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Australian cudweed key: An illustrated key to cudweed-like Gnaphalieae and related cushion plants of Australia, with notes on selected taxa

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Introduction

Australia is one of the diversity hotspots of Asteraceae tribe Gnaphalieae, and with approximately 510 of the 1,105 native species of Asteraceae, the Gnaphalieae are the most diverse tribe on the continent (A. Schmidt-Lebuhn, 2022). The diversity of Gnaphalieae in Australia includes button daisies with inconspicuous involucral bracts and everlasting paper daisies with colourful, radiating involucral bracts, and ranges in size from shrubs and treelets to eight metres tall to tiny ephemeral herbs. Plants occur in diverse habitats including around salt lakes in the arid interior, coastal areas, and alpine areas. Within this tribe are also various species commonly called cudweeds.

'Cudweed' is a term describing a morphological appearance, generally woolly, small, herbaceous Gnaphalieae with somewhat unattractive, small, brownish capitula with neither conspicuously colourful,

Abstract

Cudweeds are generally herbaceous, woolly-haired members of Asteraceae tribe Gnaphalieae with small, brownish capitula. They constitute a polyphyletic group more or less congruent with an outdated, broad circumscription of the genus *Gnaphalium*. As a consequence of their small, inconspicuous capitula, high degree of morphological homoplasy, and type specimens that comprise mixtures of species, they are characterised by taxonomic confusion and generally considered difficult to identify. Existing identification keys are restricted either to individual Australian states or to genera and not or only sparsely illustrated. Descriptions frequently use obscure characters or terminology that do not lend themselves to efficient or non-destructive identification. Presented here is a comprehensive dichotomous key to all Australian native and introduced cudweeds (*Argyrotegium*, *Euchiton*, *Gamochaeta*, *Gnaphalium*, *Filago*, *Pseudognaphalium*, *Stuartina*) and their close relatives (e.g. *Ewartia*). It prioritises characters that are visible macroscopically or with a hand lens. Every species is illustrated with an image of a representative herbarium specimen, and key characters are illustrated with microscope images. The identity of selected species in *Euchiton*, *Gamochaeta*, and *Pseudognaphalium* treated in previously published keys is also discussed. Most important among them is *Pseudognaphalium lanatum*, a recently published name for a native Australasian species that has previously been subsumed under the cosmopolitan *P. luteoalbum*.
Keywords: taxonomy, cudweeds, Gnaphalieae.

radiating bracts nor ray florets. To the degree that the common name has a basis in scientific taxonomy, it is loosely congruent with the traditional, broad circumscription of *Gnaphalium* L., and thus 'cudweeds' are polyphyletic. As used in this paper, they include five disparate groups.

Most Australian cudweeds belong to the Euchiton clade in the Australasian clade of Gnaphalieae (Schmidt-Lebuhn & Bovill, 2021). It includes the cudweed-like genera *Euchiton* Cass., *Argyrotegium* J.M.Ward & Breitw., and *Stuartina* Sond., but also the entirely alpine taxa *Ewartia* Beauverd, *Helichrysum pumilum* Hook.f., and *Pterygopappus lawrencei* Hook.f. which, with the exception of one species, have white involucral bracts. The second group of cudweed species are members of *Gnaphalium s.str.*, two of them native, one introduced to Australia. Third, the American genus *Gamochaeta* Wedd., of which several species have been introduced to Australia. Fourth are two introduced species of *Filago* L. from Europe. Both *Gamochaeta* and *Filago* are members of the FLAG clade of Gnaphalieae (Smissen et al., 2020). Finally, the Australian species of *Pseudognaphalium* Kirp., a member of the HAP clade of Gnaphalieae (Smissen et al., 2020), is also commonly called a cudweed.

Cudweeds are often described as difficult to identify (Verloove et al., 2023) and have complicated taxonomic histories (Drury, 1970; Flann, 2010a). Practical evidence for these difficulties is the large proportion of misidentified herbarium specimens and in some cases misidentified images illustrating online floras (pers. observ.). The difficulties arise perhaps partly because of the small, relatively drab capitula of cudweeds that require closer and more patient study to reveal identifying characters than the large, colourful capitula of other Gnaphalieae, and the high degree of homoplasy in the tribe.

However, the limitations of available identification keys for Australian cudweeds may also be part of the problem. Existing identification keys are generally geographically restricted. The most comprehensive ones are those in state floras, which accordingly cover only the respective states. The eFlora of Australia has not yet treated Gnaphalieae beyond a few selected genera. Taxonomic studies were also generally restricted to individual genera, thus not providing a comprehensive key to a group where end-users are likely to find it difficult to decide what genus a specimen belongs to in the first place, and some authors did not include keys even when revising taxonomies or establishing new genera (Flann, 2010a; Ward *et al*., 2003).

Most existing keys are not or only sparsely illustrated. This is compounded by another issue, the frequent obscurity of characters used in the delimitation of genera and species. Diagnostic characters such as the number of filiform and tubular florets or the nature of papillae on the cypsela do not lend themselves to efficient identification in the field, to non-destructive identification in the herbarium, or to identification by end-users who are not Asteraceae taxonomists themselves.

This work presents a dichotomous key that, it is hoped, will fill this gap. It covers all native and introduced Australian cudweeds and related species. It prioritises the use of characters that are discoverable macroscopically or with a hand lens and which are reasonably easy to describe, especially growth form, leaf shape and dimensions, leaf indumentum, persistence of rosette leaves in flowering, inflorescence structure, and colour of involucral bracts. Every species is illustrated with an image of a representative herbarium specimen and, where necessary, the key refers to microscope images illustrating characters that are more obscure or difficult to describe.

Scope of the key

The scope of the key is Australian native and introduced cudweed-like plants as defined in the introduction and alpine, mat- or cushion-forming species of the Euchiton clade, as they are closely related to *Euchiton* and *Ewartia* and sometimes morphologically similar.

The following two species are excluded from the scope of the key. *Basedowia tenerrima* (F.Muell.) J.M.Black is an annual endemic of the interior of South Australia. The author is insufficiently familiar with this species, and although it was placed in the Euchiton clade by nuclear data, it was placed outside by chloroplast data (A. N. Schmidt-Lebuhn & Bovill, 2021). More importantly, it is unlikely to be considered a cudweed because of its white involucral bracts, nor would it fall under the concept of related alpine mat-forming or cushion plants. *Facelis retusa* (Lam.) Sch.Bip. is a species introduced to Australia from South America characterised by crowded, narrowly

wedge-shaped leaves and inflorescences visually dominated by the developing pappi protruding from narrowly bottle-shaped, greenish capitula. Although it might be considered cudweed-like due to its small size and brownish-greenish appearance, its distinctive morphology otherwise puts it quite apart from the taxa covered in this key.

It should also be noted that there are other species not included in this key, as they are neither cudweeds nor closely related to them, but which could be confused with species covered by the key. For example, *Chthonocephalus pseudevax* Steetz is not included despite the possibility of confusion with *Filago pygmaea* L., as both are small rosetted plants with a sessile cluster of capitula.

Material and methods

The main sources of information consulted during development of the key are the Australian Plant Census (https://biodiversity.org.au/nsl/services/search/taxonomy), New South Wales FloraOnline hosted on PlantNet NSW (https://plantnet.rbgsyd.nsw.gov.au/floraonline.htm), a comprehensive key to the cudweeds of Queensland hosted on FloraBase (https://keybase.rbg.vic.gov.au/keys/show/8361), VicFlora (the online Flora of Victoria, https://vicflora.rbg.vic.gov.au), the Key to Tasmanian Vascular Plants hosted by the University of Tasmania (https://www.utas.edu.au/dicotkey/dicotkey/key.htm), and taxonomic studies of *Argyrotegium* (Walsh, 1999; Ward et al., 2003), *Euchiton* (Drury, 1972; Flann, 2010a, 2010b; Flann et al., 2008; Holub, 1974), *Gamochaeta* (Drury, 1971; Freire et al., 2021; Nesom, 2004; Urtubey et al., 2016; Verloove et al., 2023), and *Pseudognaphalium* (Smissen et al., 2022). Protologues of older species descriptions were consulted through the Biodiversity Heritage Library (https://www.biodiversitylibrary.org).

For the most part, examination of specimens was limited to those available at the Australian National Herbarium (CANB, including CBG) and the author's own experience with the group in the field. Specimen loans were not requested. In cases where the identity of species was in question, especially in *Euchiton* and *Gamochaeta*, images or drawings of type material were consulted. Images of type specimens were in most cases accessible through JSTOR Global Plants (https://plants.jstor.org). In other cases, herbaria were contacted with image requests.

Macroscopic images in Figures 3–8 were cropped from photo libraries of herbarium specimens produced during systematic digitisation work at the Australian National Herbarium using an Aptus Leaf II 12, 80 megapixel camera with 72 mm Rolex lens and Schneider shutter controller. Microscope images in Figures 1–2, 5A, and 5C were taken with a Google Pixel 6 mobile phone mounted with an Apexel 200x microscope lens.

Notes on selected taxa

Taxonomic revision is beyond the scope of this paper, which for the most part follows the taxonomy currently accepted by the Australian Plant Census. However, as the purpose of the paper is to provide a means of identifying specimens to the correct names, a discussion of the correct application of some names, their types, and their treatment in previously published keys is unavoidable. Of particular concern is whether introduced species are named correctly, as taxonomic confusion can frustrate research on invasion biology or biological control of weeds (Pyšek et al., 2013).

