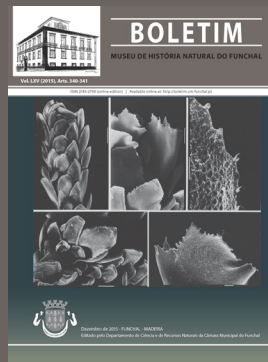


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Morphologic boundaries of *Porella canariensis* (Web.) Underw. (Porellaceae, Marchantiophyta) in Madeira (Portugal)

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With 4 figures, 1 table and 1 appendix

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ABSTRACT: In Madeira a total of 55 populations of *Porella* were analyzed. Among the 44 populations of *P. canariensis*, 73% tasted acrid, 41% presented mature perianths and 23% presented mature spores with 40 (50-60) 80 µm diameter 21% of them being longer than usual for the genus; female individuals were relatively frequent (52%) whereas males were scarce (7%); female and male shoots were found intermixed in 27% populations and 14% were sterile. Among the 11 populations of *P. obtusata* none tasted acrid, 18% presented mature perianths, 9% presented mature spores of 50 µm diameter, no males were identified and female stems were present in 73% populations, and 27% were sterile. Sixty morphological characters were scrutinized, including 15 quantitative traits, 16 ratios and 29 qualitative traits.

Despite partial overlap between species in form, there are morphological characters that can be used to distinguish them without difficulty, such as: median cells size; lobe, lobule and underleaf width; lobule and underleaf surface; decurrent part of the lobe and the underleaf; margin of the female and male bracts and perianths.

Keywords: Liverwort, Jungermannioptida, *Porella*, phenotypic plasticity, Macaronesia.

RESUMO: Foram analisadas um total de 55 populações de indivíduos do género *Porella* na Madeira. Em 44 populações de *P. canariensis*, 73% apresentam sabor picante, 41% têm periantos maduros e 23% compreendem esporos maduros com 40 (50-60) µm de diâmetro, dos quais 21% são maiores do que o referido para o género. Os indivíduos femininos são relativamente frequentes (52%), os masculinos são raros (7%), foram encontrados ramos femininos e masculinos misturados em 27% das populações e 14% apresentam ramos estéreis.

Em 11 populações de *P. obtusata* nenhuma apresenta sabor picante, 18% contemplam periantos maduros, 9% compreendem esporos maduros com 50 µm de diâmetro, não foram identificados indivíduos masculinos e os femininos estão presentes em 73% das populações, 27% apresentam ramos estéreis.

Foram examinados sessenta caracteres morfológicos, dos quais 15 são quantitativos, 16 correspondem a cálculos entre estes e 29 são qualitativos.

Embora em relação à morfologia estas espécies se sobreponham parcialmente, existem caracteres morfológicos que podem ser usados para as distinguir, como: o tamanho das células medianas; a largura do lobo, lobulo e anfigastro; a superfície do lobulo e anfigastro; a parte decorrente do lobulo e anfigastro; a margem da bráctea feminina, da masculina e do perianto.

Palavras-chave: Hepática, Jungermanniopsida, *Porella*, plasticidade fenotípica, Macaronésia.

INTRODUCTION

Species of *Porella* L. (Porellaceae) are dioecious foliose liverworts, characterized by deeply conduplicate-bilobed, incubous leaves with a large dorsal lobe and small ventral lobule with very short keel, large unlobed underleaves and gametangia developing on short lateral branches; the sporophytes are ephemeral thus rarely seen, spores are small (35-50 µm diameter) and leaf or shoot fragments function as asexual propagules (BISCHLER *et al.*, 2006). *Porella* presents high phenotypic plasticity with species showing significant morphological intergradations (BISCHLER *et al.*, 2006).

Porella canariensis (Web.) Underw. has often been considered to be conspecific with *P. arboris-vitae* (With.) Grolle or *P. obtusata* (Taylor) Trevis, or a transition between them: CASARES-GIL (1919) refers *P. canariensis* (sub *Madotheca canariensis* Nees) as doubtful species, considering it a variety of *P. arboris-vitae* [sub *Madotheca laevigata* (Schrad.) Dumort. var. *subintegra* Kaal]; MACHADO (1925) states that *Madotheca laevigata* (Schrad.) Dumort. var. *subintegra* Kaal can match *Madotheca canariensis* Nees, which is very polymorphous and may be a transition to *P. obtusata* [sub *Madotheca thuja* (Dicks.) Dum.]; TRABUT (1941) notes *P. canariensis* (sub *Madotheca canariensis* Nees) and states that can be a transitional form between *P. arboris-vitae* (sub *M. laevigata*) and *P. obtusata* (sub *M. thuja*); also GROLLE (1975) questioned whether *P. canariensis* is an independent species.

The first reference to the occurrence of *Porella* in Madeira is in the 19th century (NEES & MONTAGNE, 1836; BARKER-WEBB & BERTHELOT, 1840; COSSON, 1868). Overall, until the mid-

20th century, eight species were reported from Madeira. Recent studies have reduced the number of species to four that correspond to 50% of the *Porella taxa* reported from Europe (FREY *et al.*, 2006): *P. canariensis*, *P. cordaeana* (Hüb.) Moore, the endemic *P. inaequalis* (Gottsche ex Steph.) Perss. and *P. obtusata* (SCHUMACKER & VÁÑA, 2000; SÖDERSTRÖM *et al.*, 2002; FONTINHA, 2004; BISCHLER, 2004; BISCHLER *et al.*, 2006; ROS *et al.*, 2007; SÉRGIO *et al.*, 2008; FONTINHA *et al.*, 2010).

Morphologic and genetic research considering nine species of *Porella* from Europe and Macaronesia showed that continental populations of *P. arboris-vitae*, *P. canariensis* and *P. obtusata* were clearly distinct whereas the Madeiran samples of *P. canariensis* and *P. obtusata* overlapped partially (BISCHLER *et al.*, 2006).

High levels of isozyme or RAPDs variation have been reported for *P. canariensis*, *P. obtusata*, *P. arboris-vitae* and *P. platyphylla* (THERRIEN *et al.*, 1998; FREITAS & BREHM, 2001; WYATT *et al.*, 2005; BISCHLER *et al.*, 2006).

