Vegetative reproduction and clonal diversity in pleurocarpous mosses (Bryophytina) of mesic habitats

A combined molecular and morpho-anatomical study in
Pseudoscleropodium purum (Hedw.) M. Fleisch. ex Broth. (Brachytheciaceae),
Pleurozium schreberi (Brid.) Mitt. (Hylocomiaceae) and
Rhytidiadelphus squarrosus (Hedw.) Warnst. (Hylocomiaceae)

Dissertation zur Erlangung des akademischen Grades des

Doktors der Naturwissenschaften (Dr. rer. nat.)

eingereicht im Fachbereich Biologie, Chemie, Pharmazie

der Freien Universität Berlin

vorgelegt von

Sebastian Fritz
Geburtsort Berlin

Berlin 2009

Die Arbeit wurde im Zeitraum Nov. 2005 – Nov. 2009 unter Leitung von Prof. Dr. W. Frey am Institut für Systematische Botanik und Pflanzengeographie, der Freien Universität Berlin angefertigt

Gutachter:

1. Prof. Dr. Wolfgang Frey

2. Prof. Dr. Jürgen Schmitt

Tag der mündlichen Prüfung 23.04.2010

Für meine Großeltern und Eltern,
im Besonderen in Gedenken an meinen Großvater Bernhard Fritz
der mich auf den Weg zur Botanik gebracht hat.

Contents

Index of Figures

Index of Tables

Abbreviations

♀	female
♂	male
acc.	according
AFLP	Amplified Fragment Length Polymorphism
~	approximate
appr.	approximate
c.	circa
cf.	confer, 'compare'
c.fr.	cum fructus, 'fruiting', i.e. with sporophytes(s)
det.	determined by
e.g.	exempli gratia, 'for example'
elev.	elevation
et al.	et alii, 'and others'
GD	genetic distance
i.e.	id est, 'that is'
J	Jaccard
NJ	Neighbour Joining
p.	page
pers. comm.	personal communication
SC	similarity coefficient
SD	standard deviation
s.l.	sensu lato, 'in broad sense'
SM	Simple-matching
s.str.	sensu stricto, 'in narrow sense'
UPGMA	Unweighted Pair Group Method with Arithmetic Mean

BB	Brandenburg
BE	Berlin
BW	Baden-Württemberg
BY	Bavaria
HE	Hesse
MV	Mecklenburg-Western Pomerania
NI	Lower Saxony
NW	Northrhine-Westphalia
SA	Saxony
TH	Thuringia

Plot areas

NH1	Neuehütte (BB)
B1	Berlin Pankow (BE)
Saarm1	Saarmund (BB)
Sil1, Sil2, Sil3	Dietzhausen, Silbachtal (TH)

Sample Sets

P_{Ger}	*Pleurozium schreberi* samples from Germany
P_{WW}	worldwide *Pleurozium schreberi* samples
S_{Ger}	*Pseudoscleropodium purum* samples from Germany
S_{WW}	worldwide *Pseudoscleropodium purum* samples
R_{Ger}	*Rhytidiadelphus squarrosus* samples from Germany
R_{WW}	worldwide *Rhytidiadelphus squarrosus* samples

1 Introduction

In bryophytes, especially many dioecious species do either not, rarely or only regionally produce sporophytes, but large numbers of them are nevertheless common species (e.g., Longton 1992, Pfeiffer et al. 2006). This may be the case since most bryophytes are capable of vegetative reproduction, whether or not they produce sporophytes freely (Longton 2006). Thus the relevance of vegetative reproduction for colonisation and maintenance of habitats in rarely fruiting species (with sporogonia) is a question of great interest in bryology and will be addressed in this study.

Longton (2006) addresses one of the main open questions, before the significance of meiosis in terms of the evolutionary flexibility of bryophytes can be assessed: Is there a correlation between aspects of reproduction biology and the level and pattern of genetic variation in bryophyte species and populations? An earlier work on the pleurocarpous moss species *Rhytidium rugosum* (Pfeiffer et al. 2006) demonstrated that a very rarely fruiting species forms highly clonal patches and that small numbers of clones can dominate populations. However, the question remains whether low genotypic diversity and clonal dominance are a general trend in rarely fruiting pleurocarpous mosses or are special to *Rhytidium rugosum*.

The present study aims to analyse clonal diversity of small populations, to infer the importance of vegetative reproduction in three widespread, rarely fruiting, unisexual pleurocarpous mosses (Bryophytina): *Pseudoscleropodium purum, Pleurozium schreberi* and *Rhytidiadelphus squarrosus*. Plant material from different German plots as well as worldwide plant material was therefore investigated by molecular (AFLP fingerprinting) and morpho-anatomical analyses to test the genetic diversity in selected plots and to discover the means of vegetative reproduction as well as clonal reproduction.

Concerning life-form, the three selected species are members of the perennial stayer type, comprising: longevity, low reproduction effort (or non-fruiting) and are typically found in stable habitats (compare, e.g., During 1979, Frey & Kürschner 1991, Frey & Hensen 1995). When sporophytes are produced they show long setae, small spores (< 20 µm in diameter) and well developed peristomes (e.g., Schmidt 1918, Crum 1972, Miles & Longton 1992, Longton 1994), hence features thought to be associated with long-range dispersal. For the three studied species vegetative reproduction is not yet completely understood and specialised vegetative diaspores s.str. (propagula) are not known. Only unspecialised fragmentation of plants is suggested as a possible mechanism of vegetative reproduction (e.g., Correns 1899, Longton & Schuster 1983, Nebel & Philippi 2001, King 2003, Heinken & Zippel 2004).

All three species have a wide distribution in the Northern Hemisphere, with range extensions (introductions) to the Southern Hemisphere (e.g., Australia, New Zealand, St. Helena, Argentina and South Africa). Within their main distribution range *Pseudoscleropodium purum, Pleurozium schreberi* and *Rhytidiadelphus squarrosus* are very common species and form large patches or even carpets.

Descriptions in literature suggest different frequencies in sporophyte production (regional and between species) in the three observed species (compare, e.g., Longton & Greene 1969a, Lewinsky & Mogensen 1978, Crum & Anderson 1981, Düll 1994, Hill et al. 1994, Kuc 1997, Gradstein et al. 2001, Nebel & Philippi 2001, Crum 2004, Smith 2004), this was confirmed by own observations. In the present study sporophytes were not found in *Pseudoscleropodium purum*, sporadic found in South Thuringian populations of *Rhytidiadelphus squarrosus* and regularly found in Brandenburgian and Thuringian *Pleurozium schreberi* populations. This turned out to be a very interesting fact, since it is the first time that the genetic diversity of small populations with slightly different frequencies in sporophyte production (regional differences as well as differences between species) was compared in one analysis.

Altogether the study aims to answer the following questions:

- Are patches of the selected, rarely fruiting, species uniclonal or multiclonal?
- Is a population dominated by small numbers of clones?
- How do the examined species reproduce vegetatively, and what are the most important types of vegetative diaspores?
- How important is sexual reproduction for the selected species?
- Is it possible to show correlations between sporophyte frequencies and the genetic diversity of populations?

2 Reproduction and Dispersal

2.1 Vegetative Reproduction

Vegetative/asexual reproduction has been a field of interest in bryological research for a long time (compare, e.g., Correns 1899, Sobotka 1976, Longton & Schuster 1983, Selkirk 1984, Kimmerer 1994, Newton & Mishler 1994, Duckett et al. 1999, Stenøien & Såstad 2001, Stark 2002, Bisang et al. 2004, Heinken & Zippel 2004, Cronberg et al. 2006, Pfeiffer et al. 2006). Today the general picture of reproduction in bryophytes seems to be clear and generative as well as vegetative reproduction are well described, but less is known about clonal diversity in mainly vegetatively reproducing species and the efficiency of vegetative diaspores, especially in pleurocarpous mosses.

When discussing reproduction it is important to define standards, because lots of different terms are in use by different scientists. The definition of reproduction (production of a new, physiologically independent plant) given by Mishler (1988) is adopted here: Reproduction is sexual (generative) if the new plant develops from a spore that itself results from cross-fertilisation and meiosis, and is vegetative (asexual) if the new plant develops from a mitotically produced cell without cross-fertilisation.

Already Hofmeister (1851) mentioned vegetative reproduction in Jungermanniopsida, Marchantiopsida and Anthocerotopsida, but not in Bryopsida. For Bryopsida he only noticed that one can find several dioecious species which produce every year lots of archegonia but one will never find fruiting plants, because no male plants are present in a distance that can be covered by spermatozoids. Hence the question arises how these bryophytes reproduce. Researching this question, Correns (1899) published the first compendium on vegetative reproduction in Bryopsida, which even today is a standard work in this field of bryology. A general classification of reproduction modes in bryophytes can be found in Longton & Schuster (1983). This classification is still under discussion and has been advanced several times. Urbanska (1992) suggests for example, that vegetative (asexual) reproduction s.l. can be split into two basic types: (1) vegetative reproduction s.str. with ± specialised propagules, and (2) clonal reproduction, i.e., disintegration of genetic individuals into morphologically and physiologically independent dividuals, the ramets (e.g., Frey & Lösch 2004). This leads to the nomenclature used in this study (see Table 1), which is based on the classification by Longton & Schuster (1983) but was extended by Pfeiffer (2003) and Schaumann (2005).

Table 1. Reproduction modes in bryophytes (after Frey & Kürschner pers. comm., based on Longton & Schuster 1983, Pfeiffer 2003 and Schaumann 2005)

• Vegetative (asexual) reproduction s.l.

1) Vegetative (asexual) reproduction s.str. (with ± specialised propagules)

a) Regeneration from ± specialised caducous organs (stems, branches, leaves etc.)

- − Leaves and leaf apices
  - − Caducous leaves (complete normal leaves)
  - − Brood leaves (differentiated from normal leaves)
  - − Caducous leaf apices (leaves with abscission layer in upper part)
  - − Leaf fragments (leaves break along predetermined lines into random fragments)
- − ± Specialised branches and stems (caducous defined stem and thallus parts)
  - − Caducous shoot apices (often little modified)
  - − Caducous branchlets (condensed and deciduous branches in the leaf axils)
  - − Caducous flagelliform shoots (attenuate branches with vestigial leaves, in leaf axils)
  - − Bulbils (highly condensed, with leaf primordia)
  - − Caducous perianths
  - − Cladia (small branches developing on leaves)

b) Production of specialised propagules

- − Protonemal brood cells
- − Brood bodies, gemmae
  - − Protonemal gemmae (gemmiferous protonema)
  - − Gemmae s.str. (produced on various parts of the gametophyte, e.g. laminar, coastal, axillary, cauline, gametangial or endogenous gem-mae)
  - − Rhizoidal tubers and rhizoidal gemmae

2) Clonal reproduction

a) Production of numerous buds on the protonema of a single spore. Several gametophytes are produced by the decay of the protonema.
b) Decay of older gametophyte parts leading to disjunction of the younger parts.
c) Development of new arial shoots from stoloniferous or rhizome-like subterra-nean shoots.
d) Initiation of arial gametophytic shoots on parts of the rhizoid system (rhizoid wicks).
e) Production of basitonic innovation plants in cauline position.
f) Innovation from shoot or branch buds. Primordia, which are regularly pro-duced in many mosses, but normally, remain dormant (Frey, 1974).
g) Fragmentation (unspecialised) of gametophytes.

• Special case: reproduction with asexual spores

Spores produced sexually after selfing, vegetative clone selfing or spore clone selfing between genetic identical individuals (Newton & Mishler 1994)

2.2 Diaspore dispersal

When studying clonal diversity in small bryophyte populations, an understanding of the dispersal potential of diaspores of either sexual or asexual origin is essential. Differences are to some point obvious, for instance between mostly large vegetative diaspores (like brood branches or fragments resulting from decay of older shoot parts) and small sexual spores, which suggests short and long-range dispersal respectively, but in fact these are not the only differences, furthermore the diaspores differ in dispersability, the effectiveness of establishment, the amount of resources required from the parent plant (Söderström 1994) and in the produced number.

Although the principles of generative reproduction are clear, dispersal distances as well as establishment of spores are very difficult to track in the field (Söderström 1994). Hence experimental studies on dispersal of spores are those of deposition rates close to the mother patch (e.g., Söderström & Jonsson 1989, Kimmerer 1991a, Miles & Longton 1992, Stoneburner et al. 1992). The study by Stoneburner et al. (1992) shows that up to 94% of the spores are deposited within a short range (2m) and that 1% can be found up to 15 m from the source, suggesting that the fraction that is not caught, is dispersed even further. Additionally it seems that although long-range dispersal seems to be very likely, not all spores are equally suitable for long-range dispersal (of hundreds of kilometres). A strong correlation between spore size and fraction deposited within a couple of meters is described by Crum (1972), During (1979), Söderström & Jonsson (1989) and Miles & Longton (1992). They suggest that only spores up to 20–25 µm in diameter seem to be suitable for long-range dispersal and could be dispersed by wind for many hundreds of kilometres. On the other hand differences in spore dispersal are not only caused by diameter of the spore, they are also a result of different other factors like landscape surface, vegetation cover, wind velocity, wind direction, structure of the sporogonium (e.g. length of the seta, peristom) and the survival of spores during long-range dispersal which was studied by van Zanten (1978).

Vegetative diaspores on the other hand may have an improved probability of rapid and successful establishment compared to spores (Newton & Mishler 1994), because of the larger size and the amount of initial resources. Whereas the main vector for spore dispersal seems to be wind, a great amount of vegetative diaspores is likely to be not dispersed or only within a very short range (1–10 cm) from the parent colony, like Kimmerer (1991b) reports. Especially diaspores resulting from clonal reproduction (e.g., fragmentation) will mostly stay at or close to the mother plant because these diaspores are usually (at least in most pleurocarpous

mosses) entangled within patches (Pfeiffer et al. 2006). If dispersal of the vegetative diaspores occurs, patterns are affected by the microtopography of the habitat (Kimmerer & Young 1996) and by the type and size of the diaspores (Söderström & Herben 1997). Depending on area and structure of the diaspores wind can be a dispersal agent for vegetative diaspores, especially in Arctic and Antarctic regions (Miller & Ambrose 1976; Muñoz et al. 2004), but to a lesser extent in other regions (During 1997). In special cases, water might be a suitable vector for dispersal of vegetative diaspores, especially down slope, along rivers and streams and in estuaries (Joenje & During 1977, Pfeiffer et al. 2006). Other dispersal vectors are different animals from ants to wild boar (*Sus scrofa*) and roe deer (*Capreolus capreolus*) (compare, e.g., Heinken 2000, Heinken et al. 2001, King 2003, Rudolphi 2009). Also birds, which often use mosses as nesting material, are possible vectors for dispersal, if they are migratory birds also for long-range dispersal (Davison 1976). Besides wind, water and animals, dispersal by human activities should not be neglected (on purpose or accidentally). Especially pleurocarpous mosses played for a long period a role as packing material and were transported for this reason nearly worldwide (compare, e.g., Dickson 1967, Schofield & Crum 1972, Lewinsky & Bartlett 1982, Miller & Trigoboff 2001). Also dispersal in clothes (Van Zanten & Pocs 1981), by forestry activities and the frequent use for decoration in floristry are possibly involved in the dispersal of vegetative diaspores.

3 Materials and methods

3.1 Studied species

3.1.1 *Pseudoscleropodium purum*

Brachytheciaceae

Pseudoscleropodium purum (Hedw.) M. Fleisch. ex Broth.
in Engl., Nat. Pflanzenfam., ed. 2, 11: 395. 1925

Hypnum purum L. ex Hedw., Sp. Musc. Frond.: 253. 1801
Brachythecium purum (Hedw.) Dixon. Stud. Handb. Brit. Mosses: 410. 1896
Scleropodium purum (Hedw.) Limpr. Laubm. Deutschl. 3: 147. 1896
(Koperski et al. 2000)

The systematic placement of *Pseudoscleropodium purum* was for a long time not clear, it was either placed in *Scleropodium* or in the genus *Pseudoscleropodium*. Recent molecular and morphological findings showed that *Scleropodium* is monophyletic (Vanderpoorten et al. 2005), having a basal position in the Brachythecioideae subfamily, whereas *Pseudoscleropodium purum* is according to molecular data placed in the Eurhynchioideae subfamily within the Brachytheciaceae (compare e.g., Huttunen & Ignatov 2004, Huttunen et al. 2007, Frey & Stech 2009).

3.1.1.1 Morphology

Plants robust, dioecious, in loose, pale green to yellowish-green wefts, in which the metabolically active parts become separated from the underlying soil by a layer of dead and decomposing shoots, 5–15 cm high. Stems creeping or ascending, remotely pinnate or subpinnate, not radiculose; stems and branches softly julaceous. Leaves concave, rounded-obtuse and abruptly apiculate at the tip. Stem leaves crowded 2–2.5 mm long. Branch leaves 1.5–2 mm long. Setae elongate, smooth, reddish, 30–50 mm long. Capsules strongly inclined to horizontal, 2–2.5 mm long. Calyptra naked. Spores 11–13 µm. Capsules rare, autumn, winter. Rhizoids rare (compare, e.g., Brotherus 1923, Wigh 1972, Crum & Anderson 1981, Mägdefrau 1982, Buck 1998, Bates & Duckett 2000, Smith 2004).
Chromosome number: n = 7 Japan; n = 9–10 Central Europe; n = 11 British Isles, Poland, Norway, Sweden and Finland (Crum & Anderson 1981, Fritsch 1991).

3.1.1.2 Reproduction

Sporophytes, rare in present times, but were according to herbarium material found more frequently around 1900 in Germany (Nebel & Philippi 2001). Rarely fruiting in Great Britain (Smith 2004). Not fruiting in North America (Lawton 1960, Lawton 1971, Crum & Anderson 1981). Asexual reproduction by fragmentation, through decay of older shoots, resulting in disintegration of shoots, thus forming ramets (e.g., Longton & Schuster 1983, King 2003).

Fig. 1. Distribution of *Pseudoscleropodium purum* (green) in Germany according to Meinunger & Schröder (2007). Sampling localities of *Pseudoscleropodium purum* populations in Germany are marked. Plot localities (Sil1 and NH1) are especially indicated.

3.1.1.3 Ecology

Perennial, in calcareous to mildly acidic situations, on soil, rocks and tree bases. In at least partly shaded habitats, in grassland, on roadsides, banks, heaths, in marshes, quarries, woods (especially in grassy places or clearings of coniferous woodlands) and on cliff ledges (Crum & Anderson 1981, Heyn & Herrnstadt 2004, Smith 2004).

3.1.1.4 Plant communities

K Hylocomietea splendentis, O Hylocomietalia splendentis, V Pleurozion schreberi (Marstaller 1993); VC Pleurozion schreberi, typical companion in Vaccinio-Piceetea, frequent in Dicrano-Pinion and Piceion abietis (Nebel & Philippi 2001); Ass.: Pleurozietum schreberi (Drehwald & Preising 1991). It occurs in Pleurozion schreberi, Thlaspietea, Molinio-Arrhenatheretea, Festuco-Brometea, Koelerio-Corynephoretea, Calluno-Ulicetea, Erico-Pinetea, Alnion incanae and Quercion ilicis (Dierßen 2001).

3.1.1.5 General distribution

European temperate distribution (e.g., Frahm & Frey 2004, Smith 2004). *Pseudoscleropodium purum* is common in central and western Europe (e.g., Störmer 1969, Hill et al. 2006) including Fennoscandia where the range is markedly southern and western (Dickson 1973). The eastern border of the more continuous distribution seems to pass through Lithuania and the eastern parts of Poland, Slovakia, and northern Hungary. There are extensions of the distribution area east to the Carpathians in Romania, Greece, Bulgaria, and Turkey. Isolated occurrences are found in southern Finland and in the western and southern parts of Russia (Störmer 1969) e.g., St.-Petersburg, Belgorod and Rostov-na-Donu (Ignatov & Ignatova 2004). The moss is also found in most parts of Italy and the northern and western parts of the Pyrenean Peninsula (Störmer 1969). Beyond continental Europe it occurs on the British Isles, Iceland, the Azores, Madeira and the Canary Islands (Miller & Trigoboff 2001). It is presumably native to Europe but now widespread due to introduction, often with nursery stock (Buck 1998). It was probably introduced to the Atlantic islands of St. Helena and Tristan da Cunha as packing material of young trees (Dickson 1967). In Middle and South America it is found in Jamaica (Bartram 1936), Argentina (Buck 1998), Chile (Allen & Crosby 1987) and Brazil (Schäfer-Verwimp 1989). It is adventive in North America: Newfoundland, Nova Scotia, Maine, Massachusetts, Michigan, New Hampshire, New York and on the West Coast from California to British Columbia, where it grows commonly in

lawns, gardens and cemeteries (Lawton 1960, Miller & Trigoboff 2001, Crum 2004, Schofield 2008) and Hawaii (Hoe 1971). It occurs in Israel (Heyn & Herrnstadt 2004), Réunion, Sri Lanka (Townsend 1975), south-eastern Australia (Victoria, New South Wales and Tasmania, compare, e.g., Dalton et al. 1991, Hedenäs 2002, Streimann & Klazenga 2002), New Zealand (Lewinsky & Bartlett 1982), Japan (Iwatsuki 2004), Taiwan (Wang 1970), S. Africa (Arts 1998, O'Shea 2006) and northern Africa (Algeria, e.g., Nebel & Philippi 2001).

The distribution in Germany is shown in Fig. 1, the worldwide distribution in Fig. 2.

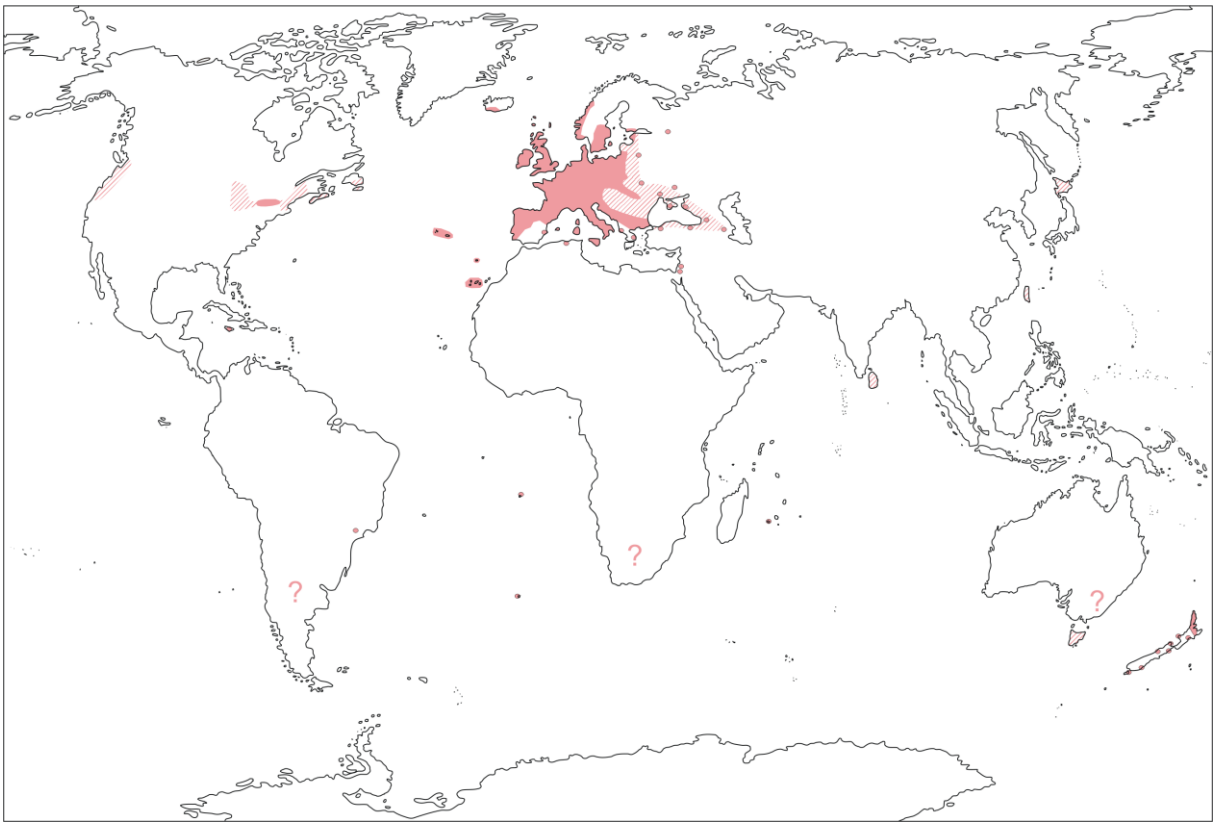


Fig. 2. Worldwide distribution of *Pseudoscleropodium purum* according to various authors (cited in chapter 3.1.1.5) and distribution maps by Schofield & Crum (1972) and Störmer (1969). Areas with low densities are marked by hachures, uncertain areas and areas without exact locality information are marked by interrogation marks.

3.1.2 *Pleurozium schreberi*

Hylocomiaceae

Pleurozium schreberi (Brid.) Mitt.
J. Linn. Soc., Bot. 12: 537. 1869

Hypnum schreberi Willd. ex Brid., Muscol. Recent. Suppl. 2(2): 88. 1801
Entodon schreberi (Brid.) Mönk.
(Koperski et al. 2000)

3.1.2.1 Morphology

Plants medium-sized to rather large, dioecious, in pale green to yellowish green patches or coarse wefts, sometimes extensive. Shoots to 7–16 (–18) cm long; stems deep red, erect-ascending from a decumbent base, central strand poorly developed, outer layer of cells undifferentiated. Shoots complanately pinnately branched, branches short and of uniform length along stems, often slightly down-curved. Leaves loosely imbricate, 2–2.8 x 1–1.5 mm, making stems and branches somewhat jualaceous; stem leaves ovate or broadly ovate, obtuse or rounded; margins incurved above, entire; costa very short, double; cells incrassate, basal trapezoid to elliptical, alar cells rectangular, yellow-brown to brown, forming distinct auricles, cells above linear, in mid-leaf 6.5–10.0 x 60–132 µm, 8-16 times as long as wide. Branch leaves smaller, obtuse to acuminate. Seta 2–4.3 cm long, thin, smooth, red, twisted. Capsules inclined, 2–2.5 mm long, ovoid, curved; lid conical, obtuse or apiculate. Peristom double; exostomen teeth yellow, finely papillose throughout, endostomen pale yellow with tall basal membrane, processes keeled with widely gaping perforations, cilia well developed. Spores rubiginose, (12–)14–18(–20) µm, finely papillose, sporophyte production in spring. Calyptra cucullate, smooth, naked (compare, e.g., Brotherus 1923, Wynne 1945, Lawton 1971, Crum & Anderson 1981, Mägdefrau 1982, Rohrer 1985, Kuta et al. 1998, Nebel & Philippi 2001, Smith 2004).
Chromosome number: n = 5 Europe, Canada (British Columbia), USA (Michigan), Japan (e.g., Crum & Anderson 1981, Fritsch 1991).

3.1.2.2 Reproduction

Pleurozium schreberi is very rarely fruiting in Great Britain and northern Europe (Longton & Greene 1969a, Smith 2004), but is mentioned to produce sporophytes rather freely in Finland (Huttunen 2003). Arctic (Canadian Arctic, Svalbard and northern Siberia) specimens with sporophytes are unknown (Kuc 1997). Sporophytes have not been observed in the Neotropics

(Gradstein et al. 2001). Nearly no fruiting specimens are known from Baden-Württemberg (Germany) after 1950, whereas there are lots of fruiting herbarium specimens from earlier periods. In other German parts it is described to be rarely fruiting (Nebel & Philippi 2001).
During fieldwork (2005–2008) four populations with sporophytes in southern Berlin and Brandenburg (Berlin Forst-Düppel, Saarmund, Löbten, Köthen), and a one population with sporophytes in Thuringia (Dietzhausen), were found.
Observations by Stoneburner (1979) suggest that clumping of sexes may influence the probability of fertilisation and therefore the production of sporophytes.
According to Crum (2004) and Gradstein et al. (2001) no apparent asexual structures are known. Longton & Schuster (1983) note that caducous leaves, including both normal vegetative and specialised diminutive leaves, regularly become detached from the parent shoots.

3.1.2.3 Ecology

Perennial with life strategy of the perennial stayer type (During 1979), according to Dierßen (2001) a competitive perennial. On humus, soil and other substrata. In dry, open woods, also in bogs and wet, coniferous forests, in acid grassland, scree, on heaths and sand-dunes, from 0–2000 m, sometimes higher (up to 5000 m in Bhutan, e.g., Gangulee 1980); considered an indicator of acid soils (compare, e.g., Lawton 1971, Crum & Anderson 1981, Smith 2004).

3.1.2.4 Plant communities

K Hylocomietea splendentis, O Hylocomietalia splendentis, V Pleurozion schreberi (Marstaller 1993); VC Pleurozion schreberi, typical companion in Vaccinio-Piceetea, frequent in Dicrano-Pinion and Piceion abietis (Nebel & Philippi 2001); Ass.: Pleurozietum schrebri AC (Drehwald & Preising 1991). It occurs in Pleurozion schreberi, Ptilidio-Hylocomietum, Allusuro-Athyrion, Potentillo-Polygonion, Caricion ferruginei, Oxycocco-Sphagnetea, Loiseleurio-Vaccinietea, Calluno-Ulicetea, Vaccinio-Piceetea, less frequently Seslerietea, Festuco-Brometea and Adenostyletalia (Dierßen 2001).

Fig. 3. Distribution of *Pleurozium schreberi* (green) in Germany according to Meinunger & Schröder (2007). Sampling localities of *Pleurozium schreberi* in Germany (and Salzburg) are marked. Plot localities (Sil1, Sil2 and Saarm1) are especially indicated.

3.1.2.5 General distribution

Circumpolar boreo-temperate distribution. Europe north to Iceland, Faroe Islands (Smith 2004) and Svalbard (Kuc 1973, Frisvoll & Elvebakk 1996), southeast to Caucasus and Turkey, west to Azores and Madeira (Smith 2004). In the western hemisphere in Greenland (Lewinsky & Mogensen 1979), Canadian Arctic (Kuc 1969, 1997) to Alaska and south (principally in uplands) to north North Carolina, Arkansas, Colorado, Idaho and Oregon (compare, e.g., Wynne 1945, Crum & Anderson 1981); Mexico, Costa Rica (Sharp et al. 1994) and northern South America (Colombia, Venezuela, Peru and Bolivia, e.g., Delgadillo et al. 1995). Across northern and central Asia (Himalaya) (Hill et al. 1994, Smith 2004), southern China (Yunnan) (He 2005), Bhutan, Japan (Gangulee 1980, Iwatsuki 2004), Korea (Horikawa 1971) and in Africa in Ethiopia (Ochyra & Bednarek-Ochyra 2002, O'Shea 2006). The distribution in Germany is shown in Fig. 3, the worldwide distribution in Fig. 4.

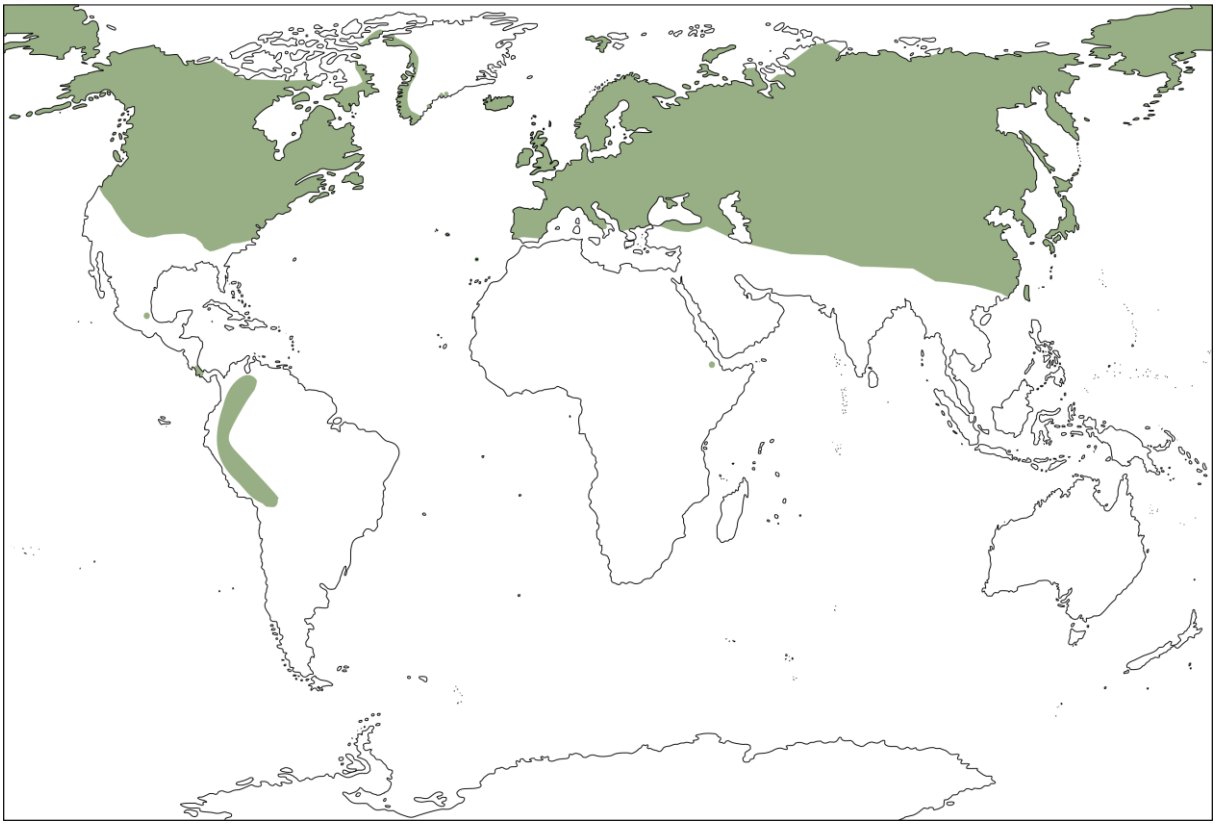


Fig. 4. Worldwide distribution of *Pleurozium schreberi* according to various authors (see chapter 3.1.2.5) and different distribution maps (e.g., Sjödin 1980).

3.1.3 *Rhytidiadelphus squarrosus*

Hylocomiaceae

Rhytidiadelphus squarrosus (Hedw.) Warnst.
Krypt.-Fl. Brandenburg, Laubm. 2: 918. 1906

Hypnum squarrosum L. ex Hedw., Sp. Musc. Frond.: 281. 1801
Hylocomium squarrosum (Hedw.) Schimp.
(Koperski et al. 2000)

3.1.3.1 Morphology

Plants robust, dioecious, pale green to yellowish, in coarse tufts or wefts, sometimes extensive, often brownish below. Shoots to 15 cm long; stems erect or ascending at least at tips, towards end reddish, elsewhere reddish brown, concealed by sheathing leaf base, irregularly or sometimes sparsely pinnately branched. Branches short or sometimes long and attenuate. Leaves not plicate; stem leaves strongly squarrose (Smith 2004), 3–4 x 1.5–2 mm (branch leaves often smaller, e.g., Lawton 1971), at tips crowded rendering tips stellate in appearance, from sheathing broadly ovate basal part narrowed to long acuminate apex; margins plane, denticulate above; costa double, extending 1/4–1/3 way up leaf; basal cells narrowly rhomboidal, alar cells enlarged, hyaline or coloured, forming distinct group, cells above linear-elliptical, smooth, in mid-leaf 6–9 x 40–80 (–86) µm, 7–10 (–12) times as long as wide (Smith 2004). Seta about 2–3.5 cm long (Brotherus 1923), flexuose, sometimes bend or twisted. Capsules horizontal 1.8–2.5 mm long (Crum & Anderson 1981), ovid, gibbous; lid conical, acute. Spores 18–20 µm. Capsules rare, winter (Smith 2004).
Chromosome number: n = 6 Great Britain, Poland Germany; n = 8 Finland; n = 10 Great Britain, Denmark, Sweden, Latvia, Ukraine and Japan (Lawton 1971, Crum & Anderson 1981, Fritsch 1991, Smith 2004).

3.1.3.2 Reproduction

Sporophytes are rare in Great Britain and Germany (compare, e.g., Düll 1994, Nebel & Philippi 2001, Smith 2004) and unknown in Greenland (Lewinsky & Mogensen 1978).
Vegetative reproduction is not described, gemmae are lacking (Hill et al. 1994), but Nebel & Philippi (2001) predict that shoot fragments likely act as vegetative diaspores. Correns (1899) mentions that protonema can be formed on intersections of stems.

3.1.3.3 Ecology

Wide ecological tolerance, occurring on all but the most acid soils in a variety of grassy habitats, including sheep pastures, roadside verges, woodland rides, lawns, dunes, streamsides, ditches and marshes (Hill et al. 1994), usually where damp, from 0–1225 m (–1700 m) (Smith 2004).

Fig. 5. Distribution of *Rhytidiadelphus squarrosus* (green) in Germany according to Meinunger & Schröder (2007). Sampling localities of *Rhytidiadelphus squarrosus* in Germany marked. Plot localities (B1 and Sil3) are especially indicated.

3.1.3.4 Plant communities

K Molinio-Arrhenatheretea (Nebel & Philippi 2001); O Hylocomietalia splendentis (Marstaller 1993, Nebel & Philippi 2001)

3.1.3.5 General distribution

European boreo-temperate (Smith 2004). Widespread throughout Europe north to Svalbard (Kuc 1973), Faroe Islands and Iceland (Smith 2004), rare or missing in Lapland (Koponen 1975). South to Caucasus, Turkey, Azores and Madeira (Smith 2004). Common in South and West Greenland, local in East Greenland (Lewinsky & Mogensen 1978). In North America from Newfoundland and Labrador to Ontario and Michigan, south in the mountains to North Carolina and Tennessee (not common in eastern North America), throughout the boreal coniferous forest zone of Canada, in the west from Alaska and Aleutians south to Oregon and Nevada at higher elevations (compare, e.g., Steere 1978, Crum & Anderson 1981). North and East Asia: China, Korea, Russia (He 2005) and Japan (Iwatsuki 2004). Introduced in New Zealand (Hill et al. 1994, Espie 1997) and Tasmania (Dalton 1997). The German distribution is shown in Fig. 5, the worldwide distribution in Fig. 6.

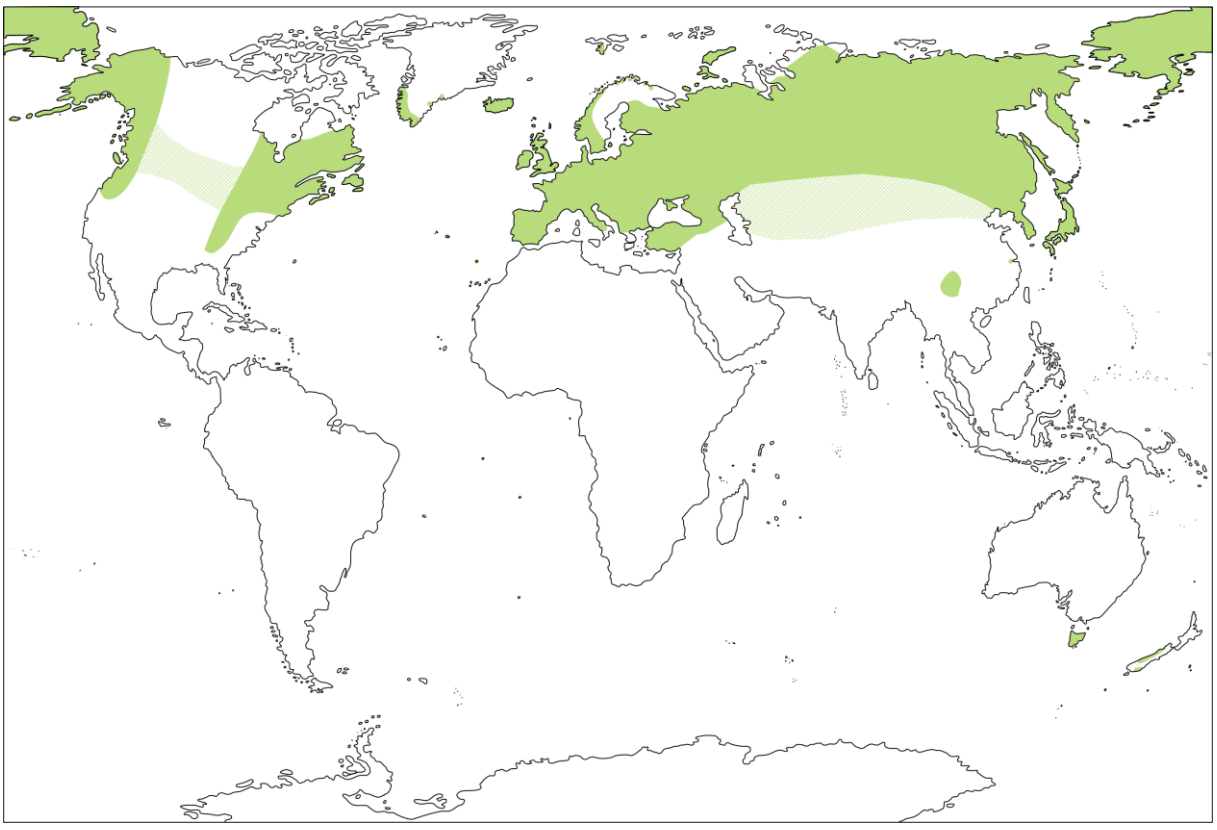


Fig. 6. Worldwide distribution of *Rhytidiadelphus squarrosus* according to various authors (see chapter 3.1.3.5) and different distribution maps (e.g., Sjödin 1980). Areas with uncertain dimensions are marked in light green.

3.2 Study areas

3.2.1 Topography

Field work was carried out in different localities in Thuringia, Berlin and Brandenburg. Altogether six plots of different size (depending on habitat conditions, see Table 2) as well as three sites for morpho-ecological analysis (gap re-colonisation, only in Brandenburg close to plot NH1) were set. For detailed information and Braun-Blanquet plant sociological relevés (Braun-Blanquet 1964) see appendix A1.

Table 2. Localisation of investigated populations, with collection date and plot size.

Plot	**Sil1**	**Sil2**	**Sil3**	**B1**	**NH1**	**Saarm1**
Locality	Dietzhausen	Dietzhausen	Dietzhausen	Berlin-Pankow	Neuehütte	Saarmund
Country	Thuringia	Thuringia	Thuringia	Berlin	Brandenburg	Brandenburg
Collection date	14.05.2007	14.05.2007	14.05.2007	16.10.2006	16.05.2007	13.06.2006
Latitude	50°35'46.8''N	50°35'45.2"N	50°35'45.6''N	52°33'38.4''N	52°52'23.8''N	52°18'53.0''N
Longitude	10°35'04.6''E	10°35'04.7"E	10°35'07.0''E	13°24'13.7''E	13°50'45.1''E	13°06'31.9''E
Altitude [m a.s.l.]	428	433	377	54	63	78
Altitudial zone	montane	montane	montane	lowland	lowland	lowland
Plot size	15 m²	12 m²	15 m²	6 m²	35 m²	18 m²
Investigated species	*P. schreberi* *P. purum*	*P. schreberi*	*R. squarrosus*	*R. squarrosus*	*P. purum*	*P. schreberi*

3.2.1.1 Thuringia (Plots Sil1, Sil2 and Sil3)

Three plots were set in the southern Thuringian Forest, in the valley Bärental (see Fig. 7 and Fig. 8) close to the village Dietzhausen, which is part of the city Suhl. The three plots are named Sil1 (50°35'46.8''N, 10°35'04.6''E Elev. 428 m, see Fig. 9), Sil2 (50°35'45.2''N, 10°35'04.7''E Elev. 433 m, see Fig. 10), and Sil3 (50°35'45.6''N, 10°35'07.0''E Elev. 377 m, see Fig. 11). Plot Sil1 and Sil2 are situated within a Vaccinio-Abietetum Oberd. 1957 in eastern exposition with high densities of *Pseudoscleropodium purum* and *Pleurozium schreberi.* Sil3 is located on the edge of the forest in transition to open grassland (Molinio-Arrhenatheretea R. Tx. 1937), which is frequently used by flocks of sheep, here *Rhytidiadelphus squarrosus* builds huge patches and dominates the vegetation

.

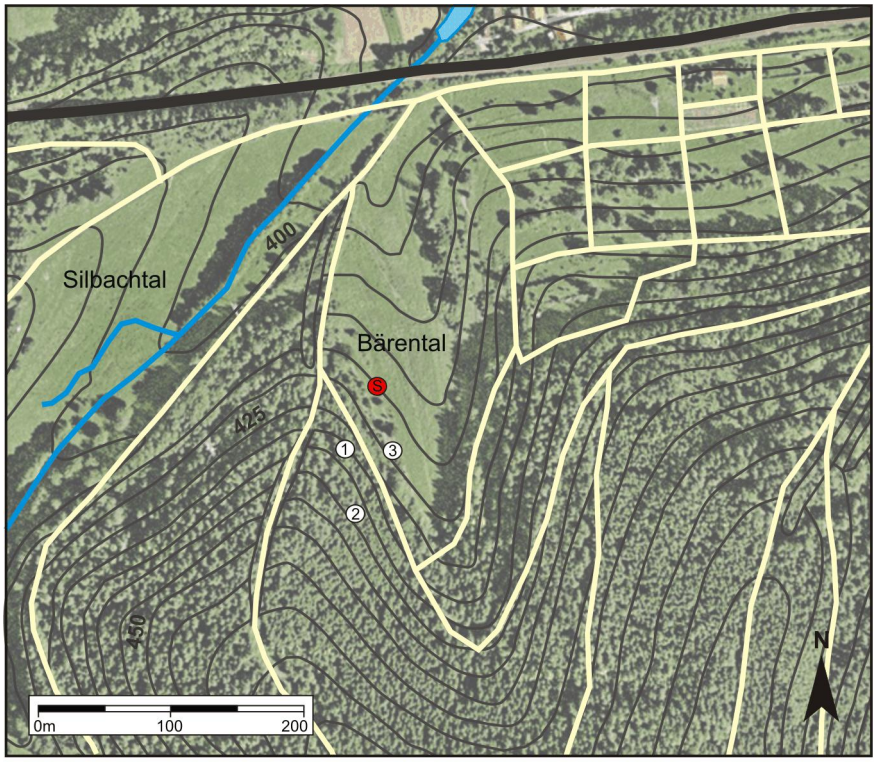


Fig. 7. Localisation of the plots Sil1 (1), Sil2 (2), Sil3 (3), and a sporophyte discovery of *Pleurozium schreberi* (S) in the valley Bärental. Railroad black, river blue, side roads and forest roads yellow. Ground layer by Google maps (10/2008), overlay TK 10.

