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A review of the tuberous *Calandrinia* species (section *Tuberrosae*), including three new species for Western Australia

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Abstract

Obbens, F. J. A review of the tuberous *Calandrinia* species (section *Tuberrosae*), including three new species for Western Australia. *Nuytsia* 16(1): 95–115 (2006). Background on the current systematic status of Australian *Calandrinia* is explained. Three new species of section *Tuberrosae* von Poellnitz are described and illustrated: *Calandrinia crispisepala* Obbens, *C. kalanniensis* Obbens and *C. translucens* Obbens. A key to section *Tuberrosae* is provided. Additional descriptive material for the previously named species is provided along with notes that explain the important differences and similarities between the six species now belonging to this section.

Introduction

By far the majority of the Australian species of *Calandrinia* are annuals while several are ‘short-lived’ perennials. In addition there are some species that are perennials with tuberous root systems. All of these tuberous species are endemic to Western Australia and comprise section *Tuberrosae* of von Poellnitz (1934) as described in his revision of the Australian species of *Calandrinia*. He recorded 8 sections, 6 being endemic to Australia (i.e. sects. *Partitae*, *Basales*, *Apicales*, *Tuberrosae*, *Uniflorae*, and *Pseudodianthoideae* – von Poellnitz 1934) while the other 2 (i.e. sects. *Axillares* and *Compressae* – Reiche 1897) were of introduced species that originated in America from where the genus was first recognized (Kunth 1823). Karl von Poellnitz described section *Tuberrosae* as containing perennial glabrous plants with root systems that consisted of a slender rhizome attached to a distinct tuber, or with the root entirely tuberous, with a one or many flowered inflorescence, the capsules valvate and with the endocarp firmly joined to the exocarp. In conclusion, he stated that all species in the section had basal leaves only. To this one should also add that species in section *Tuberrosae* have flowers that are 5-merous and have 3 stigmata that are either united onto a style or are free to the base. However, Carolin (1993) stated that this section had “stigmata 4, sometimes connate”, which I assume to have been a typographical error.

Karl von Poellnitz’s use of the word ‘rhizome’ in his section description is strictly speaking erroneous as a rhizome is considered to be a modified stem. The ‘rhizome’ appears to be a true root attached to a tuber beneath. I have used the term ‘root’ throughout the text to describe this structure so as not to perpetuate this error.

Syeda (1980) undertook the next significant research with her M.Sc. thesis, a treatment of the Australian Calandrinias. She suggested that there were only 3 recognizable endemic sections in Australia by merging *Uniflorae* into *Basales* (essentially a 4 carpel group) and merging *Apicales* into *Pseudodianthoideae* (a 3 carpel group) while maintaining *Tuberosae* (another 3 carpel group). Section *Partitae* was excluded as being conspecific with *Anacampseros australiana*. A subsequent cladistic analysis of Australian *Calandrinia* by Syeda and Ashton (1989) generally reinforced her earlier work that there are only 3 sections.

However, there are some errors within Syeda's original work that stem from incorrect identification of species, a commonly occurring problem. This M.Sc. research had Type specimens available for most, but not for all the species studied. For each species, the treatment also cited a selection of other specimens and some of these were used for the seed studies. There are no Types cited within the 12 specimens examined for *Calandrinia lehmannii* and the seed SEM and distribution shown for that species as displayed in Figure 3:19 of her thesis is incorrect. The seed SEM is actually that for *Calandrinia crispisepala* (see description below) and at least a third of the specimens she cited from the Eremaean Botanical Province are not *C. lehmannii* as this is essentially a species of the Avon Wheatbelt region and the adjoining eastern goldfields areas.

A worldwide review of the Portulacaceae by Carolin (1987) included cladistic analyses of 11 *Calandrinia* sections three being endemic to Australia (i.e. accepting Syeda's sects. *Basales*, *Tuberosae* and *Pseudodianthoideae*). The cladogram resulting from Carolin's study indicated five *Calandrinia* segregates that he suggested should each have generic status. Furthermore, the study revealed the Australian *Calandrinia* species (i.e. one of the five segregates) to be clearly different from their American counterparts. For the Australian segregate he used the generic name *Rumicastrum* Ulbrich as this appeared to be an appropriate available name, but he did not publish new combinations. Unfortunately, Ulbrich (1934) incorrectly placed *Rumicastrum* within the family Chenopodiaceae although it clearly is a member of the Portulacaceae (Wilson 1984), but its affinities within the family are uncertain. Hershkovitz (1998) has published the name *Parakeelya* for the Australian *Calandrinia* species on the basis of his belief that *Rumicastrum* belongs in the Chenopodiaceae. *Parakeelya* has not been generally accepted in Australia due to the aforementioned disagreement over the family placement of *Rumicastrum* and also whether or not *Rumicastrum* is congeneric with the other Australian species of *Calandrinia*.

Syeda and Carolin (1989) analyzed seed type and surface patterning within these *Calandrinia* segregates and this resulted in a classification table that had significant congruence to Carolin's previous research. It should suffice to acknowledge that systematic work on *Calandrinia* is still required, but all research so far has suggested that the integrity of section *Tuberosae* is not in question. As Syeda and Carolin (1989) state, "the only section which is more or less consistent is sect. *Tuberosae* with a straighter embryo, less perisperm and a tuberculate or verrucate surface". Most significant, however, is that this research has reinforced the importance of seed characters in a broad classification within the genus as well as at the species level.

In past years, there has been some difficulty in identifying the members of section *Tuberosae* to species level. Part of the problem is caused by large variations that commonly occur within species of this genus. For the most part though, this situation has arisen because of inadequate species descriptions, the confusing presence of hitherto unrecognized tuberous species and a lack of knowledge about crucial characters (e.g. seeds, tubers, flowers, stems, bracts etc.). Apart from describing the three

new species, this paper seeks to address these other problems by providing additional descriptions for the existing taxa (i.e. *Calandrinia lehmannii*, *C. primuliflora* and *C. schistorhiza*) and by outlining taxonomically important features that serve to distinguish the species within section *Tuberosae*.

Methods

For each of the new species described, measurements were taken from either dry pressed material or from material preserved in 70% ethanol. For dry pressed specimens, flowers were first soaked in a weak warm detergent solution prior to measuring while other measurements were taken directly from the specimen. All spirit specimens were measured wet. As mentioned earlier, frequent large variations in plant size and in other morphological characters occur within the genus due to environmental and seasonal conditions. This variation also occurs within and between populations. 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 undertaken using a microscope graticule. Occasionally an estimate is given where an exact measurement was not possible. Stem length is the distance from the base of the plant just below basal leaves (i.e. ground level) to the uppermost bract pair while pedicel length is the distance from the uppermost bract pair to the base of the sepals. Stem bracts were measured when flattened out, but shape is described from the bracts when in situ on the stems. Sepal shape was described and measurements taken when in position on flowering specimens.

For each of the already named species within the section some additional description is given. These are not full descriptions, but intended as a supplement to the original descriptions where information and/or some measurements were lacking or where my range of measurements differs from that of the original descriptions and particularly to note additional diagnostic characters. All measurements were taken from dry pressed specimens across the species' distribution range. Most measurements were undertaken using a ruler rather than using a microscope graticule as above.

Flowering times for each species are based on specimen collections and to some extent may not be conclusive, particularly in the more arid regions where many plants are adapted to take advantage of opportunistic events.

SEM images were produced at The University of Western Australia's Centre of Microscopy on a LEO microscope. LEO parameters were set at high current (10kv) with a 60 micron aperture and a 24 mm working distance. Seed specimens were not coated before scanning. Images were subsequently enhanced using Photoshop 2.0 (see Figure 1).

Illustrations were drawn by L. Cobb and kindly funded by the Western Australian Herbarium, Department of Conservation and Land Management. In general, the illustrations are representative for each species and were assessed from Western Australian Herbarium specimens, spirit collections and photographs. For *Calandrinia lehmannii* and *C. primuliflora* only habit is portrayed because more detailed illustrations already exist in Diels & Pritzel (1905). Strictly speaking the illustrations do not always portray these species correctly at a particular moment in their stage of development. For instance, in some species the basal leaves commonly wither once flowering commences and are often fully dried off by fruiting. All illustrations show basal leaves in the non-withered condition regardless of what stage of flowering/fruiting that is portrayed.

