

## Four new species of *Arthropodium* (Asparagaceae) from central and eastern Australia

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### Abstract

Four species of *Arthropodium* R.Br. occurring in the Northern Territory, South Australia, Queensland, and New South Wales are newly described: *Arthropodium boreale* P.F.Horsfall & Jian Wang ter sp. nov., *Arthropodium glareosorum* P.F.Horsfall & Jian Wang ter sp. nov., *Arthropodium morganiae* P.F.Horsfall & Jian Wang ter sp. nov. and *Arthropodium sejunctum* P.F.Horsfall & Jian Wang ter sp. nov. The new species are illustrated and diagnosed against related species, their distributions mapped and a key to the new species provided.

### Introduction

The genus *Arthropodium* R.Br. (Asparagaceae) was established by Brown (1810) and currently contains 13 species, predominantly Australian (eight species) with one extending to New Guinea, three in New Zealand, and one each in New Caledonia and Madagascar (CHAH 2024; POWO 2024; Wang & Horsfall 2024). Since the *Flora of Australia* (Brittan 1987a, b) there have been a number of changes to the taxonomy of Australian *Arthropodium*. These changes include one addition to the genus, *A. vanleeuwenii* S.J.Dillon (Dillon & Macfarlane 2020), the reinstatement of *A. pendulum* (Redouté) DC., (Redouté 1812; POWO 2024), and the transfer of *Dichopogon strictus* (R.Br.) Baker and *Dichopogon fimbriatus* (R.Br.) J.F.Macbr. to *Arthropodium* (Conran & Walsh 1994). Three informal species *Arthropodium* sp.1, VicFlora (2024) which equates to *A. sp.* Snowy River catchment (N.G.Walsh 6195), PlantNET (2024). *A. sp.* 2, VicFlora (2024) which equates to *A. sp.* South-east Highlands (N.G.Walsh 811), PlantNET (2024) and *A. sp.* 3, VicFlora (2024) which equates to *Arthropodium* sp. Albury (A.D.J.Piesse 9), PlantNET (2024) also occur, and are currently being reviewed. The family assignment of *Arthropodium* has also changed, i.e. Laxmanniaceae in APG II (2003), Asparagaceae in APG III (2009) and APG IV (2016). Fieldwork and a study of cultivated plants have resulted in the recognition of more new taxa. Four species, *A. boreale* P.F.Horsfall & Jian Wang ter, *A. glareosorum* P.F.Horsfall & Jian Wang ter, *A. morganiae* P.F.Horsfall & Jian Wang ter and *A. sejunctum* P.F.Horsfall & Jian Wang ter are described and compared to *A. strictum* R.Br., *A. milleflorum* (Redouté) J.F.Macbr. and *A. minus* R.Br. A distribution map for the four new species, a table of diagnostic characters and a key to the eight named species recognised in central and eastern Australia are also provided.

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## Materials and methods

This study is based on observations of live material in the field and in cultivation, and the examination of dried herbarium specimens from AD, BRI, CANB, CNS, DNA, JCT, MEL, NSW, and NT. A dissecting microscope with a camera linked to a computer was used for accurate measurements and assessment of morphological characteristics on live and dried material. Measurements of roots, leaves, and inflorescences were made from dried herbarium material using a dissecting microscope and ruler. Root measurements are approximate as it can be difficult to determine an exact length of some divisions due to the tapering of fleshy necks and tubers. Measurements for the receptacle were obtained by removing both tepal whorls and measuring between the abscission zone at the pedicel apex to the ovary base. Receptacle widths have not been included. Flower dimensions are based on living plants, material reconstituted with boiling water or pressed specimens from the senior author's collection. Caudae have been measured from the adaxial side of the filament, from the inner surface where it meets the filament (where it can usually be observed), to the end of the hairs. Colours are based on fresh material. All photos were taken by the senior author, except where noted.

## Character definitions

**Roots:** consist of the three major components. 1. The *corm*. 2. The *neck* which is between corm and the tuber and occurs in two main states, either with a *cortex* (fleshy), i.e. *A. glareosorum* and *A. sejunctum*, or *stèle* (fibrous), i.e. *A. boreale*, *A. morganiae*, and either term maybe used. The neck section in the fibrous species often starts with a cortex which is ribbed and contractile, drawing the corm down to a sustainable level in the ground. This fleshy section then shrinks away as it matures (Fig. 8B). 3. *Tubers* occur at the distal end and are swollen components for storage (Dahlgren *et al.* 1985), and also act as anchors. True roots are also present, but they are not discussed in this paper and are not included in the measurements. They can grow from the corm, from the tuber base and adventitiously on tubers. Such roots are rarely seen on herbarium specimens, no doubt due to the difficulty of collection.

**Tunic:** the term is used for the persistent remains of the main nerves from the leaf sheath (Fig. 1). It is much looser in *Arthropodium* than those found in *Iridaceae*, which have a more clinging habit, but the function is the same. The tunic surrounds and acts as a protective barrier around the corm.

**Shoots:** *single shoot* or *multiple shoots* have been observed for species in the field (sometimes differing from observations of cultivated specimens) and is used in this manuscript.

**Bracts:** are separated into three variations. *Leafy bracts* or *bracts* occurring along the scape. *Bracteoles* occur at the nodes along the branches and are small and less leafy and can have diagnostic shapes; these may be either dry or green. *Cataphylls* are a smaller, scarious bract-type primarily found on *Arthropodium* species with condensed cymules, at the base of the pedicels.

**Cymules:** the branches carrying the flowers have two forms. *Branched cymules* are elongated and generally have a single pedicel per node. *Condensed cymules* have multiple pedicels per branched node.



**Fig. 1.** Example of a tunic (remnant leaf nerves surrounding the corm) of *Arthropodium fimbriatum* R.Br. (Guyra, NSW) shown on an herbarium specimen. Voucher: *Bean 17276* (BRI).

**Receptacle:** the structure at the distal end of the pedicel and below the ovary, that seats the ovary, and holds the stamen and the tepals.

**Connective:** the material fusing the anthers together, possibly an extension of the filament (Fig. 4A).

**Connective tissue:** occurs along the filament margins from the base of the anthers and is adnate to them (Fig. 4A).

**Caudae:** the term 'tails' on *Arthropodium* has been applied by previous authors (Cheesman 1906; Conran *et al.* 1993; PlantNET 2024). These 'tails' are described here as *caudae* that are present on both sides of the filament margins, occurring either at the anther bases and adnate to both the anther base and filament margin, as shown by Stringer & Conran (1991: Fig. 1K) for *A. strictum*, or along the filament as on *A. glareosorum*. The caudae of *A. boreale*, *A. morganiae* and *A. sejunctum* are relatively obscure and rudimentary, but the connective tissue (including the hairs) extends shortly down the filament, with the caudae at the base (Fig. 4B). The caudae of *A. glareosorum* are distinct and occur further along the filament (Fig. 5B). The connective tissue between the filament and hairs is difficult to distinguish.

**Capsule:** dehiscence is loculicidal, splitting along the outer surface and centre of the locule, not from the septa.

**Seed:** of *Arthropodium* have not been discussed apart from length measurements. Seed testa have distinct patterning (Stringer *et al.* 1991), but a detailed study of the potential taxonomic significance of these patterns is beyond the scope of this paper.



## Taxonomy

***Arthropodium boreale*** P.F.Horsfall & Jian Wang ter, sp. nov.

Type: Queensland. North Kennedy District: Edwards Road and Hervey Range Road, Hervey Range. 20 February 2020, P.F. Horsfall PFH4861 (holo: BRI [AQ1045612]).

Deciduous perennial herb, foliage erect, spreading, shoots multiple, plants loosely tufted to c. 10 cm diameter. *Roots* clumping, 3.5–19 cm long; *corm* growth is lateral, sequential, and branching; cortex neck thin in new growth and fibrous at maturity; *tubers* fusiform to turbinate, 14–25(–35) mm long, 6–10 mm wide. *Leaves* narrowly ensiform, 2–9 per shoot, 8–40(–55) cm long, 2–8(–10) mm wide, erect; *sheaths* canaliculate, clasping, edges smooth, white; *lamina* openly carinate, light green, adaxial surface smooth, abaxial surface with lightly raised nerves, lamina margin bullate, continuous, overlapping, slightly wavy (in plan view), ± with irregular minute asperities (Fig. 3A); *tunic*, none observed. *Inflorescence* 1 per shoot, 33–60(–80) cm long, scape 1.5–1.8 mm diameter, round in cross section, erect, 0–1 bracts before the 1st branch, branches 0–3, angular in cross section; subtended by narrow lanceolate *bracts* and reducing in size

toward the apex; branched cymule nodes subtended by a lateral adpressed subulate *bracteole* with minute asperities on the edges toward the apex, becoming membranous toward the end of the branched cymule and with a scarious *cataphyll* subtending the pedicel (Fig. 3C), *pedicels* erect to slightly arcuate, 1, rarely 2 or 3 per node, divergent, held at c. 45–90°, 18–27 mm long, reducing in length toward the apex, becoming straight with flower pollination. *Flowers* semi-pendent to pendent, 20–25 mm diameter; *receptacle* 2.4–4 mm long, slightly nodding at anthesis, becoming erect in fruit; *tepals* dimorphic, recurved, outer tepals bicoloured, inner tepals concolorous; *outer tepals* narrow elliptic, 7–11.5 mm long, 2–4 mm wide, rib narrow, 3-veined, sometimes with 2 extra outer incomplete nerves, white to whitish-pink abaxially, pink to purple adaxially; *inner tepals* elliptic, 9–11.1 mm long, 3.8–7.5 mm wide, rib narrow, 3-veined, flanges exceeding the rib apex (notched), unevenly corrugated, edges ± finely erose to roughly dentate, pinkish-purple, rarely paler. *Stamen*: *filaments* sigmoid toward the apex, 3–4 mm long, straw yellow; *caudae*, residual; *hairs* dense, irregular lengths, abutting the base of the anthers and occurring down the filament, on connective tissue that is involute, leaving the adaxial side of

