

New south-western Australian members of the genus *Petrophile* (Proteaceae: Petrophileae), including a hybrid

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Abstract

Rye, B.L., Hislop, M., Shepherd, K.A. & Hollister, C. New south-western Australian members of the genus *Petrophile* (Proteaceae: Petrophileae), including a hybrid. *Nuytsia* 21(2): 35–67 (2011). Four additional species are recognised in the genus *Petrophile* R.Br. ex J.Knight by the reinstatement of *P. axillaris* Meisn. and the description of three new species, *P. globifera* Hislop & K.A.Sheph., *P. foremanii* Hislop & Rye and *P. septemfida* Rye & K.A.Sheph. A hybrid between *P. ericifolia* R.Br. and *P. seminuda* Lindl. is documented, the new subspecies *divaricata* Hislop & K.A.Sheph. is named for *P. conifera* Meisn., and a lectotype is selected for *P. seminuda* var. *indivisa* Benth. There is also a key for members of the genus occurring in Western Australia, excluding those belonging to *Petrophile* sect. *Arthro stigma* (Endl.) Kuntze.

Introduction

Petrophile R.Br. ex J.Knight is an endemic Australian genus belonging to the Proteaceae subfamily Proteoideae. A suprageneric classification of the family based on molecular data (Weston & Barker 2006) places *Petrophile* together with the small South African genus *Aulax* Berg. in tribe Petrophileae.

One large Western Australian section of *Petrophile*, *P.* sect. *Arthro stigma* (Endl.) Kuntze, has recently been reviewed, with seven additional species named or reinstated (Hislop & Rye 2002; Rye & Hislop 2005). Pollen presenter characters proved to be of particular importance both in defining sect. *Arthro stigma* and in distinguishing its members. In the remainder of the genus, the main progress has been the description of one new species (Cranfield & Macfarlane 2007), the informal reinstatement of *P. axillaris* Meisn. on the *Census of Western Australian Plants* (Western Australian Herbarium 1998–) and the allocation of informal names to several new taxa. Identification of Western Australian members of the genus should soon be greatly enhanced by the release of an interactive key (Hollister *et al.* in prep.).

The objective of the current study was to provide a key to all species occurring in sections other than sect. *Arthro stigma* and to name any new Western Australian members of those sections. In *Petrophile* sect. *Arthro stigma* there remains one incompletely resolved group, the *P. brevifolia* R.Br. complex, which was examined in an honours project by Natalie Murdoch (UWA) in 2008, indicating that several new taxa needed to be recognised. One member of that complex, *P. latericola* Keighery, has now been described (Keighery 2010). The current study brings the total number of species recognised in the genus to 66.

Materials and methods

Holotypes of all the taxa described in this paper are housed at PERTH. The terminology used here is as in two earlier papers (Hislop & Rye 2002; Rye & Hislop 2005) except that the bracts subtending the flowers, which later harden to become the cone scales of the fruiting stage, are referred to here as floral bracts while they are still in the flowering stage.

Measurements of the length of the pollen presenter were taken from the base of the swelling to the stigma, although there is often a short distance below the stigma that is unmodified from the style, referred to in the descriptions below as the unswollen or glabrous apical region. The receptive part of the pollen presenter, i.e. the region where the pollen is actually deposited, corresponds in almost all cases to a region of hairs, which may occur on or above the swelling, although the pollen may also be deposited a short distance above or below the hairy zone and sometimes also on the stigma.

The distribution maps were compiled using DIVA-GIS Version 5.2.0.2. They show the *Interim Biogeographic Regionalisation of Australia (IBRA) Version 6.1* regions (Department of the Environment, Water, Heritage and the Arts 2008).

Key to Western Australian members of all sections except *Arthro stigma*

Note that there are currently two difficult groups needing further study, the *P. crispata* R.Br. complex and the *P. squamata* R.Br. complex, whose members do not always key out reliably below. In these groups additional taxa may need to be recognised or some of the currently listed taxa may need to be synonymised.

1. Pollen presenter glabrous to moderately densely hairy; hairs (when present) minute or retrorse. Diaspore with a long to very reduced coma restricted to the base, not extending up the margins, terminally and often also laterally winged
2. Tepals separating to the base and tending to fall individually
3. Tepal limb either glabrous or with an obvious glabrous appendage; appendage subterminal, rod-like. Style glabrous except for the pollen presenter. Diaspore with a very reduced coma
 4. Juvenile foliage soft and fern-like; adult leaves villous when young, distinctive in appearance. Tepal limb hairy except for a long appendage. Diaspore markedly 3-lobed. (Cape Naturaliste to Hassell Beach.) **P. diversifolia**
 - 4: Leaves all similar, glabrous. Tepal limb glabrous, with no appendage. Diaspore entire or scarcely lobed. (Stirling Range to Cape Riche.) **P. carduacea**
- 3: Tepal limb densely hairy, with no appendage but sometimes with a glabrous apical point which is often rather hidden by long hairs. Style hairy for at least half its length. Diaspore with a long coma
 5. Leaves more or less terete, 10–20 mm long, deeply divided, not toothed (Eneabba to Moore River.) **P. chrysantha**
 - 5: Leaves compressed, 15–90 mm long, simple or with 2 or 3 short lobes near apex, sometimes toothed
 6. Leaves 15–35 mm long, simple or with 2 or 3 short lobes at apex, plumose, glabrescent. (Gillingarra area.) **P. plumosa**

- 6: Leaves 45–90 mm long, simple but shortly and irregularly toothed in distal half, hirsute. (Alexander Morrison National Park to Coomaloo National Park.).....**P. aculeata**
- 2: Tepals remaining joined along most of the length of the claw; swollen base (surrounding the diaspore) splitting when tepals fall together
7. Tepal apex hairy but with a long, glabrous, rod-like appendage. Pollen presenter with a very swollen base below a rod-like receptor. (Eneabba to near Donnelly River and Wagin.) **P. striata**
- 7: Tepal apex varied, if as above then pollen presenter fusiform
8. Pollen presenter more or less fusiform, with straight retrorse hairs
9. Leaves 30–200 mm long, glabrous or with scattered long hairs. Tepals with no glabrous appendage. Diaspore with a large wing extending laterally well beyond the seed; coma very reduced
10. Leaves compressed, glaucous. Tepals 10–21 mm long; appendage not obvious. (York area to Hopetoun.)..... **P. glauca**
- 10: Leaves terete, green. Tepals 20–25 mm long; appendage rod-like, very dark. (Moore River to Albany and Oldfield River.).....**P. divaricata**
- 9: Leaves 15–35 mm long, usually with both long and much shorter hairs. Tepals with a rod-like, glabrous appendage at apex. Diaspore with a terminal wing not extending laterally beyond the sides of the seed and often poorly developed; coma long, its hairs covering one surface of diaspore
11. Tepals yellow, with spreading hairs; appendage clubbed, often extending well beyond the tepal apex. Occurring inland, mainly in lateritic areas. (Near Geraldton to Busselton area to Cape Riche area.)..... **P. serruriae**
- 11: Tepals pink or pink-mauve, with more antrorse hairs on the claw; appendage more acute and less conspicuous than in *P. serruriae*. Occurring on coastal limestone. (Near Geraldton to Augusta.) **P. axillaris**
- 8: Pollen presenter with its swelling ending fairly abruptly below a rod-like receptor, which is glabrous or has very short, recurved or patent hairs
12. Tepals 17–25 mm long, pink or pink-mauve. Pollen presenter with recurved hairs on summit of basal swelling. Diaspore coma with hairs mainly directed downwards or horizontal. (Darling Range from Wannamal to Oakley Dam.)..... **P. biloba**
- 12: Tepals 8–15 mm long, cream or yellow. Pollen presenter glabrous or with patent hairs on summit of swollen base and sometimes on base of receptor. Diaspore coma with hairs mostly directed upwards but with a few of them horizontal
13. Leaves (50–)65–160 mm long. Tepals 10–15 mm long. Pollen presenter base very concave at summit. (Moore River to Stirling Range to Oldfield River.) **P. heterophylla**
- 13: Leaves 15–65 mm long. Tepals 8–10 mm long. Pollen presenter base somewhat concave to tapered at summit
14. Leaves all or at least some of them simple, spatulate, 4–10 mm wide. (Stirling Range to Stokes Inlet.)..... **P. squamata** subsp. **Ravensthorpe**
- 14: Leaves broadly to very finely divided (but lower leaves sometimes simple and spatulate); ultimate divisions linear to obovate, 1–4 mm wide

15. Involucral bracts (or at least the inner ones) somewhat hairy on abaxial surface. Swelling of pollen presenter 0.4–0.7 mm diam., its apex more or less truncate or slightly convex (may be straight or oblique) and usually abruptly differentiated from receptor; receptor often minutely hairy. (Armadale to Israelite Bay.)..... **P. squamata** subsp. **northern**
- 15: Involucral bracts usually glabrous on abaxial surface. Swelling of pollen presenter 0.3–0.4 mm diam., its apex convex, usually tapering smoothly to receptor; receptor glabrous. (Busselton to Cape Riche.) **P. squamata** subsp. **squamata**
- 1: Pollen presenter sparsely to very densely hairy; hairs usually mostly straight and more or less patent (but tending to be retrorse in *P. macrostachya* and *P. shuttleworthiana*), rarely mostly ascending or long and markedly bent. Diaspore with a long coma extending up the margins, not winged
16. Plants non-viscid, with simple leaves and tepals hairy throughout. Pollen presenter with a swollen glabrous base, which is abruptly differentiated from the more or less cylindrical hairy top or (in one species) almost fusiform, the latter with clubbed hairs sect. **Arthrostylis** (see key in Rye & Hislop 2005)
- 16: Plants variously differing from the above combination of characters by having viscid bracts or tepals, toothed or divided leaves, or tepals glabrous at least at the apex. Pollen presenter more or less fusiform or narrowly ovoid to cylindrical, hairy on the swelling, the hairs never clubbed
17. Style hairy for about half or most of its length
18. Leaves compressed, with 2–5 ultimate divisions all in one plane. (Perenjori to Welbungin.) **P. incurvata**
- 18: Leaves terete, simple or with widely spreading to divaricate divisions
19. Leaves simple. Flower heads axillary, few-flowered, sessile. (Burnerbinmah Station to Malangala Station.) **P. vana**
- 19: Leaves usually divided, sometimes all simple. Flower heads terminal, many-flowered, sometimes pedunculate
20. Tepals 5–7 mm long. Cones less than 10 mm diam., with the scales and diaspores becoming separated. Occurring in the Eremaean. (Kalli Station area to Bimbijy Station.) **P. pauciflora**
- 20: Tepals 8–15 mm long. Cones 15–20 mm diam., with overlapping scales and diaspores. Almost completely restricted to the South West Botanical Province
21. Flower heads and cones pedunculate. Tepals with appressed or closely antrorse hairs. Pollen presenter densely hairy throughout. (Cooloomia Nature Reserve to Mullewa.) **P. semifurcata**
- 21: Flower heads and cones sessile. Tepals with somewhat spreading hairs. Pollen presenter with a glabrous or sparsely hairy base, the remainder hairy
22. Involucral bracts ovate or narrowly ovate, 4–8.5 mm long, 1.9–2.2 mm wide. Flower head ellipsoid or ovoid. Pollen presenter narrowly ovoid. (Kalbarri National Park to Morawa area.) **P. conifera** subsp. **conifera**
- 22: Involucral bracts ovate or broadly ovate, 5–7.5 mm long, 3.1–4.5 mm wide. Flower head ovoid or globose. Pollen presenter narrowly fusiform. (Coorow area.) **P. conifera** subsp. **divaricata**

- 17: Style glabrous for most of its length but hairy on the pollen presenter and sometimes hairy just for a short distance above the diaspore
23. Leaves compressed, divided
24. Young stems with short, curled hairs. Flower heads more or less globular, with outer floral bracts and flowers often viscid. (Coorow to Moore River.) **P. biternata**
- 24: Young stems either with fine, straight hairs or glabrous. Flower heads elongate, not viscid
25. Stems remaining densely hairy below the flower heads. Leaves with a well defined midrib and main veins, the two primary lateral leaf lobes at least trifid. (Zuytdorp Cliffs to near Byford.) **P. macrostachya**
- 25: Stems (not including peduncles) glabrous below the flower heads. Leaves with multiple equal striations or smooth, the two primary lateral leaf lobes entire or bifid. (Kalbarri National Park (disjunct) and Perenjori to Moore River to Koorda area.) **P. shuttleworthiana**
- 23: Leaves thick, often more or less terete, simple or divided
26. Tepals glabrous
27. Leaves obtuse or acute but never pungent
28. Leaves simple, up to 15 mm long. (Lake Grace area to Stirling Range to Israelite Bay.) **P. phylloides**
- 28: Leaves divided, over 30 mm long. (Ravensthorpe to Israelite Bay.) **P. fastigiata**
- 27: Leaves sharply pungent
29. Leaves simple to multi-branched, often trifid or with 3 main spreading divisions that are further divided. Involucral bracts few to numerous, pale- to dark-brown, mostly ovate or narrowly ovate, sometimes hairy outside. Pollen presenter 3–5 mm long, with hairs up to 0.3 mm long or glabrous. (Kalbarri National Park to Pinjarra area, near Kalgoorlie, Fitzgerald River area and near Lort River.) **P. seminuda**
- 29: Leaves multi-branched. Involucral bracts numerous, mostly dark-brown and broadly ovate or ovate, glabrous outside. Pollen presenter 2.5–3.5 mm long; hairs *c.* 0.2 mm long. (Unicup to Oldfield Estuary.) **P. crispata**
- 26: Tepals sparsely to densely hairy except for apical point
30. Leaves 20–200 mm long, if less than 30 mm long then much divided
31. Leaves simple. Tepals with a glabrous apical point that is long and obvious. (Bodallin and Bullabulling to Lake King.) **P. stricta**
- 31: Leaves divided. Tepals with a glabrous apical point that is short or long, and often not obvious
32. Involucral bracts glabrous, viscid. Tepals sparsely or moderately densely hairy, viscid. (Dongara area to Dongolocking.) **P. drummondii**
- 32: Involucral bracts silky-hairy inside and sometimes also with hairs outside, not viscid. Tepals densely hairy, not viscid
33. Flower heads with exceptionally large involucral bracts (often over 20 mm long), subtended by leaves 90–200 mm long. Tepals 30–40 mm long. (Boorabbin to Pingelly to Lake King.) **P. circinata**

