There has been substantial volume of trade for nectarine from China.

Amphitetranynchus viennensis and *Tetranychus turkestanii* are assessed as being associated with nectarine from China pathway.

The URE and URE outcome for *A. viennensis* on this pathway would be changed from 'Low', which does not achieve the ALOP for Australia, to 'Very Low', which achieves the ALOP for Australia. These changes in URE and URE outcome result from the change of the overall consequences rating from 'Moderate' to 'Low', even though the likelihood of spread would be raised from 'Moderate' to 'High' (Table D.1).

As a result, specific risk management measures would be removed from this pathway for *A. viennensis*. However, this removal is not expected to impact on the overall measures for this pathway. This is because the pathway still requires risk management measures for other pests, such as mealybugs and thrips, that are the same measures as those required for *A. viennensis*.

The URE and URE outcome for *T. turkestanii* remains unchanged as 'Very Low' on this pathway, which achieves the ALOP for Australia (Table D.1).

As explained in note (a) under Table 4.1, future detection of *A. viennensis* and/or *T. turkestanii* on this pathway will trigger the change in its likelihood of importation from 'Moderate' to 'High' for *A. viennensis* and/or from 'Low' to 'High' for *T. turkestanii* resulting in the URE be changed from 'Very Low' to 'Low' and the measures be re-introduced.

Jujube from China

There has been no trade as yet for jujube from China.

Amphitetranychus viennensis is assessed as being associated with jujube from China pathway.

The URE and URE outcome for *A. viennensis* on this pathway would be changed from 'Low', which does not achieve the ALOP for Australia, to 'Very Low', which achieves the ALOP for Australia. These changes in URE and URE outcome are resulted from the change of the overall consequences rating from 'Moderate' to 'Low', even though the likelihood of spread would be raised from 'Moderate' to High' (Table D.1).

As a result, specific risk management measures would be removed from this pathway for *A. viennensis*. However, this removal is not expected to impact on the overall measures for this pathway. This is because the pathway still requires risk management measures for other pests, such as mealybugs and thrips, that are the same measures as those required for *A. viennensis*.

As explained in note (a) under Table 4.1, future detection of *A. viennensis* on this pathway will trigger the change in its likelihood of importation from 'Moderate' to 'High', resulting in the URE be changed from 'Very Low' to 'Low' and the measures be re-introduced.

Strawberry from Japan

There has been a very small volume of trade for this pathway.

Amphitetranychus viennensis, *Eotetranychus smithi*, *E. asiaticus* (now = *E. sexmaculatus*), *E. geniculatus* and *Tetranychus kanzawai* are assessed as being associated with strawberry from Japan pathway. *Eotetranychus asiaticus* (now = *E. sexmaculatus*) is no longer a quarantine pest for Australia. The URE and URE outcome for the 4 quarantine tetranychid species on this pathway would be changed from 'Low', which does not achieve the ALOP for Australia, to 'Very Low', which achieves the ALOP for Australia. These changes to URE and URE outcome result from the change of the overall consequences rating from 'Moderate' to 'Low', even though the likelihood of spread would be raised from 'Moderate' to 'High' (Table D.1).

As a result, specific risk management measures would be removed for the 4 quarantine tetranychid species associated with this pathway. However, this removal is not expected to impact on the overall measures for this pathway. This is because the pathway still requires risk

management measures for other pests, such as thrips, that are the same measures as those required for these 4 tetranychid species.

As explained in note (a) under Table 4.1, future detection of *A. viennensis*, *E. smithi*, *E. geniculatus* and/or *T. kanzawai* on this pathway will trigger the change in their likelihood of importation from 'Moderate' to 'High', resulting in the URE be changed from 'Very Low' to 'Low' and the measures be re-introduced.

4.3.3 Pathways with URE outcome for spider mites unchanged (i.e., remaining as either achieving or not achieving the ALOP for Australia)

Where the URE outcome for tetranychid species remain unchanged as not achieving the ALOP for Australia, specific risk management measures for the species will continue to be required for the respective commodity/country pathways.

The 11 commodity/country pathways for which the URE outcome of associated tetranychid species will remain unchanged as not achieving the ALOP for Australia as a result of the application of the proposed ratings include banana from the Philippines, apple from China, table grapes from China, India, Japan and Mexico, mangosteen from Indonesia, dates from MENA, avocado from Chile, apple from the USA and okra from India (Table D.2).

The commodity/country pathway for which the URE outcome of associated tetranychid species will remain unchanged as achieving the ALOP for Australia as a result of the application of the proposed ratings is Persian limes from Mexico (Table D.2).

Banana from Philippines

There has been no trade as yet for this pathway.

Oligonychus orthius, *O. velascoi*, *Tetranychus marianae* and *T. piercei* are assessed as being associated with banana from the Philippines pathway. The URE and URE outcome for these 4 tetranychid species on this pathway remains the same as 'Low', which does not achieve the ALOP for Australia, although the likelihood of distribution would be reduced from 'High' to 'Moderate' (Table D.1).

Apple from China

There has been substantial volume of trade for this pathway.

Amphitetranychus viennensis is assessed as being associated with apple from China pathway. The URE and URE outcome for *A. viennensis* on this pathway remains the same as 'Low', which does not achieve the ALOP for Australia, although the likelihood of spread would be raised from 'Moderate' to 'High' and the overall consequences rating would be reduced from 'Moderate' to 'Low' (Table D.1).

Table grapes from China, India, Japan and Mexico

There has been substantial trade for both table grapes from China and from Mexico but no trade as yet for table grapes from India and Japan.

Tetranychus kanzawai is assessed as being associated with the pathways of table grapes from China India, Japan and Mexico. The URE and URE outcome for *T. kanzawai* on these pathways remains the same as 'Low', which does not achieve the ALOP for Australia, although the

likelihood of spread would be raised from 'Moderate' to 'High' and the overall consequences rating would be reduced from 'Moderate' to 'Low' (Table D.1).

Mangosteen from Indonesia

There has been some trade for this pathway.

Species of *Tetranychus* assessed as being associated with the mangosteen from Indonesia pathway were not being identified. The URE and URE outcome for the unidentified species of *Tetranychus* on this pathway remains the same as 'Low', which does not achieve the ALOP for Australia, although the likelihood of spread would be raised from 'Moderate' to 'High' and the overall consequences rating would be reduced from 'Moderate' to 'Low' (Table D.1).

Dates from MENA

There has been no trade as yet for this pathway.

Eutetranychus palmatus, *Oligonychus afrasiaticus* and *O. pratensis* are assessed as being associated with the dates from MENA pathway. The URE and URE outcome for these 3 tetranychid species on this pathway remains the same as 'Low', which does not achieve the ALOP for Australia, although the likelihood of spread would be raised from 'Moderate' to 'High' and the overall consequences rating would be reduced from 'Moderate' to 'Low' (Table D.1).

Avocado from Chile

There has been substantial volume of trade for this pathway.

Oligonychus punicae, *O. yothersi* and *Panonychus citri* are assessed as being associated with avocado from Chile pathway.

The URE and URE outcome for *O. yothersi* on this pathway remains the same as 'Low', which does not achieve the ALOP for Australia, although the likelihood of spread would be raised from 'Moderate' to 'High' (Table D.1) and the overall consequences rating would be reduced from 'Moderate' to 'Low' (Table D.1).

However, the URE and URE outcome for *O. punicae* on this pathway would be changed from previous 'Low', which does not achieve the ALOP for Australia, to 'Very Low', which achieves the ALOP for Australia. These changes result from the change of the overall consequence rating from 'Moderate' to 'Low', although the likelihood of spread would be raised from 'Moderate' to 'High' (Table D.1).

The URE for *P. citri* on this pathway would be changed from 'Negligible' to 'Very Low', but the URE outcome would remain the same as achieving the ALOP for Australia. The change in URE results from the likelihood of distribution being raised from 'Low' to 'Moderate', the likelihood of establishment and likelihood of spread both being from 'Moderate' to 'High'.

There will be no impact on the overall measures for this pathway because the pathway still requires risk management measures for *O. yothersi* and other pests, such as mealybugs and thrips, that are the same measures as those required for *O. punicae* and *P. citri*.

Apple from the USA

There has been no trade as yet for this pathway.

Tetranychus mcdanieli, *T. pacificus* and *T. turkestanii* are assessed as being associated with apple from the USA pathway.

The URE and URE outcome for *T. mcdanieli* on this pathway remains the same as 'Low', which does not achieve the ALOP for Australia (Table D.1). The URE and URE outcome for *T. pacificus* and *T. turkestanii* remain as 'Very Low', which achieves the ALOP for Australia (Table D.1).

Okra from India

There has been no trade as yet for this pathway.

Tetranychus macfarlanei and *T. truncatus* are assessed as being associated with okra from India pathway.

The URE and URE outcome for *T. macfarlanei* and *T. truncatus* on this pathway remain the same as 'Low', which does not achieve the ALOP for Australia (Table D.1).

Persian limes from Mexico

There has been no trade as yet for this pathway.

Panonychus citri is assessed as being associated with Persian limes from Mexico pathway.

The URE and URE outcome for *P. citri* on this pathway remain the same as 'Very Low', which achieve the ALOP for Australia (Table D.1), although the likelihood of distribution would be raised from 'Low' to 'Moderate' and likelihood of establishment and of spread both would be raised from 'Moderate' to 'High'.

5 Conclusion

This draft report was conducted to determine whether the different risk ratings previously assigned for spider mite species that share common biological characteristics relevant to biosecurity risk are appropriate and, if not, propose a way to address associated issues.

The draft report was conducted in accordance with Australia's method for pest risk analysis (Appendix A), which is consistent with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: Framework for pest risk analysis (FAO 2019a) and ISPM 11: Pest risk analysis for quarantine pests (FAO 2019b), and the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO 1995).

In conclusion, this draft report confirms that most of the ratings previously assigned for the 20 quarantine species of spider mites assessed in the 21 PRAs are appropriate. The draft report also proposes adjustment for some previously assigned ratings to reflect evidence now available and/or aligned to reflect similar level of biosecurity risk posed by members of this pest group.

