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SHORT COMMUNICATION

Australasian sequestrate Fungi 20: *Russula scarlatina* (Agaricomycetes: Russulales: Russulaceae), a new species from dry grassy woodlands of southeastern Australia

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Abstract: *Russula scarlatina* sp. nov. is a common sequestrate fungus found in the dry sclerophyll *Eucalyptus* woodlands of southeastern Australia. Basidiomata are hypogeous or sometimes emergent; they are scarlet in youth and become dark sordid red or brown with advanced age. Historically, this species would have been placed in the genus *Gymnomyces,* but in light of recent revisions in the taxonomy of sequestrate Russulaceae, we place it in the genus *Russula*. It is morphologically distinct from other sequestrate species of *Russula* because of its scarlet peridium and unusual cystidial turf in youth. It has been collected only in dry grassy woodlands and open forest habitats of southeastern Australia.

Keywords: Basidiomycota, *Eucalyptus,* hypogeous fungus, grassy woodlands, open forests, Russulaceae, southeastern Australia.

Non-lactating sequestrate members of the Russulaceae were historically placed in one of six genera based on various aspects of their morphology (Lebel 1998). Recent genetic analysis supports the recombination of all of these genera with the common mushroom genus *Russula* (Lebel & Tonkin 2007; Lebel 2017; Elliott & Trappe 2018). It has been suggested that adaptations to abiotic environmental factors and symbiotic associations with vertebrates and invertebrates have led to evolution of sequestrate and hypogeous basidiomata (Thiers 1984; Trappe & Claridge 2005; Vernes & Dunn 2009; Galante et al. 2011). Nearly 60 of the approximately 145 described sequestrate *Russula* species are native to Australia and New Zealand,

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Competing interests: The authors declare no competing interests.

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and numerous undescribed taxa likely inhabit the region (Lebel 1998; Lebel & Tonkin 2007; Lebel 2017; Elliott & Trappe 2018). Australia also has a high diversity of native mammals and birds that feed on members of the Russulaceae (Nuske et al. 2017a,b; Elliott & Vernes 2019). These associations between vertebrates and the Russulaceae may have contributed to the evolution of the diverse sequestrate morphologies that are common in Australia.

During multiple collecting expeditions in the Australian Capital Territory, New South Wales, and Victoria, we have encountered *Russula scarlatina* sp. nov., a brightly colored, sequestrate fungus. It typically fruits with *Eucalyptus* spp. in dry sclerophyll woodlands, but we once found it emerging from bare, compacted soil between the base of a tree and the sidewalk in Mitchell, New South Wales.

Materials and Methods

Basidiomata examined in this study were collected during the cold months of May through September between 2000 and 2010. We found them by raking away the leaf litter under *Eucalyptus* spp. and carefully examining the soil layer below. Occasionally, basidiomata were partially emergent from the soil or were found in the tailings piles of animal digs. We collected and photographed the basidiomata, recorded their fresh macroscopic characteristics, and then placed slices on a portable dehydrator. Dried material was freehand sectioned for slide mounts under a binocular compound microscope. Thin sections were mounted and examined in 3% KOH, H_2O, cotton blue, and Melzer's reagent. Heat was used to remove bubbles and for clearer viewing. Microscopic features were measured in 3% KOH mounts. Collections are curated in the herbaria listed in the Acknowledgements section.

Taxonomic description

***Russula scarlatina* sp. nov.**

MycoBank Number: MB 829958

(Image 1)

Holotype: Australia, Australian Capital Territory, Mulligans Flat Nature Reserve, 55H 6106140, 696255, elev. 645m. In pure grove of *Eucalypus blakelyi*. Col. Ben Claridge, Georgia Claridge, Debbie Claridge, Andrew Claridge, & Jim Trappe #33233 (CANB; Isotypes OSC, MEL).

Etymology: *scarlatina* (Latin, "scarlet"), referring to the scarlet peridium covered with a turf of scarlet dermatocystia; a conspicuous feature distinguishing this species from other sequestrate *Russula* spp.