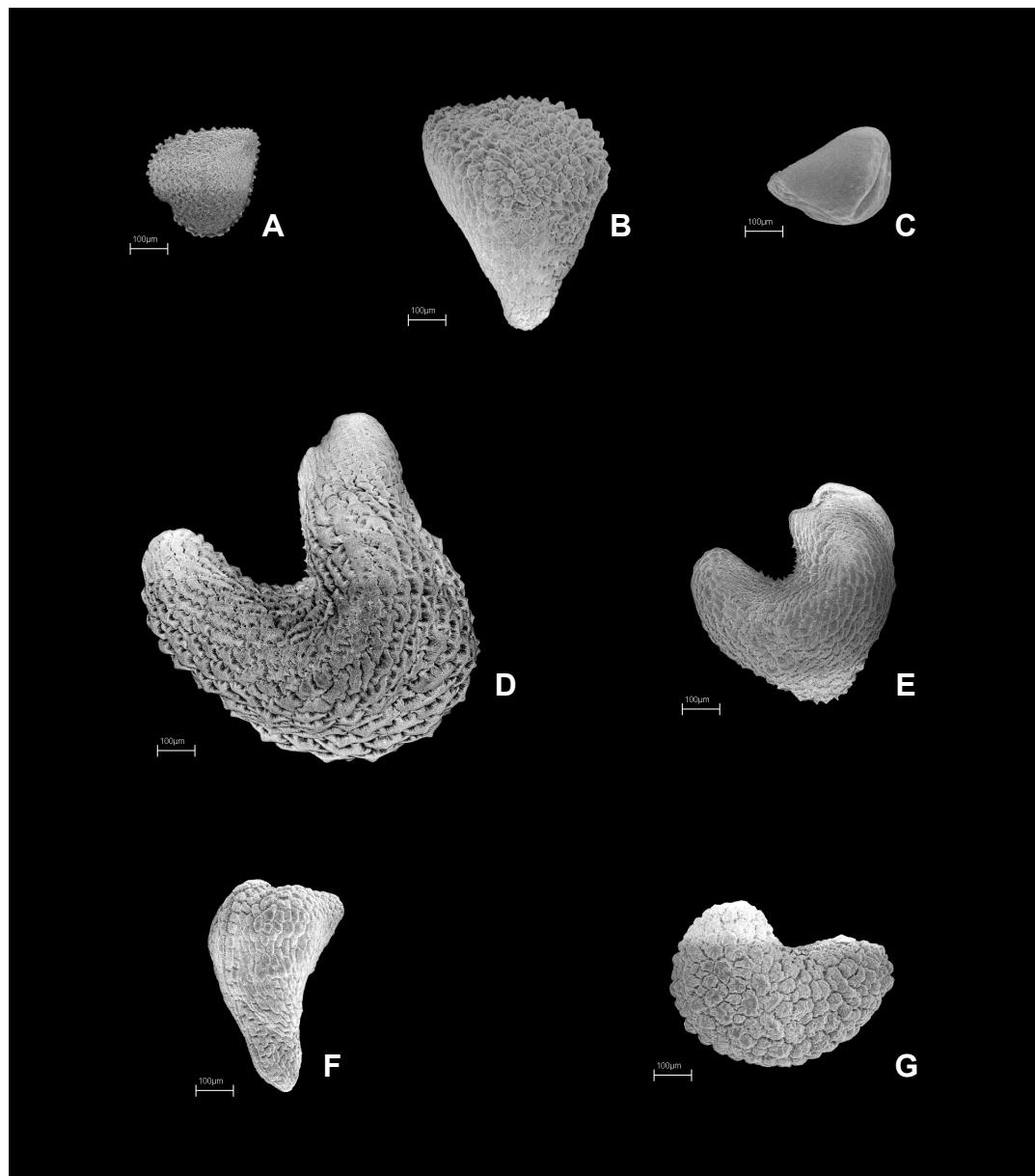


Figure 1. Scanning electron micrographs of seed of species in section *Tuberosae*. A – *Calandrinia crispisepala*; B – *C. kalanniensis*; C – *C. translucens*; D – *C. lehmannii* (from near Type locality); E – *C. lehmannii* (Northern & Eastern variants); F – *C. primuliflora*; G – *C. schistorhiza*. All are taken at the same magnification (scale bar = 100 micron).

Taxonomy

Key to species of *Calandrinia* sect. *Tuberosae*

A. Perennial, with tuberous rootstock (section *Tuberosae*)

1. Seeds black or grey black and strongly verrucose and/or tuberculate; sepals crisped; tuber taproot-like or appearing as a thickened root
 2. Flowers 10–18 mm diameter; seeds 0.2–0.3 mm long; usually smallish plant with narrow spatulate basal leaves 3.5–27.0 mm long (N of Mullewa to E of Mt Magnet and S to Paynes Find area) ***C. crispisepala***
 2. Flowers 25–40 mm diameter; seeds 0.5–0.8 mm long; usually a larger plant with broadly spatulate basal leaves 15–700 mm long and often with a strap-like petiole (widespread within the Eremaean Botanical Province) ***C. schistorhiza***
1. Seeds not black and moderately verrucose or smooth; sepals relatively smooth although may be sharply veined; a slender vertical root attached to tuber or tubers beneath
 3. Stigmata 3, free to base; flowers deep purple to magenta, floral throat constricted; usually a smallish plant (northern Avon Wheatbelt to Mt Magnet area) ***C. primuliflora***
 3. Stigmata 3, united onto a style; flowers white or pink, floral throat relatively open; small or medium sized plants
 4. Stem bracts narrowly acuminate (3.5–5.0 mm long), ± membranous, appressed, normally many pairs per stem; flowers white and shiny occasionally pale purple/mauve, summer flowering (extensive within the Avon Wheatbelt and extending into eastern goldfields) ***C. lehmannii***
 4. Stem bracts narrowly triangular to ovate (0.5–3.0 mm long), ± scarious, ± spreading, normally 3–5 pairs per stem; flowers pink occasionally bleached white, spring or summer flowering
 5. Flowers 15–25 mm diameter (often a yellow centre), spring flowering (occasionally early summer); seeds straw brown to light tan, translucent, triangular in outline, smooth, 0.25–0.35 mm long (northern Avon Wheatbelt and widespread in the Eremaean) ***C. translucens***
 5. Flowers 5–12 mm diameter (often a white centre), summer flowering (occasionally late spring); seeds off-white and light brown, pyramidal and roughly trigonous, opaque, moderately verrucose, 0.5–0.8 mm long (W of Paynes Find, Kalannie area & NE of Mukinbudin) ***C. kalanniensis***

A. Annual, or if perennial then lacking a tuberous rootstock (sections *Basales* and *Pseudodianthoideae*)

Calandrinia crispisepala Obbens, *sp. nov.*

C. schistorhiza affins sed planta erecta vel semi-erecta (nec prostrata vel decumbenti), et parviore, foliis basalibus anguste spathulatis, floribus 10–18 mm diam. differt.

C. crispisepala has affinities to *C. schistorhiza*, but differs in the plant being erect to semi-erect (rather than prostrate to decumbent), is smaller, has narrow spathulate basal leaves and flowers 10–18 mm in diameter.

Typus: Circa 9.2 km E of Yalgoo, Western Australia, 14 October 2003, *F. Obbens* FO 72/03 (*holo*: PERTH 06708307; *iso*: CANB, K).

Perennial herb; root system completely tuberous (i.e. taproot-like, but occasionally the tuber is branched). *Plant* semi-erect to erect, sometimes prostrate, 10–38 mm tall × 25–80 mm wide, glabrous. *Basal leaves* fleshy, narrowly spathulate, 3.5–27.0 mm long × 0.7–2.2 mm wide at widest point. *Stems* few to many (usually 7–16), radiating out and upwards from base, 115–270 mm long, bare except for 3 to 4 or occasionally more pairs of opposite ± scarious bracts; the lowest node sometimes with 3 bracts. *Stem bracts* ± spreading, triangular to ovate occasionally narrowly so, 0.7–2.2 mm × 0.7–2.2 mm, apex obtuse to acuminate with mid vein extending down central fold; one bract of lowest stem node with a double apex, each apex with a mid vein as above (see Figure 2). *Inflorescence* of 1 (occasionally 2) terminal pedicellate flower, very occasionally branching below. *Pedicel* 3.0–6.0 mm long, erect, slightly reflexed in fruit. *Flowers* 10–18 mm diameter. *Sepals* thin, ovate to broadly ovate, 3.1–6.6 mm × 2.5–5.4 mm, 3-nerved, free to base, extensively wrinkled or creased. *Petals* 5, bright pink to purple in apical half and white in basal half, obovate to flabellate (sometimes broadly so) with an emarginate or depressed apex, 5.9–12.3 mm × 3.2–9.6 mm, shortly connate at base. *Stamens* 38–44 in 2 or 3 ill-defined rows; filaments free, 1.7–3.6 mm long, attached to a basal cup beneath the ovary; anthers elliptic to oblong in outline, 0.6–1.2 mm × 0.25–0.6 mm, versatile, extrorse, dehiscing longitudinally. *Ovary* spheroid to ovoid, 1.4–2.3 mm × 1.3–2.3 mm. *Style* 0.3–1.3 mm long; stigmata 3, 1.6–3.9 mm long, shortly plumose. *Capsule* ovoid to slightly pyramidal, sometimes broadly so, 3.0–5.0 mm × 2.4–3.4 mm, apex obtuse or occasionally truncate, usually not protruding beyond the sepals; valves 3, splitting from apex to base. *Seeds* numerous (100+), black, dull, heart-shaped and somewhat trigonous, 0.2–0.325 mm × 0.2–0.275 mm, surface strongly and minutely verrucose and tuberculate. (Figures 1A, 2)

Other specimens examined. WESTERN AUSTRALIA: 4 miles S of Mt Magnet, 23 Oct. 1973, *H. Demarz* 4682 (KPBG); Bullardoo Station, N of Mullewa, 7 Oct. 2004, *F. Hort*, *J. Hort* & *J. Shanks* 2359 (PERTH 06873995); Burnerbinmah Station, NW of Paynes Find, 21 Oct. 1998, *S. Patrick* et al. 3044 (PERTH 05407524); 80 km W of Sandstone, 19 Oct. 1992, *L. Sweeney* S2338 (KPBG); Windimurra Station, [ESE of Mt Magnet], 11 Sep. 1992, *S. Van Vreeswyk* 3014 (PERTH 04267214).

Distribution. Eremaean Botanical Province of Western Australia. Known only from the above collections, but range may extend further. Distribution is roughly from N of Mullewa to E of Mt Magnet and then S to Paynes Find area. (Figure 8A)

Habitat. Recorded in red sandy clay soils on an eroded lateritic platform or on plains with red clayey sand over hardpan. Some sites are described as stony or as having iron-rich pebbles or rocks scattered on the surface. Occurs in very open shrubland or mulga.

Phenology. Flowers and fruits in September to October.

Conservation status. Probably a fairly common species with a relatively wide distribution. Most *C. crispisepala* habitat is affected by pastoral grazing, although some leases have recently been transferred to conservation reserves (e.g. Burnerbinmah and Twin Peaks Stations).

Etymology. From the Latin *crispus*—wrinkled or creased and *sepala*—sepals. This is seen more obviously in the dry state.

