

# Bryophytes and lichens in 16th-century herbaria

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The diversity of bryophyte and lichen collections in 9 of the oldest preserved herbaria (dating from ca 1542 to 1577) was compared, including the first reports of bryophytes and lichens from the ‘En Tibi’ herbarium (possibly 1542–1544) and the herbarium of Leonhard Rauwolf (1560–1563). Bryophytes and lichens formed only a minority in each herbarium compared to the numbers of vascular plant specimens; numbers ranged from representatives of 21 genera in the herbarium of Ulisse Aldrovandi to the single genus *Conocephalum* in the Rauwolf herbarium. The focus was on large, handsome species of bryophytes and macrolichens, apart from small amounts of additional species collected as ‘by-catch’ in mixed collections. All herbaria together included 34 genera of bryophytes (36 species and 10 specimens identified to genus level) and 13 genera of lichens (24 species and 4 specimens identified to genus level). The diversity of mosses was higher than that of liverworts, and pleurocarpous mosses were more diverse than acrocarpous mosses. The collectors probably aimed at selecting material that was either characteristic of the vegetation in the respective areas of collecting or used for certain purposes (or both). The former hypothesis is supported by the small overlap in taxonomic diversity between the herbaria, and the latter by the fact that several moss, liverwort, and lichen genera are included whose traditional uses are well documented.

**Keywords:** 16th-century herbaria, En Tibi, Lichens, Liverworts, Mosses, Rauwolf

## Introduction

Pre-Linnaean herbaria not only provide a detailed picture of the floristic biodiversity of a certain region in a particular time, but also add to our knowledge on historic plant preservation techniques, classification, and exchange, which contributed to the formation of contemporary botany (Pulvirenti *et al.*, 2015). The first herbaria are believed to have been created in 16th-century Italy, at the time when Luca Ghini (1490–1556), professor of Botany in Bologna, was teaching the art of pressing and drying plants on paper (Moggi, 2009). Several of his students and associates left remarkable plant collections, among which the ones of Michele Merini (ca 1540–1545), Gherardo Cibo or Francesco Petrollini (two collections conventionally named as Erbario A and Erbario B, the latter possibly around 1550), Ulisse Aldrovandi (1551–1586), and Andrea Cesalpino (1563), all of which were stored in Italian museums and Universities (Caruel, 1858; Penzig, 1905; De Toni, 1907; Moggi, 2009; Thijsse, 2016; Friis, 2017). Among the oldest herbaria still extant today is a

book herbarium of unspecified Italian origin, with the Latin cover text ‘*En tibi perpetuis ridentem floribus hortum*’ [‘Here for you a smiling garden of everlasting flowers’] (henceforth the ‘En Tibi herbarium’). The majority of the ca 500 specimens in this herbarium are of Mediterranean origin, with some alpine plants (Lotsy, 1907) and a few Neotropical crop specimens (Toresella, 1992), the latter probably collected in a botanical garden. The En Tibi herbarium has not been the subject of scientific research until now, apart from brief comments by Toresella (1992), who estimated that the collection was made between 1542 and 1544. A few years later, Leonhard Rauwolf (1535–1596), an ambitious German student of medicine, compiled three volumes of dried plants during his studies in Montpellier, including specimens that he collected from southern France, the Alps and northern Italy between 1560 and 1563 (Dannenfeldt, 1968; Walter, 2009; Thijsse, 2016). Later, Rauwolf became famous for his journey through the Near East that resulted in the 4th volume of his collection containing vascular plants from Syria, Lebanon and adjacent areas (Dannenfeldt, 1968; Ghorbani *et al.*, 2017) and his travel account (Rauwolf, 1583).

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Both the En Tibi and the four Rauwolf herbaria are housed in the treasure room of Naturalis Biodiversity Center at Leiden, The Netherlands. They were once owned by Queen Christina of Sweden (1626–1689), who offered them to her Dutch librarian Isaac Vossius. In 1690, Leiden University purchased this ‘codex Vossianus’ and eventually deposited the historic book herbaria in the collection of the National Herbarium of the Netherlands (now Naturalis) (Gronovius, 1755; Baas, 2005). The entire En Tibi and Rauwolf herbaria were recently digitised, and the vascular plant specimens identified (Stefanaki *et al.*, *in press*), allowing comparisons with other 16th-century herbaria for which similar information is available online or in print. These include the Italian herbaria mentioned above as well as further herbaria from the period 1550 to 1580 that are kept in various institutions in France, Germany, and Switzerland (for an overview, see Thijsse, 2016).

