

## Hornworts of Australia: three new *Anthoceros* L. (Anthocerotaceae) species from New South Wales

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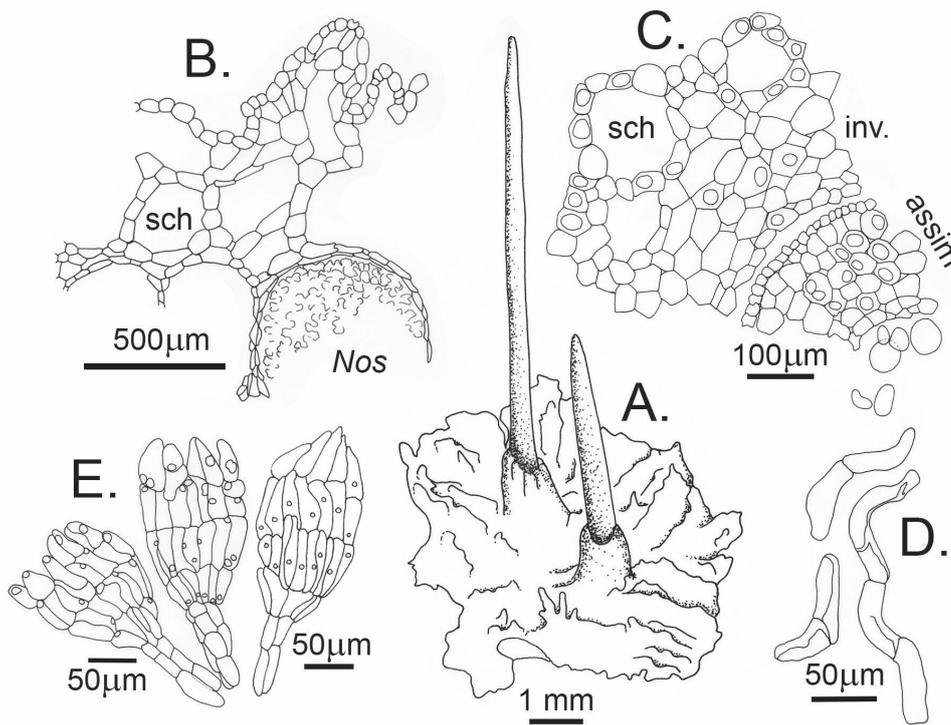
### Abstract

Three new species of *Anthoceros* sect. *Fusifformes* Grolle are described, all occurring on the North West Slopes and Plains of New South Wales and all sharing spore characteristics of a smooth unornamented strip on either side of the triradiate mark on the proximal face. Illustrations and a distribution map are provided for the three new species, *Anthoceros apocynon* Cargill & Palsson, *A. palssoniae* Cargill and *Anthoceros wellmanii* Cargill, along with a key to Australian Anthocerotaceae.

### Introduction

Populations of *Anthoceros* L. *sens. str.* in Australia are not common. The genus is defined by the presence of gametophyte internal schizogenous cavities (Fig. 1B), tiered jacket cells of the antheridia (Fig 1C, E), darkly coloured spores, and thin-walled multicellular pseudoelaters (Fig. 1D). Often, in the field it can be identified by the frilly appearance of the thallus due to numerous rows of lamellae over the dorsal surface (Fig. 1A). The most common species in Australia is *Anthoceros punctatus* L. though recent molecular data has confirmed that *A. agrestis* Paton is also present on the continent (Dawes *et al.* 2020). Both species belong to *Anthoceros* sect. *Anthoceros* (Grolle 1976) [= ‘*punctatus*-group’ of Proskauer (1958)] defined by their dimorphic spore distal and proximal patterns. The spore distal face of section *Anthoceros* is spiny and the proximal face foveate with smooth or spiny borders around the fovea. Spores of *Anthoceros* sect. *Fusifformes* Grolle (Grolle 1976) [= ‘*fusiformis*-group’ of Proskauer (1958)] are also dimorphic but the proximal face is defined by a distinct smooth strip either side of the triradiate mark.

McCarthy (2006) listed 14 species of *Anthoceros* but of those, ten species are now placed in other genera of the Anthocerotaceae or are regarded as synonymous with other species in the genus. While the genus in the strictest sense still requires a comprehensive revision for Australia, recent collections of hornworts from the North West Slopes of New South Wales revealed three unusual species. All three species bear spores with a smooth unornamented strip on either side of the triradiate mark of the proximal face, placing them in sect. *Fusifformes*. Species exhibiting this spore pattern have not previously been described for Australia and these collections represent three new species.



**Figure 1.** Characteristics of the family. A. Fertile plant with dorsal lamellae giving the plant a ‘frilly’ appearance. B. Transverse section through thallus showing schizogenous cavities (sch) throughout (Nos = *Nostoc* colony). C. Transverse section through involucre and sporogone showing schizogenous cavities (sch) in involucre (inv.) (assim = assimilative tissue). D. Pseudoelaters. E. Tiered jacket cells of the antheridia. All drawings by D.C. Cargill.

Two out of the three species were collected following a number of years of drought in western New South Wales which was broken by rains during a La Niña weather pattern year in Australia in 2020. This weather event led to significant germination of bryophyte spores and tubers, not only hornworts but also many *Riccia* L. and *Fossombronia* Raddi species (D.C. Cargill pers. obs.). The species described here are apparently confined to dryer areas of eastern Australia, regions where bryologists typically do not collect, particularly in very dry years, and hence no previous collections of these taxa have been made.

### Key to Australian species of Anthocerotaceae

1. Plants pale green to olive-green; short irregular lamellae growing perpendicular to dorsal surface, giving plants a ‘frilly’ appearance, plants prostrate or erect ..... 2
1. Plants green to olive-green; dorsal surface smooth, plants not appearing ‘frilly’; plants always prostrate..... 6
2. Sporophytes long (up to 80 mm long) and thin; spores spinose on the distal face, punctate on the proximal face only..... **Anthoceros punctatus**
2. Sporophytes short (2.4–10.8 mm long) and thick; spores with or without spines on distal face; never punctate on the proximal face ..... 3
3. Thallus in rosettes or half-rosettes if prostrate, or conical if erect, spores smooth distally ..... **Anthoceros palssoniae**
3. Thallus in rosettes or half rosettes, prostrate; spores spiny on distal face..... 4

4. Spores spiny on both distal and proximal faces ..... 6
4. Spores spiny on distal face only, with smooth strip on either side of trilete mark; proximal face with compressed vermiculate like ridges and projections ..... 5
5. Spores with numerous short spines (15–20 across the diameter) ..... **Anthoceros apocynon**
5. Spores with fewer, larger spines (8–10 across the diameter) ..... **Anthoceros wellmanii**
6. Plants broadly fan-shaped, not pinnately lobed ..... 7
6. Plants strap-shaped, ±pinnately lobed ..... **Folioceros fuciformis**
7. Spores tetrahedral; medium, 40–55 µm in diameter, all spores normal; pseudoelaters short 72.5–143 µm long, no thickenings ..... **Anthoceros fragilis**
7. Spores apolar; large, 64–82µm in diameter, mixed with aborted or immature spores; pseudoelaters short 22–170 µm long, occasionally with irregular thickening bands ..... **Anthoceros capricornii**

