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WORLD OF *SPHAGNUM* – DISTRIBUTION PATTERN AS A REFLECTION OF ECOLOGY AND TAXONOMY

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SUMMARY

Sphagnum peat mosses occur with around 300 species on almost all continents, mainly in northern South-America, North-America and east and north-east Asia as well as in Europe (Michaelis 2011). Peat mosses cover large areas in mires of the northern hemisphere but the global species diversity pattern is not related to the area of mires. Besides peatlands *Sphagna* colonize different mineral substrates, particularly in the humid tropics. The diversity pattern reflects not only habitat diversity but also the history of taxonomic research. In recent years taxonomical work has boomed in the neotropics and in the higher northern regions. Nevertheless, the recent regional *Sphagnum* species assemblages still reflect an unbalance in taxonomic research.

KEY WORDS: *Sphagnum*, distribution, habitat diversity, taxonomy

INTRODUCTION

Sphagnum mosses (peat moss) are of immense economic and ecological importance. They occur on almost all continents, mainly in northern South America, North America and east and north-east Asia as well as in Europe. The total number of *Sphagnum* species has been estimated between 150 and 450. Various approaches exist for its division in up to 4 subgenera and up to 18 sections. These numbers illustrate large differences in taxonomical perspectives of bryologists. Uncertainties also exist with regard to ecological amplitudes. Many tropical species are known from a very limited number of sites.