- 33: Flower heads with normal-sized involucre bracts, subtended by leaves 30–85 mm long. Tepals 11–15 mm long. (Regans Ford to Walpole and to Fitzgerald River National Park.)..... **P. rigida**
- 30: Leaves 5–22 mm long, if *c.* 20 mm long then divided into 3–5 short lobes
34. Leaves divided from near the base into usually 7 branches. (Watheroo area.)..... **P. septemfida**
- 34: Leaves simple or distally divided into 3–5 short lobes
35. Leaves all, or at least a few of them, distally divided into 3–5 lobes
36. Leaves with short curly hairs, minutely scabrous, 8–16 mm long. (Tammin to Quairading to Bruce Rock.) **P. misturata**
- 36: Leaves glabrous or only the younger ones hairy, smooth or very minutely scabrous, 10–21 mm long
37. Flower heads rather few-flowered, not viscid. Pollen presenter 2–3 mm long. (Coorow to Wongan Hills.) **P. trifurcata**
- 37: Flower heads many-flowered, with viscid floral bracts. Pollen presenter 3–4 mm long. (Lake Grace area.) **P. ericifolia** × **seminuda**
- 35: Leaves all simple
38. Young stems and leaves (on new shoots at least) with very curly hairs but no straight to curved hairs
39. Tepals sparsely hairy. (Involucre bracts usually very viscid.) (Southern Cross to Bullabulling to Lake King area.) **P. merrallii**
- 39: Tepals moderately densely or densely hairy
40. Leaves glabrous or very sparsely hairy and rapidly becoming glabrous. Involucre bracts often viscid. (Bullabulling area to Peak Charles area.) **P. arcuata**
- 40: Leaves hairy at first and tending to retain the curly hairs for some time. Involucre bracts not viscid
41. Leaves usually antrorse or appressed, 5–9 mm long, blunt. (Dalwallinu to near Koorda and Dowerin.) **P. wonganensis**
- 41: Leaves all spreading, 8–16 mm long, pungent. (Tammin to Quairading to Bruce Rock.) **P. misturata**
- 38: Young stems and leaves with or without curly hairs but always with curved to straight hairs at least on new shoots
42. Involucre bracts viscid and coherent into a cup-like structure that is persistent around the cone. (Corrigin to Fitzgerald River National Park.) **P. cyathiforma**
- 42: Involucre bracts free from one another and often deciduous before fruit matures
43. Involucre bracts numerous, not obviously viscid, dark with broad grey margins, hairy. Pollen presenter 3.5–6 mm long. (Brookton area to Katanning.) **P. imbricata**
- 43: Involucre bracts few to numerous, often very viscid, uniformly coloured, glabrous or hairy. Pollen presenter 2.75–4.5 mm long

44. Leaf apex with a viscid globule. Involucral bracts broad, shortly pointed, glabrous. Occurring from Piawaning to Cape Riche
45. Young stems with straight or curved hairs. Leaves usually patent, usually smooth and glabrous. (Harrismith to Ravensthorpe and Cape Riche.).....**P. ericifolia** subsp. **ericifolia**
- 45: Young stems with curled hairs. Leaves often antrorse, usually with hairs or tubercular remnants of hairs. (Piawaning to Northam and Kellerberrin.)..... **P. ericifolia** subsp. **subpubescens**
- 44: Leaf apex with a non-viscid point. Involucral bracts narrow and tapering usually into a long point, at least the lower ones slightly to obviously hairy. Occurring from Kalbarri to the Regans Ford area
46. Involucral bracts 5–9.5 mm long, usually not viscid. Tepals with a dense indumentum always extending onto lower part of apical point (i.e. above the top of the anther) and partly to completely obscuring it, the longest hairs 1.5–2.5 mm long. (Wicherina to Warradarge.).....**P. scabriuscula**
- 46: Involucral bracts 2–5(–7) mm long, viscid. Tepals with a sparse to dense indumentum, often not extending above level of top of anther, with the apical point usually obvious, the longest hairs up to 1.5 mm long
47. Tepals with a moderately dense to dense indumentum, not viscid. Occurring north of Geraldton. (Kalbarri to Hutt River.).....**P. foremanii**
- 47: Tepals with a sparse to moderately dense indumentum, viscid at apex. Occurring south of Geraldton
48. Leaves 3–5.7(–7.5) mm long, (0.5–)0.7–0.8 mm wide, often densely scabrous, distally erect (but apical point sometimes recurved). Tepal hairs all straight to somewhat wavy. Cone scales 4–8 mm wide. (Near Morawa to Marchagee and Pithara.).....**P. globifera**
- 48: Leaves 6–9(–11) mm long, 0.4–0.7 mm wide, smooth or sparsely scabrous, distally recurved. Lower tepal hairs strongly wavy. Cone scales 2–4 mm wide. (Warradarge area to Wannamal.).....**P. recurva**

Taxonomic descriptions

This section of the paper gives full descriptions of the new or reinstated taxa and other relevant taxa except for the presumed hybrid, which is treated in a separate section. Notes on other taxa are given in a final section.

Petrophile axillaris Meisn., *Hooker's J. Bot. Kew Gard. Misc.* 7: 68–69 (1855). *Type*: between Moore and Murchison Rivers [Western Australia], 1850–1851, *J. Drummond* coll. 6, no. 166 (*syn*: K (2 sheets) *n.v.*, MEL 1534425).

Illustration. D.B.Foreman, *Fl. Australia* 16: fig. 51 (1995).

Shrubs 0.4–1.5 m high, erect or ± sprawling, single-stemmed and fire-sensitive. *Branchlets* ribbed, brown or grey, with a moderately dense indumentum of patent hairs that are variable in length, overtopped by a much sparser layer of longer hairs to *c.* 4 mm long. *Leaves* spreading, usually rather irregularly bipinnatisect, sometimes tripinnatisect, 17–30 mm long, 16–33 mm wide, with scattered hairs that are mostly antrorse and 1–2 mm long; lobes narrow, slightly compressed, with a pungent point 0.6–1.2 mm long. *Flower heads* mostly axillary, often pedunculate, globose, 15–25 mm long, 17–28 mm diam.; peduncle 2.3–3.5 mm long. *Involucral bracts* erect or spreading, elliptic to ovate, 2.7–3.8 mm long, 1.3–2.0 mm wide, acute or acuminate, yellow to brown, becoming pink at the apex; outer surface with up to 5 ribs, glabrous or with a dense tuft of hairs 0.2–0.4 mm long at the base; inner surface glabrous. *Floral bracts* broadly ovate, 4.9–6.2 mm long, 2.6–4.4 mm wide, acute or acuminate, yellow-green to brown; outer surface with appressed white hairs in the basal half to two thirds, apex glabrous; inner surface glabrous. *Tepals* 11–17(–22) mm long, densely hairy; claw pink, with a variable indumentum of antrorse hairs 0.5–1.1 mm long, base glabrous; limb 2.8–3.5 mm long, with antrorse hairs 0.8–1.6 mm long and a glabrous, narrowly cylindrical, tapering apical appendage 0.3–0.7 mm long, which is often somewhat obscured by the hairs. *Anthers* 1.6–1.9 mm long. *Pistil* 12–18 mm long, with shallowly antrorse to more or less patent hairs 0.2–0.3 mm long reaching almost to the base of pollen presenter. *Pollen presenter* 3.2–4.5 mm long; swollen part narrowly ovoid to fusiform, glabrous at base, with scattered, straight or slightly curved, retrorse hairs *c.* 0.1 mm long over most of its length; glabrous apical part 0.6–1.0 mm long. *Cones* globose to ovoid, 9–20 mm long, 8–17 mm diam.; scales broadly ovate. *Diaspores* ovate in outline, 4.2–5.2 mm long, 2.3–3.1 mm wide, including a narrowly triangular, readily detached, terminal wing, upon which the style remains often form an apical beak; abaxial surface glabrous over most of surface, with scattered, appressed, white hairs less than 0.1 mm long towards the apex; adaxial surface with a moderately dense indumentum of white or purple, appressed hairs less than 0.1 mm long, overtopped towards the base by the layer of much longer, white or golden hairs up to 5 mm long, that comprise part of the basal coma. (Figure 1A)

Selected specimens examined. WESTERN AUSTRALIA: Arrowsmith River area, S of Dongara, 15 Sep. 1968, *A.C. Burns* 60 (PERTH); Yalgorup National Park, 3 km N of Lake Preston causeway, 9 Nov. 1978, *J. Dodd s.n.* (PERTH); 5 km W of Lake Indoon, 30 July 1977, *E.A. Griffin* 933 (PERTH); N side of Cervantes road, 16 km E of Cervantes, 8 Oct. 1993, *P.C. Jobson* 2268 (PERTH); Mindarie, 27 km N of Perth, 24 Sep. 1988, *G.J. Keighery* 11421 (PERTH); 4 km SE of Cape Freycinet [S of Margaret River], 24 Sep. 1990, *G.J. Keighery* 11605 (PERTH); Quadrat WMA77, N boundary, South Mimegarra Nature Reserve, C 30618, Shire of Gingin, 7 Oct. 1999, *M.A. Langley & P.M. Smith* MAL 1937 (PERTH); Star Swamp Bushland Reserve, North Beach, 13 Sep. 1987, *J.P. Pigott s.n.* (PERTH); 1 km N of Kwinana turnoff on road to Mandurah, 7 Nov. 1985, *J.M. Powell* 2094 (NSW, PERTH); 8 km from Two Rocks along Breakwater Drive, turn right on Tringa Rd a further 1.6 km, 25 Sep. 2002, *K. Richardson* KCR118 (PERTH); Bob's Hollow, track 1 km from coast, 26 Oct. 2000, *J. Scott* 275 (PERTH).

Distribution and habitat. Occurs in the South-West Botanical Province in yellow or grey-brown sand in limestone areas along the west coast from near Geraldton south to Yalgorup National Park, with an isolated occurrence further south in Leeuwin–Naturaliste National Park (Figure 2A). The disjunction between this southern occurrence of this species and the remainder of its range is about 130 km and corresponds in part with a break in the limestone habitats along the coast.

Phenology. Flowers mainly September to November.

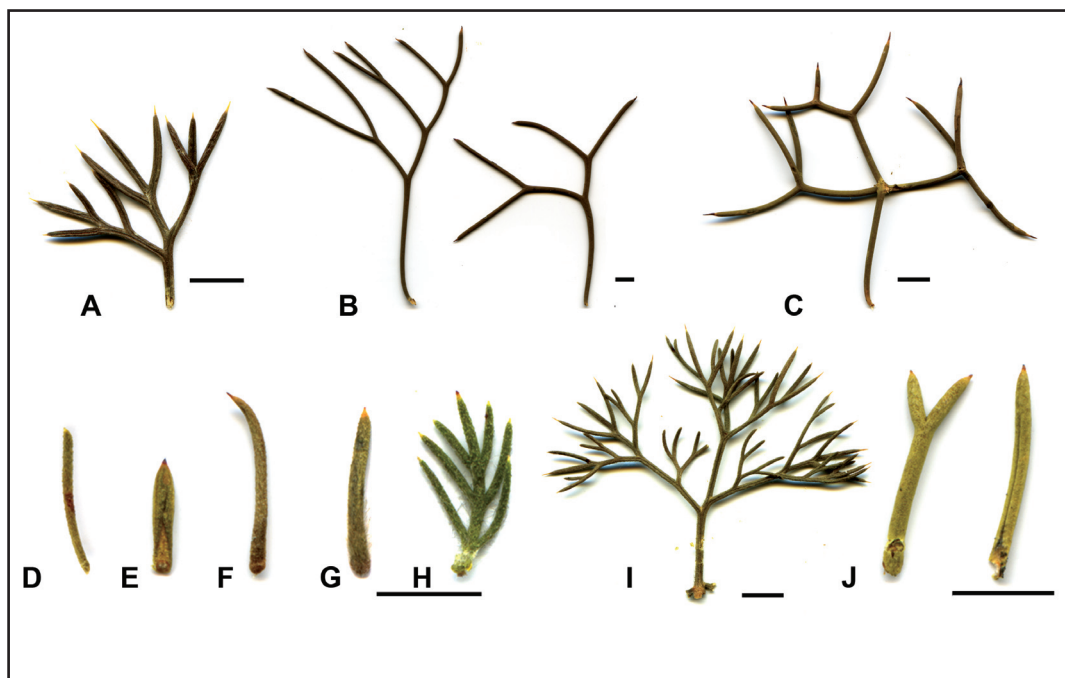


Figure 1. Leaf outlines. A – *P. axillaris* PERTH 04244788; B – *P. conifera* subsp. *conifera* PERTH 01865897, C – *P. conifera* subsp. *divaricata* PERTH 04647378, D – *P. formanii* PERTH 05039207, E – *P. globifera* PERTH 05056578, F – *P. recurva* PERTH 03440915, G – *P. scabriuscula* PERTH 04696182, H – *P. septemfida* PERTH 07978014, I – *P. serruriae* PERTH 04655257, J – *P. trifurcata* PERTH 03458903. Scale bars = 5 mm.

