Swainsona 38: 1–44 (2024)

Confirming the presence of five exotic species of *Amanita* in Australia and New Zealand

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Abstract: To aid identification of exotic species of *Amanita* Pers. in association with exotic trees found in Australia and New Zealand in urban areas, botanic gardens and exotic plantation forestry, we sequenced select collections of the genus under names originally applied to northern hemisphere material in the fungaria MEL, AD, CANB, DAR, PERTH (Australia) and PDD (New Zealand). Phylogenetic analysis and morphology support the presence of five introduced taxa: *Amanita muscaria* (L.) Lam., *A. phalloides* (Fr.) Link and *A. rubescens* Pers., occurring in Australia and New Zealand, and *A. junquillea* Quél. and *A. excelsa* var. *spissa* (Fr.) Neville & Poumarat, occurring only in New Zealand. Fifteen names of northern hemisphere taxa applied to herbarium collections of *Amanita* from Australia are all considered to be misidentifications. *Amanita vaginata* (Bull.) Lam. as currently widely applied to Australian material is considered to represent an un-named native species. Eighteen names of northern hemisphere taxa applied to sequences obtained from soil samples from Australia in the Australian Microbiome are shown to be misnomers; most sequences probably represent native species that are close relatives of the exotic species. Users of Australian Microbiome data are cautioned that species-level identifications provided by the Australian Microbiome should be checked through full analyses of related taxa. We provide brief descriptions, images and distribution maps for the five confirmed exotic amanitas and list their most common plant associates along with a discussion on early records and ecology.

Keywords: Amanitaceae, introductions, naturalised, New Zealand, Australia, invasive species, Australian Microbiome

Introduction

The genus *Amanita* Pers. is one of the larger genera of ectomycorrhizal macrofungi. Species in *Amanita* may vary considerably in size, smell and colouration, even within a species, due to environmental conditions. Thus, while they may be easy to find, species boundaries are often difficult to determine without full ecological, macro- and micro-details (Tulloss *et al.* 1995; Geml *et al.* 2006; Cai *et al.* 2014; Zhang *et al.* 2015). While the *Amanita* species of New Zealand are reasonably well known (Ridley 1991), no single modern revision exists for Australia. Rather, there are a series of publications covering the species of *Amanita* predominantly based on collections from smaller regions such as by Reid (1980) for Victoria, Miller (1991, 1992) for south-west Western Australia (W.A.) and Wood (1997) for the Sydney region. More recently, Davison and colleagues have described a number of new species from W.A. (Davison *et al.* 2013, 2015, 2017a, b, 2020, 2021; Davison & Giustiniano 2020). The native species documented in these works associate with native mycorrhizal hosts such as species of Myrtaceae, Nothofagaceae and Fabaceae.

The historical practice of adopting the names of similar-looking taxa from the northern hemisphere (May 1990) has caused some confusion in both Australia and New Zealand. In New Zealand these misapplications were resolved by Ridley (1991), who introduced new names for the indigenous species, but little work has been completed for Australia (May & Wood 1997). Sequence-based methods and morphological examination of collections made in Australia and New Zealand of fungi that are superficially similar to northern hemisphere species frequently confirm that they are novel native taxa.

Accidental and deliberate introductions of fungi have led to the presence of many exotic species including ectomycorrhizal (ECM) species associated with introduced exotic trees. Most exotic species of *Amanita* introduced to Australasia are commonly reported from urbanised areas, plantation forestry and other modified habitats dominated by exotic species of oak, birch, beech and pine (typical forms of these trees are shown in Figs 1A–F and 2A–C, and in Cooper *et al.* 2022). However, the generalist ECM fungus *A. muscaria* (L.) Lam. is a weedy species that has host-switched to

ISSN 2206-1649 (Print) • ISSN 2206-1657 (Online)

Fig. 1. Common introduced ectomycorrhizal host trees: **A, B** Red Oak (*Quercus robur*); **C, D** beech (*Fagus* sp); **E, F** chestnut (*Castanea* sp). — Photos: A J. Haska; B–H S. Kingdon.

Fig. 2. Common introduced ectomycorrhizal host tree: **A–C** Radiata Pine (*Pinus radiata*). Native trees that are sometimes ectomycorrhizal hosts: **D, E** Southern Beech (*Nothofagus cunninghamii*); **F, G** eucalypt (*Eucalyptus petiolaris*). — Photos: A, C S. Kingdon; B, D–E J. Haska; F–G A. Robinson.

native plants, particularly *Nothofagus* and more rarely *Eucalyptus* in Australasia (Fig. 2D–G), and to native species of *Quercus* in South America (Dunk *et al.* 2012; Vargas *et al.* 2019).

Some of the introduced species of *Amanita* are highly toxic and responsible for a small proportion of yearly poisonings, such as occurs for ingestions of *A. muscaria* (Michelot & Melendez-Howell 2003; Rampoli *et al.* 2021) and more seriously *A. phalloides* (Fr.) Link (Buchanan 1995; Trim *et al.* 1999; Pringle & Vellinga 2006; Pringle *et al.* 2009; Wolfe *et al.* 2009; Flament *et al.* 2020). While deadly poisonings are relatively rare in Australasia, consumption of *A. phalloides* caused 11 recorded deaths between 1998 and 2018 (Trim *et al.* 1999; Roberts *et al.* 2013; Page & Westcott 2014). Both *A. muscaria* and *A. phalloides* can be found in urban parks, botanic gardens, and similar public settings, increasing the risk of accidental poisonings.

Here we provide an assessment of the species of *Amanita* exotic to Australasia based on examination of a large series of collections, selected from those available in fungaria in Australia and New Zealand. For this paper we do not discuss in depth the saprotrophic taxa treated as a separate genus *Saproamanita* Redhead, Vizzini, Drehmel & Contu by Redhead *et al.* (2016) or as *Amanita* subgenus *Lepidella* Beauseign. by Cui *et al.* (2018). We also assessed

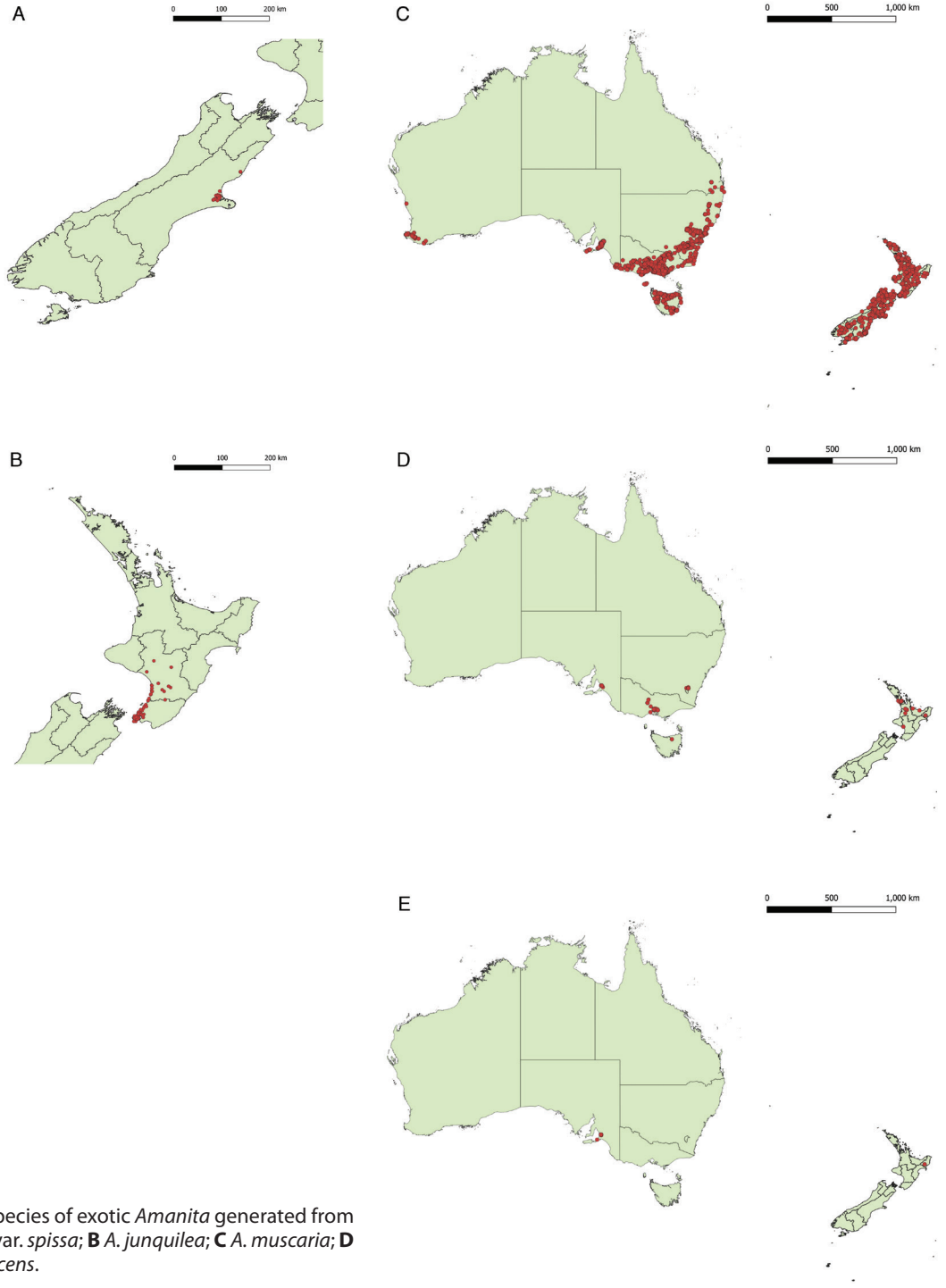

Fig. 3. Maps for each species of exotic *Amanita* generated from GBIF data: **A** *A. excelsa* var. *spissa*; **B** *A. junquilea*; **C** *A. muscaria*; **D** *A. phalloides*; **E** *A. rubescens*.

the status of all the northern hemisphere names used in the Atlas of Living Australia (ALA), iNaturalist and Australasian fungaria and provide commentary on their application in Australia and New Zealand.

Methods

We assessed *Amanita* collections in six fungaria, MEL (National Herbarium of Victoria), AD (State Herbarium of South Australia), BRI (Queensland State Herbarium), PERTH (Western Australian Herbarium), HO (Tasmanian Herbarium) and PDD (National Fungarium, Landcare Research – Manaaki Whenua, New Zealand). While not exhaustive, representative collections identified as species originally described from the northern hemisphere were examined further. Priority was given to collections accompanied by photographs, descriptions of fresh material and with notes on the associated plants. Some older fungarium material is in poor condition, making it difficult to obtain sequence data, and some morphological characters have been lost, thus species confirmation was not always possible. An issue with many collections was lack of data on associated plants, and whether exotic trees were in the vicinity.

We provide brief descriptions and notes for exotic species of *Amanita* confirmed as present in Australia and New Zealand; only species supported by sequenced collections are included. Descriptions, host associations and distributions were derived from photographs and documentation associated with Australasian collections. General information on distributions and potential mycorrhizal symbionts was added from various field guides or published scientific literature across the entire known range of each species. Microscopy was carried out on the majority of collections and presented where relevant. All cited specimens have been examined, except where indicated as "not seen". Detailed illustrations and excellent images of specific structures and their variation in the genus *Amanita*, such as the volva and stipe base, annulus or pileus margins, are provided by Kuo (2013) and Tulloss & Yang (2022).

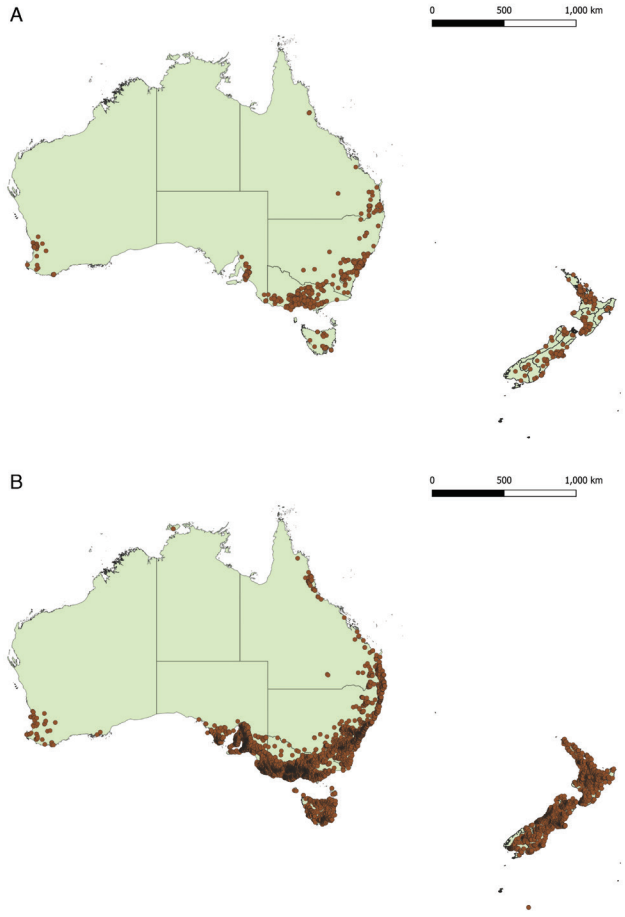

Fig. 4. Maps for main exotic ectomycorrhizal plant hosts generated from GBIF data: **A** Pinaceae (*Pinus* spp.); **B** Fagaceae (*Quercus*, *Fagus*, *Castanea*).

Australian and New Zealand occurrence maps for all five species of exotic *Amanita* (Fig. 3) and for the most common plant associates (*Pinus* spp. and Fagaceae; Fig. 4), were generated using data from the Global Biodiversity Information Facility (GBIF 2023). We excluded records of northern hemisphere species, where they occurred in natural habitats or referenced native associated plants (except where there were vouchers to confirm host jumps to native plants), and we also excluded obviously incorrect geocoded data. However, to detect broader distributions, where collections are not available in fungaria, we do include reference to selected observational records from iNaturalist and Fungimap, but only where there are good images and associated data. For each exotic species, in the material examined section, we also provide a link to all listed records from Australia and New Zealand in iNaturalist and the ALA (which includes Fungimap records). For the ALA records, we disabled the data profile and excluded records that were "material samples" [i.e. microbiome data, see analysis below] and opted in to "Exclude records with unresolved user annotations". For iNaturalist, we selected only Research Grade records. Selected observations are almost all iNaturalist records, which are given as the observation number preceded by a hash (e.g. #109609827) and can be accessed in iNaturalist by replacing the hash with "https://www.inaturalist.org/observations/". The ALA and iNaturalist data were checked for records available up to 1 June 2023 and incorrect records removed, by adding user annotations in the ALA or by re-identifying the record in iNaturalist.

For assessing records of *Amanita* from Australia, we used the listing by May & Wood (1997) as a starting point and added to this names applied in the ALA, by querying on "*Amanita*+Australia" (excluding material samples, and with the data profile disabled) and downloading the unprocessed names (1 June 2023). Authorities for species of *Amanita* mentioned in the text are provided in Tables 2 and 4.

We accessed Australian plant pathology reference collections (some of which do not deliver data to the ALA) via the Australian Plant Pest Database (APPD), Plant Health Australia online database (https://www.appd.net.au/), accessed 5 June 2023. Information on collections retrieved from APPD is cited with permission of the relevant fungarium Collection Manager.

Table 1. List of DNA data generated for this study.

Taxon	Herbarium#	Collectors#	Country: State	Date collected	Associated trees	GENBANK ITS
Amanita rubescens	AD293043	TL3356	Australia:South Australia	23 Feb. 2021	*Corylus* & *Quercus*	**OQ200146**
Amanita rubescens	AD293040	TL3379	Australia:South Australia	6 June 2021	*Pinus radiata*	**OQ200148**
Amanita rubescens	AD293207	PSC4851	Australia:South Australia	1 June 2022	*Pinus*	**OQ200147**
Amanita rubescens	AD293034	TL3232	Australia:South Australia	29 May 2020	*Quercus robur*	**OQ200145**
Amanita rubescens	PDD97032	JAC12932	New Zealand	16 May 2013	*Picea*	MT863758
Amanita luteolovelata	MELU	AGCB86	Australia:Tasmania	13 May 2021	*Eucalyptus rodwayi* & *Acacia dealbata*	**OQ200144**
Amanita luteolovelata	MELU	AGCB110	Australia:Victoria	15 Oct. 2016	*Eucalyptus* mixed	**OQ200143**
Amanita muscaria	MELU	AGCB202	Australia: Victoria	26 May 2022	*Carpinus* & *Quercus canariensis*	**OQ200154**
Amanita muscaria	AD60262; MEL2380824	JHAR514	Australia: South Australia	22 May 2014	*Pinus radiata*	**OQ200151**
Amanita muscaria	MEL2381046	Ratkowsky2932	Australia:Tasmania	15 May 2013	Wet sclerophyll	**OQ200137**
Amanita muscaria	AD293906	JHAR618	Australia: South Australia	13 May 2015	*Eucalyptus globulus*	**OQ200153**
Amanita muscaria	AD60759; MEL2380821	JHAR510	Australia: South Australia	20 May 2014	*Allocasuarina muelleriana*, *A. verticulata* & *Acacia provincialis*	**OQ200149**
Amanita muscaria	AD58620	PSC3918	Australia: South Australia	25 May 2014	*Pinus*	**OQ200152**
Amanita muscaria	AD60256; MEL2380973	JHAR550	Australia: South Australia	23 June 2014	*Allocasuarina muelleriana*	**OQ200150**
Amanita phalloides	AD293038	TL3363	Australia: South Australia	16 May 2021	*Quercus*	**OQ200159**
Amanita phalloides	AD286522	TL3405	Australia: South Australia	26 June 2021	*Quercus*	**OQ200155**
Amanita phalloides	AD	TL3407	Australia: South Australia	30 June 2021	*Quercus*	**OQ200156**
Amanita phalloides	MELU	TH2	Australia: Victoria	20 Apr. 2022	*Fagus sylvatica*	**OQ200158**
Amanita phalloides	AD-C56046	PSC2908	Australia: South Australia	21 June 2009	*Quercus*	**OQ200157**
Amanita phalloides	AD-C57073	PSC3287	Australia: South Australia	8 May 2010	*Quercus*	**OQ200161**
Amanita phalloides	AD-C57034	PSC3274	Australia: South Australia	10 Apr. 2010	*Quercus*	**OQ200160**
Amanita phalloides	MEL	RBGVP1453	Australia: Victoria	4 June 2019	*Quercus*	**OQ200138**
Amanita phalloides	PDD97031	JAC12931	New Zealand	16 May 2013	*Fagus sylvatica*	MT863757
Amanita marmorata	MEL2417153	TL295	Australia: New South Wales	10 Mar. 2017	*Eucalyptus*	**OQ200139**
Amanita eucalypti	BRI AQ0799947	FG2018025	Australia:Queensland	24 Feb. 2018	Wallum Woodland	**OQ200140**
Amanita excelsa var. *spissa*	PDD95266	JAC10739	New Zealand	9 Jan. 2009	*Quercus robur*	MT863551
Amanita junquillea	PDD105792	JAC13542	New Zealand	27 May 2014	*Pinus radiata*	MT863766
Amanita junquillea	PDD105792	JAC13542	New Zealand	27 May 2014	*Pinus radiata*	MN738646
Amanita flavella	MEL	SMF3183	Australia: Queensland	18 Mar. 2019	*Melaleuca leucodendra*	**OQ200141**
Amanita hemibapha	MEL2522018	SMF3038	Australia: Queensland	5 Mar. 2018	*Corymbia tessellaris*	**OQ200142**

Table 2. Species of non-Australian *Amanita* reported from the Australian Microbiome (AM), based on ITS1 sequences. See Appendix 2 for unique sequences and with new identifications based on RDP classifier and BLAST. Species of *Saproamanita* are at the end of the table.

Species (as identified by AM)	Originally described from	No. unique sequences	Highest BLAST match: Taxon (%)
A. excelsa (Fr.) Bertill. = *Agaricus excelsus* Fr.	Europe	8	*A. australis* (97.3%)
A. exitialis Zhu L.Yang & T.H.Li	China	2	*A. subjunquillea* (88.7%)
A. flavorubescens G.F.Atk.	U.S.A.	1	*Amanita* sp. (97.0%)
A. franzii Zhu L.Yang, Y.Y.Cui & Q.Cai	China	2	*A. farinosa* (96.5%)
A. frostiana (Peck) Sacc. = *Agaricus frostianus* Peck	U.S.A.	3	*A. frostiana* (88.7%)
A. javanica (Corner & Bas) T.Oda, C.Tanaka & Tsuda = *Amanita hemibapha* subsp. *javanica* Corner & Bas	Indonesia	4	*Amanita* sp. (94.2%)
A. morrisii Peck	U.S.A.	6	*Amanita* sp. (99.7%)
A. muscaria (L.) Lam. = *Agaricus muscarius* L.	Europe	5	*A. muscaria* (100.0%)
A. novinupta Tulloss & J.Lindgr.	U.S.A.	5	*Amanita* sp. (96.1%)
A. sepiacea S.Imai	Japan	2	*A. excelsa* (91.2%)
A. spissacea S.Imai	Japan	4	*A. griseofolia* (97.5%)
A. taiepa G.S.Ridl.	New Zealand	11	*A. taiepa* (95.0%)
A. velosa (Peck) Lloyd = *Amanitopsis velosa* Peck	U.S.A.	8	*Amanita* sp. (89.1%)
A. vestita Corner & Bas	Singapore	1	*A. vestita* (84.6%)
***Saproamanita* clade**			
A. codinae (Maire) Bertault = *Lepidella codinae* Maire	Spain	3	*A. codinae* (98.1%)
A. inopinata D.A.Reid & Bas	U.K.	2	*A. inopinata* (99.2%)
A. manicata (Berk. & Broome) Pegler = *Agaricus manicatus* Berk. & Broome	Sri Lanka	1	*A. manicata* (100.0%)
A. prairiicola Peck	U.S.A.	1	*A. silvifuga* (100.0%)

Representative recent collections were selected for sequencing. DNA extractions were carried out on fungarium samples using the EZNA forensic DNA kit (Omega Bio-tek, U.S.A.) or the REDExtract-N-Amp Plant PCR Kit (Sigma Aldrich, U.S.A.). The Internal Transcribed Spacer barcode region (ITS) was amplified using the primer pairs ITS1f/ITS4 (White *et al.* 1990; Gardes & Bruns 1993).

Datasets for phylogenetic analyses were assembled in two steps. A preliminary Maximum Likelihood analysis was performed with Australasian sequences of exotic *Amanita* and ITS data from validated European collections, including as many type specimens and as many described species as available. Identifications of Australasian specimens were then confirmed or updated, and based on these results four smaller alignments were generated comprising: (1) *A. muscaria* and related taxa (75 sequences); (2) *A. phalloides* and related taxa (74 sequences); (3) *A. rubescens* Pers., *A. excelsa* var. *spissa* (Fr.) Neville & Poumarat and related taxa (99 sequences); and (4) *A. junquillea* Quél. and related taxa (44 sequences). Alignments were made with the on-line version of MAFFT v. 7 (Katoh *et al.* 2019) using the iterative refinement method E-INS-I. Appropriate species were utilised as an outgroup in each alignment. Phylogenetic analyses were performed with Maximum Likelihood in RAxML v. 8.2.12 (Stamatakis *et al.* 2014) for 1000 replicates using the CIPRES Science Gateway v. 3.3 (Miller *et al.* 2010). Trees were visualised in FigTree v. 1.4.2. Sequences generated for this study are presented in Table 1.

