

A new key to *Grimmia* in Britain and Ireland

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Work on developing a new key to British and Irish *Grimmia* by the author was initiated in 2012, and an invitation to lead a BBS workshop on *Grimmia* (see report on p. 63) hastened its completion. Nomenclature follows Hill *et al.* (2006) (with the exception of *Grimmia sessitana* and *Grimmia cribrrosa*). This is a rather traditional approach, and disregards any phylogenetic connections. The consensus is that *Grimmia* is a polyphyletic taxon and Ochyra *et al.* (2003) proposed splitting *Grimmia* based to some extent on traditional treatments and subgenera (eg: Hagen, 1909) and recognised 7 genera: *Orthogrimmia*, *Streptocolea*, *Grimmia*, *Dryptodon*, *Guembelia*, *Hydrogrimmia* and *Schistidium*. This classification is not without merit and it has been adopted by some

△Above. *Grimmia laevigata* with sporophytes showing mitrate calyptra. R. Porley.

workers (eg: Goffinet & Buck, 2004). However, it remains to be universally accepted and it seems the jury is out pending molecular studies.

Some recent molecular evidence supports the classification of Ochyra; Hernández-Maqueda *et al.* (2008) resolved *Dryptodon* as an independent genus and *Schistidium* was strongly resolved as monophyletic. They also found *Coscinodon* was firmly rooted in *Grimmia*, as is *Hydrogrimmia* (a cold glacier-fed mountain-stream species in Europe). However, the analysis did not make use of DNA regions that were informative enough to resolve the question of further genera within *Grimmia*. Therefore, even when *Dryptodon* and *Schistidium* are excluded, *Grimmia* remains a large and enigmatic genus.

Key to *Grimmia* (including *Coscinodon*)

TS = Transverse Section

- 1a. Hyaline hair point totally absent on all leaves (beware mucous forms eg: *G. incurva*, *G. elongata*).....2
- 1b. Hyaline hair point always present, at least on some leaves, occasionally much reduced.....4
- 2a. Dorsal surface of nerve in TS with distinct wings or ridges, leaf apex toothed; capsules rare, emergent on arcuate seta.....*G. ramondii*
- 2b. Dorsal surface of nerve lacking ridges, leaf apex entire.....3
- 3a. Lamina and costa TS in upper half of leaf 2-5 stratose consisting of uniform cells; alar cells not differentiated, unistratose; apex broadly obtuse, often cucullate; capsules occasional in Britain, emergent, seta straight.....*G. unicolor*
- 3b. Lamina mostly unistratose in TS except for bistratose patches and upper margin, alar cells differentiated, bistratose, often hyaline; apex narrowly obtuse, occasionally cucullate; capsules occasional, emergent, seta straight.....*G. atrata*
- 4a. Clusters of multicellular gemmae at apex of upper leaves, apex mucronate or truncate after their release5

- 4b. Leaves lacking clusters of multicellular gemmae at apex.....6
- 5a. Gemmae brownish; leaves narrow, ±secund when moist, often falcate; lacking cuticular ridges; central strand in TS stem lacking, with nearly uniform cortical cells sharply demarcated from 2-3 layers of brownish thick-walled epidermal cells with small lumina; nerve on dorsal side angulate (rarely winged) in upper part; nerve in TS with 6 guide cells at insertion; capsules unknown in Britain and Ireland..... *G. hartmanii*
- 5b. Gemmae yellowish-brown; leaves erect with an inflated aspect when dry, broad, patent to spreading when moist; mid-leaf to apical part of leaf striolate in surface view due to cuticular ridges, appearing as papillae over cell lumens in TS of leaf; central strand in TS stem weak or absent, epidermal cells smaller; nerve in TS with 4 guide cells at insertion; capsules unknown in Britain and Ireland.....*G. anomala*
- 6a. Basal marginal cell walls thickened, often with the transverse wall more thickened than the longitudinal wall.....10
- 6b. Basal marginal cell walls uniformly thin7
- 7a. Leaves incurved when dry (reminiscent of *Dicranoweisia crispula*), in TS apex forming a terete subula (ie: not channelled) of homogenous cells, exterior cell walls more heavily thickened than interior walls (best seen in TS mid-leaf and subula), cells on the abaxial surface of nerve above mid-leaf longer than adjacent laminal cells; hair point of variable length, sometimes lacking; capsules very rare in Britain.....*G. incurva*
- 7b. Leaves ± straight to slightly flexuose when dry, leaf apex channelled.....8
- 8a. Hyaline hair point often much reduced, many leaves mucous; proximal leaf margins with 3-4 narrowly elongate rectangular hyaline thin-walled cells with outer row extending to mid-leaf, laminal cells above leaf base strongly sinuose, cells on the abaxial surface of nerve ± similar length to the adjacent laminal cells; in brownish-green cushions; capsules unknown in Britain.....*G. elongata*
- 8b. Plants lacking above combination of characters, usually hoary plants with conspicuous hyaline hair points; capsules common.....9
- 9a. Plants forming rounded cushions with ±erect, heteromallous and slightly flexuose leaves; basal marginal cells elongate-rectangular, thin walled, vanishing in broadest part of leaf; capsules common, exerted on straight seta.....*G. donniana*
- 9b. Plants forming low mats with homomallous leaves; basal marginal cells elongate-rectangular, thin walled, vanishing in broadest part of leaf; capsules common in Britain, seta curved and capsule held horizontal.....*G. arenaria*
- 10a. Upper half of leaf in TS with distinct plicae, in profile forming a 'W', appearing as lines either side of nerve, rarely extending into leaf base, plicae in TS sometimes with differentiated (smaller) ventral cells; calyptra campanulate, prominently plicate, peristome teeth strongly cribrate (perforated).....*G. (Coscinodon) cribrrosa*
- 10b. Plants lacking plicae in upper half of leaf, not forming a 'W' profile in TS, (do not confuse with