Conservation status. A relatively common, widespread species.

Lectotypification. A lectotype should probably be chosen from one of the two sheets at K, as Meissner (1855) based most of his new taxa on the material he examined while in England. K type material was examined by Alex George, who confirmed that it was of the same taxon as the MEL sheet examined by us.

Affinities. Reinstatement of *Petrophile axillaris* addresses the problem noted by George (1998) regarding the variability shown by *P. serruriae* R.Br. *s. lat.* Although *P. axillaris* is very closely related to *P. serruriae*, it differs in having pink, rather than yellow tepals, a more appressed indumentum on the claw, and in having an apical appendage which tapers towards the apex as opposed to the clavate appendage of the latter species. It also has a more compact growth habit than *P. serruriae* and has a quite distinct habitat and distribution, being confined to coastal limestone.

Notes. The pollen is deposited on the hairy part of the pollen presenter and also up to the level of the stigma. This raises the possibility that autogamous self-fertilisation may sometimes occur in this species.

Only two PERTH collections have been made from the isolated southern area of occurrence of the species in Leeuwin–Naturaliste National Park. These specimens have somewhat longer and more spreading hairs than normal on the tepals and their floral parts are at the lower end of the size range

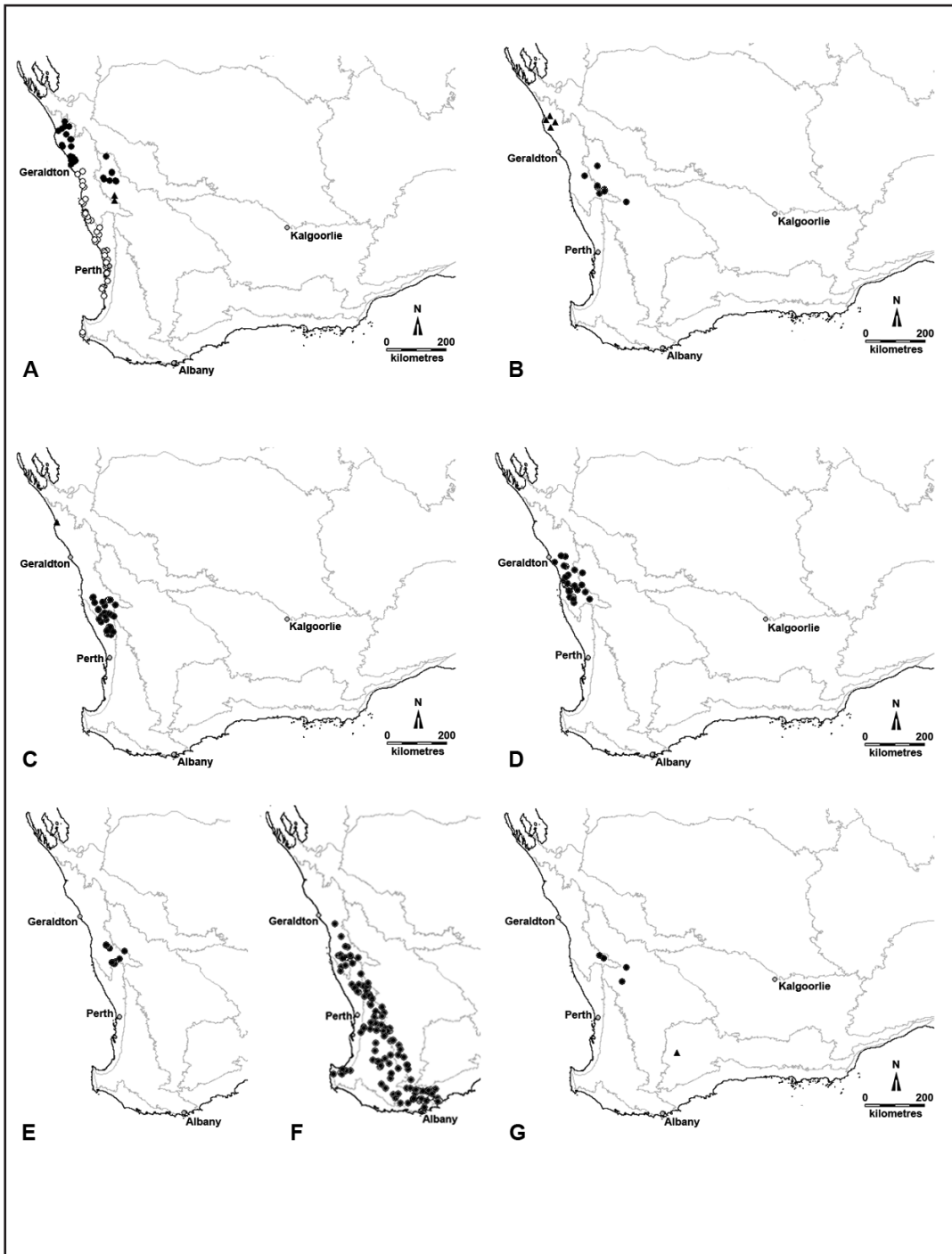


Figure 2. Distribution maps for the new taxa. A – *Petrophile axillaris* (○), *P. conifera* subsp. *conifera* (●) and *P. conifera* subsp. *divaricata* (▲); B – *P. foremanii* (▲) and *P. globifera* (○); C – *P. recurva*; D – *P. scabriuscula*; E – *P. septemfida*; F – *P. serruriae*; G – *P. trifurcata* (●) and *P. ericifolia* × *seminuda* (▲)

for the species as a whole. Those differences are not considered sufficient to warrant taxonomic recognition.

Petrophile conifera Meisn., *Hooker's J. Kew Gard. Misc.* 7: 67 (1855). *Type*: Murchison River, Western Australia, 1850–1851, *J. Drummond* coll. 6, n. 167 (*syn*: MEL 1534408).

Affinities. Closely related to *Petrophile incurvata* W.Fitzg. and *P. semifurcata* F.Muell. ex Benth., differing as discussed under those species. Note also that *P. conifera* overlaps greatly in distribution with *P. semifurcata* without losing its integrity and that its very distinctive subspecies *divaricata* Hislop & K.A.Sheph. occurs within the range of *P. incurvata*.

Notes. During the 1940s, Gardner (unpub.) considered that there were insufficient differences between *Petrophile conifera* and *P. semifurcata* to retain them as separate species. He also considered *P. incurvata* to be conspecific with *P. conifera*, and planned to reduce both taxa to varieties. In all, he recognised four varieties under *P. conifera* as he also intended to name a new taxon as *P. conifera* var. *divaricata* C.A.Gardner ms. Like Foreman (1995), we consider *P. incurvata* and *P. semifurcata* to be good species, readily distinguished from *P. conifera*. However, the new taxon is more similar in morphology to *P. conifera* and is described here as a new subspecies.

a. *Petrophile conifera* Meisn. subsp. *conifera*

Shrubs 0.4–2 m high. *Branchlets* smooth or slightly ribbed, grey-brown, with a dense, mixed indumentum of \pm straight or crinkled longer hairs up to 0.3 mm long and a layer of shorter, crisped hairs, at length glabrescent. *Leaves* rather variable, usually pinnatisect, and then often with further division of the basal lobes, but sometimes bipartite or tripartite, with or without secondary division, 30–100 mm long (including 'petiole' 20–48 mm long), 30–55 mm wide, terete, glabrous, usually recurved along the longitudinal axis, with (2–)5–9 ultimate lobes, each 7–32 mm long and terminating in a pungent point 0.5–1.5 mm long. *Flower heads* terminal, sessile, or occasionally with a very short peduncle, ovoid or ellipsoid, 22–32 mm long, 15–21 mm diam. *Involucral bracts* erect, narrowly ovate or ovate, 4.0–8.5 mm long, 1.9–2.2 mm wide, with apex acuminate, the margins densely ciliate with antrorse hairs to *c.* 1 mm long; outer surface with moderately dense, appressed hairs 0.1–0.25 mm long; inner surface with a dense indumentum of rather wavy, antrorse hairs 0.5–1 mm long. *Floral bracts* ovate, 4.5–8.1 mm long, 2.2–3.8 mm wide, acuminate, brown, margins ciliate; outer surface with a dense indumentum of antrorse hairs throughout, the longest of these (to 1.8 mm long) in the distal third; inner surface glabrous. *Tepals* 8–13 mm long, densely hairy; claw creamy yellow, with antrorse hairs 0.5–0.8 mm long, glabrous at base; limb 3.5–5 mm long, with straight hairs 0.5–1 mm long. *Anthers* 2.1–3.5 mm long. *Pistil* 12–15 mm long, with scattered simple hairs 0.3–0.4 mm long on the style. *Pollen presenter* 3.1–4.7 mm long; swelling narrowly ovoid, with a moderately dense indumentum of patent hairs 0.1–0.25 mm long over most of its length, but with a glabrous base; unswollen apical part 0.6–0.8 mm long. *Cones* ovoid or narrowly ovoid, 18–27 mm long, 12–16 mm diam.; scales broadly ovate. *Diaspores* ovate or broadly ovate in outline, 5.1–6.2 mm long including the apical beak formed by the enlarged base of the style and 3.0–4.4 mm long excluding the beak, 2.7–3.2 mm wide, with an erect coma of hairs 2–3 mm long on the lower margins and base; abaxial surface with moderately dense, white indumentum of antrorse-appressed hairs (0.3–0.7 mm long) throughout; adaxial surface with scattered long hairs of the same type that form the coma and densely covered by very short, dark-purple hairs, except at the apex where there is a zone of short, white hairs. (Figure 1B)

Selected specimens examined. WESTERN AUSTRALIA: Loop Rd, Kalbarri, 3 Aug. 1987, *D.R. & B. Bellairs* 1747 (PERTH); G. Burrows, White Peaks, 24 July 1999, *J.L. Checker* 1 (PERTH); 5 km S of Binnu on North West Coastal Highway, 9 Sep. 1997, *G. Flowers* 237 & *S. Donaldson* (PERTH); 28 km S of Tardun on Great Northern Highway, 11 Sep. 1984, *D.B. Foreman* 648 (PERTH); Koolanooka, 19 Sep. 1931, *C.A. Gardner* 2679 (PERTH); 17 km W of Morawa, 19 Aug. 1997, *F. Keast* M1A 005 (PERTH); Eurardy Station, c. 43 km N of Kalbarri turn-off on the North West Coastal Highway, 29 Aug. 2003, *Wildflower Society of Western Australia* EURA 231 (PERTH).

Distribution and habitat. Extends from Eurardy Station and Kalbarri National Park south to Spalding Park (on the Chapman River, Geraldton), and south-east to the Morawa area, in the South-West Botanical Province (Figure 2A). Occurs in a variety of sandplain and rocky locations including lateritic ridges, often with *Allocasuarina campestris*.

Phenology. Flowers July to September.

Conservation status. Not considered to be at risk at present.

Notes. This subspecies is much more widespread and variable than *Petrophile conifera* subsp. *divaricata*, and its leaves are more erectly branched. There is a disjunction in its currently known range between the near-coastal populations extending from Eurardy Station south to the Moresby Range and the inland populations extending from near Pindar south to the Morawa area. Leaves of the inland specimens invariably have the petiole curved towards the apex of the branch whereas those of the near-coastal specimens tend to be variable in orientation and more spreading on average, often with some of the petioles somewhat recurved.

b. *Petrophile conifera* subsp. *divaricata* Hislop & K.A.Sheph., *subsp. nov.*

A subspecies *conifera* foliis magis divaricatis, basis integra brevior, bracteis involucribus brevioribus et latioribus, bracteis strobilibus latioribus differt.

Typus: Coorow, Western Australia, 14 September 1932, *W.E. Blackall* 2595 (*holo:* PERTH 01865773; *iso:* PERTH 03440044).

Petrophile conifera var. *divaricata* C.A.Gardner ms, *Flora of Western Australia* 1(3): 95 (unpubl.); *in sched.* (PERTH)

Petrophile sp. Coorow (W.E. Blackall 2595), Western Australian Herbarium, in *FloraBase*, <http://florabase.dec.wa.gov.au> [accessed March 2009].

Shrubs to 1 m high. *Branchlets* smooth, grey-brown, with a dense indumentum of hairs 0.2–0.4 mm long, glabrescent. *Leaves* divaricately tripartite, the primary lobes further divided into 2 or 3 divaricate lobes, (20–)35–50 mm long (including a ‘petiole’ 12–24 mm long), 30–55 mm wide, rigid, terete, glabrous, with 6–9 ultimate lobes each 7–24 mm long and terminating in a pungent point 0.5–1.6 mm long. *Flower heads* terminal, sessile, ovoid to ellipsoid, 18–22 mm long, 18–22 mm diam. *Involucrial bracts* erect, ovate or broadly ovate, 2.5–6.5 mm long, 2.5–4.1 mm wide, acuminate, margins densely ciliate with antrorse hairs to c. 1.5 mm long; outer surface with a moderately dense indumentum of straight or wavy, appressed hairs 0.2–0.3 mm long; inner surface with a dense indumentum of straight or

curly hairs 0.4–1.0 mm long. *Floral bracts* ovate, 5–8.2 mm long, 1.5–3.5 mm wide, acuminate, brown, the margins densely ciliate; outer surface with a dense indumentum of appressed hairs 0.1–0.25 mm long; inner surface glabrous. *Tepals* 11–14 mm long, densely hairy; claw creamy yellow, with straight or wavy hairs 0.4–1.0 mm long, glabrous at base; limb 3–4 mm long, with erect hairs 0.5–1.2 mm long. *Anthers* 2.5–3.4 mm long. *Pistil* 14–15 mm long, with scattered simple hairs 0.2–0.5 mm long on the style. *Pollen presenter* 4.1–5.1 mm long; swelling narrowly fusiform, with a moderately dense indumentum of patent hairs 0.15–0.3 mm long; unswollen apical part 0.4–0.6 mm long. *Cones* ovoid, 17–20 mm long, 14–16 mm diam.; scales broadly ovate. *Diaspores* ovate in outline, 5.0–6.8 mm long including the apical beak formed by the enlarged base of the style and 3.0–4.5 mm long excluding the beak, 2.9–3.1 mm wide; indumentum as for the typical subspecies. (Figure 1C)

Other specimens examined. WESTERN AUSTRALIA: [precise localities withheld for conservation reasons], 3 Oct. 2008, *J. Borger* AD 310-4 (PERTH); 9 Sep. 1995, *F. Falconer* 44 (PERTH).

