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Rising from the ashes - *Hydrocotyle phoenix* (Araliaceae), a new annual species from south-western Australia

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Abstract

A recently discovered fire ephemeral *Hydrocotyle phoenix* A.J.Perkins sp. nov. from south-west Western Australia is described and compared to other Australian species of *Hydrocotyle*. Photographic images of the new species are provided, along with a list of diagnostic features to aid in identification. The annual fire ephemeral life history of this species is novel for the genus.

Introduction

Hydrocotyle L. (Araliaceae) is a diverse genus of mesophyllous herbs belonging to the Aralia or Ivy family, with approximately 56 species occurring in Australia (Henwood 2014; CHAH 2016). Most species in the genus exist as prostrate-stemmed perennials growing preferentially in mesic or damp habitats such as rainforests, swamps, seepages, coastal sand dunes, through to alpine creeks (Bean and Henwood 2003; CHAH 2016). Within Australia, the majority of perennial species are found in the higher rainfall regions along the east coast and tablelands (of Queensland, New South Wales and Victoria), south into Tasmania and one species (*H. hirta* A.Rich.) extending westward into the moist eucalypt forests of Western Australia (CHAH 2016).

Australia also has a significant component of *Hydrocotyle* species which exhibit annual life history (Western Australian Herbarium 1998–; CHAH 2016). The strategy of these annuals is centred on long term persistence of the seeds in the soil profile and a rapid response to favourable environmental cues for growth and subsequent reproductive output. More than half of the Australian *Hydrocotyle* species are winter annuals (CHAH 2016), often growing in habitats subject to seasonal winter rainfall with intervening periods of summer droughts and occasional wildfires (Miller and Dixon 2014). Species such as *H. callicarpa* Bunge, *H. alata* A.Rich. and *H. diantha* DC. are widely distributed in a variety of habitats including swamps, wet heath, moss swards on granitic rocks and margins of inland lakes (Western Australian Herbarium 1998–; Wheeler *et al.* 2002; CHAH 2016). Other species are quite specific and restricted to particular habitats; such as *H. lemnoides* Benth. (an aquatic species in freshwater swamps), *H. muriculata* Turcz. (grows on the margins of inland saltwater lakes) and *H. hispidula* Bunge (grows in coastal areas on calcareous sands or limestone) (Western Australian Herbarium 1998–; Wheeler *et al.* 2002). The cues for these taxa to germinate, grow and flower are solely dependent on suitable amounts of winter rainfall and independent of disturbances such as wildfires.

Annual fire ephemerals on the other hand, are predominantly dependent on fire as a cue to stimulate germination, leading to growth and reproductive output. Although no annual fire ephemerals are known in *Hydrocotyle*, they are well represented in the sister genus *Trachymene* Rudge, such as *T. anisocarpa* (Turcz.)

B.L.Burtt, *T. thysanocarpa* J.M.Hart, *T. gilleniae* (Tate) B.L.Burtt, *T. grandis* (Turcz.) Rye and *T. pyrophila* Rye (Rye 1999; Hart and Henwood 2006; Henwood *et al.* 2010). Typically, these annual fire ephemerals often appear abundant or 'weedy' in the season following the wildfire event, but rare (or absent) in the following years (Pate *et al.* 1985; Rye 1999; Hart and Henwood 2006; Miller and Dixon 2014).

In the summer of 2015, a major wildfire event occurred in the Northcliffe area (south-west Western Australia), providing opportunities to observe fire ephemeral plants flowering the following spring. During a post-fire visit to the area in early November 2015, an opportunistic voucher collection of an annual *Hydrocotyle* was made by Rob Davis (Western Australian Herbarium - PERTH). Subsequent morphological examination at PERTH and comparison to *Hydrocotyle* voucher specimens revealed it to be a new species. Herbarium records also indicated that *Hydrocotyle* specimens had been relatively well collected in the area (within 10 km) since 1965 by more than 30 voucher specimens, representing six species (Western Australian Herbarium 1998–). Later in November 2015, a follow-up trip was made to collect fruiting voucher specimens, record some of the physical attributes of the plants, as well as the general distribution and abundance of plants in the area. Based on these observations and the distinct morphology of the vouchered specimens, *H. phoenix* A.J.Perkins (described below) shows traits of being the first annual fire ephemeral in the genus *Hydrocotyle*.