Euchiton

The most comprehensive quantitative studies of *Euchiton* were conducted by Flann (2010a) and Flann *et al.* (2008). Flann demonstrated the identity of taxa shared between New Zealand and Australia and established the species delimitations that are currently accepted in Australia. Many species appear well defined, but *Euchiton japonicus* (Thunb.) Holub and its closest relatives remain problematic, as demonstrated by the many specimens Flann labelled as only "*Euchiton japonicus* complex". This group of species is characterised by strongly discolourous leaves, with the adaxial side dark green and glabrous to sparsely hairy and the abaxial side densely white-hairy, and inflorescences of distinct terminal and axillary clusters of capitula on erect to ascending stems (Figure 7).

In Australia, the genus includes under currently accepted names *Euchiton japonicus*, *E. involucratus* (G.Forst.) Holub, *E. limosus* (D.G.Drury) Holub, and *E. sphaericus*. *Euchiton sphaericus* stands out as a non-stoloniferous annual with usually a single, terminal, hemispherical to more or less globular cluster of

capitula surrounded by a ring of leaves (Figure 7A). Some variation in the leaf shape from linear to obovate may suggest internal variation that could be formally recognised at some rank, but the species as currently circumscribed is seemingly well differentiated from the other three species, which are stoloniferous perennials with terminal and often a few axillary clusters of capitula.

Euchiton involucratus and *E. limosus* occur in wet habitats such as swamps, bogs, and grassy creekbanks. A key identifying character is the cypsela surface, which is glabrous in *E. limosus* but hairy in *E. involucratus* (Flann, 2010a). Since mature cypselas are not always available, these two species can be difficult to distinguish. 'Typical' specimens of *E. limosus* have leaves only to ca. 80 mm long (Figure 7C), and the species occurs in montane to alpine areas, whereas 'typical' specimens of *E. involucratus* have much longer leaves (Figure 7D), and the species occurs at lower elevations. However, leaf length and thus the overall appearance of specimens is variable, and it is possible that the two species grade into each other. A genetic study to test their differentiation, perhaps in combination with a common garden experiment, would be desirable to resolve this question.

Euchiton japonicus occurs in well-drained habitats such as patchy grassland or woodland and may be a minor weed in urban environments. Its key identifying character is that it retains a leaf rosette when flowering (Figure 7B), whereas the other species of the complex do not, and the leaves subtending its clusters of capitula rarely exceed the clusters' length. However, the species as currently circumscribed has a very large range from eastern Asia to New Zealand and includes great variation in the shape of both rosette- and cauline leaves. Rosette leaves may be more or less elliptical and ca. 2 cm long (*J.S. Whinray 1578*, CANB482138), or oblanceolate and ca. 10 cm long (*D.M. Cameron 3141*, CBG7803264). Cauline leaves may be extremely reduced (*J.S. Whinray 777*, CANB480741) or well developed, only slightly smaller versions of the rosette leaves, even towards the top of the scape (*C.L. Gunn s.n.*, CANB261592). In the latter case, the flowering parts of the plant approach *E. limosus* in appearance. Considering the likelihood or not of ongoing gene flow between populations, it may also seem doubtful if the populations native to Japan are conspecific to those native to Australia (although some entities may have been spread by humans).

To understand the degree of morphological similarity of Australian populations to those from the type location of *Euchiton japonicus* and what morphologies existing names would apply to, it was deemed prudent to consult, where possible, photographs or illustrations of the type of *Gnaphalium japonicum* Thunb., the basionym of *E. japonicus*, and of synonymised names relevant to Australia, *Gnaphalium gymnocephalum* DC. = *E. gymnocephalus* (DC.) Holub and *Gnaphalium collinum* Labill. = *E. collinus* Cass. The name *G. collinum* Labill. is illegitimate, and *Euchiton collinus* Cass. is a replacement name.

The drawing of the type of *Gnaphalium collinum* on Tab. 189 in Labillardiere's (1804) *Novae Hollandiae Plantarum Specimen* strongly resembles *Euchiton japonicum* as currently recognised in Australia. The rosette leaves are spreading, narrowly elliptic to oblanceolate, and short compared to the scapes. Cauline leaves are few and reduced. The scapes carry one terminal cluster of capitula subtended by a leaf at most slightly exceeding it and in one case a smaller axillary cluster.

The type of *Gnaphalium gymnocephalum* (G00469164) likewise matches *Euchiton japonicum* as currently recognised in Australia in inflorescence structure, with only a single terminal cluster of capitula subtended by leaves not exceeding it in length. The few rosette leaves are, however, much longer and narrower and more erect than those of the drawing of the type of *G. collinum*, in one case to 2/3–3/4 as long as the scapes.

The type of *Gnaphalium japonicum* (UPS-THUNB 19181) shows very long, narrow, seemingly erect rosette leaves at ca. 80–120 x 2–5 mm, scapes with few, strongly reduced cauline leaves, and 1–2 clusters of capitula per scape, with the larger terminal cluster ca. 15 mm in diameter. It is a much more robust plant than G00469164, albeit similar in leaf morphology. Should future work find Australian *Euchiton japonicus* to represent several species and/or a different species to the one occurring in eastern Asia, *E. collinus* therefore appears more likely to be resurrected than *E. gymnocephalus*.

As has been discussed by Drury (1972), the type material of *Gnaphalium involucratum* Forst.f. is a mixture of that species (e.g., GOET012699) and *Euchiton sphaericus* (e.g., FR0031015), which partly explains taxonomic confusion in the complex. Similarly, the Gaudichaud specimens labelled as type material of *Gnaphalium gymnocephalum*

at P (P00704714-P00704716) are a mixture of mostly *E. limosus* and two stems that may be *E. japonicus*.

Gamochaeta

The Australian Plant Census currently recognises six species of the American genus *Gamochaeta* Wedd. as introduced to the country: *G. americana* (Mill.) Wedd., *G. antillana* (Urb.) Anderb., *G. calviceps* (Fernald) Cabrera, *G. coarctata* (Willd.) Kerguelen, *G. pensylvanica* (Willd.) Cabrera, and *G. purpurea* (L.) Cabrera. While *G. pensylvanica* is easily recognised by its loosely woolly indumentum, capitula covered in woolly hairs, and relatively spaced-out capitulescence with well-developed subtending leaves, confusion persists about the differentiation between and status of *G. americana*, *G. coarctata*, and *G. purpurea*, as well as the differentiation between and status of *G. calviceps* and *G. antillana*.

According to available identification keys in Australia (e.g., PlantNet NSW, https://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=gn&name=Gamochaeta, and KeyBase, https://keybase.rbg.vic.gov.au/keys/show/6334, accessed 1 Sept 2023), *Gamochaeta coarctata* differs from *G. purpurea* and *G. americana* in the presence of a pale mid vein on the leaves and its capitulescence usually being a closed pseudospike versus pale midvein absent and capitulescence loose. *Gamocheata purpurea* is then differentiated from *G. americana* by purple florets tips and basal leaves persistent at flowering and not stem-clasping *versus* floret tips yellow and basal leaves usually withered or withering at flowering and often stem-clasping.

Gamochaeta coarctata has recently been synonymised with *G. americana* (Freire et al., 2021). Introduced populations in the United States that had previously been treated under that name were subsequently described as *Gamochaeta impatiens* Nesom with the argument that the synonymisation of *G. coarctata* left them without a name (Nesom, 2022). Nesom did not mention *G. purpurea* but differentiated his new species from *G. americana* as follows:

Stems decumbent-ascending to nearly prostrate from the first; distal 1/3 of the lamina of the inner phyllaries rosy to light reddish-brown hyaline, the whole involucre often with a distinctly purplish or rosy cast; involucres 2.5–3 mm high; outer phyllaries depressed-ovate, apex rounded, inner with rounded apex; bisexual florets 2–3; corolla apices reddish; leaves glabrous and shiny adaxially, the basal persistent. ..... *Gamochaeta impatiens*

Stems first erect, sometimes becoming decumbent-ascending; distal half of the lamina of the inner phyllaries brown and sharply delimited in colour from the proximal portion, the whole involucre often with a distinctly brownish cast; involucres 3–4 mm high; outer phyllaries ovate to oblong-lanceolate, apex mostly acute or acuminate, inner with acute apex; bisexual florets (2–)3–7; corolla apices yellow; leaves usually glabrescent adaxially, sometimes becoming shiny, the basal often not persistent. ..... *Gamochaeta americana*

Nesom (2022) stated that *Gamochaeta impatiens* has been introduced at least to Swaziland and New Zealand and recommended the identity of introduced populations in other countries currently treated as *G. americana* or *G. coarctata* be re-examined. Fresh, flowering specimens of what appeared to be two different species growing in Canberra, ACT, were therefore sampled and photographed to ensure that floret colours could be examined.

The first had rosette leaves withered at flowering, adaxial leaf sides finely hairy and light green, stems erect from a quickly ascending base, involucres ca. 4 mm long, phyllary tips brown when young, outer phyllaries ovate and apically attenuate, and (2–)4(–5) bisexual florets with purple tips. It matches the concept of *Gamochaeta purpurea* in the Flora of North America (http://efloras.org/florataxon.aspx?flora_id=1&taxon_id=242416575, accessed 31 Oct 2023), except that the flora description also allows for purple phyllary tips in bud.