Description: *Basidiomata* hypogeous to partially emergent or sometimes exposed in animal digs, solitary or in scattered, gregarious groups. *Basidiomata* globose to subglobose, flattened, or irregular, (5–) –25 (–30) x (5–) –20 (–25) mm, in youth with a suprapellis turf of scarlet, tapered cystidia that fade when dried and a pellis mixture of pale yellow and scarlet areas that often separate into patches, with age the colors darkening to darker dull red and the turf fading and collapsing in patches, at senescence becoming dark reddish-brown with the suprapellis turf largely to entirely collapsed (Image 1a). Stipe absent or rarely present as a less than 2mm long, readily detaching stub at base of fruiting body, its surface concolorous with peridiopellis. Gleba loculate, in youth, the trama white to ivory or pale yellow, with age developing to brownish yellow with brown zones and brown tissue around worm holes, and at senescence brown overall (Image 1a & c); spores in mass in the locules white, often brownish where glebal tissue has stained brown. Odor in youth mild, later often faintly pleasant, at senescence somewhat unpleasant.

Peridium 115–180 µm thick, beset with a crowded to dispersed, scarlet pubescence. Peridiopellis 25–90 µm thick, scarlet in fresh mounts of young specimens and often with scattered red granular deposits near the surface, later darkening to brown or reddish-brown and paler towards gleba, the hyphae compact and tightly entangled, 4–8 µm broad, the suprapellis a pubescence of tapered, tangled, cystidia 20–40 µm tall, scarlet when fresh and sometimes with scattered scarlet deposits at the base but fading slowly after exposure, in microscope mounts of KOH quickly becoming hyaline (Image 1d). Subpellis averaging 90µm thick with loosely interwoven hyphae 3–8 µm thick. Gleba with a subhymenium up to 30µm thick, composed of irregularly shaped, inflated cells up to 11µm broad. Hymenophoral trama up to 18–31 µm thick, composed of tightly intertwined hyphae, 3–7 µm broad with occasional cells in trama inflated up to 18µm. Hymenophoral cystidia 39–42 x 8–11 µm, scattered, hyaline smooth, cylindrical to narrowly clavate with obtuse apices, walls less than 1µm thick (Image 1f). Basidia 41–48 x 9–11 µm, clavate, tapering near the base, smooth, less than 1µm thick, 2 and 4 spored, sterigmata 4–6 x 1–2 µm. Spores 7–8 x 7–9 µm, globose to subglobose with sterigmal attachment no more than 1µm long tapering towards the tip, spore wall less than 0.5µm thick, becoming slightly thicker near sterigmal attachment. Spore ornamentation less than 1µm tall, weakly amyloid, ranging from irregular granules to a well-developed reticulum (Image 1e).