Methods

The description of *Hydrocotyle phoenix* is based on the examination of fresh material, photographic images taken of plants *in situ* and six voucher specimens, including the type. Morphological comparisons were made with voucher and type material of other Australian species of *Hydrocotyle* held at the Western Australian Herbarium (PERTH). More detailed examination and comparisons were made between the two winter annual species, *H. hispidula* and *H. blepharocarpa* F.Muell., and one perennial species *H. geraniifolia* F.Muell. A distribution map for *H. phoenix* was produced from voucher specimen data held at PERTH using QGIS Version 2.8.1, and it includes the *Interim Biogeographical Regionalisation for Australia (IBRA) Version 7* boundaries (Department of the Environment 2013).

Taxonomy

Hydrocotyle phoenix A.J.Perkins **sp. nov**.

Diagnosis: *Hydrocotyle phoenix* A.J.Perkins is distinguishable from all other species of *Hydrocotyle* by a combination of characters which include: fire ephemeral annual herb (10–100 cm wide) consisting of a basal rosette of 6–20(–40) fleshy pedate leaves and umbellate inflorescences borne on branching decumbent stems. Distinct glaucescent surfaces on leaf laminas (abaxial), petioles and stems. Leaves with carnose (opaque) stipules with 1–9 distinct marginal cilia. Hispid, erect white hairs (often with crimson tips) on leaf laminas, petioles and stems. Umbels of 10–20 flowers, subtended by 6–10 linear involucel bracts (0.6–1.0 mm long) which are deflexed with acropetally hooked apices and are distinctly white in colour with crimson tips. All parts of flowers (including pedicels, ovaries, stamens and petals) distinctly white in colouration at anthesis. Developing mericarps light green with crimson colouration of the styles. Mature mericarps deeply chordate, testiculate and hispidulous (with fine erect hairs), turning light creamy brown before readily disarticulating due to a lack of a carpophore; commissure 25–40% the length of mericarps.

Type: Six kilometres north of Windy Harbour, D'Entrecasteaux National Park, Western Australia [precise locality withheld for conservation reasons], 20 November 2015, *R. Davis 12589 & A.J. Perkins* (*holotype*: PERTH 08703019; *iso*: CANB, MEL, NSW).

Plants annual, fire ephemeral; 4–15 cm high and 10–100 cm wide, consisting of a basal rosette of 6–20(–40) leaves and branched stems bearing leaves and umbellate inflorescences. Stems decumbent (occasionally ascending), terete, robust, glaucescent and hispid. Hairs erect, white with pinkish to crimson tips. Stipules 0.9–2.2 mm long, 0.2–0.7(–1.5) mm wide, lanceolate to linear lanceolate, fleshy (occasionally foliose in stem-leaves), opaque, light green to white, often glaucescent, ciliate. Marginal cilia fleshy, prominent, white and often with pinkish to crimson tips, 1–3(–4) each side of the stipule and one terminal. Petioles (2–)10–70(–100) mm long, glaucescent, sparsely covered with erect white hairs (often with pinkish to crimson tips). Leaves simple, dorsiventral, predominantly trilobed to pedately lobed in basal rosette and stem-leaves, trilobed to lanceolate in stem-leaves subtending terminal inflorescence umbels. Leaf laminas sparsely covered with erect white hairs on both sides, adaxial surface light green, abaxial surface glaucescent, 5–20(–25) mm long, (3–)7–26(–40) mm wide. Leaf margins toothed, obtuse to acute, teeth often crimson in colouration. Median leaf lobes ovate to obovate, 5–20(–25) mm long, 3–13 mm wide, apex comprising 3 lobules in pedate leaves,

