

Nomination of a reference specimen for *Amanita xanthocephala* (Agaricales: Amanitaceae)

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Abstract

Davison, E.M., Giustiniano, D. Bougher, N.L. & Barrett, M.D. Nomination of a reference specimen for *Amanita xanthocephala* (Agaricales: Amanitaceae). *Nuytsia* 37: 17–32 (2026). For *Amanita xanthocephala* (Berk.) D.A.Reid & R.N.Hilton we designate the specimen PERTH 08944555 from Kings Park as an informal reference specimen to complement the holotype K(M)236388, collected by Drummond from the Swan River Colony in 1843, and provide a description based on Western Australian collections. Sequences from the nuclear ribosomal transcribed spacer (ITS) region from the reference specimen and collections from Victoria and Western Australia cluster together in a well-supported clade. *Amanita xanthocephala* throughout southern Australia appears to be a single species. *Amanita xanthocephala* f. *mcalpineana* (Cleland & Cheel) D.A.Reid has a yellow pileus, however an ITS sequence published on the Atlas of Living Australia does not differ from those with an orange or reddish orange pileus, suggesting it is a common and variable species. *Amanita xanthocephala* f. *mcalpineana* is synonymised with *A. xanthocephala*.

Introduction

Amanita xanthocephala (Berk.) D.A.Reid & R.N.Hilton, or vermilion grisette, is one of the commonest mushrooms in Australia. Although it is small it is distinctive, with a yellow to orange to red pileus with yellow to orange patches of universal veil. It is one of the original 100 target species of Fungimap (Grey & Grey 2005), and the Atlas of Living Australia (2025) has more than 4250 records. It occurs in eucalypt forests and remnant woodlands in the southwest of Western Australia (WA), South Australia, Victoria (Vic), Tasmania, New South Wales (NSW), and southern Queensland. It is illustrated in many field guides to Australian fungi, e.g. Bougher and Syme (1998), Gates and Ratkowsky (2016), Catcheside and Catcheside (2024).

Amanita xanthocephala was originally collected by James Drummond from the Swan River Colony in 1843 (Figure 1). The location is unknown, but Hilton (1982, 1983) suggested that the collection was from the Drummond's Hawthornden Farm in the Toodyay district of WA. It was part of a consignment of cryptogams sent to Sir William Jackson Hooker at Kew. Hooker forwarded the fungal collections to Rev. M.J. Berkeley for naming. The Kew Herbarium acquired Herb. Berkeleyanum in 1879, and the holotype of *A. xanthocephala* (K(M)236388) is from Berkeley's herbarium (Hilton 1983). The original description is (Reid 1980):

‘On the ground.’

‘Pileus 1–2 inches broad, convex, sometimes umbonate, subcarnose with the margin very thin, varying from bright yellow to golden yellow spotted by the volva. Stem 1–2 inches high, 2–3 lines broad, strongly bulbous at the base, slightly dilated above, furnished at the base with an adnate volva whose borders are free of a beautiful cream colour. Gills of the same colour as the stem, moderately broad, but not ventricose, much attenuated behind and leaving a circular space round the top of the stem. Ring none.’

‘The specimens of this species are not so perfect as could be wished, especially as regards the gills, so that I am not absolutely certain as to the colour of the spores, but as far as I can judge from their appearance under the microscope and especially from the circumstance of the gills being remote, I think myself justified in considering it a *Volvaria*. With out the assistance of Mr Drummond’s notes, I should not have ventured to describe it, but the characters are so marked, that there can be no difficulty in recognizing it, and I shall hope to obtain more perfect specimens.’

Agaricus pulchellus Cooke & Masee (Cooke 1889) was named from material collected by Mrs. Martin from Domain, Vic, in 1885 (Figure 2). It was subsequently renamed *Amanitopsis pulchella* (Cooke & Masee) Sacc. in 1891, and *Amanita pulchella* (Cooke & Masee) E.-J.Gilbert in 1941. Reid (1980) renamed this species *A. austropulchella* as the combination *Amanita pulchella* was already occupied. Hilton drew Reid’s attention to the similarities between *A. xanthocephala* from WA and *A. austropulchella* from Vic. Reid (1980), in an addendum, examined the holotypes of both species and concluded the volval remains on the cap of both had the same structure, and the basidia and non-amyloid spores were of similar shape. As a result, he combined the two species. He commented that the spores of the holotype of *A. xanthocephala* were ‘distinctly smaller than those found on most fruit bodies of *A. austro-pulchella*, but the material is in a very poor state of preservation and spores are extremely scanty ... It is quite possible, therefore, that the observed spores were immature.’

Amanitopsis mcalpiniana Cleland & Cheel was described in 1914 (Cleland & Cheel 1914) as a species closely allied to *Amanitopsis pulchella* but with a yellow or pale orange-yellow pileus covered with mealy, easily removed warts. Gilbert (1940) considered this to be a colour variant and reduced it to a form, initially *Amanitopsis pulchella* f. *mcalpiniana* (Cleland & Cheel) E.-J.Gilbert and then transferred it to *Amanita* as *A. pulchella* f. *mcalpiniana* (Cleland & Cheel) E.-J.Gilbert (Gilbert 1941a) (Figures 3, 4). Reid (1980) then transferred it to a forma of *Amanita xanthocephala* as *A. xanthocephala* f. *mcalpineana* (Cleland & Cheel) D.A.Reid.

In summary, *A. xanthocephala* has undergone several name changes since it was described from WA; *Amanita xanthocephala* is the accepted name. *Amanita xanthocephala* f. *mcalpineana* is regarded as a colour form.