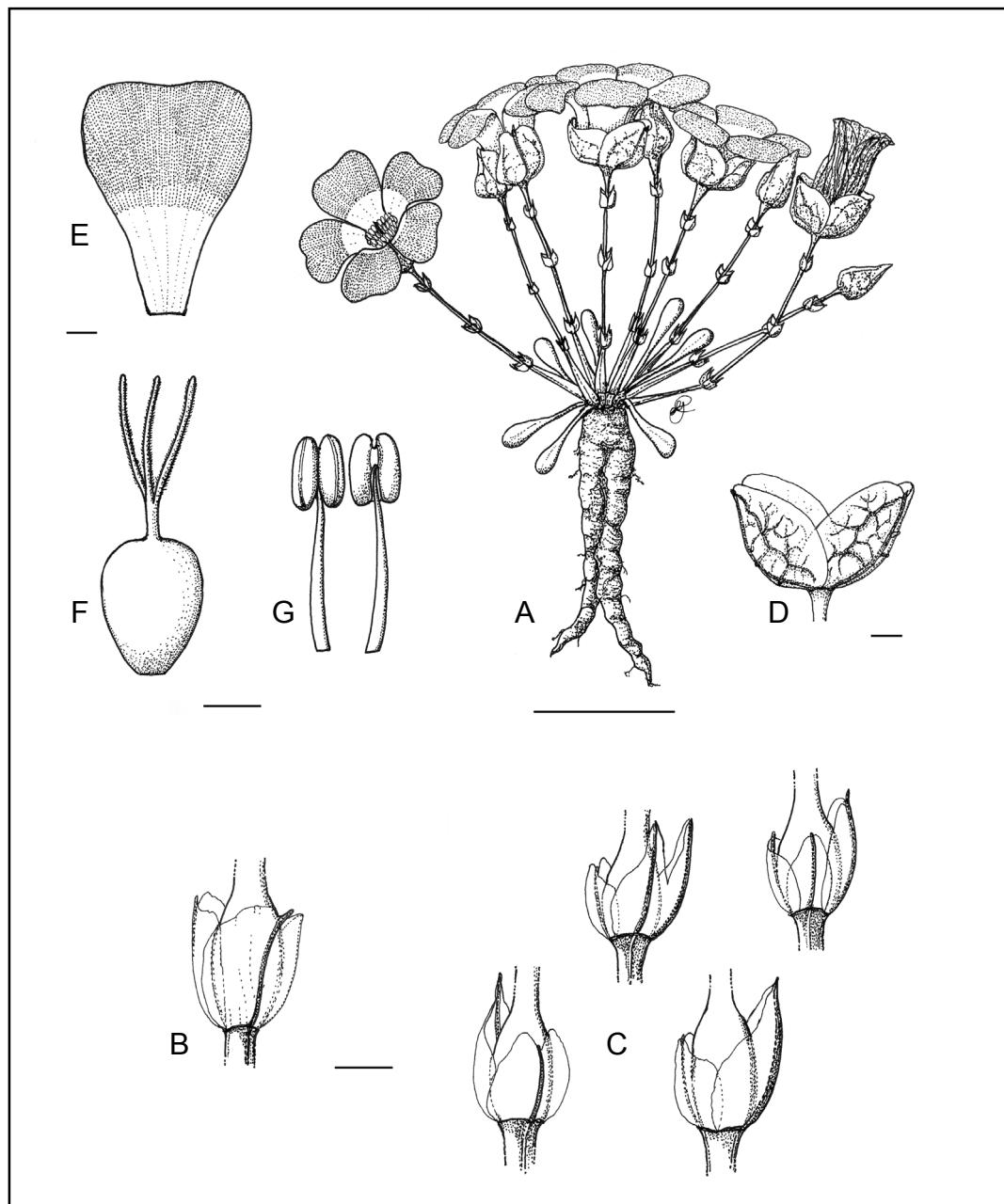


Figure 2. *Calandrinia crispisepala*. A – plant habit displaying a tap-root like tuber; B – upper stem bract; C – lower stem bracts; D – sepals; E – petal; F – gynoecium; G – stamens. Scale bars: A = 10mm; B–G = 1mm.

Notes. This species is probably most closely related to *Calandrinia schistorhiza* Morrison, since the two have similar seed, sepal and tuber characteristics (i.e. seeds black and strongly verrucose, sepals similarly crisped and tubers taproot-like or appearing as a thickened root). However, *C. schistorhiza* is a larger plant in all respects when compared to *C. crispsepala*, although *C. crispsepala* may be confused with *C. primuliflora* because of their similar size and habit (see also notes under *C. primuliflora*).

Calandrinia kalanniensis Obbens, sp. nov.

C. primuliflora affinis sed stigmatis 3 in stylo connatis, floribus roseis vel pallide roseis, fauce florali comparatae aperta differt.

C. kalanniensis has affinities to *C. primuliflora*, but differs in having 3 stigmata fused onto a style, flowers pale to mid pink and a relatively open floral throat.

Typus: Hughden Rock, c. 1.7 km N on Struggle Street from junction with Dalwallinu–Kalannie road, Western Australia, 19 January 2004, F. Obbens FO 3/04 (*holo*: PERTH 06707971; *iso*: CANB, K).

Perennial herb; root system a narrow vertical root attached to a tuber beneath (occasionally the tuber branched). *Plant* semi-erect to erect, 20–85 mm tall × 10–45 mm wide, glabrous. *Basal leaves* fleshy, linear-terete to narrow-spathulate, 1.1–8.2 mm × 0.3–1.4 mm at widest point. *Stems* one to several, radiating out and upwards from base, 12–75 mm long, bare except for 3 to 5 or occasionally more pairs of opposite ± scarious bracts. *Stem bracts* ± spreading, narrowly triangular to narrowly ovate (sometimes broader), 0.9–2.8 mm × 0.6–2.5 mm, apex acute to acuminate, strongly recurved. *Inflorescence* of 1 (occasionally 2) terminal pedicellate flower, occasionally branching below. *Pedicel* 1.2–4.2 mm long, erect, sometimes obscured by the uppermost bracts, moderately reflexed in fruit. *Flowers* 5–12 mm diameter. *Sepals* thin, ovate, 2.6–3.4 mm × 1.7–2.7 mm, strongly 3-veined, free to base. *Petals* 5, pale to mid pink usually with some white at base (sometimes appearing totally white), obovate to spatulate, occasionally broadly so, 5.4–6.3 mm × 2.2–4.0 mm, connate basally up to one third. *Stamens* 33–40 in 2 or 3 ill-defined rows; filaments free, 0.6–3.2 mm long, attached to a basal cup beneath the ovary; anthers elliptic to oblong in outline, 0.45–0.65 mm × 0.3–0.5 mm, versatile, exserted, dehiscing longitudinally. *Ovary* ovoid, 1.3–1.4 mm × 0.85–1.2 mm. *Style* 0.4–0.9 mm long; stigmata 3, 1.1–2.2 mm long, shortly to moderately plumose. *Capsule* pyriform, truncate at apex giving a pore-like appearance, 3.3–4.2 mm × 1.9–2.7 mm, slightly protruding beyond the sepals; valves 3, splitting to one third or half. *Seeds* 6–37, off-white and light-brown, dull, pyramidal and roughly trigonous, 0.5–0.8 mm × 0.4–0.65 mm, moderately verrucose (particularly at one end). (Figures 1B, 3)

Other specimens examined. WESTERN AUSTRALIA: Xantippe Rock, c. 30 km E of Dalwallinu on Kalannie Rd, 8 Jan. 2004, R. Cranfield s.n. (PERTH 06235069); Petrudor Rock, c. 16 km directly SW of Kalannie townsite, (a) 12 Oct. 2003 (b) 3 Jan. 2004 (c) 19 Jan. 2004, F. Obbens FO 60/03 (PERTH 06708129, PERTH 06708137, PERTH 06708145); Yannemooning Rock in rock garden near summit, NE of Mukinbudin, 15 Oct. 2005, F. Obbens & H. Jensen FO 2/05 (PERTH 07213093); Granite outcrop beside Elsewhere Rd near junction with Cunderdin Rd, NE of Mukinbudin, 16 Oct. 2005, F. Obbens & H. Jensen FO 5/05 (PERTH 07213123); Near Blue Hills Range, Karara Station, 14 Nov. 2005, G. Woodman & K. Rodda M13-3 (PERTH 07215568).

Distribution. South West and Eremaean Botanical Provinces of Western Australia. Originally known from only three locations NW and SW of Kalannie, however, more collections have been made recently from Karara Station, W of Paynes Find and from NE of Mukinbudin. This extends the distribution much further than previously recognized. (Figure 8B)

Habitat. Recorded in shallow brown clay soils often gritty and derived from eroded granite. All collections are from the apron areas of granite outcrops or soil pockets on granite. Occurs in open herbfields often surrounded by *Acacia* shrubland.

Phenology. Flowers and fruits in mid November to January.

