

## Five new species of *Calandrinia* (Portulacaceae) from Western Australia with additional information on morphological observations

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### Abstract

Obbens, F. J. Five new species of *Calandrinia* (Portulacaceae) from Western Australia with additional information on morphological observations. *Nuytsia* 21(1): 1–23 (2011). Four new Western Australian species in *Calandrinia* section *Pseudodianthoideae* von Poellnitz are described as: *C. flava* Obbens, *C. tholiformis* Obbens, *C. sculpta* Obbens & J.G. West and *C. vernicosa* Obbens. A fifth species of uncertain sectional placement is described as *C. pentavalvis* Obbens. One of the new species is found solely in coastal areas of the South West Botanical Province, one occurs within the Eremaean Botanical Province while the remaining three occur in both these regions. Notes on some field and laboratory observations of the morphology of *Calandrinia* are discussed.

### Introduction

One aim of this paper is to describe a number of currently phrase-named species within the genus *Calandrinia* which are endemic to Western Australia. In recent years, the number of phrase-named species has steadily increased due to ongoing taxonomic investigation and extensive fieldwork, and this trend appears likely to continue. Consequently, there is a need for documentation to enable these new species to be readily recognized, in particular by those associated with field surveys related to mining approvals. Four of these species are currently phrase-named on the *Census of Western Australian Plants* while the fifth is a closely related species to one of the four, but has not been phrase-named due to its very recent discovery.

Another aim is to provide information regarding morphological observations of some *Calandrinia* characters which may help improve species recognition especially for field workers. This section also highlights the diversity observed in the genus and helps to address a lack of adequate documentation on the morphology of *Calandrinia*.

### Methods

For each of the new species described, measurements were taken from either dried pressed material or from material preserved in 70% ethanol. All spirit specimens were measured wet. Frequent large variations in plant size and in other morphological characters occur within the genus, both within



and between populations due to environmental and seasonal conditions. Therefore, measurements are presented as ranges compiled from specimens of several populations across the species distribution and from both dried and spirit materials. Most measurements were made using a microscope graticule. Occasionally an estimate is given where an exact measurement was not possible. Stem, scape and inflorescence axis were measured as per the instructions in the last section. Bracts on the inflorescence axis were measured flattened out, but shape is described for bracts *in situ*. Sepal shape was described and measurements taken *in situ* on flowering specimens. Flowering times for each species are based on specimen details augmented by field observations.

SEM images were produced using a Zeiss 1555 VPSEM microscope. Microscope parameters varied for different images, but the ranges were: current 6–10 Kv, working distance 4–11 mm and aperture 30  $\mu$ m. Seed specimens were sputter-coated with gold before scanning. Images were subsequently processed using Photoshop 2.0.

### Taxonomy

***Calandrinia flava* Obbens, *sp. nov.***

*Calandriniae eremaeae* Ewart affinis sed petalis flavis, seminis nitidis leviter colliculatis.

*Typus*: Private property remnant just to the east of Solomon Road and ca. 0.5–1.0 km north of intersection with Bestry Road, 30–35 km directly east-south-east of Morawa townsite, Western Australia, 25 September 2008, *F. Obbens & B. Newman* FO 56/08 (*holo*: PERTH 08139962; *iso*: CANB).

*Calandrinia* sp. Murchison - Gascoyne (F. Obbens & F. Hort FO 49/04), Western Australian Herbarium, in *Florabase*, <http://florabase.dec.wa.gov.au> [accessed 24 January 2011].

*Annual herb*; root system a small taproot with several finer lateral roots. *Plant* semi-erect to erect, occasionally decumbent, 15–145 mm tall, 10–170 mm wide, glabrous. *Basal leaves* fleshy, elliptic to obovate, sometimes oblong, 2.8–25 mm long, 0.7–3.8 mm wide, with a medial shallow groove on the adaxial surface, grey-green to dark purple-brown. *Stems* few to several (usually 1–9), 3–120 mm long, radiating out and slightly upwards from base, occasionally branched. *Stem leaves* fleshy, narrowly elliptic to obovate sometimes broader, to 16 mm long and 4.4 mm wide, alternate, usually in small clusters at stem ends. *Scapes* 3.5–45 mm long and bare. *Inflorescence axis* 7.5–75 mm long, bare except for 3 to several  $\pm$  scarious bracts opposite each flower pedicel, generally forming a loose cyme. *Inflorescence axis bracts* appressed to  $\pm$  spreading, triangular, occasionally narrowly so, 0.8–3.0 mm long, 0.5–1.7 mm wide, apex acute to long-acuminate. *Pedicel* 2.5–6.8 mm long, erect, to 12 mm long in fruit, moderately reflexed. *Flowers* 2.9–5.6 mm diameter. *Sepals* thin, ovate to broadly ovate, 1.7–3.0 mm long, 1.4–3.4 mm wide, free to base, prominently 3 to 5 nerved. *Petals* 5, bright yellow occasionally suffused with red, obovate, emarginate and with a small mucro, 2.3–3.0 mm long, 1.5–2.1 mm wide, free to base. *Stamens* 6–12 in 1 row, alternating long and short, occasionally one or two stamens slightly offset from the row; filaments free, 0.7–1.7 mm long, attached to the top of a basal ring beneath the ovary, minutely papillose on lower basal adaxial portion; anthers broadly elliptic to broadly oblong in outline, 0.25–0.55 mm long, 0.2–0.5 mm wide, versatile, extrorse, dehiscing longitudinally. *Ovary* ellipsoid to obovoid, 1.0–1.2 mm diameter, light brown. *Stigmata* 3, ovate to somewhat triangular and incurved, elongating and spreading slightly outwards with maturity, 0.5–1.1 mm long, free to base of ovary, mostly covered with moderately dense and relatively long stigma trichomes. *Capsule* ovoid



to broadly ovoid, 1.7–3.8 mm long, 1.4–2.4 mm wide, apex obtuse, usually protruding beyond the sepals; valves 3, splitting from apex to base. *Seeds* 18–52, dark red-brown to black, glossy, reniform to slightly orbicular, 0.45–0.65 mm long, 0.42–0.63 mm wide, the surface is lightly patterned with moderately-sized colliculate structure. (Figures 1, 2A–C).

*Other specimens examined.* WESTERNAUSTRALIA: 22.3 km S of Wannoo (Billabong Roadhouse) on Highway 1, 11 Aug. 1991, B.G. Briggs 8848 & L.A.S. Johnson (NSW 243905); River pool, Wooramel River, 500 m downstream of crossing on road to Gilroyd Homestead, 30 Aug. 1995, G.J. Keighery & N. Gibson 671 (PERTH 04973585); c. 3.2 km E of Coolcalalaya Station homestead on road to Yallalong Station, 16 Sep. 2004, F. Obbens and F. Hort FO 49/04 (PERTH 06981291); c. 38 km E of Coolcalalaya Station homestead on road to Yallalong Station, 16 Sep. 2004, F. Obbens & F. Hort FO 53/04 (PERTH 06981259); claypan to the E of Blue Hills Range, c. 65–70 km directly NE of Perenjori, 5 Sep. 2007, F. Obbens FO 5/07 (PERTH 07701020); Koolanooka Hills towards the southern end of the main range, c. 18 km E of Morawa townsite, 24 Sep. 2008, F. Obbens & B. Newman FO55/08 (PERTH 07991452); Burnerbinmah Station, S boundary, Charraminda Paddock, 23 Aug. 1997, S. Patrick s.n. (PERTH 05207452); Quadrat East H6 on Eurardy Station, c. 43 km N of Kalbarri turnoff on the North West Coastal Highway, 4 Oct. 2003, *Wildflower Society of WA* EURA 59 (PERTH 06861458).

*Distribution.* Occurs in the south-western parts of the Eremaean Botanical Province and northern parts of the Geraldton sandplains and Avon Wheatbelt districts of Western Australia (Figure 3).

*Habitat.* Occurs in open shrubland or woodlands in red-brown sandy loams to heavier clay soils on plains, claypans or river edges to moderately steep slopes off small ranges. Some sites are described as having scattered stones or rocks on the surface. The woodlands include *Eucalyptus salmonphloia*, *E. loxophleba*, *E. camaldulensis* and *E. victrix* along arid zone rivers. Shrubland sites are generally dominated by *Acacia* species (e.g. *A. aneura*, *A. tetragonophylla*, *A. acuminata*) and sometimes melaleucas, eremophilas and various species in the families Chenopodiaceae and Asteraceae.

*Phenology.* Flowers and fruits: September to October.

*Conservation status.* Probably a fairly common species with a relatively wide distribution, although much of this area is either pastoral or agricultural. There are conservation areas within its range where it is likely to occur.

*Etymology.* From the Latin *flavus* (yellow) referring to the colour of the petals.

*Notes.* This species is usually a small to medium-sized plant superficially similar to *Calandrinia eremaea* Ewart in habit, flower size and shape and capsule morphology. It could easily be mistaken for that species when not in flower or if the seeds have been shed. It differs in having glossy, lightly patterned seeds while *C. eremaea* has seeds that are strongly patterned, finely colliculate, have a metallic lustre and are frequently papillate. *Calandrinia flava* seeds are somewhat similar to those of *C. liniflora* Fenzl, *C. calypttrata* Hook.f. and *C. remota* J.M.Black in being glossy, but seeds of *C. flava* are lightly patterned with a moderately-sized colliculate structure whereas the others are normally smooth (i.e. not patterned). *Calandrinia flava* has yellow petals sometimes suffused with red while those of *C. eremaea* are generally pink. A collection from East Yuna Nature Reserve (G.J. Keighery & B.J. Keighery 536: PERTH 07288352) is described as pink-flowered. Close examination of the specimen shows the flower buds and old flowers to be a yellowish colour like many other collections of this species and the seeds match those of *C. flava*. The label description is possibly in error and requires field confirmation.



