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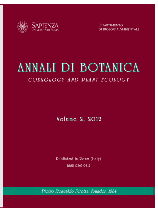

THE LICHEN SYNTAXA IN THE CHECKLIST OF HIGHER SYNTAXA OF EUROPE – AN OVERVIEW AND WHAT WE CAN DO WITH THEM

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ABSTRACT – A Checklist of Higher Syntaxa of Europe includes lichen syntaxa from the eulittoral to the nival zone, in all 15 classes, 31 orders and 63 alliances of lichen syntaxa and five mixed lichen/bryophyte classes with 12 lichen alliances. Syntaxa diversity is highest for rock substrates, followed by bark, then soil, which corresponds with species diversity of lichens. The most important habitat factors to explain floristic differences on class level are type of substrate and source of moisture.

The evaluation of the state of research shows a rather well established system of cryptogam syntaxa, however with gaps in the knowledge of the distribution of syntaxa. The epiphytic vegetation is dynamic due to changes in air pollution (less SO_2, more nutrients) and global change. Formal problems with the terms synusiae/microcommunities are discussed.

Lichens are established as bioindicators. Species and syntaxa can help to screen air purity, forest quality, water quality, global change and also microhabitat factors. Cryptogam syntaxa are especially suited to explain complexity of the vegetation on the microhabitat level.

KEYWORDS: BIOINDICATION, COMPLEXITY, CRYPTOGAMS, MICROCOMMUNITIES, SYNUSIAE, VEGETATION

INTRODUCTION

Distinct combinations of plant species with a typical habitat are described as plant communities or syntaxa. The method most commonly applied in Europe is the Braun-Blanquet-approach (e.g. Westhoff & Van der Maarel, 1973). Communities of this approach are sorted in a hierarchical system with the main levels of descending rank class, order, alliance and association. The names of syntaxa are governed by the "Code of Phytosociological Nomenclature" (Weber et al., 2000).

Also distinct combinations of cryptogam species with a typical habitat have been recognized as syntaxa since the early days of vegetation description (e.g. Frey, 1923; Gams, 1927; Ochsner, 1928). Compilations of plant communities of countries included chapters listing cryptogam syntaxa (e. g. Klika & Hadac, 1944; Klika, 1948; Tomaselli, 1956; Westhoff & Den Held, 1969). Synopses of cryptogam syntaxa followed (lichens e.g. Klement, 1955; Barkman, 1958; Wirth, 1972; 1995, James et al., 1977; Drehwald, 1993; bryophytes e.g. Hübschmann, 1986; Dierssen, 2001; Marstaller, 2006, algae e.g. den Hartog, 1959; Pignatti, 1962; Giaccone, 1965) and also bibliographies (Delzenne-van Haluwyn, 1976; Liska, 1984).

Cryptogam communities differ in their degree of independence from surrounding vascular plants. Communities on rock are indisputable independent. Epiphytic communities grow on trees, however in most cases they are not specific for one tree species or genus, but for several tree species with similar physical and chemical bark properties. In some cases commonly epiphytic communities can grow on consolidated soil or on rock. Bryophytes and lichens on soil frequently intermingle with vascular plants. Therefore the position of their communities as dependent part of the vegetation within plant communities (e.g. as synusiae) or as independent communities is discussed (Wilmanns, 1966; Barkman, 1968, 1973; Marstaller, 2006). However as most species combinations also occur independently or in gaps within the

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vegetation, those syntaxa with a high degree of independence are included in the syntaxonomical system of cryptogam communities side by side with syntaxa on rock and bark (e.g. Drehwald, 1993; Paus, 1996; Dierssen, 2001; Marstaller, 2006).

