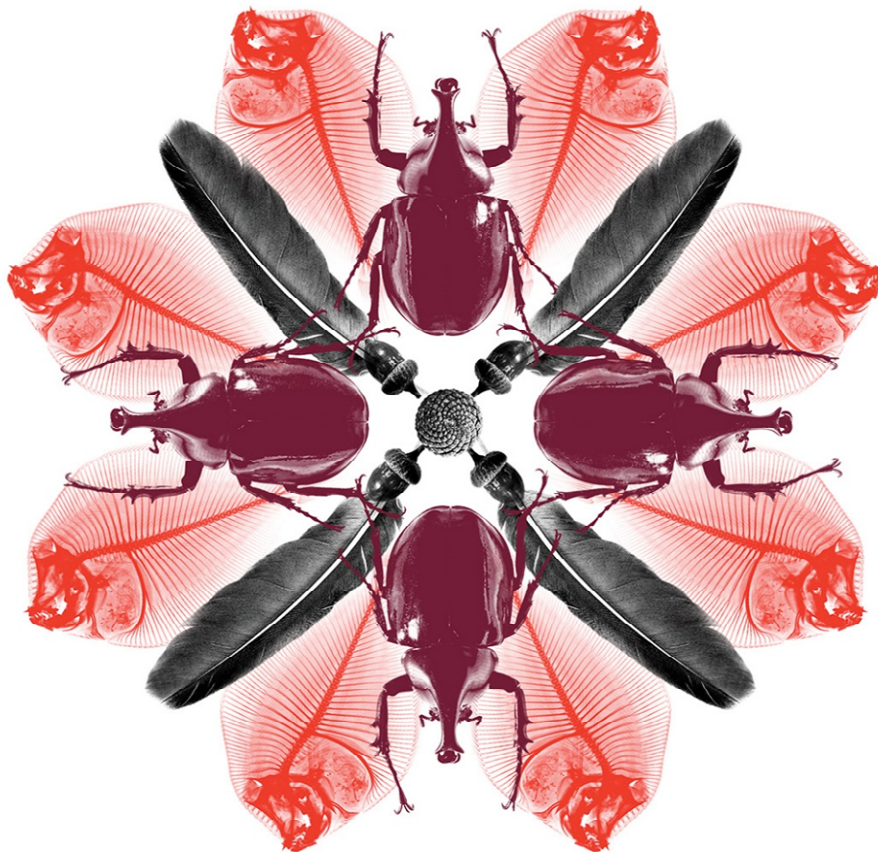




Australian Government
Department of Agriculture,
Water and the Environment

Final risk analysis report for the release of *Listronotus appendiculatus* for the biological control of *Sagittaria platyphylla* and *Sagittaria calycina*

July 2020



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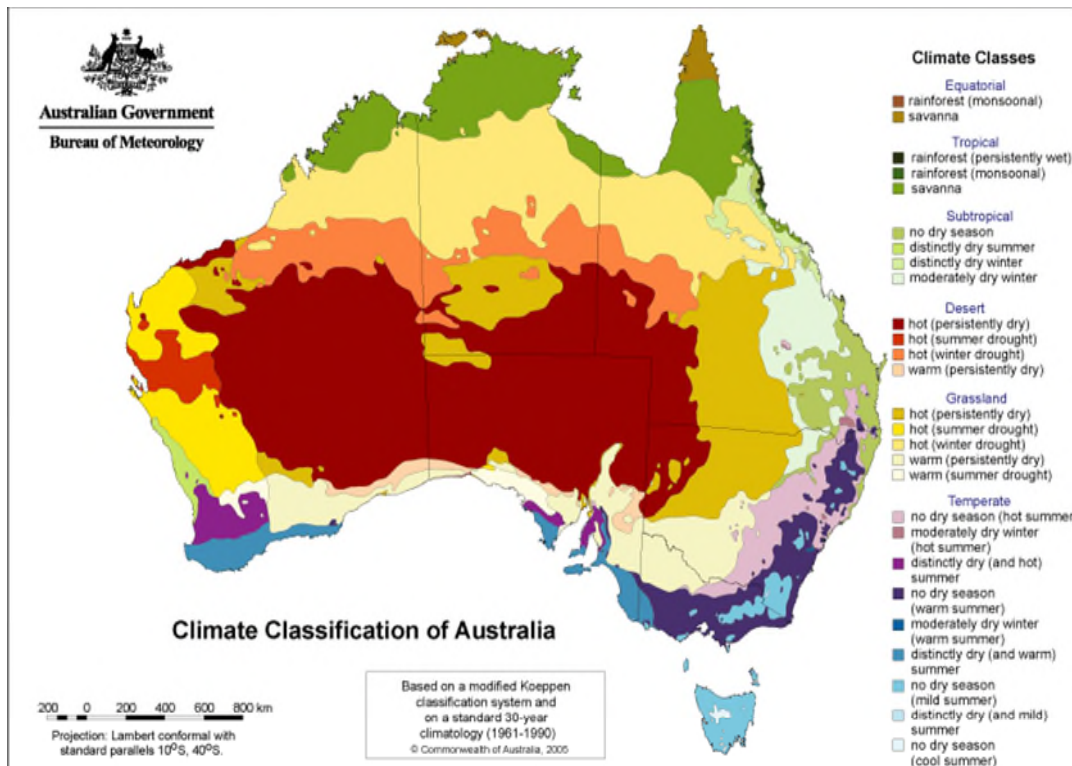
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Map 1 Map of Australia



Map 2 A guide to Australia's bio-climatic zones



Acronyms and abbreviations

Term or abbreviation	Definition
ACT	Australian Capital Territory
ALOP	Appropriate level of protection
BA	Biosecurity Advice
BCA	Biological Control Agent
BICON	The Australian Department of Agriculture, Water and the Environment Biosecurity Import Conditions database
BIRA	Biosecurity Import Risk Analysis
CSIRO	Commonwealth Scientific and Industrial Research Organisation
FAO	Food and Agriculture Organization of the United Nations
IPC	International Phytosanitary Certificate
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measures
NSW	New South Wales
NPPO	National Plant Protection Organisation
NT	Northern Territory
PRA	Pest risk assessment
Qld	Queensland
SA	South Australia
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures
Tas.	Tasmania
the department	The Australian Government Department of Agriculture, Water and the Environment
Vic.	Victoria
WA	Western Australia
WTO	World Trade Organization

Summary

The Australian Government Department of Agriculture, Water and the Environment has prepared this final report to assess the proposal by the Victorian Department of Jobs, Precincts and Regions (DJPR) to release the weevil (*Listronotus appendiculatus*) for the biological control of *Sagittaria platyphylla* and *Sagittaria calycina* in Australia.