Distribution and habitat. Occurs near Coorow in the South-West Botanical Province (Figure 2A). Recorded on an undulating rocky slope with red clay over granite, growing with Sandalwood, *Allocasuarina campestris* and *Dryandra*.

Phenology. Flowers recorded in September.

Conservation status. Listed as Priority One under Department of Environment and Conservation (DEC) Conservation Codes for the Western Australian Flora under the name *Petrophile* sp. Coorow (W.E. Blackall 2595) (Smith 2010). This subspecies is currently known from two localities on private land. Only a vague locality was recorded for the type specimen collected in 1932.

Etymology. From the Latin *divaricatus* (widely spreading), referring to the divaricately branched leaves.

Notes. This taxon occurs at least 50 km south of the range of *Petrophile conifera* subsp. *conifera*. It differs from the typical subspecies in having shorter petioles (12–24 mm vs. 20–48 mm long), broader involucre bracts (2.5–4.1 mm vs. 0.9–2.2 mm) that also tend to be shorter, and a differently shaped pollen presenter (narrowly fusiform vs. narrowly ovoid). It has more or less patent leaves with strongly divaricate branching, whereas the inland variant of *P. conifera* from the Pindar to Morawa area has more erect leaves and more erect branching of each leaf.

Petrophile foremanii* Rye & Hislop, *sp. nov.

A Petrophile scabriuscula Meisn. bracteis involucrelibus plerumque brevioribus et plus viscidibus, tepala indumento brevioribus, et distributio septentrionalibus differt.

Typus: Kalbarri National Park, 6 km north-east of Kalbarri on the Ajana–Kalbarri road, Western Australia, 9 September 1984, *D.B. Foreman* 621 (*holo:* PERTH 05222028; *iso:* CANB *n.v.*, MEL 2044008 *n.v.*).

Petrophile sp. Kalbarri (D.B. Foreman 621), Western Australian Herbarium, in *FloraBase*, <http://florabase.dec.wa.gov.au> [accessed March 2009].

Shrubs 0.6–2 m high. *Branchlets* smooth, yellow-grey to brown, with a dense indumentum of tightly coiled hairs and scattered straighter hairs 0.4–0.7 mm long, glabrescent. *Leaves* erect, crowded, simple, sub-terete, straight or incurved over most of their length but with the apex sometimes recurved, 8–11 mm long, 0.6–0.8 mm wide, scabridulous, with scattered, straight, white hairs mostly 0.5–1 mm long when young, becoming glabrous except for a row of hairs protruding along adaxial surface; apex acute, innocuous to coarsely pungent, the point 0.3–0.5 mm long. *Flower heads* terminating branchlets, sessile, depressed-ellipsoid to globose, usually 10–20 mm diam. *Involucral bracts* erect, narrowly ovate to subulate, (3.7–)4–6(–7) mm long, 0.8–1.3 mm wide, viscid, with an acuminate apex, with margins sparsely to densely ciliate, the longest cilia 0.6–1.3 mm long; outer surface sparsely hairy at the base and/or in the central region, glabrous at apex; inner surface glabrous at base, sometimes hairy distally. *Floral bracts* narrowly ovate, 3.5–5.5 mm long, mostly 0.8–1.3 mm wide (outermost ones often much broader), acuminate, brown; outer surface and margins with a dense indumentum of straight or wavy hairs 1.5–2 mm long, glabrous at apex; inner surface glabrous. *Tepals* 10–15 mm long, with a moderately dense or dense indumentum of straight hairs, the longest hairs 0.6–1.5 mm long; claw creamy yellow, glabrous at base; limb 3–4.5 mm long, not viscid, often with the indumentum extending above the top of the anther but with extreme apex of tepal glabrous, sometimes entirely glabrous above the top of the anther but with the long hairs attached below this level often extending to cover the glabrous apex. *Anthers* 2.3–2.5 mm long. *Pistil* 11–15 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 3.2–3.7 mm long; swelling narrowly ovoid to fusiform, glabrous on basal 0.5–1 mm, with patent hairs up to 0.1 mm long over most of its length; unswollen apical part 0.7–1 mm long. *Cones* ellipsoid to globose, 8–14 mm long, 8–12 mm diam.; scales broadly ovate to circular, 5–7 mm wide, with a dense indumentum of straight or curly hairs. *Diaspores* more or less elliptic to broadly obovate in outline, 3–4.3 mm long including the apical beak formed by the enlarged base of the style and 2.5–3 mm long excluding the beak, 1.9–2.6 mm wide, with a coma of straight, white, hairs 3–5 mm long and purplish black hairs up to 0.3 mm long on the margins and base; abaxial surface flat, with minute, appressed, white hairs or glabrous; adaxial surface deeply convex, with a longitudinal division down the centre, glabrous or with some appressed, white hairs 0.1–0.7 mm long and often partially covered by minute, spreading, purple-black hairs. (Figure 1D)

Selected specimens examined. WESTERNAUSTRALIA: southern boundary of Kalbarri National Park on S side of Vermin Proof Fence, 21 Oct. 1974, *J.S. Beard* 7129 (PERTH); Kalbarri National Park, Loop Rd within 0.5–2.8 km of main road, vicinity of first car park, 11 Oct. 1986, *R.S. Cowan* A271 (PERTH); N from junction of Kalbarri–Ajana road, 12 Sep. 2001, *R. Davis* 10033 (PERTH); corner of Yerina Springs Rd and Ogilvie Rd West, 9 Sep. 1984, *D.B. Foreman* 613 (PERTH).

Distribution and habitat. Occurs in the Kalbarri area of the South-West Botanical Province, extending from near the lower Murchison River south to near Hutt River (Figure 2B). Occurs in white or yellow sand, in shrublands sometimes dominated by *Banksia* or *Acacia*.

Phenology. Flowers May to October.

Conservation status. The known range of this taxon is less than 50 km but nearly all of its locations are within a large national park.

Etymology. Named in honour of Don Foreman, who made a significant contribution to the taxonomy of *Petrophile* but unfortunately was unable to complete his studies of the genus. He named 14 new species of *Petrophile* (Foreman 1990, 1995) and his collections have been used for the types of this new taxon and *P. globifera* Rye & K.A. Sheph.

Affinities. This taxon is one of four named taxa belonging to the *Petrophile scabriuscula* Meisn. species complex, which extends from Kalbarri National Park south to near Wannamal. The other three taxa occur south of its range, with the closest one, *P. scabriuscula*, separated by about 75 km. *Petrophile scabriuscula* differs in its longer involucral bracts, which are usually not viscid, and in always having densely hairy tepals, with the indumentum of the outer surface extending above the level of the top of the anther (inserted on the inner surface). See also the notes under *P. globifera* and *P. recurva* Foreman below.

Notes. In any species complex, it is difficult to determine the most appropriate taxonomic status for its members. As the new taxon described above is geographically separated from the remainder of the *Petrophile scabriuscula* complex, it is unlikely to be confused with other taxa. It does not show very large morphological differences from *P. scabriuscula* and possibly should be regarded as a subspecies of that taxon. However, it also shows some similarities to the other members of the complex, for example in having viscid involucral bracts, and there does not seem to be a good case to choose a lower taxonomic status for it than for *P. globifera* and *P. recurva*.

Note that the length of the apical point on the leaves is sometimes apparently extended on the dorsal surface, in both this taxon and *P. globifera*, by a broad brown patch but the measurements of the point exclude that region.

Petrophile globifera Rye & K.A.Sheph., *sp. nov.*

Petrophile scabriusculae Meisn. affinis sed bracteis involucralibus brevioribus, inflorescentiis plerumque plus viscidibus, pollinis praebitor plerumque longiore et distributio mediterraneis differt.

Typus: Marchagee Track, Western Australia [precise locality withheld for conservation reasons], 1 September 1984, D.B. Foreman 490 (*holo:* PERTH 05222427; *iso:* AD *n.v.*, CANB *n.v.*, MEL *n.v.*).

Petrophile sp. Pithara (P. Armstrong s.n. PERTH 06592090), Western Australian Herbarium, in *FloraBase*, <http://florabase.dec.wa.gov.au> [accessed March 2009].

Shrubs to 0.7–1.2 m high. *Branchlets* smooth or ribbed, yellow-grey or reddish brown, with a dense indumentum of wavy to tightly coiled hairs 0.1–0.3 mm long, at length glabrescent. *Leaves* erect, moderately crowded, simple, sub-terete, straight or very slightly curved towards the apex, 3–5.7(–7.5) mm long, (0.5–)0.7–0.8 mm wide, scabridulous, glabrous or with scattered, straight or wavy, white hairs 0.2–0.7 mm long; apex acute, innocuous to coarsely pungent, the point 0.2–0.4 mm long. *Flower heads* terminating branchlets (those from previous growing seasons located at lower junctions where the branchlets arise), sessile, depressed-ellipsoid to globose, 10–18 mm diam. *Involucral bracts* erect, narrowly ovate, 2.0–4.2 mm long, 0.7–1.5 mm wide, with an acuminate apex 0.7–1.2(–2) mm long, viscid, glabrous throughout or margins with scattered hairs 0.3–0.5 mm long. *Floral bracts* narrowly ovate to broadly subulate, 3.8–5.3 mm long, 1.3–2.6 mm wide, acuminate, brown; outer surface and margins with a dense indumentum of straight or wavy, cream to white hairs 0.8–2 mm long, but glabrous towards the apex; inner surface glabrous or with a few hairs at the base. *Tepals* (7.5–)10–15 mm long, with a sparse or moderately dense indumentum of straight or nearly straight hairs, the longest hairs 1–1.5 mm long; claw cream to pale-yellow, glabrous at base; limb 3.5–4 mm long, often viscid, usually glabrous above the top of the anther, with the long hairs attached below this level rarely extending beyond the glabrous apex. *Anthers* 1.5–2.5 mm long. *Pistil*

9–14 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 3.4–5.1 mm long; swelling fusiform, glabrous in basal 0.4–0.8 mm, with a moderately dense indumentum of patent hairs 0.1–0.2 mm over most of its length; unswollen apical part 0.4–0.6 mm long. *Cones* ellipsoid to globose, 9–12 mm long, 10–14 mm diam.; scales elliptic to very broadly ovate, 4–8 mm wide, with a dense indumentum of straight or curly hairs. *Diaspores* ovate to elliptic in outline, 3.3–4 mm long including the apical beak formed by the enlarged base of the style and 2.5–3.3 mm long excluding the beak, 1.6–3 mm wide, with an erect coma of cream to brown hairs 3–4.5 mm long on the margins and base; adaxial and abaxial surfaces with scattered, short, stiff, purple-brown hairs 0.1–0.15 mm long at the apex, the remainder glabrous. (Figure 1E)

Selected specimens examined. WESTERN AUSTRALIA: [localities withheld] 15 Sep. 1993, *P. Armstrong s.n.* (PERTH); 8 Oct. 1992, *A. Carr* 129 (PERTH); W of Coorow, 7 Oct. 1992, *E.A. Griffin* 7137 (PERTH); 28 Apr. 1997, *F. Keast* M2B 112 (PERTH); S of Coorow, 18 Aug. 1953, *R. Melville* 1423 & *J. Calaby* (PERTH); Irwin District, 29 Sep. 1979, *J. Taylor* 976, *M.D. Crisp* & *R. Jackson* (PERTH).

Distribution and habitat. Extends from near Morawa south to the Marchagee area and south-east to near Pithara in the South-West Botanical Province (Figure 2B). Occurs in sand, with the dominant species varied but including mallees, *Grevillea* species, *Actinostrobus arenarius* and *Allocasuarina campestris*.

Phenology. Flowers August to October.

Conservation status. Listed by Smith (2010) as Priority Three (DEC Conservation Codes for the Western Australian Flora) under the name *Petrophile* sp. Pithara (*P. Armstrong s.n.* PERTH 06592090). This taxon has been recorded from about eight localities over a distance of about 150 km. Although not specifically recorded from any national parks or other reserves, it is known from the vicinity of Watheroo National Park.

Etymology. From the Latin *globus* (sphere) and *fero* (to bear), referring to the flower heads, whose spherical shape is particularly obvious in this species because they are borne on stems with short, appressed leaves.

Affinities. This taxon is one of four named taxa belonging to the *Petrophile scabriuscula* species complex. It has the most easterly distribution within the complex, although it overlaps in range with both *P. scabriuscula* and *P. recurva*, especially the former.

Petrophile globifera differs from the three other members of the complex in its usually shorter and broader leaves, its shorter involucral bracts and its usually longer pollen presenter. It can also be distinguished from *P. foremanii* by the sparser indumentum on its stems, from *P. recurva* by its straighter leaf apex and broader cone scales, and from *P. scabriuscula* by the sparser indumentum on its tepals.