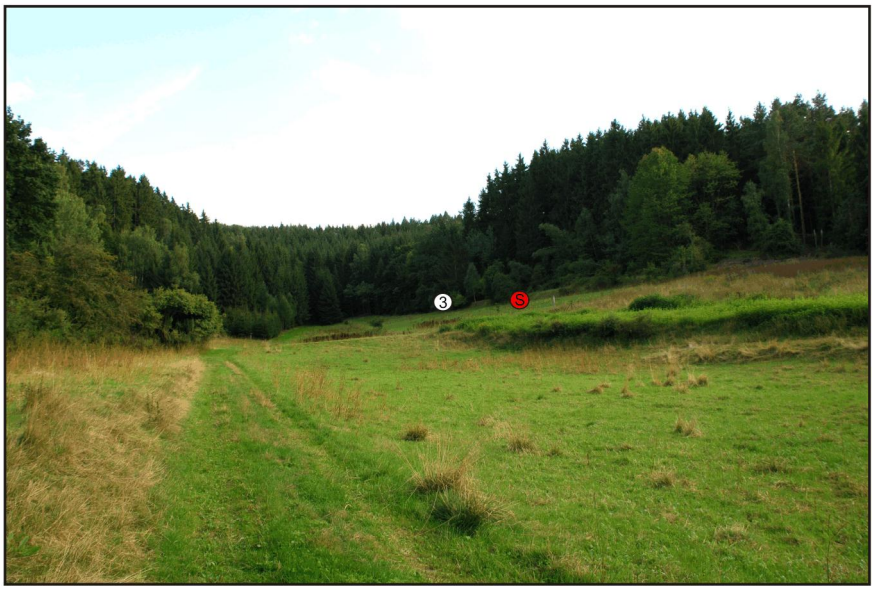


Fig. 8. View into Bärental valley in Southern direction. Plot Sil3 (3) and location of sporophyte discovery of *Pleurozium schreberi* (S) marked.

Fig. 9. Plot Sil1 (Thuringia) with *Pseudoscleropodium purum* and *Pleurozium schreberi* patches.

Fig. 10. Plot Sil2 (Thuringia) with *Pleurozium schreberi* patches and a *Vaccinium myrtillus* cover.

Fig. 11. Plot Sil3 (Thuringia) nearly totally covered by *Rhytidiadelphus squarrosus.*

3.2.1.2 Berlin (Plot B1)

Plot B1 (52°33’38.4’’N, 13°24’13.7’’E, Elev. 54 m, see Fig. 12) is located in Berlin-Pankow on a public lawn (Molinio-Arrhenatheretea R. Tx. 1937, Saatgrasland) (Schubert et al. 2001), where *R. squarrosus* dominates the vegetation in moist and shady places. Additionally to plot samples, samples were collected in a transect along the lawn edge (every 20 m).

Fig. 12. Plot B1 (Berlin-Pankow) on public a lawn, between Zillertalstraße and Maximilianstraße with large *Rhytidiadelphus squarrosus* patches.

3.2.1.3 Brandenburg (Plots NH1 and Saarm1)

Two plots were set in Brandenburg, one south of Berlin close to the village Saarmund (Saarm1: 52°18’53.0’’N, 13°06’31.9’’E, Elev. 78 m, see Fig. 13) on top of a glacial sand dune in transition between Leucobryo-Pinetum Matusz. 1962 and Vaccinio vitis-idaeae-Quercetum petraeae Oberd. (1957) 1992. The other plot is situated north of Berlin in a douglas fir plantation (e.g., Schubert et al. 2001) between Britz and Neuehütte (NH1: 52°52’23.8’’N, 13°50’45.1’’E, Elev. 63 m, see Fig. 14) close to the city Eberswalde.

Fig. 13. Plot Saarm1 (Brandenburg) during fieldwork (using a mapping frame) collecting *Pleurozium schreberi* samples.

Fig. 14. Plot NH1 (Brandenburg) with *Pseudoscleropodium purum* patches.

3.2.2 Gap re-colonisation experiments

Close to plot NH1 three small plots of 50 cm x 50 cm were set within pure colonies of *P. purum*, both vegetation and litter layer were removed, the re-colonisation was observed and photographically documented for a period of two years (four times a year).

3.2.3 Climate

The climate in the Brandenburg/Berlin study areas is sub-continental with mean annual temperatures from 8.3 °C (Angermünde), 8.7 °C (Potsdam) and 9.2 °C (Berlin-Dahlem). The annual mean precipitation is 532 mm in Angermünde, 578 mm in Berlin-Dahlem and 592 mm in Potsdam. The mean annual temperature in the southern Thuringian Forest where plots Sil1, Sil2 and Sil3 are set is 6.9 °C, thus 1.4 °C less compared to Angermünde and 2.3 °C less compared to Potsdam. The annual mean precipitation is with 560 mm, 18 mm less than in Berlin-Dahlem (Mühr 2007).

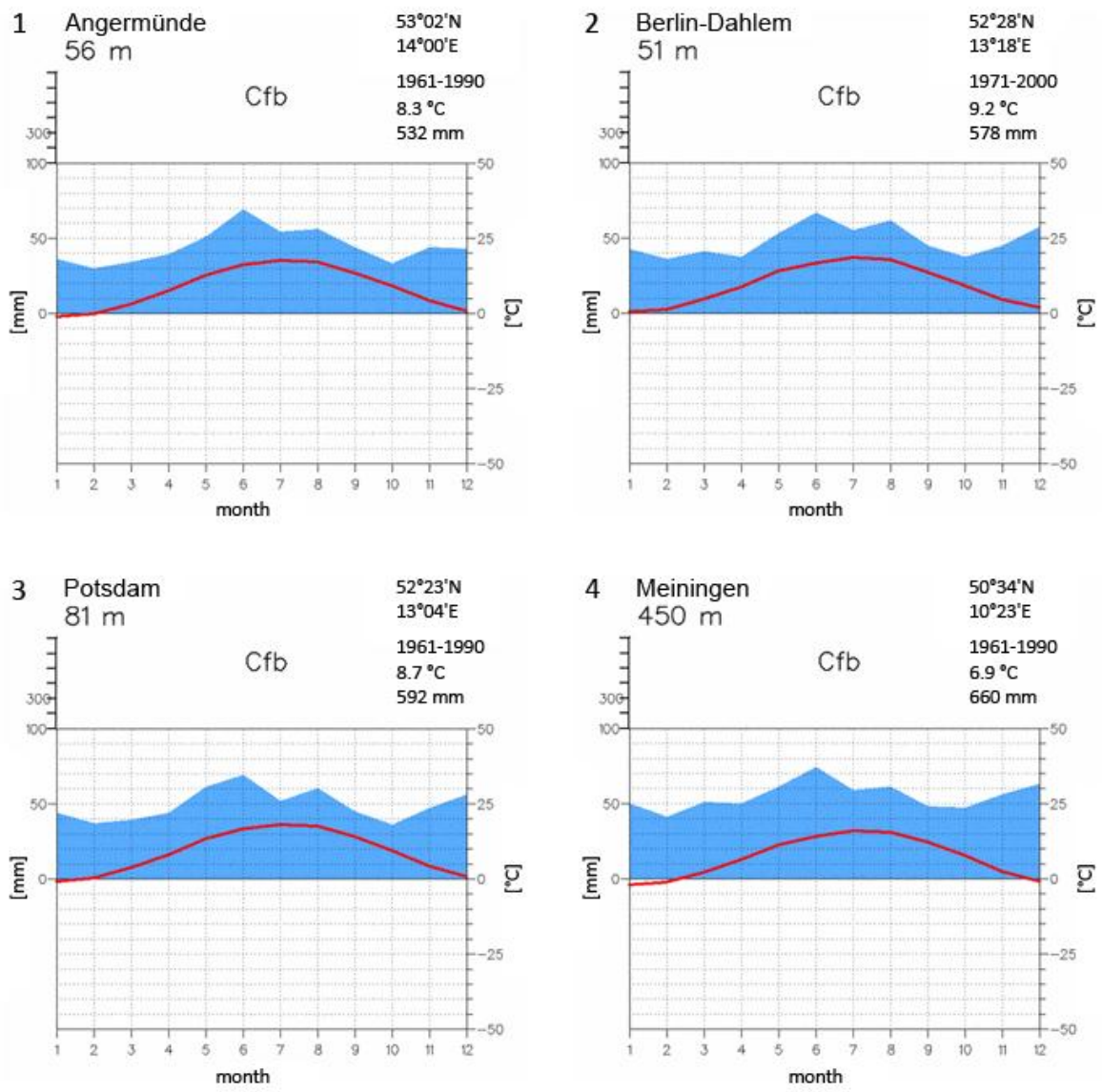


Fig. 15. Climate diagrams of study areas (Mühr 2007, modified), showing elevation [m a.s.l.], coordinates, time period, average temperature (red), average precipitation (blue) and climate classification according to Kottek et al. (2006) (Cfb = C: warm temperate, f: fully humid, b: warm summer). (1) Angermünde referring to the climate of NH1, (2) Berlin-Dahlem referring to B1, (3) Potsdam referring to Saarm1 and (4) Meiningen referring to Sil1, Sil2 and Sil3.

3.3 Sampling of plant material

3.3.1 Method of sampling

Sample material was taken from every patch of *Pleurozium schreberi, Rhytidiadelphus squarrosus* and *Pseudoscleropodium purum* within the respective plots.

Pleurozium schreberi was collected in plots Sil1, Sil2 and Saarm1.
Rhytidiadelphus squarrosus was collected in plots Sil3 and B1.
Pseudoscleropodium purum was collected in plots Sil1 and NH1.

One to several shoots (depending on patch size) were collected and air-dried in paper bags. The location was marked on a map (ratio 1:10) with the help of a self-constructed wooden "mapping frame" (1x1 m, see Fig. 13). A map of each plot can be found in appendix A4.
The vascular plant and terricolous bryophyte vegetation of every plot was conducted according to the method of Braun-Blanquet (1964). For each plot the following data were recorded (see appendix A1):

- Location with coordinates (determined with GPS Garmin Gecko)
- Altitude a.s.l. (determined with GPS Garmin Gecko)
- Altitudial zone
- Exposition (determined with a Recta compass)
- Inclination [°] (determined with a Recta compass)
- Relief
- Cover of tree and shrub layer [%] (approximation)
- Cover of herb layer [%] (approximation)
- Cover of bryophyte layer [%] (approximation)
- Ground cover [%] (approximation)
- Height of tree layer [m] (approximation)
- Height of shrub layer [m] (approximation)
- Height herb layer [m] (approximation)
- Plot size [m²]

Additional plant material from other German populations (for details see appendix) in Mecklenburg-Western Pomerania (MV), Brandenburg (BB), Berlin (BE), Saxony (SA), Thuringia (TH), Lower Saxony (NI), Hesse (HE), Northrhine-Westphalia (NW), Bavaria (BY), Baden-Württemberg (BW), and from populations in Austria, Slovakia and Slovenia were collected during field trips (2005–2008) and air-dried in paper bags.

3.3.2 Foreign specimens

Foreign air-dried plant material was kindly provided by K. Thomas (France), T.L. Blockeel (England), P.J. Dalton (Scotland and Australia) and W.B. Schofield (Canada). Additionally the herbaria (S) Naturhistoriska Riksmuseet, Stockholm; (MUB) Herbarium Universitatis Murcicae; (MHA) Main Botanical Garden, Moscow; (CHR) Allan Herbarium, Landcare Research, NZ and (JE) Herbarium Haussknecht, Jena provided material from Belgium, Norway, Sweden, Finland, Poland, Greece, Italy, France, Spain, Portugal (Azores and Madeira), Israel, United States, Canada, Russia and New Zealand (for details see specimen list in appendix A2).

3.3.3 Identification of *Rhytidiadelphus* specimens

Giving credit to the continuous discussion, whether *R. subpinnatus* is a distinct species with clear genetic differences or not (compare, e.g., Koponen 1971; Korpelainen et al. 2008; Vanderpoorten et al. 2003) and because of continuous problems with discrimination and

Table 3. List of characters used for discrimination between *Rhytidiadelphus squarrosus* and *Rhytidiadelphus subpinnatus* specimens in order of importance for identification. Characters suggested by (1) Koponen (1971), (2) Vanderpoorten et al. (2003) and (3) Müller (1995).

Characters	*R. squarrosus*	*R. subpinnatus*
Stem cortex (including epidermis) (2)	up to 4 or 5 layers (own observation often 3–4)	(1–)2–3 stratose (own observation often 2–3 or less)
Stem leaves (1,2,3)	from ovate base narrowed into a reflexed or squarrose, longly and finaly acuminate point	narrowed from a triangular or cordate base into a reflexed or squarrosely acuminate point,
Median leaf lamina (2)	cells wide, width varying between 6.0–9.5 µm	cells narrow, width varying between 4.0–8.5 µm
Branching (1,2,3)	irregularly pinnate, or branching few, secondary branching absent	mostly pinnate, secondary branches sometimes present
Stem (1,3)	concealed by sheathing leaf base	not concealed by sheathing leaf base
Branch leaves (1)	lowest often silmilar to stem leaves, upper longly acuminate, not only slightly undulate or plicate, teeth smaller	lowest mostly clearly different from stem leaves, upper shortly acuminate, often strongly undulate or plicate, teeth corase
Growth habit (1,2,3)	dense mats or tufts, stem apex often erect	loose mats, creeping, often depressed

misidentifications of *Rhytidiadelphus squarrosus* and *Rhytidiadelphus subpinnatus*, it was planned to include samples of *R. subpinnatus* as an outgroup in the AFLP fingerprinting. Because the identity of some material was doubtful all specimens coming from other than own collections were again determined. The identifications were carried out according to a list of characters suggested by Korpelainen et al. (2008), Müller (1995) and Vanderpoorten et al. (2003) (see Table 3). The best characters for identification were stem cortex layers of middle stem parts (see Fig. 16), shape of stem leaves, median leaf lamina and, to a lesser extent branching. The branching system only suits as an additional character, because secondary branching can also occur in *R. squarrosus* (according to own observations), even though it seems to be very rare. For the identification of herbarium material the growth habit turned out to be unsuitable because in most cases details are not well documented or not comparable. In the end two *R. subpinnatus* misidentifications were revealed, one from Russia and one from the USA. Both were together with two other Russian *R. subpinnatus* samples included in the molecular analysis.

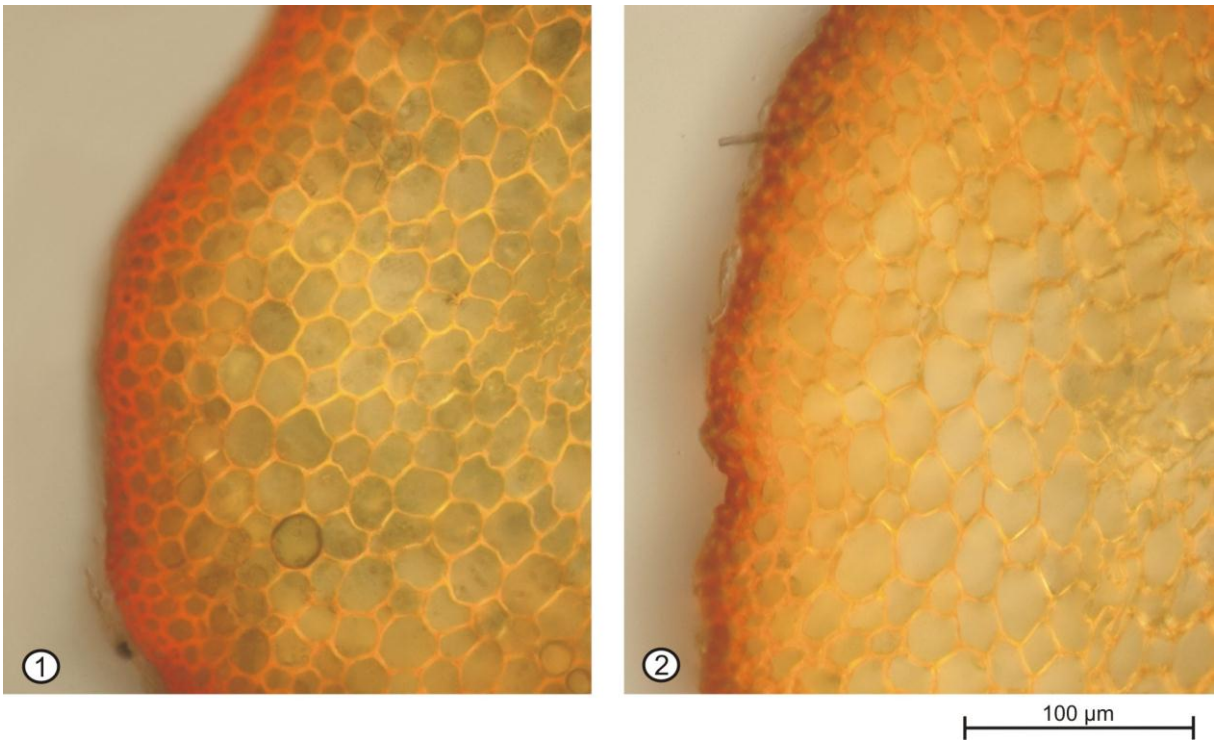


Fig. 16. Stem cross sections of *Rhytidiadelphus squarrosus* **(1)** and *Rhytidiadelphus subpinnatus* **(2)** with focus on the number of stem cortex layers (left 3–4, right 1–2) in middle stem parts (pictures by S. Fritz and Dr. R. Jahn, Zeiss Axioplan, with Zeiss AxioCam MCR, Botanic Garden and Botanical Museum Berlin-Dahlem).

3.4 Morpho-anatomical analysis

The collected shoots were investigated by binocular (Leica MS5 10–40×), light transmission microscope (Zeiss Axioplan) and scanning electron microscope (Leo 430) with a special focus on features of vegetative reproduction s.l. (see chapter 2.1), but also on those of generative reproduction.

3.5 Preparation of plant material for molecular analysis (AFLP)

Green apical branches of ≥ 1 cm in length were cleaned manually (using binocular microscope, sterile tweezers and pure water) and by ultrasound. After cleaning the material was dried and stored in silica gel Orange (Roth) until use.

3.6 Molecular analysis - AFLP Fingerprinting

3.6.1 Method

The AFLP-technique aims at detecting amplified fragment length polymorphisms by combination of restriction and PCR procedures. It comprises (i) digestion of total genomic DNA using two restriction endonucleases and ligation of double-stranded oligonucleotide-adapters (of known sequence) to the restriction fragments, (ii) selective amplification of sets of these fragments using generic primers that match the adapter sequences, but have one (preselective PCR) or more bases at the 3’ end (selective PCR), and (iii) gel electrophoresis and detection of amplified fragments (Vos et al. 1995). Because the AFLP-technique depends on good DNA quality it was tried to use fresh whenever possible and herbarium material not older than ten years.

3.6.2 Used protocol

For detection and visualisation of fragments, the original AFLP protocol (Zabeau & Vos 1993, Vos et al. 1995) uses radioactively labeled primers. In this study a protocol with a biotin-streptavidin detection system introduced by Pfeiffer et al. (2005) was used (with slight modifications). A list of used chemicals, biochemicals and enzymes can be found in Table 4.

Fresh, silicagel-dried and herbarium material of the mosses *Pseudoscleropodium purum*, *Pleurozium schreberi*, *Rhytidiadelphus squarrosus* and *Rhytidiadelphus subpinnatus* was ground using a mixer mill MM200 (Retsch).

DNA was extracted using the NucleoSpin-Plant extraction kit (Macherey-Nagel-Inc., Easton, PA, USA). DNA concentrations were determined by spectrophotometry and set to 100 ng/µl with deionised H_2O (in most cases the concentration was less than 100 ng/µl, in this cases the extraction product was used without dilution). RNA was digested by incubation with 2 µl Ribonuclease I 'A' (0.5 µg/µl) per 100 µl DNA suspension for 30 min at 37°C.

The restriction mix contained *Eco*RI (2.5 U) and *Tru*1I (=*Mse*I; 1.5 U), 2.5 µl 10x OnePhorAll-buffer, deionised H_2O ad 25 µl, and 2.5 µl of diluted DNA (30-100 ng/µl genomic DNA). After incubation for 3 h at 37°C, 5 µl of the ligation cocktail were added to each digestion sample [0.5 µl *Eco*RI-adapter EA+/- (5 pmol/µl), 0.5 µl *Tru*1I-adapter TA+/- (50 pmol/µl), 0.25 µl ATP (25mM), 0.25 µl T4 DNA ligase (~2 U), T4 ligase buffer 10x (0.5 µl) and deionised H_2O ad 5µl]. The mix was incubated for 3 h at 37°C or overnight at room-temperature.

Two PCR reactions were carried out in a Biometra Tpersonal thermocycler, a preselective amplification with *Eco*RI+A [5'-GAC TGC GTA CCA ATT CA-3'] and *Mse*I+C [5'-GAT GAG TCC TGA GTA AC-3'] followed by selective amplifications. Nine primer combinations were tested with *Pseudoscleropodium purum*, *Pleurozium schreberi* and *Rhytidiadelphus squarrosus*. Two combinations were selected for each species, the best results (high levels of intraspecific polymorphisms, good readability and low failure rate) in all three species were achieved using 5´biotinylated *Eco*RI + AAC [5´-GAC TGC GTA CCA ATT CAAC-3´] / unlabeled *Mse*I + CAT [5´ GAT GAG TCC TGA GTA ACAT-3´] and unlabeled *Eco*RI + AGG [5´-GAC TGC GTA CCA ATT CAGG-3´] / 5´biotinylated *Mse*I + CTA [5´-GAT GAG TCC TGA GTA ACTA-3´]. All primers were purchased from Roth.

For the preselective PCR 0.375 µl each of *Eco*RI+A and *Mse*I+C (50 ng/µl) were mixed with 1.25 µl 10x PCR-buffer (Y), 2.5 µl 5x Enhancer Solution P, 0.25 µl dNTP-mix (2.5 pmol/µl of each dATP, dCTP, dGTP and dTTP), 0.125 µl *Taq*DNA polymerase (5 U/µl) and deionised H_2O ad 11 µl. 1.5 µl DNA template from the digestion/ligation solution were added; the sample was covered by 10 µl Chill-Out 14 Liquid Wax. After preselective PCR (2 min at 94°C, 20 cycles of 30 s at 94°C, 30 s at 60°C and 1 min at 72°C, final extension for 5 min at 72°C, cooling to 4°C), the samples were diluted 1:9 with deionised H_2O.

Selective PCR volumes contained 0.4 µl dNTP-mix, 2 µl 10x PCR-buffer (Y), 4 µl 5x Enhancer Solution P, 0.2 µl (50 ng/µl) primer *Eco*RI-ANN, 0.6 µl (50 ng/µl) primer *Mse*I-

CNN, 0.2 µl *Taq*DNA polymerase (5 U/µl), 7.6 µl deionised H_2O and 5 µl of the diluted preselection PCR products, overlaid with 15 µl Chill-Out 14 Liquid Wax. PCR parameters included a touch-down cycling with 5 min at 94°C, 11 cycles of 30 s at 94°C, 30 s at 65°C-58°C (-0.7°C in each cycle) and 1 min at 72°C, followed by 22 cycles with 30 s at 94°C, 30 s at 56°C and 1 min at 72°C, final extension for 2 min at 72°C, and cooling to 4°C. After removing the Chill-Out 14 Liquid Wax 7 µl Stop-/Loading buffer SequiTherm Excel II were added to the selective PCR samples.

DNA fragments from the selective amplification were separated in polyacrylamide gels of 0.4 mm thickness using the S2 sequencing system (GIBCO BRL, Life Technologies, Gaithersburg, MD, USA), allowing the simultaneous run of 50 samples (later in the study with new combs up to 98). After treatment of the larger glass plate with Silane A174 (Adhesion-Silane) for 20 min and the smaller one with Dichlorodimethylsilane (Repel-Silane) for 2x 10 min, and careful cleaning with ethanol (99%), the plates were assembled. 60 ml of a 6% UreaGel - SequaGel - 6 and 8 were subjected to ultrasound for ~15 min; an additional 20 µl TEMED solution and 200 µl 10% APS solution were added just before pouring the gel. After polymerisation for at least 2 h, the gel was pre-run *c.* 30 min at 60 W with 1x TBE buffer (pH 8.56; 0.9 M Tris-HCl, 0.9 mM boric acid, 0.5 mM EDTA) and 150 ml 3M sodium acetate in the lower buffer chamber. The PCR samples were denatured for 5 min at 94°C and immediately placed on ice, then 7 µl of each sample were loaded onto the gel. After electrophoresis (*c.* 2.5 h at 60 W) the smaller glass plate was removed. A nylon-membrane (porablot NY amp, Macherey-Nagel), wetted with 1x TBE, was placed onto the gel sticking to the larger glass plate and covered by 3MM Whatman paper and a glass plate.

After blotting overnight, the DNA-fragments were crosslinked to the dried membrane by UV-radiation (2 min at 312 nm). The fragments became visible after application of a standard protocol based on treatment with streptavidin alkaline phosphatase and the enzyme's substrate 5-Bromo-4-chloro-3-indolylphosphate-p-toluidinesalt (BCIP) and Nitro blue tetrazolium chloride (NBT). The membranes (divided for better handling) were incubated for 25 min in buffer-1 (pH 7.5; 121.14 g Tris, 87.66 g NaCl ad 1 l deionised H_2O, 1:10 diluted before use) with an additional 1% skimmed milk powder to block unspecific binding sites. After a short rinsing in buffer-1, the membrane parts were sealed in PE foils, along with 30 ml buffer-1 and 6 µl streptavidin alkaline phosphatase, and incubated for 25 min on a benchtop shaker. Afterwards, the membranes were washed two times for 10–15 min in buffer-1, rinsed in buffer-2 (pH 9.5; 12.114 g Tris, 8.844 g NaCl, 10.165 g $MgCl_2$ ad 1 l deionised H_2O) and placed in PE foils. Before sealing, 20 ml buffer-2, containing 100 µl NBT and 100 µl BCIP

suspended in 70% and 100% N,N-Dimethylformamide, respectively, were added to each membrane part. After incubation in the dark for about 1–3 h (depending on staining

Table 4. List of used chemicals, biochemicals and enzymes.

Name	Molecular formula	List of suppliers
5-Bromo-4-chloro-3-indolylphosphate-p-toluidinesalt (BCIP)	$C_{15}H_{15}N_2O_4BrClP$	Roth
5x Enhancer Solution P	--	PeqLab
10x OnePhorAll buffer	--	Amersham Biosciences
10x PCR buffer (Y)	--	PeqLab
APS Ammonium peroxydisulfate	$(NH_4)_2S_2O_8$	Roth
ATP	--	Epicentre
Boric acid	H_3BO_3	Roth
Chill-Out 14 Liquid Wax	--	MJ Research, Inc.
Dichlorodimethylsilane (2% in 1,1,1-Trichloroethan) (Repel-Silane)	$SiC_2H_4Cl_2$	Merck
dNTP-mix (dATP 98%, dCTP 98%, dGTP 98%, dTTP 98%)	--	Roth
*Eco*RI	--	MBI Fermentas
Ethanol (EtOH)	C_2H_6O	Roth
Ethylenediaminetetraacetic acid (EDTA)	$C_{10}H_{14}N_2O_8Na_2$	Roth
Hydrochloric acid	HCl	Roth
Magnesium chloride	$MgCl_2$	Roth
Nitro blue tetrazolium chloride (NBT)	$C_{40}H_{30}Cl_2N_{10}O_6$	Roth
N,N-Dimethylformamide	C_3H_7NO	Merck
N,N,N',N'-Tetramethylethylenediamine (TEMED)	$C_6H_{16}N_2$	Roth
Ribonuclease I 'A'	--	usb
Silane A174 (Adhesion-Silane)	$C_{10}H_{20}O_5Si$	Merck
Sodium acetate (NaOAc)	$C_2H_3NaO_2$	Roth
Sodium chloride	NaCl	Roth
Sodium hydroxide	NaOH	Merck
Stop/Loading buffer SequiTherm Excel II	--	Epicentre
Streptavidin alkaline phosphatase	--	Promega
T4 DNA ligase	--	Epicentre
T4 DNA ligase buffer 10x	--	Epicentre
Taq DNA polymerase	--	PeqLab
Tris(hydroxymethyl)aminomethane (Tris)	$C_4H_{11}NO_3$	Roth
*Tru*1I (*Mse*I)	--	MBI Fermentas
UreaGel - SequaGel - 6 and 8	--	national diagnostics

intensity), the membranes were removed from the foils, rinsed in tap water and airdried. The applied protocol results in visualisation of the generated AFLP fragments as purple stains on the nylon membranes.

3.7 Data scoring and analysis

The AFLP fragments blotted onto membranes were scored by eye. Presence (1) and absence (0) of bands were coded in a binary matrix including monomorphic and polymorphic bands. The resulting matrixes were imported into FAMD 1.108 beta (Schlüter & Harris 2006). The program also supports the input of missing data (e.g., due to blotting errors) and uses random assignments of band presence–absence to the missing data (missing bands were coded by "?" in the binary matrix). Pair-wise genetic distances (GD) were calculated according to the complementary value of Jaccard's similarity coefficient (SC_J) and the Simple-matching coefficient (SC_{SM}):

$$GD = 1 - SC$$

$$SC_J = \frac{n_{11}}{n_{11} + n_{10} + n_{01}} = \frac{n_{11}}{n - n_{00}} \qquad \text{(Jaccard 1908)}$$

$$SC_{SM} = \frac{n_{11} + n_{00}}{n_{01} + n_{10} + n_{11} + n_{00}} = \frac{n_{11} + n_{00}}{n} \qquad \text{(Sokal \& Michener 1958)}$$

where n is the total number of scored fragments, with n_{11} and n_{00} being the numbers of fragments present or absent found for a pair of samples, respectively (Sneath & Sokal 1973).

The difference between both coefficients is that the Jaccard coefficient only takes into account the bands present in at least one of the two individuals, and therefore is unaffected by homoplastic absent bands (when absence of the same band is due to different mutations). In contrast the Simple-matching coefficient maximises the amount of information drawn from AFLP profile by considering all scored loci (Bonin et al. 2007). In analyses the Jaccard coefficient tends to give lower levels of similarity than Simple-matching coefficient (Douhovnikoff & Dodd 2003), therefore both coefficients were tested in first place.

While dealing with missing data in the sample sets (according to reading difficulties and blotting problems) FAMD's (Schlüter & Harris 2006) option of random assignments of band

presence-absence (between a pair of samples x and y), was used for analyses based on pairwise similarity. The Average similarity option in FAMD is calculating the range of values that a data set containing missing data might generate, and can be considered in data interpretation. In the case of Jaccard's coefficient, the interval of possible similarity values is defined by minimum ($SC_{Jxy,min}$) and maximum ($SC_{Jxy,max}$) values of Jaccard's coefficient, so that $SC_{Jxy,min} \leq SC_{Jxy} \leq SC_{Jxy,max}$:

$$SC_{Jxy,\min} = \frac{n_{11}}{n_{11} + n_{01} + n_{10} + n_{1?} + n_{?1} + n_{0?} + n_{?0}}$$

$$SC_{Jxy,\max} = \frac{n_{11} + n_{1?} + n_{?1} + n_{??}}{n_{11} + n_{01} + n_{10} + n_{1?} + n_{?1} + n_{??}}$$

$SC_{Jxy,min}$ and $SC_{Jxy,max}$ are differently affected by particular comparisons, e.g. 1-? comparisons affect $SC_{Jxy,max}$ if ? = 1, and $SC_{Jxy,min}$ if ? = 0. Scoring missing data predominantly as 0 would increase $SC_{Jxy,min}$ and decrease $SC_{Jxy,max}$. An estimate of the uncertainty introduced by missing data is calculated by randomly drawing values of Jaccard's coefficient that lie within the interval [$SC_{Jxy,min}$; $SC_{Jxy,max}$] γ times. This allows estimations of mean and variance of Jaccard's coefficient.

In the case of Simple-matching coefficient, the minimum ($SC_{SMxy,min}$) and maximum ($SC_{SMxy,max}$) values of Simple-matching coefficient are defined, so that $SC_{SMxy,min} \leq SC_{SMxy} \leq SC_{SMxy,max}$.

$$SC_{SMxy,\min} = \frac{n_{11} + n_{00}}{n_{11} + n_{01} + n_{10} + n_{1?} + n_{?1} + n_{0?} + n_{?0}}$$

$$SC_{SMxy,\max} = \frac{n_{11} + n_{1?} + n_{?1} + n_{0?} + n_{?0} + n_{??} + n_{00}}{n_{11} + n_{01} + n_{10} + n_{1?} + n_{?1} + n_{0?} + n_{?0} + n_{??} + n_{00}}$$

Based on the distance matrixes of Jaccard coefficient and Simple-matching coefficient UPGMA (Unweighted Pair Group Method with Arithmetic Mean) (Sokal & Michener 1958) and NJ (neighbor joining) (Saitou & Nei 1987) trees were calculated. Whereas UPGMA assumes a constant rate of evolution, NJ is based on the minimum-evolution criterion for phylogenetic trees, i.e. the topology that gives minimal total branch length is preferred at each

step of the algorithm. Bootstrap values were performed with Jaccard and Simple-matching coefficient, UPGMA, 10000 replicates and 1000 maxtrees in FAMD.

Similar to the study of Pfeiffer et al. (2006) only samples with GD = 0 were counted among clones. Very close related samples are discussed as possible dividuals (ramets) of the same clone (because of possible PCR and/or reading errors) but were never counted among clones.

4 Results

4.1 Morpho-anatomical analysis

4.1.1 *Pseudoscleropodium purum*

4.1.1.1 Plot and patch descriptions

Pseudoscleropodium purum was collected within the plots NH1 35 m² (Brandenburg) and Sil1 15 m² (Thuringia). Within these plots *P. purum* forms numerous patches of different size from a few centimeters in diameter to nearly 4 m². The largest patches were located in plot NH1 with 3 patches > 1 m², whereas the largest patches of Sil1 are appr. ¼ m² (the spatial distribution is shown in appendix A4.2 and A4.5). Additional plant material from further German and foreign populations (see 2.3 and appendix A2) was included in this study. All together 66 specimens were closely observed in morpho-anatomical analysis (see appendix A3.1).

4.1.1.2 Generative reproduction

Morpho-anatomical analysis of *P. purum* patches and plants from plots NH1 and Sil2 revealed no hints of present or past generative reproduction, such as sporophytes (observed over a period of 3 years), archegonia or antheridia. The findings in one plant from plot NH1 are uncertain, because in the rotten basal part it shows small structures that may have been archegonia or antheridia.

Eight out of 31 plants of additional (German and foreign) origins showed archegonia (7) or antheridia (1), in three plants the gender remains uncertain because of the condition of the gametangia. Female plants with archegonia came from Germany (Thuringia, Hesse, Northrhine-Westphalia), Sweden, Spain, Azores, France and England, and the only male plant from the Azores. All other plants included in this study showed no sign of generative reproduction.

4.1.1.3 Vegetative reproduction

The morpho-anatomical examinations of *P. purum* plant material showed three morphological structures probably functioning as means of vegetative (asexual) reproduction s.l.

(1) Detached shoots (ramets) separated through decaying and subsequent disintegration of (older) shoot parts. This seems to the dominant vegetative reproduction mode: In all patches examined, most plants showed decaying basal shoot parts, resulting in highly fragile shoot

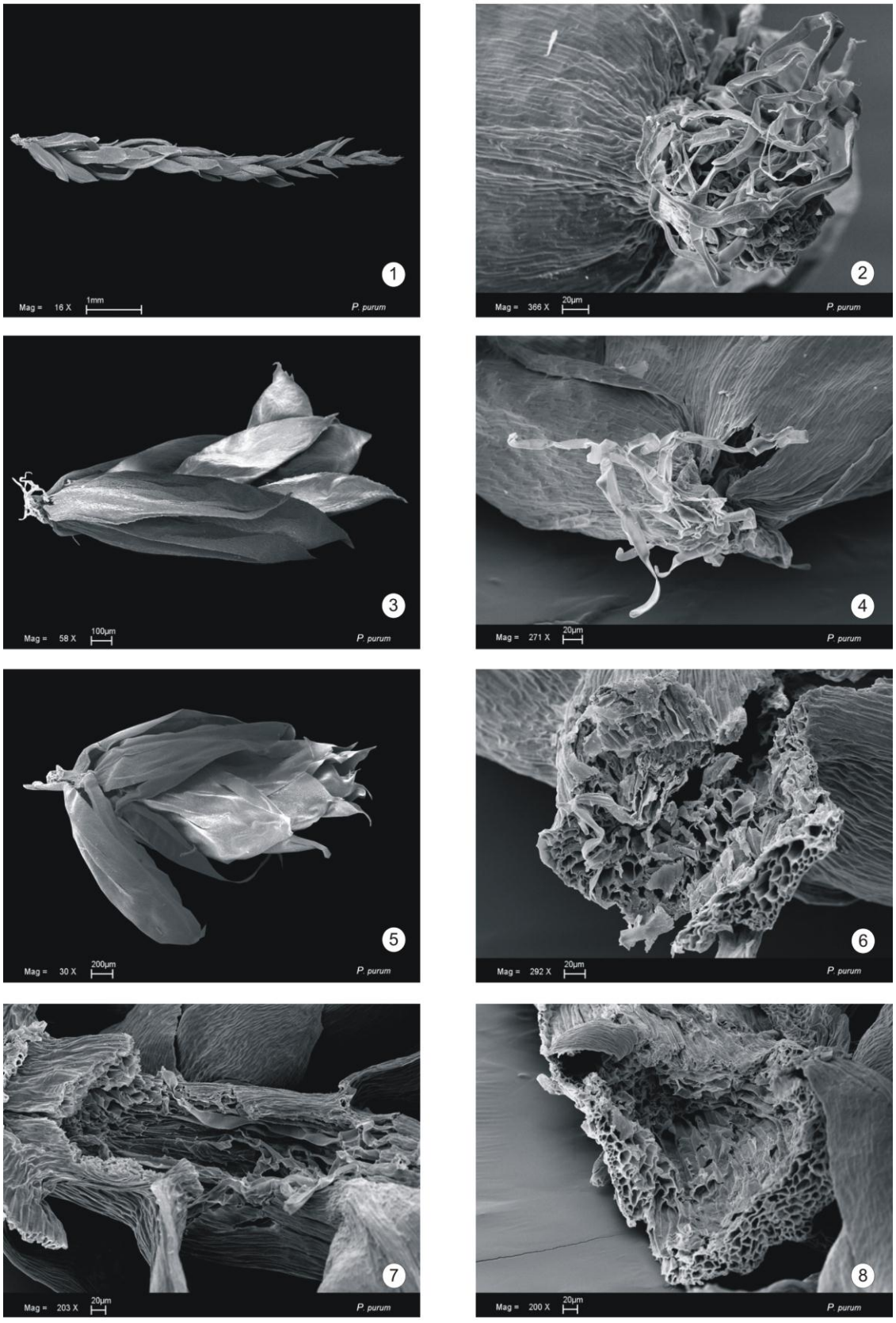


Fig. 17. Vegetative diaspores s.str. of *Pseudoscleropodium purum* [scanning electron microscope (SEM) photos]. **(1)** Brood branch/branchlet with rhizoids **(2)**. **(3)** Caducous shoot apex with **(4)** well-developed rhizoid growth. **(5)** Caducous shoot apex with starting rhizoid growth **(6)** resulting from lateral hole. Lateral holes in the apical parts of the stems **(7)** and **(8)**.

systems, their disintegration leading to separation of ramets (Longton & Schuster 1983, Pfeiffer et al. 2006), for growth forms see Fig. 30.

(2) Brood branches/branchlets sensu Correns (1899), were only observed three times in herbarium material. The observed brood branches showed basal rhizoid growth Fig. 17.1–2) and had a length of 7, 9 and 18 mm respectively.

(3) Caducous shoot apices (with basal rhizoids) sensu Correns (1899). These structures of 4–7 mm length were found eight times either separately or loosely attached to the tip of shoots in fresh and herbarium collections (Fig. 17.3–6). Two kinds of caducous shoot apices were observed. Firstly, caducous shoot apices with well developed rhizoids extending from the central part of the abscission zone (Fig. 17.3–4) were found separately in the material. Secondly, plants with lateral holes in the apical part of the stem were observed where caducous shoot apices were still loosely attached to the tip of the shoot. In these cases rhizoid development was mostly in an early stage (Fig. 17.5–6).

From 66 specimens observed, with an average of 48.1 (± 31.4) green shoot apices per plant, an average of 4.4 (± 7.2) green shoot apices were missing and could not be found in the collected material. Additionally to these findings lateral holes (of uncertain origin) in apical stem parts were observed and were interpreted as early stages of caducous shoot development (see Fig. 17.7–8).

4.1.1.4 Gap re-colonisation

With the aim of finding potential diaspores in a natural environment additional to the other observations, three small plots (50 cm x 50 cm) were set within pure colonies of *P. purum* close to NH1 (see Fig. 18). Similar to the study of Heinken & Zippel (2004) both vegetation and litter layer were removed and the re-colonisation was observed every 3 months. Similar to their description *P. purum* showed a rapid growth and gaps were re-colonised very soon. Whereas Heinken & Zippel (2004) set gaps of 1 m² which were re-colonised after three years, the smaller gaps set in this study were nearly completely re-colonised within one and a half year (see Fig. 18.1–3).

Targeting the process of re-colonisation the main mechanisms were according to own observations (compare Heinken & Zippel 2004): advance of surrounding shoots from the edge into the gaps by clonal growth and dispersal of detached single shoots as well as larger clumps of multiple shoots into the plots, resulting in new colonies by continuing growth. These detached single shoots are a result of decaying and subsequent disintegration of older shoot parts (clonal reproduction). This seems to be very common in *P. purum* and was found

in high frequencies. The dispersal of these ramets as well as the dispersal of larger clumps of multiple shoots, is most likely caused by animals (like wild boar, deer and birds), wind, water and man. Smaller diaspores like brood branches/branchlets and caducous shoot apices were not observed during the gap re-colonisation experiment, but these small diaspores are easily overlooked in field.

Fig. 18. Gap re-colonisation in a *Pseudoscleropodium purum* patch in Brandenburg. **(1)** Installation of an artificial gap (50 cm x 50 cm) in a *P. purum* colony on 19.08.2006. **(2)** Same plot on 16.05.2007, covered by lots of loose *P. purum* fragments. **(3)** Same plot on 23.02.2008, gap nearly re-colonised.

4.1.2 *Pleurozium schreberi*

4.1.2.1 Plot and patch descriptions

Pleurozium schrebei was collected within the plots Sil1 15 m² (Thuringia), Sil2 12 m² (Thuringia) and Saarm1 18 m² (Brandenburg). The patches within these plots differ in number and size. The largest patches are located in plot Sil2 were one patch covers nearly 9 m² and in plot Saarm1 were four patches are ≥ 1 m². The spatial distribution of the plots is shown in appendix A4.3, A4.4 and A4.5. Additional plant material from further German and foreign populations (see 2.3 and appendix A2) was included in this study and analysed.

4.1.2.2 Generative reproduction

No gametangia and sporophytes were found in Sil1, whereas in Sil2 only ♀ plants with archegonia and in Saarm1 both ♂ (with antheridia) and ♀ plants (with archegonia and sporophytes) were found. Of the 85 plants included in the morpho-anatomical analysis (see appendix A3.2) only one of the six ♂ plants did not come from Saarm1, it was found on the mountain Kleiner Gleichberg (Thuringia) appr. 20 km south of Sil1 and Sil2. Altogether 31 plants were identified as ♀ (six with sporophytes), six as ♂ and 48 showed neither archegonia nor antheridia. Five out of six plants with sporophytes included in this study were found in the region Berlin/Brandenburg (all in steep terrain). The other shoot with sporophytes was found one year after the main collection was taken in autumn 2006 appr. 100 m from plot Sil1, in steep terrain (30°), in a patch of c. 1 m² with about 50 other shoots with sporophytes. It was the only observation of sporophytes in Thuringia during the period of examination (2005–2008), whereas the closest focus was on the area surrounding plots Sil1 and Sil2. Female plants with archegonia came from Germany (Brandenburg, Thuringia, Hesse, Baden-Württemberg and Bavaria), Italy, Sweden, England, Russia, Ecuador and USA (Alaska). All other plants included in this study showed no signs of possible generative reproduction.

