

## **A preliminary account of the peristome structure and spores in six species of *Philonotis* (Bartramiaceae, Bryophyta)**

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**Abstract** – A morphological study of the peristome and spores of six species of European *Philonotis* is reported. New peristome and spore characters are described and discussed. Among them the characters that show consistent differences and could help with accurate discrimination of the species are the papillosity of the surface of the endostome and exostome teeth, the differentiation of the OPL median line, the papillosity and number of cell rows of the basal membrane of the exostome and endostome, the number of cilia per cluster, and spore ornamentation. Nevertheless a more intensive study and examination of more numerous specimens is needed to confirm the taxonomic value of these characters.

***Philonotis* / Peristome / SEM / Exostome / Endostome / Outer Peristomial Layer / Principal Peristomial Layer / Inner Peristomial Layer / Intertrabecular thickenings / Ornamentation / Spores**

### **INTRODUCTION**

*Philonotis* is a worldwide genus that comprises 169 species (Crosby *et al.*, 1999), most of which are distributed in the southern hemisphere. In Europe this genus is represented by only 9 species, *Philonotis caespitosa* Jur., *Ph. calcarea* (Bruch & Schimp.) Schimp., *Ph. capillaris* Lindb. ex Hartm., *Ph. cernua* (Mitt.) Griffin & Buck, *Ph. fontana* (Hedw.) Brid., *Ph. marchica* (Hedw.) Brid., *Ph. rigida* Brid., *Ph. seriata* Mitt. and *Ph. tomentella* Molendo in Lorentz. Among them only 6 have been found in different European herbaria with sufficient sporophytes to allow a study of the morphology and structure of the peristome and spores.

There are very few previous works on the peristome structure of *Philonotis*, and only drawings and light micrographs have been published. Dismier (1907) provided a good description of the exostome teeth. He described the presence of intertrabecular thickenings that he named “intertrabecular tori” and did not consider them to be taxonomically important. Zales (1973) described the structure of the endostome as “cohering cilia”, and Shaw & Rohrer (1984) correctly evaluated the structure as consisting of segments that split along their median line almost to the basal membrane, each half diverging towards the cilia where they often meet the corresponding half of the next adjacent segment, thus framing the cilia.

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In the same way, very little specific work has been done to date on the spore ornamentation of *Philonotis*. Boros & Járαι-Komlódi (1975) described the spore ornamentation in *Philonotis calcarea* and *Ph. fontana*. Subsequently, Hirohama (1977), Griffin (1981, 1982) and Griffin & Acuña (1983) described the spore ornamentation in the genera of Bartramiaceae.

In the course of a taxonomic study of the genus *Philonotis* for the Flora Briofítica Ibérica, both peristome structure and spore ornamentation appeared to vary between the studied species. To confirm this variation, a SEM study of the peristome structure and spore ornamentation was carried out. Since the number of studied specimens was limited in number, this study was not intended to test taxonomic hypotheses, but rather to describe the variation in the morphological characters of the sporophyte.

## MATERIAL AND METHODS

This study is based on the examination of more than 86 specimens from the following European herbaria: BM (London), FCO (Oviedo), GDA (Granada), H (Helsinki), Herb. J. Martínez-Abaigar (Logroño), LEB (León), MA-Musci (Madrid), MACB (Madrid), MUB (Murcia), SANT-Bryo (Santiago de Compostela), VAB (Valencia) and VIT (Vitoria) (See Appendix I for a list of selected specimens). Mature capsules and spores from them were taken for this study.

General morphology was examined using an Olympus CH-2 light microscope. In each of these preparations up to 20 measurements were made on the dimensions of the spores and peristome.

Spore and peristome surfaces were studied using a Jeol JSM-6100 scanning electron microscope (SEM), using 10-25 kv acceleration. For the SEM study, the material was fixed in 3% glutaraldehyde with 0.1M cacodylate buffer at 4°C, then washed in cacodylate and saccharose buffer, and dehydrated in an increasing acetone series, critical point dried and coated with a gold layer of 20-30 nm.

The nomenclature used for the description of the peristome structure follows Edwards (1984): OPL (Outer Peristomial Layer); PPL (Principal Peristomial Layer); IPL (Inner Peristomial Layer).

## RESULTS

*Philonotis caespitosa* Jur., *Verh. K. K. Zool.-Bot. Ges. Wien* 11: 234. 1862.

Exostome teeth 200-250 µm long, apex truncate; OPL (Fig. 1, A) with the median line well developed, the basal surface reticulate-papillose, the papillae 0.75-0.88 µm high, the apical surface with scattered tall papillae, 1.18-1.89 µm high; exostomial PPL (Fig. 1, C) trabeculate, smooth at the base and with wide, short and simple papillae extending to the apex, 0.41-0.48 µm high, with intertrabecular thickenings in the upper half, 8.4-11.6 µm high; basal membrane smooth and formed by 3-4 cell rows, 70-80 µm high. Endostome segments 100-140 µm long;

