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SPOROPHYTES OF THE RARE LIVERWORT *CEPHALOZIA MACOUNII*

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Abstract. The dioicous epixylic liverwort *Cephalozia macounii* (Aust.) Aust. is rare over its entire distribution area in the Northern Hemisphere. It is protected under the EU Habitats Directive and classified as critically endangered in Finland and Sweden. One reason cited for its rareness and the declining trend in its distribution its poor reproductive capacity. It does not produce asexual gemmae, which in general is common among liverworts. Although female plants with perianths are quite common, the male plants of the species have rarely been seen and sporophytes have not been described until now. In this paper we describe and illustrate the sporophytes of *C. macounii* on the basis of an old specimen collected in Southern Finland in the 1800s.

Key words: *Cephalozia macounii*, sporophyte, spores, rareness, EU Habitats Directive

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INTRODUCTION

The epixylic liverwort *Cephalozia macounii* (Aust.) Aust. has a wide but sporadic distribution in the Northern Hemisphere taiga zone (e.g., Schuster 1974). It is considered rare over its entire distribution area. This species is also protected under the Berne Convention and listed in Annex II of the EU Habitats Directive. It has been classified as critically endangered (CR, Anonymous 2012) in Finland (Rassi *et al*. 2010) and Sweden (Anonymous 2010). It is red-listed as vulnerable (VU) in Europe (Anonymous 1995), but Schuster (1974) stated before red-listing of bryophytes began that the species may have declined as a consequence of habitat changes caused by human activities. A recent phylogenetic study including the genus *Cephalozia* revealed that this genus needs to be divided into two genera (Vilnet *et al*. 2012). *Cephalozia macounii* was kept in the type genus and therefore needed no nomenclatural change.

Cephalozia macounii grows on decaying wood, mainly on trunks in late stages of decay, as tiny homogenous patches or as single shoots among other bryophytes. It prefers often slightly paludified old-growth conifer forest with an intact decay continuum of coarse woody debris and humid microclimate (e.g., Damsholt 2002; Laaka-Lindberg 2009; Hallingbäck 2010). Habitat loss is mainly due to forestry; for instance, most of southern Finland is covered by commercial forests with almost no suitable localities for old-growth forest specialists. The basic reason for its rareness and declining trend in its distribution is its poor reproductive ability (e.g., Laaka-Lindberg 2009). It is dioicous and does not produce asexual gemmae (Schuster 1974; Damsholt 2002). Female shoots with perianths have been found occasionally, but male plants have been found only recently in old specimens (see Plate 189 in Damsholt 2002). Sporophytes have been unknown until now (e.g., Schuster 1974; Paton 1999; Damsholt 2002). For this study, two digitalized type specimens of *C. macounii* available in JSTOR F0000068C from F and MICH514797 from MICH herbaria (see http://plants.jstor.org/search?plantName=%22Cephalozia+macounii%22&syn=1) were seen, and indeed, no sporophytes were present in them.

For compilation of the updated Finnish red list (Rassi *et al*. 2010) the herbarium materials in

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Finnish herbaria were checked through and the second author found a specimen in the H-SOL collection with sporophytes of *C. macounii*. Sextus O. Lindberg, who obviously identified the specimen collected by Emil F. Lackström, had likely seen the type specimen of *C. macounii* (*Hep. Bor. Amer. Exsic. ined.*, No. 55; see protologue, Austin 1870), as he wrote it as a note on the back of the envelope. However, no particular note on the presence of sporophytes was marked. Here we describe and illustrate the sporophyte with spores and elaters of the species.

Material and methods

A specimen of *Cephalozia macounii* collected by E. F. Lackström in southern Finland, Etelä-Savo Province, in Suomäki in Kangasniemi Parish in July 1874 (specimen H-SOL 2176001) was studied. *Cephalozia macounii* was growing on decaying wood ("ad ligna putrida"), and male and female shoots with sporophytes were present.

The structural features of the sporophytes were measured and photographed, and dissections of the sporophyte structures were studied under a light microscope mainly at 400×. The associated species in the specimen were listed. It is somewhat problematic to identify all shoots of intermingled *Cephalozia* species, but fortunately *C. macounii* is rather easy to detect under a microscope. The density of *C. macounii* shoots in the patch was measured at 40× in 3 randomly picked 1 mm^2 squares on the specimen. A Leica DSC280 microscope with a digital camera was used for photographing the microslides of opened sporophytes, spores and elaters. For size measurement the spores were kept in distilled water for *ca* 5 hours and spore diameter was calculated as the mean of 10 spores in a randomly picked field; the longest diameter was measured with a micrometer at 1000×. The spores were mostly attached to sporophyte structures (see Fig. 1). Note that the photographed spores (Fig. 2) are not the ones used for diameter measurements.