Notes. Separation of the four members of the *Petrophile scabriuscula* complex is clear-cut for most specimens but there are a few that are difficult to assign. These four taxa appear to warrant formal recognition as distinct entities but whether all should be treated as species or some as subspecies is not certain. *Petrophile globifera* is described here as a species because it appears to be as distinctive as the two previously named taxa, *P. scabriuscula* and *P. recurva*.

Petrophile recurva Foreman, *Fl. Australia* 16: 477 (1995). *Type*: c. 17 miles [c. 27 km] from Moora towards Jurien Bay, Western Australia, 23 September 1962, *M.E. Phillips s.n.* (*holo*: CBG 005328 *n.v.*; *iso*: MEL 727037, NSW *n.v.*)

Illustration. D.B. Foreman, *Fl. Australia* 16: fig. 89 (1995).

Shrubs to 0.8–1.5 m high. *Branchlets* smooth or slightly ribbed, yellow-grey or reddish brown, with a dense indumentum of simple to tightly coiled hairs 0.1–0.3 mm long, glabrescent. *Leaves* erect, crowded, simple, sub-terete, straight with a strongly recurved apex, 6–9(–11) mm long, 0.4–0.7 mm wide, smooth or rarely faintly scabridulous, glabrous or with very few scattered, straight, white hairs 0.3–0.7 mm long, sometimes more densely hairy towards the base; apex acute, coarsely pungent, the point 0.3–0.5 mm long. *Flower heads* terminating branchlets, sessile, depressed-ellipsoid to globose, 14–20 mm diam. *Involucral bracts* erect, lanceolate to subulate, 3.5–5 mm long, 0.7–1.2 mm wide, with an acuminate apex 1.5–2.5 mm long, viscid, glabrous throughout or occasionally with margins sparsely ciliate. *Floral bracts* ovate to broadly subulate, 4–7 mm long, 1.0–1.8 mm wide, acuminate, brown; outer surface and margins with a dense indumentum of straight or wavy hairs 1–2 mm long, glabrous towards the apex; inner surface glabrous. *Tepals* 9–12 mm long, with a sparse or moderately dense indumentum of straight or wavy hairs 0.5–1.5 mm long, the lower hairs always distinctly wavy; claw yellow or creamy yellow, glabrous at base; limb 3–4 mm long, viscid, usually glabrous above the top of the anther, with the long hairs attached below this level rarely extending beyond the glabrous apex. *Anthers* 2.0–2.6 mm long. *Pistil* 10–15 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 3.0–3.8 mm long; swelling narrowly ovoid to fusiform, glabrous on basal 0.7–1.2 mm, with scattered patent hairs 0.1–0.15 mm over most of its length; unswollen apical part 0.4–1.3 mm long. *Cones* broadly ellipsoid to globose, 11–21 mm long, 12–19 mm diam.; scales elliptic to broadly ovate, 2–4 mm wide, with a dense indumentum of straight or curly hairs. *Diaspores* elliptic to oblong in outline, 2.2–3.5 mm long including the apical beak formed by the enlarged base of the style and 1.7–2.5 mm long excluding the beak, 1.6–2.3 mm wide, with a coma of straight, white, hairs 2.5–5 mm long mixed with erect, purplish black hairs 0.1–0.2 mm long along the margins and base; adaxial and abaxial surfaces with a longitudinal division down the centre, usually glabrous, rarely with scattered, appressed, white hairs 0.05–0.1 mm long. (Figure 1F)

Selected specimens examined. WESTERN AUSTRALIA: 56.4 km N along Brand Highway from junction of Muchea South Rd, 23 Aug. 2001, *R. Davis* 9944 (PERTH); 67.8 km N of Gingin on Brand Highway, 14 Sep. 1997, *S. Donaldson* 1655 & *G. Flowers* (PERTH); private farmland off Green Head–Coorow road, c. 3 km W of Brand Highway, 30 July 1995, *M. Hislop* 67 (PERTH); Brand Highway, 50 km S of Cataby, 24 July 2005, *J.E. Wajon* 1376 (PERTH).

Distribution and habitat. Distributed in the northern sand-plains of the South-West Botanical Province from Warradarge east to Watheroo and south to Wannamal (Figure 2C). Occurs in deep sand or sand over laterite, in vegetation usually dominated by Myrtaceae and/or Proteaceae, often in *Banksia* woodlands.

Phenology. Flowers July to September.

Conservation status. Not considered to be at risk.

Affinities. *Petrophile recurva* was originally considered by Foreman (his determinations on the specimens) as a subspecies of *P. scabriuscula* but later named as a distinct species, which can usually

be distinguished by the recurved apex on its leaves, the more crinkled indumentum on its tepals and by its shorter involucre bracts and narrower and generally thinner cone scales. There are no obvious ecological differences between the two taxa although they are largely geographically separated, with the distribution of *P. recurva* mostly south of that of *P. scabriuscula*. However, there is a small area of overlap in the region from Warradarge east to Watheroo National Park. In that region, they can generally be readily identified by *P. scabriuscula* having its involucre bracts and tepals not or scarcely viscid whereas *P. recurva* has its involucre bracts (when in flower) and also the apex of its tepals manifestly viscid. *Petrophile recurva* also differs in the indumentum on its tepals, with the upper hairs often somewhat curled or crinkled and the lower ones strongly wavy, whereas *P. scabriuscula* has more numerous, straighter hairs.

Specimens of the new northern taxon *Petrophile foremanii* are more similar in their bract and tepal characters to *P. recurva*, although they still differ in their straighter or more incurved leaves with the apex more erect, and the surface more scabrous. See also the notes under the other new species, *P. globifera*.

Notes. According to Foreman's (1995: 173) description, the leaves in this species are up to 13 mm long, but those seen in the current study rarely exceeded 9 mm long and the largest were 11 mm long.

Petrophile scabriuscula Meisn. in J.G.C. Lehmann, *Pl. Preiss.* 1: 495 (1845). – *Petrophile ericifolia* var. *scabriuscula* (Meisn.) Benth., *Fl. Austral.* 5: 331 (1870). *Type:* Swan River Colony [Western Australia], J. Drummond 557 (*syn:* K n.v., photograph seen (MEL 2274286, PERTH 01543806), K n.v., photograph seen (MEL 2274287), MEL 1535723).

Illustration. W.E. Blackall & B.J. Grieve, *How Know W. Austral. Wildflowers* 1: 159 (1988).

Shrubs 0.4–1.5 m high. *Branchlets* smooth, yellow-grey to brown, with a dense indumentum of tightly coiled hairs and with scattered, straighter hairs 0.4–0.7 mm long, glabrescent. *Leaves* erect, crowded, simple, sub-terete, straight or incurved over most of their length but with the apex sometimes slightly recurved, 6–11(–16) mm long, 0.5–0.8 mm wide, scabridulous, with scattered, straight, white hairs 0.5–1.5 mm long; apex acute, innocuous or coarsely pungent, the point 0.3–0.7 mm long. *Flower heads* terminating branchlets (those from previous growing seasons located at lower junctions where the branchlets arise), sessile, depressed-ellipsoid to globose, 15–25 mm diam. *Involucre bracts* erect, lanceolate to subulate, 5–9.5 mm long, 0.8–1.9 mm wide, usually not viscid, with an acuminate apex 2.5–5 mm long that is often markedly recurved, with densely ciliate margins, the longest cilia up to c. 2 mm long; outer surface with scattered hairs 0.4–0.5 mm long at the base, usually glabrous above; inner surface glabrous at base, with a dense indumentum above of hairs 0.5–2.2 mm long. *Floral bracts* ovate or narrowly ovate, 4–6.5 mm long, 0.7–2.4 mm wide, acuminate, brown; outer surface and margins with a dense indumentum of straight or wavy hairs 1.0–2.1 mm long, glabrous at apex; inner surface glabrous. *Tepals* 10–14 mm long, with a dense indumentum of straight hairs, the longest hairs 1.5–2.5 mm long; claw creamy yellow, glabrous at base; limb 3.0–3.7 mm long, usually not viscid, the indumentum extending above the top of the anther and with extreme apex of tepal glabrous but with the long hairs protruding beyond the glabrous apex. *Anthers* 1.7–2.4 mm long. *Pistil* 10–16 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 2.9–3.6 mm long; swelling narrowly ovoid to fusiform, glabrous on basal 0.5–1 mm, with patent hairs 0.05–0.1 mm long over most of its length; unswollen apical part 0.3–0.8 mm long. *Cones* ellipsoid to globose, 11–14 mm long, 13–17 mm diam.; scales broadly ovate, 5–7 mm wide, with a dense indumentum of straight or curly hairs, often becoming glabrous apically. *Diaspores* more or less elliptic or obovate in outline, 3.5–5 mm

long including the apical beak formed by the enlarged base of the style and 2.0–3.3 mm long excluding the beak, 1.5–3.0 mm wide, with a coma of straight, white hairs 3–5.5 mm long and purplish black hairs 0.05–0.15 mm long on the margins and base; adaxial surface deeply convex, with a longitudinal division down the centre, largely glabrous or with scattered, appressed, white hairs 0.05–0.1 mm long, often with a dense indumentum of minute purplish black hairs at apex. (Figure 1G)

Selected specimens examined. WESTERN AUSTRALIA: 25 km S of Eneabba, 20 July 1978, *R.J. Cranfield* 262 (PERTH); road to Mt Adams, 12.9 km from Brand Highway, 28 May 1997, *R. Davis* 3264 (PERTH); Burma Rd, SE of Walkaway, 20 July 1973, *A.S. George s.n.* (PERTH); Hi Vallee property (D. & J. Williams), Warradarge, bottom of main valley, 10 July 1999, *M. Hislop* 1350 (PERTH).

Distribution. Occurs in the South-West Botanical Province from the Wicherina area south to the Warradarge area (Figure 2D), mostly in sand, sometimes over laterite, in vegetation usually dominated by Myrtaceae and/or Proteaceae, including *Banksia* woodlands.

Phenology. Flowers May to October.

Conservation status. Known from numerous collections extending at least 170 km, this taxon is not considered to be at risk currently.

Affinities. See notes under its three close relatives *Petrophile foremanii*, *P. globifera* and *P. recurva*. This species tends to have the most hairy leaves and tepals found in the *P. scabriuscula* complex, with the longest hairs on its tepals 1.5–2.5 mm long, and usually also tends to have the longest involucre bracts.

Notes. The type collection has unusually large leaves, up to 16 mm long, and large flower heads with the involucre bracts viscid, the closest approach to these characters being seen in the specimen *M. Hislop* 1350 from Hi Vallee farm in the Warradarge area. Across the species' range to the north of Warradarge, specimens of *Petrophile scabriuscula* have shorter leaves and generally lack viscid involucre bracts although matching the type material in other respects.

Petrophile septemfida* Rye & K.A. Sheph., *sp. nov.

Folia teretia, plerumque septemfida, 4–13 mm longi. Tepala dense pilosa. Pollinis praebitor angusta ovoideus ad fusiformus, 2–3 mm longus; pilis patentes. Styli glabris. Nux integris (non alata), basi et margine lato comoso.

Typus: north-east of Badgingarra, Western Australia [precise locality withheld for conservation reasons], 16 August 2008, *M. Hislop* 3804 (*holo:* PERTH 07978014; *iso:* CANB, K, MEL).

Petrophile chrysantha subsp. Watheroo (K.M. Allan 57), in G. Paczkowska & A.R. Chapman, *West Austral. Fl.: Descr. Cat.* p. 501 (2000); Western Australian Herbarium, in *FloraBase*, <http://florabase.dec.wa.gov.au> [accessed March 2009].

Shrubs 0.6–1.2 m high. *Branchlets* ribbed, grey, with a dense layer of tightly coiled hairs overlain by much sparser layer of antrorse hairs 0.4 mm long, becoming glabrous in patches. *Leaves* antrorse, usually steeply so, deeply divided mostly into seven lobes, 4–13 mm long, 1.2–8.5 mm diam., terete, with a moderately dense indumentum of hairs to 0.7 mm long, older leaves tuberculate; lobes

with a pungent point 0.3–0.8 mm long. *Flower heads* terminating branchlets (those from previous growing seasons located at lower junctions where the branchlets arise), sessile, globose, 9–14 mm long, 9–16 mm diam. *Involucral bracts* erect, mostly narrowly ovate, 4–8 mm long, 1.1–2.0 mm wide, acuminate, appearing brown, with densely ciliate margins, the cilia up to 1.2 mm long; outer surface with a moderately dense to dense indumentum of white hairs 0.4–0.9 mm long; inner surface densely covered by hairs 0.9–1.5 mm long. *Floral bracts* ovate, 3.2–3.8 mm long, 0.9–1.4 mm wide, acuminate, brown, longitudinally ribbed; outer surface glabrous towards the apex, base and margins with densely arranged hairs 0.5–1.1 mm long; inner surface with a few hairs *c.* 0.6 mm long at the base, otherwise glabrous. *Tepals* 10.5–13.5 mm long, densely hairy; claw cream or pale-yellow, with patent hairs 0.4–0.8 mm long, glabrous at base; limb 1.9–2.9 mm long, with antrorse hairs 0.5–0.7 mm long. *Anthers* 1.4–1.8 mm long. *Pistil* 11–14 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 1.9–2.9 mm long; swelling narrowly ovoid to fusiform, 0.5 mm diam., glabrous on basal 0.7–1.2 mm, with scattered, patent hairs 0.6–0.13 mm long over most of its length; unswollen apical part 0.2–0.4 mm long. *Cones* globose, 5–11 mm long, 5–10 mm diam.; scales broad. *Diaspores* broadly ovate in outline, 4.8–6.0 mm long including the apical beak formed by the enlarged base of the style and 2.5–3.3 mm long excluding the beak, 2.4–3.5 mm wide, with an erect coma of straight, white hairs 2.8–3.5 mm long on the margins and base; adaxial and abaxial surfaces shortly appressed-hairy. (Figure 1H)

Other specimens examined. WESTERNAUSTRALIA [localities withheld]: 24 July 1969, *K.M. Allan* 57 (PERTH); 30 June 1967, *C. Chapman s.n.* (PERTH); 1 Sep. 1984, *D.B. Foreman* 474 (CANB, MEL, NSW, PERTH); Sep. 1965, *C.A. Gardner s.n.* (PERTH); 1 Oct. 1982, *E.A. Griffin s.n.* (PERTH); 11 Sep. 1985, *N. Hoyle* 200 (PERTH); no locality, Sep. 1953, *A.C. Kessell s.n.* (PERTH 03431681); 8 Sep. 1986, *I.R. McGill* 13 (PERTH); 6 Oct. 1971, *R.D. Royce* 9617 (PERTH).