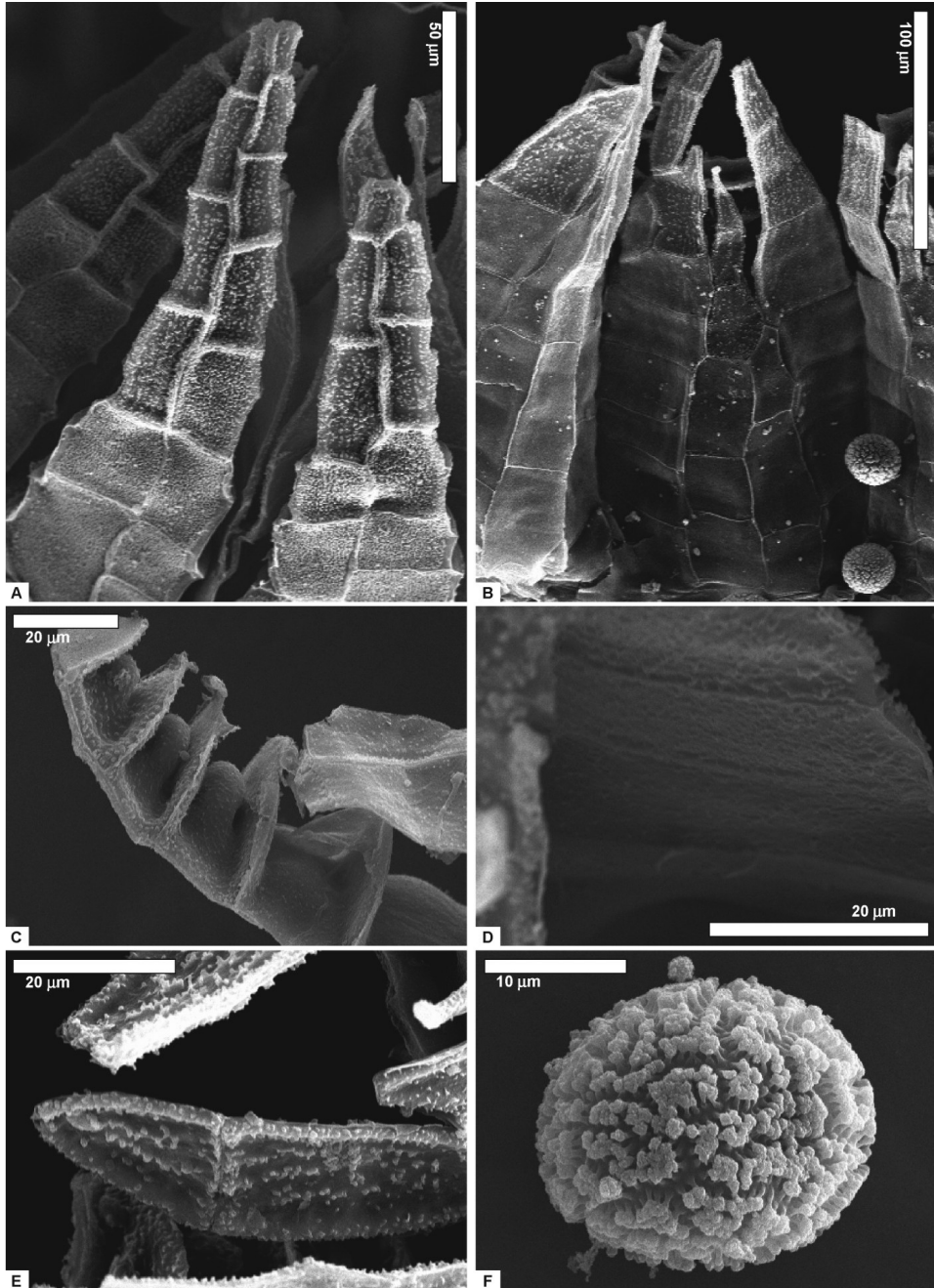


Fig. 1. *Philonotis caespitosa*. **A:** OPL view. **B:** IPL view. **C:** Exostomial PPL. **D:** Basal endostomial PPL. **E:** Apical IPL. **F:** Spore.

endostomial PPL (Fig. 1, D) with simple and irregular papillae throughout, 0.81-1.30  $\mu\text{m}$  high; IPL (Fig. 1, B) smooth at the base, papillose in the upper third, the papillae simple, sometimes bifurcate and disposed in rows (Fig. 1, E), 1.24-1.55  $\mu\text{m}$  high; cilia in clusters of 2-3, 60-100  $\mu\text{m}$  long; basal membrane smooth, formed by 4-6 cell rows, 80-90  $\mu\text{m}$  high. Peristomial formula 4:2:8.

Spores (Fig. 1, F) subspherical to reniform, 20-28  $\mu\text{m}$  in diameter, perine with pilate processes, 1.70-2.02  $\mu\text{m}$  high, finely granulate on the surface, often clustered at the level of the capitae into small, irregularly arranged groups that leave visible furrows in the exine surface.

***Philonotis calcarea*** (Bruch & Schimp.) Schimp., *Coroll. Bryol. Eur.*: 86. 1856.

Exostome teeth 250-290  $\mu\text{m}$  long, apex blunt; OPL (Fig. 2, A-C) with the median line well developed, the basal surface reticulate-papillose, with simple papillae extending to the apex, the papillae 1.86-1.95  $\mu\text{m}$  high; exostomial PPL (Fig. 2, D) trabeculate, finely papillose at the base, the papillae 0.62-1.15  $\mu\text{m}$  high, strongly papillose in the upper third, with simple papillae, 0.51-0.59  $\mu\text{m}$  high, with intertrabecular thickenings in the upper half; basal membrane smooth, formed by 3-4 cell rows, 50-70  $\mu\text{m}$  high. Endostome segments 150-200  $\mu\text{m}$  long, sometimes with perforations or thin areas in the wall (Fig. 2, F); endostomial PPL (Fig. 2, E-F) smooth at the base, finely papillose in the upper third, with simple papillae, 0.60-0.79  $\mu\text{m}$  high; IPL (Fig. 2, G) finely papillose at the base, with high and irregular papillae, sometimes bifurcate or branched in the upper third, 0.64-2.36  $\mu\text{m}$  high; cilia with incurved apex, in clusters of 3-4, 50-60  $\mu\text{m}$  long; basal membrane smooth, formed by 3-5 cell rows, 70-90  $\mu\text{m}$  high. Peristomial formula 4:2:10.

Spores (Fig. 2, H) subspherical to reniform, 24-26  $\mu\text{m}$  in diameter, perine composed of baculate to pilate processes, 1.51-1.64  $\mu\text{m}$  high, rarely coalescent, irregularly sized.

***Philonotis fontana*** (Hedw.) Brid., *Bryol. Univ.* 2: 18. 1827.

Exostome teeth 100-150  $\mu\text{m}$  long, apex truncate; OPL (Fig. 3, A-B) with the median line well developed, though sometimes not so, the basal surface rugose, sometimes with scattered papillae in the upper third; exostomial PPL (Fig. 3, C) trabeculate, smooth at the base, with thick and simple papillae in the upper third, 0.49-0.79  $\mu\text{m}$  high, with intertrabecular thickenings in the upper half, 8.5  $\mu\text{m}$  high; basal membrane formed by 3-4 cell rows, 70-80  $\mu\text{m}$  high. Endostome segments 140-150  $\mu\text{m}$  long; endostomial PPL (Fig. 3, D) rugulose throughout, the papillae 0.83-1.71  $\mu\text{m}$  high; IPL (Fig. 3, E) very papillose, with simple papillae throughout, 1.21-1.71  $\mu\text{m}$  high; cilia in clusters of 2-3, 100-130  $\mu\text{m}$  long; basal membrane finely papillose, formed by 4-5 cell rows, 80-90  $\mu\text{m}$  high. Peristomial formula 4:2:10.

