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The distribution of some species of Trentepohliaceae (Trentepohliales, Chlorophyta) in France

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Abstract — Some new and interesting green algae of the family Trentepohliaceae in northern and central France are noted. Specimens attributable to the genus *Phycopeltis* were observed on leaves of ivy in a deciduous woodland in Brittany; they had a regularly disk-shaped habit, with vegetative cells 8-20 µm long 5-10 µm wide. Most of the material is attributable to *Phycopeltis arundinacea* (Montagne) De Toni, but the occurrence of specimens producing sporangiate laterals on apical and subapical cells indicates that *Phycopeltis epiphyton* Millardet was possibly also present. This is the first record of *Phycopeltis* for France and the first of *Phycopeltis arundinacea* for continental Europe. Specimens of *Trentepohlia iolithus* (Linnaeus) Wallroth and another species of *Trentepohlia*, probably *Trentepohlia umbrina* (Kützing) Bornet, were collected from concrete and other building surfaces in northern and central France. These species occur in the same habitat as they occupy in western Ireland and are likely to be much more widespread in parts of Europe with a warm-temperate Atlantic climate than available records indicate.

France / New records / *Phycopeltis* / Subaerial algae / *Trentepohlia*

Résumé — Distribution de quelques espèces de Trentepohliaceae (Trentepohliales, Chlorophyta) en France. Plusieurs espèces intéressantes d'algues vertes appartenant à la famille des Trentepohliacées ont été identifiées dans le Nord et le Centre de la France. Des spécimens du genre *Phycopeltis* ont été observés sur des feuilles de lierre dans un bois de feuillus en Bretagne; ils présentaient un port discoïde, avec des cellules végétatives de 8-20 µm de long et de 5-10 µm de large. La plus grande partie du matériel appartient à l'espèce *Phycopeltis arundinacea* (Montagne) De Toni, mais le fait que certains spécimens forment des expansions sporocystiques sur les cellules apicales et subapicales suggère également la présence possible de *Phycopeltis epiphyton* Millardet. Cet article constitue la première mention de *Phycopeltis* en France et la première de *Phycopeltis arundinacea* en Europe continentale. Des spécimens de *Trentepohlia iolithus* (Linnaeus) Wallroth et d'une autre espèce de *Trentepohlia*, probablement *Trentepohlia umbrina* (Kützing) Bornet, ont été récoltés sur du béton et sur d'autres substrats artificiels dans le Nord et le centre de la France. Ces espèces se développent dans un habitat similaire à celui qu'elles occupent dans l'Ouest de l'Irlande et elles sont vraisemblablement beaucoup plus largement répandues dans les régions d'Europe au climat tempéré chaud océanique que ne l'indiquent les publications existantes.

Algues subaériennes / France / Nouvelles signalisations / *Phycopeltis* / *Trentepohlia*

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INTRODUCTION

The Trentepohliaceae is a family of subaerial green algae, widespread on a variety of substrata in damp habitats (Printz, 1939; Chapman, 1984; Thompson & Wujek, 1997). Most of the species currently included in the family are mainly distributed in tropical and subtropical areas (De Wildeman, 1891; Fritsch, 1907; Thompson & Wujek, 1997), but several have been also commonly reported in temperate regions (Printz, 1939, 1964; Chapman & Good, 1983; Nakano & Handa, 1984; Handa & Nakano, 1988; Rifón-Lastra & Noguerol-Seoane, 2001). Four of the five genera currently assigned to the Trentepohliaceae are known to occur in Europe: *Cephaleuros* Kunze, *Phycopeltis* Millardet, *Printzina* Thompson & Wujek and *Trentepohlia* Martius. *Trentepohlia* is the most widespread and best known (Hariot, 1889, 1893; Howland, 1929; Printz, 1939, 1964; John, 1988; Rindi & Guiry, 2002a); records of entities attributable to this genus date back to the 16th century (Linnaeus, 1753, 1759). *Printzina* has been also frequently reported (usually attributed to species of *Trentepohlia*: Hariot, 1889, 1893; Printz, 1964). Reports of *Phycopeltis* and *Cephaleuros* are much rarer, probably because of the small size and indistinct habit of these algae (Millardet, 1870; Scannell, 1978; Thompson & Wujek, 1997; Rindi & Guiry, 2002b); relatively little is currently known about their distribution.