Amanita xanthocephala is classified in subgenus *Amanita* because it has inamyloid spores. It is classified in sect. *Amanita* because the universal veil on the pileus remains as warts or patches and there is a bulb at the base of the stipe (Cui *et al.* 2018). Members of sect. *Amanita* are widespread in the northern hemisphere but are not well represented in Australia (Wood 1997), New Zealand (Ridley 1991) or South America (Truong *et al.* 2017).

Reid (1980) observed that the holotype of *A. xanthocephala* is in a very poor state of preservation, and that Berkeley would not have described it if it had not been for Drummond’s notes and its distinctive characters. Examination of the holotype by EMD shows that it has been badly attacked by mites. According to Article 9.9 of the International Code of Nomenclature for algae, fungi, and plants (Turland *et al.* 2025) an epitype is ‘a specimen or illustration selected to serve as an interpretative type when the holotype, lectotype, or previously designated neotype, or all original material associated with a validly published name, is demonstrably ambiguous and cannot be critically identified for the purpose of the precise application of the name to a taxon’. The key phrase here is ‘demonstrably ambiguous’. In the case of *Amanita xanthocephala*, because the holotype exists and is clearly able to connect to modern



Figure 1. Holotype of *Amanita xanthocephala* Drummond 107 K(M)236388.



Figure 2. Holotype of *Amanita austropulchella* Mrs. Martin 448 K(M)236414.



Figure 3. *Amanita pulchella* and *A. pulchella* f. *mcalpineana*, from Gilbert (1941b). N.B. The illustration labelled 1) is reproduced from Cleland and Cheel (1914) and shows two basidiomes of *A. pulchella* on either side of *Amanitopsis vaginata* var. *nivalis* (Grev.) Peck.

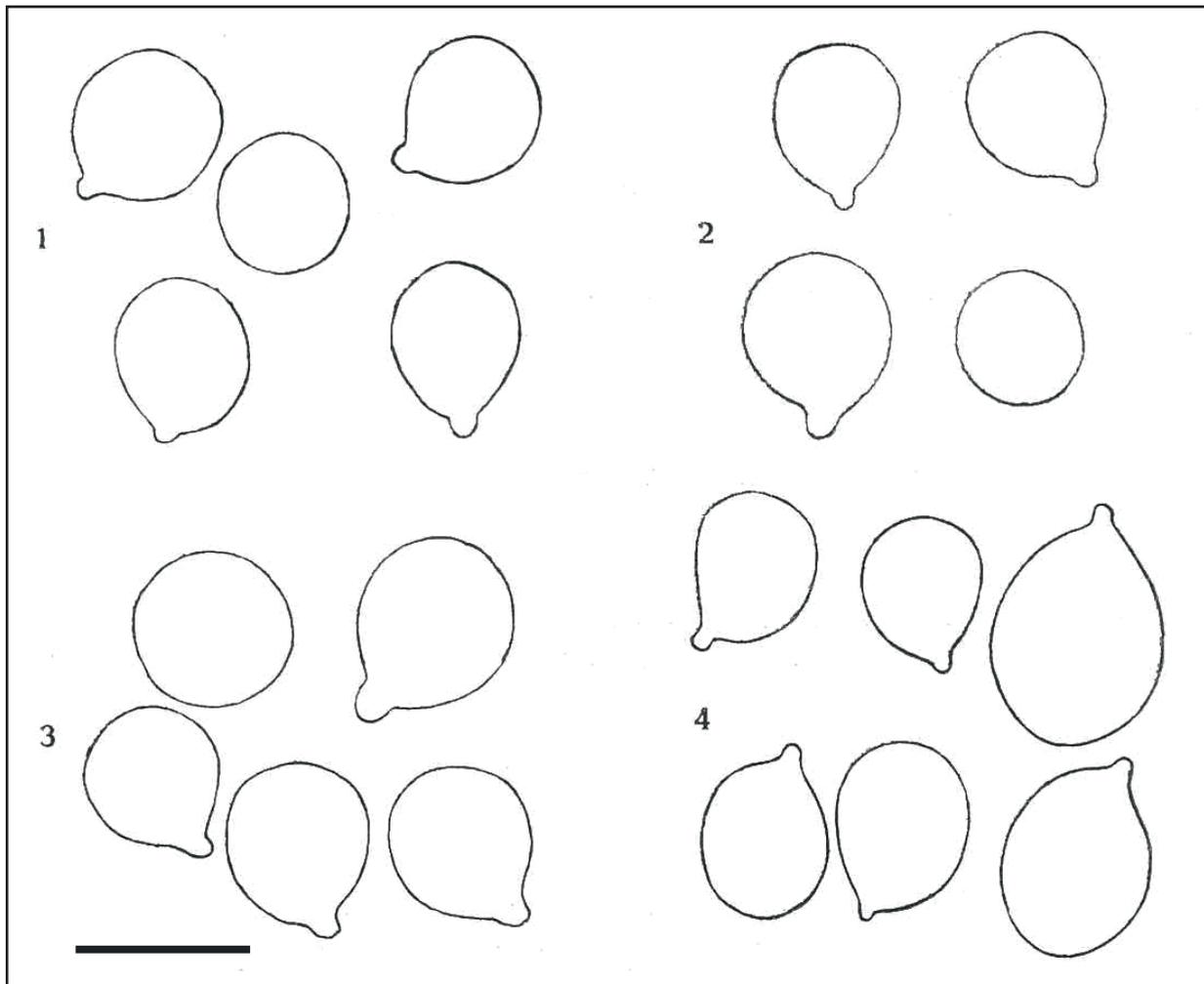


Figure 4. Spores of *Amanita pulchella* (1, 2, 4) and *A. pulchella* f. *mcalpineana* (3, collection type) from Gilbert (1940). Scale= 10 μ m.

collections that belong to a single taxon, it is not appropriate to describe an epitype. However, in such a situation, Ariyawansa *et al.* (2014) suggest that nominating a reference specimen is an acceptable option. This is an informal designation which has collection information, photographs, and genetic sequences. In this paper we nominate PERTH 08944555, a recent collection of *A. xanthocephala* from WA (Bougher & Barrett 2020) as reference specimen. We provide a detailed description together with some observations on the colour variation of collections from WA.

