

A preliminary study of the infraspecific taxa of *Hypnum cupressiforme* in Europe

Jan-Peter Frahm

Abstract: Field observations of mixed tufts demonstrate that *Hypnum cupressiforme* s.str. (excl. *imponens*, *jutlandicum*, *andoi* etc.) consists of several different genotypes which are no modifications. Within a study of herbarium material, the specimens were sorted into different phenotypes, for which names were applied from the literature. Within *Hypnum cupressiforme*, an expression with straight leaves (var. *brevisetum* Schimp.) was distinguished as well three with hamate leaves (var. *uncinulatum* Boul., var. *cupressiforme* and var. *plumosum* Mart.), which are differentiated by the size, number and form of alar cells and serrate viz. entire leaf tips. Var. *subjulaceum* is tentatively regarded as alpine variety of *Hypnum lacunosum*, var. *filiforme* is regarded as modification based on the observation of transitions.

Introduction

Hypnum cupressiforme is a cosmopolitan species (Wijk et al. 1964), but has its main distribution in Laurasia. In North America, it consists of only one medium sized phenotype. In contrast, the species shows in Europe by a high variability. This does not only concern taxa which are regarded as separate species such as *H. jutlandicum*, *H. lacunosum*, *H. resupinatum* or *H. andoi* by different authors on different levels and with different synonymies, but also within *H. cupressiforme* s.str. Field observation of mixed stands reveal that there are at least several different genotypes within *H. cupressiforme* s.str.

A possible explanation for the lack of variability of *Hypnum cupressiforme* in North America and the great variability of this species in Europe could be that the species has undergone genetic differentiation in Europe during the Ice Ages in the Pleistocene. Because of the E-W barrier of the Alps, the temperate species survived in different refugia in southern Europe, where they were separated from each other for one to two hundred thousand years. Due to the lack of such a barrier in North America, the populations of the species were not separated during the Ice Age but had gene exchange.

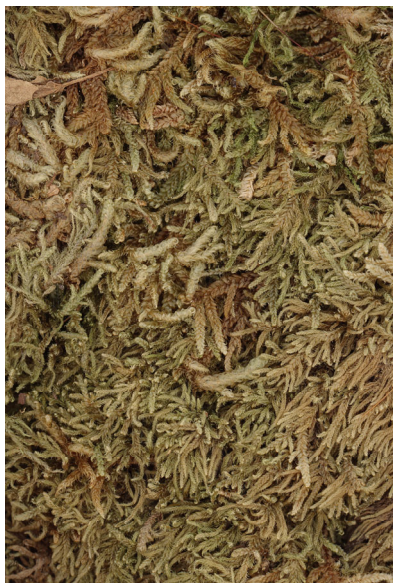


Fig. 1.



Fig. 2.

Figs. 1-2: Mixed stands of different expressions of *Hypnum cupressiforme*. 1. A large and a small form growing interwoven on a rock. France Dépt. Belfort, Lac de Alfeld, Frahm 3.9.01 s.n.; 2. A large and a small form growing on the same tree trunk. Germany, Nordrhein-Westfalen, Rhein-Siegkreis, Siebengebirge, Frahm 5773.

Several attempts have been made to sort the different phenotypes of *Hypnum cupressiforme*. Described by Hedwig in 1801 (based on an earlier publication), all expressions have been summarized in one species and more or less many infraspecific taxa for almost 150 years. The authors of the *Index Muscorum* (Wijk et al. 1964) list 84 varieties, of which 27 are accepted. Over the time but mainly during the last decades, former varieties such as the vars. *lacunosum*, *resupinatum*, *ericetorum*, *mamillatum*, *imponens*, *uncinatum* and *canariense* have been segregated and were treated by some authors of floras on a species level. For example, In the Netherlands, two species (*jutlandicum*, *cupressiforme*) were accepted (Touw & Rubers 1989), in Britain three (*cupressiforme*, *jutlandicum*, *mamillatum*, Smith 1978) and in Germany (Frahm & Frey 1987) five species (*cupressiforme*, *jutlandicum*, *lacunosum*, *mamillatum*, *resupinatum*). Reason for the high number of species distinguished in Germany was the fact that all species show – except for morphological and anatomical differences, also different ecological preferences and ranges. *Hypnum lacunosum* is characteristic for chalk grassland, *jutlandicum* for heathland and conifer forests, *mamillatum* (=andoi) is an epiphyte in beech forests and *resupinatum* has a strong oceanic range.