For the Australian Microbiome (AM) investigation, ITS1 sequences identified as *Amanita* were downloaded from the AM data portal (https://www.australianmicrobiome.com/) as denoised Amplicon Sequence Variants (ASVs, individual unique sequence variants or zOTUs) on 12 May 2022. AM data were originally presented as the Biomes of Australian Soil Environments soil microbial

diversity database (BASE, Bissett *et al.* 2016). AM methods are available online (https://github.com/AusMicrobiome). In brief, the AM generated sequences using primers ITS1F and ITS4, and after denoising, sequences had been classified against the UNITE database v. 8. The AM sequences were downloaded as sample/sequence combinations. The AM does not use unique identifiers for ASVs, but the sequence itself acts as the identifier. Duplicate sequences given the same identification by the AM (same sequences from different locations) were removed to create a set of unique ASVs per species. Sequences identified as species of *Amanita* native to Australia were removed leaving a set of sequences identified by the AM as exotic *Amanita*. The remaining sequences were additionally identified using the RDP classifier (RDP Naive Bayesian rRNA Classifier Version 2.11, September 2015, Wang *et al.* 2007, against the UNITE Fungal ITS training set 07/04/2014) and BLAST (megablast, Altschul *et al.* 1990), accepting the top hit only. The AM unique ITS1 sequences identified as exotic *Amanita* species were subject to phylogenetic analysis by aligning sequences with five to ten similar sequences downloaded from GenBank. Alignment was undertaken in the on-line version of MAFFT v. 7 (Katoh *et al.* 2019), using the iterative refinement method E-INS-I. Phylogenetic analyses were performed with Maximum Likelihood in RAxML v. 8.2.12 (Stamatakis 2014) for 1000 replicates using the CIPRES Science Gateway v. 3.3 (Miller *et al.* 2010). The resulting trees were visualised in FigTree v. 1.4.2.

Results

We confirm the presence of five exotic taxa in Australia and New Zealand: *Amanita excelsa* var. *spissa*, *A. junquillea*, *A. muscaria*, *A. phalloides* and *A. rubescens*, based on analysis of the ITS gene region. These taxa occur in a variety of modified habitats as ectomycorrhizal associates of various exotic hosts (pines, oaks, beech, cedar, chestnut). Phylogenetic trees with sequence data from Australian and New Zealand collections (Figs 6, 7, 9, 10), together with descriptions based on Australasian material, are presented for each taxon. Issues associated with correct identification are discussed under the individual taxon entries.

Among the sequences in the Australian Microbiome that had been identified as *Amanita*, there were some identifications to native species [*A. basiorubra* O.K.Mill., *A. drummondii* E.M.Davison, *A. eucalypti* O.K.Mill., *A. fibrillopes* O.K.Mill., *A. kalamundae* O.K.Mill., *A. marmorata* Cleland & E.-J.Gilbert (as *A. reidii* Eicker & Greuning), *A. preissii* (Fr.) Sacc., *A. cheelii* P.M.Kirk (as *A. punctata* (Cleland & Cheel) D.A.Reid), *A. roseolamellata* A.E.Wood and *A. walpolei* O.K.Mill.]. These were not analysed further (but see comments in the Discussion on the unreliability of AM identifications). Among the AM sequences identified to non-native species of *Amanita* (specifically, those described originally from outside of Australia), 18 species were represented (Table 2), including *A. excelsa*, *A. exitialis*, *A. flavorubescens*, *A. franzii*, *A. frostiana*, *A. javanica*, *A. morrisii*, *A. muscaria*, *A. novinupta*, *A. sepiacea*, *A. spissacea*, *A. taiepa*, *A. velosa* and *A. vestita*. These exotic species are all originally described from Europe, North America or Asia (China, Japan and Singapore), with the exceptions of *A. javanica* (Indonesia) and *A. taiepa* (New Zealand). In addition, there were identifications to four species of "*Saproamanita*" (Table 2: *A. codinae*, *A. inopinata*, *A. manicata* and *A. prairiicola*), these originally described from Spain, U.K., Sri Lanka and U.S.A. respectively. For each of the non-native species there were between one and 11 unique ASVs and the read count for a given ASV per site varied from one (123 of the ASV/site combinations) to 5117.

When identified using BLAST or the RDP classifier (Appendix 2), the identifications of the AM *Amanita muscaria* sequences were supported by high BLAST matches (all between 99% and 100% and mostly to *A. muscaria*, except for a few to an ectomycorrhizal root sample from U.K. identified as *Amanita* sp.) and high values for the RDP classifier (all between 0.96 and 1.00 against *A. muscaria* SH200305.06FU). The AM sequences identified to *A. muscaria* also fell within the clade containing other *A. muscaria* sequences in the phylogenetic analysis.

For "*Saproamanita*" sequences identified by the AM (Appendix 2): the sequences identified as *A. codinae* had high BLAST matches to *A. codinae* sequences in GenBank, with at least 98.1% similarity using BLAST, but the RDP identification was to "*Amanita* sp. *pruittii*" (SH193452.06FU) with low values of 0.33 to 0.34. The sequences identified as *A. manicata* matched 100% to Genbank sequences under that name using BLAST, but with RDP the identification was to *A. nauseosa* (Wakef.) D.A.Reid (SH238637.06FU) with a value of 1.00. For the AM sequences named as *A. prairiicola*, the BLAST match was 100% to *Amanita silvifuga* Bas, while the RDP identification was to *A. nauseosa*.

All remaining identifications to species level by the AM (Appendix 2) were not repeated in the BLAST and RDP identification, where the identification was either to a different species or to an un-named *Amanita* species and often with a low BLAST match (as low as 84.6%) or low score in the RDP (as low as 0.12). For example, the five sequences identified by the AM as *A. novinupta* had a closest match by BLAST to *Amanita* sp. (MZ828032) or *Amanita* sp. (KY773995), but with only a 96.1% or 92.6% match, respectively, and the RDP classifier gave an identification as *Amanita* sp. (SH193851.06FU) with a value of between 0.34 and 0.62.

In the phylogenetic tree (Appendix 1), apart from the sequences identified by the AM as *A. muscaria* and *Saproamanita*, none of the sequences identified by the AM as exotic *Amanita* fell within clades comprising sequences from GenBank under the same name. Instead, they resolve as strongly supported clades separate from other sequences of the same name, sometimes in more than one clade for a given AM identification.

Species descriptions

Amanita excelsa var. ***spissa*** (Fr.) Neville & Poumarat

Fungi Europaei 9: 721 (2004).

Amanita spissa (Fr.) Opiz, *Seznam* 114 (1852).

English common name: Grey Spotted Amanita.

TOXIC – Considered edible however do not consume due to the risk of confusion with poisonous species.

Pileus 60–150 mm diam., convex, becoming flat, dry or slightly sticky, surface greyish brown to grey with warts or flattened patches of veil that are white to greyish; the margin typically smooth. *Lamellae* free or narrowly attached with a small decurrent tooth, crowded, white. *Stipe* 60–140 × 8–25 mm, white, often with scales in circular bands below the annulus and lacking an obvious volva on the cylindrical to clavate stipe with a bulbous base, that is sometimes discoloured with brown spots. *Annulus* large, hanging down loosely, upper surface lined, high on the stipe. *Flesh* white, unchanging. *Smell* faint or potato- or radish-like. *Taste* none. *Spores* 7–10 × 6–8 µm, smooth, colourless, ellipsoid, amyloid. **Figs 3A, 5A.**

Notes. *Amanita excelsa* var. *spissa* is sometimes treated as a distinct species *A. spissa* (Cui *et al.* 2018), but we follow the treatment by Neville & Poumarat (2004) at varietal level. The group requires further studies of European collections to establish species boundaries and the stable application of names. Although considered edible, the group has morphological similarities with the toxic *A. pantherina* (Table 3). *Amanita excelsa* var. *spissa* can resemble *A. rubescens*, but the flesh does not turn pink when cut or bruised. *Amanita excelsa* var. *spissa* is known from the Canterbury region of South Island, New Zealand. It occurs early in the season and is common, especially in the city of Christchurch, under a range of introduced trees, most commonly oaks. Not currently recorded from Australia.

In our analysis (Fig. 6), the New Zealand sequence of *Amanita excelsa* var. *spissa* (associated with *Quercus robur*) is in a well-supported clade with sequences from Europe (Germany, Norway, France, UK) with *Alnus*, *Populus*, *Picea* and *Quercus* listed as associated trees. The species appears to have been introduced to South Africa with *Alnus glutinosa*, *Populus tremula* and *Picea abies*, as well as to South Korea (no associated plants listed).

Amanita "spissa" was reported from South Australia (S.A.) by Cooke (1892), New South Wales (N.S.W.) by Maiden *et al.* (1920: as "near") and Victoria by Willis (1934a). Willis (1963) revised his earlier description of *A. spissa* and placed it under *A. farinacea* (Sacc.) Cleland & Cheel. According to Reid (1980) "[N]o Australian material can be traced at K, and the record remains unsubstantiated". No evidence of its occurrence in Australia can be found and therefore all records can be discounted as incorrect. Several iNaturalist observations from Australia initially identified as *Amanita excelsa* var. *spissa* have been reidentified as *Amanita* sp. on the basis that there are no confirmed occurrences of the taxon in Australia and the sightings are not noted as associated with exotic trees (e.g. https://www.inaturalist.org/observations/98576839).

Material examined

Specimens. — **NEW ZEALAND.** SOUTH ISLAND. Christchurch, under *Quercus robur*, 28 Feb. 2004, *J.A. Cooper JAC 8836* (PDD81025); Christchurch, under *Q. robur*, 9 Jan. 2009, *J.A. Cooper JAC 10739* (PDD95266); Lincoln, under *Q. robur*, 22 Mar. 2011, *J.A. Cooper JAC 11760* (PDD96164).

Observations. — iNaturalist (n=124): https://inaturalist.org/observations?place_id=6803&taxon_id=119998

Amanita junquillea Quél.

Bull. Soc. Bot. France 23: 324-XL (1876).

English common name: Jewelled Amanita.

TOXIC – Contains several biologically active compounds including ibotenic acid, a neurotoxin, and muscimol.

Pileus 30–70 mm diam., spherical, convex, becoming flat, slightly sticky, surface dull to bright yellow with felty patches of veil that are white to greyish; the margin typically striate. *Lamellae* free or narrowly attached, crowded, white. *Stipe* 70–100 × 8–12 mm, cylindrical with a large bulbous base, white, smooth, generally with a cup and rim, and often with indistinct bands of tissue above the rim. *Annulus* small, fragile, soon lost, on the lower stipe. *Flesh* white, unchanging. *Smell* faint. *Taste* slightly sweet. *Spores* 8–11 × 6–8.5 µm, smooth, colourless, ellipsoid, inamyloid. **Figs 3B, 5B.**

Notes. Historically, this species has been widely called *Amanita gemmata* (Table 3), but Kibby (2016) convincingly argued that *A. gemmata*, in the original sense, is a synonym of *A. muscaria* and that the correct name for the jewelled amanita is *A. junquillea*. Forms without an annulus have been described, but the presence and persistence of an annulus is variable. *Amanita junquillea* is widespread in southern Europe in more Mediterranean climates, in North America (though uncertainty remains whether it is the same species as in Europe; Tulloss & Yang 2022) and in parts of Asia and North Africa, where it is typically found in sandy soils associated with pines (Kibby 2016; Tulloss & Yang 2022). The species is commonly associated with pines in the Wellington region of North Island, New Zealand. Not currently recorded from Australia.

In our analysis (Fig. 7), the New Zealand sequences of *Amanita junquillea* are in a well-supported clade with sequences from Europe (Germany, Czech Republic,

Fig. 5. Images of some exotic amanitas and native species of mushrooms, with which they can be confused: **A** *Amanita excelsa* var. *spissa* (N.Z.), veil remnants (vr) on pileus and annulus (an) indicated; **B** *A. junquillea* (N.Z.), veil remnants (vr) on pileus and inset showing volva (vo); **C** *A. muscaria* in association with pines, showing veil remnants on pileus (vr) and inset showing annulus (an) and white volval remnants (vo) as scaly rings around base of stipe; **D** *A. xanthocephala*, showing orange veil remnants (vr) on pileus and (inset) orange veil and volval remnants (vo) on rim of bulbous base, and native eucalypt leaves in background; **E** *A. phalloides*, showing small fragment of veil remnant (vr) on pileus, flaring volva (vo) and (inset) annulus (an), with oak leaves in background; **F** *Volvopluteus gliocephala* showing white volval cup (vo) at base of stipe, lack of annulus, and (inset) pinkish tinge to lamellae in mature sporing body. — Photos: A, B J. Cooper, inset inat5629508_tonywillis; C, D inset, E inset, F T. Lebel; D, E D. Catcheside.

Poland, France, UK, Spain), with *Picea abies* and *Pinus sylvestris* listed as associated trees. A single sequence from Chile is also part of this clade (no associated plants listed); Sierralta *et al.* (1994) list *A. gemmata* / *junquillea* in relation to mushroom poisoning in Chile. Several closely related taxa from Colombia (*A. xylinivolva*, associated with oaks and pines), Adirondack Mountains, U.S.A. (*A. stranella* (E.-J. Gilbert) E.-J.Gilbert & Snell, associated with pines and Eastern Hemlock) and Canada (*Amanita* sp. "praecox", associated with *Tsuga canadensis*) have been distinguished from *A. junquillea* (Tulloss & Yang 2022).

Nine iNaturalist records from Australia have at some stage been identified as *Amanita junquillea* but none are this species and the observations are currently assigned as other species of *Amanita* (such as *A. muscaria*), *Amanita* sp. or mushrooms in general (Agaricales).

Material examined

Specimens. **— NEW ZEALAND.** NORTH ISLAND. Wellington, 27 May 2014, *G. Ridley s.n.* (PDD105792)

Observations. — iNaturalist (n=241): https://inaturalist.org/observations?place_id=6803&taxon_id=350046

Amanita muscaria (L.) Lam.

Encycl. 1(1): 111 (1783).

English common name: Fly Agaric.

TOXIC – Contains several biologically active compounds including ibotenic acid, a neurotoxin.

Pileus 80–250 mm diam., initially globose, becoming hemispherical, then flattened, scarlet to orange with white or yellowish pyramid-shaped warts, typically dry and glossy, with striate margin; flesh white. *Lamellae* free, close, white. *Stipe* 100–220 × 10–30 mm, central, straight, widening into bulbous base, white; flesh white. *Annulus* persistent, substantial skirt, high on stipe, white, occasionally cream. *Volva* white, forming scaly rings around base of stipe. *Spores* 8.5–10.2 × 6.5–8.1 µm, smooth, colourless, broadly ellipsoid, inamyloid. *Smell* mushroomy. *Taste* not distinctive. **Figs 3C, 5C.**

Notes. *Amanita muscaria* was originally described from central Europe, but has been recorded from many temperate and boreal regions of the northern hemisphere (Geml *et al.* 2006). It is commonly found producing sporing bodies in hardwood and softwood forests associated with oaks, beech and conifers. This species has been introduced and widely distributed in the southern hemisphere, including to South Africa (Reid & Eicker 1991), South America (Vargas *et al.* 2019), Australia (Reid 1980) and New Zealand (Ridley 1991). In Australia and New Zealand it is most common in pine plantations, but is also found associated with a wide range of trees, including birch, beech, cedar, chestnuts, larch, lime, poplar and oaks. *Amanita muscaria* is an invasive weed in New Zealand and Australia (in Tasmania and Victoria), jumping host to form mycorrhizal associations with native Southern Beech (*Nothofagus*). It has also apparently spread to eucalypts and possibly *Allocasuarina* in a few localised sites in Australia (e.g. Kangaroo Island, S.A.; Figs 8A-E), with eucalypts in New Zealand (PDD56208) and Portugal (Castro 1998), and native oak species in Colombia (Vargas *et al.* 2019). Sporing bodies occur either singly or in large groups.

The Australian native species *Amanita xanthocephala* (Berk.) D.A.Reid & R.N.Hilton has been confused with *A. muscaria*. It can be distinguished by its association with native trees, its smaller size, orange tinted universal veil, which appears as patches on the pileus and an orange rim on the bulbous base of the stipe (Fig. 5D).

In our analysis (Fig. 9) the Australasian sequences of *Amanita muscaria* (associated with *Pinus*, *Eucalyptus* and *Allocasuarina*; Table 1), are in a clade with sequences from Europe, Japan, and Sweden with *Alnus*, *Pinus*, *Picea* listed as associated trees; and Colombia with dipterocarps, *Quercus*, *Acacia*, *Pinus* and *Eucalyptus* listed as associated trees.

Excluded historical records. Some early Australian records identified as exotic *Amanita* can be shown to be certainly or highly likely misidentifications. For *Amanita muscaria*, prior to the verifiable records discussed below, there were reports (as *Agaricus muscarius*) as far back as the early nineteenth century. Robert Brown, botanist on the voyage of Investigator, which circumnavigated Australia 1801–1803, included *Ag. muscarius* in a short list of fungi that were native to both Australia and Europe (Brown 1814). Cooke (1890) listed from Victoria "*Agaricus muscarius* var. *puellaris*, Fries. On the ground. Victoria". The name is not validly published and appeared only in that work. In *Handbook of Australian Fungi* (Cooke 1892) there was an entry for *Ag. muscarius* including a description and the information: "Woods, especially fir and birch. Victoria". The species was presumably included on the basis of the report by Cooke (1890), but the description may well have been taken from works on European fungi, as fir is not a commonly planted species in Australia.

These early literature reports led McAlpine (1895), Cleland & Cheel (1914a) and Killermann (1928) to list *Amanita muscaria* as occurring in Australia. Cleland & Cheel (1914a) considered that *A. muscaria* "probably" occurred in N.S.W., but provided no evidence. Inexplicably, McAlpine (1895), recording the species from S.A. and Victoria, remarks "very common", but does not refer to the species in any of his other numerous publications on Australian fungi. During the nineteenth century various naturalists and scientists visiting from Europe, who would have been familiar with the Fly Agaric, failed to record the species in

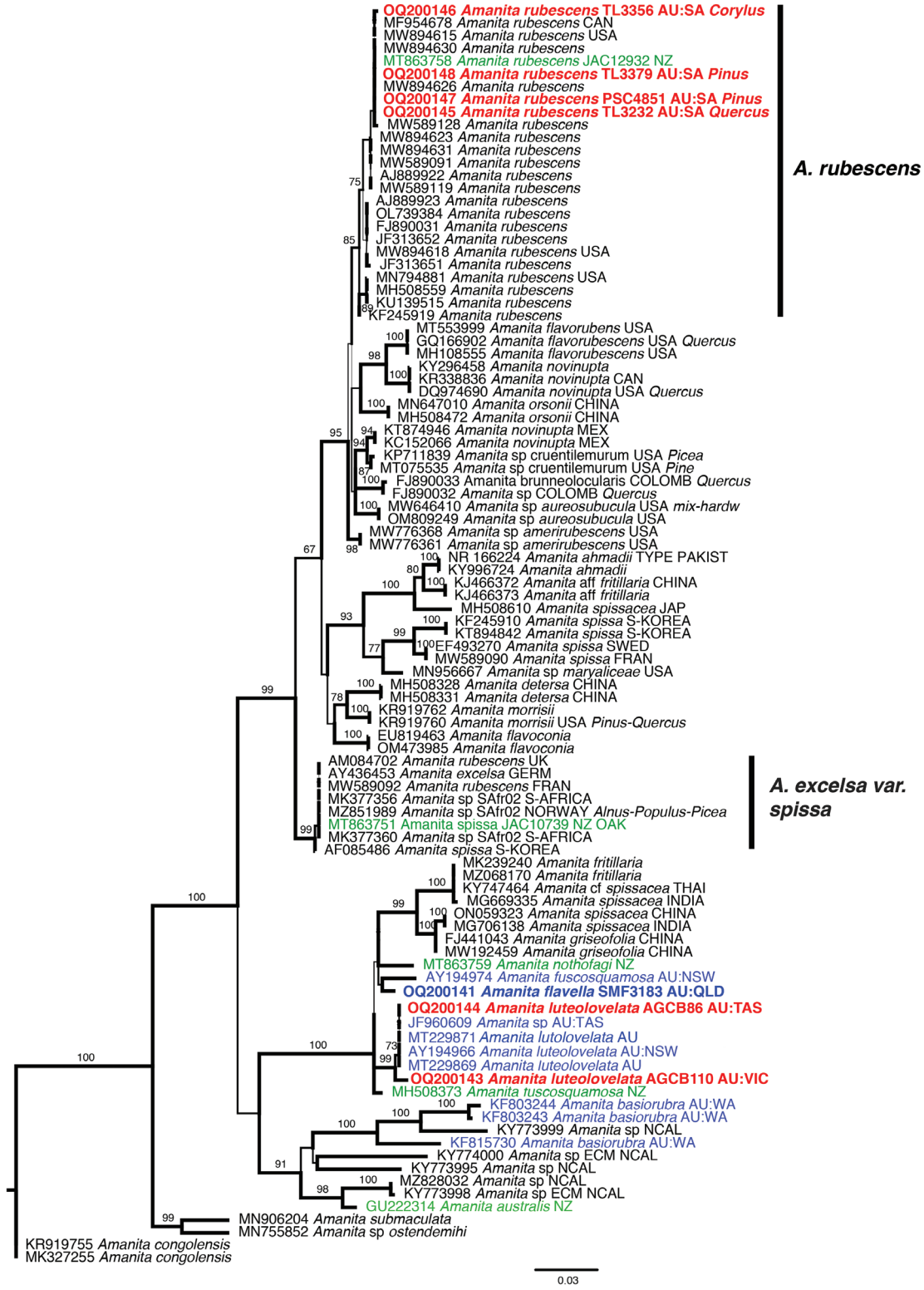

Fig. 6. Phylogenetic analysis for *Amanita excelsa* var. *spissa* and *A. rubescens*, inferred from maximum likelihood (RAxML) analysis of the nrITS region. Maximum likelihood support values are indicated on the branches >70%, and thickened lines indicate ML support >90%. Sequences from Australia generated for this study are in bold red, New Zealand sequences are shown in green, other Australian sequences are in blue.