Barkman (1973) proposes either synusiae or microcommunities as name for the cryptogam syntaxa. Both are defined by characteristic floristic compositions and microhabitats, but in a synusia additionally with all species belonging to one stratum and exploiting the environment in a similar way. A typical example of a vascular plant synusia is the group of spring geophytes in a forest community or of a lichen synusia the reindeer lichens in the ground cover of a pine forest. The latter two restrictions are not always fulfilled for the cryptogam syntaxa: e.g. they can include a layer of crust-like lichens together with shrubby lichens or parasitic lichens with purely autotrophic lichens. Thus the name "microcommunity" seems more appropriate. Nomenclature from the synusial system for cryptogam units has also led to erroneous declarations of invalidity of the concerned syntaxa (e.g. Müller & Otte, 2008), though cryptogam syntaxa defined by floristic-sociological criteria are all subject of the International Code of Syntaxonomical Nomenclature (Weber et al., 2000 Definition I) disregardful of being named communities (e.g. Marstaller, 2006), microcommunities (Bültmann, 2005) or synusiae (Dierssen, 2001, Paus, 1997; Wirth, 1972).

A conspectus of the highest syntaxonomical level, the classes, of Europe, classes, has been published more than ten years ago (Mucina, 1997). Since then an updated list extended to the higher syntaxa from alliances to classes has been elaborated (Mucina & the team of the Euro-Checklist, 2009) and will be published soon (Mucina et al., in prep.). This new version will also include the first Europe-wide conspectus of higher lichen and bryophyte syntaxa. The bryophyte syntaxa are contributed by Klaus Dierssen, the lichen syntaxa by the author. In the present article the lichen syntaxa and their significant habitat factors are presented in short. This includes an overview of the main lichen habitats in Europe. Furthermore possibilities of applications of the cryptogam syntaxa are exemplarily discussed.

THE LICHEN SYNTAXA

Abbreviations after the class name show the numbers of orders and alliances: L: lichen syntaxa, B: bryophyte syntaxa, O: orders, A: alliances

***Ceratodonto purpurei-Polytrichetea piliferi* Mohan 1978** – L: O-1, A-7 (B: O-1, A-2)

On soil: acidic to subneutral, at least acidic humus-patches.

***Peltigeretalia caninae-rufescentis* Klement 1949**: *Baeomycion rufis* Klement 1952 (pioneer), *Cladonion sylvaticae* Klement 1949 (later succession), *Cladonion rei* Paus 1997 (richer soil), *Solorinion croceae* Klement 1955 (arctic-alpine snow-beds), *Cetrarion nivalis* Klement 1955 (arctic-alpine wind exposed ridges), *Lecanorion verrucosae* Kalb 1970 & *Ochrolechion tartareae* Klement 1955 (on plant debris on calcareous & non calcareous soil).

***Psoretea decipientis* Mattick ex Follmann 1974** – L: O-2, A-4 (B: O-2, A-6)

On soil: neutral to calcareous.

***Toninietalia coeruleonigricantis* Hadač in Klika ex Hadač 1962** moderately xerophytic: *Toninion coeruleonigricantis* Hadač in Klika 1948 (less arid than following), *Sphaerothallio-Xanthoparmelion vagantis* Crespo et Barreno 1978 (semiarid-arid, vagrant lichens).

***Fulgensietalia desertori* Crespo et Barreno 1975** strongly xerophytic: *Psorion savicii* Crespo et Barreno 1975 (on soil), *Protoblastenion testaceae* Barreno 1979 (on soil in rock fissures).

Ephemeral lichen species (e.g. *Gregorella humida*, *Thelocarpon* spp.) are known from arable fields (probably in bryophyte communities of *Phascion cuspidati* Waldheim ex von Krusenstjerna 1945). They have never been included in relevés and thus their syntaxonomical position is unknown.

***Cladonio digitatae-Lepidozietea reptantis* Ježek et Vondráček 1962** – L: A-1 in mixed order (B: O-4, A-11)

On wood & raw humus, sciophytic.

***Lophocoleetalia heterophyllae* Barkman 1958**: *Cladonion coniocraeae* Duvigneaud ex James, Hawksworth et Rose 1977.

***Platyhypnidio-Fontinalietea antipyreticae* Philippi 1956**

On rock, mostly submerged in running water

Few characteristic lichen species occur within the bryophyte communities.

***Aspicilietea lacustris* Wirth 1972** – L: O-1, A-4

On rock, more or less permanently submersed in clear water.

