

***Orthotrichum cambrense* sp. nov. (Orthotrichaceae), a distinctive moss from Wales, United Kingdom**

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Abstract – *Orthotrichum cambrense* Bosanquet et F. Lara, is described from material recently collected on trees in a small area of Carmarthenshire, south Wales. The new moss has a unique combination of morphological traits, several of them highly distinctive: characteristic almost flat leaves, with plane margins and frequently rounded apices; brood bodies common on leaves and rhizoids; emergent furrowed capsules with cryptopore stomata in their lower third; a peristome of 8 pairs of teeth and 8 segments; and the calyptra hairy, especially in the upper part. This moss is not believed to be close to other species with plane leaf-margins in the subgenus *Pulchella*. However, several gametophytic and sporophytic details relate *Orthotrichum cambrense* to *O. tenellum* and similar species in this same subgenus. Reasons why such a distinctive moss has gone unnoticed until now are discussed.

Bryophytes / Taxonomy / *Orthotrichum tenellum* / British Isles

INTRODUCTION

At the beginning of spring 2011 SDS Bosanquet visited Dryslwyn Castle in the Tywi Valley between Carmarthen and Llandeilo in Carmarthenshire, south Wales (United Kingdom) to carry out a bryophyte survey. Preliminary recording in the carpark revealed an *Orthotrichum*-like moss with obtuse leaf apices, plane margins and abundant brood bodies, similar to *Nyholmiella obtusifolia* (Brid.) Holmen et E. Warncke. This species is currently known from only a single site in Wales, where it grows on a town-centre Maple. However, the Dryslwyn *Orthotrichum* sported abundant young and unripe sporophytes, and these are rare in British *N. obtusifolia*. Further searching revealed the unfamiliar moss to be present on several different trees, alongside a diverse array of common *Orthotrichum* including abundant *O. tenellum* Bruch ex Brid. Checking with a microscope revealed the sporophytes to have cryptopore stomata, conclusively ruling out *N. obtusifolia*.

Study of later collected specimens with mature capsules has revealed that the Dryslwyn moss displays a unique, previously unknown set of characters

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that make it a highly distinctive *Orthotrichum* and which warrant the description of a new species.

Nomenclature follows TROPICOS for vascular plants, Grolle & Long (2000) and Ros *et al.* (2007) for liverworts and Hill *et al.* (2006) for European mosses except in the cases where authors are indicated, and Smith *et al.* (2009) for lichens.

SPECIES DESCRIPTION

Orthotrichum cambrense Bosanquet *et* F. Lara **sp. nov.**

Figs 1-33

Plantae parvae, foliis typice ovato-lanceolatis ad oblongo-lanceolata, vix carinatis, marginibus planis vel fere planis, apiceque rotundatis, raro obtusis vel acutis; gemmae aliquando in foliis rhizoideisque praesentes. Seta minus quam 1mm longa capsulaque inter perichaetiorum folia partialiter immersa; matura capsula oblongo-urceolata, omnino 8-sulcata, exothecii vittae 4-6 cellularum seriebus, stomata cryptopora in inferiore tertia parte capsulae locata; exostoma 8 dentium paribus, sicco recurvatis, in externa superficie aequae papillois, in interna superficie fere laevibus; endostoma 8 linearibus segmentis, in interna superficie tenuibus papillis lineisque ad basim obtectis, uniseriatis; operculum basali rubello annulo praeditum. Vaginula nuda vel fere nuda; calyptra pilosa, praecipue in sua parte superiore. Sporae dense papillosae, saepe 17-20 µm.

Type: UNITED KINGDOM. **WALES.** **Carmarthenshire:** Dryslwyn Picnic Site, SN 5525 2028, vc 44, alt. 15 m. Smooth trunks of Ash trees. *S.D.S. Bosanquet*, 5 July 2011 (Holotype: NMW, Isotypes: BM, E and MAUAM).

