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Taungurungia gen. nov., from the Lower Devonian of Yea, central Victoria, Australia

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Abstract McSweeney, F.R., Shimeta, J. and Buckeridge, J.S. 2022. *Taungurungia* gen. nov., from the Lower Devonian of Yea, central Victoria, Australia. *Memoirs of Museum Victoria* 81: 43–53.

This paper records a new genus *Taungurungia*, which is the first new taxon with emergences to be described from the Lower Devonian of Victoria. The fossil is preserved primarily as a compression and impression, and lacks internal anatomy. The fossil extends our knowledge of known variations within early land plants, with most characteristics, such as emergences and H- or K-branching, redolent of affinities with the zosterophylls. However, having a large ovate terminal sporangium, the fossil adds to taxa that in some cases have been provisonally allied to the zosterophylls with elongate sporangia; this further demonstrates the need for reassessment of the Zosterophyllopsida.

Keywords embryophytes, zosterophyll, emergences, Lower Devonian, Victoria

Introduction

Banks (1968, 1975) recognised three subdivisions from the Psilophytales: the Rhyniophytina, Zosterophyllophytina and Trimerophytina. Subsequently, these have been raised to higher taxononic ranks by many workers (Hao and Xue, 2013; Kenrick and Crane, 1997). Herein, we examine a new form similar to Zosterophyllopsida *sensu* Hao and Xue (2013). Zosterophyllopsida have sporangia that have a width to height ratio ≥1 and are reniform, globose or rounded in face view (Banks, 1968, 1975). However, some rare exceptions have been noted where the sporangia are longer than wide (Edwards et al., 2016; Edwards and Li, 2018; Hao and Beck, 1991; Hao and Xue, 2013; Wang and Hao, 2002). The specimen described herein augments taxa with longer-than-wide sporangia and is significant because little is known about these aberrations and their taxonomic significance. Four Zosterophyllopsida species are known from Victoria: *Zosterophyllum australanium* Lang and Cookson, 1930; *Z. ramosum* Hao and Wang, 2000; *Parazosterophyllum timsiae* McSweeney et al., 2020; and *Gippslandites minutus* McSweeney et al., 2020. But none of these Zosterophyllopsida resemble the specimen descibed below. Furthermore, axes with emergences are rare in Devonian Victorian flora and have only been described by Cookson (1935) and McSweeney et al. (2021) from the Norton Gully Sandstone Formation of Alexandra; axes resembling *Psilophyon* were noted by Williams (1964: 285) at location A82 on Kerridale Road, Homewood, near Yea.

Locality, stratigraphy and age

Location F103 (*sensu* Garratt, 1980) occurs in the Norton Gully Sandstone Formation according to Edwards et al. (1997, 1998) and VandenBerg et al. (2000). Garratt (1980: 590) did not record any fossils at F103. The Norton Gully Formation is found throughout the Mount Easton Province and parts of the Darraweit Guim Province (fig. 1) according to Edwards et al. (1997: fig. 6; VandenBerg et al. 2000: fig. 2.106). The exposure is on the northern side of the Goulburn Valley Highway (fig. 2) and consists of a sequence of siltstones that are indicative of quiescent conditions during deposition. The Norton Gully Sandstone Formation is considered to be Emsian age by Morand and Fanning (2006) and, based on the occurrence of *Uncinatograptus thomasi* (Jaeger, 1966), is considered to be Pragian and possibly Emsian age by Lenz (2013). Therefore, a late Pragian–Emsian, (Lower Devonian) age is given herein to account for these minor disparities.

Material and methods

NMV P257028.1 (part) and NMV P257028.2 (counterpart) were found *in situ* in January 2015 by the lead author with Michael Garratt. These buff yellow fine-grained siltstones easily split along bedding planes, with the fossil preserved as an iron-stained mould and cast with some carbonaceous film.

The specimen was photographed (figs 3a, b, 4a, 5, 6, 7a) by Rod Start of Museums Victoria on 17 March 2020, using cross-polarised light (circular filter) with a Canon 5DSR camera fitted