The findings of this report are based on a comprehensive analysis of scientific literature and other relevant information.

Appendix A: Method for pest risk analysis

This section sets out the method for the pest risk analysis (PRA) used by the Department of Agriculture, Fisheries and Forestry (the department). This method is consistent with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO 2019a) and ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2019c) and the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO 1995).

It is important to note that not all aspects in the department's method for PRA outlined in this appendix are applicable to this review. The method for the likelihood and consequence assessments are specifically applicable to this review.

A PRA is 'the process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it' (FAO 2021). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent, injurious to plants or plant products' (FAO 2021). A 'quarantine pest' is '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).

Biosecurity risk consists of 2 major components: the likelihood of a pest entering, establishing and spreading in Australia for a defined import pathway; and the consequences should this happen. These 2 components are combined to give an overall estimate of the pest risk for the defined import pathway.

Unrestricted risk is estimated taking into account, where applicable, the existing commercial production practices of the exporting country and procedures that occur on arrival in Australia. These procedures include verification by the department that the consignment received is as described on the commercial documents and its integrity has been maintained.

Restricted risk is estimated with phytosanitary measure(s) applied. A phytosanitary measure is '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).

A PRA is conducted in 3 consecutive stages: initiation (A1), pest risk assessment (A2) and pest risk management (A3).

A1 Stage 1: Initiation

Initiation identifies the pest(s) and pathway(s) that are of biosecurity concern and should be considered for risk analysis in relation to the identified PRA area.

A pathway is 'any means that allows the entry or spread of a pest' (FAO 2021).

For this risk analysis, the 'PRA area' is defined as Australia for pests that are absent, or of limited distribution and under official control. For areas with regional freedom from a pest, the 'PRA area' may be defined based on a state or territory of Australia or may be defined as a region of Australia consisting of parts of a state or territory or several states or territories.

According to ISPM 11 (FAO 2019c), the PRA process may be initiated as a result of:

- the identification of a pathway that presents a potential pest hazard. For example, international trade is requested for a commodity not previously imported into the country or a commodity from a new area or new country of origin
- the identification of a pest that may require phytosanitary measures. For example, a new pest risk is identified by scientific research, a pest is repeatedly intercepted, a request is made to import an organism, or an organism is identified as a vector of other pests
- the review or revision of a policy. For example, a country's decision is taken to review phytosanitary regulations, requirements or operations or a new treatment or loss of a treatment system, a new process, or new information impacts on an earlier decision.

The basis for the initiation of this risk analysis is defined in Chapter 1 (section 1.1).

The primary elements in the initiation stage are:

- identity of the pests
- potential association of each pest with the pathway being assessed.

The identity of the pests is presented at species level by the species' scientific name in most instances, but a lower taxonomic level may be used where appropriate. Synonyms are provided where the current scientific name differs from that provided by the exporting country's National Plant Protection Organisation (NPPO) or where the cited literature used a different scientific name.

The potential association of each pest with the pathway being assessed considers information on:

- association of the pest with the host plant/commodity and
- the presence or absence of the pest in the exporting country/region relevant to the pathway being assessed.

A2 Stage 2: Pest risk assessment

The process for pest risk assessment includes 2 sequential steps:

- pest categorisation (A2.1)
- further pest risk assessment, which includes evaluation of the likelihoods of the introduction (entry and establishment) and spread of a pest (A2.2) and evaluation of the magnitude of the associated potential consequences (A2.3).

A2.1 Pest categorisation

Pest categorisation examines the pests identified in the initiation stage (A1) to determine which of these pests meet the definition of a quarantine pest and require further pest risk assessment.

ISPM 11 (FAO 2019c) states that '*The opportunity to eliminate an organism or organisms from consideration before in-depth examination is undertaken is a valuable characteristic of the categorisation process. An advantage of pest categorisation is that it can be done with relatively little information; however information should be sufficient to adequately carry out the categorisation*'. In line with ISPM 11, the department utilises the pest categorisation step to screen out some pests from further consideration where appropriate. For each pest that is not present in Australia, or is present but under official control, the department assesses its potential to enter (importation and distribution) on the pathway being assessed and, if having

potential to enter, its potential to establish and spread in the PRA area. For a pest to cause economic consequences, the pest will need to enter, establish and spread in the PRA area. Therefore, pests that do not have potential to enter on the pathway being assessed, or have potential to enter but do not have potential to establish and spread in the PRA area, are not considered further. The potential for economic consequences is then assessed for pests that have potential to enter, establish and spread in the PRA area. Further pest risk assessments are then undertaken for pests that have potential to cause economic consequences, i.e., pests that meet the criteria for a quarantine pest.

Pest categorisation uses the following primary elements to identify the quarantine pests and to screen out some pests from further consideration where appropriate for the pathway being assessed:

- presence or absence and regulatory status in the PRA area
- potential for entry, establishment and spread in the PRA area
- potential for economic consequences in the PRA area.

A2.2 Assessment of the likelihood of entry, establishment and spread

ISPM 11 (FAO 2019c) provides details of how to assess the ‘probability of entry’, ‘probability of establishment’ and ‘probability of spread’ of a pest. The SPS Agreement (WTO 1995) uses the term ‘likelihood’ rather than ‘probability’ for these estimates. In qualitative PRAs, the department uses the term ‘likelihood’ as the descriptor. The use of the term ‘probability’ is limited to the direct quotation of ISPM definitions.

A summary of the assessment process is given here, followed by a description of the qualitative methodology used in this risk analysis.

A2.2.1 Likelihood of entry

The likelihood of entry describes the likelihood that a quarantine pest will enter Australia when a given commodity is imported, be distributed in a viable state in the PRA area and subsequently be transferred to a host.

For the purpose of considering the likelihood of entry, the department divides this step into 2 components:

- **Likelihood of importation** – the likelihood that a pest will arrive in Australia in a viable state when a given commodity is imported
- **Likelihood of distribution** – the likelihood that the pest will be distributed in a viable state, as a result of the processing, sale or disposal of the commodity, in the PRA area and subsequently transfer to a susceptible part of a host.

Factors to be considered in the likelihood of importation may include:

- likelihood of the pest being associated with the pathway at origin
 - prevalence of the pest in the source area
 - occurrence of the pest in a life-stage that would be associated with the commodity
 - mode of trade (for example, bulk, packed)
 - volume and frequency of movement along each pathway

- seasonal timing of imports
- pest management, cultural and commercial procedures applied at the place of origin (for example, application of plant protection products, handling, culling, and grading)
- likelihood of survival of the pest during transport or storage
 - speed and conditions of transport and duration and conditions of storage compared with the duration of the life cycle of the pest
 - vulnerability of the life-stages of the pest during transport or storage
 - prevalence of the pest likely to be associated with a consignment
 - commercial procedures (for example, refrigeration) applied to consignments during transport and storage in the country of origin, and during transport to Australia
- likelihood of pest surviving existing pest management procedures.

Factors to be considered in the likelihood of distribution may include:

- commercial procedures (for example, refrigeration) applied to consignments during distribution in Australia
- dispersal mechanisms of the pest, including vectors, to allow movement from the pathway to a suitable host
- whether the imported commodity is to be sent to a few or many destination points in the PRA area
- proximity of entry, transit and destination points to suitable hosts
- time of year at which import takes place
- intended use of the commodity (for example, for planting, processing or consumption)
- risks from by-products and waste.

A2.2.2 Likelihood of establishment

Establishment is defined as the 'perpetuation for the foreseeable future, of a pest within an area after entry' (FAO 2021). In order to estimate the likelihood of establishment of a pest, reliable biological information (for example, lifecycle, host range, epidemiology, survival) is obtained from the areas where the pest currently occurs. The situation in the PRA area can then be compared with that in the areas where it currently occurs and expert judgement used to assess the likelihood of establishment.

Factors to be considered in the likelihood of establishment in the PRA area may include:

- availability of suitable hosts, alternate hosts and vectors in the PRA areas
 - prevalence of hosts and alternate hosts in the PRA area
 - whether hosts and alternate hosts occur within sufficient geographic proximity to allow the pest to complete its life cycle
 - whether there are other plant species, which could prove to be suitable hosts in the absence of usual host species
 - whether a vector, if needed for dispersal of the pest, is already present in the PRA area or likely to be introduced
- suitability of environment in the PRA area

- factors in the environment in the PRA area (for example, suitability of climate, soil, pest and host competition) that are critical to the development of the pest, its host and if applicable its vector, and to their ability to survive periods of climatic stress and complete their life cycles
- cultural practices and control measures in the PRA area that may influence the ability of the pest to establish
- other characteristics of the pest
 - reproductive strategy of the pest and method of pest survival
 - potential for adaptation of the pest
 - minimum population needed for establishment.

A2.2.3 Likelihood of spread

Spread is defined as ‘the expansion of the geographical distribution of a pest within an area’ (FAO 2021). The likelihood of spread considers the factors relevant to the movement of the pest, after establishment on a host plant or plants, to other susceptible host plants of the same or different species in other areas. In order to estimate the likelihood of spread of the pest, reliable biological information is obtained from areas where the pest currently occurs. The situation in the PRA area is then carefully compared with that in the areas where the pest currently occurs and expert judgement used to assess the likelihood of spread.

Factors to be considered in the likelihood of spread may include:

- suitability of the natural and/or managed environment for natural spread of the pest
- presence of natural barriers
- potential for movement with commodities, conveyances or by vectors
- intended use of the commodity
- potential vectors of the pest in the PRA area
- potential natural enemies of the pest in the PRA area.

A2.2.4 Assigning likelihoods for entry, establishment and spread

Likelihoods are assigned to each step of entry, establishment and spread. Six qualitative likelihood descriptors are used: High; Moderate; Low; Very Low; Extremely Low; and Negligible. Definitions for these descriptors and their indicative ranges are given in Table A.1. The indicative ranges are only provided to illustrate the boundaries of the descriptors and are not used beyond this purpose in qualitative PRAs. These indicative ranges provide guidance to the risk analyst and promote consistency between different pest risk assessments.