This final report recommends that the release of *L. appendiculatus* should be permitted, subject to standard quarantine conditions associated with the import and release of exotic biological control agents.

This final report has determined the overall risk associated with the release of *L. appendiculatus* to be Negligible. A risk estimate of Negligible achieves Australia's appropriate level of protection (ALOP).

The assessment of risk to off-target plants included consideration of the testing methodology used and the plant species test list, including non-target species tested in described experiments. The biology of *L. appendiculatus* and surveys undertaken in its native range were also considered.

This final report also contains details of the risk assessment process used for consideration of potential off-target effects associated with the proposed release of *L. appendiculatus*.

There is also an approval process for the import and release of biological control agents under the *Environment Protection and Biodiversity Conservation Act 1999* within the department. The approval process under that Act will commence upon finalisation of this risk analysis process.

A written submission was received from one stakeholder during the consultation period for the draft report.

The application from Victoria DJPR that was provided to the department has been included with this final report (Attachment 1).

1 Introduction

1.1 Australia's biosecurity policy framework

Australia's biosecurity policies aim to protect Australia against the risks that may arise from exotic pests entering, establishing and spreading in Australia, thereby threatening Australia's unique flora and fauna, as well as those agricultural industries that are relatively free from serious pests.

The risk analysis process is an important part of Australia's biosecurity policies. It enables the Australian Government to formally consider the level of biosecurity risk that may be associated with proposals to import goods or biological materials into Australia. If the biosecurity risks do not achieve the appropriate level of protection (ALOP) for Australia, risk management measures are proposed to reduce the risks to an acceptable level. If the risks cannot be reduced to an acceptable level, the goods or biological materials will not be imported into Australia until suitable measures are identified.

Successive Australian Governments have maintained a stringent, but not a zero risk, approach to the management of biosecurity risks. This approach is expressed in terms of the ALOP for Australia, which is defined in the *Biosecurity Act 2015* as providing a high level of protection aimed at reducing risk to a very low level, but not to zero.

Australia's risk analyses are undertaken by the Australian Government Department of Agriculture, Water and the Environment using technical and scientific experts in relevant fields, and involve consultation with stakeholders at various stages during the process.

Further information about Australia's biosecurity framework is provided in the *Biosecurity Import Risk Analysis Guidelines 2016* located on the [Australian Government Department of Agriculture, Water and the Environment website](#).

1.2 This risk analysis

1.2.1 Background

An application has been submitted by the Victorian Department of Jobs, Precincts and Regions (DJPR) to release a biological control agent (Attachment 1). The identified biological control agent, *Listronotus appendiculatus*, is a fruit-feeding weevil proposed for the biological control of *Sagittaria platyphylla* and *S. calycina*. The applicant has followed the steps outlined in the [Biosecurity Guidelines](#) for the Introduction of Exotic Biological Control Agents for the Control of Weeds and Plant Pests.

Sagittaria platyphylla and *S. calycina* are aquatic weeds of shallow ephemeral or permanent water bodies in natural and disturbed habitats throughout several states in Australia. Both species are serious invasive weeds of irrigation channels, and form dense monocultures. *Sagittaria calycina* is only present in NSW, where it is a major competitor of rice crops in the Murrumbidgee and Coleambally irrigation areas. *Sagittaria platyphylla* is more widespread, extending from Townsville in northern Queensland to the temperate regions of New South Wales, Australian Capital Territory, Victoria, South Australia and Western Australia. *Sagittaria platyphylla* is also found in natural waterways, where it threatens biodiversity.

Listronotus appendiculatus is a fruit-feeding weevil. It feeds on fruiting structures of its host plants and reduces their sexual reproductive capacity, resulting in a reduction in seed production. The native range of *L. appendiculatus* is north and central America.

1.2.2 Scope

The scope of this risk analysis is to consider the biosecurity risk that may be associated with the release of an exotic biological control agent into the Australian environment (excluding its external territories). The primary risk associated with a release of this nature is the possibility of unwanted off-target effects on other species already present in Australia. The Department of Agriculture, Water and the Environment assesses the risk under the *Biosecurity Act 2015*. There is also an approval process within the department under the *Environment Protection and Biodiversity Conservation Act 1999*. Under section 303EE(4) of the *Environment Protection and Biodiversity Conservation Act 1999*, risk analysis reports may be used by the Minister for the Environment in making a determination to include the species on the *List of specimens taken to be suitable for live import* (the Live Import List).

Plants that are considered to be weeds are sometimes also considered to have value, for example, for purposes such as ornamental display, traditional medicine, feed for stock, etc. Considerations of the benefits, and therefore of any associated concerns about eradication of the target weed species are out of the scope of this analysis.

The Department of Agriculture, Water and the Environment will not commence an assessment to release a biological control agent unless the target has been approved by an appropriate government body. Both *Sagittaria platyphylla* and *S. calycina* were approved as target species for biological control by the Invasive Plants and Animals Committee on 26 November 2015.

1.2.3 Associated pests

There are pests that may arrive with an imported exotic biological control agent. Section 9 of the *Biosecurity Act 2015* defines a pest as ‘a species, strain or biotype of plant or animal, or a disease agent, that has the potential to cause, either directly or indirectly, harm to: human, animal or plant health; or the environment.’ These pests may include, for example, parasitoids, mites or fungi. Should an application to release a biological control agent be approved, these pests will be addressed by existing operational procedures that apply to the importation and final release of the agent. These procedures include detailed examination of imported material, confirmation of identity, and breeding under containment conditions before release. For this reason, associated pests are not further considered in this risk analysis.

1.2.4 Consultation

In September 2019, a preliminary draft of this report was distributed to state and territory departments of primary industry and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) through the Plant Health Committee (PHC), and also to the former Department of the Environment and Energy.

There was no opposition to the release of *L. appendiculatus*. Queensland Department of Agriculture and Fisheries (QDAF) raised several questions about various aspects of the application, however release was supported. The applicant responded to these questions with further clarification.

On 28 April 2020, Biosecurity Advice 2020-P03 informed stakeholders of the release of a draft risk analysis report for the release of *L. appendiculatus* for the biological control of *S. platyphylla* and *S. calycina*. The draft report was released for a 30 day stakeholder consultation period that closed on 28 May 2020. One stakeholder submission was received (refer to Section 5 – Stakeholder responses to draft risk analysis report). All comments made in the submission related to the application and not the draft risk analysis report. The comments were discussed

with the applicant. Therefore, no changes to the risk analysis were required as a result of the submission.

