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What is a 'phycolichen'? Differences and changes in the meaning of an old lichenological term

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Abstract: The term 'phycolichens' has recently been introduced as a synonym for 'green algal lichens' i.e. those having phycobionts as their primary autotrophic partner, which is analogous to the contracted term 'cyanolichens'. However, a study of the history of the term 'Phycolichenes' leads us to suggest that this term should not be applied because of considerable ambiguities in past usage and the possibility of confusion. The term was first created by E. Fries in 1831, and was used later by Massalongo as a taxon for homoiomerous cyanobacterial lichens. With this, or similar meanings, it remained in use until the middle of the 20th Century. Diels (A. Engler's Syllabus der Pflanzenfamilien, Gebr. Borntr., Berlin, 1936) defined the same expression Phycolichenes as lichens with Phycomycetes as mycobiont, and this definition can still be found in recent literature. If a shortened term for green algal lichens is needed then we suggest 'chlorolichens' as a better counterpart to cyanolichens.

Key words: chlorolichen, history, phycolichen, terminology.

Introduction

The term 'cyanolichens' has become accepted and widely used in recent lichenological literature for lichens with cyanobacteria or cyanobionts, as their major photobionts (e.g. Ahmadjian 1989). In order to denote the other group of lichenized fungi with phycobionts (in the sense of Ahmadjian 1982, see Wagenitz 2003) as autotrophic partners, one of us (OLL) has used the term 'phycolichens' and defined it as "lichens with green algae as primary photobionts" (Lange 2000*a*,*b*; Lange *et al.* 2000). This name was subsequently adopted as a synonym for green algal lichens in other publications (e.g. Belnap *et al.* 2001; Büdel 2001; Lange 2001; Lange *et al.* 2001; Ullmann & Büdel 2001). However, when OLL recently submitted an ecophysiological manuscript for publication in a botanical journal, an anonymous reviewer objected to the use of the term phycolichen on the grounds that (i) it is jargon not easily understood by a broader scientific audience, and (ii) it is superfluous because it is used as a synonym for green algal lichen, a term already established in the literature. This comment encouraged us to undertake an extensive study of the history of the term 'phycolichen'.

History of the term phycolichen

The first publication in which we found the term Phycolichenes used is the *Lichenographia Europaea Reformata* by E. Fries (1831). The impression is that he, himself, generated the name and this is confirmed by Jourdan (1837) who wrote about phyco-

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lichens in his *Dictionnaire … des termes usités dans les sciences naturelles*: "Nom donné par Fries à une section de la famille des Lichenes, comprenant ceux qui, par leur organisation se rapprochent des fucus" (see also the nomenclatural list by Pfeiffer 1873/74). In one of the classifications that he presents, E. Fries (1831, p. XLV, 12–14) divided all lichens into two large groups ('phalanges'), the Myco-Lichenes and the Phyco-Lichenes. This grouping is based mainly on morphological criteria and compares the external appearance of the lichens to that of seaweeds (algae), and fungi. "Perfectiores Lichenes a Phyceis adscendant, quo imperfectiores sunt eo magis ad Hysterophyta descendunt" (the more perfect lichens rise to the seaweeds; the more imperfect they are, the more they decline down to the fungi). Growth form and formation of fruiting bodies were also taken into account in this grouping. This resulted in an arrangement in which most of the foliose and fruticose genera, such as *Parmelia*, *Sticta*, *Peltigera*, *Siphula*, *Usnea*, *Cladonia* as well as *Baeomyces*, and *Biatora* belonged to Phyco-Lichenes in contrast to Myco-Lichenes, which contained genera such as *Coniocybe*, *Calicium*, some *Lecideae*, *Verrucaria*, *Sagedia*, *Opegrapha*, and *Chiodecton* (all taxa *sensu* E. Fries). It is not possible to interpret this grouping in terms of modern lichen systematics. There was a general effort in the 18th century to establish a 'scala naturae' or a 'great chain of being' (Lovejoy 1936) in order to assemble the diversity of nature under a unifying concept (Wagenitz 1997). Within the 'chain' from less to more perfect organisms, the lichens were considered as being an independent group of plants but representing a transition from the (lower, less perfect) fungi to the (higher, more perfect) seaweeds or algae.

Twenty-four years later, Massalongo (1855, see Krempelhuber 1869) introduced the same name, Phycolichenes, as a taxon at the rank of 'Series'. However, he was using the word in a very different manner. He gave no clear diagnosis of his Series Phycolichenes, but it included all the gelatinous-homoiomerous genera (*Collema*, *Leptogium* and related genera, and all of the present *Lichinaceae*, *Placynthium*, *Thermutis*, *Ephebe* and *Phylliscum*). The *Pannariaceae* (cyanobacterial) were placed in another Series, the Gnesiolichenes (i.e. true lichens or eulichens), together with lichens containing green algae. From this it becomes evident that Massalongo intended Phycolichenes to contain all those lichens known today to have a cyanobacterium as a photobiont and which do not have a heteromerous thallus. It should be noted that at that time lichens were not yet known to be a symbiosis, a concept introduced by Schwendener in 1869. Nevertheless, colour and structure of the 'gonidia' (the photobionts) and their distribution within the thallus were important characteristics for the systematic grouping of lichens. Massalongo's classification was quickly taken up by other lichenologists. Arnold (1858) used the group Phycolichenes as a 'Sectio' in his species list "Die Lichenen des fränkischen Jura". Stizenberger (1862) also adopted Massalongo's terminology for his theoretical overview on lichen systematics. He defined his "Ord. I Phycolichenes (Fr.) Mass. Sched." as follows: "Thallo plerumque nigricante, gelatinoso, homoeomerico, substantiae viridis 'Chlorophyll' dictae egeno, hypothallo saepissime nullo" (thallus mostly dark, gelatinous, homoiomerous, poor in green substance called 'chlorophyll', hypothallus in most cases absent). His second order are the Gnesiolichenes which comprised the mostly green, non-gelatinous, heteromerous lichens.