Table A.1 Nomenclature of likelihoods

Likelihood	Descriptive definition	Indicative range
High	The event would be very likely to occur	0.7 < to ≤ 1
Moderate	The event would occur with an even likelihood	0.3 < to ≤ 0.7
Low	The event would be unlikely to occur	0.05 < to ≤ 0.3
Very Low	The event would be very unlikely to occur	0.001 < to ≤ 0.05
Extremely Low	The event would be extremely unlikely to occur	0.000001 < to ≤ 0.001
Negligible	The event would almost certainly not occur	0 < to ≤ 0.000001

A2.2.5 Combining likelihoods

The likelihood of entry is determined by combining the likelihood that the pest will be imported into the PRA area and the likelihood that the pest will be distributed within the PRA area, using a matrix of rules (Table A.2). This matrix is then used to combine the likelihood of entry and the likelihood of establishment, and the likelihood of entry and establishment is then combined with the likelihood of spread to determine the overall likelihood of entry, establishment and spread.

For example, if a descriptor of Low is assigned for the likelihood of importation, Moderate for the likelihood of distribution, High for the likelihood of establishment and Very Low for the likelihood of spread, then the likelihood of importation of Low and the likelihood of distribution of Moderate are combined to give a likelihood of Low for entry. The likelihood for entry is then combined with the likelihood assigned for establishment of High to give a likelihood for entry and establishment of Low. The likelihood for entry and establishment is then combined with the likelihood assigned for spread of Very Low to give the overall likelihood for entry, establishment and spread of Very Low. This can be summarised as:

importation x distribution = entry [E] Low x Moderate = Low

entry x establishment = [EE] Low x High = Low

[EE] x spread = [EES] Low x Very Low = Very Low

Table A.2 Matrix of rules for combining likelihoods

	High	Moderate	Low	Very Low	Extremely Low	Negligible
High	High	Moderate	Low	Very Low	Extremely Low	Negligible
Moderate	-	Low	Low	Very Low	Extremely Low	Negligible
Low	-	-	Very Low	Very Low	Extremely Low	Negligible
Very Low	-	-	-	Extremely Low	Extremely Low	Negligible
Extremely Low	-	-	-	-	Negligible	Negligible
Negligible	-	-	-	-	-	Negligible

Time and volume of trade

One factor affecting the likelihood of entry is the volume and duration of trade. If all other conditions remain the same, the overall likelihood of entry will increase as time passes and the overall volume of trade increases.

The department normally considers the likelihood of entry on the basis of the estimated volume of one year's trade. This is a convenient value for the analysis that is relatively easy to estimate and allows for expert consideration of seasonal variations in pest presence, incidence and behaviour to be taken into account. The consideration of the likelihood of entry, establishment and spread and subsequent consequences takes into account events that might happen over a number of years even though only one year's volume of trade is being considered. This difference reflects biological and ecological facts, for example where a pest or disease may establish in the year of import but spread may take many years.

The use of a one year volume of trade has been taken into account when setting up the matrix that is used to estimate the risk and therefore any policy based on this analysis does not simply apply to one year of trade. Policy decisions that are based on the department's method that uses the estimated volume of one year's trade are consistent with Australia's policy on appropriate level of protection and meet the Australian Government's requirement for ongoing quarantine protection. If there are substantial changes in the volume and nature of the trade in specific commodities then the department will review the risk analysis and, if necessary, provide updated policy advice.

A2.3 Assessment of potential consequences

In estimating the potential consequences of a pest if the pest were to enter, establish and spread in Australia, the department uses a 2-step process. In the first step, a qualitative descriptor of the impact is assigned to each of the direct and indirect criteria in terms of the level of impact and the magnitude of impact. The second step involves combining the impacts for each of the criteria to obtain an 'overall consequences' estimation.

Step 1: Assessing direct and indirect impacts

Direct pest impacts are considered in the context of the impacts on:

- the life or health of plants and plant products
This may include pest impacts on the life or health of the plants and production effects (yield or quality) either at harvest or during storage.
 - Where applicable, pest impacts on the life or health of humans or of animals and animal products may also be considered.
- other aspects of the environment.

Indirect pest impacts are considered in the context of the impacts on:

- eradication and control
This may include pest impacts on new or modified eradication, control, surveillance or monitoring and compensation strategies or programs.
- domestic trade

This may include pest impacts on domestic trade or industry, including changes in domestic consumer demand for a product resulting from quality changes and effects on other industries supplying inputs to, or using outputs from, directly affected industries.

- international trade

This may include pest impacts on international trade, including loss of markets, meeting new technical requirements to enter or maintain markets and changes in international consumer demand for a product resulting from quality changes.

- non-commercial and environment

This may include pest impacts on the community and environment, including reduced tourism, reduced rural and regional economic viability, loss of social amenity, and any 'side effects' of control measures.

For each of these direct and indirect criteria, the level of impact is estimated over 4 geographic levels, defined as:

- **Local**—an aggregate of households or enterprises (a rural community, a town or a local government area)
- **District**—a geographically or geopolitically associated collection of aggregates (generally a recognised section of a state or territory, such as 'Far North Queensland')
- **Regional**—a geographically or geopolitically associated collection of districts in a geographic area (generally a state or territory, although there may be exceptions with larger states such as Western Australia)
- **National**—Australia wide (Australian mainland states and territories and Tasmania).

For each criterion, the magnitude of impact at each of these geographic levels is described using 4 categories, defined as:

- **Unlikely to be discernible**—pest impact is not usually distinguishable from normal day-to-day variation in the criterion
- **Minor significance**—expected to lead to a minor increase in mortality/morbidity of hosts or a minor decrease in production but not expected to threaten the economic viability of production. Expected to decrease the value of non-commercial criteria but not threaten the criterion's intrinsic value. Effects would generally be reversible.
- **Significant**—expected to threaten the economic viability of production through a moderate increase in mortality/morbidity of hosts, or a moderate decrease in production. Expected to significantly diminish or threaten the intrinsic value of non-commercial criteria. Effects may not be reversible.
- **Major significance**—expected to threaten the economic viability through a large increase in mortality/morbidity of hosts, or a large decrease in production. Expected to severely or irreversibly damage the intrinsic 'value' of non-commercial criteria.

Each individual direct or indirect impact is given an impact score (A–G) using the decision rules in Figure A.1. This is done by determining which of the shaded cells with bold font in Figure A.1 correspond to the level and magnitude of the particular impact.

The following are considered during this process:

- At each geographic level below 'National', an impact more serious than 'Minor significance' is considered at least 'Minor significance' at the level above. For example, a 'Significant' impact at the state or territory level is considered equivalent to at least a 'Minor significance' impact at the national level.
- If the impact of a pest at a given level is in multiple states or territories, districts or regions or local areas, it is considered to represent at least the same magnitude of impact at the next highest geographic level. For example, a 'Minor significance' impact in multiple states or territories represents a 'Minor significance' impact at the national level.
- The geographic distribution of an impact does not necessarily determine the impact. For example, an outbreak could occur on one orchard/farm, but the impact could potentially still be considered at a state or national level.

Figure A.1 Decision rules for determining the impact score for each direct and indirect criterion, based on the *level of impact* and the *magnitude of impact*

Impact score	G	Major significance	-	-	-
	F	Significant	Major significance or equal to at least 'Significant' at National level	-	-
	E	Minor significance	Significant or equal to at least 'Minor significance' at National level	Major significance or equal to at least 'Significant' at Regional level	-
	D	Unlikely to be discernible	Minor significance	Significant or equal to at least 'Minor significance' at Regional level	Major significance or equal to at least 'significant' at District level
	C	-	Unlikely to be discernible	Minor significance	Significant or equal to at least 'Minor significance' at District level
	B	-	-	Unlikely to be discernible	Minor significance
	A	-	-	-	Unlikely to be discernible
		National	Regional	District	Local
		Geographic level			

For each criterion:

the level of impact is estimated over 4 geographic levels: local, district, regional and national

the *magnitude of impact* at each of the 4 geographic levels is described using 4 categories: unlikely to be discernible, minor significance, significant and major significance

an impact score (A–G) is assigned by determining which of the shaded cells with bold font correspond to the level and magnitude of impact.

Step 2: Combining direct and indirect impacts

The overall consequence for each pest or each group of pests is achieved by combining the impact scores (A–G) for each direct and indirect criterion using the decision rules in Table A.3. These rules are mutually exclusive, and are assessed in numerical order until one applies. For example, if the first rule does not apply, the second rule is considered, and so on.

Table A.3 Decision rules for determining the overall consequence rating for each pest

Rule	The impact scores for consequences of direct and indirect criteria	Overall consequence rating
1	Any criterion has an impact of 'G'; or more than one criterion has an impact of 'F'; or a single criterion has an impact of 'F' and each remaining criterion an 'E'.	Extreme
2	A single criterion has an impact of 'F'; or all criteria have an impact of 'E'.	High
3	One or more criteria have an impact of 'E'; or all criteria have an impact of 'D'.	Moderate
4	One or more criteria have an impact of 'D'; or all criteria have an impact of 'C'.	Low
5	One or more criteria have an impact of 'C'; or all criteria have an impact of 'B'.	Very Low
6	One or more but not all criteria have an impact of 'B', and all remaining criteria have an impact of 'A'; or all criteria have an impact of 'A'.	Negligible

A2.4 Estimation of the unrestricted risk

Once the assessment of the likelihood of entry, establishment and spread and for potential consequences are completed, the unrestricted risk can be determined for each pest or each group of pests. This is determined by using a risk estimation matrix (Table A.4) to combine the estimates of the likelihood of entry, establishment and spread and the overall consequences of pest establishment and spread.

When interpreting the risk estimation matrix, note the descriptors for each axis are similar (for example, Low, Moderate, High) but the vertical axis refers to likelihood and the horizontal axis refers to consequences. Accordingly, a Low likelihood combined with High consequences, is not the same as a High likelihood combined with Low consequences—the matrix is not symmetrical. For example, the former combination would give an unrestricted risk rating of Moderate, whereas the latter would give a Low rating.

