

REVIEW

A review of non-native scale insects (Hemiptera: Coccoomorpha: Coccoidea) of Australia and the challenges in maintaining current and accurate pest lists

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Abstract

Over 870 species of scale insects, also called coccoids (infraorder Coccoomorpha), have been recorded from Australia. Here, we systematically review literature, databases and collections to provide a revised assessment of non-native species to Australia, for which we confirm those species that are introduced and extant in Australia (including deliberate introductions and new detections), species previously reported as introduced that we consider extirpated from Australia or the result of dubious records and some previously considered introduced that are possibly native to Australia. Of the 15 new and recent species records for Australia, 14 are considered established in the environment, while one is known only from a controlled nursery environment and not considered established. Despite available resources, it is impossible to unequivocally determine the status of some taxa in terms of whether they are indigenous to Australia or have been introduced by humans. We report new records that may be either introductions or possibly native species, and we discuss taxonomic uncertainty affecting records of species, such as for the mealybug *Vryburgia trionymoides*. Nevertheless, this checklist will be of utility to biosecurity practitioners and taxonomists in providing the most authoritative list of introduced coccoids to Australia that now represent approximately 17% of all coccoid species known to be present. This list will, however, require ongoing maintenance to remain current.

KEYWORDS

Asterolecaniidae, biosecurity, Cerococcidae, Coccidae, Diaspididae, invasive alien species, Monophlebidae, Ortheziidae, Pseudococcidae, Rhizoecidae

INTRODUCTION

Scale insects (Hemiptera: Coccoomorpha: Coccoidea), otherwise known as ‘coccoids’, feed by piercing and sucking plant tissues and represent one of the world’s most economically important insect groups. Of almost 8600 described species worldwide, some 870 have been recorded from Australia (García Morales et al. 2025) and are perhaps most well known by the major plant–pest families of Diaspididae (armoured scales; 267 species

known from Australia), Pseudococcidae (mealybugs; 204 species) and Coccidae (soft scales; 88 species) and less-well-represented families (e.g., Asterolecaniidae; 27 species) that nevertheless contain pestiferous taxa (Kondo & Watson 2022).

Coccoids are, with few exceptions, relatively small, typically sessile and often cryptic (Carver, Gross, & Woodward 1991). Nevertheless, they are an important group, including species that are highly polyphagous in attacking a range of economically important host plants

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or negatively impacting plants in the environment (Moghaddam, Abdollahipour, & Fathipour 2021), while others may be equally damaging yet possess a very narrow host range such as for the giant pine scale, *Marchalina hellenica* (Bacandritsos, Saitanis, & Papanastasiou 2004). Furthermore, due to their typically small size and close host-plant associations, scale insects are readily moved around the world by human-mediated transport, as evidenced by the cosmopolitan distribution of many taxa coupled with uncertainty regarding the native origins for many of these (e.g., Lin, Tanaka, & Cook 2017). The potential for coccoid establishment is further assisted by the fact that parthenogenesis is a common reproductive strategy occurring in species from across the major families (Liebhold et al. 2024; Nur 1971), with asexuality tending to be associated with polyphagy (Ross et al. 2013). Moreover, our understanding of coccoid systematics has undergone significant recent changes with the advent of molecular technologies (e.g., Normark et al. 2019). Hence, scale insects are a group in need of regular and frequent review to ensure up-to-date species lists, especially for records of taxa recently introduced to any given country or territory.

Given the widely acknowledged impact that scale insects impose on human food security and the environment, the community has benefitted from efforts to generate publicly available and searchable records linking scale insects to geographic distributions and ecological relationships (e.g., predators, parasitoids and host plants). Online resources such as ScaleNet (García Morales et al. 2016) are a 'one-stop-shop' of authoritative information where biosecurity and agricultural practitioners, and indeed scale insect taxonomists, may turn when seeking the most current information. Critical decisions can be made using these data, thereby supporting biosecurity, trade and pest management. The value of such resources lies in reliable information drawn directly from the primary literature that often is obscure or difficult (and sometimes impossible) to access. Hence, repositories such as ScaleNet heavily rely on published accounts—especially of new detections and their attributes—to maintain currency.

Despite the breadth of quality information found in such online repositories, misinformation may be propagated due to errors in original publications and species accounts. For example, a paper may state that a taxon occurs in country 'A', yet interrogation of the primary source may reveal this to be untrue due to either misinterpretation of specimen label data or an original misidentification. Other sources may list countries where a species occurs but provide no reference to specimens or other evidence to support such a claim. Such errors and incomplete information in original sources may be inadvertently perpetuated across subsequent publications, lending ill-placed confidence in our understanding of geographic ranges and ecological correlates. The matter of amending incorrect, or at least unsupported, publicly

available data is one issue; another is providing up-to-date information and records of new pest detections absent from such public resources. A further challenge is the online publication of records for taxa on authoritative online aggregators (e.g., Global Biodiversity Information Facility) based on public-reporting citizen science portals (e.g., weekly automatic reports of 'research grade' observations from iNaturalist), where the record is based on an observation in the field and not of a confirmed and verified specimen in a collection.

Many scientists encounter a range of difficulties when seeking to publish new records, particularly for introduced species newly detected in a geographical region or collected on a new host plant. These barriers may include (i) where to publish such records, because journals may be reticent to publish simple checklists or individual species detections; (ii) challenges to publishing in open access journals, especially where significant publication costs are imposed; (iii) consideration of regulatory sensitivities associated with the publication of new geographic or host records which may impact trade; and (iv) evaluating the accuracy of primary identifications and veracity of host-plant data. These and similar issues are widely known and have been examined in greater detail elsewhere (see, e.g., Chavan & Penev 2011).

Evaluating the accuracy of identifications can be especially problematic given the natural variability of many scale insects, because morphology may be influenced by environmental conditions such as host plant, parasitisation or abiotic factors (Cox 1983). Further, workers may be hesitant to report new detections where the taxonomy of a group is either unresolved, the subject of debate or lacking, that is, insufficient diagnostic information is available in an original description to confidently support an identification. Knowledge of the diversity and taxonomy of native species may also be incomplete due to their innocuous nature and relative infrequency of field collection. The situation is made more complex by a lack of sufficient taxonomic expertise in Australia to collect, undertake research and publish on the systematics and general biology of scale insects. The depleting field of taxonomic expertise is exacerbated by the potential undervaluing—or misunderstanding—of taxonomy and systematics (Löbl et al. 2023).

Here, we review Australia's non-native scale insect fauna to update the state of knowledge for species that have established on the continent since the late 18th century. This is timely because (i) there is a need to interrogate existing records for introduced species to determine whether they likely exist in Australia or do not as indicated by either dubious records or arguable extirpation; (ii) a number of introduced species have recently been detected in Australia and are considered established, yet remain to be reported in the peer-reviewed literature or have been reported but with little information regarding their detection; (iii) authoritative and internationally respected scale insect taxonomists remain active and are

able to review and annotate these records in the context of the Australian native coccoid fauna; and (iv) knowledge of which species have established, and any information discernible regarding the circumstances of their arrival in Australia, will provide primary data to feed into global taxonomic resources (e.g., ScaleNet) to inform researchers and those making regulatory decisions, especially for non-native species. A final and important consideration is that the documentation of non-native species (along with resolving their dispersal pathways) forms part of our international obligations, such as in addressing Aichi Biodiversity Target 9, which falls under the Convention on Biological Diversity and targets the identification of ‘invasive alien species’ and their pathways as a measure towards preventing their introduction and establishment.

We have structured this review as follows: (1) a methods section wherein we provide definitions, sources of records and comments on evaluation of data veracity and (2) a combined results and discussion section that is divided into three parts: first, a species-by-species treatment for those requiring specific commentary (e.g., a change in status); second, an examination of trends over time, specifically related to date of detection of respective scale insect families; and a final part that expands on the challenges faced in producing this review (e.g., taxonomic uncertainty and inaccessibility or lack of collection records).

MATERIALS AND METHODS

Definitions of terms

States and territories of Australia are abbreviated as follows: Australian Capital Territory (ACT), New South Wales (NSW), Northern Territory (NT), Queensland (Qld), South Australia (SA), Victoria (Vic) and Western Australia (WA). Papua New Guinea is abbreviated as PNG.

We applied the below definitions regarding the status of scale insects in Australia.

- **Native:** a species we consider as having either evolved on the Australian continent or, in the absence of contrary evidence, been present prior to arrival and settlement of Europeans (c. late 18th century) and for which no evidence exists to counter natural dispersal into the continent. Native species may be considered either endemic to Australia or as part of a wider distribution, such as regionally restricted to Southeast Asia and the Pacific, or cosmopolitan.
- **Non-native:** a species we consider as having arrived in the absence of human intervention (e.g., by dispersal) or via human agency either from accidental introduction via freight (especially of plants or their products) or passenger travel or intentional importation via activities such as biological control programmes (such as for

non-native cacti) or other means and within the last circa 230 years.

- **Extirpated:** a species that we consider as having occurred in Australia (either native or non-native), as supported by collection records, specimens and/or reliable literature reports, but for which little—if any—evidence exists to support its perpetuation in the Australian environment.
- **Dubious:** a species recorded from Australia but for which we consider the original source to either be incorrect or misinterpreted and that we consider likely never occurred in Australia.

Sources and veracity of information

The following online sources were accessed for this review, listed in order of taxonomic breadth of species considered for this work: ScaleNet, Australian Faunal Database (AFD 2022), Australian Plant Pest Database (APPD 2025), Australian Insect Common Names (AICN 2022), Global Biodiversity Information Facility (GBIF 2024, 2025), Atlas of Living Australia (ALA n.d.), Pest and Disease Image Library (PaDIL n.d.), CABI Invasive Species Compendium (2025), European and Mediterranean Plant Protection Organisation (EPPO n.d.) and the Western Australian Organism List (WAOL 2025). Some of these are publicly available while others are password protected, and some are global information repositories while others are restricted to the Australian fauna. Further details on these databases including why they were selected is provided in Data S1. These databases are ‘living resources’ and subject to change; we accessed them over the course of developing this review and caution that they may have changed since time of access between the period of 2022 and 2025. The online resource ‘Plants of the World Online’ (<https://powo.science.kew.org/>) was accessed for taxonomic botanical information.

We also interrogated online sequence databases such as NCBI GenBank and the Barcode of Life Data System (BOLD), reviewed the primary literature for papers and books (e.g., Carver, Gross, & Woodward 1991; Kondo & Watson 2022) and relevant reports (e.g., DAWE 2021) and contacted Australian and international collection curators and managers to re-examine specimens where clarification was required on the identity of the species or collection data of specimens held in their institutions. We note here that tab. 2 of Kondo & Watson (2022) contains a minor, yet important, error in the caption text: ‘AU’ is an abbreviation of ‘Australasian’, not ‘Australian’ as written. Hence, some species in that table that are recorded from Australasia but *not* Australia may be misinterpreted as occurring in Australia. Species affected by this are Acleridae (*Aclerda takahashii*), Asterolecaniidae (*Russellaspis pustulans*), Coccidae (*Anthococcus keravatae*, *Coccus celatus*, *Drepanococcus chiton*, *Milviscutulus pilosus*, *Proccoccus acutissimus*, *Pulvinaria floccifera*, *Pulvinaria mammeae* and

Saissetia miranda), Diaspididae (*Aspidiella sacchari*, *Aspidiotus excisus*, *Chrysomphalus pinnulifer*, *Duplaspidotus claviger*, *Fiorinia phantasma*, *Fiorinia proboscidea* and *Genaparlatoria pseudaspidotus*), Monophlebidae (*Iceya samaraia*), Pseudococcidae (*Dysmicoccus finitimus*, *Hypogeococcus festerianus*, *Planococcus lilacinus*, *Pseudococcus jackbeardsleyi* and *Pseudococcus saccharicola*), Rhizoecidae (*Rhizoecus coffeae*) and Kerriidae (*Paratachardina pseudolobata* and *Tachardina aurantiaca*). This was brought to the attention of the book's authors and has been corrected via a corrigenda article (see Kondo & Watson 2024). However, some of these species have now been reported in Australia (see below for new and recent detections).

The principal domestic collections accessed for this review were the following: Qld Government 'Queensland Primary Industries Insect Collection' (QDPC); NSW Government 'Agricultural Scientific Collections Unit' (ASCU); Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australian National Insect Collection (ANIC); and collections of the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) and Northern Australia Quarantine Strategy (NAQS) Insect Collection (Cairns) (NCIC). Overseas collections contacted to verify records included the Natural History Museum of the United Kingdom (NHMUK) and the Systematic Entomology Laboratory (SEL) of the Agricultural Research Service of the US Department of Agriculture (USDA).

Information from these sources where species were noted as non-native was evaluated based on the following criteria: explicit reports in the primary literature or available databases with links to primary literature (e.g., CABI and EPPO), recorded in three or more independent records based on reliable data in the APPD, the presence of two or more independent records of an introduced species in the APPD and 'grey' literature (e.g., government reports and import pest risk analyses) and verified or added by taxonomic experts and biosecurity professionals who had encountered and confirmed the presence of a non-native species but for which it has yet to be publicly documented.

Importantly, we consider instances where 'Australia' is listed as the country of origin based on interception records to represent potentially unverifiable data for species detected by other countries' quarantine systems. It may be impossible to conclusively determine if such records are from commercial consignments of imported fruit/plant material or interceptions carried by passengers on vessels or aircraft. Passenger material is especially problematic in discerning whether specimens have simply transited through Australia as a last port of call rather than having been sourced from Australia itself (e.g., *Furchadaspis zamiae*, below). Similarly, material intercepted in Australia may be ambiguous in terms of whether a specimen is truly an intercept from an imported consignment or is established in the environment local to where imported goods or incoming international arrivals occur.

Wherever possible, the following metrics were associated with species identified via the process outlined above. These are, in addition to basic taxonomic information (scientific name, authority, year of description and family): (i) year of first record in Australia if known, (ii) source of information regarding date and/or origin (but see comments below), (iii) which databases or public records the species is listed in and (iv) any additional information or notes where relevant. Regarding taxonomic authority and year of description, we have taken the decision to only include these details in the [Supporting Information](#) and not the main text of the review. The reason is that this work is a review of non-native species status as present/absent in Australia, not a taxonomic paper.

Several caveats must be stipulated on these data, especially those regarding date of first record, because the date of detection does not necessarily equate to date of arrival into Australia. Some species may remain undetected or incorrectly identified for many years before they are officially recorded in the literature as present. The natal origin of species may be similarly problematic as it is both often impossible to determine and potentially open to misinterpretation with trade ramifications. Therefore, while some discussion on case-studies may refer to potential or known origin of specific taxa, we generally omitted geographic origin from our review. We also excluded host-plant data because extensive host-plant lists for most species are already available from ScaleNet (and other sources) and do not need to be repeated here, nor do they contribute to the fundamental categorisation of present or absent/native or non-native. The exception to this is for new host records that have not previously been reported in the literature, especially for recent detections. In these instances, we provide expanded information regarding locality, host and other associated collection information. Despite the above caveats, we provide an assessment of the historical trends over time regarding the detections of unintentionally introduced species to Australia.