1.2.5 Next Steps

Publication of this final report represents the end of the risk analysis process. There is also an approval process within the department under the *Environment Protection and Biodiversity Conservation Act 1999*. Risk analysis reports may be used by the Minister for the Environment in making a determination to include the species on the *List of specimens taken to be suitable for live import* (the Live Import List). This approval process will now take place. If the Department of Agriculture, Water and the Environment approves release of the biological control agent and the Live Import List is amended to include the agent, a letter will be sent to the applicant providing conditions of release.

2 Assessment of off-target risks

This section sets out the process for assessment of off-target risks that could be associated with the release of the biological control agent. Where appropriate, the methods follow those used for pest risk analysis (PRA) by the Department of Agriculture, Water and the Environment in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO 2019a), ISPM 3: *Guidelines for the export, shipment, import and release of biological control agents and other beneficial organisms* (FAO 2017) and ISPM 11: *Pest risk analysis for quarantine pests* (FAO 2019c) that have been developed under the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO 1995). The methodology for a commodity-based PRA is provided in Appendix A.

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 2.1, marked ‘very low risk’, represents the upper boundary of the ALOP for Australia.

The risk associated with the release of a biological control agent is a combination of the estimates of likelihood of off-target effects and the potential consequences of any off-target effects. A risk estimation matrix (Table 2.1) is used to combine these estimates.

Table 2.1 Risk estimation matrix.

Likelihood of off-target effects	Consequences of off-target effects					
	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

2.1 Stage 1: Initiation

Initiation commences when an applicant provides a submission proposing the release of a biological control agent. The Department of Agriculture, Water and the Environment will not

commence an assessment to release a biological control agent unless the target pest in the submission has been approved as a biological control target by an appropriate government body.

The risk analysis area is defined as all of Australia (excluding its external territories), given that once released there will be no control of spread of the agent other than environmental constraints related to the biology of the organism.

2.2 Stage 2: Risk assessment

This assessment evaluates the likelihood of off-target effects and the potential economic and environmental consequences of any such effects.

The risk assessment is based primarily on consideration of the information provided by the applicant in the application package, including the results of host specificity testing, and current information in the scientific literature, where this is available. Given that the proposal is for deliberate release, the likelihood of entry, establishment and spread is assumed to be certain, and therefore the assessment relates to the host specificity of the proposed agent.

A likelihood is assigned to the estimate of occurrence of off-target effects. Six descriptors are used: high; moderate; low; very low; extremely low; and negligible. Definitions for these descriptors and their indicative ranges are given in Appendix A, Table 1.

2.2.1 Host specificity testing methodology

The following summarised information regarding host specificity testing has been sourced from the application provided by Victoria DJPR (Attachment 1). For further details please refer to the application.

In order to determine whether any non-target species would be at risk from the candidate agent, host specificity tests were conducted with *L. appendiculatus* under contained conditions in Australia. The applicant conducted host specificity tests on 13 plant species (including the two target species) found in Australia. Eleven of the test plant species were from the family Alismataceae, with the additional two species from the families Juncaginaceae and Poaceae. The standard phylogenetic approach for test list species selection, where closely related species within the target species' family are tested, was followed (Briese 2005). Few species in the Alismataceae family are present in Australia, hence the relatively small list of plant species tested. The majority of Alismataceae species present in Australia were tested. Two native species, *Astonia australiensis* and *Butomopsis latifolia* were unable to be tested due to problems with sourcing and germination. While it would have been preferable to test these species, it is noted that this was not possible and that the native ranges of both untested native species do not overlap with the distribution of the target weeds in Australia.

Host specificity testing for this application involved several experimental methods. The tests used were divided into five trials. Trial one comprised adult no-choice and choice-minus-target oviposition trials. Trial two comprised no-choice whole-plant adult oviposition and larval survival trials. Trial three was a no-choice whole-plant larval development trial. Trial four was a continuation trial, and trial five was an achene predation trial. The five trials were designed to measure the overall possibility of off-target effects by studying oviposition, herbivory, larval feeding, adult emergence and the ability of the agent to sustain a population on the test species.

Test plants were sourced from the field or nurseries, or grown from seeds. Depending on the trial, either cut foliage and flowers or whole plants were used. Where cut foliage was used the applicant sourced plant material from different plants to ensure true replication.

As there were two target species in this application, during testing *S. platyphylla* was used as the designated “control” species. *Sagittaria calycina* was treated as a test species.

Trial 1 – Adult no-choice & choice-minus-target oviposition trials

In these trials adults (5 reproductive pairs) were placed in a testing container for four days with one (no-choice single species) or two test species (choice-minus-target), but never with the target. As a control, the target species (*S. platyphylla*) was tested with adults in a separate container. These trials used bouquets of cut foliage and flowers. Levels of oviposition and herbivory on fruit and foliage were measured. The majority of tests used the choice-minus-target technique; no-choice single species tests were used where test species came into flower much later than other species.

Trial 2 – No-choice whole plant adult oviposition and larval survival trials

Trials were conducted on flowering individually potted plants, with *S. platyphylla* used as the control. This additional oviposition trial was conducted to focus mostly on native species that had been accepted for oviposition. *Damasonium minus* and *Alisma plantago-aquatica* (both native species) were tested during this trial as they had been accepted for oviposition in Trial 1. *Cynogeton procerum* was accepted for oviposition in Trial 1 but no eggs hatched and no adult feeding occurred so this native species was not tested further. *Caldesia oligococca* was unable to be tested further as no fruiting plants were available, but *Caldesia acanthocarpa* was tested in its place. *Oryza sativa* (rice) was also tested as it was not tested during Trial 1. Two plants of each species were set up for each time series, one for adult oviposition and one for larval development. For adult oviposition trials, adults were removed after four days, and inflorescences removed from the test plant and eggs counted. For the larval development trials, plants were re-covered with gauze bags when adults were removed after four days. After five to six weeks plants were examined for adult emergence and checked for presence of larvae and pupae.

Trial 3 – No-choice whole plant larval development trial

Six species were assessed in this trial, *S. calycina*, *D. minus*, *Sagittaria latifolia*, *A. plantago-aquatica*, *Echinodorus cordifolius* and *C. acanthocarpa*. *Sagittaria subulata* was not tested, as this trial focused on species with emergent growth habits and the flowering stems of this species are mainly submerged (where larvae are unable to feed). Trials were conducted using 20 fertilised eggs per replicate, attached with string to flowering inflorescences of potted test and control (*S. platyphylla*) plants. The test and control plants were covered with gauze sleeves. After eight weeks, plants were inspected for adult emergence and the number of leaves/petioles with larval tunnelling damage were recorded.