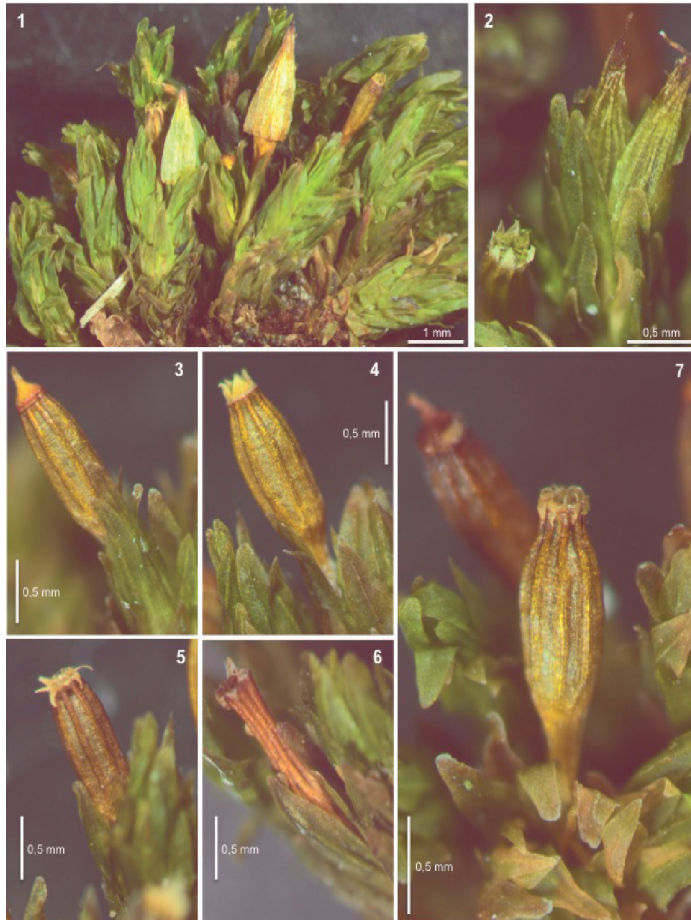
Plants to 1.1 cm tall, variably branched, olive-green, in cushions of *ca* 1 cm in diameter. **Stems** orange brown, pentagonal in section. **Axillary hairs** usually formed by 3 rectangular hyaline cells and 1 basal shorter and coloured cell. **Rhizoids** orange brown, smooth, abundant at stem base, scattered upwards. **Leaves** erect-appressed, somewhat flexuose when dry, erect-patent to patent when moist, ovate-lanceolate to oblong-lanceolate, more rarely lingulate or lanceolate, slightly keeled to almost plane, (1.3-)1.5-2.3(-2.7) × (0.35-)0.5-0.7(-0.8) mm, unistratose throughout; **leaf apex** usually rounded, less often obtuse or acute, with margins plane or seldom partially and faintly incurved on one side, commonly irregularly denticulate or papillose-crenulate near tip; **leaf margin** in the rest of leaf entire, totally or largely plane, sometimes slightly recurved on one or both sides in basal part. **Costa** vanishing below apex, 50-60 µm wide at leaf base, 40-45 µm at mid leaf. **Basal leaf cells** short or long rectangular, (11-)19-60(-72) × (6-)8-12(-14) µm, smooth, with straight or more or less nodulose cell walls, scarcely thickened, at margin mainly almost quadrate, 11-14 µm. **Median and upper leaf cells** isodiametric or ellipsoid, thick walled, (7-)11-18(-20) × (8-)9-13 (-16) µm, with (1-)2(-3) low and weak papillae. **Brood bodies** common on leaves and at apices of some rhizoids, especially on old or depauperate plants, claviform to cylindrical or irregularly sinuous filaments, with brown cell walls, (60-)90-170 (-250) µm long, sometimes branched. Gonautoicous. **Perigonia** lateral or terminal on branches; perigonial leaves ovate to shortly ovate-oblong, with rounded apices. **Perichaetia** terminal; perichaetial leaves similar to the larger vegetative ones, with

