Grimmia pulvinata with foliar gemmae from Serra de Monchique, Algarve, Portugal

Ron Porley and Silvia Pressel describe the unexpected presence of gemmae in a population of this common species

The desiccation-tolerant moss *Grimmia pulvinata* (Hedw.) Sm. is one of the most common and widespread members of its genus. Being so familiar, bryologists hardly give it a second glance. A chance encounter by the first author, on Serra de Monchique in the Algarve, Portugal, with an undistinguished *Grimmia* lacking sporophytes (but suspected in the field of being *G. pulvinata* from its leaf shape) led to a surprising discovery. Subsequent study confirmed that the plant was indeed *G. pulvinata* but most oddly some shoots bore clusters of gemmae on the leaf bases, yet foliar gemmae were hitherto unknown in this species. The detection of protonemal and rhizoidal gemmae in mosses is not uncommon (see Pressel *et al*., 2007), whereas the discovery of foliar or axillary gemmae is a much rarer event but it does occur (for examples, see Porley & Pressel, 2012 and Liu *et al*, 2018).

Foliar gemmae are defined as propagules that develop on a leaf and show a clearly differentiated abscission mechanism (Duckett & Ligrone, 1992). Such gemmae are not uncommon in other species of *Grimmia* on Serra de Monchique, such as *G. lisae* and *G. trichophylla*, and there was therefore a possibility that the cushion was a mixture of two (or more) species. The propaguliferous shoots were isolated from the cushion and carefully re-examined. Leaf shape, basal cell characters, leaf profile in TS and nerve structure all indicated, unequivocally, *G. pulvinata*. The material was sent to the late Eva Maier. She agreed that the entire cushion was composed of *G. pulvinata* but was unable to explain the gemmae, suggesting they may belong to an unknown entity.

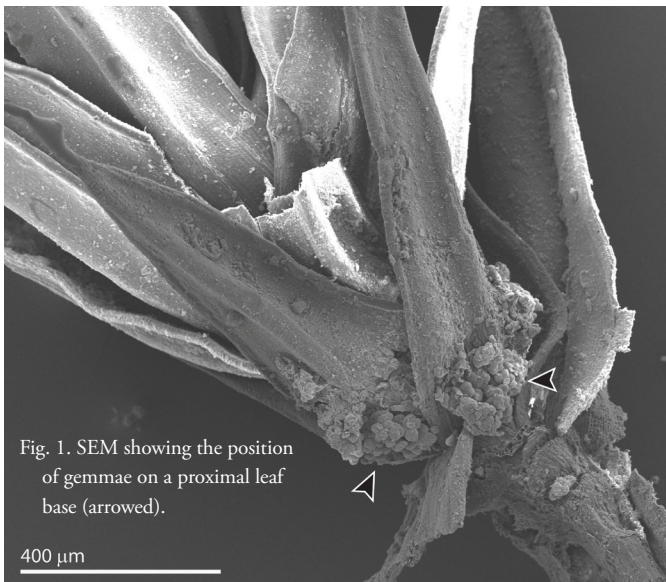


Fig. 1. SEM showing the position of gemmae on a proximal leaf base (arrowed).

◁Fig. 2. SEM showing that gemmae usually form from dorsal lamina cells. Arrowhead points to uniseriate filament with terminal gemma cluster.

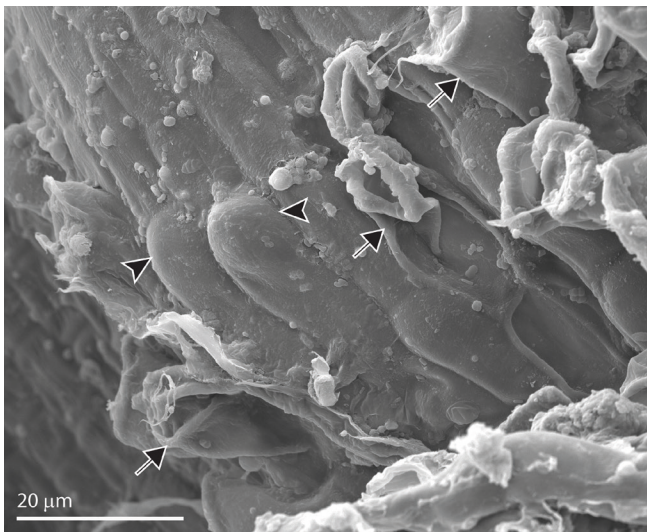
There was no doubt, however, that the shoots were propaguliferous, with gemmae comparable in structure to those that occur in *G. trichophylla* and other species. To facilitate detailed observations of the gemmae the second author was approached and readily agreed to do light and scanning electron microscopy (SEM).