During a recent visit to northern France, one of us (MDG) noted the presence of several interesting species of Trentepohliaceae. Specimens of subaerial algae attributable with certainty to *Phycopeltis* were noted. Because of the lack of observations on species of this genus in Europe, this was a very interesting record and we report here some details of the morphology and the habitat of the alga in northern France. On the same occasion, growths produced by species of *Trentepohlia* were observed to be common on walls of buildings and other artificial surfaces. In Europe, this phenomenon has been described only very rarely; western Ireland is the only region for which it has been reported in detail (Rindi & Guiry 2002a). These growths were found to consist of *Trentepohlia iolithus* (Linnaeus) Wallroth and another species of *Trentepohlia*, morphologically close to *Trentepohlia umbrina* (Kützing) Bornet. We report details of the morphology and ecology of these entities too.

MATERIALS AND METHODS

Specimens of *Phycopeltis* were collected on 21 October 2001 at Sainte Anne du Portzic, near Brest; the alga occurred epiphytically on leaves of ivy (*Hedera helix* Linnaeus) in a mixed woodland of beeches (*Fagus sylvatica* Linnaeus) and chestnuts (*Castanea sativa* Miller). Thirty leaves, for which the presence of orange patches of *Phycopeltis* was detectable by the unaided eye, were collected. The material was transported in a closed plastic bag and examined by light microscopy some days later; from each leaf, 1-2 plants were removed and examined by light microscopy (overall, 50 plants). The size of the thallus was measured for each specimen (as diameter of the plant in micrometers) and the reproductive condition was noted (absence of reproductive structures; presence of zoosporangia; presence of gametangia); for 15 plants randomly selected, length and width of 6 vegetative cells (also randomly selected) were measured.

Trentepohlia iolithus and *Trentepohlia* cf. *umbrina* were collected at several sites in northern and central France, reported in detail in Tab. 1. These

Table 1. Collections of *Trentepohlia* examined.

Date	*Locality*	*Type of substratum*	*Species*
5 Jul. 2000	Vayrac, Lot	Concrete	*Trentepohlia iolithus*
6 Jul. 2000	Souillac, Lot	Concrete	*Trentepohlia iolithus*
18 Dec. 2001	Landunvez, Finistère, Brittany	Limestone	*Trentepohlia* cfr. *umbrina*
12 Feb. 2002	Bayeux, Calvados	Limestone	*Trentepohlia* cfr. *umbrina*
14 Feb. 2002	Le Mont St. Michel, Normandy	Limestone	*Trentepohlia* cfr. *umbrina*
21 Feb. 2002	Ste Marie du Mont, Cotentin, Normandy	Limestone	*Trentepohlia* cfr. *umbrina*
21 Feb. 2002	Baupte, Cotentin, Normandy	Concrete	*Trentepohlia iolithus*
21 Feb. 2002	Baupte, Cotentin, Normandy	Concrete	*Trentepohlia iolithus*
21 Feb. 2002	Auvers, Cotentin, Normandy	Concrete	*Trentepohlia iolithus*
20 Mar. 2002	Landunvez, Finistère, Brittany	Cement	*Trentepohlia* cfr. *umbrina*