Despite focusing on vascular plants, a number of 16th-century herbaria also contain bryophyte and lichen specimens, namely the herbaria En Tibi, Erbario A and B (Penzig, 1905), Ulisse Aldrovandi (Soldano, 2000–2004, 2005), Felix Platter (1552, <https://platter.burgerbib.ch/herbar/>), Cesalpino (Caruel 1858, <http://www.botanicus.org/title/b1206175x>), Rauwolf, Erbario Ducale Estense (possibly between 1570 and 1600, Camus & Penzig, 1885; Cremonini, 2016), and Caspar Bauhin (1577, <https://herbarium.unibas.ch>). Created about 200–250 years before Johannes Hedwig (1730–1799) and Erik Acharius (1757–1819) would lay the foundations of systematic bryology and lichenology, respectively (e.g. Galloway, 1981; Frahm, 2000), these collections contain the oldest moss, liverwort, and lichen specimens we know today.

Here we report on the moss, liverwort, and lichen specimens included in the En Tibi and the first three volumes of the Rauwolf herbarium and discuss the diversity of bryophyte and lichen specimens in a total of nine 16th-century herbaria.

## Materials and Methods

Bryophytes and lichens in the En Tibi and Rauwolf herbaria were identified from the high-resolution scans and by examining the original material under a binocular microscope (Olympus SZ11). Where necessary for identification, a single leaf was taken from the bryophyte specimens for examining leaf characters using a compound microscope (Olympus BX51). Literature used for identification included Frey *et al.* (2006), Smith (2004), Cortini Pedrotti (2001–2006), and Lüth (2006–2010) for bryophytes as well as Randlane *et al.* (2009) and Smith *et al.* (2009) for lichens.

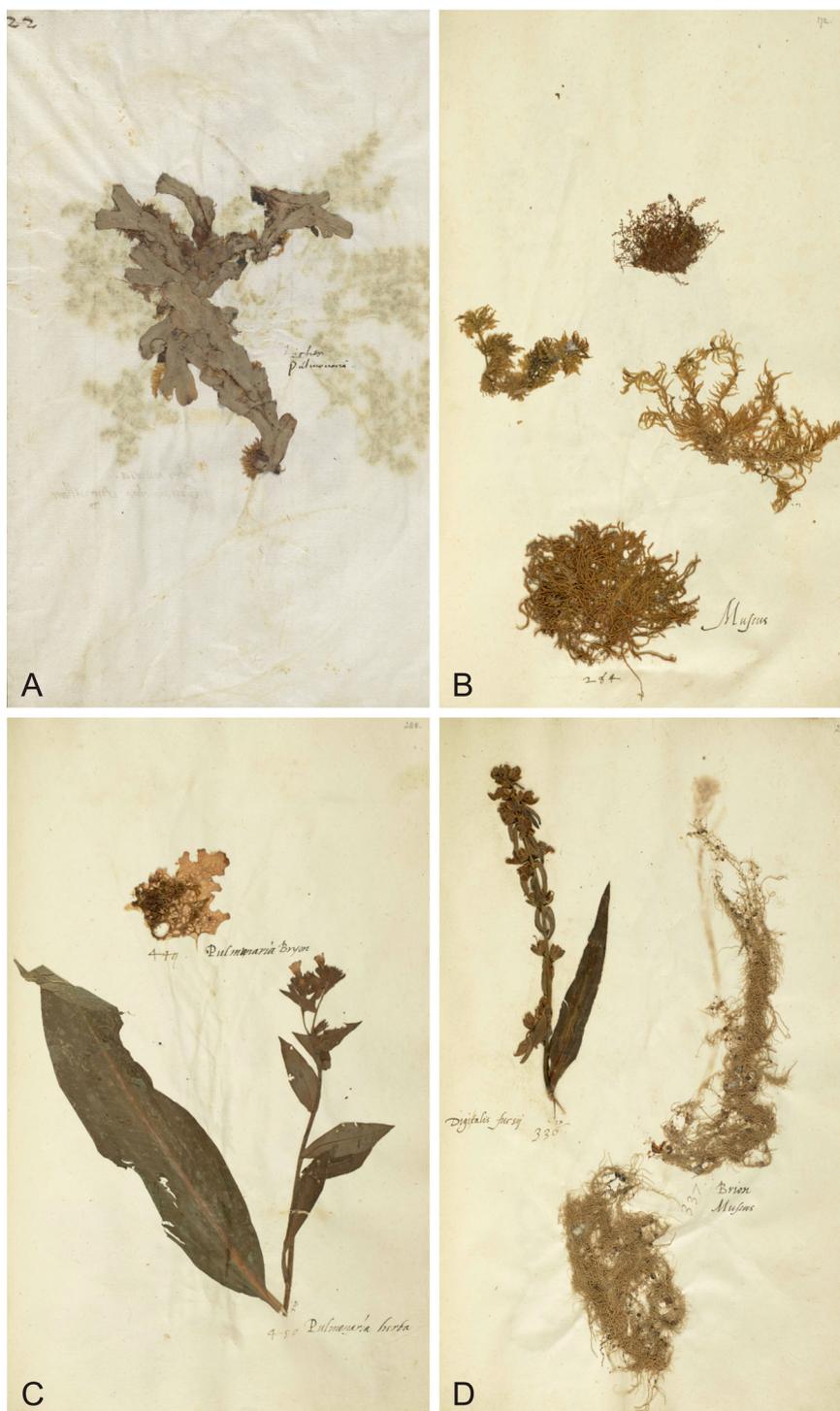
Records of bryophytes and lichens in the remaining seven herbaria were compiled from the available literature and online resources (see introduction), searching both the 16th-century names (e.g. ‘Brion’, ‘Bryon’, ‘Hepaticae’, ‘Lichen’, ‘Moscho’, ‘Muscus’, ‘Polytricum’, ‘Pulmonaria’) and the scientific names from the 18th- to 20th-century identifications. Scientific names were checked and updated according to Hill *et al.* (2006) for bryophytes as well as Randlane *et al.* (2009) and Smith *et al.* (2009) for lichens.