wider bases. **Vaginula** short cylindrical to dolioform, naked or with some partially bistratose hairs. **Sporophyte** hemiemergent, 1(2) per perichaetium. **Seta** 0.7-1.0 mm, ochrea long, covering half to 2/3 of seta length. **Capsule** 1.5-1.75 mm long, ovate-cylindrical when moist, oblong-urceolate, distinctly 8-furrowed, more or less progressively narrowing to seta and constricted below mouth when dry and full of spores, cylindric and strongly constricted from mouth to the lower third when dry and empty, brown when mature, paler at base. **Exothecial cells** pale yellowish, irregular, mostly shortly rectangular with slightly thickened walls. **Exothecial bands** well differentiated along the entire urn, formed by 4-6 cell-rows each, with darker, more thickened walls, (13-)20-40(-46) × (15-)19-28(-32) μm; the bands are separated from the capsule mouth by a ring of 2-4 horizontal rows of small oblate cells. **Stomata** cryptopore, half to entirely covered by surrounding exothecial cells, located in the lower capsule third (urn base and upper part of neck). **Peristome** double. **Exostome** of 8 teeth pairs, 180-200 μm long, recurved when dry, with no marked tendency to split; external surface (Outer Peristomial Layer, OPL) finely and densely papillose; internal surface (Primary Peristomial Layer, PPL) from almost smooth to low ornamented, with weak longitudinal lines near the base and with more or less abundant, small papillae in the upper portion. Remains of a low, papillose prostome usually present. **Endostome** of 8 segments almost as long as teeth, uniseriate, smooth on the outer side (PPL), finely ornamented on the inner side (Inner Peristomial Layer, IPL) with papillae throughout and with short lines towards the base; connective membrane complete, with an upper row of cells having the same ornamentation as base of segments. **Operculum** convex to conic and rostrate, yellowish with reddish basal rim, 0.3-0.4 mm in diameter. **Calyptra** conic to campanulate, yellowish with darker tip, usually strongly plicate, 1.6-2.1 mm long, hairy, with smooth or faintly papillose, uniseriate to biseriate hairs, especially abundant near apex. **Spores** greenish, coarsely papillose, (15-)17-20 (-21) μm in diameter.

ECOLOGY

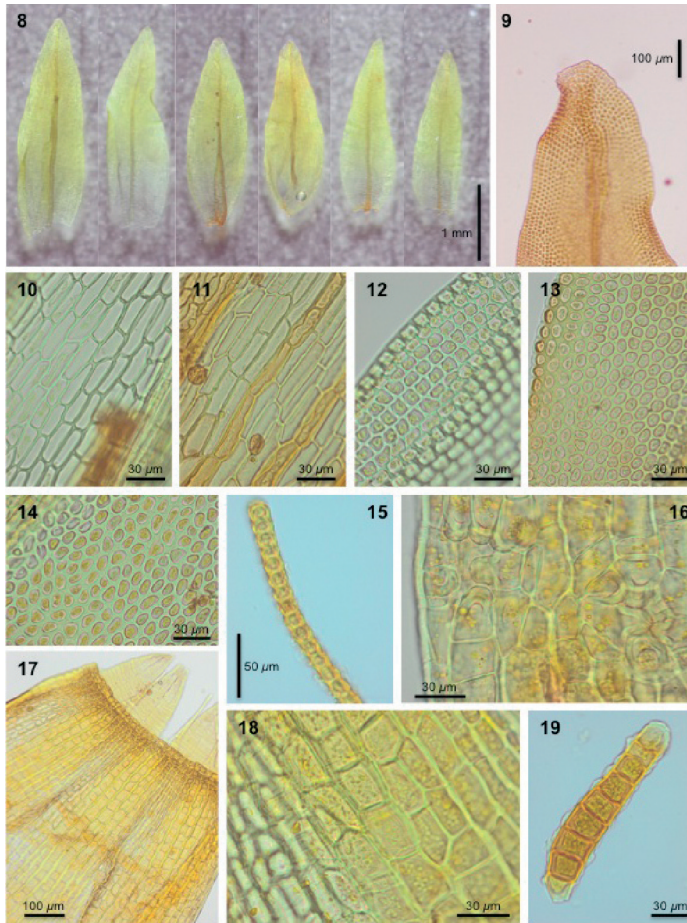
The site at which *Orthotrichum cambrense* was discovered is the carpark adjacent to Dryslwyn Castle, a Scheduled Ancient Monument. The castle occupies the top of an inlier of Silurian limestone and is surrounded by steep slopes on which Mediterranean and Sub-Mediterranean bryophytes including *Cephaloziella stellulifera*, *Fissidens curvatus*, *Microbryum rectum* and *Tortula lanceola* have been found. It is the richest site for Mediterranean bryophytes in inland Carmarthen-shire. The winter minimum temperature drops to an average of 4°C in the 5 km square around Dryslwyn, but the castle and carpark are often visibly frost-free when the rest of the Tywi valley is very frosty. The carpark lies below the south-western slopes of the limestone inlier, about 30 m from the River Tywi, a mature, meandering river with a significant silt load and bryophytes that include *Leskea polycarpa*, *Orthotrichum sprucei* and *Syntrichia latifolia*.