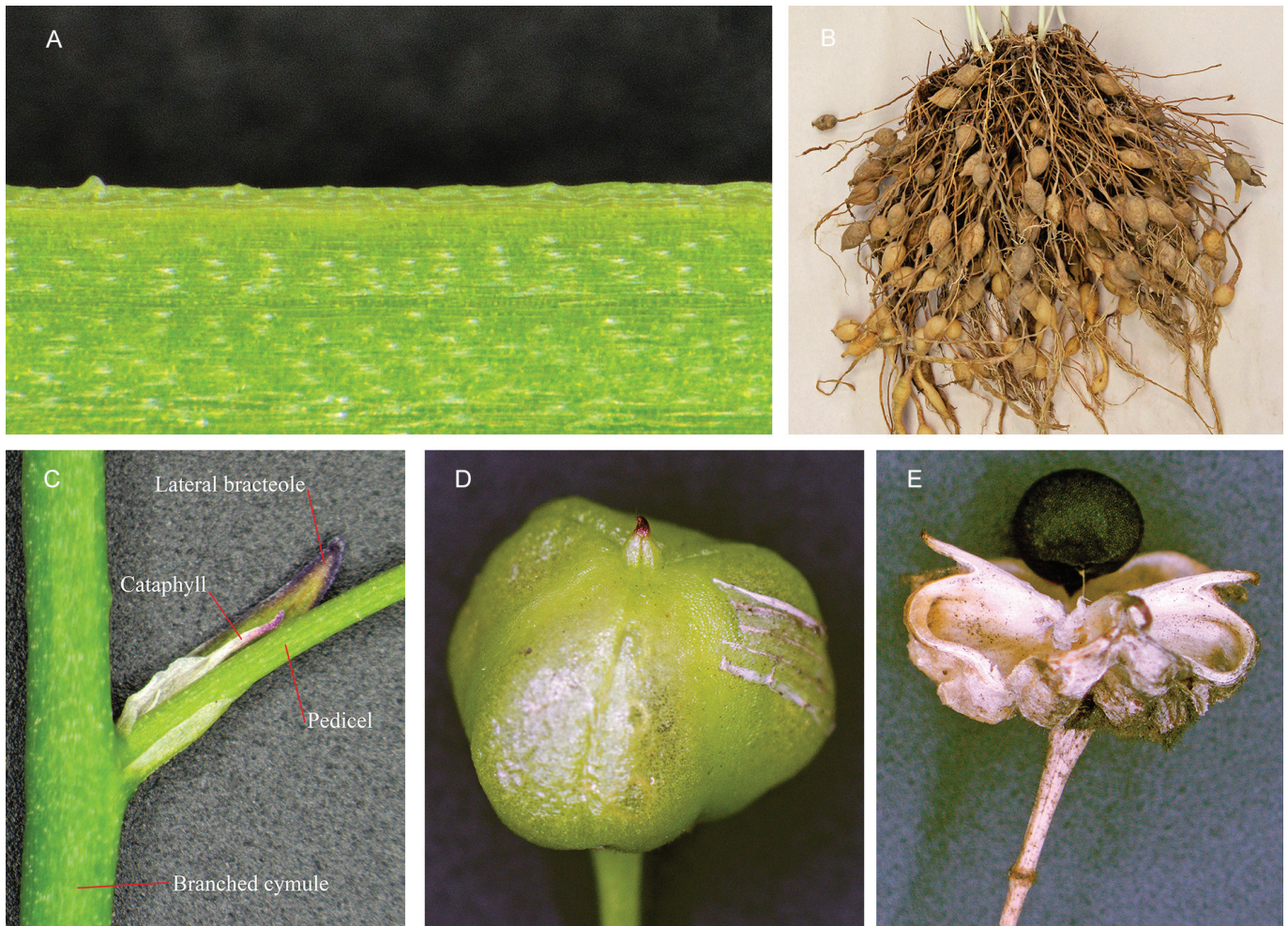


**Fig. 2.** *Arthropodium boreale* (Hervey Range, Qld, type location population). A. Flower and lateral bracteole. B. Different views of the stamen, T–B: Abaxial view showing the hairs. Adaxial view showing the open connective. Lateral view showing the apical pore of the anther and strongly sigmoid filament. C. Anther patterning on the lower theca. D. L–R: Outer tepal and inner tepal. E. Stigmatic papillae.



the filament bare and the margins and abaxial side covered (slightly elongated, cushion-like in appearance; Fig. 2B), apices glandular, bright yellow; *anthers* narrowly triangular, 3–3.8 mm long, tapering to the apex, pores flaring at the apex as the upper theca walls shrink back, pale purple to purple (rarely white), patterned with very fine forward-facing triangular, almost scale like pustules (Fig. 2C), diminishing toward the apex. *Pistil*: ovary globular, slightly lobed, 1–1.2 mm high, 1–1.3 mm wide, green; *ovules* 3, rarely 4 per locule; *style* 5.3–7.3 mm long, white

to pale yellow, opaque at the ovary, turning to purple c. 2 mm toward the stigma; *stigma papillae* erect, tufted, 0.03–0.12 mm long, just exceeding the style width, apices glandular, purple, or white, opaque. *Capsule* globular, lobed, 3.25–6.3 mm high, 4–7.6 mm wide, loculicidal dehiscence, locule apices beaked, extending beyond the capsule apex, locules dehiscent for about half the capsule height, the base shrinking upon drying forcing the locules to spread apart (Fig. 3E). *Seed* 2–2.7 mm long, testa pustulate, black, shiny. Figures 2, 3, 4B (centre).



**Fig. 3.** *Arthropodium boreale* (Hervey Range, Qld, type location population). A. Leaf laminar margin with continuous weakly undulate bullate and sparse asperities. B. Multiple shoots on clumping root structure with thinly fleshed cortex (necks) and short turbinate-fusiform tubers. C. Lateral node bracteole and inner cataphyll on a branched cymule. D. Mature capsule. E. Opened capsule showing prominent beaks (remnant style base).

**Selected specimens examined: Queensland.** Cook District: Black Rock (Lynd), Apr. 1988, *Horsup 70* (BRI). North Kennedy District: c. 72 km (45 miles) SE of Mt Garnet, Jan. 1968, *Morain 275* (BRI); near Bernhardt's Swamp, c. 5 km WNW of Ravenshoe, Mar. 1979, *Lockyer 184* (BRI); 'Taravale' near Hell Hole Ck, 0.5–1.5 km E of homestead, Mar. 1987, *Jackes 8718* (BRI); Jackes Tableland, Feb 1996, *Cumming 14342* (BRI); Kaban, Jan. 2012, *Wannan 6407, Collins, Freeman* (BRI, NSW).

**Distribution and habitat:** The occurrence of *A. boreale* is scattered in the tropics of north-eastern Queensland (Fig. 11). Currently known to occur at 380–1000 m altitude. Habitats noted on specimen labels include open woodland on rocky ground, ephemeral wet areas of rhyolite parent material, and an ephemeral soak of grey sandy soils over sandstone. The Hervey Range site is an open *Melaleuca* woodland, with an herbaceous

understorey, seasonally inundated on brown, gritty, structured shallow loam over sandstone, and badly weed infested. Associated native species at Hervey Range include *Melaleuca viridiflora* var. *viridiflora*, *Chlorophytum laxum*, *Lobelia leucotos*, *Fimbristylis dichotoma*, *Eleocharis minuta*, *Aeschynomene indica*, *Goodenia hirsuta* and *Pimelea sericostachya*, and the site has been invaded by *Lantana camara*.