## Results

The Rauwolf herbarium contained a single page with a specimen of the thallose liverwort *Conocephalum conicum* (L.) Dumort., called ‘Lichen Pulmonaria’ (Figure 1A). In the En Tibi herbarium, 4 mosses were arranged on 1 page, altogether called ‘Muscus’. These comprised 1 acrocarpous species, *Plagiomnium cuspidatum* (Hedw.) T.J.Kop., and 3 pleurocarpous species, *Anomodon viticulosus* (Hedw.) Hook. & Taylor, *Hylocomium splendens* (Hedw.) Schimp., and *Pleurozium schreberi* (Willd. ex Brid.) Mitt. (Figure 1B). Furthermore, 2 lichen species were found on separate pages in En Tibi, namely *Lobaria pulmonaria* (L.) Hoffm. (‘Pulmonaria Bryon’, Figure 1C) and *Usnea longissima* Ach. (‘Brion Muscus’, Figure 1D). Three of these specimens were mixed with small amounts of additional mosses: *C. conicum* with *Brachythecium* sp. and *Pohlia* sp., *P. cuspidatum* with *Timmia bavarica* Hessel., and *L. pulmonaria* with *Homalothecium cf. lutescens* (Hedw.) H.Rob. and *Pterigynandrum filiforme* Hedw.

Altogether, in all 9 herbaria investigated, specimens from 34 genera of bryophytes and 13 genera of lichens were recorded based on the previous and current identifications. The bryophytes comprised 36 species and 10 specimens identified to genus level (Table 1), and the lichens 24 species and 4 specimens identified to genus level (Table 2). Apart from updating the taxonomy of several species names, 2 earlier identifications of specimens in volume 8 of the Platter herbarium were revised (page 39: ‘unidentified’, identified as *Funaria hygrometrica* Hedw.; page 87: ‘Hypnales’, identified as *cf. Rhytidiadelphus* sp.). In addition, sheet B01-087 of the Bauhin herbarium also had a stem of *cf. Rhytidiadelphus* sp., which was not noticed on the website. Whether mixed collections with additional taxa occurred in the other herbaria as well could not be inferred from the available literature or online resources. The additional mosses in the mixed collections in the En Tibi and Rauwolf herbaria were therefore excluded from the further analyses below, since they were probably not collected on purpose.