Tulloss (2025) questioned whether there are two or more macroscopically similar species which differ in spore size. He suggests there is a western species with more ellipsoidal spores and an eastern species with subglobose spores. We have compared the spore shape and size of collections from WA with a small number of collections from NSW and Vic to determine whether they differ. We also compare sequences of the nuclear ribosomal transcribed spacer region (ITS) sequences from collections from WA and Vic.

Methods

Taxonomy. The methodology for describing the macroscopic and microscopic characters largely follows Tulloss (2000). Colour names, including the colour of spores in deposit and other shades of white to cream (designated by the letters A–G), follow Royal Botanic Garden, Edinburgh (1969), whilst colour codes are from Kornerup and Wanscher (1983). In the descriptions of basidiospores (and basidia) the notation [x/y/z] denotes x basidiospores measured from y basidiomes from z collections. Biometric variables for spores follow Tulloss (2000), i.e. 'L' = the average spore length computed for one specimen examined

and the range of such averages, L' = average spore length computed for all spores measured, W = the average spore width computed for one specimen examined and the range of such averages, W' = average spore width computed for all spores measured, Q = the length/breadth for a single spore and the range of the ratio of length/breadth for all spores measured, Q = the average value of Q computed for one specimen examined and the range of such averages, Q' = the average value of Q computed for all spores measured'.

Phylogenetics. DNA extraction, amplification and cloning of the ITS region follows the methodology of Davison *et al.* (2013) and five clones of each of the *A. xanthocephala* specimens PERTH 09874852 (from WA) and MEL 2359152 (from Vic) were used. The forward and reverse sequence were assembled with Geneious (version 12.2.6, <http://www.geneious.com>; Kearse *et al.* 2012) using the Geneious Alignment option (settings set to automatically determine sequence direction, cost matrix 65% similarity, gap open penalty 12, gap extension penalty 3) to generate a single consensus sequence. For PERTH 08944555, DNA extraction and amplification followed the method of Anderson *et al.* (2016). Additional ITS sequences of Australasian and South American members of sect. *Amanita*, together with similar sequences identified through a blastn search were accessed from GenBank (see <http://www.ncbi.nlm.nih.gov/> [accessed 20

Table 1. Voucher information and GenBank accession number for nuclear ribosomal transcribed spacer region (ITS) sequences for members of subgen. *Amanita* sect. *Amanita*. Newly published sequences are shown in bold. Abbreviations are: Qld, Queensland; NSW, New South Wales; WA, Western Australia; SF, State Forest; RP, Regional Park.

<i>Amanita</i> species	Number	Date	Locality	ITS
<i>A. crematelloides</i>	BRI AQ 794809	12.3.2011	Springbrook, Qld	PV037585–037588
<i>A. diemii</i>	FLAS:F-70705-MES-4179	13.5.2022	Chile	OP339698
<i>A. elata</i>	rxsbn-367			MW374166
<i>A. elata</i>	SDBR-STO20-212	30.7.2020	Chiang Mai, Thailand	OR229914
<i>A. farinosa</i>	JBRI-M23-106			OR852516
<i>A. farinosa</i>	OMDL iNat # 180375650	26.8.2023	Ohio, USA	PX115714
<i>A. fibrilloses</i>	PERTH 08353158	18.5.2008	Beeliar RP, WA	JX398314
<i>A. fibrilloses</i>	RET 447-2	18.5.2008	WA	KT072740
<i>A. fibrilloses</i>	PERTH 08793573	18.5.2016	Shire of Cuballing, WA	MN918105, MN918107
<i>A. frostiana</i>	RET 588-6	14.8.2013	New York, USA	KP313583
<i>A. frostiana</i>	ACAD21078F	24.10.2020	Nova Scotia, Canada	OL741520
<i>A. melleiceps</i>	ASIS24590		South Korea	KM052539
<i>A. melleiceps</i>	MHHNU 32785		Hunan, China	ON131769
<i>A. muscaria</i>	PRM 945840	17.9.2017	Czech Republic	MW281786
<i>A. muscaria</i>	PRM 954703	4.10.2018	Czech Republic	MW281787
<i>A. nehota</i>	PDD 87569	15.5.2008	New Zealand	MT863749
<i>A. nehota</i>	OTA 71565		New Zealand	OQ064954
<i>A. nehota</i>	OTA 73310		New Zealand	OQ065082
<i>A. rubrovolvata</i>	MHHNU 32265		Yunan, China	ON131749
<i>A. rubrovolvata</i>	SDBR-STO20-456	14.9.2020	Chiang Mai, Thailand	OR229921
<i>Amanita</i> sp. AUS14	RET 688-4	17.2.2015	Yarrahpinni SF, NSW	KY435406
<i>A. striatuloides</i>	CNS 151418	22.2.2009	Qld	PV037580–PV037584
<i>A. subglobosa</i>	MHHNU 32538		Hunan, China	ON131753