Special attention on the infraspecific taxa of *Hypnum cupressiforme* was paid by Doignon (1950). He gave a detailed account of the authors and number of taxa recognized within *H. cupressiforme*, discussed the value of the taxa and characters and distinguished (except for varieties presently accepted as species) the vars. *uncinatum* (*typicum*), *longirostrum*, *brevisetum*, *subjulaceum* and *filiforme*.

Barkmann (1966) based his publication on Doignon (1950) and distinguished the same taxa.

Later Ando published a series of seven papers on the genus *Hypnum*. In a survey of the European taxa (Ando 1985), he treated *H. imponens*, *H. andoi*, *H. uncinatum* and *H. jutlandicum* as

separate species. Within *H. cupressiforme* he distinguished the vars. *lacunosum*, *julaceum*, *subjulaceum*, *filiforme* and *resupinatum*.

Within a special study of *H. cupressiforme* (Ando 1987), the author treated *Hypnum cupressiforme* with nine varieties (var. *subjulaceum*, var. *resupinatum*, var. *filiforme*, var. *lacunosum*, var. *julaceum*, var. *mossmannianum*, var. *yashanicum*, var. *townsendii* and var. *cupressiforme*). Within the var. *cupressiforme*, Ando distinguished 12 forms: typical, terete, complanate, slender loose, pinnate, small, large, aduncoides, homomalous, pendulous filescent, subfiliform and partly filiform.

Hedenäs (1991) treated the *Hypnum cupressiforme* complex in Sweden and distinguished four species (*resupinatum*, *mamillatum*, *jutlandicum* and *cupressiforme*). Three years later (Hedenäs 1994) in survey of the *Hypnum cupressiforme* in Switzerland, he treated them as subspecies (*resupinatum*, *mamillatum*, *cupressiforme*, *ericetorum*). In both cases, the variation within *H. cupressiforme* s.str. was not considered.

On which taxonomic level these taxa are distinguished, as species (Hedenäs 1991), or subspecies (Hedenäs 1994) is a matter of taste. However, if they are “only” regarded as varieties, a chance is missed to differentiate the genotypes within *H. cupressiforme* s.str.

Recent results of molecular studies based on ISSR markers and ITS and *trnL* sequences of specimens of the *Hypnum cupressiforme* complex from Italy (*H. jutlandicum*, *andoi*, *resupinatum*, *lacunosum*, *cupressiforme*, Spagnuolo et al. 2008) revealed that all taxa except for *H. jutlandicum* were mixed up in the dendrogram. This does not exclude that other more suitable markers allow to separate infraspecific taxa of *Hypnum cupressiforme* s.str. However, these units derived from molecular data need not automatically correspond with phenotypes. Regardless the results of the molecular studies, alpha-taxonomic studies are still required for field bryology. Therefore an attempt has been made in order to find well delimited infraspecific taxa within *Hypnum cupressiforme* based on herbarium material and field observations..

The presence of mixed stands (figs. 1-2) shows that the different phenotypes of *Hypnum cupressiforme* are mostly not modifications but different genotypes. In such cases two different expressions are developed in the same habitat under the same ecological conditions (sun, shade, substrate, inclination etc.). Genotypes, especially if they look so different as in the present case, deserve taxonomic recognition, especially if they have different ecological preferences or different ranges.