The diversity of mosses was found to be clearly higher than that of liverworts (representatives of 27



**Figure 1** Scanned pages of the Rauwolf herbarium (A) and the En Tibi herbarium (B–D) containing specimens of bryophytes and lichens. (A) *Conocephalum conicum* ('Lichen Pulmonaria'), (B) *Plagiomnium cuspidatum*, *Anomodon viticulosus*, *Hylocomium splendens*, and *Pleurozium schreberi* ('Muscus'), (C) *Lobaria pulmonaria* ('Pulmonaria Bryon', above), (D) *Usnea longissima* ('Brion Muscus', right and under).

vs 4 genera, Table 1). Pleurocarpous mosses were more diverse than acrocarpous mosses (representatives of 17 vs 10 genera). Taking bryophytes and lichens together, the majority of 23 genera were present in only 1 herbarium, compared to 11 genera in two, and 10 genera present in 3 or more herbaria. Most commonly found were the lichen genera *Usnea* (5 herbaria), *Cladonia* (4), and *Lobaria* (4), followed by the moss genera *Dicranum*, *Plagiomnium*, *Sphagnum*, and

*Thamnobryum*, the liverwort genus *Marchantia*, and the lichen genera *Cetraria* and *Peltigera*, all present in 3 herbaria. *Cladonia* was also the genus with the highest species diversity of all bryophyte and lichen genera encountered, comprising 9 species (Table 2), of which only 2, *Cladonia rangiferina* (L.) F.H. Wigg. and *C. rangiformis* Hoffm., were present in more than one herbarium. In terms of genus diversity per herbarium, numbers ranged from 21 genera in the

**Table 1** Bryophyte species included in nine 16th-century herbaria using current nomenclature. Asterisks indicate taxa that were found mixed with the respective main collection.

Taxon	En Tibi (possibly 1542–1544)	Erbario A (?)	Erbario B (c. 1550)	Aldrovandi (1551–1586)	Platter (1552 onwards)	Rauwolf (1560– 1563)	Cesalpino (1563)	Ducale Estense (c. 1570– 1600)	Bauhin (1577)
<b>Bryophyta Acrocarpous mosses</b>									
<i>Sphagnum angustifolium</i> (Russow) C.E.O.Jensen									x
<i>Sphagnum capillifolium</i> (Ehrh.) Hedw.					x				
<i>Sphagnum cf. quinquefarium</i> (Lindb.) Warnst.									x
<i>Sphagnum</i> sp.				x					
<i>Polytrichum commune</i> Hedw.							x		
<i>Polytrichum</i> sp.					x				
<i>Funaria hygrometrica</i> Hedw.			x		x				
<i>Timmia bavarica</i> Hessel.*	x								
<i>Dicranodontium</i> sp.		x							
<i>Dicranum scoparium</i> Hedw.		x		x					x
<i>Dicranum undulatum</i> Schrad. <i>ex</i> Brid.									x
<i>Syntrichia</i> sp.			x						
<i>Tortula muralis</i> Hedw.				x					
<i>Trichostomum crispulum</i> Bruch			x						
<i>Plagiomnium cuspidatum</i> (Hedw.) T.J.Kop.	x								
<i>Plagiomnium undulatum</i> (Hedw.) T.J.Kop.			x						x
<i>Rhizomnium punctatum</i> (Hedw.) T.J.Kop.		x							
<i>Pohlia</i> sp.*						x			
<b>Bryophyta—Pleurocarpous mosses (Hypnales)</b>									
<i>Anomodon viticulosus</i> (Hedw.) Hook. & Taylor	x		x						
<i>Brachythecium salebrosum</i> (Hoffm. <i>ex</i> F.Weber & D.Mohr) Schimp.				x					
<i>Brachythecium</i> sp.*						x			
<i>Climacium dendroides</i> (Hedw.) F.Weber & D.Mohr									x
<i>Eurhynchiastrum pulchellum</i> (Hedw.) Ignatov & Huttunen			x						
<i>Fontinalis antipyretica</i> Hedw.									x
<i>Homalothecium lutescens</i> (Hedw.) H.Rob.								x	
<i>Homalothecium cf. lutescens</i> (Hedw.) H.Rob.*	x								
<i>Homalothecium sericeum</i> (Hedw.) Schimp.			x						
<i>Hygroamblystegium tenax</i> (Hedw.) Jenn.			x						
<i>Hylocomium splendens</i> (Hedw.) Schimp.	x	x							
<i>Hypnum cupressiforme</i> Hedw.			x						
<i>Hypnum vaucheri</i> Lesq.			x						
<i>Kindbergia praelonga</i> (Hedw.) Ochyra				x					
<i>Neckera crispa</i> Hedw.			x						x
<i>Pleurozium schreberi</i> (Willd. <i>ex</i> Brid.) Mitt.	x	x							