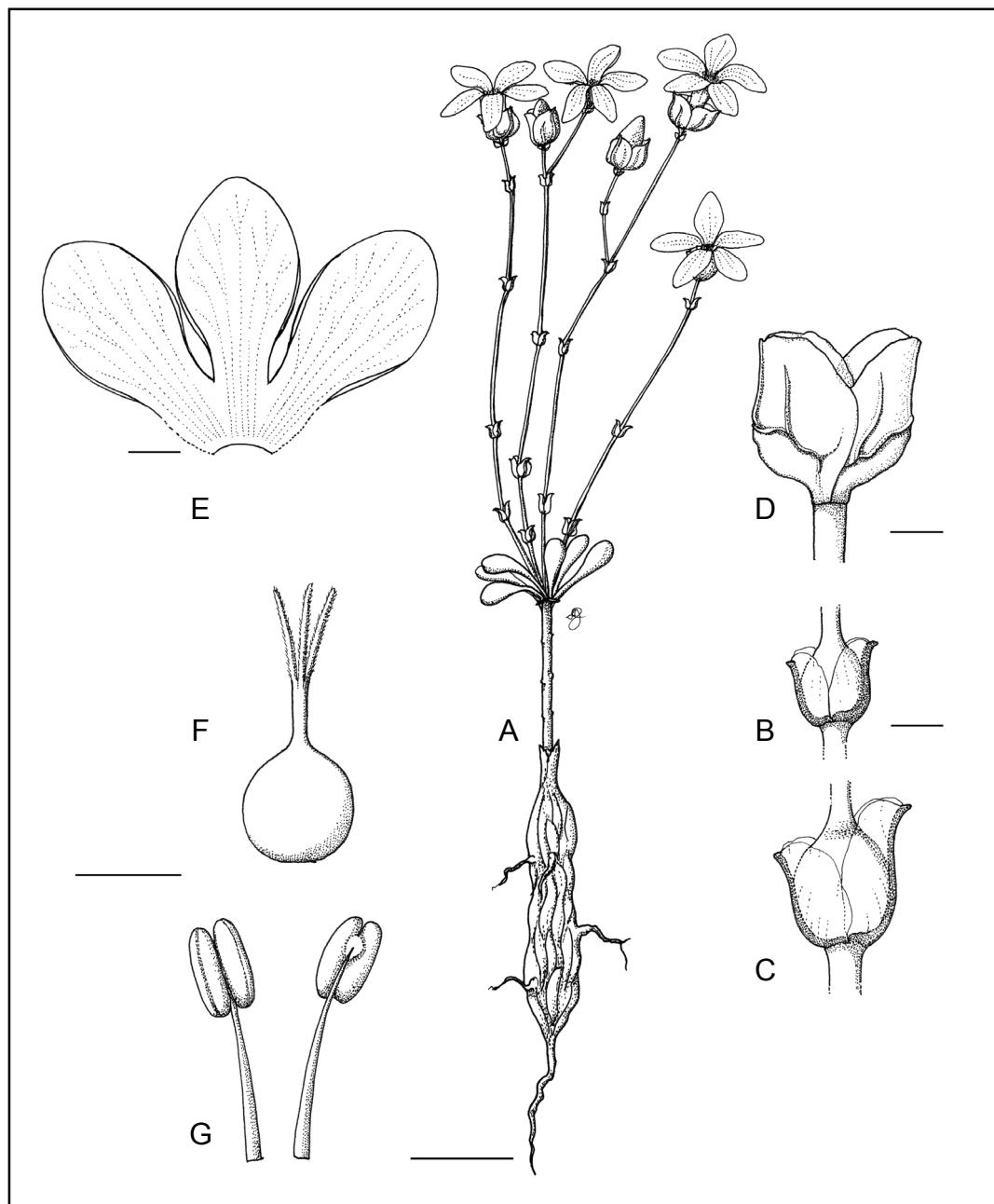


Figure 3. *Calandrinia kalanniensis*. A – plant habit displaying a narrow vertical root attached to a tuber beneath; B – upper stem bract; C – lower stem bract; D – sepals; E – petals; F – gynoecium; G – stamens. Scale bars: A = 10mm; B–G = 1mm.

Conservation status. Conservation Codes for Western Australian Flora: Priority Two. Currently, there are 6 known populations over a relatively wide area. There are many granite rocks within this region and it is likely that future survey of these should produce other collections of this species.

Etymology. Named after the closest town, Kalannie where the original collections were discovered.

Notes. This species is possibly most closely related to *Calandrinia primuliflora* both having some seed, capsule and sepal characters in common (i.e. seeds of similar colour and surface patterning, capsules with truncated apexes and with limited valve separation and sepals with 3 distinct, raised and folded nerves).

In many other characters there is little similarity between the two. For example, *C. kalanniensis* has obovate petals and stigmata united onto a style whereas *C. primuliflora* has broadly suborbicular petals and stigmata free to base. Also *C. kalanniensis* might be confused with *C. translucens* because of their somewhat similar habit.

Calandrinia translucens Obbens, sp. nov.

C. lehmannii primo aspectu maxime simulēn sed floribus roseis in vere florenti, seminibus laevisbus translucēntibus differt.

C. translucens has been confused with the superficially similar *C. lehmannii*, but differs in having pink flowers, flowering during spring and also has smooth translucent seeds.

Typus: 45.8 km N of Wubin townsite on Great Northern Highway, Western Australia, 9 November 2003, F. Obbens FO 65A/03 (*holo*: PERTH 06708226; *iso*: CANB, K). Cultivated (i.e. on-grown) from plants collected at the above location. Plants harvested when in flower.

Perennial herb; root system a narrow vertical root attached to a tuber (occasionally the tuber branched). *Plant* semi-erect or erect or occasionally almost prostrate, 15–175 mm tall × 15–170 mm wide, usually glabrous. *Basal leaves* fleshy, narrow-spathulate, 0.9–36 mm × 0.3–2.5 mm at widest point. *Stems* few to many (usually 4–9), radiating out and upwards from base, 12–75 mm long, bare except for 3 to 10 (normally 5) pairs of opposite ± scarious bracts. *Stem bracts* ± spreading, triangular to ovate, 0.6–2.7 mm × 0.4–2.6 mm, apex acute to acuminate sometimes recurved. *Inflorescence* a multi-flowered loose cyme (juveniles can be one or few flowered). *Pedicel* 2.7–11.2 mm long, erect, moderately reflexed in fruit. *Flowers* 15–25 mm diameter. *Sepals* thin, ovate, 2.1–5.6 mm × 1.5–3.1 mm, 3–5 veined, free to base. *Petals* 5, pale to mid pink (some may bleach white), often yellow at base with obvious dark pink or purple striations outside at least on the two enveloping petals when in bud, obovate, occasionally narrowly so, 6.3–12.6 mm × 2.6–5.4 mm, shortly connate at base. *Stamens* 20–72 in 2 or 3 ill-defined rows; filaments free, 0.8–4.2 mm long, attached to a basal cup beneath the ovary; anthers elliptic to oblong in outline, occasionally broadly so, 0.5–0.9 mm × 0.4–0.6 mm, versatile, extrorse, dehiscing longitudinally. *Ovary* ellipsoid to ovoid, 1.7–2.8 mm × 0.9–1.8 mm. *Style* 0.7–2.0 mm long; stigmata 3, 0.8–2.2 mm long, shortly to moderately plumose. *Capsule* ovoid, occasionally slightly pyriform, apex obtuse, sometimes narrowing, 3.0–4.6 mm × 1.5–2.3 mm, usually protruding beyond the sepals; valves 3, initially splitting only at summit, usually fully splitting with age. *Seeds* 80–100+, straw-brown to light-tan, semi-glossy and translucent, triangular in outline with 2 grooves running parallel along 2 edges, 0.3–0.4 mm × 0.2–0.3 mm, smooth. (Figures 1C, 4)

Other specimens examined. WESTERN AUSTRALIA: Near Mangilla Bore, c. 40 km directly SE of Leinster, 13 Oct. 2004, P. Armstrong Rainbow PA 20 (PERTH 07219040); Meekatharra airport, 22 Nov. 1992, M.D. Barrett MDB 47 (PERTH 02859955); On Wanna Munna flats, Fortescue [Pilbara], 15 Oct. 1965, J.V. Blockley 119 (KPBG); Coolcalalaya Station, NW corner, 21 Oct. 1995, M.N. Lyons 2433 (PERTH 04994043); 8.5 km E of NW Coastal Highway and 14.4 km N of Nerren Nerren Station turnoff, 23 Oct. 1995, M.N. Lyons 2442 (PERTH 04994140); Dawson Paddock, Burnerbimah Station, NW of Paynes Find, 23 Oct. 1998, G. Marsh et al. 301A (PERTH 05490456); 2 km SSE of Hogans Lagoon on Lake Lefroy, near Kambalda, 11 Dec. 1997, A.A. Mitchell 5100 (PERTH 05908345); 45.8 km N of Wubin townsite on Great Northern Highway, Western Australia, 20 Jan. 2004, F. Obbens FO 65B/03 (PERTH 06708234).