The area around the carpark was planted with a diverse array of tree species in the 1990s. *Orthotrichum cambrense* grows on 7 of the 14 tree species checked and on 11 of the 30 individual trees analysed. Occupied trees are: *Fraxinus excelsior* (4 trees), *Acer campestre* var. *leiocarpum* (3 trees), *Acer pseudoplatanus*, *Populus tremula*, *Salix x sepulchralis*, *Sambucus nigra* and *Tilia x vulgaris* (1 tree each); it was absent from *Alnus glutinosa*, *Betula* sp., *Crataegus monogyna*, *Fagus sylvatica*, *Larix decidua*, *Prunus avium*, *Quercus robur* and



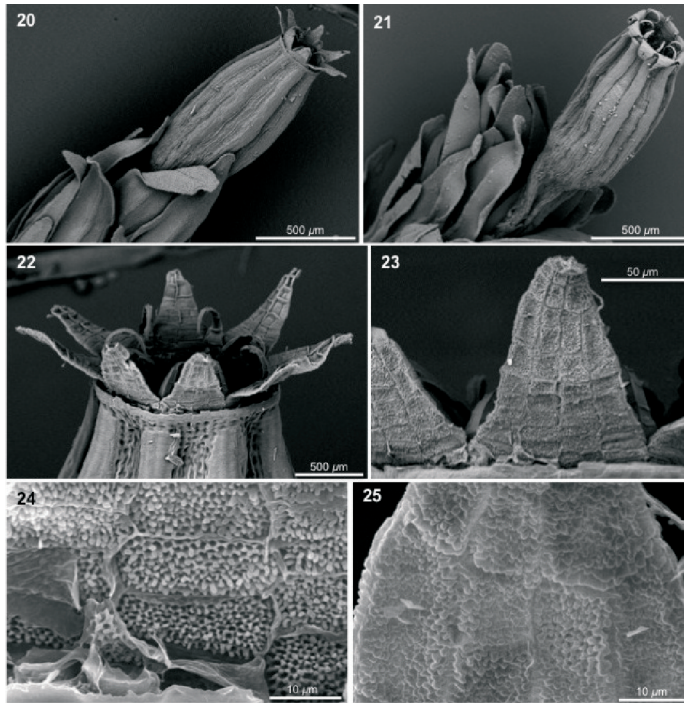
Figs 1-7. *Orthotrichum cambrense*. **1.** Habit. **2.** Perichaetial leaves and a pair of young sporophytes covered by their calyptrae, arising from the same perichaetium; a capsule mouth in the first phase of spore release is also visible at bottom left of the picture. **3-6.** Capsules at different stages of maturity, all in dry condition. **3.** Almost mature capsule with operculum. **4.** Mature capsule just after operculum detachment, with the exostomial teeth still erect. **5.** Mature capsule with the exostomial teeth recurved. **6.** Old capsule; peristome is damaged and not all the teeth remain recurved. **7.** Mature capsule showing the peristome in its typical position when dry. All from holotype except 6 from *Bosanquet*, 25 March 2011.