Trial 4 – Continuation trial

Trials were conducted using first generation adults that emerged from the no-choice larval development trials (Trial 3). Adults were placed into containers with bouquets of foliage and inflorescences of the host plant species from which they emerged. Only *D. minus*, *S. calycina* and *S. platyphylla* produced enough adults to conduct this trial. After oviposition competence was verified, four groups of adults with mixed ratios of females and males were set up in containers with a bouquet of foliage and inflorescences. The feeding element of the trial was concluded approximately five weeks later when fruit was becoming scarce due to onset of winter. Adults were then placed into hibernation for approximately 16 weeks and inspected for survival after this time. This trial was conducted to assess the reproductive performance of first generation

adults and therefore make an assessment of the potential ability of *L. appendiculatus* to maintain a viable population on the non-target species *D. minus*.

Trial 5 – Achene predation trial

This trial was conducted using *D. minus* (as Trial 3 showed that larvae could feed on this species) and *S. platyphylla* (control). The trial was a feeding trial set up to determine the number of achenes that each larva could consume. Three day old eggs were used, with ten replicates of one egg per fruiting head used for both plant species. After 23 days the number of achenes consumed by each larva were counted. For the control, fruit were often destroyed, not allowing for individual achenes to be counted – in these cases an estimate of 700 achenes was used (based on the applicant's knowledge of the average number of achenes per flowering head for *S. platyphylla* in Australia).

2.2.2 Host specificity testing results

Trial 1 – Adult no-choice & choice-minus-target oviposition trials

Eight species (in addition to *S. platyphylla* – the control) were accepted for oviposition during these trials. Oviposition occurred on all *Sagittaria* species tested, with the highest rates occurring on *S. calycina* and *S. platyphylla* (less eggs were laid on *S. latifolia* and *S. subulata*). Far less oviposition occurred on other species tested, with no eggs at all laid on *Echinodorus cordifolius* and *Hydrocleyes nymphoides*. There was a difference in location of eggs laid between the *Sagittaria* species and the other species tested. On *Sagittaria* species eggs were laid in clusters underneath the nodal bracts or under the sepals on fruiting heads (normal oviposition behaviour). On other species tested, eggs were laid individually, on the outside of plant material. Eggs laid on other species mostly desiccated; where hatching occurred larvae generally died within a few days. Larvae from eggs laid on *D. minus* survived up to 15 days, with three of 16 hatched larvae reaching pupal stage before dying.

Trial 2 – No-choice whole plant adult oviposition and larval survival trials

Three species were accepted for oviposition during this trial (including the control *S. platyphylla*). Oviposition was greatest on *S. platyphylla* (an average of 76.3 eggs) compared to *A. plantago-aquatica* (an average of less than one egg per plant) and *D. minus* (an average of 3.4 eggs). The two additional species not tested in Trial 1 (*O. sativa* and *C. acanthocarpa*) were not accepted for oviposition.

During the larval survival/development tests no adults emerged from *A. plantago-aquatica*. Few adults emerged from either the control or *D. minus* (an average of one to two adults per plant). The applicant proposes that the very low adult emergence rate on the control was due to starvation of larvae because the inflorescences were overburdened with eggs.

Trial 3 – No-choice whole plant larval development trial

During this trial no adult emergence was recorded from *A. plantago-aquatica*, *C. acanthocarpa* and *E. cordifolius*. Emergence was recorded from *D. minus* and *S. latifolia*, however this was at a significantly lower level than emergence from *S. calycina* and *S. platyphylla*. *Sagittaria calycina* adults were significantly heavier than adults emerged from other species. *Damasonium minus* adults were the lightest.

Trial 4 – Continuation trial

During this trial, conducted over four weeks using first generation adults from Trial 3, adults derived from *S. platyphylla* and *S. calycina* produced significantly higher numbers of eggs than

adults reared and fed on *D. minus*. Oviposition was also delayed for adults emerged from and fed on *D. minus*. The majority of adults of each species survived until the end of the month, however post-diapause survival was low. The post-diapause mortality was expected as adults reared from *S. platyphylla* and *S. calycina* usually die following oviposition. For adults reared from *D. minus* it was suggested by the applicant that post-diapause mortality was due to adults not accumulating enough energy reserves to survive dormancy.

Trial 5 – Achene predation trial

The results of this trial demonstrated a significantly higher achene predation rate on the control, *S. platyphylla* than on *D. minus*. Larvae consumed an average of 1443 achenes (noting that an estimate of 700 achenes per flowering head was used for completely destroyed fruit) on *S. platyphylla* compared to an average of 58.1 on *D. minus*. While the majority of hatched *D. minus* larvae survived to pupation, no adults emerged, compared to 100% of *S. platyphylla* larvae surviving to adult stage.

Overall assessment of plant damage (results from Trials 1 and 3)

Leaf damage by adult weevils

Leaf damage across test species was minimal. *Sagittaria subulata* sustained a 33% loss of leaf area, the highest feeding damage recorded; the applicant proposes this is due to the very small leaf size of this species. Less than 3% of foliage area was consumed for each of the other nine tested species.

Fruit damage by adult weevils

For the choice-minus-target trials, fruit damage on the control (*S. platyphylla*) was greatest, with a mean fruit damage of 58%. This was closely followed by *S. calycina* with a mean fruit damage of 48%. Damage to fruit of other species was lower, with the highest fruit damage on off-target species being *D. minus* (14%). For the no-choice container trials there was no statistical difference between the percentage of fruit damage for *S. platyphylla*, *S. subulata* and *S. calycina*, with levels of 49-88% recorded.

Stem (petiole and scape) damage by larvae

Larval damage was greatest on *S. calycina* (75% stems damaged) and *S. platyphylla* (44% of stems damaged). No stem damage was recorded on *A. plantago-aquatica*, *E. cordifolius* or *C. acanthocarpa*. Stem damage on *D. minus* was 12% and on *S. latifolia* 17%. Damage to *S. calycina* resulted in plant death in 89% of plants tested, whereas all other species tested were able to recover and sprout new foliage and flowers after the trial was over.

2.2.3 Comments on host specificity testing

Throughout the reported host specificity testing it was apparent that the two target species, *S. platyphylla* and *S. calycina* sustained high levels of oviposition and larval damage to fruit and stems, and supported effective adult emergence. Oviposition was also observed on several other species during no-choice and choice-minus-target container trials, and in no-choice whole plant trials. This was, however, to a much lesser extent than oviposition recorded on the target species, and larval hatch rate and survival through to adult emergence was minimal. Oviposition on species outside the *Sagittaria* genus occurred on the outside of plant material and not in the preferred oviposition location (beneath sepals or bracts) for *L. appendiculatus*, leading to high mortality through desiccation of eggs.