Continued

## Continued

Taxon	En Tibi (possibly 1542–1544)	Erbario A (?)	Erbario B (c. 1550)	Aldrovandi (1551–1586)	Platter (1552 onwards)	Rauwolf (1560– 1563)	Cesalpino (1563)	Ducale Estense (c. 1570– 1600)	Bauhin (1577)
<i>Pterigynandrum filiforme</i> Hedw.*	x								
<i>Ptilium crista-castrensis</i> (Hedw.) De Not.									x
<i>Rhytidiadelphus triquetrus</i> (Hedw.) Warnst.								x	
<i>cf. Rhytidiadelphus</i> sp.					x				x
<i>Pseudoscleropodium purum</i> (Hedw.) M.Fleisch.				x					
<i>Thamnobryum alopecurum</i> (Hedw.) Gangulee			x				x		
<i>Thamnobryum</i> sp.?				x					
<i>Thuidium tamariscinum</i> (Hedw.) Schimp.				x				x	
<b>Marchantiopsida</b>									
<i>Conocephalum conicum</i> (L.) Dumort.					x	x			
<i>Marchantia polymorpha</i> L.		x		x					
<i>Marchantia</i> sp.									x
<b>Jungermanniopsida</b>									
<i>Frullania tamarisci</i> (L.) Dumort.			x						
<i>Jungermannia</i> sp.									x

Aldrovandi herbarium to the single genus *Conocephalum* in the Rauwolf herbarium (Figure 2).

### Discussion

The records from 9 of the oldest herbaria indicate that bryophytes and lichens, despite being less conspicuous than vascular plants, were recognised by the early collectors in the field, and collected on purpose. However, they form only a minority in each respective herbarium compared to the numbers of vascular plant specimens. The most remarkable example perhaps is the large collection of Aldrovandi, which comprises a

total of 4800 specimens belonging almost exclusively to vascular plant species, and only few to bryophytes, lichens, and seaweeds (Soldano, 2005; Tables 1 and 2). Also in the newly studied En Tibi and Rauwolf herbaria, the bryophyte and lichen diversity is low, especially in the latter, which contains only one species collected on purpose, *Conocephalum conicum*. Additional species collected as ‘by-catch’ increase the diversity in both the En Tibi and Rauwolf herbarium, but that might also prove to be true of the other herbaria, if the original specimens were to be re-investigated in detail.

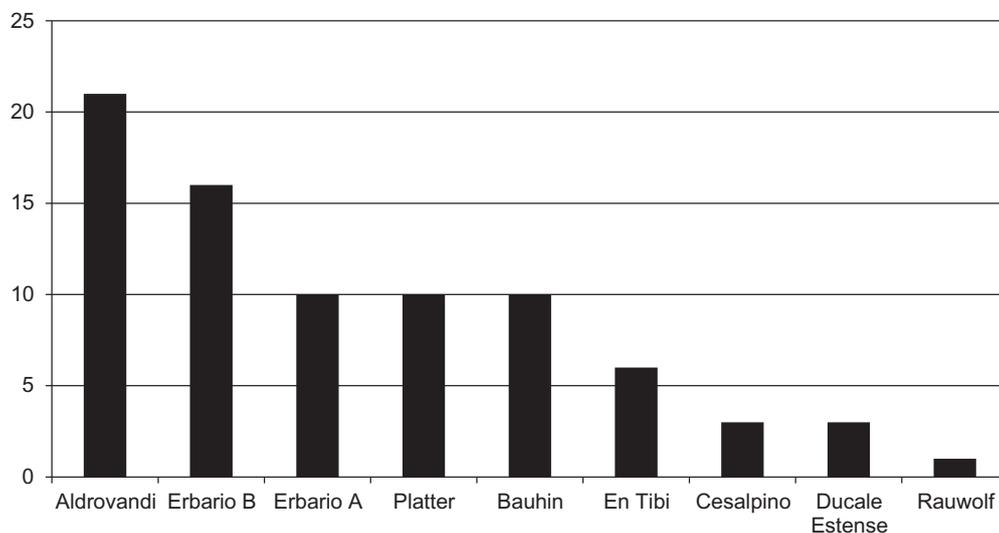


Figure 2 Number of genera of bryophytes and lichens included in nine 16th-century herbaria.