The second had rosette leaves persistent at flowering, adaxial leaf sides finely hairy and dark green, stems at first procumbent, then ascending, involucres ca. 3.5 mm long, phyllary tips purple when young, outer phyllaries ovate and apically obtuse, and 2–3 bisexual florets with purple tips. Despite failing to conform to Nesom's (2022) couplet cited above in adaxial leaf indumentum and length of the involucre, it is a close match to all photos illustrating his concept of *Gamochaeta impatiens* (Nesom 2022, Figures 11–19).

Nesom's (2022) concept of *Gamochaeta americana* matches that underlying previously published Australian keys in floret colour but not in leaf shape. Since floret colour is lost in drying, leaf shape and involucral bract shapes are similar, and the number of bisexual florets is overlapping, *G. americana* and *G. purpurea* may be difficult to differentiate as herbarium specimens. However, differentiation of living plants at the flowering stage is easy because of the conspicuous colouration

of *G. americana*, with involucral bracts basally green, apically dark brown, and strongly contrasted with the yellow floret tips (Nesom 2022, Figures 4–10; see also iNaturalist record 101802520 from Victoria for an Australian example), whereas *G. purpurea* has light brown and greenish involucral bracts and less conspicuous, dark purple florets.

Although the taxonomic concepts of Nesom (2022) and the Flora of North America therefore match three entities occurring in Australia, the correct application of names to the concepts may be more doubtful. The type of *Gnaphalium purpureum* (LINN 989.73) is only a single, seemingly young flowering stem without a rosette, although that may simply not have been collected. The lectotype of *Gnaphalium americanum* Mill. (BM001009488) had a lush rosette at flowering, and the basal leaves have broad bases, both characters more reminiscent of *Gamochaeta impatiens*. Given the number of names published in *Gamochaeta*, and the fact that *G. impatiens* was described from its introduced range, it also remains possible that the species may have an older name in its area of origin. Only a comprehensive revision of the genus across South and Central America can provide certainty in this regard.

Most Australian identification keys do not include *Gamochaeta antillana*, and one that does, on PlantNet NSW, appears to have paraphrased information from the couplet published by Nesom (2004) that differentiates this species and *G. calviceps* as follows:

Involucres 3-3.5 mm, lightly arachnose only at the base or not at all; capitulescence interrupted at least distally, main axis visible to terminal heads; phyllaries in 5–7 series, outer and middle ovate-triangular with sharply acute-acuminate apices, 1/3–1/2 as long as the inner, none with purplish colour; flowering May-Jul..... *Gamochaeta calviceps*

Involucres 2.5-3 mm, seated in tomentum; capitulescence initially cylindric and uninterrupted, at least distally, main axis obscured by clustered heads; phyllaries in 3-4(-5) series, outer and middle ovate-lanceolate with narrowly to broadly acute apices, outer 1/2-2/3 as long as inner, at least innermost commonly tinged with purple at stereome-lamina junction; flowering (Feb–)Mar–May, sometimes later with moisture..... *Gamochaeta antillana*

It was difficult to discern an arrangement of the involucral bracts into series in any of the material examined as part of this work. There are, however, two groups of specimens of *Gamochaeta* with concolourous leaves in CANB. The first is characterised by inflorescences of dense pseudospikes mostly without protruding subtending leaves except at the very base or when young (cf. *G. antillana* fide Nesom), involucres yellowish-brownish, senescing to brown (cf. *G. calviceps*), and outer involucral bracts triangular (*cf. G. antillana*) but short (cf. *G. calviceps*) (Figures 1G, 6D). These specimens match the type material of *Gnaphalium antillanum* (*N.L. Britton 9619*, NY00126654, and *N.L. Britton 10009*, NY00126655, the latter chosen as the lectotype by Nesom).

The second group is characterised by inflorescences with clusters of capitula more distant from each other, often leafy, and often branched (cf. *Gamochaeta calviceps* fide Nesom), involucres purple when in bud and beginning to flower and senescing to brown (cf. *C. antillana*), and outer involucral bracts narrowly acute (cf. *G. calviceps*) but long (cf. *G. antillana*) (Figure 1F, 6E). These specimens match the type of *G. calviceps* (*M.L. Fernald 4245*, GH) at least in inflorescence structure, with the caveat that there is uncertainty in interpreting the shape of the outer involucral bracts from viewing the specimen image alone.

It is possible that Nesom (2004) accidentally swapped involucral bract colours and outer bract apex shapes to the wrong leads in his couplet, and authors of Australian keys have copied the mistake.

Urtubey et al. (2016) listed differences primarily in plant height and leaf shape (15–25 cm tall, lower cauline leaves linear to lanceolate for *Gamochaeta antillana*, 20–40 cm tall, lower cauline leaves linear-oblanceolate for *G. calviceps*). Specimens at CANB suggest that the yellowish-brown, pseudo-spicate plants tend to remain shorter than the purplish, paniculate ones. But as these species are annuals, which can be very diminutive under poor conditions, and the type material of *G. antillana* is very robust, plant height may not be a reliable character. On the other hand, the difference in lower cauline leaves described by Urtubey *et al.* (2016) is reflected in the type specimens, with those of *G. antillana* more or less linear or only slightly oblanceolate and those of *G. calviceps* distinctly oblanceolate.

Taxonomic uncertainty about introduced species is a global phenomenon, and a recent paper discussed the identity of *Gamochaeta* species naturalised in Belgium and the Netherlands (Verloove et al., 2023). The well-illustrated study assigned specimens visually matching Australian concolourous-leafed, purple-capitulate *Gamochaeta* to *G. subfalcata* (Cabrera) Cabrera,

and indeed the type of *G. subfalcata* (*A.L. Cabrera 944*, LP000244) also matches the purple-capitulate *Gamochaeta* of Australia. However, Verloove & al. (2023) discussed only the potential synonymy of *G. subfalcata* with *G. antillana* but did not consider the name *G. calviceps* as an option. If *G. calviceps* and *G. subfalcata* are synonyms, the former name has priority. Similarly, the eFlora of New Zealand recognises concoulourous-leaved, purple-capitulate *Gamochaeta* as *G. subfalcata* (https://www.nzpcn.org.nz/flora/species/gamochaeta-subfalcata/, accessed 7 Sep 2023). It is considered likely that these plants introduced to Europe, Australia, and New Zealand are all conspecific.

For the key in this paper, the following decisions were made regarding *Gamochaeta*: (1) To follow Nesom's (2022) concepts for *G. americana* and *G. impatiens* and to differentiate *G. purpurea* from both based on the combination of purple florets, light brown involucral bracts, and outer involucral bracts acute to attenuate. The relevant section of the key therefore differs significantly from how these three species were conceptualised in previously published Australian keys. (2) To align the identity of *G. antillana* and *G. calviceps* with the morphology of their types instead of with Nesom's (2004) couplet. And (3) to refer concolourous-leaved, purple-headed *Gamochaeta* to *G. calviceps* instead of *G. subfalcata* as suggested by Verloove & al. (2023) for Europe and by the eFlora of New Zealand. However, only a dedicated study comparing the application of names in areas where *Gamochata* has been introduced with that in the American areas of origin and carefully examining type specimens would be able to resolve the existing taxonomic confusion.

Pseudognaphalium

Both the Australian Plant Census and Australian herbaria currently recognise Australian specimens of *Pseudognaphalium* as *P. luteoalbum* (L.) Hilliard & B.L.Burtt, a near-cosmopolitan weed. A recent study has shown *Pseudognaphalium* of New Zealand to be two distinct species, presumably introduced *P. luteoalbum* with usually red florets and colourless involucral bracts at anthesis and more sparsely woolly indumentum, and the native Australasian species *P. lanatum* (G.Forst) Smissen, Breitw. & de Lange with yellow florets and yellowish to brownish involucral bracts at anthesis and more densely woolly indumentum (Smissen et al., 2022). This raises the question if both species also occur in Australia.

Floret colour is unavailable or sometimes misleading on dried herbarium specimens, as the florets lose colour or may turn purplish. It also appears that the character is not reliable, i.e., that plants of *Pseudognaphalium luteoalbum* can have red or yellow florets (Rob Smissen, pers. comm.). Smissen *et al.* (2022) further remarked that the density of the indumentum, while distinctive where the two species grow together, is influenced by environmental conditions and therefore not a reliable differentiator for plants examined in isolation. This means that the most promising character for the identification of herbarium specimens would be the colour of involucral bracts of capitula that had been flowering when collected (Figure 1H–I), but identification of some specimens will be difficult, as the bracts senesce to brown.

Most of the Australian specimens of *Pseudognaphalium* at CANB from Western Australia, Northern Territory, South Australia, and Tasmania appear very characteristic of *P. lanatum*, with a distinctive contrast between white-woolly stem and leaves and golden-brownish capitula (Figure 8A). Specimens from the eastern half of the Australian mainland are morphologically more diverse. Plant from the urban area of Canberra that were easily accessible to me as fresh material have colourless involucral bracts and represent *P. luteoalbum*, albeit with yellow florets (Figure 8B).