More recently, LOPES *et al.* (2014) clearly distinguish *P. canariensis* and *P. obtusata* and support the existence of two molecular lineages within *P. canariensis*, in contrast to HENTSCHEL *et al.* (2007) and HEINRICHS *et al.* (2011). This supports earlier indications of a higher genetic diversity in Madeira than in other parts of Macaronesia (FREITAS & BREHM, 2001; FONTINHA, 2004; BISCHLER *et al.*, 2006).

Porella canariensis is a close relative of *P. obtusata* and both species share overall morphology and ecology, being the variation of *P. canariensis* and *P. obtusata* higher on Madeira than on Europe or other Macaronesian Archipelagos (BISCHLER *et al.*, 2006).

Considering the above, the present study aims to i) clarify the morphologic boundaries of *P. canariensis*, ii) compare the morphologic boundaries of *P. canariensis* with those of *P. obtusata*.

MATERIALS AND METHODS

Sampling

Forty four *P. canariensis* populations were sampled, being 39 from Madeira Island, four from Porto Santo Island and one from Deserta Grande Island; additionally 11 populations of *P. obtusata* from Madeira Island were surveyed. The populations are defined as continuous carpets ranging from 10 cm² to 20 cm² in cover, each comprising several tens of stems (BISCHLER *et al.*, 2006). From each population 10 shoots were selected and for each, five measurements were performed on the gametophyte and one on the gynoecia. Each shoot was considered an individual. Voucher specimens (Appendix 1) are housed in the herbarium MADJ.

Other herbarium vouchers of *P. canariensis*, *P. obtusata* and *P. arboris-vitae* were examined from Portuguese herbaria: COI, LISU, MADJ, MADS and from other herbaria such as BM, BONN, JE, MO, PC, STAATL, STR and TFC as well as private collections such as from Bischler, Düll, Hübschmann and Mues. Herbaria abbreviations follow VITT *et al.* (1985) and *Index Herbariorum*. Type-specimens were observed.

Porella species are dioecious, thus stems with reproductive structures analysed were female or male. Some populations were sterile.

The plant material used in the scanning electron microscope was fixed, dehydrated and prepared in accordance to SIM-SIM (1999). Scanning electron microscopy (SEM) observations of dry plant material were made with a JEOL (JSM 5200 T220).

Morphological characters

A total of 60 morphological characters were selected, following previous studies (BISCHLER *et al.*, 2006; FONTINHA, 2004; FONTINHA *et al.*, 2010). Fifteen quantitative morphological characters were considered: lobe length (Lc), lobe width (Ll), diameter of lobe cells (Lcm), lobule length (llc), lobule length without deccurence (lcsd), lobule width (ll), diameter of lobule cells (lcm), underleaf length, decurrent part included (ac), underleaf length without deccurent part (acsd), underleaf width (al), diameter of

underleaf cells (acm), stem width (Rl), perianth length (Pc), perianth width (Pl), spore diameter (Et). Sixteen ratios were also into account: Lobe surface (Rls), lobule surface (Rls), underleaf surface (Ras), lobule decurrent part (Rld), underleaf decurrent part (Ra), lobule width / stem width (Rb), underleaf width / stem width (Rc), underleaf width / lobule width (Rd), lobe width / lobule width (Re), lobule length / decurrent part of the lobule length (Rf), underleaf length / decurrent part of the underleaf length (Rg), lobule length (without decurrent part) / lobule width (Rh), lobule length / lobule width (Ri), lobe surface / lobule surface (Rj), lobe surface / underleaf surface (Rk) and lobule surface / underleaf surface (Rl).

In addition, twenty nine qualitative morphological characters were considered: lobe apex (La), lobe dorsal margin (Lms), lobe ventral margin aspect (Lmmi), lobe ventral margin type (Lmi), lobe position (Lp), trigones of lobe cells (Ltc), lobule apex (Lla), lobule margin (Lmm), lobule margin aspect (lM), lobule base (Lb), underleaf margin (Amm), underleaf margin aspect (aM), underleaf base (Ab), underleaf bilobed (Ax), hemiphyll bilobed (Hx), rhizoids (Riz), asexual reproduction (Prv), male bracts and bracteole (Bm), male bracts apex (Bma), male bracts margin (Bmm), female bracts size (Bft), lobe apex of female bracts (bfLa), lobule apex of female bracts (Bfla), lobe margin of female bracts (bfLm), lobule margin of female bracts (Bflm), apex of female bracteole (Btfa), margin of female bracteoles (Btfm), perianth margin (Pm) and spore shape (Ef). Analyses of these characters are presented in the description of both species.

RESULTS

In order document morphologic traits, scanning electron micrographs of the gametophyte and sporophyte are presented in Figs. 1 & 2. The description of both *Porella* species was based on the study of Madeira's plant material.

Morphology and sexual conditions

A total of 55 populations, containing 550 individuals were analyzed. In 44 populations of *P. canariensis*, 73% tasted acrid, 18 populations (40.9%) presented mature perianths and only 10 (22.7%) comprised mature spores. A total of 120 perianths and 145 spores were studied. Within the spores, 110 (from MADJ 2796, 2797, 2799, 2811, 2880, 2807, 2813) measured 50 µm diameter (76%), 20 (from MADJ 2796, 2797, 2808) measured 60 µm diameter (14%), 10 (from MADJ 2798, 2884) measured 40 µm diameter (7%), and 5

spores (from MADJ 2885) measured 80 μm diameter (3%). Only female individuals were frequently observed in 52.3% populations, whereas males were scanty (6.8%). Female and male stems have been found intermixed in 27.3% populations and 13.6% were composed by sterile stems. In 11 populations of *P. obtusata*, none (0%) tasted acrid, two populations (18.2%) presented mature perianths and one (9.1%) comprised mature spores. A total of 15 perianths and 5 mature spores were studied. All spores measured 50 μm long (100%). No males were observed and female stems were present in 72.7% populations, being 27.3% composed by sterile stems. Averages of the values (minimum, medium and maximum) of all the quantitative characters were determined and in addition ratios were performed, being presented in Table 1. The graphical representation of quantitative traits and calculations between characters are respectively presented in Figs. 3 & 4.