**Conservation status:** Data Deficient (IUCN 2019) is suggested for *Arthropodium boreale* until field evaluations of the known (or new) sites occur. The *A. boreale* population close to Townsville occurs in a small seasonal soak, under *Melaleuca viridiflora* var. *viridiflora* and with *Eleocharis minuta*. The problematic weed species *Andropogon gayanus* (Gamba grass) and *Lantana camara* (Lantana) are affecting the site. The long-term security of the population is not guaranteed. To date other occurrences



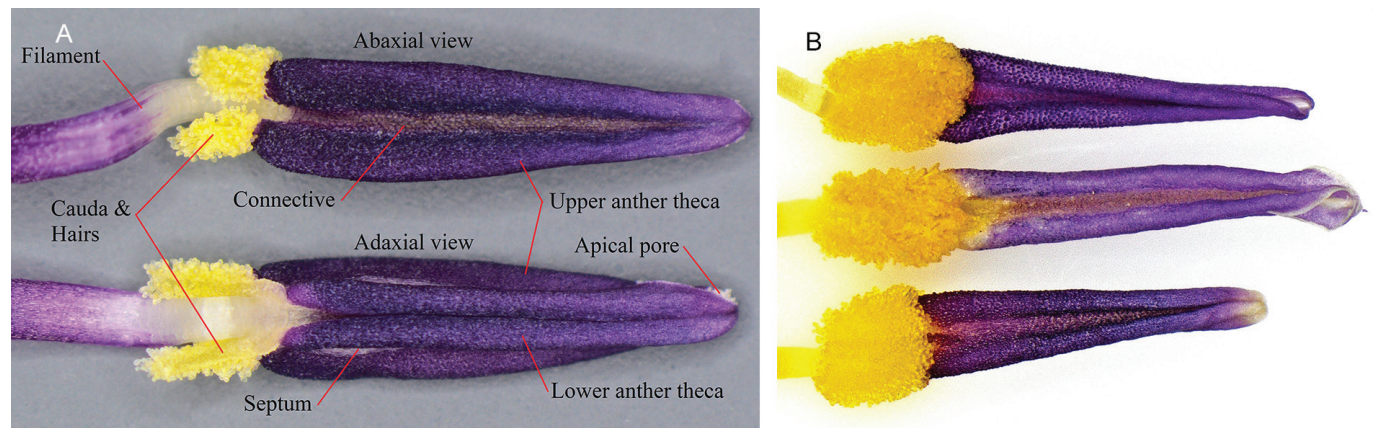
have not been observed in the field, and an assessment needs to occur to properly ascertain the species conservation status.

**Phenology:** The shoots of *A. boreale* emerge with the first rains of the northern Australia monsoonal season. Flowering mostly occurs from December to April, before plants dry off at the end of the wet and become dormant. Flowers are open for c. 10.5 hours, with up to 5 individual flowers (1 per node), opening along a branched cymule on a given day. Fruiting is recorded from January to March.

**Etymology:** The epithet *boreale* is from the Latin *borealis*, meaning north or northern, as this species has the northern most occurrence of the genus in Australia.

**Suggested common name:** 'Northern Chocolate Lily.'

**Affinities:** *Arthropodium boreale* is distinctive in the genus in having involute connective tissue on the margins of the filament's apex below the anthers, giving the attached hairs on the abaxial side a cushion-like appearance (Fig. 2B). It has previously been included with *A. strictum*, which differs in having clearly defined caudae (Fig. 4A). *Arthropodium strictum* further differs from *A. boreale* by the erect pedicels held at 25–45° to the scape; the erect, curved stamen filaments that are white and or purple; and slightly ovate anthers and the leaf margins which have raised, separate bullae.



**Fig. 4.** Stamineal comparisons A. *Arthropodium strictum* R.Br. (Benalla, Vic.). B. Comparison of stamen morphology of the three new species, T–B: *A. morganiae* (Carnarvon Gorge National Park, Qld, type location population), *A. boreale* (Hervey Range, Qld, type location population), *A. sejunctum* (Ormiston Pound, West MacDonnell National Park, NT, *Albrecht 13469*, NT).

**Notes:** Plants in the field were observed being 'buzz pollinated' by several species of native bees during field observations in January and February. However, seed set was poor over a 7-week period. Plants in cultivation have been observed to produce an aerial plantlet at the 1st inflorescence branch node, and also at the 1st flower node along a branched cymule, a trait not observed in the field. The pillow-like covering of the hairs are slightly more elongated along the connective than they are in either *A. morganiae* or *A. sejunctum*. Seed germinates readily in cultivation. White anthers occur naturally but are rare. No floral scent has been noted.

***Arthropodium glareosorum*** P.F.Horsfall & Jian Wang ter, *sp. nov.*

*Arthropodium* sp. 2, VicFlora <https://vicflora.rbg.vic.gov.au> (accessed 9 April 2024).

*Arthropodium* sp. south-east Highlands (N.G.Walsh 811) PlantNET New South Wales Flora online <https://plantnet.rbg.nsw.gov.au> (accessed 9 April 2024).

*Arthropodium* sp. Tasmania (N.Brittan s.n.) (Stringer and Conran 1991) misapplied (no specimen found).

*Arthropodium* sp. B (Conran *et al.* 1996), *p.p.* (note: description combines two species).

*Arthropodium* sp. 2 (Conran & Walsh 1994).

Type: Queensland. Darling Downs District: Mount Colliery area NE of Killarney, adjacent to Main Range National Park, 18 March

2015, P.I. Forster PIF42121, G. Leiper & S. Savage (holo: BRI [AQ838197]).

Deciduous perennial herb, foliage erect, spreading or arching, shoots single. *Roots* 2–20 cm long; *corm* growth is lateral and sequential; neck cortex fleshy; *tubers* fusiform, 1–5 cm long, 3–12 mm wide and tapering into a root from the tuber base for up to 15 cm and true roots occurring along it. *Leaves* ensiform, 2–6 per shoot, 12–35 cm long, 1.5–13(–17) mm wide; *sheath* slightly carinate, white to purple, fleshy; *lamina* flat, adaxial surface green with slightly raised nerves, abaxial surface, midrib smooth, lightly glaucous, lamina margins have rounded and or flat-topped, interrupted bullae (Fig. 5E); *tunic*, none observed. *Inflorescence* 1 per shoot, 15–50(–100) cm long; scape 0.8–1.8 mm diameter, elliptic in cross section, erect, branching 0–3(–6), with 2 or 3 leafy *bracts* below the 1st branch; branches angular, trigonal to ± elliptic in cross section, with nodes spaced along the branch length that are subtended by adpressed, smooth-edged, non-membranous, obtuse, awl-shaped to clawed *bracteoles* reducing toward the apex, 3-nerved; *cymules* condensed at the branch nodes with scarious cataphylls subtending each pedicel; *pedicels* 1–7 per node, 2–12 mm long, ± sharply declined at the bracteole, then pendent. *Flowers* 7–11 mm diameter; *receptacle* 3.1–5.5 mm long, straight, ± slightly curved, sometimes bent slightly up at the occlusion zone of the receptacle base; tepals reflexed; *outer tepals* elliptic to ovate, 3.2–5 mm long, 1–2.2 mm wide, rib 3-veined, faintly pale yellow, white, pale purple or greyish, margins entire; *inner tepals* elliptic, 3–5 mm long, 1.2–3.4 mm wide, sometimes narrower than the outer tepals, rib vaguely



3-nerved, narrow, pale yellow, white, or pale purple suffused onto the flanges, flanges white opaque, margins erose,  $\pm$  dentate (Fig. 5C). *Stamen*: filaments erect,  $\pm$  slightly curved at the ovary, 1–4 mm long, white, opaque; caudae 0.3–0.6 mm long, extending 2/3–3/4 along the filament below the anthers, adpressed; hairs not very dense to sparse, spread along the filament margin below the anther, untidy, reducing in length down the filament for about 2/3–3/4 of the way to the caudae, white, very rarely with a few minute purple hairs at the base of the anther, apices clavate; *anthers* rectangular, apex obtuse, 0.9–1.5 mm long, fully dehiscent along the septum, cream, connective between the anthers light green. *Pistil*: ovary obpyriforme (quince shaped), 1–1.3 mm high, 0.5–1.1 mm wide, pale green, ivory or fawn; *ovules* 4–6(–8) per locule; *style* 1.3–3.3 mm long, white, opaque, equal to or exceeding the stamens; *stigma papillae*, erect  $\pm$  spread, 0.03–0.07 mm long, tufted,  $\pm$  within the width of the style (untidy), apices glandular, white, opaque. *Capsule* globular, lobed, 3–3.9 mm high, 3.2–4.2 mm wide, carpels beaked and exceeding the capsule apex, dehiscence loculicidal from the distal end for about half of the height (as the lower half dries and shrinks it pulls the upper half open, freeing the seed, a bit like

opening an umbrella) (Fig. 6B). Seed 1.5–1.9 mm long, pustulate, shiny, black. Figures 5, 6.