- striae due to variable stratosity); calyptra mitrate or cucullate, \pm smooth, peristome cribose or not.....11
- 11a.** Leaf profile broadly concave in TS (lunate to semi-circular), nerve indistinct dorsally, lamina bistratose-multistratose; margins plane.....12
- 11b.** Leaf profile not concave in TS, keeled or with nerve well-defined dorsally.....14
- 12a.** Basal paracostal cells rectangular with usually smooth walls, towards margin isodiametric, in sheathing part a large well-defined zone of oblate (wider than long) or oval thick-walled cells; TS lamina bistratose (or very occasionally tristratose) above transitional part, outermost row of marginal cells mostly unistratose in 1-3 rows to near apex; leaf with a broad base partly sheathing stem, smooth and rounded on dorsal surface, nerve ill-defined; capsules exserted, rare in Britain, unknown in Ireland.....*G. laevigata*
- 12b.** Large well-defined zone of oblate cells in sheathing part of lamina absent.13
- 13a.** Leaves ovate-lanceolate, smooth dorsally with ill-defined nerve; ventral cells of nerve in TS with heavily thickened outer walls; basal paracostal cells elongate-rectangular with nodulose walls, rectangular towards margin, some marginal rows hyaline, vanishing in broadest part of leaf; guide cells at insertion 6-8, well defined; hair point variable, sometimes very short; lamina bistratose, occasionally tri- or quadristratose; capsules ovoid, emergent, rare in Britain.....*G. ovalis*
- 13b.** Leaves with a broad base partly sheathing stem, smooth and rounded on dorsal surface, nerve ill-defined; ventral cells of nerve in TS with evenly thickened walls; basal paracostal cells elongate-rectangular with smooth to slightly nodulose walls; outermost row of marginal cells in laminal part bistratose occasionally tristratose; hair point normally well-developed; guide cells in laminal part in TS ill-defined, similar to the adjacent lamina cells; capsules immersed, very rare in Britain.....*G. tergestina*
- 14a.** Upper leaf lamina in TS with scattered hemispherical papillae (sometimes obscure, best viewed in TS); basal paracostal cells thick-walled, nodulose, elongate-rectangular; nerve in TS from leaf insertion to lower laminal part with guide cells in two tiers, costal cells nearly homogenous, hydroids lacking; lamina in upper part bistratose, occasionally tri-quadristratose; margin from insertion to above mid-leaf revolute on one side, recurved on the opposite side; large robust plants; capsules unknown in Britain.....*G. elatior*
- 14b.** Upper leaf lamina in TS without papillae.....15
- 15a.** Nerve in TS with 6-8 guide cells at insertion.....16
- 15b.** Nerve in TS with 4 guide cells at insertion or with the outer two \pm contiguous with the basal cells.....20
- 16a.** Basal paracostal cells with strongly nodulose walls (very rarely thin walled and smooth).....17
- 16b.** Basal paracostal cells normally with smooth or weakly nodulose walls.....19
- 17a.** Margin recurved or revolute on the broader side of leaf from insertion to above mid-leaf and mostly plane on the opposite side; basal paracostal cells elongate-rectangular with markedly small and oblique end walls; in upper part of leaf on dorsal side smoothly keeled (channelled), in lower part of leaf in TS nerve reniform, at mid-leaf angulate; lamina in mid-leaf partly bistratose, in upper lamina mostly bistratose; capsules common, emergent on erect setae, smooth when dry.....*G. longirostris*
- 17b.** Margin recurved or revolute to mid-leaf on one side and recurved on opposite side (ie: both margins variously recurved); lamina mostly bistratose except at margins; capsules ribbed.....18
- 18a.** Basal paracostal cells strikingly narrow with heavily thickened normally nodulose walls, elongate to elongate-rectangular, abruptly contrasting with a narrow zone of hyaline short-rectangular to quadrate basal marginal cells, vanishing at broadest part of leaf; one to several marginal rows in upper part bistratose; upper part of leaf on dorsal side keeled, nerve slightly angulate or uneven, rounded at apex; leaves loosely arranged on stem, spreading (45°-60°) when moist; hyaline hair point straight and normally sharply denticulate; capsules common, strongly ribbed when dry.....*G. decipiens*
- 18b.** Basal paracostal cells wider, rectangular to elongate-rectangular, walls nodulose but not heavily thickened or narrowed, grading into short-rectangular to quadrate cells towards margin with some rows of hyaline cells extending up margin to broadest part of leaf; lamina bistratose at margin; nerve in TS angulate to emarginate in apical part of dorsal lamina; leaves densely arranged on stem, patent (\pm 45°) when moist; hair points often reflexed in dry state; capsules unknown in Britain and Ireland*G. muehlenbeckii*
- 19a.** Leaves distinctly squarrose when moist, occasionally spreading; central strand in TS stem well defined; guide cells in TS nerve at insertion 6, rarely 7 or 8; nerve on dorsal side rounded in upper part; gemmae rare to occasional, on dorsal side of leaf base; capsules very rare in Britain and Ireland.....*G. lisae*
- 19b.** Leaves narrow, \pm secund when moist, often falcate; central strand in TS stem lacking, with nearly uniform cortical cells surrounded by 2-3 layers of cells with small lumina of brownish colour; nerve on dorsal side angulate (rarely winged) in upper part; nerve in TS with 6 guide cells at insertion; brownish gemmae in clusters sometimes on leaf apices; capsules unknown in Britain and Ireland.....*G. hartmanii*
- 20a.** Mid-leaf to apical part striolate in surface view due to cuticular ridges, appearing as papillae over cell lumens in TS of leaf; leaves broad, patent to spreading when moist; globose multicellular yellowish-brown gemmae on apices of upper leaves; leaves erect with an inflated aspect when dry; central strand in TS stem weak or absent; capsules unknown in Britain and Ireland.....*G. anomala*
- 20b.** Plants lacking cuticular ridges, without gemmae on upper-leaf tips.....21
- 21a.** Plants always with catenulate (chain-like) shoots (look inside dry cushion at base of old stems) with ovate, concave leaflets with apices directed to stem; leaves asymmetric with sigmoid (S-shaped) nerve, leaves \pm spirally imbricate when dry; basal paracostal cells elongate-rectangular with heavily thickened nodulose walls; guide cells in TS nerve in laminal part of leaf oblique; stem TS central strand of thin-walled cells contrasting with heavily thick-walled, orange-coloured