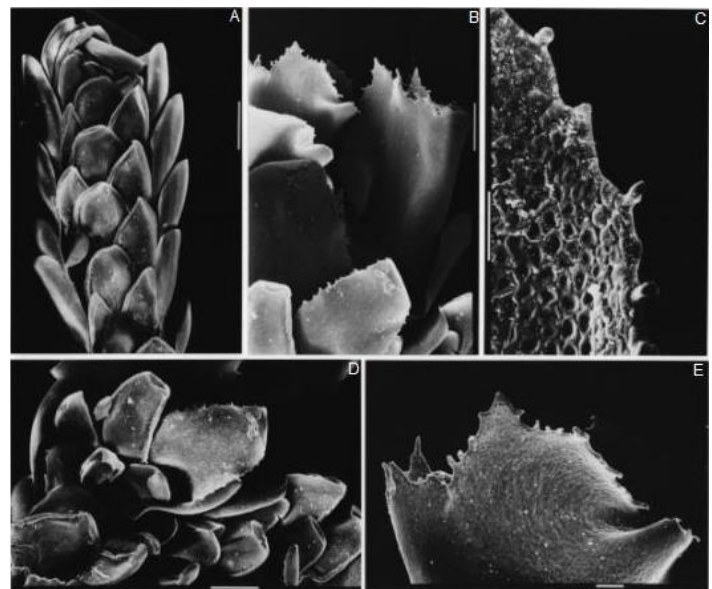


Fig. 2 – Scanning electron micrographs of *P. obtusata*. A: ventral view of apical gametophyte segment; B: female bracts and perianth; C: female bract margin; D: ventral view of lateral female ramification with bracts and bracteoles; E: perianth mouth margin. A, B, D (LISU 161874); C (MADJ 2788). Scale bars: A, B, D = 500 μm ; C = 50 μm ; E = 100 μm .



Fig.1 – Scanning electron micrographs of *P. canariensis*. A: ventral view of apical gametophyte segment; B: ventral view of ramification and gametophyte segment; C: ventral view of antheridia branch; D: spores and elaters; E-H: perianth; F: ventral view of male branch bracts and bracteoles with vegetative propagation; G: female bracts and bracteole; I: gametophyte growing on lobe surface. A, B, C (MADJ 2192); D (MADJ 2880); E (MADJ 2885); F (MADJ 2849); I (MADJ 2879); G, H (LISU 161857). Scale bars: A = 100 μm ; B, C, E, F, H, I = 500 μm ; D = 10 μm ; G = 100 μm .

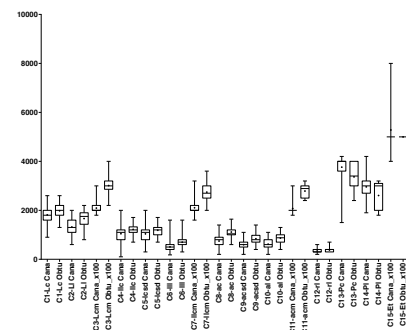


Fig. 3 – The variation of 15 morphological characters scrutinized. The abbreviations and the number of examined specimens are according to the parameters defined in the methodology. The edges of the longer segment represent the minimum and the maximum values of each character. Values are in μm .

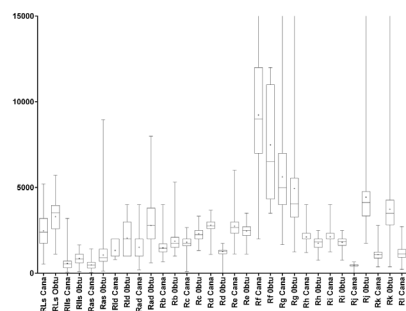


Fig. 4 – The variation of 16 ratios of morphological characters scrutinized. The abbreviations and the number of examined specimens are according to the parameters defined in the methodology. The edges of the longer segment represent the minimum and the maximum values of each character.

Table 1 – Averages of 32 morphological characters scrutinized. Abbreviations of characters and ratios are in accordance with the methodology. N corresponds to the total number of individuals analysed (440 *P. canariensis* plus 110 *P. obtusata*). Values of 15 quantitative morphological characters are in μm (on the left side is the minimum, in parenthesis the medium and on the right side the maximum). In addition 17 ratios were calculated.

Characters	N	<i>P. canariensis</i>	<i>P. obtusata</i>
Lc - lobe length	550	900 (1800) 2600	1300 (2000) 2600
LI - lobe width	550	600 (1300) 2000	800 (1750) 2200
Lcm - diameter of lobe cells	550	18 (20) 30	22 (30) 40
Ilc - lobule length	550	300 (1100) 2000	700 (1200) 1710
lcsd - lobule length without deccurrence	550	300 (1100) 2000	700 (1200) 1710
II - lobule width	550	180 (500) 1600	300 (700) 1600
lcm - diameter of lobule cells	550	16 (20) 32	20 (27) 36
ac - underleaf length, decurrent part included	550	200 (800) 1400	600 (1040) 1640
acsd - underleaf length without decurrent part	550	200 (600) 1100	400 (800) 1400
al - underleaf width	550	200 (600) 1100	400 (880) 1300
acm - diameter of underleaf cells	550	18 (20) 30	24 (28) 32
RI - stem width	550	200 (300) 600	300 (400) 700
Pc - perianth length	135*	1500 (4000) 4200	2400 (3400) 4000
PI - perianth width	135*	1900 (3000) 4200	1800 (3000) 3200
Et - spore diameter	150*	40 (50-60) 80	50
RLS - (10°) Lobe surface	550	2,5	3,2
RLs - (10°) lobule surface	550	5,8	8,7
Ras - (10°) underleaf surface	550	4,9	10,6
Rld - lobule decurrent part	550	8	35
Ra - underleaf decurrent part	550	147	279
Rb - lobule width/stem width	550	1	2
Rc - underleaf width/stem width	550	2	2
Rd - underleaf width/lobule width	550	1	1
Re - lobe width/lobule width	550	3	2
Rf - lobule length/decurrent part of the lobule length	550	9	7
Rg - underleaf length/decurrent part of underleaf length	550	6	5
Rh - lobule length without decurrent p./lobule width	550	2	2
RI - lobule length/lobule width	550	2	2
RJ - lobe surface/lobule surface	550	5	4
Rk - lobe surface/underleaf surface	550	6	4
RI - lobule surface/underleaf surface	550	1	1

* 120 perianths and 145 spores from *P. canariensis* plus 15 perianths and 5 spores from *P. obtusata*.

Porella canariensis (F. Webber) Underw. 1897

Trelease W., Bot. Observ. Azores (in 8th annual Report Missouri Bot. Gard.): 186. [synonym of *Porella canariensis* (F. Webber) Bryhn, Kongel. Norske Vidensk. Selsk. Skrift. (Trondheim. (1908) (8): 10. 1908.] B.: *Jungermannia platyphylla* δ . *canariensis* F. Webber Hist. Musc. Hep. Prodrumus: 16. Kiel. 1815. T: Teneriffa, leg. BORY; Holo: S (!), Iso: STR (SCHIFFN. Hedwigia 41:276. 1902). K. Müller 1956: *Madotheca canariensis* (F. Webber) Nees.