the 2 lateral lobules shorter than the median lobule, each lobule with 1–11 teeth. Lateral leaf lobes 3.5–13(–20) mm long, 2–12(–15) mm wide, incised into two asymmetrical lobules in pedate leaves, each lobule with 3–16 marginal teeth, sinuses 40–60% of lateral leaflet length. Inflorescence a simple umbel, umbels 10–20 flowered; flowers all hermaphrodite, protandrous, 4–6 mm wide. Peduncles much longer than subtending stem-leaves at anthesis, 5–35 mm long, glaucescent, sparsely covered with erect white hairs. Involucral bracts 0.6–1.0 mm long, linear, 6–10 per umbel, deflexed with acropetally hooked apices, white with pinkish to crimson tips. Flowers pedicellate; flowering pedicels 1–2.2 mm long, white. Ovaries white at anthesis. Calyx absent. Corolla predominantly white with pale pink to crimson colouration on the dorsal surface (towards the apices); petals 5, ovate, 0.6–0.7 mm long, 0.3–0.4 mm wide. Filaments white, 1 mm long; anthers white to light cream, 0.2 mm long. Schizocarps testiculate, prominently swollen along lateral ribs, changing colour from white to light green during development; bases deeply cordate; fruiting pedicels 1.5–2.5 mm long, light green; carpophore absent. Mericarps 0.8–0.9 mm wide, 0.9–1.1 mm long; dorsal and lateral ribs prominent, glabrous; median ribs not raised; surface between dorsal and (raised) lateral ribs convex to slightly concave, hispidulous (evenly covered in fine erect hairs), surface between lateral ribs and commissure concave, hispidulous near lateral ribs gradually becoming glabrous towards commissure; commissure 25–40% the length of mericarps. Fruiting styles 0.6 mm long, fully reflexed. Mature mericarps turning cream to light brown prior to disarticulation. (**Figs 1, 2**).

Other specimens examined: WESTERN AUSTRALIA: Warren: All five specimens north of Windy Harbour, D'Entrecasteaux National Park [precise localities withheld for conservation reasons], 19 Dec. 2015, *R. Davis 12599* (PERTH 08680914); 11 Nov. 2015, *R. Davis 12572 & A. Brown* (PERTH 08699097); 20 Nov. 2015, *R. Davis 12595 & A.J. Perkins* (PERTH 08703094); 22 Nov. 2015, *A.J. Perkins WA-110* (PERTH 08726485); 22 Nov. 2015, *A.J. Perkins WA-113* (PERTH 08726442). (Fig. 3).

Etymology: The epithet phoenix is used as a noun in apposition. It refers to the serendipitous discovery of this new species within regenerating (post-wildfire) Karri forest (Fig. 1A), near Windy Harbour. The common name of Fire Pennywort is here suggested.

Distribution and habitat: Known from one area of burnt Karri forest (and adjoining Jarrah forest) north of Windy Harbour in D'Entrecasteaux National Park (Fig. 3). Plants of *H. phoenix* were growing on dark brown loam soil over granite and were locally abundant in the burnt Karri forest (Fig. 1A) becoming less common to infrequent in the adjoining jarrah forest. Within the Karri forest, plants were growing with *Macrozamia riedlei* (Gaudich.) C.A.Gardner, *Dodonaea* sp., *Chorilaena quercifolia* Endl., *Acacia* spp., *Dampiera hederacea* R.Br., *Daucus glochidiatus* (Labill.) Fisch., C.A.Mey. & Ave-Lall., *Sida hookeriana* Miq., *Orthrosanthus* sp., *Prasophyllum* sp., *H. scutellifera* Benth., *H. callicarpa* and *Trachymene grandis*.

Phenology: Flowering from November to December. Fruiting from November to January.

Conservation status: Recommended for listing as Priority Two under Department of Parks and Wildlife Conservation Codes for Western Australian Flora (Jones 2015). *Hydrocotyle phoenix* is geographically restricted, currently only known from one area of burnt Karri forest (and adjoining Jarrah forest interzone) near Windy Harbour in D'Entrecasteaux National Park. Six common species of *Hydrocotyle* have been regularly collected and observed in the area over the past 50 years but none of *H. phoenix*, indicating the localised nature of this species distribution and the requirement for wildfires to break seed dormancy. This is the first recorded species of annual *Hydrocotyle* with an apparent fire ephemeral life history indicating the importance of further post-wildfire surveys in similar habitats.