<i>Amanita</i> species	Number	Date	Locality	ITS
<i>A. subglobosa</i>	HMAS 253798		China	OR058513
<i>A. subparvipantherina</i>	RET_717-7	31.7.2015	India	MG030644
<i>A. subparvipantherina</i>	MHHNU 32361		Yunan, China	ON131759
<i>A. sychnopyramis</i> f. <i>subannulata</i>	MHHNU 32153		Anhui, China	ON131761
<i>A. sychnopyramis</i> f. <i>subannulata</i>	MHHNU 32799		Zhejiang, China	ON131762
<i>A. xanthocephala</i>	No voucher			AY194982
<i>A. xanthocephala</i>	PERTH 08944555	3.7.2017	Kings Park, Perth, WA	MT571657
<i>A. xanthocephala</i>	MEL 2359152	18.5.2012	Royal Botanic Gardens, Melbourne, Vic	PX317805– PX317809
<i>A. xanthocephala</i>	PERTH 09874852	1.7.2014	Shire of Serpentine- Jarrahdale, WA	PX328946– PX328950
<i>A. xanthocephala</i>	https://inaturalist.ala.org.au/ observations/244625331	4.9.2024	Shire of Cranbrook, WA	
<i>A. xanthocephala</i>	https://inaturalist.ala.org.au/ observations/244586426	2.9.2024	Shire of Manjimup, WA	
<i>A. eucalypti</i> (outgroup)	PERTH 08809968	28.5.1992	Australia	KU057381

Aug. 2025]). Two additional sequences of *A. xanthocephala* were obtained from iNaturalist (Atlas of Living Australia 2025) (Table 1).

Consensus sequences were aligned with MUSCLE (Edgar 2004), and then maximum likelihood phylogenetic trees were built using MEGA version 5.05 (Tamura *et al.* 2011). The best substitution model for each dataset was selected using the Model Function, which indicated that the Tamura 3-parameter model (Tamura 1992) with a gamma distribution rate variation across sites was the best. Bootstrap consensus support was inferred from 500 replicates.

The differences between cloned haplotypes of the ITS region were obtained from the Distance Matrix: % Identity of an alignment in Geneious are presented as a contingency table.

Results

The analysis of the ITS region shows that all the *A. xanthocephala* sequences cluster together in a well-supported clade (bootstrap (BS) 100) with no distinction between sequences from Vic or WA (Figure 5). The iNaturalist sequences cluster with the GenBank sequences, however, they do not have BS values. Compared with the other species included in the analysis, all *A. xanthocephala* sequences have a nine base pair insertion in ITS1 and an 18 base pair deletion in ITS2.

A comparison between cloned haplotypes of the ITS region from collections of *A. xanthocephala* showed there was up to 4.7% variation between haplotypes from the same sample, and up to 6.8% variation between haplotypes from different collections (Table 2).

The *A. xanthocephala* sequences do not form a clade with other native Australian species from sect. *Amanita*: *A. crematelloides*, *A. fibrillopes* and *A. striatuloides*, or with *A. nehuta* from New Zealand or with *A. diemii* from South America. The exannulate *A. crematelloides* forms a well-supported clade