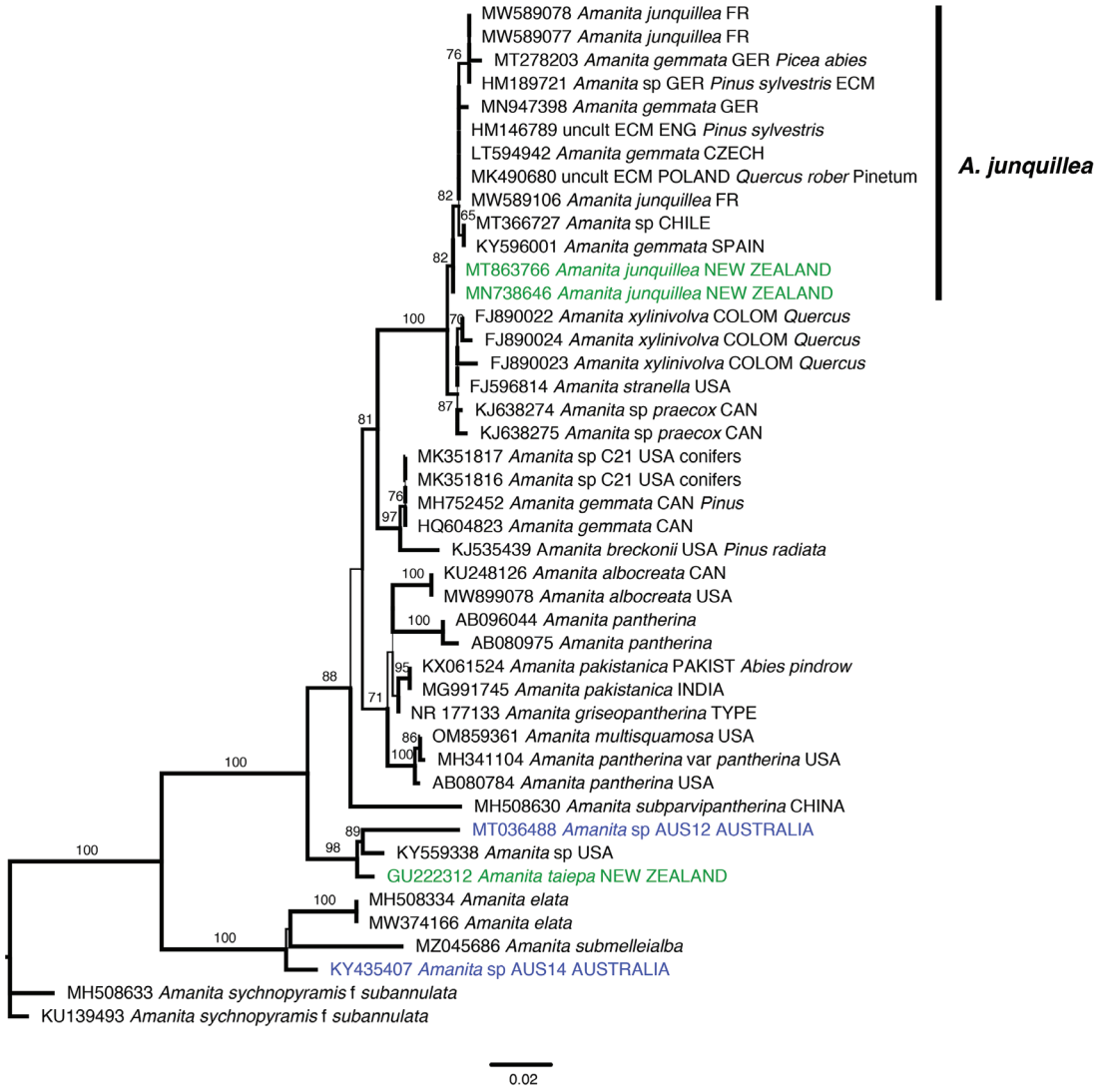

Fig. 7. Phylogenetic analysis for *Amanita junquillea* inferred from maximum likelihood (RAxML) analysis of the nrITS region. Maximum likelihood support values are indicated on the branches >70%, and thickened lines indicate ML support >90%. New Zealand sequences are shown in green, Australian sequences in blue.

Australia. German naturalist Lothar Becker specifically states that he did not observe the species during his extended stay in southern Australia (Becker 1873).

Only one specimen identified as *Amanita muscaria* collected from Australia prior to 1920 has been traced and that is a collection at MEL made by Marie Wehl at Lake Bonney in the south-east of S.A. in the 1880s and identified by Mordeccai Cooke as "*Agaricus muscarius* var. *puellaris*" (MEL227891). The specimen is broken into fragments, but a few spores could be recovered that are 7–8 × 5.5–7 µm and what appeared to be pileus tissue contained a roughly equal mix of inflated globose to clavate elements (to 40 µm in width) and cylindrical hyphae 5–7 µm in diameter. These microscopic characters are a good match to the native species *A. xanthocephala*, but not to *A. muscaria*, which has larger spores and predominantly inflated cells in the universal veil remnants on the pileus (Wood 1997). Dowe *et al.* (2020) traced Wehl collections and watercolour paintings and established that some paintings by Wehl that correspond to collections by Wehl identified by Cooke were gathered together in an album exhibited by Mueller at the Melbourne Centennial Exhibition (1888–1889) and the Paris Exposition Universelle in 1889. This album is now in the Natural History Museum, London. In the album there is an illustration of "*Agaricus muscarius*" that shows a fungus with a bright red pileus, lacking an annulus and with a yellowish brown ridge visible at the top of the bulbous stipe base. On the basis of the information recovered from the specimen in combination with the features shown in the illustration we redetermine MEL227891 as *A. xanthocephala* (Fig. 5D). Consequently, the inclusion by Mueller (1889) of *Ag. muscarius* in a list of fungi collections made by Wehl from Lake Bonney can be discounted as a misidentification. The listing by Cooke (1892) of *Ag. muscarius* can also be discounted as having any connection to *A. muscaria* as it is likely to have been based on his earlier report of *Ag. muscarius* var.

Fig. 8. *Amanita muscaria* in association with various native plant communities on Kangaroo Island, S.A.: **A–D** Yellow circles highlight the position of *A. muscaria* sporing bodies; **E** yellow circle indicating pine needles of associated trees; **F** sporing bodies of *A. muscaria* under eucalypts, but oak leaves present (yellow circles): ALWAYS check within 5–15 m for presence of exotic trees. — Photos: A–E J. Haska; F T. Lebel.

Fig. 9. Phylogenetic analysis for *Amanita muscaria*, inferred from maximum likelihood (RAxML) analysis of the nrITS region. Maximum likelihood support values are indicated on the branches >70%, and thickened lines indicate ML support >90%. Sequences from Australia generated for this study are in bold red, New Zealand sequences are shown in green, other Australian sequences are in blue.

puellaris (Cooke 1890). The location given by Cooke (1890) for *A. muscarius* var. *puellaris* was Victoria, but Mueller (1889) indicates that the collection by Wehl identified as *Ag. muscarius* by Cooke was from Lake Bonney in S.A. It is relevant that a manuscript list of Cooke's determinations of the material collected by Wehl was sent to Mueller and in that list the name is given as *Ag. muscarius* var. *puellaris* (Dowe *et al.* 2020). The discrepancy in the locality as cited by Cooke (1890) presumably originated from the circumstance that the original label with the Wehl collection does not indicate a locality and the collection was sent to Cooke by Mueller, who was based in Melbourne (Dowe *et al.* 2020).

It is relevant that the Australian mycologist Flora Martin (nee Campbell) expressed an opinion that Ferdinand von Mueller had misidentified "a brilliant small fungus in the Domain, South Yarra" as *Agaricus muscarius* (Maroske *et al.* 2018). The "brilliant small mushroom" is most likely *Ag. pulchellus* Cooke & Massee, described from a collection made by Martin. *Agaricus pulchellus* is now regarded as a heterotypic synonym of *Amanita xanthocephala* (Reid 1980; May & Wood 1997).

It is inconceivable that such a distinctive fungus was present in the eighteenth and nineteenth centuries without eliciting reports with evidence in the form of descriptions, illustrations and/or collections. We therefore regard all reports of *Amanita muscaria* from Australia prior to that of Cleland (1924), as misidentifications, most likely of *A. xanthocephala*, as already demonstrated for at least one of the early

records. For New Zealand we also regard any records prior to 1920 (PDD866), as misidentifications.

Material examined

***Specimens.* — NEW ZEALAND.** NORTH ISLAND. Wellington, Karori Cemetery, 12 Mar. 1920, *Brogan s.n.* (PDD866); Wellington, Kelburn, 12 Mar. 1922, *E.H. Atkinson s.n.* (AD11601).

SOUTH ISLAND. Canterbury, Klondyke Corner, under *Nothofagus* sp., 5 Apr. 2019, *N. Siegel NS 3605* (PDD112994); Lincoln, under planted *Nothofagus* sp., 9 Mar. 2004, *J.A. Cooper JAC 8894* (PDD81027); Christchurch, under *Tilia cordata*, 12 May 2005, *J.A. Cooper JAC 9447* (PDD80894); Craigieburn, 3 Apr. 2017, under *Nothofagus* sp., *J.A. Cooper JAC 14400* (PDD106659); Te Anau, under *Pseudotsuga menziesii*, 20 Apr. 2019, *N. Siegel NS 3752* (PDD113165).

AUSTRALIA. WESTERN AUSTRALIA. Manjimup, under *Betula pendula*, photographed, 3 June 2009, *R.M. Robinson RR 1104 WA* (PERTH06672345).

SOUTH AUSTRALIA. Aldgate, oak and spruce, 17 Mar. 1924, *M. Barclay s.n.* (AD-C3259); Aldgate, 26 Mar. 1925, *M. Barclay s.n.* (AD293969); Aldgate, 1933, *J.B. Cleland s.n.* (AD-C3260); Stirling, Apr. 1949, *A.J. Cole s.n.* (AD-C3242); Stirling, 18 May 1953, *J.E. Brown s.n.* (AD-C3240); Mount Lofty, under *Quercus* sp., May 1953, *M.J. Welch s.n.* (AD-C3241); Mount Lofty, under oaks, 24 Apr. 1954, *K.D. Leditschke s.n.* (AD-C3235); Heathfield, 9 May 1954, *E. Burns s.n.* (AD-C3237); Mt Lofty, under pines and oaks, 15 May 1955, *M.R. Schulz s.n.* (AD-C3236); Stirling, 6 May 1956, *L.M. Sherwood 116* (AD-C3253); Mt Gambier Forest Reserve, Lake Edward, 11 May 1976, *B.A. Mitchell s.n.* (AD-C9982); Church Rd, Kangaroo Island (K.I.), direct seeding revegetation of a paddock, associated plants *Allocasuarina stricta*, *A. muelleriana* and *Acacia* sp., 23 June 2013, *J. Haska JHAR 452* (AD-C583522); Church Rd, K.I., direct seeding revegetation of a paddock, associated plants *A. muelleriana*, *A. verticulata* and *Acacia provincialis*, 20 May 2014, *J. Haska JHAR 510* (AD-C60759, MEL238021); Yakka Jack Rd, K.I., *Pinus radiata* plantation, 21 May 2014, *J. Haska JHAR 512* (AD-C60258, MEL2380822); Harriett Rd, K.I., in windbreak of primarily *P. radiata* with a few scattered *Eucalyptus cladocalyx*, 22 May 2014, *J. Haska JHAR 513* (AD-C60253, MEL2380823); Church Rd, K.I., under canopy of *A. muelleriana* 23 June 2014, *J. Haska JHAR 550* (AD-C60256, MEL2380973); Playford Hwy, K.I., *P. radiata*, 22 May 2014, *J. Haska JHAR 514* (AD-C60262, MEL2380824); Adelaide, Mount Lofty Botanic Gardens, under *Chamaecyparis lawsoniana* among other exotic plants, 24 May 2014, *J. Haska JHAR 495* (AD-C60261, MEL2380820); Belair National Park, 25 May 2014, *P.S. Catcheside PSC 3918* (AD-C58620); Stokes Bay, K.I., *P. radiata* plantation, 11 June 2014, *J. Haska JHAR 536* (AD-C60257, MEL2380831); Church Road, K.I., area of revegetation under canopy of *A. muelleriana*, 23 June 2014, *J. Haska JHAR 550* (AD-C60256, MEL2380973); Tin Hut Rd, K.I., *E. globulus* plantation, 13 May 2015, *J. Haska JHAR 618* (AD293906); West End Hwy, K.I., *E. globulus* plantation, 15 May 2015, *J. Haska JHAR 625* (AD293907); Church Rd, K.I., planted *E. obliqua* of local provenance in former paddock, 21 May 2018, *J. Haska JHAR 973* (AD293910); Church Rd, K.I., planted *E. obliqua* of local provenance in former paddock, 24 May 2020, *J. Haska JHAR 2000* (AD293923).

NEW SOUTH WALES. Pilot Hill Arboretum & Picnic Area, Bago State Forest, 20 km from Batlow on Forest Way Rd, off Batlow-Tumbarumba Rd, beneath *Betula alba* grove in arboretum of introduced trees surrounded by montane forest, 24 Apr. 2000, *M. Smith 2* (MEL2076049); Raymond Terrace, Boomerang Park, c. 100 m east from corner of Elizabeth Ave. and Irrawang St., in parkland dominated by eucalypts and *P. elliottii*, 29 Mar. 2014, *M.P. Elliott 622* (MEL2380972); Oberon, in *P. radiata* forest, 24 Apr. 1999, *N.A. Sawyer & J.W.G. Cairney JC 17* (MEL2096534).

AUSTRALIAN CAPITAL TERRITORY. Canberra, Haig Park, NW corner of Torrens and Girrahween Streets, Braddon, parkland under *Pinus* spp. and exotic deciduous species, 25 May 1990, *W.F. Ganter 7* (MEL2292343).

VICTORIA. Emerald, 1939, [*A.*] *Swaby s.n.* (MELU-F006452, det. E. McLennan, *n.v.*); Emerald, 1 Apr. 1950, *s.coll.* (VPRI4473, *n.v.*); Rockley (near Montrose), 1959, *T.C. Daniell s.n.* (MEL2091027); Melbourne, Doncaster, 7 June 1964, *J.K. Dempster s.n.* (MEL2028847); Melbourne, Wattle Park, under *Cedrus*, 6 Aug. 1994, *Field Naturalists Club of Victoria WP 135* (MEL2336317); Marysville, near junction of Woods Point Rd and Lady Talbot Dve, by roadside under planted birches, 21 Apr. 1999, *A.C. Cochrane 584* (MEL2059613); Rawson, E side of Pinnacle Dve between Knotts Siding Road and Lehmann Ct, in parkland around *Betula pendula*, 27 May 2013, *N.G. Karunajeewa 607* (MEL2369969); Melbourne, Parkville, University of Melbourne, off Royal Pde, in garden bed next to Melba Conservatory, near *Q. canariensis*, 26 May 2022, *A.-G. Boxshall AGCB-202* (MELU).

TASMANIA. Tullah, Central Park, 13 Apr. 2006, under Silver Birch, *T. Lebel & M. Wright s.n.* (MEL2322083).

***Observations.* —** iNaturalist (n=6,683): https://inaturalist.ala.org.au/observations?place_id=6744,6803&quality_grade=research&subview=map&taxon_id=48715

***Selected observations.* — AUSTRALIA.** WESTERN AUSTRALIA. Bramley, 31 May 2020, *matisafunguy* (#47946164); West Ward, Collins, occurs in autumn under English Oak, River Banksia, Karri, 20 May 2022, *billby* (#117976994); Manjimup, growing under a pine tree, 11 June 2022, *ppolito* (#125788017).

SOUTH AUSTRALIA. Summertown, in a field surrounded by pines, 19 May 2018, *nikonoid* (#12591858); Kuipo, pine forest, 14 May 2020, *streglystendec* (#52513572); Mount Lofty Botanic Gardens, beneath *Q. peraea* (Irish Oak / Dumast Oak) in woodland section, 17 May 2021, *drewsinton* (#79123101); Chalks Campground, Mt Crawford, 25 June 2022, *smarsland* (#123491693).

QUEENSLAND. Growing under slash pine *P. elliottii* in the grounds of Symes Thorpe Rest Home, Toowoomba, 15 May 1999, *recorder 1069* (Fungimap record No. 42470 in ALA, https://biocache.ala.org.au/occurrences/0fb0bc6e-3bb4-4fe8-8826-ec29cb7db8b1).

NEW SOUTH WALES. Wiseman's Ferry Rd, Gunderman, growing beneath *P. radiata* and *Platanus* × *acerfolia*, rural property, 10 June 2014, *myfungi* (#7456585); Katoomba, open eucalypt forest with some *P. radiata* (from historical

plantation), 11 Apr. 2021, *helen_y* (#73598855); Berrilee Rd, Canobolas, 13 June 2022, *mitches* (#121534592); Black Soil Rd, Grattai, 18 Apr. 2022, *lukeadaml* (#127809706).

AUSTRALIAN CAPITAL TERRITORY. In nature strip under street-side planting of oak trees in Jardine St., Kingston, 15 May 2019, *nivlek* (#69121004); Growing around base of *Quercus* sp. in street planting, Watson, 29 May 2019, *kimberip* (#66623014); Parkes, nature strip below oaks, 14 May 2022, *maxie_lou* (#116936463).

VICTORIA. Redwood Plantation, East Warburton, 1 June 2014, *reiner* (#55270983); Raglan, 14 June 2021, *everythingleavesatrace* (#82937425); Yan Yean Reservoir Park, 21 May 2021, *hanssolow* (#79773316); Jericho, directly under a large oak tree, 29 Apr. 2022, *mattcampbellaus* (#113532068).

TASMANIA. Huonville, near Silver Birch Trees, 7 May 2017, *franklinhermit* (#54154990); Liffey, grassy clearing with planted conifers, at the base of a conifer, 8 May 2022, *patrice_b* (#116226495); Pegarah, King Island, 12 June 2022, *crazy_horse* (#121370798); Waratah, 26 Apr. 2022, *maatsuyker* (#14639335) [Note the *Nothofagus* leaves on the ground around the sporing body].

Excluded material

AUSTRALIA. SOUTH AUSTRALIA. [Lake Bonney], *n.d.*, [*Marie*] *Wehl 10* (MEL227891); originally determined as *Agaricus muscarius* var. *puellaris* (redetermined here as *Amanita xanthocephala*).

Amanita phalloides (Fr.) Link

Handbuch 3: 272 (1833).

English common name: Deathcap.

TOXIC – Deadly poisonous and, if early treatment is not given, death is probable within 3–10 days. Contains amanitins, phalloidins.

In a poisoning emergency phone 24 hours a day, 7 days a week:
Australia 13 11 26
New Zealand 0800 764 766

Pileus 30–100 (–155) mm diam., hemispherical becoming broadly flat, variable in colour from greenish-yellow to olive green, pale olive buff, yellow-green or olive-brown and may dry to almost white or be brown in age, smooth and shiny, with single or few large flat white veil remnants, margin smooth not striate; flesh white, may stain yellowish. *Lamellae* free, white to cream, close. *Stipe* 30–110 (–200) × 7–30 (–50) mm, central, straight, widening into a broadly bulbous base, white to cream, smooth; flesh white. *Annulus* white, robust but fragile, may collapse and stick to stipe in older specimens, or be washed off over time. *Volva* sac-like, substantial with a flaring margin, white, fragile and fragmenting when dug up. *Spores* (7.5–) 8–10.5 (–11) × (5.5–) 6.5–8 (–10) µm, colourless, subglobose to ellipsoid smooth, amyloid. *Smell* sweetish, of raw potato, becoming foetid when old. *Taste* NOT ADVISED! **Fig. 3D, 5E.**

Notes. *Amanita phalloides* is a widespread species, native to Europe, occurring as far north as Scandinavia and south to the Mediterranean basin and Algeria in north Africa (Pringle & Vellinga 2006). The species was first described from France by Vaillant (1727). This fungus grows in association with oaks (*Quercus*, Pringle *et al.* 2009; Berch *et al.* 2016), but also chestnut (*Castanea*, Pringle & Vellinga 2006), beech and pines (Neville & Poumarat 2004; Breitenbach & Kränzlin 1995). On the west coast of the U.S.A., *A. phalloides* has been found in association with pines (Pringle *et al.* 2009), and in Tanzania (Chelela *et al.* 2015) and South Africa with pines, oaks and occasionally poplar (Reid & Eicker 1991). *Amanita phalloides* has been introduced to Australia and New Zealand, where it occurs in mycorrhizal association only with various species of the family Fagaceae, including oaks as well as chestnut (*Castanea* sp.) and beech (*Fagus* sp.). Fortunately thus far, the conifer-associated strain has not been found in Australasia. Sporing bodies may be single or in groups, and scattered, often in arcs or circles around the mycorrhizal host tree.

In several countries, the Deathcap has been confused with the non-toxic mulch fungus, *Volvopluteus gloiocephalus* (DC.) Vizzini, Contu & Justo, commonly known as Stubble Rosegill. While *V. gloiocephalus* does have a sack-like volva at the base of the stipe, like the deathcap, it can be distinguished by the white to grey or grey-brown pileus, which is markedly sticky when fresh, lamellae that are initially white but soon turn pinkish then pinkish brown, pinkish brown spore deposit, and lack of an annulus on the stipe (Fig. 5F). Both species can produce sporing bodies at the same time of year, and in the same location, in leaf litter and mulch under oaks, beech or chestnut.

In our analysis (Fig. 10), the Australasian sequences of *Amanita phalloides* (associated with *Quercus*, *Fagus*, and *Castanea*; Table 1) are in a well-supported clade with sequences from Europe, China, and Canada with *Quercus* listed as the most common associated tree. *Amanita subjunquillea* S.Imai, a toxic species from forests of eastern and south-eastern Asia, is strongly supported as a sister taxon to *A. phalloides* (Zhang *et al.* 2010).