Examination of 1,042 Australian records identified as *Pseudognaphalium* on iNaturalist (inaturalist.org, accessed 31 Oct 2023) revealed one record from Victoria matching Smissen *et al.*'s (2022) description of *P. luteoalbum* in all aspects including the reddish florets (134380257), and its identity was subsequently confirmed by Rob Smissen. In summary, this suggests that both *P. luteoalbum* and *P. lanatum* occur in Australia. Further study would be desirable to increase our understanding of their ranges.

Key to the species

Asterisks indicate species introduced to Australia.

1 Capitula solitary 2

1: Inflorescences of several to many capitula 12

2 (1) Leaves narrowly linear; coastal ..... ***Euchiton litticola*** A.M.Buchanan (Figure 4A)

2: Leaves obovate to oblanceolate; montane to alpine 3

3 (2) Leaves +/- appressed onto stem, strongly overlapping, the visible part of the lamina only up to about as long as wide (Figure 2A) ..... ***Pterygopappus lawrencei*** Hook.f. (Figure 3A)

3: Leaves variously spreading, the visible part of the lamina longer than wide 4

4 (3) Involucre with white, spreading tips 5

4: Involucre brown, not spreading when in flower 8

5 (4) Capitula on robust, woolly, leafy scapes ca. 2-6 cm tall when in flower ..... ***Helichrysum pumilum*** Hook.f. (Figure 4B)

5: Capitula sessile in flower but often with elongating, weak scapes ca. 1-2 cm tall in fruit 6

6 (5) Leaves ca. 2.5-5.0 mm wide, apex obtuse-apiculate ..... ***Ewartia catipes*** (DC.) Beauverd (Figure 3B)

6: Leaves ca. 1.5-3.0 mm wide, apex acute 7

7 (6) Leaves when fresh characteristically yellowish to white on margins and abaxial surface, greenish on adaxial surface; Tasmania ... ***Ewartia meredithae*** (F.Muell.) Beauverd (Figure 3C)

7: Leaves grey-hairy on both surfaces; mainland Australia ..... ***Ewartia nubigena*** (F.Muell.) Beauverd (Figure 3D)

8 (4) Capitula on +/- robust, leafy shoots even when in flower; leaves ca. 10-30 mm long 9

8: Capitula sessile in flower but generally with elongating, weak scapes in fruit; leaves up to ca. 15 mm long 10

9 (8) Rosette leaves narrowly oblanceolate, base narrowly attenuate, green above and greyish-green below; flowering stalks ascending laterally from rosette; Tasmania ..... ***Euchiton lateralis*** (C.J.Webb) Breitw. & J.M.Ward (Figure 4C)

9: Rosette leaves oblanceolate, base cuneate, +/- equally grey on both sides; flowering stalk ascending from middle of rosette; mainland Australia or Tasmania ..... ***Euchiton traversii*** (Hook.f.) Holub (Figure 4D)

10 (8) Leaf apex with incurved mucro (Figure 2B) ..... ***Ewartia planchonii*** (Hook.f.) Beauverd (Figure 3E)

10: Leaf apex without mucro, or mucro not incurved 11

11 (10)Leaves compactly woolly with appressed hairs (Figure 2C), 5–7 mm long, only slightly narrowing towards wedge-shaped base ***Argyrotegium nitidulum*** (Hook.f.) J.M.Ward & Breitw. (Figure 3F)

11: Leaves softly woolly with loose hairs (Figure 2D), 6–12(–15) mm long, base attenuate ..... ***Argyrotegium mackayi*** (Buchanan) J.M.Ward & Breitw. (Figure 4E)

12 (1) Apices of involucral bracts recurved into hardened hooks 13

12: Apices of involucral bracts straight, papery to membranous 14

13 (12) Apices of involucral bracts yellow, ca. 1–2 mm long (Figure 5A) ..... ***Stuartina hamata*** Philipson (Figure 5B)

13: Apices of involucral bracts reddish-brownish, ca. 1(–1.5) mm long (Figure 5C) ..... ***Stuartina muelleri*** Sond. (Figure 5D)

14 (12) Inflorescences at ground level, sessile clusters of capitula surrounded by solitary or clustered rosettes of leaves ..... **Filago pygmaea*** L. (Figure 5E)

14: Inflorescences on erect or ascending stems 15

15 (14) Capitula in a narrowly pyramidal panicle or pseudospike (Figure 6) 16

15: Capitula either in terminal clusters or in terminal and axillary clusters clearly separated from each other, not pyramidal (Figures 7–8) 22

16 (15) Adaxial leaf surfaces glabrous or sparsely hairy and dark green, abaxial surfaces densely white-hairy 17

16: Leaves distinctly greyish- to white-hairy on both sides 20

17 (16) Capitula partly obscured by woolly hairs; leaves loosely woolly-hairy. ***Gamochaeta pensylvanica*** (Willd.) Cabrera (Figure 6B)

17: Peduncles woolly-hairy, but capitula freely visible; leaves with fine, appressed hairs on abaxial surface 18

18 (17) Rosette and lower stem leaves usually present at flowering, with wide base clasping around the stem; flowering stems ascending from a procumbent base; tips of outer involucral bracts obtuse (Figure 1B).. ***Gamochaeta impatiens*** Nesom (Figure 6F)

18: Rosette and lower stem leaves often withered or withering at flowering, with narrowed, petiole-like base; flowering stems usually erect; tips of outer involucral bracts acute to attenuate 19

19 (18) Involucral bracts apically light brown at flowering, the outer and middle ones sharply attenuate (Figure 1C); tips of florets purple; bisexual florets (2–)3–4(–5) ..... ***Gamochaeta purpurea*** (L.) Cabrera (Figure 6G)

19: Involucral bracts apically dark brown at flowering, the outer and middle ones acute (Figure 1D); tips of florets yellow; bisexual florets (2–)3–7 ..... ***Gamochaeta americana*** (Mill.) Wedd. (Figure 6C)

20 (16) Involucral bracts with callus-like green stereome and broad, membraneous, often dark brown apex (Figure 1E); indumentum loosely woolly; stems weak; florets yellow ..... ***Gnaphalium polycaulon** Pers. (Figure 6A)

20: Involucral bracts sometimes greenish towards base but with inconspicuous stereome and firm to the apex, light brown or purplish (Figure 1F-G); indumentum appressed; stems robust; florets purplish 20

21 (20) Involucres yellowish-brownish (Figure 1F); inflorescence a dense pseudospike; generally on sandy soils ..... ***Gamochaeta antillana** (Urb.) Anderb. (Figure 6E)

21: Involucres purplish in bud and early flowering (Figure 1G) but turning brown in fruit; inflorescence of +/- distinct clusters of capitula when mature, often basally branched; on various substrates ..... ***Gamochaeta calviceps** (Fernald) Cabrera (Figure 6D)

22 (15) Side branches overtopping the terminal clusters ..... ***Filago pyramidata** L. (Figure 5F)

22: Side branches absent or shorter than continuation of main branch 23

23 (22) Adaxial leaf surfaces glabrous or sparsely hairy and dark green, abaxial surfaces densely white-hairy 24

23: Leaves distinctly grey- or white-hairy on both surfaces 27

24 (23) Erect annuals; capitula usually in a single, subglobular to hemispherical terminal cluster subtended by several leafy bracts forming a kind of secondary involucre ..... ***Euchiton sphaericus** (Willd.) Holub (Figure 7A)

24: Stoloniferous perennials; capitula often in several clusters, generally a large terminal cluster and one or a few smaller clusters in the axils of the upper leaves, subtended by only one to few leafy bracts 25

25 (24) Basal rosette persistent in flower; leaves subtending terminal clusters of capitula short, rarely exceeding the length of the clusters; more or less well drained habitats ..... ***Euchiton japonicus** (Thunb.) Holub (Figure 7B)

25: Basal rosette absent in flower; leaves subtending terminal clusters of capitula usually exceeding the length of the clusters; wet habitats 26

26 (25) Leaves to 80 mm long; fruits glabrous (Figure 2E); montane to subalpine ..... ***Euchiton limosus** (D.G.Drury) Holub (Figure 7C)

26: Leaves to 200 mm long; fruits hairy (Figure 2F); lower elevations ..... ***Euchiton involucratus** (G.Forst.) Holub (Figure 7D)

27 (23) Annual plants with multiple leafy shoots branching to terminate in several clusters of capitula; leaves mostly cauline; of lower elevations 28

27: Perennial plants with few ascending to erect leafy shoots terminating in a cluster of capitula, potentially with few smaller clusters in the axils of the upper leaves; most and largest leaves clustered at the base of the plant (may be withering by the time of flowering), few and reduced in size on the flowering stems; of montane to alpine areas 31

28 (27) Plants with erect flowering stems, to 45 cm tall, with stems usually branching into a capitulescence only in their topmost fifth or higher 29

28: Low, compact plants up to 12 cm tall, with ascending flowering stems branching in their upper third to half 30

29 (28) Involucral bracts yellowish to brownish and involucre appearing brown to straw-coloured at anthesis (Figure 1H); plants generally densely woolly, often appearing whitish when fresh; tips of florets yellow ..... ***Pseudognaphalium lanatum** (G.Forst) Smissen, Breitw. & de Lange (Figure 8A)

29: Involucral bracts colourless and involucre appearing greenish at anthesis (Figure 1I); plants generally less woolly, often appearing greenish or greyish when fresh; tips of florets reddish or yellow ..... ***Pseudognaphalium luteoalbum** (L.) Hilliard & B.L.Burtt (Figure 8B)