***Hydroverrucarietalia* Černohorský et Hadač ex Klement 1955**: *Verrucarion siliceae* Wirth 1972 (almost permanently submerged on siliceous rock), *Aspicilion lacustris* Klement 1955 (amphibious on siliceous rock), *Porinion lectissimae* Wirth 1980 (periodically submerged on siliceous rock), *Staurothelion solventis* Roux prov. (montane-alpine on calcareous rocks).

***Verrucarietea maurae* Drehwald 1993** – L: O-1, A-1

On rock, halophytic, from the Eulittoral to mesic Supralittoral.

***Verrucarietalia maurae* Drehwald 1993:** *Caloplacion marinae* Klement 1955.

***Clauzadeetea immersae* Roux ex Roux 2009** – L: O-2, A-6 On rock, limestone, low nutrient level, typical growth form endolithic lichens.
***Verrucarietalia parmigerae* Roux ex von Brackel 1993** lowland-colline: *Acrocordion conoideae* Roux 1978 ex Roux 2009 (continuously high air humidity), *Verrucarion sphinctrinellae* Clauzade et Roux 1975 (between previous and following alliance), *Rinodinion immersae* Roux 1978 (sporadically high air humidity), *Verrucarion weddellii* Roux 2009 (porose rocks with short spills of more or less muddy water).
***Thelidietalia decipientis* Roux ex von Brackel 1993** montane-alpine: *Aspicilion coeruleae* Roux 1978 (moderately exposed), *Eiglerion homalomorphae* Roux 1978 ex Roux 2009 (skiophytic).

***Verrucarietea nigrescentis* Wirth 1980** – L: O-3, A-8 On rock, limestone, medium to high nutrient level. ***Verrucarietalia nigrescentis* Klement 1950** nitrophytic: *Caloplacion decipientis* Klement 1950 (fully exposed), *Caloplacion arnoldii* Roux 2009 (no direct rain), *Caloplacion granulosae* Roux 2009 (spills of rain water).

***Aspicilietalia calcareae* Roux 2009** heminitrophytic: *Aspicilion calcareae* Albertson ex Roux 1978 (moderate), *Acarosporion cervinae* Roux 2009 (exposed), *Aspicilion contortae* Roux 2009 (often near the ground, dew).

***Lecanoretalia bandolensis* Roux 2009** halophytic: *Lecanorion bandolensis* Roux 2009 (on compact rocks), *Caloplacion tavaresianae* Roux 2009 (porose rocks).

***Rhizocarpetea geographici* Wirth 1972** – L: O-6, A-15 On rock, siliceous.
***Rhizocarpetalia obscurati* Wirth ex Wirth 1980** moister habitats than following, shaded or near the soil: *Lecideion tumidae* Wirth 1972.
***Rhizocarpetalia geographici* Klement 1950** planar-montane, exposed rocks: *Dimelaenion radiatae* Llimona in Egea et Llimona 1987 (strongly xero- and thermophytic), *Lecanorion montagnei* Llimona in Egea et Llimona 1987 (thermophytic), *Pertusarion leucosorae* Egea et Llimona 1987 (less thermophytic), *Caloplacion irrubescentis* Llimona et Egea in Egea et Llimona 1987 (neutro- & slightly nitrophytic), *Parmelion conspersae* Hadač in Klika et Hadač 1944 (horizontal surfaces), *Umbilicarion hirsutae* Černohorský et Hadač in Klika et Hadač 1944 (vertical rock faces).
***Acarosporetalia sinopicae* Creveld 1981** rock rich in metals: *Acarosporion sinopicae* Wirth 1972 (low pH), *Lecideion inopsis* Purvis in Purvis & Halls 1996 (alcaline, here?). ***Parmelietalia saxatilis* Wirth 1972** rocks with influence of soil: *Crocynio-Hypogymnion* Wirth 1972.
***Rinodino confragosae-Xanthorietalia elegantis* Creveld 1981** rocks weakly basic to neutrophytic or nitrophytic: *Ramalinion capitatae* Rübel ex Klika 1948 (bird manure), *Physcion dimidiatae* Wirth 1972 (subneutrophytic), *Rhizocarpo geographici-Xanthorion elegantis* Creveld ex Creveld prov. (weakly basic).
***Umbilicarietalia cylindricae* Oberdorfer ex Klika et Hadač 1944** upper montane to nival or arctic: *Rhizocarpion alpicolae* Frey ex Klement 1955 (pioneer, growth form mainly crustose), *Umbilicarion cylindricae* Frey 1933 (growth form mainly foliose).