Table A.4 Risk estimation matrix

Likelihood of pest entry, establishment and spread	Consequences of pest entry, establishment and spread					
	Negligible	Very Low	Low	Moderate	High	Extreme
High	Negligible risk	Very Low risk	Low risk	Moderate risk	High risk	Extreme risk
Moderate	Negligible risk	Very Low risk	Low risk	Moderate risk	High risk	Extreme risk

Low	Negligible risk	Negligible risk	Very Low risk	Low risk	Moderate risk	High risk
Very Low	Negligible risk	Negligible risk	Negligible risk	Very Low risk	Low risk	Moderate risk
Extremely Low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very Low risk	Low risk
Negligible	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very Low risk

A2.5 The appropriate level of protection (ALOP) for Australia

The SPS Agreement defines the concept of an ‘appropriate level of sanitary or phytosanitary protection (ALOP)’ as the level of protection deemed appropriate by the WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory.

Like many other countries, Australia expresses its ALOP in qualitative terms. The ALOP for Australia, which reflects community expectations through government policy, is currently expressed as providing a high level of sanitary or phytosanitary protection aimed at reducing risk to a very low level, but not to zero. The band of cells in Table A.4 marked ‘Very Low risk’ represents the ALOP for Australia.

A2.6 Adoption of outcomes from previous assessments

Outcomes of previous risk assessments have been adopted in this assessment for pests for which the risk profile is assessed as comparable to previously assessed situations.

The prospective adoption of previous risk assessment ratings for the likelihood of importation and the likelihood of distribution is considered on a case-by-case basis by comparing factors relevant to the pathway being assessed with those assessed previously. For assessment of the likelihood of importation, factors considered/compared include the commodity type, the prevalence of the pest and commercial production practices in the exporting country/region. For assessment of the likelihood of distribution of a pest the factors considered/compared include the commodity type, the ways the imported produce will be distributed within Australia as a result of the processing, sale or disposal of the imported produce, and the time of year when importation occurs and the availability and susceptibility of hosts at that time. After comparing these factors and reviewing the latest literature, previously determined ratings may be adopted if the department considers the likelihoods for the pathway being assessed to be comparable to those assigned in the previous assessment(s), and there is no new information to suggest that the ratings assigned in the previous assessment(s) have changed.

The likelihoods of establishment and of spread of a pest species in the PRA area will be comparable between risk assessments, regardless of the import pathway through which the pest has entered the PRA area. This is because these likelihoods relate specifically to conditions and events that occur in the PRA area, and are independent of the import pathway. Similarly, the estimate of potential consequences associated with a pest species is also independent of the import pathway. Therefore, the likelihoods of establishment and of spread of a pest, and the estimate of potential consequences, are directly comparable between assessments. If there is no new information available that would significantly change the ratings for establishment or

spread or the consequences the pests may cause, the ratings assigned in the previous assessments for these components may be adopted with confidence.

A2.7 Application of Group PRA approach

The Group PRA approach is consistent with relevant international standards and requirements—including ISPM 2: *Framework for Pest Risk Analysis* (FAO 2019a), ISPM 11: *Pest Risk Analysis for Quarantine Pests* (FAO 2019c) and the SPS Agreement (WTO 1995). ISPM 2 states that ‘Specific organisms may ... be analysed individually, or in groups where individual species share common biological characteristics.’

Risk estimates derived from a Group PRA are ‘indicative’ in character. This is because the likelihood of entry (the combined likelihoods of importation and distribution) can be influenced by a range of pathway-specific factors, as explained in section A2.6. Therefore, the indicative likelihood of entry from a Group PRA needs to be verified on a case-by-case basis.

In contrast, and as noted in section A2.6, the risk factors considered in the likelihoods of establishment and spread, and the potential consequences associated with a pest species are not pathway-specific, and are therefore comparable across all import pathways within the scope of the Group PRA. This is because at these latter stages of the risk analysis the pest is assumed to have already found a host within Australia at or beyond its point of entry. Therefore, unless there is specific evidence to suggest otherwise, a Group PRA assessment can be applied as the default outcome for any pest species on a plant import pathway once the previously assigned likelihood of entry has been verified.

In a scenario where the likelihood of entry for a pest species on a commodity is assessed as different to the indicative estimate, the Group PRA-derived likelihoods of establishment and spread and the estimate of consequences can still be used, but the overall risk rating (the URE) may change.

A3 Stage 3: Pest risk management

Pest risk management describes the process of identifying and implementing phytosanitary measures to manage risks to achieve the ALOP for Australia, while ensuring that any negative effects on trade are minimised.

The proposals from pest risk assessment are used to decide whether risk management is required and if so, the appropriate measures to be used. Where the unrestricted risk estimate does not achieve the ALOP for Australia, risk management measures are required to reduce this risk to a very low level. The guiding principle for risk management is to manage risk to achieve the ALOP for Australia. The effectiveness of any proposed/recommended phytosanitary measures (or combination of measures) is evaluated, using the same approach as used to evaluate the unrestricted risk. This ensures the restricted risk for the relevant pest or pests achieves the ALOP for Australia.

ISPM 11 (FAO 2019c) provides details on the identification and selection of appropriate risk management options and notes that the choice of measures should be based on their effectiveness in reducing the likelihood of entry of the pest.

Examples given of measures commonly applied to traded commodities include:

- options for consignments—for example, inspection or testing for freedom from pests, prohibition of parts of the host, a pre-entry or post-entry quarantine system, specified conditions on preparation of the consignment, specified treatment of the consignment, restrictions on end-use, distribution and periods of entry of the commodity
- options preventing or reducing infestation in the crop—for example, treatment of the crop, restriction on the composition of a consignment so it is composed of plants belonging to resistant or less susceptible species, harvesting of plants at a certain age or specified time of the year, production in a certification scheme
- options ensuring that the area, place or site of production or crop is free from the pest—for example, pest-free area, pest-free place of production or pest-free production site
- options for other types of pathways—for example, consider natural spread, measures for human travellers and their baggage, cleaning or disinfestations of contaminated machinery
- options within the importing country—for example, surveillance and eradication programs
- prohibition of commodities—if no satisfactory measure can be found.

Appendix B: Summary of the ratings from the previous assessments of spider mites

Appendix B presents the summary of the ratings from the previous assessments of spider mites (Table B.1).

To date (August 2023), 21 species of Tetranychidae in 6 genera: *Amphitetranychus* (1 species), *Eotetranychus* (3 species), *Eutetranychus* (1 species), *Oligonychus* (6 species), *Panonychus* (1 species) and *Tetranychus* (9 species) have been assessed in 21 PRAs. Table B.1 provides a summary of ratings in the previous pest risk assessments for spider mites.

Table B.1 Summary of the ratings in the previous assessments for spider mites

Abbreviations: MENA = Middle East and North Africa, H = High, M = Moderate, L = Low, VL = Very Low, N = Negligible, EES = likelihood of entry, establishment and spread, URE = unrestricted risk estimate.

Species	PRA report	Likelihood of						Overall Consequences	URE
		Importation	Distribution	Entry	Establishment	Spread	EES		
<i>Amphitetranychus viennensis</i>	Apple from China (2010)(a)	H	M	M	H	M	L	M	L
	Nectarine from China (2016)(b)	M	M	L	H	M	L	M	L
	Adopting apple from China (2010)								
	Strawberries from Japan (2020)(b)	M	M	L	H	M	L	M	L
	Adopting apple from China (2010)								
<i>Eotetranychus asiaticus</i> (now = <i>E. sexmaculatus</i>)(d)	Jujube from China (2020)(b)	M	M	L	H	M	L	M	L
	Adopting apple from China (2010), table grapes from China (2011)								
<i>Eotetranychus geniculatus</i>	2020 Strawberries from Japan(b)	M	M	L	H	M	L	M	L
	Adopting apple from China (2010), table grapes from China (2011)								
<i>Eotetranychus smithi</i>	Strawberries from Japan (2020)(b)	M	M	L	H	M	L	M	L
	Adopting apple from China (2010), table grapes from China (2011)								

Review of pest risk assessments of spider mites

Appendix B: Summary of previous ratings

Species	PRA report	Likelihood of					Overall Consequences	URE	
		Importation	Distribution	Entry	Establishment	Spread			EES
<i>Eutetranychus palmatus</i>	Dates from Middle East and North Africa(2019)(b) Adopting apple from China (2010), table grapes from China (2011)	H	M	M	H	M	L	M	L
<i>Oligonychus afrasiaticus</i>	Dates from Middle East and North Africa (2019)(b) Adopting apple from China (2010), table grapes from China (2011)	H	M	M	H	M	L	M	L
<i>Oligonychus orthius</i>	2008 Banana from Philippines (2018)(a)	H	H	H	H	H	H	L	L
<i>Oligonychus pratensis</i>	Dates from Middle East and North Africa (2019)(b) Adopting apple from China (2010), table grapes from China (2011)	H	M	M	H	M	L	M	L
<i>Oligonychus punicae</i>	Avocado from Chile (2019)(b) Adopting apple from China (2010), table grapes from China (2011)	L	M	L	H	M	L	M	L
<i>Oligonychus velascoi</i>	Banana from Philippines (2008)(a)	H	H	H	H	H	H	L	L
<i>Oligonychus yothersi</i>	Avocado from Chile (2019)(b) Adopting apple from China (2010), table grapes from China (2011)	H	M	L	H	M	L	M	L
<i>Panonychus citri</i> ^(WA)	Sweet orange from Italy (2005)(a)	H	L	L	M	M	L	L	VL
	Mandarin (Unshu) from Japan (2009)(b) Adopting sweet orange from Italy (2005)	H	L	L	M	M	L	L	VL
	Avocado from Chile (2019)(b) Adopting sweet orange from Italy (2005)	L	L	VL	M	M	VL	L	N
	Persian limes from Mexico (2023) Adopting sweet orange from Italy (2005)	M	L	L	M	M	L	L	VL