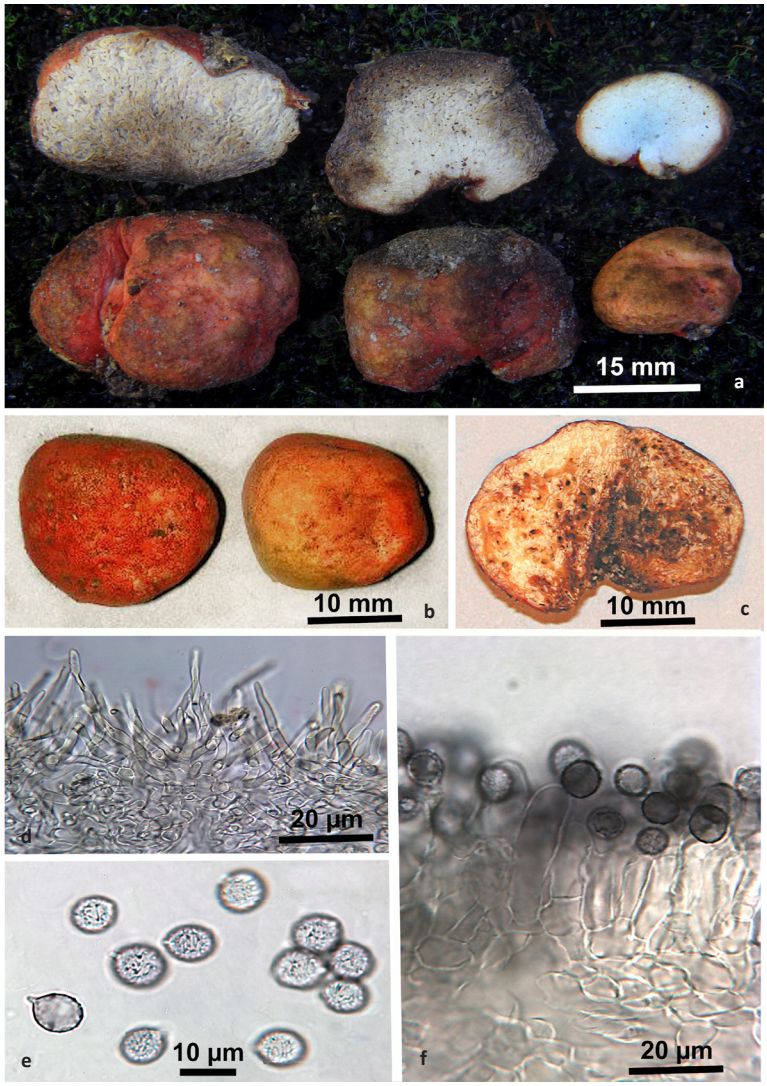

Image 1. Morphological features of *Russula scarlatina*. a—Different developmental stages in cross-section; note glebal darkening with age and maturation. b. Scarlet peridium of two young specimens | c—Gleba of a senescent specimen showing dark staining reaction around insect larval holes | d—Dermatocystidia and pigmented hyphae present in the peridiopellis turf. | e—Basisiospores, note the weak amyloid reaction and short ornamentation | f—Narrowly clavate hymenophoral cystidia. © a,d,e & f—Todd F. Elliott; b & c—James M. Trappe.

Habitat and Distribution

Primarily restricted to dry sclerophyll woodlands and open forest habitats from the Warrumbungle Mountains and New England Tablelands south through the South West Slopes, tablelands, and Riverina of New South Wales, and through the grassy woodlands of central and coastal Victoria at elevations of 10–678 m and fruiting between May and September. Associated trees are typically various mixtures of *Acacia* spp., *Allocasuarina luehmannii, Callitris endlicheri, Eucalyptus albens, E. blakeleyi, E. bridgesiana, E. camaldulensis, E. goniocalyx, E. leucoxylon, E. macrorhyncha, E. mannifera, E. melliodora, E. microcarpa, E. macrorhyncha, E. polyanthemos, E. populinea, E. sideroxylon,* and *E. tricarpa*. We have often encountered this species in nearly monodominant stands of *E. blakeley, E. camaldulensis* or *E. microcarpa*. The types of woodlands where *R. scarlatina* is commonly encountered vary considerably from North to South within its range: for example, the intensely studied box-gum grassy woodlands of the Australian Capital Territory (McIntire et al. 2010) and the Gippsland red gum grassy woodland in the Moormurng Flora and Fauna Reserve in the coastal sand plains near the Gippsland Lakes of Victoria (Australian Department of Environment 2010). The resilience and adaptability of *R. scarlatina* is graphically illustrated by collection 35049 (Mitchell, ACT) which was emergent on bare, compacted soil under an unidentified planted *Eucalyptus* sp. at the

edge of the sidewalk. All other collections were from more intact albeit often degraded woodlands or open forests.