In the following decades, the term Phycolichenes in a sense similar to that originally introduced by Massalongo (1855) is found in many mycological and lichenological publications. Although its use was sometimes slightly broader and sometimes more restricted, the definition always included lichens with a cyanobacterium as the photobiont. The term became established in general textbooks such as the *Vergleichende Morphologie und Biologie der Pilze* (Comparative Morphology and Biology of Fungi) by de Bary (1884). It was used in classical lichenological monographs such

as *Lichenographia Scandinavica* by T. M. Fries (1871), and Fries' system was reproduced by Harmand (1905) as an example of "Classification des Lichens d'après les Gonidies". Moreover, the term Phycolichenes, more or less *sensu* Massalongo (1855), appeared in publications about local lichen floras (e.g., Hy 1893), and it was used by Dughi (e.g., 1942, 1944, 1946, 1948) in his cytological and taxonomical studies on gelatinous lichens such as *Collema*, *Leptogium*, *Thyrea*, and *Lempholemma* until the middle of the 20th century.

In spite of being widely applied, especially in the second half of the 19th century, it appears that the taxon Phycolichenes has never been fully accepted by the lichenological and mycological community. Thus, it is not used, and often not even mentioned, in many of the classical monographs on lichen systematics of that period, such as by Schaerer (1850), Körber (1855, 1865), Leighton (1879), Tuckerman (1882, 1888), Marchand (1896), and Fünfstück & Zahlbruckner (1926). It is not listed in the standard book by Chadefaud (1960).

Two modern dictionaries define the term phycolichens in different ways, neither of which agrees with the original definition by Massalongo (1855) and Stizenberger (1862). In *A Glossary of Mycology* (Snell & Dick 1971) phycolichens are "lichens the fungus associate of which is one of the Myxophyceae (Cyanophyceae)", a definition which covers both homoiomerous and heteromerous cyanobacterial lichens. The *Dictionary of the Fungi* (from the 6th edition by Ainsworth, James & Hawksworth 1971 until the 9th edition by Kirk *et al.* 2001) classifies the name to be "obsolete" and defines phycolichens as: "lichens in which the vegetative thallus morphology is determined by the photobiont and which are of uncertain systematic position as the sporocarps are unknown (e.g. *Cystocoleus*, *Racodium*)". We were unable to find the original source of this unusually narrow definition of the term.

In addition to the use of phycolichens in the sense proposed by E. Fries (1831) and Massalongo (1855) as a name for a subgroup of gelatinous cyanobacterial lichens, the term has also been used and defined in a totally different way. Diels (1936) in *Engler's Syllabus der Pflanzenfamilien* was most probably the first to introduce the taxon Phycolichenes (analogous to Ascolichenes and Basidiolichenes) as an 'Unterklasse' (subclass) for "Phycomyceten, die mit Algen in Symbiose leben": coenocytic Zygomycetes (Phycomycetes) in endocytobiotic association with a *Nostoc* cyanobacterium (see Schüßler & Kluge 2000 for review of present taxonomic grouping). The only known representative of this group is *Geosiphon pyriforme* (Kütz.) v. Wettstein. Even though this organism is not usually considered to be a lichen (Honegger 1996), the taxon Phycolichenes *sensu* Diels (1936) is often cited in the modern literature. Mattick (1954) also used it in the newer edition of *Engler's Syllabus der Pflanzenfamilien*, and it can be found in recent textbooks (e.g. Sitte *et al.* 1998). The most recent *Wörterbuch der Mycologie* (Dörfelt & Jetschke 2001) lists Phycolichenes as an antiquated term for lichens in which the mycobiont belongs to the Phycomycetes.

Conclusion

The term 'phycolichen' is not modern jargon but, in fact, a word of some antiquity. Nevertheless, we suggest that it is not suited for use as a name for green algal lichens because of the considerable ambiguity in its previous usage.

Two different definitions for the name Phycolichenes (initially considered as a systematic taxon) have become established in the literature: one means 'lichens' with a Phycomycete as its mycobiont, and the other usually includes homoiomerous cyanobacterial lichens. The latter definition was defined so broadly by Snell & Dick (1971) that it includes all cyanobacterial lichens and, in this sense, would be synonymous with the expression cyanolichens. Under these circumstances, it would be inappropriate and even misleading to introduce yet another definition for the term phycolichens i.e. the name for green algal

lichens as used by Lange (2000*a*,*b*). We propose that this usage of the term phycolichens is abandoned.

If a counterpart for the term 'cyanolichens' is considered necessary for green algal lichens as a functional group, the name 'chlorolichens' might be better suited because the vast majority of eukaryotic lichen photobionts belong to the phylum Chlorophyta. Until now, this term has been rarely used in the lichenological literature; we found it only in publications by Sillett & Goslin (1999) and Ellyson & Sillett (2003). The two names 'cyanolichen' and 'chlorolichen' would resemble the terminology of Renner & Galloway (1982) for (present name) photosymbiodemes in which they use the definition: "if one of the two phycosymbiodemes of a pair contains green algae, and the other blue-green algae then the first one is called a chlorosymbiodeme, the second one a cyanosymbiodeme". This terminology seems to be accepted now and is also used by other authors (e.g. Paulsrud *et al.* 1998, 2000).

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