Review of pest risk assessments of spider mites

Appendix B: Summary of previous ratings

Species	PRA report	Likelihood of						Overall Consequences	URE
		Importation	Distribution	Entry	Establishment	Spread	EES		
<i>Tetranychus canadensis</i>	Stonefruit from USA (2010)(a)	M	M	L	H	H	L	L	VL
	Table grapes from China (2011)(a)	H	M	M	H	M	L	M	L
	Table grapes from South Korea (2011)(b)	M	M	M	H	M	L	M	L
	Adopting table grapes from China (2011)	M	M	M	H	M	L	M	L
	Table grapes from Japan (2014)(b)	H	M	M	H	M	L	M	L
	Adopting table grapes from China (2011)	H	M	M	H	M	L	M	L
	Table grapes from India (2016)(c)	-	-	-	-	-	-	-	L(d)
<i>Tetranychus kanzawai</i> ^(WA)	Table grape from Mexico (Sonora) (2016)(b)	H	M	M	H	M	L	M	L
	Adopting table grapes from China (2011)	H	M	M	H	M	L	M	L
	Strawberries from South Korea (2017)(b)	M	M	L	H	M	L	M	L
	Adopting table grapes from China (2011)	M	M	L	H	M	L	M	L
	Strawberries from Japan (2020)(b)	M	M	L	H	M	L	M	L
	Adopting table grapes from China (2011)	M	M	L	H	M	L	M	L
<i>Tetranychus macfarlanei</i>	Melons from South Korea (2023)(b)	L	M	L	H	M	L	M	L
	Adopting table grapes from China (2011)	L	M	L	H	M	L	M	L
<i>Tetranychus marianae</i> ^(WA)	Okra from India (2023)(b)	H	M	M	H	H	M	L	L
	Adopting stonefruit from USA (2011)	H	M	M	H	H	M	L	L
<i>Tetranychus marianae</i> ^(WA)	Banana from Philippines (2008)(a)	H	H	H	H	H	H	L	L
<i>Tetranychus mcdanieli</i>	Stonefruit from USA (2010)(a)	M	M	M	H	H	L	L	VL

Review of pest risk assessments of spider mites

Appendix B: Summary of previous ratings

Species	PRA report	Likelihood of					Overall Consequences	URE	
		Importation	Distribution	Entry	Establishment	Spread			EES
	Apple from USA (2022)(b) Adopting stonefruit from USA (2011)	H	M	M	H	H	M	L	L
<i>Tetranychus pacificus</i>	Stonefruit from USA (2010)(a)	M	M	L	H	H	L	L	VL
	Apple from USA (2022)(b) Adopting stonefruit from USA (2011)	M	M	L	H	H	L	L	VL
<i>Tetranychus piercei</i>	Banana from Philippines (2008)(a)	H	H	H	H	H	H	L	L
<i>Tetranychus sp.</i>	Mangosteen from Indonesia (2012)(b) Adopting table grapes from China (2011)	H	M	M	H	M	L	M	L
<i>Tetranychus truncatus</i>	Okra from India (2023)(b) Adopting stonefruit from USA (2011)	H	M	M	H	H	M	L	L
<i>Tetranychus turkestanii</i>	Stonefruit from USA (2010)(a)	M	M	L	H	H	L	L	VL
	Nectarine from China (2016)(b) Adopting stone fruit from USA (2010)	L	M	L	H	H	L	L	VL
	Apple from USA (2022)(b) Adopting stonefruit from USA (2011)	M	M	L	H	H	L	L	VL

(a): PRA report contains full pest risk assessments for the spider mite species.

(b): PRA report in which ratings for the likelihood of establishment, likelihood of spread and for overall consequences were adopted for the same or different spider mite species.

(c): There is no specific ratings provided for the likelihoods of entry, establishment and spread and for the consequences in the table grapes from India PRA (DAWR 2016b). However, it is clear the URE would be 'Low' because the report states 'The URE outcome of exceeding Australia's ALOP from existing policy has been adopted'.

(d): *Eotetranychus asiaticus* (now *E. sexmaculatus*) is no longer a quarantine pest for Australia. (WA): Regional quarantine pest for Western Australia.

(WA): Regional quarantine pest for Western Australia.

Appendix C: Interception of spider mites on the fresh fruit pathways covered by the 21 PRAs

This appendix presents information on interception of spider mites from 2005 to 2021 on the traded fresh fruit pathways covered by the 21 PRAs.

The 21 PRAs containing pest risk assessments of tetranychid species include 14 commodities and 11 countries or regions: apple (from China and the USA), avocado (from Chile), banana (from the Philippines), dates (from countries of Middle East and North Africa (MENA)), jujube (from China), mangosteen (from Indonesia), melons (from South Korea), nectarine (from China), okra (from India), sweet orange (from Italy), stonefruit (from the USA), strawberry (from Korea and Japan), table grapes (from China, Korea, Japan, India and Mexico), and Unshu mandarin (from Japan) (Table C.2)).

Trade has occurred on the pathways assessed in 11 of the 21 PRAs (comprising 8 countries and 8 commodities): Chile (avocado), China (apple, nectarine, table grapes), Indonesia (mangosteen), Italy (sweet orange), Japan (strawberry), Mexico (table grapes), South Korea (strawberry, table grapes), and the USA (stonefruit). There has been no trade as yet for the pathways assessed in 9 of the 21 PRAs: apple from the USA, banana from the Philippines, dates from MENA, jujube from China, melons from South Korea, okra from India, table grapes from Japan, table grapes from India and Unshu mandarin from Japan.

Table C.1 includes information on spider mites intercepted on the specific traded pathways in 11 of the 21 PRAs. This table also includes the likelihood of importation and the URE for spider mite species as originally assessed in the 21 final PRAs. An URE of 'Low' (not achieving the ALOP for Australia) indicates that there are measures in place for spider mites, while an URE of 'Very Low' or 'Negligible' (achieving the ALOP for Australia) indicates that no measures are in place for spider mites associated with the pathways.

Table C.1 Interception of spider mites by Australia (2005-2021) on traded fruit commodity from country or region covered in the 21 finalised PRAs

PRAs or pathways	Trade occurred?	Assessed species	Im.	URE	Interception of spider mites on the traded pathway(a)
Orange (Sweet) from Italy (Biosecurity Australia 2005)	Yes	<i>Panonychus citri</i> ^(WA)	H	VL	No
Banana from Philippines (Biosecurity Australia 2008)	No	<i>Oligonychus orthius</i> <i>Oligonychus velascoi</i> <i>Tetranychus marianae</i> ^(WA) <i>Tetranychus piercei</i>	H	L	N/A
Mandarin (Unshu) from Japan	No	<i>Panonychus citri</i> ^(WA)	H	VL	N/A
Apple from China (Biosecurity Australia 2010a)	Yes	<i>Amphitetranychus viennensis</i>	H	L	Yes Unidentified Tetranychidae intercepted on apple from China
Stonefruit from the USA(b)	Yes	<i>Tetranychus canadensis</i> <i>Tetranychus mcdanieli</i>	M	VL	Yes <i>Tetranychus mcdanieli</i> on peach and

Review of pest risk assessments of spider mites

Appendix C: Interceptions of Tetranychidae

PRAs or pathways	Trade occurred?	Assessed species	Im.	URE	Interception of spider mites on the traded pathway(a)
(Biosecurity Australia 2010b)		<i>Tetranychus pacificus</i> <i>Tetranychus turkestanii</i>			<i>Tetranychus pacificus</i> on nectarine intercepted from the USA Unidentified <i>Tetranychus</i> and Tetranychidae intercepted on nectarine, peach and plum from the USA.
Grapes (Table) from China (Biosecurity Australia 2011a)	Yes	<i>Tetranychus kanzawai</i> ^(WA)	H	L	No
Grapes (Table) from South Korea (Biosecurity Australia 2011b)	Yes	<i>Tetranychus kanzawai</i> ^(WA)	M	L	No
Mangosteen from Indonesia (DAFF 2012)	Yes	<i>Tetranychus</i> sp.	H	L	No
Grapes (Table) from Japan (Department of Agriculture 2014)	No	<i>Tetranychus kanzawai</i> ^(WA)	H	L	N/A
Grapes (Table) from India (DAWR 2016b)	No	<i>Tetranychus kanzawai</i> ^(WA)	-	L	N/A
Nectarine from China (DAWR 2016a)	Yes	<i>Tetranychus kanzawai</i> ^(WA) <i>Tetranychus turkestanii</i>	H L	L VL	No
Grapes (Table) from Mexico (Sonora) (DAWR 2016c)	Yes	<i>Amphitetranychus viennensis</i>	M	L	No
Strawberry from South Korea (DAWR 2017b)	Yes	<i>Tetranychus kanzawai</i> ^(WA)	M	L	Yes <i>Tetranychus urticae</i> (a non-quarantine pest) and unidentified <i>Tetranychus</i> and Tetranychidae intercepted on strawberry from South Korea
Avocado from Chile (Department of Agriculture 2019)	Yes	<i>Oligonychus yothersi</i> <i>Oligonychus punicae</i> <i>Panonychus citri</i> ^(WA)	H L L	L L N	No
Dates from MENA(c) (DAWR 2019b)	No	<i>Eutetranychus palmatus</i> <i>Oligonychus afasiaticus</i> <i>Oligonychus pratensis</i>	H	L	N/A
Jujube from China (Department of Agriculture 2020)	No	<i>Amphitetranychus viennensis</i>	M	L	N/A
Strawberry from Japan (DAWE 2020)	Yes(d)	<i>Amphitetranychus viennensis</i> <i>Eotetranychus smithi</i>	M	L	No

Review of pest risk assessments of spider mites

Appendix C: Interceptions of Tetranychidae

PRAs or pathways	Trade occurred?	Assessed species	Im.	URE	Interception of spider mites on the traded pathway(a)
		<i>Eotetranychus asiaticus</i> (now = <i>E. sexmaculatus</i>)(e) <i>Eotetranychus geniculatus</i> <i>Tetranychus kanzawai</i> ^(WA)			
Apples from the USA (DAFF 2022)	No	<i>Tetranychus mcdanieli</i> <i>Tetranychus pacificus</i> <i>Tetranychus turkestanii</i>	H M	L VL	N/A
Melons from South Korea (DAFF 2023c)	No	<i>Tetranychus kanzawai</i> ^(WA)	L	L	N/A
Okra from India (DAFF 2023b)	No	<i>Tetranychus macfarlanei</i> <i>Tetranychus truncatus</i>	H	L	N/A
Persian limes from Mexico (DAFF 2023a)	No	<i>Panonychus citri</i> ^(WA)	M	VL	N/A

Abbreviations: Im. = likelihood of importation, H = High, M = Moderate, L = Low, VL = Very Low, N = Negligible, N/A = not applicable, URE = Unrestricted Risk Estimate, note that an URE of 'Low' (which does not achieve ALOP for Australia) indicates measures are in place for spider mite(s) associated with the pathway, while an URE of 'VL' or 'N' (which achieves ALOP for Australia) indicates no measures in place for spider mites associated with the pathway.