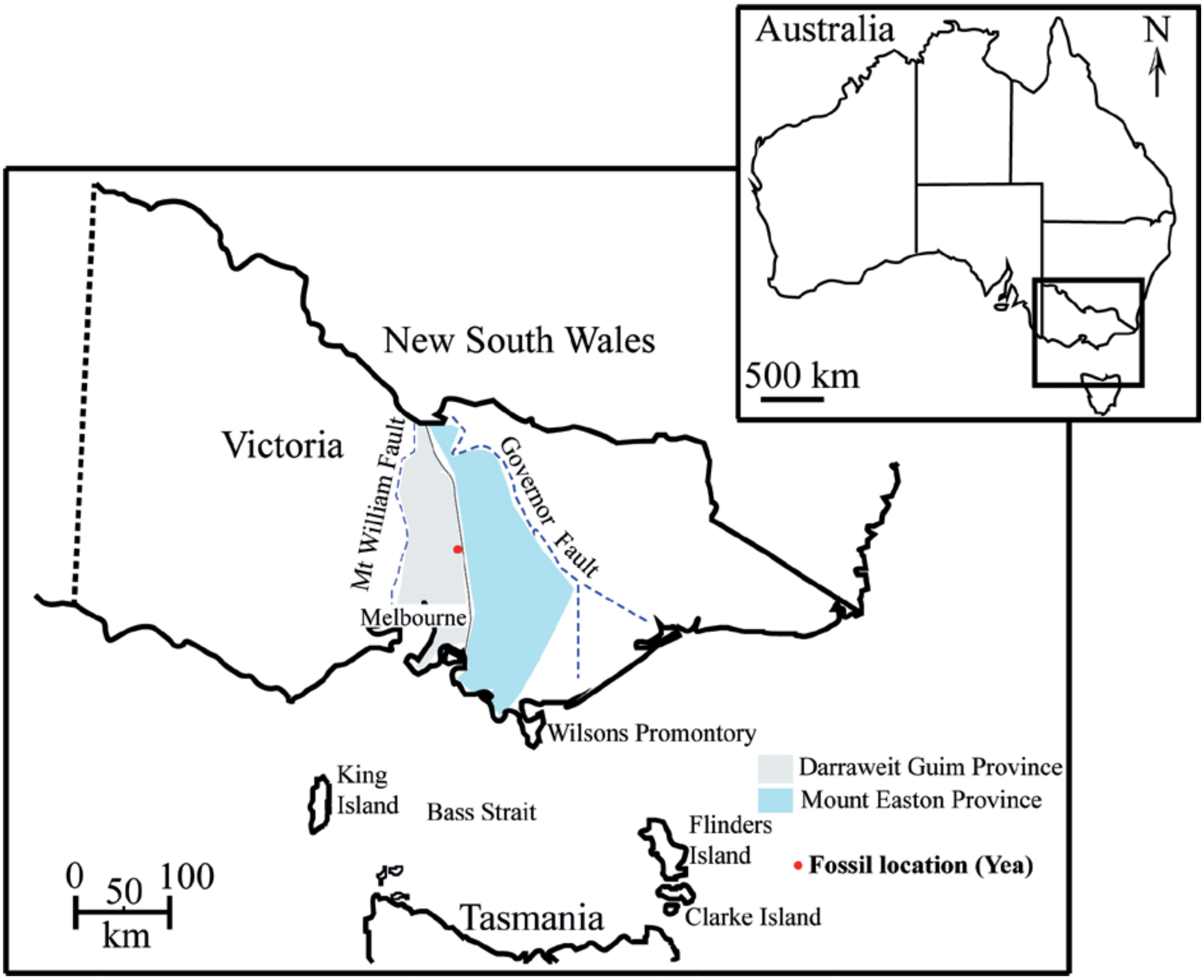

Figure 1. Map of Victoria, Australia, showing the fossil location of Yea within the Melbourne Zone. Source: adapted from Moore et al. (1998: fig. 2).

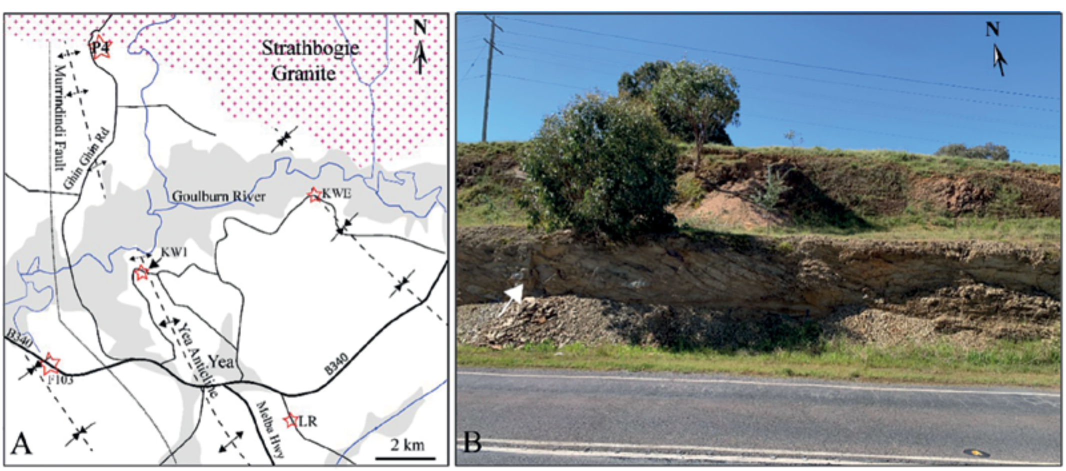

Figure 2. Goulburn Valley Highway fossil location F103 (Garratt 1980): a, F103 located about 5 km west of Yea; b, part of F103 exposure (37° 12’ 30” S; 145° 21’ 56” E) with arrow at location where *Taungurungia garrattii* gen. et sp. nov. was found *in situ*. Map after Garratt (1978) and positioning of Strathbogie Batholith after VandenBerg (1997).

with an EF 100 mm f/2.8L macro lens. Flash strip-lights were used to enhance contrast. The remaining images were taken using an AxioCamMRc5 camera attached to a Zeiss SteREO Discovery V8 stereomicroscope. Images were Z-stacked to improve depth of field using Adobe Photoshop CC 2017. ImageJ software (Image J1.52d, Wayne Rasband, USA, http://imagej.nih.gov/ij) was used to take measurements. Extensive dégagement (primarily following Fairon-Demaret et al., 1999) was undertaken by the lead author, mainly on NMV P257028.1, with a sample removed from an uncovered axis for analysis in low-vacuum mode on a FEI Quanta-200 scanning electron microscope at the RMIT Microscopy and Microanalysis Facility. No anatomical information was obtained. Dégagement of the distal region of one of the daughter axes on the counterpart (NMV P257028.2) revealed terminal small fusiform bodies along the axis (fig. 7a pre-dégagement; fig. 7b post-dégagement). Dégagement above the large terminal sporangium (fig. 3 pre-dégagement; fig. 4d post-dégagement) revealed small fusiform bodies near an axis that was poorly preserved. This dégagement was undertaken by gently loosening the overlying matrix above the spike by gently tapping the steel needle on the matrix to remove grains and work down to the fossil. Dégagement of proximally curved axis revealed additional minute fusiform bodies (fig. 7c, d post-dégagement).

Institutional abbreviations

NMV P, Museums Victoria Palaeontology Collection, Melbourne, Australia. The specimen NMV P257028.1 and NMV P257028.2, part and counterpart respectively, are housed in the Palaeontological section, Museums Victoria, Melbourne.

Systematic palaeobotany

Class. *Insertae sedis*

Genus. *Taungurungia* McSweeney, Shimeta and Buckeridge gen. nov.

Diagnosis: Terete axes with deltoid to elongate emergences. Fertile axes terminate in single large sessile ovate sporangium partially sunken into the axis with a curved junction between the axis and sporangium. Branching anisotomous and ?H- or K-branching in basal regions. Small fusiform to elliptical bodies (buds/sterile sporangia) occur on axes including the distal regions and on slender lateral axes, some with short stalks.

Etymology: Named for the indigenous Taungurung people.

Type species: *Taungurungia garrattii* McSweeney, Shimeta and Buckeridge gen. et sp. nov.

***Taungurungia garrattii* McSweeney, Shimeta and Buckeridge, sp. nov.**

Figures 3–10

Species diagnosis: As for genus. Plant at least 185 mm high with axes at least 7.8 mm wide. Emergences up to 1.5 mm wide and 3.4 mm long. Mature axes terminate in a single ovate sporangium at least 7.5 mm wide and at least 15.5 mm long. Small fusiform to elliptical bodies (buds/sterile sporangia) 0.5 mm wide and 1 mm long, some with short stalks occurring on all axes.

Etymology: Named for Michael Garratt in recognition of his work in Palaeozoic palaeontology, especially on brachiopods.

Holotype: NMV P257028.1 (part; F103-1p) and NMV P257028.2 (counterpart; F103-1cp), part and counterpart respectively.