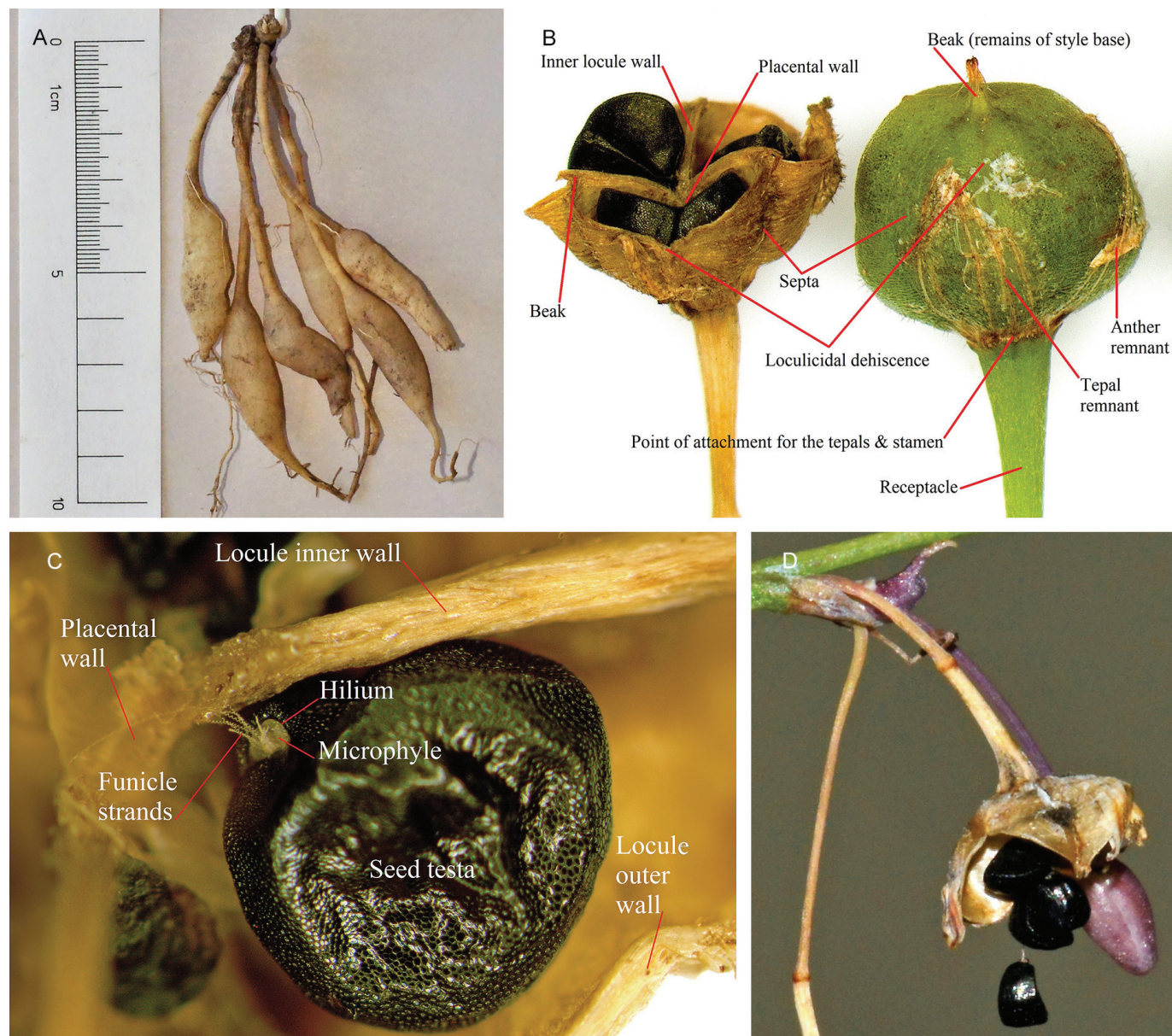
**Selected specimens examined: Queensland.** Wide Bay District: Oakview SF, 13 km SE of Kilkivan, Nov. 1990, *Pedley 5582* (BRI); Goods Road, Conondale Ranges, Feb. 1991, *Bean 2867, Drake* (BRI). Moreton District: Property of St Peters Lutheran College, 5 km NE of Crows Nest on Black Creek, Jan. 1973, *Sharpe 216 & Durrington* (BRI); Nerang River, 1 km N of Springbrook-Numinbah turnoff, Nov. 1983, *Conran s.n.* (BRI).

**New South Wales.** North Western Slopes: Slope of Ridge N of Chaffey Dam, Nov. 1993, *Hosking 874* (NSW). Northern Tablelands: 100 m S of Yarrowitch Falls, Oxley Wild Rivers National Park, Nov. 2015, *Duretto 4123 & Collins* (NSW). North Coast: Rafferty's Creek, c. 5 km direct NNE of East Kunderang Homestead, Oxley Wild Rivers National Park, Nov. 2015, *Duretto 4169 & Wright* (NSW). Central Western Slopes: Pykes Gap, Sandy Hollow to Denham Road, Jan. 1982, *Medd 160234* (NSW). Central Tablelands: Gringa Creek near Kowmung River, Mar. 1951, *Johnson s.n.* (NSW). Central Coast: Middle Harbour, Feb. 1887, *Fletcher s.n.* (NSW).



**Fig. 5.** *Arthropodium glareosorum*. A. Flower with anther thecae still to open (Ballogie, Qld). B. Hairs along the filament edges of the stamen with tepals removed (Broken Back Range, NSW). C. L–R: Outer tepal and inner tepal (Broken Back Range, NSW). D. Stigmatic papillae (Broken Back Range, NSW). E. Leaf lamina margin with flat and rounded bullate (Queen Mary Falls, Qld).





**Fig. 6.** *Arthropodium glareosorum*. A. Root structure (Broken Back Range, NSW). B. Capsules showing remnant style (beak) at the apex of the carpels and the capsule opening half-way. C. Internal structures of the capsule and seed. D. seed hanging by the funicle strands (Ballogie, Qld).

**Distribution & habitat:** Widespread in NSW from about the greater Sydney region, west and north to southeast Queensland (Fig. 11). It can be found on gravelly soils derived from rhyolite in generally shallow profiles and also on sandstone derived soils. It occurs in mixed open dry Eucalypt woodland on slopes or ridge tops at altitudes ranging from 30–1000 m.

**Conservation status:** Least Concern (IUCN 2019) is suggested. *Arthropodium glareosorum* is a common and widespread throughout its range.

**Phenology:** Flowering has been recorded from November–March with one record in July. Flowers are open for c. 9 hours. Inflorescences axes may persist (Fig. 6D) after the leaves have withered and flowering finished. Fruiting is recorded for all months.

**Etymology:** The epithet *glareosorum* is from the Latin *glareosum*, in reference to the species frequent habitat on gravelly soils.

**Suggested Common Name:** 'Yellow-anthered Rock Lily'.

**Affinities:** *Arthropodium glareosorum* has sparse to moderately dense, white, clavate hairs on the filaments and straight, cream-coloured anthers. The style is 1.3–3.3 mm long, with stigmatic papillae 0.03–0.07 mm long, with glandular apices. *Arthropodium glareosorum* has previously been confused with *A. minus* and *A. milleflorum*, but also with *A. strictum* to which there are few similarities. It is distinguished from *A. milleflorum*, which has flowers that are open for c. 10 hours, from c. 7 am–5 pm, a species with dark purple, recurved anthers (Redouté 1805); hairs along the filament margins that are denser with fine narrow-clavate apices; and a style 3–6 mm long, with clavate stigmatic papillae 0.08–0.28 mm long. It differs from *A. minus*, which has flowers that are open for about 4 hours, from c. 8 am–12 pm, a species with root tubers that are sessile; the presence of crowded purple clavate hairs along the filament margins (caudae hairs can be purple or white in *A. minus*); dark purple, recurved anthers; and a style 1–2 mm long, with globular stigmatic papillae.

**Notes:** There are occurrences from the Main Range National Park in Queensland of *A. glareosorum* [AQ625159] on rocky ridge tops



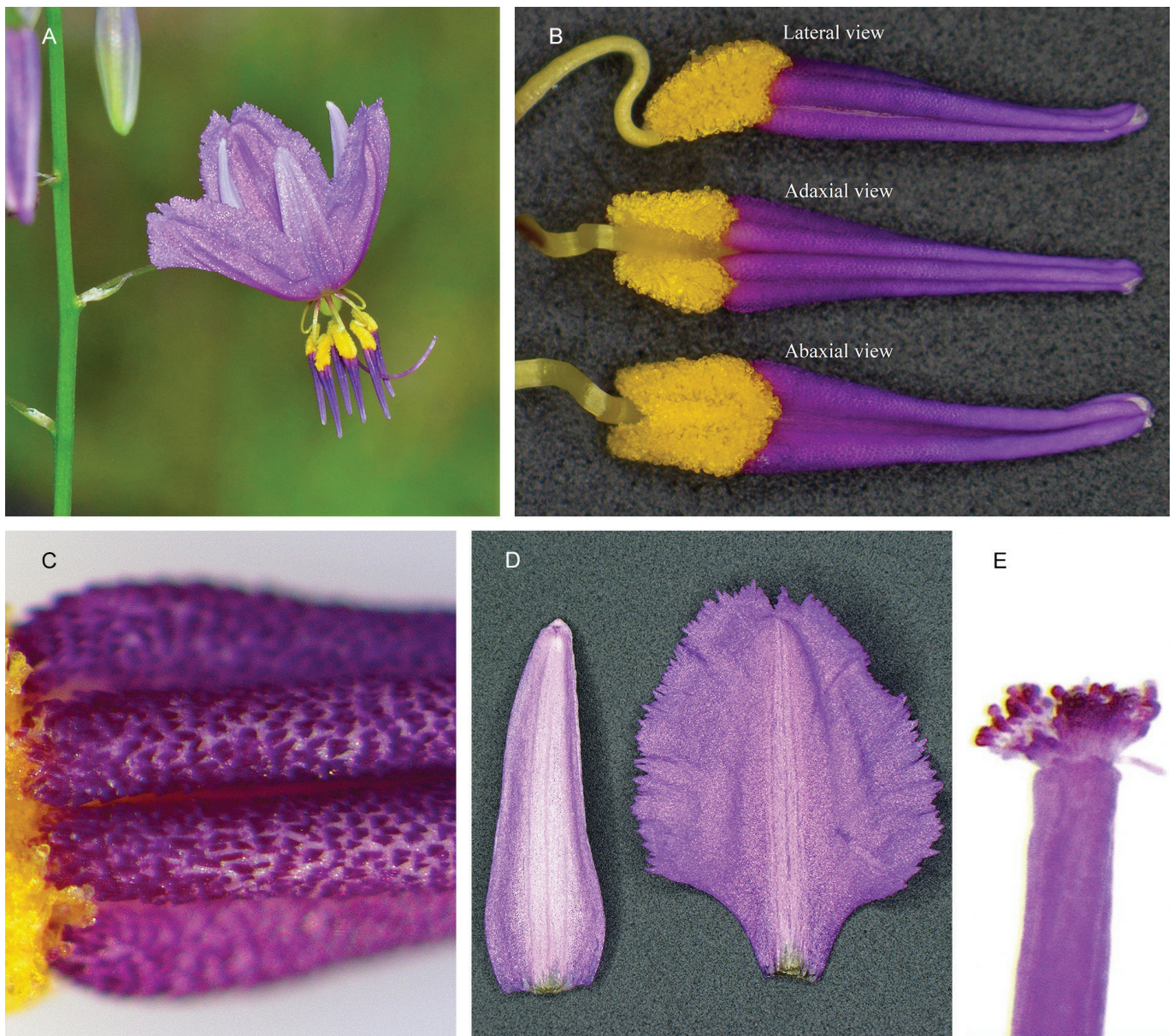
at an altitude of about 1000 m, where plants have more leaves per shoot (8–10) and are broader (c. 17 mm wide) than typical. Additionally, the stem and inflorescence are shorter and thicker, and the branched cymules are more numerous and elongated.