Affinities: *Hydrocotyle phoenix* is morphologically most similar to *H. hispidula* due to a number of shared vegetative and reproductive traits. Both species are annuals which possess a basal rosette of hispid pedate leaves, umbels borne on leafy branching stems (which are decumbent to ascending), flowers with white petals, mature mericarps with raised lateral ribs in respect to the dorsal and median ribs and surface ornamentation on both sides of the lateral mericarp ribs. *Hydrocotyle phoenix* differs from *H. hispidula* by having discolourous leaf laminas due to glaucescent abaxial surfaces (concolorous in *H. hispidula*); glaucescent petioles with erect hairs scattered along their entire length (mostly glabrous with wiry hairs often restricted to an area just beneath the junction with the leaf laminas appearing like a 'skirt' in *H. hispidula*); glaucescent, fleshy stipules with relatively few (1–9), well-defined cilia along the margins (stipules papery and translucent, with wiry laciniate margins in *H. hispidula*); stems glaucescent and hispid (stems light green and predominately glabrous in *H. hispidula*); involucral bracts distinct, linear, deflexed with acropetally hooked apices, white in colour with crimson tips (umbels subtended by a ring wiry hairs in *H. hispidula*); ovaries and pedicels white in colour at anthesis (light green in *H. hispidula*); carpophores absent (persistent in *H. hispidula*); and mature mericarps deeply cordate with hispidulous surfaces of fine erect hairs (mature mericarps elliptic in outline with tuberculate surfaces in *H. hispidula*). Both species are endemic to the southwest of Western Australia but do not appear to be sympatric as *H. hispidula* grows on sandy calcareous soils (mostly in coastal areas), whereas *H. phoenix* is restricted to granite derived loam soils.