Locality: The exposure occurs on the Goulburn Valley Highway (B340) 5 km west of Yea and was designated F103 by Garratt (1980). 37° 12' 30" S; 145° 21' 56" E.

Stratigraphy and age: Norton Gully Sandstone Formation, late Pragian–Emsian, Lower Devonian.

***Taungurungia garrattii* sp. nov.**

Description (based on one specimen part and counterpart): The specimen consists of six parent axes that are 2.4–7.5 mm wide and taper gently acropetally; three of these axes are poorly preserved. The axes are oxidised and golden to yellow in coloration, with a vascular trace evident in parts of the axes, most notably proximally measuring 1.6 mm wide. Three of the larger axes terminate in a single sessile large ovate sporangium (fig. 3a). One is poorly preserved with only part of its apical region preserved (fig. 3b). The largest sporangium is 7.5 mm wide and 15.5 mm long and is ovate, reaching its maximum width 6.4 mm up from its base (figs 3, 4a, b). The sporangium does not possess a stalk, appears sessile and is partially embedded in the axis with a curved junction. Another large sporangium occurs low on the specimen (figs 3, 5) and is 14.7 mm long and 5.6 mm wide and is missing part of its cast basally. This sporangium sits with part of its basal region embedded into its subtending axis, again with a curved junction. The distal region of this sporangium is more elongate. These two sporangia have two fractures running transversely at an oblique angle. There is no evidence of a bounded region along these fractures to indicate they are related to dehiscence. Additionally, there is no evidence of a marginal rim preserved on any of the sporangia.

Emergences are 0.6–1.5 mm wide and 1.3–3.4 mm long, varying in morphology according to length (fig. 6) and more occur on the largest axis than the other axes. The smaller emergences are deltoid, and the larger emergences are elongate and perpendicular to the parent axes. One elongate emergence extends perpendicular to the parent axis for about 0.3 mm before re-orientating at about 45° to the axis (fig. 6d). One of the deltoid emergences has a fine vascular trace 0.07 mm wide along its length (fig. 6b).

Fusiform bodies (figs 7, 8) up to 0.5 mm wide and 1 mm long occur on the axes, most occurring distally but in two instances are found to occur in discrete areas of no more than 8 mm long and 2 mm wide on the sides of the main parent axes (fig. 8a, b). Dégagement of the distal region of one of the daughter axes revealed fine fusiform bodies with short stalks (fig. 7a, b). Additionally, similar fusiform bodies were found to occur on the narrow lateral axes that emanate from the main parent axes at almost right angles (fig. 7e), and on the counterpart, faint impressions of numerous fusiform bodies were found on the large central terminal sporangium (fig. 4c). Dégagement above the main large terminal sporangium revealed more of these fusiform bodies extending beyond the large sporangium (figs 4d, 9). There is no connection between the small fusiform bodies and the large terminal sporangium.

Three types of branching are evident. The first is where a parent axis branches anisotomously and is only seen once, occurring 33 mm from its apex producing a daughter axis 2.9 mm wide that tapers to 1.5 mm wide (figs 3, 7a). The daughter axis and distal region of the parent axis both appear lax. The second type of branching occurs along the sides of the parent axes and consists of narrow lateral axes usually branching perpendicular from the parent axis. These narrow lateral axes are about 0.2 mm wide and up to 2–3 mm long and are sparsely distributed on the parent axes; some occur just beneath the large terminal sporangium of the central axis (fig. 7e). None of these narrow lateral axes branch, and they possess two to three fusiform bodies interpreted as dormant buds or sterile sporangia, one of which is always terminal. One large example of a lateral axis occurs proximally off one of the parent axes and is 15 mm long, varying in width from 0.3–1.1 mm, curving orthotropically with a terminal fusiform body 0.24 mm wide and 0.53 mm long (fig. 7c, d). A third type of branching occurs basally on the central axis with an oblique axial extension forming an approximate K-branch (fig. 3a), with some smaller protuberances, possibly remnants of fusiform bodies (fig. 8c), close to each other. The acroscopic part of this vegetation is similar in morphology to the distal regions of the two large terminal sporangia. A portion of axis was extracted from a poorly exposed axis (fig. 3) within the matrix, revealing longitudinal structures possibly indicative of the cell's original orientation (fig. 10).

Comments: The location of sporangia has been used by many workers (Edwards et al., 1989; Gensel 1992; Kenrick and Edwards, 1988; Niklas and Banks, 1990) to differentiate zosterophylls into either the Gosslingiales or Zosterophyllales. Zosterophyllales have both lateral and terminal sporangia. However, the presence of emergences suggests affinities with the Gosslingiales; but Gosslingiales lacks terminal sporangia (Hao and Xue, 2013). Additionally, the sporangia of *Taungurangia garrattii* are not reinform or globose as in zosterophylls, which precludes assignation to *Zosterophyllum* (Edwards et al., 2016; Gensel, 1992: 455). Instead, the terminal sporangia are noticeably elongate and lack a thickened zone bounding a dehiscence line as seen in most zosterophylls (Hao and Xue, 2013). The apparent limited branching and single terminal elongate sporangium suggests rhyniophytes affinities, but while branching appears limited, numerous slender axes emanate from the parent axes. Based on the primary characteristics – notably the presence of emergences, K- or H-branching, conspicuous large terminal elongate sporangium and noticeably sparse branching – we provisionally place *Taungurangia garrattii* in the Class *incertae sedis*.

We believe the small fusiform bodies may represent buds or sterile vestigial sporangia (figs 7, 8). This is a similar conundrum to the original consideration of what were originally believed to be sporangia along the axes of *Sawdonia ornata* (Dawson) Hueber but were later found to be buds/arrested apices (Gensel and Berry, 2016: 619; Hueber, 1992: fig. 3). We found no fusiform bodies of intermediary size with the large terminal sporangia; instead, they are all broadly the same size. Furthermore, most of the fusiform bodies have

