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SHORT COMMUNICATION in ECOLOGY

# An Unusual Epiphytic Habitat for *Hedwigia ciliata* (Bryophyta: Hedwigiaceae) in Poland (Central Europe)

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## Abstract

In Poland, *Hedwigia ciliata* (Hedw.) P. Beauv., an obligatory epilithic moss species, has in recent years also been observed on the bark of trees. In this paper, we describe 25 recently identified sites in which epiphytic *H. ciliata* has been observed, and provide a plausible explanation to account for this phenomenon.

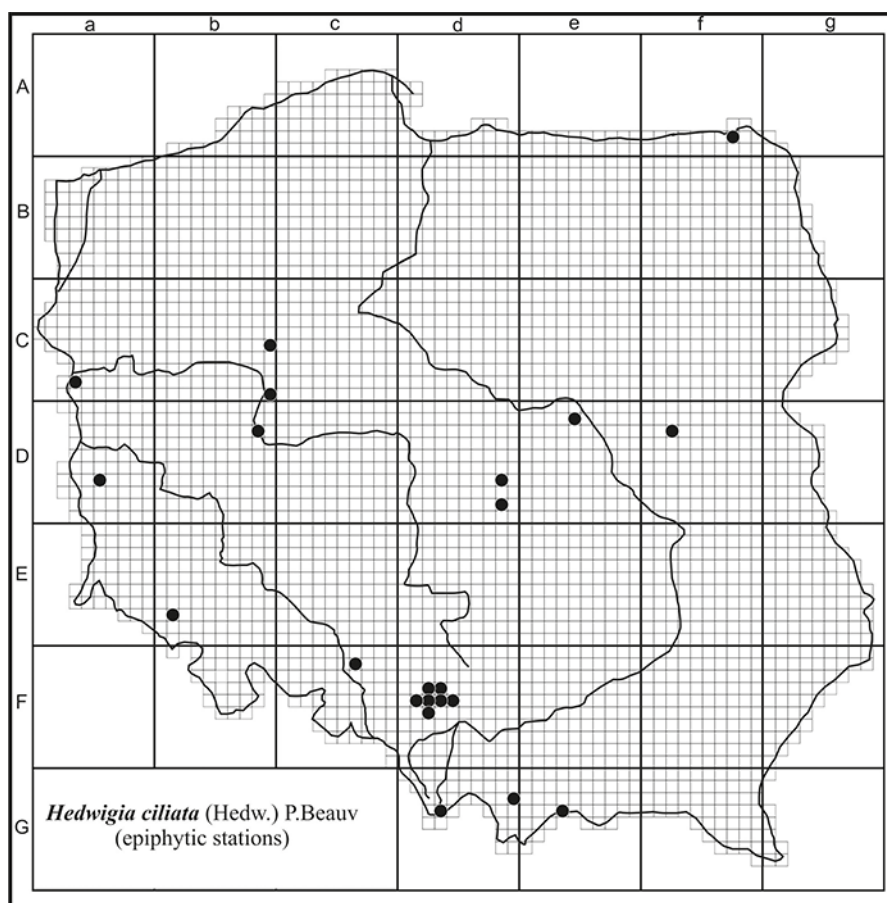
## Keywords

bryophyte; moss; epiphyte; distribution; habitat preference; climate change

## 1. Introduction

*Hedwigia ciliata* (Hedw.) P. Beauv. (Bryophyta: Hedwigiaceae) is a moss species widely distributed in Europe, North America, and Asia, wherein it is generally found in temperate and boreal zones. This moss also grows at higher altitudes in Central and South America, Africa, South Australia, and New Zealand (Eckel, 2014; Ochyra et al., 1988). It typically colonizes sunny, dry, acidic rock substrates, including exposed erratic boulders, rock outcrops, stones, and rocks in abandoned quarries (Dierßen, 2001; Ochyra et al., 1988). Considerably less often, it is also found on the bark of trees (Marques et al., 2005; Mazimpaka & Lara, 1995). Similar to other xerophytic species, this medium-sized moss is characterized by a number of morphological features (including hyaline hair on leaves and incrassate cells with papillae) that facilitate growth in strongly insolated habitats (Smith, 2004). The formation of sporophytes and capsules hidden between the leaves on short setae are also characteristic features of this taxon (Ignatova et al., 2016).