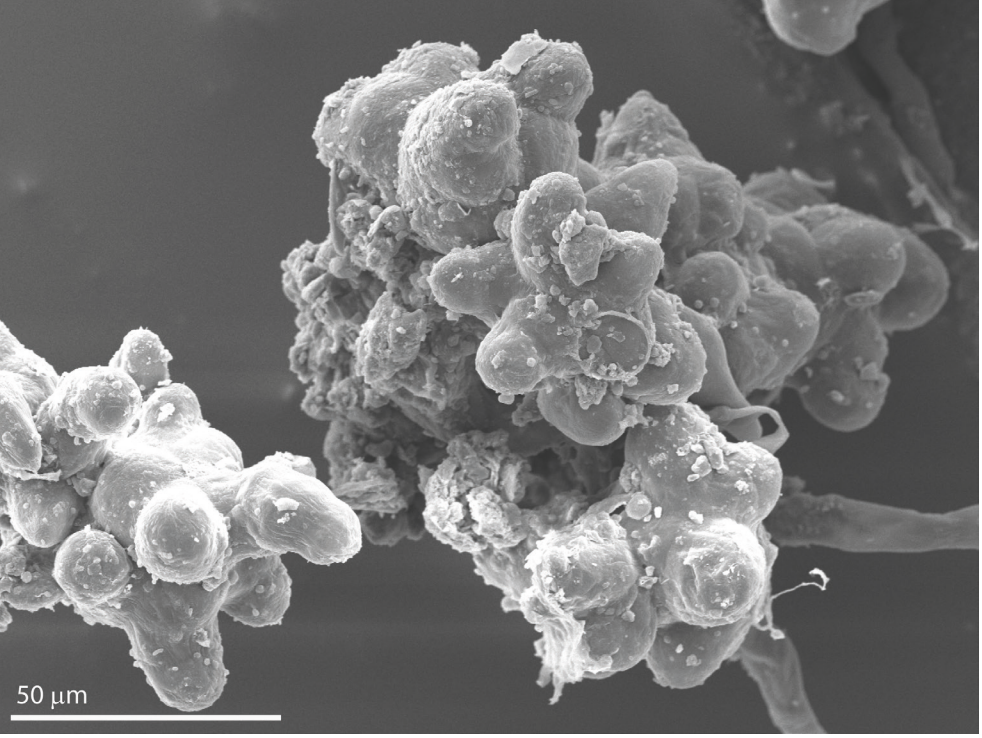
The details of the specimen examined are: Portugal: Algarve, Serra de Monchique, Portella das Eiras, 37° 19' 48.08'' N 8° 34' 35.14'' W, dust impregnated cushion on thin soil crust overlying syenite boulder at roadside in sun, 630 m a.s.l., with *Trichostomum crispulum*. Monoicous, archegonia and antheridia present, sporophytes absent (herb. Porley).

Description of gemmae

Gemma formation in *G. pulvinata* follows a similar pattern to that described previously in other *Grimmia* species (Porley & Pressel, 2012) except that in *G. pulvinata* the gemmae are produced exclusively on the proximal leaf base (Fig. 1), mainly from dorsal lamina cells, less often ventrally, and very rarely from the costa (Fig. 2). The proximal position of the gemmae might explain, at least partly, their lack of detection to date in *G. pulvinata*. Gemma formation begins with lamina cells forming protruding tips (prorae) (Fig. 3), which develop into multicellular, uniseriate filaments (Fig. 2). The distal filament cells then divide to give rise to more or less spherical gemmae, 25–30 µm in diameter, usually arranged in large, irregular clusters (Fig. 4). Gemma detachment is by formation and subsequent rupture of abscission or Tmema cells between the terminal filament cell (stalk cell) and the gemma, with scars comprising remnants of the Tmema cell walls remaining on both parent filament (Fig. 5) and gemma following detachment. After gemma liberation the parent filaments remain on the leaf lamina but eventually shrivel (Fig. 3). Detachment of gemmae from gemma clusters is also by formation of Tmema cells or might occur by breakdown of the middle lamella (Fig. 6). Examination of the gemmae under the light microscope reveals fairly thick, often pigmented cell walls (Fig. 7), suggesting that these propagules might also be rather resistant to desiccation and fairly long-lived.