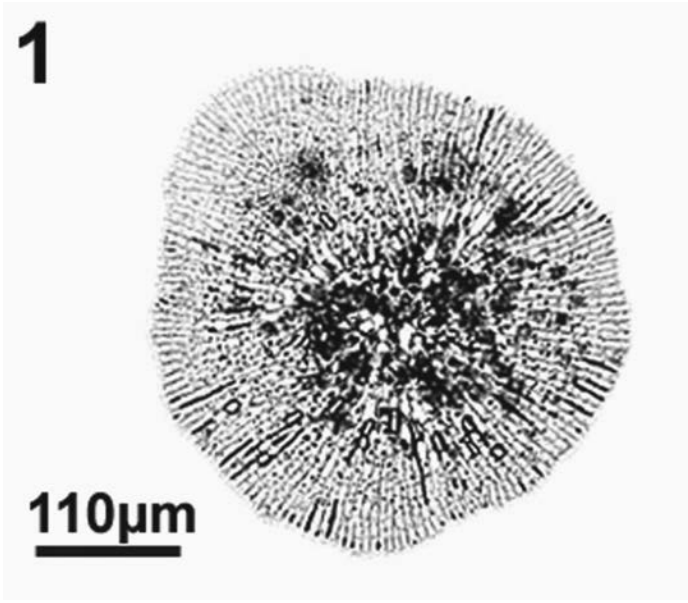
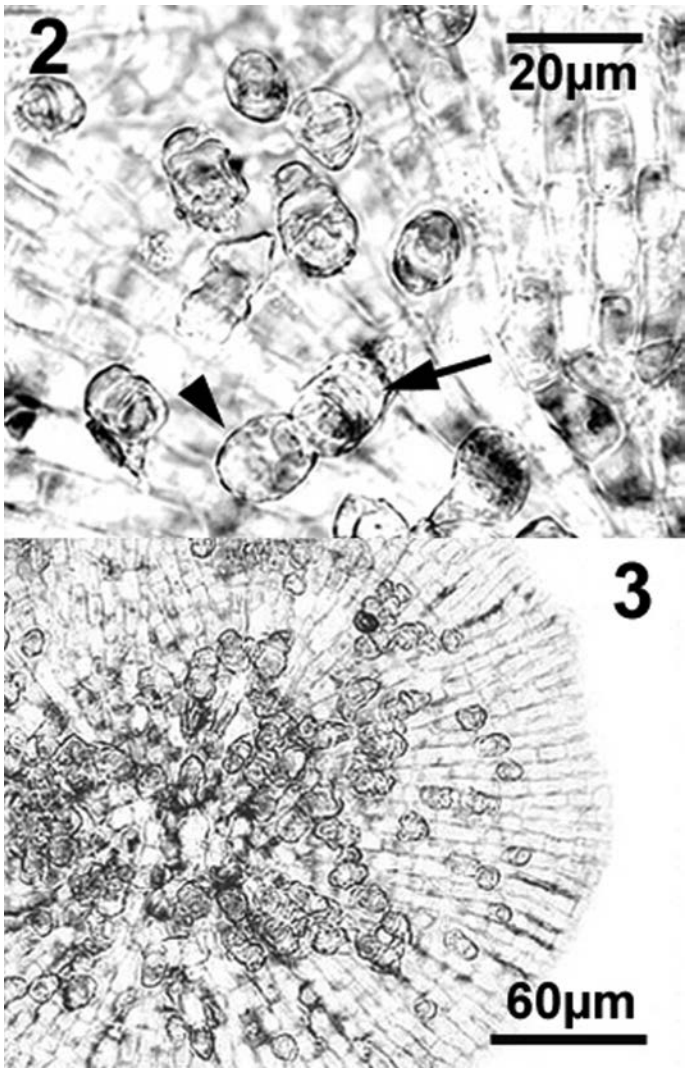


Fig. 1. *Phycopeltis arundinacea*. Habit of a specimen.

algae formed a dark red crust on artificial surfaces, from which they were removed with a sharp knife. The material was examined by light microscopy some days later and the same observations as for *Phycopeltis* were made.

Microphotographs of *Phycopeltis* and *Trentepohlia* were taken by a Nikon DXM1200 digital camera and mounted in plates by Adobe Photoshop 4.0.

For all collections, voucher specimens were deposited in the Phycological Herbarium, National University of Ireland, Galway (GALW). Some specimens of *Phycopeltis* have also been deposited in the Muséum National d'Histoire Naturelle, Paris (PC).