Excluded records. At AD, there are six collections made by J.B. Cleland under the name *Amanita phalloides*. Five collections were made in 1914 and 1915 from N.S.W. and one was collected in 1928 from Tasmania. Cleland himself seemed uncertain of the identities of his collections: those from Neutral Bay and Manly are labelled as "*Amanita phalloides*?", that from Browns River Tasmania as "*Amanita* near *phalloides*" and the collection from Atholl Gardens, Sydney simply as "*Amanita*". In his notes Cleland did not include information on habitats, surrounding vegetation or the tree species under which his collections were found. The lack of

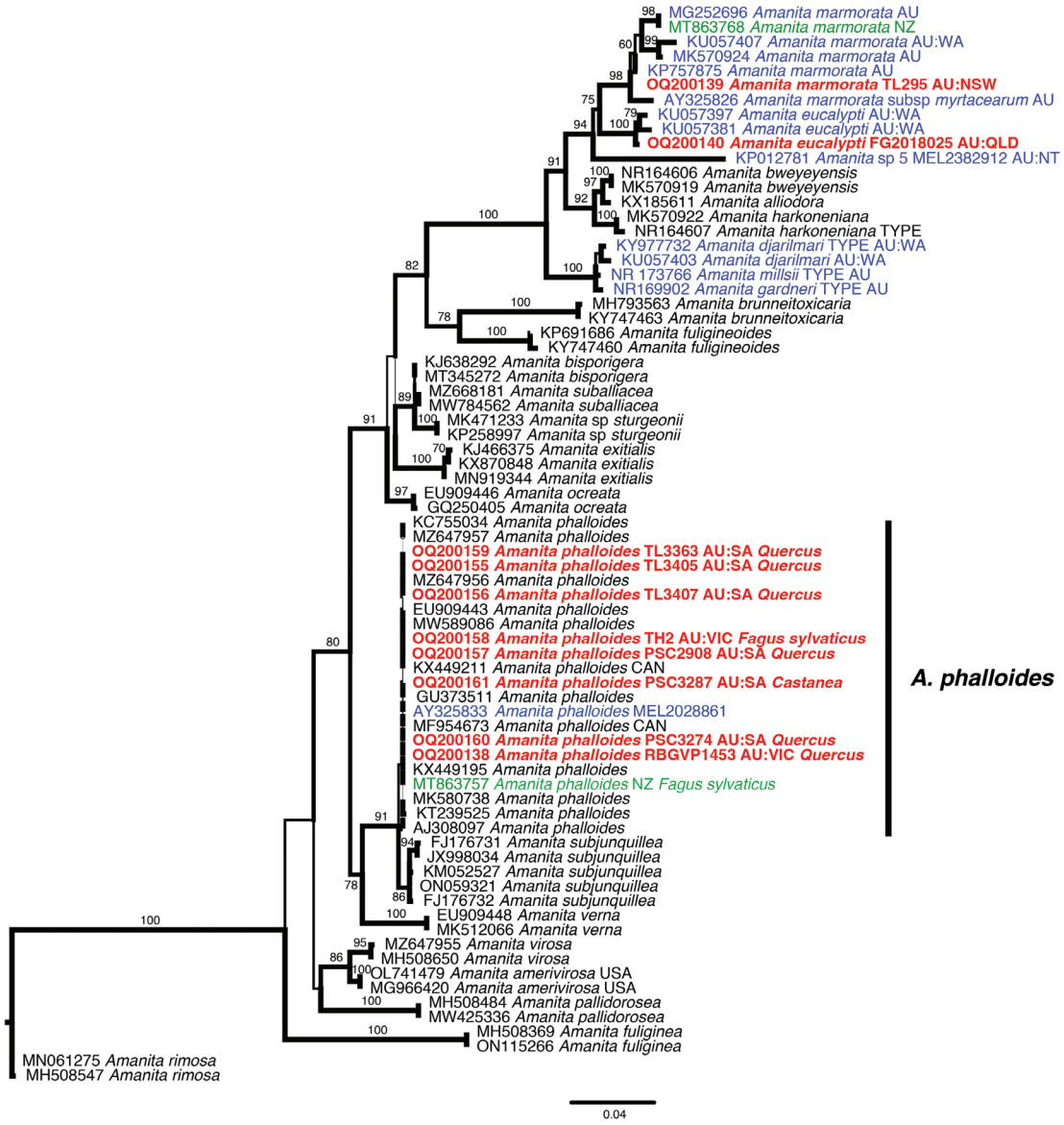

Fig. 10. Phylogenetic analysis for *Amanita phalloides*, inferred from maximum likelihood (RAxML) analysis of the nrITS region. Maximum likelihood support values are indicated on the branches >70%, and thickened lines indicate ML support >90%. Sequences from Australia generated for this study are in bold red, New Zealand sequences are shown in green, other Australian sequences are in blue.

this important information on mycorrhizal partner makes corroboration of identities more problematic. His detailed notes are all somewhat discordant with the characters of *A. phalloides*, with reference to a pure white pileus or straw pileus mottled with darker blotches, and some collections lack observations on spore amyloidity or on velar remains. The spores of this species are amyloid (Reid 1980; Wood 1997), velar remains on the pileus are hyphal (Reid 1980) or mainly hyphal with a few inflated cells (Wood 1997). The spores of the collection from Milson Island collected on 11 April 1915 (AD-C3105) are inamyloid, eliminating this collection as a possible *A. phalloides*. In addition, Cleland described the lamellae as pinkish-cream while all other collections were stated to be white or whitish. Unfortunately, the poor condition of most collections made determination of cell type of the velar remains impossible or difficult: the Neutral Bay collection (AD-C3108), half of which was in formalin, was very fragmented with most cells collapsed, as was the collection from Manly, N.S.W. (AD-C3107). The collection from Browns River, Tasmania (AD-C53211) was in somewhat better condition, but the velar remains were mainly of inflated cells, ruling out *A. phalloides*. We have adopted the conservative approach to redetermine all six collections back to "*Amanita* sp.", especially since conclusive evidence is lacking in each case, and the collections pre-date the earliest confirmed Australian collections by around five decades.

Material examined

Specimens. — **NEW ZEALAND.** NORTH ISLAND. Eastwoodhill Arboretum, Gisborne, 16 May 2013, under *Fagus sylvatica*, *J.A. Cooper JAC 12931* (PDD97031).

AUSTRALIA. SOUTH AUSTRALIA. Adelaide, Mt Lofty Botanic Gardens, under *Quercus robur*, 26 Apr. 2008, *P.S.*

Catcheside PSC 2826 (AD); Adelaide, Waite Arboretum, Fullarton Rd, under *Q. engelmannii*, 21 June 2008, *P.S. Catcheside PSC 2908* (AD-C56901); Adelaide, Waite Arboretum, Fullarton Rd, 4 July 2008, *P.S. Catcheside PSC 2942* (AD-C56043); Adelaide, Waite Arboretum, Fullarton Rd, under *Q. canariensis*, 21 July 2008, *D.E. Catcheside PSC 2952* (AD-C56050); Adelaide, Waite Arboretum, Fullarton Rd, 6 Aug. 2008, *P.S. Catcheside PSC 2975* (AD-C56122); Mt Lofty Botanic Gardens, under *Fraxinus mandshurica* but probably associated with nearby *Q. robur*, 10 Apr. 2010, *P.S. Catcheside PSC 3274* (AD-C57034); Heathfield, 8 May 2010, under *Castanea sativa*, *P.S. Catcheside PSC 3287* (AD-C57073); Mt Lofty Botanic Gardens, above conifer lawns and in oak 'grove' with *Betula pendula* nearby, under *Q. robur*, 19 Mar. 2011, *P.S. Catcheside PSC 3462* (AD-C56541); Mount Lofty Botanic Gardens, under *Q. robur*, 19 Mar. 2011, *P.S. Catcheside PSC 3463* (AD-C57222); Adelaide, Urrbrae, Waite Arboretum, Fullarton Rd, under *Q. robur*, 26 June 2021, *T. Lebel & A.-G. Boxshall TL 3405* (AD286522); Adelaide, Urrbrae, Waite Arboretum, Fullarton Rd, under *Q. cocciferus*, *Q. suber*, and *Q. ithaburensis*, 26 June 2021, *A.-G. Boxshall & T. Lebel TL 3407* (AD293978); Mt Lofty Ranges, Crafers, corner Piccadilly Rd and Georgina Ave., roadside planting of oaks with grass and introduced plants, under *Quercus* sp., 29 May 2020, *K. Grigg & T. Lebel TL 3229* (AD293016); Mt Lofty Ranges, Crafers, corner Piccadilly Rd and Georgina Ave., roadside planting of oaks with grass and introduced plants, under *Quercus* sp., 16 May 2021, *T. Lebel TL 3363* (AD293038); Mount Lofty Botanic Gardens, Lothian Lawn area under *Q. robur*, 2 Apr. 2023, *H. Vonow & T. Lebel TL 3565* (AD293193).

AUSTRALIAN CAPITAL TERRITORY. Canberra, 4 km NE of Capital Hill, Yarramundi Reach, area planted with mixed *Quercus* spp., June 1986, *P. Buckley s.n.* (MEL0258652; CBG8602333); Canberra, Reid, 3 km NE of Capital Hill, in cultivated lawn with oak (*Quercus*) trees, 25 Apr. 1988, *H. Lepp 206* (CBG9909497, n.v.).

VICTORIA. Melbourne, Kew, 18 May 1974, *I. Pascoe* (VPRI10001, *n.v.*); Melbourne, Kew, grounds of Willsmere Hospital, on the ground under *Quercus*, 20 Apr. 1978, *I. Pascoe* (VPRI10276, CANB359586, *n.v.*); Emerald, 15 Apr. 1978, *I. Pascoe* (VPRI10269, *n.v.*); near Morwell, 1 May 1978, *P. Burton s.n.* (VPRI10644, det. I. Pascoe, *n.v.*); Melbourne, Malvern East, Beaver St., under oak, 1996, *T.W. May 1321 & S.L. Maroske* (MEL2502962); Melbourne, Camberwell, under oak, 17 May 1996, *J. Slocombe s.n.* (MEL2032926, collected where dog had chewed mushrooms, dog died next day, post mortem showed marked liver necrosis); Melbourne, Sandringham, Vincent St., under oak, April 1996, *Anon.* (MEL2032951, man died from eating Deathcaps from this locality); Melbourne, Burwood, Oxford St., under *Q. palustris*, 27 May 1997, *R. Dunstan s.n.* (MEL2049991); Melbourne, Parkville, University of Melbourne, Old Botany (Building 122), in garden bed with *Fagus sylvaticus*, 20 Apr. 2022, *T.A. Hao & A.-G. Boxshall TH 2* (MELU).

TASMANIA. Launceston, under *Quercus* sp., 18 May 2017, *K. Pugh s.n.* (HO586735).

Observations. — iNaturalist, n=156: https://inaturalist.ala.org.au/observations?place_id=6744,6803&quality_grade=research&subview=map&taxon_id=52135

Select Observations. — **NEW ZEALAND.** SOUTH ISLAND. Motueka, under exotic tree, 24 Mar. 2022, *jables* (#109609827).

AUSTRALIA. SOUTH AUSTRALIA. Macclesfield, under oak trees, 30 May 2021, *jacestripes* (#80827117); Waite Arboretum (Urrbrae), under *Q. canariensis*, 6 Aug. 2021, *drewsinton* (#90123239).

NEW SOUTH WALES. Albury Botanic Gardens, Albury, under *Fagus*, 17 May 2023, *tmacvean* (#162094928).

AUSTRALIAN CAPITAL TERRITORY. Ebden St., Ainslie, under *Quercus*, 13 May 2022, *mccomas* (#116793507); McKay Gardens, Turner, under *Quercus*, 20 May 2022, *lamber2012* (#118134656).

VICTORIA. Royal Botanic Gardens, Melbourne, under *Quercus*, 29 Jan. 2020, *funkeytom* (#86821558); Melba Hwy, Yering, under *Quercus*, 17 May 2021, *hanssolow* (#79768666); Canterbury Gardens, Canterbury, 17 May 2022, *hanssolow* (#117408118); Rudolf Steiner School, Croydon, under *Quercus*, 31 May 2022, *hanssolow* (#119508204); Outtrim, under oak trees, 21 May 2023, *funkeytom* (#162815887).

TASMANIA. Westbury Village Green, Westbury, under *Quercus*, 18 Mar. 2018, *shane_marshall* (#68482175).

Excluded material

AUSTRALIA. NEW SOUTH WALES. Milson Island, 18 Apr. 1915, *J.B. Cleland s.n.* (AD-C3104), originally determined as *Amanita phalloides* (redetermined here as *Amanita* sp.); Milson Island, 11 Apr. 1915, *J.B. Cleland s.n.* (AD-C3105), originally determined as *A. phalloides* (redetermined here as *Amanita* sp.); Atholl Gardens, Sydney, 11 Apr. 1915, *J.B. Cleland s.n.* (AD-C3106), originally determined as *Amanita* ? *phalloides* (redetermined here as *Amanita* sp.); Manly, 5 Apr. 1915, *J.B. Cleland s.n.* (AD-C3107), originally determined as *A.* ? *phalloides* (redetermined here as *Amanita* sp.); Neutral Bay, 21 Mar. 1914, *J.B. Cleland s.n.* (AD-C3108), originally determined as *A.* ? *phalloides* (redetermined here as *Amanita* sp.).

TASMANIA. Brown River, 28 Jan. 1928, *J.B. Cleland s.n.* (AD-C53211), originally determined as *Amanita* near *phalloides* (redetermined here as *Amanita* sp.).

Amanita rubescens Pers.

Tent. Disp. Meth. Fungorum 67 (1797).

English common name. In S.A. it is called "Red Blusher".

TOXIC — Contains a toxin (haemolytic protein) that is destroyed when cooked[1].

Though said to be edible, eating is not advised.

Pileus 40–85 mm diam., spherical to convex, becoming flat, dry or slightly sticky, surface dull pale pinkish fawn to dull pale brown when young, becoming flushed with

1 Phillips (1981); Oldridge *et al.* (1989).

red shades, and eventually turning reddish brown to tan or brown, covered with numerous felty warts that are pale creamy yellow and densely packed at first, but soon spread and fade, becoming pinkish, grayish or dull tan; the margin typically not striate. *Lamellae* free or narrowly attached, crowded, thin, white sometimes discolouring pinkish red when bruised. *Stipe* 50–180 × 10–35 mm, cylindrical with a slightly enlarged bulbous base, which generally lacks a rim or cup, white at first, becoming beige stained pinkish to dirty red; smooth or finely roughened at base. *Annulus* persistent, membranous, fragile, white to pale pinkish with striations on upper surface, and may have a red lower margin. *Flesh* white but "blushing" slowly red when bruised or exposed to air. *Spores* 6–10.5 x 4–7 µm, smooth, ellipsoid, amyloid. *Smell* faint then becoming slightly acrid. **Fig. 3E, 11A-B.**

Notes. *Amanita rubescens* was originally described from Europe, but is widespread in the United Kingdom, North America and has been introduced to Chile (Valenzuela *et al.* 1996; Neville & Poumarat 2004; Roehl 2018). This species is commonly found producing sporing bodies in open grassy woodlands, associated primarily with oaks and beech, but also found with pines and other conifers. In Australia, thus far it is known only from S.A., where it is found under oaks, chestnut, and pines (Cleland 1934; Grgurinovic 1997); and in New Zealand under spruce in groups (Cooper, pers. obs).

Several specimens and observational records from other states in Australia determined as *Amanita rubescens* (e.g. PERTH7594615, from Queensland) include indications of uncertainty such as "cf.", and all are from native forests, such as with *Eucalyptus* or *Corymbia*. Some of the observational records are clearly misidentified (e.g. #Questagame 253747 is *A. luteolovelata* D.A.Reid. See Fig. 11E where the lovely yellow annulus is apparent). For the others, all

Fig. 11. Images of the exotic *Amanita rubescens* (**A–B**) and some native amanitas (**C–E**) that have been confused with it: **A** *A. rubescens* showing robust size, veil remnants on pileus (vr), pinkish tinge to stipe above annulus (an), red bruising on stipe (yellow circles), and oak leaves in background; **B** *A. rubescens* showing robust size, veil remnants on pileus (vr), disintegrating annulus (an), volva (vo) at base of stipe, and red bruising on pileus (yellow circle), with pine needles in background; **C–D** *A. basiorubra* showing variable colour, pinkish tinge to veil remnants (vr) on pileus, annulus (an), volva (vo), smallish size, red bruising on stipe (yellow circles), and association with native vegetation; **E** *A. luteolovelata* showing distinct yellowish tinge to annulus (an) and veil remnants (vr) on pileus, velar remnants (vo) at base of stipe, many sporing bodies can have much less obvious yellow tinges and more mature specimens when viewed only from the top may be confused with *A. rubescens*. — Photos: A T. Lebel; B–E J. Haska.

specimens and observations are considered to relate to a probable native species that is yet to be described, as none are associated with exotic tree hosts.

In Australia and New Zealand, *Amanita rubescens* is easily distinguished by the indistinct universal veil remnants at the stipe base (lacking a prominent volva or obvious rim), brassy yellowish to dull brownish pileus covered with warts that are initially yellow but turn greyish to tan, and the pinkish red rose discoloration termed "blushing". The Australian native species *A. basiorubra* also exhibits the characteristic pink staining of the stipe when damaged and in age (Bougher & Syme 1998; AD282275; Fig. 11C–D) but can be distinguished by its association with native trees, and its smaller size. While there are several other blushing amanitas worldwide, which are easily confused with some deadly poisonous amanitas, none of these other "red blusher" species appear to have been introduced to Australia or New Zealand thus far (Beeli 1935; Kumar *et al.* 1990; Tulloss *et al.* 1992; Tulloss & Lindgren 1994; Roehl 2018; Hernandéz-Rico *et al.* 2019).

In our analysis (Fig. 6), the Australasian sequences of *Amanita rubescens* (associated with *Quercus*, *Pinus* and *Corylus*; Table 1) are in a well-supported clade with sequences from Europe, China, Canada, South America, New Zealand and South Korea with Fagaceaceae and Pinaceae species.

Material examined

***Specimens.* — NEW ZEALAND.** NORTH ISLAND. Eastwoodhill Arboretum, under *Picea* sp., 16 May 2013, *J.A. Cooper JAC 12932* (PDD97032).

AUSTRALIA. SOUTH AUSTRALIA. Mt Lofty, under *Castanea*, 29 Mar. 1924, *J.B. Cleland s.n.* (AD-C3469); Mt Lofty, pre 1937, *J.B. Cleland s.n.* (AD-C3477); Mt Lofty, Apr. 1941, *J.B. Cleland s.n.* (AD-C3258); Stirling, Forest Lodge, 8 May 1985, *C.A. Grgurinovic 3585* (AD-C5307); Stirling, Forest Lodge, 11 June 1985, *C.A. Grgurinovic & J.A. Simpson 114685* (AD-C10033); Stirling, Forest Lodge, under *Fagus*, 26 June 1986, *C.A. Grgurinovic 278* (AD-C12174); Mt Lofty Botanic Gardens, under *Betula pendula*, 4 July 2008, *P.S. Catcheside PSC 2940* (AD293968); Crafers West, Castle Close, edge of roadside reserve, avenue of mixed oaks and eucalypts, 29 May 2020, *T. Lebel & K. Grigg TL 3232* (AD293034); Mylor, grassy hillside under mixed *Quercus* sp. & *Corylus* sp., 23 Feb. 2021, *T. Spokes TL 3356* (AD293043); Ironbank, under *Pinus radiata*, 6 June 2021, *T. Lebel TL 3379* (AD293040); Heathfield, private property, under large *Quercus robur* in garden, 30 May 2022, *D.E.A. & P.S. Catcheside PSC 4851* (AD293207).

***Observations.* —** iNaturalist, n=10: https://inaturalist.ala.org.au/observations?place_id=6744,6803&quality_grade=research&subview=map&taxon_id=67661

***Select Observations.* —** SOUTH AUSTRALIA. Stirling, mown rough grass near pines and oaks, 4 Nov. 2018, *rfoster* (#18085984); Piccadilly, under oak on roadside, 22 Oct. 2022, *moth_nut* (#139604910).

Excluded species

All other records from Australasia of exotic *Amanita* species (apart from *Saproamanita*) are considered incorrect (Table 3), as either (1) material has been examined and found to be mis-identified, or (2) there is no supporting information to enable confirmation of the records, and no indication that the material was growing in association with exotic hosts.

The four taxa identified in the *Saproamanita* clade are not discussed further under species descriptions or discussion. However the preliminary identifications are presented here for future reference: *A. inopinata* (New Zealand species, also occurs in Australia); *A.* "*codinae*" (probable native Australian species close to true Mediterranean *A. codinae*); *A.* "*manicata*" (probable native Australian species close to true Sri Lankan *A. manicata*); *A.* "*prairiicola*" = *A. silvifuga* (may be an exotic introduction from Texas, but requires further material for assessment; see Appendix 1).

Amanita vaginata (Bull.) Lam.

Encycl. 1(1): 109 (1783).

English common name: Grisette.

Note. Cooke (1892), Cleland & Cheel (1914b), Cleland (1934), Willis (1963) and Aberdeen (1979: as "aff."), all mention this species. Reid (1980) examined six collections from Australia at K that had been identified as *A. vaginata* (Bull.) Lam. He considered some to belong to other genera such as *Macrolepiota* Singer or *Volvariella* Speg. and identified three as belonging to the "*A. vaginata* complex", but concluded that "none of these can be assigned to […] *A. vaginata* sensu stricto". Tulloss & Yang (2022) include in *Amanita* section *Vaginatae* Quél. eight species described from Australian types. *Amanita cheelii* (= *Amanita punctata*) and *Amanita subvaginata* (Cleland & Cheel) E.-J.Gilbert were originally described by Cleland & Cheel (1919) and Cleland & Cheel (1923), respectively, both from N.S.W. Wood (1997) included these two species in his treatment of Australian *Amanita*, in section *Vaginatae*, and described three further species in that section: *A. albovolvata* A.E.Wood, *A. pallidobrunnea* A.E.Wood and *A. sordidobubalina* A.E.Wood. Wood (1997) also described *A. pallidochracea* A.E.Wood and *A. pallidofumosa* A.E.Wood as new in section *Ovigerae* Singer, which Tulloss & Yang (2022) treat under section *Vaginatae*. There are numerous (almost 100) observations in iNaturalist from Australia identified at some time as *A. vaginata*; some have been re-identified to native species such as *A. albovolvata* or *A. cheelii*, or unidentified species of *Amanita* in section *Vaginatae*, but many remain as *A. vaginata*.

Wood (1997) identified a series of collections from N.S.W. as *A. vaginata*, commenting that the Australia material "seems to correspond to the northern species". However, Wood (1997) also noted that "[I]t is quite widespread, and the locations seem strongly to indicate

Table 3. Names of exotic *Amanita* species applied to Australasian material in the literature or on specimens or observations but not confirmed to occur in that region. For complete list of records from Australia for each species to the mid 1990s see May & Wood (1997). For incorrect records based on Australian Microbiome samples, see Table 2 and Appendix 2.

Species	Records from Australia	Comments
Amanita aspera (Pers.) Pers.	Reported from Victoria by Willis (1934b). A collection from Queensland (PERTH7550073) is identified as *Amanita* cf. *aspera*.	A species originally described from Europe for which there is no evidence of occurrence in Australia.
Amanita basii Guzmán & Ram.-Guill.	Reported once in iNaturalist, from Queensland (#116403850). The record has been corrected to *Amanita* section *Caesareae*.	A North American species for which there is no evidence of occurrence in Australia. It is a member of section *Caesareae*, of which there is at least one undescribed species in northern Australia (see under *Amanita hemibapha*), no doubt the source of the misidentification.
Amanita caesarea (Scop.) Pers.	Reported in iNaturalist (#155534415). The record has been corrected to *Amanita* section *Caesareae*. Also reported in the ALA (https://biocache.ala.org.au/occurrences/7489a5a5-68a6-4330-b8d1-ea7b6fb8e6ce). The record has been flagged as misidentified.	A Northern Hemisphere species for which there is no evidence of occurrence in Australia. It is a member of section *Caesareae*, of which there is at least one undescribed species in northern Australia (see under *Amanita hemibapha*), no doubt the source of the misidentification.
Amanita cokeri E.-J.Gilbert & Kühner ex E.-J.Gilbert	A single observation from Australia on iNaturalist (#127200051) initially identified as *A. cokeri* has been redetermined as *Amanita* sp. on the basis that *A. cokeri* is a North American species.	A species originally described from North America for which there is no evidence of occurrence in Australia.
Amanita gemmata (L.) Bertillon	Reported from Victoria by Becker (1875). No voucher specimen for this record has been traced.	A species originally described from Europe for which there is no evidence of occurrence in Australia.
Amanita hemibapha (Berk. & Broome) Sacc.	Reported twice in iNaturalist from northern Australia (for example: #108153863). Both records have been corrected to *Amanita* section *Caesareae*. The name has also been applied to specimens in fungaria such as MEL.	A species originally described from Asia that belongs in *Amanita* section *Caesareae*. There is no evidence that *A. hemibapha* in the narrow sense of the type material occurs in Australia, but molecular evidence suggests that there are at least two distinct undescribed Australian taxa in *Amanita* section *Caesareae* (Sánchez-Ramírez *et al.* 2015).
Amanita magniverrucata Thiers & Ammirati	Reported from W.A. by Syme (1992) as "cf." and from time to time on iNaturalist (15 observations identified initially as this species).	A North American species for which there is no evidence of occurrence in Australia. There are several native species with well developed warts on the pileus (such as *A. pyramidifera*), no doubt the source of misidentifications. All records can be discounted as incorrect.
Amanita mappa (Batsch) Bertillon (= *A. citrina* Schaeff.)	Reported from Victoria by Cooke (1892) and Willis (1934a), and mentioned by Cleland & Cheel (1914a) as not reported yet from N.S.W., but "probably occur here".	A species originally described from Europe. Willis (1963) revised his earlier description of *A. mappa* and placed it under *A. umbrinella*. Reid (1980) examined material at K and concluded "the occurrence of this species in Australia needs confirmation". There is no evidence of its occurrence in Australia and all records can be discounted as incorrect.
Amanita ovoidea (Bull.) Link	Reported from by Berkeley & Broome (1887) on the basis of a collection by Flora Campbell [consequently this record was probably from Victoria], and by Cooke (1892) from Victoria.	A species originally described from Europe. Reid (1980) examined two collections at K made by Flora Martin (one under her maiden name Flora Campbell), one of which was labelled as "Melbourne" and concluded that "neither […] represents *A. ovoidea*". There is no evidence of occurrence in Australia.
Amanita pantherina (DC.) Krombh.	Reported from N.S.W. by Cleland & Cheel (1914a); vouchers are in AD. Also included in a field guide to Tasmanian fungi (Eygelsheim 1981); there is no voucher specimen for this record.	A species originally described from Europe. Gilbert (1940, 1941) based both *A. grisella* and *A. umbrinella* at least in part on collections identified by Cleland as *A. pantherina*. In AD, there are nine collections from N.S.W. made by Cleland, all labelled as "*Amanita* ? *pantherina*", and annotated "probably *A. umbrinella* or *A. grisella*". There is no evidence of the occurrence of *A. pantherina* in Australia and all records can be discounted as incorrect.
Amanita rufoferruginea Hongo	There are two observations in iNaturalist currently identified as this species (#102349458 and #110021593) both from near Eudlo in Queensland.	Originally described from Japan. Comments on iNaturalist record #102349458 mention the strong resemblance to the Asian species, but also raise the possibility that the Queensland occurrence represents an undescribed species. Until there is confirmation on the basis of molecular and micro-characters, *A. rufoferruginea* is considered not to occur in Australia.
Amanita strobiliformis (Paulet ex Vittad.) Bertillon	Reported from N.S.W. by Cleland & Cheel (1914b) and from Victoria by Willis *et al.* (1936: as *Amanita* sp. "like a small form of *A. strobiliformis*")	A species originally described from Europe. Cleland (1924) reidentified as *A. ochrophylla* material placed under *A. strobiliformis* by Cleland & Cheel (1914b). There is no evidence for the occurrence of *A. strobiliformis* in Australia and all records can be discounted as incorrect.
Amanita vaginata	See main text.	