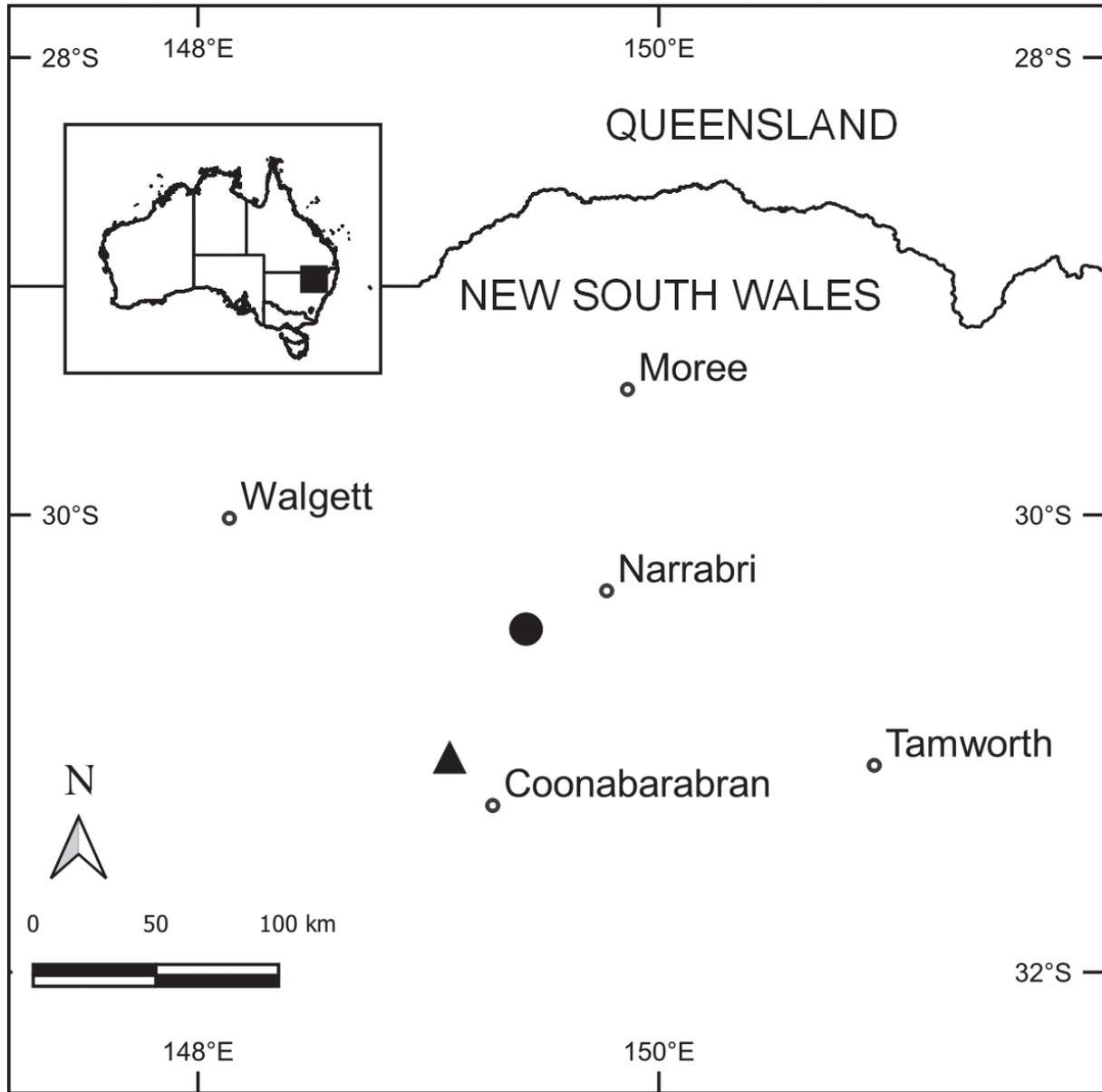
### Descriptions of new taxa

#### *Anthoceros apocynon* Cargill & Palsson, *sp. nov.*

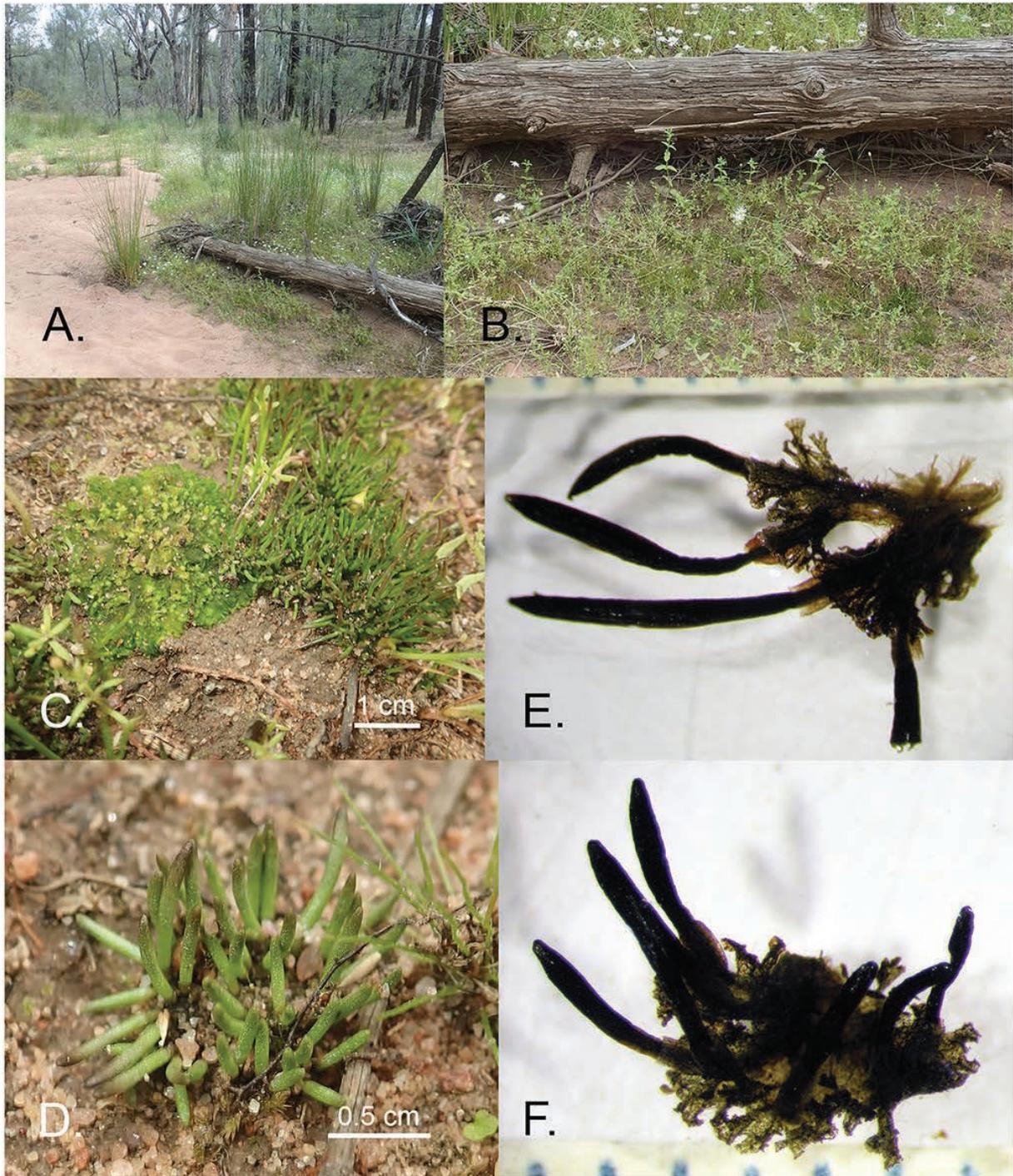
**Diagnostic characters:** Similar to *Anthoceros palssoniae* and *A. wellmanii* with which it shares short, thick sporophytes and the presence of lamellae on the dorsal surface of the gametophyte thallus, but differs in spore patterning. *Anthoceros apocynon* spores are distally spiny (vs smooth distal face in *A. palssoniae*) and there are numerous, finer spines on the distal face (vs fewer and larger spines in *A. wellmanii*).

**Type:** AUSTRALIA. New South Wales. North West Slopes. Pilliga State Conservation Area (SCA), Dog Proof Fence Rd, in tributary of Goona Ck, edge of creekline in plain of *Allocasuarina luehmannii* – ironbark woodland, 13 Sept. 2020 *R.L.Palsson & K.D.Durham 398(3)pp* (holotype: CANB 923469; isotype: NSW).

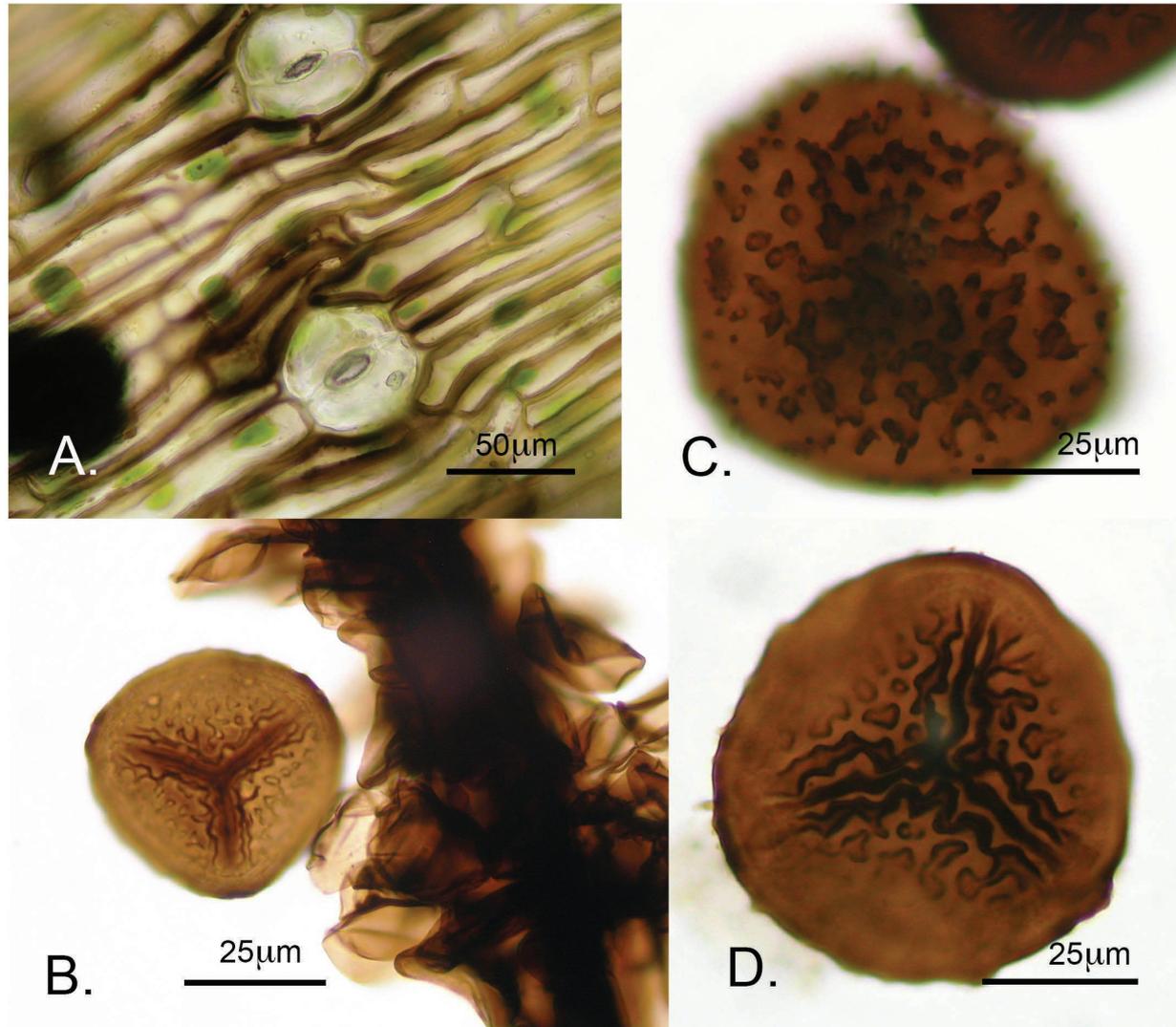
?Dioicous or strongly protandrous. Plants in patches of rosettes or half rosettes; unbranched or 2 or 3 branches forming ± fan-shaped plants, growing prostrate; 2.9–4.5 mm long, 3.0–4.75 mm wide, lobes 0.1–0.9 mm wide, margins highly dissected into smaller lobes; live plants not seen, plants becoming dark blackish green when dry. Thallus cavernous, ecostate, mid-thallus two to three mucilaginous cavity layers thick, plano-convex to fusiform in transverse section. Dorsal surface with many short lamellae and lobes. Dorsal epidermal cells polygonal, quadrate to hexagonal, isodiametric towards the apex, becoming elongate-rectangular basally, 65–150 × 30–62.5 µm, internal cells not measured; a single chloroplast per cell, pyrenoid absent, starch-free zone present. Ventral clefts not observed. Ventral epidermal cells polygonal, quadrate to hexagonal, isodiametric towards the apex becoming elongate-rectangular basally, 65–150 × 30–62.5 µm, a single chloroplast per cell, pyrenoid absent, starch-free zone present. *Nostoc* colonies present, few, scattered through thallus, appearing as large dark olive-green globose colonies. Rhizoids ventral, hyaline to pale brown, empty or mainly granular. Specialised asexual reproduction absent. Androecium not seen. Involucre erect, turbinate, 0.8–1.45 mm long, 3–5 cell layers thick or reduced to a compressed thin layer at maturity. Capsule thickly conical, emergent, 2.35–6.8 mm long, bearing two valves, opening only on one side, remaining straight and not twisted upon drying, becoming dark brown to black with maturity, foot not observed. Capsule assimilative layer 3–5 cells thick (95–190 µm thick) and sporogenous layer 1 tetrad layer thick, with well-developed columella occupying from 3/4 to full length of capsule, number of cells making up columella not observed, pseudoelaters frequently remaining attached. Epidermal cells of capsule elongate-rectangular, 50–137.5 × 12.5–25 µm, walls very thick, stomata present, 42.5–60 × 35–50 µm. Spores dark brown to almost black, irregularly globose to triangular-globose in polar view, tetrahedral shape in equatorial view, concave at centre of proximal surface apex due to flanges on either side of triradiate mark, equatorial diameter 67.5–85 µm, polar height 42.5–57.5 µm. Distal face covered with short clavate-shaped spines coalescing to form short ridges, spiny around the circumference; cingulum absent; proximal face with a flange on either side of the triradiate mark, narrow, wavy subtending a smooth strip either side of the triradiate mark; triradiate mark thin, but distinct. Pseudoelaters translucent brown, remaining attached or becoming detached from columella, thin-walled; 1–4 cells long, 32.5–87.5 µm long, 15–37.5 µm wide; frequently branched, surface smooth. Figs 2–7.