Spores (Fig. 3, F) ovate to reniform, 24-28  $\mu\text{m}$  in diameter, with diverse perinate processes, from granulae and verrucae to pila or clavae, 1.28-2.68  $\mu\text{m}$  high, smooth on the surface, eventually clustered into small groups.

***Philonotis rigida*** Brid., *Bryol. Univ.* 2: 17. 1827.

Exostome teeth 220-330  $\mu\text{m}$  long, apex blunt; OPL (Fig. 4, A-C) with the median line well developed, the basal surface reticulate-smooth, papillose in the upper third, the papillae 0.96-1.15  $\mu\text{m}$  high; exostomial PPL (Fig. 4, D-E) trabeculate, smooth at the base, papillose in the upper third, with simple papillae, 0.69-1.16  $\mu\text{m}$  high, with intertrabecular thickenings in the upper half, 11.3-14.3  $\mu\text{m}$

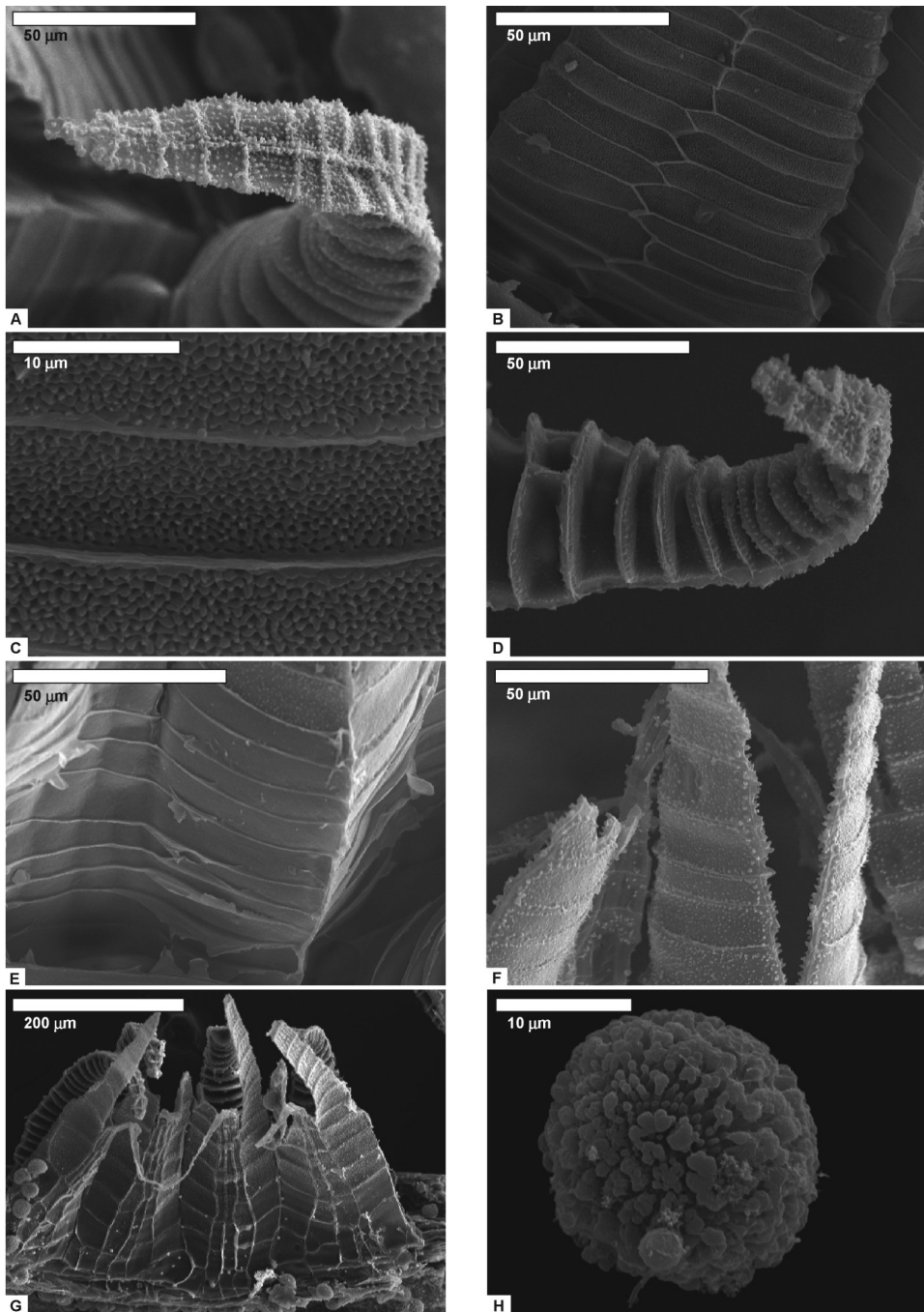


Fig. 2. *Philonotis calcarea*. **A:** Apical OPL. **B:** Basal OPL. **C:** Detail of basal OPL. **D:** Exostomial PPL. **E:** Basal endostomial PPL. **F:** Apical endostomial PPL. **G:** IPL view. **H:** Spore.