(a): It is important to note that not all intercepted specimens were identified to species level. Several factors contribute to the intercepted specimens not being identified to species level, including damage to specimens, life stage and sex of specimens, and/or importers opting for treatment of goods without requesting specimen identification.

(b): Stonefruit from the USA includes apricots, nectarine, peaches and plums, as well as inter-specific hybrids including, but not limited to, pluots and pluocots.

(c): MENA = Middle East and North Arica, which is taken to comprise Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Palestinian Territories, Qatar, Saudi Arabia, Syria, Tunisia, Turkey, the United Arab Emirates (UAE) and Yemen.

(d): only 172 kg being traded.

(e): *Eotetranychus asiaticus* (now = *E. sexmaculatus*) is no longer a quarantine pest for Australia. (WA): Regional quarantine pest for Western Australia.

Appendix D: Comparison of previous and proposed ratings

Appendix D tables the comparison of previous ratings assigned in the 21 PRAs and proposed ratings in this review and indicates the changes of URE resulting from application of the proposed rating for the specific pathways.

Comparison of previous and proposed ratings

Table D.1 provides a detailed comparison of previous and proposed ratings for the likelihoods, overall consequences and unrestricted risk estimates.

Table D.1 Comparison of previous and proposed ratings for the likelihoods, overall consequences and unrestricted risk estimates

Final PRAs/pathways (In chorological order of publication of the final report)	Trade occurred?	Assessed species	Likelihood of (a)						Overall consequences (a)	URE(a)
			Importation	Distribution	Entry	Establishment	Spread	EES		
Sweet orange from Italy	Yes	<i>Panonychus citri</i> ^(WA)	H	M[L]	M[L]	H[M]	H[M]	M[L]	L	L[VL]
Banana from Philippines	No	<i>Oligonychus orthius</i> <i>Oligonychus velascoi</i> <i>Tetranychus marianae</i> ^(WA) <i>Tetranychus piercei</i>	H	M[H]	M[H]	H	H	M[H]	L	L
Unshu mandarin from Japan	No	<i>Panonychus citri</i> ^(WA)	H	M[L]	M[L]	H[M]	H[M]	M[L]	L	L[VL]
Apple from China	Yes	<i>Amphitetranychus viennensis</i>	H	M	M	H	H[M]	M[L]	L[M]	L
Stonefruit from USA	Yes	<i>Tetranychus canadensis</i> <i>Tetranychus mcdanieli</i> <i>Tetranychus pacificus</i> <i>Tetranychus turkestanii</i>	H[M]	M	M[L]	H	H	M[L]	L	L[VL]
Table grapes from China	Yes	<i>Tetranychus kanzawai</i> ^(WA)	H	M	M	H	H[M]	M[L]	L[M]	L
Table grapes from South Korea	Yes	<i>Tetranychus kanzawai</i> ^(WA)	M	M	L	H	H[M]	L	L[M]	VL[L]

Review of pest risk assessments of spider mites
Appendix H: Comparison of previous and proposed ratings

Final PRAs/pathways (In chorological order of publication of the final report)	Trade occurred?	Assessed species	Likelihood of (a)						Overall consequences (a)	URE(a)
			Importation	Distribution	Entry	Establishment	Spread	EES		
Mangosteen from Indonesia	Yes	<i>Tetranychus</i> sp.	H	M	M	H	H[M]	M[L]	L[M]	L
Table grapes from Japan	No	<i>Tetranychus kanzawai</i> ^(WA)	H	M	M	H	H[M]	M[L]	L[M]	L
Table grapes from India(b)	No	<i>Tetranychus kanzawai</i> ^(WA)	H[-]	M[-]	M[-]	H[-]	H[-]	M[-]	L[-]	L
Nectarine from China	Yes	<i>Amphitetranychus viennensis</i>	M	M	L	H	H[M]	L	L[M]	VL[L]
		<i>Tetranychus turkestani</i>	L	M	L	H	H	L	L	VL
Table grapes from Mexico	Yes	<i>Tetranychus kanzawai</i> ^(WA)	H	M	M	H	H[M]	M[L]	L[M]	L
Strawberry from South Korea	Yes	<i>Tetranychus kanzawai</i> ^(WA)	M	M	L	H	H[M]	L	L[M]	VL[L]
		<i>Oligonychus punicae</i>	L	M	L	H	H[M]	L	L[M]	VL[L]
Avocado from Chile	Yes	<i>Oligonychus yothersi</i>	H	M	M	H	H[M]	M[L]	L[M]	L
		<i>Panonychus citri</i> ^(WA)	L	M[L]	L[VL]	H[M]	H[M]	L[VL]	L	VL[N]
		<i>Eutetranychus palmatus</i>								
Dates from MENA(c)	No	<i>Oligonychus afrasiaticus</i>	H	M	M	H	H[M]	M[L]	L[M]	L
		<i>Oligonychus pratensis</i>								
Jujube from China	No	<i>Amphitetranychus viennensis</i>	M	M	L	H	H[M]	L	L[M]	VL[L]
Strawberry from Japan	Yes(d)	<i>Amphitetranychus viennensis</i>								
		<i>Eotetranychus smithi</i>	M	M	L	H	H[M]	L	L[M]	VL[L]
		<i>Eotetranychus geniculatus</i>								
		<i>Tetranychus kanzawai</i> ^(WA)								
		<i>Tetranychus mcdanieli</i>	H	M	M	H	H	M	L	L

Review of pest risk assessments of spider mites
Appendix H: Comparison of previous and proposed ratings

Final PRAs/pathways (In chorological order of publication of the final report)	Trade occurred?	Assessed species	Likelihood of (a)						Overall consequences (a)	URE(a)
			Importation	Distribution	Entry	Establishment	Spread	EES		
Apple from the USA	No	<i>Tetranychus pacificus</i> <i>Tetranychus turkestanii</i>	M	M	L	H	H	L	L	VL
Melons from South Korea	No	<i>Tetranychus kanzawai</i>	L	M	L	H	H[M]	L	L[M]	VL[L]
Okra from India	No	<i>Tetranychus macfarlanei</i> <i>Tetranychus truncatus</i>	H	M	M	H	H	M	L	L
Persian limes from Mexico	No	<i>Panonychus citri</i> ^(WA)	M	M[L]	L	H[M]	H[M]	L	L	VL

Abbreviations: H = High, M = Moderate, L = Low, VL = Very Low, N = Negligible, URE = Unrestricted Risk Estimate.

(a): Where a proposed rating is different from a previous rating, the proposed rating is presented in bold e.g. **M** and the previous rating is presented in square brackets and not in bold, e.g. [L]. Colour code: **Brown** for likelihood, **blue** for consequences, for URE, **red** indicates URE outcome changed from achieving ALOP to not achieving ALOP, **green** indicates URE outcome changed from not achieving ALOP to achieving ALOP, black indicates no change.

(b): There are no specific ratings provided for the likelihoods of entry, establishment and spread and for the consequences in the table grapes from India PRA (DAWR 2016b). However, it is clear the URE would be 'Low' because the report states 'The URE outcome of exceeding Australia's ALOP from existing policy has been adopted'.

(c): MENA = Middle East and North Africa, which is taken to comprise Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Palestinian Territories, Qatar, Saudi Arabia, Syria, Tunisia, Turkey, the United Arab Emirates (UAE).

(d): only 176 kg being traded.

(WA): Regional quarantine pest for Western Australia.

Changes of URE and URE outcome resulting from application of the proposed ratings

Table D.2 indicates the changes of URE and URE outcome for spider mites on the specific pathways resulting from application of the proposed ratings.

Table D.2 Changes of URE and URE outcome for spider mites on the specific pathways resulting from application of the proposed ratings

Final PRA/pathway	Trade occurred?	URE(a)	URE outcome(b)	Tetranychid species
Sweet orange from Italy	Yes	VL → L	achieving → not achieving ALOP	<i>Panonychus citri</i> ^(WA)
Banana from Philippines	No	L	no change – not achieving ALOP	<i>Oligonychus orthius</i> <i>Oligonychus velascoi</i> <i>Tetranychus marianae</i> ^(WA) <i>Tetranychus piercei</i>
Unshu mandarin from Japan	No	VL → L	achieving → not achieving ALOP	<i>Panonychus citri</i> ^(WA)
Apple from China	Yes	L	no change – not achieving ALOP	<i>Amphitetranychus viennensis</i>
Stonefruit from the USA	Yes	VL → L	achieving → not achieving ALOP	<i>Tetranychus canadensis</i> <i>Tetranychus mcdanieli</i> <i>Tetranychus pacificus</i> <i>Tetranychus turkestanii</i>
Table grapes from China	Yes	L	no change – not achieving ALOP	<i>Tetranychus kanzawai</i> ^(WA)
Table grapes from South Korea	Yes	L → VL	not achieving → achieving ALOP	<i>Tetranychus kanzawai</i> ^(WA)
Mangosteen from Indonesia	Yes	L	no change – not achieving ALOP	<i>Tetranychus</i> sp.
Table grapes from Japan	No	L	no change – not achieving ALOP	<i>Tetranychus kanzawai</i> ^(WA)
Table grapes from India	No	L	no change – not achieving ALOP	<i>Tetranychus kanzawai</i> ^(WA)
Nectarine from China	Yes	L → VL	not achieving → achieving ALOP	<i>Amphitetranychus viennensis</i>
		VL	no change - achieving ALOP	<i>Tetranychus turkestanii</i>
Table grapes from Mexico	Yes	L	no change – not achieving ALOP	<i>Tetranychus kanzawai</i> ^(WA)
Strawberry from South Korea	Yes	L	not achieving → achieving ALOP	<i>Tetranychus kanzawai</i> ^(WA)
		L	no change – not achieving ALOP	<i>Oligonychus yothersi</i>
Avocado from Chile	Yes	L → VL	not achieving → achieving ALOP	<i>Oligonychus punicae</i>
		N → VL	no change - achieving ALOP	<i>Panonychus citri</i> ^(WA)
Dates from MENA(d)	No	L	no change – not achieving ALOP	<i>Eutetranychus palmatus</i> <i>Oligonychus afrasiaticus</i> <i>Oligonychus pratensis</i>