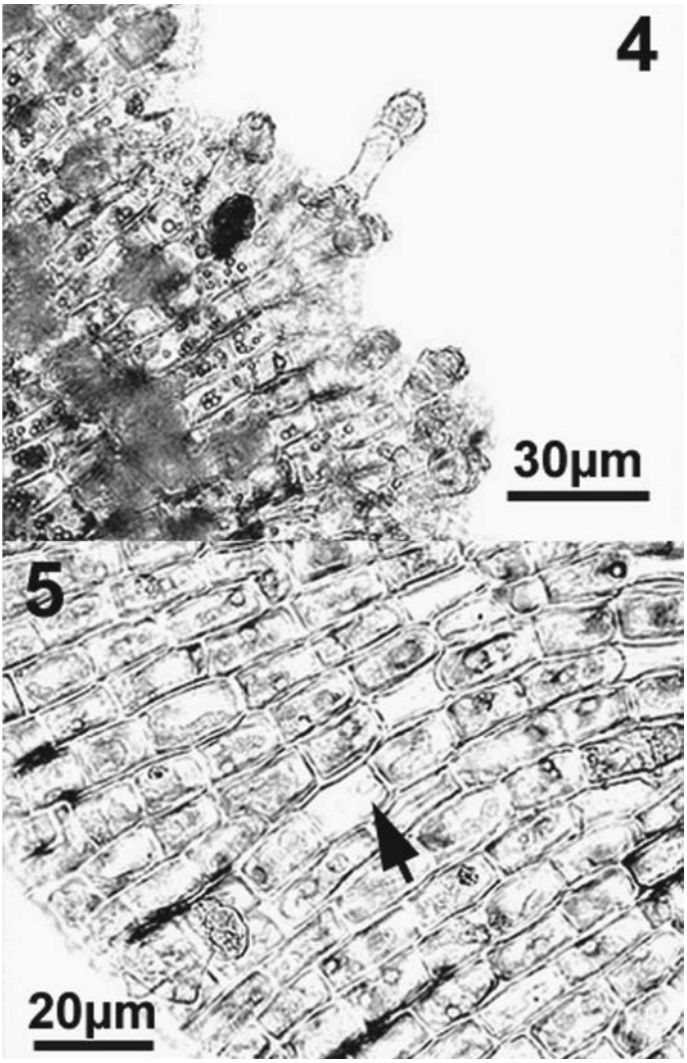
Figs 2-3. *Phycopeltis arundinacea*. Fig. 2. Surface view of a thallus showing detail of some sporangiate laterals, with zoosporangium (arrowhead) and suffultory cell (arrow). Fig. 3. Surface view of a thallus, showing zoosporangia concentrated in the central parts.

OBSERVATIONS

Phycopeltis

Specimens of *Phycopeltis* consisted of orange or yellowish-brown disks, formed by the adhesion of numerous filaments radiating from the centre of the plant and branching dichotomously. The thalli had a regular, entire or slightly lobed margin and individual specimens were up to 1200 µm wide (Fig. 1). When

the margins of two individual plants met, they stopped growing in the area of contact and their growth continued in other directions; so, if large numbers of thalli occurred on a same leaf, *Phycopeltis* produced growths extending for some mm^2 or cm^2, with irregular edges. The cells were 8-20 µm long (mostly 13-17 µm) and 5-10 µm wide (mostly 6-8 µm), the length: width ratio ranging between 1.5 and 3 (mostly 2-2.5). The mean lengths and widths, calculated for 90 cells, were 14.23 µm (SD: 1.57) and 7.34 µm (SD: 0.77), respectively; the mean length: width ratio was 1.96 (SD: 0.33).



Figs 4-5. *Phycopeltis* sp. and *Phycopeltis arundinacea*. Fig. 4. *Phycopeltis* sp.: surface view of the margin of a specimen, showing marginal production of zoosporangia. Fig. 5. *Phycopeltis arundinacea*: marginal part of a specimen, showing the ostiole of a presumptive empty gametangium (arrow).

The most common reproductive structures were sporangiate laterals, which were observed on all specimens examined. Sporangiate laterals consisted of a zoosporangium borne on the top of a retorted suffultory cell (Fig. 2); in fully developed sporangiate laterals, the suffultory cell was constantly bent towards the centre of the thallus and the zoosporangium was oval, 10-20 µm long and 8-16 µm wide. In most plants, production of sporangiate laterals took place in the centre of the thallus and the mature sporangiate laterals were concentrated in the central parts of the algae, with the marginal parts of the thallus being largely sterile (Fig. 3). However, specimens occurring on some leaves showed a markedly different pattern: the sporangiate laterals were produced on apical and subapical cells, and consequently also occurred in the marginal parts of the thallus (Fig. 4). Specimens with apical and intercalary sporangiate laterals were clearly segregated on different leaves and the two forms were never observed occurring together on the same leaf; no differences in the size of vegetative cells were evident between the two forms. No detachment of zoosporangia and release of zoospores was observed for any specimen.