In the author’s personal opinion, the genotypic variability within *H. cupressiforme* s.str. requires a distinction of taxa. Therefore a provisional attempt has been made based on the specimens in the author’s herbarium (BONN). For that purpose small samples of herbarium specimens were glued on small file cards and then sorted by similarity. The specimens within these groups were then described and compared with descriptions in the literature that a name could be applied for these taxa. As expressed in the title, the study is provisionally. The types of the varieties have not been studied, the priority of names was not checked and the study was based on a relatively small number of specimens. Main purpose was to see whether the enormous variability within this species can be grouped into distinguishable taxa and to get names for these taxa, or whether intermediates prohibit the distinction of varieties.

Infraspecific taxa of *Hypnum cupressiforme* in Europe

In the following, *Hypnum cupressiforme* is treated in a narrow sense exclusively *H. imponens*, *jutlandicum*, *lacunosum*, *andoi*, *uncinatum*, *resupinatum* (cf. Frey et al. 2006). Several of these species are distinguished by sporophytic characters: *H. andoi* with mamillate lid, *H. resupinatum* with longly rostrate lid, *H. uncinatum* with ovoid capsules. *Hypnum imponens* differs by its pseudoparaphyllia, *H. lacunosum* by the shape of the laminal cells and *H. jutlandicum* by the leaves serrate all around.

Within the remaining *H. cupressiforme* s.str., distinct genotypes could be distinguished by the size of the leaves, the number and shape of the alar cells and entire vs. serrulate leaf tips:

1. Leaves hamate, homomallous.
2. Leaves 1-1.2 mm long and 0.4 mm wide, alar cells 10-15.
var. *uncinatum*
- 2*. Leaves larger, alar cells more numerous.
3. Leaves 1.5-2 mm long. Leaf tips serrulate.
var. *cupressiforme*
- 3*. Leaves 2.3-2,7 mm long, Leaf tips entire.
var. *plumosum*
- .. 1* Leaves straight
var. *brevisetum*

Var. *cupressiforme* (Fig. 4, 9c)

Hypnum cupressiforme var. *uncinatum* Boul.

Leaves 1,5-2 mm long and <1 mm wide, from oval base contracted into a serrulate tip which is as long or shorter than the basal part. Alar cells forming a large group of up to 50 cells, the lower ones lighter coloured and inflated, the upper ones darker and smaller. Laminal cells 40-60 x 3-4 µm.

The typical variety is based on the type of *H. cupressiforme*, which was studied by Ando (1985). It consists of medium sized plants, 5(-10) cm long, prostrate, regularly to somewhat irregularly branched, with strongly falcate leaves. Ando (1985) includes here 12 “forms” listed above.

Two expressions can be observed in the field: a large and a small form. The latter has the size of var. *uncinatum* but serrulate leaf apices and larger alar cells and can be distinguished in the field by more or less regularly branched plants. It may be a form of nutrient poor habitats. On vertical substrates the plants turn (often but not always) into filiform, pendant modifications, which resemble *H. andoi* or *H. cupressiforme* var. *uncinatum* in appearance. The colour of var. *cupressiforme* is usually green but be or also brownish or yellowish. The branchig my be more or less regularly. The leaves can be strongly hamate or less curved. Some expressions resemble *H. lacunosum* var. *tectorum* in colour and size. The latter has, however, shorter and wider laminal cells (5-7 x 40-60 instead of 3-4x60 µm).

Ecology: on rocks and bark of trees.




small	medium	large
<i>uncinatum</i>	<i>cupressiforme</i>	<i>plumosum</i>
		
Fig. 3	Fig. 4	Fig. 5

Fig. 3-5: Intraspecific taxa of *H. cupressiforme* with homomallous leaves. The pictures (scans) are in the same scale.

Rarely specimens are observed, which have branches with straight leaves on plants with curved leaves (Fig. 6). They show that the characters curved and straight are genetically fixed.



Fig. 6: *Hypnum cupressiforme* var. *cupressiforme* with straight as well as hamate leaves (France, Gironde, Grayan-L'Hoptal, De Sloover 28403).