- cortical cells; capsules occasional, emergent, seta arcuate when moist.....*G. funalis*
- 21b.** Catenulate shoots lacking (if flagelliform shoots present, then leaflets not concave or with apices directed to stem); plants lacking above combination of characters.....22
- 22a.** Leaves in TS in distal $\frac{2}{3}$ predominately bistratose, only leaf base unistratose.....23
- 22b.** Leaves in TS in distal $\frac{2}{3}$ predominately unistratose, or bistratose at margins, in apical part or as patches in lamina.....25
- 23a.** Exterior walls of laminal cells in TS conspicuously bulging on dorsal and ventral sides, all cells isodiametric, rounded; margins plane throughout; capsules unknown in Britain (very rare mountain plant).....*G. alpestris*
- 23b.** Exterior walls of laminal cells in TS smooth, or if slightly bulging then at least some cells in mid-to upper part of lamina with isodiametric rounded cells together with some short-rectangular lumens aligned side by side; margins plane or recurved; capsules present or not.....24
- 24a.** Leaf margin plane throughout; in profile leaf concave from leaf base to upper part of leaf, upper third of lamina keeled, margins from leaf base becoming gradually more strongly incurved (in TS resembling tongs); laminal cells in TS mostly with short-rectangular lumens aligned side by side; in laminal part of leaf bistratose, tristratose to occasionally quadristratose in apex; plant forming dark green cushions; capsules rare in Britain, lacking stomata.....*G. montana*
- 24b.** Margin recurved from base to \pm broadest part of leaf, or in mid-leaf only or plane, lamina spreading from nerve, weakly incurved in upper part, ventral sinus of nerve narrow; basal paracostal cells of upper leaves thin-walled, smooth, elongate-rectangular with basal marginal cells similar in length, contrasted to lower leaves with short-rectangular to quadrate marginal cells; lamina in TS with some bistratose patches, in surface view seen as striae, sometimes partly or completely bistratose in upper part; plants forming blackish patches; capsules common, stomata in base...
.....*G. sessitana*
- 25a.** Leaf lamina and margin unistratose throughout; leaves markedly narrowed at insertion, greatest width above middle (spathulate), tapering to rounded apical part ending in hyaline hair point of variable length, often pointing in same direction; margins plane or slightly recurved in upper part of leaf; capsules common, ovoid, immersed on short curved seta.....*G. crinita*
- 25b.** At least margin in upper part of leaf bistratose.....26
- 26a.** Plants in dry state with crispate leaves, loosely spirally twisted around stem; lower stem dark brown in colour, stem tip yellowish-green; rounded, brown multicellular gemmae on filaments developed on proximal dorsal side of nerve of older leaves; basal paracostal cells heavily thickened, nodulose, cells towards margin rectangular; hair point short (sometimes reduced to a few hyaline cells); capsules unknown in Britain and Ireland.....*G. torquata*
- 26b.** Plants in dry state with \pm straight or flexuose leaves, not spirally twisted around stem.....27
- 27a.** Leaf margins plane throughout; nerve widening in upper part of leaf; nerve in TS with median group of hydroids throughout, stereids lacking; laminal cells in TS rectangular (2x long as wide) aligned side by side at right angles to lamina; basal paracostal cells elongate-rectangular, smooth walled, towards margin cells rectangular or quadrate, at margin 2 or 3 rows of rectangular hyaline

- cells extending to broadest part of leaf; in upper lamina 1 or 2 rows marginal cell rows bistratose; capsules common, ovoid ventricose, immersed on curved or straight setae, mouth wide following dehiscence, peristome absent.....*G. anodon*
- 27b.** Leaf margins variously recurved.....28
- 28a.** Leaf base ovate, \pm broadest at mid-leaf, leaf \pm elliptic in shape, apex obtuse.....31
- 28b.** Leaves tapering from just above leaf base, narrowing to an acuminate apex.....29
- 29a.** Guide cells in nerve TS at insertion and in leaf base arranged in 2 layers, the median layer of 1-2(3) cells smaller than the ventral guide cells but larger than surrounding costal cells; basal paracostal cells elongate-rectangular, \pm smooth, basal marginal cells narrow elongate-rectangular, hyaline, extending up margin to transitional part; capsules occasional, ellipsoid, ribbed, exerted on arcuate seta.....*G. trichophylla*
- 29b.** Guide cells in nerve TS at insertion and in leaf base arranged in a single layer; basal paracostal cells elongate-rectangular, \pm nodulose, basal marginal cells mostly short-rectangular.....30
- 30a.** Basal paracostal cells in few rows, rectangular, weakly nodulose, other basal cells broad, short rectangular, of nearly the same length, walls thickened, nodulose; at margin some rows of nearly isodiametric cells with smooth walls; margin recurved at one side from leaf base to upper part of lamina, if recurved on opposite side then only weakly so; hydroids present in costa; leaves widely spreading when moist; (normally on basic rock such as limestone); capsules unknown in Britain and Ireland.....*G. dissimulata*
- 30b.** Basal paracostal cells in several rows, broad, rectangular to elongate-rectangular, walls not thickened, nodulose, basal marginal cells short-rectangular to quadrate, at margin some rows of hyaline cells, vanishing in transitional part; broader side of leaf recurved to above mid-leaf, on opposite straight side recurved at mid-leaf only; leaf asymmetric (best seen in TS of lower leaf, with greater number of cells from margin to nerve on the broader straighter side, and fewer cells on the narrow curved side); hydroids lacking; leaves densely arranged, patent (\pm 45°) when moist; hair points often reflexed when dry; (normally on basic igneous and ultra-basic rocks); capsules unknown in Britain and Ireland.....*G. muehlenbeckii*
- 31a.** Basal paracostal cells rectangular-elongate, walls \pm nodulose, towards margin rectangular to quadrate, hyaline, transverse walls thickened, smooth; margins recurved on both sides at mid-leaf; nerve in TS at base on dorsal side with bulging cells; margin bistratose at most in 1-(2) rows in apical part; profile of leaf spreading ($>90^\circ$) viewed in TS; forms lax readily disintegrating tufts; perigonia terminal; capsules common, ovoid, seta exerted, curved when moist, operculum conical, mammillate, calyptra cucullate.....*G. orbicularis*
- 31b.** Basal paracostal cells rectangular, walls smooth, weakly sinuose or not, towards margin rectangular or short-rectangular, at margin quadrate, transverse walls thickened, smooth; margin recurved on one side from leaf base, on opposite side from above leaf base to above the broadest part of leaf; nerve in TS at base on dorsal side smooth; margin (1 or 2 rows) bistratose in upper part, occasionally tristratose; profile of leaf forming a right angle ($\pm 90^\circ$) viewed in TS; forms neat rounded cushions; perigonia axillary; capsules common, obloid, in immature/mature state when moist seta arcuate and capsule hidden in cushions, operculum rostrate or rostellate, occasionally conical, calyptra mitrate.....*G. pulvinata*