Distribution and habitat. Occurs from north of Tathra National Park east to near Coorow and south-east to Watheroo National Park in the South-West Botanical Province (Figure 2E). Recorded in sand or in sand over laterite, in shrubland, at one locality growing with *Dryandra* and *Hakea* species.

Phenology. Flowers recorded late June to early October.

Conservation status. Listed by Smith (2010) as Priority Three (DEC Conservation Codes for the Western Australian Flora) under the name *Petrophile chrysantha* subsp. Watheroo (*K.M. Allan* 57). This species has a range of about 75 km, including two national parks and a reserve.

Etymology. From the Latin *septemfidus* (seven-cleft), as most of the leaves are deeply divided into seven branches. A typical leaf is shown in Figure 1H.

Affinities. This taxon has been confused with *Petrophile chrysantha* Meisn. but differs in many characters including its finer and more hairy leaves, its narrower involucral bracts that are hairy outside, its creamy yellow tepals with a prominent glabrous tip, its glabrous style and its pollen presenter with somewhat shorter and more spreading hairs, and its non-winged diaspore. In *P. chrysantha* the leaves are more scabrous and more prominently pungent, the involucral bracts are glabrous outside but distinctly ciliate, the vividly yellow tepals have longer hairs, and the lower half of the style is hairy.

Petrophile septemfida is more closely related to the species group that includes *P. misturata* Foreman and *P. scabriuscula* but does not appear to have any very close relatives. It differs from members of

that group in its finer, more divided leaves with simple, straight, white hairs, and it has a shorter pollen presenter than all or most members of that group.

Petrophile serruriae R.Br., *Suppl. Prodr. Fl. Nov. Holl.* 6 (1830). *Type*: south-west coast of New Holland, [Stirling Range to King George Sound, Western Australia], 1828–1829, *W. Baxter s.n.* (*lecto*: BM 000759018, *fide* D.B. Foreman, *Fl. Australia* 16: 477 (1995); *isolecto*: BM *n.v.*). *Paralecto*: Swan River, [Western Australia], *C. Fraser s.n.* (BM 000759019).

Petrophile glanduligera Lindl., *Sketch Veg. Swan R.* 35 (1840). *Type*: Swan River, 1839 [Western Australia, collected 1835–1838], *J. Drummond s.n.* (*holo*: CGE (2 sheets) *n.v.*, photograph PERTH 01543814; *iso*: K *n.v.*).

Illustrations. W.E. Blackall & B.J. Grieve, *How Know W. Austral. Wildflowers* 1: 159 (1988); D.B. Foreman, *Fl. Australia* 16: fig. 97C–E (1995).

Shrubs to 0.2–1.5 m high. *Branchlets* ribbed, grey, with a moderately dense indumentum of patent hairs *c.* 0.1 mm long and scattered hairs 1.0–2.8 mm long. *Leaves* spreading, usually irregularly bipinnatisect, straight, 12–32 mm long, 10–33 mm wide, with a variable indumentum of long and short, often tubercle-based, antrorse hairs to 1.8 mm long; lobes narrow but somewhat compressed, rigid, with a pungent point 0.2–1.2 mm long. *Flower heads* mostly axillary, often pedunculate, ± globose, 15–30 mm long, 18–34 mm diam.; peduncle 3–9 mm long. *Involucral bracts* erect or spreading, narrowly ovate to ovate, 1.2–4.2 mm long, 1.1–3.4 mm wide, obtuse or acute; outer surface with a dense tuft of hairs at the base, glabrous above; inner surface with 1–3 ribs, glabrous. *Floral bracts* ovate or narrowly ovate, 3.9–5.2 mm long, 1.7–2.9 mm wide, acute or acuminate, brown, with glabrous margins; outer surface with a dense indumentum of antrorse hairs to 1.9 mm long in the lower half, glabrous towards the apex; inner surface glabrous. *Tepals* 13–25 mm long, moderately densely hairy; claw yellow, with antrorse hairs 0.4–0.7 mm long, glabrous at base; limb 2.9–4.1 mm long, with hairs 1.1–1.7 mm long rarely exceeding the apex of the limb, with a clavate subapical appendage 0.7–1.2 mm long. *Anthers* 1.2–3.1 mm long. *Pistil* 15–22 mm long, the style with scattered hairs 0.1–0.2 mm long along most of its length. *Pollen presenter* 3.1–5 mm long; swelling narrowly obovoid to fusiform, with a sparse indumentum of fine, retrorse hairs *c.* 0.2 mm long over distal 1/2–2/3, glabrous towards base; glabrous apical part 0.7–1.4 mm long. *Cones* globose to ovoid, 9–21 mm long, 8–17 mm diam.; scales ovate or broadly ovate. *Diaspores* narrowly ovate in outline, 4.9–6.1 mm long, 1.7–2.8 mm wide, including a narrowly triangular, readily detached, terminal wing upon which the style remains often form an apical beak; abaxial surface glabrous in the basal 1/3–2/3, with fine, appressed hairs *c.* 0.1 mm long towards the apex; adaxial surface with a sparse or moderately dense indumentum of white or brown, appressed hairs *c.* 0.1 mm long, these becoming intermixed with the long hairs of the coma about the base and lower margins; coma hairs restricted to base of diaspore, 3.5–5 mm long, white to pale-gold. (Figure 11)

Selected specimens examined. WESTERN AUSTRALIA: Site 14, Deefor Rd, 3 km SSW Coolakin Spring [SW of York], 11 Nov. 1996, *M.G. Allen* 527 (PERTH); lower slopes of Mt Magog, 1 km from picnic area and along gully at picnic area, 18 km to Stirling Range Drive from Chester Pass Rd, 31 Oct. 1986, *R.S. Cowan* A-546 (NY, PERTH); Reserve No. 30363, Inkpen and Woottating Rds, 4 Dec. 1988, *R.J. Cranfield* 7621 (PERTH); O'Connor Rd Reserve, located on both sides of O'Connor Rd *c.* 695 m NE from its junction with Dardadine South Rd, Shire of West Arthur, 1 Oct. 1999, *J.W. Horn & R. Butcher* 2714 (DUKE, PERTH); Hi Vallee property (D. & J. Williams), Warradarge, track along N head of main valley, 13 Sep. 1999, *M. Hislop* 1543 (PERTH); Tathra National Park, 4.9 km E on Carnamah–Eneabba road from intersection with Touche Rd (*c.* 26.5 km due E of Eneabba), 11 Sep.

1985, *N. Hoyle* 202 (PERTH); 16 km WSW of Badgingarra, 7 Aug. 1973, *A. Kanis* 1529 (CANB, PERTH); Muradup, 25 km W of Kojonup, 5 Nov. 1996, *C. Lewis* CML 67 (PERTH); near Two Mile Lake, Nov. 1988, *W.L. McCaw, R.H. Smith & J.E. Neal s.n.* (PERTH); 25 km SE of Toodyay, 14 Oct. 1989, *B. Nordenstam & A. Anderberg* 699 (PERTH); Yoongarillup, 19 Oct. 1952, *R.D. Royce* 3890 (PERTH); 40 km from Borden on Albany–Borden road, 10 Oct. 2000, *J.F. Smith* 42 (PERTH); Gravel Reserve, Williams Loc. 20020, corner Narrakine and Contine roads, 25 Nov. 1998, *G. Warren* 24 (PERTH).

Distribution and habitat. Occurs mainly in orange-brown, sandy gravel with ironstone in the South-West Botanical Province, extending from near Geraldton south-east to Albany and Cape Riche, with a disjunct occurrence on the Whicher Range in the south-west corner of the State (Figure 2F).

Phenology. Northern plants flower mainly from August to October, while southern plants tend to flower from September to December.

Conservation status. A relatively common, widespread species.

Affinities. See notes under its closest relative *Petrophile axillaris*, which was previously regarded as a synonym.

Notes. This description is needed since the circumscription of this species has been significantly reduced by the reinstatement of *Petrophile axillaris*. There is one record of *P. serruriae* regenerating after fire from a multi-stemmed base but observations by one of us (MH) do not support this. The clavate and outwardly projecting tepal appendage is always conspicuous in *P. serruriae*. The shape of the club varies from globular to almost cylindrical, but even when it is at its narrowest it is still differentiated from the stalk of the appendage by its darker colour.

The Whicher Range populations are separated by a disjunction of over 80 km from the remainder of the range of the species but morphologically seem very similar.

Petrophile trifurcata Foreman, *Fl. Australia* 16: 479 (1995). *Type:* Wongan Hills, Western Australia [precise locality withheld for conservation reasons], 9 September 1983, *P. Roberts* 172 (*holo:* PERTH 03418308; *iso:* MEL *n.v.*).

Illustration. D.B.Foreman, *Fl. Australia* 16: fig. 92 (1995).

Shrubs 0.3–0.65 m high. *Branchlets* ribbed, grey to red-brown, with a moderately dense indumentum of wavy to coiled hairs 0.1–0.4 mm long. *Leaves* antrorse, not crowded, sometimes simple, usually divided distally into 2 or 3 lobes, straight, 11–16 mm long, 0.6–0.7 mm diam., rigid, terete, glabrous; lobes with an acute or pungent point 0.3–1.1 mm long. *Flower heads* terminating branchlets (those from previous growing seasons located at lower junctions where the branchlets arise), sessile, globose, 8–10 mm diam. *Involucral bracts* erect, narrowly ovate or ovate, 2.5–3.75 mm long, *c.* 1.3 mm wide, long-acuminate, densely ciliate on margins with white hairs 0.5–0.8 mm long; outer surface glabrous; inner surface glabrous towards the base, densely hairy above with hairs similar to the marginal cilia. *Floral bracts* ovate, 3–4 mm long, *c.* 1.5 mm wide, acute, brown; outer surface glabrous towards the apex, with a dense indumentum of curly hairs 0.6–1 mm long in the lower half; inner surface densely hairy at the base, glabrous above. *Tepals* 8–11 mm long, with a moderately dense indumentum of somewhat curled hairs 0.4–1 mm long; claw yellow or pale-yellow, glabrous at base; limb *c.* 3 mm long,

with a glabrous apex *c.* 0.4 mm long. *Anthers c.* 2 mm long. *Pistil* 10–15 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 2–3 mm long; swelling fusiform, glabrous on basal 0.4–0.6 mm, with a moderately dense indumentum of patent hairs 0.1–0.2 mm long over most of its length; unswollen apical part 0.3–0.4 mm long. *Cones* globose, 12–15 mm long, 12–18 mm diam.; outermost scales very broadly elliptic or depressed-elliptic. *Diaspores* broadly obovate in outline, 3–3.5 mm long including an apical beak 0.5–0.6 mm long, 2.5–3.5 mm wide, with an erect coma of white hairs 4–5 mm long and brown or dark-purplish hairs 0.2–0.3 mm long along the margins and base; abaxial surface glabrous or with short, appressed hairs towards margins, fairly flat; adaxial surface glabrous except for short, appressed hairs along the centre or towards margins, flattened on each side of a raised longitudinal rib along the centre. (Figure 1J)

Other specimens examined. WESTERN AUSTRALIA [localities withheld]: 23 Feb. 2000, *P. Armstrong s.n.* (PERTH); 13 Sep. 1932, *W.E. Blackall* 2574 (PERTH); 8 Oct. 1992, *E.A. Griffin* 7166 (PERTH).

Distribution and habitat. Occurs from near Coorow south-east to Wongan Hills in the South-West Botanical Province (Figure 2G). Recorded in sandy soils, with *Actinostrobus arenarius*.

Phenology. Flowers recorded from early September to early October. A fruiting specimen collected in late February still has the remnants of old flowers attached, suggesting the flowering period for this species may continue until January or early February.

Conservation status. DEC Conservation Codes for the Western Australian Flora: Priority Two (Smith 2010). This species is known from four collections over a distance of at least 100 km, with one of the collections from a nature reserve.

Affinities. Closely related to *Petrophile misturata* and superficially similar to the hybrid *P. ericifolia* × *seminuda*, which keys out together with it in couplet 37. See the discussion under the hybrid.

Notes. The most recently collected specimen of *Petrophile trifurcata* differs from the rest in having only a few of its leaves divided. This raises the possibility that some plants of this species may have all of their leaves simple and might therefore not key out in the species key given above. The closely related species *P. misturata* certainly has some specimens with all of their leaves simple.