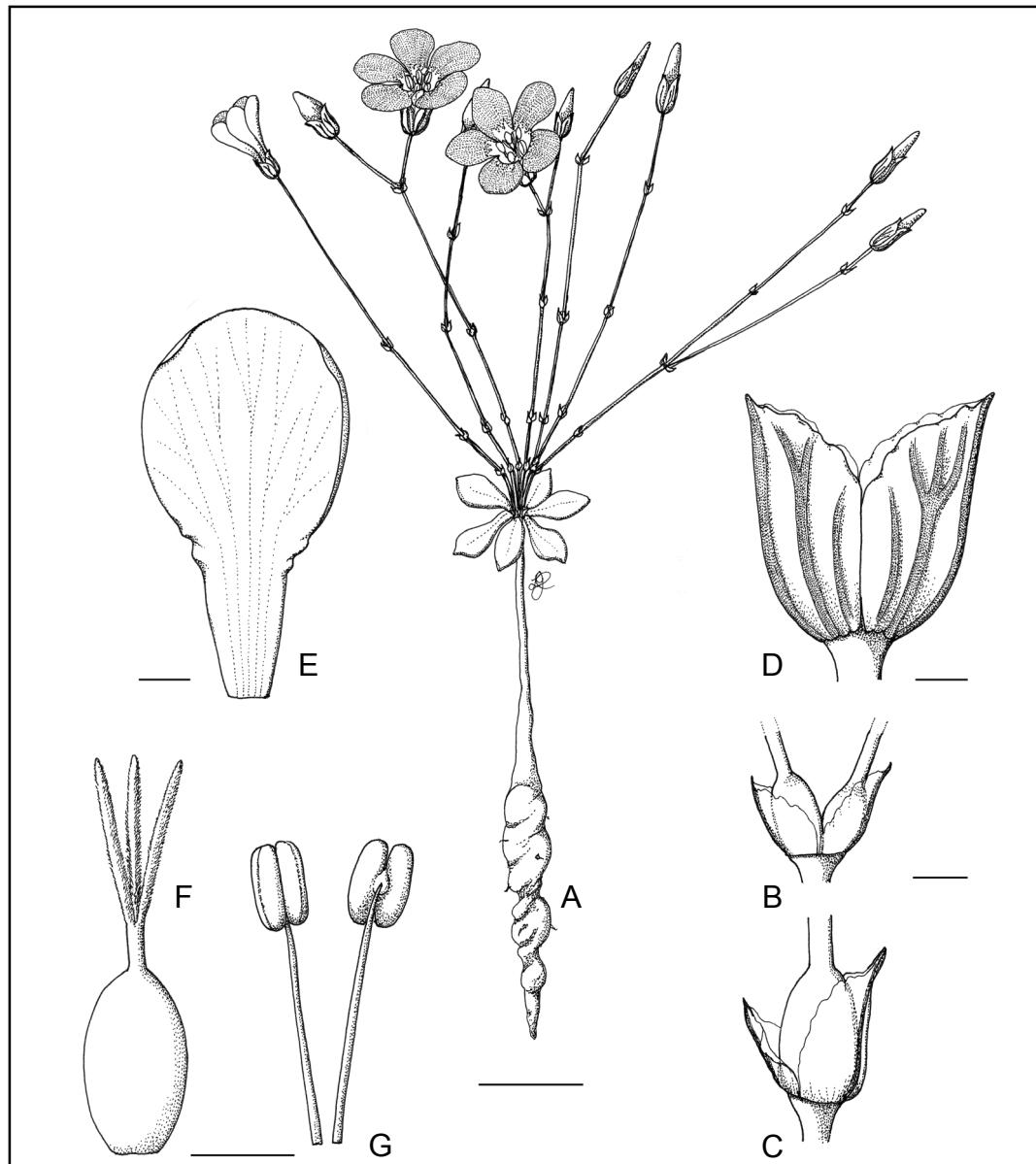


Figure 4. *Calandrinia translucens*. A – plant habit displaying a narrow vertical root attached to a tuber beneath; B – upper stem bract; C – lower stem bract; D – sepals; E – petal; F – gynoecium; G – stamens. Scale bars: A = 10mm; B–G = 1mm.

Distribution. A widespread species of the northern Avon Wheatbelt and Eremaean Botanical Province. In the latter it ranges from the Goldfields to the Pilbara and further east into desert areas. (Figure 8C)

Habitat. Recorded in orange to red clayey sand or in sand over clay soils. Occurs in a variety of habitats including open shrublands, amongst open vegetation fringing pans or salt lakes and in the understorey of very open *Eucalyptus loxophleba* woodland.

Phenology. Flowers and fruits in September to November (occasionally in early December).

Conservation status. This taxon has an extensive distribution and is found in several habitats and there is a high probability that it is quite common, but has been under collected throughout much of its range.

Etymology. From the Latin for translucent, in reference to the seeds.

Notes. Superficially, *Calandrinia translucens* has a similar habit to *Calandrinia kalanniensis* although it is generally a larger plant. The flower size of *C. translucens* and sometimes even the shape can be somewhat similar to that of *C. lehmannii*, although the obovate petals of *C. translucens* are quite variable with the apex being rounded to bluntly acute (see notes under *C. lehmannii*). *Calandrinia translucens* is distinctive in having smooth translucent seeds.

The specimen *F. Obbens* FO 65B/03 comes from the exact Type location and is material collected later on when these plants were in late seed. It is not part of the Type material. Additionally, the specimen *M.N. Lyons* 2442 is slightly unusual in having dense and shortly pilose to glandular hairs on the sepals and pedicels, however, it is typical of *C. translucens* in all other respects.

Calandrinia lehmannii Endl. in Lehm. Pl. Preiss 2: 235 (1848). *Type citation:* “In solo sublimoso-glareoso prope paludem Barrelanjin (in fluvio Avon) haud longe a Vilemattin v. Davy’s place (York) 26. Febr. 1839. Herb. Preiss. No. 1528. (Endl.).” (*holo:* LD n.v.; *iso:* !MEL 110919).

There are no records referring to Barrelanjin (whether a lake, a river pool or a river backwater, etc.) in Western Australia. However, Battye Library records show the Davy’s property to have been located between the lower slope of Mt Bakewell and the Avon River, York. Much of this area is now cleared or modified for agriculture while very few native remnants remain and these are mostly in a disturbed condition. A search of parts of this area during summer 2004 failed to find any *Calandrinia lehmannii* and it is likely to have become locally extinct here.

Perennial herb; root system complex usually consisting of multiple tubers interconnected by slender roots (fewer tubers relatively common), sometimes appearing like a string of beads. *Plant* erect, 45–200 mm × 15–50 mm (i.e. small to medium sized), glabrous. *Basal leaves* fleshy, narrow-spathulate to linear, 5–10 mm long × 1–5 mm at widest point. Individual plants frequently single-stemmed, occasionally up to 3 stems, normally few branched and few flowered although some mature plants or those with larger tubers can be multi-branched and several flowered. *Stems* with numerous bract pairs, internodes short with bract pairs occasionally overlapping. *Stem bracts* appressed, ±membranous, narrowly triangular to ovate, 3.5–5 mm long with a long acuminate apex. *Inflorescence* usually of 1 to 3 terminal pedicellate flowers, if with several flowers forming loose cymes. *Pedicel* 4–16 mm, erect, slightly deflexed in fruit. *Flowers* 10–26 mm diameter. *Sepals* thin, broadly elliptic to broadly ovate, usually 5-nerved although the outer 2 often appear indistinct amongst the reticulation. *Petals* 5, normally white (see notes below),

6–14 mm long, elliptic to obovate and often with light brown striations particularly on the two enveloping petals when in bud. *Stamens* numerous; filaments free; anthers versatile. *Ovary* ellipsoid to ovoid, sometimes narrowly so; stigmata 3, shortly to moderately plumose and united onto a style equal to or slightly less than the length of the stigmata. *Capsule* ovoid, 3–6 mm × 1.5–2.5 mm, somewhat erect with 3 valves splitting fully to base. *Seeds* several to numerous, usually >20, crescent to U-shaped, normally dull light brown, verrucose and partly tuberculate, 0.5–1.0 mm long. (Figures 1D, 1E, 5)

Specimens examined. WESTERN AUSTRALIA: Coalseam Reserve, upstream from Miners Camp [Mingenew area], 17 Feb. 2003, G. Byrne 1 (PERTH 06451950); Emu Rock [near Hyden], 9 Apr. 1997,

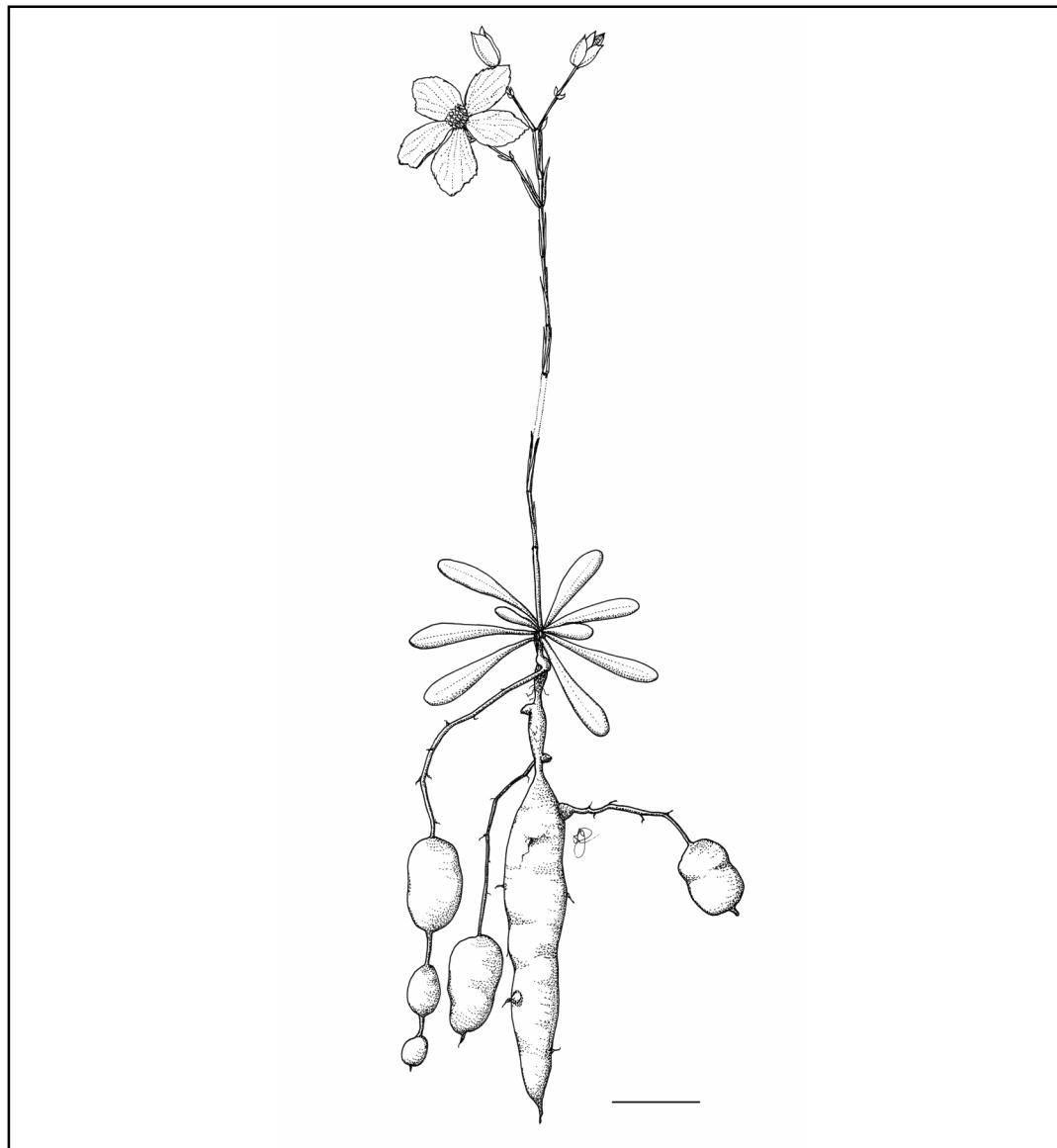


Figure 5. *Calandrinia lehmannii*. Plant habit displaying the intricate root system consisting of tubers interconnected by narrow roots. Scale bar = 10mm.