Seed is sometimes retained in the open capsules long after dehiscence, which may account for seed occurring in all months on herbarium sheets. They can often be seen to hang from the open capsule by the funicle threads (Fig. 6C, D). In examining specimens held at MEL, there is no definitive specimen that would equate to *A. glareosorum*, which Conran & Walsh (1994) considered to be *Arthropodium* sp. 2, or to *Arthropodium* sp. B (PlantNET 2024). There is, however, a distinct species in the Eastern Highlands of Victoria, which also occurs in New South Wales. Seed of *A. glareosorum* readily germinates in cultivation. No floral scent has been noted.

***Arthropodium morganiae*** P.F.Horsfall & Jian Wang ter, sp. nov.

Type: Queensland. Leichhardt District: Mickey Creek walk car park area, Carnarvon Gorge National Park, 15 November 2021, P.F. Horsfall PFH4797 (holo: BRI [AQ1045613]; iso: MEL, NSW).

Deciduous perennial herb, foliage erect, spreading, shoots single. *Roots* 2–12 cm long, cortex initially thick, with contractile ribbing and tapering to the tuber, withering at maturity to thinly cover the fibrous stele; *tubers* fusiform, 18–20 mm long, 7–10 mm wide. *Leaves* narrowly ensiform, canaliculate, 3–11 per shoot, 15–31(–66) cm long, 3–8 mm wide; *sheath* canaliculate, clasping, margins smooth, white; *lamina* shallowly canaliculate to flat, dull-green, adaxial surface smooth, abaxial surface ± faintly glaucous (easily brushed off), with slightly raised nerves, midrib smooth, laminar margins have interrupted, flat topped bullae with occasional acute asperities (Fig. 8A); *tunic* occasionally with a few short main vein remnants. *Inflorescence* 1 or 2 per shoot, 26–70(–100) cm long, scape to 2 mm diameter, round in cross section; *bracts* 1–2 before the 1st branch, long, narrow,

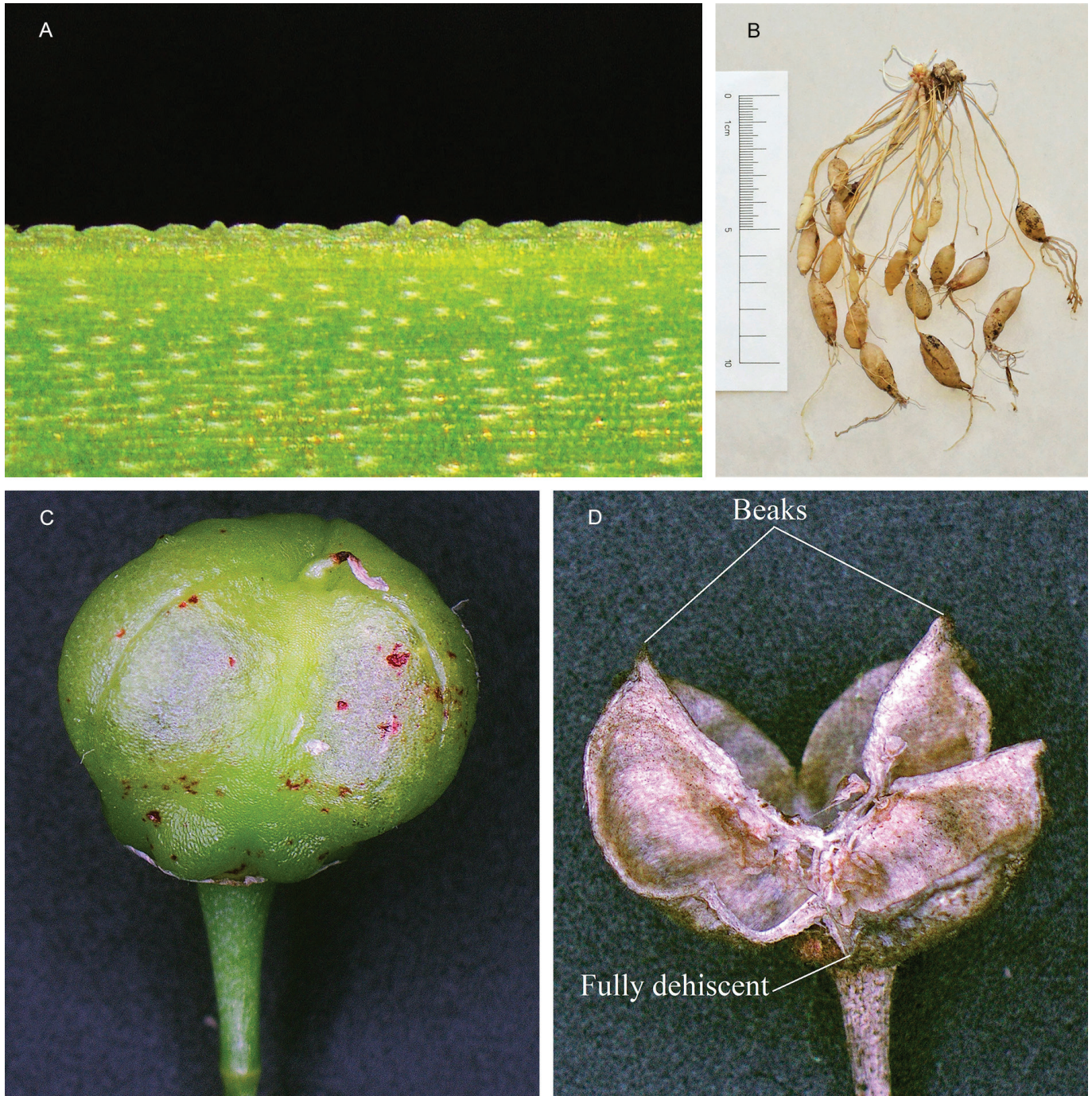


**Fig. 7.** *Arthropodium morganiae* (Carnarvon Gorge National Park, Qld, type location population). A. Flower and bracteole at the base of the pedicel. B. Different views of the stamen, T–B: Lateral view showing the small apical pore of the anther and sigmoid filament. Adaxial view showing the open connective. Abaxial view showing the hairs. C. Anther patterning detail lower theca. D. L–R: Inner tepal and outer tepal. E. Stigmatic papillae.



encompassing c. half the stem, reducing in size toward the apex, edges smooth; *branched cymules* 1–5, terete in cross section, becoming semi-terete, usually held erect and spreading, but held relatively close to each other, green to lightly glaucous; secondary branchlets sometimes present; *pedicels* erect,  $\pm$  slightly bowed, 1, rarely 3 per node, 42–22 mm long, widely divergent at 45–100°, becoming erect after pollination or flower aborting; subtended by an addressed unguiculate *bracteole* with membranous edges clasping the pedicel and nearly encircling it at the base, then sharply reducing from about 1/3 of its length from the base, apex with minute forward-facing asperities on the edges and abaxially. *Flowers* 18–28 mm diameter, nodding; *receptacle* 2–4 mm long, erect or slightly curved at anthesis, from

the articulation of the receptacle and pedicel, then becoming erect with pollination and fruit maturity, sometimes darkening to a blackish colour; tepals dimorphic, reflexed, concolorous; *outer tepals* lanceolate, 7–12 mm long, 2–4.6 mm wide, ribs 3-nerved occasionally 5, abaxially pale whitish pink, adaxially pale pinkish to purplish, base green, edging onto the tepals on both sides; *inner tepals* elliptic, 8–12.5 mm long, 3.5–10 mm wide, notched at the apex, rib wide, 3-nerved, nerves closely spaced, flanges extended, unevenly undulate, finely and unevenly dentate on the edges, pinkish-purple to purple, base green edging onto the tepals on both sides, rarely white at the base. *Stamen*: *filaments* sigmoid nearer the apex, tapering, 3.2–3.5 mm long, base purple, becoming pale greenish–yellow toward the hairs,



**Fig. 8.** *Arthropodium morganiae* (Carnarvon Gorge National Park, Qld, type location population). A. Lamina margin with flat topped bullate. B. Root structure with single sequential corm growth, cortex (neck) initial thickened growth, tapering and reducing to the fibrous stele. C. Mature capsule. D. Opened capsule.



rarely white; *caudae*, rudimentary; *hairs* dense, irregular lengths, abutting the base of the anthers and shortly down the filament, on connective tissue that is involute, leaving the adaxial side of the filament relatively bare and the margins and abaxial side covered (angular, cushion-like appearance), apices glandular,  $\pm$  angustata, clavate, bright yellow; *anthers* 3.2–4.7 mm long, 0.7–0.9 mm wide, narrowly triangular,  $\pm$  twisting to c. 90°, apex acute, poricidal opening small, anthers covered with distinct forward-facing, triangular, dark purple pigmentation, scale-like (Fig. 7C), becoming finer and paler toward the apex. *Pistil*: *ovary* elliptic, 1.2–1.3 mm high, 1.4 mm wide, pale green to mid-green; *ovules* 6–9 per locule; *style* 5.8–8 mm long, pale yellow or white from the base for c. 1.5 mm then becoming purple toward the stigma; *stigma papillae* 0.12–0.16 mm long, tufted, exceeding the style width with glandular and clavate apices, purple, white, or mixed. *Capsule* globular, slightly lobed and locules slightly countersunk at the apex, 4.5–6.4 mm high, 4.3–6.4 mm wide, loculicidal dehiscence, locule apices beaked, locules fully dehiscent (Fig. 8D). *Seed* 1.6–2.4 mm long, testa pustulate black, shiny. Figures 4B (top), 7, 8.