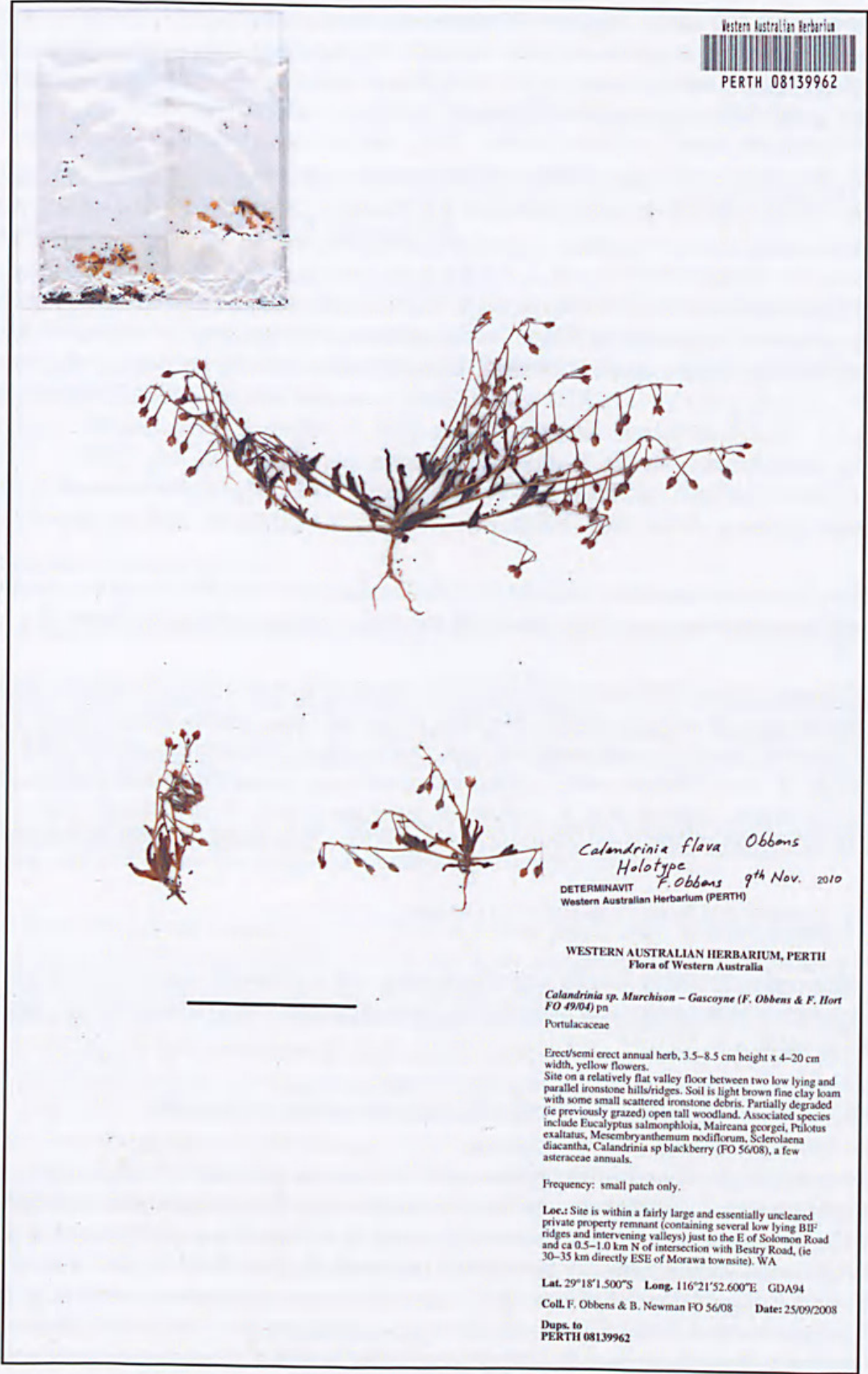


Figure 1. Holotype of *Calandrinia flava* (F. Obbens & B. Newman FO 56/08; PERTH 08139962). Scale bar = 5 cm.



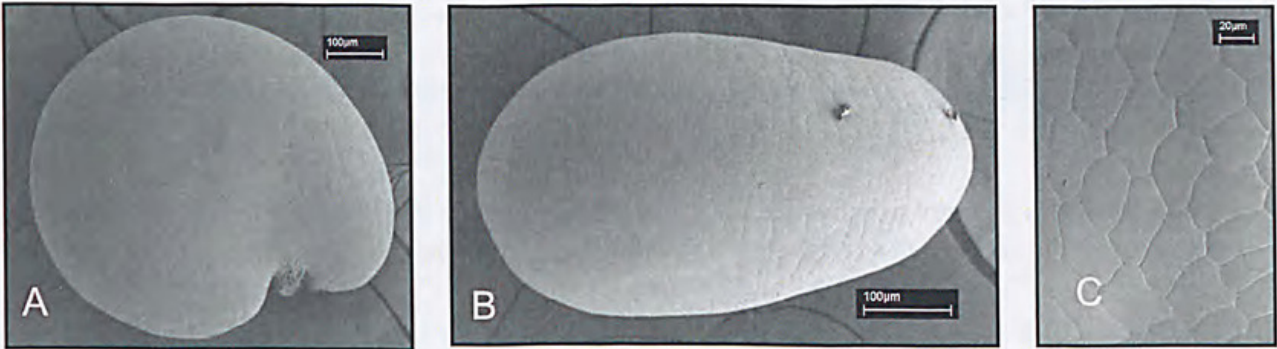


Figure 2. SEM of *Calandrinia flava* seed. A – plan view; B. – dorsal view; C – surface pattern at higher magnification.

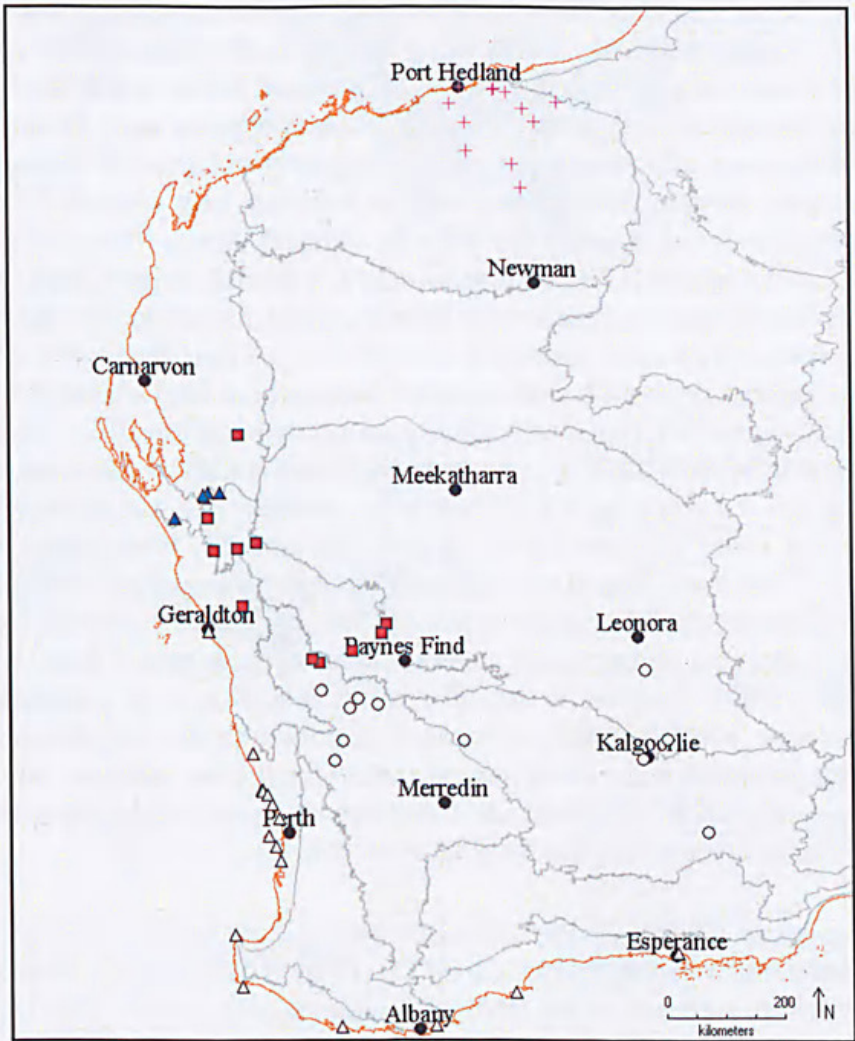


Figure 3. Distributions for *Calandrinia flava* (■), *C. tholiformis* (Δ), *C. pentavalvis* (+), *C. sculpta* (○) and *C. vernicosa* (▲).



***Calandrinia tholiformis* Obbens, *sp. nov.***

*Calandriniae eremaeae* Ewart affinis sed seminis aliquantum grandioribus, colliculis alte tholiformibus differt.

*Typus:* c. 1.5 km north along Burns Beach, in dune/swale area off beach, Western Australia, 13 September 2003, *F. Obbens* FO 24/03 (*holo:* PERTH 06523315; *iso:* CANB, MEL).

*Calandrinia* sp. SW Coastal (J. Dodd 753), Western Australian Herbarium, in *FloraBase*, <http://florabase.dec.wa.gov.au> [accessed 24 January 2011].

*Annual herb*; root system a small taproot with several finer lateral roots. *Plant* semi-erect to erect, occasionally decumbent, 30–150 mm tall, 30–200 mm wide, glabrous. *Basal leaves* fleshy, obovate to spatulate, 2.8–37 mm long, 0.7–7.8 mm wide, with a medial shallow groove on the adaxial surface, green to yellow-green. *Stems* few to several (usually 2–9), 5–75 mm long, radiating out and slightly upwards from the base, sometimes with a short erect central stem forming an axis for a few lateral stems. *Stem leaves* fleshy, narrowly obovate to narrowly spatulate, sometimes elliptic, frequently with a small mucro at apex, to 24 mm long and 4.3 mm wide, alternate, usually in small clusters at stem ends. *Scapes* 7–66 mm long, bare except for 1–3 reduced leaves near base. *Inflorescence axis* 5–60 mm long, bare except for 2 to several  $\pm$  scarious bracts opposite each flower pedicel, forming a loose cyme. *Inflorescence axis bracts*  $\pm$  spreading, narrowly triangular to triangular, 1.3–3.7 mm long, 0.4–2.0 mm wide, the apex acuminate. *Pedicel* 4.8–15 mm long, erect, to 28 mm long in fruit, moderately to strongly reflexed. *Flowers* 4.6–8.2 mm diameter. *Sepals* thin, ovate to broadly ovate, 2.2–4.1 mm long, 2.2–4.4 mm wide, free to base, usually 3–5 nerved. *Petals* 5, light to mid pink, rarely white, narrowly obovate to obovate, occasionally broader, with a distinct notch at the apex, 3.1–4.6 mm long, 1.6–2.8 mm wide, very shortly connate at base for 0.3–0.5 mm. *Stamens* 9–20 in 1 row (or ?2 rows), alternating long and short, with each alternate stamen (or at least a third of the stamens) very slightly offset laterally to the next (not always clearly seen); filaments free, 0.7–2.3 mm long, attached to the top of a basal ring beneath the ovary, minutely papillose on adaxial side at base; anthers elliptic to oblong in outline, 0.4–0.6 mm long, 0.4–0.5 mm wide, versatile, extrorse, dehiscing longitudinally. *Ovary* obovoid, 1.1–1.3 mm diameter, brown. *Stigmata* 3, narrowly triangular to linear, spreading with maturity, 0.7–1.1 mm long, free to base of ovary, covered with sparse to moderately dense long stigma trichomes. *Capsule* ovoid to broadly ovoid, 2.5–3.7 mm long, 1.7–2.9 mm wide, apex obtuse, usually equal to or slightly exceeding sepals; valves 3, splitting from apex to base. *Seeds* 13–61, dark red-brown to black,  $\pm$  shiny, reniform to orbicular with a relatively large strophiole, 0.5–0.65 mm long, 0.5–0.63 mm wide, surface pattern of broad, high domes on the sides and smaller domes on the dorsal area, with no boundaries evident around each dome (i.e. no ‘cellular’ structure). For some variants the domes on the seed’s side faces are closer and elongated producing a normal colliculate pattern (i.e. with cellular boundaries) locally. (Figures 4, 5A–H).