R. Cranfield 11298 (PERTH 04695623); Broomehill townsite reserve, 1987, *R. Garstone s.n.* (PERTH 05699215); Yanneymooning Hill 40 km NE of Mukinbudin, 24 Feb. 1993, *K.F. Kenneally* 11357 (PERTH 02999293); 29 km SSW of Norseman, 13 Mar. 1980, *K. Newbey* 6733 (PERTH 04209087); Beverley Airfield Reserve, 10 Jan. 2004, *F. Obbens* FO 1/04 (PERTH 06707955); Petrudor Rocks [near Dalwallinu/Kalannie], 19 Jan. 2004, *F. Obbens* FO 2/04 (PERTH 06707963); c. 1.2 km N along Buntine Rock track [Buntine area], 20 Jan. 2004, *F. Obbens* FO 4/04 (PERTH 06707998); Kokeby Water Reserve [near Beverley], 29 Dec. 2001, *T. Watson* 51 (PERTH 06359159).

Distribution and habitat. Extensive within the Avon Wheatbelt and extending into the eastern goldfields areas. Frequently associated with exposed granite sheets or shallow soils over granite. In these habitats the species occurs as part of a herbfield community often surrounded by *Acacia* or *Melaleuca* species. It has also been found in open shrublands and in open wandoo or mixed woodlands on sandy clay soils. One collection was located near a river. (Figure 8D)

Phenology. Flowers and fruits in January to March (occasionally April).

Conservation status. This taxon is relatively common, but likely to be under-collected due to its summer flowering. *C. lehmannii* has a wide distribution and although much of its range is now agricultural there are still numerous remnants or reserves dotted throughout this cleared Avon region where it is likely to occur.

Etymology. Named after the noted German botanist Johann Georg Christian Lehmann (1792 – 1860).

Notes. *Calandrinia lehmannii* has frequently been confused with *C. translucens*, both having a similar flower size and sometimes a similar shape, however, *C. lehmannii* flowers are commonly white while *C. translucens* are usually bright mid pink. Endlicher described the petals inside as covered with white sericeous hairs and later Diels and Pritzel (1905) stated that the flower was pale purple and shiny inside with the outside yellowish. However, my own observations at several localities indicate that the flower is white, but occasionally at closer inspection appears tinged pale purple/mauve and is indeed somewhat shiny. Examination of several specimens including the isotype did not reveal any sericeous hairs, although the corolla throat is often papillate to shortly pilose. No other specimens examined in this section appear to have this characteristic. Diels and Pritzel's description might be explained if their observations were of an unusually deeper coloured variant while it is also common for *C. lehmannii* flowers to yellow quickly when pressed.

Many other of its characters are quite different to those of *C. translucens* and to other members of the section. For example, *C. lehmannii* normally has a very erect habit, flowers during summer, often has light brown striations on the petals (particularly the two enveloping petals when in bud), and has numerous acuminate stem bracts. These opposite bract pairs are appressed and ±membranous, while others in the section are ±scarious. Most specimens are single stemmed and few flowered, however, Diels and Pritzel illustrate a more mature multi-flowered specimen and fail to show the lower stem and intricate root system. These distinctive features have been included in the illustration of *C. lehmannii* (Figure 5).

C. lehmannii may have the ability to clone off new plants. A few specimens examined display slender horizontal roots growing from a single tuber and leading to separate stems above ground level. When these stems are tightly clustered the plant appears as a multi-stemmed individual above ground. However, if these stems are spaced some distance apart they appear as separate individuals and may form new cloned plants if the initial connection breaks and the new plant forms its own tuber. This characteristic may not be unique within the section, for some recent collections of *C. primuliflora* and

C. translucens also display the start of an extended horizontal root similar to the above. Further investigations are required to determine whether or not asexual reproduction truly occurs and whether this is biological or a response to environmental factors such as drought.

An examination of seed shows the *C. lehmannii* collection from Beverley (just south of the Type locality) to be significantly larger-seeded than collections further north and east (Figure 1D & 1E). This might indicate clinal variation, polyploidy or an environmental affect. More research is required to determine if these entities should be formally recognized.

Calandrinia primuliflora Diels, Bot. Jahrb. Syst. 35: 198 (1904). *Type citation*: “Hab. In distr. Irwin a Northampton septentrionem versus in rupium graniticarum fissuris lutosis non nisi uno loco (ibi socialis) observata flor. m. Nov. exeunte (D. 5649).” (*holo*: B, destroyed; *iso*: PERTH, *n.v.*).

The exact Type location is unknown, but the collection was made near Northampton (i.e. c. 52 km N of Geraldton) from a granite outcrop area in November 1901. In the late 1930's, C.A. Gardner, Chief Botanist of the Western Australian Herbarium, obtained a portion of the Type (i.e. an isotype) from Berlin. This is now on loan to the Australian National Herbarium, Canberra, while the original ‘holotype’ was destroyed during World War II. I have not seen the isotype, however, the illustration from Diels' original publication clearly enables the species to be identified.

Perennial herb; root system a narrow vertical root attached to a tuber beneath. *Plant* erect or semi-erect to decumbent, 10–40 mm × 10–90 mm, glabrous. *Basal leaves* fleshy, spatulate, 3–15 mm × 0.5–5 mm at widest point. *Plant* normally with 3–15 stems, very occasionally once branched below the inflorescence. *Stems* with 4–7 bract pairs; stem bracts ±spreading, ±scarious, triangular to ovate, 1–2.5 mm long. *Inflorescence* a terminal solitary flower on a very short erect pedicel 0.5–2.0 mm long that is largely obscured by the uppermost pair of stem bracts. *Pedicel* and the adjacent lower stem portion moderately to strongly deflexed in fruit. *Sepals* thin, normally whitish, greenish or light brown, or a combination thereof, ovate to broadly ovate, strongly 3-nerved (nerves raised and folded) with no interconnecting reticulation. *Petals* 5, normally deep purple to magenta, whitish near the ovary, 4–12 mm long, broadly suborbicular and often with a slightly crenulate apex. *Stamens* numerous; filaments free; anthers versatile. *Ovary* spheroid to ellipsoid; stigmata 3, moderately to densely plumose, free to base. *Capsule* ovoid/pyriform, 3–4 mm × 1.5–2 mm, truncate at apex giving a pore-like appearance, 3 valved. *Seeds* off-white or light yellow-brown, somewhat pyramidal, slightly curved and moderately verrucose, 0.5–0.7 mm long. (Figures 1F, 6)

Specimens examined. WESTERN AUSTRALIA: 182 km from Mt Magnet on Geraldton Rd, 1 Nov. 1963, D.W. Goodall 1989 (PERTH 06635954); Canna Nature Reserve, 26 Oct. 1998, G.J. Keighery & N. Gibson 7127 (PERTH 06802346); Carnamah, 4 Nov. 1906, A. Morrison (PERTH 03332837); 28 km W of Mt Magnet, 7 Oct. 1989, B. Nordenstam & A. Anderberg No. 433 (PERTH 01962302); c. 7.5 km W of Mongers Lake causeway on the Paynes Find–Yalgoo road, 13 Oct. 2003, F. Obbens FO 67/03 (PERTH 06708250); near SE cnr of Lochada Nature Reserve, 1 Oct. 1995, S. Patrick et al. 2488 (PERTH 05949335); 7.9 km S of Gutha East Rd and 0.2 km N of Fitzgerald Rd on Morawa–Yalgoo road, 13 Oct. 2003, B.L. Rye & M.E. Trudgen BLR 231012 (PERTH 06588379); Pullagaroo Station [E of Paynes Find], 15 Oct. 1993, S. Van Vreeswyk 30034 (PERTH 04429575).

Distribution. Occurs within the northern parts of the Avon Wheatbelt region (SW Botanical Province) and parts of the Yalgoo and Murchison regions (Eremaean Botanical Province). (Figure 8E)

Habitat. Often found on aprons of granitic rocks on gritty sandy soils, but also known to occur on heavier soils (e.g. claypans or eroded loams of lateritic plains or low ridges). Always appears to be within herbfields or open shrubland communities.

Phenology. Flowers and fruits in October to November.

Conservation status. A number of collections exist from a relatively wide area including some from conservation reserves. The species appears to be relatively common over its range.

Etymology. The name refers to its supposed resemblance to plants of the genus *Primula*.