Sorbus aucuparia. It is abundant on one *Fraxinus* and three *Acer campestre*, favouring the south-eastern, eastern, north-eastern and northern sides of the *Fraxinus* and occurring on all aspects of the *A. campestre*, from 10 cm above ground level up to at least 5 m above the ground. Most of the recorded population grows on tree trunks, but a few tufts were on a 3 cm diameter twig in the fork of one *Acer* and other branches and twigs were inaccessibly high up. One tuft was discovered on a silty *Salix* branch overhanging the river, with *Orthotrichum sprucei* nearby. The only other tuft found was growing on a *Fraxinus excelsior* twig by the River Tywi downstream of Pont Llandilo-yr-ynys, some 6 km west of Dryslwyn.



Figs 8-19. *Orthotrichum cambrense*. **8.** Leaves. **9.** Typical rounded leaf apex; left margin near the top is faintly incurved in this case. **10-12.** Basal leaf areolation. **10.** Common aspect of the paracostal basal leaf cells. **11.** Basal leaf cells with intercalated orange rows of cells with coloured thickened and sinuous walls as seen occasionally. **12.** Basal leaf cells towards margin. **13-14.** Laminal leaf cells. **15.** Marginal leaf section. **16.** Stomata. **17.** Upper part of a capsule, where three exothecial bands are visible. **18.** Detail of the exothecial cells showing the differentiated coloured cells of an exothecial band. **19.** Brood body. All from holotype.

Direct associates of *Orthotrichum cambrense* in seven 25 × 50 cm quadrats sampled on two *Fraxinus* are: *Frullania dilatata* (7 quadrats), *Orthotrichum tenellum* (6), *O. affine* (5), *Ulota bruchii* (4), *Hypnum cupressiforme* (3), *Cryphaea heteromalla* (2), *Ulota phyllantha* (2), *Metzgeria furcata* (1), *M. fruticulosa* (1) and *Zygodon conoideus* (1), with *F. dilatata*, *O. affine* and *O. tenellum* being the only species making more than 10% cover. Other epiphytes on these trees and the three *Acer campestre* on which *O. cambrense* is abundant include *Orthotrichum diaphanum*, *O. pulchellum*, *O. stramineum* and *O. striatum*. Associated lichens include *Flavoparmelia caperata*, *Lecanora chlorotera*, *Parmelia sulcata*, *Parmotrema perlatum*, *Pertusaria pertusa*, *Physcia tenella*, *Punctelia subrudecta*, *Rama-*