4.1.2.3 Vegetative reproduction

The morpho-anatomical examinations of *P. schreberi* plant material shows four morphological structures functioning as means of vegetative (asexual) reproduction s.l.
(1) Detached shoots (ramets) separated through decaying and subsequent disintegration of (older) shoot parts. This dominant vegetative reproduction mode was discovered in all examined patches, most plants showed decaying basal shoot parts, resulting in highly fragile

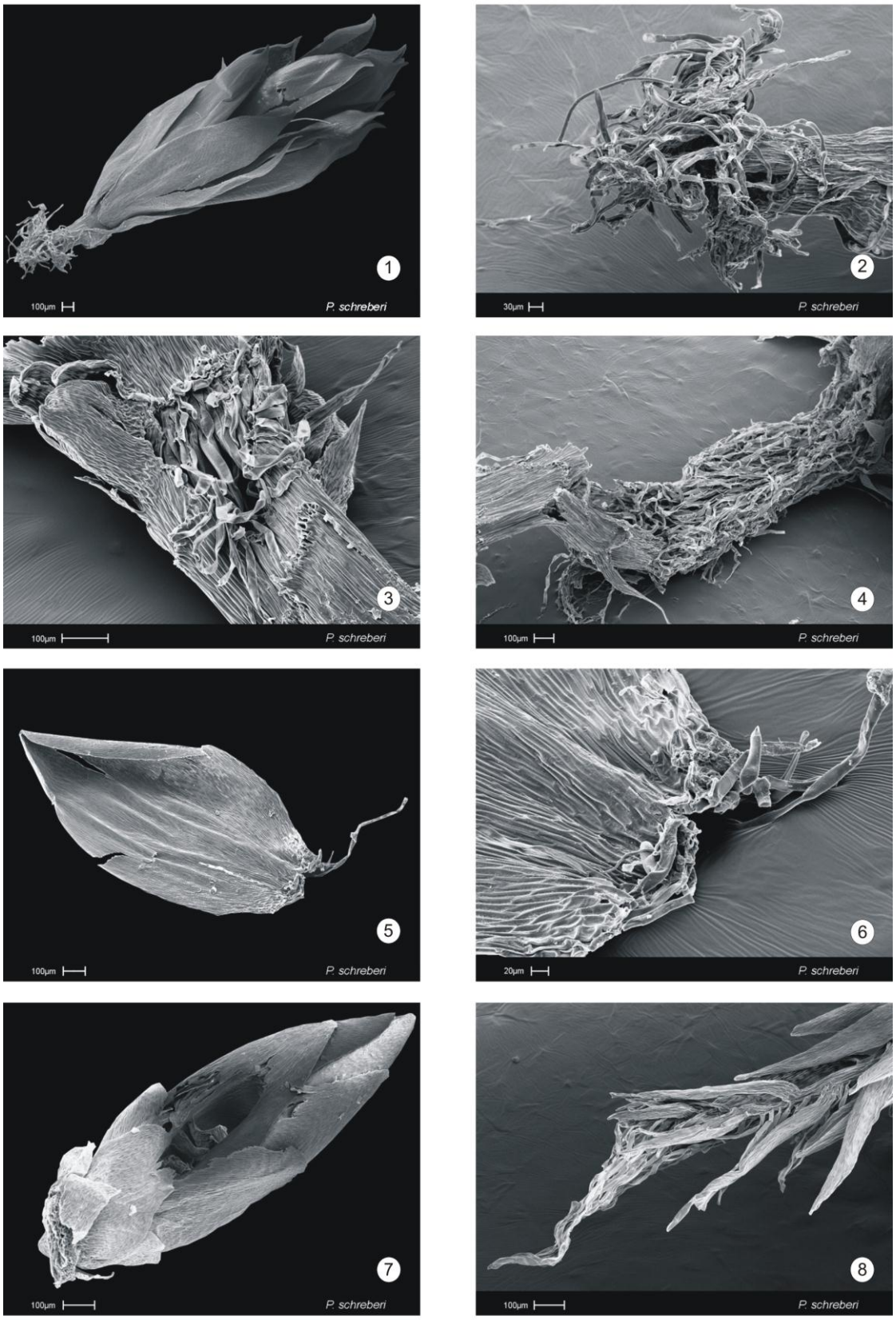


Fig. 19. Vegetative diaspores s.str. of *Pleurozium schreberi* (1–2 and 5–6) [scanning electron microscope (SEM) photos]. **(1)** Caducous shoot apex with **(2)** well-developed rhizoid growth. Early stages of caducus shoot development **(3)** lateral stem hole with rhizoid development, **(4)** later stage. **(5)** Brood leaf with **(6)** basal rhizoid growth **(7).** Shoot apex with lateral hole of unknown cause **(7)**. **(8)** Tip of side branch with rhizoids.

shoot systems, their disintegration leading to separation of ramets (see Fig. 30).

(2) Brood branches/branchlets sensu Correns (1899) were observed twelve times loose and attached in the plant material. The observed brood branches were branched, had a length of 9 to 14 mm and showed basal rhizoid growth.

(3) Caducous shoot apices (with basal rhizoids) sensu Correns (1899). These structures of 5–7 mm length were found six times separately in fresh or herbarium collections (Fig. 19.1). All six showed well developed rhizoids extending from the central part of the abscission zone (Fig. 19.2). Like in *P. purum* plants with lateral holes in the apical part of the stem were observed regularly. In this case possible caducous shoot apices were still loosely attached to the tip of the shoot, the rhizoid development was at different stages (see Fig. 19.3–4).

Of the 85 specimens observed, with an average of 39.2 (± 21.9) green shoot apices, an average of 5.7 (± 7.7) green shoot apices were missing and could not be found in the collected material.

(4) Brood leaves sensu Correns (1899). Two leaves with basal rhizoids were found separately in the observed plant material (Fig. 19.5–6).

4.1.3 *Rhytidiadelphus squarrosus*

4.1.3.1 Plot and patch descriptions

Rhytidiadelphus squarrosus was collected within the plots Sil3 15 m² (Thuringia) and B1 (Berlin Pankow) 5 m² and in an additional 150 m long transect along the same urban lawn. Both plots are nearly completely covered by *R. squarrosus* which dominates the vegetation. In both cases patches are much bigger than plot size. The spatial distribution within the plots is shown in appendix A4.6 and A4.7. Additional plant material from further German and foreign populations (see appendix A2) was included in this study and analysed as well as five *Rhytidiadelphus subpinnatus* samples.

4.1.3.2 Generative reproduction

In both *R. squarrosus* Plots Sil3 and B1 gametangia (archegonia and antheridia) were observed. In Sil3 ♂ and ♀ plants with antheridia and archegonia, respectively, in B1 only ♀ plants (with archegonia) were found. Altogether 84 *R. squarrosus* samples were included in the morpho-anatomical analysis (see appendix A3.3), 41 of these showed archegonia (two sporophytes), 8 antheridia, and 35 showed neither archegonia nor antheridia.
The main collection was taken in autumn 2006. The two included plants with sporophytes were found in spring 2007 and in spring 2008 during repeated observation of the plot localities. In the year 2007 a very small spot of plants with sporophytes was observed in the study area Bärental (close to Sil3), whereas in spring 2008 lots of plants with sporophytes were observed (mostly in steep terrain) in Bärental and surrounding area, as well as in Lengfeld. No sporophytes could be found in other areas apart from Thuringia.
In general ♀ plants with archegonia were found in Germany (Berlin, Mecklenburg-Western Pomerania, Brandenburg, Lower Saxony, Thuringia, Hesse and Bavaria), Norway, Sweden, Poland, England and Russia. Male plants were found in Germany (Thuringia), Belgium, Sweden, Russia, Spain and USA (Alaska).

4.1.3.3 Vegetative reproduction

The morpho-anatomical examinations of *R. squarrosus* plant material showed three morphological structures functioning as possible means of vegetative (asexual) reproduction s.l. (1) Detached shoots (ramets) separated through decaying and subsequent disintegration of (older) shoot parts seems to be possible, since nearly all plants examined showed decaying basal shoot parts, but is not as obvious as in *P. purum* and *P. schreberi*.

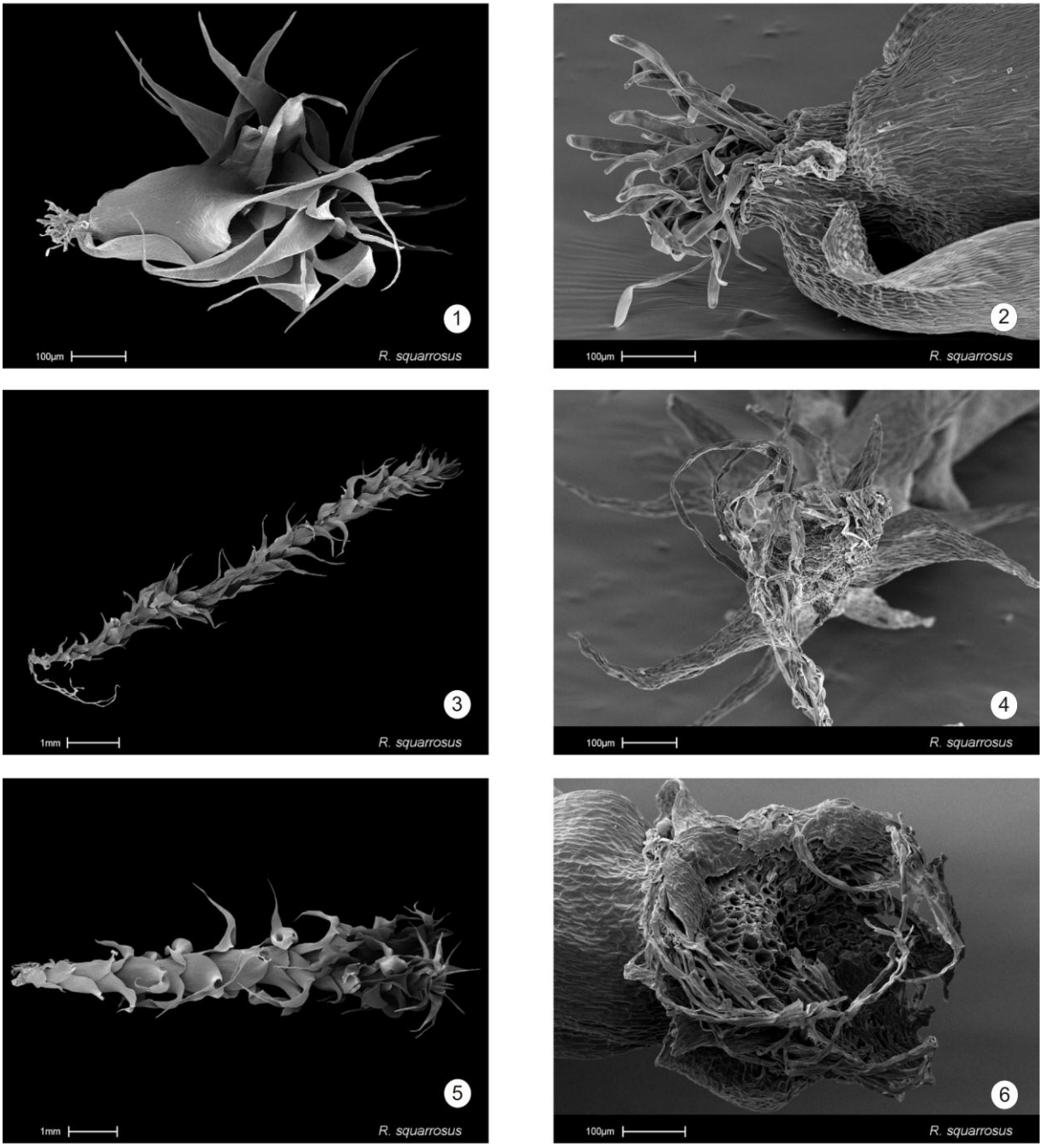


Fig. 20. Vegetative diaspores s.str. of *Rhytidiadelphus squarrosus* [Scanning electron microscope (SEM) photos]. **(1)** Caducous shoot apex with **(2)** well-developed rhizoid growth. **(3)** and **(5)** Brood branch/branchlet with corresponding rhizoids **(4)** and **(6)**.

(2) Caducous shoot apices (with basal rhizoids) sensu Correns (1899). These structures of 3 to 3.5 mm length were found three times slightly attached or tangled in herbarium material (Fig. 20.1) all three with well developed rhizoids extending from the central part of the abscission zone (Fig. 20.2). Plants with lateral holes in the apical part of the stem were observed sporadically. From 84 specimens analysed, with an average of 15.1 (± 8.2) green shoot apices,

an average of 1.4 (± 2.9) green shoot apices were missing and could not be found in the collected material.

(3) Brood branches/branchlets sensu Correns (1899), were observed six times loose or attached in the plant material. These brood branches/branchlets showed basal rhizoid growth (Fig. 20.3–6) and had a length of 9 to 16 mm.

4.2 Molecular analysis

In this study six sample sets, S_{Ger} and S_{WW} (from *Pseudoscleropodium purum*), P_{Ger} and P_{WW} (from *Pleurozium schreberi*) and R_{Ger} and R_{WW} (*Rhytidiadelphus squarrosus*) were analysed ($_{Ger}$ = German, $_{WW}$ = world-wide). Sample set sizes of of max. 50 samples were set because of physical limitations by the S2 sequencing system (only the set P_{Ger} had more samples because of new equipment in the end of the study). The AFLP analysis was performed with two primer combinations each (5´biotinylated *Eco*RI + AAC / unlabeled *Mse*I + CAT and unlabeled *Eco*RI + AGG / 5´biotinylated *Mse*I + CAT). The obtained results for each sample set are summarised in Table 5.

Table 5. Matrix statistics of *Pseudoscleropodium purum*, *Pleurozium schreberi* and *Rhytidiadelphus squarrosus* sample sets used in molecular analysis, using FAMD.

Species	***Pseudoscleropodium purum***		***Pleurozium schreberi***		***Rhytidiadelphus squarrosus***	
Sample Set	Sger	Sww	Pger	Pww	Rger	Rww
Samples	48	36	53	43	45	40
Loci	139	147	159	235	170	214
Matrix dimension	6672	5292	8427	10105	7650	8560
Missing data	0.45%	0.53%	1.20%	0.05%	0.05%	0.29%
Bands per individual	Mean = 73.6 SD = 4.0	Mean = 73.4 SD = 5.0	Mean = 82.2 SD = 6.2	Mean = 85.5 SD = 8.4	Mean = 75.5 SD = 8.7	Mean = 90.4 SD = 9.4
Polymorphic bands	104 (= 74.8%)	111 (= 75.5%)	142 (= 89.3%)	224 (= 95.3%)	161 (= 94.7%)	199 (= 93.0%)
Shannon's index (I) and variance (after Bowman & al., 1969)	I = 6.05467 Var(I) = 0.04333	I = 6.18328 Var(I) = 0.06962	I = 6.81193 Var(I) = 0.03684	I = 7.20223 Var(I) = 0.08537	I = 6.71160 Var(I) = 0.06054	I = 7.04521 Var(I) = 0.08554
AMOVA	Var= 85.85% (among populations) Var= 14.15% (within populations)		Var = 44.86% (among populations) Var= 55.14% (within populations)		Var= 44.31% (among populations) Var= 55.69% (within populations)	

4.2.1 *Pseudoscleropodium purum*

Altogether 67 *P. purum* samples were molecularly analysed (in two sample sets), including 10 samples from Sil1, 26 from NH1, 15 further German samples, 13 European and 3 worldwide samples.

4.2.1.1 German sample set (S_{Ger})

The 48 German samples analysed in this set yielded a total number of 139 loci (Missing Data: 0.45%). The number of polymorphic loci found was 104 = 74.8%, whereas the samples from NH1 showed 47 (33.2%) polymorphic loci as well as the samples from plot Sil1. The 48 samples comprised 45 AFLP genotypes.

In both plots (NH1 and Sil1) clones could be identified. Clone-Sil1S1 comprises two samples (Sil1-C2-S22-2 and Sil1-C3-S22-3) of the same patch. Clone-NH1 comprises three samples (NH1-B2-S20, NH1-A1-S4 and NH1-A2-S5) from the same patch in plot NH1; two other analysed samples from the same patch showed small differences to Clone-NH1 samples NH1-A3-S10 with $GD_J = 0.0133/GD_{SM} = 0.0073$ and NH1-A3-S9 with $GD_J = 0.0263/GD_{SM} = 0.0145$. Pairwise genetic distances between NH1 samples varied from 0 (in Clone-NH1) to $GD_J = 0.2236/GD_{SM} = 0.1377$ between NH1-E2-S80 and NH1-A1-S2. In Sil1 genetic distances varied from 0 (in Clone-Sil1S1) to $GD_J = 0.3171/GD_{SM} = 0.1940$ between Sil1-A5-S11-1 and Sil1-B4-S17-3. Altogether pairwise genetic distances were higher in Sil1 with a mean of $GD_J = 0.1783$ than in plot NH1 with a mean of $GD_J = 0.1007$ (for further information see distance matrix in appendix A5.1).

Based on the distance matrices of Jaccard's similarity and SM coefficient (see appendix A5.1) UPGMA trees were calculated, of which the Jaccard UPGMA tree is shown (SM tree showed identical topology) in Fig. 21. It shows two main clusters A and B which are supported by a bootstrap value of 100% (from Jaccard, UPGMA, 10000 replicates). Cluster A comprises samples from southwest Germany (including all samples from Sil1). Cluster B includes all samples from northeast Germany (including all samples from NH1), within this clade bootstrap support (BS) is below 50%, despite Clone NH1 (BS 100%). Pairwise genetic distances (Jaccard) between samples of cluster A versus samples of cluster B varied from $GD_J = 0.3488$ to $GD_J = 0.5258$ with a mean of $GD_J = 0.4268$. The number of polymorphic loci in cluster A is 71 = 51.1%, whereas the number of polymorphic loci in cluster B is 60 = 43.2%.

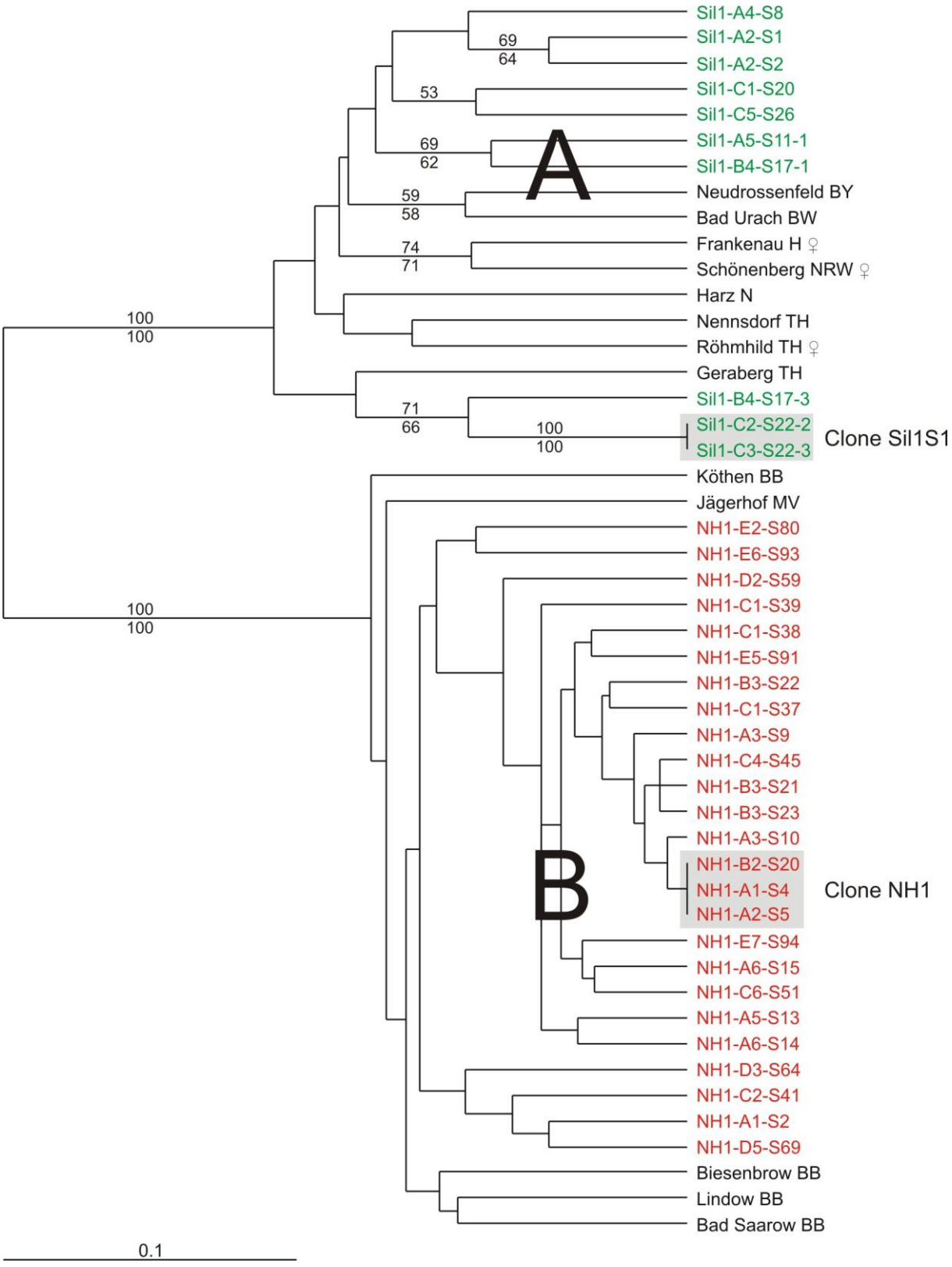


Fig. 21. S_{Ger} UPGMA dendrogram (calculated in FAMD) based on Jaccard distances between German *Pseudoscleropodium purum* samples. Numbers above and below branches are Jaccard and Simple-matching bootstrap values > 50%, respectively, from 10000 draws; ♀ = female plant; Sil1 = samples (green) from Bärental (Thuringia), NH1 = samples (red) from Neuehütte (Brandenburg); clones and clusters (A and B) are especially indicated.

4.2.1.2 Worldwide sample set (S_{WW})

The 36 samples analysed in this set (20 German, 13 further European and three worldwide samples) yielded a total number of 147 loci (Missing Data: 0.53%). The number of polymorphic loci found was 111 = 75.5%. Like in the sample set S_{Ger} two clusters A and B were formed (see Fig. 22). The two clusters are supported by a bootstrap value of 60/62% (A) and 58/60% (B) (from Jaccard and SM, UPGMA, 10000 replicates). Three samples are not clearly included in the clusters A and B, the samples from Sweden and Scotland are associated with cluster A, whereas the sample from Spain groups with cluster B. Within cluster A 59.9% out of 147 loci were polymorphic whereas in cluster B only 44.2% of the loci were polymorphic. Cluster A comprises samples from southwest Germany, as well as samples from Slovakia, Italy, Greece, Slovenia, France, Azores, Madeira, England, New Zealand, Australia and Canada. In cluster A samples of Bad Urach and Slovakia (BS 87/90%), Azores and Madeira (BS 66/73%), Frankenau and Schönerberg (BS 63/67%), Dietzhausen, Geraberg, Sil1-B4-S17-3 and Clone Sil1S1 (BS 51/52%) cluster together, within the latter clade samples of Sil1 cluster together with 74/78% bootstrap support. Cluster B comprises samples from northeast Germany which cluster together (BS 58/60%) and differ from the sample from Spain. In each cluster clones were found. Like in S_{Ger} Clone Sil1S1 comprises the two samples Sil1-C2-S22-2 and Sil1-C3-S22-3. The second "clone" comprises the two samples NH1-A1-S4-br1 and NH1-A1-S4-br2 from the same plant which were taken to test whether two different branches of the same plant lead to identical AFLP banding patterns.

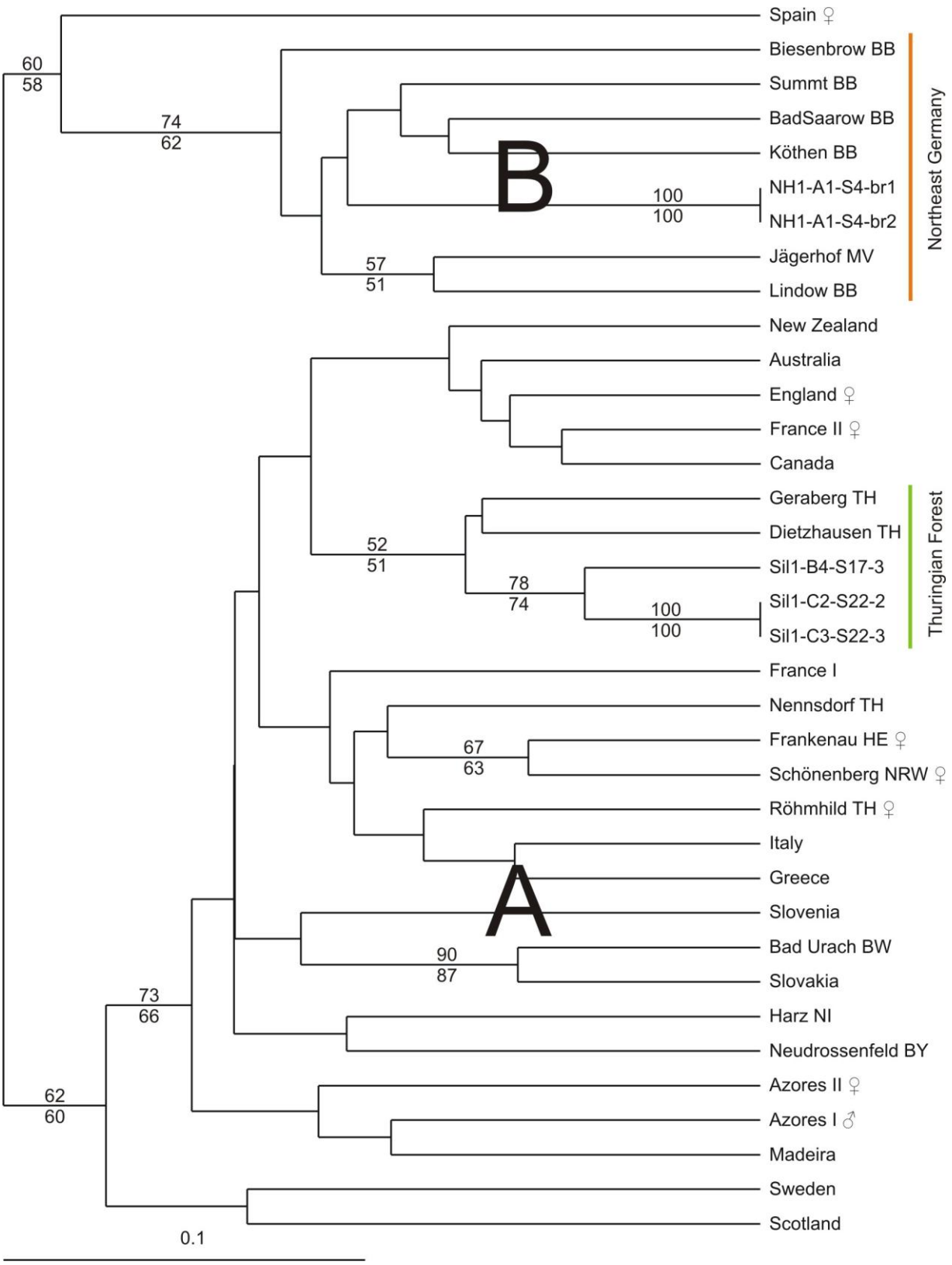


Fig. 22. S_{WW} UPGMA dendrogram (calculated in FAMD) based on Jaccard distances between worldwide *Pseudoscleropodium purum* samples. Numbers above and below branches are Jaccard and Simple-matching bootstrap values > 50%, respectively, from 10000 draws; ♀ = female plant, ♂ = male plant; Sil1 = samples from Bärental (Thuringia), NH1 = samples from Neuehütte (Brandenburg); clusters are especially indicated.

4.2.2 *Pleurozium schreberi*

Altogether 85 *P. schreberi* samples were included in this part of the study, 20 samples from Sil1, eight from Sil2, 14 from Saarm1, 22 further German samples, 15 European and six world-wide samples.

4.2.2.1 German sample set (P_{Ger})

The 52 German samples and one sample from Salzburg (Austria) analysed in this set (inclusive plots Sil1, Sil2 and Saarm1) yielded a total number of 159 loci (Missing Data: 1.20%). Number of polymorphic bands found: 142 = 89.3%; Saarm1 114 = 71.7%; Sil1 93 = 58.5%; Sil2 79 = 49.7%. The 53 samples comprised 51 AFLP genotypes.

The Jaccard UPGMA tree shown in Fig. 23 (for distance matrix see appendix A5.2), shows a cluster with samples of the plot Sil1 and a cluster with plot Sil2 samples. The cluster Sil1 comprises all samples of plot Sil1 and the sample Sil2-B1-P18 from the adjacent plot Sil2. The samples from Saarm1 form two clusters, cluster Saarm1f with mostly female plants and cluster Saarm1m with generally male plants; the samples Saarm1-A2-P5 and Saarm1-C3-P29 are separated from both clusters.

In plot Sil1 one clone was identified, the Clone-Sil1P1 comprised the two samples Sil1-A1-P1 and Sil1-A2-P3. In the Jaccard UPGMA tree Clone-Sil1P1 clustered together with Sil1-A1-P2 (GD_J = 0.0337/GD_{SM} = 0.0191; BS 100%), all three samples were from small patches found within the quadrant (A1). Other very close related samples were (possible belonging to a clone) Sil1-C1-P14-1, Sil1-C1-P14-2, Sil1-C1-P14-3 (from the same patch; GD_J = 0.0117–0.0174/GD_{SM} = 0.0064–0.0095; BS 85–86%) and Sil1-C1-P15.

Pairwise genetic distances between Sil1 samples varied from 0 (in Clone Sil1P1) to a maximum of GD_J = 0.4451/GD_{SM} = 0.2771 between Sil1-C3-P17 and Sil1-B4-P13. In Sil2 genetic distances varied from GD_J = 0.2114/GD_{SM} = 0.1134 between Sil2-B4-P31 and Sil2-B3-P27 (which cluster together with BS 61/65%) to a maximum of GD_J = 0.3847/GD_{SM} = 0.2524 between Sil2-B1-P20 and Sil2-A2-P5 as well as Sil2-B1-P20 and Sil2-B4-P31. Mean Jaccard genetic distances in plot Saarm1 (GD_J = 0.3788) are much higher than in Sil1 (GD_J = 0.2646) and Sil2 (GD_J = 0.2510) and varied within plot Saarm1 from GD_J = 0.2290 between Saarm1-A1-P1 and Saarm1-A1-P2 (BS 90%) to a maximum of GD_J = 0.5859 between Saarm1-A2-P5 and Saarm1-C1-P23 (for further information see distance matrix in appendix A5.2).

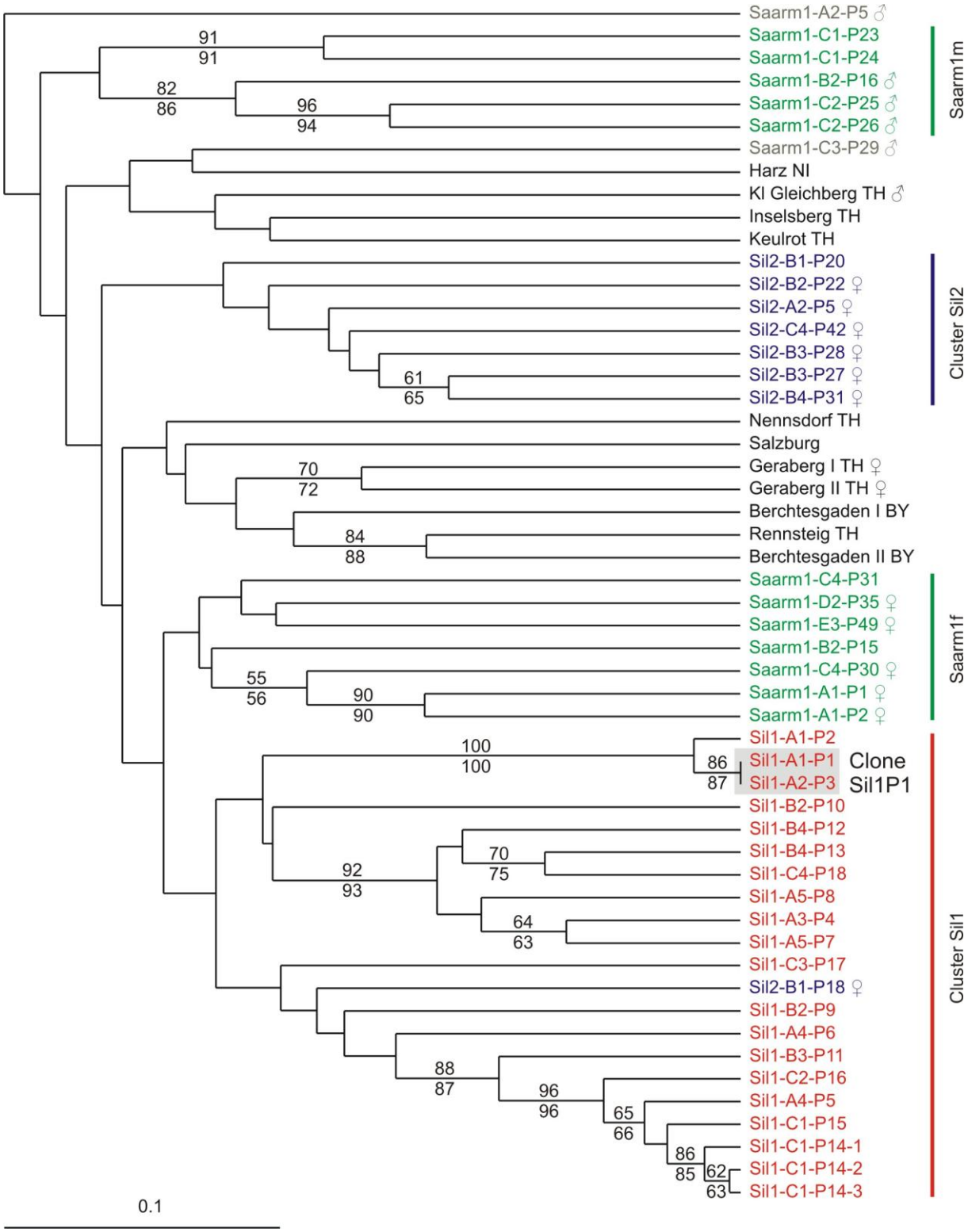


Fig. 23. P_{Ger} UPGMA dendrogram (calculated in FAMD) based on Jaccard distances between German *Pleurozium schreberi* samples. Numbers above and below branches are Jaccard and Simple-matching bootstrap values > 50%, respectively, from 10000 draws; ♀ = female plant, ♂ = male plant; Sil1, Sil2 = samples from Bärental (Thuringia), Saarm1 = samples from Saarmund (Brandenburg); samples from different plots are indicated by different color, clusters are especially indicated.

Other clusters with good bootstrap support were Geraberg I and Geraberg II (BS 70/72%) as well as Rennsteig and Berchtesgaden II (BS 84/88%), together both clusters form a clade with Berchtesgaden I, Nennsdorf and Salzburg.

4.2.2.2 Worldwide sample set (P_{WW})

The 43 samples analysed in this set (22 German, 15 further European and six world-wide samples) yielded a total number of 235 loci (Missing Data: 0.05%). Number of polymorphic bands found: 224 = 95.3%; in all European samples 207 = 88.1%; in German samples 166 = 70.6%. The 43 samples comprised 43 AFLP genotypes. Jaccard and Simple-matching genetic distances were very high throughout the sample set and varied from $GD_J = 0.3226/GD_{SM} = 0.1339$ between England I and England II to a maximum of $GD_J = 0.8760/GD_{SM} = 0.4732$ between the samples Russia I and Keulrod TH (for further information see distance matrix in appendix A5.2). In both UPGMA trees tested (Jaccard and SM) tendencies of relationships were shown but clear relationships remain somewhat ambiguous (Pww Jaccard and Simple-matching UPGMA trees are shown in Fig. 24). Bootstrap support in all clades is below 50%. Samples Russia I, Russia III and Russia VI showed the greatest differences compared to all other samples included. Samples from USA (Alaska) always cluster together as do samples from Scotland, England and England II. Other regularly observed clusters are [Jägerhof MV, Neuehütte BB], [Köthen BB, Löbten BB], [Sil1-B4-P13, Dietzhausen TH] and [Mönchberg BW, Waldenbuch BW].

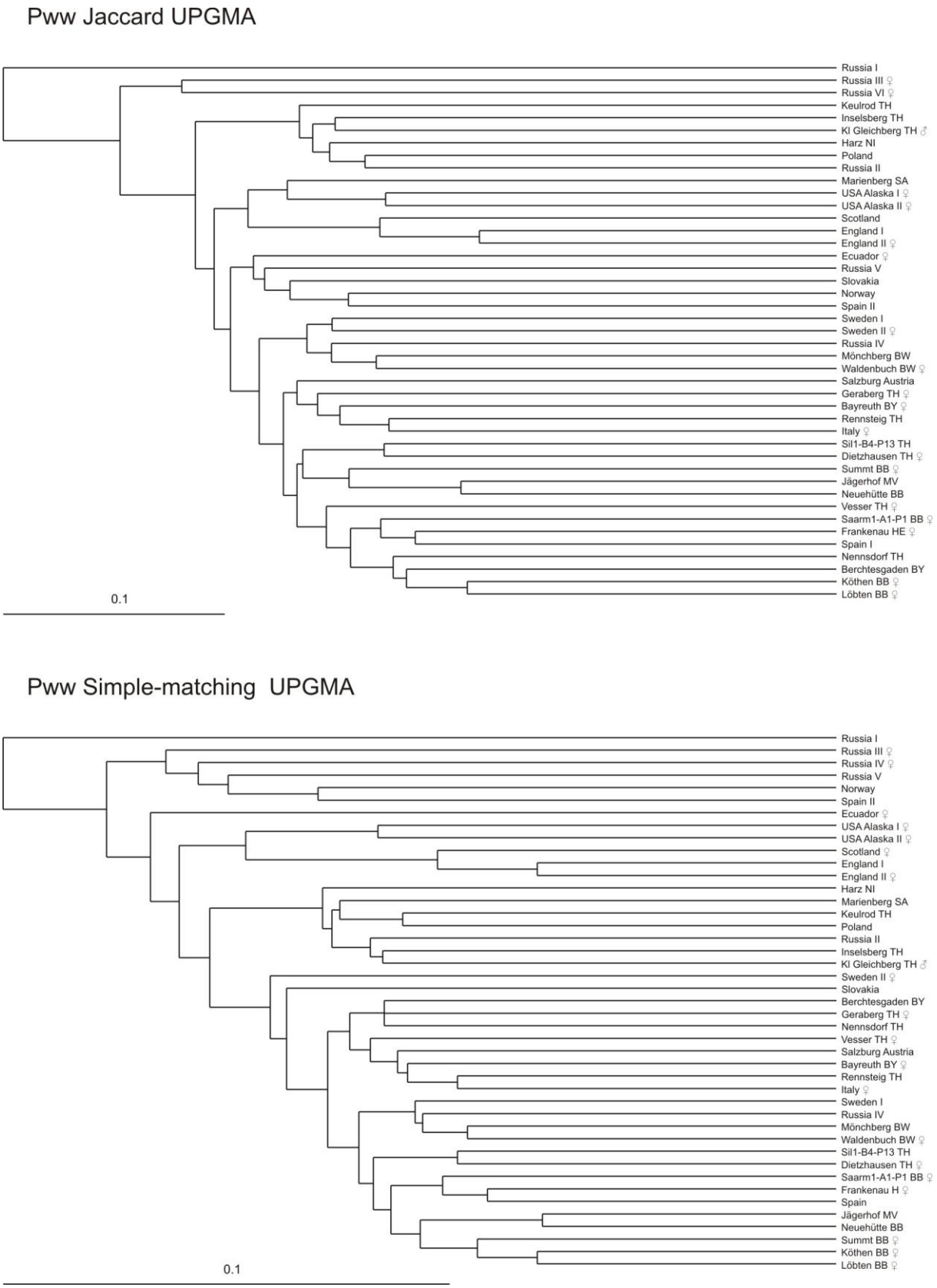


Fig. 24. P_{WW} UPGMA dendrogram (calculated in FAMD) based on Jaccard (top) and Simple-matching (bottom) distances between worldwide *Pleurozium schreberi* samples. Bootstrap values are below 50% (not shown); ♀ = female plant, ♂ = male plant; Sil1 = samples from Bärental (Thuringia), Saarm1 = samples from Saarmund (Brandenburg).

4.2.3 *Rhytidiadelphus squarrosus*

Altogether 77 samples of *R. squarrosus* and four of *R. subpinnatus* were included in this part of the study, 23 samples from Sil3 and seven close to Sil3, nine from B1 and three close to B1, 17 further German samples, 16 European and seven world-wide samples (the latter including the four *R. subpinnatus* samples).

4.2.3.1 German sample set (R_{Ger})

The 45 samples analysed in this set yielded a total number of 170 loci (Missing Data: 0.05%). Number of polymorphic bands found: 161 = 94.7%; Sil3 120 = 70.6%; B1 68 = 40.0%. The 45 samples comprised 45 AFLP genotypes, no clones were found.

Pairwise genetic distances between Sil3 samples varied from $GD_J = 0.0814/GD_{SM} = 0.0412$ between the samples Sil3-A1-R11 and Sil3-A1-R12 (BS 65/71%) to a maximum of $GD_J = 0.5418/GD_{SM} = 0.2825$ between Sil3-A1-R1 and Sil3-A4-R24.

In B1 genetic distances varied from $GD_J = 0.1299/ GD_{SM} = 0.0588$ between B1-A2-R7 and B1-A2-R8 (BS 84/86%) to a maximum of $GD_J = 0.4421/GD_{SM} = 0.2471$ between B1-A1-R5 and B1-A3-R13. Mean Jaccard genetic distances are higher in Sil3 ($GD_J = 0.2817$) than in B1 ($GD_J = 0.2332$) (for further information see distance matrix in appendix A5.3).

The Jaccard UPGMA tree (Fig. 25) shows a cluster with samples from Berlin, including sample Sil-R115 but excluding the Berlin sample B1-R23. Significant bootstrap support is only gained for subclusters within the Berlin and Thuringia clusters.

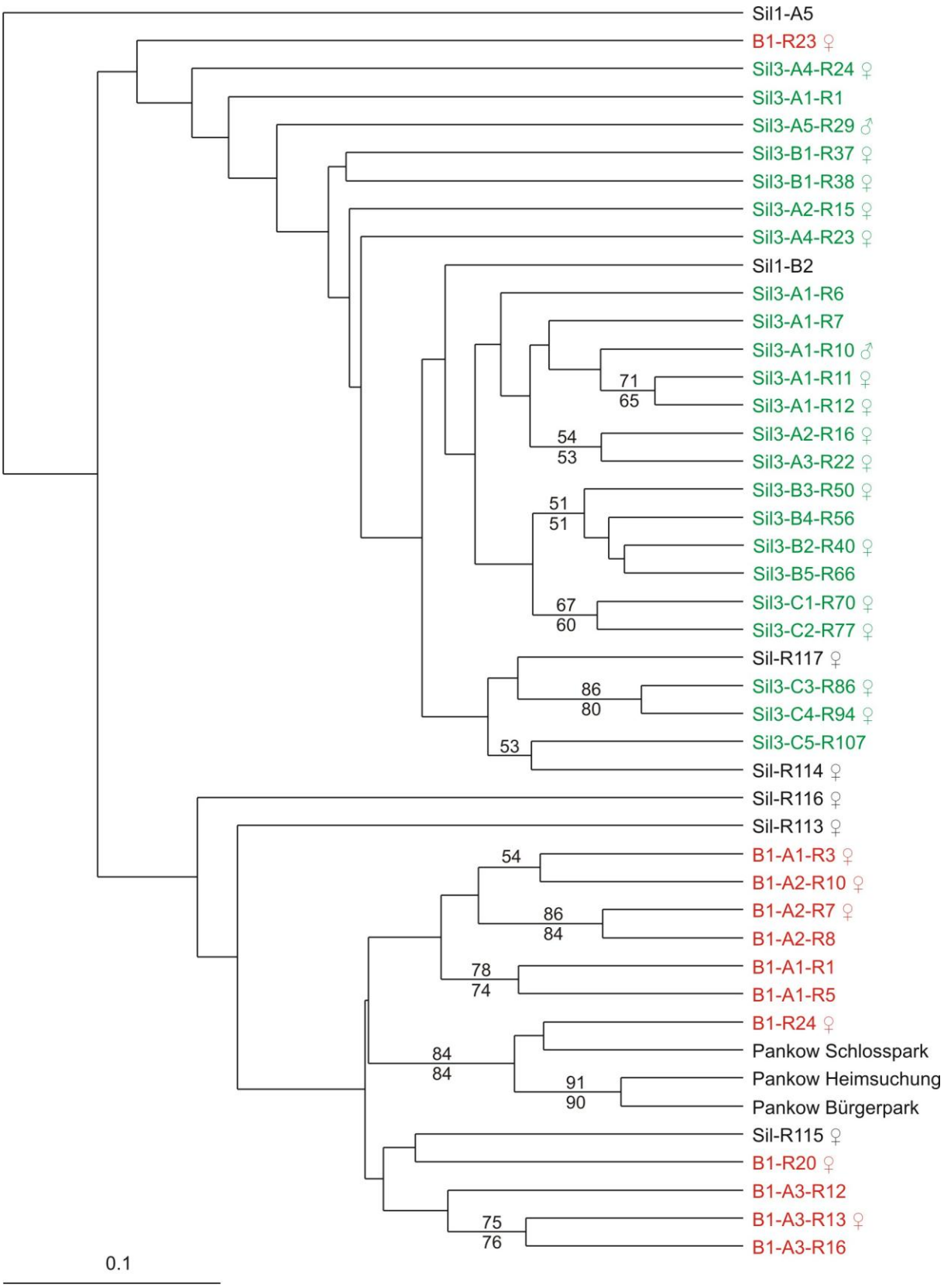


Fig. 25. R_{Ger} UPGMA dendrogram (calculated in FAMD) based on Jaccard distances between German *Rhytidiadelphus squarrosus* samples. Numbers above and below branches are Jaccard and Simple-matching bootstrap values > 50%, respectively, from 10000 draws; ♀ = female plant, ♂ = male plant; Sil, Sil1, Sil3 (green) = samples from Bärental (Thuringia), B1 = samples from Berlin-Pankow (red).

4.2.3.2 Worldwide sample set (R_{WW})

The 36 *R. squarrosus* and four *R. subpinnatus* (USA, Russia III, Russia IV and Russia V) samples analysed in this set yielded a total number of 214 loci (Missing Data: 0.29%). Number of polymorphic bands found: 199 = 93.0%; in all European (only *R. squarrosus*) samples 178 = 83.2%; in German samples 81 = 37.9%. The 40 samples comprised 40 AFLP genotypes.

Pairwise genetic distances varied throughout the *R. squarrosus* sample set from GD_J = 0.1134/GD_{SM} = 0.0514 between England I and England II to a maximum of GD_J = 0.6400/GD_{SM} = 0.3738 between New Zealand II and Belgium. Within German samples pairwise genetic distances varied from GD_J = 0.1196/GD_{SM} = 0.0514 between samples from Bayreuth BY and Frankenau HE to a maximum of GD_J = 0.3333/GD_{SM} = 0.1682 between the samples Lengfeld TH and B1-A3-R12 with a mean of GD_J = 0.2064 whereas the world-wide mean is GD_J = 0.3400 and the mean between *R. squarrosus* and *R. subpinnatus* samples GD_J = 0.6230.

UPGMA and NJ trees based on genetic distances matrices of Jaccard's similarity coefficient were calculated (both shown in Fig. 26). The UPGMA analysis showed that *R. subpinnatus* samples cluster together and differ from those of *R. squarrosus* with high bootstrap support (see Fig. 26).