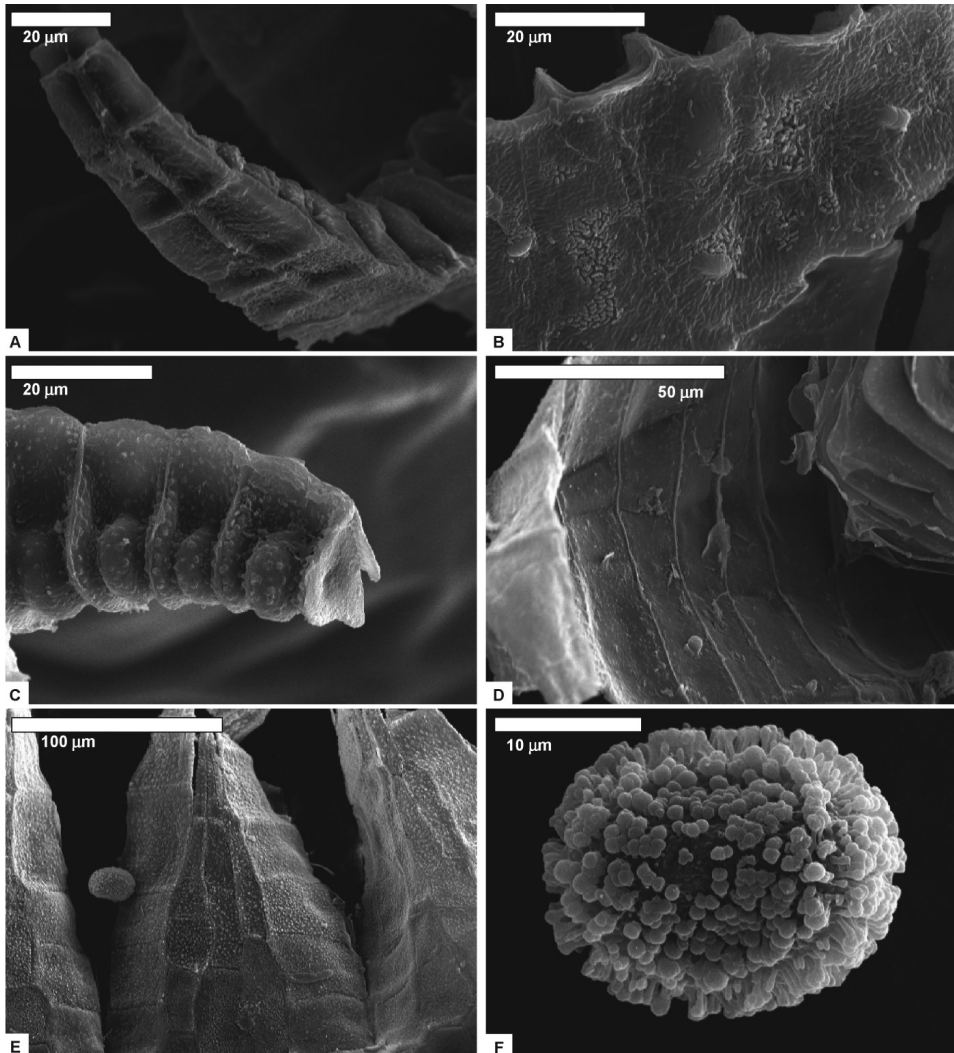


Fig. 3. *Philonotis fontana*. **A:** Apical OPL. **B:** Basal OPL. **C:** Apical exostomial PPL. **D:** Basal endostomial PPL. **E:** IPL view. **F:** Spore.

high; basal membrane formed by 3 cell rows, 50-60 µm high. Endostome segments 220-330 µm long; endostomial PPL (Fig. 4, F-G) smooth at the base, weakly papillose in the upper third, with simple and scattered papillae, 0.42-0.56 µm high; IPL smooth at the base, with papillose ridges near the apex, the papillae 1.05-1.23 µm high; cilia in clusters of 3, 90-100 µm long; basal membrane smooth, formed by 3-5 cell rows, 80-90 µm high. Peristomial formula 4:2:6.

Spores (Fig. 4, H) from subspherical to reniform, 32-34 µm in diameter, perine with pilum-like processes with relatively prominent capitae, 1.75-2.05 µm high, densely granulate on the surface, and often coalescent at the apex.

