Exormotheca bulbigena sp. nov. (Hepaticae, Marchantiales) and its relation to E. holstii in southern Africa

T. BORNEFELD*, O.H. VOLK** and R. WOLF***

Keywords: Exormotheca bulbigena, E. holstii, Hepaticae, Marchantiales, southern Africa

ABSTRACT

A new species Exormotheca bulbigena is described from southern Africa and its relation to E. holstii Steph. is discussed. Morphologically these species are very similar and can be distinguished only when fertile. The chromosome numbers, however, n = 32 for E. bulbigena and n = 18 for E. holstii, distinguish sterile living plants.

INTRODUCTION

Stephani (1899), in his Species hepaticarum, described a new species, Exormotheca holstii, from Muse (Tanzania). Subsequently, Marquand (1930), apparently unaware of Stephani's publication, described E. megastomata from a site near Middelburg, Mpumalanga (Transvaal), South Africa, as a new species. Finally Arnell (1953) published a new species, E. youngii, from Pilgrim's Rest, Mpumalanga, (Transvaal) South Africa, which he himself later placed in synonymy under E. holstii in 1963. After a morphological examination of all the respective herbarium samples Perold (1994) sank E. megastomata under E. holstii. However, an additional new species, E. bulbigena, has to be established.

MATERIALS AND METHODS

Dry herbarium samples of Exormotheca from southern Africa were cultivated in a greenhouse on a mixture of garden mould and sand over a base of peat.

For chromosome counts, thallus tips were fixed, extracted and stained with orceine as described earlier (Bornefeld 1984). In the present study only samples with known chromosome numbers are considered, although the number of Exormotheca localities is far greater (Perold 1994). The localities are listed according to Edwards & Leistner (1971).

For SEM studies the samples were fixed in a mixture of 70% ethanol/glacial acetic acid/40% formalin = 90/5/5 v/v/v at room temperature for 24 hrs, and then dehydrated in an acetone series. After critical point drying with CO₂ and sputtering with gold, SEM micrographs were taken with a DSM 962 model by Zeiss.

Exormotheca bulbigena Bornefeld, O.H.Volk & R.Wolf, sp. nov.

Thallus monoicus. Frons hyalina, usque ad 20 mm longa, simplex vel furcata, linearis, antica plana, crassa. Costa maxima, strato antico aequialta, postice valde rotundata, lateribus convexo-adscendentibus. Squamae posticae magnae, cellulis longissimis (50-600 μm) formatae, uno latere ad basin grosse lacinulatae, oblique oblongae acuminatae obtusae. Stratum anticum costae aequialtum, in fundo fila aggregata gerens. Stomata densissima, altissima, ad 2/3 coalita, tertio supero libera, cylindrica, obtusa, vertice poro oblongo (± 50 x 140 μm) perforata. Frons ad apicem stolonum bulbillos pulviniformes ± 2~4 mm longos et latos 2-3 m altos gerens. Antheridia minuta in duabus lineis (30 x 40 μm) caudaliter et sagittaliter carpocephali, in strato antico, stomatibus contecta, disposita. Ostiola ± 160 μm lata, e sulco prominentes. Carpocephala in fundo alveoli nudis, strato antico recedente et ante di-
FIGURE 1.—Exormathecia bulbigena: A, thallus with carpocephalum; arrow shows antheridial necks. C, stomata with pores. E, F, bulb: E, dorsal view, where surface is broken (arrow), spongy interior tissue is visible; F, ventral view, arrow shows remnant of stolon which formed bulb. E. holstii: B, female thallus. D, stomata with pores near thallus tip. Scale bars: A, B, 2 mm; C, D, 500 μm; E, 1 mm; F, 500 μm.

chotomiam frondis. Complura carpocephala sequentialiter et aequidistantes (± 3-4 mm) in una frons inserta esse possunt. Receptacula sessilia globosa, vertice hau porosa stratoque chlorophyllifero tecta; subtus obconico-angustata, utroque latere involucrata; involucra 2, opposita, capituli vertice convexo-prominente separata, oblique ascendentia, conchaeformia, antice subcarinata, subtus apiceque aperta, labis late hiantibus usque ad basin decurrentibus; capsula longius pedicellata, irregulariter quadrivalvata, valvae rufo-brunneae, maxime incrassatae. Sporae ± 140 μm, papulae distales irregulariter vermiculiformes. Elateres degeneratae (20 μm latae et 50–150 μm longae) cum anulis et spiralis brevis. Chromosoma numerus: n = 32.

TYPE.—Namibia, 2216 (Otjimbingwe) Farm Otjua, granitic outcrop, (–AA), Volk 85766 c. fr. (M, holo.; M, PRE).
DISCUSSION

In her study of *Exormotheca holstii* samples from southern Africa, Perold (1994) necessarily used dry material from various localities collected in different years. In our studies, samples of *E. holstii* from Namibia and Mpumalanga (eastern Transvaal) and of *E. bulbigena*, grown under identical conditions, developed carpocephala (Figure 1A, B). Other characters such as overall size and shape, shape in cross-section, cell shape of the assimilatory tissue, width and height of the stomata [the papillae on top of (or) side of which stomata are located], shape of the ventral scales, and colour were all the same. Because these characters are meticulously described by Perold (1994) they are not repeated here, where the differences between the two species are emphasized. The only morphological feature which differs in the sterile thalli are the pores of the stomata; they are more elongate in *E. bulbigena* than in *E. holstii* (Figure 1C, D; Table 1). Whether or not these relations are affected by ecological factors in the field is unknown and therefore these differences should not be overestimated.