No-choice whole plant larval development trials also showed that the two target weeds were preferred hosts, with significantly higher rates of eggs surviving through to adults (*S. platyphylla* 43% and *S. calycina* 45%) than on the only two other species that supported adult emergence, *D. minus* (17.5%) and *S. latifolia* (2.2%). Continuation trials were conducted on the two target weeds and *D. minus*, as these were the only plant species that produced enough adults to conduct the trials. The continuation trials showed that significantly more eggs were produced from adults that emerged from and fed on *S. platyphylla* and *S. calycina* than those that had emerged from and fed on *D. minus*. Survival rates were low from pre- to post-diapause for all three species, and insufficient adults were available to continue the trials beyond the first generation.

The applicant predicts that it is unlikely that the native species *D. minus* will be attacked in the field, as few eggs were laid on test plants (suggesting a lack of recognition as a host by the agent), fecundity was poor and survival rates through to the second generation were low. It is possible that there may be spill-over damage where *D. minus* is in direct contact with the target weeds in the field. The agent was unable to complete its lifecycle on any other native species tested.

The agent was also able to complete its lifecycle on *S. latifolia*, a non-native ornamental species. There was only minimal survival from egg to adult on *S. latifolia*, and the applicant suggests that this is due to the lack of fruit (only the sterile variety of *S. latifolia* is present in Australia). It is possible that this species may sustain some spill-over feeding damage if in proximity to the target weeds in the field. The remaining *Sagittaria* species tested, *S. subulata*, while not able to support complete development of *L. appendiculatus*, may also be at risk of spill-over adult feeding if in proximity to the target weeds under field conditions. During no-choice container testing, *S. subulata* sustained the highest amount of adult leaf feeding (33% loss), probably due to its small leaf size, and also sustained a high amount of fruit damage by adult feeding. However, oviposition was minimal and due to its growth habit (floating leaves, all other parts of plant underwater) it is considered that it would be unlikely to support complete development of the agent in the field.

Throughout the testing the only plant deaths that were recorded were from *S. calycina*, where 89% of plants were dead on completion of Trial 3 (no-choice whole plant larval development). Plant death was caused by larvae burrowing into petioles and crowns. Other species (*D. minus*, *S. latifolia* and *S. platyphylla*) that sustained stem damage during this trial were able to sprout new foliage and flowers after the trial concluded. *Sagittaria calycina* does not produce tubers, and plants were not able to re-sprout. On the basis of these observations the applicant predicts that the impact of *L. appendiculatus* is likely to be greater on *S. calycina* than on *S. platyphylla*.

The applicant also noted in the application that asynchrony between the lifecycle of *L. appendiculatus* and the flowering period of the target weeds is unlikely – this is due to the long flowering periods of *S. platyphylla* and *S. calycina* (September to June).

In addition to host specificity testing, the applicant conducted host utilisation studies in the native range of *L. appendiculatus* (southern USA) over a two month period for two consecutive years. *Listronotus appendiculatus* was only found feeding on *S. platyphylla* and *S. calycina*. The survey results indicate that in the southern USA, *L. appendiculatus* is host specific to the target weeds. Two of the plant species tested during host specificity testing, *S. latifolia* and *E. cordifolius*, were also present in the native range and sampled as part of the survey. These results add confidence to the outcomes of the laboratory-based host specificity testing done in Australia.

2.2.4 Likelihood of off-target effects

The likelihood of off-target effects is estimated on the basis of the outcomes of host specificity testing and other relevant information presented in the application (Attachment 1).

Testing in Australia indicates that off-target effects may occur on species other than the two target weeds, *S. calycina* and *S. platyphylla*. Off-target effects, should they occur, would be likely to take the form of spill-over adult feeding on other *Sagittaria* species. As *L. appendiculatus* was able to complete its lifecycle during testing on *D. minus* and *S. latifolia* it is possible that these species may experience attack in a field situation, however it is noted that this would be unlikely in the presence of its preferred hosts (*S. calycina* and *S. platyphylla*), and potentially minimal should it occur. It is also noted that no-choice laboratory testing can result in host acceptance of species which in the field would not normally be accepted. This appears to be the case with *S. latifolia*, which field surveys indicate is not a host in the agent's native range.

On the basis of the results of host specificity testing reported in this application, together with results of host utilisation studies in the native range, it is concluded that the likelihood of occurrence of off-target effects in Australia is **Moderate**.

2.2.5 Assessment of potential consequences of off-target effects

The potential consequences of the off-target effects of this biological control agent have been assessed using the same methodology (Appendix A) as used in the import risk analysis process for pests associated with imported fresh produce.

Criterion	Estimate and rationale
Direct	
Plant life or health	<p>A—indiscernible</p> <p>With the exception of some minor off-target impacts that may occur on non-target <i>Sagittaria</i> species and the native, <i>D. minus</i>, host specificity testing has demonstrated that <i>L. appendiculatus</i> is host specific to the target weeds <i>S. platyphylla</i> and <i>S. calycina</i>.</p> <p><i>Damasonium minus</i> is a major weed of rice crops in Victoria and NSW and is subject to control via herbicides. Investigations have been made into the efficacy of a pathogenic fungus for biological control of this species (ALA 2019). Any off-target impacts that may occur on <i>D. minus</i> would likely be indiscernible as this species was not preferred for oviposition and sustained minimal seed damage during testing. At no stage during testing did plant death occur.</p> <p>Non-target <i>Sagittaria</i> species in Australia (including <i>S. latifolia</i> and <i>S. subulata</i>) may sustain some off-target feeding when in proximity to the target <i>Sagittaria</i> species. However, surveys in the native range failed to find <i>L. appendiculatus</i> associated with <i>S. latifolia</i>, so the off-target feeding and ability to complete its lifecycle may be an artefact of the laboratory testing environment. In addition, it is unlikely that any off-target damage would be discernible as adult feeding would be limited to locations where one or both target weeds and non-target <i>Sagittaria</i> are present – non-target <i>Sagittaria</i> are not naturalised in Australia. At no stage during testing was plant death recorded on any <i>Sagittaria</i> species other than <i>S. calycina</i>.</p>
Other aspects of the environment	<p>A—indiscernible</p> <p>No negative direct impacts on other aspects of the environment are anticipated. Reduction of the target weeds would result in clearer waterways in affected areas and less herbicide usage.</p>
Indirect	