30 (28) Plants ca. 3-6(-10) cm tall; leaves ca. 5-15 x 1-2 mm; capitula woolly at base ..... ***Gnaphalium indutum** Hook.f. (Figure 8C)

30: Plants ca. 6-12 cm tall; leaves ca. 10-25 x 1-3 mm; capitula densely woolly all over ..... ***Gnaphalium diamantinense** Paul G.Wilson (Figure 8D)

31 (27) Leaves ca. 10-60 x 5-20 mm, obovate, the basal ones with long, slender petioles, dark grey-green on adaxial surface, white to grey on abaxial surface ..... ***Euchiton umbricola** (J.H.Willis) Anderb. (Figure 8E)

31: Leaves narrower, oblanceolate, more or less equally grey-hairy on both surfaces 32

32 (31) Leaves with tightly appressed silvery to rust coloured hairs; basal leaves present when in flower ..... ***Argyrotegium fordianum** (M.Gray) J.M.Ward & Breitw. (Figure 8F)

32: Leaves softly woolly with loose white hairs; basal leaves generally withered when in flower ..... ***Argyrotegium poliochlorum** (N.G.Walsh) J.M.Ward & Breitw. (Figure 8G)

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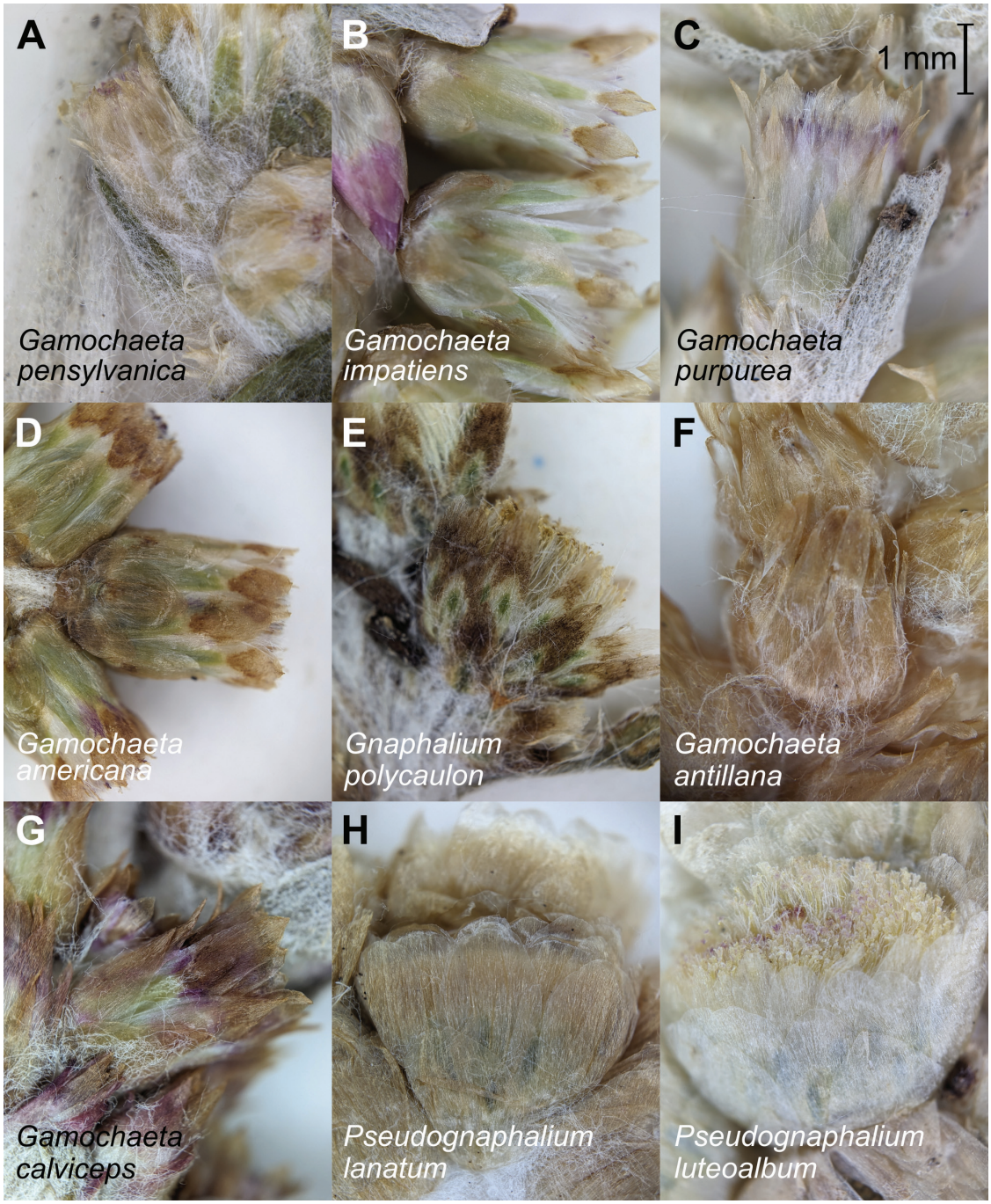

Figure 1. Capitula of selected species of cudweeds. A. *Gamochaeta pensylvanica* (*M. Gray 5210*, CANB345111). B. *Gamochaeta impatiens* (*B.J. Lepschi 664*, CANB420076). C. *Gamochaeta purpurea* (*R.W. Purdie 9200*, CANB869445). D. *Gamochaeta americana* (*D.M. Cameron 939*, CBG7803269). E. *Gnaphalium polycaulon* (*E. Chesterfield 2551*, CANB400540). F. *Gamochaeta antillana* (*C.W.E. Moore 9263A*, CANB449516). G. *Gamochaeta calviceps* (*L.G. Adams 3424*, CANB381845). H. *Pseudognaphalium lanatum* (*A.N. Schmidt-Lebuhn 1516*, CANB813011). I. *Pseudognaphalium luteoalbum* (*D.E. Albrecht 15432*, CANB909690). All images are to the same scale.

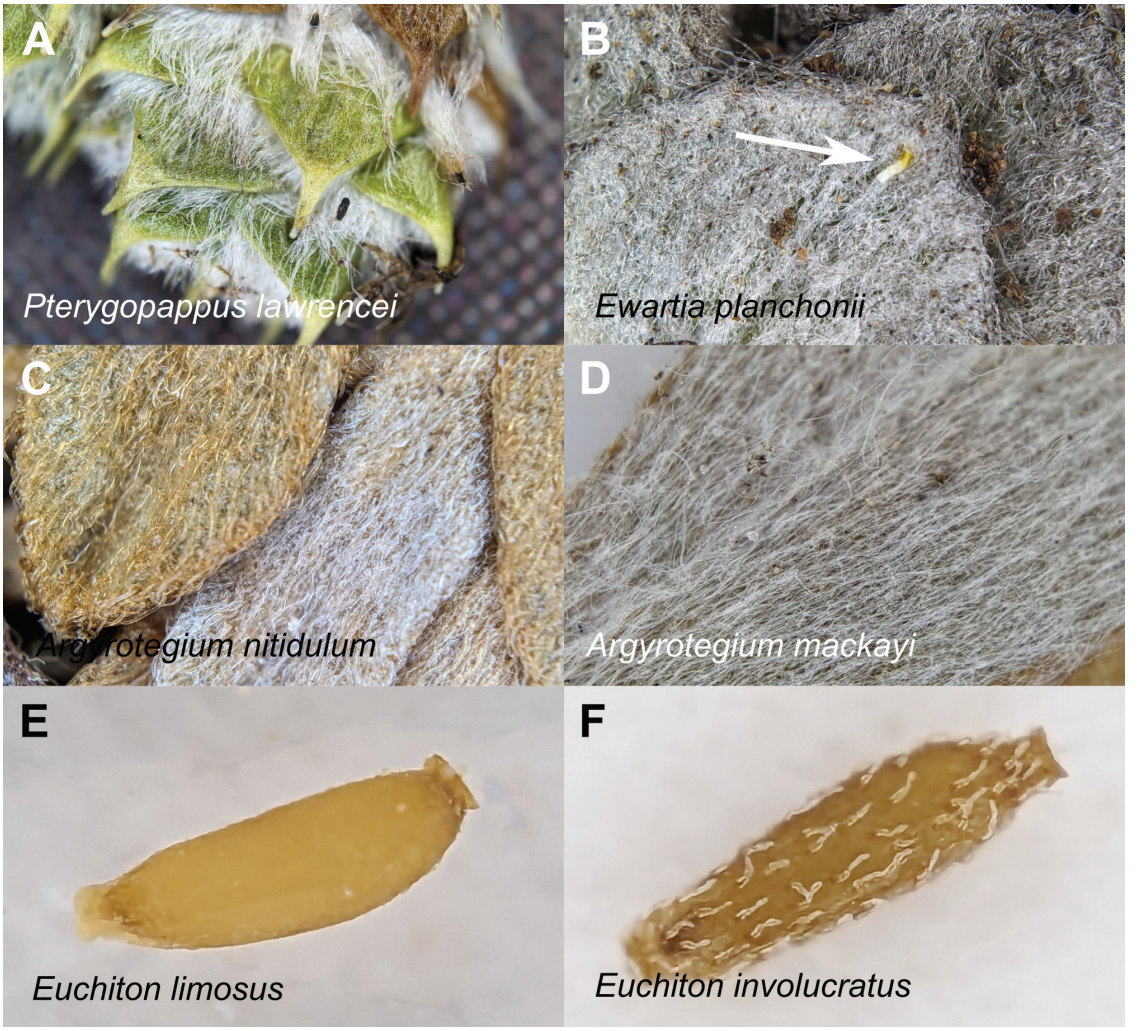

Figure 2. A. Leaves of *Pterygopappus lawrencei* (*A.N. Schmidt-Lebuhn 2061*, CANB). B. Incurved mucro at leaf apex of *Ewartia planchonii* (arrow) (*A.N. Schmidt-Lebuhn 2040*, CANB). C. Appressed leaf indumentum of *Argyrotegium nitidulum* (*M. Gray 6609*, CANB366615). D. Loose woolly leaf indumentum of *Argyrotegium mackayi* (*P.A. Keane 23*, CANB344252). E. Cypsela of *Euchiton limosus* (*N.T. Burbidge 7561*, CBG177139). F. Cypsela of *Euchiton involucratus* (*L.G. Adams 3979*, CANB376797). Images were not calibrated.