**Table 2** Lichen species included in nine 16th-century herbaria using current nomenclature.

Taxon	En Tibi (possibly 1542–1544)	Erbario A (?)	Erbario B (c. 1550)	Aldrovandi (1551–1586)	Platter (1552 onwards)	Rauwolf (1560– 1563)	Cesalpino (1563)	Ducale Estense (c. 1570–1600)	Bauhin (1577)
<i>Alectoria ochroleuca</i> (Hoffm.) A.Massal.				x					
<i>Bryoria</i> sp.				x					
<i>Cetraria islandica</i> (L.) Ach.		x		x	x				
<i>Cladonia arbuscula</i> (Wallr.) Flot.			x		x				
<i>Cladonia coniocraea</i> (Flörke) Sprengel				x					
<i>Cladonia cornuta</i> (L.) Hoffm.		x							
<i>Cladonia fimbriata</i> (L.) Fr.			x						
<i>Cladonia foliacea</i> (Huds.) Willd.			x						
<i>Cladonia furcata</i> (Huds.) Schrad.		x							
<i>Cladonia pyxidata</i> (L.) Hoffm.		x							
<i>Cladonia rangiferina</i> (L.) F.H.Wigg.		x			x				
<i>Cladonia rangiformis</i> Hoffm.			x	x					
<i>Dermatocarpon miniatum</i> (L.) W.Mann.					x				
<i>Evernia prunastri</i> (L.) Ach.				x					
<i>Hypogymnia physodes</i> (L.) Nyl.				x					
<i>Letharia vulpina</i> (L.) Hue				x	x				
<i>Lobaria pulmonaria</i> (L.) Hoffm.	x		x	x			x		
<i>Parmelia caperata</i> (L.) Ach.				x					
<i>Parmelia</i> sp.				x					
<i>Peltigera aphthosa</i> (L.) Willd.		x							
<i>Peltigera canina</i> (L.) Willd.			x						
<i>Peltigera</i> sp.				x					
<i>Pseudevernia furfuracea</i> (L.) Zopf				x					
<i>Usnea barbata</i> (L.) Weber <i>ex</i> F.H.Wigg.		x	x	x					
<i>Usnea ceratina</i> Ach.					x				
<i>Usnea longissima</i> Ach.	x								
<i>Usnea subfloridana</i> Stirt.					x				
<i>Usnea</i> sp.				x					

The focus in all studied herbaria was clearly on collecting large, handsome species of bryophytes and macrolichens. Although the early collectors may have been good observers, it is likely that the full diversity of bryophyte and lichen morphotypes remained unknown to them, about 200–250 years before bryology and lichenology emerged as scientific disciplines of their own. Lichens were considered as types of moss until the end of the 17th century (Gilbert, 2000). That the distinction between bryophytes and lichens had not yet been clearly established in the 16th century, is evident from the names given to some specimens, e.g. *Conocephalum* was called ‘Lichen’ and *Lobaria* ‘Bryon’ (Figure 1).

Small and inconspicuous species may be missing because they were simply overlooked. If recognised

in the field, some groups like crustose lichens on rock may not have been collected because including them in a book herbarium was considered too difficult. However, it is also possible that the collectors aimed at selecting representative material that was either characteristic of the vegetation in the respective areas of collecting or used for certain purposes (or both). The former hypothesis is supported by the small overlap in taxonomic diversity between the studied herbaria, indicating that different genera or species dominated the different geographic areas. The latter hypothesis is supported by the fact that several moss and liverwort genera are included whose traditional uses are well documented. These include, for example, the ‘top three genera’ (Harris, 2008) that are the most commonly reported to have