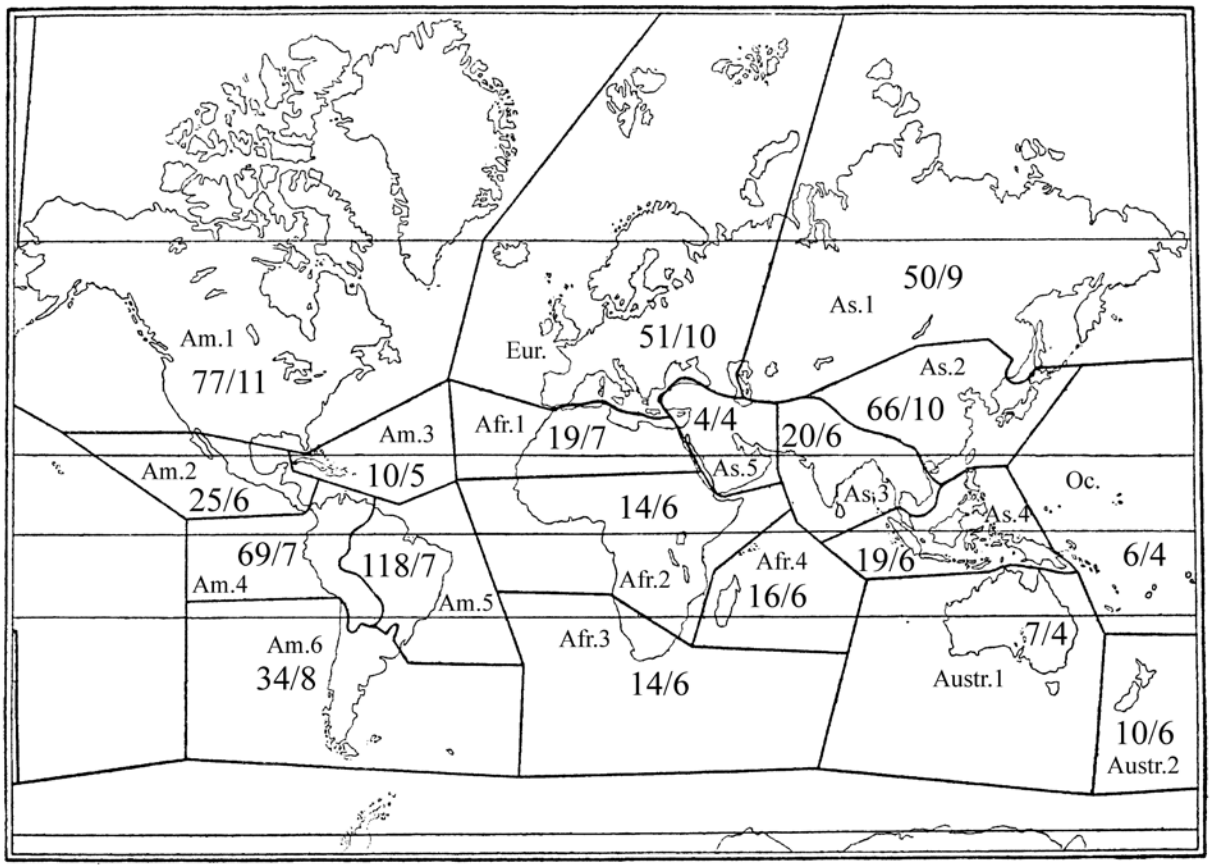
Sphagnum phylogeny and distribution

Based on genetic research Shaw et al. (2010) concluded that *Sphagnum* developed its large variability during climate cooling beginning in the Miocene. Then, extensive areas of the northern hemisphere became dominated by temperate and boreal climate conditions. The authors have further shown on the example of sections *Acutifolia* and *Subsecunda* that in the tropics and Southern Hemisphere only derived, evolutionary younger species occur whereas in the Northern Hemisphere derived and basal species live. That means that the tropical regions would be colonized by *Sphagnum* coming from the north.

Fossils from the Jurassic indicate *Sphagnum* sect. *Sphagnum* (see Reisinger, 1950), fossils from the Eocene (Frahm, 2009) and Oligocene (Johnson, 1951) indicate *Sphagnum* sect. Sphagnum and sect. Acutifolia. At least, a few sections are probably of mesozoic origin. Most of these fossils come from ancient subtropical to tropical regions. The genus *Sphagnum* has a

long-time development in warm climates which could have an impact on recent species and niche diversity.
The recent distribution of species shows a non-uniform pattern with different centres of diversity (Fig. 1). The northern regions together with East Asia are rich in species with 50 or more taxa. In the tropics, only the Neotropics is extremely rich in species, the Paleotropics seems to be relatively species-poor.

Fig. 1: The number of *Sphagnum* species (based on Michaelis, 2011) and *Sphagnum* sections. The number of sections is based on the differentiation of following sections: sect. *Sphagnum*, sect. *Rigida*, sect. *Insulosa*, sect. *Acutifolia*, sect. *Squarrosa*, sect. *Polyclada*, sect. *Acrosphagnum*, sect. *Subsecunda*, sect. *Isocladus*, sect. *Cuspidata*, sect. *Mollusca*, sect. *Hemitheca*, sect. *Acocosphagnum*, sect. *Inretorta*.



The pattern is different at the section level (Fig. 1). North America, Europe and East Asia have the highest number of sections. The reason is the separation of a few, species-poor sections like Insulosa, Polyclada, Isocladus, Mollusca and Hemitheca, which have their main distribution in the northern hemisphere. The status of these sections is discussed. If these sections would be incorporated into the sections Acutifolia (for Insulosa and Polyclada), Subsecunda (for Isocladus) and Cuspidata (for Mollusca and Hemitheca), as suggested by Shaw (2000) and Shaw et al. (2005), the number of sections would be well balanced between the northern and the moist tropical regions.
However, on the level of genetic distance, the tropical regions exhibit the largest diversity because they are the home range of the genetic rather distant sections Acocosphagnum (synonym to Sericea) in Southeast Asia, Acrosphagnum (synonym to Mucronata) in Africa and Ceylon, and Inretorta in Bolivia and Chile (see Shaw et al., 2003).

Sphagnum habitats

In order to compare niche diversity in the tropical and temperate zone, regions with well-known species composition of *Sphagna* were chosen (Fig. 2). The attribution of ecological amplitudes follows Daniels and Eddy (1985) for Central Europe and Eddy (1977) for Southeast Asia.