Plants medium-sized to large, sometimes small and attenuated, glossy or not, usually with acrid taste, leaf lamina translucent to opaque, forming extensive or small, dense or loose, green to brownish-green mats. *Frullania*-type branched 1 (2-3) irregularly pinnate, stems (1.3-) 5.6 (-11.5) cm in length and (200-) 300 (-600) cm in width. Cortex cells narrower than those from the medulla. Dorsal lobes contiguous, 1/3 imbricate, rarely separate, crossing partially the stem, apex obtuse-rounded or slightly truncate and acute, margin entire to undulate, occasionally paucispinose, oval to oblong, longer (900-) 1800 (-2600) μm than wide (600-) 1300 (-2000) μm and entire at base. Median cells oval to polygonal (18-) 20 (-30) μm diameter. Ventral lobes slightly or not decurrent, with the same width as the stem, longer (300-) 1100 (-2000) μm than wide

(180-) 500 (-1600) μm , apex usually truncate, occasionally apiculate, rounded to oblong, margin paucispinose to entire. Median cells oval to polygonal (16-) 20 (-32) μm diameter. Underleaves slightly to not decurrent, wider than the stems, margin paucispinose to entire, sometimes reflexed, longer (200-) 800 (-1400) μm than wide (200-) 600 (-1100) μm . Median cells oval to polygonal (18-) 20 (-30) μm diameter. Rhizoids, when present, pale brownish, usually in tufts from the middle basal cells of the underleaves. Gynoecia terminal or on lateral abbreviate branches. Archegonia branches 4 (8-12) per stem, with 2 pairs of bracts. Margin of bracts and bracteoles irregularly dentate or ciliate to paucispinose. Antheridial branches 10 (16-32) per stem, with 8 pairs of bracts, bilobed, and closely imbricate, bracts more or less closed to bracteoles with entire margin. Antheridia spherical with short pedicels. After the release of gametes, apical part of male stems may continuously grow. Number of perianths per stem 4 (6-8). Perianth longer (1500-) 4000 (-4200) μm than wide (1900-) 3000 (-4200) μm , margin lobed or not, irregularly dentate to paucispinose. Capsule spherical to slightly ovoid, opening by four valves. Spores warty, (40-) 50 (-80) μm diameter. Elaters free, yellow, thin, elongate and 2 (-3) spiralled. Asexual reproduction by cell release.

It presents the widest distribution in the archipelago, existing in Madeira Island, Porto Santo Island and Deserta Grande Island, where colonizes different habitats from the lowest till the highest altitudes (FONTINHA *et al.*, 2010). It is one of the most dominant bryophytes in laurel and heather forest formations (SIM-SIM *et al.*, 2014). Atlantic distribution, not found north of the Iberian Peninsula. Its distribution is restricted to continental Europe (Portugal and Spain, including Baleares Islands), Morocco, Macaronesia (Azores, Madeira and Canary archipelagos) and Cape Verde (SÖDERSTRÖM *et al.*, 2002; FONTINHA, 2004; SÉRGIO *et al.*, 2013). The species needs equilibrated climates with cool summers and mild winters and substrata with low pH (FONTINHA *et al.*, 2010).

Porella obtusata (Taylor) Trevis

Memorie Reale Instit. Lombard. Sci. Mat. Nat. Ser. 3. 4: 407. 1877. B: *Madotheca obtusata* Taylor. London Journ. Bot. 5: 380. 1846. T: Kanaren, leg. Lemann (in errore "Lemain" in sched.); Holo: FH masc. (Grolle, Lindbergia 3: 53. 1975)!, Iso: JE masc.!, MANCH masc.!, S masc.!, W masc., LINDENB. Hep. No. 5713! K. Müller 1956: *Madotheca thuja* auct., non (Dicks.) Dum. Nom. illeg.; vgl. Grolle, 1969, 1975b.

Plants medium-sized to large, glossy or not, not tasting acrid, leaf lamina opaque, forming extensive, dense

green to brownish-green mats. Frullania-type branched 1 (2-3) irregularly pinnate, stems (1,6-) 4,5 (-9,5) cm in length and (300-) 400 (-700) cm in width. Cortex cells narrower than those from the medulla. Dorsal lobes contiguous, 1/3 imbricate, crossing partially the stem, apex rounded to oval, margin entire to undulate, longer (1300-) 2000 (-2600) μm than wide (800-) 1750 (-2200) μm and entire at base. Median cells oval to polygonal (22-) 30 (-40) μm diameter, trigones bulging and confluent. Ventral lobes not decurrent, wider than the stem, longer (700-) 1200 (-1710) μm than wide (300-) 700 (-1600) μm , apex usually rounded to oblong, margin entire. Median cells oval to polygonal (20-) 27 (-36) μm diameter. Underleaves slightly decurrent, wider than the stems, margin entire and reflexed, longer (600-) 1040 (-1640) μm than wide (400-) 880 (-1300) μm . Median cells oval to polygonal (24-) 29 (-32) μm diameter. Rhizoids, when present, pale brownish, usually in tufts from the middle basal cells of the underleaves. Gynoecea terminal or on lateral abbreviate branches. Ciliate margin of the archegonia bracts, with cilia similar to papillae. Androecea not observed on material from Madeira. Perianth longer (2400-) 3400 (-4000) μm than wide (1800) 3000 (-3200) μm , margin not lobed, irregularly dentate, with cilia similar to papillae. Capsule spherical opening by four valves. Spores warty, 50 μm diameter. Elaters free, yellow, thin, elongate and 2 (-3) spiralled. Vegetative propagation may occur.

It is recorded only to Madeira Island, mainly at the peaks, 900-1850 m *a.s.l.*, being more abundant in the heather forest, but also occurring in the humid laurel forest (FONTINHA *et al.*, 2010). It withstands high summer temperature and grows in the lowlands (BISCHLER *et al.*, 2006; FONTINHA *et al.*, 2010). Continental distribution (north and west Europe, central Asia, north America) and Atlantic distribution including Macaronesia, existing in Madeira Island, Azores and Canary Islands, being this last archipelago the meridional limit of the species distribution.