Within *R. squarrosus* some clusters with medium to high bootstrap support are formed such as [Spain I, England I and England II; BS 84/82%] and [Russia I and Russia II; BS 72/77%]. Pairwise genetic distances between German samples are comparatively low compared to distances between world-wide samples. Consequently German samples cluster together; only both samples from Sil3 are slightly separated from the other German samples.

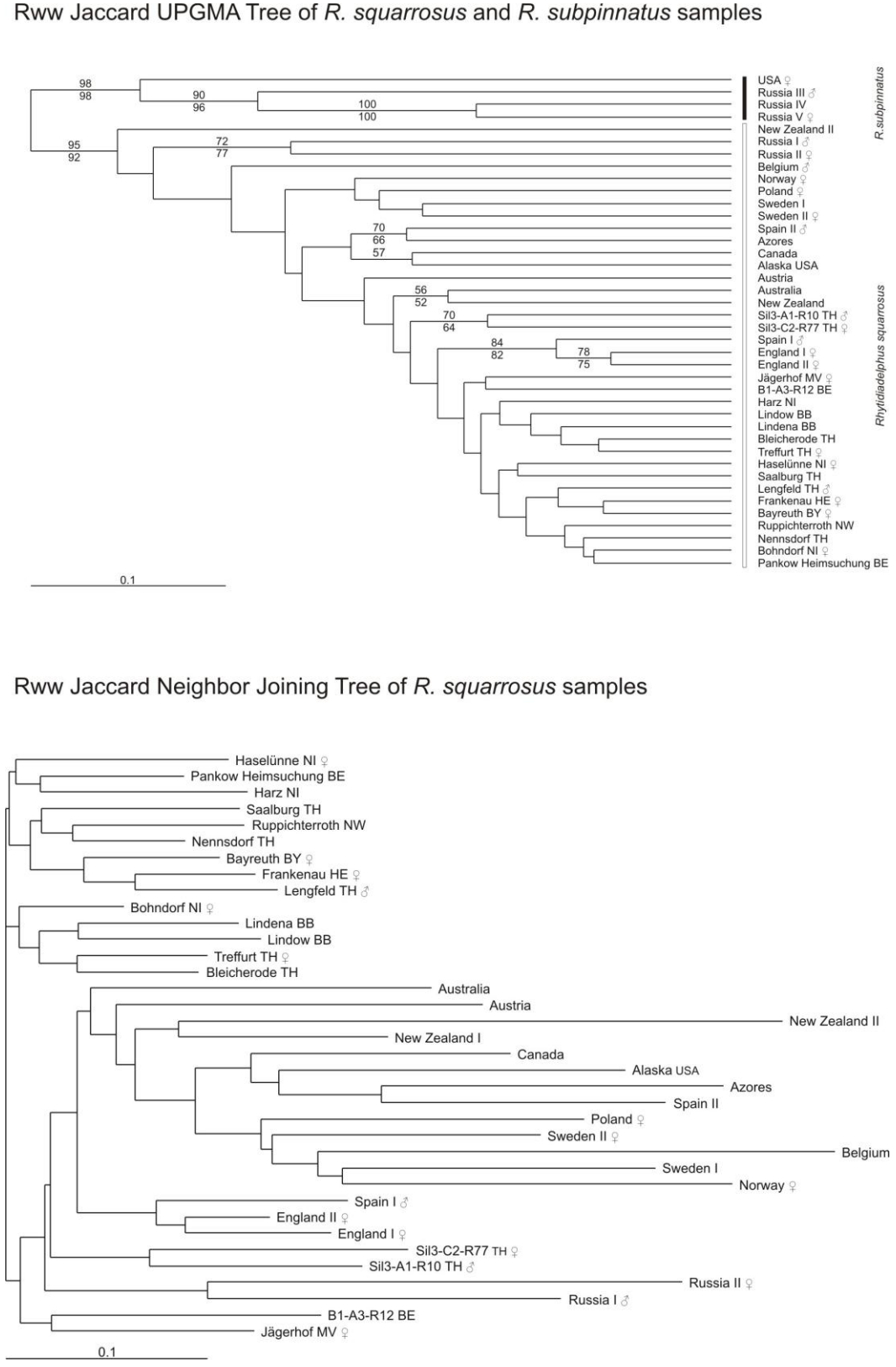


Fig. 26. R_{WW} UPGMA and Neighbor Joining dendrogram (calculated in FAMD) based on Jaccard distances between worldwide samples of *Rhytidiadelphus*. (Above) UPGMA tree based on *Rhytidiadelphus squarrosus* and *Rhytidiadelphus subpinnatus* samples (indicated on right side, black *R. suppinatus*, white *R. squarrosus*). (Bottom) Neighbor Joining tree based on *R. squarrosus* samples. Numbers above and below branches are Jaccard and Simple-matching bootstrap values > 50%, respectively, from 10000 draws; ♀ = female plant, ♂ = male plant; Sil3 = samples from Bärental (Thuringia), B1 = samples from Berlin-Pankow.

5 Discussion

5.1 General

This study aims to analyse clonal diversity and to document mechanisms of vegetative reproduction in three rarely fruiting, dioecious, pleurocarpous bryophytes *Pseudoscleropodium purum*, *Pleurozium schreberi* and *Rhytidiadelphus squarrosus*. In an earlier study on vegetative reproduction and clonal diversity in *Rhytidium rugosum* (Pfeiffer et al. 2006) low levels of clonal diversity were detected in this likewise very rarely fruiting, dioecious, pleurocarpous moss. Hence the question arose whether similar patterns of clonal diversity, habitat colonisation and maintenance can be found in other rarely fruiting pleurocarpous bryophytes or not? To answer this question three dioecious, pleurocarpous bryophytes (*P. purum*, *P. schreberi* and *R. squarrosus*) were chosen and closely observed in the years 2005–2008 using the same or slightly modified methods like those used by Pfeiffer et al. (2006).

For the molecular approach AFLP fingerprinting was used to examine genetic structure and clonal relationships within populations and smaller entities such as patches. Originally mainly used for higher plants (compare, e.g., Winfield et al. 1998, Muluvi et al. 1999, Van der Hulst et al. 2000, Zhang et al. 2001, Wong et al. 2002, Albach et al. 2006, Lieske & Pfeiffer 2007, Pfeiffer 2007), AFLP technique becomes more utilised in the field of population-orientated biology of bryophytes (e.g., Vanderpoorten & Tignon 2000, Fernandez et al. 2006, Pfeiffer et al. 2006, Zartman et al. 2006). Although Shaw et al. (2008) point out that the genetic structure of a population could be quantified and described using a broad range of molecular markers like isozymes (introduced for population-based studies by Harris 1966 and Lewontin & Hubby 1966, first applied to bryophytes in the 1970s, e.g., Meyer et al. 1974, Krzakowa 1977, Szweykowski & Krzakowa 1979) and more recently DNA-based "fingerprinting" methods. These methods utilise hypervariable markers that should be polymorphic enough to identify and distinguish individual clones and their members and hence to genotype genetic individuals (Shaw et al. 2008). Fingerprinting methods that have been applied to bryophyte populations include Random Amplified Polymorphic DNA (RAPDs) (e.g., Boisselier-Dubayle et al. 1995, So and Grolle 2000), Inter Simple Sequence Repeats (ISSRs) (Werner et al. 2003), microsatellites (Van der Velde et al. 2001) and Amplified Fragment Length Polymorphism (AFLPs) (e.g., Pfeiffer et al. 2006, Zartman et al. 2006). In this study AFLP fingerprinting was used because it allows according to Mueller & Wolfenbarger (1999) and Ziegenhagen et al. (2003) the unambiguous identification of genets (genetic individual, i.e.

the developmental product of a single zygote, consisting of genetically identical and semi-autonomous construction units the ramets; e.g., Tuomi & Vuorisalo 1989, Eriksson & Jerling 1990) and shows the absence of genetic diversity in clones (e.g., Frey & Lösch 2004). All methods used in this study are based on the study by Pfeiffer et al. (2006) to generate comparable datasets. Following the AFLP protocol by Pfeiffer et al. (2005) AFLP fingerprinting turned out to be a very suitable and reproducible technique with high resolutions in all three species.

During long time observation of plots and study areas (2005–2008), fruiting material was found in different quantities. Although all three species are described to be rarely fruiting or non fruiting in parts of their distribution ranges (compare, e.g., Longton & Greene 1969a, Lawton 1971, Crum & Anderson 1981, Düll 1994, Kuc 1997, Gradstein et al. 2001, Nebel & Philippi 2001, Huttunen 2003, Smith 2004) significant differences were observed and have to be discussed.

5.2 *Pseudoscleropodium purum*

Molecular analysis of *P. purum* samples from two German Plots (NH1 and Sil1) and further German samples showed few samples with identical AFLP banding patterns (two clones), various closely related samples especially in plot NH1 (33.2% polymorphic loci), and the formation of two distinct clusters in Germany. Both clones were exclusively found within patches (see Fig. 21, as well as A4.2 and A4.4 in appendix). Clone-Sil1S1 was found in plot Sil1 consisting of two samples (Sil1-C2-S22-2 and Sil1-C3 -S22-3) both from the same patch in quadrant C2 of plot Sil1. The second clone (Clone-NH1) comprises three samples (NH1-A1-S4, NH1-A2-S5 and NH1-B2-S20) of a (~ 1 m²) patch situated in quadrants A1–A3 and B1–B3 of plot NH1.

Various samples showed small differences in the AFLP banding patterns, these differences are maybe due to somatic mutations or are caused by technical or methodical mistakes like scoring errors or polymerase chain reaction (PCR) artefacts (compare, e.g., Mueller & Wolfenbarger 1999, Douhovnikoff & Dodd 2003, Meirmans & van Tienderen 2004). If these differences are by technical or methodical mistakes, Clone-NH1 might be larger and possibly includes the samples NH1-A3-S10, NH1-B3-S21, NH1-B3-S23 from patches near by and the single plant NH1-C4-S45 (appr. 2 m away from Clone-NH1). This estimation is not certain, but would not alter the findings completely. In either way compared to *R. rugosum* (Pfeiffer et al. 2006), the found clones are smaller, at most they include patches up to few (in this study up to appr. 1 m²) square meters and can dominate areas up to 6 m² (10 m² if the closely related

genotypes belong to the same clone). In contrast, clones of *R. rugosum* can dominate plot areas of 40 m² with lots of patches and clonal patches of up to 8 m². In *R. rugosum* even on a larger scale (several hundred square meters) genotypes are genetically similar, whereas in *P. purum*, especially in the valley Bärental surrounding plot Sil1, the samples partly showed genetic distances comparable with those of samples from different regions, such as Neudrossenfeld and Bad Urach (which are more than 250 km apart) and are therefore thought to be of sexual origin.

Molecular analyses of both sample sets (German and world-wide) showed a separation of two clusters (see Fig. 21 and Fig. 22). One cluster was formed by samples from South and West Germany (cluster A) whereas the other one comprises North-east German samples (cluster B). The strong separation of both clusters is visualised in Fig. 27, it shows that pairwise Jaccard distance values within clusters are clearly separated from pairwise distance values among both clusters.

The worldwide samples showed a similar picture, where cluster B comprises the North-East German samples and cluster A comprises nearly all other samples from the rest of Europe, Canada, Australia and New Zealand. Only the samples from Spain, Sweden and Scotland did

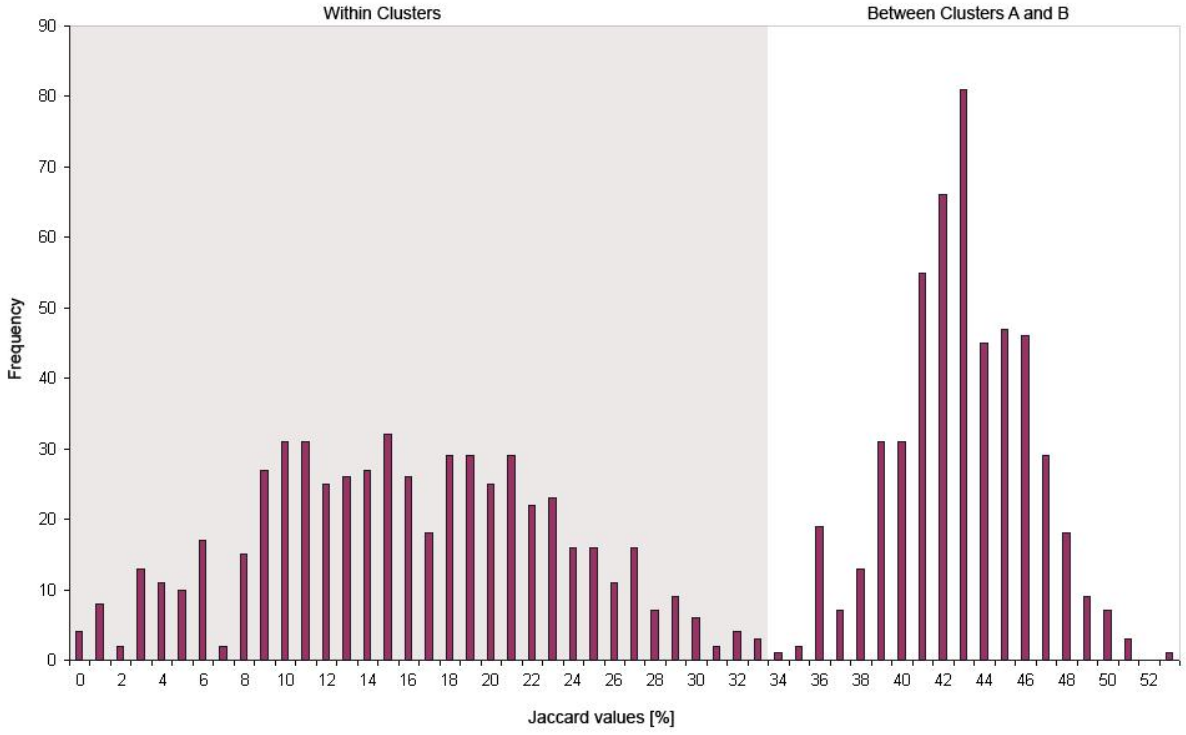


Fig. 27. S_{Ger} (German *Pseudoscleropodium purum* sample set) frequency histogram of pairwise Jaccard distances for 48 *P. purum* samples from Plots Sil1, NH1 and further German samples.

not show clear affinities (see Fig. 22). In this context the chromosome numbers should be mentioned (n = 7 Japan; n = 9–10 Central Europe; n = 11 British Isles, Poland, Norway, Sweden and Finland; e.g., Crum & Anderson 1981, Fritsch 1991), which may explain the topology of the samples from Sweden and Scotland, and are maybe also a reason for the separation of cluster A and B, but since chromosome numbers were not examined in this study this is only hypothetical.

Morphological research showed no clear evidence which supports the clusters by morphological means. Even though different growth forms were found in *P. purum*, one was very prominent in cluster B (plants were very symmetrically pinnate, with reflexed branches), but also observed several times in cluster A, and a second in cluster A (compared to plants of cluster A plants were either not pinnate or branches were not reflexed, or both).

Based on these findings some explanations are possible, either in North-East Germany a distinct population with small range extension, maybe with different chromosome number (not tested), exists (its range extension to the east is not certain because samples from Poland and Baltic states were not included in this study), or cryptic speciation occurs. Cryptic speciation in mosses was recently discovered by different authors (e.g., Shaw 2000, Feldberg et al. 2004, Stech & Wagner 2005, Fernandez et al. 2006, Hedenäs & Eldenäs 2007), since new genetic methods are available and are now frequently used in bryophytes, but were suggested earlier by Wyatt (1985). Shaw (2001) mentions that the discovered cases of cryptic speciation clearly showed that many bryophyte species are genetically complex, and that genetic subdivision has occurred within morphologically uniform species, with in most but not all cases, broadly overlapping geographical ranges. In the present case no overlapping was detected and regarding the here presented data it rather seems that cluster B is delimited to North-East Germany since it was exclusively found in the federal states Berlin, Brandenburg and Mecklenburg-Western Pomerania (the eastern dimension remains open, see above). Overlapping ranges along the margins to cluster A are possible, but further research is needed to validate this assumption.

Within cluster A (S_{WW}) a subcluster was formed, including samples of New Zealand, Australia, England, France II and Canada, with close genetic distances. Since it is widely agreed that *P. purum* is introduced to Canada, Australia and New Zealand (compare, e.g., Lawton 1960, Schofield & Crum 1972, Lewinsky & Bartlett 1982, Fife 1995, Miller & Trigoboff 2001, Streimann & Klazenga 2002), the data indicates that the ancestors of these populations most probably came from England and France, both countries with close connections to Canada, Australia and New Zealand regarding their colonisation and economic

activities. Hence it can be assumed that *P. purum* was brought to Canada, Australia and New Zealand as packing material of trees, other living plant material or with animal transports or seeds, as suggested by Schofield & Crum (1972), Lewinsky & Bartlett (1982) and Miller & Trigoboff (2001).

Although generative diaspores definitively play a role in possible long distance dispersal and maybe also in habitat colonisation, considering the great differences between the genotypes especially in plot Sil1, the main reproduction mode for patch colonisation and maintenance is clearly asexual reproduction. In both plots (Sil1 and NH1) patches of clonal origin were found and Clone-NH1 shows that patches of up to 1 m² (and surrounding areas) can be dominated by single clones. The modes of vegetative reproduction can thereby differ (see above). Three different structures of vegetative reproduction s.l. were identified in *P. purum*, including

Fig. 28. Detached clumps of *Pseudoscleropodium purum* in plot NH1 (2008).

Fig. 29. Detached clumps of *Pleurozium schreberi* in plot Saarm1 (2008).

vegetative reproduction s.l. and vegetative reproduction s.str. by caducous shoot apices and brood braches/branchlets.

The mechanism of utmost importance for patch colonisation and maintenance seems to be clonal reproduction through decay of older shoots, resulting in disintegration of shoots and the formation of new ramets (dividuals). These new dividuals grow and form new ramets after further decay and disintegration of older parts. This process of "self cloning", described by Pfeiffer et al. (2006) for *R. rugosum*, is preprogrammed in the life cycle and leads to consequent vegetative multiplication (e.g., Urbanska 1992, Frey & Lösch 2004). Ramets resulting from "self cloning" are to a great extent entangled with numerous shoots in the patch. Moreover the majority of ramets will remain at their site of origin and enhance expansion and maintenance of patches. However in some cases dispersal of detached single shoots as well as larger clumps of multiple shoots into the plots occurred (see Fig. 28), resulting in the formation of new colonies by continuing growth as described by Heinken & Zippel (2004). Especially loose clumps of multiple shoots were found several times close to the plot areas (also in *P. schreberi* see Fig. 28). Own observations lead to the conclusion that most of these possible diaspore clumps are caused by feeding wild boar, smaller clumps by feeding birds like the Eurasian jay (*Garrulus glandarius*) or woodpeckers (Picidae), or by ants as it was also observed by Heinken et al. (2001), King (2003) and Heinken & Zippel (2004). The expected use as nesting material could not be confirmed. Although the groundcover was immense and often comprehensive none of three nests found close to plot areas were build or partly build of *P. purum* (also not of *R. squarrosus* and *P. schreberi*) but with other moss species. As well as animals, man's activities have direct or indirect influences on dispersal and distribution of mosses (e.g., Glime 2007). In *P. purum* especially the former use as packing material of young trees (Dickson 1967, Allen & Crosby 1987), its escape and establishment in widely ranging parts of the world has to be mentioned, regarding the present distribution of *P. purum*.

Not only clonal reproduction has to be considered as means of vegetative reproduction s.l. for *P. purum*. additionally, vegetative reproduction s.str. was observed, by brood branches and branchlets (cf. Fig. 17) as well as caduceus shoot apices with already well developed rhizoids. The latter seem to be of special importance for vegetative reproduction s.str. It is not obvious in the number of such diaspores found (only 8 caducous shoot apices and 3 brood branches/branchlets were found), but it is indicated by the fact that 9.1% of all green branches/branchlets showed missing shoot apices. Altogether *P. purum* showed a slightly

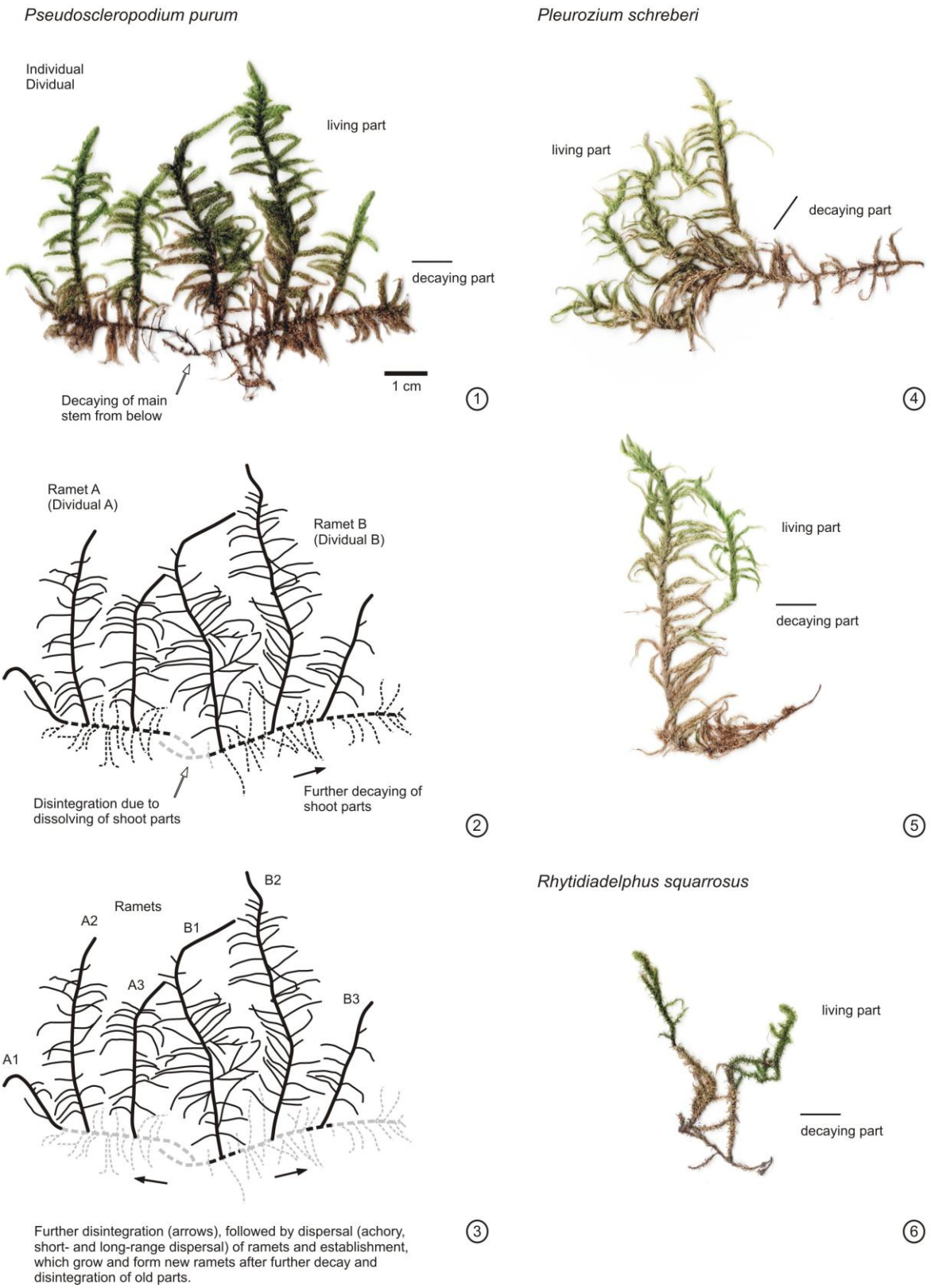


Fig. 30. (1) Growth form of *Pseudoscleropodium purum* from Neuehütte BB, (1–3) process of self-cloning (clonal reproduction) in *P. purum.* (4–5). Growth forms of *Pleurozium schreberi* from Summt BB and (6) *Rhytidiadelphus squarrosus* from Bohndorf N.

different pattern compared to *R. rugosum*. In terms of vegetative reproduction s.l. (self cloning) and vegetative reproduction s.str. (caducous shoot apices and brood braches/branchlets) it appears to be quite similar, but in contrast to *R. rugosum* also sexual reproduction (although not observed) seems to be important for habitat colonisation and maintenance of *P. purum*. This conclusion arises since clones and clonal patches were much smaller than in *R. rugosum* and the genetic diversity within plots (as shown by the genetic diversity detected in the molecular analyses) was comparatively higher in *P. purum*, even though plots were smaller.

5.3 *Pleurozium schreberi*

The rarely fruiting species *P. schreberi*, with some findings of sporophytes during the observation period, showed a slightly different picture than *P. purum*. In the molecular analysis of 85 samples from three plots (Sil1, Sil2 and Saarm1), further German and foreign samples, clones were only found in plot Sil1 and here only in two very small patches. Hence only in the same plot where neither inflorescences nor sporophytes were found.

In the plots Sil2 and Saarm1 patches were larger and presumably older than in Sil1. In both plots gametangia were found, sporophytes were only found in Saarm1. Both plots showed higher genotypic diversity compared to Sil1.

A possible explanation for vegetative reproduction and the finding of clones only in plot Sil1 is that this plot might show an early stage of habitat colonisation. This conclusion arises since all patches (including the clonal patches) of this plot are smaller than in both other observed plots and further away (see appendix A4.4). Therefore clonal reproduction may occurs here because male and female plants are not close enough for fertilisation. It is described to be a general reason in unisexual species, especially in early stages of habitat colonisation (Bisang et al. 2004), that sexual reproduction is often difficult to achieve either because of the fertilisation range, absence of gametangia (male, female or both) for some unknown reason or when only one sex is present.

If sexual reproduction is not possible in new colonised habitats, vegetative reproduction is necessary for habitat colonisation and maintenance until both sexes have arrived and/or are in fertilisation range. Another explanation for the lack of sporophytes in some areas is given by Longton & Greene (1969a). They emphasise the relationship between distribution of sexes and sporophyte production in *P. schreberi*, and suppose that the rarity of sporophytes is correlated with a rarity of plants bearing antheridia. This effect is increased by a natural high ratio of female to male plants observed by Longton & Greene (1969b, 1979) in British

populations as well as in German populations in this study. Longton (1976) suggests that a comparable sexual imbalance of adult plants may be widespread among dioecious bryophytes and that this may be the principal cause of the rarity of sporophytes in such species. Although sex determination is likely to be genetically fixed, resulting in an expectation at meiosis of 1♀:1♂, male rarity is observed in many dioecious species and may results from different survival of spores and/or individuals or different clonal growth (Bowker et al. 2000), but the reason is not yet clear.

Consequently, it is no surprise that in the very same plot (Saarm1) where sporophytes were found the detected ♂ to ♀ ratio was higher than in both other plots. Here 36% of the analysed samples turned out to be male, whereas in both other plots no male plants and no sporophytes were found. Therefore the chances for fertilisation in Saarm1 were much better than in both other plots.

In the P_{Ger} UPGMA tree (see Fig. 23) samples from the three different plots predominantly cluster with each another, but it is also shown that genetic distances within the plots are high, in some cases higher than between other German samples. Especially within plot Saarm1 genetic distances between samples were very high. Overall genetic distances were much higher in *P. schreberi* than in *P. purum* (see. 5.2) and *R. rugosum* (e.g., Pfeiffer et al. 2006), and even within medium size patches, samples with great genetic distances were found. This was not expected for Sil2 and Sil1 since no sporophytes were found during fieldwork in Thuringia. However, a possible explanation is given by the later observation of fruiting plants close to these plots (appr. 200 m apart). For plot Saarm1 the detection of great genetic diversity was no surprise, regarding the relative frequent occurrence of sporophytes in Brandenburg and even within the plot, especially considering the knowledge that most spores are dispersed within a short range (Miles & Longton 1992). For instance in *Atrichum angustatum* 94% of the spores fell within 2 m of the colony centre (Stoneburner et al. 1992).

The fact, that clones could only be found in the plot were neither inflorescences nor sporophytes were found, whereas in plot Saarm1 (with sexueal reproduction) a higher genetic diversity and no clones were detected among the analysed samples, has to be pointed out. Comparing plots Saarm1 and Sil1 the findings reveal how genetic composition differs in small populations with or without sexual reproduction and it seems that in populations with sexual reproduction vegetative reproduction is reduced. To be more precise it turned out that in plot Saarm1 (plot with fruiting specimens), the offspring is genetically more diverse, hence most likely of sexual origin. These findings are supported by the fact that caducous shoot apices and brood branches/branchlets were not found in Saarm1. In contrast, in plot (Sil1)

without inflorescences and sporophytes, vegetative reproduction seems to have a greater importance for patch recruitment and maintenance. Although lots of different genets were detected in Sil1, effective vegetative reproduction was proven only for plot Sil1, were a clone (Clone-Sil1P1) comprises two samples (Sil1-A1-P1 and Sil1-A2-P3), from two very small patches within short range. A possible second clone Clone-Sil1P2 comprises three very close related samples (Sil1-C1-P14-1, Sil1-C1-P14-2 and Sil1-C1-P14-3) from a small patch in quadrant C1 of plot Sil1, which are presumably ramets that differ because of somatic mutations. In both other plots no clones were found, although in case of Sil2 samples came from a single large-scale patch. Regarding the data possible clonally patches are even smaller in *P. schreberi* than in *P. purum* (see above) and *R. rugosum* (compare, Pfeiffer et al. 2006).

Although other vegetative diaspores (see below) could be described in this study, vergetative reproduction in *P. schreberi* seems to be mainly caused by fragmentation through decay of older shoots (see Fig. 30) resulting in disintegration of shoots and forming of new ramets (e.g., Longton & Greene 1979, Frego 1996, Heinken & Zippel 2004). This is not unexpected for bryophytes, because physical connections between young (distal) portions and older parts decompose after only a few years (Frego 1996). According to Frego (1996) and Heinken & Zippel (2004) the dispersal of shoots or shoot fragments of *P. schreberi* is limited to short distances, so that experimental gaps are primarily colonised by encroachment of intact shoots that grow in range of centimeters per year, whereas detached shoots or fragments were observed several meters apart from patches (dispersal by the same vectors earlier described for *P. purum*, see above). In this context the great number of plants with rhizoids at different locations shall be mentioned (see A3.2 in appendix), 76.5% of the investigated samples showed rhizoid growth, 86.2% of these on tips of side branches (mostly basal), the other along branches, stems or leaves. Thus most of these structures are well prepared to form new dividuals by fragmentation through decay of older shoots. Regarding findings by Longton & Greene (1979) that *P. schreberi* (mature) in general has little or no rhizoidal connection with the substrate, the author likes to suggest that rhizoid growth in *P. schreberi* has to be seen in the context of vegetative reproduction. Hence the main function of rhizoids in this weft forming, ectohydric species maybe is to keep potential diaspores in position after successful dispersal.

Besides unspecialised fragmentation (clonal reproduction) three types of propagules as means of vegetative reproduction s.str. were observed and characterised (see 4.1.2.3). (1) Brood branches/branchlets sensu Correns (1899) with basal rhizoid growth (found loose or attached in the plant material twelve times). (2) Caducous shoot apices (six times) sensu Correns

(1899), with basal rhizoids. (3) In addition to these two structures brood leaves sensu Correns (1899) were found twice independently in the material of *P. schreberi*. Both leaves showed basal rhizoid growth (see Fig. 19) and might also play a role in vegetative reproduction s.str. as earlier assumed by Longton & Schuster (1983).

Like in *P. purum* a great number of green shoot apices were missing in the observed material. The observation of 85 specimens resulted in an average of 39.3 (± 22.4) green shoot apices, 5.6 (± 7.7) of these were missing and could not be found in the collected material. That equates 14.2% of green shoot apices and is thus more than 5% higher than in *P. purum*. That finding hints to the fact that also in *P. schreberi* caducous shoot apices might play a noteworthy role in vegetative reproduction s.str.

AFLP fingerprinting data is shown in both Jaccard and Simple-matching UPGMA trees (Fig. 24) but in both dendrograms, intraspecific relationships are not certain, only tendencies are indicated. The Simple-matching tree shows that the Russian samples I, III and IV have the greatest genetic differences between each other and compared to all other samples. Samples England I, England II, and Scotland cluster together and among two samples from Alaska. It is also shown that there is more similarity within samples from north-east Germany than in the samples from other parts of Germany, but populations are not clearly distinguished. Besides some closely related samples from Germany the only other detected affinities are between samples England I and England II. The latter could be due to very rarely fruiting populations in southern Britain which therefore maybe reproduce asexually in general (Longton & Greene 1969a). In contrast the findings of this study showed great genetic differences between samples, even in areas where fruiting specimens are supposed to be rare or absent. High levels of genetic variability were detected in small German populations (polymorphism 49.7–71.7%), even within plots and patches, whereas the highest values were found within plot Saarm1 (71.7% polymorphism), thus the plot with highest sporophyte occurrence, which impressively shows the influence of sexual reproduction on the genetic variability of plots.

The detected high levels of genetic variability match with earlier studies by Zielinski et al. (1994), Zielinski & Wachowiak-Zielinska (1995), Wachowiak-Zielinska & Zielinski (1995), Kuta et al. (1998), Wachowiak & Zielinski (2001) and Kotelko et al. (2008). The authors detected high levels of genetic variability in Polish populations by isozyme electrophoresis (86% polymorphism in 14 isozyme loci, Wachowiak-Zielinska & Zielinski 1995) and in Canadian populations (where sporophytes are more frequent) using ISSR primers (48–82%

polymorphism per population, comparing 10 populations within some kilometer range, Kotelko et al. 2008).

Kuta et al. (1998) notes that this great intra- and interpopulation genetic variability was unexpected, at least in Poland where *P. schreberi* is predicted to reproduce exclusively vegetatively. The authors attribute this to sexually reproducing populations in the past, a later loss of sexual reproduction, and populations today being unisexual.

A reason for the loss of sexual reproduction, at least in some areas, is described by Huttunen (2003). She describes a decreasing production of gametangia in *P. schreberi* as a result of pollution, studying areas surrounding copper smelters in Finland. Huttunen (2003) showed that while the rate of sexual reproduction decreased a shift from sexual to asexual reproduction appeared and predicts that this is the most common trend in increasingly polluted environments. For some parts of Germany that might be true as well, but at least in the Berlin/Brandenburg region (rare to frequent) and in Thuringia (very rare) sporophytes were observed. The produced spores maybe affected populations in other parts of Germany and as well in Poland and therefore genetic diversity by long distance dispersal. Thus on the authors opinion similar levels of genetic variability in Poland (non fruiting), Germany (rarely fruiting) and Canada (rarely to frequently fruiting) show that sexual reproduction still plays a noteworthy role in all these populations.

5.4 *Rhytidiadelphus squarrosus*

Rhytidiadelphus squarrosus, the third investigated rarely fruiting species, has a wide ecological tolerance and forms huge patches in different grassy habitats. Two populations in different environments were compared in this study, on the one hand a population from an urban meadow in Berlin city (plot B1 and a 150 m long transect along the meadow), with patches up to 20 m². The meadow is frequently mown during the summer period and has not changed for at least 20 years (own observation). On the other hand a natural population along a forest edge in the valley Bärental (Dietzhausen, Thuringia) was analysed. Investigations in the village chronicles indicate that the grassland has had the same shape for at least 150 years. In former times the valley had been used for agriculture but it was given up in the sixties of 20th century. Until today the installation of terraces in Bärental, which is very typical for agriculture along slopes in this area, can be seen. Since 1990 grassland is occasionally grazed by flocks of sheep.

Although according to literature (compare, e.g., Düll 1994, Nebel & Philippi 2001, Smith 2004) sporophytes are described to be very rare, sporophytes were found in two locations in

spring and summer 2008 in Thuringia. According to the great numbers of ♂ and ♀ gametangia found in the sample material of 2006 and 2007, the later findings of sporophytes were not surprising. Populations with both sexes as well as sporophytes were only observed in Thuringia (sporophytes only in 2008) nearly in the same places were sexually mixed populations were encountered the years before, namely Lengfeld and Bärental (close to Sil3). Whereas in Lengfeld (ca. 10 km from Bärental) in a similar habitat to Bärental (along the edge of a *Pinus*/*Picea* forest) several medium size patches with sporophytes were found, in Bärental only two small spots with sporophytes were observed in a large *R. squarrosus* carpet, some meters from Sil3 (sporophytes occurred within a diameter of appr. 5 cm in the carpet). Despite the late (at the end of the study) and locally much delimited findings of sporophytes the author assumes that *R. squarrosus* does not reproduce solely sexually (especially since several potential vegetative diaspores were found), although no molecular evidence for clonal

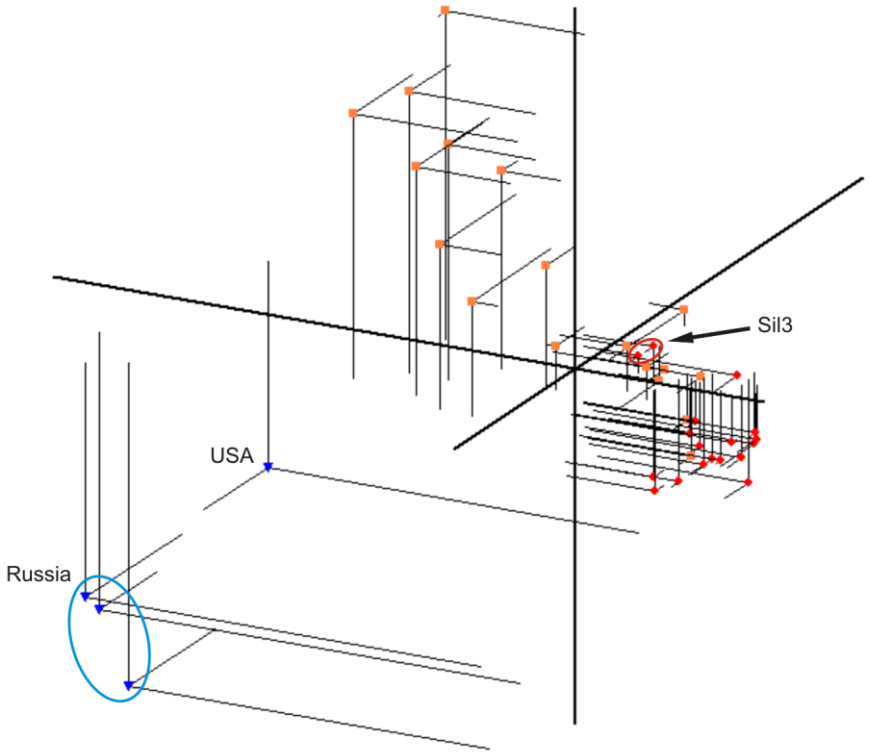


Fig. 31. Principal component analysis of worldwide *Rhytidiadelphus squarrosus* (German samples marked with red diamonds, foreign samples with orange squares) and *Rhytidiadelphus subpinnatus* samples (blue triangles), based on Jaccard distances from 214 AFLP loci; using FAMD.

reproduction was encountered. It still is possible that clones were overlooked especially because the gathering of sampling differed from that in both other species observed, since *R. squarrosus* was collected randomly in single large scale patches, whereas *P. schreberi* and *P. purum* were collected in plots composed by smaller patches. Thus the structure and the composition of these, possibly old large scale patches, is probably different from small possibly new formed patches.

On the other hand samples of the large scale patch in plot Sil3 are in parts closely related (see above), but since some of these closely related samples are from different sexes (results from morpho-anatomical analysis, see A3.3 in appendix) and therefore not of clonal origin (e.g. Sil3-A1-R10, Sil3-A1-R11 and Sil3-A1-R12, Fig. 25), it is clear that even minor genetic diversity is probably based on generative reproduction. The most likely explanation is occasional generative reproduction with long and short range dispersal of spores, which may often not be recognised and may depend on some ecological and climatic factors like wet autumns and summers (important for fertilisation) or relatively warm wet winters with nearly no snow cover (for example the winter of 2007/2008).

In the molecular analysis the worldwide sample set shows that all German samples, are similar and form a well delimited clade. Only the samples from Sil3, hence from the area where sexual reproduction was detected, differed somewhat and showed greater genetic distance to other German samples (see Fig. 26). For some reason the German population is somewhat related to the samples from England and the sample Spain I, whereas samples from close geographic neighbors like Poland and Belgium are separated and cluster among the samples from Sweden and Norway. The results suggest that vegetative reproduction has, at least in the investigated plots, only very little influence on habitat occupation and maintenance in *R. squarrosus*.

As an additional result the inclusion of *Rhytidiadelphus subpinnatus* samples in this study showed that besides ISSR (Vanderpoorten et al. 2003) and microsatellite markers (Korpelainen et al. 2008), AFLP markers are suitable to discriminate between *R. squarrosus* and *R. subpinnatus* (see Fig. 26 and Fig. 31).

5.5 Conclusion

The results from German populations of three presumed clonally reproducing pleurocarpous mosses *Pseudoscleropodium purum, Pleurozium schreberi* and *Rhythidiadelphus squarrosus*, as well as results from Polish populations of *P. schreberi* (compare, e.g., Zielinski et al. 1994, Wachowiak-Zielinska & Zielinski 1995, Zielinski & Wachowiak-Zielinska 1995, Kuta et al. 1998, Wachowiak & Zielinski 2001) and Norwegian *Hylocomium splendens* populations (Cronberg 2002, Cronberg et al. 2006), showed that patches are often occupied by different, sometimes closely related, genets. In most cases the results reject, that a local population could consist of a single clone or few widespread clones, as found in other clonally reproducing bryophytes like *Rhytidium rugosum and Abietinella abietina* (e.g., Pfeiffer et al. 2006, Lieske 2010). Cronberg et al. (2006) already suggested that the general picture of local populations in rarely fruiting pleurocarpous mosses is maybe defined by a number of patches of limited size, each dominated by a small number of more or less intermingling clones. This matches the findings in *P. purum* and *P. schreberi* in this study, especially the findings from plots NH1 and Sil1 (both without any sign of sexual reproduction). Whereas in all other included plots no clones were found and patches were composed of lots of differed, sometimes genetically very different, genets.

The findings were a little different in the very rarely fruiting pleurocarpous moss *R. rugosum*, for which it was showed that a plot up to 40 m² including multiple patches up to 8 m² can be dominated by a single clone, accompanied by only a few very close related clones (e.g., Pfeiffer et al. 2006). In contrast, the results of this study showed that rarely fruiting pleurocarpous mosses do not necessarily form clones of similar size like in *R. rugosum*. In this context it seems that the size of clones is negatively correlated with sporophyte production frequencies, which is according to own observations and literature smaller in *R. rugosum* then in the here investigated species. This question is also discussed by Cronberg (2002), he suggested that the frequency of sporophytes in populations of unisexual bryophytes can be used as an indicator of clonal diversity and genetic variability. He argues that increased mixing of clones, increased number of fertile ramets and less skewed sex ratios, with increasing population age, would predict greater chances of successful fertilisation and subsequent production of sporophytes, spores and generative offspring.

According to Longton & Schuster (1983) sexual reproduction depends on several factors: general failure of expressing only one of both sexes, skewed sex ratios, spatial segregation of sexes, availability of water for fertilisation and gamete dispersal distances. Thus the

investigated species differ somewhat, but at least in *P. schreberi* and *R. squarrosus* plots, where both sexes were expressed (Sil3 and Saarm1), the only obvious limiting factor seems to be gamete dispersal distance because of spatial segregation both of sexes. Bisang et al. (2004), Richardson (1981) and Rydgren & Økland (2002) observed that fertilisation distances depend on substrate inclination, arguing that spermatozoids are primarily passively transported by water and therefore have a greater dispersal range in steep terrain, hence a greater chance for fertilisation. Thus it is no surprise that nearly all observations of sporophytes of included species were made at steeply inclined locations or at least in comparable lower positions in the area (like in Saarm1).

In the very rarely fruiting but gametangia bearing species *Pseudoscleropodium purum* no sporophytes were found during the observation period. It seems that a general failure of expressing one or both sexes plays a role in this species, since in both plots (Sil1 and NH1) none of both sexes was expressed. Regarding the suggestion by Cronberg (2002) that the frequency of sporophytes in populations of unisexual bryophytes can be used as an indicator of clonal diversity and genetic variability, it is no surprise that the biggest patches of clonal origin, in all three observed species, were found for *P. purum*. However, clonal patches were of smaller size than in *R. rugosum* and in both plots single clones were not dominating the plots in the way it was found for *R. rugosum*. *Pseudoscleropodium purum* showed low genetic distances between different genets in plot NH1 (Brandenburg), whereas in plot Sil1 (Thuringia) genetic distances between genets were nearly as high as between south German samples of great distance, and only some small patches were of clonal origin. Regarding this, although sexual reproduction was not observed in Sil1, the spatial genetic structure of the plot seems to be a result of former sexual reproduction and establishment rather than vegetative reproduction.

Similar findings were discovered for *Pleurozium schreberi*. In Sil1 with no sign of sexual reproduction (no gametangia and sporophytes within the patch), *P. schreberi* showed clonal reproduction, a greater number of genetically closely related samples, but also genets with higher genetic distances. In both other *P. schreberi* plots (Sil2 and Saarm1) genetic distances between genets were larger. This was not unexpected in plot Saarm1 (Brandenburg) which was chosen because of sexual reproduction occurring within this plot, but not in plot Sil2 (Thuringia) which was more ore less covered by a single patch, but with the difference to Sil1 that in Sil2 most plants were female with well developed archegonia. Although it seems that vegetative reproduction has not the same relevance in all *P. purum* and *P. schreberi* plots (more important in areas without sexual reproduction), the found clonal patches for both

species are a product of the relatively fast colonisation capability. This was earlier described in gap re-colonisation experiments by Heinken & Zippel (2004) and is supported by own observations (see Fig. 18). This effective colonisation mode according to Heinken & Zippel (2004) is facilitated by the combination of three vegetative reproduction mechanisms: (1) dispersal of detached stem fragments (in most cases for short-distance dispersal), (2) germination of soil-buried stem fragments (not observed in this study), and (3) clonal growth and subsequent clonal reproduction of both existing bryophyte patches and single stem fragments resulting from (1) and (2). This list must be extended with respect to (4) brood branches/branchlets, (5) caducous shoot apices, and (6) brood leaves (only in *P. schreberi*), which were found during morphological examination in this study. Yet it is hard to tell how efficient the new found diaspore types are, but since in re-colonisation experiments the important mechanisms obviously were (1) – (3), the smaller diaspores (4) – (6) are maybe of importance for greater dispersal distances but are of minor importance for patch maintenance or gap re-colonisation.