Notes on the 29 British & Irish *Grimmia* (including *Coscinodon*)

Grimmia alpestris (F. Weber & D. Mohr) Schleich.

Most bryologists are unlikely to encounter this species in Britain, although in central Europe it is not uncommon in the mountains. Indeed, there is some doubt regarding the provenance of the British specimen. Transverse leaf sections are required to confirm this species; the key characters are isodiametric rounded bulging cells and plane to incurved margins. Striae are sometimes apparent in the upper leaf due to variable stratosity but do not represent folds (plicae) as seen for example in *G. cribrata* (*Coscinodon*). For separation from *G. sessitana* see comments under that species. The brownish capsules lack stomata and the exothecial cells are thick-walled but sporophytes are not known in Britain.

Grimmia anodon Bruch & Schimp.

Usually *G. anodon* is abundantly fertile with cushions carrying capsules, and then identification is straightforward. The immersed ventricose capsule, held on a short sigmoid seta, has no peristome and the mouth is very wide at dehiscence.

Grimmia anomala Schimp.

This recently recognised species in Britain and Ireland (Lönnell *et al.*, 2012) has been confused with *G. hartmanii* because it also has gemmae, albeit yellowish rather than brownish, on upper leaf tips. However, the leaf shape in both dry and moist states differs, being broader and somewhat concave in *G. anomala*.

In transverse leaf sections however the pseudopapillae (joint thickenings) are evident, seen as faint striae on the lamina surface. The central stem strand is weakly developed. Capsules are unknown in Europe.

Grimmia arenaria Hampe

Typical plants of *G. arenaria* are distinctive with homomallous leaves when dry pointing in one direction as if brushed, often with very long hyaline hair-points, and capsules held horizontal on curved setae. Maier (2010) is of the opinion that *G. arenaria* is synonymous with *G. donniana* and of the rank form. Limpricht (1889) and Loeske (1930) concurred with this view and Corley *et al.* (1981) also considered it to be synonymous with *G. donniana*; in Smith (1978) it was treated at varietal level as *G. donniana* var. *curvula*. A full range of intermediates between straight seta (*G. donniana*) to curved seta (*G. arenaria*) has been reported (Maier, 2010). Seta length from 0.8–2.5 mm may be present in the same cushion (varieties with short seta have been named *G. triformis*). The homomallous leaves, characteristic of *G. arenaria*, are probably a response to environmental conditions (costal architecture and basal areolation remain identical with *G. donniana*).

Grimmia atrata Hornsch.

This species forms dark green to blackish cushions with mucous lingulate-lanceolate leaves sometimes with a cucullate apex. The leaves in TS are predominately unistratose, bistratose only at the margin and apex, not manifesting the multistratose lamina revealed in the superficially similar *G. unicolor*. Uniquely in *Grimmia*, the alar cells are bistratose (sometimes only on one side of the leaf) and often hyaline (in older leaves the alar walls are thicker and brown).

The isolated position of this taxon has been recognized for some time, and Ochyra *et al.* (2003) raised subgenus *Streptocolea* (established by Hagen, 1909) to genus rank to accommodate *G. atrata*. This is on the basis of at least 4

characters; the most peculiar of these is torsion of the vaginula to the left, a character not known in the Grimmiaceae or indeed any other moss genus. It is likely that Ochyra's opinion will prove correct, but it seems molecular support is waited for.

Grimmia cribrata Spruce

More familiar as *Coscinodon cribratus*, the use in the present key of *Grimmia cribrata* is a departure from the most recent checklist of mosses of Europe (Hill *et al.*, 2006) and census catalogue (Hill *et al.*, 2008). Molecular analysis (Hernández-Maqueda *et al.*, 2008) has placed *Coscinodon* within *Grimmia* and this view appears to be consensual. It is more convenient to have *Coscinodon* in the same key as *Grimmia*, and does not add to its complexity.

Coscinodon species have gametophytes identical to species in *Grimmia* and conventionally both genera can only be distinguished by sporophytic characters; *Coscinodon* has a plicate campanulate calyptra covering most or the entire capsule whilst *Grimmia* has a smooth, mitrate or cucullate calyptra not reaching much beyond the capsule mouth. However, this is not as absolute as once thought, as *Grimmia* may have calyptrae that are essentially campanulate (see *G. montana*). Furthermore, not all *Coscinodon* have perforated peristomes or plicate leaves, whereas some *Grimmia* have plicae or perforated peristomes (eg: *G. orbicularis*, *G. montana*). *Grimmia cribrata* when sterile can be confused with *G. caespitica* but this species (which also has distal plicae, albeit with mammillose bulging cells in TS) does not occur in Britain or Ireland.

Grimmia cribrata has plicae in the upper lamina, seen in TS as folds, or as lines of multistratose cells on either side of the nerve which gives a distinctive 'W' profile on a microscope slide. The plicae in TS sometimes show smaller ventral cells

reminiscent of a secondary costa. At other times the plicae are weakly developed, and they only rarely extend into the leaf base. The sporophyte characters (plicate campanulate calyptra, cribrate peristome teeth, brownish in colour and darker than the capsule) help with identification, but only rarely are capsules present. *Grimmia cribrata* is said to be hygrocastic, that is, the peristome opens when wet and closes when dry. The capsules superficially resemble those of *Schistidium* species, but the columella is persistent, not falling with the operculum.