Specimens examined: Britain: Scotland, Argyll, Morvern, Frahm 7.7.1978. Danmark, Jütland, Ulfborg Planatage, epiphytic, Frahm 24.7.1975. France, Dept. Haute-Saône, on wall, Frahm V5668; Eisenbahnbrücke zw. Luxeuil und Vesoul, Frahm 23.3.1992; Dépt. Vosges, zwischen La Montagne und Le Val d'Ajol, Frahm 30.7.93; Remiremont, on walls of fort, Frahm 27.3.1992. Germany, Baden Württemberg, Heidelberg, Glime 8091; Nordrhein-Westfalen Kr. Kempen-Krefeld, Munitionsdepot Bracht, on trunk, Frahm 10111; Kr. Kleve, Schaephuysen, epiphytisch, Frahm 9791; Rhein-Siegkreis, Siebengebirge, Löwenburg, Frahm 8.12.1996; Kr. Monschau, Rurtal, on rock, Frahm 4.7.07; Kr. Siegburg, Brenig bei Bornheim, Quarzsandgrube, Frahm 11146; Rheinland-Pfalz Kr. Bernkastel-Wittlich, Windsborner Maar, on lava rocks, Frahm 99907; Kr. Ahrweiler, Dungskopf bei Remagen, on basalt with var. *plumosum*, Frahm 16.11.1994; Kammerslei bei Kesseling, on schist, Frahm 9786; Reutersley bei Rheineck, on schist, Frahm 9598; Staatsforst Adenau bei Herschbach, on schist, Frahm 10069; Kr. Neuwied, Ober-Hammerstein, on schist, Frahm 9674; Hummelsberg bei Linz, on basalt, Frahm 30.6.02; Idar-Oberstein, Kammerslei, on rock, Frahm 13.4.1996. Baden-Württemberg, Kr. Lindau, Eistobel, Frahm 10.3.1973. Crete, Chania, Schlucht zwischen Skines und Neo Roumata, Frahm K-140; Elos, Straßenand, Frahm K-238; Madeira, Paúl da Serra, Posto Florestal Estanquinhos, on rock, Frahm M-143, M 145. Spain, Asturia, Munoz 4012. Small forms: Germany, Nordrhein-Westfalen Kr. Düren, Jülih, epiphytic, Frahm 12.3.1994; Rheinland-Pfalz Kr. Ahrweiler, Reutersley bei Rheineck, on oak, Frahm 9597; Kempenich, on tufa

rock, Frahm 9787; Kr. Bernkastel-Wittlich, Lieser Tal S Manderscheid, on schist, Frahm 9915; Kr. Koblenz, Stadtwald, epiphytic, Frahm 9934. France, Dépt. Haute-Saône, Valbert, on rock, Frahm V5680; Dépt. Vosges, Hamanxard. epiphytic, Frahm V5781; Aude, Montagne Noir, De Sloover 45.207.. Crete, Chania, along road Sougia – Nea Roumata, Frahm K-123;

Var. uncinulatum B.S.G. (Fig. 3,9a)

non *H. uncinulatum* Jur. (= *H. canariense* Mitt.)

Plants small, only up to 2,5 cm long and only 0.4 – 0.8 mm wide. Leaves 1-1.2 mm long and 0.4 mm wide, in the lower part oval-ovate, suddenly contracted into a long homomalous tip which is entire. The upper part is as long or longer than the lower part. Alar cells few, 12-15, of which 5-10 are inflated, incrassate, brownish. Laminal cells incrassate, almost straight, not sinuose, 40-60 x 3-4µm, 12-20 x longer than wide.

Similar to the typical variety with regard to the leaf shape and branching, but only half size. The lid is described as longly rostrate, which may indicate the independent status of this taxon, because the var. *cupressiforme* has a conical lid with a beak (and *H. andoi*, previously treated as *H. cupressiforme* var. *mamillatum*, a blunt lid with a mamilla). Ando (1985) names it “small form” and refers it with some doubt to var. *uncinulatum*, since he has not seen the type.