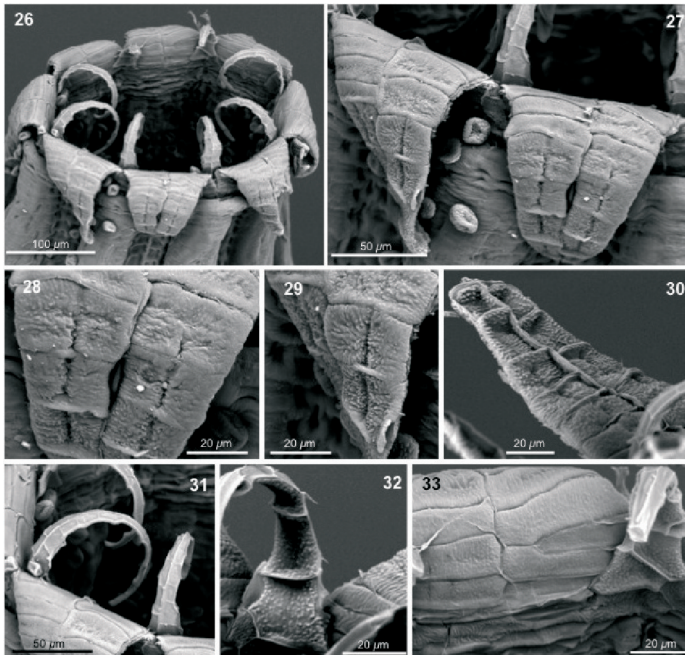


Figs 20-25. *Orthotrichum cambrense*, SEM images. **20-21.** General views of sporophytes and upper leaves. **20.** A capsule with exostomial teeth not yet recurved. **21.** Capsule with the peristome in the typical position when dry. **22.** Close view of the peristomial configuration, with 8 pairs of exostomial teeth alternating with 8 thin endostomial segments. **23.** External surface (OPL) of an exostomial tooth pair, densely ornamented by simple papillae, distributed uniformly. **24.** Detail of the basal part of the external side of a tooth: OPL is formed by a reticulum from which numerous papillae protrude; a prostome remnant can be seen at the bottom. **25.** Detail of the upper part of the same tooth: OPL is densely ornamented by low papillae. All from holotype.

lina farinacea, *R. fastigiata* and *Xanthoria parietina*, species that range between 4 and 8 on the 10 point “Hawksworth and Rose” scale of SO₂ intolerance but are mostly somewhat nitrophilous, especially *X. parietina* (Richardson, 1992).

DISCUSSION

Orthotrichum cambrense is an unmistakable species in spite of its superficial resemblance to *Nyholmiella obtusifolia*. Numerous characters allow the distinction of these two species, but some of them are especially significant and easy to observe: *O. cambrense* is an autoicous moss, with almost flat leaves that have plane margins and usually bear scattered brood bodies, its calyptrae are visibly hairy and its capsules have cryptopore stomata; in contrast, *N. obtusifolia* is a dioicous moss, with more or less concave leaves that show characteristic erect-



Figs 26-33. *Orthotrichum cambrense*, SEM images. **26-27.** Views of the peristomial configuration after tooth recurvation. **28-30.** Different aspect of the internal surface (PPL) of exostomial teeth; trabeculae are more or less obvious and general ornamentation varies from an almost smooth surface to a clear but low papillosity, more evident in the upper parts. **31.** External side (PPL) of the endostomial segments, scarcely keeled and essentially smooth. **32.** Basal part of the internal side (IPL) of an endostomial segment, neatly papillose; PPL basal parts of adjacent exostomial teeth where an unusual ornamentation, formed by low longitudinal lines, can be seen. **33.** Inner aspect of the basal part of the peristome, with a portion of the endostomial connective membrane at the bottom. All from holotype.

incurved margins and normally have abundant brood bodies, its calyptrae are completely naked and its capsules possess phaneropore stomata.

Immersed stomata and the peristomial configuration, with teeth that are recurved when dry and endostomial segments basally united by a connecting membrane, allow the inclusion of *Orthotrichum cambrense* in subgenus *Pulchella* (Schimp.) Vitt *sensu* Lewinsky (1993). Within this group, most species have leaves with recurved margins. Only 16 out of 73 currently accepted members of the subgenus *Pulchella* in the world have leaves with margins totally plane or, more commonly, leaves that occasionally have a minor part of the margins narrowly recurved (Lewinsky-Haapasaari & Hedenäs, 1998), as occur in *O. cambrense*. Most of these mosses are found in Eastern Asia (7 species) and South America (6 species), whereas in Australasia, Africa, North America, and Europe/Western Asia only one or two species are known (Table 1). Among all these species, *Orthotrichum erubescens* from Japan and Eastern China is the most similar to *O. cambrense*, because of its flattened, apically rounded upper leaves. However, the Asian moss is tinier (*ca* 3.5 mm tall), does not produce brood bodies, has shorter capsules, ovoid when wet, urceolate when dry, possesses distinctive endostomial segments, which are much shorter than the teeth, basally widened