▽Fig. 3. SEM showing prorae (arrowheads) adjacent to shrivelled filaments after gemma detachment (arrows).





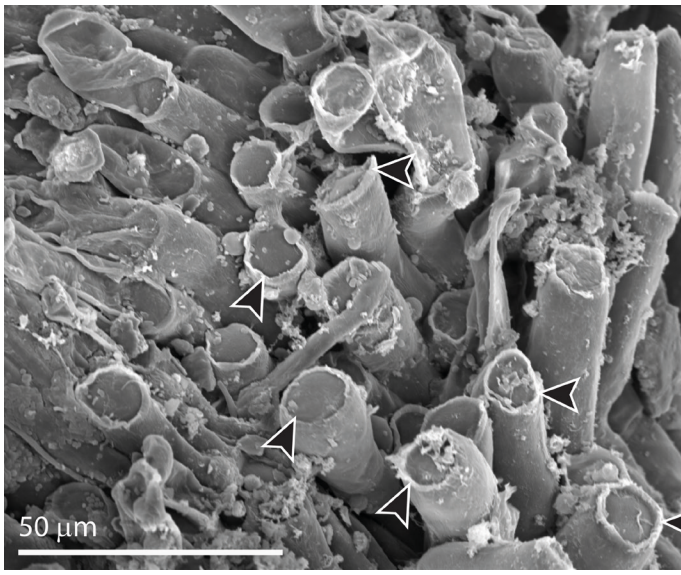
◁Fig. 4. SEM of a large cluster of gemmae.

▽Fig. 5. SEM showing scars (arrowed) comprising remnants of Tmema cell wall on parent filaments.

Discussion

Asexual propagules are rare in the Grimmiaceae and to date are known only in *Grimmia s.l.* Foliar gemmae (with possibly one exception) are known only in species traditionally placed in *Rhabdogrimmia* Limpr., a subgenus defined by a curved seta and furrowed capsule (but not all members are known to produce gemmae). The possible exception is *Grimmia shastai* Greven (Greven, 2003), a Californian endemic. From the illustration and description Maier (2010) regards this species as probably *G. montana* but the type specimen could not be found and 'the identity of the gemmae mentioned in the description remains unknown'. *G. montana* is in subg. *Orthogrimmia* and is dioicous. *Grimmia pulvinata* is a member of subg. *Rhabdogrimmia*, and thus it is perhaps not so surprising that this species has also now been added to the list of *Grimmia* with foliar gemmae.

Grimmia pulvinata is usually an abundantly fertile species. Recent studies have challenged the generally held assumption that richly fruiting species lack vegetative propagules (Duckett *et al.*, 2001; Pressel *et al.*, 2007). Nevertheless, foliar gemmae would seem to be very rare in the monoicous species *Grimmia pulvinata*



and *G. fuscolutea*, in which sporophytes are also usually abundant. Other species in subg. *Rhabdogrimmia* that are known to produce foliar gemmae (*G. anomala*, *G. austrofunalis*, *G. consobrina*, *G. dissimulata*, *G. hartmanii*, *G. lisae*, *G. meridionalis*, *G. muehlenbeckii*, *G. torquata* and *G. trichophylla*) are dioicous and rarely or only occasionally produce sporophytes.