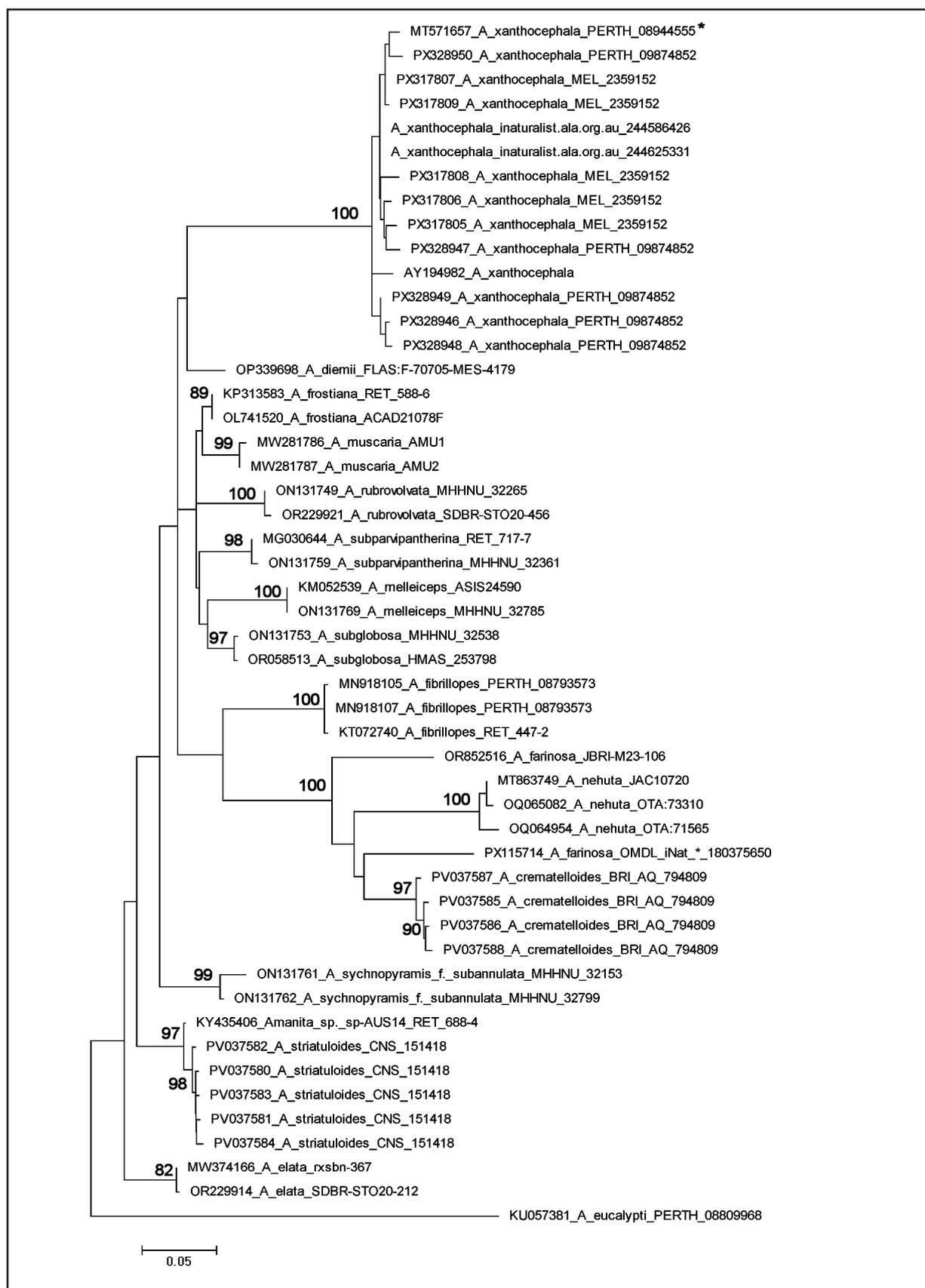


Figure 5. Molecular phylogenetic analysis by the maximum likelihood method of ITS (nuclear ribosomal transcribed spacer region) sequences (486 base pair positions), showing the position of *Amanita xanthocephala* in relation to other selected species from subgen. *Amanita* sect. *Amanita*. The reference sequence is indicated by *. The tree is rooted in on *A. eucalypti* (subgen. *Amanitina* sect. *Phalloideae*). Branches corresponding to less than 50% of the bootstrap replicates are collapsed. The tree is drawn to scale with branch lengths measured in the number of substitutions per site. Maximum likelihood bootstrap values greater than 80% are shown on the branches.

Table 2. Percentage difference between ITS clones from collections of *A. xanthocephala*. GenBank ITS sequence numbers are given in Table 1. The ITS region is 578–590 base pairs long. Column ‘Cl.’ is the number of clones or sequences.

Number	Cl.	PERTH 08944555	No voucher (AY194985)	MEL 2359152	PERTH 09874852	No voucher (244625331)
PERTH 08944555	1					
No voucher (AY194985)	1	4.2				
MEL 2359152	5	3.6–5.1	4.1–4.9	0.7–3.9		
PERTH 09874852	5	3.8–5.8	4.8–5.9	3.9–6.2	0.3–4.7	
No voucher (244625331)	1	6.2	5.5	4.7–5.2	5.7–6.8	
No voucher (244586426)	1	5.8	5.0	4.2–5.1	5.2–6.3	0.7

(BS 100) with *A. nehuta* from New Zealand and *A. farinosa* from North America, whilst the exannulate *A. striatuloides* forms a well-supported clade (BS 97) with *Amanita* sp. AUS14.

Taxonomy

Amanita xanthocephala (Berk.) D.A.Reid & R.N.Hilton, *Aust. J. Bot.*, Suppl. Ser. 8: 65–66 (1980) [MB118375]; *Agaricus xanthocephalus* Berk., *London J. Bot.* 4: 45 (1845); *Volvaria xanthocephala* (Berk.) Sacc., *Syll. fung.* (Abellini) 5: 661 (1887). *Type*: Swan River Colony, Australia, 1843, Drummond 107 (*holo*: K (K(M)236388!)) (reference specimen of *Amanita xanthocephala*: WESTERN AUSTRALIA: Kings Park, 3 July 2017, N.L. Bougher NLB 1518 (PERTH 08944555!)).

Agaricus pulchellus Cooke & Masee, in Cooke, *Grevillea* 18 (no. 85):1 (1889); *Amanitopsis pulchella* (Cooke & Masee) Sacc., *Syll. fung.* (Abellini) 9:2 (1891); *Vaginata pulchella* (Cooke & Masee) Kuntze, *Revis. gen. pl.* (Leipzig) 3(3):539 (1898); *Amanita pulchella* (Cooke & Masee) E.-J.Gilbert, in Bresadola, *Iconogr. Mycol.*, Suppl. II (Milan) 27:204 (1941); *Amanita austropulchella* D.A.Reid [as ‘*austro-pulchella*’], *Victorian Nat.* 95(2):47 (1978). *Type*: Domain, Victoria, Australia, 1885, Mrs. Martin 448 (*holo*: K (K(M)236414!)).

Amanitopsis mcalpineana Cleland & Cheel [as ‘*mcalpiniana*’], *Agric. Gaz. N.S.W., Sydney* 25:1049 (1914); *Amanita mcalpineana* (Cleland & Cheel) E.-J.Gilbert, in Bresadola, *Iconogr. Mycol.*, Suppl. I (Milan) 27: 69 (1940); *Amanita pulchella* f. *mcalpineana* (Cleland & Cheel) E.-J.Gilbert [as ‘*mcalpiniana*’], in Bresadola, *Iconogr. Mycol.*, Suppl. II (Milan) 27:204 (1941); *Amanita austropulchella* f. *mcalpineana* (Cleland & Cheel) D.A.Reid, *Aust. J. Bot.*, Suppl. Ser. 8:16 (1980); *Amanita xanthocephala* f. *mcalpineana* (Cleland & Cheel) D.A.Reid, *Aust. J. Bot.*, Suppl. Ser. 8:66 (1980). *Type*: not cited.