*Other specimens examined.* WESTERNAUSTRALIA: Hilltop E of Quokka Information, near entrance to Kingstown, Rottnest Island, 18 Sep. 1999, *J. Dodd* 753 (PERTH 05565979); c. 5 km SSE of Geraldton and c. 3 km directly E from the coast, 26 Sep. 2007, *C. Godden* SLU113-5 (PERTH 07578008); Seabird, vacant crown land, 14 Sep. 1995, *G.J. Keighery* 14099 (PERTH 04582535); Port Kennedy Scientific Park, 19 Oct. 2001, *F. Littleton* 68 (PERTH 06019714); Ridgeway Drive, Short Beach, Bremer Bay, 2 Oct. 2004, *K. Macey* 685 (PERTH 06943187); c. 1.5 km N of Skippy Rock Road on Cape to Cape Track, Cape Leeuwin area, 27 Sep. 2003, *F. Obbens* FO 51/03 (PERTH 06550789); on walk trail c. 0.33 km directly NE of Cape Naturaliste Lighthouse, 27 Sep. 2003, *F. Obbens* FO 52/03 (PERTH 06550770); between Moates Lake and Gardner Lake just S of Juniperina Creek, Two Peoples Bay



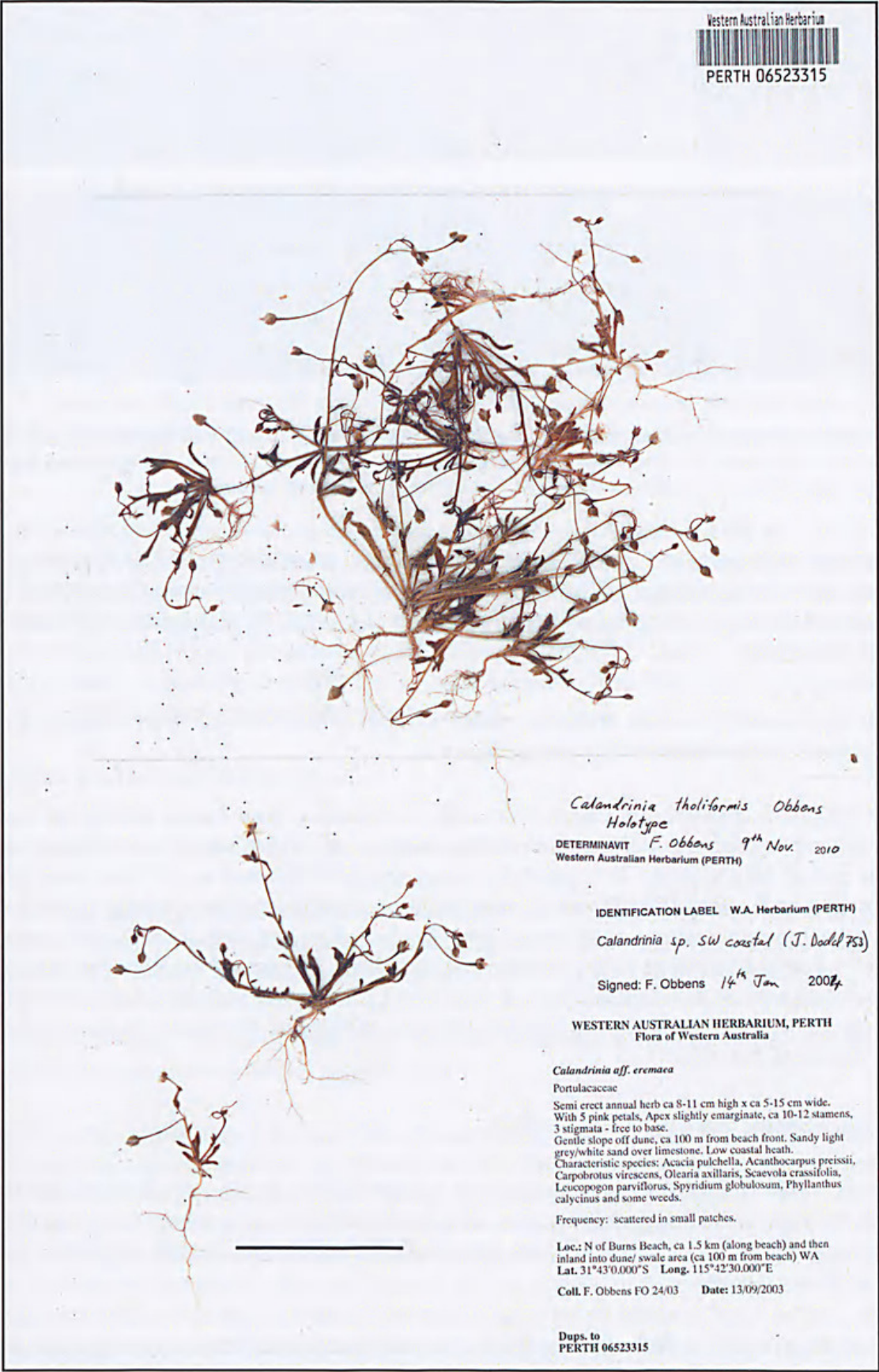


Figure 4. Holotype of *Calandrinia tholiformis* (F. Obbens FO 24/03 – PERTH 06523315). Scale bar = 5 cm.



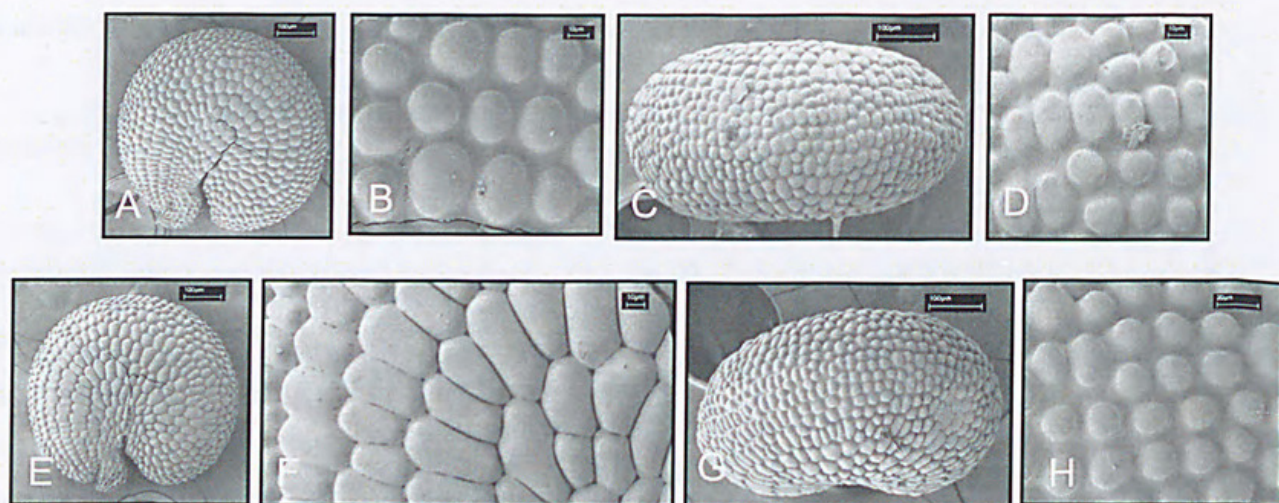


Figure 5. SEM of *Calandrinia tholiformis* seeds. A–D. Variant 1. A – plan view whole seed; B – plan view higher magnification; C – dorsal view whole seed; D – dorsal view higher magnification; E–H. Variant 2. E – plan view whole seed; F – plan view higher magnification; G – dorsal view whole seed; H – dorsal view higher magnification.

Nature Reserve, 21 Oct. 1975, *G.T. Smith & L.A. Moore s.n.* (PERTH 05319412); domestic property, Frank Freeman Drive, Esperance, 4 Sep. 2005, *C.D. Turley* 1/905 (PERTH 07409281); Tiwest mineral sand lease (Mullering survey project), Cataby area, 20 Oct. 2005, *G. Woodman & K. Rodda* M74-4 (PERTH 07215576).

**Distribution.** Located in coastal areas and nearby islands within the South West Botanical Province from just south of Geraldton to Esperance (Figure 3).

**Habitat.** *Calandrinia tholiformis* occurs in a number of coastal or near coastal habitats including the lower slopes of large dunes, smaller dunes, within swale areas, in shallow soils over limestone ridges and near coastal lake systems. It is generally found within 100 m and up to 3 km from the coast, rarely occupying the immediate foreshore areas. Soils are usually grey, grey-brown to yellow-brown sandy loams. It occurs in a variety of vegetation types including low coastal heath, grass/sedge flats, low open woodland and open areas between tall shrubland. Frequently associated species include *Acanthocarpus preissii*, *Acacia rostellifera*, *A. lasiocarpa*, *Conostylis candicans*, *Guichenotia ledifolia*, *Lomandra maritima*, *Lepidosperma gladiatum*, *Melaleuca huegelii*, *M. systema*, *Scaevola crassifolia* and *Spyridium globulosum*.

**Phenology.** Flowers: September and October.

**Conservation status.** This taxon is quite common. Currently there are 16 collections in PERTH from localities between Geraldton and Esperance. The greatest threat to its conservation is future urban expansion having localized impacts. There are significant coastal areas under conservation title in the region where it exists.

**Etymology.** From the Latin *tholus* (dome) and *formis* (shape) referring to the dome-shaped protrusions on the seed surface of this species.

**Notes.** *Calandrinia tholiformis* may be related to *C. eremaea* because of their superficial similarities in habit, flower size and flower structure. It differs in having slightly larger seeds with a surface pattern



of high, broad domes while *C. eremaea* seeds are colliculate with a metallic lustre and are often papillate. The *C. tholiformis* seed surface pattern described above is somewhat variable, typically displaying no 'cellular' structure in between the high, globular domes (Figure 5B). In some variants the domes are closely packed and elongated on the seed's side faces producing a somewhat normal colliculate pattern (Figure 5F).

Several other species occur along the south west coastal zone including *C. brevipedata* F.Muell., *C. calyptrata*, *C. corrigioloides* Benth., *C. granulifera* Benth., *C. liniflora* and *C. polypetala* Fenzl. Most of these prefer different habitats, infrequently co-occur, rarely are found on the foreshore areas (i.e. within 0.5–1.0 km of the beachfront, apart from *C. brevipedata*) and in the main are relatively easy to distinguish from each other. A recent addition to this list is *Calandrinia* sp. Two Rocks (K. Richardson 211). *Calandrinia* sp. Two Rocks (K. Richardson 211) is a much larger, erect plant than *C. tholiformis* and has significantly larger flowers, many more stamens and larger seeds. It appears to prefer the immediate foreshore and dune habitats generally less than several hundred metres from the beach front. Both species co-occur at some sites (e.g. Port Kennedy Scientific Park, near Rockingham, Western Australia).