***Aspicilietea candidae* Asta et Roux ex Roux prov.** – L: O-2, A-3
On rock, calcareous schists and decalcified calcareous rocks, subalpine-alpine, only short-time snow covered.
***Aspicilietalia verruculosae* Asta et Roux ex Roux prov.** thermophytic: *Aspicilion mashiginensis* Asta et Roux ex Roux prov. (parvocalcicol), *Seirophorion contortuplicati* Roux prov. (mediocalcicolous to valdecalcicolous).
***Lecideetalia confluescentis* Roux prov.** not thermophytic: *Lecideion confluescentis* Roux ex Roux prov.

***Porpidietea zeoroidis* Roux prov.** – L: O-1, A-1 On rock: calcareous schists and decalcified calcareous rocks, subalpine-alpine, prolonged snow cover.
***Porpidietalia zeoroidis* Asta et Roux ex Roux prov.:** *Porpidion zeoroidis* Asta et Roux ex Roux prov.

***Collematetea cristati* Wirth 1980** – L: O-1, A-3 On rock, calcareous or base-rich rocks, seepage or drip water.
***Collematetalia cristati* Wirth 1980:** *Collemation tuniformis* Klement 1955 corr. Wirth 1980 (skiophytic), *Peccanion coralloidis* Moreno et Egea 1991 (at most moderately skiophytic), *Peltulion euplocae* Llimona et Egea 1985 (base-rich siliceous rocks).

***Leprarietea chlorinae* Wirth 1972** – L: O-1, A-2 On rock: siliceous rocks in rain-shade.
***Leprarietalia chlorinae* Hadač in Klika et Hadač 1944:** *Leprarion chlorinae* Šmarda et Hadač in Klika et Hadač 1944 (moderately skiophytic), *Cystocoleion nigri* Wirth 1972 (strongly skiophytic).

***Roccelletea phycopsis* Egea ex Egea prov.** – L: O-2, A-3 On rock, siliceous or carbonatic rocks in rain-shade, halotolerant, mainly in coastal areas of Europe and northern Africa.
***Dirinetalia massiliensis* Egea ex Egea prov.** on carbonatic rocks: *Roccellion phycopsis* Egea et Llimona 1984.
***Roccelletalia fuciformis* Egea ex Egea prov.** volcanic-acidic rocks: *Lecanographion monstrosae* Egea ex Egea prov. (less aerohygrophytic), *Roccellion tinctoriae* Klement 1965 (strongly aerohygrophytic, optimum in Macaronesian region).

Neckeretea complanatae **Marstaller 1986** – L: A-1? (B: O-1, A-2)
or *Frullanio dilatatae-Leucodontetea sciuroidis* Mohan 1978 – L: A-1? (B: O-3, A-10)
On non-acidic partly soil covered rocks or on bark *Lobarion pulmonariae* Ochsner 1928 (attribution of this alliance to one of the classes above unclear).

Arthonio radiatae-Lecidelletea elaeochromae **Drehwald 1993** – L: O-3, A-4
On bark: smooth bark, neutrophytic - moderately acidophytic, not very toxitolerant.
Bacidinetalia phacodis **Bricaud et Roux prov.** on porose bark: *Agonimion octosporae* Bricaud et Roux prov.
Graphidetalia scriptae **Hadač in Klika et Hadač 1944** on very smooth bark: *Graphidion scriptae* Ochsner ex Felföldy 1941 (rather aerohygrophytic, preference for Fagus), *Lecanorion subfuscae* Ochsner 1928 (pioneer, more toxi- and xerotolerant).
Schismatommetalia decolorantis **Bricaud et Roux prov.** thermomediterranean to thermoatlantic, subhumid, coastal: *Bactrosporion patellarioidis* Roux et Bricaud prov.