RESULTS AND DISCUSSION

Part 1: Overview and species notes

ScaleNet lists over 870 scale insect species from 21 families as recorded from Australia. The majority of these are endemic to Australia and not considered any further, with the remaining 196 species from 14 families recorded from Australia and at least one other country: Asterolecaniidae (6 species), Cerococcidae (2), Coccidae (32), Conchaspidiidae (1), Dactylopiidae (5), Diaspididae (79), Eriococcidae (10), Marchalinidae (1), Margarodidae (2), Monophlebidae (4), Ortheziidae (3), Pseudococcidae (44), Rhizoecidae (5) and Xenococcidae (2). Each of these 196 species must, therefore, represent either (a) a non-native introduced

species present in Australia, (b) an Australian native species that has been introduced elsewhere or has a natural distribution wider than Australia, (c) an erroneous record or (d) a bona fide record but for which the species in question is extirpated from Australia. Family Xenococcidae is not treated any further as the two species listed in ScaleNet as recorded from Australia (*Xenococcus acropygae* and *Xenococcus annandalei*) have wider distributions associated with *Acropyga* ants and are regarded as native species by the present authors.

The AFD lists 20 families present in Australia, including all families listed above for ScaleNet, except for Marchalinidae, which is represented by a single recently introduced species in Australia, *M. hellenica* (Nahrung, Loch, & Matsuki 2016).

Of the 196 coccoid species referred to above, 191 (Data S2 for all details) were considered as having been accepted or suspected as non-native to Australia, with those considered native but more widely distributed removed from further assessment, such as the two species of Xenococcidae discussed above. These remaining 191 represent the following families and number of species: Asterolecaniidae (6 species), Cerococcidae (1), Coccidae (37), Conchaspidae (1), Dactylopiidae (5), Diaspididae (86), Eriococcidae (1), Marchalinidae (1), Margarodidae (1), Monophlebidae (4), Ortheziidae (3), Pseudococcidae (40) and Rhizoecidae (5).

Of these, 146 species from 10 families are non-natives that have established in Australia (see Data S2). We note that 12 species from the following three families are not included on ScaleNet but we regard them as occurring in Australia, as they are reported from Australia in other sources (see Data S2) and we have no reason to question their presence in the country: Coccidae (*Ceroplastes rusci* and *Eulecanium tiliae*), Diaspididae (*Aonidiella comperei*, *Aulacaspis rosarum*, *C. pinnulifer*, *Diaspidiotus pyri*, *D. claviger*, *G. pseudaspidotus*, *Gymnaspis aechmeae*, *Lepidosaphes camelliae* and *Parlatoria crotonis*) and Monophlebidae (*Icerya aegyptiaca*). Most non-native species are not dealt with in any further detail within this review, other than being listed in Data S2, as we consider their status as non-native species and persistence in the Australian environment to be unequivocal based on the breadth of information available, especially ongoing collections having been made of these taxa resulting in verifiable records in collections.

The following non-native species reported in Australia we consider absent due to dubious records: Cerococcidae (*Cerococcus catenarius*), Coccidae (*Parthenolecanium rufulum*), Diaspididae (*Anzaspis cordylinidis*, *Aspidiella hartii*, *F. zamiae*, *Lepidosaphes flava*, *Lepidosaphes pallida*, *Lopholeucaspis cockerelli*, *Octaspidotus australiensis*, *Odonaspis secreta*, *Parlatoria camelliae*, *Pinnaspis mussaendae*, *Selenaspis articulatus*, *Selenaspis rubidus*, *Thysanoflorinia nephelii* and *Unaspis yanonensis*), Ortheziidae (*Insignorthezia insignis* and *Orthezia urticae*) and Pseudococcidae (*Paracoccus burnerae*).

We consider the following species to have been present in Australia as non-natives in the past but are likely extirpated: Coccidae (*D. chiton*, *Pulvinaria aurantii* and *Pulvinaria elongata*), Diaspididae (*Aulacaspis tegalensis*, *Diaspidiotus lenticularis*, *Lepidosaphes pallidula*, *Lopholeucaspis japonica*, *Oceanaspidotus spinosus*, *Parlatoria ziziphi* and *Selenaspis albus*) and Rhizoecidae (*Geococcus coffeae* and *Rhizoecus cacticans*).

The following species we affirm as either to be native to Australia or likely to be native, with some of which requiring further study to conclusively resolve their status: Coccidae (*Coccus praetermissus*), Diaspididae (*Aspidiotus nerii* and *Schizentaspis silvicola*), Monophlebidae (*Icerya imperatae*), Pseudococcidae (*Cannococcus ikshu*, *Maconellicoccus hirsutus*, *Palmicultor browni*, *Pseudococcus longispinus* and *Saccharicoccus sacchari*) and Ortheziidae (*Nipponorthezinella guadalcanalia*). Although *Ceroplastes rubens* was described from material collected in Brisbane (Qld) and suggested to possibly have originated in the Australasian region by Hodgson & Peronti (2012), a claim that appears to have been copied by Peronti & Kondo (2022), it is here considered more likely to be African in origin, as suggested by Qin et al. (1994); furthermore, no other species of *Ceroplastes* are considered to be native to Australia, with *Ceroplastes insulanus*, known only from Lord Howe Island, being only doubtfully different from the introduced *Ceroplastes ceriferus* (Qin & Gullan 1994).

We also provide here further details on species documented for Australia since 2000 including the most recent detections, which we consider to be established and where little to no reporting in the literature has occurred to date. These are Asterolecaniidae (*Planchonia stentae*), Coccidae (*Kilifia acuminata*, *P. acutissimus*, *Protopulvinaria pyriformis*, *S. miranda* and *Saissetia neglecta*), Diaspididae (*A. sacchari*, *Carulaspis minima* and *Thysanoflorinia leeii*) and Pseudococcidae (*Paracoccus marginatus*, *P. lilacinus*, *Pseudococcus cryptus*, *P. jackbeardsleyi* and *Vryburgia trionymoides*). We note that *V. trionymoides* is the subject of taxonomic uncertainty with respect to a putative native Australian species (elaborated on below).

One further species is discussed below, which we report here as *Velataspis* sp., possibly *Velataspis dentata* or a close relative, which was detected and eradicated from a controlled nursery environment and for which there is no evidence that it has established in the Australian environment. We report it here as we expect further instances of this species to be detected via the nursery trade.

Finally, there are the following species of deliberately introduced biological control agents that we consider have persisted in the environment: Dactylopiidae (*Dactylopius austrinus*, *Dactylopius ceylonicus*, *Dactylopius confusus*, *Dactylopius opuntiae* and *Dactylopius tomentosus*) and Pseudococcidae (*Hypogeococcus* sp. 2). These *Dactylopius* species are listed in Data S2 but are not discussed further in the text. The case of *Hypogeococcus* is provided in detail below, including discussion on the introduction of

a biological control agent to Australia under the name *H. festerianus*, which is now regarded as a different undescribed species that is closely related to *Hypogeococcus pungens* (Poveda-Martínez et al. 2019).

Species considered absent and never present in Australia based on dubious and ambiguous records

Cerococcidae

Cerococcus catenarius. Records of this species from Australia are based on the work of Hodgson & Williams (2016), who examined specimens reportedly collected from Australia in 1903. Material examined was labelled 'Australia, no other locality data, on *Eucalyptus cladocalyx* (Myrtaceae), 27.vii.1903, D. Clark (USNM): 4/4adff (fair to poor)' (Hodgson & Williams 2016, p. 156). This may, therefore, represent a quarantine intercept in the United States.

Hodgson & Williams (2016) go on to state, '... it is considered most likely that these slides have the wrong label stuck on them and, therefore, whilst the specimens are indeed *C. catenarius*, they did not originate from Australia' (Hodgson & Williams 2016, p. 158). The GBIF and ScaleNet databases also list these specimens as occurring in Australia, citing Hodgson & Williams (2016), with all other material listed being from South America, especially Brazil.

We have located no other records of this species from Australia; therefore, we regard it as absent.

Coccidae

Parthenolecanium rufulum. ScaleNet does not include Australia as part of this species' geographic distribution; however, there are reports in the literature of this species as present on broom (*Cytisus scoparius* [Fabaceae]) at Barrington Tops and southern NSW (Hosking, Sheppard, & Sagliococco 2012; Memmott et al. 2000; Syrett et al. 1999). Further, Syrett et al. (1999) refer to field trials near Canberra (ACT) where *P. rufulum* caused a 33% reduction in seed production in *C. scoparius*; however, this is based on unpublished data. We have been unable to locate vouchered specimens of this species in Australian collections, including those in NSW.

Unless specimens can be validated and confirmed, we regard *P. rufulum* as unlikely to be present in Australia and consider it absent.

Diaspididae

Anzaspis cordylinidis. Girault (1940) is cited as the source of the Australian record for this species (formerly in *Mytilaspis*) in ScaleNet, wherein a male and two females of a new species of parasitoid wasp (*Bachiana curiosa*) are reported to have been '... reared from *Mytilaspis cordylinidis*, Perth, West Australia, L. J. Newman' (Girault 1940, p. 150). No further information on this scale is provided, and no vouchers are known.

A single record for *A. cordylinidis* existed in the APPD: catalogue number ASCT00003484 collected from Sydney (NSW) but without collection date or collector known. Following re-examination of this record, we confirm that this specimen is, in fact, *Leucaspis cordylinidis* (known only from Australia and New Zealand), not *A. cordylinidis*, with a simple error in transcription into the collection database having occurred and which has now been corrected.

Given the above, and that there are no specimens of this species known from Australian collections, we consider it absent.

Aspidiella hartii. ScaleNet notes this species as occurring in Australia based on Kondo & Watson (2022); and this species is listed as present in Australia (coastal NSW) according to the AFD, which states it as introduced on imported yams from the Pacific. This record appears to have derived from Froggatt (1914), wherein under the former combination *Aspidiotus hartii*, he comments that, 'A great number of the large yams brought into Sydney from the New Hebrides and other Pacific Islands are often thickly encrusted with these white or dull brownish grey scales in all stages of development' (Froggatt 1914, p. 314). Australia is listed in the occurrence records for *A. hartii* in GBIF, with a picture of the source slide which names Froggatt as the collector and the host plant as '? *Geijera salicifolia*' with no further collection details.

A more recent reference to this species is that of Williams & Watson (1988a), who examined material from Fiji, PNG, Solomon Islands, Tonga and Vanuatu, for which there is no mention of Australia as part of its distribution. Further, there are no reports of specimens collected from Australia and only a single record in the APPD for *A. hartii* (ASCT00180595) from NSW (unplaced). The host is listed as *Dioscorea* (true yams), yet no collection date or collector was found to be available for this record. In re-examining this specimen, we confirm that this was intercepted material and that there is no evidence that *A. hartii* is present in Australia. We therefore consider it absent.

Furchadaspis zamiae. Kondo & Watson (2022) refer to Qld as part of this species' distribution, with references cited therein (e.g., Gill 1997) also referring to Australia but without specific reference to verifiable specimens to support this. Watson (2002) also lists 'Australia', citing Gill (1997), stating there are 'no further details' associated with this information. Nakahara (1982) similarly lists Australia as part of this species' distribution but provides no further citations to support this yet notes that many of the records were obtained from the literature and quarantine intercept records. As Nakahara (1982) goes on to refer to slide material at the USNM, we have confirmed four specimens for that species in that collection, which have been re-confirmed as *F. zamiae* by Dr Scott Schneider. All four specimens were collected from cycads for which Australia was the 'last port' before being intercepted in Miami

(one specimen 60-0598, 1959, 'on cycad-leaf') and DC (three specimens: two intercepted in 1935 [35-3902] and one in 1938 [38-524]; all on *Macrozamia corallipes* [now *Macrozamia spiralis*]). We consider *F. zamiae* to be absent from Australia, especially given no other sources include Australia as part of its geographic distribution.

Lepidosaphes flava. This species is recorded on the AFD as occurring in every Australian state and territory, yet other resources (including ScaleNet) do not include Australia as part of its geographic distribution. We note, however, that the AFD explicitly states that this species is 'doubtfully recorded from Australia'. No records of this species exist in collections as far as we are aware, including the QDPC, and we have interrogated records of *Lepidosaphes* sp. on the APPD (as well as under the old genus name of *Mytilaspis*) and confirm that none of the host plants for these unidentified APPD records match what is known for *L. flava*. The only possible explanation we propose for *L. flava* being listed on the AFD relates to one of the cited references on that species record being Maskell (1895), which references 'Australasia' in the title, yet records this species from Hawaii only. Regardless of the cause and given the absence of confirmed specimens collected from Australia, we support the statement on the AFD and regard this species as absent.

Lepidosaphes pallida. *Lepidosaphes pallida* is listed on the AFD as occurring in Australia; however, we consider this an incorrect name and that this record may need to be corrected to *L. pallidula*. The AFD entry includes a single reference, Fernald (1903), noting 'as *Lepidosaphes pallida*' in parentheses in association with this citation.

Lepidosaphes pallida is a valid species, but Australia is not listed as part of its geographic distribution in any other source, including ScaleNet; however, Australia is considered part of the range for *L. pallidula* as reported on ScaleNet (citing Williams & Williams 1988), yet is not on the AFD (*n.b.*, we consider *L. pallidula* as likely extirpated, see below). Further, the nomenclatural history of *L. pallidula* includes *L. pallida* as a former combination, which is where we suspect the confusion may have originated (see ScaleNet for a more expansive description of the taxonomic history of these two species).

The QDPC contains no specimens of *L. pallida* yet does house nine specimens of *L. pallidula*, all collected from Qld localities (Beerwah, Toowoomba, Teviotville and Marmor) between 1936 and 1956 and for which records have been made available on the APPD (along with one additional record from the ASCU). These localities occur within the AFD distribution report for *L. pallida*. No other records of *L. pallida* are known from Australian collections, and this species is not listed in the APPD. We therefore consider *L. pallida* to be absent from Australia.

Lopholeucaspis cockerelli. This species is recorded from Australia on ScaleNet as based on Woodruff et al. (1998).

The Australian record in Woodruff et al. (1998) does not provide any further collection data to validate this record. Nakahara (1982) is also cited as a reference for this species recorded from Australia as stated on the website, 'Diaspididae of the World' (Watson 2002), accessed July 2025, and wherein Australia is listed among 'Other Areas' alongside Bonin Island, Fiji, Hawaii, Niue, Ponape and Tonga (Nakahara 1982) with no additional information on what this distributional record is based on. Further, available online records of this species in the collections of the NHMUK (where Gillian Watson was based) do not include any specimens collected from Australia. The image website PaDIL also states this species as being present in Australia; however, the source of this information is ScaleNet. There are no records of this species in either the APPD or AFD, nor has it been collected in NAQS surveys, despite being known to occur on several targeted host plants. Consequently, the Australian Government regarded the record of this species in Australia as unreliable, and it remains a quarantine pest (DAWE 2021). Given the lack of verifiable information to support the original determination of this species in Australia, combined with no records of this species having been collected and databased in the major collections, we regard this species to be absent from Australia.

Octaspidiotus australiensis. This species was described from material reportedly collected from orchids on Thursday Island (Torres Strait); however, the description is from a publication titled 'New scale insects and white fly found upon plants entering Japanese ports' (Kuwana & Muramatsu 1931) and therefore based on intercepted material for which the origin is unconfirmed (see our notes on *U. yanonensis* regarding reports based on intercepted material). Further, (i) it appears the type material for this species has been lost (Takagi 1984), (ii) the origin of interceptions remains open to question and (iii) there is no evidence that the species is native to Australia or nearby countries in the Pacific at all and is likely native to the Himalayas where it has been collected from wild plants (Takagi 1984). We note that while Takagi (1984) is the source that explicitly raises doubts over Australia being part of the native range, Australia is included as part of its geographic distribution on ScaleNet, which cites this paper as the source of that information. The AFD also lists *O. australiensis* in Australia, listing all states and territories as part of its range. Given the reliance on intercepted species, affinity for wild plants in the Himalayas and absence of any specimens of this species in Australian collections that are confirmed as collected from Australia, we consider this species to likely never have occurred in Australia and to be considered absent despite it having been recorded as described from this continent.