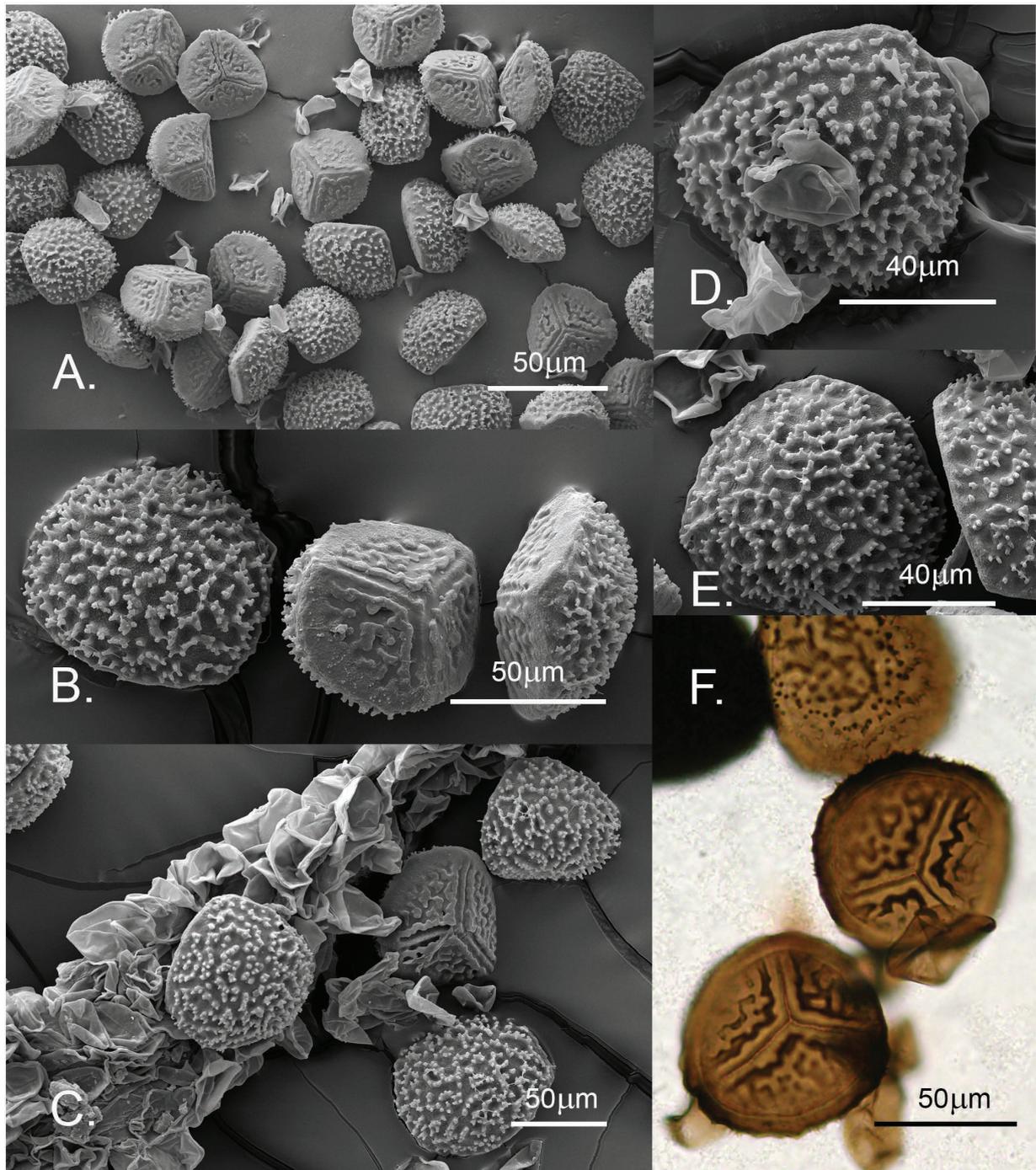
**Figure 2.** Distribution of *Anthoceros apocynon* and *A. palssoniae* (●) *A. wellmanii* (▲).



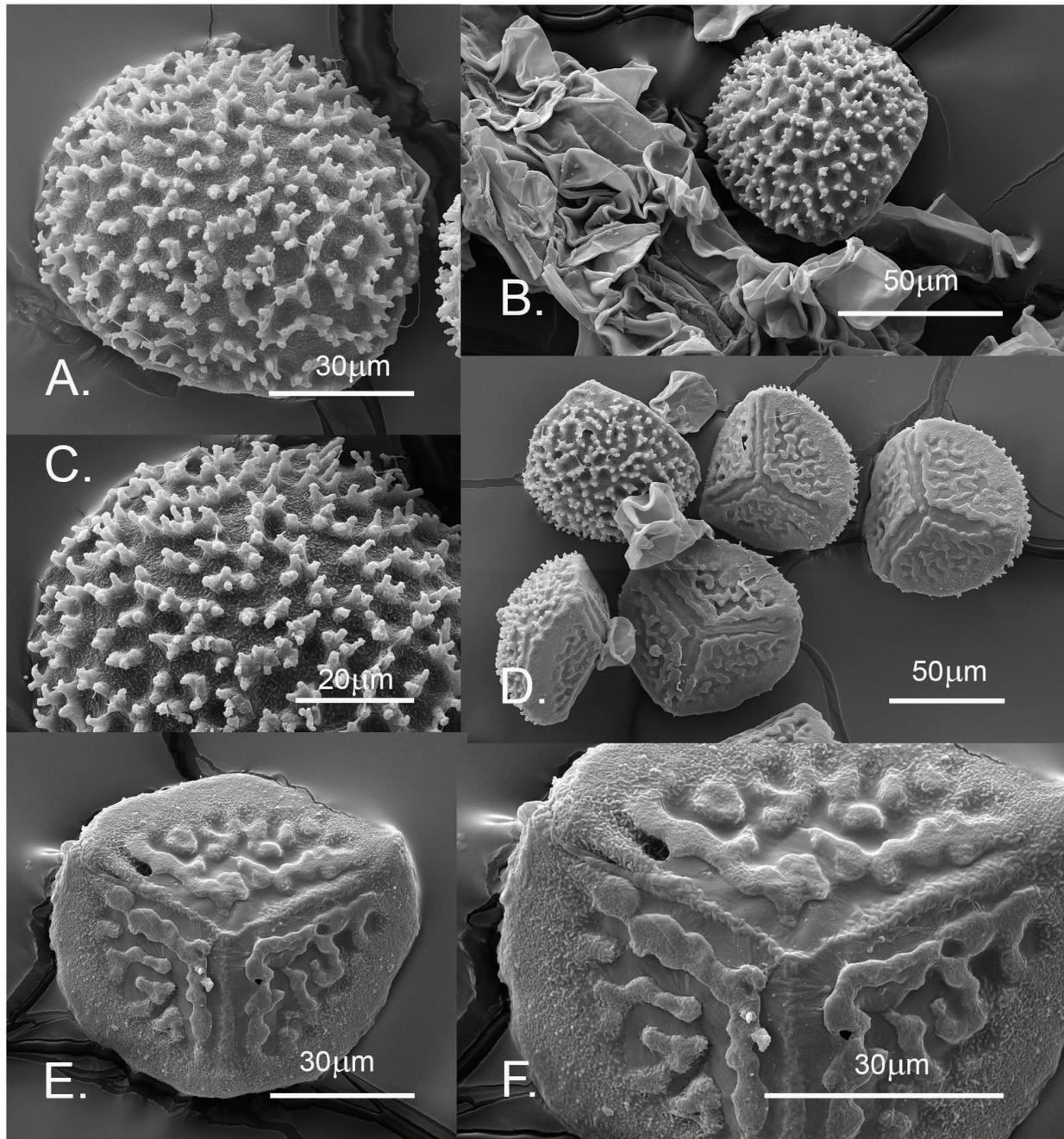
**Figure 3.** A, B. Habitat of *Anthoceros apocynon* and *A. palssoniae*. C. *Anthoceros apocynon* (on the right next to a rosette of *Phaeoceros* sp.) in situ (from *R.Palsson* 398(2) CANB). D. Fertile plants of *A. apocynon* in their natural habitat (from *R.Palsson* 398(3) CANB). E, F. Individual plants of *A. apocynon*, scale divisions = 1 mm (from *R.Palsson* 398(3) CANB). Photos A–D by R. Palsson; photos E–F by D.C. Cargill.