**Selected specimens examined: Queensland.** Leichhardt District: Palmgrove NP, NW of Taroom, Bigge Range, Nov. 1998, *Forster PIF23713* & *Booth* (BRI); Kentucky Holding, at Dawson River, c. 48 km NE of Injune, S Central Qld, Oct. 2011, *Aisthorpe CPE1972* & *Wamer* (BRI). Burnett District: Narayen, 1 Mar. 1973, *ignotus N1338* (BRI); Three Moon Ck, S of Mulgildie, Nov. 1995, *Bean 9171* & *Turpin* (BRI). Wide Bay District: Chowey Ck, 4 km NNE of Didcot, Jul. 1990, *Forster PIF6965* (BRI). Maranoa District: 'Six Mile', north flat paddock, NNW of Roma, Nov. 2005, *Eddie CPE959* (BRI); 'Oakwells', W of Injune, Oct. 2007, *Eddie BC020* & *Cosh* (BRI). Darling Downs District: Chinchilla, Nov. 1933, *Beasley 202* (BRI); Sundown NP, along 4WD track in northern section of the park, Nov. 1998, *Hazelgrove 74* (BRI). Moreton District: Gatton, 1 Nov. 1903, *Bailey s.n.* (BRI).

**New South Wales.** Northern Tablelands: Jennings, Dec. 1903, *Maiden s.n.* & *Boorman* (NSW). North West Slopes: About 22 km (direct) NNW of Ashford; 150 m SE of Macintyre Falls carpark and picnic area, Macintyre Falls Fauna and Flora Reserve. Oct. 1990, *Makinson 684*, *Coveny* & *Quirico* (NSW).

**Distribution & habitat:** *Arthropodium morganiae* occurs in southeast Queensland from Carnarvon Gorge National Park, south to northeast New South Wales (Fig. 11). In Queensland it is found as an understorey plant in open *Angophora*, *Corymbia* and *Eucalyptus* woodlands, grassland, and heathland. Occurring from 120–1180 m altitude and on a range of soils including clays, clay and sandy loams, sandy soils, and alluvium and can sometimes be locally common.

**Conservation status:** Data Deficient is suggested (IUCN 2019). Populations of *A. morganiae* appear to be somewhat disjunct throughout the SE Queensland and NE New South Wales range and poorly understood.

**Phenology:** Flowering is recorded from October through to March with one record occurring in July. Flowers are open for c. 9.5 hours. Fruit is recorded for October, February, and March.

**Etymology:** This species is named in honour of Caroline Morgan formerly of 'Vegetation Matters' in SE Queensland for

her commendable skills of hands-on ecological field-work and botanical assessment work.

**Suggested Common Name:** 'Caroline's Chocolate Lily'.

**Affinities:** *Arthropodium morganiae* and *A. boreale* are distinctive in the genus in having involute connective tissue on the margins of the filament's apex below the anthers, giving the attached hairs on the abaxial side a cushion-like appearance. *Arthropodium morganiae* can be distinguished from *A. boreale* by not having roots that are clumping or with fleshy necks. Leaves with low almost separated bullate on the margins. Pedicel bases with subtending bracteoles that are clawed and clasp at the base. The outer flange of the inner tepals is finely serrate. The overall form of the hairs on the abaxial side of the filaments are angular with a small cleft at the base (almost a pentagon in shape). Anthers with an acute apex. It has previously been included with *A. strictum*, which differs in having clearly defined cauda. *Arthropodium strictum* further differs from *A. morganiae* by the erect pedicels held at 25–45° to the scape, the erect, curved stamen filaments that are white and or purple. Slightly ovate anthers and the leaf margins which have raised separate bullae.

**Notes:** *Arthropodium morganiae* is a warm-temperate species, occurring below the tropic of Capricorn. It has been confused in NSW with *A. strictum*, but that species does not seem to occur much north of Sydney, at least not in the east. No floral scent has been noted.

***Arthropodium sejunctum*** P.F.Horsfall & Jian Wang *ter*, *sp. nov.*

Type: Northern Territory. Southern Region: NE Mt. Sonder, 8 July 1998, *P.F. Horsfall PFH 534* (holo: NT [A0096391]).

Deciduous perennial herb, foliage initially erect, spreading,  $\pm$  reclining, shoots single. *Roots* 6.5–15 cm long; *corm* growth is lateral and sequential; *neck* cortex fleshy, increasing in diameter toward the tuber, with contractile ribbing along the length; *tubers* fusiform to narrowly ovoid, 30–50 mm long, 7–15 mm wide. *Leaves* linear to narrowly ensiform, canaliculate, 5–16 per shoot, 10–50 cm long, 1–6 mm wide; *sheath* canaliculate, clasping at the base of the shoot, margins smooth, white; *lamina* 15–33 cm long, 4–6 mm wide, adaxial surface smooth, glabrous, abaxial surface matt with ridged venation, margins entire (acute in cross section), with occasional minute asperities (Fig. 10A); *tunic* short, sparse, consisting of remnant leaf sheath nerves surrounding the corm. *Inflorescence* 1 or 2 per shoot, 31–113 cm long, usually much shorter; scape 1.1–4.5 mm diameter, elliptic to circular in cross section, glabrous, smooth, subtended by 1 or 2 *bracts* before the 1st branch and reducing in size toward the apex; branched cymules 0–6, occasionally 2 or 3 at a node on the main scape, secondary branchlets sometimes present; *pedicels*  $\pm$  weakly undulate, 1 per node, spread to between 45–80° at anthesis, 10–45 mm long and reducing in length toward the branch apex, with a collar at the pedicel base; subtended by a solitary adpressed bracteole; bracteole narrow elliptic to oblanceolate, deeply concave midpoint  $\pm$  loosely clasping the pedicel, membranous margins becoming scarious in fruit. *Flowers* 16–26 mm diameter, erect to semi-nodding, 1–3 open per branched cymule (1 per node) at any one time; *receptacle* 0.9–3.5 mm long, straight to slightly recurved at anthesis,  $\pm$  declined in fruit; *tepals* dimorphic, recurved; *outer tepals* narrowly elliptic, 7.5–13 mm long, 2.5–3.8 mm wide, abaxial surface pale bluish-purple, adaxial surface purple, *rib* 3-nerved;



*inner tepals* broadly elliptic, 8–12 mm long, 5–10.5 mm wide, pink or purple, *rib* 3-nerved; *flange* undulate, margins irregularly dentate, erose, exceeding the rib apex. *Stamen*: *filaments* tapering and sigmoid toward the apex, 2.7–4.5 mm long, golden yellow; *caudae* 0.3–0.4 mm long; *hairs* dense, relatively uniform in length and abutting the anther bases and slightly extending down the filament on connective tissue that is involute, leaving the adaxial side of the filament bare and the margins and abaxial side covered (a compact cushion-like appearance), apices glandular, golden yellow; *anthers* narrowly triangular, 2.5–5 mm long, pink or purple with irregular pustule-like scaly covering (Fig. 9C) becoming smaller and paler toward a blunt, obtuse apex. *Pistil*: *ovary* globular, weakly lobed, apex well recessed, beaks not visible, 0.9–1.7 mm high, 0.9–2 mm wide, light green; *ovules* 6–8 per locule; *style* 5.2–8 mm long, cream to yellow for c. 1 mm at the base, purple above; *stigma papillae* 0.14–0.18 mm long, uniformly clavate, tufted, untidily arranged, dark purple, or