There are three problematic collections, all with seeds that appear almost identical to *C. sp. Two Rocks* (K. Richardson 211), but whose smaller habit, smaller flowers and collection locations are more akin to *C. tholiformis*. All three collections are currently undetermined and include PERTH 07811152 from Grey Point, Peel Harvey Inlet; PERTH 07215584 from the Mullering area of Tiwest mining lease, Cataby and PERTH 07771207 from a track south of Wongonderrah Rd, Cataby. These three collections are either hybrids or possibly represent one or more unnamed taxa. The Grey Point specimen, in particular, probably represents the latter option.

### ***Calandrinia pentavalvis* Obbens, sp. nov.**

Species planta erecta petalis 9–12 et capsula 5-valvi a congeneribus diversa.

*Typus*: ca. 7 km east of the Shaw River along the Marble Bar-Hillside Road, then follow minor track north for ca. 400 m. Area referred to as the Spear Hills, and is ca. 60 km SW at Marble Bar, Western Australia, 28 May 2004, F. Obbens & B. Bromilow FO 16/04 (*holo*: PERTH 06609570).

*Calandrinia* sp. Pinga (T.R. Lally TRL 722), Western Australian Herbarium, in *FloraBase*, <http://florabase.dec.wa.gov.au> [accessed 24 January 2011].

*Annual herb*; root system a taproot with several lateral roots. *Plant* semi-erect to erect, rarely prostrate and sometimes scrambling, 70–520 mm tall, 80–1000 mm wide, glabrous. *Basal leaves* fleshy, narrowly linear to narrowly oblanceolate tapering to an acute apex, 6.0–83 mm long, 0.5–3.3 mm wide, subterete, dull green to green-brown. *Stems* few to several (usually 1–6), 30–175 mm long, radiating out and upwards from base, occasionally branched low near base. *Stem leaves* fleshy, narrowly linear to narrowly oblanceolate, often with a small mucro at apex, to 66 mm long and 2.8 mm wide, alternate, occasionally with leaf clusters at stem ends. *Scapes* 15–85 mm long, bare. *Inflorescence axis* 35–460 mm long, bare except for several or more  $\pm$  scarious bracts opposite each flower pedicel, forming a loose cyme. *Inflorescence axis bracts*  $\pm$  appressed, narrowly triangular to triangular, 2.5–6.6 mm long, 1.1–5.0 mm wide, apex acuminate, occasionally long-acuminate with recurved apices. *Pedicel* 8.0–49.5 mm long, erect, to 85 mm long in fruit, moderately to strongly reflexed. *Flowers* 17–30 mm diameter, usually with a long calyptra after flowering is complete. *Sepals* thin, ovate to broadly ovate,



4.6–9.1 mm long, 4.5–9.8 mm wide, free to base, with midvein and some reticulation obvious and a hyaline edge. *Petals* 9–12, bright mid-pink, sometimes lighter, narrowly obovate to obovate, with a distinct, small mucro at apex, 7.7–16.5 mm long, 2.4–5.2 mm wide, free to base, occasionally shortly connate at base. *Stamens* 64–121 in three ill-defined rows; filaments free, 1.5–5.5 mm long, attached to the top of a basal ring beneath the ovary, minutely papillose on lower half of filament on adaxial side; anthers elliptic to oblong in outline, 0.9–1.6 mm long, 0.5–0.8 mm wide, versatile, extrorse, dehiscing longitudinally. *Ovary* obovoid, 1.8–2.4 mm diameter, cream to light brown. *Stigmata* (4) 5 (6), narrowly triangular, spreading somewhat at maturity, 1.8–3.3 mm long, on a short style 0.15–0.6 mm long, sparsely covered with moderately long stigma trichomes. *Capsule* ovoid, occasionally broadly ovoid, 5.2–8.4 mm long, 3.8–5.7 mm wide, apex obtuse, normally equal to or slightly exceeding sepals; valves (4) 5 (6), initially splitting to one third then from apex to base with age. *Seeds* 43–107, dark red-brown to black, dull, subreniform, 0.8–1.0 mm long, 0.52–0.9 mm wide, 0.45–0.65 mm thick; surface of radially swirled ridges, each ridge topped with a row of papilla-like spheres and with colliculate pattern continuing perpendicular to and between the ridges. (Figures 6, 7A–C).

*Other specimens examined.* WESTERN AUSTRALIA: FMG Cloudbreak Mine-Pilbara, 15 May 2006, *J. Atkinson s.n.* (PERTH 07887337); Oyster Inlet, near Hedland [i.e. Port], 30 September 1981, *G. Craig* 318 (PERTH 06491944); 19.1 km N of Pinga Creek, c. 130 km by road S of Port Hedland towards Wittenoom Gorge to Roy Hill Road, 9 Sept 1995, *T.R. Lally* TRL 722 (PERTH 04355342); C235, Coongan station, Pilbara Region, 23 June 1997, *A.A. Mitchell* PRP 1567 (PERTH 05100933); 13 km SW of Shay Gap (town), 16 July 1984, *K. Newbey* 10569 (PERTH 07423322); Beside Great Northern Highway c. 54 km E of Port Hedland turnoff and several kilometers before Strelley River bridge, 25 May 2004, *F. Obbens & B. Bromilow* FO 7/04 (PERTH 06609465); c. 21 km S along the Great Northern Highway from Wodgina mine access road turnoff (i.e. c. 100–110 km directly S of Port Hedland), then site is c. 200 m E of Highway, 29 May 2004, *F. Obbens & B. Bromilow* FO 20/04 (PERTH 06609619); Site I745, 1 km W of Warralong Community, Coongan Station, E Pilbara, 23 Aug 1997, *S.M.E. Van Vreeswyk* PRP 1871 (PERTH 05908191).

*Distribution.* Wholly distributed in the Pilbara Region of the Eremaean Botanical Province within roughly a 100 to 150 km radius of Port Hedland (Figure 3).

*Habitat.* Collected from a fairly wide variety of situations including flats, alluvial plains, near estuarine inlet, undulating country, sandplain adjacent to claypan and drainage lines. Soils at collecting sites are red-brown, sandy or clayey, often gritty-loams with one collection from orange quartz loam, frequently in association with granitic geology at the surface. *Calandrinia pentavalvis* usually occurs in grassland often dominated by *Triodia* spp. (e.g. *T. wiseana*, *T. pungens*, *T. brizoides*) with some sparse, taller, emergent shrubs such as *Grevillea wickhamii*, *Indigofera monophylla*, *Acacia pyriformis* and *Tribulus platypterus*. The species is often a weak, scrambling plant using grass tussocks and smaller shrubs for support, but has also been observed as being quite capable of self support. It is also known to occur in very open *Acacia* shrubland (dominated by e.g. *A. ancistrocarpa*, *A. orthocarpa*, *A. stellariceps*). The understorey at many of these sites includes grasses, *Pluchea tetranthera*, *Gomphrena kansii*, *Dampiera candicans*, *Polycarpha corymbosa* etc.

*Phenology.* Collections in flower range from late May to early September, however, the actual flowering period each year is probably shorter with a start and finish dependent on seasonal conditions.

*Conservation status.* There are currently eleven collections of *Calandrinia pentavalvis* at PERTH distributed over a wide area. It appears to be quite common although much of its range is either pastoral or mining lease.



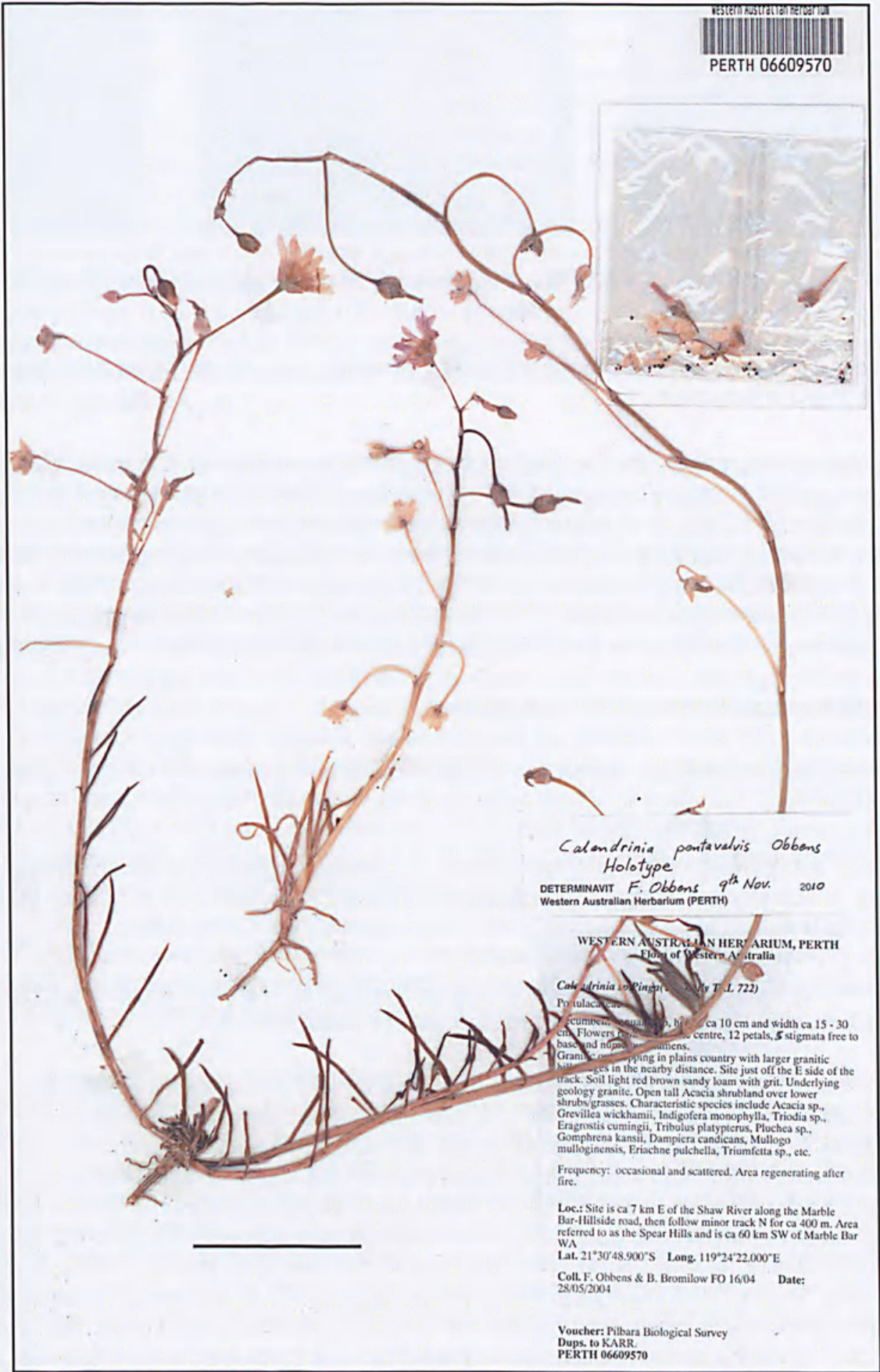


Figure 6. Holotype of *Calandrinia pentavalvis* (F. Obbens & B. Bromilow FO 16/04; PERTH 06609570). Scale bar = 5 cm.