Odonaspis secreta. ScaleNet lists *O. secreta* as occurring in Australia based on Leonardi (1897); however, Ben-Dov (2015) states that no known specimens, as referred to by

Leonardi (1897), exist to support this. No other records for this species exist in Australian collections, and it is not listed as present on any available databases such as the APPD or AFD (it is listed on the latter database, but there is no Australian distributional or specimen data). Therefore, given there are no specimens known to exist, we consider *O. secreta* to be absent from Australia.

Parlatoria camelliae. Danzig & Pellizzari (1998) are listed on ScaleNet as the source for including Australia as part of this species' geographic distribution. We can find no other records of this species from Australia, including specimens in reference collections. Given the absence of verified voucher specimens, we consider this species to be absent.

Pinnaspis mussaendae. Green (1937) is the sole reference on ScaleNet for this species being present in Australia; however, Green (1937) states it as doubtfully recorded from Australia. No further details are provided. A single specimen (ASCT0003456, NSW DPI collection) was listed on the APPD as *P. mussaendae* collected by G. Hill on 23 September 1920 from the NT, Australia. Any earlier slide-mounted material, if it existed, could not be located, but dry material from this accession was slide mounted and examined by one of the authors (M.G.). Only a single specimen was useful for identification and would be referable to *P. mussaendae* according to the key in Ferris & Rao (1947) due to lacking both the second and third lobes. However, in the description of Ferris & Rao (1947), *P. mussaendae* is distinguished from most of its congeners by lacking both second and third lobes, lacking an elongate median scleritis at the base of the median lobes and having well-developed sclerites anterior to the anal opening. The Hill specimen, though agreeing with the first and last statements, differed from the description in Ferris & Rao (1947) in possessing a median scleritis at the base of the median lobes. We consider this sufficient for concluding that the Hill specimen was not *P. mussaendae*, particularly in light of documented variation of the sclerites and pygidial lobes, particularly within the *Pinnaspis aspidistrae* complex (Ferris & Rao 1947; Takgai 1963, 1970; Beardsley 1966; Williams & Watson 1988a), and observed variability in *Pinnaspis* specimens collected in Northern Australia (housed in NCIC). The precise identity of this specimen is yet to be resolved and is beyond the scope of this review, and we here refer to it as *Pinnaspis* cf. *mussaendae*. Given the doubtful Australian record of this species in Australia (Green 1937), combined with readily misinterpreted variable morphological characters, we consider *P. mussaendae* to be absent from Australia until conclusive evidence comes to light.

Selenaspis articulatus. This species is listed as recorded from Australia in ScaleNet based solely on Mamet (1958), who lists Australia among other localities across the Americas, Asia and Africa. Mamet provided no supportive

information in relation to the Australian record, including no reference to vouchered specimens. There are no other records of this species in any public databases, and the authors are unaware of this species occurring in Australia. Therefore, given there are no documented specimens for this species in Australia, we consider it to be absent.

Selenaspis rubidus. While ScaleNet does not include Australia as part of the range for this species, the AFD includes an entry for '*Selenaspis rubidus*', which appears to be a misspelling of '*Selenaspis*' as there are no diaspidid genera named '*Selenaspis*'. The distribution under the AFD entry includes all of Qld, specifically referencing 'Brisbane' under 'Extra Distribution Information'. We are unaware of where these records originate, as the only species of this genus that the QDPC holds are for *S. albus* and the only records for this genus collected from Australia on the APPD are for *S. albus* (= QDPC records). In the absence of any supporting evidence or vouchered specimens supporting its presence, we consider it to be absent from Australia.

Thysanoflorinia nephelii. Two references for this species as occurring in Australia are listed on ScaleNet: Maskell (1897b) (NSW record) and Leonardi (1906) (Qld record). Maskell (1897b), in the original description of the species, lists it from China, Qld and Taiwan (as 'Formosa'); no reference is made to NSW. Leonardi (1906) appears to duplicate the host and country list of Maskell (1897b), in which the validity of this species was queried due to uncertainty in relation to the description of Maskell (noting that Leonardi referred to it under its original generic name, '*Fiorinia*'). Maskell later redescribed this species, apparently based on the same material; he said: 'Specimens sent from Hongkong, Tamsui [this is in Taiwan], and Brisbane by Mr. Koebele (his No. 1417)' (Maskell 1898, p. 234). Confusingly, Maskell's two descriptions of *T. nephelii* differ in the structure of the median lobes of the adult female. Maskell's first description (Maskell 1897a) recorded the female's median lobes with a broad notch and without serrated sides. This character state is more consistent with *T. leei*, described by Williams (1971) and previously mistakenly identified as *T. nephelii* from Taiwan by Takahashi (1942). However, Maskell (1898) described and depicted the adult female's posterior abdomen with serrated median lobes, although in both descriptions Maskell (1897b, 1898) stated that the second-instar cuticle (from which he extracted the adult female) had minutely serrulate lobes. The difference between these two descriptions might result from mixed species in Maskell's samples, especially as he had been sent specimens from China, Taiwan and Brisbane by Koebele. Although there is the possibility that Maskell's 1897 description was based on *T. leei*, if based on *T. nephelii*, then Maskell's slide-mounted specimens may have been from mainland China or Taiwan, rather than Qld. Dietz & Tocker (1980) listed four original Maskell slides in the New Zealand Arthropod

Collection (NZAC) in Auckland. Three of these four slides were located (G. Hall, pers. comm. to P.J.G. June 2025) but only one slide had a single adult female (in poor condition) and none of the labels contain any locality information. Thus, we cannot determine the country of origin of Maskell's type specimens of *Fiorinia nephelii* in NZAC. Dry material from Maskell's scale insect collection was sent on loan in the early 1900s to the United States (Dietz & Tocker 1980), where slides were made of many species and a number were retained in what is now SEL of USDA. Dietz and Tocker listed 10 subsequent slides of *F. nephelii* in the latter collection; the envelopes of all of these slides give the species name and state: 'Maskell Coll./China Formosa/Queensland' and 'Mask. Coll. 571', but the labels on all 10 slides give the locality only as 'China: Formosa'. Four slides have adult female specimens and the identity of these specimens has been confirmed to be *T. nephelii* (S. A. Schneider, pers. comm. to P.J.G., July 2025). Thus, it is possible that Maskell also only prepared and examined slide-mounted specimens from Taiwan or mainland China.

We cannot locate any records of *T. nephelii* specimens in Australian collections (including the QDPC), whereas there are records of *T. leei* (e.g., APPD). Examination of the type material in NZAC would not help to determine which species of *Thysanofiorinia* had been collected in Qld and subsequently received by Maskell because his material has no locality data. In any case, if *T. nephelii* was indeed present in Qld in the late 1890s, we can find no evidence of it having persisted, and therefore, unless verified specimens of this species can be located, we consider it to be absent from Australia. We also consider the NSW reference on ScaleNet to be erroneous as Maskell only referred to Qld in his descriptions and early records of *T. nephelii* from Qld are potentially *T. leei*.

Unaspis yanonensis. The arrow-head scale has been recorded from Australia in ScaleNet based on Blackburn & Miller (1984), who refer to quarantine specimens in the United States from two USDA interceptions from Australia (1979 and 1982) and a listing in a USDA technical handbook. Blackburn & Miller (1984) also examined specimens from Australia that were deposited in the US National Museum of Natural History (Beltsville, MD). These latter specimens, labelled numbers #3988 and #45062, have been confirmed by US-NMNH curators as intercepted material, collected from *Citrus sinensis* (Rutaceae) transiting through Hawaii, and for which definitive determination of Australia as the true origin remains uncertain. There are no records of this species in the APPD, and we are unaware of specimens in any Australian collections that have been collected in Australia (there are, however, specimens collected from overseas, e.g., China).

The primary host plant of *U. yanonensis* is citrus, which is regularly targeted by NAQS surveillance operations, and while *Unaspis citri* (and other citrus armoured scales) has been frequently collected across northern Australia,

including during targeted citrus industry surveys, there are no records for *U. yanonensis* having been encountered. Notably, CABI also regards the Australian distributional record as 'Absent, invalid presence record(s)'. We consider *U. yanonensis* to be absent from Australia.

Ortheziidae

Insignorthezia insignis. ScaleNet includes Australia as part of this species' geographic distribution as per Morrison (1952), who lists Australia among a long line of countries for which *I. insignis* has '... been reported, or from which it has now been identified ...' (Morrison 1952, p. 32). No further detail on Australian records was provided, and it is unclear from the list of Morrison (1952) which records are associated with specimens in collections (i.e., verifiable) or are simply reports without specimens. Kozár (2004) also states this species as occurring in Australia, but similarly no details are provided regarding locations or verifiable specimens. We suspect Kozár may have been simply citing Morrison (1952). Lapolla et al. (2008) perpetuated this record, citing Kozár (2004).

Insignorthezia insignis has a broad host range including commercial hosts grown in temperate and tropical regions, yet there are no verifiable Australian records for this species in ANIC, NAQS surveillance records or in the APPD (although specimens from the United States are listed in the Waite Insect and Nematode Collection [WINC] collection under *Orthezia*). Given the lack of verifiable specimens from earlier reports (that appear to have been perpetuated by subsequent authors) and the absence of records for this species in Australian collections or databases, we consider *I. insignis* to be absent from Australia.

Orthezia urticae. The nettle ensign scale was listed on the AICN website (now defunct) as of 'uncertain presence' in Australia. Lapolla et al. (2008) listed *O. urticae* as among the 10 ortheziids known from Australia but did not include it in that publication's key to species. Further, the cited reference provided that justifies their inclusion of this species as among ortheziids in Australia is Kozár (2004); however, Kozár (2004) does not list Australia as part of the distribution (but does list 'Austria') (Kozár 2004, p. 374). As no other databases—including the APPD, AFD (where it is listed, but with no Australian distributional or specimen information) and ScaleNet—list Australia as part of its geographic range, we consider the inclusion by Lapolla et al. (2008) of *O. urticae* as present in Australia to be erroneous, that 'Austria' was misread as 'Australia' and that *O. urticae* is absent from Australia.

Pseudococcidae

Paracoccus burnerae. There is only one published record for this species as being present in Australia: Masten Milek & Pellizzari (2016) (as cited on ScaleNet) who cite Miller, Rung, & Parikh (2014), who list Australia as one of the locations from which specimens were intercepted by quarantine. No other records for this species exist in

Australian collection databases. Hence, as no further specimens of this species exist in Australia, and no other records other than intercept data exist for this species, we consider it to be absent from Australia.

Introduced species considered likely extirpated from Australia or uncertain

Coccidae

Drepanococcus chiton. This coccid occurs in PNG (Williams & Watson 1990), and one of the authors (P.J.G.) mounted two adult female specimens collected in Darwin in 1915 (NT, dry collection with the label: 'Ctenochiton/sp. nov./WWF 2.9.15/on *Hibiscus tiliaceus* L./Darwin N.T./G. F. Hill July' [ANIC]: 2 adff [mounted from dry material by P.J.G.]). Further, surveillance activities undertaken by another author (M.G.) in Far North Qld in 2012 and 2016 resulted in material identified to genus *Drepanococcus* only, due to poor specimen quality (specimens deposited in the NAQS collection). Until this species is collected and confirmed via new material, we consider its status as uncertain and possibly extirpated.

Pulvinaria aurantii. This species was first reported from Australia and described as a new species, *Pulvinaria ornata*, by Froggatt (1921) from specimens collected in 1920 on a lemon tree in Sydney; however, as that name was preoccupied, Borchsenius (1957) coined the replacement name *Pulvinaria decorata*. *Pulvinaria ornata* and *P. decorata* were recently synonymised with *P. aurantii* by Tanaka & Kamitani (2021). There are no records of *P. aurantii* on the APPD; however, there are records under the synonyms *P. ornata* and *P. decorata* (all ASCU), for which the Australian material of *P. decorata* is confirmed as having all been collected by Froggatt between the years 1910 and 1921. There are no collection details (including locality) on the slide labels for the three ASCU specimens of *P. ornata*; however, details of Froggatt's material from these early 20th century collections are provided in Qin & Gullan (1992). This species has not been reported since Froggatt's original record as far as we can ascertain. We therefore consider it extirpated from Australia.

Pulvinaria elongata. *Pulvinaria elongata* has been reported as occurring in Australia according to a number of sources (e.g., ScaleNet, AFD and the defunct AICN), with the earliest reports dating from the 1950s and 1960s from sugarcane on Magnetic Island (*n.b.*, the sugarcane had been introduced from PNG in 1957) (Wilson 1959), or intercepted on sugarcane in Brisbane (Williams 1982). Qin & Gullan (1992) include the species in their treatment of *Pulvinaria* species in Australia, noting the following specimens they examined at the NHMUK: three females intercepted in Brisbane (Qld) and 11 females from Eight Mile Plains (Qld). They go on to note that it has no economic importance in Australia, although heavy infestations

had occurred on sugarcane elsewhere (Williams 1982). A search of the NHMUK database (<https://data.nhm.ac.uk/search>, accessed 12 September 2024) reveals 10 slides of this species collected by A. R. Brimblecombe in 1968 and 1969, both on sugarcane and from either Eight Mile Plains, Qld (coll. 18.vii.1969) or intercepted at Brisbane (7.ii.1968).

There are very few additional records of specimens of *P. elongata* in Australia. The APPD lists only five accessions, all collected from *Saccharum officinarum* (Poaceae) in 1993 from Bundaberg Qld (a major sugarcane region) and held at the QDPC. At the time of writing, there are no records of this species having been collected from sugarcane or other grasses for nearly 30 years. Given the economic importance of sugarcane and the frequent surveillance for plant pests on this commodity, we consider it unlikely that this species has persisted in the landscape and escaped collection over this time. We therefore consider this species to be likely extirpated from Australia.

Diaspididae

Aulacaspis tegalensis. While ScaleNet does not list this species as occurring in Australia, specimens exist in the QDPC and APPD, and this species is noted as occurring in Qld on the AFD (Thursday Island, Torres Strait). To our knowledge, these represent the only specimens of *A. tegalensis* collected in Australia. The QDPC holds 31 accessions, all collected from Thursday Island between 1983 and 1989. All specimens were collected from sugarcane. Sugarcane is regularly surveyed for pests by NAQS, and while the closely related species *Aulacaspis madiunensis* is collected in the Torres Strait, no collections of *A. tegalensis* appear to have been made since 1989. Given backyard cultivation of sugarcane on Thursday Island is less prevalent than in the past, and there have been no subsequent detections of this species for the last 30+ years, we consider this species to be extirpated from the Torres Strait and not present in any part of the Australian environment, especially given its restricted host range rendering it unlikely ability to survive and reproduce in the absence of cultivated or wild *Saccharum* spp. (Williams & Greathead 1973).