Table 3. continued

Species	Records from Australia	Comments
Amanita verna (Bull.) Lam.	Reported from various locations in Australia such as by Cooke (1892, including with a coloured illustration), Baker (1899) and Aberdeen (1954).	A species originally described from Europe. According to Reid (1980) "the presence of *A. verna* in Australia has yet to be unequivocally established". There is no evidence of its occurrence in Australia and all records can be discounted as incorrect.
Amanita virgineoides Bas	Reported from W.A. by Hilton (1982) without any details of macro- or micro-characters.	Originally described from Japan. Until there is confirmation on the basis of molecular and micro-characters, *A. virgineoides* is considered not to occur in Australia.
Amanita virosa Secr.	Included in a field guide to Tasmanian fungi (Eygelsheim 1981); there is no voucher specimen for this record.	A species originally described from Europe for which there is no evidence of occurrence in Australia.

an endemic species". None of the collections cited by Wood (1997) under *A. vaginata* are connected with exotic hosts and all appear to be from native forests. Given that there are no confirmed examples of exotic *Amanita* occurring in Australia in native forest (without first having established with exotic trees), we consider that it is likely that Wood (1997) misidentified a native species as *A. vaginata* and that this native species may need to be formally described. All other records of *A. vaginata* from Australia can be discounted as incorrect, as they have either been re-identified (as by Reid 1980) or do not indicate association with exotic hosts and are likely to be one of the several similar native species in section *Vaginatae*.

Discussion

We confirm the presence of five exotic species of *Amanita* in Australia and New Zealand, based on examination of morphological characters of voucher material and DNA sequence information. Three of these species occur in both countries, *A. muscaria*, *A. phalloides* and *A. rubescens*, the other two, *A. junquillea* and *A. excelsa* var. *spissa*, are currently known only from New Zealand. Records of 14 further exotic species (all described originally from Europe) can be found in the literature, specimen databases, the Australian Microbiome dataset, or observational databases (e.g. iNaturalist), but in all cases we regard these reports as erroneous. Early reports of agarics from Australia and New Zealand by European mycologists often applied names of Northern Hemisphere species to material presumably collected from native forests, and this occurred for *Amanita* (Table 3). Local mycologists also used Northern Hemisphere names, when first attempting to identify local *Amanita* species from native forests. However, it is apparent that many such usage of Northern Hemisphere names were later realised to be misapplications and either re-identified as species already described from Australian or New Zealand types, or described as new. For example, Gilbert (1940, 1941), when describing *A. umbrinella* (E.-J.Gilbert & Cleland) E.-J.Gilbert, cites material originally identified by Cleland as *A. pantherina* and *A. spissa*, including the illustration of *A. pantherina* in Cleland & Cheel (1914a). Willis (1934a) included entries for *A. mappa* (Table 3) and *A. spissa*, but later placed much the same descriptive information under *A. umbrinella* and *A. farinacea*, respectively (Willis 1963). Other reports of exotic amanitas are discounted, as they lack vouchers or images upon which to assess the reports, and there is no evidence of Northern Hemisphere species of *Amanita* occurring naturally in Australasia. All species of *Amanita* originally described from Australia are considered to be native, as they are all either explicitly from native vegetation, such as *Eucalyptus*, *Allocasuarina* or *Nothofagus*, or there is no reason to doubt that original material was collected from native vegetation. Australian records of species of *Amanita* originally described from New Zealand, such as *A. australis* G.Stev. and *A. nothofagi* G.Stev., have not been investigated. Such trans-Tasman distributions are plausible, but are yet to be confirmed for *Amanita* by detailed morphological and molecular analyses.

As stated in Cooper *et al.* (2022), documenting the occurrence and distribution of introduced fungal species is important for several reasons: (1) the majority of introduced fungi are concentrated in urban areas where they are more likely to be gathered for consumption; (2) the general ability to correctly identify fungal species is low, due to a lack of accessible information allowing unambiguous identification and the inherent difficulty in identifying fungi, although a target species approach (May 2021) can assist in focussing on species that are readily identifiable in the field (such as *Amanita muscaria*) with appropriate training and support; (3) a greater understanding of the occurrence and distribution of verified records and tracing the historical pathways by which exotic ECM fungi have been introduced can provide important insights into how ectomycorrhizal fungal species are initially translocated, and subsequently become established and spread.

Given the ectomycorrhizal status of the majority of species of *Amanita* (excluding "*Saproamanita*") it is reasonable to assume that exotic species would first establish in association with exotic trees. Historical records indicate that "larch, spruce and scotch firs" were first introduced into Australia prior to 1850, presumably from England as potted plants (Fielding 1957; Kloot 1985), and North American *Pinus radiata* (Monterey Pine; Fig. 2A–C) was first introduced into Australia and New Zealand in the 1850s (Fielding

1957; Berg 2008). Thus, incidental introductions of exotic ECM fungi potentially date back as far as the mid nineteenth century, although confirmed evidence from specimens is lacking.

Since the mid 1920's Australian foresters have accepted that exotic pines need to be inoculated in the nursery with suitable mycorrhizal symbionts to aid establishment and growth (Hartigan 1969). This followed the discovery in W.A. that the "development of satisfactory planting stock was dependent on some soil organism, probably a fungus not generally present in soils of southern Australia". Improvement was noted in the test plots "after treatment with light dressing of soil from an old established pine nursery" (Kessell 1927). The inoculum was possibly *Rhizopogon luteolus* Fr., an introduced species, and implies an earlier introduction of an inoculum. This early inoculum in W.A. was not *Amanita muscaria*, as this species was first recorded from W.A. in 2009 (Robinson 2010) in association with birch (*Betula pendula*) in a suburban garden. The first reports of sporing bodies of exotic *Amanita* supported by images or voucher collections in fungaria are discussed below.

Timing of introductions

Amanita muscaria was first reported from Australia (Fig. 12) with supporting evidence (i.e. images, illustrations and/or fungarium collections) by Cleland (1924) who listed a 1924 collection from Aldgate, S.A., which is extant (AD-C3259). *Amanita muscaria* appears to have been present in N.S.W. plantations by the late 1960s (Sawyer *et al.* 2001). The first record from Victoria is a specimen (MELU-F006452a) collected by [Arthur] Swaby from Emerald to the east of Melbourne in 1939 and identified by Ethel McLennan. There were a number of accounts of the occurrence of the species at Emerald in the 1940s (e.g. Anon. 1941; Anon. 1942; Morrison 1942, as "fly agaric"; Coleman 1945) and the species was also reported for the first time from Lalla near Launceston in Tasmania around the same time (Anon. 1942). In the illustrated report "The fly agaric is here" the author stated "[I]t is believed that the photographs [...] are the first published of this fungus growing in Australia" and noted that there are only two known sites, at Aldgate and Emerald, at both of which the fungus "may be found growing in some profusion in limited areas" (Anon. 1941).

Morrison (1942) stated, without providing any details, that the occurrences at Aldgate, Emerald and Lalla [as "Lara"] "have all been traced to the importation of nursery stock". Emerald was the site of the tree nursery commenced by Carl Nobelius, eventually occupying more than 200 acres and growing several million trees at any one time. The focus of the nursery was fruit trees but "European shade trees" were also supplied (Anon. 2023; Ericksen 2023).

In an endnote in Coleman (1945), James Willis mentioned a further sighting at Mount Macedon in 1945, the first report from Victoria "outside of

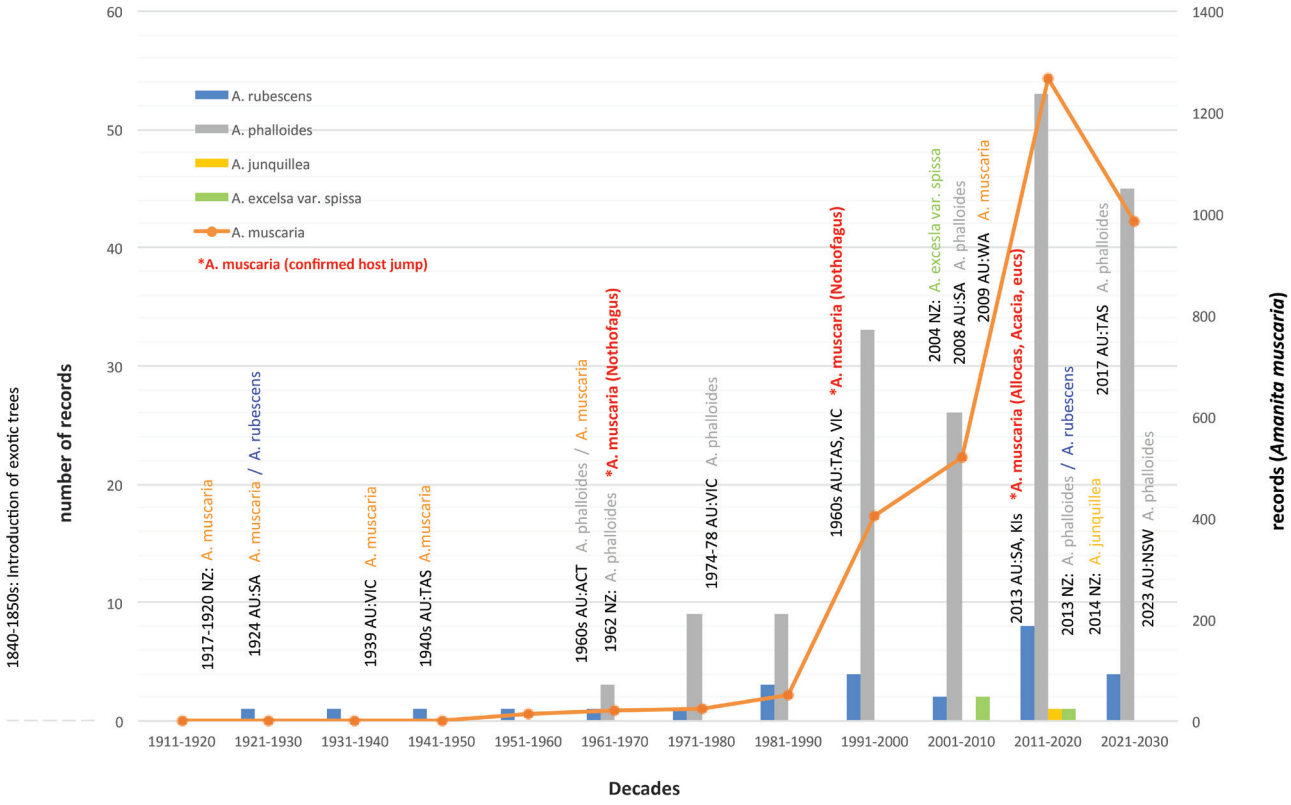

Fig. 12. Timeline of records for exotic amanitas from Australia and New Zealand, based on specimen and observation data from the Atlas of Living Australia (excluding reports considered erroneous). Some key dates for records of each species are indicated in coloured text, and the first confirmed records of *Amanita muscaria* host jumps to native species are also indicated (bold red text).

its well-known habitat at Emerald". Given the wide reporting of these first documented occurrences in Victoria, we regard it as very unlikely that the species was established in Australia prior to the early decades of the twentieth century. However, it is worth noting that despite *Amanita muscaria* being reported from outer Melbourne and elsewhere in various publications from 1940, there were only two collections made in the 1940s and 1950s, one from Nobelius Nursery in 1950 (VPRI4473a) and one from Rockley, near Montrose, in 1959 (MEL2091027). In the 1960s eight collections were made and lodged at MEL. The lack of initial collections reflects the generally low collecting activity (as far as lodging specimens in fungaria) prior to the 1990s (Fig. 12).

The spread of the species in Victoria is documented through the various editions of articles and books by Jim Willis, who was active in collecting and observing mushrooms in the state from the 1930s. In his account of the gilled fungi of Victoria, Willis (1934a) includes several species of *Amanita*, but not *A. muscaria*. In *Victorian Fungi* (Willis 1941) he notes that *A. muscaria* occurs "in Victoria, only under birch trees […] but is a rarity". In the revised editions published as *Victorian Toadstools and Mushrooms* (Willis 1950, 1957) the species is reported as "occasionally" present in Victoria, under "birches, chestnut, etc.", but in the last edition (Willis 1963) the species is now "abundant in many parts of Victoria […] under pines, birches, etc.". Willis (1960) collated known occurrences leading to further reports, summarised by Anon. (1963), who described the distribution as "from just east of Melbourne to the Dandenongs and the Upper Yarra […] with reports as far afield at Shoreham, South Gippsland, Narbethong, Mount Macedon and the Otway Ranges". Anon. (1963) noted that in most cases the species "grew under pines" but also "chestnut, birch, oak and spruce".

Coleman (1945) seems to suggest deliberate movement of soil in order to inoculate potential host trees. After observing the soil underneath sporing bodies "powdered with spores" she notes "it will presently be scattered under large maple trees in the garden". Maple is not ectomycorrhizal, but nevertheless Coleman (1945) was aware of the relationship between *Amanita muscaria* and trees such as chestnut.

Early reports indicate *Amanita muscaria* was present in South Island, New Zealand, prior to 1880 (Armstrong 1880). Subsequent reports appeared for North Island in 1917 and were accompanied by illustrations.[2] The first fungarium collection (PDD866) is from Wellington in 1920. The species was widely reported in association with *Pinus radiata* plantations by the 1960s (Ridley 1991). Anecdotal reports suggest the species had started to invade beech forest in the Nelson Area and Canterbury from the 1960s (Ridley 1991; Fig. 12). The species has now spread into native beech forests throughout most of New Zealand.

For *Amanita phalloides*, Hurst (1942) stated that it "is not yet recorded from Australia, but may possibly be present" and Willis (1963) indicated that *A. phalloides* "is providentially absent from Australia". Literature records make reference to the establishment of the species from the 1960s for the Australian Capital Territory (A.C.T.) and the 1970s for Victoria (Fig. 12). For example, Anon. (1964) indicated that "we have quite an astonishing variety of toadstools growing in the Australian Capital Territory" amongst which is "the extremely poisonous *Amanita phalloides* found quite recently in Canberra", while Francis & Southcott (1967) specify that *A. phalloides* "so far has only been recorded from Canberra". Macdonald & Westerman (1979) mentioned that *A. phalloides* was "only recently found in Melbourne, growing under oaks and other European trees". As with *A. muscaria*, there is a much older record of *A. phalloides* from Australia, by Becker (1873, as *Agaricus phalloides*), but this can be discounted as a misidentification (May & Darragh 2019).

For the A.C.T., the first account of the presence of *Amanita phalloides* was provided by mycologist and plant pathologist Clifford Jack Shepherd of the CSIRO Division of Plant Industry, who gave detailed information quoted in Southcott (1974). Shepherd recounts that *A. phalloides* was first observed in Canberra in 1961, in association with oak trees, at two sites: (1) a tree nursery on Cotter Road, and (2) at the former Canberra Hospital site on the Acton Peninsula. According to Shepherd, oaks at both sites were removed to allow for development (in 1963 for the hospital site and 1964 for the tree nursery), and the fungus disappeared and "we have lost it completely"; specifically mentioning that as at August 1974 "the species has not been found again in Canberra or surrounding areas". Shepherd mentioned that a collection was lodged in the "Forestry and Timber Bureau herbarium". According to Smith (2022), the functions of the Forest and Timber Bureau were absorbed into the CSIRO Division of Forest Research in 1978. The fungal reference collection maintained by the CSIRO Division of Forest Research was transferred to MEL around 2003, but did not include any specimens of *A. phalloides*; the 1961 collection is also not present in CANB or CBG.

Shepherd considered that *Amanita phalloides* was introduced to Canberra by the import of rooted material of American Oaks and noted that the practice of introducing rooted material had been replaced by the import of seeds and cuttings and thus it was "most improbable that the *Amanita* might be brought in a second time" (Southcott 1974). Despite the apparent disappearance of *A. phalloides* from Canberra after its initial introduction, it persisted or was re-introduced, with Graham Chilvers at the Australian National University, Canberra, mentioning that "during observations over several years" a number of exotic ectomycorrhizal fungi were detected, including *A. phalloides* which was "found occasionally under

2 *New Zealand Herald*, issue 16560, p. 4, Local and general news, 8 June 1917.

Quercus" (Chilvers 1973). The first extant collection from the A.C.T. was made in 1986 (CBG8602333). The species is now present across Canberra, with a number of recent records in iNaturalist.

For N.S.W., no fungarium records or observational records had been confirmed prior to an observational record from May 2023 from Albury (iNaturalist #162094928) (Fig. 12). At least in southern N.S.W. there are suitable exotic tree associates, and similar climatic conditions to those occurring in the A.C.T., Victoria, Tasmania and S.A. Therefore, it is possible that there are further un-documented occurrences in N.S.W. However, as there are plenty of observers recording fungi in N.S.W., the lack of observations indicates that if *Amanita phalloides* is present north of Albury, it is not common. Further records and observations of *A. phalloides* in N.S.W. will be of interest.

For Victoria, Southcott (1974) provides details and illustrations from a "near-fatal case of poisoning" in 1974 caused by consumption of *Amanita phalloides* gathered at Kew in Melbourne, at the Willsmere Hospital site. Specimens were identified by Ian Pascoe at the Victorian Department of Agriculture. There is a voucher for the 1974 case (VPRI10001) and another collection from the Willsmere Hospital site made in 1978 (CANB359586). An earlier fatal mushroom ingestion by another patient at Willsmere Hospital a few years prior is also documented by Southcott (1974), who mentions that the mushroom in that case was identified by James Willis at the National Herbarium of Victoria as *A. umbrinella*. No voucher can be located in MEL to match this record, but it is possible that the fungus in question was in fact *A. phalloides*, given that ingestion led to death. Southcott (1974) cites a newspaper article (Anon. 1974), which refers to the near-fatality in 1974 and mentions that *A. phalloides* was at that time also known from Emerald. In subsequent decades, *A. phalloides* spread to become common across parks and gardens in greater Melbourne, from Parkville in the west to Emerald in the east, and also established in some regional centres: Castlemaine, Gisborne, Bendigo and Drysdale (on the Bellarine Peninsula), as well as in locations in Gippsland, e.g. Loch.

For Tasmania, the earliest verified specimen is from Launceston, collected in May 2017 (HO586710) and there are few other reports from that state. The earliest documentation for S.A. is a collection made on 26 Apr. 2008 (*PSC 2826*) in the Adelaide Hills, then subsequently on 21 June 2008 from the Waite Arboretum (AD-C56901; and observational Fungimap record 1207761).

For New Zealand, 19th century reports of *A. phalloides* probably represent misidentification, as discussed by Ridley (1991). The earliest confirmed report is from Auckland in association with oaks (Taylor 1970) and the first collection (PDD84853) is from 1962 (Fig. 12).

Range expansion and host associations

While most invasive ectomycorrhizal fungi remain restricted to alien plant hosts (Dickie *et al.* 2016), a smaller number do spread to native hosts, as documented by Orlovich & Cairney (2004) for New Zealand. An allied phenomenon occurs for the indigenous Australasian *A. marmorata*, an associate of Myrtaceae, which has become established in exotic pine plantations in New Zealand (PDD99082).

Amanita excelsa var. *spissa* associates with a broad range of angiosperm and gymnosperm hosts, and *A. junquillea* with conifers in both native and introduced ranges. Both *A. excelsa* var. *spissa* and *A. junquillea* currently have restricted distributions in the south of the North Island and central north of the South Island, respectively (Fig. 3A–C). Potential tree associates are fairly widely distributed across New Zealand (Fig. 4A–B), thus it is interesting that fungarium collections and observational records are so restricted geographically. Given the intensive observation efforts for the genus, it is likely that these are recent introductions, and the species are just beginning to spread.

Amanita muscaria has a broad host range in its native habitat, and is a classic invader species, capable of producing abundant sporing bodies and large quantities of spores where established, and outcompeting native fungi in some highly disturbed habitats (i.e. path edges, camping grounds, compacted or highly disturbed soils; Dickie *et al.* 2016). On the basis of DNA recovered from roots, *A. muscaria* is confirmed to have host-switched to *Nothofagus* in Australia, Tasmania and Victoria (Dunk *et al.* 2012), and wherever Southern Beech occurs in New Zealand (Dunk *et al.* 2012; Dickie *et al.* 2016).

Amanita muscaria has also been reported in association with *Eucalyptus*, in Sardinia by Contu (1992: as "s. lat."), in Algeria and Morocco by Malençon & Bertault (1970) and in New Zealand by Ridley (1991). We confirm the association with *Eucalyptus* from new collections made in S.A., in disturbed locations such as *E. globulus* plantations or former paddocks being replanted with native species on Kangaroo Island (AD-C60759, AD293910, AD293923; Fig. 8A–D), but none thus far from the mainland in S.A. All except one of the Kangaroo Island sites were burnt during the devastating bushfires of late 2019 and early 2020. To date no new specimens have been seen at the Church Road sites and the *E. globulus* plantations, which are scheduled to be returned to pasture. However, specimens of *A. muscaria* were observed in 2023 in a regenerating *E. globulus* plantation subjected to a lower intensity fire. Thus it will be fascinating to observe if *A. muscaria* survived and persists in some of the intensively burnt sites or not.