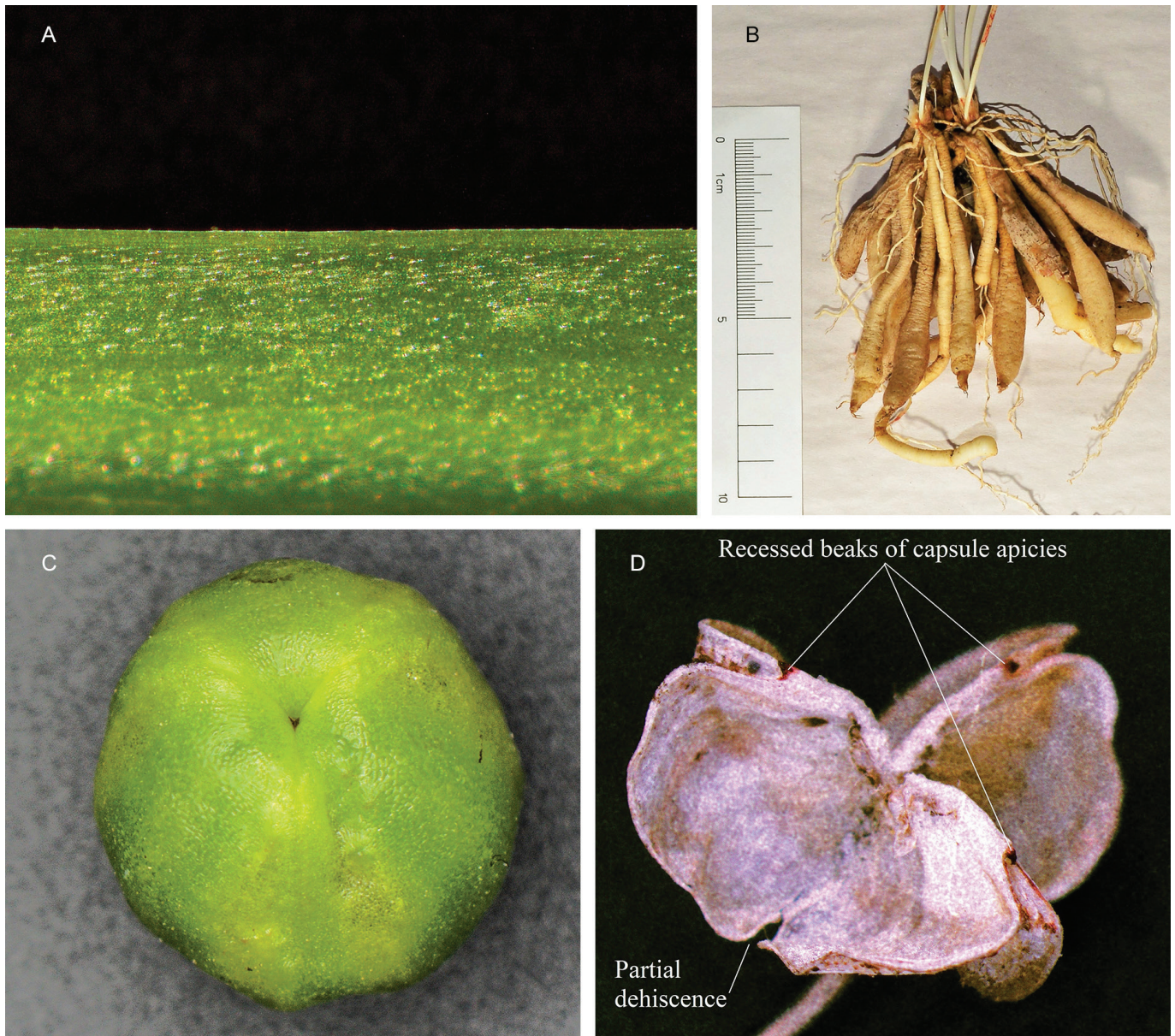
some white. *Capsule* globular, lobed, 2.5–4.7 mm high, 1.2–5 mm wide, partially dehiscent for about 1/3 of length. Capsule base shrinks upon drying and locules become fully reflexed, capsule thin and papery, brittle; locules recessed at the apex with small apical beaks (remnant style base) well-recessed (Fig. 10D). *Seed* 1.5–1.8 mm long, pustulate, shiny, black. Figures 4B (bottom), 9, 10.

**Selected specimens examined: Northern Territory.** Central Australia South Region: Ormiston Pound; c. 9 km due West of Mt Giles, Jun. 2010, *Albrecht 13469* (NT); Petermann Ranges Reserve, Pottoyu Hills 16 km south of Lasseters Cave, Sept. 1978, *Henshall 2252* (DNA); NE of Mt Sonder, Jul. 1998, *Horsfall 534* (NT); Fringe Lily Gorge, East Chewing Range, Oct. 1984, *Latz 9963* (DNA); Learmouth Park, Livingstone Pass, National Park, Mar. 1967, *Butler s.n.* (PERTH).



**Fig. 9.** *Arthropodium sejunctum* (Ormiston Pound, West MacDonnell National Park, NT). A. Flower and concave bracteole at the base of the pedicel (Photo: David Albrecht). B. Different views of the stamen, T–B: Lateral view showing the rounded (blunt) and pale anther apex and sigmoid filament. Adaxial view showing the open connective. Abaxial view showing the hairs. C. Anther patterning on upper theca. D. L–R: Outer tepal and inner tepal. E. Stigmatic papillae. Voucher: *Albrecht 13469* (NT).





**Fig. 10.** *Arthropodium sejunctum* (Ormiston Pound, West MacDonnell National Park, NT). A. Lamina margin entire (acute in cross section) with occasional minute asperities. B. Root structure (2 plants shown). C. Recessed apex of mature capsule. D. Opened capsule showing the partial loculicidal dehiscence and deeply recessed small beaks. Voucher: *Albrecht 13469* (NT).

**South Australia.** North West Region: Mann Ranges, Edwin Valley Springs, Apr. 2001, *Bates 58257* (AD); Mintabie area, Apr. 1997, *Bates 47358* (AD); S slopes of Mt Lindsay proper, c. 1 km E of Watarunga Rockhole, Aug. 1978, *Donner 6421A* (AD); Mountain 5 km S of Oortoominna Springs and E side of Jacky Pass, Musgrave Ranges, Jul. 2009, *Duguid 1022 & Latz* (AD); Mt Etitinna, 19 km SW of Mimili, Sept. 2009, *Latz 24936* (AD). Flinders Ranges: Arkaroola Sanctuary, S of Headquarters, Oct. 1971, *Kuchel 2991* (AD).

**Distribution and habitat:** *Arthropodium sejunctum* has a disjunct occurrence in southern Northern Territory and north-western South Australia (Fig. 11). In the Northern Territory it occurs in the west MacDonnell Ranges and in the Pottoyu Hills (Petermann Ranges area). In South Australia it occurs in the Musgrave Ranges, the Mann Ranges, Mount Lindsay, Illbillee Range, and the Everard Ranges. There is also a single occurrence (*Kuchel 2991*), from the Flinders Ranges. It occurs on depauperate soils. Habitat is varied. In the Northern Territory it can be found along

seasonal drainage lines, on low hills, and soaks. In South Australia it has been recorded from hilly and low-mountainous locations.

**Conservation status:** Least Concern is suggested (IUCN 2019). This species is secure in the central Australia Southern Region of the Northern Territory and the North-west Region of South Australia as locations are remote.

**Phenology:** Flowering is recorded April, June–July, September–October. Flowers are open for c. 10.5 hours. Fruit is recorded in June–July, September–October.

**Etymology:** The Latin epithet *sejunctum* means separately, in reference to the separateness and remoteness of its occurrence relative to other *Arthropodium* species (*A. vanleeuwenii* is another exception).