ethnobotanical uses, viz. *Sphagnum*, *Marchantia*, and *Polytrichum*, as well as *Funaria* (Drobnik & Stebel, 2015). In particular, the peat mosses (*Sphagnum*) were used for a variety of purposes due to their absorbent and antimicrobial properties (Glime, 2007; Harris, 2008). The medical use of *Marchantia*, and probably *Polytrichum* as well, was guided by the ‘Doctrine of Signatures’ (medicinal properties of plants suggested by their shape), since the thallus of the former was considered to resemble a human liver, and the hairs on the calyptra of the latter were reminiscent of human hair (Pant, 1998; Glime, 2007; Harris, 2008). Apart from *Polytrichum* and *Sphagnum*, several other moss genera included in the early herbaria (e.g. *Brachythecium*, *Dicranum*, *Hylocomium*, *Hypnum*, *Neckera*, *Pseudoscleropodium*, *Rhytidiadelphus*) have had daily uses for constructing, stuffing, packing, and protecting household goods and food items in various civilisations since the Stone Age (Glime, 2007). Lichens were quite widely used as well (e.g. Schöller, 1997); they were already used as an agent for the preservation of ancient Egyptian mummies, feature in the Bible (manna), and are still widely used nowadays as food (especially *Umbilicaria esculenta* (Miyoshi) Minks), tea infusions (e.g. *Thammodia*), and in various medicines. One example is ‘Isla Moos’, a coughing elixir based on *Cetraria islandica* (L.) Ach., a lichen which was present in three of the studied herbaria (Table 2).

Some names of the collected bryophyte and lichen species seem to have been given in analogy to uses of vascular plants. For example, the scientific name of the vascular plant genus *Pulmonaria* L. is derived from Latin *pulmo* (lung), since the spotted oval leaves of *P. officinalis* L. were thought to symbolise ulcerated lungs, and according to the Doctrine of Signatures, were used to treat pulmonary infections (Munting, 1696). ‘Pulmonaria’ was also used for *Conocephalum* and *Lobaria* in the Rauwolf and En Tibi herbaria; in the latter, specimens of *Lobaria* and *Pulmonaria* (‘Pulmonaria herba’) were even mounted together on the same page (Figure 1C). In fact, the thallus of *Lobaria* had been considered to resemble human lung tissue as well and was recommended for treating lung diseases in the 16th century (e.g. Gilbert, 2000). The thallus of *Conocephalum* may have been considered similar to *Pulmonaria* leaves due to the whitish dots marking the opening of the air chambers, although it seems that medicinal uses of *Conocephalum* did not include treating lung diseases (Pant, 1998; Glime, 2007; Harris, 2008).

Herbals are a complementary source of information on the recognition of bryophytes and lichens in the 16th century. Compared to the 16th-century herbaria, however, the herbals seemed to focus on a few, medicinally important taxa, most importantly *Marchantia*,

*Polytrichum*, and *Lobaria*. One example from the same group of botanists in northern Italy that collected the specimens for the En Tibi as well as the Erbario A and B is the herbal ‘Commentaries of Dioscorides Materia Medica’ by Pietro Andrea Mattioli (Mattioli, 1544; several later editions, with illustrations for some editions by Gherardo Cibo). He included *Marchantia* (‘Lichene’) and *Lobaria* (‘Polmonaria’, the latter being displayed next to *Pulmonaria officinalis* as “Un’ altra Polmonaria [sic!]”) as well as two other bryophytes named ‘Muschio arboreo’ and ‘Muschio terrestre’, which cannot be identified from the respective illustrations. *Marchantia* and *Pulmonaria* were furthermore included in the Germans herbals ‘Das Kreütter Buch’ by Hieronymus Bock (Bock, 1539; 2nd edition with illustrations 1546) and ‘New Kreüterbuch’ by Leonhart Fuchs (Fuchs, 1543; Dressendörfer, 2001), and *Marchantia* in the English ‘New Herball’ by William Turner (Turner, 1551) and the Dutch ‘Cruijdeboeck’ by Rembert Dodoens (Dodoens, 1554; <http://www.leesmaar.nl/cruijdeboeck/>). *Polytrichum* was already mentioned by Brunfels (1530) (cf. Drobnik & Stebel, 2015) and displayed in the ‘Cruijdeboeck’ and the ‘New Kreüterbuch’. Examples of other mosses were *Bryum* or *Funaria* in the latter (cf. Dobat, 2001), and a moss displayed as growing on a human skull in Gerard’s Herball (Gerard, 1597).

The advantage of herbals is that the recognition of at least some medicinally important bryophytes and lichens could be traced back over a longer period, probably from the ancient times onwards, which is, however, beyond the scope of this study. On the other hand, species illustrated and described in Medieval (and older) herbals are more difficult to identify, since it was only in the 16th century (the Renaissance period) that botanical artists started to display plants in a natural way (Heilmann, 1973).

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