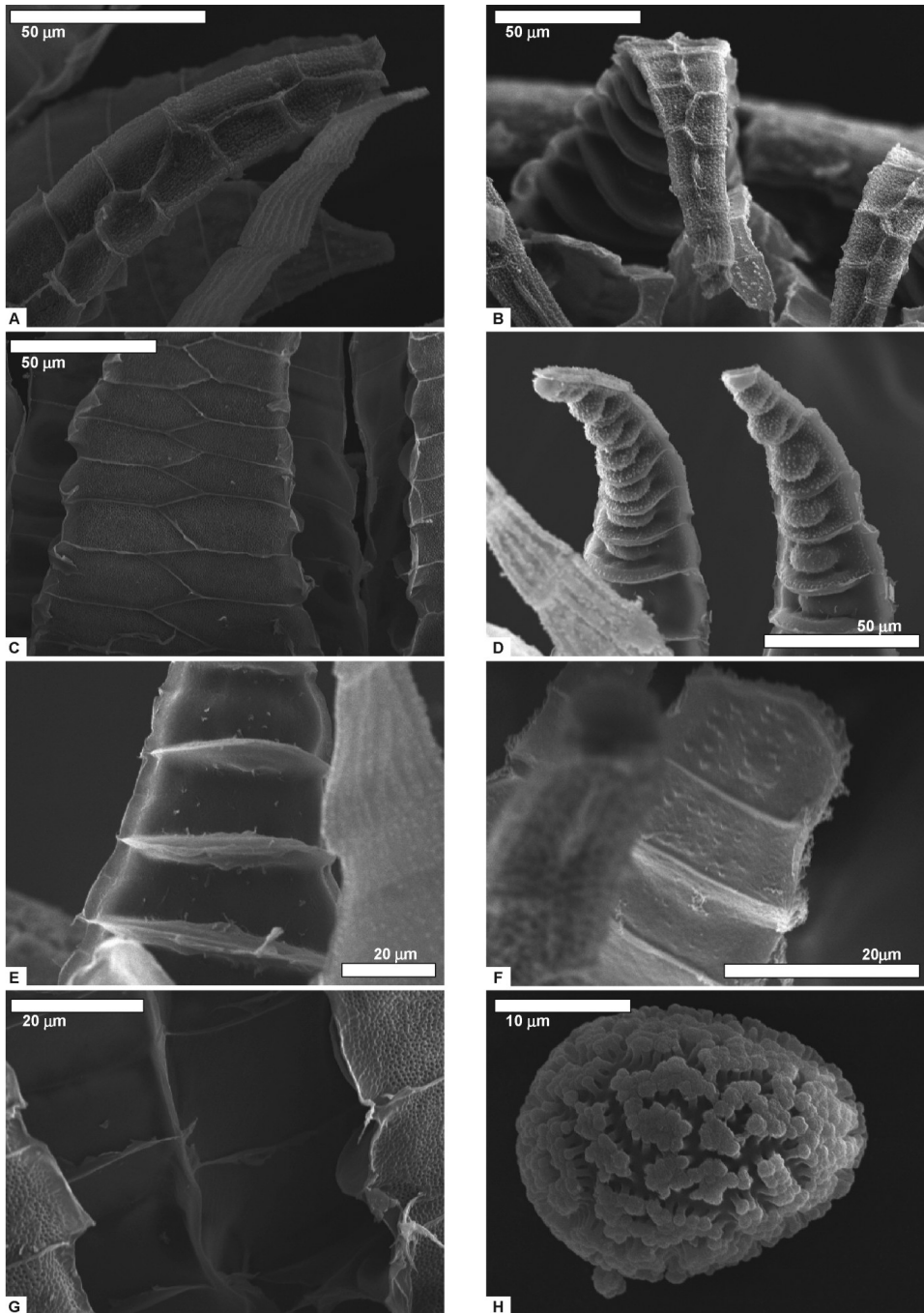


Fig. 4. *Philonotis rigida*. **A:** Apical OPL and IPL. **B:** Apical OPL and endostomial PPL. **C:** Basal OPL. **D:** Apical exostomial PPL. **E:** Basal exostomial PPL. **F:** Apical endostomial PPL. **G:** Basal endostomial PPL. **H:** Spore.

***Philonotis seriata*** Mitt., *J. Proc. Linn. Soc., Bot. Suppl.* 1: 63. 1859.

Exostome teeth 140-180  $\mu\text{m}$  long, apex truncate; OPL (Fig. 5, A) with the median line sometimes absent, surface reticulate-smooth throughout; exostomial PPL (Fig. 5, B) trabeculate, smooth at the base, upper third finely papillose, with intertrabecular thickenings in the upper third, 16  $\mu\text{m}$  high; basal membrane (Fig. 5, C) formed by 3-6 cell rows, 60-90  $\mu\text{m}$  high. Endostome segments 120-150  $\mu\text{m}$  long; endostomial PPL (Fig. 5, D) smooth at the base; IPL (Fig. 5, E-G) finely papillose in the upper third, the papillae 0.56-0.60  $\mu\text{m}$  high, with thinned areas in the walls; cilia in clusters of 2-3, 70-110  $\mu\text{m}$  long; basal membrane finely papillose or smooth, formed by 4-5 cell rows, 80-90  $\mu\text{m}$  high. Peristomial formula 4:2:8.

Spores (Fig. 5, H) spherical to reniform, 26-30  $\mu\text{m}$  in diameter, perine consisting of predominantly bacula-like processes, 1.09-1.44  $\mu\text{m}$  high, isolated, less often clustered into small groups.

***Philonotis tomentella*** Molendo in Lorentz, *Moosstudien*: 170. 1864.

Exostome teeth 200-240  $\mu\text{m}$  long, apex truncate; OPL (Fig. 6, A-B) with the median line well developed, the basal surface smooth, the middle porose, and the upper third smooth, sometimes with scattered papillae; exostomial PPL (Fig. 6, C) trabeculate, smooth at the base, finely papillose in the upper third, the papillae 0.37-0.56  $\mu\text{m}$  high; basal membrane formed by 3-4 cell rows, 40-60  $\mu\text{m}$  high. Endostome segments 100-150  $\mu\text{m}$  long; endostomial PPL (Fig. 6, D) smooth at the base, finely papillose near the apex, the papillae 0.42-0.53  $\mu\text{m}$  high; IPL (Fig. 6, E-F) finely papillose throughout; cilia in pairs, 90-100  $\mu\text{m}$  long; basal membrane smooth, formed by 7 cell rows, 40-60  $\mu\text{m}$  high. Peristomial formula 4:2:6.

Spores (Fig. 6, G-H) reniform, 24-26  $\mu\text{m}$  in diameter, perine largely composed of pilum-like processes, which become verrucae towards the proximal surface, 1.04-1.42  $\mu\text{m}$  high, smooth, clearly tending to cluster in their capitae.

## DISCUSSION

The peristome in *Philonotis* may be double, simple or absent (*Philonotis cernua* (Mitt.) Griffin & Buck). The peristomial formula, following Edwards (1979, 1984), varies from 4:2:6 (*Philonotis rigida*, *Ph. tomentella*), to 4:2:8 (*Philonotis caespitosa*, *Ph. seriata*) and 4:2:10 (*Philonotis calcarea*, *Ph. fontana*).

The exostome is formed by 16 brownish or reddish triangular teeth, with an obtuse (*Philonotis calcarea*, *Ph. rigida*) or truncate apex (*Philonotis caespitosa*, *Ph. fontana*, *Ph. seriata*, *Ph. tomentella*). The OPL is usually reticulate-papillose, sometimes smooth (*Philonotis tomentella*, *Ph. fontana*) or reticulate-smooth (*Ph. fontana*, *Ph. seriata*) at the base, papillose near the apex, with a median line that is usually distinct, but sometimes less clear (*Philonotis fontana*, *Ph. seriata*). The exostomial PPL is trabeculate, usually smooth, sometimes papillose (*Philonotis calcarea*) at the base and densely papillose with intertrabecular thickenings in the upper third. The basal membrane of the exostome is formed by 3-6 rows of oblate, hyaline or brownish, smooth or lightly papillose cells (Table 1).