Dulacaspis lenticularis. *Dulacaspis lenticularis* was reported from Australia in Brookes & Hudson (1968) (as cited on ScaleNet) under its prior name, *Quadraspidiotus lenticularis*, following its detection during field surveys in SA (Brookes 1964), during which it was recorded from four localities in that state. Brookes & Hudson (1968) stated that it was '... identified for the first time in November, 1958, as a light infestation on wood of *Pyrus communis* L. (pear) and *Prunus domestica* L. (plum) at Mypolonga, South Australia' (Brookes & Hudson 1968, p. 93) and that this was the only state or territory from which this species had been found. The APPD (accessed October 2023) contains 13 records for '*Quadraspidiotus lenticularis*': two registered with Invertebrate Collection Database (ICDb, DPIRD, WA) and the remaining with the Tasmanian Plant

Pest Database (TPPD), with all being collected between 1958 and 1965. There is one record on the APPD under the name '*Diaspidiotus lenticularis*', also collected in SA, in 1960. The EPPO Global Database records Australia as part of the distribution for *D. lenticularis*; no further details are provided. No other databases or information sources refer to this species as occurring in Australia; however, the AFD includes a limited entry for '*Diaspidiotus lenticulatus*' (distribution = 'South Australia'), which appears to be a misspelling of the specific epithet.

Despite a lack of records for this species in recent decades, we nevertheless consider it possible for this species to have persisted in the landscape and consider its status as unknown, possibly extirpated from Australia.

Lepidosaphes pallidula. The ScaleNet reference for this species as occurring in Australia is Williams & Williams (1988), who cite Mamet (1943) as the source of the Australian record, wherein 'Northern Australia' is recorded against the former combination of *L. pallida*.

Given the last known collection date for this species was 1956 (nearly 70 years ago; refer to details above under *L. pallida*), we question whether this species continues to persist in the environment and consider it as potentially extirpated from Australia.

Lopholeucaspis japonica. Several sources list this species as present in Australia, including AICN (defunct), AFD, ALA, DAWE (2021) and ScaleNet, the latter of which cites a single reference that is the earliest known instance which refers to it under the former combination of *Leucaspis japonica* var. *darwiniensis*, nov., collected from the foliage of *Ficus orbicularis* (Moraceae) in Darwin (NT) (Green 1916), and for which specimens are held in the collection of the NHMUK. These specimens represent the only confirmed material for this species from Australia, and given they were collected in 1914 (i.e., over 100 years ago), we consider this species to be extirpated from Australia.

Oceanaspidotus spinosus. No public databases or literature include Australia as part of the distribution for this species. There is, however, a single record on the APPD: one specimen collected from Gosford (NSW) on *Camelia* in 1974, which has since been re-examined by one of the authors (P.S.G.) and confirmed as morphologically consistent with *O. spinosus*. Other records of it are from Norfolk Island (an external Australian territory ~1600 km north-east of Sydney in the Pacific Ocean) (Williams & Watson 1988a), but a recent comprehensive survey on Norfolk Island did not find this species (Maynard, Lepschi, & Malfroy 2018). Given the length of time since last detection (of a single specimen) and the absence of any further records from collections, we consider this species to have likely been extirpated from Australia.

Parlatoria ziziphi. This species is listed as present in Australia on ScaleNet based on Maskell (1896) and Green

(1914). Maskell (1896, 1897a) refers to this species in WA, in association with imported citrus from Sicily. Ten records for this species are listed on the APPD, including four ASCU specimens collected from the NT with *Citrus acida* (Rutaceae) as host plant for three of the slides. A further two are recorded from NSW as intercepted material: one ex *C. sinensis* 'navel' (Rutaceae) and one ex *Citrus hystrix* (Rutaceae) as intercepted material from Vic. The remaining APPD records are for overseas collections. Smith, Bellis, & Gillespie (2013) provide extensive argument that *P. ziziphi* be regarded as absent from Australia, referring specifically to the above mentioned ASCU NT records listed on the APPD, and we find no further evidence to challenge this assessment and agree it be considered no longer present. We note that BOLD refers to sequence data for *P. ziziphi* from Australia; however, we are unable to verify this because data were deposited directly to BOLD from Thailand intercept material, and the remainder was mined from GenBank for which we can find no reference to Australia.

Selenaspis albus. Only eight slides are known to exist for this species from Australia, all collected in 1953 from Holland Park in Brisbane, Australia, and housed at the QDPC. This species is not documented on the AFD, and APPD records for these slides identified them only so far as genus *Selenaspis*. We have examined these slides and confirm their identity as *S. albus*. Nevertheless, given no subsequent collections of this species have been made for at least 70 years, combined with the fact the host plant *Euphorbia caput-medusae* (Euphorbiaceae) is not considered to be naturalised in Australia (but can be purchased in the nursery trade), we consider it unlikely that this species has persisted, and it should be considered extirpated from Australia.

Rhizoecidae

Geococcus coffeae. ScaleNet lists the following sources in supporting this species from Australia: Kaydan, Kozar, & Erkiş (2014), Ben-Dov (1994) and Williams (1985).

Kaydan, Kozar, & Erkiş (2014) examined specimens from Türkiye and included Australia as part of this species' distribution list, but with no further references or specimens examined to support it. Ben-Dov (1994) similarly lists Australia, citing Williams (1985), who in turn refers to specimens that were collected in Darwin (NT) from the roots of *Vitis vinifera* in 1980. This remains the only known record for *G. coffeae* in Australia and is represented in the APPD as a single accession: WINC 0125789, collected 29 October 1980 by A. J. Allwood from 'underground on cutting' (collection data matching that as provided by Williams (1985)). We take it that this record is the basis for its entry on the AFD (as occurring in the NT).

As the host is described as a cutting, it is unclear if this was recently imported for planting and thus may represent a border interception rather than successful establishment of the pest in the environment. Except for its

subterranean habit, given such a broad host range and regular surveillance of host plants across northern Australia, further records would be expected should this species have persisted in the environment. While regarded as present in other sources (e.g., the defunct AICN), we nevertheless consider it unlikely to be still present in Australia given that no further collections of this species have apparently been made over the last 40 years and we consider it absent.

Rhizoecus cacticans. ScaleNet records this species from Australia based on a single record by Williams (1985), who examined material collected from cactus in a suburb in Adelaide (Hawthorn), SA, 7.vii.1965. The entry does not include details on where the specimens were deposited. We note, however, the existence of a slide-mounted specimen (NHMUK013556984) located at the NHMUK and bearing the following collection details written in William's handwriting on the slide labels: SA, Hawthorn, Cactus, 7.vii.1966. Given the identical details, except the year of collection (1966 vs. 1965), it is possible the 1965 date is erroneous. Helen M. Brookes (the only coccidologist in Adelaide at that time) did not record any collections of *R. cacticans* on her Specimen Index Cards, as confirmed by one of the authors (P.J.G.), who considers it likely that any Australian material was sent by Brookes to Williams at the time.

Evidence of this species in Australia has not been located in any other sources, either collections or the literature, including the APPD, which while containing many records of *Rhizoecus* spp. includes none collected from Cactaceae and no collection records between 1964 and 1966. The species is listed on the AFD as occurring in SA; however, this record is likely drawn from the information as discussed above. We do not question the record as this species was reported by a highly regarded scale taxonomist; yet, given no other representatives of this species appear to have been recorded for over 50 years, we consider it to be potentially extirpated from Australia.

Status considered as possibly native or native to Australia

Coccidae

Coccus praetermissus. This species was described by Lin, Tanaka, & Cook (2017), who state '... this species might be restricted to tropical regions of eastern Asia and Oceania including Australia, whereas *C. hesperidum* s.s. is much more widespread' (Lin, Tanaka, & Cook 2017, p. 584). While Lin, Tanaka, & Cook (2017) do not speculate on the origin of *C. praetermissus*, personal correspondence between one of the authors (P.J.G.) and Lin revealed that given that the species is so widely distributed (e.g., Taiwan, Malaysia and Australia), its Australian status remains unresolved and that it may be considered as possibly native.

Diaspididae

Aspidiotus nerii. The species group to which *A. nerii* belongs is considered Australasian in origin (Provencher et al. 2005), with several undescribed Australian species detected using DNA sequence data, including two species specialised on *Macrozamia* (Zamiaceae) (Andersen et al. 2010; McDougall et al. 2021). Recently, three new Australian species of the *A. nerii* complex that were originally recognised based on molecular data have been described and named, and *A. nerii* has been assessed as native to Australia (Normark, Normark, & Gullan 2022). Hence, we regard *A. nerii* as native.

Monophlebidae

Icerya imperatae. This species is part of a group of *Icerya* species found in northern Australia, and it is possibly native, despite molecular data being inconclusive other than indicating it as being of Australasian or Southeast Asian origin (Unruh & Gullan 2008a). *Icerya imperatae* also occurs in the Philippines, Malaysia and the Pacific (Fiji, Palau) (Hodgson & Łagowska 2011; Williams et al. 2006). Morphologically, the adult female does not group closely with other known *Icerya* species (Unruh & Gullan 2008b). We do note, however, that most records of this species from Australian collections are from introduced grasses (Poaceae), such as *Oryza sativa*, *Bothriochloa pertusa*, *Sorghum bicolor* and *Digitaria milanijana*.

Ortheziidae

Nipponorthezinella guadalcanalia. ScaleNet cites Williams (1991) as the record for this species in Australia, as he had stated it as 'known from Qld in litter ...' (Williams 1991, p. 459). It is also regarded as present in Australia by Lapolla et al. (2008) who cited Kozár (2004), and there are three specimens accessioned in the QDPC (collected from Brisbane, Qld; ex roots of *Achillea millefolium* [Asteraceae]) and available on the APPD. These specimens were likely determined by D. J. Williams as their collection date (1978) aligns with his visit to Australia, and one of the authors (P.J.G.) considers it probable that he mounted and identified at least some of these. The specimens have been examined by one of the authors (M.K.S.) and confirmed as morphologically consistent with *N. guadalcanalia*. While inconclusive, we consider this to possibly be a species native to Australia, noting it also occurs in PNG, Indonesia and other countries in the Pacific region (see references in García Morales et al. 2025). This ortheziid species, as for most others, is saprophagous in leaf litter and may feed on roots; therefore, it is relatively cryptic and unlikely to be collected or even if it is collected to be accurately identified.

Pseudococcidae

Maconellicoccus hirsutus. This species is known from Qld, NT and WA (AFD, QDPC, NAQS), with earliest records dating back to 1940 for Qld specimens collected from *Eucalyptus tereticornis* (Myrtaceae). Although the origin of *M.*

hirsutus is unknown, four other species from this genus are endemic to Australia and have been recorded from only Australian native plants (*Maconellicoccus australiensis*, *Maconellicoccus lanigerus*, *Maconellicoccus leptospermi* and *Maconellicoccus tasmaniae*). A further four *Maconellicoccus* species are known from Asia and the Pacific (*Maconellicoccus multipori* and *Maconellicoccus ramchensis*), northern Africa/Middle East (*M. cressae*) and the African endemic, *Maconellicoccus ugandae* (see references in García Morales et al. 2025).

Molecular phylogenetic data have placed *M. hirsutus* as sister to the unequivocally Australian taxon, *M. australiensis*, and separate these two species from other mealybug genera (Hardy, Gullan, & Hodgson 2008). The two species sampled in the study of Hardy, Gullan, & Hodgson (2008) were included in the recent analysis of Choi & Lee (2022) and *Maconellicoccus* is again sister to all other sequenced members of subfamily Pseudococcidae (i.e., Choi & Lee confirmed the result of Hardy et al.). These data are supported by unpublished data from one of the present authors (M.G.), in which *M. multipori* from PNG is sister to *M. hirsutus* and *M. australiensis* (based on COI), and *M. australiensis* is sister to *M. hirsutus* and *M. multipori* based on 28S. Given this, we cannot assert that *M. hirsutus* is introduced and consider Australia as possibly part of its native range, which may also include PNG.

Palmicultor browni. Williams (1985) records *P. browni* from Brisbane, Qld, on *Howea* palm, an endemic species to Lord Howe Island and a garden plant in mainland Australia. Recent morphological and molecular data place *P. browni* as sister to the Pacific species *Palmicultor guamensis* (the former also occurring in the Pacific) (von Ellenrieder, Kinnee, & Watson 2022). We consider Australia as potentially part of the native range of *P. browni* until evidence demonstrates otherwise, noting that the only region outside the Pacific that this species may be considered invasive is Florida, USA (Stocks 2013).

Pseudococcus longispinus. The phylogenetic analysis of Hardy, Gullan, & Hodgson (2008) places this species as part of a group of three, with the other two being one unequivocal Australian species, *Eucalyptococcus lobulatus* and *Neosimmondsia hydnophytum* known only from the Pacific. While Choi & Lee (2022) do not include *E. lobulatus* and *N. hydnophytum*, nor any native Australian *Pseudococcus* species, in their study, their analysis places *P. longispinus* as sister to *P. jackbeardsleyi*, a recent arrival to far north Qld and undeniably non-Australian in origin. *Pseudococcus longispinus* bears morphological similarity (e.g., oral rim ducts associated with the cerarii) to two Australian *Pseudococcus* species, but its broader similarity to non-Australian conspecifics is yet to be fully evaluated. Many more *Pseudococcus* species require molecular analysis to fully resolve relationships within the genus to determine the origin and status of this species. Williams (1985) discussed the economic importance of *P. longispinus* in

Australia and his detailed information on its native natural enemies suggests that this mealybug is native too. We also regard it as possibly native.

Saccharicoccus sacchari. Molecular data place this species in a group with *Planococcus citri* and *Planococcus ficus* (Hardy, Gullan, & Hodgson 2008), neither of which are native to Australia yet their origin remains unknown. We note that *S. sacchari* was not in the molecular study of Choi & Lee (2022); however, they did include the two other described species of *Saccharicoccus*, which are widely separated in their tree. We note that available records of *S. sacchari* from Australia include only one record from a host other than sugarcane: an introduced grass, *Cortaderia selloana* (Poaceae). While we cannot determine where this species originated, and suspect it was introduced, we nevertheless categorise it here as possibly native.

Details of species reported from the Australian environment during the last two decades, including recent detections

Asterolecaniidae

Planchonia stentae. While surveying for mealybugs and aphids, the first record of *P. stentae* was from the collection of a single specimen on the stem of a weed growing outside of a nursery primarily housing orchids and *Hoya* spp. (Apocynaceae). The nursery was formerly used as a post-entry quarantine facility mostly for bromeliads and orchids and was no longer operational at the time of the detection. The collection details for this specimen are the following: Kennedy Highway, Mareeba, Qld, 13.viii.2019 (sample number 359145, NAQS), ex *Emilia sonchifolia* (Asteraceae) in a weedy area outside nursery shade house, collected and identified by one of the authors (M.G.).

A subsequent detection of multiple specimens was made under a similarly controlled environment in a private shade house in southeast Qld, collected on 22.iv.2020 and 14.v.2020 from *Hoya pauciflora* (Apocynaceae) and *Adromischus marianae* var. *antidorcatum* (Crassulaceae). Specimens from this detection are held in the QDPC under accession numbers 0-175613–0-175615, 0-175658 and 0-177194–0-177199; all were determined by one of the authors (M.K.S.) based on morphological and genetic data (28SD2D3; primers s3660 and a335). Specimens have been further detected via interstate domestic interceptions of *Hoya* (specifically on *Hoya kerrii*) nursery stock during 2020, demonstrating the movement of this species within the nursery trade.