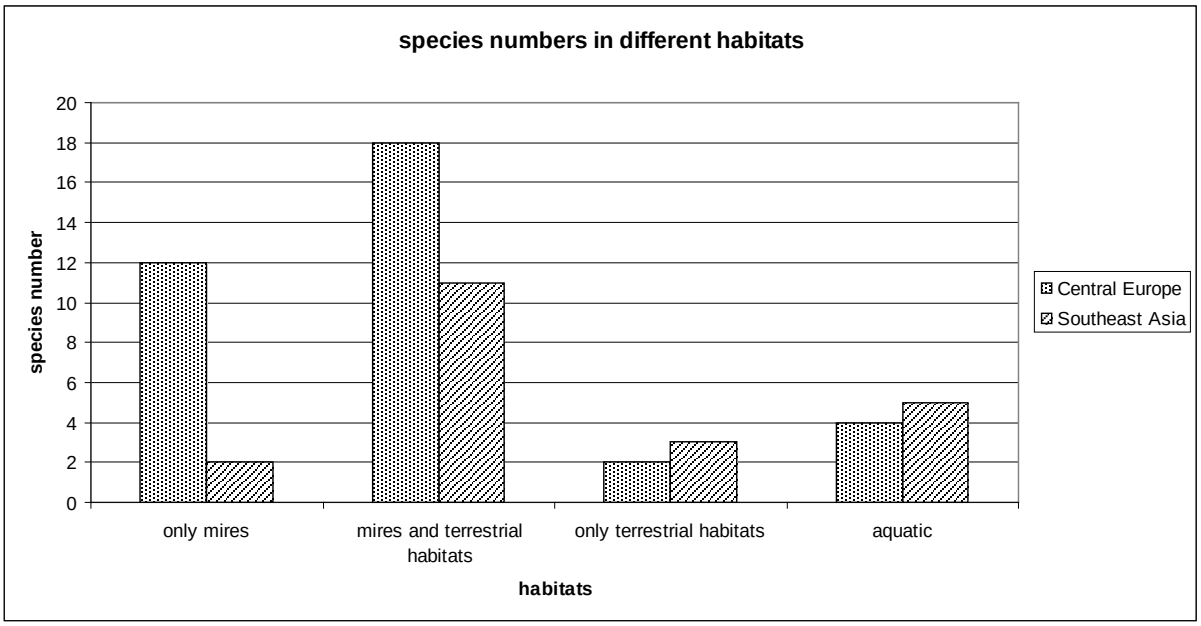


Fig. 2: Habitat preference of *Sphagnum* species in Central Europe (36 species) and Southeast Asia (17 species).

The largest difference between the two regions occurs within the fraction of species, which are restricted to mire habitats. One third of the central European species grows only in mires whereas only about ten percent of the species in Southeast Asia are growing exclusively in mires. The limited recycling of nutrients in temperate and boreal zones allows the formation of extensive oligotrophic and mesotrophic mires that favour the establishment of bryophyte vegetation. Such comparatively nutrient poor conditions are also present in the tropics on sites such as rocks, steep slopes, but rarely on tropical mires. In the tropics peat mosses are less strongly associated with the occurrence of mires.
Beside specific, partly human influenced vegetation (heath), the terrestrial niche diversity of *Sphagnum* vegetation is more or less similar in the tropical and temperate zone (Fig. 3). However, in the tropics a significantly higher number of species occurs on wet rocks.

Sphagnum taxonomy

To illustrate the influence of individual taxonomists, the number of *Sphagnum* species descriptions of important bryologists and their regional focus of work is given in table 1.

The three most productive bryologists (Crum, Müller, Warnstorf) gave their name to over 500 species. Although numerous names were taken now as synonyms, these three scientists and their species concepts dominate our understanding of *Sphagnum* species. Yet, there are some specific problems within their species concepts. Warnstorf, for example, used to separate *Sphagnum* species of the section Subsecunda on the basis of the numbers of leaf cell pores.