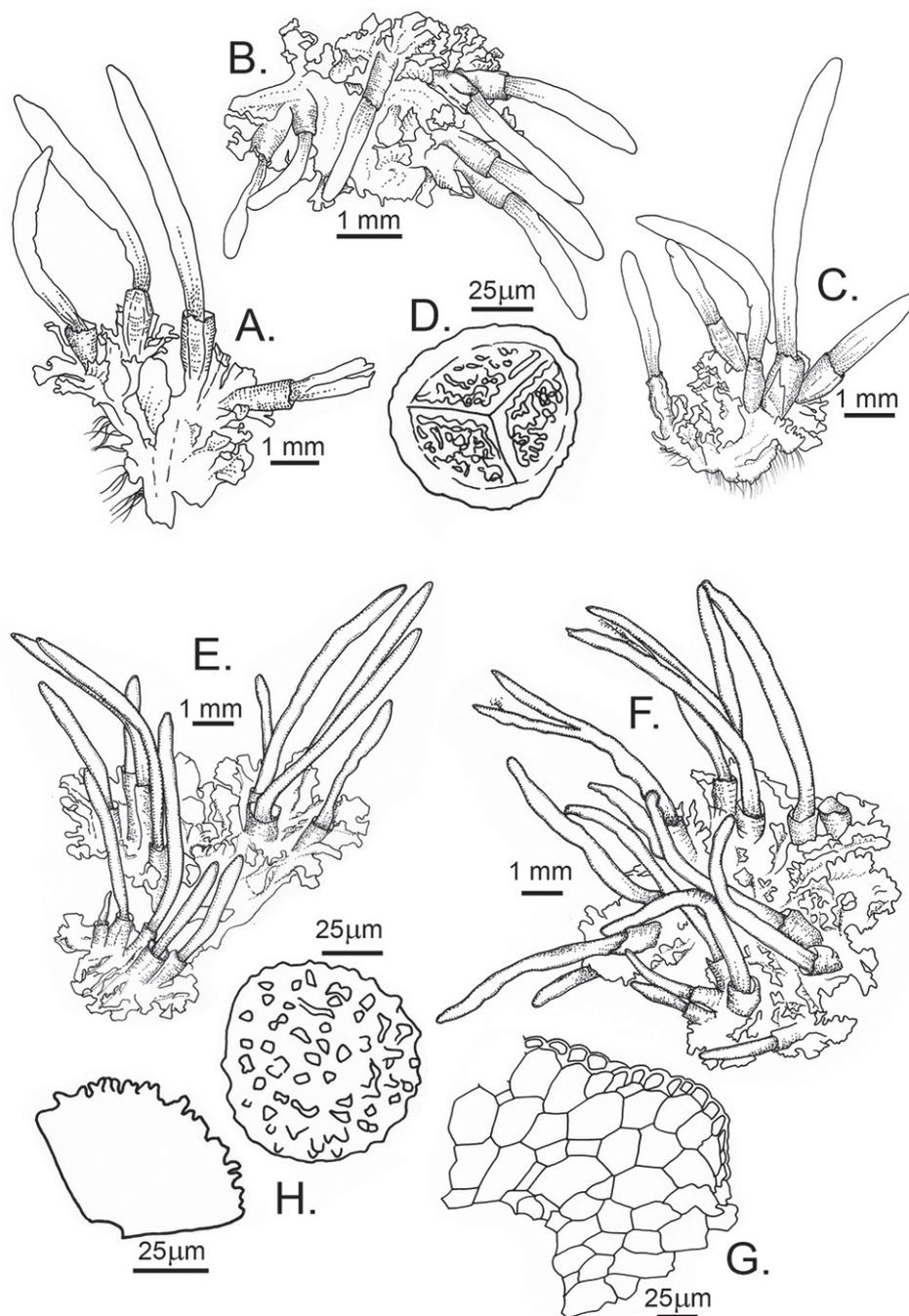
**Figure 4.** *Anthoceros apocynon*. A. Light micrographs (LM) of epidermal cells of the sporophyte. B. LM of columella with pseudoelaters attached and proximal view of spore to the left. C. LM of distal view of spore. D. LM of proximal view of spore. (All images from *R. Palsson* 398(3) CANB). Photos by D.C. Cargill.



**Figure 5.** SEM and LM images of spores of *Anthoceros apocynon*. A, B, D, E. Showing different faces of spores: distal, proximal and side views. C. Columella of sporophyte with spores and pseudoelaters attached. F. LM view of spores showing both distal and proximal faces. (All images from *R. Palsson* 398(3) CANB). Photos by D.C. Cargill.



**Figure 6.** A–F. SEM images of spores of *Anthoceros apocynon* showing variations in the distal and proximal patterns. (All images from *R. Palsson* 398(3) CANB). Photos by D.C. Cargill.



**Figure 7.** A–C. Whole plants of *Anthoceros apocynon*. D. Proximal view of spore of *A. apocynon*. (All drawings from R.Palsson 398(3) CANB). E, F. Whole fertile plants of *Anthoceros wellmanii*. G. Cross-section through the sporophyte of *A. wellmanii*, showing the single layer of epidermal cells and the 5-celled assimilative layer below that. H. Distal view and side view of spores of *A. wellmanii*. (All drawings from P.Wellman 588A.1 CANB). Drawings by D.C. Cargill.

**Notes.** The spores of this species bear a smooth strip either side of the triradiate mark, placing it in sect. *Fusifformes*. The proximal flange and the ornamentation within each of the facets consist of wide, flat, hamulate muri which run into a broad ring around the proximal face with a micro-ornamentation of tiny papillae and baculae (Fig 5E, F). The distal face is covered in numerous clavate spines which occur in short rows of two or more spines coalescing into ridges. The micro-ornamentation on the face of the distal surface consists of numerous baculae (Figs 4, 5A, B, C). Also, pseudoelaters are uncharacteristically short, a phenomenon of species with large spores (Figs 4A, C, D and 5B, D) (Villarreal *pers. comm.* 13<sup>th</sup> Oct. 2020; see *A. adscendens*, *A. capricornii*).

Vegetatively *A. apocynon* is very similar to the other two new species in the frilly nature of the thallus due to dorsal lamellae, however, plants grow prostrate rather than erect, as seen in *A. palssoniae*. The chloroplasts

of the species epidermal cells lack a pyrenoid instead showing a ‘starch-free zone’ (Villarreal *pers. comm.*) or ‘pseudopyrenoid’ a term coined by Vaughn *et al.* (1992).

**Etymology.** From Greek, ἀπόκύνον, dog’s bane, a noun in apposition. The epithet is in reference to Dog Proof Fence Road, adjacent to the collection locality of the type material.

**Distribution and habitat.** Known only from the type locality in the Pilliga State Conservation Area on the north-western slopes of New South Wales. The type collection was made from *Allocasuarina luehmannii* – ironbark woodland on a fine layer of silt over pink-brown sand. Growing with other hornworts including *Anthoceros punctatus*, *A. palssonii* and *Phaeoceros* sp.