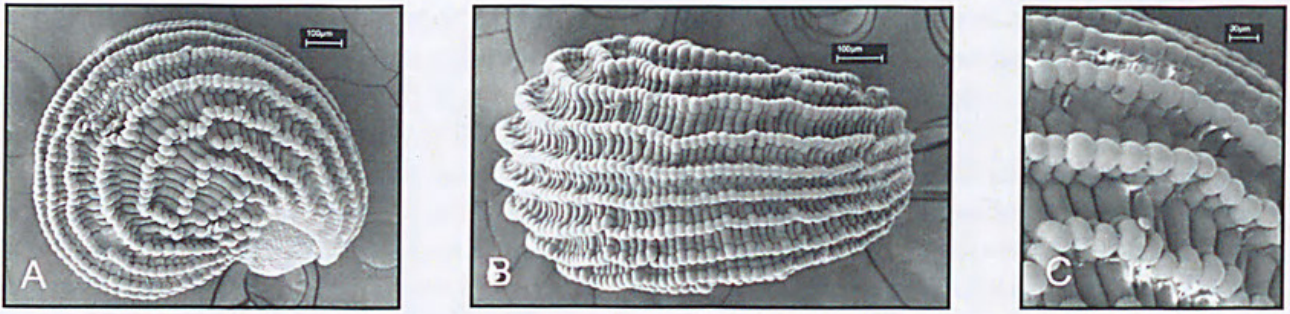


Figure 7. SEM of *Calandrinia pentavalvis* seed. A – plan view; B – dorsal view; C – edge view at high magnification.

**Etymology.** From the Latin *penta* (five) and *valvis* (valved), in reference to the normally five-valved capsules found in this taxon.

**Notes.** *Calandrinia pentavalvis* is a relatively large, mostly an erect plant with quite large flowers and nine to twelve bright pink petals. Only *C. strophiolata* (F.Muell.) Ewart, B.Rees & B.Wood and *C. sp.* Mt Clere (R.J. Dadd 5) are larger-flowered plants with similar petal numbers to *C. pentavalvis*, but these two species appear unrelated in all other respects. The affinities of *C. pentavalvis* are uncertain, and it is unusual in the genus because of its normally five-valved capsules. The currently recognized sections within *Calandrinia* are based on whether species have three-valved or four-valved capsules or are tuberous. Future molecular studies may help to resolve the relationships of *C. pentavalvis*.

***Calandrinia sculpta*** Obbens & J.G.West, *sp. nov.*

Flore *C. polyandro* Benth. affinis sed seminis aliquantum grandioribus et aliter colliculosis differt.

**Typus:** ca. 45.8 km north of Wubin townsite, Western Australia, on Great Northern Highway, north-west side of highway and at edge of saltpan/samphire area, 13 October 2003, *F. Obbens* FO 64/03 (*holo*: PERTH 06708196 (sheet 1), PERTH 06708218 (sheet 2); *iso*: CANB, MEL).

*Calandrinia* sp. ridged papillate (M. Hislop & E. Hudson MH161), Western Australian Herbarium, in *FloraBase*, <http://florabase.dec.wa.gov.au> [accessed 24 January 2011].

**Annual herb;** root system a small to moderately-sized taproot with several lateral and finer roots. **Plant** decumbent, semi-erect or erect, 42–170 mm tall, 25–350 mm wide, glabrous. **Basal leaves** fleshy, narrowly obovate to narrowly spatulate, sharply tapering to apex with small distinct mucro, 7.5–38 mm long, 1.0–7.7 mm wide, with a distinct shallow medial groove on adaxial surface, green to greenish red-brown or greenish grey-brown. **Stems** few to several (usually 1–9), 10–190 mm long, radiating out and upwards from base, rarely once-branched. **Stem leaves** fleshy, narrowly elliptic to obovate, occasionally broadly obovate, to 16 mm long and 5.5 mm wide, alternate, with leaf clusters at stem ends. **Scapes** 15–155 mm long, bare. **Inflorescence axis** 15–85 mm long, bare except for a few to several ± scarious bracts opposite each flower pedicel, forming a loose cyme. **Inflorescence axis bracts** ± spreading, narrowly triangular to triangular, 1.2–4.2 mm long, 0.6–3.0 mm wide, apex long-acuminate. **Pedicel** 8.5–31.5 mm long, erect, to 37 mm in fruit, moderately reflexed. **Flowers** 9–27 mm diameter. **Sepals** ± thin, ovate to broadly ovate, 3.0–6.5 mm long, 3.6–8.8 mm wide, free to base, with 3 or 5 prominent veins and some reticulation. **Petals** 5, mid-pink to purple, broadly obovate to very broadly obovate, sometimes narrower, slightly undulate towards the apex with a shallow notch



at mid-apex, 7.5–13.6 mm long, 5.7–12 mm wide, free to base. *Stamens* 44–90 in three ill-defined rows; filaments free, 0.9–4.1 mm long, attached to the top of a basal ring beneath the ovary, moderate to strongly papillose on lower fifth of filament on adaxial side; anthers elliptic to oblong in outline, occasionally ovate in outline, 0.6–1.0 mm long, 0.4–0.6 mm wide, versatile, extrorse, dehiscing longitudinally. *Ovary* obovoid, occasionally broadly so, 0.8–2.1 mm diameter, brown, with 3 obvious, shallow valve abscission lines. *Stigmata* 3, broadly triangular becoming narrowly triangular and spreading with maturity, 1.8–3.3 mm long, densely covered with moderately long stigma trichomes, free to base. *Capsule* ovoid, occasionally broadly ovoid, 2.9–5.7 mm long, 2.6–4.7 mm wide, the apex obtuse, normally equal to or slightly shorter than the sepals; valves 3, splitting from apex to base with age. *Seeds* 35–71, dark red-brown to black, occasionally metallic, shiny particularly on large papilla facets, subreniform, 0.75–1.0 mm long, 0.55–0.85 mm wide, 0.5–0.65 mm thick; surface of several, prominent dorsal ridges formed by rows of large irregular papillae with the most outer ridges formed by elongate and raised cells that protrude to the side and with colliculate pattern elsewhere on the side faces. (Figures 8, 9A–C)

*Other specimens examined.* WESTERN AUSTRALIA: 5 miles from Kalgoorlie on Coolgardie Road, 18 Aug. 1947, *N.T. Burbidge* 1898 (PERTH 07692811); 1 km S of Niagara Dam [i.e. Menzies/Leonora area], 4 Sep. 1985, *B.J. Conn* 1950 (NSW 199959); Geranium Rock c. 60 km NE of Kalannie, 3 Sep. 1995, *M. Hislop & E. Hudson* MH161 (PERTH 04864883); decomposed granite breakaways, c. 800 m WNW of granite peak of Geeraning Rock, NE of Mukinbudin, 16 Oct 2005, *M. Hislop & F. Hort* MH3533C (PERTH 07421435); saline pan 8 km S of Bunjil, 8.5 km WNW of intersection of Coorow-Latham Road and Mullewa-Wubin Road, SAP wetland site SPS 172B, 3 Oct. 2000, *M.N. Lyons & S.D. Lyons* 3993 (PERTH 07867735); Camp Rock, 20 Sep. 1980, *K.R. Newbey* 7493 (PERTH 06144276); on Piawanning - Wongan Hills Road where it crosses the Mortlock River North flats, small rise on S verge nearly opposite intersection with Smith Road, 12 Oct. 2003, *F. Obbens* FO 57/03 (PERTH 06708080 – sheet 1 & PERTH 06708099 – sheet 2); c. 11.2 km N of Ballidu townsite on W side of main road to Dalwallinu and just S of saline pan, 12 Oct. 2003, *F. Obbens* FO 59/03 (PERTH 06708110); c. 22.4 km N of Wubin townsite on Great Northern Highway, junction with old rabbit proof fence track, NW side of highway, 13 Oct. 2003, *F. Obbens* FO 61/03 (PERTH 06708153); 22 km NE Kanowna, 14 Oct 1992, *L. Sweedman* S2264 (KPBG).

*Distribution.* The distribution of *Calandrinia sculpta* covers a wide band running diagonally from the Paynes Find and Wongan Hills areas to the south-east around Leonora and Norseman straddling the border of the South West and Eremaean Botanical Provinces (Figure 3).

*Habitat.* *Calandrinia sculpta* has been collected most frequently from areas adjacent to saline flats or saline pans; however, it also has been collected from decomposed granitic breakaways and from around granite rocks. In these locations the soils range from brown, sandy loams to grey-brown, silty sand-loam to orange-brown sands. One site was described as red-brown clayey loam. The range of vegetation types is diverse including open tall shrubland of *Melaleuca lateriflora*, *M. stereophloia*, *Acacia inceana*, *Eremophila oldfieldii* and *E. miniata* etc. Other vegetation types include dwarf shrubs over herbs, thicket over low shrubs and shrub or heath communities where these intergrade with samphire. Common to many of these sites are chenopod species in the genera *Atriplex*, *Maireana*, *Rhagodia* and *Tecticornia*, sometimes with *Frankenia* species and salt-tolerant Asteraceae species.

*Phenology.* Flowers between late August and early November with the peak period during September and October. The considerable range of distribution somewhat accounts for the long apparent flowering period plus responses to yearly seasonal conditions.