Many *Grimmia pulvinata* cushions have been

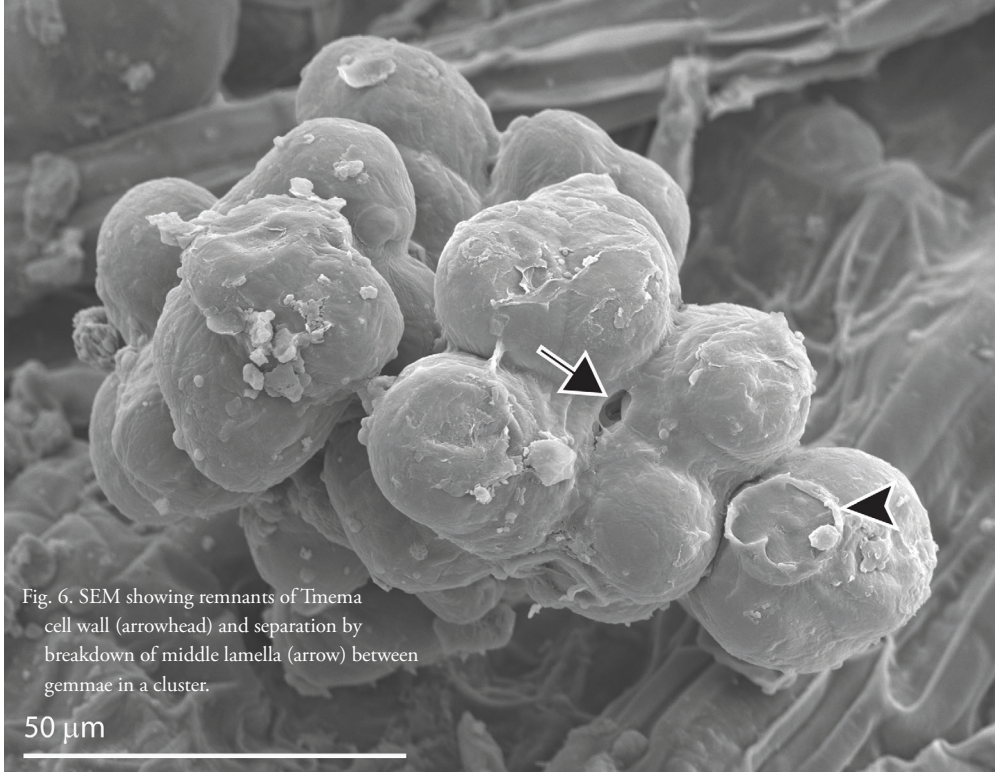


Fig. 6. SEM showing remnants of Tmema cell wall (arrowhead) and separation by breakdown of middle lamella (arrow) between gemmae in a cluster.

examined on Serra de Monchique but no more propaguliferous populations have so far been detected. We know little about the factors that initiate foliar gemmae development in mosses, although it is likely that substrate, nutrients, temperature and light all have a role.

References

Duckett, J.G., Goode, J.A. & Matcham, H.W. (2001). Studies of protonemal morphogenesis in mosses. VIII. The gemmiferous protonemata of *Orthodontium* and *Dicranoweisia*. *Journal of Bryology* 23: 181–193.

Duckett, J.G. & Ligrone, R. (1992). A survey of diaspore liberation mechanisms and germination patterns in mosses. *Journal of Bryology* 17: 335–354.

Greven, H. (2003). *Grimmias of the world*. Backhuys Publishers, Leiden.

Liu, Y., Mamtimin, S. & Zhao, J. (2018). Axillary gemmae in *Pohlia nutans* (Hedwig) Lindb. (Mielichhoferiaceae, Musci) in China. *Journal of Bryology* 40: 191–193.

Maier, E. (2010). The genus *Grimmia* Hedw. (Grimmiaceae, Bryophyta). A morphological-anatomical study. *Boissiera* 63: 1–377.

Porley, R.D. & Pressel, S. (2012). *Grimmia fuscolutea* with gemmae and observations on other propaguliferous *Grimmia*. *Polish Botanical Journal* 57: 295–315.

Pressel, S., Matcham, H.W. & Duckett, J.G. (2007). Studies of protonemal morphogenesis in mosses. XI. *Bryum* and allied genera: a plethora of propagules. *Journal of Bryology* 29: 241–258.

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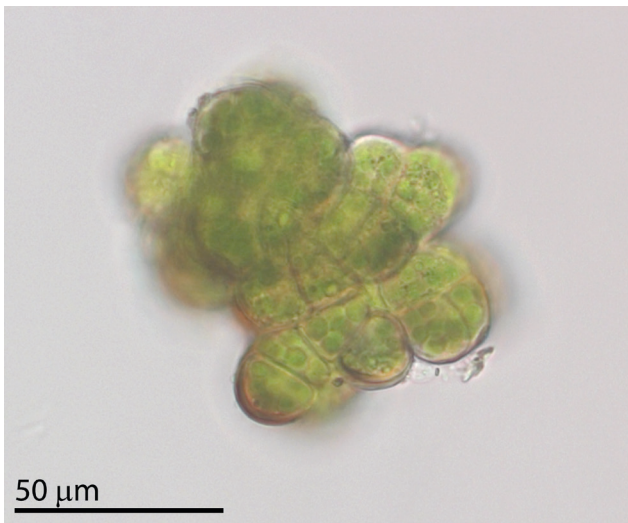

△Fig. 7. Light micrograph of a gemma cluster showing thick pigmented walls of the gemmae.