No mature gametangia were observed in any plant. In a number of specimens some cells were discoloured and in surface view they showed a hole with the appearance of a gametangial ostiole (Fig. 5); this suggests that these cells were empty gametangia which had previously released gametes.

Trentepohlia iolithus

Trentepohlia iolithus was found to produce dark red growths on concrete surfaces at Vayrac and Souillac (Department of Lot), and Baupte and Auvers (peninsula of Cotentin, Normandy). Specimens consisted of extensive creeping axes, producing irregularly branched erect axes (Fig. 6). Generally, the erect parts of the thallus tended to become deeply entangled and to assume a decumbent habit; this produced an almost crustose, pseudoparenchymatous thallus. Individual cells varied in shape from cylindrical to globular (Fig. 7); usually, they were more or less cylindrical in parts of the thallus in active growth and tended to get globular in the older ones. Cell length ranged between 13 and 28 µm (mostly 16-22 µm), cell width between 10 and 26 µm (mostly 14-18 µm).

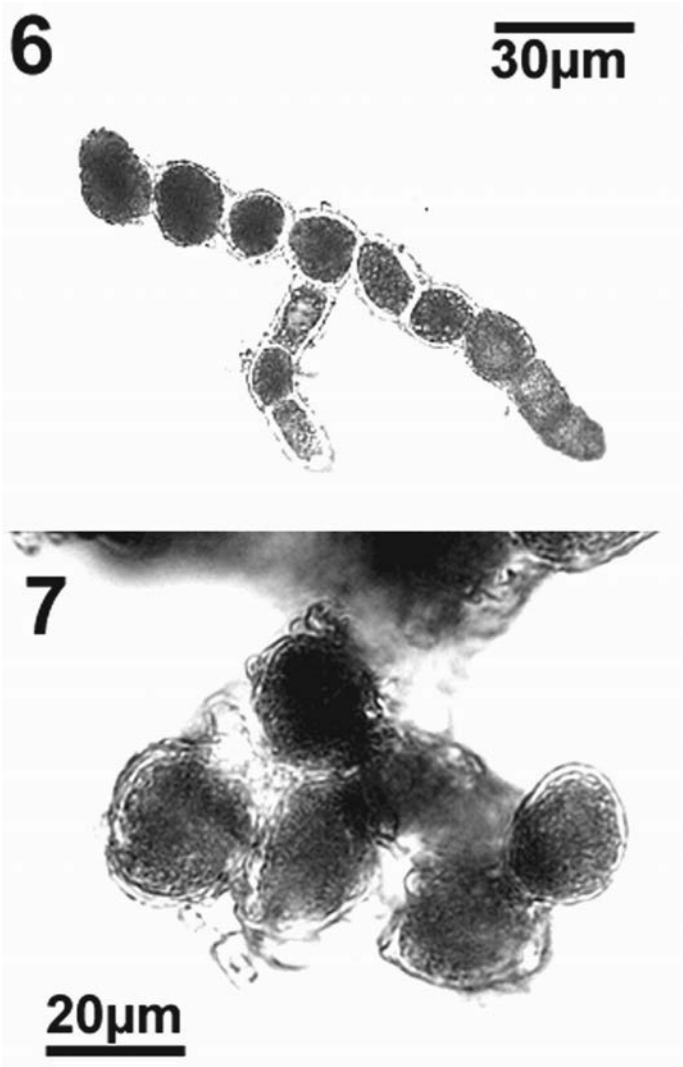
No reproductive structures were observed.

Trentepohlia cf. umbrina

This species occurred in samples collected at Landunvez (Brittany), Bayeux (Calvados), le Mont St. Michel and Ste Marie du Mont (Normandy), where it produced brownish-red growths on limestone walls; in a sample collected at Landunvez, the growth attributable to this species occurred on a cement wall, in a narrow and shaded street. Specimens were irregular, compact masses of entangled filaments (Fig. 8), easily separable into fragments a few cells in length (Fig. 9). The cells were globular or swollen, 9-20 µm wide (mostly 13-17 µm) and 10-22 µm long (mostly 14-18 µm), with a more or less thick cell wall. Specialised reproductive structures were absent in the specimens examined.