Ecology: on base and nutrient poor rock (schist, trachyt, tufa), also epiphytic, 200 – 500 m alt.

There exists some nomenclatural confusion with the epithet *uncinulatum*. This taxon was described as variety of *H. cupressiforme* in the *Bryologia Europaea* in 1854 but Juratzka in 1866 described a species as new under the same name. The name was then misspelled by Lange in 1869 as *uncinatulum*. Later Limpricht in 1899 synonymized var. *uncinulatum* Boul. with var. *uncinulatum*. *Hypnum uncinulatum* Jur. is very similar to this variety with the same name, but is an endemic of the Macaronesian Islands and was also found in Ireland. It differs by the ellipsoid capsules with a wide mouth when empty, a serrulate leaf tip, very long and narrow laminal cells (25:1) and 6-8 alar cells of which two are inflated. *Hypnum andoi* also has a strong resemblance to this variety but has a blunt (mamillate) lid.

Mixed stands were found with var. *plumosum* which demonstrates that the small size is not induced by nutrient poor habitats and on the other hand the large forms a result of base rich and nutrient rich habitats.

Specimens examined: Germany: Rheinland-Pfalz, Kr. Ahrweiler, zw. Herschbach und Kesseling, Frahm 9788; Kempenich, Steinrausch, Frahm 9712; Langfigtal bei Altenahr, Frahm 11277; Vinxtbachtal, Frahm 5606; Kr. Mayen, Nitztal, Frahm 3940; France: Dépt. Haute-Saône, Valbert, Frahm V5679; zwischen Froideconche und Valbert, Frahm V 5682; Dépt. Vosges Moseltal oberhalb Lepage, Frahm 11.4.1991. Poland, Gorze, *Bryotheca Polonica* no. 1100.

Var. plumosum (Fig. 5, 9d)

Hypnum semi-revolutum C. Müll. ?

Stereodon cupressiforme var. *pinnatum* Warnst.

Largest variety. Plants robust, to more than 10 cm long and 2 mm wide, usually light green to yellowish or golden green, more or less regularly branched. Leaves strongly hamate, the tips sometimes twisted, 2,3-2,7 mm long and 1,2 mm wide, from ovate base suddenly contracted to a narrow hooked tip, which is shorter than the basal part. Leaf apex entire. Alar cells yellowish brown, strongly collenchymatous, consisting of 20-30 larger and 10-20 smaller, lighter coloured cells. Laminal cells 60-75 x 4-5 mm.

According to Ando (1985), this variety intergrades with *H. lacunosum*, In fact, *H. lacunosum* has about the same size and can have a similar appearance, but it has shorter and wider laminal cells and stems not attached by rhizoids to the substrate.

Ecology: on (base rich) rocks e.g. basalt, limestone, concrete, also on clay. Distribution perhaps more southern in Europe.

Specimens examined: Madeira, Paúl da Serra, Frahm M-144; Austria: Kärnten, Plöckenpass, Frahm 2007361. Germany, Schleswig-Holstein, Nordstrand, Eternitdach, Abts 13.7.1994; Nordrhein-Westfalen Kr. Düsseldorf-Mettmann, Angerbachtal, Steinbruch, Frahm 20.3.1973; Kr. Köln, Wahner Heide, Frahm 9188; Rhein-Siegkreis, Siebengebirge, Stenzelberg, Frahm 13.5.1995; Niederpleis, Tongrube, Frahm 14.11.1998; Rheinland-Pfalz Kr. Ahrweiler, Dungskopf bei Remagen, on basalt with var. *cupressiforme*, Frahm 16.11.1994. France, Puy de Dome, O'Shea 28.8.1982; Dépt. Haute Vaucluse, Bollène, Frahm 14.3.2000. Spain, Burgos, Munoz 2463; Mallorca, Lewinsky 18.4.1970. Greece, Samos, Düll 24.6.1996.

var. *brevisetum* Schimp. (Figs. 7-8, 9b)

var. *strictifolium* (Warnst.) als var. von *Stereodon cupressiformis*

var. *ovatum* Ren. & Card.?

var. *longirostrum* Schimp. ?

terete form sensu Ando 1989 ?