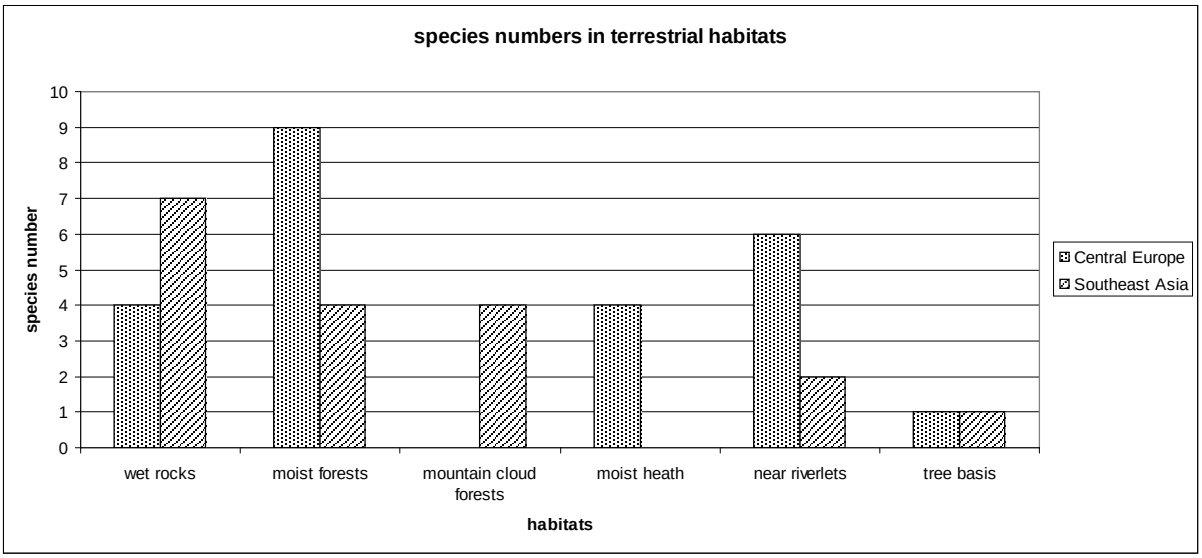


Fig. 3: Preference of terrestrial habitats by *Sphagnum* species in Central Europe (20 species) and Southeast Asia (14 species).

Table 1: Bryologists, the numbers of their species descriptions (including synonyms) and their regional focus of work based on Margadant and Florschütz (1967) and Michaelis (2011)

Bryologist	Number of *Sphagnum*-names	Regional focus of investigation
Andrus	15	North America
Bescherelle	15	Central and South America, Africa
Crum	114	North and South America
Dixon	9	Asia, Africa
Flatberg	16	Europe, North America
Hampe	25	South America, Africa
Mitten	13	South America,
Müller	131	Europe, South America, Africa
Warnstorf	291	Europe, North and South America

During this time, the end of the 19th and beginning of the 20th century, other sphagnologists noted that the number of pores is dependent on habitat conditions, especially moisture (Röll, 1913). On the other hand, Crum described many isophyllous and hemiisophyllous species. These morphological features can also be influenced by site conditions and even by the age of the plant. These three bryologists with very narrow morphological species concepts had a regional focus on South America. Therefore, the high species number for South America requires further evaluation.

In the northern latitudes, Andrus and Flatberg described during the last three decades some new species and reintroduced a few older names. A few of them were already called into question by genetic studies (Shaw et al., 2005, 2009). Thus, the exact number of *Sphagnum* species is also not yet fully clarified in regions with a long research history.

CONCLUSIONS

Besides a general trend towards higher species diversity in the northern hemisphere and the Neotropics, the exact species number of Sphagna is still not fully evaluated. The influence of bryologists with the tendency towards "species-splitting" could be estimated as rather high. However, the biggest genetic variety of *Sphagnum* is concentrated in the subtropic and tropic regions.
The spectrum of habitats with *Sphagnum* vegetation is more or less similar for the tropical and northern latitudes. These mosses colonize moist, wet and aquatic sites on organic and inorganic soils.
Although *Sphagnum* mosses are in the focus of many studies, we need more evaluation of taxonomical problems and more knowledge about *Sphagnum* ecology outside of the northern hemisphere.

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