The endostome is formed by 16 double segments, articulate, hyaline, and variously fused together throughout or free at the apex. They alternate with



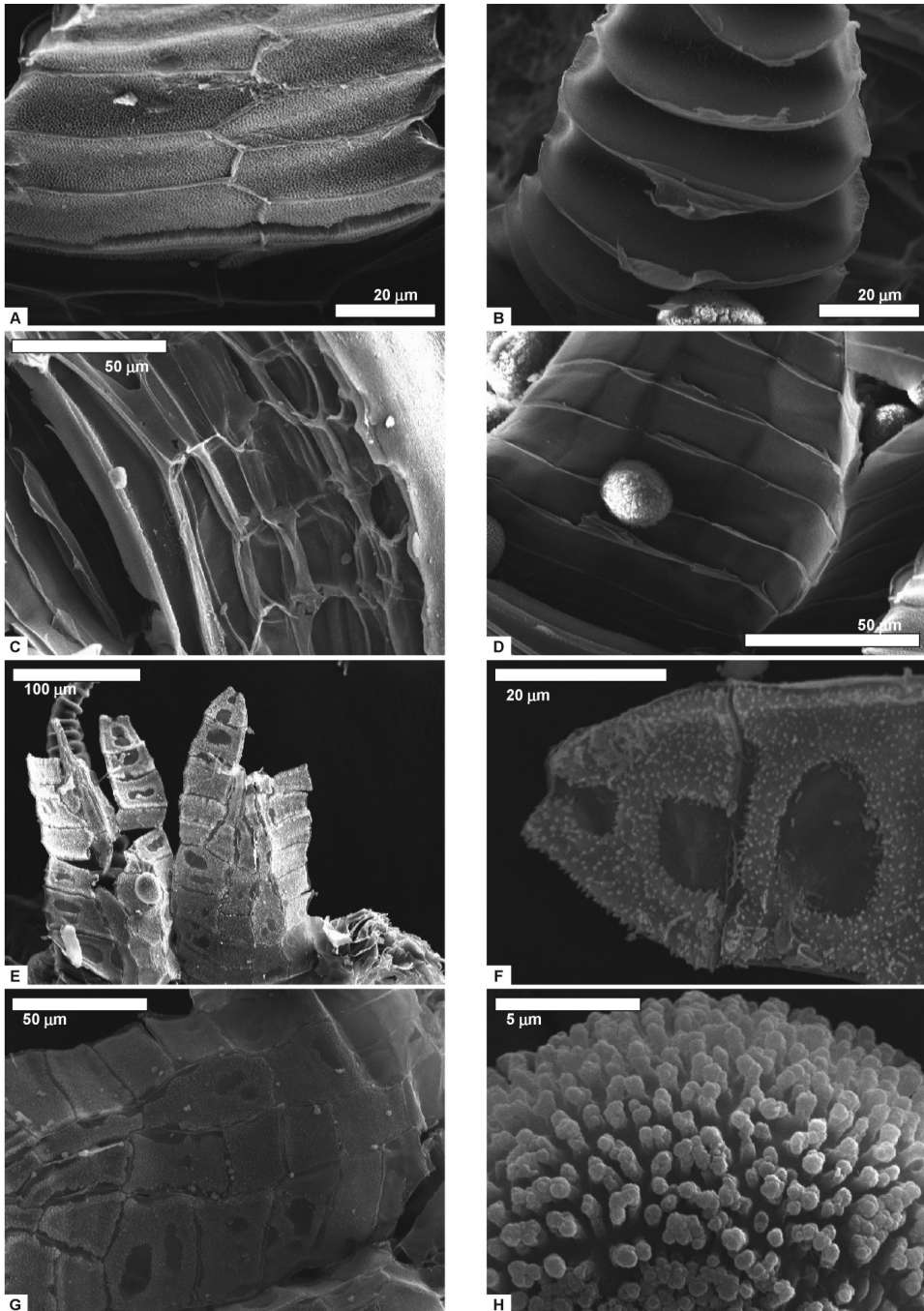


Fig. 5. *Philonotis seriata*. **A:** Basal OPL. **B:** Basal exostomial PPL. **C:** Basal membrane of exostome. **D:** Basal endostomial PPL. **E:** IPL view. **F:** Apical IPL with thinned areas in the wall. **G:** Basal IPL. **H:** Detail of the spore ornamentation.