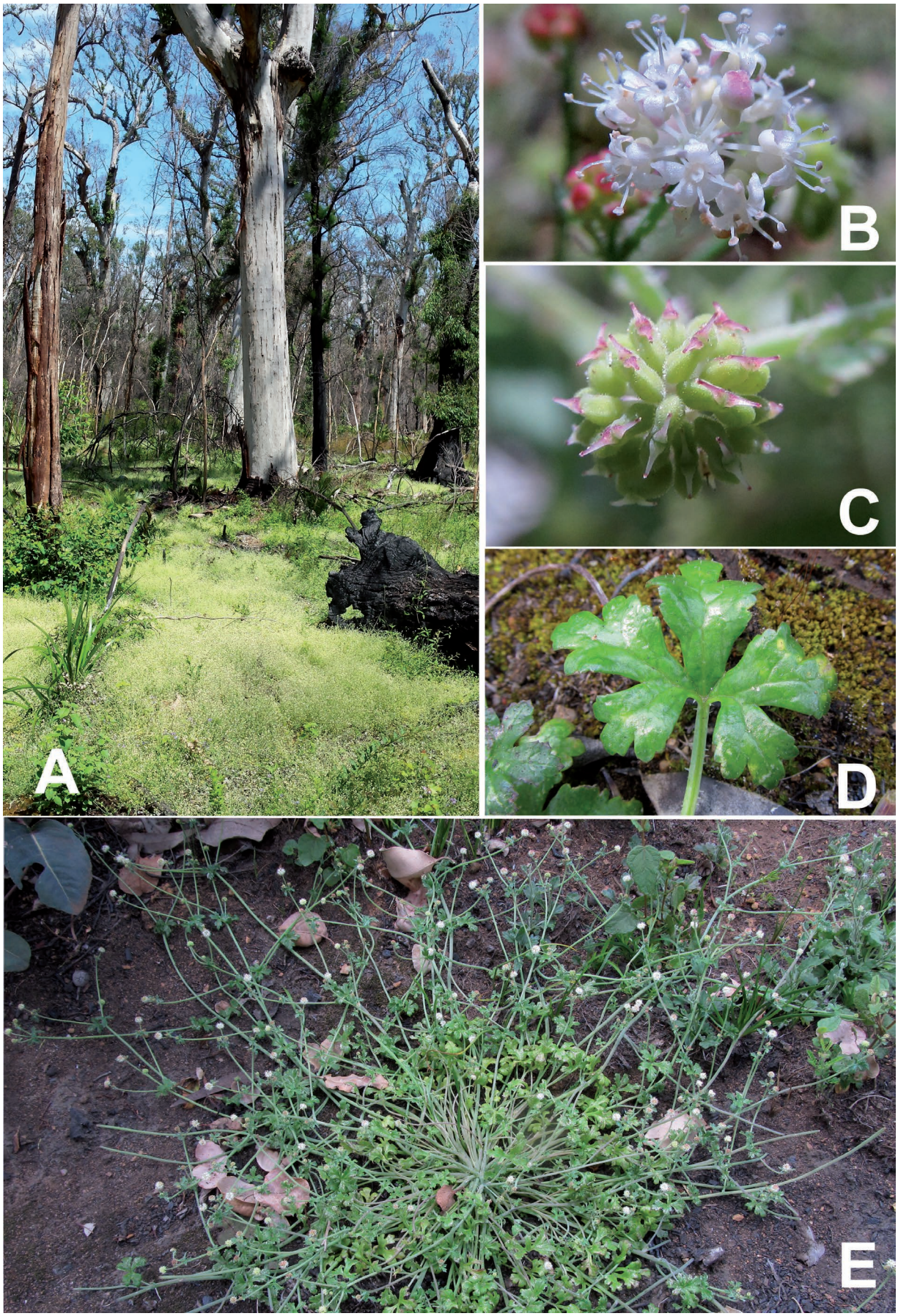

Fig. 1. *Hydrocotyle phoenix*: **A.** plants as the dominant herb in burnt Karri forest; **B.** flowering umbel at anthesis showing predominantly white coloured petals, stamens, ovaries and pedicels; **C.** fruiting umbel showing finely hispid mericarps with crimson colouration on the styles; **D.** pedate leaf from the basal rosette; **E.** habit of flowering plant *in situ*.