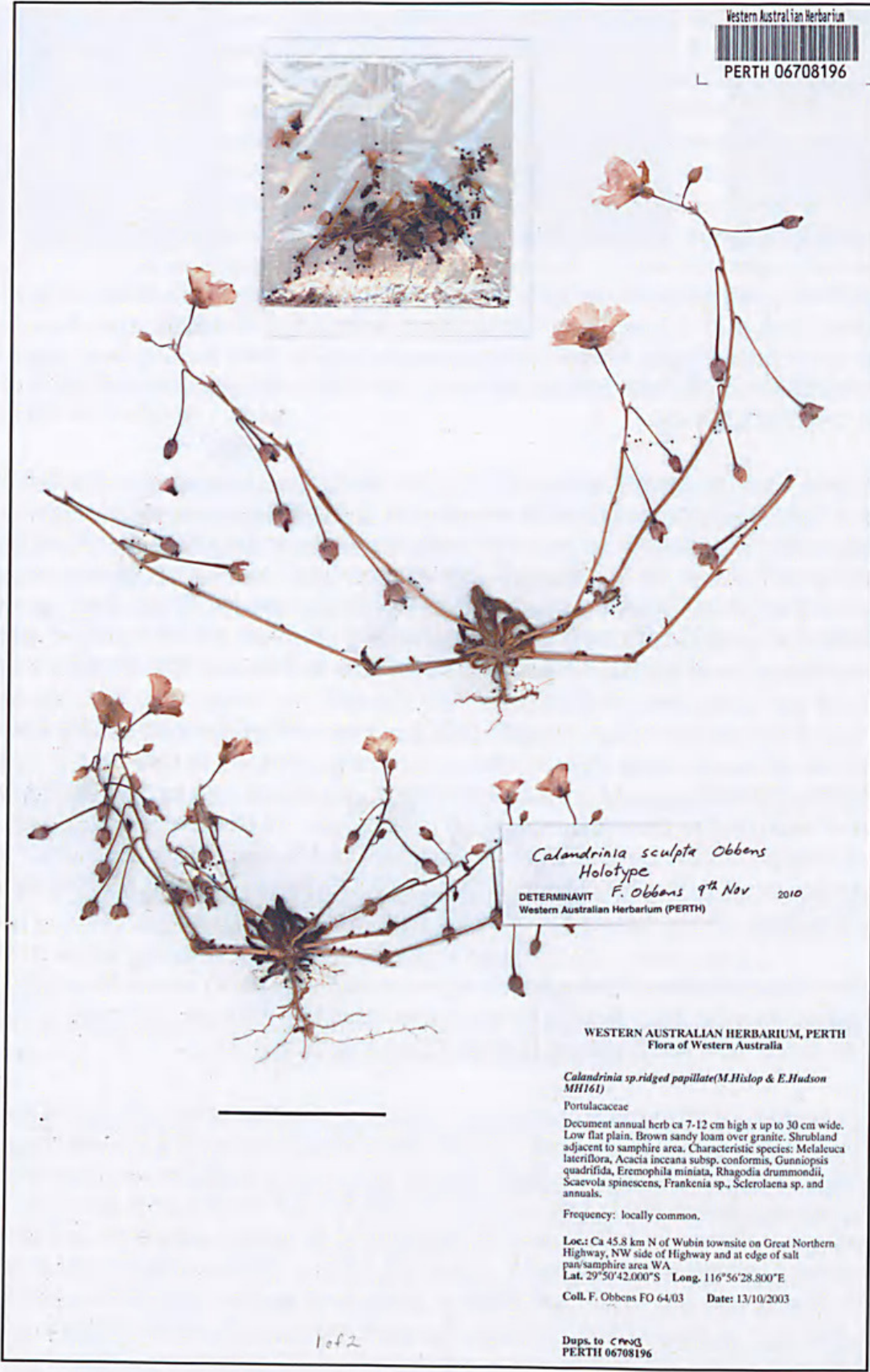


Figure 8. Part of the holotype of *Calandrinia sculpta* (F. Obbens FO 64/03; PERTH 06708196). Scale bar = 5 cm.



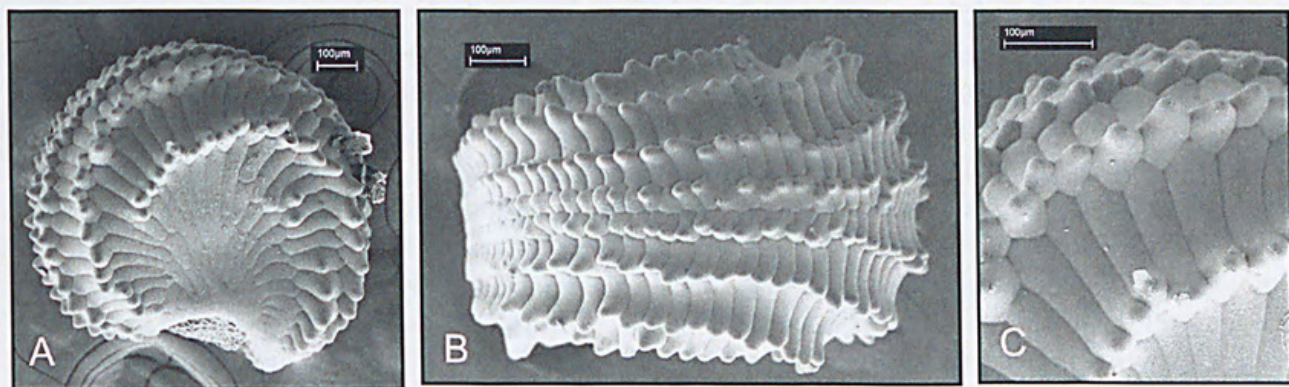


Figure 9. SEM of *Calandrinia sculpta* seed. A – plan view; B – dorsal view; C – edge view at high magnification. Scale bar on each image.

**Conservation status.** There are currently 15 collections of *Calandrinia sculpta* at PERTH distributed over a very wide area. Mining, pastoral and agricultural activities occur throughout its range. It probably occurs in a number of large conservation reserves throughout this area.

**Etymology.** From the Latin *sculptus*, referring to the highly sculptured effect of the patterned seeds.

**Notes.** The affinities of *Calandrinia sculpta* are uncertain. There are a small number of other five-petalled species with mid-pink and mid-sized flowers within the range of *C. sculpta* which are commonly mistaken for and have a superficial likeness to, *C. polyandra* Benth. These species include *C. remota*, *C. sculpta*, *C. vernicosa* and *C. sp. Blackberry* (D.M. Porter 171). However, close examination of seeds will clearly separate all five taxa. Of the above, only *C. vernicosa* (see below) is probably closely related; as it has similar seed, ovary and stigmata characters, but it is relatively easy to separate from *C. sculpta* by closely comparing the characters described.

***Calandrinia vernicosa* Obbens, sp. nov.**

Structura floris *C. polyandro* Benth. affinis sed floribus grandioribus et seminis aliter colliculosis differt.

**Typus:** Coburn Station, Western Australia [precise locality withheld for conservation reasons], 18 August 2008, F. Obbens, F. Hort & J. Hort FO 04/08 (*holo*: PERTH 07957408 (sheet 1), PERTH 07957718 (sheet 2); *iso*: CANB).

**Annual herb;** root system a taproot with several lateral and finer roots. **Plant** decumbent to semi-erect, occasionally erect, 80–300 mm tall, 60–450 mm wide, glabrous. **Basal leaves** fleshy, narrowly obovate to obovate, occasionally spatulate, 1.5–13.4 mm wide, with a distinct, deep medial groove on adaxial surface which expresses as a midvein on the abaxial surface, green or grey-green (appearing bright and somewhat shining in sunshine); apex acute, 6.5–99 mm long. **Stems** few to several (usually 1–8), 8–140 mm long, radiating out and upwards from base. **Stem leaves** fleshy, narrowly obovate to obovate, occasionally linear or orbicular and sometimes asymmetric, to 67 mm long and 12.8 mm wide, alternate, with leaf clusters at stem ends. **Scapes** 20–125 mm long, bare. **Inflorescence axis** 35–180 mm long, bare except for a few to several  $\pm$  scarious bracts opposite each flower pedicel, forming a loose cyme. **Inflorescence axis bracts**  $\pm$  spreading, narrowly triangular to triangular, 2.8–8.5 mm long, 2.0–4.8 mm wide, the apex long-acuminate. **Pedicel** 15–38 mm long, erect, to 47 mm long in fruit, moderately reflexed. **Flowers** 26–42 mm diameter. **Sepals**  $\pm$  thin, ovate to broadly ovate,



5.5–11.7 mm long, 5.0–6.4 mm wide, with 3 prominent veins and a distinct mucro at apex, free to base. *Petals* 5, deep bright pink adaxially, whitish or yellowish with distinct striations abaxially, broadly to very broadly obovate, occasionally orbicular, with a shallowly emarginate apex, 16.7–19.8 mm long, 13.0–17.0 mm wide, free to base. *Stamens* 59–78 in three ill-defined rows; filaments free, 1.6–4.3 mm long, attached to the top of a basal ring beneath the ovary, moderately long-papillose on lower quarter of filament on adaxial side; anthers elliptic to oblong in outline, 1.0–1.25 mm long, 0.47–0.7 mm wide, versatile, extrorse, dehiscing longitudinally. *Ovary* obovoid, 2.0–2.4 mm diameter, brown, with 3 obvious sunken grooves (valve abscission lines). *Stigmata* 3, squatly triangular becoming narrowly triangular, longer and spreading with maturity, 0.95–3.7 mm long, densely covered with moderately long stigma trichomes, free to base. *Capsule* ovoid to broadly ovoid, 4.5–7.0 mm long, 3.6–5.6 mm wide; apex obtuse, normally shorter than the sepals; valves 3, splitting from apex to base. *Seeds* 76–137, mid brown or tan, sometimes darker particularly on the papillae, with a varnish-like gloss, subreniform to reniform, 0.57–0.77 mm long, 0.35–0.70 mm wide, 0.42–0.47 mm thick; surface with four dorsal ridges formed by rows of moderately large and irregular papillae with an additional outer ridge formed on each side by elongate and raised colliculate cells, each cell with a papilla protruding from the surface while the remainder of each side surface consists of more elongated colliculate cells. (Figures 10, 11A–C)

*Other specimens examined.* WESTERN AUSTRALIA: [localities withheld for conservation reasons]. 23 Aug. 1991, A.H. Burbidge 4490 (PERTH 05043123); 28 Aug. 1991, A.H. Burbidge 4632 (PERTH 05020220); 18 Aug. 2008, F. Obbens, F. Hort & J. Hort FO 06/08 (PERTH 07957424); 18 Aug. 2008, F. Obbens, F. Hort & J. Hort FO 07/08 (PERTH 07957432); 21 Sep. 1994, L. Sweedman S3448 (KPBG).

*Distribution.* All collections to date are from a roughly 50 km stretch of the North West Coastal Highway and adjacent areas around the Billabong and Overlander roadhouses. This area encompasses the boundary region between the Geraldton Sandplains District (South West Botanical Province) and a southern portion of the Yalgoo District (Eremaean Botanical Province) (Figure 3).

*Habitat.* *Calandrinia vernicosa* occurs on undulating sandplains interspersed with low hills or ridges. The soils are either red-orange, light orange or orange-brown sandy loams as is often seen on old and vegetated dunal landscapes. It appears to have a relatively narrow habitat preference of tall *Acacia* shrubland, dominated by *A. ramulosa* and/or *A. microcalyx*, with a sparse understorey of *Eremophila* spp., *Dodonaea* spp., *Dicrastylis linearifolia* etc and annuals including *Ptilotus polystachyus* and everlasting daisy species. One collection is described as being from open low woodland over scrubs with *Melaleuca* and *Hakea* spp.

*Phenology.* Flowering mid August to late September.

*Conservation status.* There are five collections of this taxon at PERTH and one collection at KPBG. The current distribution is quite restricted; future survey may well extend the known range as there appears to be a significant amount of typical habitat yet to be explored. Recently listed as Priority Two under Department of Environment and Conservation (DEC) Conservation Codes for Western Australian Flora.

*Etymology.* From the Latin *vernica*, referring to the ‘varnished’ appearance of the seed coat.