Description of the presumed hybrid

Petrophile ericifolia* × *seminuda

Shrubs 0.6–1.2 m high. *Branchlets* ribbed, grey to red-brown, with a moderately dense indumentum of wavy to coiled hairs 0.05–1 mm long, glabrescent. *Leaves* antrorse, not crowded, distally divided into 2 or 3, when 3 the central one sometimes further divided into 2 or 3 lobes, straight, 15–25 mm long, 4.5–6 mm diam., rigid, terete, glabrous; lobes 2–5, with a pungent point 0.2–0.5 mm long. *Flower heads* terminating branchlets, sessile, globose, 20–25 mm long, 16–22 mm diam. *Involucral bracts* erect, narrowly ovate to ovate, 2.7–6 mm long, 1.2–2 mm wide, acuminate, appearing darker towards the apex, with densely ciliate margins, the conspicuous white cilia up to 0.4 mm long; outer surface glabrous; inner surface glabrous towards the base, appressed-hairy above. *Floral bracts* ovate,

6.2–7.8 mm long, 2.2–3.6 mm wide, acute, yellowish brown, longitudinally ribbed, viscid; outer surface with a dense indumentum of curly hairs 1.7–2 mm long in the lower half, glabrous towards the apex; inner surface glabrous. *Tepals* 11–13 mm long, moderately densely hairy; claw yellow, with slightly twisted, antrorse hairs 0.2–0.3 mm long, glabrous at base; limb 2.5–3.8 mm long, viscid, with steeply antrorse, slightly twisted hairs 0.2–0.4 mm long, becoming glabrous towards the apex. *Anthers* 1.9–2.2 mm long. *Pistil c.* 13 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 3.1–3.9 mm long; swelling fusiform, glabrous on basal 0.4–0.6 mm, moderately densely hairy above with patent hairs 0.1–0.2 mm long; unswollen apical part 0.3–0.6 mm long. *Cones* depressed-globose, 16–18 mm long, 20–23 mm wide; scales broadly ovate, 4–6 mm wide. *Diaspores* obovate to elliptic in outline, 3.8–4.5 mm long including apical beak and 2.6–3.2 mm long excluding the beak, 1.8–2.5 mm wide, with an erect coma of white hairs 2.5–4.3 mm long and minute dark-red hairs 0.05–0.1 mm long along the margins and base; abaxial surface glabrous, fairly flat; adaxial surface ± glabrous, with a raised longitudinal rib along the centre. (Figure 1K)

Specimens examined. WESTERN AUSTRALIA: [locality withheld] 15 Oct. 2009, *A. Coates* 6035 (PERTH); 15 Oct. 2009, *A. Coates* 6036 (PERTH); 5 Oct. 1998, *A.E. Slarke* 44 (PERTH).

Distribution and habitat. Recorded from west of Lake Grace in the South-West Botanical Province (Figure 2G), on a gentle slope in sandy gravel over clay.

Phenology. Flowers in September and October.

Conservation status. This hybrid is currently known from two plants at a single locality.

Notes. In October 2009, two plants of the hybrid were collected (*A. Coates* 6035, 6036) growing with the presumed parents, *Petrophile ericifolia* R.Br. subsp. *ericifolia* (*A. Coates* 6038) and *P. seminuda* Lindl. (*A. Coates* 6037). Both parent species belong to *Petrophile* R.Br. ex J.Knight sect. *Petrophile* and they have similar flowering periods. There is a large area of overlap in their distributions but they may not often grow together as they may tend to differ in habitat preference, with *P. seminuda* showing a greater tendency to occur in lateritic habitats.

The two recent specimens of the hybrid were recorded as 1 m and 1.2 m high respectively but a specimen collected at the same locality in 1998 was recorded as 0.6 m high. If one or both of the plants sampled in 2009 were previously sampled in 1998 then they have probably doubled in height over that period. The previously collected specimen had longer leaves, up to 21 mm, but this may reflect seasonal or other variation in the environmental conditions when the two samples were taken.

The parent taxa and the hybrids all have young stems that are hairy at first but soon glabrescent, terete leaves, sessile flower heads, involucre bracts that are glabrous on the outer surface, yellow tepals, a glabrous style, and a fusiform pollen presenter with more or less patent hairs. The hybrid resembles each of the parent species in one or two characters but is intermediate in most (Table 1). For example its leaves are intermediate in length between those of the two parent species at the site.

Previously the hybrid was considered on the basis of its unusual morphology to be closely related to *Petrophile trifurcata* and *P. misturata*, all three taxa having curled hairs on the young stems, very similar diaspores and leaves tending to be divided distally into 2–5 branches. Unlike the hybrid,

Table 1. Morphological comparison of the presumed hybrid and its two parent species of *Petrophile* collected near Lake Grace in October 2009. A total of four specimens were sampled, one of each parent and two of the hybrid.

Character	<i>Petrophile ericifolia</i>	<i>Petrophile</i> hybrid	<i>Petrophile seminuda</i>
Indumentum of young stems	± straight or crisped	crisped or curled	tightly curled
Leaf shape	simple	with 2–4 divisions	with 4–9 divisions
Leaf maximum length	c. 10 mm	c. 15 mm	c. 45 mm
Involucral bracts	viscid	viscid	dry
Marginal hairs of involucral bracts	absent	crisped or curled	curled
Tepal length	14–15 mm	10.5–13 mm	8–10 mm
Tepal indumentum	sparsely hairy	sparsely hairy	glabrous
Pollen presenter length	3.8–4.5 mm	3.0–3.9 mm	2.3–3.0 mm

P. misturata and *P. trifurcata* are also known to produce simple leaves, the former species readily distinguished from the hybrid by the more persistent indumentum on its stems and leaves, and the latter differing in having non-viscid flower heads with fewer flowers.

Notes on other taxa

Petrophile crispata R.Br., *Suppl. Prodr. Fl. Nov. Holl.* 6 (1830). *Type*: south-west coast of New Holland [Stirling Range to south coast, Western Australia], 1828–1829, *W. Baxter s.n.* (*holo*: BM 000759017).

Illustrations. No published illustrations have been found. The illustration labelled *Petrophile crispata* in Blackall and Grieve (1988: 162) is clearly not this species as it is keyed and shown as having hairy tepals.

Notes. Although Brown (1830) gave the type locality as ‘King George’s Sound’, this species is not known from the vicinity of the sound and is likely to have been collected either further east along the coast or inland towards or on the Stirling Range, as most of William Baxter’s collections came from

those areas. More recently collected specimens from the Stirling Range to Cape Riche region have short tepals 8–10 mm long, a small pollen presenter 2.5–3.5 mm long, and numerous, short, broad involucre bracts, which are always glabrous on the outside (but densely hairy inside). Some adjacent areas inland to Ongerup, west to Unicup and eastwards along the south coast have similar specimens. These have been identified as *Petrophile crispata* while the remaining PERTH specimens, ones with narrower involucre bracts, are currently identified as a broadly defined *P. seminuda* and the combined group is referred to here as the *P. crispata* complex. In western and most inland areas, the involucre bracts in this complex are often hairy as well as invariably being narrower than those of *P. crispata* s. str. and there may be relatively few of them. Specimens currently housed under *P. seminuda* s. lat. are much more widespread and variable than those housed as *P. crispata*, including having tepals 8–13.5 mm long and pollen presenters 3–5 mm long. For further details of these variants see the notes under *P. seminuda*.

In the region surrounding Hopetoun there are some specimens that appear somewhat intermediate between *Petrophile crispata* and *P. seminuda* s. lat. in their involucre bracts, and the whole complex undoubtedly needs further work to determine how many taxa should be recognised and at what rank. If the two currently accepted taxa should prove to be conspecific, *P. seminuda* will become a synonym of the older name *P. crispata*.

The involucre and/or floral bracts of some specimens of this complex are obviously viscid while those of other specimens appear to be dry. This may reflect seasonal or microclimatic differences at the time of collection and differences in the drying of the specimens or may be due to differences in the genetic make-up of the specimens.

Petrophile incurvata W.Fitzg., *J. Bot.* 50: 22 (1912). *Type*: Watheroo rabbit fence, Western Australia, September 1905, *M. Koch* 1522 (*syn*: PERTH 04381025, PERTH 06539009).

Petrophile semifurcata var. *planifolia* F.Muell., *Fragm.* 10: 47 (1876). *Type*: near Mt Churchman, Western Australia, *J. Young* s.n. (*holo*: MEL n.v.).

Petrophile conifera var. *incurvata* (F.Muell. ex Benth.) C.A.Gardner ms, *Flora of Western Australia* 1(3): 95 (unpubl.); *in sched.* (PERTH)

Illustrations. W.E.Blackall & B.J.Grieve, *How Know W. Austral. Wildflowers* 1: 157 (1988); D.B. Foreman, *Fl. Australia* 16: fig. 96D&E (1995).

Description as given in Foreman (1995: 185).

Affinities. This species is closely related to *Petrophile conifera* and *P. semifurcata*, but is readily distinguished from both species by its flattened leaves. It occurs south of the range of both *P. semifurcata* and *P. conifera* subsp. *conifera* but the northernmost part of its range encloses the very small area where *P. conifera* subsp. *divaricata* occurs.

Notes. Mueller (1876) regarded *Petrophile incurvata* as a variety of the next species, *P. semifurcata*, whereas Gardner (unpub.) considered both of them to be varieties of *P. conifera*. Foreman (1995) treated all three as distinct species; his treatment omitted all unpublished synonyms.

Petrophile semifurcata F.Muell. ex Benth., *Fl. Austral.* 5: 335–336 (1870). *Type*: Murchison River, Western Australia, *A.F. Oldfield s.n.* (*holo*: K *n.v.*, photograph seen (MEL 22742880); *iso*: MEL 1524421, 1534422).

Petrophile conifera var. *semifurcata* (F.Muell. ex Benth.) C.A.Gardner ms, *Flora of Western Australia* 1(3): 95 (unpubl.); *in sched.* (PERTH)

Petrophile sp. Zuytdorp (P. Roberts 761), Western Australian Herbarium, in *FloraBase*, <http://florabase.dec.wa.gov.au> [accessed April 2009].

Illustrations. W.E.Blackall & B.J.Grieve, *How Know W. Austral. Wildflowers* 1: 161 (1988); D.B. Foreman, *Fl. Australia* 16: fig. 96J–M (1995).

Description as given in Foreman (1995: 185) except that the leaves can also be simple.

Affinities. This species is closely related to *Petrophile conifera*, differing in its usually more erect leaves, which are often simple or have few divisions, its pedunculate flower heads and its more appressed hairs on the tepals. Its pollen presenter also tends to be longer and more cylindrical. The two species become more similar in leaf morphology, and therefore harder to distinguish when not in flower, in the southern parts of their ranges.

Notes. Based on the long, more or less cylindrical pollen presenter found in *Petrophile semifurcata*, Bentham (1870) erected a new section just for this species. He correctly noted that the species could have entire leaves, but Foreman (1995) described it as always having divided leaves and only included it in the part of the key for species with divided leaves. Consequently, simple-leaved specimens keyed out to *P. stricta* R.Br. and two of these that lacked mature flowers were given the informal name *Petrophile* sp. Zuytdorp (P. Roberts 761), which is here reduced to a synonym of *P. semifurcata*. Specimens with all of their leaves simple, or with a mixture of simple and divided leaves, are fairly common in the northern part of the geographic range but all southern specimens have divided leaves.

An earlier unpublished synonym, that of Gardner's listed above, was not listed in Foreman's (1995) treatment of the genus.

Petrophile seminuda Lindl., *Sketch Veg. Swan R.* 34 (1840). *Type*: Swan River District [Western Australia], 1837, *J. Drummond s.n.* (*lecto*: CGE, *fide* D.B. Foreman, *Fl. Australia* 16: 477 (1995) *n.v.*, photograph seen). *Other material*: Swan River District [Western Australia, 1839], *D. Toward* 42 (*lectopara*: CGE *n.v.*, photograph seen).

Petrophile seminuda var. *indivisa* Benth., *Fl. Austral.* 5: 333 (1870). *Type*: Western Australia, *J. Drummond s.n.* (*lecto*: K specimen on right side of sheet 000035126, here selected, photograph MEL 2147396; *lectopara*: K specimen on left side of sheet 000035126, photograph MEL 2147396).

Isopogon pedunculatus R.Br., *Suppl. Prodr. Fl. Nov. Holl.* 7–8 (1830). *Type*: Swan River, [Western Australia], 1827, *C. Fraser* 8 (*holo*: BM 000759012).

Illustration. W.E.Blackall & B.J.Grieve, *How Know W. Austral. Wildflowers* 1: 160 (1988).

Conservation status. A relatively common, widespread species.

Lectotypification. The K type sheet of *Petrophile seminuda* var. *indivisa* has two pieces mounted, the larger one on the right with all leaves entire being selected here as the lectotype. The specimen on the left appears to have been collected from a separate plant, as it has somewhat broader leaves, with some of the leaves divided, and a narrower fruiting cone; it is therefore treated as a lectoparatype. It is likely that this variant was collected from near Perth and coexists with specimens that have divided leaves as it resembles material collected from the Lower Canning River by A. Morrison in 26 Oct. 1899, which has two pieces with divided leaves (α , β) and one with undivided leaves (γ). The latter specimen is mounted together with several specimens with divided leaves and appears to be an insignificant variant coexisting with the normal variant.

Affinities and synonyms. See notes under its closest relative *Petrophile crispata*. The oldest available name, *Isopogon pedunculatus*, cannot be used for *P. seminuda* by making a recombination because the epithet *pedunculata* has already been used for a *Petrophile* species from eastern Australia. In flower, *P. seminuda* has sessile flower heads in the sense that there is no peduncle below the base of the lowest involucre bracts, although in some of the fruiting specimens (e.g. D.B. Foreman 1105) the involucre bracts have been shed, revealing a very short, bare stalk that could be mistaken for a peduncle. The type material of *I. pedunculatus* is in fruit and resembles the Foreman specimen, including having a short, peduncle-like region, hence the choice of its epithet.