Review of pest risk assessments of spider mites
Appendix H: Comparison of previous and proposed ratings

Final PRA/pathway	Trade occurred?	URE(a)	URE outcome(b)	Tetranychid species
Jujube from China	No	L → VL	not achieving → achieving ALOP	<i>Amphitetranychus viennensis</i>
Strawberry from Japan	Yes(c)	L → VL	not achieving → achieving ALOP	<i>Amphitetranychus viennensis</i> <i>Eotetranychus smithi</i> <i>Eotetranychus geniculatus</i> <i>Tetranychus kanzawai</i> ^(WA)
Apple from USA	No	L	no change - not achieving ALOP	<i>Tetranychus mcdanieli</i>
		VL	no change - achieving ALOP	<i>Tetranychus pacificus</i> <i>Tetranychus turkestanii</i>
Melon from South Korea	No	L → VL	not achieving → achieving ALOP	<i>Tetranychus kanzawai</i>
Okra from India	No	L	no change - not achieving ALOP	<i>Tetranychus macfarlanei</i>
				<i>Tetranychus truncatus</i>
Persian limes from Mexico	No	VL	no change - achieving ALOP	<i>Panonychus citri</i> ^(WA)

Abbreviations: L = Low, N = Negligible, VL = Very Low, URE = Unrestricted Risk Estimate

(a): Changes to URE as the results of application of the proposed ratings are indicated by an arrow '→'. (b): Changes to the URE outcome as the results of application of the proposed ratings are indicated by an arrow '→'. (c): only 172 kg being traded. (d): MENA = Middle East and North Africa, which is taken to comprise Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Palestinian Territories, Qatar, Saudi Arabia, Syria, Tunisia, Turkey, the United Arab Emirates (UAE). (WA): Regional quarantine pest for Western Australia.

Glossary, acronyms and abbreviations

Term or abbreviation	Full name and/or definition
ALOP	Appropriate level of protection
Appropriate level of protection (ALOP)	The level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory (WTO 1995). The <i>Biosecurity Act 2015</i> defines the ALOP for Australia as a high level of sanitary and phytosanitary protection aimed at reducing biosecurity risks to very low, but not to zero.
Area	An officially defined country, part of a country or all or parts of several countries (FAO 2019b).
Arthropod	The largest phylum of animals, including the insects, arachnids and crustaceans.
Biosecurity	The prevention of the entry, establishment or spread of unwanted pests and infectious disease agents to protect human, animal or plant health or life, and the environment.
Biosecurity risk	The <i>Biosecurity Act 2015</i> refers to biosecurity risk as the likelihood of a disease or pest entering, establishing or spreading in Australian territory, and the potential for the disease or pest causing harm to human, animal or plant health, the environment, economic or community activities.
Commodity	A type of plant, plant product, or other article being moved for trade or other purpose (FAO 2019b).
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 2019b).
Establishment (of a pest)	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2019b).
FAO	Food and Agriculture Organization of the United Nations
Goods	The <i>Biosecurity Act 2015</i> defines goods as an animal, a plant (whether moveable or not), a sample or specimen of a disease agent, a pest, mail or any other article, substance or thing (including, but not limited to, any kind of moveable property).
GVP	Gross value of production
Infestation (of a commodity)	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (FAO 2019b).
Inspection	Official visual examination of plants, plant products or other regulated articles to determine if pests are present or to determine compliance with phytosanitary regulations (FAO 2019b).
Instar	An instar is a developmental stage of arthropods, such as insects, between each moult (ecdysis), until sexual maturity is reached. Arthropods must shed the exoskeleton in order to grow or assume a new form.
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced or used (FAO 2019b).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2019b).
International Plant Protection Convention (IPPC)	The IPPC is an international plant health agreement, established in 1952, that aims to protect cultivated and wild plants by preventing the introduction and spread of pests. The IPPC provides an international framework for plant protection that includes developing International Standards for Phytosanitary Measures (ISPMs) for safeguarding plant resources.
International Standard for Phytosanitary Measures (ISPM)	An international standard adopted by the Conference of the Food and Agriculture Organization, the Interim Commission on Phytosanitary Measures or the Commission on Phytosanitary Measures, established under the IPPC (FAO 2019b).
Introduction (of a pest)	The entry of a pest resulting in its establishment (FAO 2019b).

Review of pest risk assessments of spider mites
Glossary, acronyms and abbreviations

Term or abbreviation	Full name and/or definition
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measures
MENA	Middle East and North Arica, which is taken to comprise Algeria, Bahrain, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Palestinian Territories, Qatar, Saudi Arabia, Syria, Tunisia, Turkey, the United Arab Emirates (UAE) and Yemen.
Nymph	The immature form of some insect species that undergoes incomplete metamorphosis. It is not to be confused with larva, as its overall form is already that of the adult.
Official control	The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests (FAO 2019b).
Parthenogenesis	Reproduction from an ovum without fertilization, especially as a normal process in some invertebrates and lower plants.
Pathway	Any means that allows the entry or spread of a pest (FAO 2019b).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2019b).
Pest categorisation	The process for determining whether a pest has or has not the characteristics of a quarantine pest or those of a regulated non-quarantine pest (FAO 2019b).
Pest risk analysis (PRA)	The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it (FAO 2019b).
Pest risk assessment (for quarantine pests)	Evaluation of the probability of the introduction and spread of a pest and of the magnitude of the associated potential economic consequences (FAO 2019b).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2019b).
Pest status (in an area)	Presence or absence, at the present time, of a pest in an area, including where appropriate its distribution, as officially determined using expert judgement on the basis of current and historical pest records and other information (FAO 2019b).
Phytosanitary measure	Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2019b).
PRA	Pest risk analysis
PRA area	Area in relation to which a pest risk analysis is conducted (FAO 2019b).
Quarantine	Official confinement of regulated articles for observation and research or for further inspection, testing or treatment (FAO 2019b).
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 2019b).
Restricted risk	Risk estimate with phytosanitary measure(s) applied.
Risk analysis	Refers to the technical or scientific process for assessing the level of biosecurity risk associated with the goods, or the class of goods, and if necessary, the identification of conditions that must be met to manage the level of biosecurity risk associated with the goods, or class of goods to a level that achieves the ALOP for Australia.
Risk management measure	Conditions that must be met to manage the level of biosecurity risk associated with the goods or the class of goods, to a level that achieves the ALOP for Australia. In this risk analysis, the term 'risk management measure' and 'phytosanitary measure' may be used interchangeably.

Review of pest risk assessments of spider mites
Glossary, acronyms and abbreviations

Term or abbreviation	Full name and/or definition
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO 2019b).
SPS	Sanitary and Phytosanitary
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures.
The department	The Department of Agriculture, Fisheries and Forestry (this current name and all its previous names are referred to as 'the department')
Treatment	Official procedure for the killing, inactivation or removal of pests, or for rendering pests infertile or for devitalisation (FAO 2019b).
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk mitigation measures.
URE	Unrestricted risk estimate
USA	United States of America
WA	Western Australia
WTO	World Trade Organization

References

- ABS 2019, *Value of Agricultural Commodities Produced, Australia, 2017-18*, 75030D0001_201718, Australian Bureau of Statistics, Canberra, ACT.
- AFFA 2003, *Extension of existing policy for cherry fruit (Prunus avium) exported from New Zealand into Western Australia*, Australian Department of Agriculture, Fisheries and Forestry, Canberra, available at <http://www.daff.gov.au/ba/reviews/final-plant/cherry-nztowa>.
- APVMA 2008, *APVMA Operating principles in relation to spray drift risk*, Australian Pesticides and Veterinary Medicines Authority, Canberra, available at <https://apvma.gov.au/node/27941>.
- Biosecurity Australia 2005, *Final report: extension of existing policy for sweet oranges from Italy*, Department of Agriculture, Fisheries and Forestry, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/oranges-italy>.
- -- 2008, *Final import risk analysis report for the importation of Cavendish bananas from the Philippines. Part A, B and C*, Biosecurity Australia, Department of Agriculture, Fisheries and Forestry, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/banana-philippines>.
- -- 2009, *Final import risk analysis report for fresh unshu mandarin fruit from Shizuoka prefecture in Japan*, Department of Agriculture, Fisheries and Forestry, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/unshu-mandarin-from-japan>.
- -- 2010a, *Final import risk analysis report for fresh apple fruit from the People's Republic of China*, Biosecurity Australia, Department of Agriculture, Fisheries and Forestry, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/apples-china>.
- -- 2010b, *Final import risk analysis report for fresh stone fruit from California, Idaho, Oregon and Washington*, Biosecurity Australia, Department of Agriculture, Fisheries and Forestry, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/stonefruit-usa> (pdf 1.4 mb).
- -- 2011a, *Final import risk analysis report for table grapes from the People's Republic of China*, Department of Agriculture, Fisheries and Forestry, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/table-grapes-china>.
- -- 2011b, *Final non-regulated risk analysis report for table grapes from the Republic of Korea*, Department of Agriculture, Fisheries and Forestry, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/grapes-korea>.
- Bolland, HR, Gutierrez, J & Flechtmann, CHW 1998, *World catalogue of the spider mite family (Acari: Tetranychidae)*, Brill, Boston.
- Carey, JR & Bradley, JW 1982, 'Developmental rates, vital schedules, sex ratios and life tables for *Tetranychus urticae*, *T. turkestanus* and *T. pacificus* (Acarina: Tetranychidae) on cotton', *Acarologia*, vol. 23, no. 4, pp. 333-45.
- Crooker, A 1985, 'Embryonic and juvenile development', in *Spider mites: their biology, natural enemies and control*, Helle, W & Sabelis, MW (eds), Elsevier Science Publishers B.V., Amsterdam.
- DAFF 2012, *Final report for the non-regulated analysis of existing policy for fresh mangosteen fruit from Indonesia*, Department of Agriculture, Fisheries and Forestry, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/mangosteens-indonesia>.