DISCUSSION

The Madeiran samples of *P. canariensis* and *P. obtusata* overlap partially, however there are morphological characters that can be used to distinguish them easily, as the following ones.

In general the diameter of the median cells of lobe, lobule and underleaf of *P. canariensis* are 20 μm , and the cells present uniformly thickened walls; in contrast *P. obtusata* presents median cells 30 μm size, with large bulging trigones.

The width of the lobe, lobule and underleaf are smaller in *P. canariensis* than in *P. obtusata* as well as the

lobule and underleaf surfaces; in contrast the lobe surface is smaller in *P. canariensis* than in *P. obtusata*. The decurrent part of the lobe and the underleaf is smaller in *P. canariensis* than in *P. obtusata*.

The female bracts of *P. canariensis* presents dentate or ciliate to paucispinose margins, male bracts entire to paucispinose margins, and perianths with lobed or unlobed, irregularly dentate to paucispinose margins without papilla-like teeth; in contrast *P. obtusata* shows female bracts with ciliate margins, male bracts with entire margins, and perianths with unlobed, irregularly dentate margins with papilla-like teeth.

The acrid taste is usually present in *P. canariensis*; in contrast the plants of *P. obtusata* do not taste acrid.

In *P. canariensis* male individuals were less numerous than female, as observed in many others liverworts (BISCHLER *et al.*, 2006); in contrast no males were observed within *P. obtusata* populations. A high number of females with perianths characterize *P. canariensis*, being in accordance to BISCHLER *et al.*, 2006; in contrast only 18% of *P. obtusata* populations showed perianths.

Within *P. canariensis* 23% populations carried mature spores, and 17% of them (14% and 3% respectively 60 μm and 80 μm diameter) were larger than 35-50 μm diameter mentioned for the genus (BISCHLER *et al.*, 2006). No mixed spore's size was found within populations. More research concerning the spores should be done.

Further studies should be done regarding the size of the spores within *P. canariensis* populations.

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Appendix 1

Voucher specimens

UTM squares (1 x 1 km²) are referred.

Porella canariensis

Deserta Grande Island: Risco, 350 m, CA5899, 15.05.1995, *Silva* 2682.

Madeira Island: Achada do Marques, 410 m, CB2130, 16.05.1993, *Fontinha* 2794; Achada do Teixeira, 1520 m, CB2026, 9.07.1993, *Fontinha* 2809; Achadas da Cruz, 400 m, BB9336, 5.11.1994, *Fontinha* 2816; Achadas da Cruz, 550 m, BB9235, 5.11.1994, *Fontinha* 2818; Achadas da Cruz, 750 m, BB9535, 8.04.1994, *Fontinha & Bischler* 2805; Achadas da Cruz, 240 m, BB9337, 5.11.1994, *Fontinha* 2817; Bica da Cana, 1250 m, CB0925, 17.01.1995, *Fontinha & Sérgio* 2846; Bica da Cana, 1300 m, CB0724, 27.01.1994, *Fontinha* 2802; Cabo Girão, 550 m, CB1214, 25.10.1994, *Fontinha* 2810; Camacha, 800 m, CB2616, 22.01.1994, *Fontinha* 2812; Camacha, 800 m, CB2718, 22.01.1994, *Fontinha* 2800; Camacha, 800 m, CB2820, 22.01.1994, *Fontinha* 2813; Camacha, 800 m, CB2718, 22.01.1994, *Fontinha* 2801; Camacha, 800 m, CB2719, 22.01.1994, *Fontinha* 2799; Caminho dos Pretos, 700 m, CB2317, 3.11.1994, *Fontinha* 2811; Fajã da Nogueira, 700 m, CB2025, 3.12.1993, *Fontinha* 2797; Fajã da Nogueira, 850 m, CB2025, 3.12.1993, *Fontinha* 2879; Fajã da Nogueira, 900 m, CB2025, 3.12.1993, *Fontinha* 2885; Fajã da Nogueira, 900 m, CB2025, 3.12.1993, *Fontinha* 2796; Fajã da Nogueira, 900 m, CB2025, 3.12.1993, *Fontinha* 2864; Fanal, 1100 m, BB9832, 13.05.1993, *Fontinha* 2880; Fanal, 1100 m, BB9932, 13.05.1993, *Fontinha* 2792; Fanal, 1100 m, BB9833, 13.05.1993, *Fontinha* 2793; Machico, 320 m, CB3521, 29.12.1994, *Fontinha* 2819; Monte, 550 m, CB2216, 3.11.1994, *Fontinha* 2815; Prazeres, 600 m, BB9425, 2.02.1995, *Fontinha* 2849; Ribeira Brava, 550 m, CB0817, 10.07.1993, *Fontinha* 2795; Ribeira da Janela, 500 m, BB9636, 3.02.1994, *Fontinha* 2851; Ribeira da Janela, 500 m, BB9635, 3.02.1994, *Fontinha* 2804; Ribeiro Frio, 900 m, CB2223, 19.10.1993, *Fontinha* 2808; Ribeiro Frio, 800 m, CB2323, 6.01.1994, *Fontinha* 2814; Ribeiro Frio, 800 m, CB2323, 6.01.1994, *Fontinha* 2798; Ribeiro Frio, 900 m, CB2223, 19.10.1993, *Fontinha* 2807; Santana, 900 m, CB2028, 29.05.1993, *Fontinha* 2884; Santana, 900 m, CB2028, 29.05.1993, *Fontinha* 2883; São Jorge, 600 m, CB1930, 2.06.1993, *Fontinha* 2881; São Jorge, 600 m, CB1930, 14.10.1993, *Fontinha* 2882; Seixal, 650 m, CB0230, 8.04.1994, *Fontinha & Bischler* 2806; Terreiro da Luta, 940 m, CB2217, 3.11.1994, *Fontinha* 2852.

Porto Santo Island: Pico Branco, 500 m, CB7862, 25.02.1995, *Fontinha* 2848; Pico Castelo, 600 m, CB7560, 23.01.1995, *Fontinha & Silva* 2850; Pico Castelo, 600 m, CB7560, 23.01.1995, *Fontinha & Silva* 2845; Pico do Facho, 500 m, CB7661, 27.02.1995, *Fontinha* 2847.