**Suggested Common Name:** ‘Desert Chocolate Lily’.



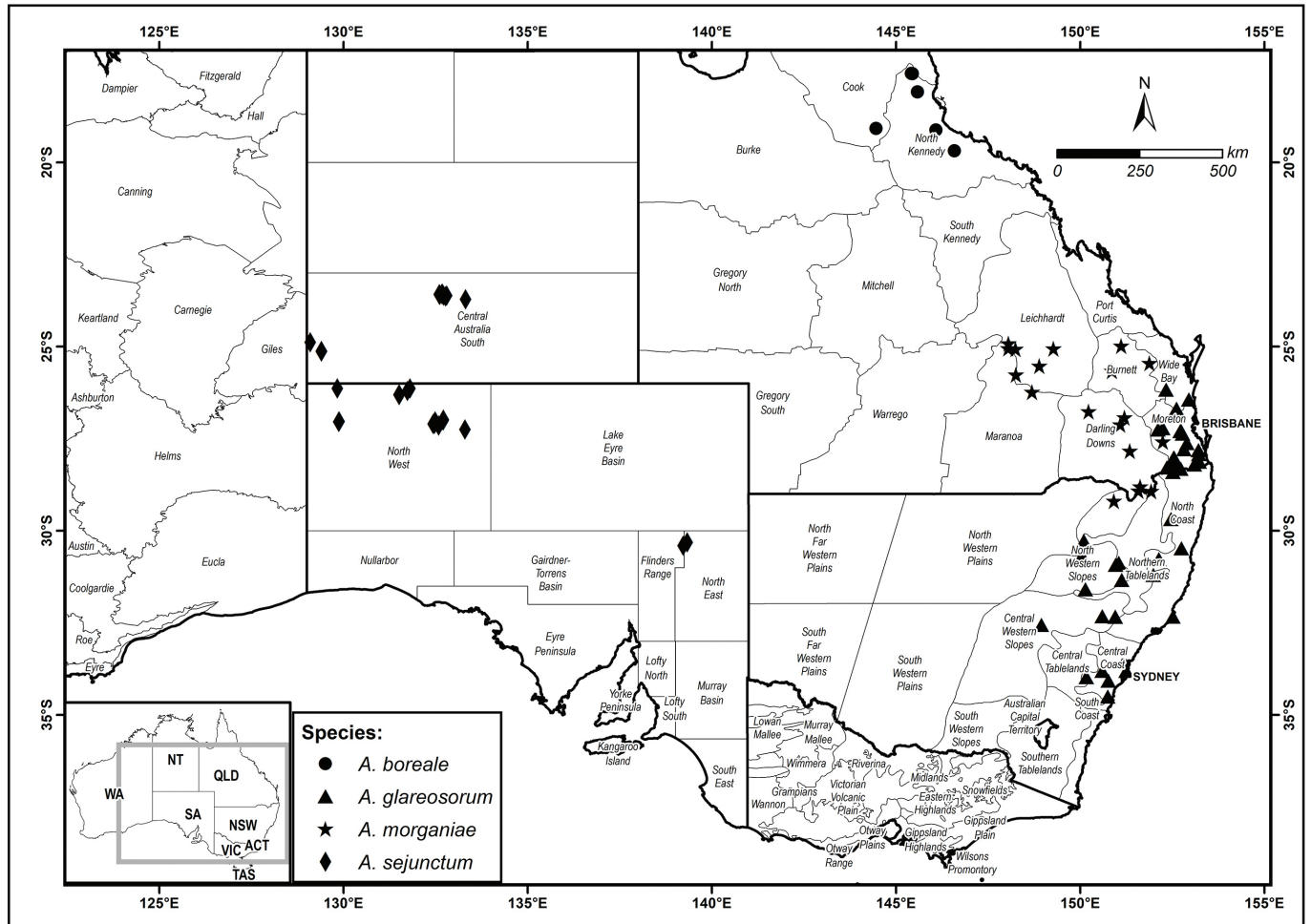


Fig. 11. Distribution map of the four new *Arthropodium* species. ● *A. boreale*; ▲ *A. glareosorum*; ★ *A. morganiae*; ◆ *A. sejunctum*.

**Affinities:** *Arthropodium sejunctum*, *A. boreale* and *A. morganiae* are distinctive in the genus in having involute connective tissue on the margins of the filament's apex below the anthers, giving the hairs on the abaxial side a cushion-like appearance. *Arthropodium sejunctum* can be distinguished from *A. boreale* and *A. morganiae* by the thicker root necks and longer tubers that taper gradually to the neck (10B); filaments and hairs that are golden yellow (rather than paler and different shades of yellow); hair clusters that are compact; the anther apex more obtuse and paler in colour, but not flared or acute; the outer flange of the inner tepals is coarsely serrate; and the leaf margins are mostly smooth, with occasional asperities. It has previously been included with *A. strictum*, which differs in having clearly defined cauda. *Arthropodium strictum* further differs from *A. sejunctum* by the shorter, fusiform to turbinate tubers with fibrous necks; the erect pedicels held at 25–45° to the scape; the erect and curved stamen filaments that are white or purple; slightly ovate anthers; and the leaf margins which have raised bullae.

**Notes:** Some specimens from the Everard Range appear intermediate between *A. sejunctum* and *A. strictum*. Some pedicels are more erect and not widely spreading as is the case with *A. strictum*, which are held at c. 25–45°, whereas *A. sejunctum* is held at c. ± 80°. The specimen *Kraehenbuehl* 3938 has an inflorescence nearly 140 cm long. The longest recorded inflorescence for *A. sejunctum* is 113 cm and *A. strictum* is 127 cm, both not far off 140 cm, but these measurements are at the far end of average lengths for both species and this might

suggest hybrid vigour. The stamens have filaments that are purple in colour at the base, which can be seen in *A. strictum* but not in *A. sejunctum*, which are a uniform golden yellow. The stamen filament shape is sigmoid as occurs in *A. sejunctum* but not in *A. strictum*, which are erect. The anthers appear to have distinct caudae, unlike *A. sejunctum*. The specimen *Eichler* 17512 has stamens with distinct caudae, but the filaments are sigmoid, and pedicel bracteoles as occur on *A. sejunctum*. The specimen *Canty* BS104–994 from the Gammon Ranges also appears to be a hybrid with *A. strictum*. Its stamens resemble those of *A. sejunctum*, but the base of the inflorescence has remnant leaf nerves (tunic) which is common on *A. strictum*.

The South Australian Everard Range material is determined as *A. sejunctum*, but needs further study. If *A. strictum* does occur through the Everard Range, it is the furthest NW and disjunct occurrence known for that species. The closest occurrence of *A. strictum* is the northern end of the Flinders Ranges. The same applies to the occurrence of *A. sejunctum* in the Flinders Ranges and both require further scrutiny to see if both parents occur in those areas. It should be noted that *A. strictum* also naturally hybridises with a number of other *Arthropodium* species. *Arthropodium sejunctum* is likely to be found in the Central East of Western Australia, given its proximity near Docker River, Northern Territory (10 km east of the Western Australia border).

Several small native bee and hoverfly species have been observed visiting flowers in cultivation. The bees buzz-pollinate



the flowers, and the flies while hovering very close have a similar effect. The vibration results in the pollen being ejected from the hollow anthers. Floral scent has been noted for Northern Territory populations by a visitor to the first authors material as being faint and sweet. A collection of the species by R.J. Bates (AD) at one site in South Australia describes the scent as a “sweet vanilla odour, not chocolate” and at other sites not having an odour. Bates also noted the difference of the stamen. In cultivation, *A. sejunctum* flowers almost continuously and plants will form clumps with multiple shoots.

## Conclusions

We here provide a key and a table of diagnostic characters (Table 1) to distinguish the four new species from currently names species in central and eastern Australia.

## Key to the *Arthropodium* species of central and eastern Australia

- 1 Anthers with lateral dehiscence .....2
1. Anthers with apical dehiscence.....4

- 2 Anthers straight, yellow..... **A. glareosorum**
2. Anthers recurving, purple .....3
- 3 Roots with fleshy necks and fusiform tubers; tepals white, ± pinkish..... **A. milleflorum**
3. Roots sessile, tubers narrowly turbinate; tepals purple..... **A. minus**
- 4 Anthers purple, with a yellow-haired cushion; caudae indistinct.....5
4. Anthers purple, without a yellow-haired cushion; caudae distinct .....7
- 5 Anther apex flared; shoots multiple..... **A. boreale**
5. Anther apex not flared; single shoot.....6
- 6 Anther apex acute; root neck fibrous..... **A. morganiae**
6. Anther apex blunt, rounded; root neck fleshy ..... **A. sejunctum**
- 7 Pedicels multiple, drooping; filaments sigmoid; caudae with purple hairs..... **A. fimbriatum**
7. Pedicels single, erect; filaments erect; caudae with yellow hairs ..... **A. strictum**

Note: Other keys to *Arthropodium* species can be found in Brittan (1987), Conran & Walsh (1994) and KeyBase (2024).

**Table 1.** Diagnostic characters for *Arthropodium* species in Central and Eastern Australia.

	<i>A. fimbriatum</i>	<i>A. strictum</i>	<i>A. boreale</i>	<i>A. morganiae</i>	<i>A. sejunctum</i>	<i>A. milleflorum</i>	<i>A. minus</i>	<i>A. glareosorum</i>
<b>Root systems</b>	necks fibrous, tubers fusiform	necks fibrous, tubers turbinate to fusiform	necks fibrous, tubers turbinate to fusiform	necks fibrous, tubers fusiform	necks fleshy, tubers fusiform	necks fleshy, tubers fusiform	tubers sessile, fusiform	necks fleshy, tubers fusiform
<b>Inflorescence No.</b>	1–5	1–5	1	1 or 2	1 or 2	1–3	1–4	1
<b>Inflorescence length (cm)</b>	30–90	19–127	33–60	26–70	31–113	14–98	8–47	15–50
<b>Cymule type</b>	condensed	branched	branched	branched with branchlets	branched with branchlets	condensed	scape, branching rare	condensed
<b>Flower width (mm)</b>	15–27	12–30	20–25	18–28	16–26	9–18	8–10	7–11
<b>Flower colour*</b>	purple	purple	purple	purple	purple	white	purple	white
<b>Flowers open / close</b>	5am–1pm	3am–4pm	5am–3.30pm	5am–2.30pm	6.30am–5pm	7am–5pm	8am–12pm	5am–2pm
<b>Staminal hairs</b>	purple on caudae, apex obtuse	yellow on caudae, apex glandular	yellow, cushion-like abaxially at filament apex, apex glandular	yellow, cushion-like abaxially at filament apex, apex glandular	yellow, cushion-like abaxially at filament apex, apex glandular	all white or ½ white & ½ purple or all yellow, apex clavate	all purple or along filament purple & caudae white, apex clavate	white along filament, apex clavate
<b>Anther length (mm)</b>	3.6–5.5	3–4.5	3–3.8	3.2–4.7	2.5–5	1.5–2.5	0.7–1.2	0.9–1.5
<b>Anther shape</b>	triangular	narrowly ovate	triangular	triangular	triangular	rectangular, recurving ± 180°	rectangular, recurved	rectangular, straight
<b>Anther colour</b>	purple	purple	purple	purple	purple	purple	purple	yellow
<b>Anther dehiscence</b>	poricidal	poricidal	poricidal	poricidal	poricidal	lateral	lateral	lateral
<b>Occurrence</b>	Qld, NSW, Vic., SA, WA	NSW, Vic., SA, Tas.	N Qld	SE Qld, NE NSW	NT, SA	Qld, NSW, Vic., SA, Tas.	Qld, NSW, Vic., SA, Tas.	Qld, NSW



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The authors declare no conflict of interest.

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## Data availability statement

The data that support this study are all available in the manuscript.

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