Recently another widely discussed vegetative reproduction mode in mosses is by protonemal gemmae, but those are described as extremely rare for pleurocarps (Duckett et al. 1999, 2004) and were therefore not considered to be important.

Since it is not impossible that mistakes occurred in AFLP fingerprinting, data reading, or due to fungal contamination of samples, at least closely related samples could be misidentified ramets of the same clone. Thus it is hard to tell whether closely related samples belong to the same clone or not, but since the risk was minimised by intensive cleaning of the samples and double proofreading, the author tends to see these closely related samples not as clones, but rather as asexual lineages. But even if they would belong to one or another of the detected clones the general pattern of vegetative reproduction in the investigated species would not differ that much, because even if the clones would include these samples, the clones would be only slightly bigger.

Newton & Mishler (1994) mention that the role of mutation could be of particular importance in enhancing genetic diversity in bryophytes, because a mutation occurring in the single apical cell of a shoot, can give rise to dividuals carrying the mutant allele in every cell. Given this apical cell mode of growth, somatic mutation can within a considerable time form asexual lineages, thus providing levels of genetic variation equivalent to those of purely sexual lineages. On the other hand *R. rugosum* showed huge clonal patches (Pfeiffer et at. 2006) which might be even older. Hence either mutation rates are specific in different species or

more likely sexual reproduction is the reason for the genetic variability found in the investigated species.

Regarding this, the author agrees with Cronberg (2002) and Cronberg et al. (2006) that recruitment by sexual produced spores is maybe rare but appears to be more common than extinction of clones, so that a net recruitment into the total population occurs over time. Furthermore Cronberg (2002) noticed in case of *Hylocomium splendens*, that the number of clones, and the tendency of colonies (patches) to be multiclonal, increased significantly with increasing age of the observed plots and that populations of species that only experience recruitment after some sort of initial disturbance tend to have declining levels of diversity, whereas in those with repeated recruitment levels tend to increase over time.

This might be true in all observed species with different levels of repeated recruitment. In case of *P. purum* and at least partially in *P. schreberi* (Sil1) the clonal diversity seems to be similar to the findings in *H. splendens*, were the clonal diversity is determined by vegetative reproduction at the within-patch level and structured by sexual processes at the among-patch level (Cronberg et al. 2006).

A somewhat different picture was found for *Rhytidiadelphus squarrosus*, while it is forming genetically more or less distinguishable German subpopulations with lots of more or less closely related genets, no direct sign of vegetative reproduction could be found (see Fig. 25). These subpopulations belong to the same clade in the analysis of the worldwide sample set (see Fig. 26). The German clade shows comparable low genetic distances between the samples, only excluding both samples of Sil3 (from the plot where sexual reproduction was detected). Male plants in German populations were only found in Sil3 (Thuringia) close to the places were later in the study sporophytes were found. In this presumable rarely fruiting species with large scale patches, clones could be identified neither in a more or less natural environment nor on an urban lawn. Regarding the data of both plots it appears that *R. squarrosus* is as a sexually reproducing species rather than the predicted asexually reproducing species. This conclusion could also be an illusion because both plots were set within large scale and possibly old patches and the picture might be different observing small patches, thus considering Newton & Mishler (1994) also somatic mutation could be a reason for the found genetic diversity. All in all the author does not predict that *R. squarrosus* reproduces exclusively sexually in the investigated plots, especially because potential vegetative diaspores (although to a lesser amount than in both other analysed species) were found.

The low numbers of potential vegetative diaspores found in *R. squarrosus* are maybe a result from the irregularly or sometimes sparsely pinnately branching pattern in this species, which differs from both other remotely pinnate species. Especially since brood branches/branchlets as well as caducous shoot apices may act as potential diaspores, the relatively low number of branches in *R. squarrosus* with 15.0 (± 8.0) compared to *P. purum* with 48.1 (± 31.4) and *P. schreberi* with 39.2 (± 21.9) has to be taken into account. The same holds for the number of missing shoot apices (that maybe potential diaspores), that is with 1.4 (± 2.9) only a third compared to *P. purum* with 4.4 (± 7.2) and *P. schreberi* with 5.7 (± 7.7). Perhaps this is a misinterpretation of the given data, since a single branching would be enough for clonal reproduction through decaying and subsequent disintegration of older shoot parts, but the chance would be still higher if more branches could act as possible diaspores. Hence the reason that clonal reproduction was not found in the investigated plots might be the consequence of a lesser amount of potential vegetative diaspores and a much more effective sexual reproduction than assumed. Thus recruitment of sexual reproduction outnumbers those of vegetative reproduction, which were therefore not detected in the molecular analysis. In this case spore dispersal has to be very effective too, at least within the range of several hundred kilometers, but than the questions arise, 1. where are the locations where sexual reproduction is more common? and 2. is sexual reproduction more common than intended throughout the distribution range but has always been overlooked?

Although it was tried to select natural plot areas or areas untouched for at least 20 years (urban population of *R. squarrosus*) to show the aspects of maintaining and clonal growth, it was nevertheless discovered how fast plot structure can even change in three years of time (one plot is completely destroyed by construction vehicles, two plots were heavily changed (damaged) due to the hurricane Kyrill in January 2007, and two gap re-colonisation sides were damaged by forest vehicles and wild boar activities), and there is reasonable doubt that the selected sites were not influenced by man. Hence one can not see the presented genetic diversity only in a natural context; one has also to consider that the investigated populations were influenced by other factors. The way differs from case to case, but the special case of *R. squarrosus* shows that a natural population (Sil3) influenced by rare sexual reproduction is genetically more divers (70.6% polymorphism) than a population (B1, 40.0% polymorphism, only female plants found) without sexual reproduction, but influenced by constant mowing and man's activities (and therewith dispersal of artificial diaspores).

The influences of sexual reproduction on the genetic diversity of small populations can also be seen for *P. schreberi* were in plot Saarm1 (with sporophytes, and within an area with

frequent sexual reproducing populations in Brandenburg) 71.7% polymorphism was found, whereas in Thuringia were in three years only one patch with sporophytes (close to Sil1 and Sil2) was found the polymorphism was 58.5% in plot Sil1 and 49.7% in plot Sil2. Thus regarding all data of the three selected species, the species without any sporophyte records and the fewest gametangia records in the study (*P. purum*) showed the lowest genetic diversity (within populations) and the largest clones in plot NH1, but smaller clones than in *R. rugosum* with even lesser sexual reproduction. Whereas in the both other species (*P. schreberi* and *R. squarrosus*) with observed sexual reproduction, on one hand high genetic diversity was found in plots with or nearby sexual reproduction (like Saarm1) and on the other hand lower genetic diversity was found in populations with lesser or without sporophyte occurrence, plot Sil2 and B1 respectively.

Altogether the given data, with high numbers of different genets, multiclonal patches, and small clonal patches (in *P. purum* and *P. schreberi*) suggest that in all three species recruitment by sexual and asexual diaspores, as well as somatic mutations in asexual lineages, contribute to the present genetic diversity.

Still some questions remain open and should be addressed in further research: 1. To which extent do somatic mutations influence the clonal diversity in asexually reproducing bryophytes? 2. What are the resulting genetic differences after a few generations of vegetative reproduction? 3. Are those differences comparable to genetic differences resulting from sexual reproduction? 4. Are these results transferable to other bryophyte species? This requires further research and the comparison of more species, but it might also be favourable to alter the methods slightly to assess more of the given questions. For example a screening of younger versus older plots, as well as asexual cultivated lineages could also give interesting results.

6 Summary

In this study three dioecious, pleurocarpous mosses *Pseudoscleropodium purum*, *Pleurozium schreberi* and *Rhytidiadelphus squarrosus* (Bryophytina), with rare sexual reproduction, were investigated with focus on genetic diversity and clonal reproduction.

The study provided information about genetic structure of small populations and patches, it showed positive correlations between genetic diversity of a population and sporophyte occurrence, as well as the discovery of not yet documented possibilities for vegetative reproduction, using molecular (AFLP) and morpho-anatomical analysis.

Although all three species are described to be rarely fruiting and therefore vegetative reproduction was expected to be mainly responsible for maintenance and expansion of patches and populations, this is only partly true. In fact the results of the molecular analysis rather showed that the genetic diversity within small populations and larger patches is to some extent relatively high in all three species. This favours the conclusion that sexual reproduction is more common than estimated. Another possible reason for the genetic diversity are somatic mutations but it seems that this is not the only reason, especially regarding the frequent findings of antheridia and archegonia in all three species, as well as sporadic findings of sporophytes in *P. schreberi* and *R. squarrosus*. The latter showed that the data on sporophytes occurrence in this three species has to be seen critically in recent literature.

With the molecular approach clonal reproduction was revealed for *P. purum* and *P. schreberi*, but not for *R. squarrosus.* Clonal plants were mainly found within patches or small areas of up to 6 m², and only in populations where neither gametangia (or only gametangia of one sex) nor sporophytes were found. Additionally populations without any sign of sexual reproduction showed lesser genetic diversity than populations with sporophytes.

The morpho-anatomical analysis showed possible options for clonal reproduction and vegetative reproduction s.str. in all three species, but especially *P. purum* and *P. schreberi* seem to have the greatest potential to form asexual diaspores. Most important for vegetative reproduction is consequent vegetative multiplication (clonal reproduction) due to decay and disintegration of older shoot parts and the forming of new dividuals (ramets). This type of clonal reproduction is accompanied by three types of vegetative reproduction s.str.: brood branches/branchlets, caducous shoot apices and brood leaves (only observed in *P. schreberi*) with basal rhizoid growth. These were described for the first time in this study for the selected species. In addition great numbers of missing shoot apices were observed in *P. purum* and *P. schreberi*, which may act as diaspores.

Altogether the molecular results indicate that small populations are more influenced by sexual reproduction than predicted, although sexual reproduction is relatively rare. All three species showed abilities to reproduce vegetatively, so that maintenance and expansion of patches and small populations by asexual means is possible. Never the less the investigated populations indicate that sporadic sexual reproduction events play a major role in long term establishment of the three species.

7 Zusammenfassung

In dieser Arbeit wurden drei diözische, pleurocarpe Laubmoose *Pseudoscleropodium purum*, *Pleurozium schreberi* und *Rhytidiadelphus squarrosus* (Bryophytina), mit Focus auf genetische Diversität und klonale Reproduktion untersucht.

Gezeigt werden konnte die genetische Struktur kleiner Populationen und von Patches, eine positive Korrelation von genetischer Diversität und Sporogonhäufigkeit auf Ebene kleiner Populationen, sowie bis jetzt nicht erkannte Möglichkeiten asexueller Reproduktion. Zum Erreichen dieser Ergebnisse wurden Freilandarbeit, molekulare (AFLP) und morphologische Methoden kombiniert.

Obwohl bei allen drei Arten selten Sporogone auftreten und daher asexuelle Reproduktion zur Erhaltung und Ausweitung von Patches/Populationen angenommen wurde, konnte dieses nicht oder nur teilweise bestätigt werden. Vielmehr wurden für alle drei Arten zum Teil große genetische Unterschiede innerhalb kleinerer Populationen und größerer Patches nachgewiesen, was auf sexuelle Reproduktion hindeutet. Als ein Grund müssen natürlich auch somatische Mutationen in Betracht gezogen werden, diese scheinen aber als alleiniger Grund für die gezeigte genetische Diversität recht unwahrscheinlich zu sein. Dafür sprechen auch regelmäßige Funde von Antheridien und Archegonien in allen drei Arten sowie vereinzelte Funde von Sporogonen für *P. schreberi* und *R. squarrosus*. Diese zeigen außerdem, dass die Literaturangaben zur Sporogonhäufigkeit in den drei untersuchten Arten kritisch zu sehen sind.

Molekular konnte klonale Reproduktion für *P. purum* und *P. schreberi*, jedoch nicht für *R. squarrosus* nachgewiesen werden. Klone wurden dabei nur in Plots und kleineren Populationen gefunden, in denen weder Gametangien (oder nur Gametangien eines Geschlechts) noch Sporogone nachgewiesen wurden. Dabei erfolgten die Nachweise hauptsächlich innerhalb von Patches oder patchübergreifend auf Flächen von bis zu 6 m². Zusätzlich zeigten Populationen ohne Nachweise sexueller Reproduktion eine geringere Genetische Diversität, als Populationen in denen Sporogone gefunden wurden.

Morphologisch konnten für alle drei Arten Möglichkeiten und Typen der klonalen Reproduktion und vegetativen Reproduktion s.str. beschrieben werden, wobei *P. purum* und *P. schreberi* das größte Potenzial der drei untersuchten Arten zeigten. Der wichtigste Mechanismus asexueller Reproduktion ist hierbei die Fähigkeit zur Selbstklonierung (klonale Reproduktion) durch Verrottung und die Teilung der Mutterpflanze in selbständige Dividuen (Ramets). Hinzu kommen drei Typen der vegetativer Reproduktion s.str., Brutäste,

Brutknospen und Brutblätter (diese nur bei *P. schreberi*), die in dieser Arbeit für die untersuchten Arten erstmals beschrieben werden konnten. Zusätzlich muss eine auffällig große Anzahl fehlender Astspitzen und Endknospen als mögliche vegetative Diasporen in Betracht gezogen werden.

Insgesamt deuten die molekularen Ergebnisse darauf hin, dass die untersuchten Populationen einem stärkeren Einfluss von sexueller Reproduktion unterliegen und diesem eine bedeutendere Rolle zukommt, als zuvor auf Grund von zum Teil sehr selten nachgewiesener sexueller Reproduktion angenommen wurde. Zusätzlich zur sexuellen Reproduktion verfügen jedoch alle drei Arten über Möglichkeiten der asexuellen Reproduktion, um den Erhalt und die Ausweitung von Patches und kleineren Populationen auch ohne sexuelle Reproduktion zu sichern.

Acknowledgements

This study was carried out at the Department of Plant Geography and Systematics, Institute of Biology, Free University Berlin. I am deeply grateful to my supervisor, Prof. Dr. Wolfgang Frey.

I warmly thank PD Dr. Michael Stech, Dr. Tanja Pfeiffer, Dr. Lars Schwichtenberg, Dr. Torsten Rosenauer, Dipl.-Chem. Katrin Bossmann and Prof. Dr. Harald Kürschner for assistance in various problems, Dipl.-Biol. Kathrin Lieske for ongoing discussions and the atmosphere, working together with her on bryophytes was a pleasure. Many thanks to Dr. Regine Jahn for assistance using the Zeiss Axioplan microscope and to the technicians Ms Bettina Gisecke and Ms Christine Grüber for help in the laboratory and assistance with the SEM.

Many thanks to all the people who collected and/or provided specimens for my work and answered open questions namely T.L. Blockeel, P.J. Dalton, W.B. Schofield, K. Thomas, F. Müller, M.S. Ignatov, M. Fritz, B. Röllig, F. Ielo, U. Gebhardt, the H.H. Allan Herbarium (Christchurch, New Zealand), the Herbarium of the Swedish Museum of Natural History (Stockholm, Sweden), the Herbarium Haussknecht of the Friedrich-Schiller-Universität (Jena, Germany) and the Herbarium of the Berlin Botanical Garden (Berlin, Germany).

Finally, without my family and friends love and support, I would not have succeeded over all the barriers on the way through this study process.

References

Albach DC, Schönswetter P, Tribsch A (2006) Comparative phylogeography of the *Veronica alpina* complex in Europe and North America. Molecular Ecology 15: 3269–3286

Allen BH, Crosby MR (1987) *Pseudoscleropodium purum* re-established in South America. Journal of Bryology 14: 523–525

Arts T (1998) A contribution to the moss flora of the Cape Provinces (South Africa). Journal of Bryology 20: 429–447

Bartram EB (1936) New and noteworthy mosses from Jamaica. Journal of the Washington Academy of Sciences 26: 6–16

Bates JW, Duckett JG (2000) On the occurrence of rhizoids in *Scleropodium purum*. Journal of Bryology 22: 300–302

Bisang I, Ehrlen J, Hedenäs L (2004) Mate limited reproductive success in two dioicous mosses. Oikos 104: 291–298

Boisselier-Dubayle MC, Jubier MF, Lejeune B, Bischler H (1995) Genetic variability in the three subspecies of *Marchantia polymorpha* (Hepaticae): Isozymes, RFLP and RAPD marker. Taxon 44: 363–376

Bonin A, Ehrich D, Manel S (2007) Statistical analysis of amplified fragment length polymorphism data: a toolbox for molecular ecologists and evolutionists. Molecular Ecology 16: 3737–3758

Bowker MA, Stark LR, McLetchie DN, Mishler BD (2000) Sex expression, skewed sex ratios, and microhabitat distribution in the dioecious desert moss *Syntrichia caninervis* (Pottiaceae). American Journal of Botany 87: 517–526

Braun-Blanquet J (1964) Pflanzensozioligie. Grundzüge der Vegetationskunde. 3., Aufl, 3 edn. Springer, Berlin

Brotherus VF (1923) Die Laubmoose Fennoskandias. Flora Fennica 1: 635

Buck WR (1998) Pleurocarpous mosses of the West Indies. The New York Botanical Garden, New York

Correns C (1899) Untersuchungen über die Vermehrung der Laubmoose durch Brutorgane und Stecklinge. Verlag von Gustav Fischer, Jena

Cronberg N (2002) Colonization dynamics of the clonal moss *Hylocomium splendens* on islands in a Baltic land uplift area: reproduction, genet distribution and genetic variation. Journal of Ecology 90: 925–935

Cronberg N, Rydgren K, Okland R (2006) Clonal structure and genet-level sex ratios suggest different roles of vegetative and sexual reproduction in the clonal moss *Hylocomium splendens*. Ecography 29: 95–103

Crum HA (1972) The geographic origin of the mosses of North America's eastern deciduous forest. Journal of the Hattori Botanical Laboratory 35: 269–298

Crum HA (2004) Mosses of the Great Lakes Forest, 4 edn. The University of Michigan

Crum HA, Anderson LE (1981) Mosses of Eastern North America. Columbia University Press, New York

Dalton PJ (1997) *Rhytidiadelphus squarrosus* - an adventive species in western Tasmania. Australian Bryological Newsletter 36: 4–6

Dalton PJ, Seppelt RD, Buchanan AM (1991) An annotated checklist of Tasmanian mosses. In: Banks MR (ed) Aspects of Tasmanian botany - A tribute to Winifred Curtis, vol 31. Roy. Soc. Tasm., Horbat, pp 15–32

Davison GWH (1976) Role of birds in moss dispersal. British Birds 69: 65–66

Delgadillo CM, Bello B, Cárdenas AS (1995) Latmoss. A catalogue of Neotropical mosses. Missouri Botanical Garden

Dickson JH (1967) *Pseudoscleropodium purum* (Limp.) Fleisch. on St. Helena and its arrival on Tristan da Cunha. The Bryologist 70: 267–268

Dickson JH (1973) Bryophytes of the Pleistocene. University Press, Cambridge

Dierßen K (2001) Distributuion, ecological amplitude and phytosociological characterization of European bryophytes. Bryophytorum Bibliotheca 56: 289

Douhovnikoff V, Dodd RS (2003) Intra-clonal variation and a similarity threshold for identification of clones: application to *Salix exigua* using AFLP molecular markers. Theoretical and applied genetics 106: 1307–1315

Drehwald U, Preising E (1991) Die Pflanzengesellschaften Niedersachsens - Moosgesellschaften. Niedersächsisches Landesverwaltungsamt, Fachbehörde für Naturschutz, Hannover

Duckett JG, Burch J, Fletcher PW, Matcham HW, Read DJ, Russell AJ, Pressel S (2004) In vitro cultivation of bryophytes: a review of practicalities, problems, progress and promise. Journal of Bryology 26: 3–20

Duckett JG, Matcham HW, Hedderson TA (1999) Protonemata, propagules, peristomes and phylogeny. Bulletin of the British Bryological Society 72: 28–31

Düll R (1994) Deutschlands Moose. IHD - Verlag, Bad Münstereifel, Ohlerath

During HJ (1979) Life strategies of bryothytes: a preliminary review. Lindbergia 5: 2–18

During HJ (1997) Bryophyte diaspore banks. Advances in Bryology 6: 103–134

Eriksson O, Jerling L (1990) Hierarchical selection and risk spreading in clonal plants. In: van Groenendael J, de Croon H (eds) Clonal growth in plants: regulation and function. The Hague: SPB Academic Publishing, pp 79–94

Espie J (1997) *Rhytidiadelphus triquetrus* (Hedwig) Warnst. - in New Zealand. Australian Bryological Newsletter 37: 4

Feldberg K, Groth H, Wilson R, Schafer-Verwimp A, Heinrichs J (2004) Cryptic speciation in *Herbertus* (Herbertaceae, Jungermanniopsida): range and morphology of *Herbertus sendtneri* inferred from nrITS sequences. Plant Systematics and Evolution 249: 247–261

Fernandez C, Shevock J, Glazer A, Thompson J (2006) Cryptic species within the cosmopolitan desiccation-tolerant moss *Grimmia laevigata*. Proceedings of the National Academy of Sciences of the United States of America 103: 637–642

Fife AJ (1995) Checklist of the mosses of New Zealand. The Bryologist 98: 313–337

Frahm JP, Frey W (2004) Moosflora, 4., neubearbeitete und erweiterte. Aufl. Ulmer, Stuttgart

Frego KA (1996) Regeneration of four boreal bryophytes: colonization of experimental gaps by naturally occuring propagules. Canadian Journal of Botany-Revue Canadienne De Botanique 74: 1937–1942

Frey W (1974) Entwicklungsgeschichtliche Untersuchungen an Hypnodendron dendroides (Brid.) Touw (Hypnodendraceae, Musci). Ein Beitrag zur systematischen Stellung der Hypnodendraceae. Nova Hedwegia 25: 229–249

Frey W, Hensen I (1995) Lebensstrategien bei Pflanzen: ein Klassifizierungsvorschlag. Botanische Jahrbücher für Systematik 117: 187–209

Frey W, Kürschner H (1991) Life strategies of terrestrial bryophytes in the Judean desert. Botanica Acta 104: 172–182

Frey W, Lösch R (2004) Lehrbuch der Geobotanik. Pflanze und Vegetation in Raum und Zeit, 2 ed. Elsevier, Spektrum Akademischer Verlag, München

Frey W, Stech M (2009) Marchantiophyta, Bryophyta, Anthocerotophyta. In: Frey W (ed) Syllabus of plant families, Part 3, Bryophytes and seedless vascular plants, 13 ed. Borntraeger, Berlin, Stuttgart, pp 1–269

Frisvoll AA, Elvebakk A (1996) 2. Bryophytes. In: Elvebakk A, Prestud P (eds) A catalogue of Svalbard plants, fungi, algae and cyanobacteria. Norsk Polarinstitutt Skrifter 198: 57–172

Fritsch R (1991) Index to bryophyte chromosome counts. Bryophytorum Bibliotheca 40:352

Gangulee HC (1980) Mosses of Estern India and adjacent regions. Hypnobryales (Hypnineae). Foreign Distributor: Otto Koeltz Antiquariat, Koenigstein-Taunus, Germany, Calcutta

Glime, JM (2007) Bryophyte ecology. Volume 1. Physiological ecology. Ebook sponsored by Michigan Technological University and the International Association of Bryologists. [Online in the Internet:] URL: http://www.bryoecol.mtu.edu/chapters/4-8DispersalVeg.pdf [accessed on 20.12.2009, 14:40]

Gradstein SR, Churchill SP, Salazar-Allen N (2001) Guide to the bryophytes of tropical America. The New York Botanical Garden Press, New York

Harris H (1966) Enzyme polymorphism in man. Proceedings of the Royal Society, Series B Series B: 298–310

He S (ed) (2005) Moss flora of China. English Version. Science Press & Missouri Botanical Garden Press, Beijing, New York, St. Louis

Hedenäs L (2002) An overview of the family Brachytheciaceae (Bryophyta) in Australia. Journal of the Hattori Botanical Laboratory 92: 51–90

Hedenäs L, Eldenäs P (2007) Cryptic speciation, habitat differentiation, and geography in *Hamatocaulis vernicosus* (Calliergonaceae, Bryophyta). Plant Systematics and Evolution 268: 131–145

Heinken T (2000) Dispersal of plants by dog in a deciduous forest. Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 122: 449–467

Heinken T, Zippel E (2004) Natural re-colonization of experimental gaps by terricolous bryophytes in Central European pine forests. Nova Hedwigia 79: 329–351

Heinken T, Lees R, Raudnitschak D, Runge S (2001) Epizoochorous dispersal of bryophyte stem fragments by roe deer (*Capreolus capreolus*) and wild boar (*Sus scrofa*). Journal of Bryology 23: 293–300

Heyn CC, Herrnstadt I (eds) (2004) The bryophyte flora of Israel and adjacent regions. The Israel Academy of Sciences and Humanities, Jerusalem

Hill MO, Preston CD, Smith AJE (eds) (1994) Altas of the bryophytes of Britain and Ireland. Volume 3: Mosses (Diplolepideae). Harley Books, Colchester

Hill MO, Bell N, Bruggeman-Nannenga MA, Brugués M, Cano MJ, Enroth J, Flatberg KI, Frahm JP, Gallego MT, Garilleti R, Guerra J, Hedenäs L, Holyoak DT, Hyvönen, Ignatov MS, Lara F, Mazimpaka V, Muñoz J, Söderström L (2006) An annotated checklist of the mosses of Europe and Macaronesia. Journal of Bryology 28: 198–267

Hoe WJ (1971) Additional new and noteworthy records for Hawaiian mosses. The Bryologist 74: 501–502

Hofmeister W (1851) Vergleichende Untersuchungen der Keimung, Entfaltung und Fruchtbildung höherer Kryptogamen (Moose, Farrn, Equisetaceen, Rhizocarpeen und Lycopodiaceen) und die Samenbildung der Coniferen. Verlag von Friedrich Hofmeister, Leipzig

Horikawa Y (1971) The range of East-Asian plants (13). Hikobia 6: 1–3

Huttunen S (2003) Reproduction of the mosses *Pleurozium schreberi* and *Pohlia nutans* in the surroundings of copper smelters at Harjavalta, S.W. Finland. Journal of Bryology 25: 41–47

Huttunen S, Ignatov MS (2004) Phylogeny of the Brachytheciaceae (Bryophyta) based on morphology and sequence level data. Cladistics 20: 151–183

Huttunen S, Gardiner AA, Ignatov MS (2007) Advances in knowledge of the Brachytheciaceae (Bryophyta). In: Newton AE, Raymond ST (eds) Pleurocarpous mosses: Systematics and evolution. Systematics Association Special Volume 71. CRC Press, Boca Raton, pp 117–143

Ignatov MS, Ignatova EA (2004) Moss flora of the Middle European Russia. Vol. 2: Fontinalaceae - Amblystegiaceae. KMK Scientific Press Ltd., Moscow

Iwatsuki Z (2004) New catalog of the mosses of Japan. Journal of the Hattori Botanical Laboratory 96: 1–182

Jaccard P (1908) Nouvelles recherches sur la distribution florale. Bulletin de la Société Vaudoise des Sciences Naturelles 44: 223–270

Joenje W, During HJ (1977) Colonisation of a desalinating wadden-polder by bryophytes. Plant Ecology 35: 177–185

Kimmerer RW (1991a) Reproductive ecology of *Tetraphis pellucida*. II. Differential success of sexual and asexual propagules. The Bryologist 94: 284–288

Kimmerer RW (1991b) Reproductive ecology of *Tetraphis pellucida*. I. Population density and reproductive mode. The Bryologist 94: 255–260

Kimmerer RW (1994) Ecological consequences of sexual versus asexual reproduction in *Dicranum flagellare* and *Tetraphis pellucida*. The Bryologist 97: 20–25

Kimmerer RW, Young CC (1996) Effect of gap size and regeneration niche on species coexistence in bryophyte communities. Bulletin of the Torrey Botanical Club 123: 16–24

King TJ (2003) Mosses and aspect; why is *Scleropodium purum* abundant on the north-facing sides of ant-hills? Journal of Bryology 25: 211–213

Koperski M, Sauer M, Braun W, Gradstein SR (2000) Referenzliste der Moose Deutschlands. Bundesamt für Naturschutz, Bonn

Koponen T (1971) *Rhytidiadelphus japonicus* and *R. subpinnatus*. Hikobia 6: 18–35

Koponen T (1975) The distribution of *Rhytidiadelphus* and *Hylocomium* in Finland. Annales botanici Fennici 12: 59–62

Korpelainen H, Virtanen V, Kostamo K, Karttunen H (2008) Molecular evidence shows that the moss *Rhytidiadelphus subpinnatus* (Hylocomiaceae) is clearly distinct *from R. squarrosus*. Molecular Phylogenetics and Evolution 48: 372–376

Kotelko R, Doering M, Piercey-Normore MD (2008) Species diversity and genetic variation of terrestrial Lichens and Bryophytes in a boreal Jack Pine forest of Central Canada. The Bryologist 111: 594–606

Kottek M, Grieser J, Beck C, Rudolf B, Rubel F (2006) World map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift 15: 259–263

Krzakowa M (1977) Isozymes as markers of inter- and intraspecific differentiation in hepatics. Bibliophytorum Bibliotheca 13: 427–434

Kuc M (1969) Additions to the Arctic moss flora - I. Revue bryologique et lichénologique: 135–142

Kuc M (1973) A review of the mosses of Svalbard. Revue bryologique et lichénologique 39: 401–472

Kuc M (1997) The northernmost extension of the moss *Pleurozium schreberi* (Bird.) Mitt. in the Canadian High Arctic. The Canadian Field-Naturalist 111: 630–633

Kuta E, Przywara L, Hejmej J (1998) Karyotype variability in *Pleurozium schreberi* (Brid.) Mitt. Acta Biologica Cracoviensia Series Botanica 40: 75–84

Lawton E (1960) *Pseudoscleropodium purum* in the Pacific Northwest. The Bryologist 63: 235–237

Lawton E (1971) Moss flora of the Pacific Northwest. Suppl. No. 1 Journal of the Hattori Botanical Laboratory: 331

Lewinsky J, Bartlett J (1982) *Pseudoscleropodium purum* (Hedw.) Fleisch. in New Zealand. Lindbergia 8: 177–180

Lewinsky J, Mogensen G (1978) Distribution maps of bryophytes in Greenland 5. Lindbergia 4: 299–306

Lewinsky J, Mogensen G (1979) Distribution maps of bryophytes in Greenland 6. Lindbergia 5: 105–108

Lewontin R, Hubby J (1966) A molecular approach to the study of genic heterozygosity in natural populations. II. Amount of variation and degree of heterozygosity in natural populations of *Drosophila pseudoobscura*. Genetics 54: 595–609

Lieske K (2010) Vegetative reproduction and clonal diversity in pleurocarpous mosses (Bryophytina) of xeric habitats. Dissertation. Institute of Biology, Free University Berlin

Lieske K, Pfeiffer T (2007) May lily's multiplication: Morpho-ecological and molecular analyses in a patch of *Maianthemum bifolium* (Convallariaceae). Nova Hedwigia: 165–176

Longton RE (1976) Reproductive biology and evolutionary potential in bryophytes. Journal of the Hattori Botanical Laboratory 41: 205–223

Longton RE (1992) Reproduction and rarity in British mosses. Biological Conservation 59: 89–98

Longton RE (1994) Reproductive biology in bryophytes the challenge and the opportunities. Journal of the Hattori Botanical Laboratory 76: 159–172

Longton RE (2006) Reproductive ecology of bryophytes: what does it tell us about the significance of sexual reproduction? Lindbergia 31: 16–23

Longton RE, Greene SW (1969a) Relationship between sex distribution and sporophyte production in *Pleurozium schreberi* (Brid.) Mitt. Annals of Botany 33: 107–126

Longton RE, Greene SW (1969b) The growth and reproductive cycle of *Pleurozium schreberi* (Brid.) Mitt. Annals of Botany 33: 83–105

Longton RE, Greene SW (1979) Experimental studies of growth and reproduction in the moss *Pleurozium schreberi* (Brid.) Mitt. Journal of Bryology 10: 321–338

Longton RE, Schuster RM (1983) Reproductive biology. In: Schuster RM (ed) New manual of bryology, vol 1. Hattori Botanical Laboratory, Nichinan, pp 386–462

Mägdefrau K (1982) Life-formes of bryophytes. In: Smith AJE (ed) Bryophyte ecology. Chapman and Hall, London, pp 45–58

Marstaller R (1993) Synsystematische Übersicht über die Moosgesellschaften Zentraleuropas. Herzogia 9: 513–541

Meinunger L, Schröder W (2007) Verbreitungsatlas der Moose Deutschlands. Eigenverlag der Regensburgischen Botanischen Gesellschaft von 1790 e. V., Regensburg

Meirmans PG, van Tienderen PH (2004) GENOTYPE and GENODIVE: two programs for the analysis of genetic diversity of asexual organisms. Molecular Ecology Notes 4: 792–794

Meyer MW, Greenberg J, Tedeschi S (1974) Enzymes of the Moss *Funaria hygrometrica* II: The Isoenzymes of Malate Dehydrogenase. The Bryologist 77: 577–581

Miles CJ, Longton RE (1992) Deposition of moss spores in relation to distance from parent gametophytes. Journal of Bryology 17: 355–368

Miller NG, Ambrose LJH (1976) Growth in culture of wind-blown bryophyte gametophyte fragments from Arctic Canada. The Bryologist 79: 55–63

Miller NG, Trigoboff N (2001) A European feather moss, *Pseudoscleropodium purum*, naturalized widely in New York State in cemeteries. The Bryologist 114: 98–103

Mishler BD (1988) Reproductive ecology of bryophytes. In: Lovett-Doust J, Lovett-Doust L (eds) Plant reproductive ecology: patterns and strategies. Oxford University Press, New York, pp 285–306

Mueller UG, Wolfenbarger LL (1999) AFLP genotyping and fingerprinting. Trends in Ecology & Evolution 14: 389–394

Mühr B (2007) Klimadiagramme weltweit. Version 01.06.2007. [Online in the Internet:] URL: http://www.klimadiagramme.de [accessed on 07.08.2008, 11:19]

Müller F (1995) *Rhytidiadelphus subpinnatus* - Verbreitung und Ökologie in Deutschland. Herzogia 11: 101–107

Muluvi GM et al. (1999) Amplified fragment length polymorphism (AFLP) analysis of genetic variation in *Moringa oleifera* Lam. Molecular Ecology 8: 463–470

Muñoz J, Felicísimo ÁM, Cabezas F, Burgaz AR, Martínez I (2004) Wind as a long-distance dispersal vehicle in the Southern Hemisphere. Science 304: 1144–1147

Nebel M, Philippi G (eds) (2001) Die Moose Baden-Württembergs, Bd 2: Spezieller Teil (Bryophytina II, Schistostegales bis Hypnobrynobryales). Ulmer, Stuttgart

Newton AE, Mishler BD (1994) The evolutionary significance of asexual reproduction in mosses. Journal of the Hattori Botanical Laboratory 76: 127–145

O'Shea BJ (2006) Checklist of the mosses of sub-Saharan Africa (version 5, 12/06). Tropical Bryology Research Reports 6: 1–252

Ochyra R, Bednarek-Ochyra H (2002) *Pleurozium schreberi* (Musci, Hylocomiaceae) recorded for tropical Africa and a review of its world distribution. Cryptogamie, bryologie 23: 355–360

Pfeiffer T (2003) Terricolous bryophyte vegetation of New Zealand temperate rain forests. J. Cramer in Gebrüder Borntraeger Verlagsbuchhandlung, Berlin, Stuttgart

Pfeiffer T (2007) Vegetative multiplication and patch colonisation of *Asarum europaeum* subsp. europaeum L. (Aristolochiaceae) inferred by a combined morphological and molecular study. Flora - Morphology, Distribution, Functional Ecology of Plants 202: 89–97

Pfeiffer T, Zippel E, Fritz S, Stech M (2005) Application of the nonradioactive biotin-streptavidin system to visualize AFLP fragments. Molecular Ecology Notes 5: 673–675

Pfeiffer T, Fritz S, Stech M, Frey W (2006) Vegetative reproduction and clonal diversity in *Rhytidium rugosum* (Rhytidiaceae, Bryopsida) inferred by morpho-anatomical and molecular analyses. Journal of Plant Research 119: 125–135

Richardson DHS (1981) The biology of mosses. Blackwell Scientific Publications, Oxford, UK

Rohrer JR (1985) A generic revision of the Hylocomiaceae. Journal of the Hattori Botanical Laboratory 59: 241–278

Rudolphi J (2009) Ant-mediated dispersal of asexual moss propagules. The Bryologist 112: 73–79

Rydgren K, Økland RH (2002) Sex distribution and sporophyte frequency in a population of the clonal moss *Hylocomium splendens*. Journal of Bryology 24: 207–214

Saitou N, Nei M (1987) The neighbor-joining method: a new method for reconstructing phylogenetic trees. Molecular Biology and Evolution 4: 406–425

Schäfer-Verwimp A (1989) New or interesting records of Brazilian bryophytes, II. Journal of the Hattori Botanical Laboratory 67: 313–321

Schaumann F (2005) Terricolous bryophyte vegetation of Chilean temperate rain forests Communities, adaptive strategies and divergence patterns. J. Cramer in Gebrüder Borntraeger Verlagsbuchhandlung, Berlin, Stuttgart

Schlüter PM, Harris SA (2006) Analysis of multilocus fingerprinting data sets containing missing data. Molecular Ecology Notes 6: 569–572

Schmidt T (1918) Die Verbreitung von Samen und Blütenstaub durch Luftbewegung. Österreichische botanische Zeitschrift 67: 313–328

Schofield WB (2008) *Pseudoscleropodium* - Brachytheciaceae. In: Bryophyte Flora of North America, Provisional Publication. Version: 1, 13.02.2008. [Online in the Internet:] URL: http://www.mobot.org/plantscience/BFNA/V2/BracPseudoscleropodium.htm [accessed on 20.12.2009, 14:40]. Missouri Botanical Garden.

Schofield WB, Crum HA (1972) Disjunction in bryophytes. Annals of the Missouri Botanical Garden 59: 174–202

Schubert R, Hilbig W, Klotz S (2001) Bestimmungsbuch der Pflanzengesellschaften Deutschlands. Spektrum, Akad. Verl., Heidelberg, Berlin

Selkirk PM (1984) Vegetative reproduction and dispersal of bryophytes on Subantarctic Macquarie Island and in Antarctica. Journal of the Hattori Botanical Laboratory 55: 105–111

Sharp AJ, Crum HA, Eckel PM (eds) (1994) The moss flora of Mexico. Part two Orthotrichales to Polytrichales. The New York Botanical Garden, New York

Shaw A (2000) Molecular phylogeography and cryptic speciation in the mosses, *Mielichhoferia elongata* and *M. mielichhoferiana* (Bryaceae). Molecular Ecology 9: 595–608

Shaw A (2001) Biogeographic patterns and cryptic speciation in bryophytes. Journal of Biogeography 28: 253–261

Shaw A, Cao T, Wang LS, Flatberg KI, Flatberg B, Shaw B, Zhou P, Boles S, Terracciano S (2008) Genetic variation in three Chinese peat mosses (*Sphagnum*) based on microsatellite markers, with primer information and analysis of ascertainment bias. The Bryologist 111: 271–281

Sjödin Å (1980) Index to distibution maps of bryophytes 1887–1975 I. Musci. Svenska Växtegeografiska Sällskapet, Uppsala

Smith AJE (2004) The moos flora of Britain and Ireland, 2 edn. Cambridge University Press, Cambridge

Sneath PH, Sokal RR (1973) Numerical taxonomy - the principles and practice of numerical classification. Freeman, San Francisco

So ML, Grolle R (2000) Description of *Plagiochila detecta* sp. nov. (Hepaticae) from East Asia based on morphological and RAPD evidence. Nova Hedwigia 71: 387–393

Sobotka D (1976) Regeneration and vegetative propagation of *Sphagnum palustre* as factor of population stability. Acta Societatis Botanicorum Poloniae 45: 357–367

Söderström L (1994) Scope and significance of studies on reproductive biology of bryophytes. Journal of the Hattori Botanical Laboratory 76: 97–1003

Söderström L, Herben T (1997) Dynamics of bryophyte metapopulations. Advances in Bryology 6:205–240

Söderström L, Jonsson BG (1989) Spatial pattern and dispersal in the leafy hepatic *Ptilidium pulcherrimum*. Journal of Bryology 15: 793–802

Sokal RR, Michener CD (1958) A statistical method for evaluating systematic relationships. University of Kansas science bulletin 38: 1409–1438

Stark LR (2002) Phenology and its repercussions on the reproductive ecology of mosses. The Bryologist 105: 204–218

Stech M, Wagner D (2005) Molecular relationships, biogeography, and evolution of Gondwanan *Campylopus* species (Dicranaceae, Bryopsida). Taxon 54: 377–382

Steere WC (1978) The mosses of Arctic Alaska. J. Cramer, Vaduz

Stenøien HK, Såstad SM (2001) Genetic variability in bryophytes: does mating system really matter? Journal of Bryology 23: 313–318

Stoneburner A (1979) Fruiting in relation to sex ratios in colonies of *Pleurozium schreberi* in Northern Michigan. The Michigan botanist 18: 73–81

Stoneburner A, Lane DM, Anderson LE (1992) Spore dispersal distances in *Atrichum angustatum* (Polytrichaceae). The Bryologist 95: 324–328

Störmer P (1969) Mosses with a Western and Southern Distribution in Norway. Universitetsforlaget, Oslo

Streimann H, Klazenga N (2002) Catalogue of Australian Mosses. Australian Biological Resources Study, Canberra

Szweykowski J, Krzakowa M (1979) Variation in four isozyme systems in Polish populations of *Conocephalum conicum* (L.) Dum. (Hepaticae, Marchantiales). Bulletin de l'Académie Polonaise des Sciences Biologiques, II 27: 27–41

Townsend CC (1975) *Pseudoscleropodium purum* on two more tropical islands. The Bryologist 78: 73–74

Tuomi J, Vuorisalo T (1989) Hierarchical selection in modular organisms. Trends in Ecology & Evolution 4: 209–213

Urbanska KM (1992) Populationsökologie. UTB. G.Fischer, Stuttgart

Van der Hulst RGM, Mes THM, Den Nijs JCM, Bachmann K (2000) Amplified fragment length polymorphism (AFLP) markers reveal that population structure of triploid dandelions (*Taraxacum officinale*) exhibits both clonality and recombination. Molecular Ecology 9: 1–8

Van der Velde M, During HJ, Van de Zande L, Bijlsma R (2001) The reproductive biology of *Polytrichum formosum*: clonal structure and paternity revealed by microsatellites. Molecular Ecology 10: 2423–2434

Vanderpoorten A, Tignon M (2000) Amplified fragments length polymorphism between populations of *Amblystegium tenax* exposed to contrasting water chemistries. Journal of Bryology 22: 257–262

Vanderpoorten A, Hedenäs L, Jacquemart A-L (2003) Differentiation in DNA fingerprinting and morphology among species of the pleurocarpous moss genus, *Rhytidiadelphus* (Hylocomiaceae). Taxon 52: 229–236

Vanderpoorten A, Ignatov MS, Huttunen S, Goffinet B (2005) A Molecular and morphological recircumscription of *Brachytheciastrum* (Brachytheciaceae, Bryopsida). Taxon 54: 369–376

Vos P, Hogers R, Bleeker M, Reijans M, van de Lee T, Hornes M, Frijters A, Pot J, Peleman J, Kuiper M, et al. (1995) AFLP: a new technique for DNA fingerprinting. Nucleic acids research 23: 4407–4414

Wachowiak M, Zielinski R (2001) *Pleurozium schreberi*: One of the most variable bryophyte species. Biological Bulletin of Poznan 38: 228

Wachowiak-Zielinska M, Zielinski R (1995) Genetic variation of the haploid moss *Pleurozium schreberi* (Musci, Hylocomiaceae) from Poland. Fragmenta Floristica et Geobotanica 40: 417–423

Wang CK (1970) Phytogeography of the mosses of Formosa. Tunghai University, Taichung

Werner O, Ros RM, Guerra J, Shaw AJ (2003) Molecular data confirm the presence of *Anacolia menziesii* (Bartramiaceae, Musci) in southern Europe and its separation from *Anacolia webbii*. Systematic Botany 28: 483–489

Wigh K (1972) Chromosome numbers in some mosses from Central and South Europe. The Bryologist 75: 136–146

Winfield MO, Arnhold GM, Cooper F, Le Rey M, White J, Karp A, Edwards KJ (1998) A study of genetic diversity in *Populus nigra* subsp. *betulifolia* in the Upper Severn area of the UK using AFLP markers. Molecular Ecology 7: 3–10

Wong C, Kiew R, Argent G, Set O, Lee SK, Gan YY (2002) Assessment of the validity of the sections in *Musa* (Musaceae) using AFLP. Annals of Botany 90: 231–238

Wyatt R (1985) Species concepts in bryophytes: input from population biology. The Bryologist 88: 182–189

Wynne FE (1945) Studies in *Calliergon* and Related Genera. The Bryologist 48: 131–155

Zabeau M, Vos P (1993) Selective restriction fragment amplification: a general method for DNA fingerprinting. In. Publication no: EP 0534858 A1

Zanten BO v. (1978) Experimental Studies on trans-oceanic long-range dispersal of moss spores in the Southern Hemisphere. Journal of the Hattori Botanical Laboratory 44: 455–482

Zanten BO v., Pocs T (1981) Distribution and dispersal of bryophytes. Advances in Bryology 1: 479–562

Zartman C, McDaniel S, Shaw A (2006) Experimental habitat fragmentation increases linkage disequilibrium but does not affect genetic diversity or population structure in the Amazonian liverwort *Radula flaccida*. Molecular Ecology 15: 2305–2315

Zhang DP, Comes HP, Kadereit JW (2001) Phylogeny and quaternary history of the European montane/alpine endemic *Soldanella* (Primulaceae) based on ITS and AFLP variation. American Journal of Botany 88: 2331–2345

Ziegenhagen B, Bialozyt R, Kuhlenkamp V, Schulze I, Ulrich A, Wulf M (2003) Spatial patterns of maternal lineages and clones of *Galium odoratum* in a large ancient woodland: inferences about seedling recruitment. Journal of Ecology 91: 578–586

Zielinski R, Wachowiak-Zielinska M (1995) Genetic structure of a single population of *Pleurozium schreberi* (Musci, Hylocomiaceae) detected by isoenzyme electrophoresis. Fragmenta Floristica et Geobotanica 40: 425–435

Zielinski R, Wachowiak-Zielinska M, Soroka M (1994) Electrophoretic polymorphism of three enzymes, PX, GOT and LAP, in a single population of *Pleurozium schreberi* (Musci, Hylocomiaceae) from Poland. Fragmenta Floristica et Geobotanica 39: 461–469

Appendix

A1 Vegetational records

A1.1 *Pseudoscleropodium purum*

Pseudoscleropodium purum				
Plot	**NH1**		**Sil1**	
Locality	Neuehütte		Silbachtal/Bärental	
Country	Brandenburg		Thuringia	
Date	16.05.2007		14.05.2007	
Latitude, Longitude	52°52'23.8''N 13°50'45.1''E		50°35'46.8''N 10°35'04.6''E	
Altitude [m a.s.l.]	63		428	
Altitudial zone	lowland		montane	
Inclination/Exposition	10-15° / West		20° / NWW	
Relief	middle slope		middle slpoe	
Tree cover [%] / hight [m]	90 / 15		90 / 25	
Shrub cover [%] / hight [m]	5 / 0.6		0	
Herb cover [%] / higth [m]	15 / 0.2		30 / 20	
Moss cover [%]	30		60	
Ground cover [%]	40		5	
Plot size [m²]	35		15	
Trees	1	*Pseudotsuga menziesii*	1	*Picea abies*
Shrubs	s	*Fagus sylvatica*	s	*Sorbus aucuparia*
	s	*Sorbus aucuparia*	s	*Picea abies*
	s	*Quercus robur*		
	s	*Prunus serotina*		
Herbs	2b	*Agrostis capillaris*	2a	*Agrostis capillaris*
	+	*Arrhenatherum elatius*	+	*Vaccinium myrtillus*
	+	*Moehringia trinerria*		
	+	*Carex pilulifera*		
	+	*Oxalis acetosella*		
	+	*Dryopteris carthusiana*		
Bryophytes	3	*Pseudoscleropodium purum*	2a	*Pleurozium schreberi*
	1m	*Aulacomnium androgynum*	2a	*Pseudoscleropodium purum*
	1m	*Mnium hornum*	1m	*Polytricum formosum*
	1m	*Plagiothecium laetum var. curvifolium*	1m	*Rhytidiadelphus squarrosus*
	1m	*Brachythecium starkei*	1m	*Plagiomnium affine*
	1m	*Hypnum cupressiforme*	1m	*Hypnum cupressiforme*
			1m	*Lophocolea bidentata*
			+	*Brachythecium salebrosum*

(s) seedling, (r) 1 individual; (+) 2-5 individuals; (1) 6-50 Individuals or 1-5 Individuals with great habitus, cover ≤ 5%; (1m) more than 50 individuals, cover ≤ 5%; (2a) cover > 5-15%; (2b) cover > 15-25%; (3) cover > 25-50%; (4) cover > 50-75%; (5) cover > 75-100%.