In 2023, the species was collected from a weed, *Gomphocarpus physocarpus* (Apocynaceae) growing from a crack in a sealed hardstand at the Port of Brisbane, Qld, during routine surveillance by the Australia DAFF National Border Surveillance team (sample number 487025, NAQS).

The presence of this species on a widespread weed in a harsh, temporary habitat and unconnected with any obvious live plant pathway suggests it has become established more broadly in the Australian environment.

Further, the APPD includes eight records for *P. stentae* collected from Alstonville (NSW) on the 20 February 2020 (ex *Hoya* sp.), registered by the ICDB collection under accession numbers 142215–144222.

Planchonia stentae has a relatively restricted geographic distribution, including at least Colombia, the Hawaiian Islands, Martinique, Puerto Rico, South Africa and parts of mainland United States (California and Florida) (see references in García Morales et al. 2025). Its host range is extensive, however, having been associated with 41 plant genera across 16 families. While *Hoya* is a known host-plant genus, it appears that *Adromischus* (Crassulaceae) from the southeast Qld shade house detection represents a new record for this species; the only other Crassulaceae from which *P. stentae* is known are *Echeveria* and *Kalanchoe* (see references in García Morales et al. 2025).

While most earlier detections of this species have been made under contained conditions (e.g., in nurseries), the most recent detection of *P. stentae* in the environment indicates this species is likely to be established in the Australian environment and should be considered as present.

Coccidae

Kilifia acuminata. A distinctive species, yet morphologically similar to its close relatives (especially *Kilifia deltoides*), *K. acuminata* was first collected in Australia from Mt Coot-tha on 20.iv.2017 ex *Notelaea* sp. (Oleaceae) (from two separate plants: MG170620-5 and MG170620-6, NAQS) by one of the authors (M.G.), who recognised it as one of the NAQS target species. Specimens were associated with a large amount of sooty mould.

Subsequent collections were made (Mt Coot-tha, Qld; 03.viii.2017; coll. MKS, DJT, Lin YP; ex *Notelaea punctata* det. M. Thomas Qld Herbarium) and are accessioned in the QDPC as a wet-preserved bulk sample of multiple specimens (0-175654) and the following slide-mounted adult female specimens: 0-176395–0-176402.

Kilifia acuminata has previously been recorded from 58 host-plant genera across 36 families including several economically important species such as *Citrus* spp., avocado and mangoes. This species has been recorded from 49 countries across the Americas, the Pacific, Asia, Africa and Europe (see references in García Morales et al. 2025).

While known from Oleaceae, this is the first record of this species from *Notelaea*, a native Australian genus endemic to the east coast of the mainland and Tasmania. Megan Thomas (Qld Herbarium) advised that *N. punctata* was formerly known as *Notelaea longifolia* forma *glabra* and that following re-examination of type specimens by Gordon Guymer (Director, Qld Herbarium) it is now *N. punctata*. Given the presence of this coccid in the natural environment on a native Australian plant species and its

widespread cosmopolitan distribution, we consider it likely that *K. acuminata* has existed as a non-native species in the Australian landscape for some time, may occur undetected in other parts of Qld and Australia and that further surveillance for its presence in other regions is recommended to document its range.

Prococcus acutissimus. A single specimen was collected from *Litchi chinensis* (Sapindaceae) on the 1.vii.2021 (sample number m.4.A) as part of a lychee project monitoring scale insect diversity in Mareeba, Qld. The specimen was determined as *P. acutissimus* following 28S sequencing analysis by DAF Grow Help Australia staff before referral to Biosecurity Queensland for confirmation by M.K.S., where it was found to be morphologically consistent with that species and lodged within the QDPC under accession number 0-177305.

Prococcus acutissimus is highly distinctive due to its asymmetrical ‘banana’ shape. ScaleNet includes 42 plant genera across 29 families as hosts for this species, which has been recorded from 23 countries in Africa, Asia, the Pacific and the Americas. The closest geographical locality to Australia is PNG. Given the presence of this species in the environment, we consider it likely to be established despite this being the only known specimen collected from Australia.

Protospulvinaria pyriformis. This non-native species was first recorded on ornamental ivy, *Hedera* sp. (Araliaceae), in Perth, WA, in 2015, but has since spread across the Perth metropolitan area and to other host plants (IPPC 2017; C. Brumley, pers. comm. to P.J.G., 2023). Specimens were identified by C. Brumley based on morphological examination and confirmed by one of the present authors (P.J.G.). Pyriform scale has been causing heavy infestations on bay trees and ivy, and has been found on figs, lilly pilly and umbrella trees, but has not yet reached any avocado growing regions in WA (C. Brumley, pers. comm. to P.J.G.). Currently, it is not known from other Australian states or territories. The pyriform scale is polyphagous and is a known pest of fruit trees and ornamentals (Gill 1988; Kondo, Gavrillov-Zimin, & Watson 2022).

Saissetia miranda. This species was first collected by L. Halling on 02.ix.2009 at Kununurra, WA, ex *Adansonia gregorii* (Malvaceae) (LH498, NAQS). The specimen was confirmed via morphological examination and supported by secondary unpublished molecular data.

Subsequent collections and confirmation of this species via morphological examination of slide-mounted material held in the NAQS insect collection are as follows, noting (i) the WA and Torres Strait detections were made during NAQS surveys and (ii) the Townsville (Qld) detection resulted from an international seaport surveillance exercise: ADR825, Kirriri, Torres Strait, Qld, ex *Erythrina variegata* (Fabaceae), 15.viii.2011, A. Rice; LH985b, Broome, WA, ex *Heliconia* sp. (Heliconiaceae), 15.ix.2011,

L. Halling; MJG004, Poruma, Torres Strait, Qld, ex *Terminalia* sp. (Combretaceae), 31.vii.2012, M. Gorton; MJG027, Boigu, Torres Strait, Qld, ex *Manihot esculenta* (Euphorbiaceae), 01.viii.2012, M. Gorton; MJG040, Kirriri, Torres Strait, Qld, ex *Plumeria* sp. (Apocynaceae), 03.viii.2012, M. Gorton; 228681, Townsville, Qld, ex *Mangifera indica* (Anacardiaceae), 04.xii.2015, V. King; SAC1174, Boigu, Torres Strait, Qld, ex *Musa* sp. (Musaceae), 11.vi.2019, S. Cowan.

This species has previously been reported from 59 host-plant genera across 27 families, and prior to its detection in Australia was known from 38 countries across the Americas, the Pacific, Europe, Asia, the Middle East and parts of Africa (see references in García Morales et al. 2025). This Australian detection expands the host range to include a new family (Musaceae) and *M. esculenta* in a previously recorded family.

Saissetia neglecta. Australia is not listed as part of this species' geographic distribution according to ScaleNet or Kondo & Watson (2022); however, the QDPC holds the following three accessions for this species: 0-018408, Napranum, Qld, ex *Psidium guajava* (Myrtaceae), 27.iii.1999, GN Maynard; 0-177260 and 0-177261, Sarina, Qld, ex *L. chinensis* (Sapindaceae), 9.xii.2020, Y. Diczbalis. The first of these, 0-018408, was initially identified only to genus in 1999 (det. J. F. Donaldson) but was subsequently determined by Y. P. Lin to be *S. neglecta* in August 2017. Lin also reported on the presence of this species in Qld and the NT in his conference paper to the 48th Australian Entomological Society Scientific Conference (Terrigal, NSW, 17–20 September 2017).

Therefore, while the first collection of this species from Australia is over 20 years ago (i.e., 1999), its confirmation as *S. neglecta* is relatively recent in having been confirmed in 2017.

Diaspididae

Aspidiella sacchari. This species has been recorded from Australia since at least 2002. The earliest record from collection data is 27.v.2002 for 10 specimens collected from Nhulunbuy, NT, ex *S. officinarum* (Poaceae), P. Samson. Additional collections were made from other locations in the NT from *S. officinarum* by the same collector between 28 and 30.v.2002: Yirrkala (1 specimen), Galiwinku (12), Gapuwiyak (5), Ramingining (1), Maningrida (4) and Daly River (4). Additional specimens have been collected from Kalumburu (6), WA, 2.vi.2002, ex *S. officinarum*, P. Samson; Derby (5), WA, 3.vi.2002, ex *S. officinarum*, P. Samson; 12 Mile (2), WA, 26.viii.2003, ex *S. officinarum*, A. C. Postle; and Pormpuraaw (6), Qld, 19.vi.2003, ex *S. officinarum*, P. Samson. All specimens referred to above are held in the QDPC. More recent material has been collected 1.v.2015 from Bamaga, Cape York Peninsula, Qld, ex *S. officinarum*, L. Halling (LH1373c), as part of a NAQS survey and held in the NAQS insect collection.

Prior to these records, *A. sacchari* has been recorded from at least 41 countries from the Americas, the Pacific,

Asia and Africa, with a host-plant range including 20 genera from six families (see references in García Morales et al. 2025). Records of *A. sacchari* from Australia are all from sugarcane, *S. officinarum*, and thus do not extend the host range for this species. Given *A. sacchari* has been recorded from at least NT, WA and Qld and has been collected from the environment within the last 10 years, we consider it present and established in Australia.

Carulaspis minima. The presence of *C. minima* in Australia was investigated by Federal biosecurity staff following a suspected border interception on imported cypress, *Cupressus leylandii* (Cupressaceae), in late 2017. Specimens were subsequently collected at Centre Road, Melbourne Airport (Vic) on 23.i.2018 from *Hesperocyparis macrocarpa* (Cupressaceae), L. Watson (332452); at Somerville Road, Footscray, Melbourne, Vic, 02.ii.2018, on *H. macrocarpa*, L. Watson (315768); at Werribee, Melbourne, Vic, 5.iii.2018, on *Cupressus sempervirens* (Cupressaceae), L. Watson; and at Wellington Square, North Adelaide, SA, 20.iii.2018 on *H. macrocarpa*, L. Watson. Specimens are held in the NAQS insect collection, Cairns.

There are no records of *C. minima* in the AFD, but this is not unusual. There are also no published records of *Carulaspis* from mainland Australia, although one of the authors (M.G.) has examined specimens of *Carulaspis juniperi* collected from Argyle Street, Moss Vale, NSW, southern tablelands, on 'cypress' (likely *Cryptomeria japonica*, Cupressaceae) 20.v.2023, A. Carnegie and C. Trollip. The only published records of *Carulaspis* in Australia are of *C. juniperi* in Tasmania. There are records of *Carulaspis* sp. nr *minima* in NSW from 1986 in the APPD which may be a record of this species and will only be confirmed following examination of the specimens. The APPD also has records of an unidentified *Carulaspis* species in Qld and NSW, which could be *C. juniperi* or *C. minima* (or another species), and *C. visci* from NSW, which is almost certainly a misidentification of either *C. minima* or *C. juniperi*. The earliest records of *Carulaspis* sp. are from the early 1960s (ex *Cupressus* sp.), and if confirmed as *C. minima* would indicate this species has been established in Australia for at least 60 years.

ScaleNet reports *C. minima* as widespread, occurring in 48 countries and recorded primarily from Cupressaceae; however, while this species is known from other species of *Hesperocyparis* (e.g., *Hesperocyparis goveniana*), *H. macrocarpa* appears to be a new host-species record for this scale insect.

Schizentaspis silvicola. Currently, this species is known only from PNG and the Solomon Islands from five genera in different host-plant families (Williams & Watson 1988a). This new record for Australia, of a presumed native species, is from a single representative specimen collected on the 22.xi.2017 by one of the authors (M.G.) during a NAQS survey collection at Daintree, Qld, Australia, ex *Camellia sinensis* (Theaceae) (MG161122-9). The specimen

was collected from within a tea plantation (from tea leaves among other scale insects) situated adjacent to the Daintree World Heritage rainforest. *S. silvicola* is currently known from outside Australia on a small number of rainforest hosts. As there is no evidence to indicate this species was introduced, we consider Australia (at least far northern tropical Qld) to likely represent part of this species' native range. The specimen is held in the NAQS insect collection, Cairns.

Thysanofiorinia leei. Earliest records for this species from Australia date to two specimens collected on 17.viii.1981 from Woombye, southeast Qld, ex *L. chinensis* (Sapindaceae), G. K. Waite. The QDPC holds an additional 59 accessions of this species from Qld and NT collected between 1981 and 2020, all ex *L. chinensis*. A further specimen was collected as part of a NAQS survey from Mt Poverty Road, North Qld, 21.iii.2013, ex *L. chinensis*, coll. Anthony Rice (ADR990b).

This species has a relatively limited host-plant range, recorded from only two genera of the Sapindaceae in four countries: China, India, Taiwan and the United States (Florida and Hawaiian Islands) (see references in García Morales et al. 2025). These new records extend this species' geographic distribution, but all Australian detections are from the known major host plant, *L. chinensis*. Given its long history of detections in the Australian environment, we consider this species well established on the continent, yet apparently restricted to the NT (Darwin) and Qld from Cape York Peninsula to southeast Qld (e.g., Brisbane).

Monophlebidae

Icerya samaraia. We report this species from Australia based on specimens collected from *P. guajava* (Myrtaceae) on 1 August 2012, Boigu, Torres Strait, Qld, collected and identified by one of the authors (M.G.), and verified by P.J.G., as part of a NAQS survey. Further specimens were collected from *Citrus* sp. on 15 May 2023, also on Boigu. All specimens are held in the NAQS insect collection, Cairns.

This species may be native to New Guinea, or New Guinea and northern Australia, a case supported by its morphological similarity to the Australian species, *Icerya nudata* (Unruh & Gullan 2008b). Nevertheless, the only collection of this species from Australia is Boigu, which is only 6.5 km from PNG; therefore, human-mediated movement of this species from mainland New Guinea to the Torres Strait cannot be discounted, and to date, no specimens of this species have been collected on the Australian mainland. All specimens are held in the NAQS insect collection, Cairns.

Pseudococcidae

Cannococcus ikshu. This is a new record for Australia, collected as part of a NAQS survey by L. Halling (17.v.2012) and determined by one of the present authors (P.J.G.) on

10 August 2012. It was collected from *Sorghum alnum* at Kununurra, WA (LH1071), and is held in the NAQS insect collection, Cairns.

The type data for this species is the Highlands of PNG (sugarcane as the host) (Williams & Watson 1988b); therefore, given sugarcane and sorghum are farmed in Kununurra, we cannot rule out the possibility this species was introduced to Australia through sugarcane and its status (native or introduced) in Australia remains unresolved.

Paracoccus marginatus. This is a recent detection in Australia. The first record was made by the NT Department of Industry, Tourism and Trade (DITT) biosecurity and entomology officers in response to a public query (photograph of mealybugs on papaya fruit) on 10.vii.2023. Specimens were collected by DITT and NAQS entomologists and verified by one of the authors (M.G.) on 17.vii.2023 (B. Thistleton, pers. comm). Initial surveillance efforts collected the mealybug from *Plumeria* spp. (Apocynaceae), *Hibiscus* spp. (Malvaceae) and *Carica papaya* (Caricaceae), among others, and confirmed establishment within several inner Darwin suburbs. Subsequent surveillance by NAQS confirmed the species had established further afield at Wagait Beach on the Cox Peninsula, collected from papaya by L. Watson (LW465) on 10.x.2023, and later at Jabiru, also from papaya on 28.viii.2024, A. Genge (APG082406). Samples from the initial DITT record and subsequent NAQS survey material are held in the NAQS insect collection, Cairns.