Porella obtusata

Madeira Island: Bica da Cana, 1300 m, CB0825, 27.01.1994, *Fontinha* 2952; Fajã da Nogueira, 900 m, CB2025, 03.12.1993, *Fontinha* 2790; Fanal, 1100 m, BB9932, 13.05.1993, *Fontinha* 2783; Fanal, 1110 m, BB9931, 13.05.1993, *Fontinha* 2859; Pico do Areeiro, 1750 m, CB1824, 24.06.1993, *Fontinha* 2860; Pico Ruivo de Santana, 1850 m, CB1825, 24.06.1993, *Fontinha* 2784; Pico Ruivo de Santana, 1850 m, CB1825, 24.06.1993, *Fontinha* 2863; Poiso, Achada Grande, 1540 m, CB2021, 19.10.1993, *Fontinha* 2786; Poiso, Achada Grande, 1540 m, CB2021, 19.10.1993, *Fontinha* 2789; Ribeiro Frio, 900 m, CB2323, 19.10.1993, *Fontinha* 2788; Santana, Caldeirão Verde, 900 m, CB2028, 29.05.1993, *Fontinha* 2785.

Other specimens observed

Porella arboris-vitae

Germany: Gerolstein, Eifel, Sauer, 14.08.1985, (MADJ 2691 ex Herb. Mues 1166); Regensburg, Dolomifelsen bei Etterzhausen, Familler, 05.1906, (MO 2329860); Baiern, Isartall bei Hellriegelsgreuth an Nagelfluh und Bäumen, Neumann, 10.1903, (MO 2237103).

Bulgary: M. Strandza, *ad rupes silic., in fageto*, l. d. Goljam Draganovski dol, prope vic. Slivarovo, 200 m, Petrov, 29.05.1956, (MO 4436704).

Scotland: Ross, near Loch Maree, in wood, Carrington, 09.1889, (MO 2559687).

Spain: Astúrias, Oviedo, 300 m, Mues, 02.09.1980, (MADJ 2690 ex Herb. Mues 1163); Barcelona, Sant Llorenç del Munt,

canal de les Teixoneres, sobre *Buxus sempervirens*, 750 m, Casas, 16.04.1989, (MO 4412136); Barcelona, Montserrat, sobre pedras calcárias, xerófila, 950 m, Allorge, 18.04.1927, (MO 2567489).

France: Herault, 10 m, Boisselier, Bischler & Pujos, 14.10.1992, (MADJ 2772 ex Herb. Bischler 501); Le collet de Dèze-Lozère, 300 m, Cheminat, 08.1988, (MADJ 2699 ex Herb. Mues) (Qf); Tarn, saxícola, 350 m, Boisselier, Bischler & Pujos, 13.10.1992, (MADJ 2773 ex Herb. Bischler 480).

Hungary: Ungvár, Kokanu, 400 m, Mues, 14.08.1985, (MADJ 2692 ex Herb. Mues 1167) (Qf).

England: Bolton Abbey Woods, Yorkshire, Hodgetts, 23.06.1999, (MADJ 2976) (Qf); Tyn-y-groes, Merioneth, Pearson, 05.1877, (MO 2560460); Seatoller, Borrowdale, base of trees, Carrington & Pearson, 06.1890, (MO 2559688).

Romany: Carpatica, Transsilvania, Alpes Fogarasi, Havakok, 1200 m, Pocs, 28.07.1968, (MO 4447865).

Sweden: Skåne, "Skärälid", Lindberg, 14.07.1875, (MO 4432043).

Switzerland: Vaud, Montreux, Gorges du Chaudron, saxícola, 350 m, Bischler, 24.09.1992, (MADJ 2782 ex Herb. Bischler 461).

Turky: Esche, 1350 m, Sauer, 13.03.1985, (MADJ 2689 ex Herb. Mues).

P. canariensis

Azores: Faial, Cabeço dos Trinta, Fontinha, Gomes & Neves, 16.07.1997, (MADJ 2734); Faial, Caldeira, Schwab, 21.06.1981, (Herb. Schwab-Flora Azorica sub *Madotheca canariensis* Nees); Faial, Mistérios, V. & P. Allorge, 30.06.1937, (PC – Iter Azoricum); Flores, Valleé Cedros, V. & P. Allorge, 03.07.1937, (PC – Iter Azoricum); Flores, Valleé Cedros, V. & P. Allorge, 06.07.1937, (PC – Iter Azoricum); Flores, Ribeira Grande, V. & P. Allorge, 23.07.1937, (PC – Iter Azoricum); Flores, V. & P. Allorge, 14.07.1937, (PC – Iter Azoricum); Flores, Pico do Fransiscão, V. & P. Allorge, 17.07.1937, (PC – Iter Azoricum); Flores, Fajãzinha, V. & P. Allorge, 22.07.1937, (PC – Iter Azoricum); Flores, Fajãzinha, V. & P. Allorge, 22.07.1937, (PC – Iter Azoricum); Flores, Rochão, V. & P. Allorge, 22.07.1937, (PC – Iter Azoricum); Flores, Allorge, 28.07.1937, (MO 2568273); Pico, Mistério da Prinha, Sim-Sim, 09.06.1997, (MADJ 2736); Pico, Furna, V. & P. Allorge, 9.08.1937, (PC – Iter Azoricum); Pico, Serra, V. & P. Allorge, 8.08.1937, (PC – Iter Azoricum); Santa Maria, Pico Alto, V. & P. Allorge, 21.06.1937, (PC – Iter Azoricum); São Jorge, Fajã dos Cubres MH1577, Sérgio & Schumacker, 21.06.1999, (LISU); São Jorge, Fajã dos Cubres, Norte Pequeno, Sérgio & Schumacker, 21.06.1999, (LISU); São Jorge, Fajã dos Cubres, Norte Pequeno, Sérgio & Schumacker, 21.06.1999, (LISU); São Jorge, Fajã dos Cubres, Sérgio, 19.06.1999, (LISU); São Jorge, Norte Grande, Sérgio & Schumacker, 22.06.1999, (LISU); São Jorge, Pedras Brancas, Sérgio & Schumacker, 22.06.1999, (LISU); São Jorge, próximo de Pico da Esperança, vertente norte, 950 m, MH0678, Sérgio & Schumacker, 23.06.1999, (LISU); São Miguel, Lagoa do Congro, Schwab, 05.06.1981, (Herb. Düll 30959); São Miguel, Lagoa do Fogo, Hübschmann, 10.05.1973, [MADJ 2718 ex Herb. Düll 31900 sub *P. chamaedryfolia* (With.) Grolle]; São Miguel, próximo de Furnas, Hübschmann, 04.05.1973, (Herb. Hübschmann sub *P. canariensis* fo. *subintegra*); São Miguel, próximo do Pico da Cruz, Hübschmann, 04.05.1973, (MADJ 2749 ex Herb. Hübschmann 731733 sub *P. canariensis* fo. *subintegra*); São Miguel, próximo do Pico da Cruz, Hübschmann, 18.10.1970, (MADJ 2750 ex Herb. Hübschmann); São Miguel, Lagoa do Congro, Schwab, 5.06.1981, (Herb. Düll 30959 ex Herb. Schwab-Flora Azorica); São Miguel, Parque José do Canto na Lagoa das Furnas, Schwab, 4.06.1981, (Herb. Schwab-Flora Azorica sub *Porella*); São Miguel, Parque próximo do Hotel Terra Nostra, Schwab, 13.06.1981, (Herb. Schwab-Flora Azorica sub *Madotheca canariensis* Nees); São Miguel, Parque do Hotel Terra Nostra, 200 m, Schwab, 4.06.1981, (Herb. Schwab Flora Azorica); São Miguel, Lagoa do Congro, V. & P. Allorge, 31.05.1937, (PC – Iter Azoricum); São Miguel, Cratera das Sete Cidades, V. & P. Allorge, 24.08.1937, (PC – Iter Azoricum); São Miguel, Lagoa Furnas, V. & P. Allorge, 28.05.1937, (PC – Iter Azoricum); São Miguel, Tronqueira, V. & P. Allorge, 1937, (PC – Iter Azoricum); São Miguel, Furnas, V. & P. Allorge, 1937, (PC – Iter Azoricum); São Miguel, Furnas, V. & P. Allorge, 14.06.1937, (PC – Iter Azoricum); São Miguel, Ribeira Quente, V. & P. Allorge, 12.06.1937, (PC – Iter Azoricum); Pico, Furna, V. & P. Allorge, 9.08.1937, (PC – Iter Azoricum); Terceira, Falca, Fontinha, 24.06.1992, (MADJ 2838).