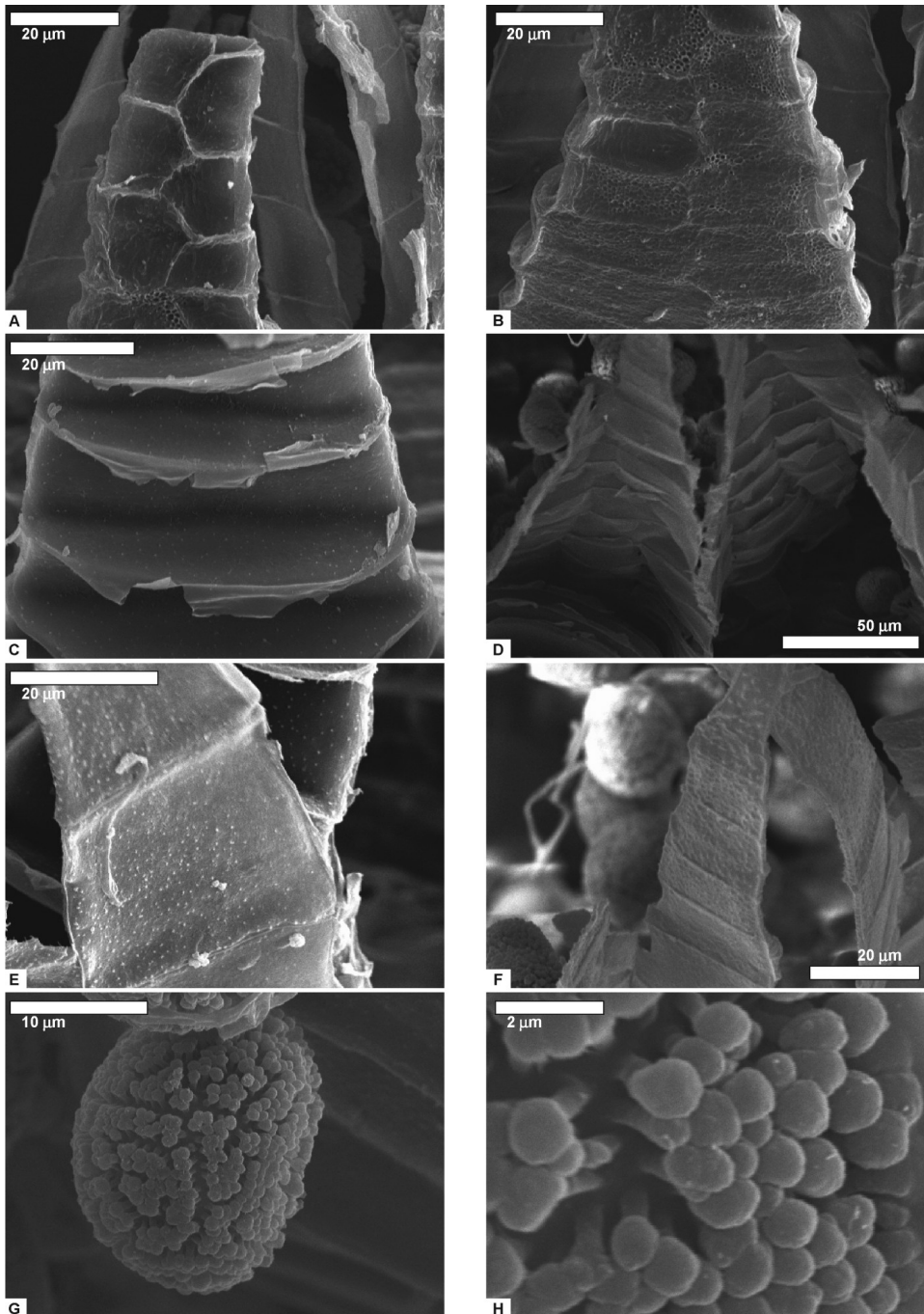


Fig. 6. *Philonotis tomentella*. **A:** Apical OPL. **B:** Basal OPL with pores. **C:** Basal exostomial PPL. **D:** Basal endostomial PPL. **E:** Detail of apical IPL. **F:** Apical IPL. **G:** Spore. **H:** Detail of the spore ornamentation.

Table 1. Exostome characters in *Philonotis*.

	Length ( $\mu\text{m}$ )	Upper third (OPL)	Base (OPL)	Median line	Upper third (PPL)	Base (PPL)	Basal membrane
<i>Ph. caespitosa</i>	200-250	With high scattered papillae	Reticulate-papillose	Well developed	Papillose with intertrabecular thickenings	Smooth	3-4 cell rows
<i>Ph. calcarea</i>	250-290	With simple papillae	Reticulate-papillose	Well developed	Strongly papillose with intertrabecular thickenings	Finely papillose	3-4 cell rows
<i>Ph. fontana</i>	100-150	Sometimes with scattered papillae	Rugose	Well developed, though sometimes not so	Papillose with intertrabecular thickenings	Smooth	3-4 cell rows
<i>Ph. rigida</i>	220-330	Papillose	Reticulate-smooth	Well developed	Papillose with intertrabecular thickenings	Smooth	3 cell rows
<i>Ph. seriata</i>	140-180	Reticulate-smooth	Reticulate-smooth	Sometimes absent	Finely papillose with intertrabecular thickenings	Smooth	3-6 cell rows
<i>Ph. tomentella</i>	200-240	Smooth or porose, sometimes with scattered papillae	Smooth	Well developed	Finely papillose	Smooth	3-4 cell rows

Table 2. Endostome characters in *Philonotis*.

	Length ( $\mu\text{m}$ )	Upper third (PPL)	Base (PPL)	Upper third (IPL)	Base (IPL)	Number of cilia per cluster	Basal membrane
<i>Ph. caespitosa</i>	100-140	Papillose with simple papillae	Papillose with simple papillae	Papillose with simple papillae, sometimes bifurcate and disposed in rows	Smooth	2-3	4-6 cell rows
<i>Ph. calcarea</i>	150-200	Finely papillose with simple papillae	Smooth	Papillose with high and irregular papillae, sometimes branched or bifurcate	Finely papillose	3-4	3-5 cell rows
<i>Ph. fontana</i>	140-150	Rugulose	Rugulose	Papillose with simple papillae	Papillose with simple papillae	2-3	4-5 cell rows
<i>Ph. rigida</i>	220-330	Weakly papillose with simple and scattered papillae	Smooth	With papillose ridges	Smooth	3	3-5 cell rows
<i>Ph. seriata</i>	120-150	–	Smooth	Finely papillose with thinned areas in the walls	–	2-3	4-5 cell rows
<i>Ph. tomentella</i>	100-150	Finely papillose	Smooth	Finely papillose	Finely papillose	2	7 cell rows

Table 3. Spore characters in *Philonotis*.

	<i>Shape</i>	<i>Size (µm)</i>	<i>Surface ornamentation</i>
<i>Ph. caespitosa</i>	Subspherical to reniform	20-28	Pilate
<i>Ph. calcarea</i>	Subspherical to reniform	24-26	Baculate or pilate
<i>Ph. fontana</i>	Ovate to reniform	24-28	Granulate and verrucate to pilate or clavate
<i>Ph. rigida</i>	Subspherical to reniform	32-34	Pilate
<i>Ph. seriata</i>	Spherical to reniform	26-30	Predominantly baculate
<i>Ph. tomentella</i>	Reniform	24-26	Pilate, verrucae towards the proximal surface

groups of 2-3 (*Philonotis caespitosa*, *Ph. fontana*, *Ph. rigida*, *Ph. seriata*, *Ph. tomentella*) or 3-4 (*Philonotis calcarea*) cilia of the same or similar length as the segments. The endostomial PPL is usually less papillose and with lower papillae than the IPL, and also is crossed by lines that correspond to the trabeculae of the exostome teeth. The IPL is smooth (*Philonotis caespitosa*, *Ph. rigida*), papillose (*Philonotis calcarea*, *Ph. fontana*, *Ph. tomentella*) at the base and papillose or sometimes striate (*Philonotis rigida*) in the upper third. On the internal side, the endostome has lines that show the position of the cell walls that formed the inner peristomial layer. The cilia usually have the same ornamentation as the segments, and it is sometimes difficult to distinguish the differences between them. The basal membrane of the endostome is formed by 3-6(7) rows of variously polygonal, usually hyaline, papillose cells (Table 2).

The spores are reniform or subspherical, sometimes ovate (*Philonotis fontana*) or spherical (*Philonotis seriata*), brownish. The perine may consist of pilum-like processes (*Philonotis caespitosa*, *Ph. calcarea*, *Ph. rigida* and *Ph. tomentella*), bacula-like processes (*Philonotis seriata*) or may vary from granulae and verrucae to pila or clavae (*Philonotis fontana*). Spore size is quite consistent across the genus, though *Philonotis rigida* may have the largest of the group. However as Clarke (1979) stated, spore shape and size are the characters most affected by environmental conditions (Table 3).