Grimmia crinita Brid.

The obovate leaves, narrowed at the base and widest above mid-leaf with a rounded apex, plane margins (occasionally recurved in upper part of leaf) and long hyaline hair-points pointing in the same direction serve to identify this species in the field. Microscopically the leaf shape together with a unistratose lamina and smooth broad rectangular basal paracostal cells confirms *G. crinita*.

Grimmia decipiens (Schultz.) Lindb.

Normally well-developed *G. decipiens* does not present any great identification issues. It is typically a robust species, often with falcate upper leaves and with strongly ribbed elongate emergent capsules on curved or flexuose setae. The hyaline hair-point is usually dentate but this is variable. The basal laminal cells are distinctive, with a broad zone (up to $\frac{3}{4}$ of width of leaf base) of elongate-rectangular, thick-walled and nodulose paracostal cells (although sometimes thin-walled and smooth) abruptly giving way to a few rows of short-rectangular to quadrate marginal cells. In TS the broad angulate reniform nerve is 6 (sometimes up to 8) heavily thickened guide cells at insertion, keeled in the upper part, and the upper lamina is variously bistratose.

Grimmia dissimulata E. Maier

In habit similar to *G. trichophylla*, although when dry the leaves tend to be more flexuose than that species. The substrate is a good clue that *G. dissimulata* may be to hand – it is usually associated with limestones and other base-rich rocks, quite unlike *G. trichophylla*. In Europe however, *G. dissimulata* can also occur on granitic rocks. Under the microscope, transverse leaf sections show 4 guide cells at insertion in a single tier only. Also the elongate-rectangular basal paracostal cells are often slightly nodulose and occupy only a few (3 or 4) rows (often double the number of rows in *G. trichophylla*) and the basal marginal cells are not as narrow and elongate as in that species. Propagules are present on the proximal dorsal lamina in European plants but have not been observed in Britain or Ireland.

Grimmia meridionalis (Maier, 2002a), a species similar to *G. dissimulata* and *G. trichophylla* and which occurs in Europe (particularly the Mediterranean region), could turn up in Britain. This species also has 4 guide cells in the costa at insertion in a single tier, but the basal elongate-rectangular paracostal cells are distinctly thick-walled and nodulose, the guide cells in the broadest part of the leaf are \pm elliptic and oblique forming an angle to the axis (but not always convincing) and the basal region of the lamina is often yellow (pigmented cell walls).

Grimmia donniana Sm.

This and *G. arenaria* are impossible to separate on microscopic leaf characters and can only be distinguished on sporophytic characters. Maier (2010) considers them to be conspecific, citing identical peristomal characters and a range of intermediates in terms of length and curvature of seta. *G. donniana* has straight setae, whilst *G. arenaria* has curved setae. Whether this represents one variable taxon awaits molecular analysis.

Grimmia elatior Bruch ex Bals.-Criv. & De Not.

This relatively robust species is rare in Britain, but identification is normally straightforward. Under the microscope the basal paracostal cells are elongate-rectangular with distinctly nodulose and thickened cell walls, becoming shortly-rectangular at the margin. The upper lamina in TS usually shows papillose cells (occasionally smooth) and the lamina is inserted ventrally on an angulate costa forming a narrow channel or deep furrow. There is also a second row of guide cells immediately below the ventral guide cells (see *G. trichophylla*).

Grimmia elongata Kaulf.

The clue to this species is the brownish to dark green cushions with very short hyaline hair-points, sometimes apparently mucicous (but under the microscope at least a few hyaline cells are present at the apex). Particularly characteristic of *G. elongata* are the thin-walled basal marginal cells with the outermost row extending to the broadest part of the leaf where the cells abruptly become short-rectangular and strongly sinuose.

Grimmia funalis (Schwaegr.) Bruch & Schimp.

When dry the neat spirally arranged leaves of *G. funalis* normally allow for easy identification, although this is not always so well-developed – then it can be puzzling. The leaves are characterized by a slightly sigmoid (S-shaped) nerve, seen when a leaf is placed flat on a microscope slide, and this results in the characteristic twist of each leaf when dry, the shoots often described as string-like. When moist the twisting is much less evident. More or less diagnostic however is the distinctive catenulate flagelliform shoots hidden within the cushions, consisting of concave leaflets with apices incurved towards the axis. Other species also have flagelliform shoots, for example *G. montana*. Important microscopic

characters are found in the TS of stems which have a thin-walled central strand (rarely lacking) surrounded by thick-walled orange-tinged cortical and epidermal cells, and in nerve TS obliquely arranged guide cells in the laminal part of the leaf.

Grimmia bartmanii Schimp.

Can be confused with the trichophylla group, but when moist the leaves tend to be secund, sometimes falcate, when dry they are more or less straight (not flexuose), and when the characteristic brownish gemmae on upper leaf tips are present there can be little doubt that this species is at hand. Upper leaves with gemmae released are truncate or mucronate.

In transverse leaf sections the nerve is wide, with 6 guide cells at insertion, avoiding confusion with *G. trichophylla*. From *G. lisae* it can be separated by the shorter basal cells and, in TS, the usually distinctly angular, sometimes emarginate nerve and absence of a central strand in the stem.

Grimmia incurva Schwaegr.

Normally easy to recognise by the dark green to blackish cushions with incurved narrow leaves looking more like *Dicranoweisia crispula* than a *Grimmia* since hair-points are usually very short and not immediately obvious. The rounded leaf apex consisting of homogenous cells with thickened exterior walls when viewed in TS is very distinctive of this species.

Two ‘morphs’ were once recognised: a long leaved form (fo. *longifolia*) and a short leaved form (fo. *brevifolia*). These are distinct enough in the field, but mixed cushions also occur. Maier (2010) states the mucicous short-leaved form are sterile plants, whilst long-leaved forms with longer hair-points are fertile capsule-bearing plants.

Grimmia laevigata (Brid.) Brid.