Eradication, control	A—indiscernible <i>Listronotus appendiculatus</i> is a biological control agent proposed for release for the biological control of <i>S. platyphylla</i> and <i>S. calycina</i> , which are weeds of economic importance. As there are only minimal off-target effects predicted, none of which are likely to cause plant death or affect viability, it would be very unlikely to subsequently require attempted eradication or control.
Domestic trade	A—indiscernible <i>Listronotus appendiculatus</i> is a biological control agent proposed for release for the biological control of <i>S. platyphylla</i> and <i>S. calycina</i> , which are weeds of economic importance. The results of host specificity testing show that this species is likely to be largely host specific, although some minor off-target effects may occur on other <i>Sagittaria</i> species, and to a lesser extent on the native <i>D. minus</i> . This is unlikely to affect domestic trade as ornamental <i>Sagittaria</i> species are not of high economic importance; in Victoria the entire genus is prohibited due to its weediness potential.
International trade	A—indiscernible <i>Listronotus appendiculatus</i> is a biological control agent proposed for release for the biological control of <i>S. platyphylla</i> and <i>S. calycina</i> , which are weeds of economic importance. No off-target impacts are expected to occur on any plant species of significance to international trade.
Environmental and non-commercial	A—indiscernible <i>Sagittaria platyphylla</i> and <i>S. calycina</i> are introduced weeds. The reduction of these species in the environment is not anticipated to have any negative indirect environmental or non-commercial effects. It is expected that any off-target effects on other species, including <i>D. minus</i> and other <i>Sagittaria</i> species would be minimal, if any, and therefore no indirect environmental or non-commercial impacts are expected.

Based on this assessment the potential consequences of off-target effects are assessed as: **Negligible**.

2.2.6 Off-target risk estimate

Unrestricted risk is the result of combining the likelihood of off-target effects with the outcome of potential consequences. Off-target effects and consequences are combined using the risk estimation matrix shown in Table 2.1.

Risk estimate for <i>Listronotus appendiculatus</i>	
Likelihood of off-target effects	Moderate
Consequences	Negligible
Risk	Negligible

As indicated, the risk estimate for release of *Listronotus appendiculatus* has been assessed as 'Negligible', which achieves the appropriate level of protection (ALOP) for Australia.

3 Recommendation on release

The overall risk estimate for release of *Listronotus appendiculatus* has been assessed as Negligible, which achieves the ALOP for Australia. Therefore, it is recommended that this biological control agent be permitted to be released, subject to standard import and release conditions to ensure that the released material is free of other organisms.

This recommendation is made on the basis of the high level of host specificity demonstrated by *Listronotus appendiculatus* on *Sagittaria platyphylla* and *S. calycina*, and is based on currently available information.

4 Attachment 1

Attachment 1 - Application for field release of *Listronotus appendiculatus* LeConte (Coleoptera: Curculionidae) for the biological control of *Sagittaria platyphylla* (Engelmann) JG Smith and *S. calycina* Engelmann (Alismataceae) in Australia.

5 Stakeholder responses to draft risk analysis report

This section summarises key stakeholder comments raised in consultation on the draft report, and the department's responses. One submission was received, from Dr Penelope Greenslade, during the consultation period for the draft risk analysis report. All comments made in the submission relate to the application.

Issue 1: How much damage the two weeds currently are responsible for? Some estimate of this in particular in relation to cost of crop losses is needed.

There is information provided in the application (Attachment 1 - Section 2.7.1 – Detrimental) regarding damage caused by the two *Sagittaria* species. This is considered adequate information as the two weeds have already been approved as targets for biological control – therefore it is considered in the national interest that these species be controlled. Any assessment of economic damage caused by the weeds is outside the scope of this risk analysis.

Issue 2: It seems that the beetle proposed for importation is only responsible for 60% of damage to one of the plants and this is in ideal conditions in a glass house. I am wondering if it will be therefore efficacious in reducing populations in the wild in Australia to any useful extent. Perhaps this point could be addressed.

Any assessment on the efficacy of the agent is outside the scope of this risk analysis. The risk analysis assesses the potential biosecurity risks associated with the release of the agent – this focuses on the potential for off-target effects and their consequences. It is useful to understand the agent's potential for control of the target weeds, however, these aspects of a specific biological control agent or overall control program would need to be considered by the proponent when funding and undertaking the initial work to survey the native range and conduct host specificity testing. For this risk analysis, information on damage is only considered in relation to any off-target damage recorded on non-target species.

Issue 3: There is no evidence given as to any data on the likelihood of it spreading. Does it disperse well for instance? Do new adults actively seek new hosts for instance? Can this point be elaborated on?

It is not essential for this information to be included in the application, as the risk analysis focuses on the potential for off-target impacts and their consequences. Given that the weevil is widely distributed in its native range it is assumed that it has the ability to readily seek new hosts.

Issue 4: I do not think the author has addressed the risk to a related plant to the host which is endemic to Cape York. There seems to be a serious risk to this plant.

The applicant sourced seeds and achenes of the related plant in Cape York, *Astonia australiensis*, however germination was not successful. It is noted in the draft risk analysis report that it would have been preferable to test this species. It is not always possible to test every plant identified as a possible host when conducting host specificity testing. The applicant made attempts to include this plant, however this was not possible. It was explained on page 30 of the application that this species was not considered as higher priority due to a lack of overlap of the native distribution of this species with the current distribution of the weeds. It was considered that sufficient potential off-target species were tested for this application to enable a risk analysis to be conducted.

Issue 5: One topic not addressed is the likelihood of predation on the weevil. The bird life in Australia is quite different to that in eastern/central USA and might well prey on beetles such as this species.

The likelihood of predation on the weevil, and therefore possible reduction in its efficacy as a biological control agent, is not within the scope of the risk analysis – and therefore the applicant is not required to provide information on this. While it is noted that the birdlife in Australia differs to the USA, it would be very difficult to predict potential predation.

Issue 6: It is disappointing that not all potential hosts could be sourced. This is another possible unassessable risk.

It is not always possible to test every plant identified as a possible host when conducting host specificity testing. By testing a sufficient number of closely related plant species to the target enough information is gathered to be able to assess the potential for off-target effects and their consequences. When conducting a risk analysis, DAWE's approach to the management of biosecurity risks is expressed in terms of the Appropriate Level of Protection (ALOP) for Australia, which is defined in the *Biosecurity Act 2015* as providing a high level of protection aimed at reducing risk to a very low level, but not to zero. In the case of this risk analysis, the risk was estimated to be Negligible, which achieves ALOP.

Issue 7: The climate maps produced and based presumably on the past 20 or maybe 50 years of weather data. As the climate is changing fast, past climates do not necessarily produce accurate data on which to base predictive distributions. This point must be addressed.