Pileus 15–60 mm wide, up to 6 mm thick, convex to plane with slightly depressed centre and decurved margin, yellowish cream (E), pale ochraceous (F), straw, luteous, saffron, orange, apricot, scarlet (3A3–4A4–5A4–6A7–7A8–8A8), without surface staining and bruising, tacky when moist; margin striate, striations 10%–42% of radius, not appendiculate. *Universal veil on pileus* initially crustose breaking into patches and straight sided warts, white, ivory (B), cream (C), yellowish cream (E), pale ochraceous (F), straw, saffron, salmon, orange (3A2–4A7–5A6–6A3), some with whitish arachnoid layer over warts, warts easily removed. *Lamellae* adnexed to free, subcrowded to crowded, white, ivory (B), cream (C), yellowish cream (D) straw (2A2–3A2–4A3), to 6 mm broad, margin concolorous or yellowish orange, fimbriate; lamellulae truncate or attenuate, infrequent. *Stipe* 15–73 × 4–9 mm, cylindrical or narrowing upwards, white, ivory, straw, saffron (2A2–3A5–4A2), surface smooth. *Partial veil* absent. *Bulb* 5–20 × 5–20 mm globose or ovoid or napiform. *Remains of universal veil at top of bulb* a free limb to 7 mm high, white often with ivory (B) or straw or saffron or orange margin (3A2–4A4–5A4–7A7), may remain in soil. *Pileus and stipe context* white, ivory (B), straw (3A2–3), unchanging. *Smell* none. *Spore deposit* white or ivory (B). (Figure 6)

Basidiospores [410/22/19] (6–)7–9.5(–11.5) × (5–)5.5–7.5(–8.5) μm, (L = 7.1–9.1 μm; L' = 8.1 μm; W = 5.8–7.8 μm; W' = 6.6 μm; Q = (1.00–)1.07–1.42(–1.60); Q = 1.10–1.34; Q' = 1.24), hyaline, colourless, thin walled, smooth, inamyloid, subglobose to broadly ellipsoid to ellipsoid, contents monoguttulate or granular, apiculus sublateral, cylindrical, *c.* 1 × 1 μm, truncate. *Pileipellis* up to 500 μm thick with a colourless gelatinised suprapellis up to 150 μm thick and pale yellow or colourless subpellis, consisting of filamentous hyphae and frequent or not seen vascular hyphae (inflated cells not observed); filamentous hyphae 3–8 μm wide with widest constricted at septa, radially orientated with some interweaving, colourless, gelatinising; vascular hyphae 2–15 μm wide, occasionally branched, pale yellow or brownish yellow or colourless. *Pileus context* consisting of dominant or equal filamentous hyphae, inflated cells and frequent or not seen vascular hyphae; filamentous hyphae 4–25 μm wide with widest constricted at septa, thin walled, colourless; inflated cells up to 200 × 40 μm, clavate or ventricose or ovoid, terminal, colourless; vascular hyphae 3–10 μm wide, very pale yellow. *Lamella trama* bilateral divergent. *Central stratum* up to 40 μm wide, consisting of filamentous hyphae (inflated cells and vascular hyphae not observed); filamentous hyphae 2–20 μm wide with widest constricted at septa, thin walled, colourless, axially orientated. *Subhymenial base* with angle of divergence *c.* 25–45° from central stratum with filamentous hyphae following smooth broad curve to subhymenium, consisting of dominant or frequent filamentous hyphae, inflated cells and very infrequent vascular hyphae; filamentous hyphae 2–12 μm wide, widest constricted at septa, thin walled, colourless; inflated cells up to 80 × 25 μm, thin walled, clavate or ovoid or ellipsoid or pyriform; vascular hyphae to 8 μm wide, pale yellow. *Subhymenium* ramose, basidia arising terminally from narrow or barely inflated hyphal segments 4–5 μm wide which become inflated to 10 μm. *Lamella edge cells* sterile with frequent cylindrical or ovoid or clavate inflated cells; inflated cells up to 30 × 13 μm, with slightly thickened walls, colourless. *Basidia* [90/5/5] (30–)36–45(–48) × (8–)10–12(–13) μm, thin walled, colourless, *c.* 90% 4-spored, *c.* 6% 3-spored, *c.* 4% 2-spored, sterigmata to 6 μm. *Universal veil on pileus* layered with narrow distal layer (often missing) with radial orientation and wide proximal layer with somewhat upright orientation. Distal layer consisting of dominant filamentous hyphae and infrequent inflated cells (vascular hyphae not seen); filamentous hyphae 5–15 μm wide with widest constricted at septa, often adhering laterally, grey, gelatinising; inflated cells to 60 × 30 μm, ovoid, terminal, grey, gelatinising. Proximal layer consisting of frequent or dominant filamentous hyphae, inflated cells and very infrequent vascular hyphae; filamentous hyphae 3–18 μm wide, widest constricted at septa, colourless or grey, gelatinising; inflated cells to 70 × 50 μm, spherical or ovoid or clavate or pyriform, terminal or occasionally in chains of up to 3 cells, gelatinising; vascular hyphae 3 μm, very pale yellow. *Universal veil at stipe base* not layered, elements with no dominant orientation, consisting of equal or dominant filamentous hyphae and inflated cells (vascular hyphae not observed); filamentous hyphae 3–15 μm wide with widest constricted at septa, colourless or pale grey, gelatinising; inflated cells to 60 × 40 μm, spherical or ovoid or pyriform or clavate, terminal or in chains of 2 cells, colourless, gelatinising. *Stipe context* longitudinally acrophysalidic, consisting of filamentous hyphae, dominant acrophysalides and infrequent to frequent vascular hyphae; filamentous hyphae 2–10 μm wide, thin walled, colourless; acrophysalides up to 230 × 50 μm, clavate or cylindrical, terminal, colourless, gelatinising; vascular hyphae 3–17 μm wide, occasionally branched, pale yellow or colourless. *Partial veil* absent. *Clamp connections* not seen in any tissue. (Figure 7)

Diagnostic features. Fruiting bodies are very small to medium with a yellow or orange or scarlet pileus that is covered with patches and straight sided warts of universal veil which are white or cream or yellow or saffron or orange. The gills are white or cream. The stipe is white or yellow or saffron; the partial veil is absent. There is a free limb of universal veil at the top of the bulb which often has a yellow or orange margin. The spores are inamyloid, subglobose to broadly ellipsoid to ellipsoid. Clamp connections are absent.