Cape Vert: São Nicolau, Monte Caldeirinha, Lindlar, 24.01.1995, [MADJ 2731 ex BONN sub *P. arboris-vitae* (With.) Grolle]; São Vicente, Monte Verde, Lindlar, 26.01.1995, [MADJ 2730 ex BONN sub *P. arboris-vitae* (With.) Grolle]; São Vicente, Monte Verde, Lindlar, 26.01.1995, [MADJ 2732 ex BONN sub *P. arboris-vitae* (With.) Grolle].

Canary Islands: Hierro, Riscos de Sabinosa, Pitard, 03.1906 (Herb. Pitard- PLANTAE CANARIENSIS 756 sub *Madotheca canariensis* Nees); La Palma, Düll, 20.03.1978, [Herb. Düll 017561 sub *P. arboris-vitae* (With.) Grolle]; La Palma, Düll, 15.03.1978, (Herb. Düll 17567); La Palma, Düll, 16.03.1978, [MADJ 2725 ex Herb. Düll 017562 sub *P. arboris-vitae* (With.)

Grolle]; La Palma, Cumbre Nueva, Bornmüller, 08.05.1901, (MADJ 2727 ex BM 518655 ex Herb. Schiffner sub *Madotheca canariensis* (Nees) sensu Schiffn. fo. *integra*]; La Palma, Cumbre nueva, Bornmüller, 08.05.1901, [MADJ 2728 ex JE sub *Madotheca canariensis* (Nees) sensu Schiffn. fo. *integra*]; La Palma, Losada *et al.*, 10.02.1990, (MADJ 2821 ex TFC 9125); Tenerife, 1969, (S B3430 HOLOTIPO sub *Jungermannia platyphylla* var. *canariensis*); Tenerife, 1969, (S B3431 HOLOTIPO sub *Jungermannia platyphylla* var. *canariensis*); Tenerife, Anaga, 900 m, Düll, 1978, [Herb. Düll ex DUIS Flora von Makaronesien sub *P. arboris-vitae* (With.) Grolle var. *thuja*]; Tenerife, Anaga, 900 m, Koppe, 01.04.1975, (LISU 161862 sub *P. arboris-vitae*); Tenerife, Anaga, Siegel, 02.09.1980, [MADJ 2693 ex Herb. Mues 2359 sub *P. arboris-vitae* (With.) Grolle]; Tenerife, Anaga, Crundell, 09.04.1979, (Herb. Düll 26405 ex Herb. Crundell 439); Tenerife, Bory, (HB Nees –STR ISOTIPO, HB Web sub *Madotheca canariensis* Nees); Tenerife, Bosque de Esperanza, Düll, 30.12.1973, (Herb. Düll 10007); Tenerife, Casa de la Cumbre, Fontinha & Santos-Guerra, 07.09.1995, (MADJ 2829); Tenerife, Las Mercedes, Bornmüller, 03.1838, (MADJ 2729 ex JE N. ab Esenb., Naturg. d. europ. Leberm., III (I 838), p. 207; cfr. Schiffner in Hedwigia, Bd. XLI (1902), p. 276 (sub *Madotheca canariensis*); Tenerife, Monte de las Mercedes, Fontinha & Santos-Guerra, 07.09.1995, (MADJ 2826); Tenerife, Monte del Agua, Fontinha & Santos-Guerra, 06.09.1995, (MADJ 2822); Tenerife, Monte del Agua, Fontinha & Santos-Guerra, 06.09.1995, (MADJ 2824); Tenerife, Monte del Agua, Fontinha & Santos-Guerra, 06.09.1995, (MADJ 2823); Tenerife, Monte del Agua, Fontinha & Santos-Guerra, 06.09.1995, (MADJ 2825); Tenerife, Pico del Ingles, Fontinha & Santos-Guerra, 07.09.1995, (MADJ 2827); Tenerife, Pijaral, Fontinha & Santos-Guerra, 07.09.1995, (MADJ 2830); Tenerife, Pijaral, Fontinha & Santos-Guerra, 07.09.1995, (MADJ 2832); Tenerife, Pijaral, Fontinha & Santos-Guerra, 07.09.1995, (MADJ 2833); Tenerife, Pijaral, Fontinha & Santos-Guerra, 07.09.1995, (MADJ 2831); Tenerife, próximo de La Laguna, Düll, 05.01.1974, [Herb. Düll 016355 sub *P. arboris-vitae* (With.) Grolle, cf. *macroloba*]; Tenerife, próximo de Puerto de la Cruz, Düll, 30.12.1973, (MADJ 2724 ex Herb. Düll); Tenerife, Tacoronte, Losada & Beltran, 05.05.1986, [MADJ 2820 ex TFC 3878 sub *P. arboris-vitae*]; Tenerife, Casa de la Cumbre, Fontinha & Santos-Guerra, 07.09.1995, (MADJ 2828); Tenerife, Las Mercedes, Bornmüller, 06.1900, (Herb. Bornmüller – *Plantae Exsiccatae Canariensis*).