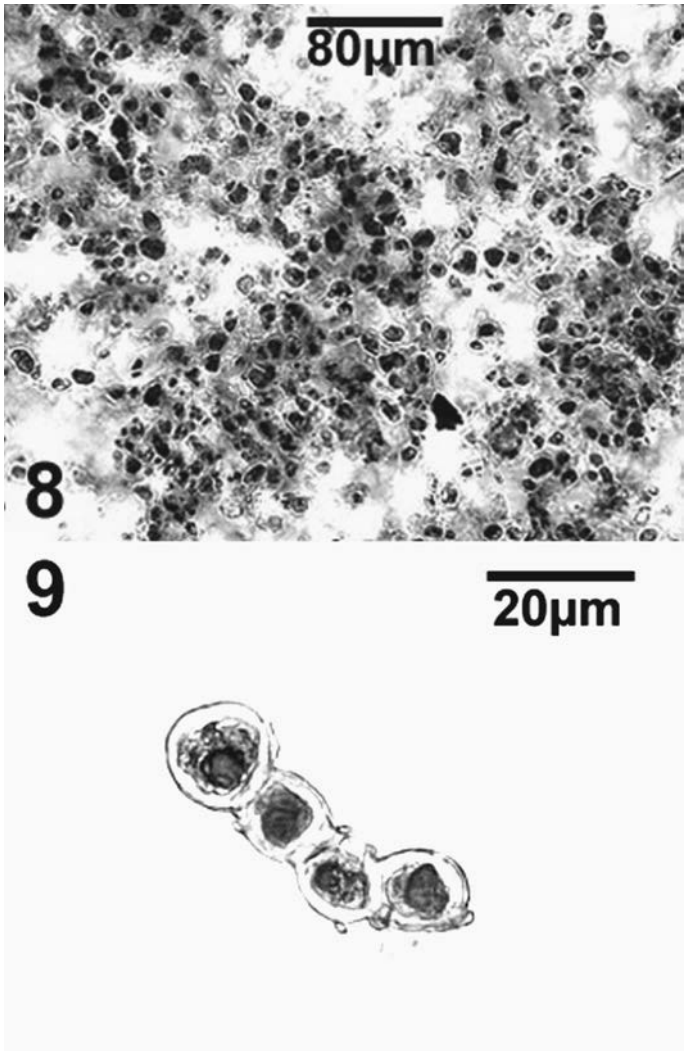
DISCUSSION

The morphology of *Phycopeltis* from northern France is generally characterized by the regularly disk-shaped habit, the smooth and entire margin, the intercalary position of the sporangiate laterals and the cells ranging between



Figs 6-7. *Trentepohlia iolithus*. Fig. 6. Habit of a short fragment. Fig. 7. Habit of some cells.

8-20 µm in length and 5-10 µm in width. This considerably reduced the number of candidate species for attribution. Two major monographs on the taxonomy of this genus have been published: Printz (1939) attributed 12 species to *Phycopeltis*, whereas Thompson & Wujek (1997) recently included in the genus 18 species (11 of which were newly described). Following Printz's (1939) concept two species can accommodate the French material: *Phycopeltis arundinacea* (Montagne) De Toni and *Phycopeltis expansa* Jennings. These are the only entities that produce an entire, regular disk and have vegetative cells more than 4 µm wide (mostly 7-9 µm); Printz (1939) based the distinction between them on the origin of the



Figs 8-9. *Trentepohlia* cf. *umbrina*. Fig. 8. Habit of a specimen (squashed for microscopic observation). Fig. 9. A short fragment.

sporangiate lateral. In *P. expansa* the sporangiate lateral is borne on the top of a stalk cell produced by transverse division of a vegetative cell, whilst in *P. arundinacea* it is sessile on the vegetative cell. Conversely, following Thompson & Wujek (1997) the specific attribution of the French material is not clear; on the basis of their determination key, the only entity which seems suitable to accommodate French *Phycopeltis* is *Phycopeltis novae-zelandiae* Thompson & Wujek, described on the basis of material from Smith's Bush, Tokapuna, New Zealand. This is the only species showing wholly radial-filamentous thalli with an entire margin, documented presence of zoosporangia, sporangiate laterals intercalary in origin, and

cells 16-22 µm long in sporangial specimens (mean: 18 µm); however, for this last feature, *P. novae-zelandiae* does not agree completely with our plants, in which the cells are usually 13-17 µm long (mean: ~14 µm).