Other specimens examined. NEW SOUTH WALES: Myall Lakes National Park, 18 July 1976, *D.A. Reid* R.D. 60 (DAR 32030); VICTORIA: Domain, 1885, *Mrs Martin* 448 (K(M)236414: holotype of *Agaricus pulchellus*); Warradyte State Park, 3 Aug. 2008, *T.W. May* 1755 & *I.M. Maroske* (MEL 2044318); Wilsons Promontory, 7 July 1976, *D.A. Reid* R.D. 85 (DAR 32032); Royal Botanic Gardens Melbourne, 18 May 2012, *V. Stajsic* 6215 & *N.G. Karunajeewa* (MEL 2359152); WESTERN AUSTRALIA: Mount Lesueur, 5 Aug. 1989, *E.M. & P.J.N. Davison* EMD 24-1989 (PERTH 09874763); Ellis Brook Reserve, 15 May



Figure 6. *Amanita xanthocephala* basidiomes. Images from *N.L. Bougher* 1518 (PERTH 08944555).

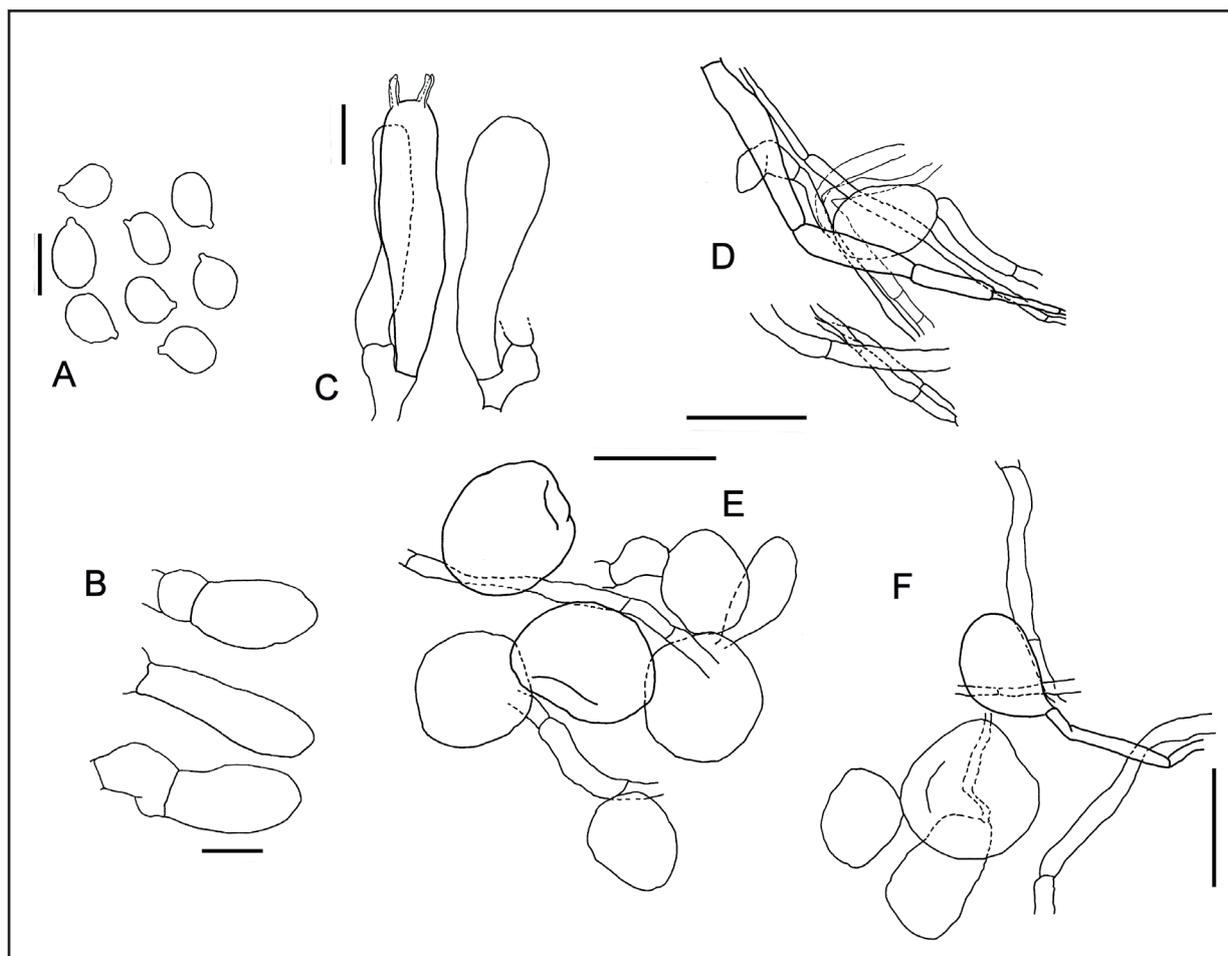


Figure 7. *Amanita xanthocephala*. A – spores; B – lamella edge cells; C – basidia; D – universal veil from pileus, distal layer, unsquashed; E – universal veil from pileus proximal layer, unsquashed; F – universal veil at stipe base, gentle squash. Scale bars = 10 µm (A–C), 50 µm (D–F). Images from *N.L. Bougher* NLB 1518 (PERTH 08944555).