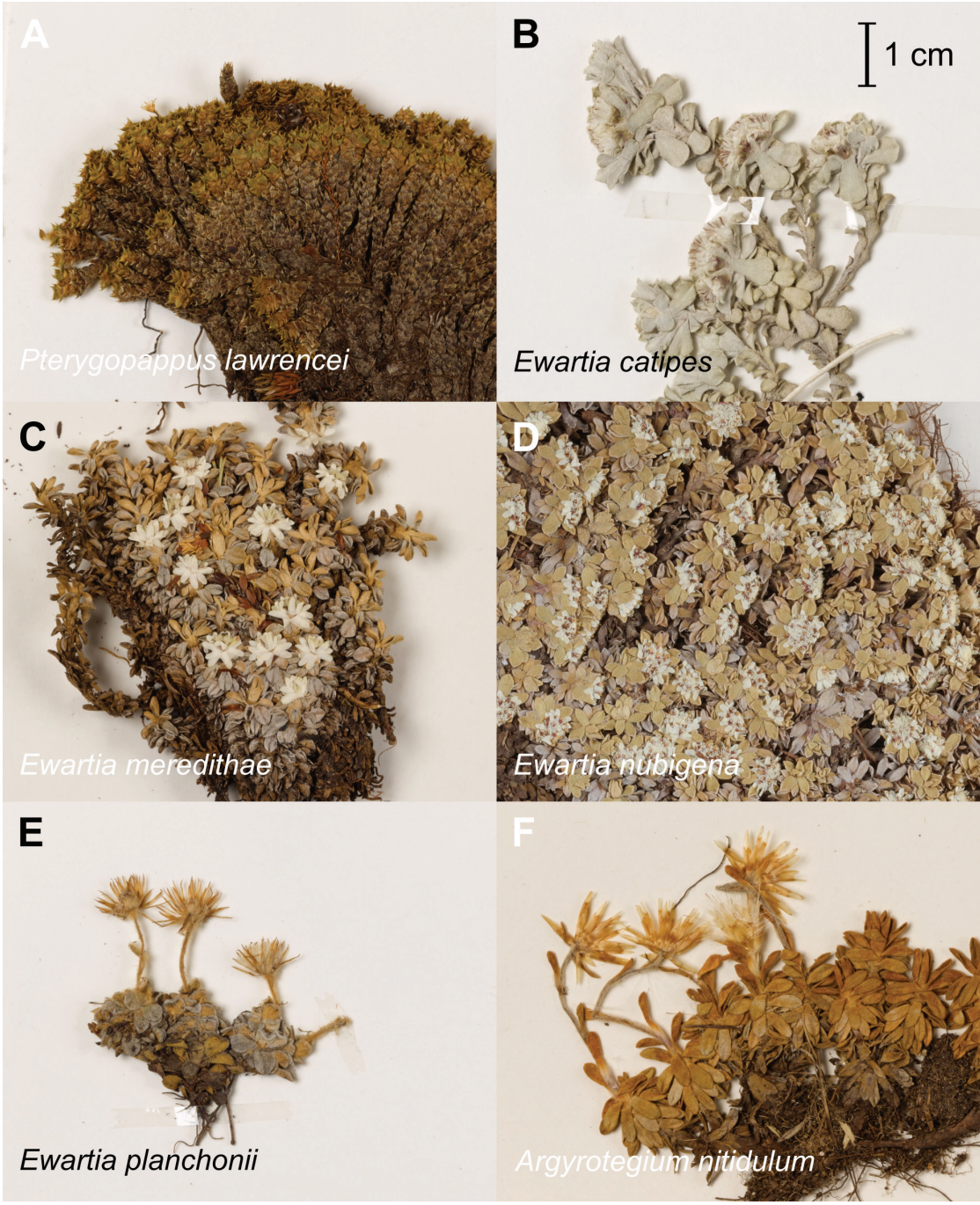

Figure 3. Small, mostly mat- or cushion-forming species with solitary capitula. A. *Pterygopappus lawrencei* (*I.R. Telford 2218*, CBG26614). B. *Ewartia catipes* (*J. Wood 329*, CANB818796). C. *Ewartia meredithae* (*I.R. Telford 2215*, CBG27596). D. *Ewartia nubigena* (*E. Gauba s.n.*, CBG12850). E. *Ewartia planchonii* (*T. Shimizu 3915*, CANB508103). F. *Argyrotegium nitidulum* (*M. Gray 6609*, CANB366615). All images are to the same scale.

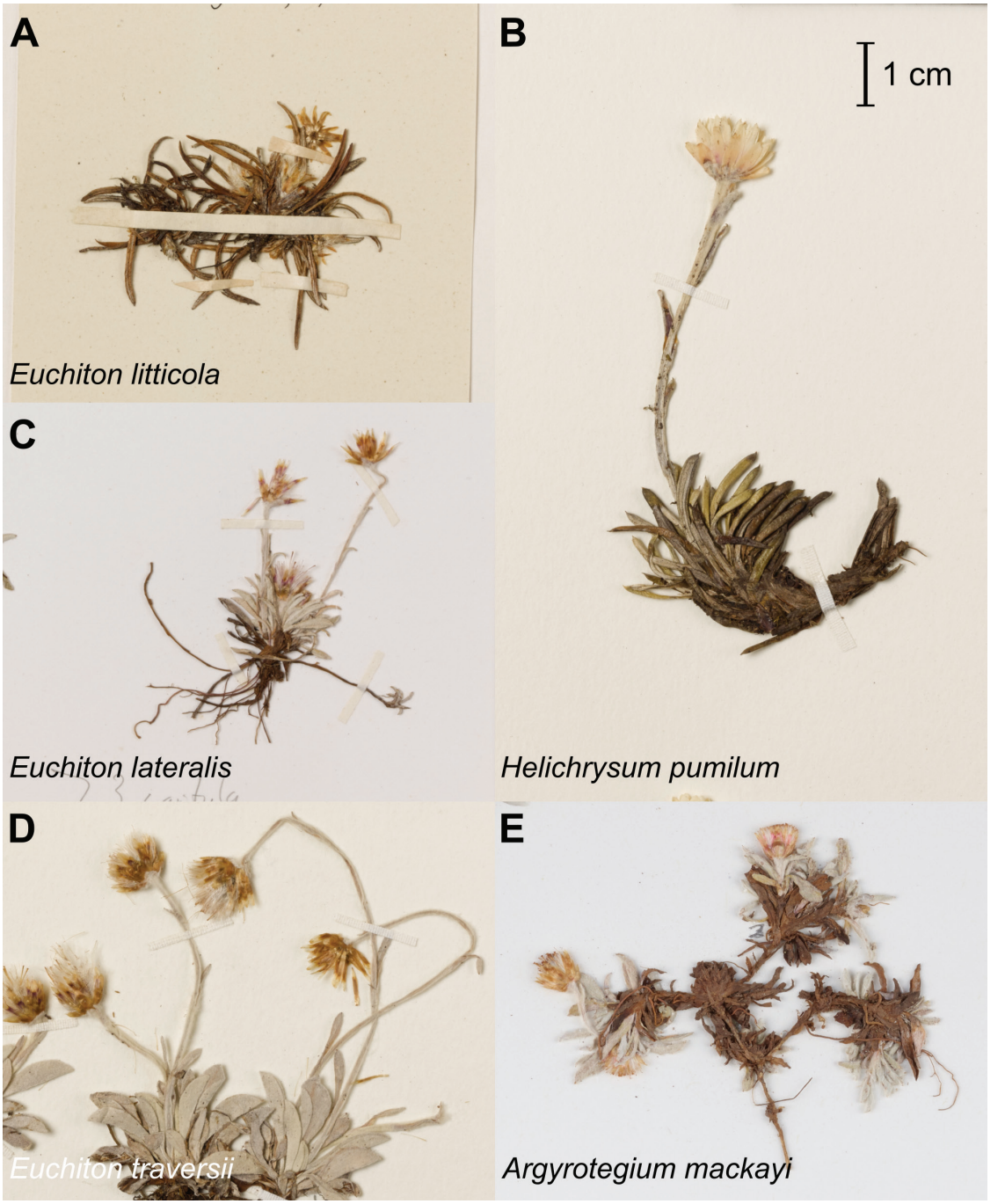

Figure 4. Larger species with solitary flowerheads. A. *Euchiton litticola* (*J.H. Willis s.n.*, CANB177044). B. *Helichrysum pumilum* (*B. Barnsley 1248*, CBG8001095). C. *Euchiton lateralis* (*B. Barnsley 1218*. CBG8001065). D. *Euchiton traversii* (*P. Gilmour 6341*, CBG8802311). E. *Argyrotegium mackayi* (*D.N. McVean s.n.*, CANB344257). All images are to the same scale.