The broad concave imbricate (when dry) leaves with a smooth dorsal surface, plane margins and long hyaline hair-points usually render *G. laevigata* readily identifiable in the field. However, mucicous forms do exist, and when moist such forms can superficially resemble an *Andreaea* rather than *Grimmia*. Microscopically the large zone of oblate cells in the leaf base towards the margin is more or less diagnostic for *G. laevigata*. Another good character is that although much of the upper lamina is bistratose the outermost marginal row is mostly unistratose (as opposed to *G. tergestina* where the outermost row is mostly bistratose). Another useful character to separate *G. laevigata* from *G. tergestina* in doubtful cases is that the former, in the upper lamina, has 2 guide cells sunken into a narrow channel with very heavily thickened ventral walls.

Grimmia lisae De Not.

This is a very variable species in habit and areolation. It looks similar to *G. trichophylla* and *G. dissimulata* when in the dry state, but when moistened the leaves quickly bend backwards and normally remain squarrose, but there are forms with patent to spreading leaves when moist. It differs from the aforementioned species in the leaf TS at insertion with at least 6 guide cells, rarely 7 or 8, in a single tier. The basal rectangular paracostal cells are smooth to weakly nodulose and the basal marginal cells are rectangular to quadrate (generally shorter than in *G. trichophylla*). Propagules do not seem to be as common in British or Irish material as they are in plants from Mediterranean regions; gemmae occur on the proximal dorsal lamina (see Porley & Pressel, 2012 for information on gemmae in *Grimmia*). Sporophytes have only once been reported in Britain (Blockeel, 2016). In the first edition of Smith (1978) *G. lisae* was under the

name of *G. retracta*, and was then considered to be a largely western species; today there are increasing numbers of records from the east.

***Grimmia longirostris* Hook.**

Neat round cushions of *G. longirostris* characteristically adorned with emergent smooth capsules with a long beak are normally easy to recognise, but it can be puzzling at times. The narrow leaves are rounded on their backs (dorsal surface) in the upper part with an indiscernible nerve, and the margin is recurved below to above mid-leaf (as distinct from *G. ovalis*) normally on one side only. Under the microscope, the leaf in TS at insertion consists of 6 (rarely less) guide cells in a single tier, and the basal paracostal cells, in several rows, are conspicuously elongate-rectangular with thickened nodulose longitudinal walls with markedly narrow and oblique end walls. The upper part of the leaf in TS shows the smooth keeled lamina, whereas in the lower half of the leaf the nerve is prominent, angulate and tending towards reniform. The last character, a reniform costa with a U-shaped adaxial sinus, is said by Smith (2004) to provide an absolute character separating *G. longirostris* from all other *Grimmia* species. A reniform costa is seen in other species and anyway shows variability. The hair-point varies from obscurely to strongly denticulate.

***Grimmia montana* Bruch & Schimp.**

Under dry field conditions the upper lamina is narrow with incurved margins and a smooth dorsal surface, and often the plants are dark green to blackish, sometimes with a glaucous (greyish) aspect. Transverse leaf sections normally confirm this species if in doubt. The form of the leaf in TS is characteristic; it is concave with a 'U' shaped profile, with the margins from leaf base to apex becoming gradually more incurved,

never recurved. If the plant presents a recurved leaf margin (however weak) then *G. sessitana* must be considered. The lamina lacks plicae but may appear striate due to variable stratosity. The cell lumens in TS are short-rectangular, aligned side by side at right angles to the lamina, and there is a row of transversely oval marginal cells at or just above the shoulder, a character said to separate *G. montana* from *G. sessitana* (Maier, 2010) (although *G. sessitana* plants may also show a few oblate cells at the shoulder region so this character must be used with caution). In both species the basal marginal cells have thickened transverse walls, and there is much overlap in length of the basal paracostal cells of both species.

Grimmia montana capsules lack stomata. In the description of *G. montana* in *Flora briofítica Ibérica* (Muñoz *et al.*, 2015) it states "estomas en el cuello" but this is an error (the key is correct). The calyptra appears to be variable. In the literature it is usually described as cucullate, but I have seen material with mitrate if not campanulate calyptra, covering the entire capsule. Calyptrae are often absent from collections and statements regarding form tend to be repeated.

Smith (2004) suggested that *G. ungeri* could be confused with *G. montana* (separated by supposed autoicous condition) or *G. sessitana* and could not be separated in the absence of sporophytes; at this time *G. ungeri* was considered a good species and was on the British list based on a couple of old collections from Scotland. It is now considered a synonym of *G. montana* (Maier, 2010).

***Grimmia muehlenbeckii* Schimp.**

This species often forms largish dense and blackish cushions typically on dry basic igneous and ultra-basic rock such as basalt and periodotite. A good character is the densely

arranged straight patent leaves when moist (place a few shoots in a drop of water on slide). Like *G. trichophylla* it has 4 guide cells at insertion in leaf TS (occasionally 5 or 6), but in a single tier only. The elongate-rectangular basal paracostal cells are markedly nodulose (unlike *G. trichophylla* or *G. lisae*) in several rows but do not form narrow heavily thickened cells typical of *G. decipiens*.

Another useful character is the asymmetric leaf, with the straight and broader side being recurved from base to above mid-leaf, and the narrower rounded side recurved slightly at mid-leaf only. In a TS of the lower part of the leaf the broader side comprises a greater number of cells (counted from margin to nerve) compared to the rounded narrow side of the lamina. In the dry state the hyaline hair-points are often (but not exclusively) somewhat reflexed, reminiscent of *Campylopus introflexus*.

Propagules (on lamina) are reported in European plants but have not been observed in British or Irish material.

***Grimmia orbicularis* Bruch ex Wilson in Sm.**

Usually a species of limestone, *G. orbicularis* typically forms readily disintegrating blackish tufts or mats rather than neat cushions. When young sporophytes are present the conical mammillate lid and the rounder capsule and a small cucullate calyptra indicate *G. orbicularis*. In the absence of capsules separation from *G. pulvinata* can be difficult (see below and key).