A1.2 *Pleurozium schreberi*

Pleurozium schreberi						
Plot	**Sil1**		**Sil2**		**Saarm1**	
Locality	Dietzhausen Silbachtal/Bärental		Dietzhausen Silbachtal/Bärental		Saarmund	
Country	Thuringia		Thuringia		Brandenburg	
Date	14.05.2007		14.05.2007		13.06.2006	
Latitude, Longitude	50°35'46.8''N 10°35'04.6''E		50°35'45.2''N 10°35'04.7''E		52°18'53.0''N 13°06'31.9''E	
Altitude [m a.s.l.]	428		433		78	
Altitudial zone	montane		montane		lowland	
Inclination/exposition	20° / NWW		10° / NWW		10° / N	
Relief	middle slope		middle slope		middle slope	
Tree cover [%] / hight [m]	90 / 25		70 / 25		5 / 2	
Shrub cover [%] / hight [m]	0		40 / 5		0	
Herb cover [%] / higth [cm]	30 / 20		20 / 20		20 / 30	
Moss cover [%]	60		85		80	
Ground cover [%]	5		-		10	
Plot size [m²]	15		12		18	
Trees	1	*Picea abies*			1	*Quercus robur*
Shrubs	s s	*Sorbus aucuparia* *Picea abies*	s s	*Sorbus aucuparia* *Picea abies*		
Herbs	2a +	*Agrostis cappilaris* *Vaccinium myrtillus*	2a 2a +	*Agrostis cappilaris* *Vaccinium myrtillus* *Melampyrum sylvaticum*	2b 1m	*Calluna vulgaris* *Deschampsia flexuosa*
Bryophytes	2a 2a 1m 1m 1m	*Pleurozium schreberi* *Pseudoscleropodium purum* *Polytricum formosum* *Rhytidiadelphus squarrosus* *Hypnum cupressiforme*	5 1 1 1 1m	*Pleurozium schreberi* *Hylocomium splendens* *Polytrichum formosum* *Hypnum cupressiforme* *Lophocolea bidentata*	2b 1m 1m	*Pleurozium schreberi* *Hypnum cupressiforme* *Dicranium scoparium*
Lichens					1m 1m 1m 1m	*Cladonia macilenta* *Cladonia abuscula* *Cladonia scamosa* *Cladonia glauca*

(s) seedling, (r) 1 individual; (+) 2-5 individuals; (1) 6-50 Individuals or 1-5 Individuals with great habitus, cover ≤ 5%; (1m) more than 50 individuals, cover ≤ 5%; (2a) cover > 5-15%; (2b) cover > 15-25%; (3) cover > 25-50%; (4) cover > 50-75%; (5) cover > 75-100%.

A1.3 *Rhytidiadelphus squarrosus*

Rhytidiadelphus squarrosus				
Plot	**Sil3**		**Pankow 1**	
Locality	Silbachtal/Bärental		Berlin	
Country	Thuringia		Berlin	
Date	14.05.2007		16.10.2006	
Latitude, Longitude	50°35'45.6''N 10°35'07.0''E		52°33'38.4''N 13°24'13.7''E	
Altitude [m a.s.l.]	377		54	
Altitudial zone	montane		lowland	
Inclination/exposition	3° / E		0°	
Relief	flat meadow		flat meadow	
Tree cover [%] / hight [m]	0		0	
Shrub cover [%] / hight [m]	0		0	
Herb cover [%] / higth [m]	60 / 30		30	
Moss cover [%]	95		85	
Ground cover [%]	5		0	
Plot size [m²]	15		6	
Trees		-		-
Shrubs	s s s s	*Populus tremula* *Picea abies* *Pinus sylvestris* *Quercus robur*		-
Herbs	3 2a 1 1 1m +	*Anthoxanthum odoratum* *Agrostis capillaris* *Melampyrum sylvaticum* *Luzula campestris* *Galium saxatile* *Cytisus scoparius*	1 1 1 1m 1m 1m 1m +	*Poa spec.* *Taraxacum officinale* *Bellis perennis* *Trifolium repens* *Trifolium pratense* *Plantago major* *Prunella vulgaris* *Ranunculus repens*
Bryophytes	5 2a 1m 1m	*Rhytidiadelphus squarrosus* *Pseudoscleropodium purum* *Pleurozium schreberi* *Polytrichum formosum*	5	*Rhytidiadelphus squarrosus*

(s) seedling, (r) 1 individual; (+) 2-5 individuals; (1) 6-50 Individuals or 1-5 Individuals with great habitus, cover ≤ 5%; (1m) more than 50 individuals, cover ≤ 5%; (2a) cover > 5-15%; (2b) cover > 15-25%; (3) cover > 25-50%; (4) cover > 50-75%; (5) cover > 75-100%.

A2 List of specimens

A2.1 List of used specimens from herbarium Sebastian Fritz

Herbar. No.	Collection No.	Date	Species	Country	State	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
8		03.09.2005	*Pleurozium schreberi*	Scottland		Inverness, W of city, Dunain Hill	57°28'N 4°18'W	230	S.Fritz	S.Fritz	25.10.2005
16		09.09.2005	*Scleropodium purum*	Scottland		Glen Nevis	56°47'N 4°59'W	250	S.Fritz	S.Fritz	25.10.2005
113	Sil1-A1-P1	14.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
114	Sil1-A1-P2	14.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
115	Sil1-A2-P3	14.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
116	Sil1-A3-P4	14.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
117	Sil1-A4-P5	14.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
118	Sil1-A4-P6	14.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
119	Sil1-A5-P7	14.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
120	Sil1-A5-P8	14.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
121	Sil1-B2-P9	15.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
122	Sil1-B2-P10	15.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
123	Sil1-B3-P11	15.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
124	Sil1-B4-P12	15.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
125	Sil1-B4-P13	15.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
126	Sil1-C1-P14-1	15.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
127	Sil1-C1-P14-2	15.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
128	Sil1-C1-P14-3	15.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
129	Sil1-C1-P15	15.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005

Herbar. No.	Collection No.	Date	Species	Country	State	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
130	Sil1-C2-P16	15.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
131	Sil1-C3-P17	15.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
132	Sil1-C4-P18	15.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
133	Sil1-A2-S1	14.10.2005	*Scleropodium purum*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
134	Sil1-A2-S2	14.10.2005	*Scleropodium purum*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
140	Sil1-A4-S8	14.10.2005	*Scleropodium purum*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
143	Sil1-A5-S11-1	14.10.2005	*Scleropodium purum*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
150	Sil1-B4-S17-1	15.10.2005	*Scleropodium purum*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
152	Sil1-B4-S17-3	15.10.2005	*Scleropodium purum*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
156	Sil1-C1-S20	15.10.2005	*Scleropodium purum*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
159	Sil1-C2-S22-2	15.10.2005	*Scleropodium purum*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
160	Sil1-C3-S22-3	15.10.2005	*Scleropodium purum*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
165	Sil1-C5-S26	15.10.2005	*Scleropodium purum*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
166	Sil1-A5	15.10.2005	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
169	Sil1- B2	15.10.2005	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil1	50°35'51.1"N 10°35'09.3"E	423	S.Fritz	S.Fritz	07.11.2005
176		05.10.2005	*Pleurozium schreberi*	Germany	Bavaria	Berchtesgadener Alpen, Kühroint Alm	47°34'16"N 12°57'37"E	1380	S.Fritz	S.Fritz	09.10.2005
177		08.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Römhild, Kl. Gleichberg	50°24'17"N 10°35'22"E	469	S.Fritz	S.Fritz	09.10.2005
178		10.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Wegscheide, Rennsteig	50°37'00"N 10°45'56"E	824	S.Fritz	S.Fritz	10.10.2005
180		16.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Keulrot, Frankenblick	50°33'40.3"N 10°41'38.0"E	648	S.Fritz	S.Fritz	16.10.2005
181		16.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Vesser	50°35'58.9"N 10°47'29.8"E	681	S.Fritz	S.Fritz	16.10.2005
182		17.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Inselsberg, Rennsteig	50°51'05.8"N 10°27'56.9"E	910	S.Fritz	S.Fritz	17.10.2005
183		19.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Geraberg	50°43'49.4"N 10°52'06.9"E	515	S.Fritz	S.Fritz	19.10.2005

Herbar. No.	Collection No.	Date	Species	Country	State	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
184		19.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Geraberg	50°43'39.7"N 10°52'11.9"E	494	S.Fritz	S.Fritz	19.10.2005
187		21.10.2005	*Pleurozium schreberi*	Germany	Thuringia	Jena, Nennsdorf	50°53'28"N 10°33'22"E	344	S.Fritz	S.Fritz	21.10.2005
190		07.10.2005	*Scleropodium purum*	Germany	Thuringia	Dietzhausen, Dietzhausener Wald	50°35'26"N 10°34'53"E	418	S.Fritz	S.Fritz	09.10.2005
191		08.10.2005	*Scleropodium purum*	Germany	Thuringia	Römhild, Kl. Gleichberg	50°24'17"N 10°35'22"E	469	S.Fritz	S.Fritz	09.10.2005
196		19.10.2005	*Scleropodium purum*	Germany	Thuringia	Geraberg	50°43'40.6"N 10°52'11.4"E	513	S.Fritz	S.Fritz	19.10.2005
200		21.10.2005	*Scleropodium purum*	Germany	Thuringia	Jena, Nennsdorf	50°53'27"N 10°33'09"E	280	S.Fritz	S.Fritz	21.10.2005
211		04.10.2005	*Pleurozium schreberi*	Austria	Salzburg	Salzburg, Untersberg	47°44'04"N 13°00'24" E	1100	S.Fritz	S.Fritz	15.11.2005
215		05.10.2005	*Pleurozium schreberi*	Germany	Bavaria	Berchtesgadener Alpen, Grünstein	47°36'14"N 12°57'01"E	760	S.Fritz	S.Fritz	15.11.2005
239		29.10.2005	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Bleicherode	51°25'55.7"N 10°34'45.3"E	316	M.Fritz	S.Fritz	23.11.2005
240		28.10.2005	*Pleurozium schreberi*	Germany	Brandenburg	Summt	52°41'38.3"N 13°22'54.7"E		S.Fritz	S.Fritz	23.11.2005
241		28.10.2005	*Scleropodium purum*	Germany	Brandenburg	Summt	52°41'38.3"N 13°22'54.7"E		S.Fritz	S.Fritz	23.11.2005
242		10.12.2005	*Rhytidiadelphus squarrosus*	Germany	Lower Saxony	Harz	51°50'22.8"N 10°31'59.6"E	607	S.Fritz	S.Fritz	10.12.2005
243		10.12.2005	*Pleurozium schreberi*	Germany	Lower Saxony	Harz	51°50'22.8"N 10°31'59.6"E	607	S.Fritz	S.Fritz	10.12.2005
244		10.12.2005	*Scleropodium purum*	Germany	Lower Saxony	Harz	51°50'38.5"N 10°33'20.9"E	527	S.Fritz	S.Fritz	10.12.2005
254	Sil2-A2-P5	05.04.2006	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil2	50°35'49.6"N 10°35'09.4"E	433	S.Fritz	S.Fritz	05.04.2006
267	Sil2-B1-P18	05.04.2006	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil2	50°35'49.6"N 10°35'09.4"E	433	S.Fritz	S.Fritz	05.04.2006
269	Sil2-B1-P20	05.04.2006	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil2	50°35'49.6"N 10°35'09.4"E	433	S.Fritz	S.Fritz	05.04.2006
271	Sil2-B2-P22	05.04.2006	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil2	50°35'49.6"N 10°35'09.4"E	433	S.Fritz	S.Fritz	05.04.2006
276	Sil2-B3-P27	05.04.2006	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil2	50°35'49.6"N 10°35'09.4"E	433	S.Fritz	S.Fritz	05.04.2006
277	Sil2-B3-P28	05.04.2006	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil2	50°35'49.6"N 10°35'09.4"E	433	S.Fritz	S.Fritz	05.04.2006
280	Sil2-B4-P31	06.04.2006	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil2	50°35'49.6"N 10°35'09.4"E	433	S.Fritz	S.Fritz	06.04.2006
291	Sil2-C4-P42	06.04.2006	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Sil2	50°35'49.6"N 10°35'09.4"E	433	S.Fritz	S.Fritz	06.04.2006

Herbar. No.	Collection No.	Date	Species	Country	State	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
302		08.04.2006	*Pleurozium schreberi*	Germany	Baden Würtemberg	Mönchberg, Schönbuch	48°35'13.0"N 08°55'19.0"E	521	S.Fritz	S.Fritz	08.04.2006
304		09.04.2006	*Scleropodium purum*	Germany	Baden Würtemberg	Bad Urach, Waterfall	48°29'29.7"N 09°22'32.1"E	470	S.Fritz	S.Fritz	09.04.2006
309		12.04.2006	*Pleurozium schreberi*	Germany	Baden Würtemberg	Waldenbuch, Schönbuch	48°38'42.4"N 09°06'53.6"E	370	S.Fritz	S.Fritz	12.04.2006
313	Sarm1-A1-P1	23.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	23.05.2006
314	Sarm1-A1-P2	23.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	23.05.2006
317	Sarm1-A2-P5	23.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	23.05.2006
327	Sarm1-B2-P15	23.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	23.05.2006
328	Sarm1-B2-P16	23.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	23.05.2006
335	Sarm1-C1-P23	23.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	23.05.2006
336	Sarm1-C1-P24	23.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	23.05.2006
337	Sarm1-C2-P25	23.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	23.05.2006
338	Sarm1-C2-P26	23.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	23.05.2006
341	Sarm1-C3-P29	23.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	23.05.2006
342	Sarm1-C4-P30	23.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	23.05.2006
343	Sarm1-C4-P31	23.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	23.05.2006
347	Sarm1-D2-P35	24.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	24.05.2006
361	Sarm1-E3-P49	24.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Saarmund, Eichenberg, Saarm1	52°18'57.8"N 13°06'38.1"E	78	S.Fritz	S.Fritz	24.05.2006
369		26.05.2006	*Pleurozium schreberi*	Germany	Brandenburg	Neue Hütte	52°52'14.9"N 13°51'17.9"E		S.Fritz	S.Fritz	26.05.2006
374		15.04.2006	*Pleurozium schreberi*	Germany	Hesse	Frankenau, Bärenmühle	51°05'47"N 08°54'00"E	300	F.Ielo	S.Fritz	26.05.2006
375		15.04.2006	*Scleropodium purum*	Germany	Hesse	Frankenau	51°05'32"N 08°56'00"E	420	F.Ielo	S.Fritz	26.05.2006
376		15.04.2006	*Rhytidiadelphus squarrosus*	Germany	Hesse	Frankenau	51°05'32"N 08°56'00"E	420	F.Ielo	S.Fritz	24.05.2006
377		03.06.2006	*Pleurozium schreberi*	Germany	Brandenburg	Löbten	52°09'00"N 13°41'31"E	40	S.Fritz	S.Fritz	03.06.2006

Herbar. No.	Collection No.	Date	Species	Country	State	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
378		04.06.2006	*Pleurozium schreberi*	Germany	Brandenburg	Köthen, Krausnicker Berge	52°04'06.3"N 13°48'24.4"E	62	S.Fritz	S.Fritz	04.06.2006
379		04.06.2006	*Scleropodium purum*	Germany	Brandenburg	Köthen, Krausnicker Berge	52°03'35.0"N 13°47'53.1"E	52	S.Fritz	S.Fritz	04.06.2006
380		23.07.2006	*Pleurozium schreberi*	Germany	Mecklenburg-Western Pomerania	Jägerhof	54°02'21.3"N 13°38'58.6"E	30	S.Fritz	S.Fritz	27.07.2006
381		23.07.2006	*Scleropodium purum*	Germany	Mecklenburg-Western Pomerania	Jägerhof	54°02'21.3"N 13°38'58.6"E	30	S.Fritz	S.Fritz	27.07.2006
382		23.07.2006	*Rhytidiadelphus squarrosus*	Germany	Mecklenburg-Western Pomerania	Jägerhof	54°02'31.0"N 13°39'07.1"E	30	S.Fritz	S.Fritz	27.07.2006
387		14.01.2003	*Pleurozium schreberi*	England	Derbyshire	Via Gellia, above Middleton Wood	Grid reference: SK27.56.	260	T.L. Blockeel	T.L. Blockeel	14.01.2003
388		29.05.2006	*Pleurozium schreberi*	England	Derbyshire	below Mam Tor, near Castleton	Grid reference: SK131836	360	T.L. Blockeel	T.L. Blockeel	29.05.2006
390	NH1-A1-S2	08.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	08.08.2006
392	NH1-A1-S4	08.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	08.08.2006
393	NH1-A2-S5	08.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	08.08.2006
397	NH1-A3-S9	08.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	08.08.2006
398	NH1-A3-S10	08.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	08.08.2006
401	NH1-A5-S13	08.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	08.08.2006
402	NH1-A6-S14	08.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	08.08.2006
403	NH1-A6-S15	08.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	08.08.2006
408	NH1-B2-S20	08.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	08.08.2006
409	NH1-B3-S21	08.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	08.08.2006
410	NH1-B3-S22	08.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	08.08.2006
411	NH1-B3-S23	08.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	08.08.2006
425	NH1-C1-S37	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006
426	NH1-C1-S38	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006

Herbar. No.	Collection No.	Date	Species	Country	State	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
427	NH1-C1-S39	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006
429	NH1-C2-S41	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006
433	NH1-C4-S45	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006
439	NH1-C6-S51	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006
447	NH1-D2-S59	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006
452	NH1-D3-S64	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006
457	NH1-D5-S69	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006
468	NH1-E2-S80	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006
479	NH1-E5-S91	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006
481	NH1-E6-S93	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006
482	NH1-E7-S94	09.08.2006	*Scleropodium purum*	Germany	Brandenburg	Neuehütte, NH1	52°52'28.8"N 13°50'51.8"E	63	S.Fritz	S.Fritz	09.08.2006
485		28.08.2006	*Rhytidiadelphus squarrosus*	Austria	Kärnten	Seeboden	46°49'N 13°31'E	600	S.Fritz	S.Fritz	28.08.2006
486		28.08.2006	*Scleropodium purum*	Slovenia			45°53'52"N 14°15'25"E	500	S.Fritz	S.Fritz	28.08.2006
487		09.09.2006	*Scleropodium purum*	Slovakia			48°32'59"N 17°00'42"E	170	S.Fritz	S.Fritz	09.09.2006
488		09.09.2006	*Pleurozium schreberi*	Slovakia			48°32'59"N 17°00'42"E	170	S.Fritz	S.Fritz	09.09.2006
490		09.09.2006	*Pleurozium schreberi*	Germany	Saxony	Marienberg	50°35'47"N 13°10'47"E	740	S.Fritz	S.Fritz	09.09.2006
492		29.09.2006	*Pleurozium schreberi*	Germany	Bavaria	Neudrossenfeld	50°01'39.2"N 11°30'05.2"E	358	S.Fritz	S.Fritz	29.09.2006
493		29.09.2006	*Scleropodium purum*	Germany	Bavaria	Neudrossenfeld	50°01'39.2"N 11°30'05.2"E	358	S.Fritz	S.Fritz	29.09.2006
494		29.09.2006	*Rhytidiadelphus squarrosus*	Germany	Bavaria	Bayreuth	49°56'56.2"N 11°37'17.0"E	386	S.Fritz	S.Fritz	29.09.2006
496		02.10.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Lengfeld	50°31'19.3"N 10°39'19.3"E	410	S.Fritz	S.Fritz	02.10.2006
497	Sil3-A1-R1	25.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	25.09.2006
502	Sil3-A1-R6	25.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	25.09.2006

Herbar. No.	Collection No.	Date	Species	Country	State	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
503	Sil3-A1-R7	25.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	25.09.2006
506	Sil3-A1-R10	25.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	25.09.2006
507	Sil3-A1-R11	25.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	25.09.2006
508	Sil3-A1-R12	25.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	25.09.2006
511	Sil3-A2-R15	25.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	25.09.2006
512	Sil3-A2-R16	25.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	25.09.2006
518	Sil3-A3-R22	25.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	25.09.2006
519	Sil3-A4-R23	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
520	Sil3-A4-R24	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
525	Sil3-A5-R29	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
533	Sil3-B1-R37	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
534	Sil3-B1-R38	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
536	Sil3-B2-R40	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
546	Sil3-B3-R50	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
552	Sil3-B4-R56	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
562	Sil3-B5-R66	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
566	Sil3-C1-R70	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
573	Sil3-C2-R77	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
582	Sil3-C3-R86	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
590	Sil3-C4-R94	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
603	Sil3-C5-R107	26.09.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Sil3	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
609	Sil-R113	03.10.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Bärental	50°35'47.2"N 10°35'06.7"E	426	S.Fritz	S.Fritz	03.10.2006

Herbar. No.	Collection No.	Date	Species	Country	State	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
610	Sil-R114	03.10.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Bärental	50°35'46.3"N 10°35'07.3"E	426	S.Fritz	S.Fritz	03.10.2006
611	Sil-R115	03.10.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Bärental	50°35'44.7"N 10°35'08.7"E	430	S.Fritz	S.Fritz	03.10.2006
612	Sil-R116	03.10.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Bärental	50°35'47.3"N 10°35'10.6"E	425	S.Fritz	S.Fritz	03.10.2006
613		26.09.2006	*Pleurozium schreberi*	Germany	Thuringia	Dietzhausen, Bärental	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	26.09.2006
615	B1-A1-R1	16.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow, B1	52°33'38.4"N 13°24'13.6"E	54	S.Fritz	S.Fritz	16.10.2006
617	B1-A1-R3	16.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow, B1	50°35'46.7"N 10°35'07.1"E	54	S.Fritz	S.Fritz	16.10.2006
619	B1-A1-R5	16.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow, B1	50°35'46.7"N 10°35'07.1"E	54	S.Fritz	S.Fritz	16.10.2006
621	B1-A2-R7	16.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow, B1	50°35'46.7"N 10°35'07.1"E	54	S.Fritz	S.Fritz	16.10.2006
622	B1-A2-R8	16.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow, B1	50°35'46.7"N 10°35'07.1"E	54	S.Fritz	S.Fritz	16.10.2006
624	B1-A2-R10	16.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow, B1	50°35'46.7"N 10°35'07.1"E	54	S.Fritz	S.Fritz	16.10.2006
626	B1-A3-R12	16.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow, B1	52°33'38.4"N 13°24'13.6"E	54	S.Fritz	S.Fritz	16.10.2006
627	B1-A3-R13	16.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow, B1	52°33'38.4"N 13°24'13.6"E	54	S.Fritz	S.Fritz	16.10.2006
630	B1-A3-R16	16.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow, B1	52°33'38.4"N 13°24'13.6"E	54	S.Fritz	S.Fritz	16.10.2006
634	B1-R20	17.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow, B1	52°33'38.4"N 13°24'13.6"E	54	S.Fritz	S.Fritz	17.10.2006
637	B1-R23	17.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow, B1	52°33'38.4"N 13°24'13.6"E	54	S.Fritz	S.Fritz	17.10.2006
638	B1-R24	17.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow, B1	52°33'38.4"N 13°24'13.6"E	54	S.Fritz	S.Fritz	17.10.2006
639		18.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow	52°33'38.4"N 13°24'13.6"E	50	S.Fritz	S.Fritz	18.10.2006
640		18.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow	52°34'13.3"N 13°24'52.9"E	50	S.Fritz	S.Fritz	18.10.2006
641		18.10.2006	*Rhytidiadelphus squarrosus*	Germany	Berlin	Pankow	52°34'13.1"N 13°23'41.3"E	50	S.Fritz	S.Fritz	18.10.2006
645	R.s.1	09.04.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Saalburg	50°31'43"N 11°42'47"E	404	K.Lieske	K.Lieske	09.04.2006
646	R.s.0	11.04.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Nennsdorf	50°53'31"N 11°32'49"E	223	K.Lieske	K.Lieske	11.04.2006
647	R.s.Lindena	01.08.2006	*Rhytidiadelphus squarrosus*	Germany	Brandenburg	Lindena	51°35'27.3"N 13°32'13.2"E	92	K.Lieske	K.Lieske	01.08.2006

Herbar. No.	Collection No.	Date	Species	Country	State	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
648	R.s.3	12.04.2006	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Treffurf, Schnellmannshausen	51°06'32"N 10°12'27"E	290	K.Lieske	K.Lieske	12.04.2006
650		28.10.2006	*Rhytidiadelphus squarrosus*	Germany	Brandenburg	Lindow, Seebeck	52°56'19.9"N 13°01'55.7"E	55	S.Fritz	S.Fritz	28.10.2006
651		28.10.2006	*Scleropodium purum*	Germany	Brandenburg	Lindow, Seebeck	52°56'19.9"N 13°01'55.7"E	55	S.Fritz	S.Fritz	28.10.2006
652		27.12.2006	*Scleropodium purum*	Germany	Brandenburg	Bad Saarow	52°17'39"N 14°02'28"E	60	S.Fritz	S.Fritz	27.12.2006
653		30.12.2006	*Scleropodium purum*	Germany	Brandenburg	Biesenbrow	53°07'34.4"N 13°59'38.5"E	50	S.Fritz	S.Fritz	30.12.2006
655		12.04.2006	*Scleropodium purum*	Germany	Northrhine-Westphalia	Gde. Ruppichteroth, Schönenberg	TK25 5110.41		M.Stech	M.Stech	12.04.2006
657		11.2006	*Scleropodium purum*	France	Bretagne	Le Faou	48°17'N 04°10'E		K.Thomas	S.Fritz	07.02.2007
658		21.05.2006	*Scleropodium purum*	England	Derbyshire	Calver Low, near Stoney Middleton	53°16'N 01°39'W	190	T.L.Blockeel	T.L.Blockeel	
660	06.35	17.08.2006	*Pseudoscleropodium purum*	Australia	Tasmania	Horbat, University of Tasmania campus	147°20'E 42°53'S		P.J.Dalton	P.J.Dalton	17.08.2007
661		17.03.2007	*Rhytidiadelphus squarrosus*	Germany	Lower Saxony	Bohndorf	53°10'43.4"N 10°39'27.6"E	96	S.Fritz	S.Fritz	17.03.2007
662		13.01.2007	*Rhytidiadelphus squarrosus*	Germany	Lower Saxony	Andrup-Lage, Haselünne	52°39'14.3"N 07°32'36.0"E		B.Röllig	S.Fritz	16.04.2007
664	M. Stech B060411.1	11.04.2006	*Rhytidiadelphus squarrosus*	Germany	Northrhine-Westphalia	Rhein-Sieg-Kreis, Gde. Ruppichteroth	TK25 S110.24		M.Stech	M.Stech	11.04.2006
665		14.05.2007	*Rhytidiadelphus squarrosus*	Germany	Thuringia	Dietzhausen, Bärental	50°35'46.7"N 10°35'07.1"E	426	S.Fritz	S.Fritz	14.05.2007
666		04.06.2006	*Rhytidiadelphus squarrosus*	England	Cumbria	Scout Scar, near Kendal	54°19'N 02°47'E	135	T.L.Blockeel	T.L.Blockeel	
667		21.05.2006	*Rhytidiadelphus squarrosus*	England	Derbyshire	Calver Low near Stoney Middleton	53°16'N 01°38'E	160	T.L.Blockeel	T.L.Blockeel	
668		02.02.2007	*Rhytidiadelphus squarrosus*	Canada	BC	Vancouver, Dunbar area	49°15'N 123°06'E		W.B. Schofield	W.B. Schofield	
669	97.61	02.06.1997	*Rhytidiadelphus squarrosus*	Australia	Tasmania	Rosebery Golf Cours, ca 5km west of Rosebery	145°30'E 41°47'S		P.J.Dalton	P.J.Dalton	02.06.1997
670		29.01.2007	*Rhytidiadelphus squarrosus*	Canada	BC	E Vancouver	49°15'N 123°06'E		O. Lee	W.B. Schofield	

A2.2 List of used duplicates and samples of other herbaria

Duplicat No.	Orginal Collection	Herbar. No.	Date	Species	Country	State/ Province	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
D1	(S) Naturhistoriska Riksmuseet, Stockholm	B93195	30.06.2004	*Pleurozium schreberi*	Schweden	Åsele Lappmark	Klimpfjäll area, the northern spur of Mt. Stikken	65°07'N 14°31'E	760-860	L. Hedenäs	L. Hedenäs	30.06.2004
D2	Herbarium H. Kürschner	7739	15.09.2001	*Pleurozium schreberi*	Ecuador	Prov. Napo: Cordillera Oriental	Quito		3900	H. Kürschner & G. Parolly	H. Kürschner & G. Parolly	15.09.2001
D3	(S) Naturhistoriska Riksmuseet, Stockholm	B82824	16.07.2003	*Pleurozium schreberi*	Norway	Troms, Lyngen	Mts. Kjostindane, E portion of Mt. Rundtinden	69°36'N 20°12'E	720	L. Hedenäs	L. Hedenäs	16.07.2003
D4	(S) Naturhistoriska Riksmuseet, Stockholm	B95393	24.06.2003	*Pleurozium schreberi*	Poland	Western Carpathians, Beskid Wysoki Mts.	Mt. Leszczak, Raba Wyzna coummune, SE of peak	ATMOS grid square: Gd 29	830	A. Stebel	A. Stebel	24.06.2003
D5	(S) Naturhistoriska Riksmuseet, Stockholm	B84958	15.07.1999	*Pleurozium schreberi*	U.S.A.	Alaska Peninsula area	Nakchamik Island	56°21'N 157°50'W		W.B. Schofield & S. Talbot	W.B. Schofield	15.07.1999
D6	(S) Naturhistoriska Riksmuseet, Stockholm	B63488	06.07.1999	*Pleurozium schreberi*	U.S.A.	Alaska Peninsula area	Ivanof Bay, outwash area beyond settlement behind Ivanof River delta	56°00'N 159°30'W		W.B. Schofield & S. Talbot	W.B. Schofield	06.07.1999
D7	(S) Naturhistoriska Riksmuseet, Stockholm	B103725	16.06.2005	*Pleurozium schreberi*	Italy	Süd-Tirol	Brommersein, along path No. 23	46°54'N 11°25'E	1200	L. Hedenäs	L. Hedenäs	16.06.2005
D8	(S) Naturhistoriska Riksmuseet, Stockholm	B105173	11.09.2005	*Pleurozium schreberi*	Sweden	Jämtland	Kall, along lake Kallsjön, 0.7 km SW to 1.4 Km SSW of Bratteggen	63°26'N 13°22'E	385	L. Hedenäs	L. Hedenäs	11.09.2005
D9	(MUB) Herbarium Universitatis Murcicae	18553	12.08.2005	*Pleurozium schreberi*	Spain	León	Puerto de las Señales	43°04'28"N 05°14'31"W	1640	M.J. Cano 2513	M.J. Cano	12.08.2005
D10	(MUB) Herbarium Universitatis Murcicae	17521	12.08.2004	*Pleurozium schreberi*	Spain	La Rioja	2 km NE del Puerto de Piqueras	42°04'01"N 02°31'00"W	1685	M.J. Cano 1641	M.J. Cano	12.08.2004

Duplicat No.	Orginal Collection	Herbar. No.	Date	Species	Country	State/ Province	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
D11	(MHA) Main Botanical Garden, Moscow	-	18.06.1996	*Pleurozium schreberi*	Russia	European Russia	Moscow Prov. Serpukhov Distr., Pushchino	54°50'N 37°36'E		M. Ignatov	M. Ignatov	
D12	(MHA) Main Botanical Garden, Moscow	-	19.08.2001	*Pleurozium schreberi*	Russia	European Russia	Vologda	58°39'N 40°25'E		M. Ignatov & Ignatova	M. Ignatov & Ignatova	
D13	(MHA) Main Botanical Garden, Moscow	-	10.08.1999	*Pleurozium schreberi*	Russia	European Russia	Volgograd Prov.			M. Ignatov	M. Ignatov	
D14	(MHA) Main Botanical Garden, Moscow	-	19.06.2001	*Pleurozium schreberi*	Russia	Urals	Bashkortostan			Zolotov #13-65	Zolotov	
D15	(MHA) Main Botanical Garden, Moscow	-	08.07.1993	*Pleurozium schreberi*	Russia	Altai	Sibiria	51°09'N 86°30'E	1800	M. Ignatov & Ignatova	M. Ignatov & Ignatova	
D16	(MHA) Main Botanical Garden, Moscow	-	24.08.1997	*Pleurozium schreberi*	Russia	Russia, Far East	Khabarovsk Territory	51°49'N 134°42'E		M. Ignatov 97-369	M. Ignatov	
D17	(CHR) Allan Herbarium, Landcare Research	CHR 573303	12.09.2003	*Pseudoscleropodium purum*	New Zealand	South Auckland Land District	Hunua Ranges, Lower Wairoa Loop Track	NZMS 260: S12 990 523	120	Macmillan BH 03/11	Macmillan BH	12.09.2003
D20	(CHR) Allan Herbarium, Landcare Research	CHR 515090	27.11.1997	*Rhytidiadelphus squarrosus*	New Zealand	Nelson Land District	Reefton, town domain	NZMS 260: L30 166 979 NZMS1: S38 335 281	200	A. Fife 11128	A. Fife	27.11.1997
D21	(CHR) Allan Herbarium, Landcare Research	CHR 510557	08.05.1996	*Rhytidiadelphus squarrosus*	New Zealand	Westland Land District	Whataroa, St Lukes Churchyard	NZMS 260: L35 936 685 NZMS1: S71 987 890	40	Macmillan BH 96/43	Macmillan BH	
D23	(S) Naturhistoriska Riksmuseet, Stockholm	B34273	20.06.2000	*Pseudoscleropodium purum*	Sweden	Uppland, Möja	1 km WNW of Långvik			L. Hedenäs		
D25	(S) Naturhistoriska Riksmuseet, Stockholm	B62874	26.09.2001	*Pseudoscleropodium purum*	France	Alpes Maritimes, Sospel, Fort de Castès		43°50'N 07°30'E	600	Gillis & Patricia Een		

Duplicat No.	Orginal Collection	Herbar. No.	Date	Species	Country	State/ Province	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
D26	(MUB) Herbarium Universitatis Murcicae	Bryotheca 16725	08.11.1003	*Scleropodium purum*	Spain	Avila: Sierra de Gredos, Hoyocasero		40°39'N 04°41'E		J. Guerra		
D27	(S) Naturhistoriska Riksmuseet, Stockholm	B42787	26.09.2000	*Pseudoscleropodium purum*	Azores	São Miguel, Sete Cidades	Romangos	37°52'N 25°49'W	280	L. Hedenäs		
D28	(S) Naturhistoriska Riksmuseet, Stockholm	B42788	30.09.2000	*Pseudoscleropodium purum*	Azores	Flores, Faja Grande	along first c. 2 km of road to Morro Alto	39°26'N 31°14'W	500-600	L. Hedenäs		
D29	(S) Naturhistoriska Riksmuseet, Stockholm	B22295	1999	*Pseudoscleropodium purum*	Madeira	Ribeira do Moreno (Norte)	CB 31 19 e CB 32 19		300-350	S. Fontinha 11	L. Hedenäs	
D30	(JE) Herbarium Haussknecht, Jena	-	17.09.2002	*Scleropodium purum*	Italy	Liguria: Riviera di Levanta	zwischen Bonassola u. Auzo			R. Marstaller	R. Marstaller	17.09.2002
D31	(JE) Herbarium Haussknecht, Jena	-	07.06.2001	*Scleropodium purum*	Greek	N Aegaeis: Thassos: NO Küste UTMLF2			500-550	R. Düll	R. Düll	07.06.2001
D32	(S) Naturhistoriska Riksmuseet, Stockholm	B47979	21.05.1997	*Pseudoscleropodium purum*	Canada	Saturna Island	East Piont	48°47'N 123°05'W		W.B. Schofield 107765		
D34	(S) Naturhistoriska Riksmuseet, Stockholm	B75208	04.09.2002	*Rhytidiadelphus squarrosus*	Belgium	Luxembourg, Léglise, forêt d'Anlier				A. Vanderpoorten R4	A. Vanderpoorten	
D35	(S) Naturhistoriska Riksmuseet, Stockholm	B82975	17.07.2003	*Rhytidiadelphus squarrosus*	Norway	Troms, Lyngen, Vardu	around large waterfall of Rive Storelva	69°37'N 20°15'E	170	L. Hedenäs	L. Hedenäs	
D36	(S) Naturhistoriska Riksmuseet, Stockholm	B104945	11.09.2005	*Rhytidiadelphus squarrosus*	Sweden	Jämtland, Kall	along lake Kallsjön, 0.7km SW to 1.4km SSW of Bratteggen	63°26'N 13°22'E	385	L. Hedenäs	L. Hedenäs	
D37	(S) Naturhistoriska Riksmuseet, Stockholm	B91732	25.05.2004	*Rhytidiadelphus squarrosus*	Sweden	Småland, Norra Unnaryd	just N of N. Unnaryd's school	57°36'N 13°45'E	180	L. Hedenäs	L. Hedenäs	

Duplicat No.	Orginal Collection	Herbar. No.	Date	Species	Country	State/ Province	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
D38	(S) Naturhistoriska Riksmuseet, Stockholm	B92414	15.06.2003	*Rhytidiadelphus squarrosus*	Poland	Western Carpathians, Beskid Makowski Mts.	Harbutowice-Końce, Sułkowice commune	ATMOS grid square Fd 98	540	A. Stebel		
D39	(MHA) Main Botanical Garden, Moscow	-	21.07.1996	*Rhytidiadelphus squarrosus*	Russia	European Russia	Smolensk Provice, Sergo-Ivanovskoye	55°28'N 34°45'E	200	M. Ignatov	M. Ignatov	
D40	(MHA) Main Botanical Garden, Moscow	-	03.08.1996	*Rhytidiadelphus squarrosus*	Russia	European Russia	Moscow, Losiny Ostrov (Лосиный Остров)	55°51'N 37°47'E	168	M. Ignatov	M. Ignatov	
D41	(MHA) Main Botanical Garden, Moscow	-	08.08.1998	*Rhytidiadelphus subpinnatus*	Russia	European Russia	Murmansk Province, Khibiny rocks (Чъибиний)	67°40'N 33°12'E		M. Ignatov	S. Fritz	20.09.2008
D42	(MUB) Herbarium Universitatis Murcicae	18567	13.08.2005	*Rhytidiadelphus squarrosus*	Spain	León: Maraña, base del Mampodre	valle de Valverde	43°02'03"N 05°12'12"W	1650	M.J. Cano 2526	M.J. Cano	
D43	(MUB) Herbarium Universitatis Murcicae	17534	12.08.2004	*Rhytidiadelphus squarrosus*	Spain	Soria	Barranco de las Monjas	42°06'01"N 02°30'17"W	1415	M.J. Cano 1653	M.J. Cano	
D44	(S) Naturhistoriska Riksmuseet, Stockholm	B44105	30.09.2000	*Rhytidiadelphus squarrosus*	Portugal	Azores, Flores, Faja Grande	along first c. 2 km of road to Morro Alto	39°26'N 31°14'W	500-600	L. Hedenäs	L. Hedenäs	
D46	(S) Naturhistoriska Riksmuseet, Stockholm	B92235	28.07.2003	*Rhytidiadelphus subpinnatus*	USA	West Virginia, Pocahontas County, Mill Point	100 yds N of exit, Cranberry Glades Boardwalk Trail, Cranberry Glades Botanical Area	38°09'N 80°10'W	3000 f	C.E. Darigo 3959	S. Fritz	20.09.2008
D47	(S) Naturhistoriska Riksmuseet, Stockholm	B95136	20.08.2000	*Rhytidiadelphus squarrosus*	USA	Alaska, Murder Point, Attu Island, Aleutian Is.	open area near road	52°48'N 173°10'W		W.B. Schofield 116281	W.B. Schofield	

Duplicat No.	Orginal Collection	Herbar. No.	Date	Species	Country	State/ Province	Location	Coordinates	Altitude [m a.s.l.]	Coll.	Det.	Det. date
D48	(MHA) Main Botanical Garden, Moscow	-	16.08.2001	*Rhytidiadelphus subpinnatus*	Russia	European Russia	Vologda Province	60°17'N 41°30'E		M. Ignatov & Ignatova	S. Fritz	20.09.2008
D50	(MHA) Main Botanical Garden, Moscow	-	14.08.2000	*Rhytidiadelphus subpinnatus*	Russia	European Russia North	Archangelsk (Архангельск) Province, Carl			Churakova	S. Fritz	20.09.2008

A3 Morpho-anatomical analysis

A3.1 *Pseudoscleropodium purum*

Pseudoscleropodium purum		Rhizoids		Missing shoot apices			Branches	Asexual reproduction	Sex	Remarks
Lab. No.	Herbar. No.		Localisation	basal	middle	apical	Total number			
Australia	660	no	-	0	0	0	51	-	no sex	
Azores I	D27	no	-	3	1	0	24	-	male	
Azores II	D28	no	-	2	0	2	49	-	female	
Bad Saarow BB	652	yes	Side branch tips	0	0	4	134	-	no sex	
Bad Urach BW	304	yes	Along shoot	8	9	0	65	-	no sex	
Biesenbrow BB	653	yes	Side branch tips	0	0	1	66	-	no sex	
Canada	D32	no	-	0	2	1	19	-	no sex	
Dietzhausen TH	190	no	-	0	0	0	46	-	no sex	
England	658	no	-	0	0	0	18	-	female	
France I	D25	no	-	3	1	0	33	-	no sex	
France II	657	no	-	0	0	0	18	-	female	
Frankenau H	375	no	-	0	5	0	64	-	female	
Geraberg TH	196	no	-	3	0	0	95	2 Caducous shoot apices	no sex	
Greece	D31	yes	Basis	1	0	0	27	-	no sex	
Harz N	244	no	-	0	4	1	23	-	no sex	
Italy	D30	yes	Basis	0	1	0	20	-	no sex	
Jägerhof MV	381	yes	-	2	2	1	35	Caducous shoot apex	no sex	
Köthen BB	379	no	-	0	0	0	23	-	not certain	
Lindow BB	651	yes	Side branch tips, shoot	1	1	1	65	-	no sex	
Madeira	D29	no	-	4	1	0	35	-	no sex	
Nennsdorf TH	200	no	-	0	1	0	30	-	no sex	
Neudrossenfeld BY	493	yes	Side branch tips	2	2	0	33	-	no sex	
New Zealand	D17	no	-	0	0	0	26	-	no sex	
NH1-A1-S2	390	no	-	5	2	0	27	-	no sex	
NH1-A1-S4-br1	392	no	-	0	3	2	158	-	no sex	
NH1-A1-S4-br2	392	no	-	0	3	2	158	-	no sex	2. branch, same plant