2008, *E.M. & P.J.N. Davison* EMD 7-2008 (PERTH 09874771); Lowlands, 31 May 2008, *E.M. & P.J.N. Davison* EMD 11-2008 (PERTH 09874798); Thomsons Lake, 27 June 2010, *E.M. & P.J.N. Davison* EMD 26-2010 (PERTH 09874801); Boranup Forest, 20 Aug. 2011, EMD 38-2011 (PERTH 09874828); Quenda Wetland Reserve [City of Melville], 15 Aug. 2012, *E.M. & P.J.N. Davison* EMD 40-2012 (PERTH 09874836); Perup, 3 June 2013, *E.M. & P.J.N. Davison* EMD 34-2013 (PERTH 09874844); Watkins Road Flora Reserve [Shire of Serpentine-Jarrahdale], 1 July 2014, *E.M. & P.J.N. Davison* EMD 11-2014 (PERTH 09874852); Chidlow Road [Shire of Mundaring], 30 July 2015, *E.M. & P.J.N. Davison* EMD 49-2015 (PERTH 09874860); Ambergate Reserve [Shire of Busselton], 12 Aug. 2015, *E.M. & P.J.N. Davison* EMD 54-2015 (PERTH 09874879); Cypress Farm [Shire of Waroona], 25 June 2017, *E.M. & P.J.N. Davison* EMD 49-2017 (PERTH 09874887); Chelodina Wetland, Murdoch University, 9 July 2017, *E.M. & P.J.N. Davison* EMD 55-2017 (PERTH 09874895); Beedelup National Park, 12 June 2018, *E.M. & P.J.N. Davison* EMD 18-2018 (PERTH 09874909); Cardup Reserve [Shire of Serpentine-Jarrahdale], 17 July 2019, *E.M. & P.J.N. Davison* EMD 27-2019 (PERTH 09874917); Dale Forest, 9 May 1976, *D.A. Reid* s.n. (DAR 32033); Walpole, 13 May 1976, R.D. 9A (DAR 32031).

Phenology. Fruiting period is May to August.

Distribution and habitat in WA. Singly or gregarious, in sand or peaty sand or clayey loam or clayey lateritic gravel in eucalypt woodland or forest. Nearby plants include *Agonis flexuosa*, *Allocasuarina fraseriana*, *Corymbia calophylla*, *Eucalyptus diversicolor*, *A. gomphocephala*, *E. marginata*, *E. rudis*, *E. wandoo*, and *Jacksonia sternbergiana*. Occurs in the Swan Coastal Plain SWA, Jarrah Forest JAF and Warren WAR IBRA subregions (Department of Agriculture Water and the Environment 2024).

Notes. The holotype of *A. xanthocephala* (K(M)236388) was collected in 1843, is in poor condition, and has limited descriptive notes (Reid 1980). We have nominated PERTH 08944555 (NLB 1518) as a reference specimen for comparison of this widespread Australian species. Our phylogenetic analysis of collections from WA and Vic shows that there is no distinction between ITS sequences.

The spores of 15 collections from WA are subglobose to ellipsoidal ([340/18/15] (6–)7–9.5(–11.5) × (5–)5.5–7.5(–8.5) μm, (L = 7.4–9.1 μm; L' = 8.2 μm; W = 5.8–7.8 μm; W' = 6.5 μm; Q = (1.00–)1.08–1.42(–1.60); Q = 1.14–1.34; Q' = 1.26), whilst those from four collections from NSW and Vic are subglobose to broadly ellipsoidal ([70/4/4] (6.5–)7–8.5(–9) × (5.5–)6–7.5 μm, (L = 7.1–8.1 μm; L' = 7.7 μm; W = 6.1–7.3 μm; W' = 6.7 μm; Q = 1.07–1.23(–1.33); Q = 1.10–1.18; Q' = 1.15); they appear to be similar. However, spore measurements from more collections from eastern Australia may show a consistent difference in spore shape, as suggested by Tulloss (2025).

One of the features of *A. xanthocephala* is the colour of the pileus which can vary from shades of yellow, through orange to scarlet and can vary within a single collection. The hue of the pileus and universal veil on the pileus is often similar, and the rim of the universal veil at the base of the stipe is often of a similar hue to the pileal warts. However, our data are insufficient for a statistical analysis of these observations.

The collection <https://inaturalist.ala.org.au/observations/244586426> by Damon Tighe, has a vivid yellow pileus which would indicate that it is *A. xanthocephala* f. *mcalpineana* (Figure 8A). However, its ITS sequence shows 4.2–6.3% difference from other collections of *A. xanthocephala* with a bright orange (PERTH 08944555) and reddish orange (PERTH 09874852) pileus which is within the range of haplotypes from different collections, and it has 0.7% difference from collection inaturalist.ala.org.au/observations/244625331 by Damon Tighe which has a light orange pileus (Figure 8B), Table 2). The yellow form cannot be distinguished from collections with a red or orange pileus on the basis of its ITS



Figure 8. *Amanita xanthocephala*. A – <https://inaturalist.ala.org.au/observations/244586426>. B – <https://inaturalist.ala.org.au/observations/244625331>. Images from Damon Tighe, with permission.

sequence; *A. xanthocephala* is a common and variable species. *Amanita xanthocephala* f. *mcalpineana* is therefore synonymised with *A. xanthocephala*.

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