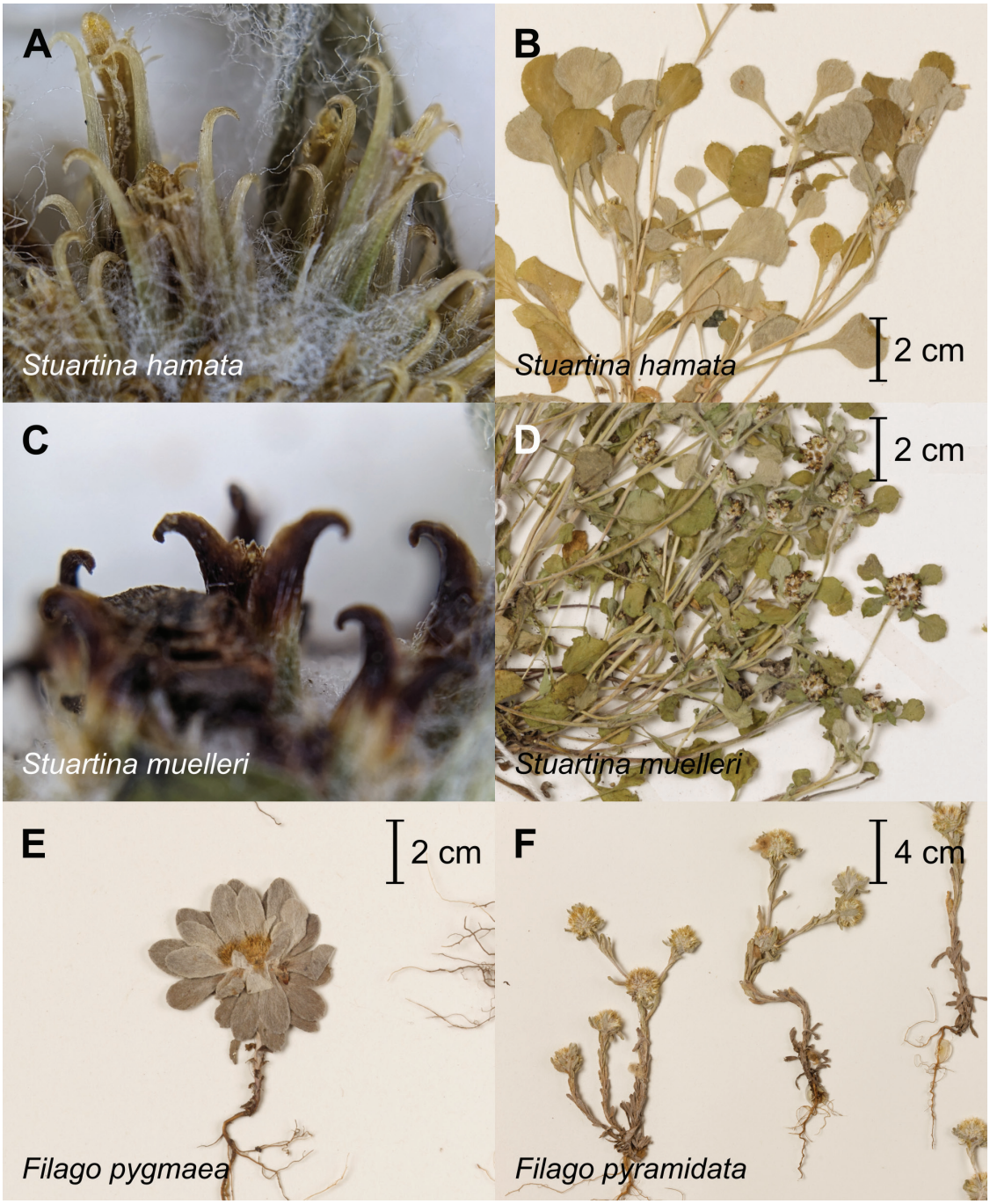

Figure 5. *Filago* and *Stuartina*. A-B. *Stuartina hamata*, with A showing apices of involucral bracts (*A. Slee 726*, CANB382198). C-D. *Stuartina muelleri*, with C showing apices of involucral bracts (*A.N. Schmidt-Lebuhn 1107*, CANB795970). E. *Filago pygmaea* (*J. Stefani s.n.*, CANB346441). F. *Filago pyramidata* (*B. Copley 2386*, CANB346495). Images have individual scale bars except for A and C, which were not calibrated.

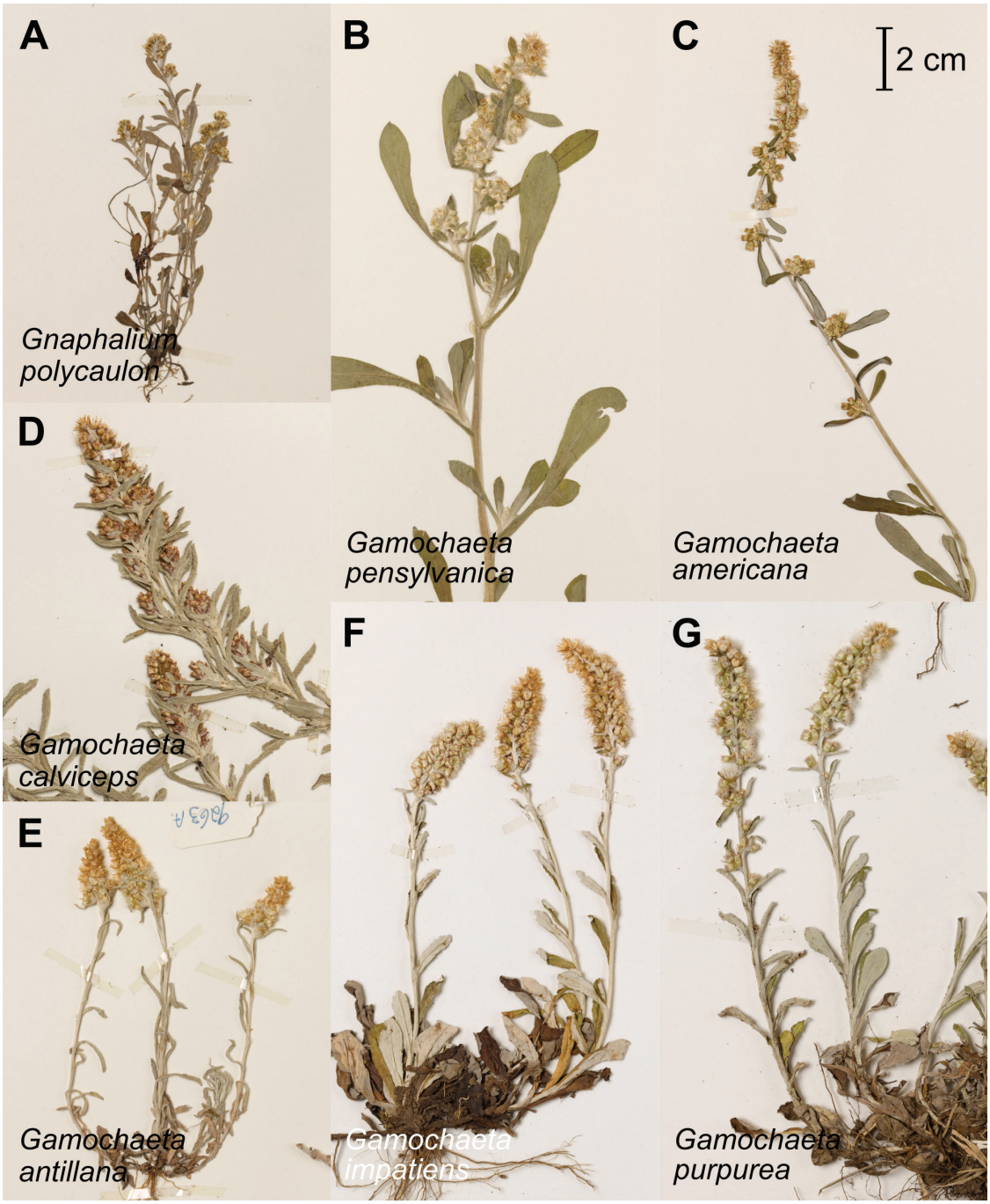

Figure 6. Species with flowerheads in narrowly pyramidal panicles or pseudospikes. A. *Gnaphalium polycaulon* (*E. Chesterfield 2551*, CANB400540). B. *Gamochaeta pensylvanica* (*M. Gray 5210*, CANB345111). C. *Gamochaeta americana* (*D.M. Cameron 939*, CBG7803269). D. *Gamochaeta calviceps* (*L.G. Adams 3424*, CANB381845). E. *Gamochaeta antillana* (*C.W.E. Moore 9263A*, CANB449516). F. *Gamochaeta impatiens* (*B.J. Lepschi 664*, CANB420076). G. *Gamochaeta purpurea* (*R.W. Purdie 9200*, CANB869445). All specimens are to the same scale.