***Grimmia ovalis* (Hedw.) Lindb.**

This species is best recognised by the stiff erect leaves when dry, with a smooth and shining dorsal upper leaf surface with an indistinct nerve, concave in TS, with plane to incurved margins. Transverse leaf sections show a characteristic wide nerve (6-8 or more guide cells at insertion) and bistratose (to multistratose) upper lamina.

***Grimmia pulvinata* (Hedw.) Sm.**

The combination of neat cushions, abruptly tapering leaf apex into a hyaline hairpoint combined with young sporophytes on a curved seta so the oval capsule is buried in the cushion normally makes this a readily recognized species. However, leaf shape and other gametophytic and sporophytic characters are very variable. Problems arise when sporophytes are absent or old (note that capsule is held erect when old). The elliptical shape of the leaf separates this species from all other British and Irish *Grimmia* except *G. orbicularis* and the two species can and often do occur together. A useful character for *G. pulvinata* is the TS of the upper lamina rests on the microscope slide with a profile of 90°, whilst in *G. orbicularis* the lamina is more spreading from the nerve and hence produces angles >90°. Also, the basal laminal cells of *G. pulvinata* tend to be shorter than in *G. orbicularis* but this is subject to much overlap.

With young capsules there should be little confusion since *G. pulvinata* has oval capsules, a longly rostrate lid and a mitrate lobed calyptra; only occasionally are lids with short beaks encountered, and these were once distinguished as *G. pulvinata* var. *africana*, but a whole range of intermediates links the two forms. In *G. orbicularis* the lid is conical mammillate and the capsule is shorter and rounder. The position of perigonia should also enable separation; in *G. pulvinata* they are axillary and in *G. orbicularis* are terminal.

***Grimmia ramondii* (Lam. & DC.) Margad.**

Normally presents no identification problems. The dorsal costal wings are a good distinguishing character. Rarely *G. hartmanii*, which sometimes has leaves that lack hair-points, may have costal wings but these are seldom as well developed as in *G. ramondii* and the basal areolation is different.

European material of *G. muehlenbeckii* often has dorsal costal wings (not expressed in British or Irish material) but again other leaf characters will easily separate the species.

Grimmia ramondii was moved back into *Dryptodon* by Ochyra *et al.* (2003) and recent molecular analysis supports this view (Hernández-Maqueda *et al.*, 2008), and is thus once again correctly known as *Dryptodon patens* (Hedw.) Brid. In the present treatment however it is retained as *G. ramondii*.

Grimmia sessitana De Not.

A particularly challenging species, but it is unlikely to be encountered in Britain; indeed despite targeted searches at its Scottish site it has not been refound and there is some doubt over its provenance given the low altitude (150 m). The *sessitana-alpestris-montana* group (see Long, 2008) can be problematical and it is impossible to confidently name all collections particularly in the absence of capsules in good condition.

Stomata are present in stramineous (straw coloured) capsules of *G. sessitana*, but absent in castaneous (brownish or fawn coloured) capsules of *G. alpestris*, so it would seem that capsulate specimens present no problem. However, capsule colour should be treated with caution - in older material colour is unreliable (eg: Muñoz, 1998 p396) - and stomata in *Grimmia* are difficult to demonstrate at the best of times due to waxy deposits and can be easily overlooked.

The gametophyte is also problematic. *Grimmia sessitana* is said to sometimes have bulging-mammillose laminal cells (thereby confusable with *G. alpestris*) but a significant number of specimens are reported to have only weakly bulging laminal cells (eg: Flora of North America, 2007, p237) or indeed smooth laminas (Maier, 2010).

Grimmia sessitana sometimes has one or

both leaf margins recurved in the lower part or at mid-leaf, and when this feature is present it separates it from *G. alpestris* (and *G. montana*). However, it is also described as sometimes having plane leaf margins. Maier (2010) notes that the basal paracostal cells in *G. alpestris* are generally shorter than in *G. sessitana*. Striae are sometimes apparent in the upper part of the leaf, but these are due to variable stratosity and are not folds (plicae) as seen in *G. cribrosa*.

Confusion with *G. montana* is also possible. As mentioned before, the recurved (*sessitana*) vs. plane (*montana*) leaf margin is a good discriminatory character. Another useful character is the degree to which the leaves are keeled; in *G. sessitana* the nerve is \pm distinct into the apex when viewed (under the binocular) from the dorsal side and seen in TS it is prominent. In *G. montana* the nerve is inconspicuous giving the dorsal surface of the upper part of the leaf a smooth rounded appearance, and in TS in the upper part of the leaf is concave or channelled. Maier (2010) highlights oblate marginal cells at the shoulder (transitional zone between leaf base and upper lamina) as being a good character for *G. montana*, but this character is sometimes seen in *G. sessitana*. Maier (2010) also emphasises that in the base of upper stem leaves the marginal cells are elongate \pm equal to the paracostal cells, but in the base of lower stem leaves cells are short-rectangular to quadrate towards the margin. The shape of the laminal cells in TS in the upper part of the leaf may be useful; in *G. sessitana* there is a mix of isodiametric and short-rectangular cells, whereas *G. montana* mostly has short-rectangular cells aligned at right angles to the lamina - but this may also show some overlap.

Nomenclatural and taxonomic confusion further complicates the picture. Maier (2002b) demonstrated that the type specimen from Chile of *G. reflexidens* Müll. Hal., a name proposed by

Muñoz (1998), could not replace *G. sessitana* since the material examined by Muñoz is a *Coscinodon*, with distinct bistratose plications of the leaf running down to the leaf insertion. Although the material had sporophytes, it lacked calyptrae which are critical to generic placement. Ochyra (2004) subsequently formally transferred *G. reflexidens* to *Coscinodon reflexidens* (Müll. Hal.) Ochyra *comb. nov.*

Apparently this interpretation is not universally accepted. Ignatova & Muñoz (2004) argue that an error was made in annotating a lectotype, and that the type of *Grimmia reflexidens* from Chile is not a *Coscinodon*, pointing out that strong plications in a leaf are not unique to *Coscinodon* and that another collection of *G. reflexidens* with sporophytes shows a typical *Grimmia* peristome without perforations. In *Flora Briofítica Ibérica* (Muñoz *et al.*, 2015) the name *Grimmia reflexidens* is retained by Muñoz, and by Delgadillo-Moya (2015) in his Neotropical monograph. Furthermore, in the account of *Grimmia* in Flora of North America (2007) both *G. sessitana* (autoicous, capsules with stomata) and *G. reflexidens* (dioicous, capsules said to lack stomata) are recognized and regarded as good species. The situation is still somewhat confused.