The formation of small bulbs is known for *E. tuberifera* (Kashyap 1914) and for *Corbierella (= Exormotheca) algeriensis* Douin & Trabut (1919). Therefore we investigated our cultures for such organs and indeed found these in *E. bulbigena* (inde nomen). They are cushion-shaped, 2-4 mm long and broad, and 2-3 mm thick. The bulbs consist of a chlorophylliferous, spongy tissue with some oil cells, somewhat more compact ventrally. When mature these little bulbs are no longer attached to the thallus and are easily overlooked in the field. Figure 1E & F shows the dorsal and ventral view of bulbs which were rehydrated for one day after seven months of desiccation. On the lower side the remnant of the stolon which formed the bulb is visible (arrow). *Exormotheca holstii* also forms short stolons with a slightly enlarged terminal bud, but these are not drought tolerant and upon remoistening become covered by mould.

As there appears to be little variation in the caryotype, the main character for discrimination of sterile plants remains the chromosome number: *n = 32* for *Exormotheca bulbigena* and *n = 18* for *E. holstii* (Figure 2A, C). Chromosome analysis (Bornefeld 1984) reveals that *E. bulbigena* is eutetraploid to a basic number of eight chromosomes and *E. holstii* is eudiploid to a basic number of nine chromosomes (Figure 2B, D). The difference in the basic numbers is not surprising when taking into account that for *E. bulbigena* ([Crosby 1151](https://www.crosby.co.za)) and for *Corbierella* (= *Exormotheca*) (*algeriensis* Douin & Trabut 1919) we observed the formation of small bulbs. The difference is the deep sulcus caudal to the carpocephalum of *E. bulbigena* (Figure 1A, B) which is lacking in the female *E. holstii* plant (Figure 1B). Closer inspection of the sulcus shows the antheridial necks which are composed of eight rows of cells (Figure 3A). The whole structure has a diameter of ± 160 μm. The antheridial necks of *E. holstii* (Figure 3B, D) have a diameter of only 100 μm. A series of sagittal sections of the carpocephalum of *E. bulbigena* (Figure 4A, B) reveals the presence of two rows of additional 'microantheridia' 40 × 30 μm; the respective values for the main antheridia in the depth of the sulcus, which are arranged in two parallel rows, are 350 and 150 μm. These microantheridia are a unique feature not described as yet for liverworts. The reinforcing bands in the sporangium wall are very variable within one sporangium and thus are of no value for distinguishing between the two species. The spores of both species are about the same size (120-150 μm), dark brown to black, anisopolar, without a wing. The ornamentation of the distal face of *E. bulbigena* can be described as 'vermiculate' (sensu Perold 1989) (Figure 5A). If the ridges become very short (e.g. Perold 1994, fig. 6A) it can form a papillate pattern. The corresponding structure of *E. holstii*, very broad, indented papillae, could be described as 'polygonal'. Figure 5C shows a spore of the sample *Crosby 1115* from Zoetvlei and its similarity to that of the type of *E. holstii* (Figure 5E) proves the cor-

![Diagram](https://example.com/diagram.png)

**TABLE 1.**—Size relations of stomatal pores of *Exormotheca bulbigena* and *E. holstii* grown simultaneously under identical conditions 

| Feature                | *E. bulbigena* | *E. holstii* |
|------------------------|----------------|--------------|
| Long axis              | 138 ± 37.9 μm  | 127.8 ± 24.6 μm |
| Short axis             | 52.9 ± 20.1 μm | 88.1 ± 13.6 μm |
| Long axis: short axis  | 2.61           | 1.45         |