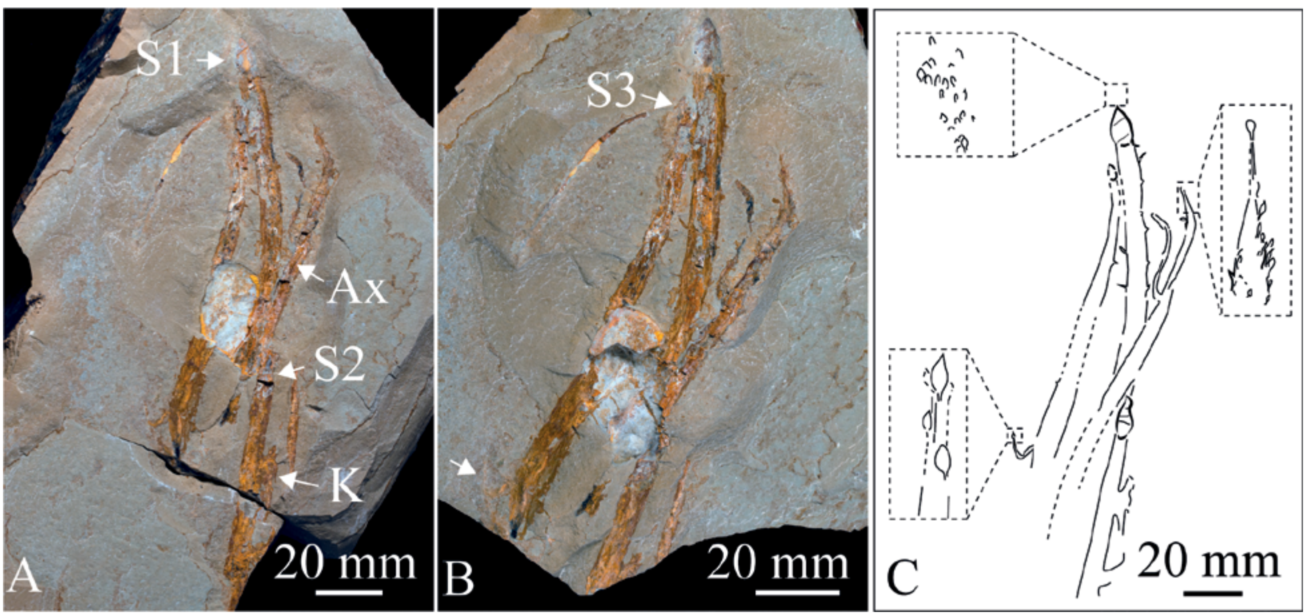

Figure 3. *Taungurungia garrattii* gen. et sp. nov., holotype: a, part specimen (NMV P257028.1) with lower arrow at K-branching. Terminal ovate sporangia at S1 and S2. At Ax is an axis that goes into the matrix. K- or H-branching at lower arrow; b, counterpart (NMV P257028.2). At upper arrow S3 is poorly preserved sporangium. Lower arrow points the axis curving upwards which is visible in fig. 7c, d close-up after dégagment. The counterpart image is reversed to be in the same orientation as the part; c, line-drawing without small bud/sterile sporangial bodies included. Images a and b were taken by Rodney Start © Museums Victoria.

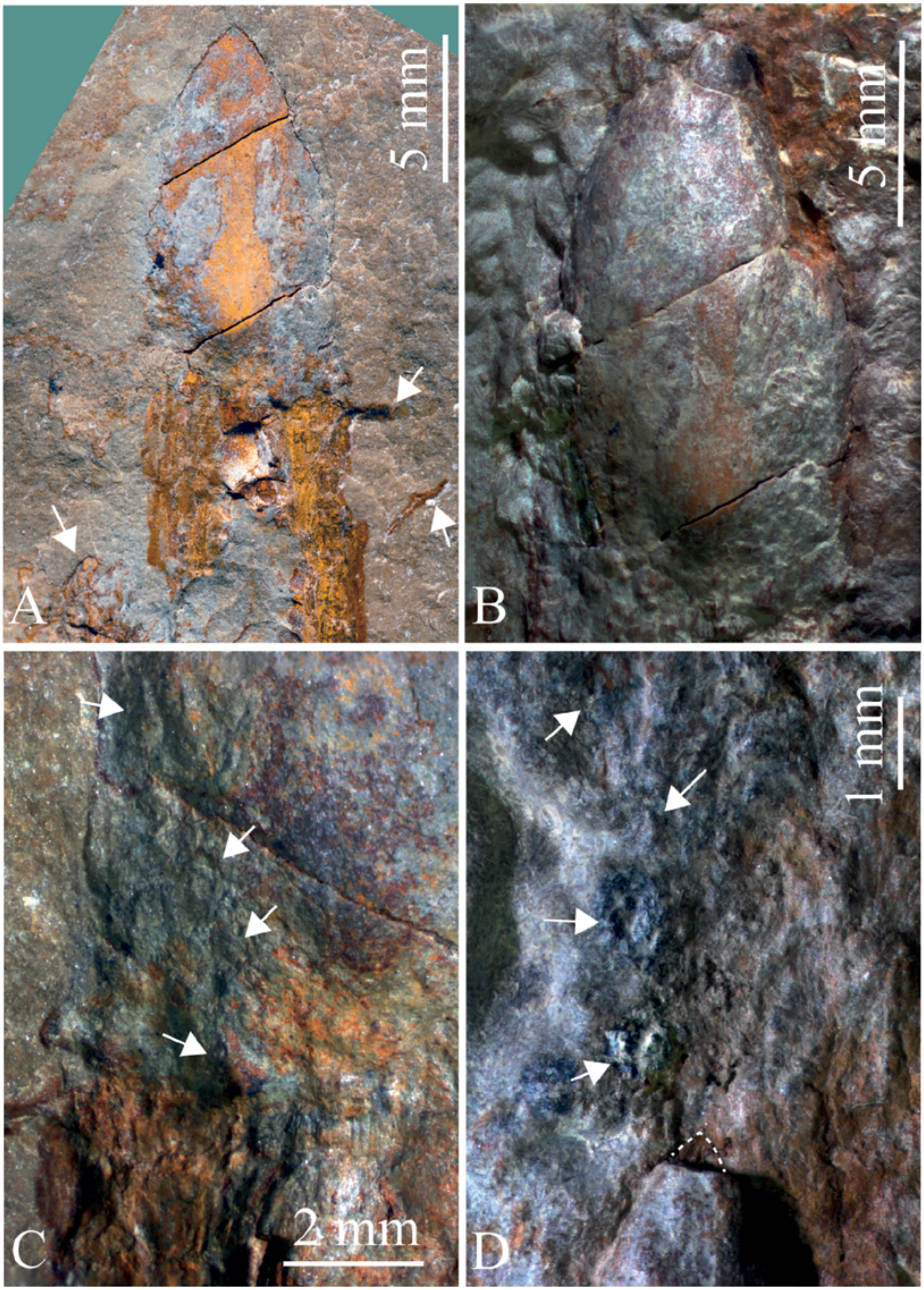

Figure 4. *Taungurungia garrattii* gen. et sp. nov., holotype, part specimen NMV P257028.1: a, ovate sporangium pre-dégagement. Left arrow is at apex of poorly preserved sporangium. Right arrows are at two lateral axes close to the base of the sporangium. Close-up of lower axis in fig. 7e; b, post-dégagement, reveals sporangium preserved in relief; c, faint impressions at arrows of fusiform bodies (buds/sterile sporangia) on counterpart. Lower arrow shows a fusiform body attached directly to the axis at the junction with the sporangium; d, dégagement above the sporanium revealed numerous small fusiform bodies (buds/sterile sporangia) at arrows similar to c. Tip of sporangium disintegrated during dégagement, positioning highlighted with dotted line. Image a taken by Rodney Start © Museums Victoria.