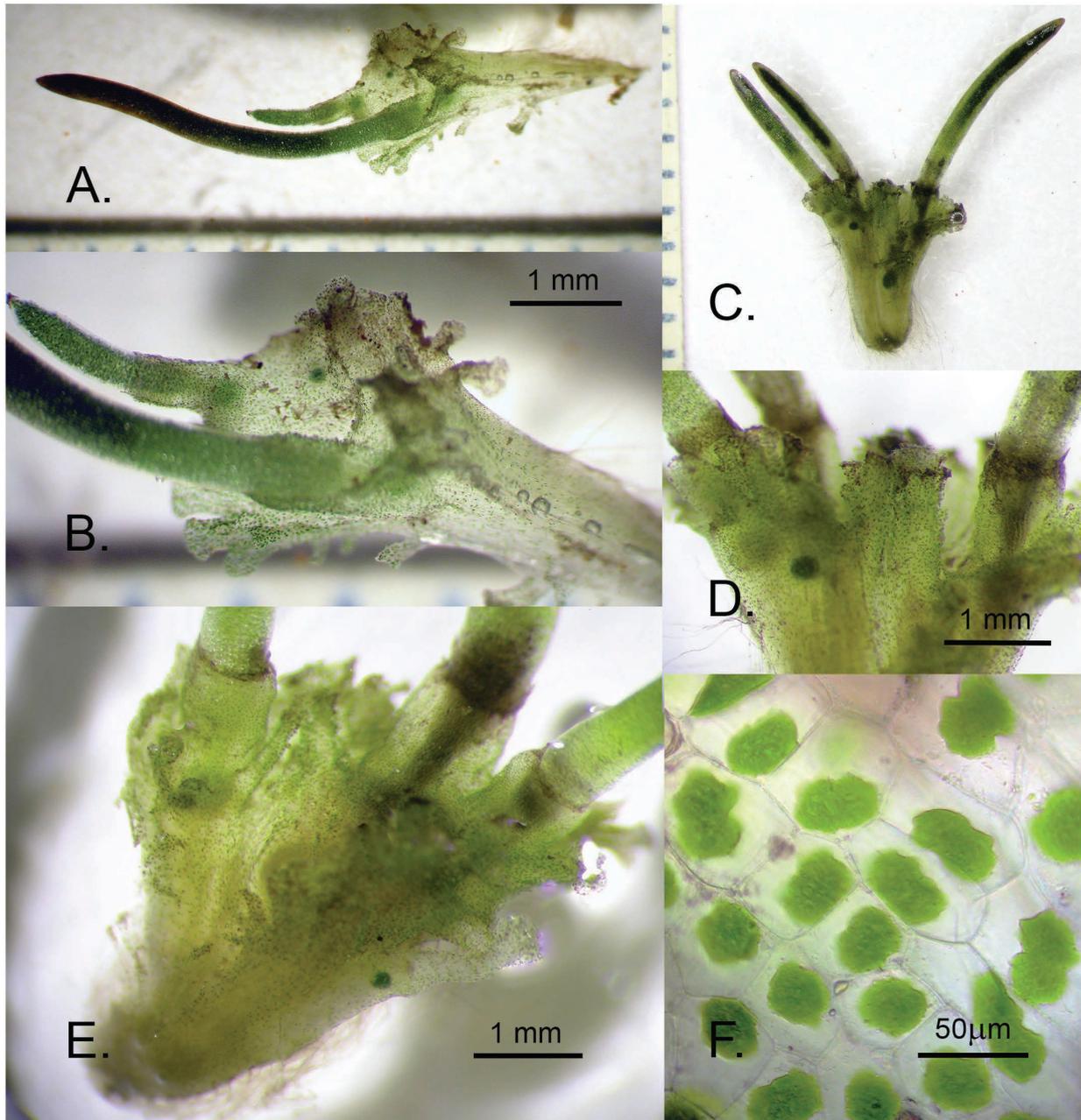
**Conservation status.** This species has not been formally evaluated. A conservation coding of “Not Evaluated” (IUCN 2019) is therefore appropriate.

***Anthoceros palssoniae* Cargill, *sp. nov.***

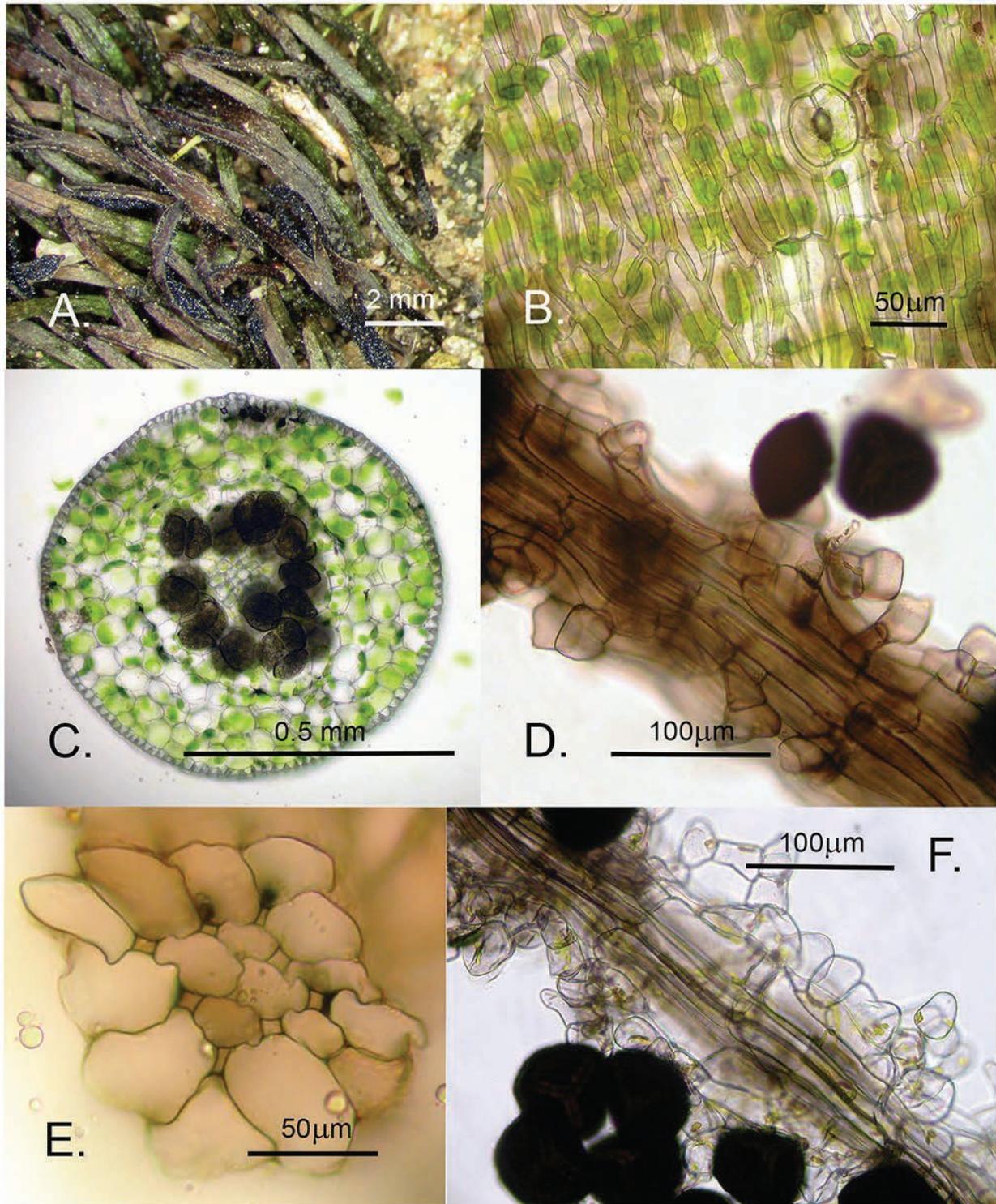
**Diagnostic characters:** Similar to *Anthoceros apocynon* and *A. wellmanii*, with which it shares numerous short lamellae on the gametophyte dorsal surface and short thick sporophytes, but differing in spore patterning, the spores of *A. palssoniae* are smooth distally, whereas spores are distinctly spiny distally in both *A. apocynon* and *A. wellmanii*.

**Type:** AUSTRALIA. New South Wales: North West Slopes. Pilliga State Conservation Area (SCA), Dog Proof Fence Rd, in tributary of Goona Ck, edge of creekline in plain of *Allocasuarina luehmannii* - ironbark woodland, 13 Sept. 2020 *R.L.Palsson & K.D.Durham* 398(2) (holotype: CANB 923468; isotype: NSW).