Further records and collections of *Amanita muscaria* in association with native species would be of interest.

Care needs to be taken in determining the potential host, as *A. muscaria* can persist (producing sporing bodies) on the roots of a cut stump of the exotic host for 1–3 years after the tree is cut down (Lebel, pers. obs.) and the roots of the host species can spread a considerable distance. In Fig. 8F, note the presence of oak leaves and eucalypt bark and leaves in the photo.

Amanita phalloides is strictly associated with members of the Fagaceae in Australia and New Zealand; mostly with *Quercus*, rarely with *Fagus* and even less commonly with chestnut, hazelnut and beech. Thus far there are no confirmed records in Australia or New Zealand of association with other exotic hosts, such as pines, or with native hosts, such as *Nothofagus* or *Eucalyptus*. We are fortunate that the pine associated strains found elsewhere (e.g. in the U.S.A.; Pringle & Vellinga 2006) do not appear to have been transported to Australasia, even though there are extensive pine plantations and plantings in parks and gardens around major urban centres that potentially were sourced from the U.S.A. and not Europe.

Fraiture *et al.* (2019) described *Amanita bweyeyensis* Fraiture, Raspé & Degreef from Burundi, Rwanda and Tanzania, where it occurs in association with *Eucalyptus*, presumably as an introduction from Australia, although the fungus has not been found in that country. *Amanita bweyeyensis* is in *Amanita* sect. *Phalloideae* and bears some resemblance to *A. phalloides*, although the pileus is white, pale yellow or pale brown, rather than the stronger yellow or green tints usually present in *A. phalloides*. Nevertheless, it is possible that the record of *A. phalloides* from under *Eucalyptus* in Tanzania by Pegler (1977) represents *A. bweyeyensis*. Another example of a species of *Amanita* associated with *Eucalyptus* that was described from outside of Australia but not found in that country, is *A. aliena* Wartchow & Cortez from Brazil (Wartchow & Cortez 2016). Whether these associations between *Amanita* and *Eucalyptus* reported from outside of Australia are local species that have made a host-switch to *Eucalyptus* or whether they are Australian species waiting to be described (or existing Australian species that were overlooked) remains to be determined.

Amanita rubescens can be found associated with oaks and pines in S.A., and with spruce in New Zealand. Given the widespread distribution of potential hosts and the restricted distribution to S.A. of *A. rubescens* (Figs 3E, 4A–B), it would seem likely that the roots of the original oak tree seedlings planted in SA had this species on their roots. There are no currently confirmed records with native trees, and all records from other Australian States or Territories have been confirmed as probable native species associated with native plants or mis-identifications.

Further observational records of exotic amanitas, particularly where associated plants are recorded, can be valuable additions to fungarium records, indicating range extensions, suggesting potential new native hosts or verifying outlying records from soil DNA, and even suggesting whether the causal factors are natural or inadvertent, such as climate change or land management practises, respectively.

Bi-modal appearance of *A. phalloides* sporing bodies

For the last decade or so, *Amanita phalloides* has been recorded as producing sporing bodies in autumn (June–July) and summer (Dec.–Feb.) in Victoria. Also, in late Dec. 2021, the first record and collection was made for the Adelaide Hills region, S.A. This was possibly related to the La Niña climate conditions – which continued into early 2023. The preferred environmental range of *A. phalloides* in native habitat is production of sporing bodies in autumn and early winter in the southern U.S.A. (California), although Arora (1986) notes that the species "may even turn up in the summer if the moisture is sufficient". This is also true for summer to autumn in New Zealand and in Switzerland (Breitenbach & Kranzlin 1995), and for late summer to autumn in Europe (Phillips 1981).

Observational records aid understanding of distributions and hosts

Amanita muscaria is found on the east coast of Australia, from south of Brisbane through to the Mount Lofty Ranges in S.A., throughout Tasmania and in the south-west of W.A., south of Perth (Fig. 3C). Overall, the distribution data for *A. muscaria* shown in the ALA appears to be very clean as far as points falling in plausible areas consistent with occurrences of exotic hosts. However, examination of maps and checking of occurrences at the edges of the distribution revealed some outliers that proved to be incorrectly identified.

A record in the ALA from Tewantin in south-eastern Queensland, around 160 km to the north-east of Toowoomba (https://biocache.ala.org.au/occurrences/f585b29a-0a88-4543-bd0d-1da1d3d8683d) is regarded as incorrect. From the image it is not able to be confirmed as *Amanita muscaria* as the sporing bodies depicted are immature and the surface of the pileus under the universal veil is not visible. It is consistent with an immature native *A. pyramidifera* D.A.Reid as there are distinct dense pyramidal warts on the pileus and stipe. Some apparent other outliers can be confirmed from accompanying photographs. For example, the isolated inland occurrence in far western Victoria at Edenhope (https://biocache.ala.org.au/occurrences/59cd172c-e5db-4a00-b8ac-ab5c2e51935e), some 80 km from the nearest occurrences in the Hamilton district, is supported by a photograph as is a record near Bidgeemia in central N.S.W. (about 60 km to the north-west of the closest occurrences at Albury). All incorrect occurrences were removed prior to generation of maps.

For *A. muscaria*, the most northerly occurrence in Australia is at Toowoomba, for which there are 17 observation records and a voucher collection

(BRI-AQ0660879). The iNaturalist observations #127809706 and #121534592 from Grattai and Canobolas, respectively, represent the most westerly N.S.W. records. Fungimap No. 42470 is *A. muscaria* under *Pinus ellottii* (Slash Pine) in a suburban setting in Middle Ridge, Toowoomba. *Pinus ellottii* is one of the main softwood plantation timbers in Queensland, with plantations ranging from the border with N.S.W. to Bundaberg, with isolated plantations near Rockhampton, Mackay and Ravenshoe, which raise the possibility of occurrences to the north (HQ plantations 2022). Alternatively, climatic factors may be limiting the northward spread of the fungus, even though suitable hosts are present.

In connection with soil DNA records, in W.A., the AM record FungiITS1-8096-254021, near Mt Lesueur National Park, c. 250 km north of Perth, is an outlier for *Amanita muscaria*, being more than 350 km north of the nearest records confirmed by images or specimens in the south-west of W.A., well south of Perth. Given that AM sequences of *A. muscaria* are strongly supported as part of this species' clade, this outlier is intriguing. The coordinates place the record on the very western edge of the Park, near the start of a drive trail and with cleared land to the south. In the 1950–60s, the WA Forests Department established experimental pine plantations from Geraldton southwards. However, current data on softwood plantations in W.A. show the majority are less than 180 km north of Perth, though there are some small plantations near Warradarge, off the Brand Hwy c. 60 km to the east (SOFR 2018). Ground truthing, to check if an appropriate exotic tree associate has been planted at the Park/agricultural land boundary, would provide support for this record. The lack of sequences of *A. rubescens* and *A. phalloides* in the AM data is likely indicative of the lack of sampling of soil under exotic tree associates within the known range of these species.

In both Australia and New Zealand, *Amanita phalloides* appears to be restricted to major population centres, some rural Botanic Gardens, and arboreta with oak collections. In Australia, *A. phalloides* is found in the A.C.T., across the suburbs of Canberra; at one location in southern N.S.W. near the border with Victoria, at Albury; at one location in Tasmania, in Launceston; in S.A. only in Adelaide and nearby surrounds; and in Victoria it is widespread in Melbourne, but also occurs in some regional centres to the east and west of Melbourne (Fig. 3D). In New Zealand the species has been commonly recorded in Auckland and Hamilton, but is now widespread in the North Island and recently confirmed in the South Island.

The ALA includes a number of records of this species with accompanying images that are clearly incorrectly identified or otherwise are well outside the known range with no indication of associated exotic ectomycorrhizal trees, or with images that do not show features required for identification. Incorrect records include two from 'ALA species sightings and OzAtlas', one an image (https://biocache.ala.org.au/occurrences/2d951731-caad-4f57-b917-b5ebe15814b1) from an unspecified locality in the Northern Territory that is an *Amanita*, but not consistent with *A. phalloides*, the other an image from western Victoria (https://biocache.ala.org.au/occurrences/75e8402e-d6fa-4d2d-bd90-bc685d12c57c) that shows only the top view of a mushroom that could be a species of *Bolbitius* Fr. Observations lacking images from Wandiligong (Fungimap 427, 3011 and 4469) and Ocean Grove (Fungimap 605 and 615) are all regarded as likely to be incorrect, as they do not include mention of oaks and some are specifically from native forests with *Eucalyptus*, *Casuarina* or *Acacia*. The observation from near Morwell (Fungimap 26214), also lacking an image, is from "edge of pine forest" and there is no mention of oaks. However, there are iNaturalist records that confirm the presence of *A. phalloides* to the east of Melbourne, at Loch and Outtrim, and a collection from near Morwell (VPRI10644).

Correcting erroneous records

The data aggregation function of the ALA is extremely useful in bringing together information from various sources, including fungarium databases and citizen science recording schemes such as Fungimap and iNaturalist. When incorrect records are re-determined at the source, the identification in the ALA will be updated in due course if the original data repository provides regular updates to the ALA, as occurs for fungaria and iNaturalist. However, some data in the ALA is connected to data collections that do not have regular curation and it is consequently not possible to correct errors in the original data. In particular, the ALA provides a "simple species sighting recording tool" referred to as 'ALA species sightings and OzAtlas' (https://collections.ala.org.au/public/show/dr364), which does not appear to be under active curation.

The ALA has implemented a useful feature where a Data Profile is used to filter data on various features such as that the record is spatially suspect (based in environmental outlier analysis). The default is for an "ALA General" data filter to be applied. Users can opt out of data filtering, to see all data. There is a facility for users to annotate individual records as suspect, for reasons such as misidentification, mismatches between the geographic location and the geographic coordinates, etc. We have annotated several *Amanita muscaria* and *A. phalloides* records in the ALA (including some in the 'ALA species sightings and OzAtlas') as suspect, and these do not show up when the ALA General data filter is applied. However, the observations are visible among the set of data supplied by the ALA to GBIF. Further work is required to ensure that incorrect data is not ported through to data aggregators, which essentially comes back to the need for active curation by the ALA of data in 'ALA species sightings and OzAtlas' or where data collection projects are discontinued, the ability for third parties to change the identification.

Veracity of Australian Microbiome identifications

Almost all of the identifications provided by the AM for sequences generated by that project were not able to be confirmed by us using either the RDP classifier, BLAST matches or phylogenetic analysis. Some variation in identifications could be due to different versions of the UNITE database used by the AM and RDP, which would not be completely up to date compared to the GenBank sequences used in the BLAST matches. However, the use of different underlying databases does not explain the frequent mis-identifications of the AM sequences provided by the AM. Rather they have been over-identified to species level, as revealed by the best BLAST matches often being much lower than expected at species level and the AM sequences not falling with other sequences of the same species within the phylogenetic tree. The only exotic species that appears to have been correctly identified in AM is *Amanita muscaria*. It is likely that AM sequences incorrectly identified as exotic species simply represent native species that either have not been described yet or described species that lack reference sequences. Novel species of Australian *Amanita* continue to be described (e.g. Davison *et al.* 2013, 2015, 2017a, 2021) and many of the more than 100 known species of the genus included in the Australian Fungi List (https://fungi.biodiversity.org.au/nsl/services/search/taxonomy) do not yet have reference sequences. Overall, we consider that identifications to species level provided by AM are not reliable and users are recommended to re-analyse AM data using more stringent settings in the identification step. When identification is important, it should be by comparison methods and also by incorporating target sequences into a phylogenetic tree. AM identifications have been ported to the ALA, where the AM data is visible as *Basis of record* "Material sample". The AM data is filtered out by the default "ALA General" data profile, which users have to de-select in order to visualise the AM data. However, data in the ALA is ported to other data aggregators, such as GBIF, providing misleading information about species present in Australia. We recommend that AM revisit the identification steps in their data analysis pipeline and utilise a more stringent value in the algorithm that provides the species level identification.

Acknowledgments

Staff at the National Herbarium of Victoria (MEL), State Herbarium of South Australia (AD), Victorian Plant Pathology Herbarium (VPRI) and the New Zealand Fungarium (PDD) are thanked for providing access to and information about collections. Duckchul Park (Manaaki Whenua – Landcare Research) carried out the sequencing of PDD collections. Sapphire McMullan-Fisher (MEL) carried out microscopic examination of some MEL collections. Teresa Lebel acknowledges the support of the State Herbarium of South Australia and Flinders University. Jerry Cooper & Duckchul Park are supported by funding from the Science and Innovation Group of the New Zealand Ministry of Business, Innovation and Employment. Members of the iNaturalist community provided valuable records, as well as images of host trees. Steve Kingdon (Botanic Gardens of South Australia) provided several photos of potential host trees. Noah Siegel (U.S.A.) is thanked for the use of several of his images of collections deposited in PDD. Pat Leonard (Nelson, Queensland), Geoff Ridley (Manaaki Whenua – Landcare Research) are thanked for useful discussions and collections.

Julia Haska acknowledges landowners Ruth Wandel, Peter Hammond, Nirbeeja Saraswati, and Jamie Doube, along with PF Olsen (now Kiland), for permission to collect on their land. Naomi Murton alerted her to the presence of *A. muscaria* within a *Eucalyptus globulus* plantation and Hugh Watters of PF Olsen facilitated entry. Jason Laverty, Vanessa Messer and Dayna Hoadly of the Australian Wildlife Conservancy also notified her of the presence of *A. muscaria*.

We would like to acknowledge the contribution of the Australian Microbiome consortium in the generation of data used in this publication. The Australian Microbiome initiative is supported by funding from Bioplatforms Australia and the Integrated Marine Observing System (IMOS) through the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS), Parks Australia through the Bush Blitz program funded by the Australian Government and BHP, and the CSIRO.

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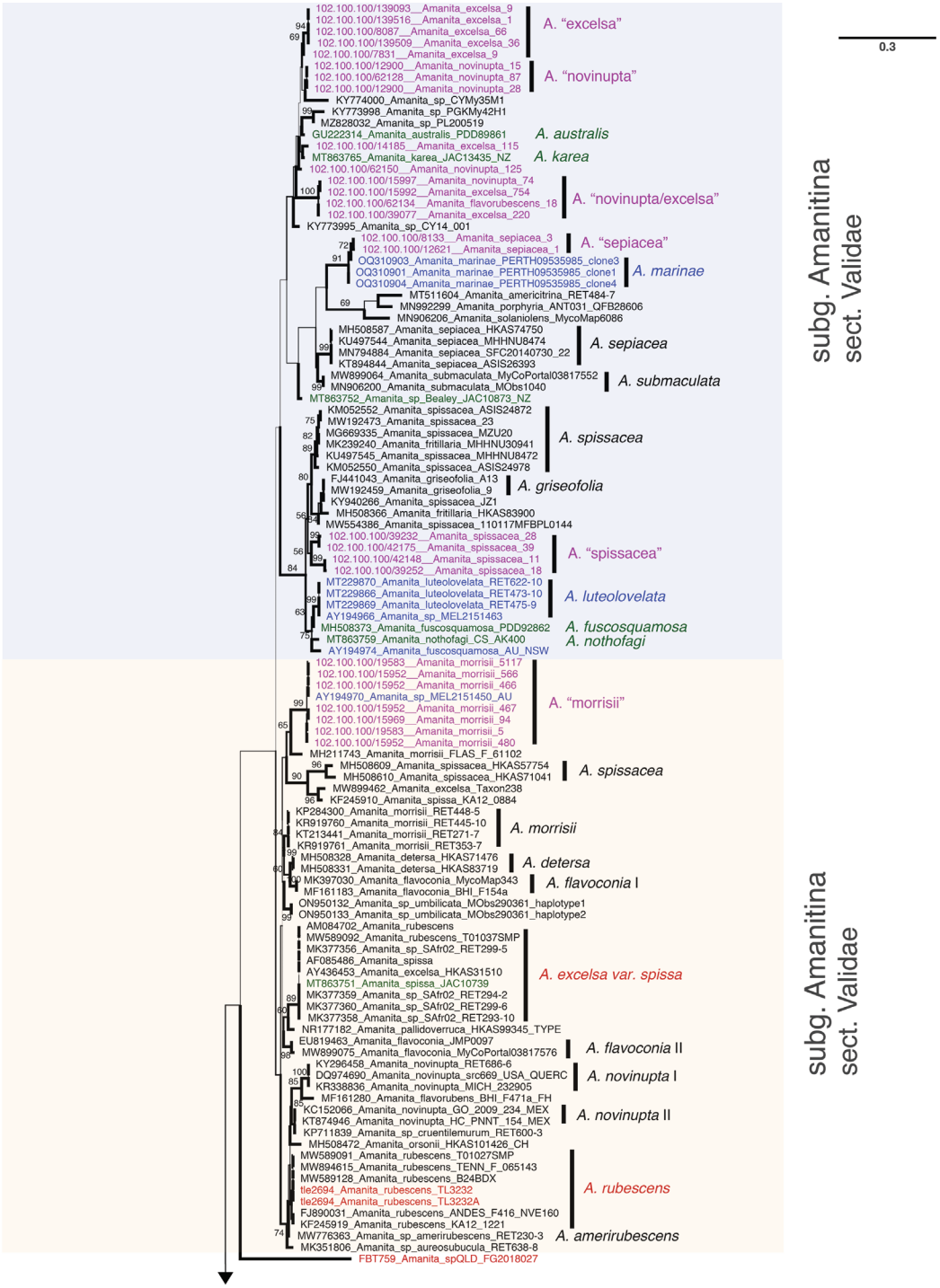
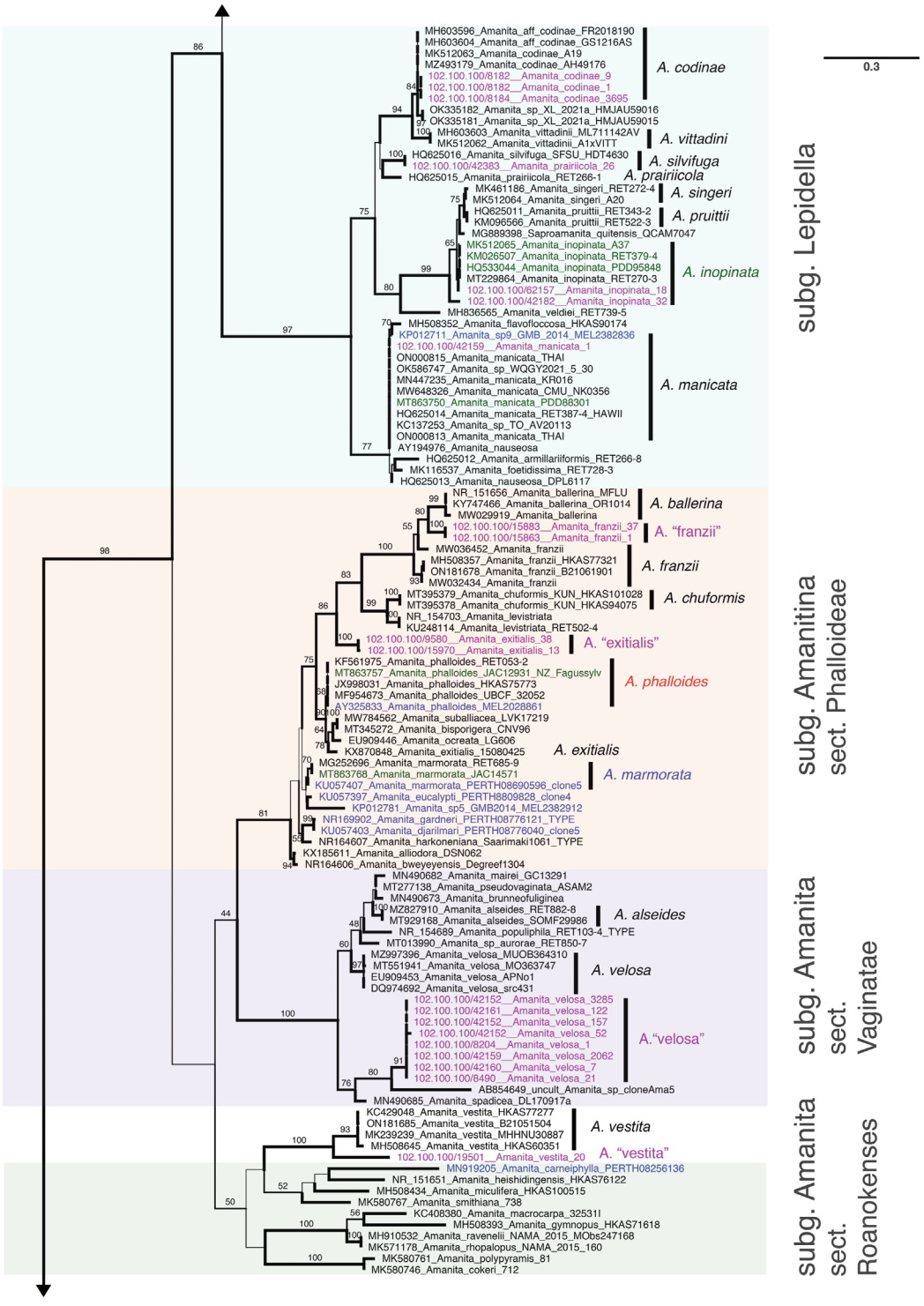
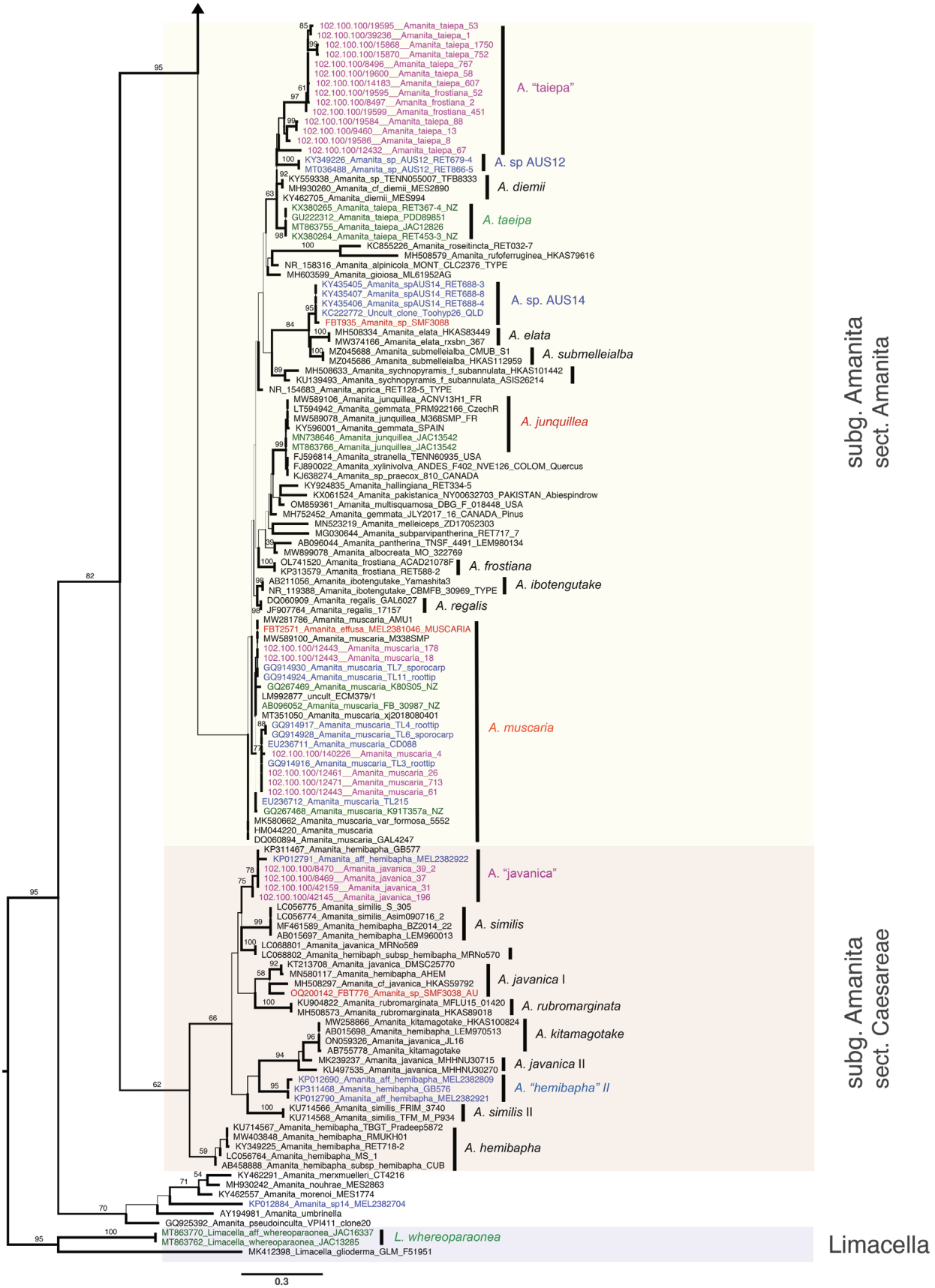


Appendix 1. Phylogenetic analysis for *Amanita* including Australian Microbiome data inferred from maximum likelihood (RAxML) analysis of the nrITS-1 region. Maximum likelihood support values are indicated on the branches >50%, and thickened lines indicate ML support >90%. Sequences from Australia generated for this study are in bold red, New Zealand sequences are shown in green, other Australian sequences are in blue (with AM sequences in pink). Subgenera and sections within *Amanita* are indicated.