In Poland, *H. ciliata* is found at numerous sites in the south (particularly in the Sudetes), and in the moraine belt in the northern part of the country (West Pomerania, Masurian Lakeland, and Wielkopolska region) (Bednarek-Ochyra, 1998; Ochyra et al., 1988). Until relatively recently, at all sites in Poland in which this moss has been reported, it had been found exclusively on acidic rocky substrates (Bednarek-Ochyra, 1998; Fojcik, 2011; Górski et al., 2014; Górski, Fudali, et al., 2017; Górski, Pawlikowski, et al., 2017; Ochyra et al., 1988; Stebel, 2006; Wierzcholska et al., 2010; Żarnowiec & Stebel, 2014). Interestingly, however, in recent years, *H. ciliata* has also been found on limestone rocks (Stebel et al., 2010;



**Figure 1** Distribution of the sites of epiphytic *Hedwigia ciliata* in Poland in 10 × 10-km ATMOS square grids.

Vončina & Stebel, 2016), and notably observed on the bark of trees (Stebel & Vončina, 2014). In this paper, we present data on the current distribution of the sites of epiphytic *H. ciliata* in Poland and the characteristics of colonized substrates, and also propose an explanation to account for this phenomenon.

## 2. Material and Methods

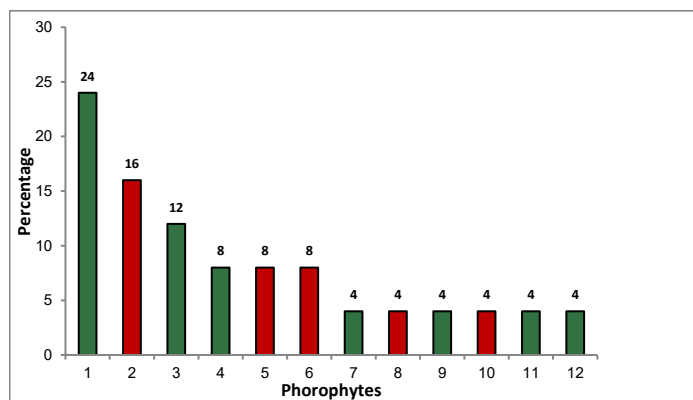
A list of sites with epiphytic *H. ciliata* was compiled based on the ATMOS grid square system (Ochyra & Szmajda, 1981) and is presented in Table S1.

The nomenclature used for mosses follows that described by Hodgetts et al. (2020) and the one used for phorophytes follows that of Mirek et al. (2002). The locations of the epiphytic *H. ciliata* sites are indicated on the map shown in Figure 1.

## 3. Results

### 3.1. The Geographical Distribution of Epiphytic Sites

The first documented occurrence of *H. ciliata* growing on bark in Poland was on that of a roadside *Populus × canadensis* Moench tree found in the Western Carpathians (Stebel & Vončina, 2014) in 2011, and to date, epiphytic *H. ciliata* have been recorded at a total of 25 sites in Poland (Figure 1) distributed in 22 ATMOS squares. The distribution of these sites spans virtually the entire length and breadth of Poland, although with an evident concentration in the south-west region of the country. Few of these sites are distributed in mountainous areas, with records from only one site in the Sudetes and three in the Carpathians. The highest altitude at which *H. ciliata* has been found growing epiphytically is 890 m above sea level in the Beskid Żywiecki range of the Carpathian Mountains.



**Figure 2** Percentage of occurrence of *Hedwigia ciliata* on phorophytes in Poland. 1 – *Fraxinus excelsior*; 2 – *Populus ×canadensis*; 3 – *Quercus robur*; 4 – *Acer pseudoplatanus*; 5 – *F. pennsylvanica*; 6 – *Salix ×sepulcralis* ‘Chrysocoma’; 7 – *Fagus sylvatica*; 8 – *P. ×berolinensis*; 9 – *P. ×canescens*; 10 – *Q. rubra*; 11 – *S. fragilis*; 12 – *S. ×rubens* (1). Green bars – species native to Poland; red bars – alien species.