The type of *Exormotheca holstii* is dioecious; the types of Marquand (1930) and of Arnell (1953) are sterile. In our cultures out of 12 samples from South Africa only one contained both sexes; four were female, three were male, and four remained sterile. When comparing fertile plants of *E. bulbigena* and *E. holstii* the most obvious difference is the deep sulcus caudal to the carpocephalum of the monoecious *E. bulbigena* (Figure 1A) which is lacking in the female *E. holstii* plant (Figure 1B). Closer inspection of the sulcus shows the antheridial necks which are composed of eight rows of cells (Figure 3A). The whole structure has a diameter of ± 160 μm. The antheridial necks of *E. holstii* (Figure 3B, D) have a diameter of only 100 μm. A series of sagittal sections of the carpocephalum of *E. bulbigena* (Figure 4A, B) reveals the presence of two rows of additional 'microantheridia' 40 × 30 μm; the respective values for the main antheridia in the depth of the sulcus, which are arranged in two parallel rows, are 350 and 150 μm. These microantheridia are a unique feature not described as yet for liverworts. The reinforcing bands in the sporangium wall are very variable within one sporangium and thus are of no value for distinguishing between the two species. The spores of both species are about the same size (120-150 μm), dark brown to black, anisopolar, without a wing. The ornamentation of the distal face of *E. bulbigena* can be described as 'vermiculate' (sensu Perold 1989) (Figure 5A). If the ridges become very short (e.g. Perold 1994, fig. 6A) it can form a papillate pattern. The corresponding structure of *E. holstii*, very broad, indented papillae, could be described as 'polygonal'. Figure 5C shows a spore of the sample *Crosby 1115* from Zoetvlei and its similarity to that of the type of *E. holstii* (Figure 5E) proves the cor-
rectness of the identification by Perold (1994). In the description of *E. holstii*, with respect to the papillae of the spores, Stephani (1899) mentions 'papulis saepe rostratis'. In Figure 5E no rostrum-like structures can be detected on the papillae and it remains unclear to which structures Stephani refers; elaters stuck to the papillae probably led to the remark mentioned. The ornamentation of the proximal face of the spores is rather fine and the triradiate mark is inconspicuous (Figure 5B, D, F). The differences of the distal face become visible in another way by dark-field microscopy where the spores are seen in a bright orange colour. With this method structures are visible on the ridges of the ornaments which in *E. bulbigena* are punctiform or very short grooves, for *E. holstii* they may be

![Image of Figure 3](image3.png)

**FIGURE 3.**—Antheridial necks. A, C, *E. bulbigena*: A, from sulcus, arrow shows broken neck with 8 rows of cells forming the channel. B, D, *E. holstii*: B, male thallus with antheridial necks. Scale bars: A, 200 μm; B, 2 mm; C, D, 50 μm.

![Image of Figure 4](image4.png)

**FIGURE 4.**—*E. bulbigena*: A, sagittal section through carpocephalum; arrow shows site of microantheridia. B, microantheridia. Scale bars: A, 1 mm; B, 100 μm.
described as long, finely branched furrows (Figure 6A, B). The elaters of both species are degenerate, about 20 µm in diameter and between 50 and 150 µm long, with rings or incomplete spirals. Summarising all the differences between *E. bulbigena* to *E. holstii* (Table 2) we consider it obligatory to consider the former as a distinct species, even though sterile plants are very similar.

Consideration of the climate diagrams (Walter & Lieth 1967) for typical sites of the two species (Figure 7A, B) suggests that *E. bulbigena* is better adapted to a hotter and drier climate than *E. holstii*. The site of the latter at Rietfontein in Namibia is near a fountain and thus not contrary to this suggestion.

The immediate influence of external ecological factors on physiological activity of these plants is difficult to estimate. Both species form droplets of condensed water inside the stomata which consist of living cells. By cooling down the air within the stomata by evaporation and
by their sheltered humidity the plants seem to establish a greenhouse-like microclimate of their own, certainly favourable for photosynthesis. Figure 8 shows the distribution of the two species in southern Africa. So far E. bulbigena has only been found in Namibia and may thus be considered endemic to this region.

ACKNOWLEDGEMENTS

We wish to thank Mrs C. Gehrig for excellent work in preparing the SEM samples, Prof. W. Hartung for reading the manuscript, Dr S.M. Perold, NBI, Pretoria, for the loan of the photographs of the spores of the E. holstii type, and Mr R. Wacker for the microtomy of the carpocephalum of E. bulbigena.

SPECIMENS EXAMINED

Exormotheca bulbigena, n = 32

NAMIBIA.—1918 (Grootfontein): Gaikos, on quartzite sand, (-AD), Volk 81/124 (M, PRE). 2116 (Otjimbingwe): Otjua, granitic outcrop, (-AA), Volk 84/696, 85/766, 86/030 (M, PRE).

Exormotheca holstii, n = 18

NAMIBIA.—2217 (Windhoek): Rietfontein, Granitzersatz, durch Sickerwasser zeitweise feucht bis nass, (-CA), Volk 88/026. 2529 (Lydenburg), S of Lydenburg, Spitskop, drier ledge above waterfall, (-AB), Perold 2872 (PRE). 2629 (Bethal): Ermmelo, (-DB), s.n. 2630 (Carolina): Knock Dhu Farm, 13 km SE of Lake Chrissie on Lothair road, common on rich black loamy soil, in grassland, (-AD), Germishuizen 2839 (PRE).

REFERENCES

ARNELL, S.W. 1953. A new South African species of Exormotheca. Transactions of the British Bryological Society 2: 283, 284.

ARNELL, S.W. 1963. Hepaticae of South Africa. Swedish Natural Science Council, Stockholm.

BORNEFELD, T. 1984. Chromosomenanalyse der Gattung Riccia L. aus S- und SW-Afrika und allgemeine Bemerkungen zur Zytogenetik der Lebermoose. Nova Hedwigia 40: 313-328.

BORNEFELD, T. 1989. The Riccia species of S- and SW-Africa. Chromosome numbers and composition of the chromosome sets. Nova Hedwigia 48: 371-382.