Figure 5. *Taungurungia garrattii* gen. et sp. nov., holotype, part specimen NMV P257028.1. Large sporangium low down on the specimen. The apex is slightly curved (upper arrow) and more elongate then the sporangium in fig. 4. Branching visible (lower arrow). Note: the sporangium appears partly embedded in its subtending axis. Image taken by Rodney Start © Museums Victoria.

narrow subtending axes that clearly differ from the large sporangia, which are sessile. If these fusiform bodies were to grow to a similar size as the terminal sporangia, they would likely have caused the plant to become unstable because they occur on narrow lateral axes and at the end of daughter axes.

The oblique region of extended vegetation (?K- or H-branching) seen basally is indicative of creeping vegetation, such as that seen with *Discalis longistipia* Hao (1989: 159) and other zosterophylls (Walton, 1964). Branching frequency and pattern from the emergences could not be determined. The lax appearance of the daughter axes (fig. 7a) could be interpreted as being almost recurved, a similar pattern of growth as circinate axes (Lyon and Edwards, 1991: 327) associated with indeterminate growth (Niklas and Banks, 1990). However, we consider this lax appearance to be due to partial wilting because there is no evidence of recurved growth on the smaller axes, which would be expected for this characteristic.

Comparison to other taxa

The specimen described herein has some similarities to *Halleophyton zhichangense* Li and Edwards, 1997, from the Zhichang section of the Posongchong Formation, Yunnan, China, in that rhomboidal depressions (Li and Edwards, 1997: fig. 5) are found on the axes and bear a passing resemblance to the depressions found on the sporangium mould (fig. 4c). However, *H. zhichangense* has much smaller sporangia, which are ellipsoidal and globose, 1.9–3.3 mm long and 1.7–3.1 wide (Li and Edwards, 1997).

Elongate-ovoid sporangia are characters of rhynialeans, but the presence of emergences and ?K- or H-branching suggests affinities with the zosterophylls. Elongate sporangia occurring on taxa with presumed affinities to the zosterophylls broadly similar to *T. garrattii* comprises six species (Table 1) that lived on the South China plate. Five of these (*Guangnania cuneata* Wang and Hao, 2002, *Guangnania minor* Edwards et al., 2016, *Sichuania uskielloides* Edwards and Li, 2018, *Baoyinia sichuanensis* Edwards and Li, 2018 and *Yunia Guangnania* Hao and Xue,

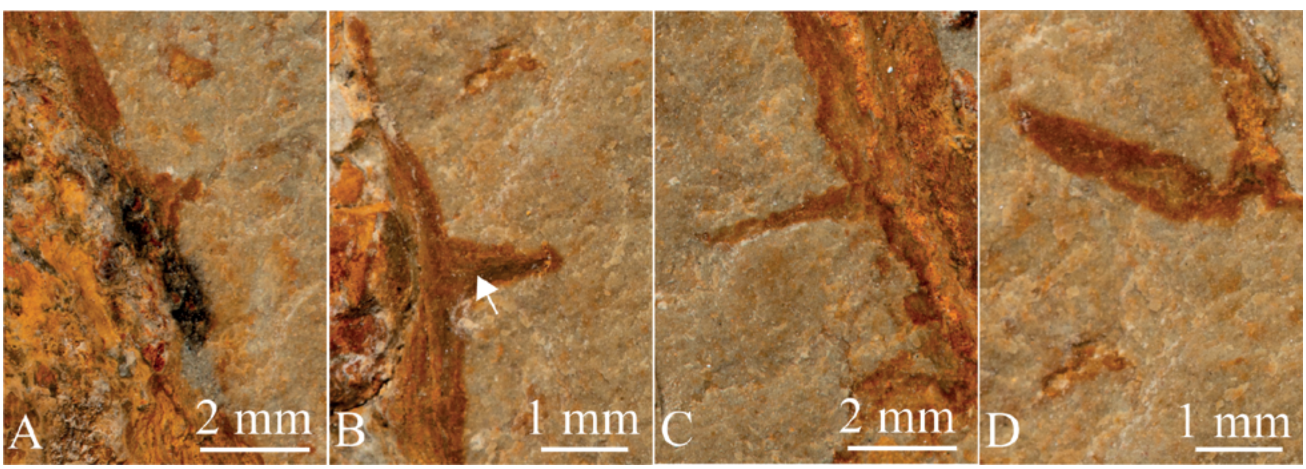

Figure 6. *Taungurungia garrattii* gen. et sp. nov. holotype, part specimen NMV P257028.1: a–d, ontogenetic changes in morphology and orientation of emergences. In image b, arrow at possible vascular trace extending out to tip. Images were taken by Rodney Start © Museums Victoria.

2013) have naked axes and therefore *T. garrattii* can be easily distinguished from them. *Yunia dichotoma* Hao and Beck, 1991, does have emergences in the form of sparely distributed spines and therefore differs from *Taungurungia garrattii*. Additionally, *Y. dichotoma* differs from *T. garrattii* because it has a marginal rim on the sporangia; this character is also found with *Ramoferis amalia* Hao and Xue, 2011, and *Baoyinia sichuanensis* (Edwards and Li, 2018). *Ramoferis amalia* also differs from *T. garrattii* in having ovoid to pear-shaped sporangia (Hao and Xue, 2011).

The sporangia of *Y. dichotoma* differ from those of *T. garrattii* in that they are elliptical to ovoid with rounded apices (Hao and Beck, 1991). The sporangia of these six taxa are also noticeably much smaller than *T. garrattii*. The largest sporangia *G. cuneata*, 2.8 mm wide and 9.6 mm long (Edwards et al., 2016; Wang and Hao, 2002), is much smaller than the largest sporangium of *T. garrattii*, which is 7.5 mm wide and 15.5 mm long. Additionally, the largest axial width for these six taxa (Table 1) is 5.0 mm for *Y. dichotoma* (Hao

Table 1. Zosterophyllopsida *sensu* Hao and Xue (2013) with longer than wide sporangia in comparison to *Taungurungia garrattii gen*. et sp. nov.