Appendix 1. continued



Appendix 1. continued

Appendix 2. New identifications (id) of unique sequences from the Australian Microbiome, originally identified by the AM as exotic species of *Amanita*. Identifications from the RDP classifier are against UNITE and BLAST matches against GenBank. The identifier for each sequence used by the AM is the sequence itself and therefore an "AM identifier" presented here, taken from an example of each unique sequence from the AM with a label formed from the site number, the identification and the read count. For example, "102.100.100/139093__A_excelsa_9" where 102.100.100/139093 is the site number, *Amanita excelsa* is the AM identification and 9 is the read count for the particular sequence for that site. Identifications to *Saproamanita* species are given at the end of the table.

AM identifier (preceded by sample identifier and followed by read count)	RDP id	RDP id SH	RDP id score	BLAST id	BLAST id GenBank	BLAST id % Pairwise Identity	Sequence
102.100.100/139093__A_excelsa_9	*Amanita* sp.	SH193851.06FU	0.42	*Amanita australis*	GU222314	95.70	CTGAACGAAAAGGGTGGCAAGACTGTCGCTGGCTTGAACGAGCA TGTGCACGTCTTTTGCTGCTTATTTCATTCTCTTTTCCACCTGTGCA CCTTTTGTAGACACTTGGGATGGGGAGGAGAGGTTGGCATTGACT GTTGACCTCTGTCTCTTGATATTGAAAAGTCTGGGTGTCTATGCATT TTTGACGTACACATTTGAATGTCTATAGAATGAGATTGTAGGCTTTT GTGAGCCTTTAAATGATAAAATACA
102.100.100/139509__A_excelsa_36	*Amanita* sp.	SH193851.06FU	0.39	*Amanita australis*	GU222314	95.30	CTGAACGAAAAGGGTGGCAAGACTGTCGCTGGCTTGAATGAGCA TGTGCACGTCTTTTGCTGCTTATTTCATTCTCTTTTCCACCTGTGCA CCTTTTGTAGACACTTGGGATGGAGAAGGAGAGGTTGGCGTTGA CTGTTGACCTCTCTCTCTTGATAGTGAGAAGTCTGGGTGTCTATGCA TTTTTGACATACACATTTGAATGTCTATAGAATGAGATTGTAGGCTT TTGTGAGCCTTTAAATGATGAAATA
102.100.100/139516__A_excelsa_1	*Amanita* sp.	SH193851.06FU	0.47	*Amanita australis*	GU222314	94.90	CTGAACGAAAAGGGTGGCAAGACTGTCGCTGGCTTGAATGAGCA TGTGCACGTCTTTTGCTGCTTATTTCATTCTCTTTTCCACCTGTGCA CCTTTTGTAGACACTTGGGATGGAGAAGGAGAGGTTGGCATTGAC TGTTGACCTCTCTCTCTTGATAGTGAGAAGTCTGGGTGTCTATGCAT TTTTGACATACACATTTGAATGTCTATAGAATGAGATTGTAGGCTTT TGTGAGCCTTTAAATGATGAAATA
102.100.100/14185__A_excelsa_115	*Amanita* sp.	SH193851.06FU	0.46	*Amanita karea*	MT863765	96.10	CTGAACGAAAAGGGGTGGCAAGACTGTCGCTGGCTTGAATAAGC ATGTGCACGTCTTTTGCTGCTTATTTCATTCTATTTCCACCTGTGCA CATTTTGTAGACACTTGGGATGGGGGGAGAGGTTGGCATTGGATT TGTTGACTTCTTGATATTGAAAAGTCTGGGTGTCTATGCATTTTTGA CATACACATTGAAATGTCTATAGAGTGAGATTGTAGGCTTTTGTCAG CCTTTAAATGATAAAATACAACTT
102.100.100/15992__A_excelsa_754	*Amanita* sp.	SH193851.06FU	0.42	*Amanita* sp.	KY773995	93.00	CTGAACGAAAAGGGTGGCAAGACTGTCGCTGGCTTGAATGAGCA TGTGCACGTCTTTTGCTGCTTATTTCATTCTCTTTTCCACCTGTGCA CCTTTTGTAGACACTTGGGATGGAGAGGAGAGGTTGGCATTGACT GTTGACCTCTCTCTTGATAGTGAAAAGTCTGGGTGTCTATGCATTTT TGACATACACATTTGAATGTCTATAGAATGAGATTGTAGGCTTTTGT GAGCCTTTAAATGATGAAATACAAA
102.100.100/39077__A_excelsa_220	*Amanita* sp.	SH193851.06FU	0.38	*Amanita* sp.	MZ828032	92.50	CTGAACGAAAAGGGGTGGCAAGACTGTCGCTGGCTTGAATGAGC ATGTGCACGTCTTTTGCTGCTTATTTCATTCTACTTTCCACCTGTGC ACATTTTGTAGACACTTGGGATGGGGAGAGGTTGGCATTGGATTT GTTGACTTCTTGATATTGAAAAGTCTGGGTGTCTATGCATTTTTGAC ATACACATTGAAATGTCTATAGAGTGAGATTGTAGGCTTTTGTCAGC CTTTAAATGATAAAATACAACTTTT
102.100.100/7831__A_excelsa_9	*Amanita* sp.	SH193851.06FU	0.50	*Amanita australis*	GU222314	97.30	CTGAACGAAAAGGGTGGCAAGACTGTCGCTGGCTTGAATGAGCA TGTGCACGTCTTTTGCTGCTTATTTCATTCTCTTTTCCACCTGTGCA CCTTTTGTAGACACTTGGGATGGAGAGGAGAGGTTGGCATTGACT GTTGACCTCTCTCTTGATAGTGAAAAGTCTGGGTGTCTATGCATTTT TGACATACACATTTGAATGTCTATAGAATGAGATTGTAGGCTTTTGT GAGCCTTTAAATGATGAAATACAAA

Appendix 2. continued

AM identifier (preceded by sample identifier and followed by read count)	RDP id	RDP id SH	RDP id score	BLAST id	BLAST id GenBank	BLAST id % Pairwise Identity	Sequence
102.100.100/8087__A_excelsa_66	*Amanita* sp.	SH193851.06FU	0.52	*Amanita australis*	GU222314	95.70	CTGAACGAAAAGGGTGGCAAGACTGTCGCTGGCTTGAATGAGCA TGTGCACGTCTTTTGCTGCTTATTTCATTCTCTTTTCCACCTGTGCA CCTTTTGTAGACACTTGGGATGGAGAAGGAGAGGTTGGCATTGAC TGTTGACCTCTCTCTCTTGATAGTGAGAAGTCTGGGTGTCTATGCAT TTTTGACATACACATTTGAATGTCTATAGAATGAGATTGTAGGCTTT TGTGAGCCTTTAAATGATGAAATAA
102.100.100/15970__A_exitialis_13	*Amanita* sp.	SH200690.06FU	0.33	*Amanita subjunquillea*	FJ375332	88.70	ATGAATGAACTTGAGGCTGTTGCTGGCCTGGCCACAGGCATGTGC ACGTCTCTTTTCATCACCAATTCCACCTGTGCACATTTGTAGACATT TGGGAATGAGAGGCTTTGACCAGTCTTTTGTAAATTGAAATCTGG GTGTCTATGCCATTTTATCAAACGCTAGTTGCATGTCCATAGAATGA TGATGTAGGCTTTTAAAGTA
102.100.100/9580__A_exitialis_38	*Amanita exitialis*	SH239861.06FU	0.41	*Amanita subjunquillea*	FJ375332	89.20	ATGAATGAACTTGAGGCTGTTGCTGGCCTGGCCACAGGCATGTGC ACGTCTCTTTTCATCACCAATTCCACCTGTGCACATTTGTAGACATT TGGGAATGAGAGGCTTTGACCAGTCTTTTGTAAATTGAAATCTGG GTGTCTATGCCATTTTATCAAACACTAGTTGCATGTCCATAGAATGA TGATGTAGGCTTTTAAAGTA
102.100.100/62134__A_ flavorubescens_18	*Amanita* sp.	SH193851.06FU	0.50	*Amanita* sp.	KY773995	93.00	CTGAACGAAAAGGGGTGGCAAGACTGTCGCTGGCTTGAATGAGC ATGTGCACGTCTTTTGCTGCTTATTTCATTCTATTTCCACCTGTGCA CATTTTGTAGACACTTGGGATGGGGAGAGGTTGGCATTGGATTTG TTGACTTCTTGATATTGAAAAGTCTGGGTGTCTATGCATTTTTGACA TACACATTGAAATGTCTATAGAGTGAGATTGTAGGCTTTTGTCAGC CTTTAAATGATAAAATACAACTTTCA
102.100.100/15863__A_franzii_1	*Amanita* sp.	SH200690.06FU	0.18	*Amanita franzii*	MH508358	89.40	ATGAATGGACTTGAGGCTGTTGCTGGCCCTCGAAAAGAAGGGGG GGGGGAGGGCATGTGCACGTCTCTATTCATCACCCATCCCACCTGT GCACTACTGTAGATACCTAGGAATGAGGAGAGATCTTGATTGGTCT ATTAGCTTATTGAAATCTGGGTGTCTATGATATTTGTATTAAACACTG TTTGGCATGAATGATAAAAAAGTAGGGCTTTTTGCCTGTAATTAAA GTACAACTTTCAACAACGGATCT
102.100.100/15873__A_franzii_12	*Amanita exitialis*	SH239861.06FU	0.22	*Amanita farinosa*	LC176771	96.50	TTGAATGAACTTGAGGCTGTCGCTGGCCCTTGAAAAAGGGGCAT GTGCACGTCTCTATTCAGCACCCATCCCCCACCTGTGCATTACTGTA GACACCTGGGAATGAGAGAGAGAGAGGACCTTCATTGGTCTCTTG GCTTATTGAAATCTGGGTGTCTATGATATTTGTATGAAACACTGTTT GGCATGAATGATAAAAAGTAGGGCTTTTATGCCTGTAATAAAAGTA CAACTTTCAACAACGGATCTCTTGG
102.100.100/19595__A_frostiana_52	*Amanita* sp. LG1045	SH200325.06FU	0.26	*Amanita frostiana*	OL741520	88.20	TTGAAAGAAACCTCAGGCAAAGTGGGAAGTGGTTGTAGCTGGTC CCTAGGGGCATGTGCACACTGCCTCCCTTGCTTGTTTCTTCATTTT CTCCACTTGTGCATTGTTTGTAGGCAGCTTGGCGCTGTTCAGGTTG TCTATGATTTTTCTTTTACATACATGAAATAAATATTGTATAGAATGT GATAAAATGAAATAATA
102.100.100/19599__A_frostiana_451	*Amanita* sp. LG1045	SH200325.06FU	0.17	*Amanita frostiana*	OL741520	88.70	TTGAAAGAAACCTCAGGCAAAGTGGGAAGTGGTTGTAGCTGGTC CCTAGGGGCATGTGCACACTGCCTCCCTTGCTTGTTTCTTCATTTT CTCCACTTGTGCATTGTTTGTAGGCAGCTTGGCACTGTTCAGGTTG TCTATGATTTTTCTTTTACATACATGAAATAAATATTGTATAGAATGT GATAAAATGAAATAATA
102.100.100/8497__A_frostiana_2	*Amanita* sp. LG1045	SH200325.06FU	0.27	*Amanita frostiana*	OL741520	87.70	TTGAAAGAAACCTCAGGCAAAGTGGGAAGTGGTTGTAGCTGGTC CCTAGGGGCATGTGCACACTGCCTCCCTTGCTTGTTTCTTCATTTT CTCCACTTGTGCATTGTTTGTAGGCAGCTTGGTGCTGTTCAGGTTG TCTATGATTTTTCTTTTACATACATGAAATAAATATTGTATAGAATGT GATAAAATGAAATAATA

Appendix 2. continued

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102.100.100/8470__A_javanica_39	*Amanita hemibapha* subsp. *javanica*	SH223625.06FU	0.44	*Amanita* cf.	MH508297	93.60	TTGGAATGAAATCTCTAGCAAGGGGCTGTTGCTGGGCACTAGCCATGTGCACGCCTTTTGTCTATTTCTTCTCCCTGTGCACCACTTGTAGACTTTGCCTGTCTACGTATCACATAACCTTATGAAAGCATCTTTTGCAATATTATATTTATATATATATA
102.100.100/42159__A_javanica_31	*Amanita hemibapha* subsp. *javanica*	SH223625.06FU	0.49	*Amanita javanica*	KU714572	93.70	TTGGAATGAAATCTCTAGCAAGGGGCTGTTGCTGGGCACTAGCCATGTGCACGCCTTTTGTCTATTTCTTCTCCCTGTGCACCACTTGTAGACTTTGCCTGTCTACGTATCACATAACCTTATGAAAGCATCTTTTGCAATATTATATTTATATATATA
102.100.100/8469__A_javanica_37	*Amanita* cf. *hemibapha* TRTC 150314	SH223627.06FU	0.36	*Amanita javanica*	KU714572	92.50	TTGGAATGAAATCTCTAGCAAGGGGCTGTTGCTGGGCACTAGCCATGTGCACGCCTTTTGTCTATTTCTTCTCCCTGTGCACCACTTGTAGACTTTGCCTGTCTACGTATCACATATAACCTTATGAAAGCATCTTTTGCAATATTATATTTATATATATATA
102.100.100/42145__A_javanica_196	*Amanita hemibapha* subsp. *javanica*	SH223625.06FU	0.51	*Amanita* cf.	MH508297	94.20	TTGGAATGAAATCTCTAGCAAGGGGCTGTTGCTGGGCACTAGCCATGTGCACGCCTTTTGTCTATTTCTTCTCCCTGTGCACCACTTGTAGACTTTGCCTGTCTACGTATCACATAACCTTATGAAAGCATCTTTTGCAATATTATATATATA
102.100.100/15952__A_morrisii_467	*Amanita* sp.	SH206703.06FU	0.58	*Amanita* sp.	AY194970	99.30	CTGAACGAAATGGGTGGCAAGGCTGTCGCTGGCTCAAATGAGCATGTGCACGTCTTTTGCTGCTTGCTTCATTCTCTTTTCCACCTGTGCACTTTTTGTAGACACTCAGGGATTGGGAGCAGAGAGAGGTTTGGCATTGATTGTTGGACCCTCTCCGTCTTGATATTGCTGGGTGTTTATGTATTTTCTTGACATATACACACTTTGAATGTCTATAGAATGAAATTATAGGCTTTTATCAGCCTTTAAATGATT
102.100.100/15952__A_morrisii_466	*Amanita* sp.	SH206703.06FU	0.58	*Amanita* sp.	AY194970	99.70	CTGAACGAAATGGGTGGCAAGGCTGTCGCTGGCTCAAATGAGCATGTGCACGTCTTTTGCTGCTTGCTTCATTCTCTTTTCCACCTGTGCACTTTTTGTAGACACTCAGGGATTGGGAGCAGAGAGAGGTTTGGCATTGATTGTTGGACCCTCTCCGTCTTGATATTGCTGGGTGTCTATGTATTTTCTTGACATATACACACTTTGAATGTCTATAGAATGAAATTATAGGCTTTTATCAGCCTTTAAATGATG
102.100.100/19583__A_morrisii_5117	*Amanita* sp.	SH206703.06FU	0.57	*Amanita* sp.	AY194970	99.70	CTGAACGAAATGGGTGGCAAGGCTGTCGCTGGCTCAAATGAGCATGTGCACGTCTTTTGCTGCTTGCTTCATTCTCTTTTCCACCTGTGCACTTTTTGTAGACACTCAGGGATTGGGAGCAGAGAGAGGTTTGGCATTGATTGTTGGACCCTCTCCGTCTTGATATTGCTGGGTGTCTATGTATTTTCTTGACATATACACACTTTGAATGTCTATAGAATGAAATTATAGGCTTTTATCAGCCTTTAAATGAT
102.100.100/15952__A_morrisii_480	*Amanita* sp.	SH206703.06FU	0.60	*Amanita* sp.	AY194970	99.30	CTGAACGAAATGGGTGGCAAGGCTGTCGCTGGCTCAAATGAGCATGTGCACGTCTTTTGCTGCTTGCTTCATTCTCTTTTCCACCTGTGCACTTTTTGTAGACACTCAGGGATTGGGAGCAGAGAGAGGTTTGGCATTGATTGTTGGACCCTCTCCGTCTTGATATTGCTGGGTGTTTATGTATTTTCTTGACATATACACACTTTGAATGTCTATAGAATGAAATTATAGGCTTTTATCAGCCTTTAAATGATG
102.100.100/19583__A_morrisii_5	*Amanita* sp.	SH206703.06FU	0.58	*Amanita* sp.	AY194970	99.30	CTGAACGAAATGGGTGGCAAGGCTGTCGCTGGCTCAAATGAGCATGTGCACGTCTTTTGCTGCTTGCTTCATTCTCTTTTCCACCTGTGCACTTTTTGTAGACACTCAGGGATTGGGAGCAGAGAGAGGTTTGGCATTGATTGTTGGACCCTCTCCGTCTTGATATTGCTGGGTGTTTATGTATTTTCTTGACATATACACACTTTGAATGTCTATAGAATGAAATTATAGGCTTTTATCAGCCTTTAAATGAT

Appendix 2. continued

AM identifier (preceded by sample identifier and followed by read count)	RDP id	RDP id SH	RDP id score	BLAST id	BLAST id GenBank	BLAST id % Pairwise Identity	Sequence
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102.100.100/12461__A_muscaria_26	*Amanita muscaria*	SH200305.06FU	1.00	*Amanita muscaria*	ON564697	100.00	TTGAAAGAAACCTCAGGCAGGGGGAGATGGTTGTAGCTGGCCTCT AGGGGCATGTGCACACTGTGTCTCTCTTGCTTGTTTCTTCATTCTCT CCACTTGTGCACTGCTTGTAGGCAGCCCTGGCATTGTTCAGGCTGT CTATGATTTTATTTACATACATGAACAATTGTTGTACAGAATGTGATA AAAAATAGTAATA
102.100.100/12443__A_muscaria_178	*Amanita muscaria*	SH200305.06FU	1.00	*Amanita muscaria*	MW589123	100.00	TTGAAAGAAACCTCAGGCAGGGGGAGATGGTTGTAGCTGGCCTCT AGGGGCATGTGCACACTGTGTCTCTCTTGCTTGTTTCTTCATTCTCT CCACTTGTGCACTGCTTGTAGGCAGCCCTGGCATTGTTCAGGCTGT CTATGATTTTATTTACATACATGAACAATTGTTGTACAGAATGTGATT AAAAATAGTAATA
102.100.100/12443__A_muscaria_61	*Amanita muscaria*	SH200305.06FU	1.00	*Amanita muscaria*	MZ955957	100.00	TTGAAAGAAACCTCAGGCAGGGGGAGATGGTTGTAGCTGGCCTCT AGGGGCATGTGCACACTGTGTCTCTCTTGCTTGTTTCTTCATTCTCT CCACTTGTGCACTGCTTGTAGGCAGCCCTGGCATTGTTCAGGCTGT CTATGATTTTATTTACATACATGAACAATTGTTGTACAGAATGTGATA AAAAAATAGTAATA
102.100.100/12443__A_muscaria_18	*Amanita muscaria*	SH200305.06FU	1.00	*Amanita* sp.	FJ876157	99.50	TTGAAAGAAACCTCAGGCAGGGGGGAGATGGTTGTAGCTGGCCT CTAGGGGCATGTGCACACTGTGTCTCTCTTGCTTGTTTCTTCATTCT CTCCACTTGTGCACTGCTTGTAGGCAGCCCTGGCATTGTTCAGGCT GTCTATGATTTTATTTACATACATGAACAATTGTTGTACAGAATGTGA TTAAAAATAGTAATA
102.100.100/140226__A_muscaria_4	*Amanita muscaria*	SH200305.06FU	0.96	*Amanita muscaria*	MZ955957	99.00	TTGAAAGAAACCTCAGGCAGGGGGAGATGGTTGTAGCTGGCCTCT AGGGGCATGTGCACACTGTGTCTCTCTTGCTTGTTTCTTCATTCTCT CCACTTGTGCACTGCTTGTAGGCAGCCCTGGCATTGTTCAGGCTGT CTATGATTTTATTTACTTACATGGACAATTGTTGTACAGAATGTGATA AAAAAATAGTAATA
102.100.100/12900__A_novinupta_15	*Amanita* sp.	SH193851.06FU	0.62	*Amanita* sp.	MZ828032	95.70	CTGAAGGAAAAGGGTGGCAAGACTGTCGCTGGCTTGAATGAGCA TGTGCACGTCTTTTGCTGCTTATTTCATTCTCTTTCCACCTGTGCAC CTTTTGTAGACACTTGGGATGAGGAGAGGTTGGCATTGACTTGTT GACCTCTTGATAGTGAAAAGTCTGGGTGTCTATGCATTTTTGACATA CACATTTGAATGTCTATAGAATGAGATTGTAGGCTTTTGTGAGCCTT TAAATGATAAAACACAACTTTCAAC
102.100.100/12900__A_novinupta_28	*Amanita* sp.	SH193851.06FU	0.62	*Amanita* sp.	MZ828032	95.70	CTGAAGGAAAAGGGTGGCAAGACTGTCGCTGGCTTGAATGAGCA TGTGCACGTCTTTTGCTGCTTATTTCATTCTCTTTCCACCTGTGCAC CTTTTGTAGACACTTGGGATGAGGAGAGGTTGGCATTGACTTGTT GACCTCTTGATAGTGAAAAGTCTGGGTGTCTATGCATTTTTGACATA CACATTTGAATGTCTATAGAATGAGATTGTAGGCTTTTGTGAGCCTT TAAATGATAAAACACAACTTTCAAA
102.100.100/15997__A_novinupta_74	*Amanita* sp.	SH193851.06FU	0.40	*Amanita* sp.	KY773995	92.60	CTGAACGAAAAGGGGTGGCAAGACTGTCGCTGGCTTGAATGAGC ATGTGCACGTCTTTTGCTGCTTATTTCATTCTACTTTCCACCTGTGC ACATTTTGTAGACACTTGGGATGGGGAGAGGTTGGCAATTGGATT TGTTGACTTCTTGATATTGAAAAGTCTGGGTGTCTATGCATTTTTGA CATACACATTGAAATGTCTATAGAGTGAGATTGTAGGCTTTTGTCAG CCTTTAAATGATAAAATACAACTTT