A subsequent detection of *P. marginatus* was made in early April 2024 in Brisbane (Qld), with specimens submitted by the public to the Plant Biosecurity Laboratory (Biosecurity Queensland) for confirmatory diagnostics. The specimens were morphologically and genetically (28S) confirmed by one of the authors (M.K.S.) as *P. marginatus*, which had been reported in large numbers on *Plumeria* spp. where symptoms included sooty mould and leaf distortion. Other samples, although in fewer numbers, were also submitted from *C. papaya*, and at the time of writing, *P. marginatus* is yet to be collected from *Hibiscus* in Qld. Anecdotal observations suggest the papaya mealybug had been present in Qld since at least late 2023, with initial detections from Brisbane and focussed on the inner northern suburbs. Targeted surveillance activities in Cairns, Cooktown, Weipa and communities in the Northern Peninsula area and Torres Strait in 2023 and 2024, following the NT and southern Qld detections, failed to detect *P. marginatus* in these locations, until Biosecurity Queensland confirmed *P. marginatus* from Townsville in November 2024 (ex *Plumeria* sp.). While the link between the NT and Qld remains to be resolved, we consider human-mediated transport, rather than natural spread, to represent the most likely scenario explaining its occurrence in different regions of Australia.

Paracoccus marginatus, commonly known as the papaya mealybug, is suspected to be native to Central America but was observed to spread rapidly through the

Caribbean and into North America during the 1990s (Miller 1999). The papaya mealybug is highly polyphagous and recorded from 193 genera in 58 families in a total of 70 countries (García Morales et al. 2025). The species was first detected in India and Indonesia in 2008 (Muniappan et al. 2008) and shortly thereafter in several other South-east Asian countries and West Africa (Muniappan et al. 2009). Climate modelling combined with spatial data on cropping has suggested further potential for future expansion of this species, including the east coast of Northern Australia (Finch et al. 2021). The reasonably localised distribution in the NT coupled with the lack of earlier detections across northern Australia, despite targeted surveillance for this pest, indicates a relatively recent arrival in Australia via human-mediated transport at an international port rather than human-mediated or natural dispersal from PNG via the Torres Strait.

Planococcus lilacinus. The earliest Australian collection record for *P. lilacinus* is of two specimens collected on 14. iv.1983 from an unknown host plant on Boigu, Torres Strait, Qld, by J. W Turner. While Boigu is part of Australian territory, it is only 6.5 km away from PNG but 160 km from the Australia mainland. Subsequent NAQS survey collections of this species are the following: Saibai, Torres Strait, 03.iii.2008, ex *Citrus reticulata* (Rutaceae), A. Rice (ADR397b); Boigu, Torres Strait, 02.vi.2010, ex *Cocos nucifera* (Arecaceae), L. Halling (LH793b); Boigu, Torres Strait, 01.viii.2012, ex *Citrus* sp., M. Gorton (MJG023); Seisia, Qld, 01.v.2015, ex *C. nucifera*, L. Halling (LH1374); Prince of Wales Island, Torres Strait, 14.vi.2017, ex *C. nucifera*, L. Halling (LH1756); Injinoo, Qld, 27.vi.2017, ex *C. nucifera*, S. Cowan (SAC924); Dauan, Torres Strait, 10.vi.2019, ex *Citrus* sp., S. Cowan (SAC1166); Boigu, Torres Strait, 16.vi.2021, ex *Annona muricata* (Annonaceae), M. Gorton (MG210616-1); Saibai, Torres Strait, 18.v.2022, ex *Citrus* sp., M. Gorton (MG220518-4); Thursday Island, Torres Strait, 18.v.2023, ex *Tecoma* sp., M. Gorton (MG230518-1); Saibai, Torres Strait, 06.vi.2023, ex *Morinda citrifolia* (Rubiaceae), T. Greenwood (TAG085); and Saibai, Torres Strait, 19. vi.2024, ex *Manilkara kauki* (Sapotaceae), M. Gorton (MG240619-1). A further detection was made via public enquiry, collected on 28.xi.2011 ex *M. indica* (Anacardiaceae) on Horn Island, Torres Strait, collected by R. Ahwang (PEHID001). All specimens are held in the NAQS insect collection, Cairns.

This species is highly polyphagous and widespread, recorded from 92 host-plant genera in 42 families and at least 37 countries across Asia, Africa, the Pacific and Central and South America (see references in García Morales et al. 2025). Most of the host plants from which Australian specimens have been collected are part of the known host range for this species (i.e., *C. nucifera*, *M. indica* and *Citrus* spp.). The introduced ornamental *Tecoma* sp. (Bignonaceae) and the Australian natives *M. citrifolia* and *M. kauki* are new host records for this species. As PNG is part of the known range of *P. lilacinus*, it is

unsurprising that this species has been collected from the islands of the Torres Strait. At present, the distribution of this species appears limited to the tip of Cape York and Torres Strait; however, given the wide host range for this species, we anticipate it may be detected further south in Qld in future or in other jurisdictions.

Pseudococcus cryptus. This species was first collected in Australia from Bamaga, Qld, on 24.v.2007, ex *Citrus limon* (Rutaceae) by S. Cowan (SAC028) as part of a NAQS survey. Subsequent collections of this species, also NAQS surveys, are as follows: New Mapoon, Qld, 16.iv.2008, ex *Musa* sp. (Musaceae), A. Rice (ADR428a); Masig, Torres Strait, 27.vi.2011, ex *Musa* sp., L. Halling (LH924); Bamaga, Qld, ex *M. indica* (Anacardiaceae), 18.vi.2012, A. Rice (ADR936); New Mapoon, Qld, ex *Musa* sp., 20.vi.2012, A. Rice (ADR944); Boigu, Torres Strait, ex *C. nucifera* (Arecaceae), 01.viii.2012, M. Gorton (MJG019); Nanum, Weipa, Qld, 06.vi.2013, ex *Musa* sp., A. Rice (ADR1037); Nanum, Weipa, Qld, 27.vi.2013, ex *Citrus* sp., I. Schneider (ICS007b); Nanum, Weipa, Qld, 05.vi.2014, ex *Musa* sp., S. Cowan (SAC417); Masig, Torres Strait, 16.vi.2014, ex *C. nucifera*, S. Cowan (SAC495); Masig, Torres Strait, 16.vi.2014, ex *Musa* sp., S. Cowan (SAC432); Thursday Island, Torres Strait, 21. vi.2014, ex *Musa* sp., S. Cowan (SAC461b); Smithfield, Cairns, Qld, 25.xi.2014, S. Cowan (SC141125); Yorkeys Knob, Cairns, Qld (16°48'38.61" S, 145°43'38.06" E), 04. xii.2014, M. Gorton (MG141204c); Rocky Point, Weipa, Qld, ex *Musa* sp., 24.iii.2015, L. Halling (LH1317b); Boigu, Torres Strait, 18.vi.2015, ex *Musa* sp., S. Cowan (SAC538a); Saibai, Torres Strait, ex *Musa* sp., 19.vi.2015, S. Cowan (SAC544); Aurukun, Qld, 24.viii.2015, ex *Citrus* sp., L. Halling (LH1506); Aurukun, Qld, 24.viii.2015, ex *C. nucifera*, L. Halling (LH1505); Portsmith, Cairns, Qld, 30.ix.2015, ex *Calophyllum* sp. (Calophyllaceae), M. Gorton (MG150930b); Cooktown, Qld, 16.ii.2016, ex *C. nucifera*, L. Halling (LH1516a); Redlynch, Cairns, Qld, 05.v.2016, ex *Citrus* sp., M. Gorton (MG160505); Cape Tribulation, Qld, 23.xi.2016, ex *Musa* sp., M. Gorton (MG161123-2); Badu, Torres Strait, 17.vi.2017, ex *Musa* sp., L. Halling (LH1766); Cairns, Qld, 14.vi.2019, ex *Dyopsis lutescens* (Arecaceae), N. Sallam (NS190614); and Wurrimiyanga, Bathurst Island, NT, 07. vii.2022, ex *C. nucifera*, L. Watson (LJW209). An additional record via public enquiry is from Mena Creek, Qld, 19. i.2019, ex *Areca catechu* (Arecaceae), R. Piper (MG190119-2). All the above specimens are held in the NAQS insect collection, Cairns.

In addition to the above records, the QDPC holds 60 accessions of *P. cryptus* collected from the following locations in Qld from 2015 to 2017: Weipa, Cairns, Seisia, Injinoo, New Mapoon and Nanum; and from the following host plants: *C. nucifera*, *Ixora* sp. (Rubiaceae), *D. lutescens*, *Solanum lycopersicum* (Solanaceae), *Musa* sp., *Ananas comosus* (Bromeliaceae) and *Calathea* sp. (Marantaceae).

Pseudococcus cryptus is another extremely widespread and polyphagous species, known from 94 host-plant genera across 53 families and recorded from at least

45 countries (see references in García Morales et al. 2025). Most of the Australian collection records above are from known host plants; however, two appear to be new host records for the literature: *D. lutescens* (Arecaceae) and *Calathea* sp. (Marantaceae); the latter represents a new host-family record. We note that all Australian records of *P. cryptus* are from the far north of Qld, with the southernmost detection limit being from Mena Creek at latitude 17°39'28.27" S. While this species has only been collected from NT and northern Qld (including Torres Strait), given its wide host range, we consider it likely this species will eventually spread to other hosts and geographic regions in Australia.

Pseudococcus jackbeardsleyi. The earliest record of this species is for three QDPC specimens collected on 28. vi.2001 from Poruma, Qld, ex *M. esculenta* (Euphorbiaceae), coll. J. F. Grimshaw and B. M. Waterhouse. Poruma Island is in the Torres Strait, approximately 92 km from mainland Qld. A further six accessions of this species are held in the QDPC, all collected between 2004 and 2017 from far northern mainland Qld (Umagico and Nanum) and the Torres Strait (Warraber) from *Ipomoea batatas* (Convolvulaceae) and *Musa* sp. (Musaceae), with the most recent collection dated 7. xii.2022 from Nanum, Qld ex *Cucurbita* sp. (Cucurbitaceae) (QDPC accessions 0-177361-0-177365).

The following additional collections have been made as part of NAQS surveys between 2010 and 2022: Boigu, Torres Strait, 02. vi.2010, ex *Desmodium* sp. (Fabaceae), L. Halling, (LH792); Prince of Wales Island, Torres Strait, 06. iv.2011, ex *M. esculenta*, L. Halling, (LH820); Masig, Torres Strait, 27. vi.2011, ex *M. esculenta*, L. Halling (LH925); Saibai, Torres Strait, 28. vi.2011, ex *M. esculenta*, L. Halling (LH932a); Horn Island, Torres Strait, 02. vii.2011, ex *M. esculenta*, L. Halling (LH956); Poruma, Torres Strait, 31. vii.2012, ex *M. esculenta*, M. Finlay-Doney (MFD103); Mer, Torres Strait, 02. viii.2012, ex *M. esculenta*, M. Gorton (MJG031); Weipa, Qld, 06. vi.2013, ex *Citrus* sp. (Rutaceae), I. Schneider, (ICS007a); Mabuia, Torres Strait, 12. vi.2013, ex *C. papaya* (Caricaceae), S. Cowan (SAC329); Saibai, Torres Strait, 14. vi.2013, ex *Citrullus lanatus* (Cucurbitaceae), S. Cowan (SAC337); Prince of Wales Island, Torres Strait, 10. v.2014, ex *Basella alba* (Basellaceae), A. Rice (ADR1053a); Poruma, Torres Strait, 20. vi.2014, ex *M. esculenta*, S. Cowan (SAC458); Badu, Torres Strait, 16. vi.2015, ex *M. esculenta*, S. Cowan (SAC528); Nanum, Qld, 22. viii.2015, ex *Ixora* sp. (Rubiaceae), NT1516-W38-1-1 (QDAF surveillance record); Horn Island, Torres Strait, 11. iii.2016, ex *M. esculenta*, S. Cowan (SAC721); Warraber, Torres Strait, 04. vi.2019, ex *I. batatas*, E. Finlay (EGF1906-03-1); Thursday Island, Torres Strait, 08. vi.2019, ex *M. esculenta*, E. Finlay (EGF1906-27-2); Mer, Torres Strait, 11. vi.2021, ex *M. esculenta*, M. Gorton (MG210611-8); Kirriiri, Torres Strait, 12. vi.2021, ex *M. esculenta*, M. Gorton, (MG210612-9); Lockhart, Qld, 20. ix.2021, ex *M. esculenta*, T. Greenwood

(TAG039); Badu, Torres Strait, 21. x.2021, ex *Solanum melongena* (Solanaceae), M. Gorton (MG211021-10); Prince of Wales Island, Torres Strait, 23. x.2021, ex Cucurbitaceae, M. Gorton, (MG211023-3); Prince of Wales Island, Torres Strait, 23. x.2021, ex *Brassica rapae*, M. Gorton (MG211023-4); Prince of Wales Island, Torres Strait, 23. x.2021, ex *A. comosus* (Bromeliaceae), M. Gorton (MG211023-5); Prince of Wales Island, Torres Strait, 23. x.2021, ex *C. papaya*, M. Gorton (MG211023-6); Thursday Island, Torres Strait, 15. vi.2022, ex *M. esculenta*, T. Greenwood (TAG079); Prince of Wales Island, Torres Strait, 21. v.2022, ex *Ixora* sp., M. Gorton (MG220521-1); Cairns, 13. ii.2025, ex *Brassica* sp., M. Gorton (MG250213-6), Seisia, 31. iii.2025, ex *S. lycopersicum*, M. Gorton (MG250331-2); and New Mapoon, 31. iii.2025, ex *M. esculenta*, M. Gorton (MG250331-4). All the above specimens are held in NAQS insect collection, Cairns.

Pseudococcus jackbeardsleyi is a highly polyphagous species recorded from at least 122 host-plant genera across 55 plant families and reported from 61 countries across much of the world except Europe, the Middle East and most of Africa (García Morales et al. 2025). Known from PNG, it is unsurprising that it has been detected multiple times in the Torres Strait and the far north Qld mainland. New host records for this species based on Australian collections are *Desmodium* sp. (Fabaceae), *B. alba* (Basellaceae) and *Ixora* sp. (Rubiaceae), of which one, *B. alba*, appears to also represent a new family record. At present, this species does not appear to have spread further south than Weipa, Cape York Peninsula (Qld), but given its broad host range on commercial hosts, natural or human-mediated dispersal in the future cannot be ruled out.