Table 1. All other species in subgenus *Pulchella* with plane or almost plane leaf margins and their distribution in the World

<i>Species</i>	<i>Distribution area</i>	<i>References</i>
<i>O. microcarpum</i> De Not.	Europe, SW Asia	Lara <i>et al.</i> , 2010
<i>O. consobrinum</i> Cardot	Sino-Japanese region, SW Asia, SW Europe	Lara <i>et al.</i> , 2010; Jia <i>et al.</i> , 2010
<i>O. crispifolium</i> Broth.	W Himalaya	Lewinsky, 1992; Porley, 2002
<i>O. erubescens</i> Müll. Hal.	Japan and China	Lewinsky, 1992; Jia <i>et al.</i> , 2010
<i>O. griffithii</i> Mitt. ex Dixon	W Himalaya	Lewinsky, 1992; Jia <i>et al.</i> , 2010
<i>O. notabile</i> Lewinsky-Haapasaari	China	Lewinsky-Haapasaari, J., 1996
<i>O. sinuosum</i> Lewinsky	China	Lewinsky, 1992
<i>O. subpulum</i> Bartr. ex Lewinsky	China	Lewinsky, 1992; Jia <i>et al.</i> , 2010
<i>O. calvum</i> Hook. f. et Wilson	New Zealand	Lewinsky, 1984
<i>O. gigantosporum</i> Lewinsky (= <i>O. macrosporum</i> Lewinsky, <i>hom. illeg.</i>)	S South America	Lewinsky & Deguchi, 1989
<i>O. inclinatum</i> Müll. Hal. (= <i>O. compactum</i> Dusén)	S South America	Matteri, 2000
<i>O. liliputanum</i> Broth.	Bolivia	Lewinsky, 1985
<i>O. perexiguum</i> Dusén ex Lewinsky	Chile	Lewinsky, 1985
<i>O. trachymitrium</i> Mitt.	South America, Mexico	Lewinsky, 1985; Vitt, 1994
<i>O. aequatoreum</i> Mitt.	South America, Central America, Mexico, E Africa	Lewinsky, 1978, 1985; Vitt, 1994; Allen, 2002
<i>O. underwoodii</i> F. Lara, Garilleti <i>et</i> Mazimpaka	California	Garilleti <i>et al.</i> , 2001

and non papillose, and exhibits characteristic campanulate calyptrae with hairs restricted to an apical comal tuft. In Europe and the Mediterranean basin only *Orthotrichum microcarpum* and *O. consobrinum* have leaves with plane margins (Lara *et al.*, 2009a). Both can easily be distinguished from *O. cambrense* as their leaves are visibly keeled and acute at the apex, and they have naked calyptrae and urceolate (clearly contracted below mouth) capsules, among other differences (Lara *et al.*, 2009b, 2010).

While the peculiar leaves of *Orthotrichum cambrense* are its main distinguishing feature, a meaningful set of other gametophytic and sporophytic traits point to the relationship of this moss with *Orthotrichum tenellum* and allied species, as for example the two North American recently described *O. norrisii* F. Lara, R. Medina *et* Garilleti and *O. pilosissimum* R. Medina, F. Lara *et* Garilleti (Medina *et al.*, 2008, 2011). *Orthotrichum cambrense* shares with these: capsule shape, peristomial arrangement and shape, cryptopore stomata in the lower half of the urn, propagules, and a hairy calyptra with hairs mainly concentrated near the apex. Although the leaves of the new moss are typically rounded and plane at the apex, they sometimes exhibit irregular denticulations or have one side partially and faintly incurved, recalling the characteristic apical denticulations and margin incurvation of the alluded species in the *O. tenellum* group. Of course, in *Orthotrichum tenellum* and similar mosses the leaf margins are consistently and noticeably recurved for most of their length. The brood bodies found in *O. cambrense* are unusual, since they are frequently very elongated and arise both on leaves and rhizoids; these facts have, however, a parallel in the case of *O. pilosissimum* (Medina R. *et al.*, 2011).