- -- 2022, *Final report for the review of biosecurity import requirements for fresh apple fruit from the Pacific Northwest states of the United States of America*, Department of Agriculture, Fisheries and Forestry, Canberra.
- -- 2023a, *Final report for the review of biosecurity import requirements for fresh Persian lime fruit from Mexico*, Department of Agriculture, Fisheries and Forestry, Canberra, Australia, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/lime-from-mexico>.
- -- 2023b, *Okra from India: biosecurity import requirements final report*, Department of Agriculture, Fisheries and Forestry, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/okra-from-india>.
- -- 2023c, *Oriental melon and rockmelon fruit from Korea: biosecurity import requirements final report*, Department of Agriculture, Fisheries and Forestry, Canberra, Australia, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/melons-from-korea>.
- Dalvi, RR & Salunkhe, DK 1975, 'Toxicological implications of pesticides: their toxic effects on seeds of food plants', *Toxicology*, vol. 3, pp. 269-85.
- DAWE 2020, *Final report for the review of biosecurity import requirements for fresh strawberry fruit from Japan*, Department of Agriculture, Water and the Environment, Canberra, ACT, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/strawberries-from-japan>.
- -- 2021, *Final group pest risk analysis for soft and hard scale insects on fresh fruit, vegetable, cut-flower and foliage imports*, Department of Agriculture, Water and the Environment, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/group-pest-risk-analyses/scales>.
- DAWR 2016a, *Final report for the non-regulated analysis of existing policy for fresh nectarine fruit from China*, Department of Agriculture and Water Resources, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/nectarines-from-china> (pdf 3.58 mb).
- -- 2016b, *Final report for the non-regulated analysis of existing policy for table grapes from India*, the Australian Government Department of Agriculture and Water Resources, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/memos/ba2016-25>.
- -- 2016c, *Final report for the non-regulated analysis of existing policy for table grapes from Sonora, Mexico*, Department of Agriculture and Water Resources, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/mexico-table-grapes/final-rep-table-grapes-mexico>.
- -- 2017a, *Final group pest risk analysis for thrips and orthospoviruses on fresh fruit, vegetable, cut-flower and foliage imports*, Department of Agriculture and Water Resources, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/group-pest-risk-analyses/group-pra-thrips-orthospoviruses/final-report>.
- -- 2017b, *Final report for the non-regulated analysis of existing policy for fresh strawberry fruit from the Republic of Korea*, Department of Agriculture and Water Resources, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/strawberries-from-korea/final-report>.
- -- 2019a, *Final group pest risk analysis for mealybugs and the viruses they transmit on fresh fruit, vegetable, cut-flower and foliage imports*, Department of Agriculture and Water Resources, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/group-pest-risk-analyses/mealybugs/final-report>.

-- -- 2019b, *Final report for the review of biosecurity import requirements for fresh dates from the Middle East and North Africa region*, Australian Government Department of Agriculture and Water Resources, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/fresh-date-middle-east-north-africa>.

Department of Agriculture 2014, *Final report for the non-regulated analysis of existing policy for fresh table grapes from Japan*, Department of Agriculture, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/table-grapes-japan>.

-- -- 2019, *Final report for the review of biosecurity import requirements for fresh avocados from Chile*, Department of Agriculture, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/avocado-from-chile>.

-- -- 2020, *Final report for the review of biosecurity import requirements for fresh Chinese jujube fruit from China*, Department of Agriculture, Canberra, available at <https://www.agriculture.gov.au/biosecurity-trade/policy/risk-analysis/plant/jujubes-from-china>.

FAO 2019a, *International Standards for Phytosanitary Measures (ISPM) no. 2: Framework for pest risk analysis*, Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome, Italy, available at <https://www.ippc.int/en/core-activities/standards-setting/ispms/>.

-- -- 2019b, *International Standards for Phytosanitary Measures (ISPM) no. 5: Glossary of phytosanitary terms*, Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome, Italy, available at <https://www.ippc.int/en/core-activities/standards-setting/ispms/>.

-- -- 2019c, *International Standards for Phytosanitary Measures (ISPM) no. 11: Pest risk analysis for quarantine pests*, Secretariat of the International Plant Protection Convention, Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy, available at <https://www.ippc.int/en/core-activities/standards-setting/ispms/>.

-- -- 2021, *International Standards for Phytosanitary Measures (ISPM) no. 5: Glossary of phytosanitary terms*, Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations, Rome, Italy, available at <https://www.ippc.int/en/core-activities/standards-setting/ispms/>.

Fasulo, TR 2009, *Twospotted spider mite: Tetranychus urticae Koch (Arachnida: Acari: Tetranychidae)*, University of Florida: Featured Creatures, available at http://entnemdept.ufl.edu/creatures/orn/twospotted_mite.htm.

Gerson, U 1986, 'Webbing', in *Spider mites: their biology, natural enemies and control*, Helle, W & Sabelis, MW (eds), Elsevier Science Publisher, Amsterdam, Netherlands.

Gotoh, T, Moriya, D & Nachman, G 2015, 'Development and reproduction of five *Tetranychus* species (Acari: Tetranychidae): do they all have the potential to become major pests?', *Experimental and Applied Acarology*, vol. 66, pp. 453-79.

Government of Western Australia 2022, 'Western Australia Organism List (WAOL)', Department of Primary Industries and Regional Development, Perth, Western Australia, available at <https://www.agric.wa.gov.au/bam/western-australian-organism-list-waol>, accessed 2022.

Helle, W & Pijnacker, LP 1985, 'Parthenogenesis, chromosomes and sex', in *Spider mites: their biology, natural enemies and control. Vol. 1A*, Helle, W & Sabelis, MW (eds), Elsevier Science Publishers B.V., Amsterdam.

Helle, W & Sabelis, MW, (eds) 1985a, *Spider mites. Their biology, natural enemies and control*, Elsevier Science Publisher, Amsterdam, Netherlands.

- --, (eds) 1985b, *Spider mites. Their biology, natural enemies and control*, Elsevier Science Publisher, Amsterdam, Netherlands.
- Jeppson, LR, Keifer, HH & Baker, EW 1975, *Mites injurious to economic plants*, University of California, Berkeley.
- Kennedy, GG & Smitley, DR 1985, 'Dispersal', in *Spider mites: their biology, natural enemies and control*, Helle, W & Sabelis, MW (eds), Elsevier Science Publisher, Amsterdam, Netherlands.
- Krantz, GW & Walter, DE 2009, *A manual of Acarology*, Krantz, GW & Walter, DE (eds), Texas Tech university Press, Lubbock, Texas.
- Liu, ZG & Liu, NZ 1986, '*Tetranychus piercei* McGregor' (in Chinese), *Insect Knowledge [Kunchong Zhishi]*, vol. 23, pp. 18-9.
- McMurtry, JA 1985, 'Citrus', in *Spider mites: their biology, natural enemies and control*, Helle, W & Sabelis, MW (eds), Elsevier Science Publishers B.V., Amsterdam.
- Migeon, A & Dorkeld, F 2022, 'Spider Mites Web: a comprehensive database for the Tetranychidae', available at <http://www1.montpellier.inra.fr/CBGP/spmweb>, accessed 2022.
- NSW DPI 2012, *Impacts of urban and rural development*, NSW Department of Primary Industries, available at <https://www.dpi.nsw.gov.au/fishing/habitat/threats/urban>.
- -- 2016, *Plant quarantine manual for New South Wales*, Primary Industries and Resources, New South Wales, available at <http://www.dpi.nsw.gov.au/content/biosecurity/plant>.
- Plant Health Australia 2019, *Subcommittee on domestic quarantine and market access*, Australian Interstate Quarantine, <https://www.interstatequarantine.org.au/producers/committees/>.
- Rabbinge, R 1985, 'Aspects of damage assessment', in *Spider mites: their biology, natural enemies and control*, Helle, W & Sabelis, MW (eds), Elsevier Science Publishers B.V., Amsterdam.
- Sabelis, MW 1985, 'Reproductive strategies', in *Spider mites: their biology, natural enemies and control*, Helle, W & Sabelis, MW (eds), Elsevier Science Publishers B.V., Amsterdam.
- Sands, DPA & New, TR 2002, *The action plan for Australian butterflies*, Environment Australia, Canberra.
- Seeman, O & Beard, J 2005, *National diagnostic standards for Tetranychus spider mites*, Plant Health Australia, Canberra, Australia.
- Ullah, MS, Gotoh, T & Lim, UT 2014, 'Life history parameters of three phytophagous spider mites, *Tetranychus piercei*, *T. truncatus* and *T. bambusae* (Acari: Tetranychidae)', *Journal of Asia-Pacific Entomology*, vol. 17, pp. 767-73.
- Vacante, V 2009, *Citrus mites - identification, bionomy and control*, Wallingford, Oxfordshire, UK.
- -- 2016, *The handbook of mites of economic plants: identification, bio-ecology and control*, CABI, Croydon, UK.
- Veerman, A 1985, 'Diapause', in *Spider mites: their biology, natural enemies and control. Vol. 1A.*, Helle, W & Sabelis, MW (eds), Elsevier Science Publishers B.V., Amsterdam.
- Walter, DE & Proctor, HC 2013, *Mites: ecology, evolution and behaviour*, 2nd edn, Springer, Dordrecht, The Netherlands.
- WTO 1995, *Agreement on the application of sanitary and phytosanitary measures*, World Trade Organization, Geneva, available at https://www.wto.org/english/docs_e/legal_e/15-sps.pdf (pdf 91 kb).
- Zhang, L 2008, *Biology and pest management of spider mites*, Factsheet no. ENT4, Department of Regional Development, Northern Territory.

Zhang, ZQ 2003, *Mites of greenhouses: identification, biology and control*, CABI Publishing, Wallingford, U.K.