Vryburgia trionymoides. The first official records of *V. trionymoides* from Australia relate to a greenhouse detection of two specimens at the Ecosciences Precinct (ESP), Dutton Park, Qld, with collections made by Australian Government personnel from quarantine containment material of *Kalanchoe delagoense* (Crassulaceae) on 10 July 2019 (both specimens deposited in the NAQS Insect Collection, Cairns): ESP, Dutton Park Qld, 10. vii.2019, ex *K. delagoense*, B. Hitchcock (BISS331478); ESP, Dutton Park Qld, 10. vii.2019, ex *K. delagoense*, M. Missen (BH9A-1). Subsequent collections were made on 25. vii.2019 from the same location and host, consisting of three specimens deposited at the Operational Science and Surveillance Insect Collection, Brisbane, and one, BH12, which is held at the NAQS Insect Collection, Cairns: ESP, Dutton Park Qld, 25. vii.2019, ex *K. delagoense*, M. Missen (BH12, 5735QA, 5736QA, 5737QA and BH12). All material collected 10. vii.2019 and 25. vii.2019 was identified by M.G. Additional material was collected from the greenhouses at the same location and determined as *V. trionymoides* by M.K.S. and accessioned as 13 specimens in the QDPC under accession numbers 0-175542-0-175544, 0-175546-48, 0-176632-34 and 0-176636-39; all ex

K. delagoense except 0-176636 that was ex *Kalanchoe blossfeldiana*. Subsequent collections outside of quarantine containment were made at nurseries located at Brookfield (five QDPC accessions: 0-175551–0-175553, 0-176614 and 0-176650) and Seventeen Mile Rocks (11 QDPC accessions: 0-175554–175556, 0-175656, 0-176615, 0-176616, 0-176653, 0-176654 and 0-176656–0-176658) in southeast Qld between 28.ix.2019 and 01.x.2019, ex *Sedum adolphi* (Crassulaceae) and *Echeveria* sp. (Crassulaceae). Another detection occurred at ESP on 14.i.2020 and 24.i.2020, also under contained glasshouse conditions, again on *K. delagoense* (QDPC 0-175657 and 0-177188, respectively). Additional material has been collected in NSW, also under glasshouse conditions at the NSW DPI Orange Agricultural Institute, collected by A. Seago on 27.xi.2019, ex *K. delagoense*, *K. blossfeldiana* and *Carpobrotus* sp. (Aizoaceae), det. P.J.G.

Although we here recognise *V. trionymoides* as a new record for Australia, it is possible that this species may have been introduced much earlier. Williams (1985) described *Vryburgia succulentarum* on succulent plants in the Aizoaceae, Cactaceae and Crassulaceae from Tasmania and SA. *V. trionymoides* also feeds on succulent plants. We have examined the Tasmanian holotype and the SA paratypes of *V. succulentarum* and these adult females are very similar to the adult female specimens of *V. trionymoides* that we have examined, as listed above. The adult females of *V. succulentarum* appear to have slightly fewer multilocular pores on the ventral abdominal segments, perhaps no dorsal multilocular pores and slightly fewer oral collar tubular ducts on the dorsal thorax, but there also is some variation in numbers of these pores and ducts among specimens of *V. trionymoides* from NSW and Qld. Numbers of pores and ducts are known to vary with temperature of development in some other mealybugs (Charles, Froud, & Henderson 2000). It is beyond the scope of this review to determine the taxonomic status of *V. succulentarum*, but if further studies (which should include molecular evidence) reveal the latter to be the same as the earlier named *V. trionymoides*, then the record of first collection of this species would become 1960 in Hobart, Tasmania, by Williams (1985).

Species recently detected under controlled conditions and not considered established in Australia

Diaspididae

Velataspis sp.. An initial detection of *Velataspis* was made at a single location in southeast Qld, where specimens were collected between 22.vii.2019 and 12.viii.2019 from multiple species of *Tillandsia* (Bromeliaceae), including *Tillandsia exserta* and *Tillandsia zacapanensis*, held under nursery conditions. Specimens had been supplied to the plant pest identification service ‘Grow Help’ due to die-back symptoms on the plant material and were then

referred to Biosecurity Queensland and identified by one of the authors (M.K.S.).

The closest match for these specimens was *V. dentata* based on morphological characters (Ferris 1937) and analysis of 28SD2D3 sequence data amplified using primers s3660 and a335, which returned a 98.08% match to NCBI GenBank accessions KY219290 and KY219291, these being specimens D0971A and D0971B of *V. dentata* as reported in Normark et al. (2019) with the following collection data: United States: Florida, Sixmile Rd., 13.xii.2005, ex *Cornus foemina*, coll. B.B.N.

Twenty-two specimens from this Qld detection have been accessioned into the QDPC under accession numbers 0-175540, 0-175541, 0-176602–0-176606 and 0-176617–0-176631. A subsequent detection was made on 14.ix.2020 from Kewarra Beach, Qld; also collected from *Tillandsia* sp. This was another plant health sample supplied to M.K.S. for examination, from which most specimens had perished with only a single adult female recovered and slide mounted. This specimen was accessioned into the QDPC under number 0-177227.

V. dentata has a highly restricted geographic distribution, previously recorded only from Panama and the United States (Alabama, Florida, Georgia, Louisiana, Mississippi, Tennessee and Texas), yet it is relatively polyphagous being recorded from 33 plant genera from 27 families (García Morales et al. 2025). Importantly, neither *Tillandsia* nor its family (Bromeliaceae) are recorded as hosts (ScaleNet, accessed July 2025). Further, a 98% similarity at the highly conservative 28S locus in Diaspididae (Park et al. 2011) suggests that, despite the morphological similarity of specimens to *V. dentata*, the Qld specimens may represent a different and potentially undescribed species, given even closely related species of armoured scales may be identical at this locus (McDougall et al. 2021).

Regarding the status of this *Velataspis* sp. in Australia, we consider it to be highly restricted, potentially no longer present and arguably not established in the Australian environment. This is because the first detection in southeast Qld was followed by extensive pest management to eradicate the scale insect from the contained nursery, with the owner fully complying with biosecurity directives, and the second instance resulting in predominantly dead and perished specimens with only a single intact and alive (though moribund) adult female. As for *P. stentae*, future detections of *Velataspis* specimens will likely continue to be linked to the nursery trade.

Intentionally introduced species: Biological control agents

Pseudococcidae

Hypogeococcus species. Williams (1985) noted the successful establishment of the biological control agent *H. festerianus*, the ‘harrisia cactus mealybug’, from

Argentina to Qld to control *Harrisia* cactus; however, the identity of this species was disputed by Williams & Granara de Willink (1992), who stated that the species introduced to Australia was *H. pungens*, a species described by Granara de Willink (1981).

This has been disputed, in that the species introduced to Australia is neither *H. festerianus* nor *H. pungens* but an undescribed species (Poveda-Martínez et al. 2019). This species, referred to as '*Hypogeococcus* sp. 2' by Poveda-Martínez et al. (2019), was proposed based on molecular and reproductive compatibility studies on members of the *H. pungens* species complex, following on from the work of Aguirre et al. (2016) who first documented biological and reproductive variation indicative of a cryptic species complex. Poveda-Martínez et al. (2019) demonstrated that the Australian population is sister to the *Hypogeococcus* sp. '*Cactaceae* host clade', with these two together sister to the *H. pungens* sensu stricto '*Amaranthaceae* host clade' and distinct from *H. festerianus* and that '... the cactus feeding *Hypogeococcus* sp. mealybug introduced into Australia from Argentina was neither *H. pungens* sensu stricto nor *H. festerianus*' (Poveda-Martínez et al. 2019, p. 11).

More recently, Ezech et al. (2023) undertook an integrative approach to confirm the identity of *Hypogeococcus* in Australia. This research, while comprehensive, nevertheless concluded by stating that although 'the Australian population of *Hypogeococcus* should be regarded as *H. pungens*, it will likely require another name once the cryptic species complex is fully taxonomically revised' (Ezech et al. 2023, p. 243).

Consequently, *H. festerianus* should be regarded as absent from Australia and the presence of *H. pungens* s.s. should be regarded as unresolved, and all reports of *Hypogeococcus* species in Australia should be reported as '*Hypogeococcus* sp.' or '*Hypogeococcus pungens* group' for specimens found consistent with *H. pungens*. We propose this approach in line with advice for similarly unresolved species groups likely representing a species complex, such as the '*Phenacoccus madeirensis* group' (Kondo & Watson 2022).

Until recently, the only record of *Hypogeococcus* sp. from collections that we could locate was for a single specimen housed at the QDPC and collected on 12 February 1979 (accession 0-013997). Further specimens of *Hypogeococcus* sp. were, however, recently collected from *Harrisia* sp. at Dingo, Qld, on 30 October 2019 (QDPC accessions 0-177099–0-177101), thus demonstrating its persistence in the environment.

Part 2: Historical trends of relative diversity of non-native species established in Australia

Based on the year of the first non-native species detection (1889 for *Pulvinaria camelicola*, accession

ASCU:ASCT00021054 on the ALA), the rate of accidental introductions and invasions of coccoids to Australia has averaged 1.1 (± 1.2 SD) species per year (from 1889 to 2023) for a total of 147 records for which we have the date of detection, including species that we consider extirpated from Australia. (We note, however, that the first recorded specimens of *P. camelicola* from Australia were reported as *P. floccifera* (Qin & Gullan 1992); however, this species is referred to as *P. camelicola* here because (i) specimens worldwide previously identified as *P. floccifera* may be either *P. floccifera* or *P. camelicola* (see Tanaka & Kamitani 2022); (ii) the specimens studied by Qin & Gullan (1992) were collected from camellias; (iii) the description of '*P. floccifera*' in the latter publication at least partly match what Tanaka & Kamitani (2022) call *P. camelicola*; and (iv) specimens in ANIC that were re-examined by P.J.G. are consistent with *P. camelicola*.) Fifty per cent of these ($n = 73$) detections were made within 49 years following the detection of *P. camelicola*, that is, between 1889 and 1937, which broadly aligns with the first of two waves of globalisation that occurred from ~1820 to 1914 (Bonnamour, Gippet, & Bertelsmeier 2021). Since 1960 (i.e., the start of the second wave of globalisation sensu Bonnamour, Gippet, & Bertelsmeier 2021), the increase in trade and air travel has not seen a distinct and significant increase in the number of detections over time, as may otherwise be expected, as clearly seen by the relatively steady cumulative rate of detection seen over time (Figure 1). We consider this attributable to a range of factors, including Australia's relative geographical isolation from the rest of the world and history of plant biosecurity measures, especially regarding nursery stock for commercially significant hosts on which scale insects are typically spread (Evans & Dooley 2013; Suh 2016; Whattam et al. 2024).

For most of the time since 1889, there were detections every 2 or 3 years. Notable exceptions to this were prolonged periods of nil reports of new non-native species between 1940–1946 and 1968–1973, dates that coincide with two major conflicts of the 20th Century: the Second World War (1939–1945) and the Vietnam War (1962–1973); although the early stages of the latter conflict did include multiple single-species/year reports up until 1967 (Figure 2). A reduction in detections during times of widespread conflict is unsurprising due to a range of factors, not least of which being conscription drawing attention away from taxonomic research and border security, but perhaps more significantly due to greatly reduced openness of trade during times of global conflict where, for insects in general, the First World War saw a distinct downturn in invasive species rates, only to increase in the 1970s and long after the Great Depression and Second World War (Bonnamour, Gippet, & Bertelsmeier 2021). We note that there are other periods of reduced detections outside of these time periods of major global conflict, which may be due to a range of other factors.

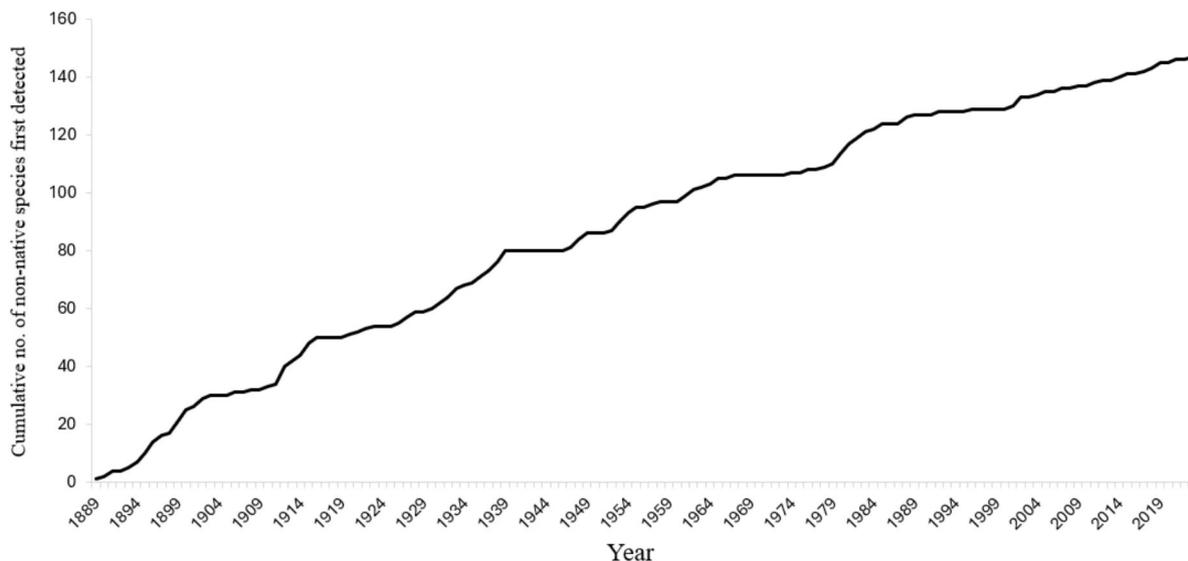


FIGURE 1 Cumulative number of detections each year (1889–2023) of non-native scale insects that have become established in the Australian environment. Dates given every 5 years on x axis for clarity.

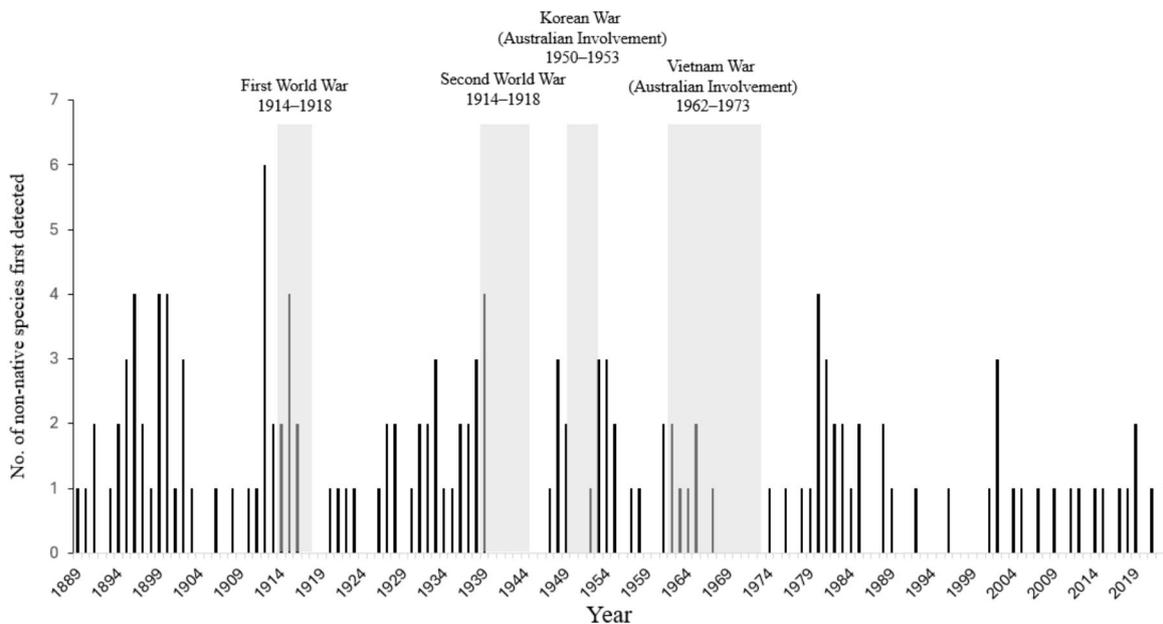


FIGURE 2 Number of detections each year (1889–2023) of non-native scale insects that have become established in the Australian environment. Years of major conflicts in the 20th century shown as grey bars. Dates given every 5 years on x axis for clarity.