Alectorietea **Hadač 1962** – L: O-2, A-7
On bark and twigs, acidic, rather nutrient poor, rather high air humidity.
Alectorietalia **Dahl et Hadač in Klika et Hadač 1944** dominant growth forms fruticose and foliose lichens, sensitive to air pollution: *Cetrarion pinastri* Ochsner ex Kusan 1933 (high air humidity or prolonged snow cover), *Parmelion physodis* Beschel 1958 (rather exposed, dominated by medium sized foliose or fruticose lichens), *Parmelion perlatae* James, Hawksworth et Rose 1977 (slightly nitrophytic or neutrophytic, oceanic, large foliose species dominant), *Parmelion laevigatae* James, Hawksworth et Rose 1977 (similar to previous but more acidic & nutrient-poor due to leaching of bark by heavy rain), *Usneion barbatae* Ochsner 1928 (temporary high air humidity by fog or clouds, beard-like lichens typical).
Lecanoretalia variae **Barkman 1958** strongly acid bark, rather aeroxerophytic and toxitolerant, dominant growth form crustose lichens: *Lecanorion conizaeoidis* Wirth 1995 (strongly acidophytic and toxitolerant), *Lecanorion variae* Barkman 1958 (moderately acidophytic and toxitolerant).

Physcietea adscendentis **Tomaselli et De Micheli 1952** – L: O-1, A-2
On bark, nitrophytic.
Physcietalia adscendentis **Hadač in Klika et Hadač 1944:** *Buellion canescentis* Barkman 1958 (less nitrophytic than following), *Xanthorion parietinae* Ochsner 1928 (strongly nitrophytic).

Fellhaneretea bouteillei **Bricaud et Roux 2009** – L: O-1, A-2
On leaves, in Europe mainly meridional or macaronesian.
Fellhaneretalia bouteillei **Bricaud et Roux 2009:** *Fellhanerion bouteillei* Bricaud ex Bricaud et Roux 2009 (unstable aerohygrophytic conditions), *Bacidinion vasakii* Bricaud et Roux 2009 (constant aerohygrophytic conditions).

Leprarietea candelaris **Wirth 1980** – L: O-1, A-2
On bark, in rain-shade.
Leprarietealia candelaris **Barkman 1958:** *Calicion hyperelli* Černohorský et Hadač in Klika et Hadač 1944 (less scio- and aerohygrophytic than the following), *Leprarion incanae* Almborn 1948 (very scio- and aerohygrophytic, leprose lichens dominant).

The present checklist of cryptogam syntaxa comprises 26 classes with 50 orders and 130 alliances. Six classes include only bryophyte syntaxa, 15 classes only lichen syntaxa and five classes are mixed. In two other bryophyte classes lichen species are characteristic, however with low diversity and without participating in names.

With ten classes and 46 alliances the diversity of lichen syntaxa is highest for rock habitats and syntaxa are known from the Eulittoral to the alpine zone. Five classes with 17 alliances are epiphytic. This includes one class from leaves and needles. The terricolous lichen syntaxa belong to three mixed lichen/bryophyte classes with 12 lichen dominated alliances.

The diversity of lichen syntaxa corresponds with the diversity of lichen species, which is highest on rocks, followed by bark and lastly soil (Bültmann, 2010).

The classes are distinguished by substrate type (rock, bark, leaves, soil), substrate chemistry (calcareous–non-c., nitrophytic–non-n., halophytic–non-h.), source of water (submerged–seepage–rain, fog or dew–air humidity) and once snow cover duration (short–prolonged). Orders are distinguished by special substrate chemistry (occurrence of heavy metals), climate factors (thermophytic–non-t., arid–non-a., altitudinal belts) and light conditions (shaded–exposed). Alliances represent succession stages and gradual differences of habitat factors.

Reason for substrate and source of moisture being such important for the floristic composition is that lichens are passively subjected to their environment and that the growth form of lichens is important for the exploitation of water (Rundel, 1982).