Plants small, dark to grey green, up to 1 mm wide and 2 cm long. Leaves almost straight, ca. 0.8 mm long and 0.3 mm wide, sometimes slightly hooked on stem or branch tips, with broadly ovate base. more or less gradually narrowed into a straight and smooth tip. Alar cells 10-15, dark green, incrassate. Median laminal cells about 4 x 40 µm. Setae less than 1 cm long. Capsule longly rostrate. Warnstorff (1906) gives an excellent description of this variety.

This taxon differs markedly from all other varieties, having the appearance rather of a *Pylaisia polyantha* than a *Hypnum cupressiforme*. Specimens of *Hypnum resupinatum* are very similar and often misidentified but can be distinguished in the field by the upright turned leaves. Ando (1985) mentions no orthophyllous taxa in his treatment of the European taxa of *Hypnum cupressiforme* s.lat. but mentions a terete form (Ando 1989), which shall often be transitional to the typical form. However, mats with orthophyllous plants and uncinat plants are found growing together on the same tree trunk (fig. 7).

The name refers to a short seta, which is rarely present, however, Warnstorff's epithet *strictifolium* is more characteristic but has no priority.

Ecology: Usually on bark of deciduous trees, also on acidic rocks (schist, trachyt).

Var. *longirostrum* is described as having straight leaves and a long operculum (Doignon 1950) and may belong to this taxon. Doignon (l.c.) calls it a transitional form. Warnstorff (1906) describes it a weakly hamate, which seems to support Doignon's view. The leaves are slightly longer as in var. *brevisetum* (up to 1,4 mm) and the apex shall sometimes be indistinctly serrulate, both again intermediate between var. *brevisetum* and var. *cupressiforme*.

Specimens examined: France, Dept. Haute-Saône, Valbert, epiphytic, Frahm V5681; Germany, Nordrhein-Westfalen, Kr. Euskirchen, Fringshaus bei Blankenheim, on poplar, Frahm 5.4.91; Kr. Mettmann, Urdenbacher Kämpfe Frahm 11303; Schlackenhalde bei Bruchhausen, epiphytic, Frahm 9921; Rhein-Sieg-Kreis, Drachenfels, Frahm 3922; Ölberg, Frahm 26.3.1995; Rheinland-Pfalz Kr. Cochem-Zell, Klotten, Frahm 10177, 10178; Kr. Bernkastel-Wittlich, Lieser Tal S Manderscheid, on schist, Frahm 9850. Netherlands, Brabant, Boxmeer, on *Fraxinus*, Frahm 8.4.07; Gelderland, Waardenburg, Frahm 3.7.1975 det. Ando as *H. cupressiforme* terete form.