Families represented by these 147 species include, in descending order of relative contribution to total number of species detected (percentages rounded to nearest whole number): Diaspididae (67 spp. = 46%), Coccidae (32 spp. = 22%), Pseudococcidae (30 spp. = 20%), Asterolecaniidae (6 spp. = 4%), Rhizoecidae (5 spp. = 3%), Monophlebidae (3 spp. = 2%), Conchaspidae (1 sp. = 1%), Eriococcidae (1 sp. = 1%), Marchalinidae (1 sp. = 1%) and Margarodidae (1 sp. = 1%).

The total number of described species for each of the families above is the following, in descending order with

relative percentage of contribution to the total for the 10 families listed (total = 7596 spp.): Diaspididae (2716 spp. = 36%), Pseudococcidae (2065 spp. = 27%), Coccidae (1244 spp. = 16%), Eriococcidae (681 spp. = 9%), Monophlebidae (267 spp. = 4%), Asterolecaniidae (251 spp. = 3%), Rhizoecidae (226 spp. = 3%), Margarodidae (115 spp. = 2%), Conchaspidae (30 spp. ≤ 1%) and Marchalinidae (1 sp. ≤ 1%) (García Morales et al. 2025).

The armoured scales (Diaspididae), therefore, represent the greatest contribution to the non-native scale

insect fauna of Australia; almost double the next contributing family, the soft scales (Coccidae). Given the relative diversity of the family, the armoured scales are over-represented among the non-native fauna, constituting at least 46% of Australia's introduced taxa, yet only 36% of world species from among the 10 families considered here (Figure 3). Several factors may account for this, such as their smaller size, absence of honeydew or mealy wax, and their immobility and firm attachment to the host plant under a protective scale cover (relative to many other scale insects, such as mealybugs), which are all features rendering them less likely to be detected, dislodged or killed during the transport of host plants. Conversely, the globally diverse family Eriococcidae is under-represented, making up less than 1% of all non-native species detected in Australia. A reason for this under-representation of eriococcids in the non-native fauna of Australia is yet to be determined; however, their relative host-genus and/or family specificity, as compared with other scale families that contain more polyphagous taxa, may be a factor, as may the size of the native Australian eriococcid fauna which comprises just over a quarter of known world species. Additional human influences may further contribute to the disproportionate representation of introduced species in certain families relative to their global diversity, such as sampling efforts, inadequate resourcing for maintaining collections or a shortage of taxonomic expertise for certain groups.

Part 3: Challenges in compiling non-native species lists

In compiling this review, we have encountered issues familiar to similar studies seeking to generate authoritative species' distribution lists, especially concerning confident determinations of native vs non-native status

for pest groups of economic importance. The main issues we faced in compiling this review are detailed below.

Taxonomic uncertainty

Whether a scale insect was categorised as introduced or native was problematic for some species due to unresolved taxonomy. An example is whether the mealybugs *V. trionymoides* and *V. succulentarum* are conspecific. This is important because the latter was described decades ago from southern Australia based on morphology (Williams 1985), but the former has been detected recently in NSW and Qld, mostly in controlled environments, but it is considered a quarantine pest (Anon 2019). In other groups, the presence of species complexes in which taxa are morphologically similar, but genetically and biologically different, greatly complicates identification. Similarly, high intraspecific morphological variability induced by differences among host plants or by climatic factors, such as temperature, may confuse taxonomy and thus impinges on accurate identification. An example is the introduced mealybug *Heliococcus summervillei*, which displays morphological variation that caused initial uncertainty for recent diagnosis when it became a serious pasture pest (Hauxwell 2018) and is the subject of ongoing taxonomic research. Furthermore, many historical descriptions of scale insects contain limited morphological information that can be insufficient for identification, especially if there are multiple species in a genus; only by thorough taxonomic revisions based on examination of type material can we resolve many of these identification issues. Taxonomic training and research that combines morphological data with molecular data will help to resolve some issues relating to the identification of scale insect species considered to be pests (e.g., Unruh & Gullan 2008a, 2008b).

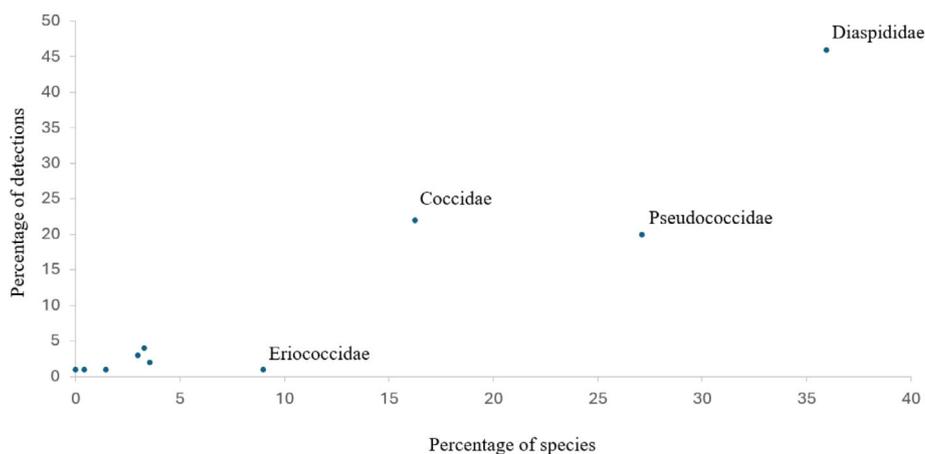


FIGURE 3 Percentage of introduced/non-native species from each of the scale insect families against the relative percentage of known species. Note that only the top three most well-represented families (Diaspididae; Pseudococcidae; Coccidae) and Eriococcidae are labelled for clarity. The remaining data points are for 'minor' families (Monophlebidae; Asterolecaniidae; Rhizoecidae; Margarodidae; Conchaspidae; Marchalinidae) that represent <5% of detections and species.

Native versus non-native status

Limitation of taxonomic knowledge is just one difficulty in deciding whether some species are native or not. Often the native distribution of species that are well known taxonomically is unknown or uncertain because of a lack of knowledge of species' relationships within their genus, especially if the genus is geographically widespread. Nucleotide sequence data can assist by establishing the closest relatives of a pest species, but the native distribution of those relatives must be known to predict the origin of the target pest species with any confidence (Qin et al. 1994). For example, molecular data suggest that Australia may be part of the native range of the mealybug *M. hirsutus* because its closest known relatives occur only in Australia or PNG (discussed above). Conversely, and using *H. summervillei* as an example again, *Heliococcus* is a genus that occurs primarily in the Northern Hemisphere, with diversity centred on the Eurasian region (see references in García Morales et al. 2025). Given the absence of close relatives in the Australasian region, it is unlikely that *H. summervillei* is native to Australia, despite the holotype having been collected from Qld (Brookes 1978). Indeed, holotype geographic data may lead to additional confusion, because where the primary type was collected does not necessarily denote that location or region as part of its native range, especially for pest species (see also *C. rubens*, discussed above). In some rare instances, type specimens may not have even been collected from where they were reported to occur (e.g., *O. australiensis*, discussed above).

Detection versus establishment

Not all scale insect detections have led to permanent establishment in Australia. For example, we consider *P. aurantii*, *P. elongata*, *G. coffeae* and *R. cacticans* as previous introductions to Australia that are now probably extirpated. Thus, simply detecting a new introduction, especially in a greenhouse or only in one or a few locations, does not mean that the species will persist. Many factors, such as the presence of natural enemies, Allee effects or unfavourable environmental conditions—including poor availability of suitable host plants—may limit their spread and ultimately lead to extirpation from Australia (e.g., *A. tegalensis*, discussed above). Nevertheless, a few species may experience periods of abundance, then seem to disappear, but later reappear in great numbers and to significant negative effect, as in the case of *H. summervillei*, which first caused considerable pasture damage to *Paspalum* in Qld in the 1920s (Brookes 1978) and has recently been associated with widespread pasture dieback in Qld and northern NSW (Hauxwell 2018).

In addition, the 'date of detection' may differ significantly from the true 'date of arrival', and an assumption that these are the same may greatly impede our

interpretation and understanding of non-native species spread. Taking the recently detected *K. acuminata* as an example, this species was serendipitously collected in southeast Qld during a local whitefly diagnostics training course in 2017. We have no knowledge of when, or how, *K. acuminata* entered Australia or for how long it has persisted at seemingly low levels in the natural environment on native host plants. Indeed, it is possible that it has occurred here for many years, yet in low numbers and overlooked, and may be widespread.

Lack of vouchered specimens in collections

Even if taxonomic knowledge is adequate, a taxon may not be recognised as present in Australia, or as persisting through time, due to the lack of voucher specimens in collections. If species establish in native habitats, they may go undetected for lengthy periods, as is likely the case for *K. acuminata*. Such 'sleeper species' may evade detection and eventually expand their distribution to become serious pests. This is especially problematic for common species in non-agricultural and non-horticultural environments and is a concern not limited to scale insects.

Most specimens of common native and non-native established species (including those regularly collected as part of area-wide surveillance programmes) are often discarded and not lodged in major collections, especially for those institutions not historically considered 'biodiversity' focussed such as the primary industries/agricultural/biosecurity collections. Such surveillance programmes seldom accommodate specimen deposition as part of their workflow, typically due to the high volume of samples and limited resourcing capacity to process and accession material into a permanent collection. Hence, there are major temporal and spatial gaps in our record of species across the continent; not through lack of collecting, but more so a lack of 'specimen visibility', either through not being reported in the literature or not accessioned in a collection that makes such records more widely available (via either public or restricted databases). The situation is made worse for infrequently encountered species where the last date of collection might be decades past and for which a confident determination of either extant or extirpated from Australia remains unresolved, such as for *L. pallidula* (discussed above), which was last collected almost 70 years ago. Under such scenarios, it becomes a judgement call based on knowledge of collection histories and available expertise as to whether a species that was last sighted many years ago has persisted in the environment. It is worth reinforcing here that despite the advances citizen science initiatives such as iNaturalist bring to addressing this problem for charismatic groups such as dragonflies, butterflies and beetles, the scale insects, thrips, whiteflies and aphids seldom benefit from such platforms due to their relative unpopularity, small

size, cryptic nature and the impossibility of securing a reliable identification, based on gross morphology or machine learning algorithms. For instance, a search on iNaturalist (accessed December 2024) for ‘Coccoidea’ observed from ‘Australia’ returns 11 777 observations and 155 species (approx. 20% of species in Australia) compared with 160 000 observations and 289 species (approx. 90% of species in Australia) for Odonata.

In addition, the absence of voucher specimens for species recorded as present in Australia is equally—if not more—problematic. We encountered several sources that referred to a species as occurring in Australia but for which we could find no specimens to support the claim (e.g., *P. rufulum*, discussed above). The potentially erroneous or mistaken distribution records are propagated by subsequent authors, resulting in authoritative distribution lists on data aggregators (e.g., ScaleNet) inadvertently perpetuating potentially erroneous information. An example is *P. camelliae*, which was reported by Danzig & Pellizzari (1998) as occurring in Australia, but for which we could find no evidence of voucher specimens in any collection. Operationally this has significant consequences, as species may not be actioned at the border under the false assumption that they are already established (e.g., the armoured scale *A. hartii* and the ortheziid *I. insignis*, both discussed above). Importantly, we acknowledge here that we have not verified records and sources for species distributions for countries other than Australia as provided in this review, as that is beyond the scope of this work. We do, however, actively encourage workers in other parts of the world to regularly undertake similar reviews to ensure that species listed as invasive, introduced or non-native in their respective countries are accurate and up to date.

Gaps in databased and accessible records

A lack of physical specimens is compounded by incomplete digitised collection data. This is not a new problem and is one widely recognised as an impediment to fundamental research and documenting our knowledge of non-native species distributions towards supporting Australia’s biosecurity (Popov et al. 2021) and in meeting international obligations linked to the Convention on Biological Diversity; this is especially the case for Aitchi Target 9 that calls on countries to identify and prioritise non-native species and their pathways.

The issue is twofold: (i) the need for collections’ personnel to database specimens ‘in house’ and (ii) making these collection database records publicly available for others to interrogate. For the Australian context, access to records relies on state and national collections having databased their material and then making it available to data aggregators such as the ALA (an open public database) or the APPD (password protected and restricted access); the former database is focussed on biodiversity,

the latter on biosecurity. This division between data aggregators leads to a division of information that, while appropriate given the *raison d’être* of the platforms, nevertheless perpetuates a disparity on which data are shared where, and the need to consistently access multiple sources to form a (relatively) complete picture. The ALA, for example, aggregates records from a wide range of sources, from museum collections to iNaturalist observations, yet lacks data from most major agricultural collections, noting, however, that this is now being addressed via data mobilisation grants offered by the CSIRO. In contrast, the APPD is focussed on species of agricultural and biosecurity concern that collates and provides data for ‘... for a range of plant pests’, aggregating collection records for many pest groups such as the scale insects, yet also many that are neither plant pests (e.g., several thousand dragonfly records) nor collected from Australia, thereby rendering the name ‘*Australian Plant Pest Database*’ potentially misleading to users (i.e., is it a database of Australian plant pests or the plant pest database of Australia?). Furthermore, these data are incomplete and often out of date given the challenges of reviewing, updating and uploading records by under-resourced collections staff, compounded by often legally and politically challenging data-sharing agreements. Indeed, less than one quarter of our non-native species were listed in more than six of the main databases, and none were listed in all. The level of detail about these specimens is often minimal, with information such as status (introduced or native) or whether a specimen was collected from the environment or via intercepted imported material often challenging (or impossible) to determine; this, as we have demonstrated, can lead to erroneous distribution records. Hence, reviews and updates of species (including non-natives) such ours (which has precipitated corrections in our own collection records and databases) continue to remain likely incomplete as records remain inaccessible and unverified, regardless of the efforts taken to capture the most accurate and current information.

Final remarks

In summary, we consider Australia to host some 146 non-native scale insect species in addition to a diversity of over 700 native taxa. Of these, 15 are relatively recent introductions that are documented here for the first time or have been reported elsewhere but for which we provide additional information relating to their detection and establishment. We also report here for the first time two additional species that we consider to be either native or of uncertain status. Eight species previously considered introduced, or of uncertain origin, we regard as potentially representing native taxa although requiring further research to fully resolve their status. Thirty-three species variously documented in the literature as occurring in

Australia we consider to be absent due to either dubious records (19 spp.), the result of misidentifications (two spp.) or having been extirpated or probably extirpated from the Australian environment (12 spp.). One introduced species reported here we do not consider to have established, as it was only detected within a single nursery and was eradicated.

Despite this work, we are acutely aware it is incomplete for the reasons outlined above, and that much more work needs to be done to gain a complete view of our non-native scale insect species, let alone for other groups that have received less attention. Nevertheless, we consider this a step forward in clarifying the status of non-native Australian coccoids and trust that this will (i) form the basis of further stocktakes and reviews, especially in confirming the taxonomic status of problematic taxa; (ii) encourage the collection and vouchering of material (especially common species); and (iii) facilitate data aggregators, such as ScaleNet, in maintaining up-to-date information which forms the basis for major biosecurity decisions and regulations, especially pest risk analyses, and wider research.

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CONFLICT OF INTEREST STATEMENT

All authors declare they have no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available in the [Supporting Information](#) of this article.

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SUPPORTING INFORMATION

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