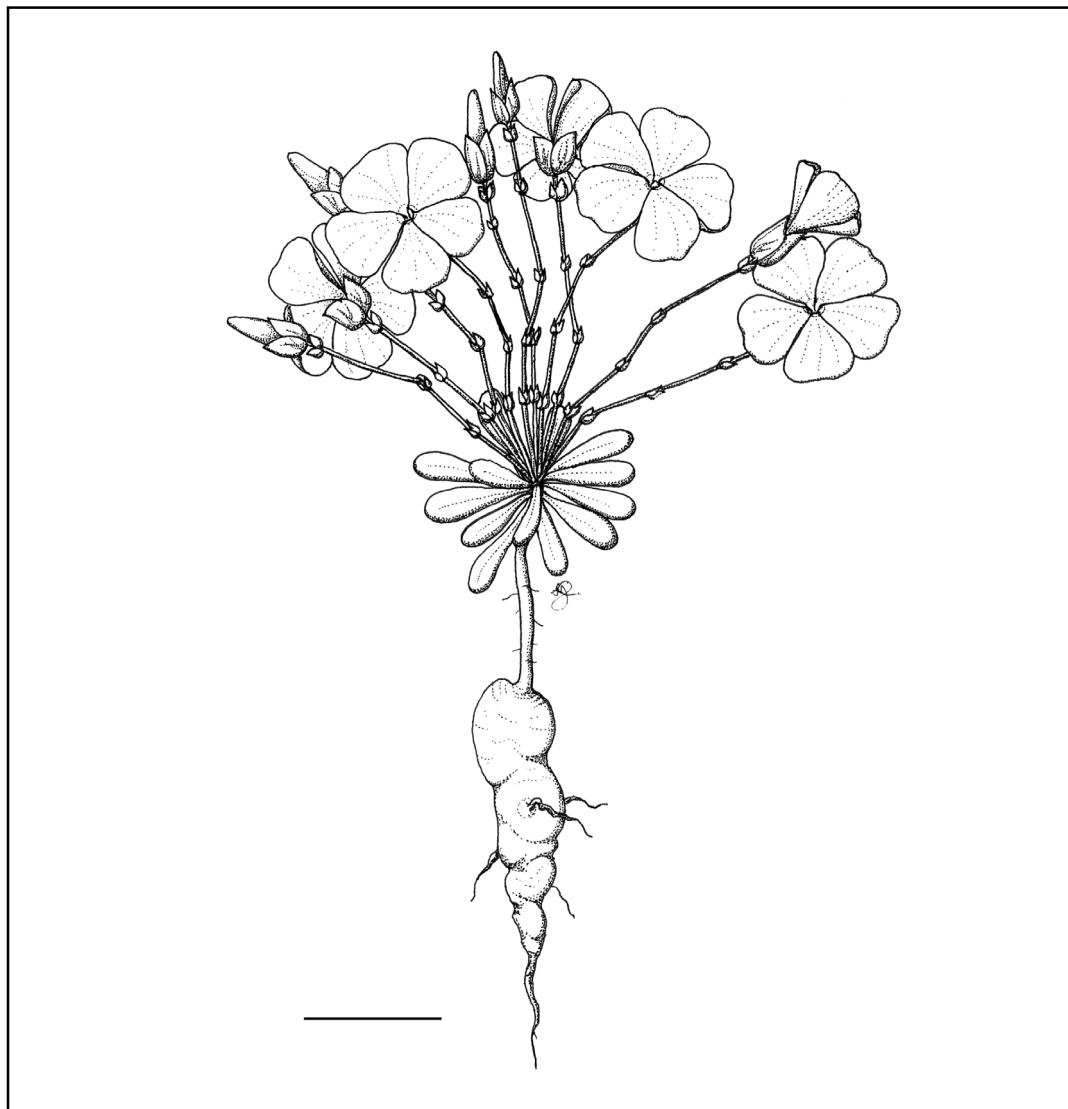


Figure 6. *Calandrinia primuliflora*. Plant habit displaying the root system consisting of a narrow vertical root attached to a tuber beneath. Scale bar = 10mm.

Notes. It might be possible to confuse *Calandrinia primuliflora* with *C. crispisepala* as both are small-sized plants with partially overlapping distributions. When in flower they are easy to distinguish because *C. primuliflora* has a constricted floral throat while *C. crispisepala* has an open floral throat with a large and distinctive white centre. Seeds of the two species are very different (*cf.* Figure 1A & 1F) and so too are their root systems (*cf.* Figures 2 & 6). *C. primuliflora* has deep purple or magenta flowers whereas all the others members of this group have pink, white or pale mauve to pale purple flowers. *C. primuliflora* is the only species in this section with stigmata free to base and it has distinctive whitish sepals that are strongly three-veined. *C. primuliflora* and *C. kalanniensis* are the only two species in this section that have similarly shaped capsules, both appearing to have a pore-like apex and valves that split to about a third of their length (i.e. at least initially, but these may split more fully with age). Both also have sepals with 3 prominent veins and somewhat similar seeds (i.e. shape and colour). However, *C. kalanniensis* is quite different to *C. primuliflora* in having a higher degree of petal fusion (i.e. up to a third the petal length) and a habit more akin to *C. translucens*.

Diels' original illustration of *C. primuliflora* is a reasonable representation, but the illustrator has used some artistic licence in drawing reproductive structures (i.e. stamens) above the floral throat. It is sometimes possible to observe the reproductive structures from above the flower, but it is most unlikely that the illustrated specimen would have displayed this characteristic from the angle it was drawn. Figure 6 above provides a more realistic representation of *C. primuliflora*.

Calandrinia schistorhiza Morrison, J. Bot. 50: 164 (1912). *Type citation:* “Boulder, Sept.; W.D. Campbell.” (*holo*: BM, n.v.).

The exact Type location is unknown, however, Mr. Campbell apparently collected the specimens from a dry rocky place at Boulder in September 1900. He informed Morrison that the habitat was similar to that of *C. primuliflora*. Morrison's description of *C. schistorhiza* stated its close affinity to *C. primuliflora* except for its coarser size, but this is quite erroneous (see under notes below). I have not examined the Type as it is on loan to the Australian National Herbarium, Canberra. However, I have been able to establish the identity of *C. schistorhiza* from specimens determined by R. Carolin and J. West at the Western Australian Herbarium and from the illustration in the ‘Flora of Central Australia’ displaying both plant habit and seed. This species, although quite variable, is easy to recognize (see under notes below).

Perennial herb; root system consisting of a tap-root like tuber (sometimes appearing as a thickened root), the tuber often branched. *Plant* prostrate to decumbent, 30–140 mm tall × 40–300 mm wide, glabrous. *Basal leaves* fleshy, broadly spatulate, 15–700 mm × 3–25 mm at widest point. *Plant* with 4–22 stems, occasionally once branched below the inflorescence. Commonly 2–4 bract pairs per stem with a whorl of 3 bracts frequently occurring on the lowest node. *Stem bracts* spreading, ±scarious, triangular to broadly ovate, 3–7 mm long, apex sometimes recurved. *Inflorescence* a terminal solitary flower on an erect pedicel (11–36 mm) which may deflex moderately when in fruit. *Sepals* thin, normally light tan, greenish or reddish, orbicular, 7–11.5 mm long, sometimes with a relatively strong central nerve and several weaker nerves with some interconnecting reticulation, commonly spreading and crinkled when dry, often with a hyaline margin. *Petals* 5, normally bright to deep pink, 14–28 mm long, obovate to broadly obovate and often with a slightly crenulate and depressed apex. *Stamens* numerous; filaments free; anthers versatile. *Ovary* ellipsoid to subglobose. *Stigmata* 3, united onto a short style. *Capsule* ellipsoid to broadly ovoid, 8–11 mm × 3–5 mm; valves 3, splitting fully to base. *Seeds* black, roughly kidney-shaped, strongly verrucose and sometimes tuberculate, 0.5–0.8 mm long. (Figures 1G, 7)

Specimens examined. WESTERN AUSTRALIA: Flats S of mine, Paraburadoo, 24 Sep. 1979, K.J. Atkins 583 (PERTH 04221087); 19 km S of Wiluna, 13 Sep. 1978, A.C. Beaglehole & E.G. Errey ACB 59488 (PERTH 06189652); c. 283 km SE of Onslow on Nanaturra–Wittenoom road, 10 Aug. 1970, R.C. Carolin 7802 (PERTH 03332969); 14.5 km SE of Windidda homestead, Carnegie District, 6 Sep. 1973, R.J. Chinnock 818 (PERTH 01953451); Cue area, s.dat., J. Coxon S 8 (PERTH 04100840); Mileura [Station NW of Cue], 24 Sep. 1969, S.J.J. Davies s.n. (PERTH 06040039); S of Rudall River, 10 Aug. 1992, A.E. de Jong s.n. (PERTH 03198073); Munarra Station, Meekatharra area, 14 July 2004, F. & J. Hort 2263 (PERTH 06870163); E of Dynamite Bore on Wongawol Station, 9 Sep. 2003, K.F. Kenneally & D.J. Edinger K 12666, E3863 (PERTH 06704271); On hills behind Newman Caravan Park, Newman, 11 Sep. 1995, T.R. Lally TRL735 (PERTH 04354214); Balfour Downs Station, Pilbara Region, 1 June 2004, F. Obbens & B. Bromilow FO 31/04 (PERTH 06609732).

Distribution. *C. schistorhiza* is found throughout a wide area of the Eremaean Botanical Province from the Goldfields to the Pilbara. (Figure 8F)

Habitat. Usually grows in red sandy loam or clays often stony or rocky and probably does not occur on the lighter desert soils or near the coast. Can be found in a variety of arid shrub communities including mulga, gibber plains, open grassy flats and very open woodland.

Phenology. Flowers and fruits in June to September.

Conservation status. A species with a widespread distribution although it appears to be lightly collected across its range. However, it does not appear to be uncommon.

Etymology. From the Greek *schistos* – divided and *rhiza* – root. This is in reference to the divided or branched tubers of the Type specimen.

Notes. *Calandrinia schistorhiza* is usually a medium to larger sized plant and has large flowers regardless of the plant size making it the most recognizable species within the group (Figure 7). The length of the basal leaves is extremely variable; the blade always broadly spatulate and the petiole often strap-like. The tuber type somewhat resembles that of *C. crispisepala* although it is much larger (see Figures 2, 7). Additionally, the sepals of *C. schistorhiza* are somewhat crinkled like *C. crispisepala* and have sometimes a hyaline margin similar to *C. balonensis* Lindl. (sect. *Pseudodianthoideae*). As stated previously, Morrison considered *C. schistorhiza* to be closely related to *C. primuliflora*. It is easy to understand how he came to this conclusion because the two look superficially alike, however, on detailed inspection there are a number of clear differences. For instance, *C. schistorhiza* has an open flower with broadly obovate petals while *C. primuliflora* has a constricted floral throat with broadly suborbicular petals. Additionally, the stigmata of *C. schistorhiza* are united onto a style while those of *C. primuliflora* are free to base. The seed and tuber of *C. schistorhiza* and *C. primuliflora* are also very different. It is in fact these same characters that make *C. schistorhiza* appear to be more closely related to *C. crispisepala*, as outlined earlier.