Pseudoscleropodium purum		Rhizoids		Missing shoot apices			Branches	Asexual reproduction	Sex	Remarks
Lab. No.	Herbar. No.		Localisation	basal	middle	apical	Total number			
NH1-A2-S5	393	no	-	0	0	0	30	-	no sex	
NH1-A3-S10	398	no	-	0	0	0	35	-	no sex	
NH1-A3-S9	397	no	-	0	0	1	59	-	no sex	
NH1-A5-S13	401	no	-	2	2	0	49	-	no sex	
NH1-A6-S14	402	yes	Basal side branch tips	0	5	0	66	-	no sex	
NH1-A6-S15	403	yes	Basal side branch tips	0	0	0	35	-	no sex	
NH1-B2-S20	408	no	-	0	0	0	86	-	no sex	
NH1-B3-S21	409	no	-	2	0	0	46	-	no sex	
NH1-B3-S22	410	no	-	0	6	0	59	-	no sex	
NH1-B3-S23	411	no	-	0	2	1	61	-	no sex	
NH1-C1-S37	425	yes	Along shoot	2	0	0	21	-	no sex	
NH1-C1-S38	426	yes	Along shoot	0	0	0	35	-	no sex	
NH1-C1-S39	427	yes	Side branch tips	4	0	0	118	-	no sex	
NH1-C2-S41	429	no	-	0	0	1	62	-	no sex	
NH1-C4-S45	433	no	-	1	1	0	44	-	not certain	
NH1-C6-S51	439	no	-	0	0	0	30	-	no sex	
NH1-D2-S59	447	no	-	0	0	0	28	-	no sex	
NH1-D3-S64	452	yes	Along shoot	0	0	0	5	-	no sex	
NH1-D5-S69	457	no	-	0	0	0	52	-	no sex	
NH1-E2-S80	468	yes	Shoot basal	0	1	0	27	-	no sex	
NH1-E5-S91	479	no	-	5	0	0	43	-	no sex	
NH1-E6-S93	481	yes	Side branch tips, shoot	8	4	0	141	2 Brood branches	no sex	
NH1-E7-S94	482	no	-	0	6	0	127	-	no sex	very big plant
Röhmhild TH	191	no	-	2	3	1	63	-	female	
Schönenberg NRW	655	no	-	2	0	4	32	-	female	
Scotland	16	no	-	0	3	0	19	-	not certain	
Sil1-A2-S1	133	yes	Along side branch	5	8	9	61	-	no sex	
Sil1-A2-S2	134	yes	Side branch tips	3	10	1	30	-	no sex	
Sil1-A4-S8	140	yes	Side branch Tips, shoot	7	4	3	50	Caducous shoot apex	no sex	
Sil1-A5-S11-1	143	yes	Shoot	13	10	9	58	-	no sex	
Sil1-B4-S17-1	150	yes	Shoot	9	9	1	43	Caducous shoot apex	no sex	

Pseudoscleropodium purum		Rhizoids		Missing shoot apices			Branches	Asexual reproduction	Sex	Remarks
Lab. No.	Herbar. No.		Localisation	basal	middle	apical	Total number			
Sil1-B4-S17-3	152	yes	-	2	1	3	26	-	no sex	
Sil1-C1-S20	156	yes	Side branch tips	0	1	0	16	-	no sex	
Sil1-C2-S22-2	159	yes	Side branch Tipps, shoot	0	0	3	39	Brood branch	no sex	
Sil1-C3-S22-3	160	no	-	0	0	0	24	-	no sex	
Sil1-C5-S26	165	no	-	3	3	3	24	3 Caducous shoot apices	no sex	
Slovakia	487	no	-	3	0	1	31	-	no sex	
Slovenia	486	yes	Along shoot	8	4	0	40	-	no sex	
Spain	D26	no	-	2	1	0	43	-	female	
Summt BB	241	yes	Side branch tips	0	0	0	90	-	no sex	
Sweden	D23	yes	Side branch tips	0	0	0	45	-	no sex	

A3.2 *Pleurozium schreberi*

Pleurozium schreberi		Rhizoids		Missing shoot apices			Branches	Asexual reproduction	Sex	Remarks
Lab. No.	Herbar. No.		Localisation	basal	middle	apical	Total number			
Bayreuth BY	492	yes	Side branch tips	0	1	0	80	-	female	
Berchtesgaden I	176	yes	Side branch tips	0	4	2	44	-	no sex	
Berchtesgaden II	215	yes	Along side branch	0	4	0	28	-	no sex	
Dietzhausen TH	613	yes	Side branch tips	3	2	3	39	-	female	c.fr.
Ecuador	D2	no	-	0	2	0	20	-	female	
England I	387	yes	Side branch tips	0	0	0	20	-	no sex	
England II	388	yes	Along side branch	3	6	0	49	-	female	
Frankenau H	374	no	-	0	4	0	37	-	female	
Geraberg I	183	yes	Side branch tips	0	0	0	72	2 Brood branches	female	
Geraberg II	184	no	-	5	4	0	33	-	female	
Harz N	243	yes	Leaf	3	1	0	18	-	no sex	
Inselsberg TH	182	yes	Side branch tips	0	6	9	36	-	no sex	
Italy	D7	yes	Side branch tips	2	0	1	35	-	female	
Jägerhof MV	380	yes	Side branch tips	1	3	0	31	-	no sex	
Keulrod TH	180	yes	Side branch tips	0	0	0	37	-	no sex	
Kl. Gleichberg TH	177	yes	Side branch tips	1	3	0	45	-	male	
Köthen BB	378	yes	Side branch tips	2	2	0	66	-	female	c.fr.
Löbten BB	377	yes	Side branch tips	2	2	1	36	-	female	c.fr.
Marienberg S	490	yes	Side branch tips	2	8	5	79	2 Brood branches	no sex	
Mönchberg BW	302	yes	Brood branch	5	2	3	47	Brood branch	no sex	
Nennsdorf TH	187	yes	Side branch tips	0	3	0	19	-	no sex	
Neuehütte BB	369	yes	Side branch tips	1	0	1	23	-	no sex	
Norway	D3	yes	Side branch tips	0	0	1	26	-	no sex	
Poland	D4	yes	Side branch tips	0	3	2	19	-	no sex	
Rennsteig TH	178	no	-	2	2	0	37	-	no sex	
Russia I	D11	yes	Side branch tips	5	7	3	50	-	no sex	
Russia II	D12	yes	Side branch tips	0	4	0	65	-	no sex	
Russia III	D13	yes	Side branch tips	4	3	2	65	-	female	

Pleurozium schreberi		Rhizoids		Missing shoot apices			Branches	Asexual reproduction	Sex	Remarks
Lab. No.	Herbar. No.		Localisation	basal	middle	apical	Total number			
Russia IV	D14	no	-	0	0	3	36	-	no sex	
Russia V	D15	yes	Side branch tips	0	1	1	30	-	no sex	
Russia VI	D16	yes	Side branch tips	0	1	2	45	-	female	
Saarm1-A1-P1	313	yes	Side branch tips	6	2	3	60	-	female	c.fr.
Saarm1-A1-P2	314	no	-	1	0	0	62	-	female	c.fr.
Saarm1-A2-P5	317	yes	Side branch tips	1	0	1	29	-	male	
Saarm1-B2-P15	327	no	-	2	3	0	29	-	no sex	
Saarm1-B2-P16	328	yes	Side branch tips	0	1	1	55	-	male	
Saarm1-C1-P23	335	yes	Side branch tips	0	1	0	20	-	no sex	
Saarm1-C1-P24	336	yes	Side branch tips	0	0	0	31	-	no sex	
Saarm1-C2-P25	337	yes	Side branch tips	2	0	0	29	-	male	
Saarm1-C2-P26	338	yes	Side branch tips	0	0	0	22	-	male	
Saarm1-C3-P29	341	yes	Side branch tips	0	1	0	24	-	male	
Saarm1-C4-P30	342	yes	Side branch tips	1	0	0	94	-	female	
Saarm1-C4-P31	343	yes	Side branch tips	0	0	0	41	-	no sex	
Saarm1-D2-P35	347	yes	Side branch tips	1	1	1	25	-	female	c.fr.
Saarm1-E3-P49	361	no	-	0	0	0	51	-	female	
Salzburg	211	yes	Along side branch	0	6	0	26	-	no sex	
Scotland	8	yes	Side branch tips	1	3	0	61	-	female	
Sil1-A1-P1	113	no	-	2	7	0	27	Caducous shoot apex	no sex	
Sil1-A1-P2	114	no	-	5	0	2	18	-	no sex	
Sil1-A2-P3	115	no	-	5	0	0	17	-	no sex	
Sil1-A3-P4	116	yes	Along Side branch and on tips	0	0	0	45	Caducous shoot apex	no sex	
Sil1-A4-P5	117	no	-	0	0	0	24	-	no sex	
Sil1-A4-P6	118	no	-	0	2	0	14	-	no sex	
Sil1-A5-P7	119	yes	Side branch tips	0	0	2	18	-	no sex	
Sil1-A5-P8	120	no	-	0	4	1	10	-	no sex	
Sil1-B2-P9	121	yes	Side branch tips	3	0	1	17	-	no sex	
Sil1-B2-P10	122	yes	Leaf	2	2	0	24	-	no sex	
Sil1-B3-P11	123	yes	Stem and side branch tips	3	1	0	47	2 Caducous shoot apices	no sex	
Sil1-B4-P12	124	yes	Side branch tips	0	2	3	-	2 Brood branches	no sex	

Pleurozium schreberi		Rhizoids		Missing shoot apices			Branches	Asexual reproduction	Sex	Remarks
Lab. No.	Herbar. No.		Localisation	basal	middle	apical	Total number			
Sil1-B4-P13	125	yes	Side branch tips	0	2	0	18	-	no sex	
Sil1-C1-P14-1	126	yes	Side branch tips	0	3	5	21	-	no sex	
Sil1-C1-P14-2	127	yes	Side branch tips	3	3	0	39	Brood branch	no sex	
Sil1-C1-P14-3	128	yes	Side branch tips	0	4	0	11	Caducous shoot apex	no sex	
Sil1-C1-P15	129	yes	Basis	1	1	0	19	-	no sex	
Sil1-C2-P16	130	no	-	0	3	3	35	Caducous shoot apex	no sex	
Sil1-C3-P17	131	yes	Side branch tips	3	0	1	66	-	no sex	
Sil1-C4-P18	132	yes	Side branch tips	3	2	5	42	-	no sex	
Sil2-A2-P5	254	yes	Side branch tips	5	10	13	46	-	female	
Sil2-B1-P18	267	yes	Side branch tips	6	4	12	65	-	female	
Sil2-B1-P20	269	yes	Side branch tips	3	6	11	112	4 Brood branches	no sex	
Sil2-B2-P22	271	yes	Side branch tips	1	4	8	36	-	female	
Sil2-B3-P27	276	yes	Anlong side branch	11	11	8	47	-	female	
Sil2-B3-P28	277	no	-	3	6	6	34	-	female	
Sil2-B4-P31	280	no	-	6	11	5	42	-	female	
Sil2-C4-P42	291	yes	Side branch tips	0	3	10	52	-	female	
Slovakia	488	yes	Side branch tips	0	1	0	37	-	no sex	
Spain I	D9	yes	Along stem	1	0	0	10	-	no sex	
Spain II	D10	no	-	8	5	0	19	-	no sex	
Summt BB	240	yes	Side branch tips	0	3	0	86	-	female	
Sweden I	D1	yes	Side branch tips	1	1	0	26	-	no sex	
Sweden II	D8	no	-	0	0	0	18	-	female	
USA Alaska I	D5	no	-	0	3	1	55	-	female	
USA Alaska II	D6	yes	Side branch tips	1	1	0	28	-	female	
Vesser TH	181	yes	Side branch tips	5	5	0	117	-	female	
Waldenbuch BW	309	yes	Side branch tips	0	1	0	21	-	female	

A3.3 *Rhytidiadelphus squarrosus* and *R. subpinnatus*

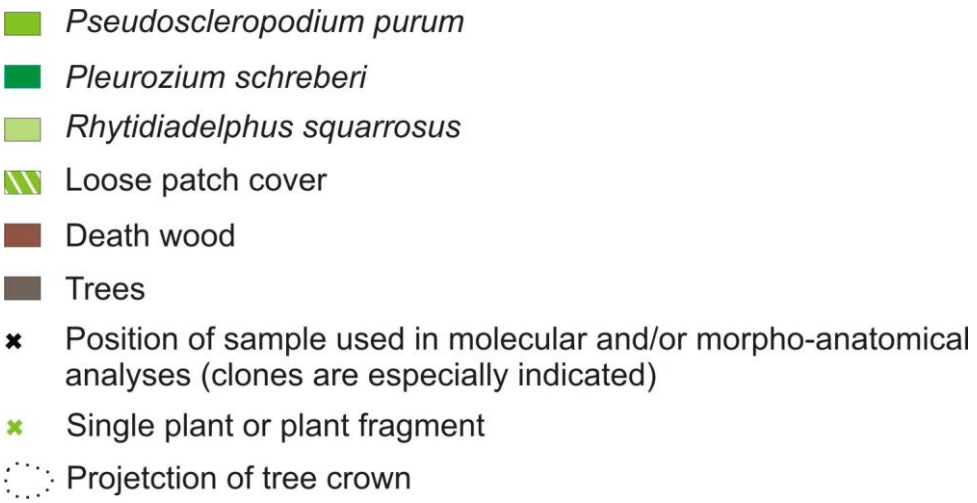
Rhytidiadelphus squarrosus		Rhizoids		Missing shoot apices			Branches	Asexual reproduction	Sex	Remarks
Lab. No.	Herbar. No.		Localisation	basal	middle	apical	Total number			
Alaska	D47	yes	Along side branch and stem	0	1	0	14	-	male	
Australia	669	yes	Side branch tips	0	1	0	8	-	no sex	
Australia II	669	yes	Along stem	1	1	0	0	-	no sex	
Australia III	669	yes	Along stem	1	1	1	14	-	no sex	
Austria	485	no	-	0	9	0	38	-	no sex	
Azores	D44	no	-	0	0	0	13	-	no sex	
B1-A1-R1	615	yes	Side branch tips	0	0	0	15	-	no sex	
B1-A1-R3	617	yes	Side branch tips	0	0	0	13	-	female	
B1-A1-R5	619	yes	Side branch tips and stem	0	1	0	14	-	no sex	
B1-A2-R10	624	yes	Side branch tips	0	0	0	18	2 brood branches	female	
B1-A2-R7	621	yes	Side branch tips and stem	0	0	0	11	-	female	
B1-A2-R8	622	yes	Along stem	0	0	0	3	-	no sex	
B1-A3-R12	626	no	-	0	0	0	8	-	no sex	
B1-A3-R13	627	yes	Along stem	0	0	0	15	-	female	
B1-A3-R16	630	no	-	0	0	0	13	-	no sex	
B1-R20	634	no	-	0	4	0	8	-	female	
B1-R23	637	no	-	0	0	0	17	-	female	
B1-R24	638	yes	Along stem	0	1	0	17	-	female	
Bayreuth BY	494	yes	Along stem	0	0	1	9	-	female	
Belgium	D34	yes	Side branch tips	1	0	0	26	-	male	
Bleicherode TH	239	yes	Side branch tips	0	1	0	25	-	no sex	
Bohndorf NI	661	yes	Side branch tips	0	0	0	25	-	female	
Canada I	668	no	-	0	1	0	19	-	no sex	
Canada II	670	no	-	0	0	0	8	-	no sex	
Dietzhausen TH	665	yes	Side branch tips	0	0	0	25	-	female	c.fr.
England I	666	yes	Side branch tips	1	0	0	12	-	female	
England II	667	yes	Caducous shoot apex	0	1	4	19	Caducous shoot apex	female	
Frankenau HE	376	no	-	0	2	0	17	-	female	

Rhytidiadelphus squarrosus		Rhizoids		Missing shoot apices			Branches	Asexual reproduction	Sex	Remarks
Lab. No.	Herbar. No.		Localisation	basal	middle	apical	Total number			
Harz NI	242	yes	Side branch tips	1	0	0	12	-	no sex	
Haselünne NI	662	yes	Along stem	0	0	0	6	Brood branch	no sex	
Jägerhof MV	382	yes	Along stem	3	1	0	12	-	female	
Jägerhof MV II	382	yes	Side branch tips	1	0	0	15	-	female	
Lengfeld TH	496	yes	Along stem and side branch	0	5	0	12	-	male	
Lindena BB	647	yes	Along stem	0	0	0	9	-	no sex	
Lindow BB	650	yes	Caducous shoot apex	1	0	0	32	Caducous shoot apex	no sex	Very big plant
Nennsdorf TH	646	no	-	1	1	1	25	-	no sex	
New Zealand I	D21	yes	Side branch tips	1	1	1	21	-	no sex	
New Zealand II	D20	no	-	0	0	0	7	-	no sex	
Norway	D35	yes	Side branch tips	1	0	0	40	-	female	
Pankow Bürgerpark	641	yes	Side branch tips and stem	1	1	0	26	-	no sex	
Pankow Heimsuchung	640	yes	Along stem	1	0	0	13	-	no sex	
Pankow Schlosspark	639	yes	Side branch tips	3	0	0	20	-	no sex	
Poland	D38	yes	Side branch tips	2	0	0	9	-	female	
Ruppichteroth NW	664	no	-	2	4	0	14	-	no sex	
Russia I	D39	yes	Along stem	0	0	1	4	-	male	
Russia II	D40	yes	Side branch tips	0	0	0	14	-	female	
Saalburg TH	645	yes	Side branch tips	2	2	0	19	-	no sex	
Sil1-A5	166	no	-	0	0	0	6	-	no sex	
Sil1-B2	169	no	-	0	0	0	6	-	no sex	
Sil1-B2 II	169	no	-	3	1	0	13	-	female	
Sil1-B2 III	169	no	-	0	0	1	11	-	no sex	
Sil3-A1-R1	497	yes	Along stem and side branch	0	1	0	16	-	no sex	
Sil3-A1-R10	506	yes	Along side branch	1	0	1	14	-	male	
Sil3-A1-R11	507	yes	Along side branch	0	0	0	14	-	female	
Sil3-A1-R12	508	no	-	0	0	0	11	-	female	
Sil3-A1-R6	502	no	-	0	0	0	33	-	no sex	
Sil3-A1-R7	503	no	-	0	0	0	11	-	no sex	
Sil3-A2-R15	511	yes	Side branch tips	0	2	0	13	-	female	
Sil3-A2-R16	512	yes	Along stem	0	1	0	11	-	female	

Rhytidiadelphus squarrosus		Rhizoids		Missing shoot apices			Branches	Asexual reproduction	Sex	Remarks
Lab. No.	Herbar. No.		Localisation	basal	middle	apical	Total number			
Sil3-A3-R22	518	yes	Side branch tips	0	0	0	15	Brood branch	female	
Sil3-A4-R23	519	yes	Basis	2	0	0	13	-	female	
Sil3-A4-R24	520	yes	Along stem and side branch	0	0	0	17	-	female	
Sil3-A5-R29	525	yes	Side branch tips	0	1	0	10	-	male	
Sil3-B1-R37	533	no	-	0	1	0	8	-	female	
Sil3-B1-R38	534	yes	Along side branch	2	0	0	25	-	female	
Sil3-B2-R40	536	yes	Side branch tips	0	1	0	9	-	female	
Sil3-B3-R50	546	yes	Along stem	0	0	0	10	-	female	
Sil3-B4-R56	552	no	-	0	0	0	12	-	no sex	
Sil3-B5-R66	562	yes	Along stem	1	0	0	17	-	no sex	
Sil3-C1-R70	566	no	-	0	0	0	18	-	female	
Sil3-C2-R77	573	no	-	0	0	0	20	-	female	
Sil3-C3-R86	582	no	-	0	0	1	22	-	female	
Sil3-C4-R94	590	no	-	1	1	0	12	-	female	
Sil3-C5-R107	603	yes	Side branch tips	0	0	0	6	-	no sex	
Sil-R113	609	no	-	0	0	0	7	-	female	
Sil-R114	610	yes	Side branch tips	1	0	0	13	-	female	
Sil-R115	611	yes	Side branch tips	2	3	1	18	-	female	
Sil-R116	612	yes	Side branch tips	0	0	0	23	-	female	
Sil-R117	665	no	-	4	4	1	46	-	female	c.fr.
Spain I	D42	no	-	0	4	0	9	-	male	
Spain II	D43	no	-	0	1	0	8	-	male	
Sweden I	D36	yes	Along stem	0	0	0	7	-	no sex	
Sweden II	D37	yes	Basis of brood branch	0	0	0	11	Brood branch	female	
Treffurt TH	648	yes	Side branch tips	1	3	1	20	Caducous shoot apex and brood branch	female	
Russia III	D41	no	-	0	1	0	19	-	male	subpinnatus
Russia IV	D48	yes	Side branch tips	0	4	0	21	-	female	subpinnatus
Russia V	D50	no	-	1	1	0	11	-	no sex	subpinnatus
USA WV	D46	yes	Basis	0	0	1	6	-	no sex	subpinnatus

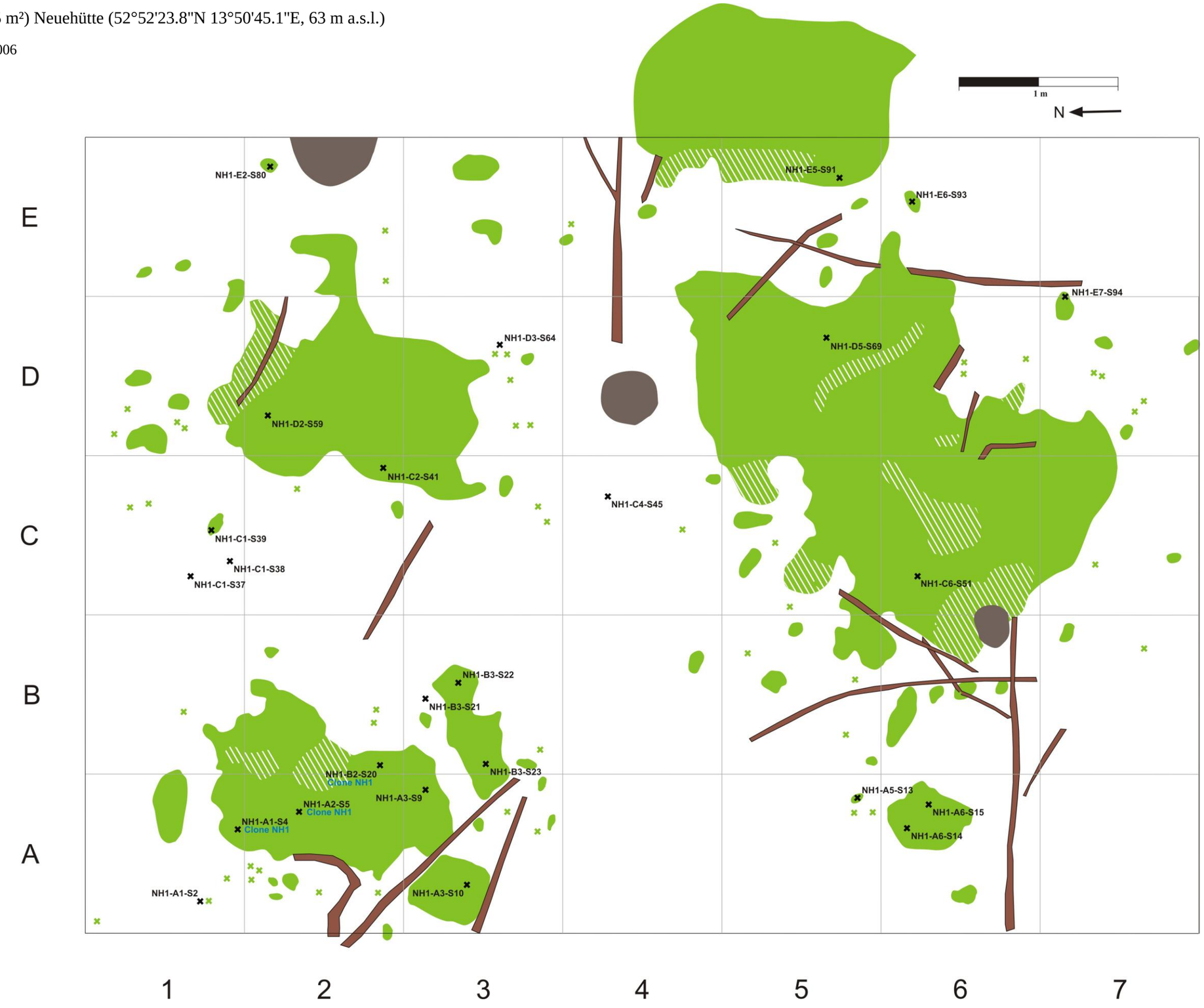
A4 Maps of sapital distribution and extension of patches in investigated plots

A4.1 Caption



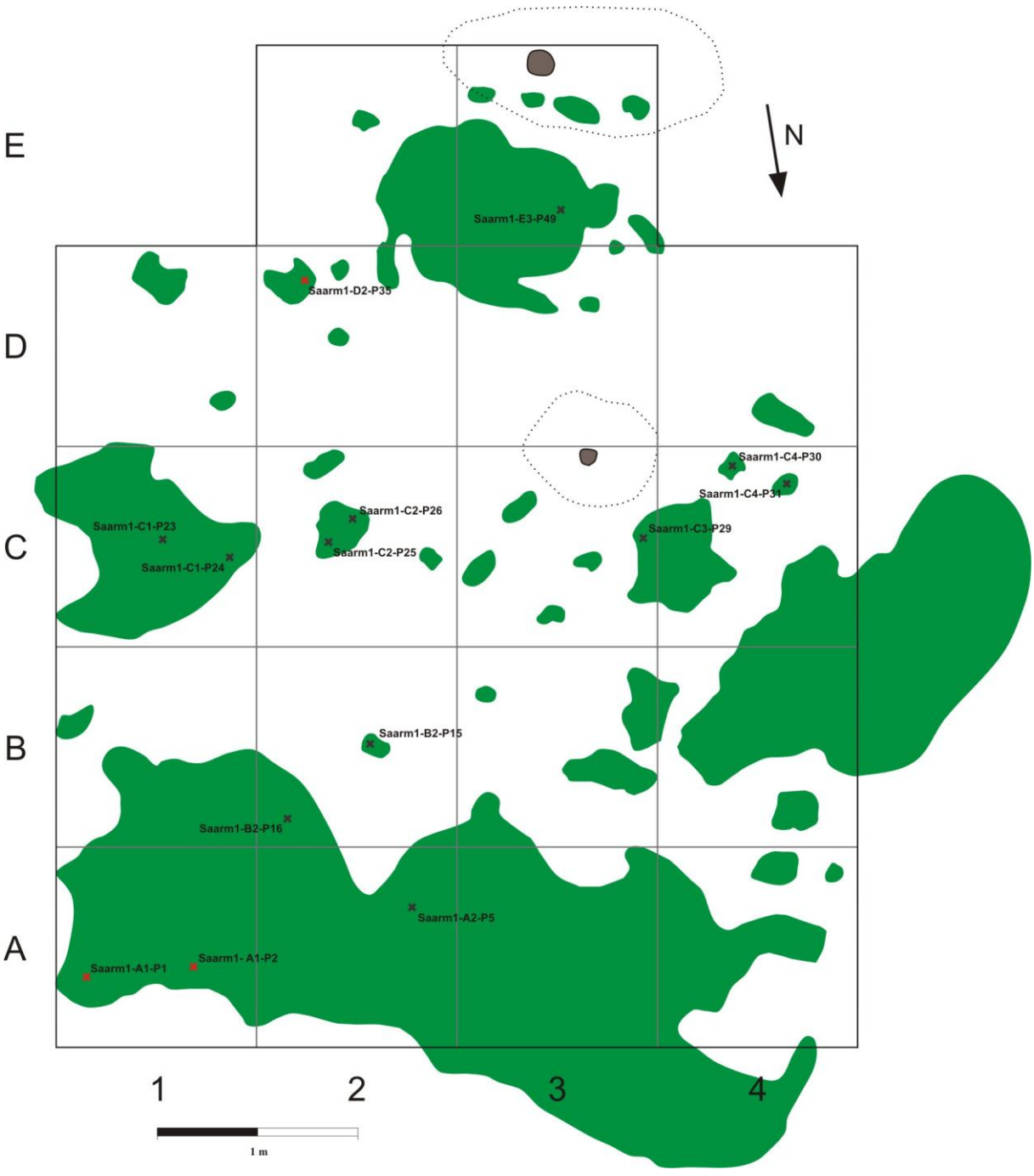
A4.2 Plot NH1 (35 m²) Neuehütte (52°52'23.8"N 13°50'45.1"E, 63 m a.s.l.)

Col. date: 08.-09.08.2006



A4.3 Plot Saarm1 (18 m²) Saarmund (52°18'57.8"N 13°06'38.1"E, 78 m a.s.l.)

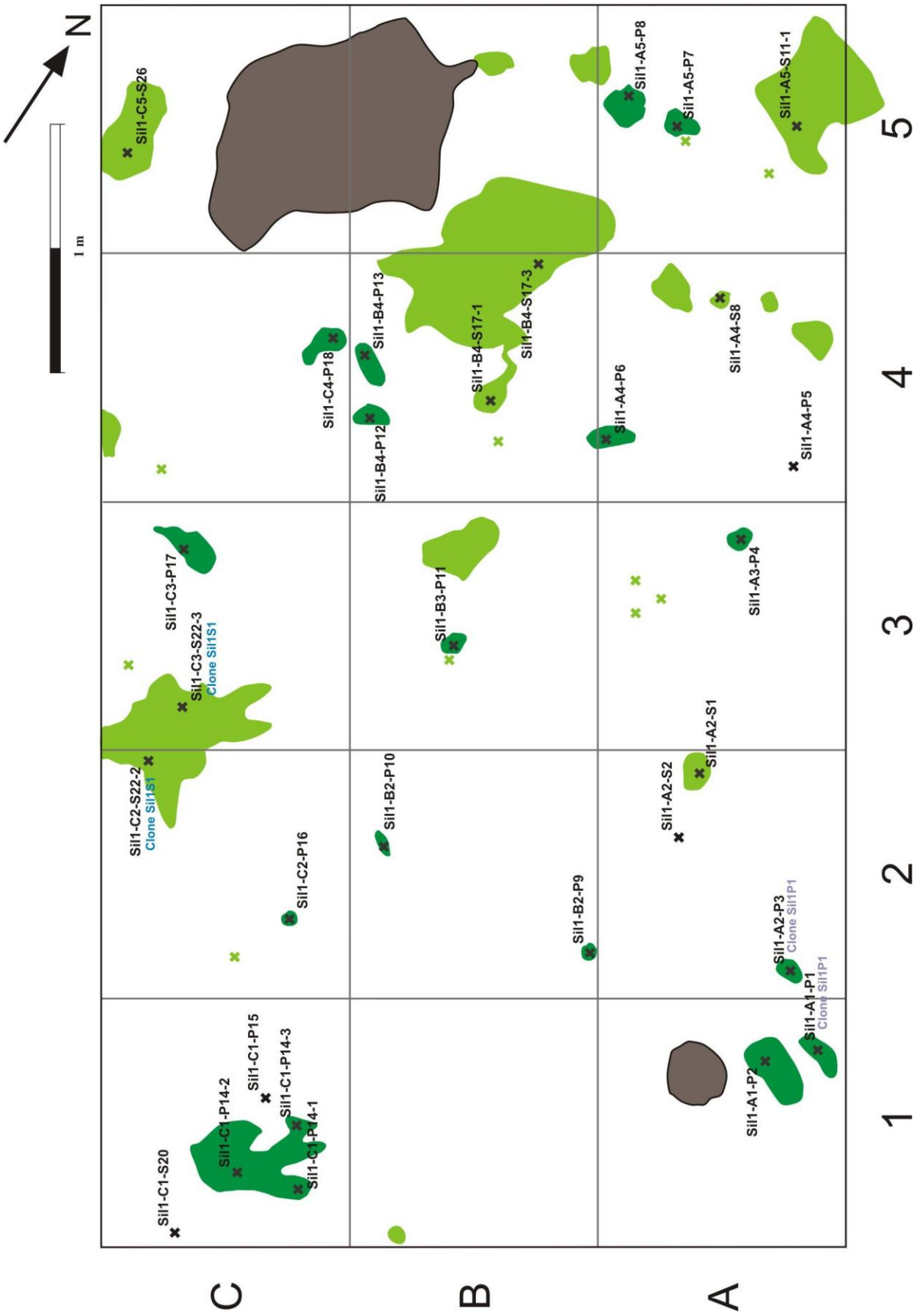
Col. date: 23.-24.05.2006



Red = plant with sporophyte

A4.4 Plot Sil1 (15 m²) Dietzhausen (50°35'46.8"N 10°35'04.6"E, 428 m a.s.l.)

Col. date: 14.-15.10.2005



A4.5 Plot Sil2 (12 m²) Dietzhausen (50°35'45.2"N 10°35'04.7"E, 433 m a.s.l.)

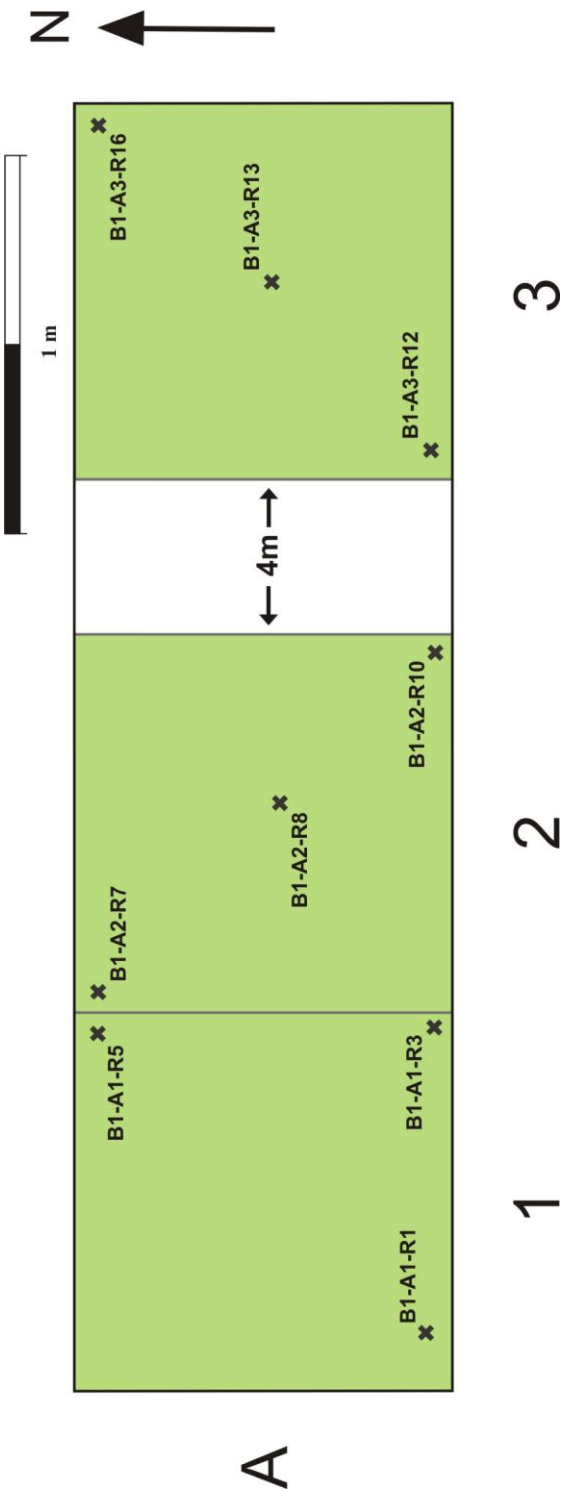
Col. date: 4.-6.04.2006

A4.6 Plot Sil3 (15 m²) Dietzhausen (50°35'45.6"N 10°35'07.0"E, 377 m a.s.l.)

Col. date: 25.09.2006

A4.7 Plot B1 (7 m²) Berlin-Pankow (52°33'38.4"N, 13°24'13.7"E, 54 m a.s.l.)

Col. date: 16.10.2006



A5 Distance matrices

A5.1 *Pseudoscleropodium purum*

Sger Distance values between German *Pseudoscleropodium purum* samples. Simple matching distances in the upper right, Jaccard distances in the lower left part.

Jacc\SM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1 Jägerhof MV	-	0,1151	0,1079	0,1232	0,1232	0,1223	0,1367	0,1223	0,1295	0,1151	0,1295	0,1223	0,1439	0,1295	0,1439	0,1439	0,1151	0,1079	0,1007	0,1367	0,1583	0,1151	0,1223	0,1151
2 Biesenbrow BB	0,2051	-	0,0935	0,1087	0,0797	0,0791	0,0791	0,0791	0,0863	0,0719	0,0863	0,0791	0,1151	0,1151	0,1151	0,1007	0,0863	0,0935	0,1151	0,1079	0,1151	0,1295	0,0935	0,0863
3 Lindow BB	0,1974	0,1711	-	0,1159	0,1014	0,1007	0,1151	0,1007	0,1079	0,0935	0,0935	0,1007	0,1367	0,1223	0,1223	0,1079	0,1079	0,0863	0,1079	0,1295	0,1367	0,1079	0,1007	0,1079
4 NH1-A1-S2	0,2179	0,1923	0,2078	-	0,0725	0,0725	0,0725	0,0725	0,0797	0,0797	0,0942	0,0725	0,0725	0,0797	0,0942	0,0725	0,0797	0,1014	0,0797	0,1159	0,1377	0,0942	0,0870	0,0507
5 NH1-A1-S4	0,2125	0,1410	0,1795	0,1299	-	0,0000	0,0145	0,0000	0,0072	0,0072	0,0217	0,0145	0,0580	0,0507	0,0652	0,0290	0,0362	0,0580	0,0652	0,0725	0,0942	0,1087	0,0435	0,0507
6 NH1-A2-S5	0,2125	0,1410	0,1795	0,1299	0,0000	-	0,0144	0,0000	0,0072	0,0072	0,0216	0,0144	0,0647	0,0504	0,0647	0,0360	0,0360	0,0576	0,0647	0,0719	0,0935	0,1079	0,0432	0,0504
7 NH1-A3-S9	0,2317	0,1392	0,2000	0,1282	0,0263	0,0263	-	0,0144	0,0216	0,0216	0,0360	0,0144	0,0647	0,0504	0,0647	0,0360	0,0504	0,0719	0,0791	0,0863	0,0935	0,1223	0,0576	0,0647
8 NH1-B2-S20	0,2125	0,1410	0,1795	0,1299	0,0000	0,0000	0,0263	-	0,0072	0,0072	0,0216	0,0144	0,0647	0,0504	0,0647	0,0360	0,0360	0,0576	0,0647	0,0719	0,0935	0,1079	0,0432	0,0504
9 NH1-A3-S10	0,2222	0,1519	0,1899	0,1410	0,0133	0,0133	0,0390	0,0133	-	0,0144	0,0288	0,0216	0,0719	0,0576	0,0719	0,0432	0,0432	0,0647	0,0719	0,0791	0,0863	0,1151	0,0504	0,0576
10 NH1-B3-S21	0,2025	0,1299	0,1688	0,1429	0,0135	0,0135	0,0395	0,0135	0,0267	-	0,0144	0,0072	0,0576	0,0576	0,0576	0,0288	0,0288	0,0504	0,0719	0,0647	0,0863	0,1007	0,0360	0,0576
11 NH1-B3-S22	0,2222	0,1519	0,1667	0,1646	0,0395	0,0395	0,0641	0,0395	0,0519	0,0267	-	0,0216	0,0719	0,0719	0,0432	0,0288	0,0432	0,0647	0,0863	0,0791	0,0863	0,1151	0,0360	0,0576
12 NH1-B3-S23	0,2125	0,1410	0,1795	0,1299	0,0267	0,0267	0,0263	0,0267	0,0395	0,0135	0,0395	-	0,0504	0,0504	0,0504	0,0216	0,0360	0,0576	0,0791	0,0719	0,0935	0,1079	0,0432	0,0647
13 NH1-A5-S13	0,2410	0,1951	0,2317	0,1282	0,1013	0,1125	0,1111	0,1125	0,1235	0,1013	0,1235	0,0886	-	0,0432	0,0576	0,0432	0,0432	0,0647	0,1007	0,0791	0,1151	0,1295	0,0504	0,0863
14 NH1-A6-S14	0,2169	0,1928	0,2073	0,1375	0,0875	0,0875	0,0864	0,0875	0,0988	0,1000	0,1220	0,0875	0,0741	-	0,0576	0,0719	0,0432	0,0504	0,0576	0,0791	0,1151	0,1151	0,0504	0,0719
15 NH1-A6-S15	0,2381	0,1928	0,2073	0,1605	0,1111	0,1111	0,1098	0,1111	0,1220	0,1000	0,0750	0,0875	0,0976	0,0964	-	0,0576	0,0576	0,0647	0,1007	0,0935	0,1007	0,1295	0,0360	0,0719
16 NH1-C1-S37	0,2439	0,1750	0,1899	0,1299	0,0526	0,0649	0,0641	0,0649	0,0769	0,0526	0,0519	0,0395	0,0759	0,1220	0,0988	-	0,0576	0,0791	0,1007	0,0935	0,1007	0,1295	0,0504	0,0863
17 NH1-C1-S38	0,2000	0,1519	0,1899	0,1410	0,0649	0,0649	0,0886	0,0649	0,0769	0,0526	0,0769	0,0649	0,0759	0,0750	0,0988	0,1013	-	0,0504	0,0719	0,0504	0,0863	0,1007	0,0360	0,0576
18 NH1-C1-S39	0,1875	0,1625	0,1538	0,1750	0,1013	0,1013	0,1235	0,1013	0,1125	0,0897	0,1125	0,1013	0,1111	0,0864	0,1098	0,1358	0,0886	-	0,0791	0,0719	0,1079	0,1079	0,0432	0,0791
19 NH1-C2-S41	0,1728	0,1928	0,1852	0,1375	0,1111	0,1111	0,1325	0,1111	0,1220	0,1235	0,1446	0,1341	0,1647	0,0964	0,1628	0,1667	0,1220	0,1325	-	0,1079	0,1151	0,0863	0,0791	0,0576
20 NH1-D2-S59	0,2317	0,1852	0,2222	0,1975	0,1250	0,1250	0,1463	0,1250	0,1358	0,1139	0,1358	0,1250	0,1341	0,1325	0,1548	0,1585	0,0886	0,1235	0,1765	-	0,1223	0,1367	0,0719	0,0935
21 NH1-E2-S80	0,2558	0,1905	0,2262	0,2235	0,1548	0,1548	0,1529	0,1548	0,1429	0,1446	0,1429	0,1548	0,1839	0,1818	0,1609	0,1647	0,1429	0,1744	0,1818	0,1954	-	0,1295	0,0647	0,1007
22 NH1-D3-S64	0,2000	0,2195	0,1899	0,1646	0,1829	0,1829	0,2024	0,1829	0,1928	0,1728	0,1928	0,1829	0,2118	0,1882	0,2093	0,2143	0,1707	0,1807	0,1446	0,2235	0,2069	-	0,0935	0,0863
23 NH1-C6-S51	0,2099	0,1625	0,1772	0,1519	0,0769	0,0769	0,1000	0,0769	0,0886	0,0649	0,0641	0,0769	0,0875	0,0864	0,0625	0,0886	0,0641	0,0759	0,1325	0,1235	0,1084	0,1585	-	0,0647
24 NH1-D5-S69	0,2025	0,1538	0,1923	0,0933	0,0909	0,0909	0,1139	0,0909	0,1026	0,1039	0,1026	0,1154	0,1481	0,1235	0,1235	0,1500	0,1026	0,1375	0,1000	0,1605	0,1667	0,1500	0,1139	-
25 NH1-E7-S94	0,2179	0,1688	0,1948	0,1447	0,0800	0,0800	0,1039	0,0800	0,0921	0,0676	0,0667	0,0800	0,1026	0,1013	0,0769	0,1169	0,0667	0,0909	0,1375	0,0789	0,1585	0,1750	0,0658	0,0933
26 NH1-E5-S91	0,1899	0,1169	0,1795	0,1299	0,0526	0,0526	0,0769	0,0526	0,0395	0,0400	0,0649	0,0526	0,1125	0,1111	0,1111	0,0897	0,0649	0,1013	0,1341	0,1250	0,1325	0,1605	0,0769	0,0909
27 NH1-E6-S93	0,2439	0,1975	0,1772	0,1519	0,0897	0,0897	0,1125	0,0897	0,1013	0,1026	0,1013	0,1139	0,1687	0,1220	0,1446	0,1250	0,1250	0,1358	0,1446	0,1807	0,1429	0,1807	0,0886	0,1500
28 NH1-C4-S45	0,2125	0,1410	0,1795	0,1538	0,0267	0,0267	0,0519	0,0267	0,0395	0,0135	0,0395	0,0267	0,1125	0,1111	0,1111	0,0649	0,0649	0,1013	0,1341	0,1250	0,1325	0,1829	0,0769	0,1154
29 Bad Saarow BB	0,1667	0,1646	0,1558	0,2000	0,1500	0,1500	0,1707	0,1500	0,1605	0,1392	0,1605	0,1500	0,1807	0,1566	0,1566	0,1829	0,1375	0,1250	0,1566	0,1707	0,1977	0,2048	0,1481	0,1852
30 Köthen BB	0,2152	0,1899	0,2500	0,2025	0,1975	0,1975	0,1951	0,1975	0,2073	0,2099	0,2289	0,2195	0,2262	0,2024	0,2442	0,2289	0,2073	0,1951	0,1807	0,2381	0,2614	0,2706	0,2169	0,2099
31 Harz N	0,4574	0,4362	0,4516	0,4468	0,3871	0,3871	0,3830	0,3871	0,3936	0,3804	0,3936	0,3871	0,4388	0,4343	0,4343	0,4105	0,4105	0,4167	0,4343	0,4330	0,4300	0,4592	0,4167	0,4149
32 Frankenau H	0,4615	0,4565	0,4556	0,4333	0,4066	0,4066	0,4022	0,4066	0,4130	0,4000	0,4130	0,3889	0,4255	0,4211	0,4211	0,4130	0,3956	0,4362	0,4375	0,4362	0,4490	0,4632	0,4194	0,4348
33 Schönenberg NRW	0,4432	0,4556	0,4545	0,4835	0,4222	0,4222	0,4348	0,4222	0,4286	0,4157	0,4286	0,4222	0,4574	0,4526	0,4362	0,4457	0,4111	0,4348	0,4688	0,4348	0,4479	0,4787	0,4348	0,4505
34 Nennsdorf TH	0,4333	0,4286	0,4444	0,4222	0,4130	0,4130	0,4086	0,4130	0,4194	0,4066	0,4194	0,4130	0,4479	0,4433	0,4271	0,4362	0,4022	0,4086	0,4271	0,4255	0,4388	0,4526	0,4255	0,4239
35 Geraberg TH	0,4943	0,4535	0,4524	0,4096	0,4186	0,4186	0,4318	0,4186	0,4253	0,4118	0,4253	0,4186	0,4556	0,4674	0,4674	0,4253	0,4253	0,4667	0,4505	0,4835	0,4624	0,4778	0,4494	0,4302
36 Sil1-B4-S17-3	0,5109	0,4891	0,5055	0,4607	0,4333	0,4396	0,4516	0,4396	0,4286	0,4505	0,4624	0,4565	0,4737	0,4845	0,5000	0,4457	0,4624	0,4842	0,4688	0,5000	0,5100	0,5258	0,4842	0,4839
37 Sil1-C2-S22-2	0,5000	0,4783	0,4945	0,4318	0,4045	0,4111	0,4239	0,4111	0,4176	0,4222	0,4348	0,4286	0,4301	0,4255	0,4742	0,4176	0,4176	0,4737	0,4421	0,4737	0,4848	0,5000	0,4574	0,4396
38 Sil1-C3-S22-3	0,5000	0,4783	0,4945	0,4318	0,4045	0,4111	0,4239	0,4111	0,4176	0,4222	0,4348	0,4286	0,4301	0,4255	0,4742	0,4176	0,4176	0,4737	0,4421	0,4737	0,4848	0,5000	0,4574	0,4396
39 Sil1-A2-S1	0,4432	0,4494	0,4719	0,4205	0,4045	0,4045	0,4000	0,4045	0,4111	0,4157	0,4286	0,4045	0,4348	0,4301	0,4468	0,4111	0,4222	0,4457	0,4301	0,4457	0,4898	0,4731	0,4457	0,4444
40 Sil1-A2-S2	0,4348	0,4301	0,4457	0,4409	0,3804	0,3804	0,3936	0,3804	0,3871	0,3913	0,4043	0,3978	0,4490	0,4286	0,4444	0,4211	0,4043	0,4271	0,4124	0,4433	0,4706	0,4694	0,4271	0,4255
41 Sil1-A4-S8	0,3902	0,4286	0,4458	0,3855	0,3735	0,3735	0,3882	0,3735	0,3810	0,3855	0,4000	0,3929	0,4138	0,4091	0,4270	0,4000	0,3810	0,4070	0,3908	0,4070	0,4565	0,4432	0,4070	0,3929
42 Sil1-A5-S11-1	0,4556	0,4505	0,4205	0,4615	0,4066	0,4066	0,4194	0,4066	0,4130	0,4000	0,4130	0,4066	0,4468	0,4316	0,4316	0,4239	0,4066	0,3956	0,4316	0,4301	0,4747	0,4574	0,4301	0,4457
43 Sil1-B4-S17-1	0,4318	0,3908	0,3882	0,4205	0,3563	0,3563	0,3708	0,3563	0,3636	0,3488	0,3636	0,3563	0,4130	0,4086	0,4086	0,3820	0,3636	0,3708	0,4086	0,3889	0,4375	0,4348	0,3889	0,4045
44 Sil1-C1-S20	0,4565	0,4516	0,4333	0,4457	0,4022	0,4022	0,3978	0,4022	0,4086	0,4130	0,4255	0,4022	0,4536	0,4167	0,4490	0,4255	0,4255	0,4316	0,4330	0,4479	0,4752	0,4583	0,4479	0,4468
45 Sil1-C5-S26	0,4556	0,4505	0,4667	0,4444	0,4176	0,4176	0,4301	0,4176	0,4239	0,4286	0,4409	0,4348	0,4688	0,4479	0,4639	0,4574	0,4239	0,4468	0,4479	0,4130	0,4747	0,4737	0,4468	0,4286
46 Röhmhild TH	0,3976	0,3735	0,3902	0,3855	0,3571	0,3571	0,3721	0,3571	0,3647	0,3494	0,3647	0,3571	0,4157	0,4111	0,4111	0,3837	0,3647	0,3908	0,3933	0,4091	0,4239	0,4023	0,3908	0,3690
47 Neudrossenfeld	0,4111	0,4409	0,4396	0,4681	0,3913	0,3913	0,4043	0,3913	0,3978	0,3846	0,3804	0,3913	0,4271	0,4063	0,4227	0,4149	0,3804	0,4043	0,4063	0,4211	0,4653	0,4639	0,4211	0,4194
48 Bad Urach BW	0,4457	0,4574	0,4396	0,4842	0,4086	0,4086	0,4211	0,4086	0,4149	0,4022	0,3804	0,4086	0,4433	0,4227	0,4227	0,4149	0,3978	0,4211	0,4388	0,4211	0,4653	0,4639	0,4211	0,4362