This morphological study reveals significant differences in peristome structure between the six studied species. These are the development of the OPL median line and the papillosity of the exostome teeth, the papillosity of the endostomial segments, the number of cilia per cluster and the number of cell rows of the basal membrane. Regarding the spores, the character that mainly appears to be differential is the surface ornamentation. Although these are potentially the most accurate discriminatory characters between the studied species, further study and examination of all the European species are necessary to substantiate their taxonomic significance.

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## APPENDIX I. SELECTED SPECIMENS STUDIED

***Philonotis caespitosa***. SPAIN: Zamora, Arribes del Duero, arroyo que cruza la carretera entre Fermoselle y Pinilla de Fermoselle, *Fernández Mendoza* (MA-Musci 25426, MACB 80802).

***Philonotis calcarea***. DENMARK: Möen, Klinteskov, *Möler* (BM). FINLAND: Lappi, Salla, Kutsan luonnonpuisto, *Ruskeakuru, Tuomikoski* (H 4104619). FRANCE: Provenza-Alpes-Costa Azul, Hautes Alpes, Près de Villard-d'Arène, lac du Pontet, *De Sloover* (BM). Savoie, Massif de Beaufort 17 km from Bourg-Saint Maurice on minor road to Cornet de Roseland, *Akeroyd et al.* (BM). ITALY: Aosta, 5 km from Colle del Picolo San Bernardo on SS26 to La Thuile and Aosta, *Akeroyd et al.* (BM). SPAIN: Asturias, Puerto de Ventana, *Simó* (MACB 60111). Cantabria, Alrededores de Quintana, *Fuertes & Martínez-Conde* (MACB 21981). Castellón, Penyagolosa, Barranco del Manzanar, *Puche* (VAB 308, VAB 310, VAB 669, VAB 670). Lérida, Tredós, valle de Ruda, *Heras* (VIT 8840). Navarra, Belagua, Puerto de Eraize, *Heras* (VIT 3738). Vizcaya, Urkiola, *Heras* (VIT 919, VIT 3781).

***Philonotis fontana***. PORTUGAL: Beira Alta, Serra da Estrela, Lagoa Comprida, *Fuertes et al.* (MA-Musci 22653, MA-Musci 25124, MA-Musci 26855, MA-Musci 26856, MACB 78565, MACB 79897). SPAIN: Álava, Valdegobia, Barrio, *Heras* (VIT 8690). Asturias, Puerto del Rañadoiro, *Guerra* (MUB 17516). Ávila, Sierra de Gredos, Piedrahita, Puerto de la Peña Negra, *Granzow & Ron* (MACB 11279). Burgos, Neila, *Heras* (VIT 10188). Cantabria, Sierra de Peña Sagra, Pozo de la Vega, *Fuertes & Oliván* (MACB 75780). Granada, Sierra de Baza, camino de Cerro Alonso, *Mateo & Varo* (GDA 19179). Guadalajara, Campillo de las Ranas, *Ladero* (MACB 60108, GDA 7633). Huesca, Candanchú, *Ron* (MACB 12812). Huesca, Valle de Echo, Ibón de Acherito, *Guerra* (MUB 18449). La Coruña, Caaveiro, *Reinoso Franco* (SANT-Bryo 90-B). La Rioja, Tobía, Río Tobía, El Rajao, *García Álvaro* (Herb. J. Martínez-Abaigar). León, de San Emiliano al Puerto de Ventana, *Silvestre*

(FCO 587). Lérida, La Cerdanya, torrent de Moixero, *Álvaro* (VAB 3327, MACB 60033). Lugo, Ancares, camino de Campo da Braña a Bornado, *Casas & Puche* (VAB 1737). Madrid, Puerto de Canencia, arroyo frente a la Tejera, *Vicente & Ron* (MACB 27865). Navarra, Señorío de Bertiz, Valle del Baztán, *Fuertes* (VAB 1134, GDA 7634, MACB 24742, MACB 60109). Orense, Melón, *Silvestre* (FCO 588). Segovia, Riofrío de Rianza, Puerto de la Quesera, en el hayedo de la Pedrosa, *Fuertes & Bermejo* (MACB 56655, MA-Musci 13403). Soria, Covalada, *Heras* (VIT 5330). Zaragoza, Sierra del Moncayo, cerca de la ermita, *Fuertes et al.* (MACB 60039).

***Philonotis rigida***. SPAIN: Álava, Amurrio, Ziorraga, *Heras* (VIT 5056). Asturias, Cangas de Onís, La Mexadoria, Margolles, *Fernández-Ordóñez* (MUB 15761, VAB 6780). Cádiz, Algeciras, Río de la Miel, *Varo et al.* (GDA 7640). Guipúzcoa, Berástegui, Valle de Leizarán, *Heras* (VIT 14136). La Coruña, Caaveiro, *Reinoso Franco* (SANT-Bryo 101, SANT-Bryo 619, SANT-Bryo 1009).

***Philonotis seriata***. ANDORRA: Valle de Junclar, *Costa & Rivas-Martínez* (MACB 60102, GDA 7641). SPAIN: Asturias, Somiedo, Puerto de Somiedo, Vega Cimera, *Fernández-Ordóñez* (FCO 2728). Granada, Sierra Nevada, Cañada de las Siete Lagunas, *Gil* (GDA 28186). Huesca, Bielsa, Circo de Pinara, *Infante & Heras* (VIT 28227). La Rioja, Anguiano, Río Roñas, *García Álvaro* (Herb. J. Martínez-Abaigar). Madrid, Sierra de Guadarrama, del Puerto de Cotos a la estación de Valdesquí, *Cano* (MUB 17242).

***Philonotis tomentella***. FINLAND: Ahvenanmaa, Saltvik, klippsprimgor på Liby berg vid Kuggsund, *Rancken & Gottberg* (H 4105683). Enontekiö, Kilpisjärvi, *Huuskonen* (H 4106070). SPAIN: Ávila, Sierra de Gredos, *Ros* (MUB 15331).