Grimmia tergestina Bruch & Schimp.

In the field *G. tergestina* can be mistaken for *G. laevigata* (despite not being closely related) as it shares with this species the broad concave smooth leaves with an indistinct nerve and a long hyaline hair-point. Material growing on limestone, calcareous rocks and stonework and concrete is however likely to be this species, but it also occurs on igneous base-rich rocks such as basalt. Microscopically the leaf shape and profile in TS is very similar to *G. laevigata*, and although it may have a few oblate cells in the leaf base, they do not occur in a large well-defined zone

as in *G. laevigata*. Additional useful characters is the mostly bistratose outermost marginal row of cells and the guide cells which are hardly distinguishable from the adjacent laminal cells in leaf TS.

Grimmia torquata Drumm.

This species, scarcely looking like a *Grimmia*, has a very characteristic habit when dry: the leaves are loosely spirally arranged around the stem with incurved apices. The shoots are brown below with a yellowish-brown tip, and the leaves are often muticous but some leaves always have a short hyaline hair-point. The nerve is sigmoid (S-shaped), seen when a leaf is laid flat under the microscope. The basal paracostal cells are elongate-rectangular with and strikingly incrassate longitudinal walls and thinner transverse walls, and all laminal cells have conspicuously small lumens due to heavily thickened walls. Although not always present, brown stalked multicellular gemmae on the dorsal surface of the nerve in the leaf base are characteristic. Capsules are unknown in Europe.

Grimmia trichophylla Grev.

This species can cause confusion when considered alongside *G. lisae*, *G. dissimulata*, *G. muehlenbeckii* and sometimes *G. longirostris*. The habit can vary from stiff erect leaves to flexuose when dry. Important characters of *G. trichophylla* include TS of the leaf at insertion; there are 4 guide cells with an additional tier ventral to the guide cells that may consist normally of 1 (or up to 3) slightly smaller cells but otherwise similar to the guide cells. Rarely there are more than 4 cells at insertion (up to 6), but there is always a second tier of guide cells. These cells are larger than the other costal cells (steroids, hydroids). In addition *G. trichophylla* has smooth \pm elongate-rectangular basal paracostal cells, straight walled,

rarely weakly nodulose, and narrow hyaline elongate basal marginal cells that extend a little way up the margin. The upper part of the leaf is variously bistratose, often only at the margin, but sometimes the entire upper lamina may be bistratose. Propagules are present on the proximal dorsal lamina and nerve, and are occasionally observed on plants in Britain and Ireland.

Grimmia unicolor Hook. in Grev.

Normally presents no identification problems. The leaves are characterized by a rounded muticous and cucullate apex with a multistratose upper lamina. Only some forms of *G. atrata* may cause confusion (see under that species).

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Glossary

- Abaxial** – the underside of a leaf as attached to the stem, or the dorsal side
- Adaxial** – the upperside of a leaf as attached to the stem, or the ventral side
- Campanulate** – bell-shaped, with a wide mouth
- Catenulate** – chain-like
- Costa** - nerve
- Cribose** – of a peristome with numerous fine perforations
- Cucullate** – of a calyptra, resembling a hood, split up one side; also applied to a leaf tip that is hooded
- Cuticular** – referring to the cuticle, the outermost layer of cells of a leaf, stem etc.
- Cymbiform** – shaped like a shallow boat
- Distal** - the end or portion of a structure furthest away from its base or origin
- Emarginate** – broadly notched, for example the abaxial surface of a nerve in transverse section
- Exothecial** – of cells of the outermost layer of a capsule
- Guide cells** – large vacuolated cells in costa (ventral) seen in TS
- Heteromallous** – of leaves, pointing in various directions
- Homomallous** – of leaves, all pointing in the same direction
- Hydroids** – thin-walled water conducting cells in nerve and stem, sometimes collapsed in transverse section forming a star shape
- Keeled** – folded along the middle, like the ridge of a boat, forming a ‘v’ shape in transverse section of a leaf; occasionally may be rounded or ‘u’ shape for example near leaf apex
- Mitrate** – of a calyptra, shaped like a bishop’s cap, with an entire or lobed base
- Mucronate** – ending suddenly in a short point
- Muticous** – of a leaf, lacking a hair-point which ordinarily would be present (but often lower leaves may be muticous whilst upper leaves have a hair-point)
- Nodulose** – cell wall thickenings appearing as minute knobs seen in surface view
- Oblate** – wider than long
- Obloid** – solid object with an oblong shape
- Obovate** – shaped like an egg with broad rounded side at top
- Operculum** – the lid covering the capsule mouth
- Paracostal** – the cells next to the nerve/costa, usually in leaf base (basal)
- Perigonia** – the male sex organs plus the modified leaves surrounding them
- Plicae** – lengthwise fold or pleat
- Proximal** – the end or portion of a structure nearest to its base or origin
- Reniform** – kidney shaped
- Rostellate** – short-beaked, in the operculum of a capsule
- Rostrate** – long-beaked, in the operculum of a capsule
- Secund** – strongly turned or bent to one side
- Sinuose** – wavy or undulating cell walls seen in surface view
- Spathulate** – shaped like a spatula, tapering towards the base from a flat broad rounded apex
- Stereids** – mechanical ‘stiffening cells’; thick-walled cells, in groups or bands in the nerve
- Striae** – longitudinal lines or ridges (singular: striate) due to variable stratosity
- Striolate** – fine longitudinal lines or ridges (plural: striolae) due to variable stratosity
- Subula** – a long slender needle-like point, normally referring to the leaf apex
- Terete** – cylindrical, in transverse section rounded
- Truncate** – cut off abruptly at apex (eg. of a leaf)
- Ventricose** – shaped like a stomach, bulging on one side towards the base