The climate maps used in the application are considered appropriate to the current situation. In the application, climate information was used to select areas for collection of agents compatible with the climate range that the weeds are found within Australia. Climate information was also used to provide evidence that the two *Sagittaria* species are unlikely to invade the equatorial climate regions in Australia where the native tropical Alismataceae (*Astonia* and *Caldesia*) are found. The use of currently available climate data for these purposes is appropriate. While climate maps may look different in the future – the risk analysis is based on the currently available information.

Issue 8: In spite of the very competent and full application before me, I am not convinced that the supposed benefits the introduction of this beetle will bestow, that they actually outweigh the risks of unanticipated and unwanted consequences and the costs involved. I therefore urge caution in approving this application.

The risk analysis process undertaken by the department is based on biosecurity risk and carried out under the *Biosecurity Act 2015*. There is no provision under the Act to undertake a cost-benefit analysis. Weighing the benefits of introduction of the biological control agent against the risks of unanticipated consequences and the costs involved is out of scope for this risk analysis. The department's assessment of the risk of off-target effects of *L. appendiculatus* is Negligible, which achieves Australia's ALOP regardless of the degree of benefits that may accrue from the release of this weevil species.

Appendix A: Method for pest risk analysis

This chapter sets out the method used for the pest risk analysis (PRA) in this report. The Department of Agriculture, Water and the Environment has conducted this PRA in accordance 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) that have been developed under the SPS Agreement (WTO, 1995).

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, 2019b). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO, 2019b). This definition is also applied in the *Biosecurity Act 2015*.

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

Unrestricted risk is estimated taking into account the existing commercial production practices of the exporting country and that, on arrival in Australia, the department will verify 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 and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests' (FAO, 2019b).

A glossary of the terms used in the risk analysis is provided at the end of this report.

The PRAs are conducted in the following three consecutive stages: initiation, pest risk assessment and pest risk management.

Stage 1 Initiation

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

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 on the basis of 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.

For pests that had been considered by the department in other risk assessments and for which import conditions already exist, this risk analysis considered the likelihood of entry of pests on the commodity and whether existing policy is adequate to manage the risks associated with its import. Where appropriate, the previous risk assessment was taken into consideration in this risk analysis.

Stage 2 Pest risk assessment

A pest risk assessment (for quarantine pests) is the 'evaluation of the probability of the introduction and spread of a pest and of the magnitude of the associated potential economic consequences' (FAO, 2019b).

The following three, consecutive steps were used in pest risk assessment:

Pest categorisation

Pest categorisation identifies which of the pests with the potential to be on the commodity are quarantine pests for Australia and require pest risk assessment. 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, 2019b).

The pests identified in Stage 1 were categorised using the following primary elements to identify the quarantine pests for the commodity being assessed:

- identity of the pest
- presence or absence in the PRA area
- regulatory status
- potential for establishment and spread in the PRA area
- potential for economic consequences (including environmental consequences) in the PRA area.

Assessment of the probability of entry, establishment and spread

Details of how to assess the 'probability of entry', 'probability of establishment' and 'probability of spread' of a pest are given in ISPM 11 (FAO, 2019c). The SPS Agreement (WTO 1995) uses the term 'likelihood' rather than 'probability' for these estimates. In qualitative PRAs, the department uses the term 'likelihood' for the descriptors it uses for its estimates of likelihood of entry, establishment and spread. The use of the term 'probability' is limited to the direct quotation of ISPM definitions.

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

Likelihood of entry

The likelihood of entry describes the likelihood that a quarantine pest will enter Australia as a result of trade in a given commodity, be distributed in a viable state in the PRA area and subsequently be transferred to a host. It is based on pathway scenarios depicting necessary steps in the sourcing of the commodity for export, its processing, transport and storage, its use in Australia and the generation and disposal of waste. In particular, the ability of the pest to survive is considered for each of these various stages.

The likelihood of entry estimates for the quarantine pests for a commodity are based on the use of the existing commercial production, packaging and shipping practices of the exporting country. Details of the existing commercial production practices for the commodity are set out in the report. These practices are taken into consideration by the department when estimating the likelihood of entry.

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

- **Likelihood of importation**—the likelihood that a pest will arrive in Australia when a given commodity is imported.
- **Likelihood of distribution**— the likelihood that the pest will be distributed, 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:

- distribution and incidence 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 of the commodity along each pathway
- seasonal timing of imports
- pest management, cultural and commercial procedures applied at the place of origin
- speed of transport and conditions of storage compared with the duration of the lifecycle of the pest
- vulnerability of the life-stages of the pest during transport or storage
- incidence 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.

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 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 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.

Likelihood of establishment

Establishment is defined as the ‘perpetuation for the foreseeable future, of a pest within an area after entry’ (FAO, 2019b). 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 hosts, alternative hosts and vectors

- suitability of the environment
- reproductive strategy and potential for adaptation
- minimum population needed for establishment
- cultural practices and control measures.

Likelihood of spread

Spread is defined as ‘the expansion of the geographical distribution of a pest within an area’ (FAO, 2019b). 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.

Assigning likelihoods for entry, establishment and spread

Likelihoods are assigned to each step of entry, establishment and spread. Six descriptors are used: high; moderate; low; very low; extremely low; and negligible (Table 1). Definitions for these descriptors and their indicative probability ranges are given in Table 1. The indicative probability ranges are only provided to illustrate the boundaries of the descriptors and are not used beyond this purpose in qualitative PRAs. These indicative probability ranges provide guidance to the risk analyst and promote consistency between different pest risk assessments.

Table 1 Nomenclature of likelihoods

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

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 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 the likelihood of importation is assigned a descriptor of ‘low’ and the likelihood of distribution is assigned a descriptor of ‘moderate’, then they 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 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.

Assessment of potential consequences

The objective of the consequence assessment is to provide a structured and transparent analysis of the potential consequences if the pests or disease agents were to enter, establish and spread in Australia. The assessment considers direct and indirect pest effects and their economic and environmental consequences. The requirements for assessing potential consequences are given in Article 5.3 of the SPS Agreement (WTO, 1995), ISPM 5 (FAO, 2019b) and ISPM 11 (FAO, 2019c).

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

- plant life or health
- other aspects of the environment.

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

- eradication, control
- domestic trade
- international trade
- non-commercial and environmental.

For each of these six criteria, the consequences were estimated over four 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 the potential consequence at each of these levels was described using four categories, defined as:

Indiscernible—pest impact unlikely to be noticeable.

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.

The estimates of the magnitude of the potential consequences over the four geographic levels were translated into a qualitative impact score (A-G) using Table 3. For example, a consequence with a magnitude of 'significant' at the 'district' level will have a consequence impact score of D.