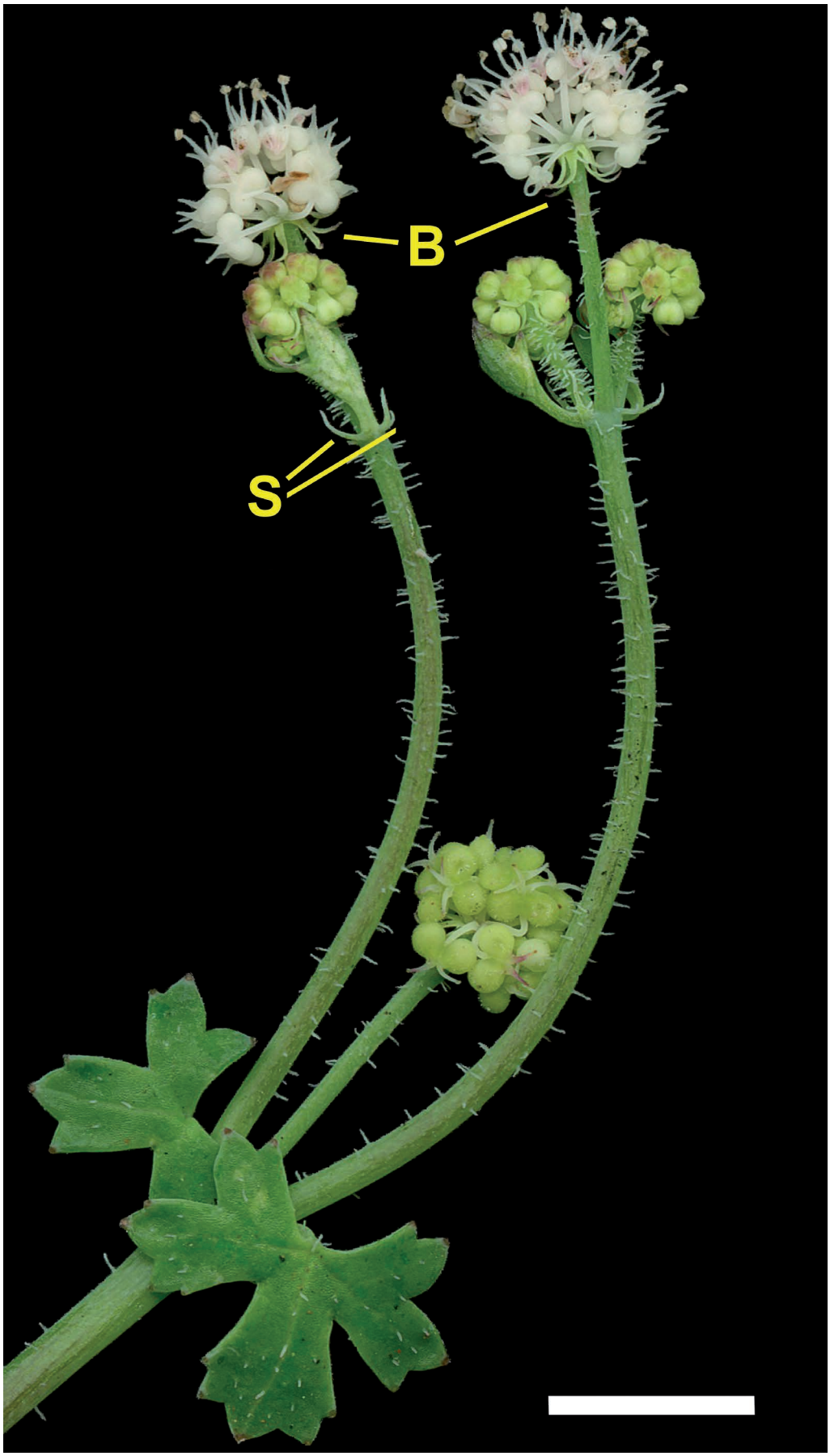

Fig. 2. Flowering stem of *Hydrocotyle phoenix* showing flowering umbels subtended by linear involucral bracts; **B.** young stem-leaves with carnose stipules (S). Image from *A.J. Perkins WA-110*. Scale = 5 mm.