We propose that the French material of *Phycopeltis* is mostly *P. arundinacea*. We have investigated in detail the morphology of this species in a recent review of the taxonomy of *Phycopeltis* in Ireland, based on extensive collections examined both by light and scanning electron microscopy (Rindi & Guiry, 2002b). In that study, we also examined in detail the type specimen of *Phyllactidium arundinaceum* Montagne (1846), the basionym of *P. arundinacea*, based on specimens found growing on reeds in Algeria. *P. arundinacea* is the species to which Irish specimens of *Phycopeltis* should be attributed, and the morphology of most of the French plants is clearly in complete agreement with that of Irish material. Thompson & Wujek (1997) reported for *P. arundinacea* a range of size of the cells considerably larger than the one reported by Printz (1939): they stated that cells of *P. arundinacea* are 7-12 µm wide and 28-38 µm long, with a length: width ratio of 1: 3.5-4.5. This is, however, in marked contrast with the morphology of the type of *P. arundinaceum* (with which Printz's description agrees); for 45 vegetative cells we measured a mean length of 12.8 µm (SD = 2.35) and a mean width of 5.60 µm (SD = 0.94), the mean length: width ratio being 2.33 (SD = 0.50). We think that Thompson & Wujek's (1997) concept of *P. arundinacea* requires revision and that *P. novae-zelandiae* might be conspecific with *P. arundinacea* or *P. expansa*. Pending further studies, we also prefer to regard *P. arundinacea* and *P. expansa* as separate species. Unfortunately, the discriminating character (stalked or sessile condition of the sporangiate laterals) is usually difficult to observe in light microscopy; in the Irish material, scanning electron microscopy has shown that the absence of a stalk cell seems to be a consistent feature (Rindi & Guiry, 2002b). Given the general close similarity between French and Irish material, we think that this is also probably true for the French material; we acknowledge, however, that further observations are necessary (and that the distinction between *P. arundinacea* and *P. expansa* requires further study).

Despite of the general similarity between French and Irish *Phycopeltis*, an important difference was also observed. In some of the French specimens the sporangiate laterals occurred on the margin, indicating production by apical or subapical cells; this situation was never observed in the Irish material (Rindi & Guiry, 2002b). There is general agreement about the taxonomic importance of the origin of the sporangiate laterals (Printz, 1939; Thompson & Wujek, 1997) and the fact that plants with both intercalary and apical production of sporangiate laterals were observed in the French material indicates the possibility that two species were present. In this regard, the occurrence of *Phycopeltis epiphyton* in Europe has been known since 1870, when Millardet (1870: 48) described the genus and the species on the basis of specimens growing on needles of fir (*Abies*) in southern Germany; Thompson & Wujek (1997) and John (2002) cited it for England, Wales and Scotland. *P. epiphyton* is characterized by the apical production of sporangiate laterals. However, it is generally reported to be a very small species. The original specimens upon which the name was based were about 100 mm in diameter (Millardet, 1870; see also Printz, 1939, 1964), with small cells, 2-4 µm wide (Printz, 1939; but note in this case too the contrast with the observations of Thompson & Wujek, 1997, reporting a width of 4-7.7 µm). This last feature is in contrast with the material from France. *P. arundinacea* and *P. epiphyton* perhaps occur together in the same habitats in northern France; in such case, this is the first record for continental Europe of *P. arundinacea*, which has been previously reported for Algeria (Montagne, 1846), Ireland (Scannell, 1965, 1978; Rindi & Guiry, 2002b)

and many tropical areas (Printz, 1939). In any case, this is the first report of the genus Phycopeltis for France.