Since *Orthotrichum cambrense* is such a distinctive moss, an inevitable question arises as to why it has not been discovered previously. The answer is, of course, speculative. Carmarthenshire was very poorly worked by bryologists until the 1990s; indeed most of the southern half of Wales was poorly known except for a few areas of Glamorgan. Since then there has been considerable and wide-ranging recording throughout south Wales. *Orthotrichum cambrense* has not been seen elsewhere in south Wales and therefore is likely to have a genuinely restricted distribution. At the same time there have been very considerable increases in the region's epiphyte flora, with species that are now frequent such as *Orthotrichum pulchellum*, *O. striatum*, *O. tenellum* and *Radula complanata* being extremely rare or entirely unknown in Glamorgan in the 1960s to 1990s (Perry, 1994).

It is plausible that *Orthotrichum cambrense* might have colonised a previously epiphyte-poor Dryslwyn from further south, in a similar way to what is assumed for some other recent British *Orthotrichum* records: *O. consimile*, *O. acuminatum* and *O. scanicum* (Blockeel, 2008, 2009, 2012). Most of southern Britain has been reasonably well-worked in the past, and Hill *et al.* (1994) show numerous records of other *Orthotrichum* from south-western Britain. This makes a British origin relatively improbable and leads us to think of a more southern source, although in the last two decades there has been intense work on the Mediterranean Orthotrichaceae (Lara *et al.*, 2009a). Even if *Orthotrichum cambrense* is a recent colonist in Wales, its abundance at Dryslwyn suggests a well-established population, rather than merely a transient record. A further possibility is that it was imported as protonema or young plants on the introduced, non-British trees used for landscaping the carpark area twenty years ago; this might explain the species' local abundance but lack of penetration into the nearby countryside. It has long been common practice in Britain to source supposedly native tree species from non-British sources to save money. The *Acer campestre* belongs to the non-native var. *leiocarpum* (I.K. Morgan, pers. comm.), which originates from further east in Europe, although this does little to help narrow down an under-studied area that might be the origin of *O. cambrense*. Unfortunately we have been unable to trace details of the original tree planting.

An alternative hypothesis to a recent arrival of *Orthotrichum cambrense* is that it represents a local endemic, being globally restricted to a small area around Dryslwyn. This is not as implausible as the high capacity for spread of most mosses may suggest and, in fact, there are several good examples of other bryophytes with very narrow ranges (Medina N.G. *et al.*, 2011). Among the *Orthotrichum* of Europe and adjacent areas, two other cases of rigorous local endemics are known: *O. handiense* limited to the top of the mountains of southern Fuerteventura, in eastern Canary Islands (Lara *et al.*, 1999, 2003), and *O. casaianum* from northern Spain (Mazimpaka *et al.*, 1999). The latter, as *O. cambrense*, is only known from the riversides along a short stretch of one river, but unlike the Welsh moss, it is quite difficult to differentiate from other species, especially *O. pallens*. Future bryophyte recording in south Wales should give indications of whether *O. cambrense* is spreading outwards from Dryslwyn, whilst molecular studies may provide further evidence of its relationships to other *Orthotrichum* species.

OTHER SPECIMENS EXAMINED (PARATYPI)

UNITED KINGDOM. WALES. Carmarthenshire: Dryslwyn Picnic Site, SN 5525 2028, vc 44, alt. 15 m, smooth trunks of Ash trees, S.D.S. Bosanquet, 25 March 2011 (VAL-Brief.

and MAUAM); *Idem*, on trunks of Ash & Maple, S.D.S. Bosanquet, 30 March 2011 (BCB); by River Tywi, Dryslwyn, SN 552 202, vc 44, alt. 15 m, rare on silty *Salix* base (S.D.S. Bosanquet pers. herb).

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