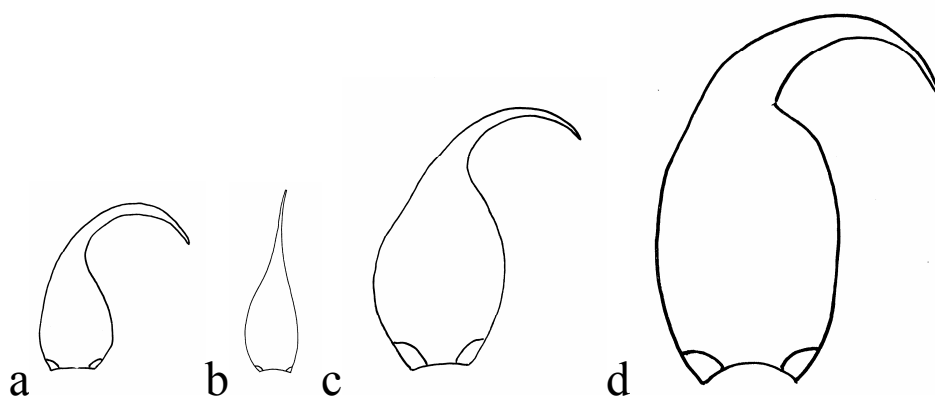
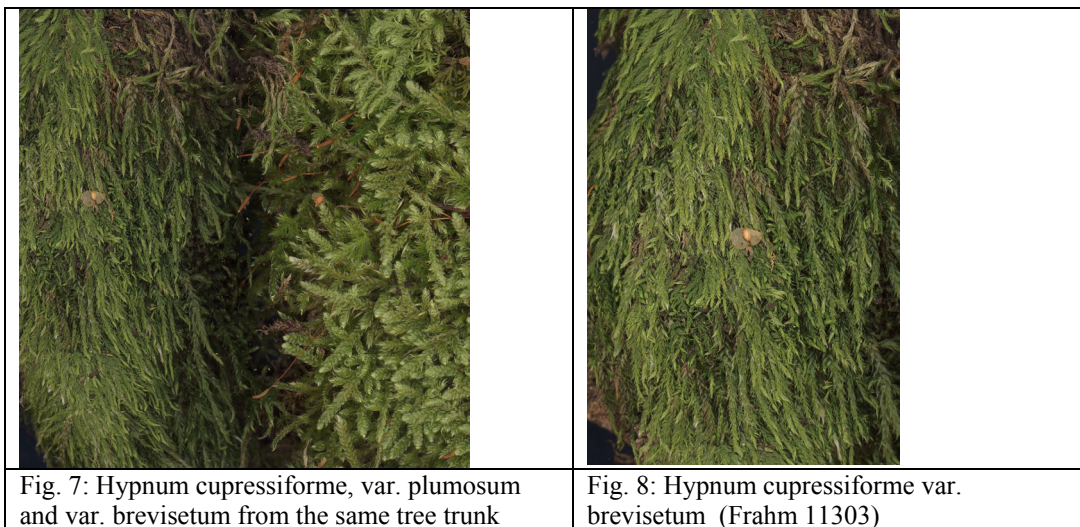


Fig. 9: Leaf sizes and Leaf shapes of *Hypnum cupressiforme* a. var. *uncinulatum*, b. var. *brevisetum*, c. var. *cupressiforme*, d. var. *plumosum*.

Excluded taxa

Var. *subjulaceum* described by Molendo from the Alps is a glossy plant with ascendend stems, no rhizoids and straight, densely imbricate leaves. The leaves are up to 2 mm long und 0.6 mm wide. The laminal cells measure 40-50 x 4-6 μm .

The dimensions of the laminal cells. lacking rhizoids and imbricate leaves suggest that this variety could be an alpine expression of *Hypnum lacunosum*.

Var. *resupinatum* (Tayl.) Schimp. has been treated as species (Frey et al. 2006 amongst others). It differs only slightly from var. *brevisetum* by the leaves turned upwards and would not require the status of a species. Since this taxon has a distinct range in the oceanic parts of western Europe, in contrast to the varieties described above, which have not distinct ranges, it is kept as species.

The status of var. *filiforme* is doubtful. Although regarded as a variety by most authors, observations in the field reveal that it can be just a modification of pendent plants. As shown by transitions between plants grown horizontally (e.g. on the surface of branches and rocks) and pendant (Fig. 10,11). On the other hand, not all *Hypnum* mats grown vertically are filiform, there are also normally developed forms on vertical tree trunks or rocks. As in other pendant forms, this seems to be an effect of high humidity. In many cases, *Hypnum andoi* has been taken for *H. cupressiforme* var. *filiforme* in the past. Also Ando (1985) argues that the vars. *cupressiforme* and var. *filiforme* often intergrade and therefore var. *filiforme* might be a habitat modification. On the other hand, forms such as var. *filiforme* do not exist in western North Americas and Japan (except for few specimens from soil!). In these regions the humidity should be sufficient to produce filiform modifications.