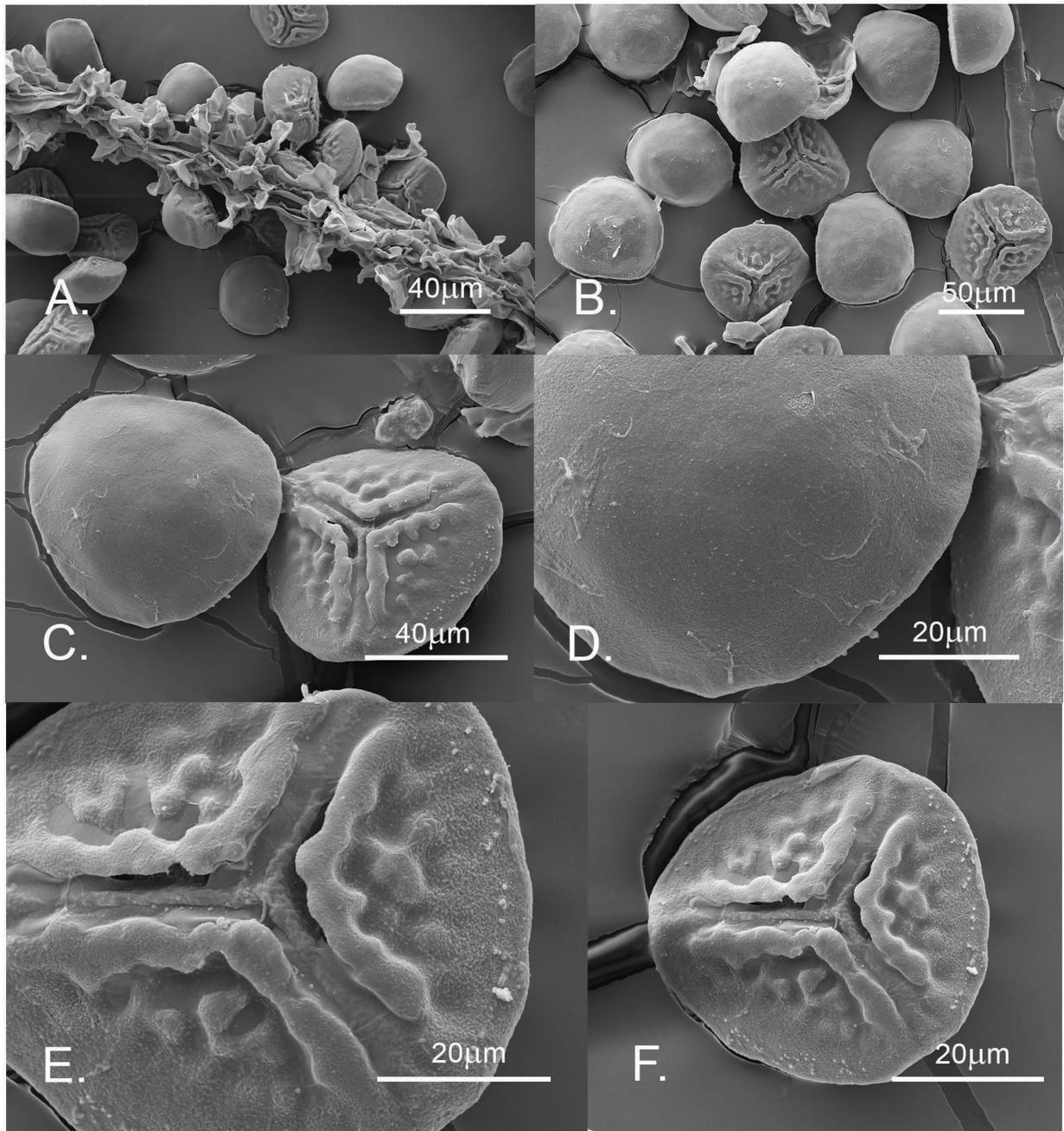
?Dioicous or strongly protandrous. Plants in patches of rosettes or half rosettes.. Multiple basal branching pattern to form fans of plants or single funnel-shaped plants, growing erect; 2.0–6.0 mm long, 3.4–9.0 mm wide, lobes 0.1–1.35 mm wide, margins dissected into smaller lobes; plants bright green (RHS 144A (yellow-green group) becoming dark greenish black when dry. Thallus cavernous, ecostate, mid-thallus two mucilaginous cavity layers thick, plano-convex to concave-convex to terete-shaped in transverse section. Dorsal surface with many short lamellae and ridges. Dorsal epidermal cells polygonal, quadrate to septagonal, isodiametric towards the apex, becoming elongate-rectangular basally, 40–245 × 25–57.5 μm, internal cells 62.5–345 × 22.5–125 μm, a single chloroplast per cell, pyrenoid absent, starch-free zone present. Ventral clefts not observed. Ventral epidermal cells polygonal, quadrate to octagonal, isodiametric towards the apex becoming long, thin and elongate-rectangular basally, 32.5–272.5 × 12.5–67.5 μm, a single chloroplast per cell, pyrenoid absent, starch-free zone present. *Nostoc* colonies present, few, scattered through thallus, appearing as large dark olive-green globose dots. Rhizoids ventral, hyaline to pale brown, empty or mainly granular. Specialised asexual reproduction absent. Androecium not seen. Involucre erect, cylindrical, 0.55–1.2 mm long, one layer of mucilaginous cavities and from 4–6 cell layers thick. Capsule thickly conical, emergent, 4.0–10.8 mm long, bearing two valves, frequently opening only on one side, remaining straight not twisted upon drying, becoming dark brown to black with maturity, foot bulbous. Capsule assimilative layer 4–5 cells thick (112.5–350 μm thick) and sporogenous layer 1 tetrad layer thick, with well-developed columella 16–20 cells, pseudoelaters frequently remaining attached. Epidermal cells of capsule elongate-rectangular, 47.5–150 × 12.5–27.5 μm, walls very thick, stomata present, 45–65 × 32.5–52.5 μm. Spores dark brown to almost black, irregularly globose in polar view, tetrahedral shape in equatorial view concave at centre of proximal surface apex due to flanges on either side of triradiate mark, equatorial diameter 65–80 μm, polar height 42.5–55 μm. Distal face smooth, micro-ornamentation finely papillate, shallowly crenulate around the circumference; cingulum absent; proximal face dominated by a flange on either side of the triradiate mark, margin quite wavy when mature and protrudes out from the proximal surface; the area between the flange and the triradiate mark is smooth without any ornamentation, triradiate mark thin, very distinct. Pseudoelaters translucent brown, detached or remaining attached to columella, thin-walled; from 1–5 cells long, 30–107.5 μm long, 20–40 μm wide, frequently branched, sometimes several branches per pseudoelater, surface smooth. Figs 2, 8–12.



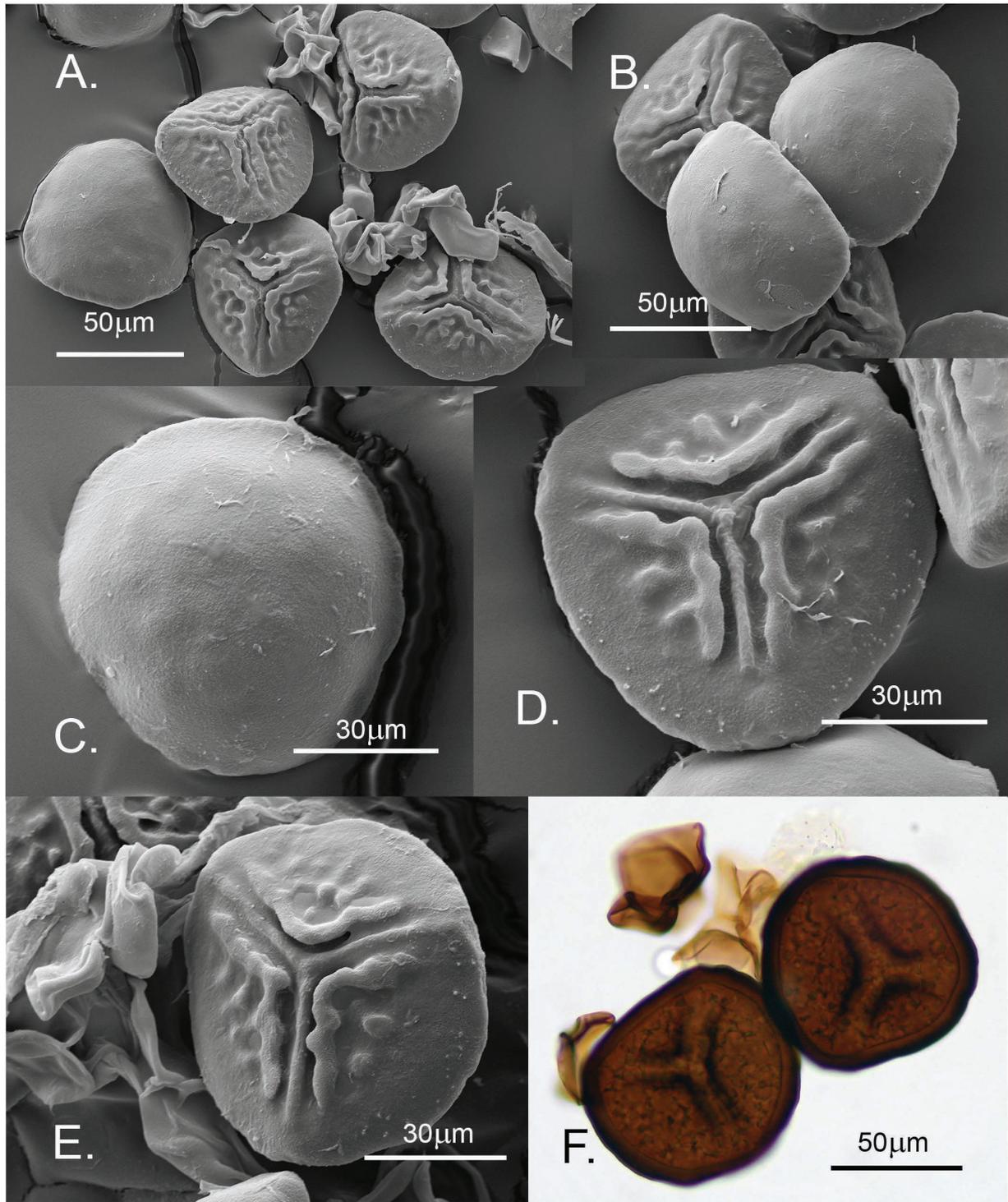
**Figure 8.** A–E. Whole individual plants of *Anthoceros palssoniae*. Scale divisions in A, C = 1 mm. F. Chloroplasts of the epidermal cells of the thallus of *A. palssoniae* showing a lack of a pyrenoid. (All images from *R. Palsson 398(2) CANB*). Photos by D.C. Cargill.