Madeira Island: Faldas do Pico Jorge, Levada para o Ribeiro Bonito, C. Sérgio & M. Nóbrega 6148; 12.04.1988, (LISU 161857).

Portugal: Mafra?, saxícola, Veiga, (COI 3 sub *P. platyphylla*, *P. arboris-vitae*); Montachique, Cabeço de Montachique, Tavares, 1949, (LISU 148036); Montejunto, Quinta da Serra, Romariz & Mendes, 1947, [LISU 148027 sub *P. arboris-vitae* (With.) Grolle]; Sintra, Castelo dos Mouros, Bischler, 09.1991, (MADJ 2838 ex Herb. Bischler 343); Sintra, Cruz Alta, Bischler, 09.1991, (MADJ 2775 ex Herb. Bischler 340); Sintra, Cruz Alta, Bischler, 09.1991, [MADJ 2837 ex Herb. Bischler 338 sub *P. obtusata* (Tayl.) Trev.]; Sintra, Figueiredo & Asakawa, 07.09.1997, (MADJ 2735 ex LISU); Sintra, Welwitsch, 1839, (COI sub *P. thuja*); Sintra, Palácio da Pena, Fontinha, 06.03.1996, (MADJ 2740); Sintra, Palácio da Pena, Fontinha, 06.03.1996, (MADJ 2739); Sintra, Palácio da Pena, Fontinha, 06.03.1996, (MADJ 2747); Sintra, Palácio da Pena, Fontinha, 06.03.1996, (MADJ 2738); Sintra, Pena, Sérgio, 1972, [LISU 148023 sub *Madotheca laevigata* Dum. var. *thuja* Nees, *P. arboris-vitae* (With.) Grolle]; Sintra, Pena, Tavares, 1951, [LISU 148025 sub *P. arboris-vitae* (With.) Grolle]; Sintra, Parque Salazar, Mendes, 1948, [LISU 148030 sub *P. thuja* (Dicks.) Moore, *P. arboris-vitae* (With.) Grolle]; Sintra, Castelo dos Mouros, Melo, 1973, [LISU 148031 sub *P. arboris-vitae* (With.) Grolle]; Sintra, Sá Nogueira, 1954, (LISU 148034); Sintra, Castelo dos Mouros, Sá Nogueira, 1948, (LISU 148035); Sintra, Castelo dos Mouros, I. Tavares, 1941, [LISU 148053 sub *P. thuja* (Dicks.) Moore, *P. arboris-vitae* (With.) Grolle]; Sintra, I. Tavares, 1946, [LISU 148054 sub *P. thuja* (Dicks.) Moore, *P. arboris-vitae* (With.) Grolle]; Sintra, Pena, Cruz Alta, Sérgio, Schumacker & Bisang, 1987, [LISU 153619 sub *P. arboris-vitae* (With.) Grolle]; Sintra, Castelo dos Mouros, Sérgio, Schumacker & Bisang, 1987, [LISU 153620 sub *P. arboris-vitae* (With.) Grolle]; Sintra, Parque da Pena, Lagoa dos Cisnes, Sérgio, 1973, [LISU 160400 sub *P. arboris-vitae* (With.) Grolle]; Sintra, Cruz Alta, Bischler, 1991, (LISU 160402); Sintra, Welwitsch, 1849, [LISU 53165 sub *Bellincinia thuja* Dicks., *P. obtusata* (Tayl.) Trev.]; Sintra, Welwitsch, 1852, [LISU 53177 sub *P. arboris-vitae* (With.) Grolle, *Bellincinia laevigata* (Schrad.) O. Ktze.]; Sintra, Quinta da Penha Verde, Welwitsch, 1852, [LISU 53179 sub *P. arboris-vitae* (With.) Grolle, *Madotheca platyphylloidea* Nees, *Bellincinia laevigata* (Schrad.) O. Ktze.]; Socorro, próximo de Torres Vedras, Luisier, 1908, [LISU 53169 sub *Bellincinia thuja* Dicks., *P. obtusata* (Tayl.) Trev.].

Spain: Cadiz, Algeciras, 13.04.1963, (MADJ 2719 ex Herb. Düll).

P. obtusata

Canary Island: without locality, Sir W. J. Hooker, 1843, (JE HI448 ISOTYPE).

France: Hennebont, Bischler & Boisselier, 08.04.1992, (MADJ 2770 ex Herb. Bischler 426); Le Coudon, 660 m, John, 02.09.1980, (MADJ 2696 ex Herb. Mues 1180).

Madeira Island: Machico, Koppe, 22.03.1970, (STAATL ex Herb. F. & Koppe); Madeira Island, Poiso, Ade, 03.06.1926, (STAATL ex Herb. F. & Koppe); Madeira Island, Ribeiro Frio, Koppe, 09.04.1970, (STAATL ex Herb. F. & Koppe); Bussaco, Cruz Alta, Bischler, 09.1991, (MADJ 2777 ex Herb. Bischler 346); Entre a Pousada dos Vinháticos e Encumeada, C. Sérgio 2377, 13.05.1979, (LISU 161874).

Portugal: Bussaco, Fernandes & Sérgio, 24.06.1965, (COI 91); Coimbra, Sérgio & M. Sim-Sim, 26.06.1996, (MADJ 2698 ex Herb. Mues 2131); Estremadura, próximo de Pataias, Sérgio, 11.12.1996, (MADJ 2834 ex LISU); Fraga da Pena, Sérgio & M. Sim-Sim, 19.07.1995, (MADJ 2716 ex LISU 9789); Santo Tirso, Sérgio, 30.12.1995, (MADJ 2715 ex LISU 10236); Serra da Estrela, Sérgio, Brugués & Cros, 25.01.1995, (MADJ 2955 ex LISU 9583).

Spain: Astúrias, Oviedo, Mues, 02.09.1980, (MADJ 2697 ex Herb. Mues 1179).