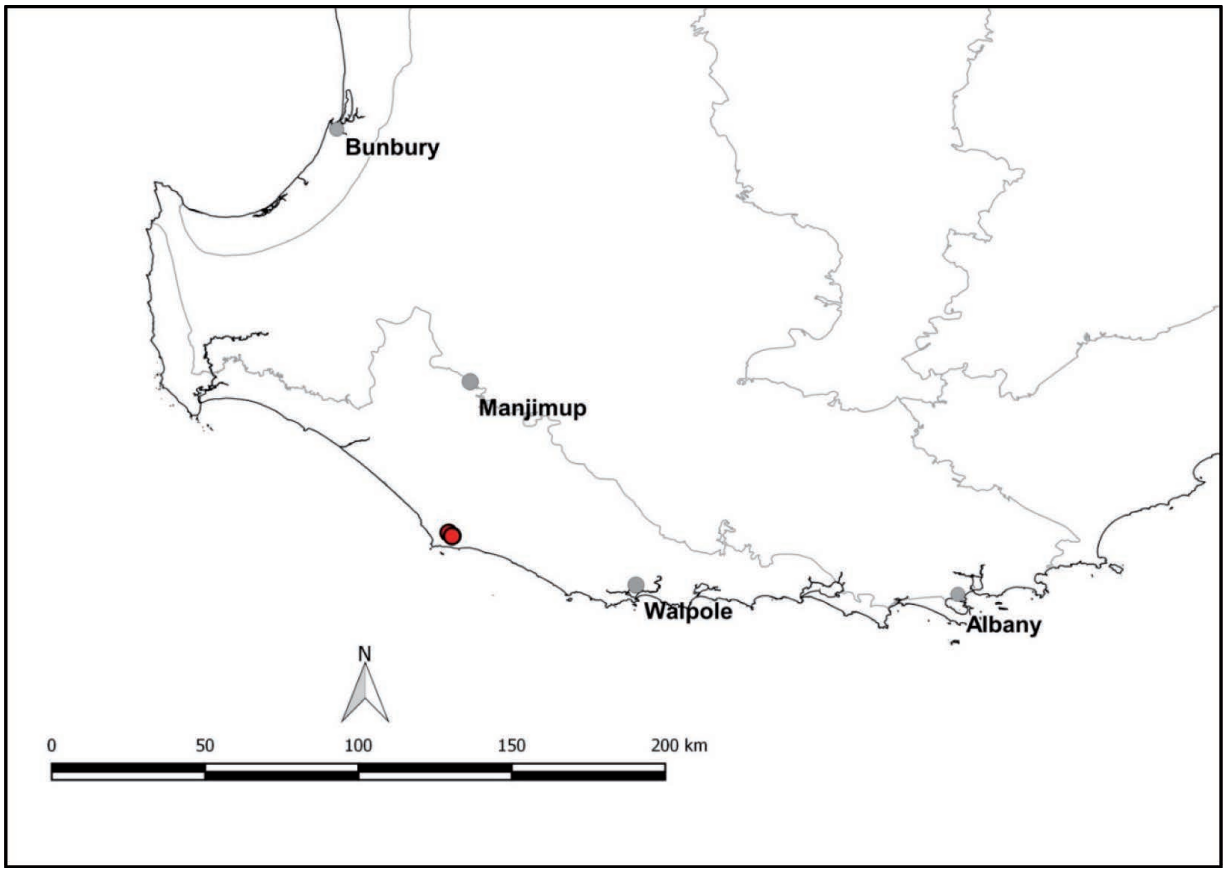

Fig. 3. Distribution of *Hydrocotyle phoenix* in the Warren bioregion of south-west Western Australia, indicated by the red dots; *Interim Biogeographic Regionalisation for Australia version 7* bioregions are shown in grey.

In southwest Western Australia, six species of *Hydrocotyle* are known to occur within the vicinity of the type locality of *H. phoenix* (Western Australian Herbarium 1998–) and of those, *H. blepharocarpa* is the only other species that possesses hairs on the mericarp surface. The hairs on *H. blepharocarpa* fruit are only found between the lateral and dorsal ribs, mostly in close proximity of the dorsal mericarp ribs, giving them a bristly appearance along the outer margin of the mericarp. The surface between the lateral ribs and the commissure in *H. blepharocarpa* is distinctly concave with a glabrous surface. Both *H. blepharocarpa* and *H. phoenix* lack a carpophore, but the mericarps are more ellipsoid in shape and the commissure proportionally longer in *H. blepharocarpa* (60–80% the length of the mericarps) compared to *H. phoenix* (commissure 25–40% the length of mericarps). Aside from these two reproductive synapomorphies, *H. blepharocarpa* is a low spreading herb (lacking a basal rosette of leaves) with membranous laciniate stipules; glabrous leaves, stems and peduncles; and a 'skirt' of wiry hairs subtending the umbellate inflorescences.

One of the distinctive floral features of *H. phoenix* is the white colouration of the flowers (including pedicels, ovaries, stamens and petals) when they first open. The flowers then continue to remain white in colour until the early stages of fruit development, in which they start turning light green (Figs 1B, C and 2). This specific pattern or change of floral colouration (from white to green) has been observed in the eastern Australian perennial species *H. geraniifolia*. This species inhabits moist forests in Victoria, New South Wales and Queensland, and it possesses ornamented fruit similar to a number of endemic annual species, including *H. phoenix*. The ornamentation on the mature mericarps of *H. geraniifolia* similarly contains erect hairs distributed on both sides of the prominent lateral ribs but differs by the relatively flat profile of the mericarps and the pronounced winged margin along the dorsal ribs. Other shared morphological character traits between these two species include; the presence of involucral bracts subtending the umbels, erect hairs on leaf lamina surfaces and glaucescent stems, petioles and peduncles. *Hydrocotyle geraniifolia* differs from *H. phoenix* in having compound leaves (predominantly palmatisect); glabrous stems, petioles and peduncles; membranous stipules; and leaf opposed umbellate inflorescences.

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