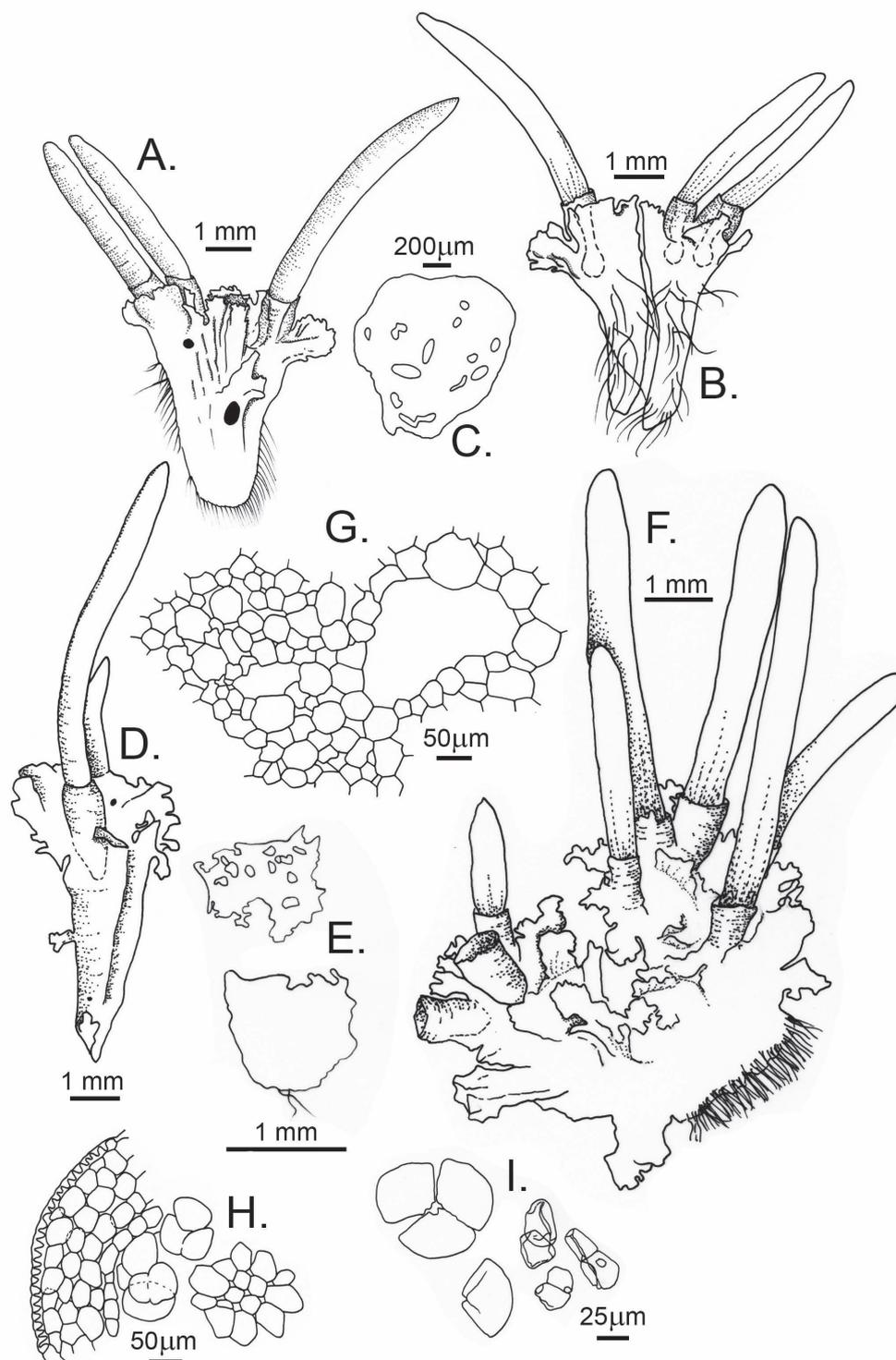
**Figure 9.** *Anthoceros palssoniae*. A. Fertile plants *in situ* (from *R. Palsson 398(1)* CANB). B. Epidermal cells and stomata of sporophytes. C. Cross-section through the sporophytes. D. Columella of sporophyte. E. Cross-section through columella. (Images C–E from *R. Palsson 398(2)* CANB). F. Columella with short pseudoelaters attached (from *R. Palsson 398(3)* CANB). Photos by D.C. Cargill.



**Figure 10.** *Anthoceros palssoniae*. SEM images. A. Columella with spores and pseudoelaters attached. B. Group of spores showing both distal and proximal views. C. Distal and proximal view of spores. D. Close up of distal surface. E. Close-up of proximal surface. F. Proximal face of spore. (All images from *R. Palsson 398(2)* CANB). Photos by D.C. Cargill.



**Figure 11.** *Anthoceros palssoniae*. A–E. SEM images of spores and pseudoelaters. F. Light micrograph image of spores and pseudoelaters. (All images from *R.Palsson* 398(2) CANB). Photos by D.C. Cargill.



**Figure 12.** *Anthoceros palssoniae*. A. Dorsal view of whole fertile plant. B. Ventral view of same plant, showing that it is two plants growing vertically, side by side. C. Cross-section through the thallus of the vertically growing plants. D. Whole fertile plant. E. Cross-section through thallus. F. Whole fertile plant. G. Cross-section through thallus showing schizogenous cavities. H. Transverse section through sporophyte. I. Spores and short pseudoelaters. (A–E, G, H from *R.Palsson* 398(2) CANB). (F, I from *R.Palsson* 398(1) CANB). All drawings by D.C. Cargill.

**Notes.** *Anthoceros palssoniae* belongs to sect. *Fusifformes*, with spores bearing distinct smooth strips either side of the triradiate mark. Spores bear a proximal flange along the triradiate mark and wide, flat hamulate muri within each of the proximal facets like *A. apocynon*, although the muri are fewer and not as flat. The muri run into a wider, plane border around the proximal face with a micro-ornamentation of tiny papillae and baculae (Fig 9E) and an irregular sprinkling of larger papillae at the very edge (Fig 9E, F) like that of *A. apocynon*. Distally, the spores of *Anthoceros palssoniae* are smooth, readily distinguishing it from all other species in the group

when fertile. Vegetatively it stands apart from all other Australian species due to the erect growth habit, which is otherwise very similar to the Indian species *A. erectus* Kahyap. However, the thallus cells of *A. erectus* have chloroplasts with pyrenoids (S. Chantanaorrapint, *pers. comm.* 2021) and the spores have a patterned distal face.

**Etymology.** Named for the collector of the type, Ruth Palsson, a botanist with a particular interest in the Australian cryptogamic flora.

**Distribution and habitat.** Known only from the type locality in the Pilliga State Conservation Area on the North West Slopes of New South Wales. The type collection was made from *Allocasuarina luehmannii* – ironbark woodland on a fine layer of silt over pink-brown sand. Growing with other hornworts including *Anthoceros punctatus*, *A. apocynon* and *Phaeoceros* species.

**Conservation status.** This species has not been formally evaluated. A conservation coding of “Not Evaluated” (IUCN 2019) is therefore appropriate.

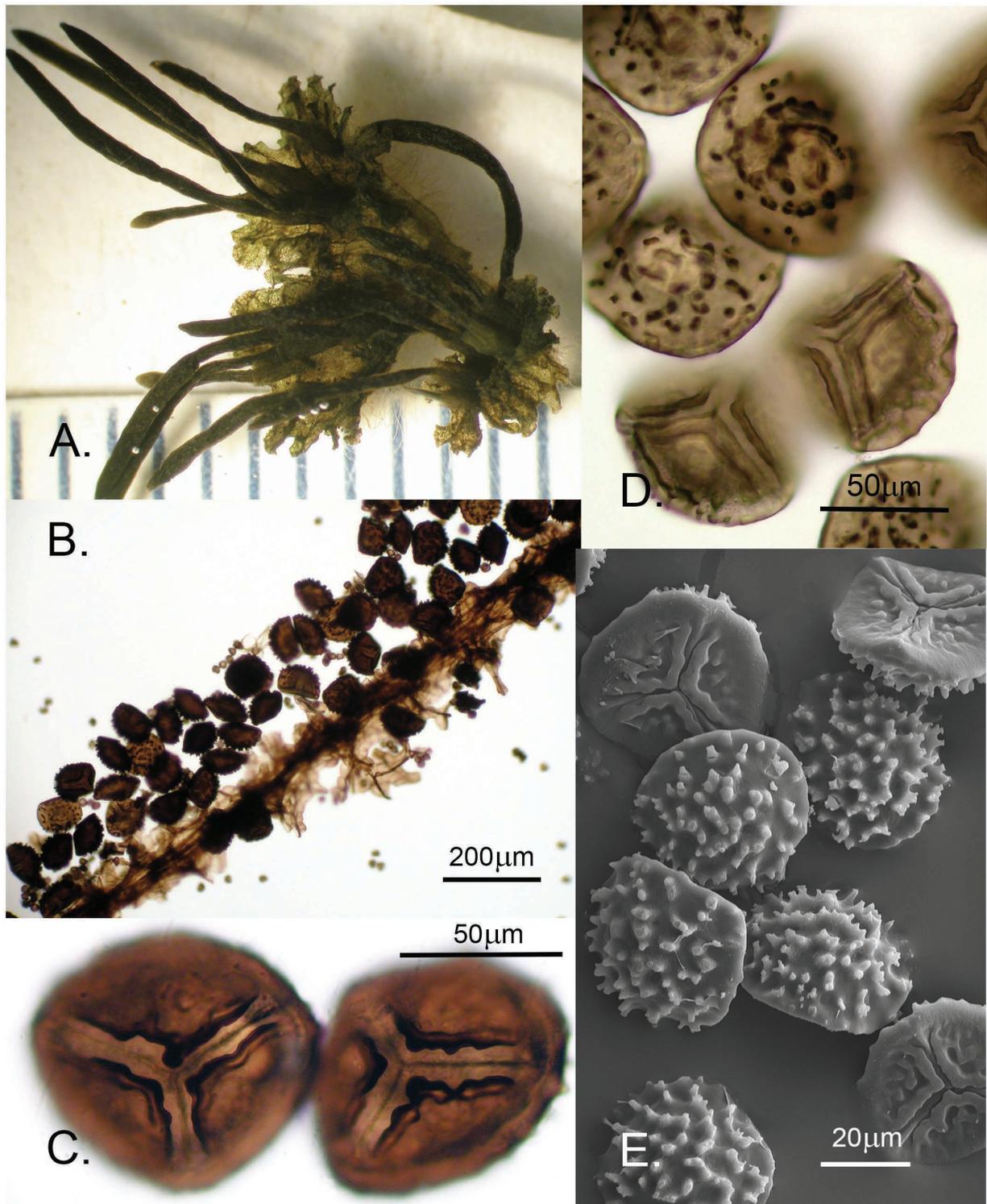
**Other specimens examined.** New South Wales: Pilliga State Conservation Area (SCA), Dog Proof Fence Rd, in tributary of Goona Ck, edge of creek line in plain of *Allocasuarina luehmannii* - ironbark woodland, 13 Sept. 2020, R.L.Palsson & K.D.Durham 398(1) (CANB 923467); R.L.Palsson & K.D.Durham 398(3)pp. (CANB 923469).