### 3.2. Habitats

Epiphytic *H. ciliata* has been most frequently found on solitary trees growing along roadsides or in parks, although less often in forests. Typically, recorded populations have been small (single tufts of several square centimeters in area) and found colonizing tree bases, trunks, and even crowns, in both rural and urban areas. The moss has been recorded growing epiphytically on 12 types of phorophytes, both those native [*Acer pseudoplatanus* L. (two sites), *Fagus sylvatica* L. (one), *Fraxinus excelsior* L. (six), *Quercus robur* L. (three), *Populus ×canescens* (Aiton) Sm. (one), *Salix fragilis* L. (one), and *S. ×rubens* Schrank (one)] and alien [*Fraxinus pennsylvanica* Marshall (two), *P. ×berolinensis* (K. Koch) Dippel (one), *P. ×canadensis* (four), *Q. rubra* L. (one), and *S. ×sepulcralis* Simonk. ‘Chrysocoma’ (two)] to Poland. The numerical distribution of *H. ciliata* populations on different phorophytes is presented in Figure 2.

### 4. Discussion

To date, the occurrence of epiphytic *H. ciliata* has only rarely been reported in Europe [e.g., Spain, Germany, Portugal (Geyer & Margenburg, 2015; Marques et al., 2005; Mazimpaka & Lara, 1995; Meinunger & Schröder, 2007; Otte, 2002; Rätzel et al., 2000, 2001), and Turkey (Erdağ et al., 2003)] and North America (Eckel, 2014), with all authors emphasizing the atypical nature of this epilithic growth habit on trees. Epilithic and epiphytic habitats tend to have certain physical characteristics in common, notably strong insolation and alternating periods of humidity and extreme drought (Vitt, 1981), and this ecological similarity implies that many bryophyte species can colonize both types of substrates (Mazimpaka & Lara, 1995). It has been suggested that a change in bryophyte habitat of this type may be associated with climatic factors. Barkman (1958), for example, concluded that as the climate becomes drier, epiphytic species move onto phorophytes, which have a greater water-holding capacity, sometimes on decaying wood, and finally rocks and soil. Moreover, with growth, the conditions on trees can begin to resemble those typical on rocks, and thus epilithic species increasingly often colonize trees (Vitt, 1981). This habitat transition is facilitated to a large extent by the xeromorphic features of bryophytes that confer a certain degree of resistance to desiccation or contribute to reducing insolation. In this regard, *H. ciliata* is noted as a desiccation-tolerant bryophyte (Streusand et al., 1986), with several adaptations designed to minimize exposure, including hyaline leaf tips and upwardly curved branch tips (Glime, 2020). Changes in the ecological niche occupied by epilithic mosses and its association with

climate change has also been discussed by Bates et al. (2004), who presented the examples of *Syntrichia ruralis* (Hedw.) F. Weber & D. Mohr, *Grimmia pulvinata* (Hedw.) Sm., and *Tortula muralis* Hedw., which are commonly found on the walls of buildings in Great Britain, whereas in localities characterized by warm dry climates, they typically grow only as epiphytes. It can thus be speculated that the observed expansion of the habitat range of *H. ciliata* to the trunks of trees, a new habitat type for this species in Poland, may represent a response to the ongoing changes in climate in this region of Europe (increases in temperature and the number of dry days per year, along with short but very heavy rainfall, alternating with long periods of drought) (Kundzewicz & Matczak, 2012). Given the large number of sites, their broad distribution, and the diversity of phorophyte hosts and habitats, it would appear that we are witnessing a particularly interesting phenomenon, which is certainly worthy of further investigation and monitoring. Moreover, *H. ciliata* is far from unique in this respect, given that in recent years in Poland, other moss species, hitherto known as obligatory epiliths, have also been increasingly found on the bark of trees, such as *Cynodontium strumiferum* (Hedw.) Lindb., *Grimmia hartmanii* Schimp. (Stebel, 2006), *G. pulvinata* (Fudali & Szymanowski, 2019; Fudali & Żoźnierz, 2019; Wilhelm et al., 2015), *Orthotrichum anomalum* Hedw. (Fudali & Szymanowski, 2019; Stebel & Fojcik, 2016), and *Tortula muralis* (Fudali & Szymanowski, 2019; Plášek et al., 2014).

## 5. Supplementary Material

The following supplementary material is available for this article:

Table S1. List of sites with epiphytic *Hedwigia ciliata* in Poland.

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