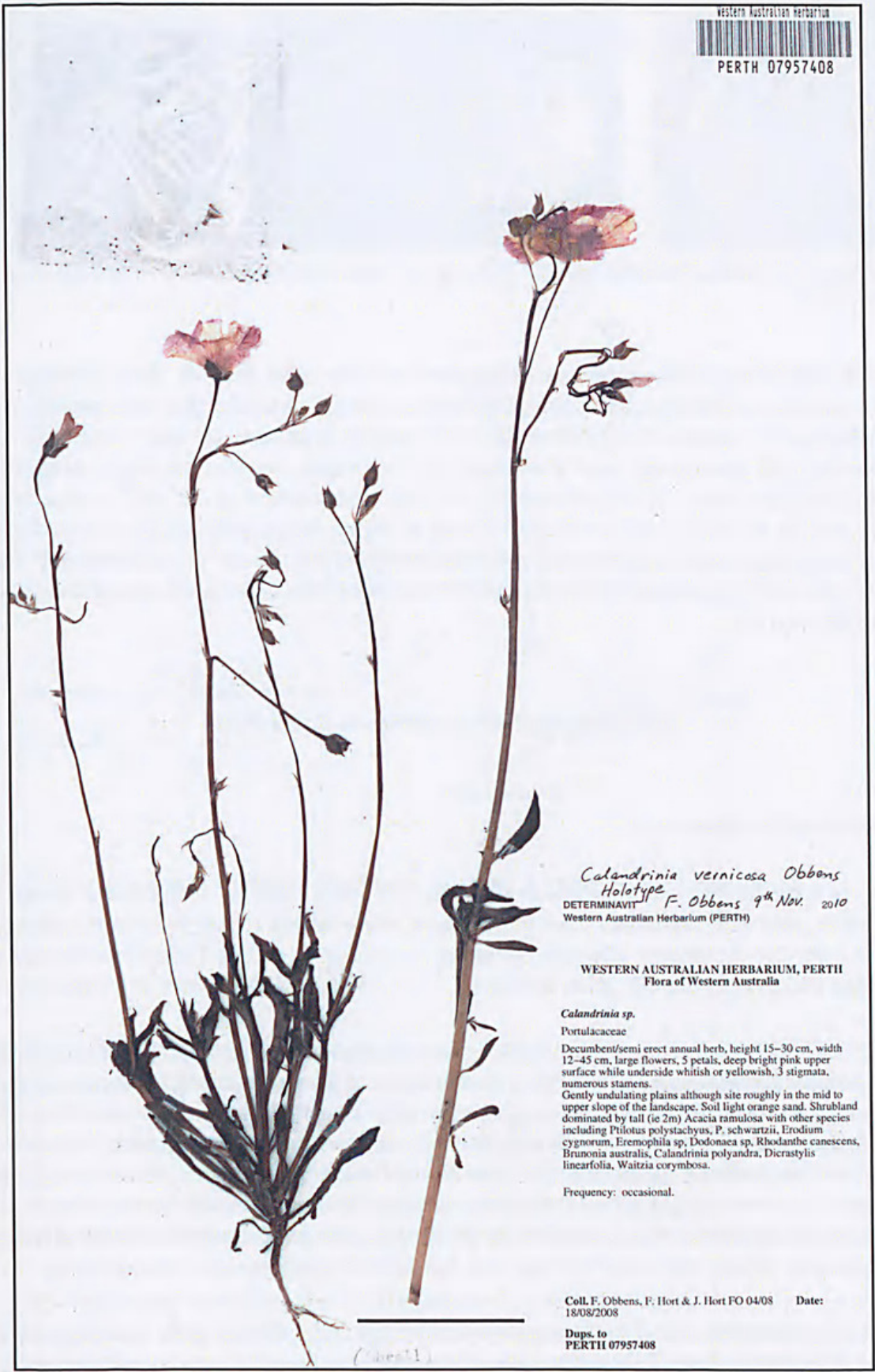


Figure 10 . Part of the holotype of *Calandrinia vernicosa* (F. Obbens, F. Hort & J. Hort FO 04/08; PERTH 07957408). Scale bar = 5 cm.



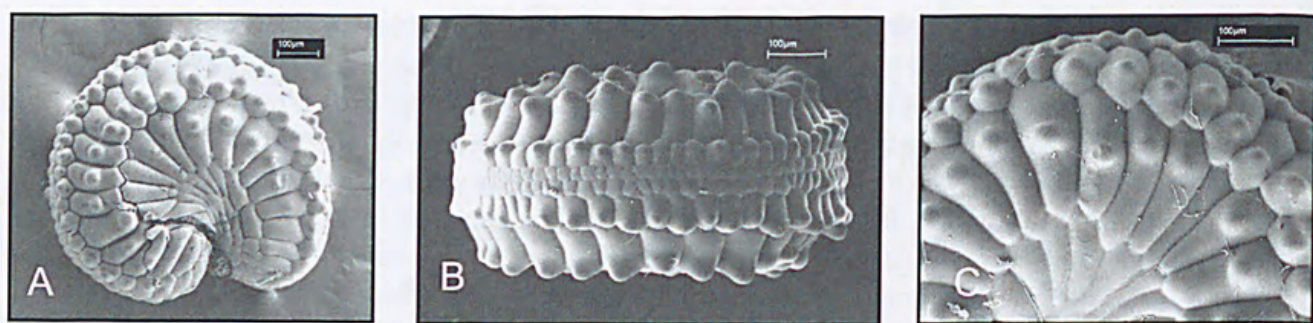


Figure 11. SEM of *Calandrinia vernicosa* seed. A – plan view; B – dorsal view; C – edge view at high magnification. Scale bar on each image.

*Notes.* The affinities of *Calandrinia vernicosa* are uncertain other than its likely relationship to *C. sculpta* as noted under that species. It has been confused with *C. polandra* (see notes under *C. sculpta*). In *C. sculpta* and *C. vernicosa*, abscission lines on the ovary at anthesis are clearly visible at very low magnification with these being more prominent in *C. vernicosa* because they are in slightly sunken grooves. Abscission lines in the earlier stages of ovary development in *Calandrinia* species are not normally seen or at least are not noticeable except at higher magnifications. The ovary from above of most *Calandrinia* species is generally circular in outline, but in both *C. sculpta* and *C. vernicosa* this outline is shallowly depressed at three equally spaced intervals giving the appearance of a typical three-locular ovary.

### Morphological observations in *Calandrinia*

#### Plant habit and architecture

There is considerable variation observed within the plant habit of *Calandrinia*. Many species may be either prostrate, decumbent and/or semi-erect while others appear to remain constant. Habit variability added to a common situation of finding a number of similar *Calandrinia* species at any one location makes field identification difficult.

Apart from section *Tuberosae* (Obbens 2006), most calandrinias have an architecture comprising three main elements. The first are stems that grow and radiate out from the basal leaf rosette and generally do not branch or rise substantially above ground level. For a few species, there is occasionally an additional short central ‘stem’ that grows erect with a number of lateral stems arising from this vertical axis (e.g. see description *C. tholiformis*). These laterals develop features typical of stems normally derived from within the basal rosette. Stem leaves are usually held alternately or sometimes clustered. Stems frequently terminate with a compact leaf cluster and often have an obvious ‘knee’ or bend where the scapes begin. Where this is not obvious then the last stem leaf represents that juncture.

Scapes represent the second element in the plant architecture. Rarely, more than one scape arises from the junction point and occasionally there may be a few rudimentary leaves running up the lower portion of the scape. Scapes rarely branch and if so usually only once.

The final element is the inflorescence axis. This arises at the end of the scape beginning at the lowest fertile bract and pedicel opposite the bract. Even if a pedicel only produces a rudimentary bud



which does not mature, it is still considered to mark the beginning of the flowering axis. Thus the full 'radiating arm' unit consists of a stem attached to a scape and that attached to an inflorescence axis (Figure 12).

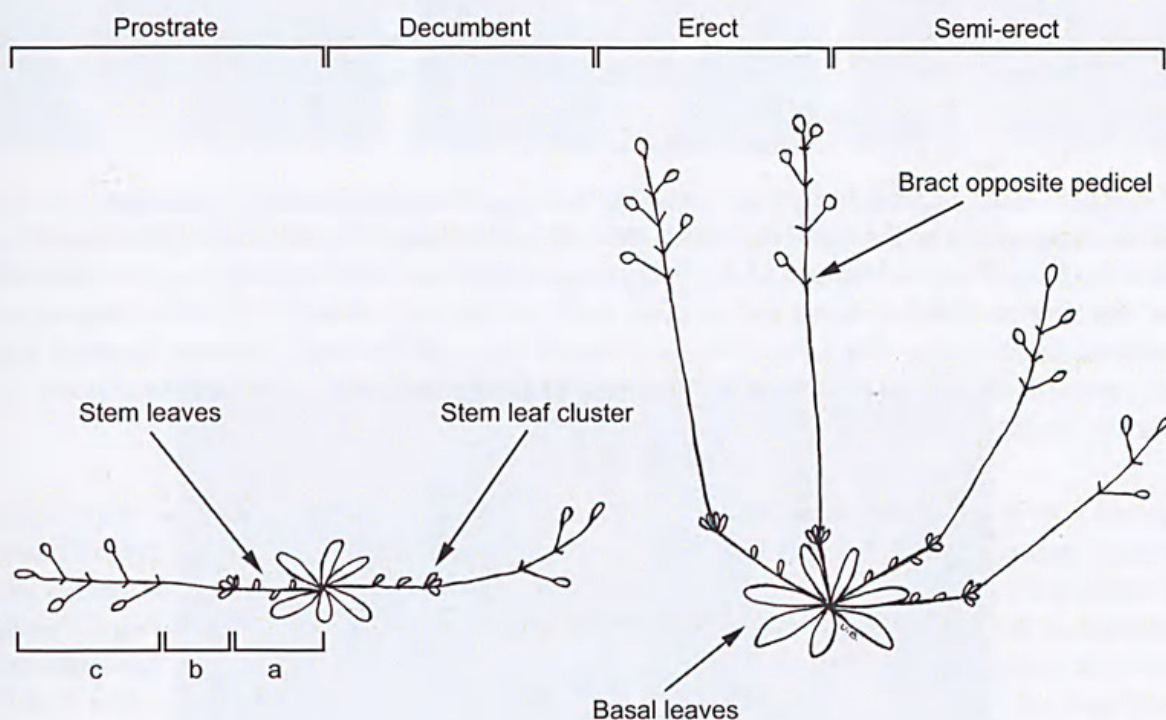


Figure 12. *Calandrinia* plant habits and architecture. a – stem; b – scape; c – inflorescence axis.

### Stamen arrangements and basal ring

Stamens in *Calandrinia* arise from the upper edge of a basal ring which subtends the ovary. The basal ring comprises a thin, narrow ring of tissue which is frequently obscured by the lower portion of the ovary. Close examination of the basal ring and attached staminal filaments reveals that there are a wide variety of diagnostic features, including basal ring width, staminal number, staminal lengths, staminal insertion point/shape, staminal series positioning and differences in other associated structure such as nectaries. Examination of spirit collections of about 20 *Calandrinia* species reveals some broad differences; other variations are likely to occur with further investigation of this genus.