Table 3 Decision rules for determining the consequence impact score based on the magnitude of consequences at four geographic scales

Magnitude	Geographic scale			
	Local	District	Region	Nation
Indiscernible	A	A	A	A
Minor significance	B	C	D	E
Significant	C	D	E	F
Major significance	D	E	F	G

Note: In earlier qualitative PRAs, the scale for the impact scores went from A to F and did not explicitly allow for the rating 'indiscernible' at all four levels. This combination might be applicable for some criteria. In this report, the impact scale of A to F has been changed to become B-G and a new lowest category A ('indiscernible' at all four levels) was added. The rules for combining impacts in Table 4 were adjusted accordingly.

The overall consequence for each pest is achieved by combining the qualitative impact scores (A-G) for each direct and indirect consequence using a series of decision rules (Table 4). These rules are mutually exclusive, and are assessed in numerical order until one applies.

Table 4 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'.	Negligible

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 groups of pests. This is determined by using a risk estimation matrix (Table 5) to combine the estimates of the likelihood of entry, establishment and spread and the overall consequences of pest establishment and spread. Therefore, risk is the combination of likelihood and consequence.

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 be rated as a 'low' unrestricted risk.

Table 5 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

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 5 marked ‘very low risk’ represents the upper boundary of the ALOP for Australia.

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 conclusions 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 phytosanitary measures (or combination of measures) is evaluated, using the same approach as used to evaluate the unrestricted risk, to ensure 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.

Risk management measures are identified for each quarantine pest where the level of biosecurity risk does not achieve the ALOP for Australia.

Glossary

Term or abbreviation	Definition
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).
Appropriate level of protection (ALOP) for Australia	The <i>Biosecurity Act 2015</i> defines the appropriate level of protection (or ALOP) for Australia as a high level of sanitary and phytosanitary protection aimed at reducing biosecurity risks to very low, but not to zero.
Australian territory	Australian territory as referenced in the <i>Biosecurity Act 2015</i> refers to Australia, Christmas Island and Cocos (Keeling) Islands.
Biological control agent	A natural enemy, antagonist or competitor, or other organism, used for pest control (FAO 2019b).
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 measures	The <i>Biosecurity Act 2015</i> defines biosecurity measures as measures to manage any of the following: biosecurity risk, the risk of contagion of a listed human disease, the risk of listed human diseases entering, emerging, establishing themselves or spreading in Australian territory, and biosecurity emergencies and human biosecurity emergencies.
Biosecurity import risk analysis (BIRA)	The <i>Biosecurity Act 2015</i> defines a BIRA as an evaluation of the level of biosecurity risk associated with particular goods, or a particular class of goods, that may be imported, or proposed to be imported, into Australian territory, including, if necessary, the identification of 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. The risk analysis process is regulated under legislation.
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.
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2019b).
The department	The Australian Government Department of Agriculture, Water and the Environment.
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss (FAO 2019b).
Endemic	Belonging to, native to, or prevalent in a particular geography, area or environment.
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).
Fumigation	A method of pest control that completely fills an area with gaseous pesticides to suffocate or poison the pests within.
Genus	A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics. In taxonomic nomenclature the genus name is used, either alone or followed by a Latin adjective or epithet, to form the name of a species.
Host	An organism that harbours a parasite, mutual partner, or commensal partner, typically providing nourishment and shelter.
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO, 2019b).

Term or abbreviation	Definition
Infection	The internal 'endophytic' colonisation of a plant, or plant organ, and is generally associated with the development of disease symptoms as the integrity of cells and/or biological processes are disrupted.
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).
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).
Larva	A juvenile form of animal with indirect development, undergoing metamorphosis (for example, insects or amphibians).
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2019b).
Non-regulated risk analysis	Refers to the process for conducting a risk analysis that is not regulated under legislation (Biosecurity import risk analysis guidelines 2016).
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.
Pathogen	A biological agent that can cause disease to its host.
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 free area (PFA)	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (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 assessment (for regulated non-quarantine pests)	Evaluation of the probability that a pest in plants for planting affects the intended use of those plants with an economically unacceptable impact (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 risk management (for regulated non-quarantine pests)	Evaluation and selection of options to reduce the risk that a pest in plants for planting causes an economically unacceptable impact on the intended use of those plants (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

Term or abbreviation	Definition
	the basis of current and historical pest records and other information (FAO 2019b).
Phytosanitary certificate	An official paper document or its official electronic equivalent, consistent with the model of certificates of the IPPC, attesting that a consignment meets phytosanitary import requirements (FAO 2019b).
Phytosanitary certification	Use of phytosanitary procedures leading to the issue of a phytosanitary certificate (FAO 2019b).
Phytosanitary measure	Phytosanitary relates to the health of plants. 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). In this risk analysis the term 'phytosanitary measure' and 'risk management measure' may be used interchangeably.
Phytosanitary procedure	Any official method for implementing phytosanitary measures including the performance of inspections, tests, surveillance or treatments in connection with regulated pests (FAO 2019b).
Phytosanitary regulation	Official rule to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests, including establishment of procedures for phytosanitary certification (FAO 2019b).
Polyphagous	Feeding on a relatively large number of hosts from different plant family and/or genera.
Practically free	Of a consignment, field or place of production, without pests (or a specific pests) in numbers or quantities in excess of those that can be expected to result from, and be consistent with good cultural and handling practices employed in the production and marketing of the commodity (FAO 2019b).
Pupa	An inactive life stage that only occurs in insects that undergo complete metamorphosis, for example butterflies and moths (Lepidoptera), beetles (Coleoptera) and bees, wasps and ants (Hymenoptera).
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).
Regulated article	Any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (FAO 2019b).
Regulated non-quarantine pest	A non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party (FAO 2019b).
Regulated pest	A quarantine pest or a regulated non-quarantine pest (FAO 2019b).
Restricted risk	Restricted risk is the risk estimate when risk management measures are 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	Are 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.
Saprophyte	An organism deriving its nourishment from dead organic matter.

Term or abbreviation	Definition
Spread (of a pest)	Expansion of the geographical distribution of a pest within an area (FAO 2019b).
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures.
Stakeholders	Government agencies, individuals, community or industry groups or organizations, whether in Australia or overseas, including the proponent/applicant for a specific proposal, who have an interest in the policy issues.
Surveillance	An official process which collects and records data on pest occurrence or absence by surveying, monitoring or other procedures (FAO 2019b).
Systems approach(es)	The integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of protection against regulated pests.
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 management measures.
Vector	An organism that does not cause disease itself, but which causes infection by conveying pathogens from one host to another.
Viable	Alive, able to germinate or capable of growth.

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