Results and discussion

Specimen H-SOL 2176001 contains a mixture of liverwort species with *Cephalozia macounii*. The size of the specimen is *ca* 4 cm^2.Shoot density on the patch is on average 30/mm^2 (n = 3). The measured frequency of shoot modes is shown in Table 1. On average 73% of the shoots are sterile, 4% males and 23% females. Not all female shoots bear a sporophyte but 47% do. The rarity of male shoots is noticeable even in this fertile patch, probably explaining the observed overall rarity of sexual reproduction in this species. No sporophytes were present in the specimen used for illustration by Damsholt (2002; Sweden, Härjedalen, Hede, *leg. J. Persson*, 1911). Both sexes obviously were present in that specimen. It has generally been considered that the sperm dispersal range of most bryophytes is short, on a scale of centimeters or even only millimeters, depending also on plant size (e.g., Crum 2001). It is not clear whether the male and female plants of *C. macounii* were close to each other in the specimen cited by Damsholt (2002). The presence of both sexes does not ensure sexual reproduction if the distance between them is too long or the occurrence of both sexes together is very rare.

Specimen H-SOL collected by E. F. Lackström was dated at the end of July, and practically all the *C. macounii* sporophytes present were open (Fig. 1). This suggests spore maturation in mid to late summer in southern Finland. Spores were found attached to capsule sectors and seta (Fig. 2), as were also the few elaters found (Fig. 3). The length of the mature seta is 2–3(–4) mm, and the oval capsule is *ca* 740 μm long and 320 μm wide (Fig. 1). The cells of the capsule valves are rectangular, (14–)15–17 μm long, 3–4 times the width, with rather clear zigzag thickenings. The seta consists of 4 medullary cells surrounded by 8 cortical cells, as is characteristic for the genus *Cephalozia*

Table 1. Frequency of sexual modes of shoots measured on specimen H-SOL 2176001 of *Cephalozia macounii* (Aust.) Aust. Actual number of sterile shoots, males and females without sporophytes but with perianths and females with sporophytes in 3 randomly picked 1 mm^2 squares on the specimen.

Sample/ sexual mode	Sterile shoots	Males	Females with perianths	Females with sporophytes
1	13	1	2	2
2	35	3	6	8
3	17	0	2	1
Mean	22	1.3	3.3	3.7

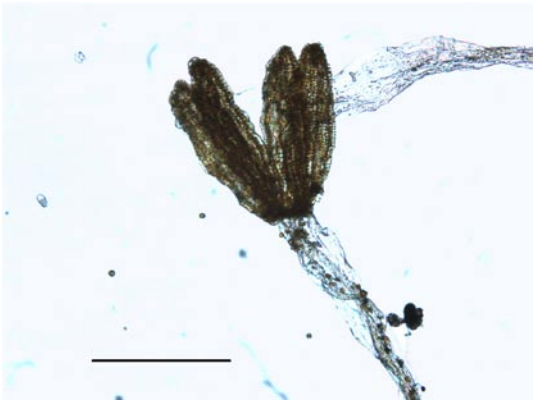

Fig. 1. Photograph of opened sporophyte of *Cephalozia macounii* (Aust.) Aust. Scale bar = 1 mm.

(e.g., Schuster 1974). In this specimen the seta structure was somewhat difficult to see, however, since the setae were all flattened and partly decomposed. The overall sporophyte characteristics are similar to those in its close relative *C. leucantha* Spruce (e.g., Damsholt 2002), including the shape and size of the spores.

The spores of *C. macounii* are globular, (reddish) brown, with a slightly verrucose surface, and diameter of *ca* 10 µm, ranging from 8 to 11 µm (Fig. 2). The elaters are laxly bi-spiral, 8–11 µm wide and 60 µm long (Fig. 3). The small size of the spores is often considered an advantage in long-distance dispersal (e.g., van Zanten & Pocs 1981). On the other hand, small spores may face hazards in the germination phase, which reduces the reproductive benefit of easily dispersed spores. Most likely, however, the infrequency of spore production is more important in determining the rarity of *C. macounii* than dispersal ability as such.

Fig. 2. Photograph of spores of *Cephalozia macounii* (Aust.) Aust. Scale bar = 10 µm.

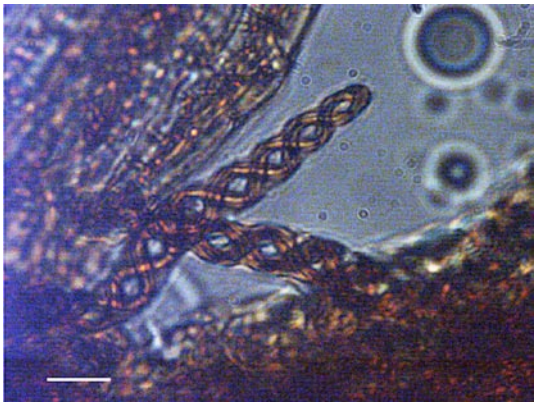

Fig. 3. Photograph of elaters of *Cephalozia macounii* (Aust.) Aust. Scale bar = 10 µm.

The small specimen studied also included other liverwort specialists of decaying wood which are now red-listed in Finland, such as *Cephalozia catenulata* (Huebener) Lindb. *Anastrophyllum hellerianum* (Nees *ex* Lindenb.) R. M.Schust., *Calypogeia suecica* (Arnell & J. Perss.) Müll. Frib. and *Lophozia ascendens* (Warnst.) R. M. Schust. Most of these red-listed species seem to have a limited capacity to colonize isolated patches of old-growth forests in the heavily managed forest landscape of southern Finland, even though most of them produce both capsules and gemmae unlike *C. macounii*.

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