Variants. Many variants are known, occurring widely in the South-West Botanical Province and extending into the South-western Interzone. The typical variant occurs on the eastern side of the Swan Coastal Plain and on the Darling Range near Perth, mainly from Chittering south to Jarrahdale, and has long leaves with few to many, slender ultimate divisions, or rarely the leaves are simple as discussed above. Its involucre bracts are glabrous on the outer surface, subtending large, dense flower heads, and the pollen presenter has short to long hairs.

The variant occurring furthest north, which always has multi-divided leaves, tends to have even larger flower heads and longer hairs on the pollen presenter than the typical variant. In the Perth region, there is a second main variant, i.e. in addition to the typical variant noted above, associated with swamps on the coastal plain and extending north to Lesueur National Park. The western swamps variant has its leaves commonly just divided into three but sometimes with most leaves divided further, its few-flowered heads subtended by involucre bracts that are glabrous on the outer surface, and its pollen presenter either glabrous or with very short hairs. Specimens with the involucre bracts hairy outside are common in the Eneabba area and extend south-east to east of Hyden, but are absent from the Perth region, the far north and regions close to the south coast. Towards the south coast, specimens of *Petrophile seminuda* s. lat. seem to intergrade with those of *P. crispata* and so identification of the two taxa is problematic.

The furthest inland specimens are those from between Southern Cross and Kalgoorlie. All of these specimens have fruiting cones but lack flower heads so their involucre bracts and flowers have not been examined. Flowering material needs to be obtained for this region to determine how these specimens compare with others in the *Petrophile crispata* complex. Three of the variants which differ from the description given by Foreman (1995: 160) for *P. seminuda* are briefly treated below.

a. northern variant

Selected specimens examined. WESTERN AUSTRALIA: Kalbarri National Park, 38 km by main road from waterfront and 0.5 km N of road, 10 Oct. 1996, *M.G. Corrick* 11386 & *B.A. Fuhrer* (PERTH); Bullock Rd, 6 km NE of homestead, Riverside Ajana property (R. & D. Porter), E of Galena, 30 Nov. 2000, *D.M. Porter* 31 (PERTH).

Distribution and habitat. Occurs in the north of the South-West Botanical Province, in yellow or white sand over gravel, extending from near Ross Graham Lookout in Kalbarri National Park east to beyond Galena. Possibly the same variant occurs east of Geraldton, from near Ambania south to Indarra Springs Reserve, where it is recorded in sand over limestone, and also in some areas further south.

Notes. The distribution map for *Petrophile seminuda* currently on *FloraBase* (Western Australian Herbarium 1998–) has a disjunction in the north between the specimens from the Kalbarri area and the next closest specimens from east of Geraldton, but the latter ones seem to have very similar morphology. This northern variant probably extends southwards, overlapping in range, and perhaps intergrading, with the variant that commonly has the outside of the involucre bracts hairy. It differs from Foreman's (1995: 160) description in having numerous, relatively long hairs on the pollen presenter.

b. variant with hairy bracts

Selected specimens examined. WESTERN AUSTRALIA: Corrigin Reserve, 5 June 1998, *E. Bennett* CG 4.3 (PERTH); 11.2 km N along Vermin Proof Fence from junction of Norseman–Hyden track, 29 Oct. 2002, *R. Davis* 10502 (PERTH); 3 km N of Mungedar Rd turnoff on Badgingarra Rd, 31 Aug. 1984, *D.B. Foreman* 414 (AD, CANB, K, NSW, all *n.v.*, PERTH).

Distribution and habitat. Occurs in yellow or white sand over gravel, from the Eneabba area south-east to beyond Hyden. Possibly the same variant occurs from near Ambania south to Indarra Springs Reserve, where it is recorded in sand over limestone.

Foreman's (1995: 160) description of *Petrophile seminuda* describes the involucre bracts as being glabrous outside, as they are for the majority of specimens. However, many specimens from the Eneabba area south-east to near Hyden have their involucre bracts sparsely to densely hairy outside. This character on its own cannot be used to define a subspecies or other category as it coexists with specimens that have the normal glabrous outer surface on the involucre bracts. Recent collections from Corrigin, for example, have involucre bracts varying from glabrous (e.g. *R. Campbell* 395) to densely hairy outside (*E. Bennett* CG 4.3).

c. western swamps variant

Selected specimens examined. WESTERN AUSTRALIA: Cockatoo Rd, 3.5 km NE of Wabling Hill in Reserve 24436, 28 Oct. 1993, *N. Gibson* & *M.N. Lyons* 1407 (PERTH); Carrabungup Nature Reserve, part of Austin Bay Nature Reserve, SW of Pinjarra, 9 Oct. 1995, *G.J. Keighery* 13973 (PERTH); 10 km E of Nambung Homestead along Wongonderrah Rd, 30 Oct. 1999, *R. Orifici* LE 34.22 (PERTH).

Distribution and habitat. Occurs in near-coastal areas from Lesueur National Park south to Austin Bay Nature Reserve, mostly associated with swamps.

Notes. The pollen presenter normally has very short hairs, but sometimes this indumentum is very sparse or entirely absent as in all three specimens cited above. The complete lack of hairs on the pollen presenter of some specimens deviates from Foreman's (1995: 160) description. The correlation between the distribution and habitat preferences of this variant, its leaf characters as outlined earlier and its pollen presenter characters suggest that this might represent a distinct subspecies or species within the *Petrophile crispata* complex.

Petrophile squamata R.Br., *Trans. Linn. Soc. London* 10: 70 (1810). *Type:* towards Cape How [Lake Powell, Western Australia], December 1810, *R. Brown s.n.* (*lecto:* BM *n.v.*, *fide* D.B. Foreman, *Fl. Australia* 16: 478 (1995)).

Petrophile propinqua R.Br., *Suppl. Prodr. Fl. Holl.* 7 (1830). – *Petrophile squamata* var. *propinqua* (R.Br.) C.A. Gardner ms. *Type:* Swan River Colony [Western Australia, 1827], *C. Fraser* 4 (*lecto:* BM *n.v.*, *fide* D.B. Foreman, *Fl. Australia* 16: 476 (1995); *isolecto:* BM *n.v.*).

Petrophile colorata Meisn. in J.G.C. Lehmann, *Pl. Preiss.* 2, 246 (1848). – *Petrophile squamata* var. *colorata* (Meisn.) C.A. Gardner ms. *Type:* Swan River Colony [Western Australia, 1827], *J. Drummond* coll. 2, no. 296 (*iso:* MEL *n.v.*; PERTH 01593404 (photograph), PERTH 04244893).

Other synonyms as listed by Foreman (1995: 191).

Illustrations. W.E. Blackall & B.J. Grieve, *How Know W. Austral. Wildflowers* 1: 155, 156 (1988); D.B. Foreman, *Fl. Australia* 16: fig. 97B (1995).

Notes. Many names have been published for this difficult species complex, all listed by Foreman (1995) and most not repeated above. However, two manuscript names in Gardner (unpub.: 86) are given above as they were not included in Foreman's treatment, and one of Gardner's illustrations, reproduced here as Figure 3, evidently includes four parts (J–M) drawn from the type of *Petrophile colorata* as that was the only specimen cited for this taxon.

Currently three subspecies are recognised informally. The typical subspecies, *Petrophile squamata* R.Br. subsp. *squamata*, extends from the south-west corner of the State east to Mt Manypeaks (but with a significant disjunction in its known range between the Scott River area and the Walpole area) and extends north at least to Wagerup. *Petrophile squamata* subsp. *Ravensthorpe* (E.M. Bennett 2597), which was previously known as *P. squamata* subsp. *integra* Keighery ms, is mainly found in the Fitzgerald River region but has outliers in the west near Mt Success in the Stirling Range and in the east near Stokes Inlet. These two subspecies are so distinct that they could easily be recognised as distinct species if it were not for the existence of the third, more widespread subspecies, *P. squamata* subsp. *northern* (J. Monks 40).

This northern taxon extends from Armadale east to Cape Arid and was once regarded as a separate species, *Petrophile propinqua*, which is included above among the list of synonyms. However, reinstatement of *P. propinqua* does not appear to be supported as *P. squamata* subsp. *northern* (J. Monks 40) seems to intergrade too completely with subsp. *squamata* in the region from Darling Range to north of Stirling Range. The northern subspecies does not reach the south-coastal region where subsp. *squamata* is most common but overlaps with virtually the entire range of the Ravensthorpe subspecies. It differs from the typical subspecies in having usually narrower and more hairy bracts. There are also slight differences in the style, with *P. squamata* subsp. *squamata* having a glabrous pollen presenter with a long, slender summit whereas the northern subspecies usually has minute hairs on the pollen presenter and a broader, more suddenly contracting, swollen base.

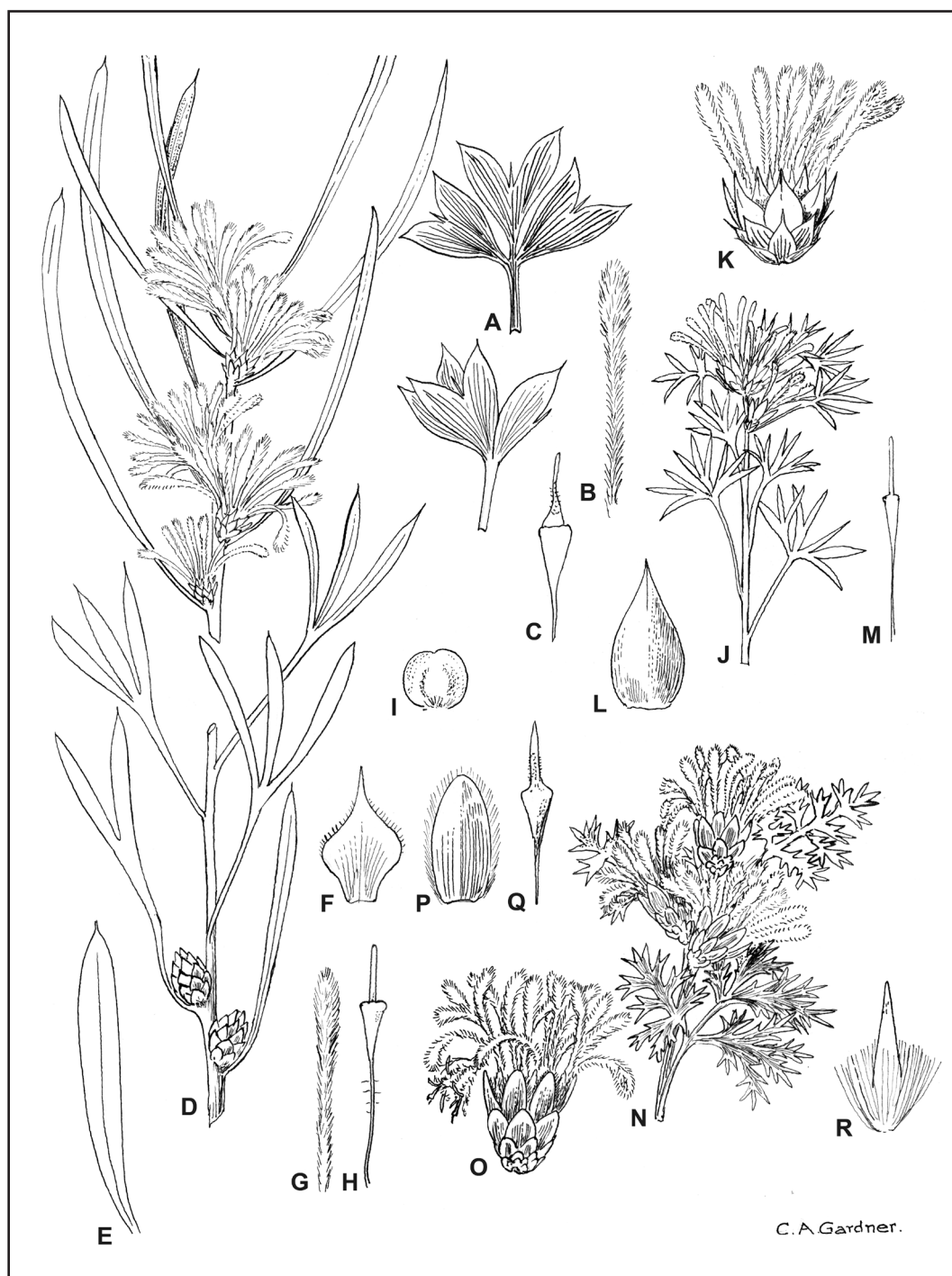


Figure 3. *Petrophile* illustration drawn by C.A. Gardner (Plate XIII [as XIX] of unpublished bound copy of *Flora of Western Australia* vol. 1, part 3). A–C. *P. biloba*. A – leaves; B – flower bud; C – pollen presenter. D–I. *P. heterophylla*. D – habit; E – leaf; F – floral bract; G – flower bud; H – upper half of style; I – diaspore. J–M. *P. squamata* var. *colorata*. J – habit; K – flower head; L – bract; M – pollen presenter. N–R. *P. striata*. N – habit; O – flower head; P – floral bract; Q – pollen presenter; R – diaspore.

Petrophile squamata subsp. Ravensthorpe (E.M. Bennett 2597) is the most easily recognised subspecies because of its large, entire leaves, which are 4–10 mm wide, but one specimen has most of its leaves divided. This subspecies is identical with the northern subspecies in its involucre bracts and pollen presenters and some specimens of the northern taxon from the region of overlap have their lower leaves entire, although in this case only 2.5–4 mm wide. Still, there is a possibility that these two subspecies do intergrade completely in the Ravensthorpe area.

There might also be differences in habit and habitat preferences of the variants in the *Petrophile squamata* complex, as both single-stemmed and resprouter specimens have been recorded, and they have been recorded in rocky and swampy habitats. This complex has been under study by Greg Keighery.

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