Paratypes: Australia, Australian Capital Territory: Goorooyaroo Nature Reserve, 55H 699328 N, 6103996 E, elev. 695 m, Trappe 32837, 9 Sep 2008 (OSC 158775, CANB); Mitchell, Hoskins St. T. Elliott, Trappe 35049, 2 Sep 2010 (CANB). NEW SOUTH WALES: Benambra Nature Reserve, from Holbrook on Mountain Creek Rd. 4.5km from Mullengandra Rd., J. Trappe 31627.1 & B. Skoro, 1 Aug 2006 OSC 158771, CANB); Burrinjuck Nature Reserve SE of Yass, P. Thrall, Trappe 31959, 28 Jun 2007 (OSC 158774, CANB) Murray River, Cottadidda State Forest, under *Eucalyptus camaldulensis,* R. Strömmer & J. Trappe 25209, 3 Jun 2000 (OSC 158744, CANB). Kosciuszko National Park, Barry Way 0.5km N of Pinch River crossing, Claridge Site 6, Jacobs Mapsheet Grid 625600 Easting 5927350 Northing, under *Acacia implexa* & *Eucalyptus albens,* A. Jumpponen, AWC 3305, 14 May 2001 (OSC 158814, CANB) Parkes Shire, Genaren Farm, Genaren Hill Sanctuary near N boundary fence, Tullamore map 8432-1 & 4, AMG 579900 E, 6396200 N, under *Eucalyptus dealbata, E. sideroxylon, Acacia doratoxyon, A. deanii,* and *Callitris glaucophylla*, J. Trappe 26478, 22 Jun 2001 (OSC 158757, CANB); Riverina, Kilpa Farm, 17.5km SE of Berrigan, under *Eucalyptus microcarpa. R. Strömmer,* J. Trappe 25144, 4 Jun 2000 (OSC 158741); Savernake Station, Horse Paddock, 26.5km N of Mulwala, under *Eucalyptus melliodora,* and *E. microcarpa*, J. Trappe 25197, 4 Jun 2000 (OSC 158743, CANB); Womboyne Farm N of Barooga, under *Acacia* sp., J. Trappe 25368, 28 Jun 2000 (OSC 158754, CANB); Wandook Traveling Stock Route 10km W of Deniliquin, 35^{0}27'47"S, 145^{0}0'40"E, elev 90m, J. Trappe 28651, 16 Jul 2003 (OSC 158765, CANB); Warrumbungle National Park, E of Visitors Center, T. Elliott, Trappe 35062, 3 Sep 2010 (DAR). Weddin Mountains National Park, Weddin Gap, AMG 592950 E, 6241050 N, J. Trappe 26437, 19 Jun 2001 (OSC 158756, DAR). VICTORIA: Chiltern Box-Ironbark National Park, Donchi Hill Rd, R. Strömmer & J. Trappe 25219, 6 Jun 2000 (OSC 158745); East Gippsland, Moormurng Flora and Fauna Reserve, Leathams Dam Rd, T. Elliott, Trappe 35049, 26 Aug 2010 (OSC 158812, MEL); Maldon State Forest, Red White and Blue Track 1.7km S from Pullens Rd, AMG 242534 E, 5895655 N, elev 300m, J. Trappe 27595, 9 July 2002 (OSC 158759, MEL), Reef Hills Regional Park, Roes Rd., by pond, under *Eucalyptus albens,* J. Trappe 25263, 7 Jun 2000 (OSC 158749, MEL).

Discussion

Russula scarlatina is easy to recognize in the field because of its vibrant scarlet peridium, totally enclosed loculate gleba, and lack of a stipe; these characters set it apart from other members of the genus. Some *Arcangeliella* (sequestrate *Lactarius*) species appear somewhat similar but are readily distinguished from *R. scarlatina*. The most similar of these taxa have bright orange (not scarlet) peridia and lactate and/or have laticiferous hyphae, unlike *R. scarlatina*. Other distinctive characters of *R. scarlatina* include unusually short spore ornamentations that are weakly amyloid and a distinctive peridiopellis turf; furthermore, this species has been found only in dry sclerophyll woodlands and open forest habitats.

Russula theodoroui (T. Lebel) T. Lebel sometimes has reddish to scarlet peridia, but it differs from *R. scarlatina* in having a short but prominent stipe, a pileopellis epithelium of inflated cells (but lacking a turf of dermatocystidia), and larger spores (8–10 x 8–9.5 µm) with much larger and more strongly amyloid ornamentation. Because of its peridiopellis of inflated cells, *R. theodoroui* had earlier been placed in the genus *Cystangium* but now is in the genus *Russula* (Lebel 2017; Elliott & Trappe, 2018). *Russula theodoroui* has never been collected south of Queensland, whereas *R. scarlatina* has not been collected north of the Warrumbungle Mountains of New South Wales.

Russula westresii (T. Lebel) T. Lebel is one of the more common and widespread species in eastern Australia and resembles *R. scarlatina* in having a brown staining gleba, spores with short ornamentation, and sometimes orange to brick red streaks and patches on an otherwise yellowish-white to pale brownish-yellow peridium (but not the overall scarlet of *R. scarlatina*). *Russula westresii* also lacks a peridiopellis turf of dermatocystidia, and its spores are larger (8–10 x 7.5–9 µm) than those of *R. scarlatina*.

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