Flowers with numerous stamens (i.e. > 30) have three, sometimes four, ill-defined rows crowded on top or slightly aside the top of the basal ring. This arrangement often occurs in species with medium-sized to large-sized flowers, and includes three of the five species described above (*C. pentavalvis*, *C. sculpta* and *C. vernicosa*). Melville (1959) described this stamen arrangement for *C. polyandra*, although the accompanying illustration did not show it clearly.



In medium-sized to smaller-flowered species (i.e. < 30 stamens) there is substantial variation in stamen and basal ring configurations. Flowers with ~12–30 stamens often have two rows of equally spaced stamens, the inner and outer series commonly alternating and sometimes of different lengths. *Calandrinia creethae* Morrison (12 stamens) has this arrangement, with an unusually wide basal ring that envelops the lower third or less of the ovary. In this species the longer inner series is attached to the top of the ring while the shorter outer series is attached lower down on the side wall of the ring. *Calandrinia stagnensis* J.M.Black (8–11 stamens published, although in Western Australia up to 15 stamens) has a similar arrangement with a narrower basal ring and fewer stamens within the outer series. These two species also have similar stigmata, capsule shape and seeds and may be closely related. In contrast to the above, *C. polypetala* Fenzl with 12 stamens has only one series of stamens all equally spaced and all of equal length.

In medium-sized or smaller flowers with less than 12 stamens the usual configuration is a single row of stamens on top of the basal ring, with alternating short and long filaments (see description of *Calandrinia flava* above and Figures 13A–C). Once again, there are exceptions such as *C. liniflora* which has an inner series of five stamens and an outer series of five (sometimes six and four respectively). *Calandrinia liniflora* also has a relatively wide basal ring with the inner series of stamens equally spaced around a slightly undulate rim and the outer series equally spaced and attached lower on the side wall of the basal ring.

Several species have very small flowers (i.e. usually < 5 mm diameter) with few stamens in one row equally spaced around the ovary. *Calandrinia corrigioloides* (three stamens) is a typical example. *C. sp. Bungalbin* (G.J. Keighery & N. Gibson 1656) is unusual in having three stamens equally spaced and inserted at the apex of basal lobes rather than a continuous basal ring. These lobes are partially adnate to the base of adjacent petals and appear to be disconnected from each other. Two other small-flowered species examined, *C. sp. Piawaning* (A.C. Beaglehole 12257) and *C. sp. The Pink Hills* (F. Obbens FO 19/06), have five and three stamens respectively, both with one row of equally spaced filaments. These species also have some other unusual characters such as coriaceous, one or two-seeded, indehiscent and deciduous capsules with valve rudiments at the apex. These two species, along with *C. disperma* J.M.Black which has many similar attributes (very small flowers, four or five stamens, coriaceous capsules with two seeds, one of which is released and one retained in the deciduous capsule) appear morphologically anomalous within *Calandrinia*.

All species examined, are papillose to some degree on the lower portion of the filament facing the ovary, and sometimes also on the basal ring.

### Stigmata morphology

Stigmata in *Calandrinia* are generally described as plumose (Bentham 1863, Morrison 1912, Black 1927, Obbens 2006) although Melville (1959) used the term 'glandular papillose'. High magnifications reveal that the stigmata are mostly covered with trichomes, each with a slightly bulbous apex. It is probable that viscous substances produced from stigmatic glands exude onto the trichomes and this aids the capture of pollen grains, as readily observed in the field.

An examination of 20 *Calandrinia* species showed significant variation in stigmata characteristics such as shape, cross-section, colour and trichome length and density. The stigmata for *C. sculpta* and *C. vernicosa* (Figure 14A–D) are very similar being triangular. *Calandrinia polyandra*, *C. remota* and



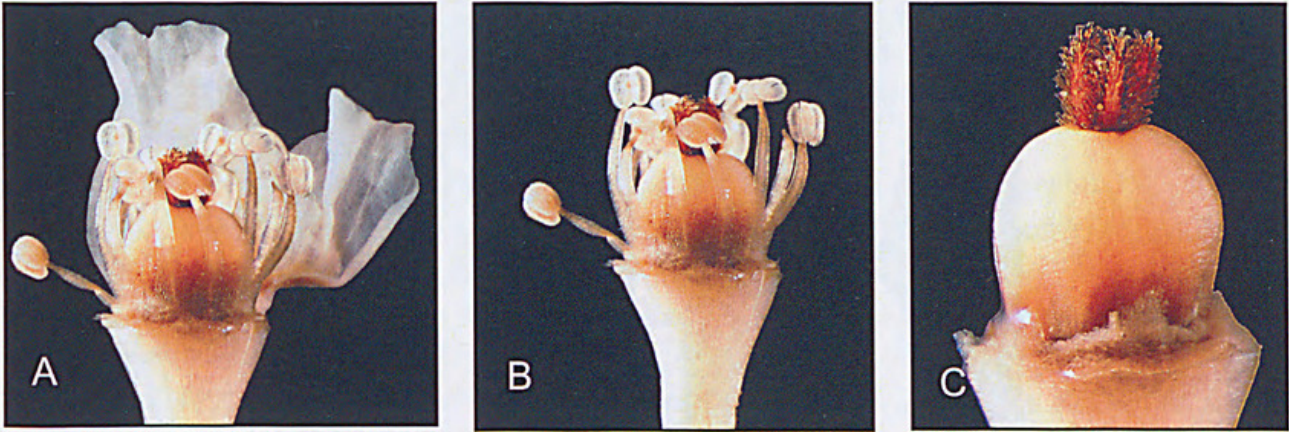


Figure 13. *Calandrinia flava* flower structure. A – single row of stamens with a few petals removed; B – with all petals removed (tapering filaments and nectaries near basal ring); C – with all petals and stamens removed (stigmata at early stage of maturation).

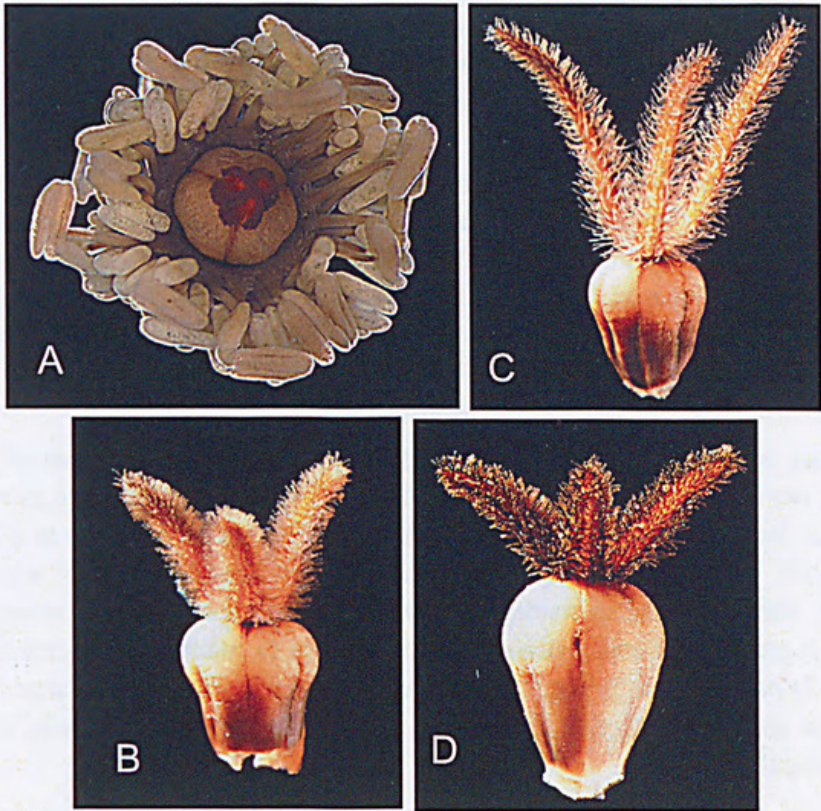


Figure 14. *Calandrinia vernicosa* flower structure and stigma maturation. A – stigma maturation at early development stage showing the plan view of staminal whorl, ovary and stigma; B – stigma maturation at intermediate development stage. C – stigma maturation at late development stage; D – *Calandrinia sculpta* stigma at intermediate development stage.



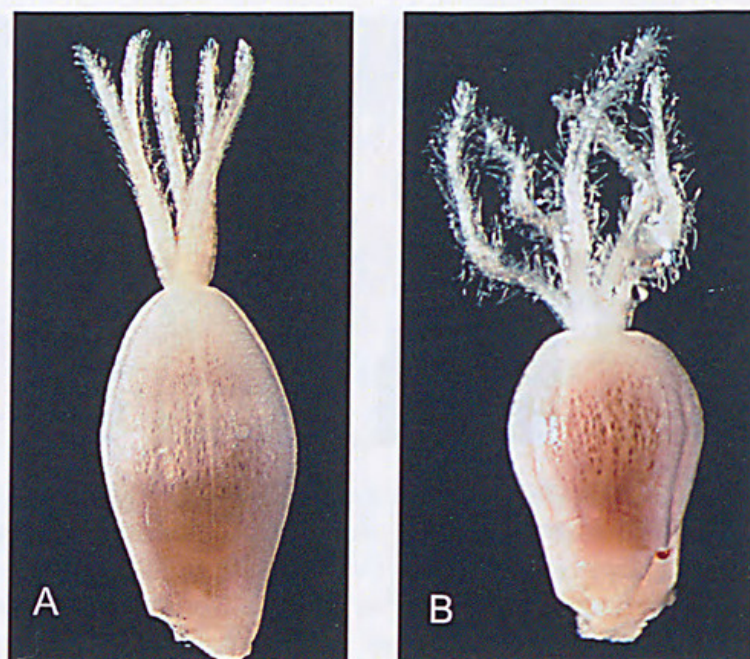


Figure 15. *Calandrinia pentavalvis* stigma maturation. A – stigma maturation at early to intermediate development stage; B – stigma maturation at late development stage.

*C. sp.* Meckering (F. Obbens 42/02) also have relatively similar triangular stigmata. Trichome length and density differs somewhat for all five species listed above. *Calandrinia pentavalvis* is markedly different to the above in having linear stigmata with moderately long trichomes (Figure 15A, B). *Calandrinia flava* has short stigmata, incurved at the apex although these slightly diverge with maturity (Figure 13). There are other stigma variations and further examination of the genus would probably highlight this to a greater extent.

Protandry appears common amongst the mid-sized to large flowered species of *Calandrinia*, the sequence of events occurring relatively quickly (Figures 14, 15). First, pollen is released from the extrorse anthers then the immature stigmata begin to grow dramatically (some to triple their original length). The stigmatic arms diverge becoming increasingly more receptive while the appressed stigmatic trichomes slowly spread at maturation to maximize capture of incoming pollen. The use of nectaries to attract pollinators and protandry are strategies to maximize outcrossing. This concurs with Carolin's (1993) *pers. comm.* from J. West that, '*Calandrinia* spp. with large flowers and large numbers of stamens are self-incompatible, whilst those with small flowers and small numbers of stamens are self-compatible.'

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