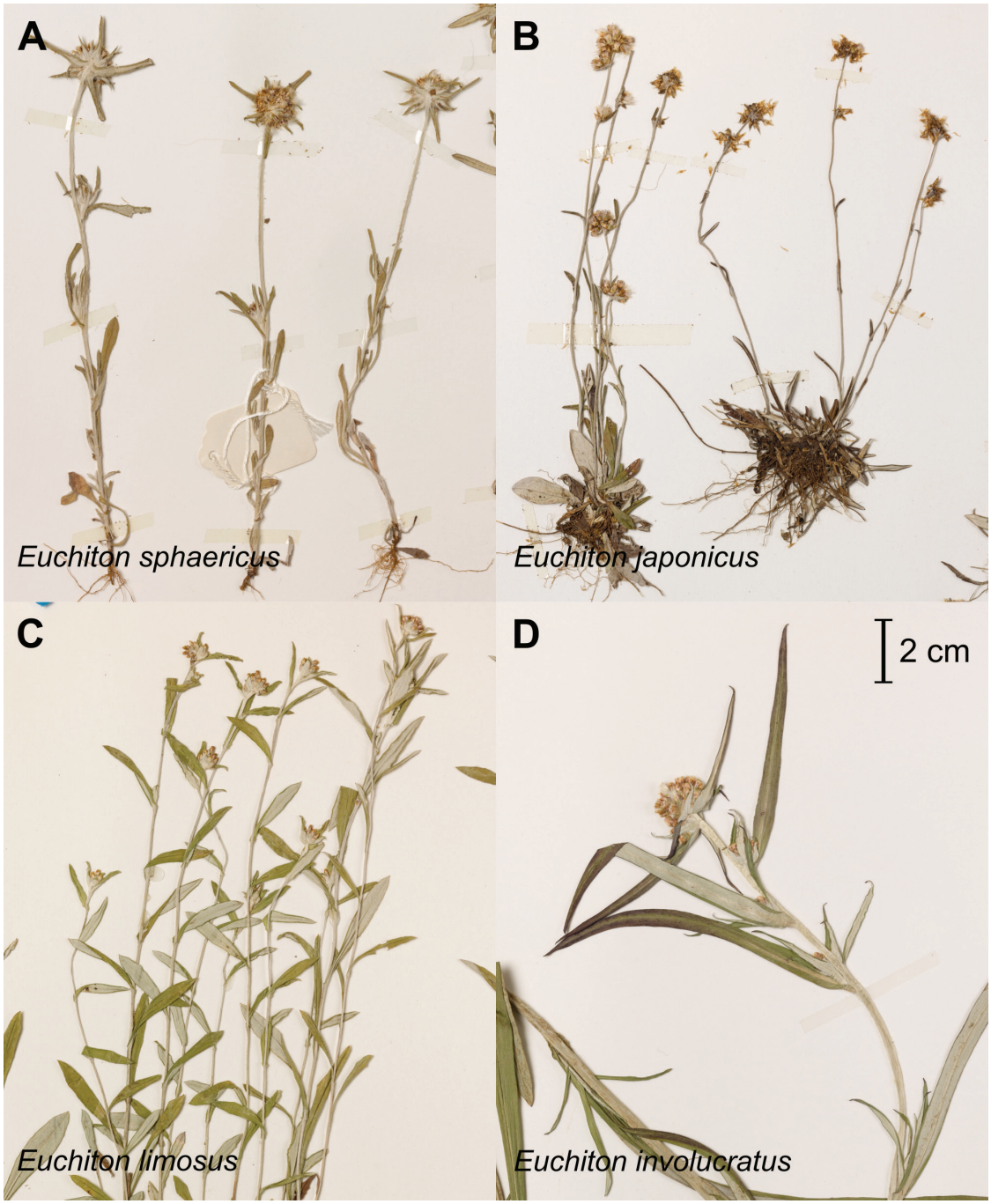

Figure 7. Species with clusters of flowerheads on erect to ascending stems and leaves glabrous or weakly hairy on the adaxial surface. A. *Euchiton sphaericus* (E.M. Canning 4835, CBG7910036). B. *Euchiton japonicus* (*B.J. Lepschi 737*, CANB425560). C. *Euchiton limosus* (*L.G. Adams 3950*, CANB376767). D. *Euchiton involucratus* (*N.M. Taws 1240*, CANB619562). All images are to the same scale.

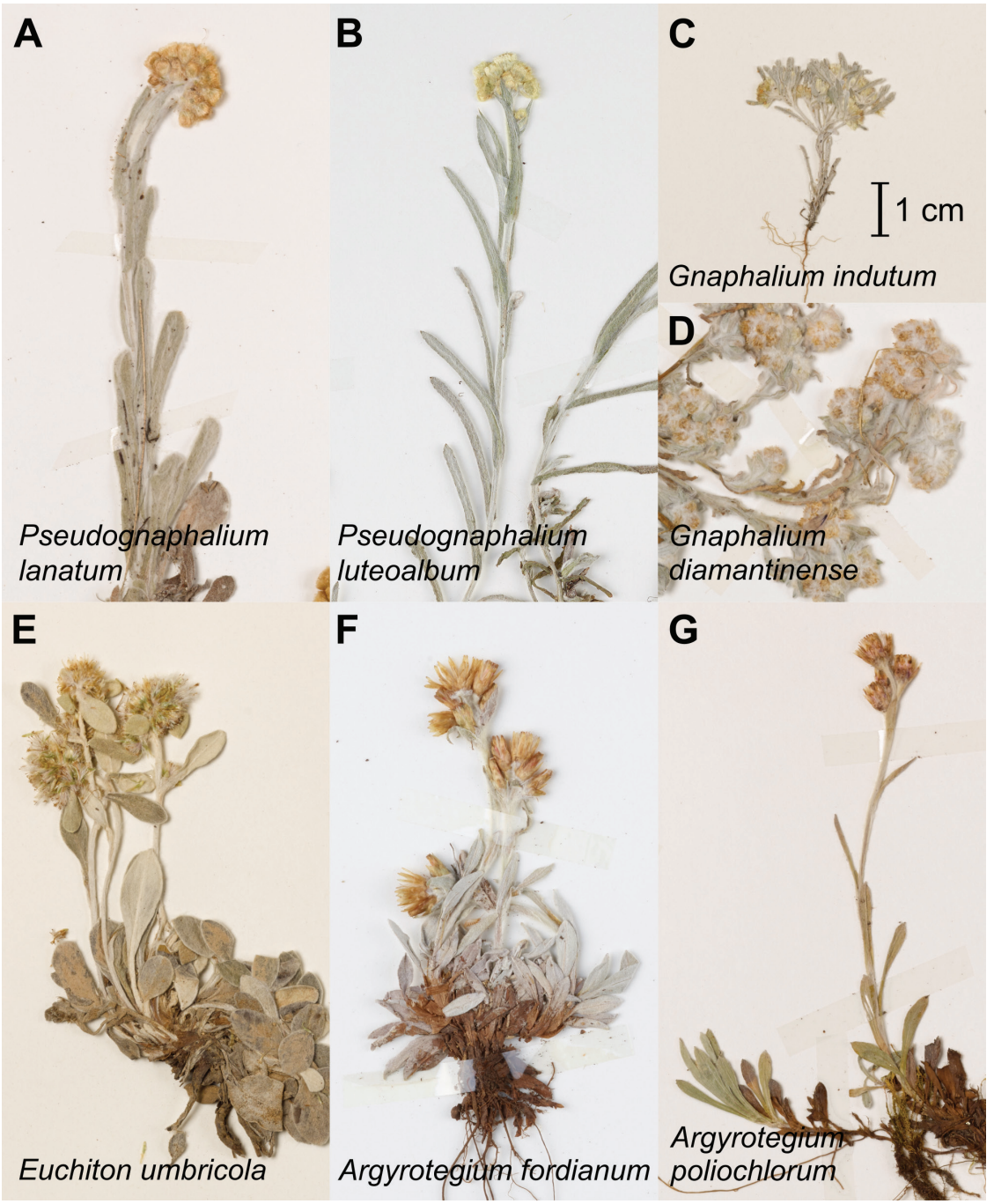

Figure 8. Species with clusters of flowerheads on erect to ascending stems and leaves distinctly hairy on both surfaces. A. *Pseudognaphalium lanatum* (*A.N. Schmidt-Lebuhn 1516*, CANB813011). B. *Pseudognaphalium luteoalbum* (*D.E. Albrecht 15432*, CANB909690). C. *Gnaphalium indutum* (*P.C. Heyligers 83003*, CANB349085). D. *Gnaphalium diamantinense* (*R.W. Purdie 8642*, CANB811339). E. *Euchiton umbricola* (*C. Totterdell s.n.*, CANB332612). F. *Argyrotegium fordianum* (*A.N. Schmidt-Lebuhn 1593*, CANB867561). G. *Argyrotegium poliochlorum* (*G.T. Wright s.n.*, CANB578743). All images are to the same scale.