Appendix 2. continued

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102.100.100/62128__A_novinupta_87	*Amanita* sp.	SH193851.06FU	0.55	*Amanita* sp.	MZ828032	95.70	CTGAAGGAAAAGGGTGGCAAGACTGTCGCTGGCTTGAATGAGCA TGTGCACGTCTTTTGCTGCTTATTTCATTCTCTTTCCACCTGTGCAC CTTTTGTAGACACTTGGGATGAGGAGAGGTTGGCATTGACTTGTT GACCTCTTGATAGTGAAAAGTCTGGGTGTCTATGCATTTTTGACATA CACATTTGAATGTCTATAGAATGAGATTGTAGGCTTTTGTGAGCCTT TAAATGATAAAACACAACTTTCAA
102.100.100/62150__A_novinupta_125	*Amanita* sp.	SH193851.06FU	0.34	*Amanita* sp.	MZ828032	96.10	CTGAAGGAAAAGGGTGGCAAGACTGTCGCTGGCTTGAATGAGCA TGTGCACGTCTTTTGCTGCTTATTTCATTCTCTTTCCACCTGTGCAC ATTTTGTAGACACTTGGGATGGGGAGAGGTTGGCATTGACTGTTG ACCTCTTGATAGTGAAAAGTCTGGGTGTCTATGGATTTTTGACATAC ACATTTGAATGTCTATAGAATGAGATTGTAGGCTTTTGTGAGCCTTT AAATGATAAAATACAACTTTCAACA
102.100.100/8133__A_sepiacea_3	*Amanita* sp.	SH193851.06FU	0.81	*Amanita excelsa*	MW258873	91.20	TTGAATGACAAAAAAGGTGGCAAGGCTGTCGCTGGCTTGAATGA GCATGTGCACGTCTTTTGCTGCTTATTTCATTGTCTTTTCCACCTGT GCACTTTTTGTAGACACTTGGGAATGGGAGGTTGGATTGATTTTTT TGACCTCTTGGTATTGAAAAGTCTGAGTGTCTATGAATTTTTATATAT ACACAGTTGTATGTCTATAGAATGGAGTTATAGGCTCTCTTGTAAGC CTTTAAATGATAAAGTACAACTT
102.100.100/12621__A_sepiacea_1	*Amanita* sp.	SH193851.06FU	0.81	*Amanita excelsa*	MW258873	92.00	TTGAATGACAAAAAAGGTGGCAAGGCTGTCGCTGGCTTGAATGA GCATGTGCACGTCTTTTGCTGCTTATTTCATTGTCTTTTCCACCTGT GCACTTTTTGTAGACACTTGGGAATGGGAGGTTGGATTGATTTTTT GACCTCTTGGTATTGAAAAGTCTGAGTGTCTATGAATTTTTATATATA CACAGTTGTATGTCTATAGAATGGAGTTATAGGCTCTCTTATAAGCC TTTAAATGATAAAGTACAACTTT
102.100.100/39252__A_spissacea_18	*Amanita* sp.	SH198945.06FU	0.92	*Amanita spissacea*	MW554386	89.70	CTGAAAGAAAAGAGTGGCAAAACTGTTGCTGGCTCCAAAAGAGC ATGTGCACGTTTTTTTTGCTGCTCGATTCATTCTCTTTCCACCTGTG CACTCTTTGTAGACACTTGGATATACCGAAAAAGTTCTCTGGGTGT CTATGTACTTTTTGATACACACGGTTGAATGTCTATAGAATGAGATT TGTAGGCTTTTGATGGCCTTTAAATGATAAAATA
102.100.100/39232__A_spissacea_28	*Amanita* sp.	SH198945.06FU	0.74	*Amanita griseofolia*	MW374202	98.00	CTGAAGGAAAAGAGTGGCAAGACTGTCGCTGGCTCGAAAGAGCA TGTGCACGTTTTTTGCTGCTTGATTCATTCTCTTTCCACCTGTGCAC TCTTTGTAGACGCTTGGATGAGTGTCTATGTACTTTTTTATATACACA CAGTTGAATGTCTATAGAATGAGATTTGTAGGCTTTTGATAGCCTTT AAATGATAAAATA
102.100.100/42148__A_spissacea_11	*Amanita* sp.	SH198945.06FU	0.90	*Amanita spissacea*	MW554386	89.70	CTGAAAGAAAAGAGTGGCAAAACTGTTGCTGGCTCAAAAAGAGC ATGTGCACGTTTTTTTTGCTGCTCGATTCATTCTCTTTCCACCTGTG CACTCTTTGTAGACACTTGGATATACCGAAAAAGTTCTCTGGGTGT CTATGTACTTTTTGATACACACGGTTGAATGTCTATAGAATGAGATT TGTAGGCTTTTGATGGCCTTTAAATGATAAAATA
102.100.100/42175__A_spissacea_39	*Amanita* sp.	SH198945.06FU	0.74	*Amanita griseofolia*	MW374202	97.50	CTGAAGGAAAAGAGTGGCAAGACTGTCGCTGGCTCGAAAGAGCA TGTGCACGTTTTTTGCTGCTTGATTCATTCTCTTTCCACCTGTGCAC TCTTTGTAGACACTTGGATGAGTGTCTATGTACTTTTTTATATACACA CAGTTGAATGTCTATAGAATGAGATTTGTAGGCTTTTGATAGCCTTT AAATGATAAAATA
102.100.100/39236__A_taiepa_1	*Amanita* sp. LG1045	SH200325.06FU	0.28	*Amanita frostiana*	OL741520	87.70	TTGAAAGAAACCTCAGGCAAAGTGGAAGTGGTTGTAGCTGGTCCC TAGGGGCATGTGCACACTACCTCCCTTGCTTGTTTCTTCATTTTCTC CACTTGTGCATTGTTTGTAGGCAGCTTGGCGCTGTTCAGGTTGTCT ATGATTTTTCTTTTACATACATGAAATAAATATTGTATAGAATGTGAT AAAATGAAATAATA

Appendix 2. continued

AM identifier (preceded by sample identifier and followed by read count)	RDP id	RDP id SH	RDP id score	BLAST id	BLAST id GenBank	BLAST id % Pairwise Identity	Sequence
102.100.100/19600__A_taiepa_58	*Amanita* sp. LG1045	SH200325.06FU	0.25	*Amanita frostiana*	OL741520	88.20	TTGAAAGAAACCTCAGGCAAAGTGGAAGTGGTTGTAGCTGGTCCCTAGGGGCATGTGCACACTGCCTCCCTTGCTTGTTTCTTCATTTTCTCCACTTGTGCATTGTTTGTAGGCAGCTTGGCGCTGTTCAGGTTGTCTATGATTTTTCTTTTACATACATGAAATAAATATTGTATAGAATGTGATAAAATGAAATAATA
102.100.100/19584__A_taiepa_88	*Amanita muscaria*	SH200314.06FU	0.19	*Amanita taiepa*	MT863755	94.90	TCGAAAGAAACCTCAGGCAAAGTGGAGGTGGTTGTAGCTGGCCCCTAGGGGCATGTGCACACTGCCTCTGTTGCTTGTTTCTTCATTCTCTCCACTTGTGCACTGTTTGTAGGCAGCCTGGCAATGTTCAGGTTGTCTATGATTTTCTTTACATACATGAAATAAATTTTGTATAGAATGGTGATAAAACAATAATA
102.100.100/15868__A_taiepa_1750	*Amanita* sp. LG1045	SH200325.06FU	0.22	*Amanita frostiana*	OL741520	87.30	TTGAAAGAAACCTCAGGCAAAGTGGAAGTGGTTGTAGCTGGTCCCTAGGGGCATGTGCACACTGCCTCCCTTGCTTGTTTCTTCATTTTCTCCACATGTGCATTGTTTGTAGGCAGCTTGGCGCTGTTCAGGTTGTCTATGATTTTCTTTTACATACATGAAATAAATAATTGTATAGAATGTGATAAAATGAAATAATA
102.100.100/8496__A_taiepa_767	*Amanita* sp. LG1045	SH200325.06FU	0.28	*Amanita frostiana*	OL741520	84.90	TTGAAAGAAACCTCAGGCAAAGTGGAAGTGGTTGTAGCTGGTCCCTAGGGGCATGTGCACACTGCCTCCCTTGCTTGTTTCTTCATTTTCTCCACTTTCTCCACTTGTGCATTGTTTGTAGGCAGCTTGGCGCTGTTCAGGTTGTCTATGATTTTCTTTTACATACATGAAATAAATATTGTATAGAATGTGATAAAATGAAATAATA
102.100.100/15870__A_taiepa_752	*Amanita* sp. LG1045	SH200325.06FU	0.18	*Amanita frostiana*	OL741520	88.20	TTGAAAGAAACCTCAGGCAAGGTGGAAGTGGTTGTAGCTGGTCCCTAGGGGCATGTGCACACTGCCTCCCTTGCTTGTTTCTTCATTTTCTCCACTTGTGCATTGTTTGTAGGCAGCTTGGCGCTGTTCAGGTTGTCTATGATTTTCTTTTACATACATGAAATAAATAATTGTATAGAATGTGATAAAATGAAATAATA
102.100.100/14183__A_taiepa_607	*Amanita* sp. LG1045	SH200325.06FU	0.25	*Amanita frostiana*	OL741520	87.70	TTGAAAGAAACCTCAGGCAAAGTGGAAGTGGTTGTAGCTGGTCCCTAGGGGCATGTGCACACTGCCTCCCTTGCTTGTTTCTTCATTTTCTCCACTTGTGCATTGTTTGTAGGCAGCTTGGCGCTGTTCAGGTTGTCTATGATTTTCTTTTACATACATGAAATAGATATTGTATAGAATGTGATAAAATGAAATAATA
102.100.100/12432__A_taiepa_67	*Amanita* sp. LG862	SH200322.06FU	0.47	*Amanita taiepa*	MT863755	91.00	TTGAAAGAAACCTCAGGCAAAGTAAGAGGTGGTTGTAGCTGGCCCCCTTGGGGCATGTGCACACTGCCTCTGTTGCTTGTTTCTTTATTTTCTCCACTTGTGCACTGCTTGTAGGCAGCTTGGCATTGTTCAAGTTGTCTATGATATTGTTTTACATACATGAAATAATGGTTGTATAGAATGTAATAAAACAAATAATA
102.100.100/19595__A_taiepa_53	*Amanita* sp. LG1045	SH200325.06FU	0.28	*Amanita frostiana*	OL741520	87.30	TTGAAAGAAACCTCAGGCAAAGTGGAAGTGGTTGTAGCTGGTCCCTAGGGGCATGTGCACACTTGCCTCCCTTGCTTGTTTCTTCATTTTCTCCACTTGTGCATTGTTTGTAGGCAGCTTGGCGCTGTTCAGGTTGTCTATGATTTTTCTTTTTACATACATGAAATAAATATTGTATAGAATGTGATAAAATGAAATAATA
102.100.100/9460__A_taiepa_13	*Amanita muscaria*	SH200314.06FU	0.18	*Amanita taiepa*	MT863755	95.00	TTGAAAGAAACCTCAGGCAAAGTGGAGGTGGTTGTAGCTGGCCCCTAGGGGCATGTGCACACTGCCTCTGTTGCTTGTTTCTTCATTCTCTCCACTTGTGCACTGTTTGTAGGCAGCCTGGCAATGTTCAGGTTGTCTATGATTTTCTTTACATACATGAAATAAATTTTGTATAGAATGGTGATAAAACAATAATA

Appendix 2. continued

AM identifier (preceded by sample identifier and followed by read count)	RDP id	RDP id SH	RDP id score	BLAST id	BLAST id GenBank	BLAST id % Pairwise Identity	Sequence
102.100.100/19586__A_taiepa_8	*Amanita muscaria*	SH200314.06FU	0.17	*Amanita taiepa*	MT863755	94.00	TTGAAAGAAACCTCAGGCAAAGTGGAGGTGGTTGTAGCTGGCCCCTAGTAGGGGCATGTGCACACTGCCTCTGTTGCTTGTTTCTTCATTCTCTCCACTTGTGCACTGTTTGTAGGCAGCCTGGCAATGTTCAGGTTGTCTATGATTTTCTTTACATACATGAAATAAATTTTGTATAGAATGTGATAAAACAATAATA
102.100.100/42152__A_velosa_52	*Amanita* sp.	SH240738.06FU	0.36	*Amanita* sp.	ON950150	85.50	TTGAACGAAGCTCCTGGCTGGGCGCTGTTGTGCTGGCCCTTTGGGGCAATGTGCACGCTTTGTCTAGTCATCTGTTTCTTTTGTTCCACCTGTGCACTGCCTGTAGACACGCTCTGTGTCTATGTATATCACACACACACATGTTATGATGTTGTTGGCATTTAATATATGTATATATATATATAATA
102.100.100/42152__A_velosa_157	*Amanita* sp.	SH240738.06FU	0.38	*Amanita* sp.	ON950150	84.90	TTGAACGAAGCTCCTGGCTGGGCGCTGTTGTGCTGGCCCTTTGGGGCAATGTGCACGCTTTGTCTAGTCATCTGTTTCTTTTGTTCCACCTGTGCACTGCCTGTAGACACGCTCTGTGTCTATGTATATCACACACACACATGTTATGATGTTGTTGGCATTTAATATATGTATATATATATAATA
102.100.100/12838__A_velosa_15	*Amanita* sp.	SH240738.06FU	0.42	*Amanita* sp.	ON950150	85.30	TTGAACGAAGCTCCTGGCTGGGCGCTGTTGTGCTGGCCCTTTGGGGCAATGTGCACGCTTTGTCTAGTCATCTGTTTCTTTTGTTCCACCTGTGCACTGCCTGTAGACACGCTCTGTGTCTATGTATATCACACACACACATGTTATGATGTTGTTGGCATTTAATATATGTATATATATATAATA
102.100.100/42159__A_velosa_2062	*Amanita* sp.	SH240738.06FU	0.38	*Amanita* sp.	MT980924	85.00	TTGAACGAAGCTCCTGGCTGGGCGCTGTTGTGCTGGCCCTTTGGGGCAATGTGCACGCTTTGTCTAGTCATCTGTTTCTTTTGTTCCACCTGTGCACTGCCTTGTAGACACGCTCTGTGTCTATGTATATCACACACACACACATGTTATGATGTTGTTGGCATTTAATATATGTATATATATATAATA
102.100.100/42161__A_velosa_122	*Amanita* sp.	SH240738.06FU	0.40	*Amanita* sp.	MW425341	89.10	TTGAACGAAGCTCCTGGCTGGGCGCTGTTGTGCTGGCCCTTTGGGGCAATGTGCACGCTTTGTCTAGTCATCTGTTTCTTTTGTTCCACCTGTGCACTGCCTGTAGACACGCTCTGTGTCTATGTATATCACACACACACACATGTTATGATGTTGTTGGCATTTAATATATGTATATATATATAATA
102.100.100/8204__A_velosa_1	*Amanita* sp.	SH240738.06FU	0.39	*Amanita* sp.	MT980924	85.50	TTGAACGAAGCTCCTGGCTGGGCGCTGTTGTGCTGGCCCTTTGGGGCAATGTGCACGCTTTGTCTAGTCATCTGTTTCTTTTGTTCCACCTGTGCACTGCCTGTAGACACGCTCTGTGTCTATGTATATCACACACACACACATGTTATGATGTTGTTGGCATTTAATATATGTATATATATATAATA
102.100.100/42160__A_velosa_7	*Amanita* sp.	SH240738.06FU	0.24	*Amanita* sp.	MT980924	84.90	TTGAACGAAGCTCCTGGCTGGGCGCTGTTGTGCTGGCCCTTTGGGGCAATGTGCACGCTTTGTCTAGTCATCTGTTTCTTTTGTTCCACCTGTGCACTGCCTTGTAGACACGCTCTGTGTCTATGTATATCACACACACACACATGTTATGATGTTGTTGGCATTTAATATATGTATATATATAATA
102.100.100/8490__A_velosa_21	*Amanita* sp.	SH240738.06FU	0.49	*Amanita* sp.	MT980924	85.30	TTGAACGAAGCTCCTGGCTGGGCGCTGTTGTGCTGGCCCTTTGGGGCAATGTGCACGCTTTGTCTAGTCATCTGTTTCTTTTGTTCCACCTGTGCACTGCCTGTAGACACGCTCTGTGTCTATGTATATCACACACACACACATGTTATGATGTTGTTGGCATTTAATATATGTATATATATAATA
102.100.100/19501__A_vestita_20	*Amanita* sp.	SH200690.06FU	0.12	*Amanita vestita*	MH508644	84.60	TTGAGTGATAGTGGCTTGAGGCTGTTGCTGGCCCCCCCCAGGGGCATGTGCACGTCTCTCGCTATTGATGTTTTTCCACCTGTGCACAAATTGTAGACAACTGGGATTGAGGGACCTTGTAATCGGACTCTTGATTCAATCCAGTTGCCTATGCCATTTAATTTAAATCCCTTGCATGTTTTAAAGAATGTAATTGTACTGGCTTTACTGAAAGCCTTTAAACATATATACAACTTTCAACAATGGATCTCTTGG

Appendix 2. continued

AM identifier (preceded by sample identifier and followed by read count)	RDP id	RDP id SH	RDP id score	BLAST id	BLAST id GenBank	BLAST id % Pairwise Identity	Sequence
Saproamanita							
102.100.100/8182__A_codinae_1	*Amanita* sp. *pruittii*	SH193452.06FU	0.33	*Amanita codinae*	MZ493179	98.10	CTGAATAAACCTTGGTAGAGGTTGTTGCTGGCCTCTTTGGGGCATGTGCACACCTTTACCATTGCTTTCTTCATCTTCCACCTGTGCACCTTATGTAGACCCTTGGGTTAGAGGAGGTTTTCTTGCCTCCTTGGTTTTGAAGTCCAGGGTCTATGATTTATTCTACATACACTCTATTTGAATGTCTATAGAATGTCATTAGATAGGCTTTAAATAGCCTTTTAAACAAAAATATACAACTTTCAACAACGGATT
102.100.100/8182__A_codinae_9	*Amanita* sp. *pruittii*	SH193452.06FU	0.33	*Amanita codinae*	MZ493179	98.10	CTGAATAAACCTTGGTAGAGGTTGTTGCTGGCCTCTTTGGGGCATGTGCACACCTTTACCATTGCTTTCTTCATCTTCCACCTGTGCACCTTATGTAGACCCTTGGGTTAGAGGAGGTTTTCTTGCCTCCTTGGTTTTGAAGTCCAGGGTCTATGATTTATTCTACATACACTCTATTTGAATGTCTATAGAATGTCATTAGATAGGCTTTAAATAGCCTTTTAAACAAAAATATACAACTTTCAACAACGGATC
102.100.100/8184__A_codinae_3695	*Amanita* sp. *pruittii*	SH193452.06FU	0.34	*Amanita codinae*	MZ493179	98.10	CTGAATAAACCTTGGTAGAGGTTGTTGCTGGCCTCTTTGGGGCATGTGCACACCTTTACCATTGCTTTCTTCATCTTCCACCTGTGCACCTTATGTAGACCCTTGGGTTAGAGGAGGTTTTCTTGCCTCCTTGGTTTTGAAGTCCAGGGTCTATGATTTATTCTACATACACTCTATTTGAATGTCTATAGAATGTCATTAGATAGGCTTTAAATAGCCTTTTAAACAAAAATATACAACTTTCAACAACGGAT
102.100.100/42159__A_manicata_1	*Amanita nauseosa*	SH238637.06FU	1.00	*Amanita manicata*	ON692927	100.00	TTGAAATGAAACCTTTGGTGAAGGTTGTAGCTGGCTCTAATAAGAGCATGTGCACACCTTTGCTATTGCTTCTTTCATTTTTCCACCTGTGCACCTTTTGTAGACCTGGGTTAGAGGAGGTTACATTTTATTATGATATGCCTCCTTGTTTCGAATGTGAATTTGAATTCTCTAGGTCTATGTATTTACATATACACTATTTGAATGTTTATAGAATGATCATTAGTTTTGGGCTTACTACTATGTATGTAGC
102.100.100/42182__A_inopinata_32	*Amanita* sp. *pruittii*	SH193452.06FU	1.00	*Amanita* sp.	ON695870	96.10	TTGAATGAACCTTGGTGATGGGTTGTTGCTGGCCTCTAGAGGCATAGTGCACACCTCTTTACCATTGCTTCTTTCTCTTTTTCCACCTGTGCACTTATTGTAGACCTTGGGTTGTGAGGAGCTGAGTGGTTAAGCTTGGCTCCTTGTAAAACCTTTTTTTCCAAGGCCTATGTCATTTTACATACACTCTACATGAATGTTTATAGAATGTAGTTTTGTAAGGTTTTTCACAAAGCCTTTAAACAAATAATACAA
102.100.100/62157__A_inopinata_18	*Amanita* sp. *pruittii*	SH193452.06FU	1.00	*Amanita inopinata*	MK512065	99.20	TTGAATGAACCTTGGTGAGGGGTTGTTGCTGGCCTCTAGAGGCATTGTGCACACCTCTTTACCATTGCTTCTTTCTCTTTTTCCACCTGTGCACTTATTGTAGACCTTGGGTTGTGAGGAGCTGGGTGGTCAAGCCCCTTGGCTCTTTGTTAAGCCCCTTTTTCCAAGGTCTATGTTATCTTTACATACACTCTGCATGAATGTTTATAGAATGTAGTTTTGTAAGGCTTTTCTCAAAGCCTTTAAACAAATAAT
102.100.100/42383__A_prairiicola_26	*Amanita nauseosa*	SH238637.06FU	0.46	*Amanita silvifuga*	HQ625016	100.00	TTGAATGAACCTTGGTAGGGGTTGTAGCTGGCCTCTCGGGGCATGTGCACACCTTTGCCATTGCTTCTTTCATTTTCCACCTGTGCACCTTTTGTAGACCAGGGTTAGAGGAGGTTAGCTGCCTCCTTGTTATAAAGTCCAGGTCTATGCTATTCTACATACACTCTGAATGTTTATAGAATGTCTCTACTCAGGCTTTTATAGCCTTTAAACAAATATA