Taxon	**Age; formation; type location**	**Axial width**	**Emergences type; width (basally) and length**	**Sporangia (face view)**	**Comment**	**Source(s)**
***Guangnania cuneata* Wang and Hao, 2002**	Pragian, Lower Devonian; Posongchong Formation; Daliantang, Yunnan, China	W: 0.6–3.0 L: 80	None	Elongate-cuneate W: 1.2–2.8 L: 3.5–9.6	Found also in the Xujiachong Formation. Lose spikes, stalks at least 5.2 mm long. Nonterminate	Wang and Hao (2002); Edwards et al. (2016: table 3)
***G. minor* Edwards et al., 2016**	Loch–Pragian, Lower Devonian; Pingyipu Group, Yanmenba section; North Sichuan, China	W: 1.2–1.4 L: 155	None	Elongate-cuneate W: 1.2–1.9 L: 1.7–3.2	Sporangia helically arranged in terminal spikes	Edwards et al. (2016: table 3)
***Sichuania uskielloides* Edwards and Li, 2018**	Loch–Pragian, Lower Devonian; Pingyipu group, Yanmenba section; North Sichuan, China	W: 1.2–2.3 (spike) L: >45	None	Elliptical-oval W: 2.8–4.8 L: 4.0–6.0	Sporangia laterally flattened; stalks up to 1.5 mm wide. Spike lax	Edwards and Li (2018)
***Baoyinia sichuanensis* Edwards and Li, 2018**	Loch–Pragian, Lower Devonian; Pingyipu group, Yanmenba section; North Sichuan, China	W: 2–3 (spike axis)	None	Ovoid W: 2.5–3.5 L: 4.0–7.5	Stalks up to 2 mm wide. Sporangia isovalvate occurring in clusters; no vegetative parts	Edwards and Li (2018)
***Yunia dichotoma* Hao and Beck, 1991**	Pragian, Lower Devonian; Posongchong Formation, Zhichang section; Yunnan, China	W: 5.0 L: 90	Axial spines W: 0.5–1.4 L: 0.6–1.5	Elongate-elliptical to ovoid W: 1.3–3.5 L: 2.2–5.1	Peripheral border; axes sparsely covered in small spines	Hao and Beck (1991); Hao and Xue (2013: 119)
***Y. Guangnania* Hao and Xue, 2013**	Pragian, Lower Devonian; Posongchong Formation; Diliantang, Yunnan, China	W: 3.5–4.0 L: 50	None	Elongate-elliptical W: 2.2–4.8 L: 5.0–8.3	Peripheral border; stalks <1 mm long; sporangia scatted spirally; isotomous branching	Hao and Xue (2013: 122)
***Taungurungia garrattii gen*. et sp. nov.**	Late Pragian–Emsian, Lower Devonian; Norton Gully formation; Yea, central Victoria, Australia	W: 2.4–7.5 L: 185	Deltoid-elongate W: 0.6–1.5 L: 1.3–3.4	Ovate W: 5.3–7.5 L: 14.4–15.5	No stalk evident on large sporangia; fusiform and elliptical bud/sterile sporangia c. W: 0.5 L: 1.0	Herein

Note: All dimensions are in mm; L, length; W, width and Beck, 1991), and the longest specimen is for *G. minor,* attaining a height of at least 155 mm (Edwards and Li, 2018). In both cases, *T. garrattii* is noticeably larger, with its axes up to at least 7.5 mm wide and 185 mm long.

The emergences on *T. garrattii* are broadly similar in morphology to those of *Crenaticaulis* Banks and Davis, 1969, and in some respects to those of *Forania* Jensen and Gensel, 2013, in that they are deltoid and elongate-triangular (Banks