Further observations are necessary and the problem of the distinction between *P. arundinacea* and *P. epiphyton* requires investigation, considering also that plants with apical and intercalary sporangiate laterals were found only on separate leaves; this suggests that this character might be controlled by environmental factors working on small spatial scales, rather than genetically. Unfortunately, several morphological features of *Phycopeltis* are known to be variable and dependent on environmental factors (Thompson & Wujek, 1997) and a comparative approach considering also molecular data is necessary to elucidate several problems at genus and species level.

Despite the absence of reproductive structures, the identification of *Trentepohlia iolithus* does not present particular problems. The specimens from France are in good agreement with descriptions available in the literature and are identical both morphologically and ecologically to western Irish material described by Rindi & Guiry (2002a). In contrast to *Phycopeltis*, *Trentepohlia iolithus* is widespread and it has been recorded for most of Europe (De Wildeman, 1888; Hariot, 1889; Printz, 1964; Rindi & Guiry, 2002a). *Trentepohlia umbrina* has also a very wide distribution, having been reported for most temperate and tropical areas of the world (Hariot, 1889; Printz, 1920, 1964; Thompson & Wujek, 1997). The alga regarded here as *Trentepohlia* cf. *umbrina* is probably common in Europe, since it is also in perfect agreement with corresponding western Irish forms (Rindi & Guiry, 2002a). In this case, however, we do not propose an identification at species level because of the type of substratum colonised. For species of *Trentepohlia*, the type of surface colonised is considered an important character, with considerable relevance for specific identification (Printz 1939, 1964). *Trentepohlia umbrina* has usually been reported as a very common corticolous alga (Hariot, 1889; Printz, 1939, 1964) and it seems very rare on stone (which is the favoured surface of both the French and western Irish populations) or other substrata. A comparison with fresh collections from the type locality (southern Germany), perhaps combined with molecular data, is necessary to elucidate the taxonomic position of this entity. Interestingly, the type of substratum occupied by *Trentepohlia iolithus* and *Trentepohlia* cf. *umbrina* seems to be very constant. Both in France and in Ireland, *Trentepohlia iolithus* has been observed forming well-developed populations only on cement and concrete, and *Trentepohlia* cf. *umbrina* predominantly on limestone (in fact, in Galway City species of *Trentepohlia* are the only subaerial algae that show a precise substratum preference; Rindi, unpublished observations).

The vigorous growth of species of *Trentepohlia* on buildings is a well-known practical problem in Singapore and other tropical areas, where the species involved is usually *Trentepohlia odorata* (Wiggers) Wittrock (Wee & Lee, 1980; Lee & Wee, 1982; Ho *et al*., 1983; Ong *et al*., 1992). For temperate areas, this problem has been rarely mentioned (John, 1988; Wakefield *et al*., 1996; Rifón-Lastra & Noguerol-Seoane, 2001; Rindi & Guiry, 2002a). In western Ireland, *Trentepohlia iolithus* is very common on concrete walls, where it forms characteristic, extensive deep-red discolourations (Rindi & Guiry, 2002a). The growth of species of *Trentepohlia* depends on high levels of atmospheric relative humidity, which may serve as a source of water (Ong *et al*., 1992). Consequently, these algae find favourable conditions in humid places and the peculiar climate of western Ireland (with relatively mild winter conditions and persistently high humidity and rainfall) provides obviously very suitable conditions from this point of view. This is probably the case for northern and western France too and we suspect that in the parts

of Europe close to the Atlantic, which experience a more humid climate than the rest of the continent, species of *Trentepohlia* are much more common in these habitats than present records indicate. Interestingly, in a detailed study of the epilithic subaerial algae of Normandy, Frémy (1925) reported the common occurrence of *Trentepohlia aurea*, but did not make any mention of *Trentepohlia iolithus* and *Trentepohlia umbrina*.

It is also remarkable that this type of growth occurs in more southern parts of France, such as Vayrac and Souillac, in the Department of Lot. However, *T. iolithus* and other species of *Trentepohlia* have been commonly reported in mountainous districts of central and southern Europe (Diels, 1914; Ercegovic, 1925; Jaag, 1945; Fjerdingstad, 1965; Golubic, 1967), where climate conditions are cooler and moister than in lowlands, probably closer to Atlantic situations. This is probably the case for the area of Lot, where the samples were collected.

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