***Anthoceros wellmanii* Cargill, *sp. nov.***

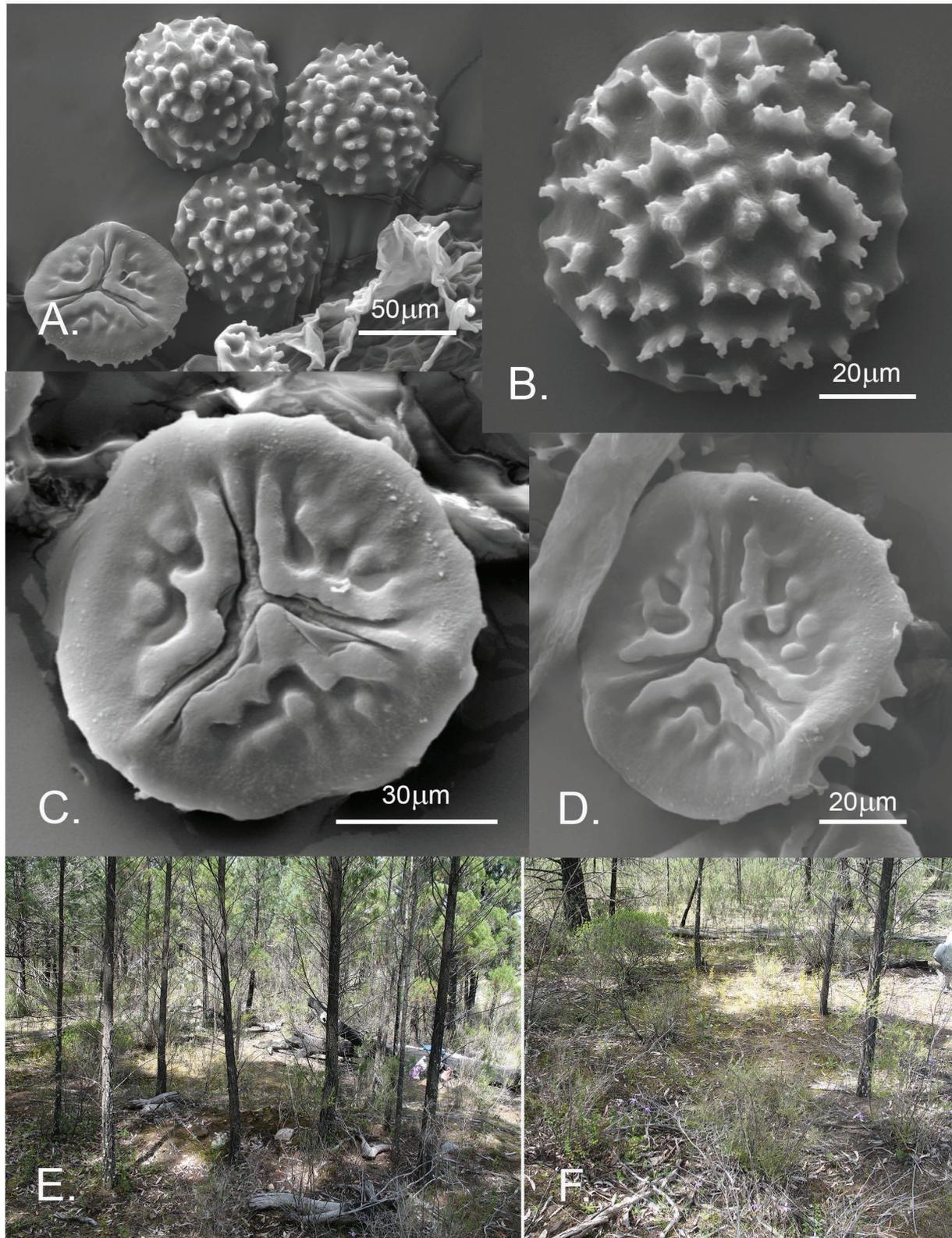
**Diagnosis.** Similar to *Anthoceros apocynon* with which it shares spores that are spiny on the distal face, with a smooth strip either side of the proximal triradiate mark. *Anthoceros wellmanii* differs in the type of spines, which are fewer, coarser, and larger than the numerous fine spines on the distal face of spores in *A. apocynon*.

**Type:** AUSTRALIA. New South Wales: North West Slopes. Yarrigan National Park, 12 km S Baradine, 33.1 km NW Coonabarabran on Baradine Rd, 21 Sept. 2010, P.Wellman 588A.1 (holotype: CANB 923459; isotype: NSW).

?Dioicous or strongly protandrous. Plants in patches of rosettes or half rosettes, multiple dichotomous branching pattern to form half rosettes or fans, 5.0–9.0 mm long, 3.2–7.8 mm wide, lobes from 0.1–5.8 mm long, 0.1–5.1 mm wide, margins dissected into smaller lobes; plants green to brown becoming dark green to brown or black when dry. Thallus cavernous, ecostate, mid-thallus one mucilaginous cavity layer thick, gradually decreasing in thickness to the margins, plants difficult to section to describe shape in transverse section. Dorsal surface with many short lamellae and ridges. Dorsal epidermal cells polygonal, quadrate to heptagonal, 30–87.5 × 20–57.5 µm, internal cells 55–135 × 45–65 µm. Chloroplast and pyrenoid details unknown. Ventral clefts not observed. *Nostoc* colonies absent or few, scattered through ventral half of thallus, appearing as olive green dots. Rhizoids ventral, pale brown, empty or mainly granular. Specialised asexual reproduction absent. Androecium not seen. Involucre sub-erect to erect, elongate goblet-shape to cylindrical, 0.6–1.6 mm long, sometimes contracted at the base, at least one layer of mucilaginous cavities and 2–5 cell layers thick. Capsule club-shaped, emergent, 3.5–7.9 mm long, bearing two valves, frequently opening only on one side, remaining straight not twisted upon drying, becoming dark brown to black with maturity. Capsule assimilative layer 3–5 cells thick and sporogenous layer 1 tetrad layer thick, with well-developed columella ~ 16 cells (cross section of the columella not obtained) due to pseudoelaters being permanently attached. Epidermal cells of capsule elongate-rectangular, 65–184.5 × 7.5–27.5 µm, but cell walls outlining individual cells difficult to observe, walls becoming thickened with maturity, stomata present, 40–55 × 25–27.5 µm. Spores brown (RHSCC 200A brown group), globose in polar view, a compressed tetrahedral shape in equatorial view but truncated at proximal surface apex due to flanges on either side of triradiate mark, equatorial diameter 77.5–92.5 µm, polar height 45–62.5 µm. Distal face with numerous rounded, truncated or forked protuberances, frequently coalescing to form short ridges, protuberances appear as spines around the circumference of the spore and are 2.5–10 µm long; cingulum present, 2.5–10 µm wide; proximal face dominated by a flange on either side of the triradiate mark, quite wavy when mature at its margins and protrudes away from the proximal surface; the area between the flange and the triradiate mark is smooth without any ornamentation, very few small verrucae or papillae occur in each proximal facet, triradiate mark very distinct. Pseudoelaters translucent brown, difficult to measure as remaining attached to columella, very few detaching, thin-walled; 2–5 cells long, 87.5–112.5 µm in length and 20–30 µm wide, frequently branched, several branches per pseudoelater, surface smooth. Figs 2, 7, 13–14.



**Figure 13.** *Anthoceros wellmanii*. A. Whole single fertile plant. Scale divisions = 1 mm. B. Columella with pseudoelaters and spores attached. C. Proximal view of spores. D. Distal and proximal view of spores. E. SEM images of spores – distal and proximal views. (Images from P. Wellman 588A CANB). All photos by D.C. Cargill.



**Figure 14.** SEM images of spores of *Anthoceros wellmannii*. A, B. Distal views of spores. C, D. Proximal view of spores. (Images from *P. Wellman 588A.1* CANB). E, F. Habitat views of *A. wellmannii*. A–D. Photos by D.C. Cargill. E, F. Photos by P. Wellman.

**Notes.** The proximal face of the spores in *A. wellmannii* are very similar to those of *A. palssoniae*, with the distinct flange and few muri on the proximal facets. However, the distal face in *A. wellmannii* has spines (Figs 12D, E, 13A, B) unlike the smooth distal face of *A. palssoniae*. Spines in *A. wellmannii* are similar to those of *A. apocynon* but are fewer and larger in *A. wellmannii* as compared to *A. apocynon*. The spores of this species are also similar to two Indian species; *Anthoceros alpinus* and *A. bharadwajii* (Asthana and Srivastava 1991) and

China (Peng and Zhu 2013) and similar species from the Americas; *A. cavernosus* Steph., *A. fusiformis* Austin, *A. macounii* M. Howe and *A. orizabensis* (Steph.) Hässel (Hassel de Menendez 1990), sharing the smooth strip either side of the triradiate mark and numerous blunt spines over the distal face. However, *Anthoceros wellmanii* spores are much larger in diameter (77.5–92.5 µm) than the Indian and American species and the proximal face is distinctly different from any of the Indian or American species (Asthana and Srivastava 1991, Hassel de Menendez 1990), which are in the most part spiny.

**Etymology.** Named for the collector of the type material and Australian National Herbarium affiliate and Australian slime mould expert, Dr Peter Wellman.

**Distribution and habitat.** Known from two populations near Coonabarabran in the North West Slopes region of New South Wales. Both collections were made in disturbed habitats. The type collection (*P. Wellman* 588A.1) was made on a 4WD track and scrapings at side of track on silty soil in a *Eucalyptus* and *Callitris* woodland. The other collection (*P. Wellman* 587A) was made on a gently sloping site on silt or clay in a *Callitris* woodland under shrubs (Figs 12 E, F). Growing amongst other hornworts such as *Anthoceros punctatus*, and *Phaeoceros* sp.

**Conservation status.** This species has not been formally evaluated. A conservation coding of “Not Evaluated” (IUCN 2019) is therefore appropriate.

**Other specimens examined.** New South Wales. 17 km NW Coonabarabran on Baradine Rd, possibly in Yearinan State Forest, between road and railway line, 21 Sept. 2010, *P. Wellman* 587A.3 (CANB 923460).

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