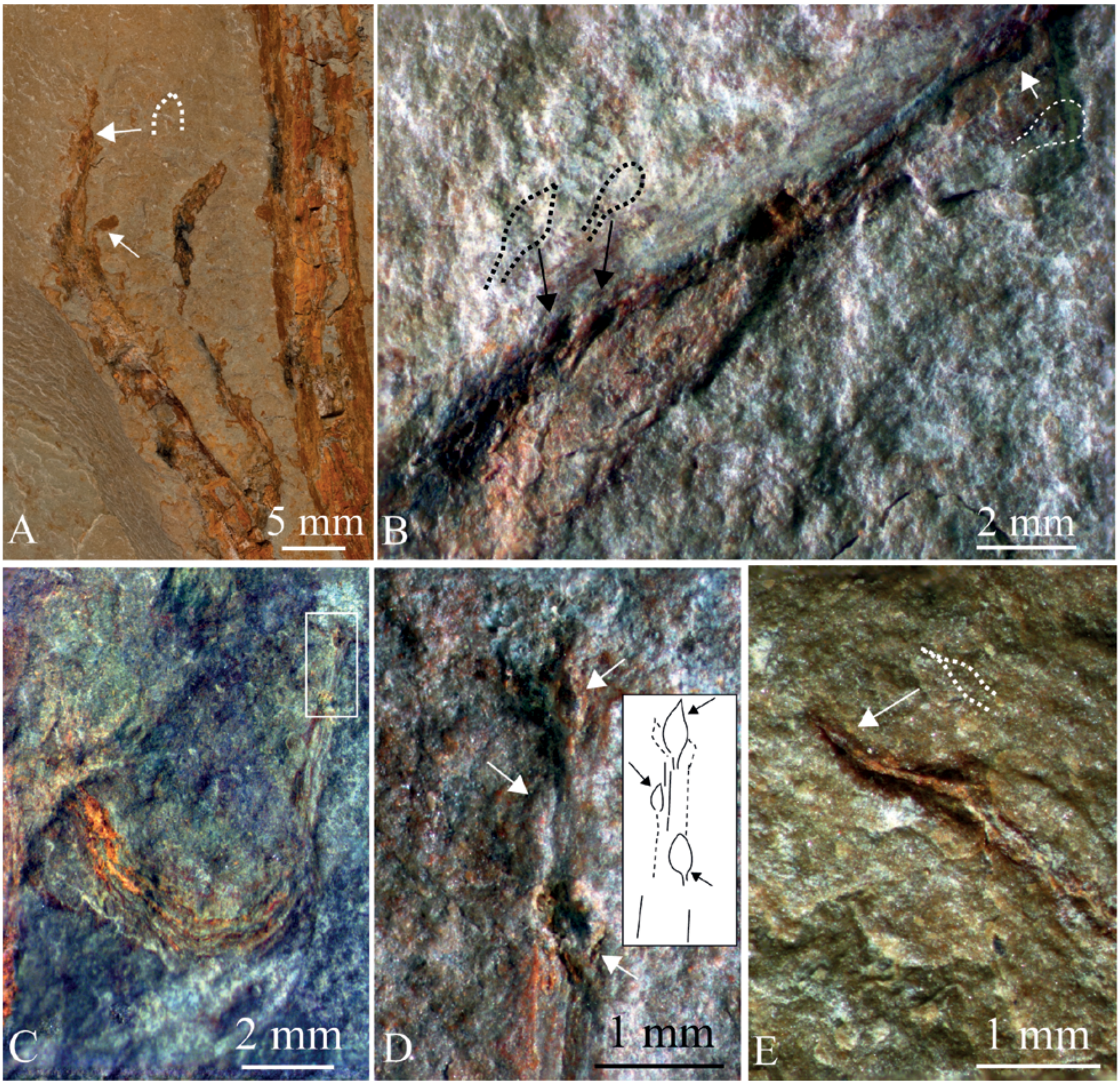

Figure 7. *Taungurungia garrattii* gen. et sp. nov. holotype, fusiform bodies (buds/sterile sporangia). Some of these are highlighted with enlarged dotted outlines near them: a, anisotomous branching with terminal partial fusiform body (upper arrow). Emergence or branching (lower arrow); b, post-dégagement, several fusiform bodies with short subtending axes are visible along the edge of the axis. Distally the axis narrows and terminates in an elongate rounded body (Arrow on right); c, curved axis displaying negative geotropism. Close-up (rectangular region) is in (d); d, distal part of curved axis possesses minute fusiform bodies (at arrows). An insert highlights the morphology. Evidence of determinate growth can be seen as the axis is terminated by one of these fusiform bodies; e, fine axis emanating about 4 mm on the same axis subtending the large central terminal sporangium, with arrow at small terminal body. All images are from the counterpart (NMV P257028.2). Image a was taken by Rodney Start © Museums Victoria. Images b–e were taken with a unidirectional light source.

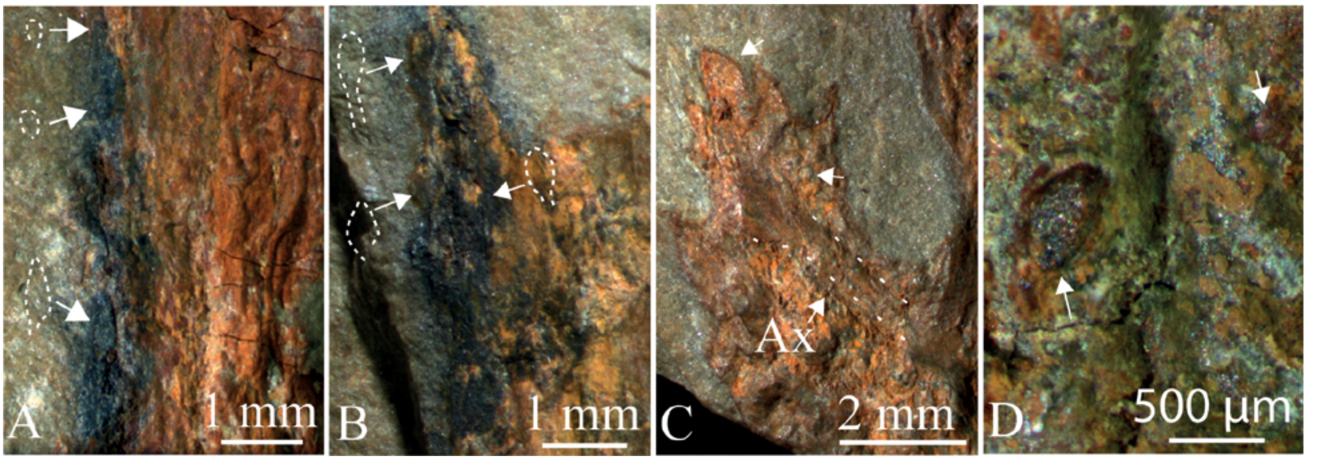

Figure 8. *Taungurungia garrattii* gen. et sp. nov. holotype, fusiform to elongate rounded (buds/sterile sporangia) bodies with some highlighted with enlarged dotted outlines beside them: a, b, on the side of axes in carbonised matter; c, faint axis (Ax) with ?fusiform bodies; d, close-up of fusiform bodies (arrows) on one of the large parent axes. No clear dehiscence lines are present. A short narrow stalk is subtending the sporangium on the left. Images a, b and d are from the counterpart (NMV P257028.2).