The illustration of *C. schistorhiza* in the ‘Flora of Central Australia’ is a reasonable representation of the plants habit and seed. The illustration also portrays a flower in longitudinal section with the stigmata incorrectly appearing to be free to the base. As stated above, *C. schistorhiza* always has 3 stigmata united onto a short or moderate length style. The illustration of *C. schistorhiza* (i.e. Figure 7) displays a habit type somewhat different to that depicted in the ‘Flora of Central Australia’ and also shows some of the basal leaf variation and other details that are useful in identification of this species.

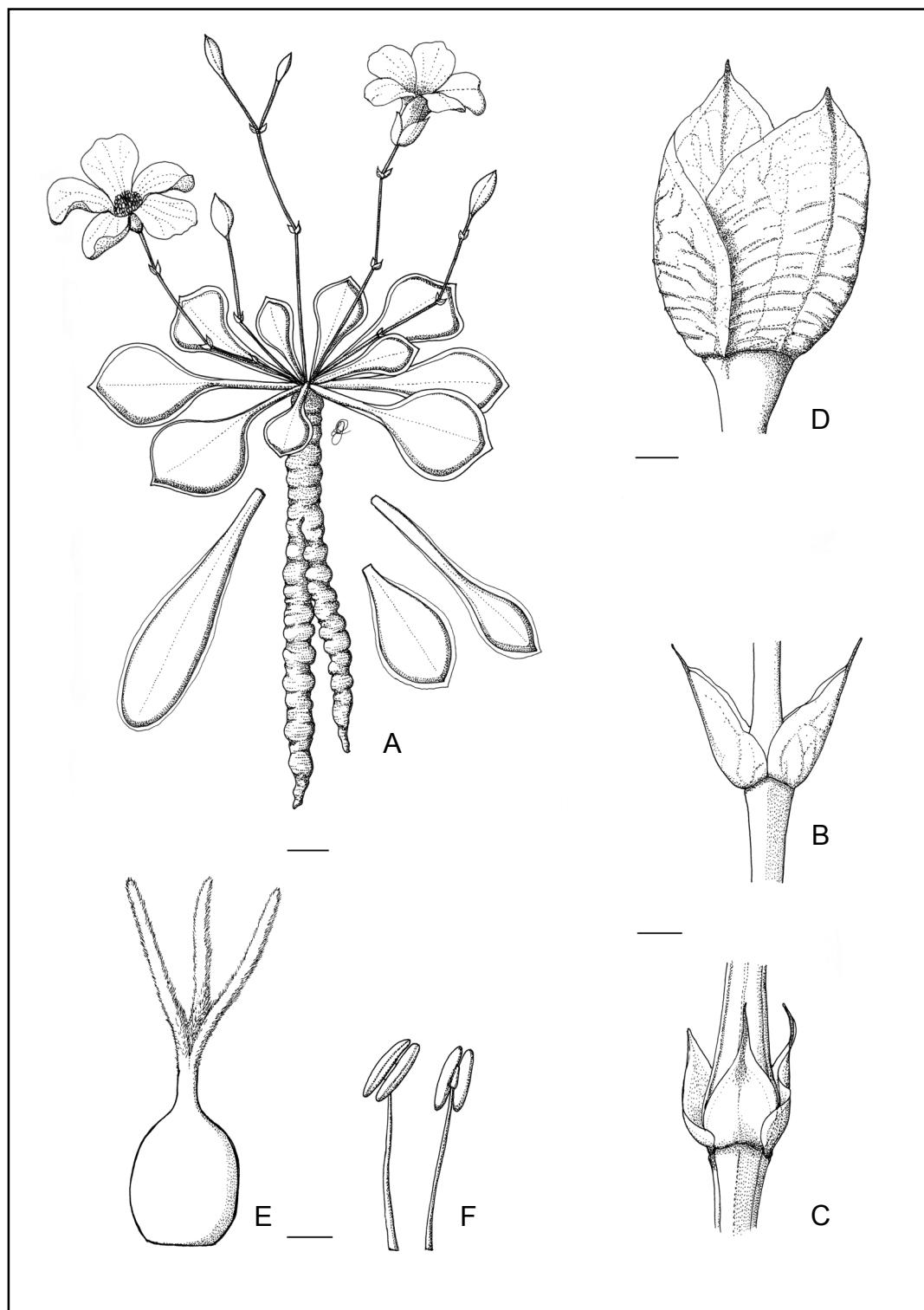


Figure 7. *Calandrinia schistorhiza*. A – plant habit displaying a tap-root like tuber (sometimes appearing as a thickened root); B – upper stem bract; C – lower stem bract; D – sepals; E – gynoecium; F – stamens. Scale bars: A = 10mm; B–D = 2mm; E–F = 1mm.

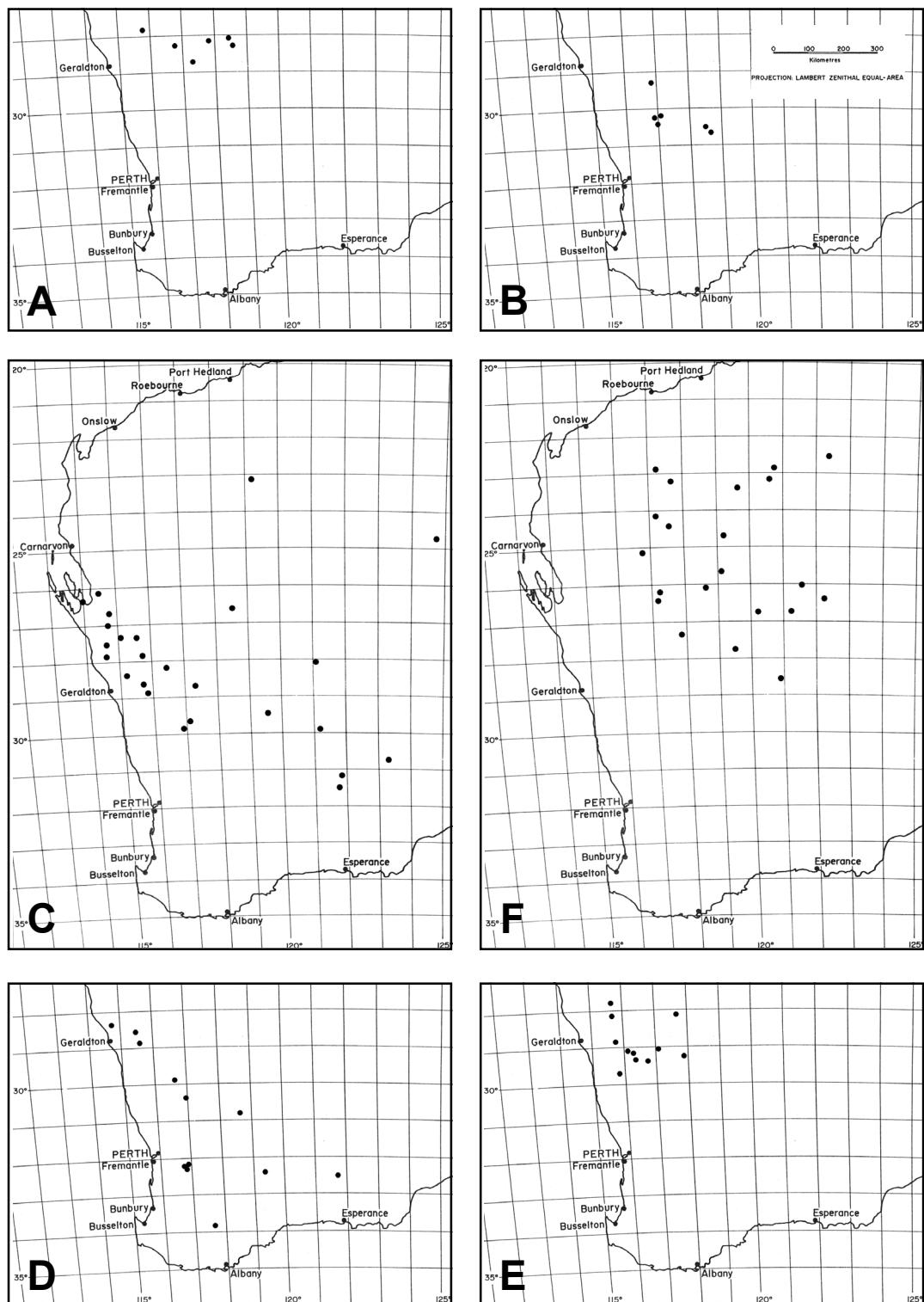


Figure 8. Species distributions. A – *Calandrinia crispisepala*; B – *Calandrinia kalanniensis*; C – *Calandrinia translucens*; D – *Calandrinia lehmannii*; E – *Calandrinia primuliflora*; F – *Calandrinia schistorhiza*.

Discussion

This review has highlighted many of the differences and similarities between members of *Calandrinia* section *Tuberosae* and should go some way towards alleviating past confusions and problems with identification. The review has found no radical deviations away from von Poellnitz's original section description although, as previously mentioned, I would add that section *Tuberosae* has 5-merous flowers and 3 stigmata which are either free to base or are united onto a style. One might also add to this description some of Syeda and Carolin's (1989) comments regarding seed structure and patterning.

However, I have concluded from this review that there appear to be two broad sub-groups within section *Tuberosae*. The first, with black strongly verrucose seeds and taproot-like tubers or appearing as a thickened root comprises *C. crispsepala* and *C. schistorhiza*. This sub-group also has crisped sepals and often has a whorl of 3 bracts at the lowest stem node. The second sub-group contains the remaining 4 species, all of which possess a narrow vertical root attached to a tuber or tubers. In this second sub-group the seed characters are somewhat similar in *C. kalanniensis*, *C. lemannii* and *C. primuliflora* which have lighter coloured, moderately verrucose seeds, while *C. translucens* has light coloured, but smooth seeds. There appears to be some strong morphological evidence to suggest taxonomic ranking of the first sub-group, but there is less so for the second. Only a significant cladistic or genetic study would reveal whether or not these subgroups deserve formal recognition.

Acknowledgements

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