Fig. 10: *Hypnum cupressiforme* var. *cupressiforme* on a horizontal branch (Frahm V5781a)



Fig. 11: *Hypnum cupressiforme* mod. *filiforme* pendant from the same branch as in fig. 8 (Frahm V 5881b)

Discussion

Ando (1985) described “forms” which are in part modifications and can in part be attributed to the varieties mentioned here. The “partly filiforme, pendulous filescent, pinnate, slender, subfiliform and slender loose forms” are probably modifications. the large form as well as var. *aduncoides* resemble var. *plumosum*. Var. *uncinulatum* as well as var. *uncinatum* is regarded as synonym of var. *cupressiforme*,

Doignon (1950) as well as Barkman (1966) distinguish no typical variety, which was perhaps hardly possible without having seen the type specimen of *Hypnum cupressiforme*. According to their keys, var. *uncinatum* resembles the type. The vars. *subjulaceum* and var. *brevisetum* are the only varieties with straight leaves and the same of the present study. Var. *longirostrum* could not be attributed.

A general problem is that the taxa of the *Hypnum cupressiforme* complex show parallel modifications. Thus *Hypnum andoi*, *Hypnum cupressiforme* var. *uncinulatum* und *Hypnum cupressiforme* mod. *filiforme* are very similar appearance when growing on vertical trunks of trees and can only be differentiated by sporophytic or microscopical gametophytic characters.

Mönkemeyer (1927) lists (except for the taxa nowadays accepted as species) three varieties: var. *crispatisimum*, var. *filiforme* and var. *subjulaceum*. Var. *crispatisimum* could be the var. *plumosum* of this study, var. *filiforme* includes a fo. *uncinatula*, which is identical with the

var. uncinatum of the present study and var. subjulaceum covers all expressions with straight leaves inclusive *Hypnum resupinatum*.

Warnstorf (1906), who is known for his excessive use of infraspecific taxa, distinguishes (again except for the taxa accepted today as species) the vars. *brevisetum*, *uncinatum* and *plumosum* as in the present study, and in addition the vars. *filiforme*, *longirostris* and *subjulaceum* (= *strictum*, *orthophyllum*).

References

- Ando, H. 1985. *Hypnum cupressiforme* Hedw. and its close allies in Europe. *Abstracta Botanica* 9, Suppl. 2: 11-18
- Ando, H. 1989. Studies in the genus *Hypnum* (VI). *Hikobia* 10: 269-291.
- Barkman, J. J. 1966. De varieteiten van *Hypnum cupressiforme* Hedw. in Nederland. *Buxbaumia* (Amsterdam) 20 (1-2): 1-6.
- Doignon, P. 1950. Ecologie et variations de l'*Hypnum cupressiforme* L. *Revue Bryol. Lichénol.* 19 : 208-220.
- Frahm, J.-P., Frey, W. 1987. *Moosflora*, 2nd. ed. Stuttgart.
- Frey, W., Frahm, J.-P., Fischer, E., Lobin, W. 2006. *The liverworts, Mosses and Ferns of Europe*. Martins (Harley Books).
- Hedenäs, L. 1991. Översikt över *Hypnum cupressiforme* Komplexet i Sverige. *Myrnia* 1: 2-7.
- Hedenäs, L. 1994. Schlüssel für die Sippen des *Hypnum cupressiforme* - Komplexes der Schweiz. *Meylania* 6: 10-14.
- Mönkemeyer, W. 1927. *Die Laubmoose Europas*. Leipzig.
- Smith, A.J.E. 1978. *The Moss Flora of Britain and Ireland*. Cambridge.
- Touw, A., Rubers, W.V. 1989. *De Nederlandse Baldmossen*. Utrecht.
- Warnstorf, C. 1906. *Kryptogamenflora der Mark Brandenburg* Bd. 2. Leipzig.
- Wijk, R. van der, Margadant, W.D., Florschütz, P.A. 1964. *Index Muscorum* vol. 3. Utrecht,