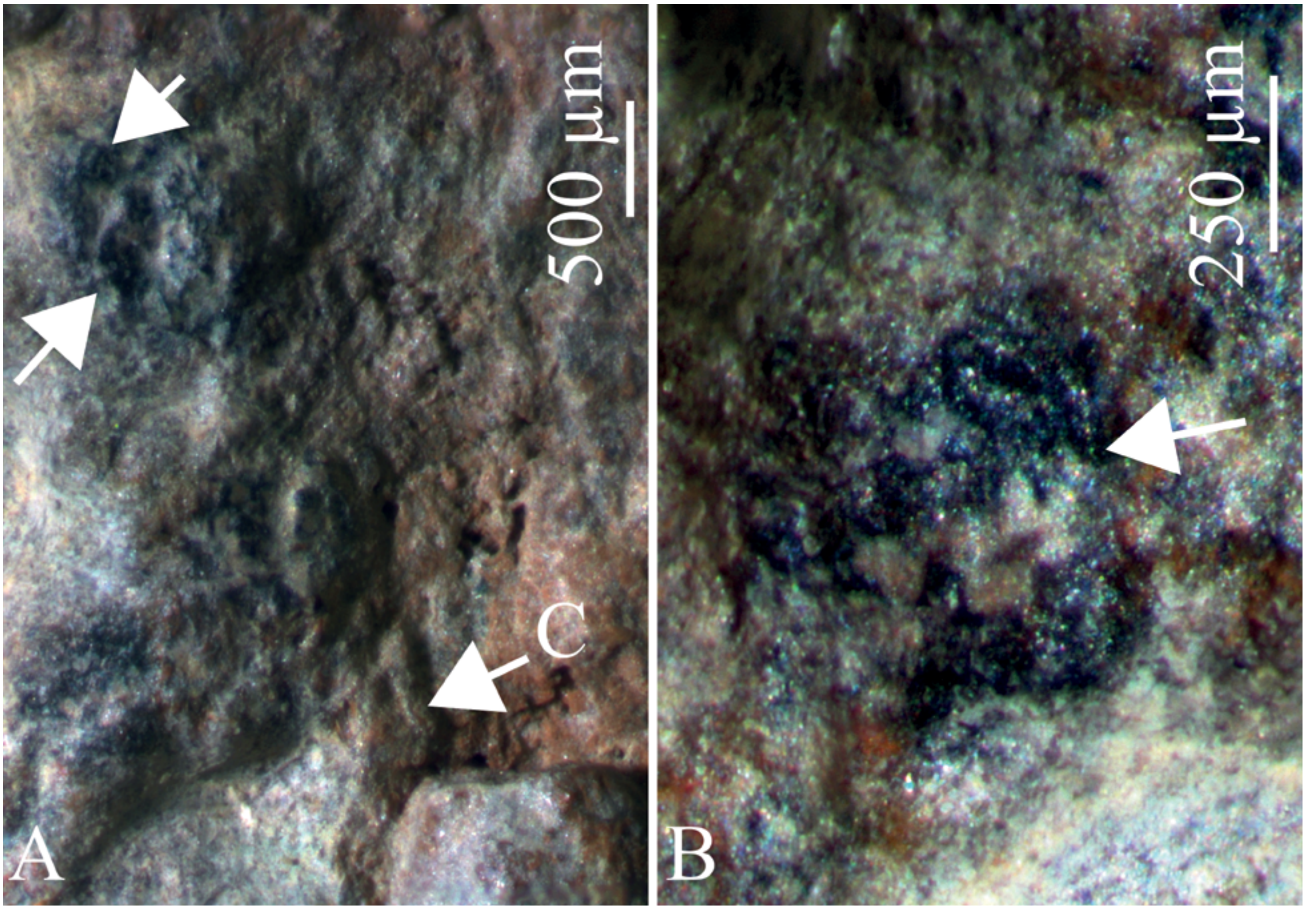

Figure 9. *Taungurungia garrattii* gen. et sp. nov. holotype, part specimen, NMV P257028.1 close-up of fusiform to elongate rounded (buds/sterile sporangia) body: a, immediate area above and right of the main terminal sporangium with some poorly preserved casts of fusiform bodies evident at the arrows. An ovate body (arrow c) pre-dégagement; b, the same ovate body post-dégagement. Its shape may represent partial compression because it is slightly dipping down into the matrix from its subtending axis. At arrow evidence of possible dehiscence line.

and Davis, 1969; Jensen and Gensel, 2013). However, *Crenaticaulis* emergences are biseriate, continuous and in 1–2 rows per side, while the emergences of *Forania* are biseriate and discontinuous (Jensen and Gensel, 2013: table 1). With *T. garrattii*, the emergences appear scattered and change significantly with maturity.

Discussion

Hueber (1992: 479) noted zosterophylls as having sporangia that were either reinform or globose, and that this morphology remained the same throughout their history while exhibiting variations in axial morphology. Thenceforth, several genera such as *Guangnania, Baoyinia* and *Yunia* from the South China Plate have been described as having noticeably elongate sporangia, but with characters indicative of affinities with the zosterophylls. This suggests that zosterophylls exhibited far more variation in sporangial morphology, or that these taxa may represent a separate group(s), as suggested by Hao and Xue (2013: 119) for *Guangnania* and *Yunia*. This paper describes the first known occurrence of elongate sporangia in association with zosterophyll characters in Australia. However, it cannot be assumed they have a common ancestor because the elongate sporangia may be an analogous structure brought about by homoplasy. Anatomical evidence in the form of xylem anatomy would be required to better determine their suprageneric positioning. Unfortunately, xylem structures have only been found in one taxon, namely *Yunia dichotoma,* which differs from zosterophylls (and lycophytes) in showing centrarch maturation rather than exarch, and similar in having G-type tracheidal structure (Hao and Beck, 1991), which is similar to *Huia gracilis* Wang and Hao, 2001. However, *Huia gracilis* is considered by Wang and Hao (2001) as a questionable rhyniopsid based on stalk length and its ovate sporangia, despite the present of a loose spike and K- or H-branching, while Kenrick and Crane (1997: 172) consider *H. gracilis* a basal lycopsid. Differing rates of evolutionary change within Zosterophyllopsida and Rhyniopsida may have also played a role in certain characters evolving to a point outside their respective classes while maintaining other characters for extended periods, resulting in modular evolution.

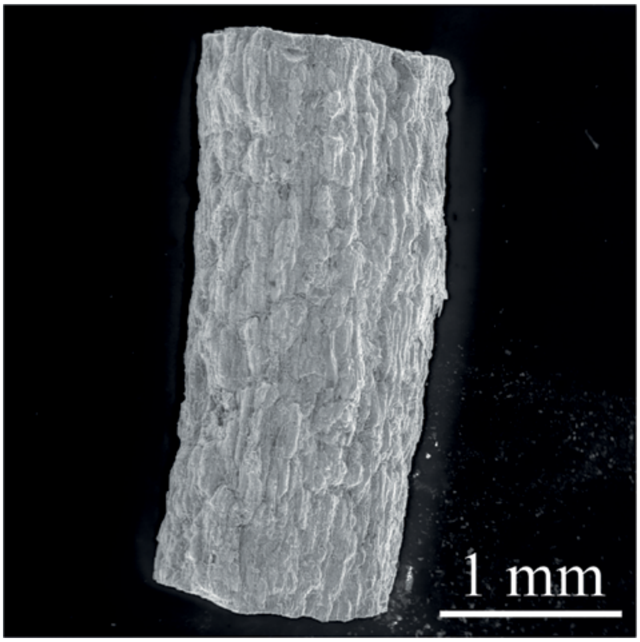

Figure 10. *Taungurungia garrattii* gen. et sp. nov. holotype, counterpart, P257028.2. Micrograph of an axis (part specimen) with longitudinal structures, possibly indicative of cell orientation. Taken using an FEI Quanta 200 scanning electron microscope in low vacuum mode.

Conclusions

In this paper we describe the first taxon from Victoria with emergences and an unusually large terminal elongate sporangium. We did not assign *T. garrattii* to Zosterophyllopsida because anatomical information for sporangial dehiscence, xylem type and spike is required to better determine its suprageneric positioning.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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