STATE OF RESEARCH

The cryptogamic vegetation of Europe is rather well explored for the countries with a tradition in vegetation description, e.g. France (Asta & Roux, 1977; Roux, 1981; Bricaud, 2005; Menard, 2009; Roux et al., 2009), Germany (Wirth, 1972; Paus, 1997), Italy (Nimis, 1984; Zedda, 2001), the Netherlands (Daniels & Harkema, 1992), Poland (e.g. Bielczyk, 1986), Spain (Crespo, 1975; Crespo & Bueno, 1984; Egea & Llimona, 1987; Casares-Porcel & Gutiérrez-Carretero, 1993), former Yugoslavia (Kusan, 1933) etc. Less studied is northernmost Europe (Klement, 1959; Daniëls, 1975; Creveld, 1981; Bültmann, 2005).

Lichen vegetation on rock is rather well known (e.g. Wirth, 1972; Roux, 1981; Egea & Llimona, 1987; Menard, 2009), however the alpine rock vegetation seems underrepresented (e.g. Frey, 1922, 1937; Klement, 1965; Gloßner & Türk, 1999).

Also the corticolous lichen vegetation is well studied (e.g. Ochsner, 1928; Barkman, 1958). Strong changes affected the cryptogamic epiphytes in the 19th and 20th century. First high air pollution led to a dramatic decrease in the diversity in all areas subjected to SO_2-immission. Efforts to improve air purity allowed bark lichens to come back since around 1980. However influence of global warming (van Herk et al., 2002; van Herk, 2009) and eutrophication caused by cattle farms and recently along roads also by catalytic converters of cars (van Herk, 2009) could be observed from long-term studies of epiphytic lichens in the Netherlands. Thus the epiphytic lichen vegetation is in many parts of Europe not identical to the original flora. Foliicolous lichen syntaxa are well known in Europe (Bricaud et al., 2009), however should be studied in Macaronesia and in context with foliicolous bryophyte syntaxa (Zippel, 1998).

Terricolous lichen syntaxa of lowland to montane areas are well known (e.g. Paus, 1997; Crespo & Barreno, 1978). Probably gaps of knowledge exist in S Europe including Macaronesia and also N Europe. Little is known about the syntaxonomical position of the inconspicuous ephemeral taxa.

Considering the comparatively small number of researchers, the existing system of cryptogam syntaxa is well established. Still, as most research was restricted to one country, there are gaps in the knowledge of the distribution areas. Also the merging of bryophyte and lichen syntaxa is probably not complete.

Lichen taxonomy is very intensively studied at the moment and frequent changes in lichen species concepts also affects characteristic species (e.g. *Caloplaca saxicola*-group) and new species are potentially good character species but have never been recorded or knowingly named in plots. The checklist will be the first synopsis of lichen syntaxa on a large scale and including all substrates after Klement (1955) and hopefully will simplify and stimulate the use of the existing but neglected cryptogam syntaxa.

WHAT CAN WE DO WITH LICHEN SYNTAXA?

Lichen species are known to be excellent bioindicators. Established are lichens as bioindicators of air purity. The approaches in present use avoid problematic species and thus can be applied by non-lichenologists (e.g. VDI, 1995). Lichens are also used to estimate forest quality (e.g. Rose, 1976; Zedda, 2002), water quality (Thüs, 2002) and recently, global change (e.g. van Herk, 2002). Ecological indicator values have been established for lichens same as for vascular plants and bryophytes (Bültmann, 2006; Wirth, 2010). In addition, lichen species and communities can indicate presence of heavy metals (*Acarosporetalia sinopicae*). Vegetation displays habitat, cryptogam vegetation microhabitat. Cryptogam syntaxa display number and distribution of microhabitats, in short, they are good indicators of complexity. Schuhwerk (1986) studied complexity of forest phytocoenoses and added cryptogam syntaxa with a cover value to a phytosociological table instead of species.

Studies of the author in arctic and alpine vegetation showed that high richness in plots, which could be as high as 47 lichen species on an area of 50 x 50 cm^2 is due to co-occurrence of species of several higher syntaxa: of the class *Ceratodonto-Polytrichetea* with alliances *Cladonion arbusculae* on acidic soil, *Cetrarion nivalis* in the uppest windexposed layer, *Solorinion croceae* in the gaps and *Ochrolechion tartareae* and *Lecanorion verrucosae* on plant debris and moss cushions. This microhabitat complexity is well shown by the cryptogam syntaxa, which can be used to explain the high diversity in certain types of terricolous vegetation, e.g. in the Arctic.

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