Jacc\SM	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1 Jägerhof MV	0,1259	0,1079	0,1449	0,1223	0,0935	0,1223	0,3094	0,3022	0,2806	0,2806	0,3094	0,3381	0,3309	0,3309	0,3000	0,2878	0,2462	0,3060	0,2734	0,3022	0,2950	0,2374	0,2662	0,2950
2 Biesenbrow BB	0,0963	0,0647	0,1159	0,0791	0,0935	0,1079	0,2950	0,3022	0,2950	0,2806	0,2806	0,3237	0,3165	0,3165	0,3077	0,2878	0,2769	0,3060	0,2446	0,3022	0,2950	0,2230	0,2950	0,3094
3 Lindow BB	0,1111	0,1007	0,1014	0,1007	0,0863	0,1439	0,3022	0,2950	0,2878	0,2878	0,2734	0,3309	0,3237	0,3237	0,3231	0,2950	0,2846	0,2761	0,2374	0,2806	0,3022	0,2302	0,2878	0,2878
4 NH1-A1-S2	0,0821	0,0725	0,0876	0,0870	0,1159	0,1159	0,3043	0,2826	0,3188	0,2754	0,2464	0,2971	0,2754	0,2754	0,2846	0,2971	0,2462	0,3134	0,2681	0,2971	0,2899	0,2319	0,3188	0,3333
5 NH1-A1-S4	0,0448	0,0290	0,0511	0,0145	0,0870	0,1159	0,2609	0,2681	0,2754	0,2754	0,2609	0,2826	0,2609	0,2609	0,2769	0,2536	0,2385	0,2761	0,2246	0,2681	0,2754	0,2174	0,2609	0,2754
6 NH1-A2-S5	0,0444	0,0288	0,0507	0,0144	0,0863	0,1151	0,2590	0,2662	0,2734	0,2734	0,2590	0,2878	0,2662	0,2662	0,2769	0,2518	0,2385	0,2761	0,2230	0,2662	0,2734	0,2158	0,2590	0,2734
7 NH1-A3-S9	0,0593	0,0432	0,0652	0,0288	0,1007	0,1151	0,2590	0,2662	0,2878	0,2734	0,2734	0,3022	0,2806	0,2806	0,2769	0,2662	0,2538	0,2910	0,2374	0,2662	0,2878	0,2302	0,2734	0,2878
8 NH1-B2-S20	0,0444	0,0288	0,0507	0,0144	0,0863	0,1151	0,2590	0,2662	0,2734	0,2734	0,2590	0,2878	0,2662	0,2662	0,2769	0,2518	0,2385	0,2761	0,2230	0,2662	0,2734	0,2158	0,2590	0,2734
9 NH1-A3-S10	0,0519	0,0216	0,0580	0,0216	0,0935	0,1223	0,2662	0,2734	0,2806	0,2806	0,2662	0,2806	0,2734	0,2734	0,2846	0,2590	0,2462	0,2836	0,2302	0,2734	0,2806	0,2230	0,2662	0,2806
10 NH1-B3-S21	0,0370	0,0216	0,0580	0,0072	0,0791	0,1223	0,2518	0,2590	0,2662	0,2662	0,2518	0,2950	0,2734	0,2734	0,2846	0,2590	0,2462	0,2687	0,2158	0,2734	0,2806	0,2086	0,2518	0,2662
11 NH1-B3-S22	0,0370	0,0360	0,0580	0,0216	0,0935	0,1367	0,2662	0,2734	0,2806	0,2806	0,2662	0,3094	0,2878	0,2878	0,3000	0,2734	0,2615	0,2836	0,2302	0,2878	0,2950	0,2230	0,2518	0,2518
12 NH1-B3-S23	0,0444	0,0288	0,0652	0,0144	0,0863	0,1295	0,2590	0,2518	0,2734	0,2734	0,2590	0,3022	0,2806	0,2806	0,2769	0,2662	0,2538	0,2761	0,2230	0,2662	0,2878	0,2158	0,2590	0,2734
13 NH1-A5-S13	0,0593	0,0647	0,1014	0,0647	0,1079	0,1367	0,3094	0,2878	0,3094	0,3094	0,2950	0,3237	0,2878	0,2878	0,3077	0,3165	0,2769	0,3134	0,2734	0,3165	0,3237	0,2662	0,2950	0,3094
14 NH1-A6-S14	0,0593	0,0647	0,0725	0,0647	0,0935	0,1223	0,3094	0,2878	0,3094	0,3094	0,3094	0,3381	0,2878	0,2878	0,3077	0,3022	0,2769	0,3060	0,2734	0,2878	0,3094	0,2662	0,2806	0,2950
15 NH1-A6-S15	0,0444	0,0647	0,0870	0,0647	0,0935	0,1511	0,3094	0,2878	0,2950	0,2950	0,3094	0,3525	0,3309	0,3309	0,3231	0,3165	0,2923	0,3060	0,2734	0,3165	0,3237	0,2662	0,2950	0,2950
16 NH1-C1-S37	0,0667	0,0504	0,0725	0,0360	0,1079	0,1367	0,2806	0,2734	0,2950	0,2950	0,2662	0,2950	0,2734	0,2734	0,2846	0,2878	0,2615	0,2910	0,2446	0,2878	0,3094	0,2374	0,2806	0,2806
17 NH1-C1-S38	0,0370	0,0360	0,0725	0,0360	0,0791	0,1223	0,2806	0,2590	0,2662	0,2662	0,2662	0,3094	0,2734	0,2734	0,2923	0,2734	0,2462	0,2761	0,2302	0,2878	0,2806	0,2230	0,2518	0,2662
18 NH1-C1-S39	0,0519	0,0576	0,0797	0,0576	0,0719	0,1151	0,2878	0,2950	0,2878	0,2734	0,3022	0,3309	0,3237	0,3237	0,3154	0,2950	0,2692	0,2687	0,2374	0,2950	0,3022	0,2446	0,2734	0,2878
19 NH1-C2-S41	0,0815	0,0791	0,0870	0,0791	0,0935	0,1079	0,3094	0,3022	0,3237	0,2950	0,2950	0,3237	0,3022	0,3022	0,3077	0,2878	0,2615	0,3060	0,2734	0,3022	0,3094	0,2518	0,2806	0,3094
20 NH1-D2-S59	0,0444	0,0719	0,1087	0,0719	0,1007	0,1439	0,3022	0,2950	0,2878	0,2878	0,3165	0,3453	0,3237	0,3237	0,3154	0,3094	0,2692	0,2985	0,2518	0,3094	0,2734	0,2590	0,2878	0,2878
21 NH1-E2-S80	0,0963	0,0791	0,0870	0,0791	0,1223	0,1655	0,3094	0,3165	0,3094	0,3094	0,3094	0,3669	0,3453	0,3453	0,3692	0,3453	0,3231	0,3507	0,3022	0,3453	0,3381	0,2806	0,3381	0,3381
22 NH1-D3-S64	0,1037	0,0935	0,1087	0,1079	0,1223	0,1655	0,3237	0,3165	0,3237	0,3094	0,3094	0,3669	0,3453	0,3453	0,3385	0,3309	0,3000	0,3209	0,2878	0,3165	0,3237	0,2518	0,3237	0,3237
23 NH1-C6-S51	0,0370	0,0432	0,0507	0,0432	0,0863	0,1295	0,2878	0,2806	0,2878	0,2878	0,2878	0,3309	0,3094	0,3094	0,3154	0,2950	0,2692	0,2985	0,2518	0,3094	0,3022	0,2446	0,2878	0,2878
24 NH1-D5-S69	0,0519	0,0504	0,0870	0,0647	0,1079	0,1223	0,2806	0,2878	0,2950	0,2806	0,2662	0,3237	0,2878	0,2878	0,3077	0,2878	0,2538	0,3060	0,2590	0,3022	0,2806	0,2230	0,2806	0,2950
25 NH1-E7-S94	-	0,0444	0,0815	0,0444	0,0815	0,1333	0,2815	0,2593	0,2667	0,2815	0,2889	0,3259	0,3037	0,3037	0,3175	0,2889	0,2698	0,3000	0,2519	0,3111	0,2889	0,2444	0,2741	0,2963
26 NH1-E5-S91	0,0800	-	0,0652	0,0288	0,0863	0,1295	0,2734	0,2806	0,2878	0,2878	0,2734	0,3022	0,2950	0,2950	0,3077	0,2806	0,2615	0,2910	0,2374	0,2950	0,2878	0,2158	0,2734	0,2878
27 NH1-E6-S93	0,1392	0,1139	-	0,0507	0,1014	0,1087	0,3043	0,3116	0,3188	0,3188	0,2754	0,3043	0,2826	0,2826	0,3256	0,2971	0,2868	0,3083	0,2681	0,2971	0,3188	0,2609	0,2971	0,2971
28 NH1-C4-S45	0,0800	0,0526	0,0897	-	0,0863	0,1295	0,2590	0,2662	0,2734	0,2734	0,2590	0,3022	0,2806	0,2806	0,2923	0,2662	0,2538	0,2761	0,2230	0,2806	0,2878	0,2158	0,2590	0,2734
29 Bad Saarow BB	0,1410	0,1500	0,1707	0,1500	-	0,1007	0,2734	0,2518	0,2446	0,2590	0,2734	0,3022	0,2950	0,2950	0,2692	0,2518	0,2231	0,2537	0,2230	0,2518	0,2590	0,2158	0,2446	0,2734
30 Köthen BB	0,2250	0,2195	0,1852	0,2195	0,1750	-	0,3165	0,3381	0,3309	0,3022	0,3022	0,3165	0,3094	0,3094	0,3231	0,3094	0,2769	0,3284	0,2950	0,3237	0,3309	0,2878	0,2878	0,3165
31 Harz N	0,4130	0,4043	0,4330	0,3871	0,4043	0,4583	-	0,1511	0,1583	0,1151	0,1727	0,2014	0,1511	0,1511	0,1846	0,1511	0,1615	0,1567	0,1367	0,1367	0,1295	0,1583	0,1583	0,2014
32 Frankenau H	0,3977	0,4239	0,4526	0,4066	0,3889	0,4947	0,2500	-	0,0791	0,1511	0,1511	0,1511	0,1295	0,1295	0,1538	0,1295	0,1385	0,1567	0,1295	0,1295	0,1223	0,1367	0,1223	0,1655
33 Schönenberg NRW	0,4138	0,4396	0,4681	0,4222	0,3864	0,4946	0,2651	0,1467	-	0,1295	0,1583	0,1583	0,1511	0,1511	0,1615	0,1223	0,1308	0,1493	0,1223	0,1367	0,1007	0,1151	0,1151	0,1583
34 Nennsdorf TH	0,4222	0,4301	0,4583	0,4130	0,3956	0,4516	0,1951	0,2561	0,2278	-	0,1439	0,2014	0,1942	0,1942	0,1692	0,1511	0,1231	0,1493	0,1367	0,1511	0,1151	0,1007	0,1583	0,2014
35 Geraberg TH	0,4535	0,4368	0,4318	0,4186	0,4368	0,4773	0,2963	0,2727	0,2895	0,2597	-	0,1295	0,1079	0,1079	0,1846	0,1655	0,1615	0,1716	0,1079	0,1511	0,1583	0,1151	0,1871	0,2014
36 Sil1-B4-S17-3	0,4835	0,4565	0,4516	0,4565	0,4565	0,4783	0,3256	0,2625	0,2785	0,3333	0,2432	-	0,0791	0,0791	0,1385	0,0935	0,1308	0,1940	0,1367	0,1655	0,1727	0,1583	0,1583	0,2014
37 Sil1-C2-S22-2	0,4556	0,4457	0,4239	0,4286	0,4457	0,4674	0,2530	0,2278	0,2658	0,3214	0,2055	0,1486	-	0,0000	0,1308	0,1007	0,1385	0,1716	0,1295	0,1583	0,1655	0,1655	0,1223	0,1799
38 Sil1-C3-S22-3	0,4556	0,4457	0,4239	0,4286	0,4457	0,4674	0,2530	0,2278	0,2658	0,3214	0,2055	0,1486	0,0000	-	0,1308	0,1007	0,1385	0,1716	0,1295	0,1583	0,1655	0,1655	0,1223	0,1799
39 Sil1-A2-S1	0,4494	0,4396	0,4516	0,4222	0,3977	0,4615	0,2857	0,2532	0,2692	0,2716	0,3077	0,2338	0,2208	0,2208	-	0,0538	0,0930	0,1615	0,1308	0,1308	0,1154	0,1538	0,1231	0,1923
40 Sil1-A2-S2	0,4239	0,4149	0,4271	0,3978	0,3804	0,4526	0,2442	0,2195	0,2125	0,2500	0,2875	0,1667	0,1772	0,1772	0,0933	-	0,0769	0,1493	0,1007	0,1295	0,1223	0,1223	0,0791	0,1655
41 Sil1-A4-S8	0,4096	0,4000	0,4253	0,3929	0,3537	0,4235	0,2658	0,2400	0,2329	0,2133	0,2877	0,2329	0,2432	0,2432	0,1600	0,1370	-	0,1318	0,1077	0,1231	0,0923	0,1077	0,1154	0,1538
42 Sil1-A5-S11-1	0,4333	0,4239	0,4362	0,4066	0,3820	0,4731	0,2500	0,2593	0,2532	0,2469	0,2949	0,3171	0,2840	0,2840	0,2561	0,2410	0,2237	-	0,0746	0,1343	0,1343	0,1567	0,1418	0,1418
43 Sil1-B4-S17-1	0,3908	0,3750	0,4066	0,3563	0,3563	0,4505	0,2317	0,2278	0,2208	0,2375	0,2055	0,2436	0,2308	0,2308	0,2208	0,1772	0,1944	0,1333	-	0,1007	0,1079	0,1079	0,1223	0,1223
44 Sil1-C1-S20	0,4516	0,4362	0,4316	0,4194	0,3846	0,4737	0,2262	0,2222	0,2375	0,2530	0,2692	0,2805	0,2683	0,2683	0,2152	0,2169	0,2133	0,2222	0,1795	-	0,0791	0,1223	0,1367	0,1511
45 Sil1-C5-S26	0,4333	0,4348	0,4632	0,4348	0,4000	0,4894	0,2195	0,2152	0,1842	0,2025	0,2857	0,2963	0,2840	0,2840	0,1974	0,2099	0,1667	0,2278	0,1948	0,1429	-	0,1007	0,1439	0,1583
46 Röhmhild TH	0,3929	0,3571	0,4091	0,3571	0,3571	0,4545	0,2716	0,2468	0,2162	0,1867	0,2254	0,2857	0,2949	0,2949	0,2632	0,2179	0,2000	0,2692	0,2027	0,2208	0,1892	-	0,1295	0,1583
47 Neudrossenfeld	0,4111	0,4086	0,4316	0,3913	0,3736	0,4301	0,2558	0,2099	0,2025	0,2619	0,3210	0,2683	0,2125	0,2125	0,2025	0,1375	0,2000	0,2317	0,2125	0,2289	0,2439	0,2308	-	0,0863
48 Bad Urach BW	0,4348	0,4255	0,4316	0,4086	0,4086	0,4632	0,3146	0,2738	0,2683	0,3218	0,3415	0,3294	0,2976	0,2976	0,3012	0,2674	0,2597	0,2317	0,2125	0,2500	0,2651	0,2750	0,1500	-

Sww Distance values between world-wide *Pseudoscleropodium purum* samples. Simple matching distances in the upper right, Jaccard distances in the lower left part.

Jacc\SM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 Jägerhof MV	-	0,1600	0,0956	0,1328	0,1328	0,1051	0,1465	0,1327	0,2960	0,2482	0,2690	0,2412	0,2347	0,2483	0,2347	0,2412	0,2415	0,2383
2 Biesenbrow BB	0,2761	-	0,1465	0,1497	0,1497	0,1973	0,1497	0,1565	0,3333	0,3129	0,3061	0,2789	0,2857	0,3265	0,3265	0,3061	0,3061	0,3026
3 Lindow BB	0,1806	0,2470	-	0,1460	0,1466	0,1326	0,1598	0,1600	0,2825	0,2755	0,2689	0,2555	0,2345	0,2755	0,2620	0,2551	0,2551	0,2657
4 NH1-A1-S4-br1	0,2413	0,2500	0,2529	-	0,0000	0,1429	0,1224	0,1156	0,2653	0,2585	0,2517	0,2381	0,2177	0,2585	0,2449	0,2109	0,2109	0,2349
5 NH1-A1-S4-br2	0,2410	0,2500	0,2529	0,0000	-	0,1429	0,1224	0,1156	0,2653	0,2585	0,2517	0,2381	0,2177	0,2585	0,2449	0,2109	0,2109	0,2346
6 Summt BB	0,2028	0,3258	0,2391	0,2530	0,2530	-	0,1156	0,1088	0,2857	0,2517	0,2449	0,2449	0,1973	0,2381	0,2381	0,2313	0,2313	0,2551
7 Bad Saarow BB	0,2556	0,2444	0,2668	0,2093	0,2093	0,2048	-	0,1020	0,2925	0,2857	0,2653	0,2381	0,2585	0,2993	0,3129	0,2925	0,2925	0,2756
8 Köthen BB	0,2331	0,2527	0,2655	0,1977	0,1977	0,1928	0,1724	-	0,2857	0,2789	0,2585	0,2585	0,2381	0,2653	0,2789	0,2585	0,2585	0,2687
9 Harz N	0,4653	0,4804	0,4345	0,4105	0,4105	0,4468	0,4343	0,4242	-	0,1429	0,1769	0,1769	0,1429	0,1973	0,1973	0,1769	0,1769	0,1869
10 Nennsdorf TH	0,4080	0,4600	0,4285	0,4043	0,4043	0,4066	0,4286	0,4184	0,2442	-	0,1156	0,1156	0,0952	0,1361	0,1633	0,1565	0,1565	0,1260
11 Frankenau H	0,4362	0,4545	0,4223	0,3978	0,3978	0,4000	0,4063	0,3958	0,2955	0,2048	-	0,0680	0,1156	0,1565	0,1973	0,1769	0,1769	0,1190
12 Schönenberg NRW	0,4053	0,4271	0,4098	0,3846	0,3846	0,4045	0,3763	0,4000	0,2989	0,2073	0,1282	-	0,1020	0,1701	0,1973	0,1633	0,1633	0,1328
13 Geraberg TH	0,4032	0,4421	0,3896	0,3636	0,3636	0,3452	0,4086	0,3804	0,2530	0,1772	0,2125	0,1923	-	0,0816	0,0952	0,0748	0,0748	0,1122
14 Dietzhausen TH	0,4078	0,4752	0,4285	0,4043	0,4043	0,3889	0,4444	0,4021	0,3222	0,2353	0,2674	0,2907	0,1538	-	0,0952	0,0748	0,0748	0,1665
15 Sil1-B4-S17-3	0,4038	0,4898	0,4255	0,4000	0,4000	0,4023	0,4742	0,4316	0,3333	0,2857	0,3372	0,3412	0,1842	0,1772	-	0,0476	0,0476	0,1533
16 Sil1-C2-S22-2	0,4153	0,4688	0,4190	0,3563	0,3563	0,3953	0,4526	0,4086	0,3059	0,2771	0,3095	0,2927	0,1486	0,1429	0,0972	-	0,0000	0,1462
17 Sil1-C2-S22-3	0,4149	0,4688	0,4188	0,3563	0,3563	0,3953	0,4526	0,4086	0,3059	0,2771	0,3095	0,2927	0,1486	0,1429	0,0972	0,0000	-	0,1460
18 Röhmhild TH	0,4049	0,4586	0,4264	0,3832	0,3837	0,4210	0,4264	0,4152	0,3157	0,2258	0,2162	0,2403	0,2120	0,2882	0,2778	0,2686	0,2685	-
19 Neudrossenfeld BY	0,4525	0,4536	0,4381	0,3956	0,3956	0,4505	0,4375	0,4105	0,2289	0,2410	0,2530	0,2346	0,2278	0,3023	0,3333	0,3049	0,3049	0,2639
20 Bad Urach BW	0,4310	0,4257	0,4332	0,4021	0,4021	0,4848	0,4563	0,4314	0,3226	0,2184	0,2697	0,2529	0,2674	0,3152	0,3444	0,3182	0,3182	0,2703
21 Sweden	0,3029	0,4132	0,3344	0,3381	0,3388	0,2723	0,3292	0,3179	0,4306	0,4408	0,4065	0,4122	0,4283	0,4485	0,4285	0,4030	0,4016	0,4111
22 Scotland	0,4254	0,5104	0,4463	0,4725	0,4725	0,4235	0,4286	0,4000	0,3529	0,3253	0,2963	0,3415	0,2949	0,3452	0,3165	0,3077	0,3077	0,2644
23 England	0,4124	0,4554	0,4158	0,3478	0,3478	0,4194	0,4082	0,4141	0,2809	0,2118	0,2024	0,2471	0,2195	0,2529	0,2824	0,2738	0,2738	0,2438
24 France I	0,3991	0,4707	0,4204	0,4399	0,4408	0,4072	0,4294	0,4022	0,3085	0,2568	0,2167	0,2423	0,2564	0,2884	0,3413	0,3329	0,3328	0,2367
25 France II	0,3940	0,3918	0,3991	0,3478	0,3478	0,3846	0,3579	0,3814	0,3000	0,2118	0,1807	0,2262	0,1975	0,2326	0,2824	0,2317	0,2317	0,2018
26 Spain	0,2833	0,4296	0,3745	0,3667	0,3661	0,3475	0,3764	0,3276	0,4274	0,4384	0,4325	0,4015	0,4174	0,4387	0,4713	0,4467	0,4476	0,4375
27 Italy	0,4057	0,4433	0,4097	0,4022	0,4022	0,4045	0,4105	0,4000	0,2989	0,2500	0,1519	0,2222	0,2375	0,2706	0,2805	0,2716	0,2716	0,1732
28 Greece	0,4248	0,4356	0,4279	0,4124	0,4124	0,4316	0,4200	0,4412	0,3333	0,2093	0,2209	0,2644	0,2381	0,2697	0,3182	0,3103	0,3103	0,1990
29 Slovakia	0,4216	0,4490	0,4410	0,3736	0,3736	0,4787	0,4646	0,4545	0,3444	0,2588	0,2706	0,2738	0,2892	0,3371	0,3095	0,3214	0,3214	0,2394
30 Slovenia	0,4347	0,4211	0,4033	0,3956	0,3956	0,4674	0,4694	0,4271	0,3295	0,2619	0,2738	0,2976	0,2500	0,3409	0,3133	0,2840	0,2840	0,2638
31 Azores I	0,4256	0,4208	0,4107	0,4308	0,4298	0,4417	0,4366	0,4274	0,3111	0,2837	0,2644	0,2780	0,2285	0,3019	0,3142	0,3055	0,3051	0,2637
32 Azores II	0,4403	0,4851	0,4560	0,4060	0,3959	0,4447	0,4539	0,4374	0,3627	0,3743	0,2808	0,3190	0,2937	0,3104	0,3122	0,2923	0,2895	0,2758
33 Madeira	0,3987	0,4375	0,4210	0,3778	0,3778	0,3977	0,3696	0,3936	0,3295	0,3218	0,2530	0,2561	0,2716	0,3596	0,3133	0,3049	0,3049	0,2089
34 Canada	0,4356	0,4455	0,4043	0,3548	0,3548	0,4086	0,3980	0,4040	0,2500	0,2000	0,2118	0,2353	0,1625	0,2414	0,2706	0,2410	0,2410	0,2321
35 Australia	0,4530	0,4314	0,4237	0,3750	0,3750	0,4271	0,4000	0,3737	0,2747	0,2273	0,2584	0,2809	0,2353	0,2472	0,3146	0,2874	0,2874	0,2785
36 New Zealand	0,4416	0,4510	0,4281	0,3789	0,3789	0,4149	0,4200	0,4257	0,3152	0,2093	0,2614	0,2841	0,2169	0,2299	0,2588	0,2500	0,2500	0,2613

Jacc\SM	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1 Jägerhof MV	0,2755	0,2756	0,1599	0,2420	0,2552	0,2281	0,2412	0,1501	0,2414	0,2688	0,2552	0,2622	0,2544	0,2734	0,2347	0,2755	0,2959	0,2824
2 Biesenbrow BB	0,2993	0,2925	0,2520	0,3333	0,3129	0,3063	0,2585	0,2685	0,2925	0,2993	0,2993	0,2721	0,2717	0,3420	0,2857	0,3061	0,2993	0,3129
3 Lindow BB	0,2752	0,2894	0,1866	0,2692	0,2688	0,2552	0,2552	0,2178	0,2553	0,2824	0,2823	0,2481	0,2551	0,3051	0,2623	0,2623	0,2823	0,2822
4 NH1-A1-S4-br1	0,2449	0,2653	0,1907	0,2925	0,2177	0,2719	0,2177	0,2144	0,2517	0,2721	0,2313	0,2449	0,2728	0,2604	0,2313	0,2245	0,2449	0,2449
5 NH1-A1-S4-br2	0,2449	0,2653	0,1910	0,2925	0,2177	0,2718	0,2177	0,2145	0,2517	0,2721	0,2313	0,2449	0,2726	0,2588	0,2313	0,2245	0,2449	0,2449
6 Summt BB	0,2789	0,3265	0,1429	0,2449	0,2653	0,2382	0,2381	0,1938	0,2449	0,2789	0,3061	0,2925	0,2726	0,2890	0,2381	0,2585	0,2789	0,2653
7 Bad Saarow BB	0,2857	0,3197	0,1903	0,2653	0,2721	0,2719	0,2313	0,2277	0,2653	0,2857	0,3129	0,3129	0,2861	0,3097	0,2313	0,2653	0,2721	0,2857
8 Köthen BB	0,2653	0,2993	0,1834	0,2449	0,2789	0,2519	0,2517	0,1937	0,2585	0,3061	0,3061	0,2789	0,2787	0,2938	0,2517	0,2721	0,2517	0,2925
9 Harz N	0,1293	0,2041	0,2591	0,2041	0,1701	0,1773	0,1837	0,2620	0,1769	0,2109	0,2109	0,1973	0,1834	0,2358	0,1973	0,1497	0,1701	0,1973
10 Nennsdorf TH	0,1361	0,1293	0,2658	0,1837	0,1224	0,1432	0,1224	0,2688	0,1429	0,1224	0,1497	0,1497	0,1633	0,2376	0,1905	0,1156	0,1361	0,1224
11 Frankenau H	0,1429	0,1633	0,2387	0,1633	0,1156	0,1148	0,1020	0,2621	0,0816	0,1293	0,1565	0,1565	0,1501	0,1689	0,1429	0,1224	0,1565	0,1565
12 Schönenberg NRW	0,1293	0,1497	0,2375	0,1905	0,1429	0,1290	0,1293	0,2348	0,1224	0,1565	0,1565	0,1701	0,1561	0,1998	0,1429	0,1361	0,1701	0,1701
13 Geraberg TH	0,1224	0,1565	0,2444	0,1565	0,1224	0,1359	0,1088	0,2410	0,1293	0,1361	0,1633	0,1361	0,1227	0,1811	0,1497	0,0884	0,1361	0,1224
14 Dietzhausen TH	0,1769	0,1973	0,2723	0,1973	0,1497	0,1641	0,1361	0,2685	0,1565	0,1633	0,2041	0,2041	0,1771	0,1938	0,2177	0,1429	0,1497	0,1361
15 Sil1-B4-S17-3	0,1905	0,2109	0,2455	0,1701	0,1633	0,1910	0,1633	0,2823	0,1565	0,1905	0,1769	0,1769	0,1763	0,1876	0,1769	0,1565	0,1905	0,1497
16 Sil1-C2-S22-2	0,1701	0,1905	0,2244	0,1633	0,1565	0,1834	0,1293	0,2621	0,1497	0,1837	0,1837	0,1565	0,1703	0,1702	0,1701	0,1361	0,1701	0,1429
17 Sil1-C2-S22-3	0,1701	0,1905	0,2244	0,1633	0,1565	0,1841	0,1293	0,2621	0,1497	0,1837	0,1837	0,1565	0,1693	0,1740	0,1701	0,1361	0,1701	0,1429
18 Röhmhild TH	0,1461	0,1597	0,2354	0,1391	0,1392	0,1264	0,1126	0,2585	0,0916	0,1123	0,1330	0,1462	0,1468	0,1627	0,1118	0,1330	0,1668	0,1535
19 Neudrossenfeld BY	-	0,1429	0,2717	0,1973	0,1905	0,1495	0,1769	0,2688	0,1565	0,2041	0,1224	0,1497	0,1837	0,2032	0,1769	0,1565	0,1769	0,1769
20 Bad Urach BW	0,2442	-	0,2989	0,2177	0,1701	0,1901	0,1565	0,3300	0,1769	0,1837	0,0748	0,1565	0,1842	0,2082	0,1973	0,1633	0,1973	0,1701
21 Sweden	0,4595	0,4698	-	0,1421	0,2723	0,1919	0,2447	0,1673	0,2315	0,2786	0,2720	0,2176	0,2115	0,2445	0,1841	0,2797	0,2853	0,2989
22 Scotland	0,3537	0,3636	0,2837	-	0,2245	0,1422	0,1837	0,2348	0,1633	0,1837	0,1973	0,1429	0,1565	0,1835	0,1293	0,2177	0,2245	0,2245
23 England	0,3182	0,2747	0,4448	0,3793	-	0,1629	0,0816	0,2826	0,0884	0,1088	0,1633	0,1905	0,1496	0,2102	0,1905	0,0748	0,0952	0,1088
24 France I	0,2750	0,3201	0,3543	0,2759	0,2865	-	0,1494	0,1801	0,1088	0,1434	0,1902	0,1357	0,1166	0,1752	0,1429	0,1565	0,1630	0,1903
25 France II	0,2989	0,2556	0,4090	0,3214	0,1446	0,2650	-	0,2687	0,0884	0,0952	0,1633	0,1633	0,1359	0,1729	0,1361	0,0612	0,0952	0,1088
26 Spain	0,4488	0,4999	0,3195	0,4202	0,4514	0,3327	0,4338	-	0,2622	0,2960	0,3230	0,2687	0,2474	0,2951	0,2413	0,2757	0,2685	0,3234
27 Italy	0,2771	0,2921	0,4028	0,3000	0,1605	0,2067	0,1605	0,4375	-	0,0748	0,1701	0,1565	0,1364	0,1786	0,1429	0,1224	0,1565	0,1565
28 Greece	0,3333	0,2903	0,4494	0,3176	0,1860	0,2519	0,1647	0,4631	0,1358	-	0,1905	0,1633	0,1297	0,2032	0,1905	0,1156	0,1361	0,1361
29 Slovakia	0,2222	0,1341	0,4543	0,3494	0,2759	0,3334	0,2759	0,5105	0,2941	0,3111	-	0,1361	0,1977	0,1794	0,1633	0,1565	0,2041	0,1769
30 Slovenia	0,2683	0,2644	0,3849	0,2692	0,3182	0,2534	0,2791	0,4490	0,2771	0,2759	0,2439	-	0,1361	0,1831	0,1497	0,1701	0,1905	0,1905
31 Azores I	0,3198	0,3036	0,3751	0,2909	0,2586	0,2196	0,2380	0,4213	0,2459	0,2251	0,3355	0,2470	-	0,1666	0,1088	0,1298	0,1630	0,1900
32 Azores II	0,3340	0,3272	0,4134	0,3244	0,3272	0,3030	0,2766	0,4712	0,2933	0,3302	0,2905	0,3117	0,2712	-	0,1352	0,1826	0,2098	0,2115
33 Madeira	0,3095	0,3222	0,3351	0,2468	0,3182	0,2643	0,2381	0,4125	0,2561	0,3146	0,2857	0,2683	0,2043	0,2176	-	0,1565	0,2041	0,2041
34 Canada	0,2674	0,2637	0,4491	0,3678	0,1325	0,2736	0,1098	0,4401	0,2143	0,1954	0,2644	0,2874	0,2250	0,2836	0,2674	-	0,0748	0,1020
35 Australia	0,2921	0,3053	0,4509	0,3708	0,1628	0,2793	0,1628	0,4247	0,2614	0,2222	0,3261	0,3111	0,2729	0,3258	0,3297	0,1294	-	0,0952
36 New Zealand	0,2955	0,2717	0,4725	0,3750	0,1860	0,3214	0,1860	0,4947	0,2644	0,2247	0,2921	0,3146	0,3147	0,3364	0,3333	0,1744	0,1609	-

- Northeast Germany
- Plot NH1
- South and West Germany
- Plot Sil1

A5.2 *Pleurozium schreberi*

Pger Distance values between German *Pleurozium schreberi* samples. Simple matching distances in the upper right, Jaccard distances in the lower left part.

Jacc\SM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Saarm1-A1-P1	-	0,1289	0,3429	0,2830	0,2797	0,2706	0,2541	0,3425	0,3486	0,2702	0,1919	0,2579	0,2915	0,2423	0,3179	0,2640
2 Saarm1-A1-P2	0,2290	-	0,2954	0,2924	0,2640	0,3237	0,3018	0,3395	0,3459	0,2863	0,1761	0,2547	0,2897	0,2326	0,3397	0,2923
3 Saarm1-A2-P5	0,5477	0,4677	-	0,2809	0,3587	0,3870	0,3608	0,3220	0,3405	0,3061	0,3020	0,2923	0,3394	0,3092	0,3268	0,3555
4 Saarm1-B2-P16	0,4786	0,4673	0,4864	-	0,2864	0,2765	0,2996	0,2111	0,2050	0,2964	0,2924	0,2579	0,3356	0,2869	0,3303	0,3145
5 Saarm1-B2-P15	0,4382	0,4000	0,5402	0,4596	-	0,3108	0,2889	0,2722	0,3266	0,2746	0,2139	0,2358	0,2582	0,2701	0,3149	0,2989
6 Saarm1-C1-P23	0,4387	0,4813	0,5859	0,4615	0,4668	-	0,1736	0,2864	0,2805	0,3015	0,2674	0,2450	0,3362	0,2425	0,3867	0,3835
7 Saarm1-C1-P24	0,4231	0,4616	0,5616	0,4950	0,4461	0,3019	-	0,3030	0,2776	0,2305	0,2511	0,2352	0,3026	0,2460	0,3579	0,3492
8 Saarm1-C2-P25	0,5265	0,4996	0,5125	0,3722	0,4191	0,4500	0,4750	-	0,1449	0,2557	0,2768	0,2546	0,3413	0,2848	0,3079	0,3252
9 Saarm1-C2-P26	0,5284	0,5022	0,5294	0,3592	0,4812	0,4380	0,4401	0,2540	-	0,2684	0,3083	0,2609	0,3716	0,3155	0,3081	0,3493
10 Saarm1-C3-P29	0,4296	0,4292	0,4826	0,4748	0,4143	0,4593	0,3745	0,4030	0,4148	-	0,2359	0,2766	0,2935	0,2115	0,2545	0,3025
11 Saarm1-C4-P30	0,3335	0,2947	0,4897	0,4819	0,3470	0,4263	0,4127	0,4404	0,4733	0,3790	-	0,2171	0,2392	0,2329	0,2642	0,2798
12 Saarm1-C4-P31	0,4205	0,3971	0,4745	0,4338	0,3732	0,3957	0,3876	0,4082	0,4126	0,4271	0,3595	-	0,2295	0,2103	0,3110	0,2767
13 Saarm1-D2-P35	0,4666	0,4425	0,5331	0,5352	0,4030	0,5096	0,4754	0,5139	0,5425	0,4493	0,3912	0,3761	-	0,2023	0,3215	0,2614
14 Saarm1-E3-P49	0,3988	0,3684	0,4919	0,4692	0,4152	0,3904	0,3999	0,4430	0,4763	0,3419	0,3795	0,3470	0,3364	-	0,2704	0,2674
15 Harz N	0,4902	0,4931	0,5118	0,5195	0,4650	0,5560	0,5325	0,4709	0,4662	0,3972	0,4178	0,4712	0,4859	0,4216	-	0,3070
16 Nennsdorf TH	0,4487	0,4624	0,5729	0,5288	0,4702	0,5811	0,5502	0,5145	0,5387	0,4767	0,4608	0,4538	0,4362	0,4405	0,4849	-
17 Geraberg I TH	0,5025	0,5185	0,5687	0,5024	0,4314	0,5353	0,5314	0,4598	0,5071	0,4609	0,4444	0,4604	0,4672	0,4852	0,4975	0,3993
18 Geraberg II TH	0,4450	0,4579	0,5481	0,5271	0,3981	0,5694	0,5526	0,4489	0,5023	0,4278	0,3776	0,5139	0,4631	0,4593	0,4787	0,3708
19 Rennsteig TH	0,5242	0,5182	0,5673	0,5323	0,4404	0,5072	0,5305	0,4526	0,5209	0,4692	0,4904	0,5255	0,4827	0,4562	0,4975	0,4258
20 Inselsberg TH	0,4721	0,4615	0,5253	0,5478	0,3590	0,5284	0,4722	0,3954	0,4784	0,3487	0,3789	0,3968	0,4360	0,4399	0,4062	0,3900
21 Sil1-A1-P1	0,4788	0,4408	0,4851	0,5879	0,4409	0,4903	0,4864	0,4808	0,5556	0,5086	0,4237	0,4464	0,4005	0,4340	0,5278	0,4885
22 Sil1-A1-P2	0,4590	0,4284	0,4803	0,5717	0,4212	0,4861	0,4804	0,4768	0,5391	0,4916	0,4107	0,4266	0,3806	0,4221	0,5245	0,4827
23 Sil1-A2-P3	0,4786	0,4407	0,4855	0,5879	0,4412	0,4902	0,4859	0,4813	0,5557	0,5090	0,4239	0,4467	0,3996	0,4340	0,5276	0,4883
24 Sil1-A3-P4	0,4927	0,4470	0,4549	0,5355	0,3799	0,4545	0,4571	0,4592	0,5442	0,4678	0,4450	0,4077	0,3908	0,3870	0,5290	0,4652
25 Sil1-A4-P5	0,4725	0,4280	0,4857	0,5803	0,4136	0,4837	0,4581	0,5155	0,5550	0,4824	0,4104	0,4329	0,3640	0,3916	0,5216	0,4375
26 Sil1-A4-P6	0,4743	0,4154	0,4735	0,5502	0,3704	0,4511	0,4742	0,4557	0,5325	0,4503	0,4122	0,3750	0,4051	0,3926	0,5235	0,4389
27 Sil1-A5-P7	0,4784	0,4474	0,4998	0,5561	0,3649	0,4328	0,4123	0,4679	0,5440	0,4471	0,4157	0,4007	0,4154	0,3645	0,5216	0,4805
28 Sil1-A5-P8	0,5046	0,4870	0,5047	0,5592	0,4392	0,4683	0,4338	0,4860	0,5472	0,4457	0,4727	0,4521	0,4511	0,3963	0,5195	0,5342
29 Sil1-B2-P9	0,4603	0,4434	0,5049	0,5414	0,3980	0,5025	0,5115	0,4709	0,5427	0,4647	0,4100	0,3622	0,3937	0,3653	0,4421	0,4218
30 Sil1-B2-P10	0,4759	0,4731	0,4756	0,5606	0,4303	0,5091	0,4694	0,5199	0,5291	0,4864	0,3808	0,4431	0,3803	0,3529	0,4719	0,5071
31 Sil1-B3-P11	0,4315	0,4167	0,4831	0,5736	0,3863	0,4751	0,4397	0,5397	0,5413	0,4793	0,4135	0,4068	0,3984	0,4022	0,5064	0,4330
32 Sil1-B4-P12	0,5112	0,4652	0,5332	0,5688	0,4138	0,4736	0,4605	0,5067	0,5807	0,4999	0,4791	0,4039	0,4567	0,3907	0,5534	0,4925
33 Sil1-B4-P13	0,4847	0,4510	0,5230	0,5309	0,3793	0,4901	0,4692	0,4654	0,5471	0,5093	0,4490	0,4416	0,4562	0,4286	0,5449	0,4706
34 Sil1-C1-P14-1	0,4862	0,3964	0,4629	0,5692	0,4263	0,4971	0,4709	0,5292	0,5627	0,4948	0,3921	0,4309	0,3763	0,3725	0,5353	0,4500
35 Sil1-C1-P14-2	0,4885	0,3990	0,4652	0,5780	0,4139	0,4853	0,4590	0,5177	0,5646	0,4846	0,3793	0,4335	0,3794	0,3753	0,5369	0,4526
36 Sil1-C1-P14-3	0,4955	0,4063	0,4729	0,5780	0,4140	0,4926	0,4666	0,5247	0,5710	0,4908	0,3873	0,4412	0,3790	0,3831	0,5368	0,4525
37 Sil1-C1-P15	0,4815	0,4219	0,4735	0,5772	0,4359	0,4796	0,4672	0,5236	0,5456	0,5042	0,4038	0,4559	0,3886	0,3844	0,5306	0,4604
38 Sil1-C2-P16	0,4998	0,4420	0,5073	0,6114	0,4421	0,5043	0,4930	0,5657	0,5550	0,5338	0,4399	0,4752	0,3948	0,4354	0,5152	0,4597
39 Sil1-C3-P17	0,4622	0,4526	0,5217	0,5373	0,4223	0,4975	0,4705	0,4800	0,5183	0,4597	0,4044	0,4515	0,4357	0,4759	0,5228	0,4719
40 Sil1-C4-P18	0,4780	0,4171	0,5140	0,5291	0,3785	0,4616	0,4563	0,4802	0,5182	0,5156	0,4292	0,4146	0,4130	0,3939	0,5488	0,5098
41 Sil2-A2-P5	0,4351	0,4203	0,4945	0,4872	0,4273	0,4787	0,4947	0,4899	0,5068	0,4907	0,3601	0,3363	0,3688	0,3893	0,4695	0,4589
42 Sil2-B1-P18	0,4312	0,3857	0,5115	0,4902	0,3855	0,3921	0,4166	0,4202	0,4388	0,4149	0,3484	0,3159	0,4209	0,3449	0,4866	0,3829
43 Sil2-B1-P20	0,4713	0,4104	0,5627	0,5496	0,4960	0,4908	0,5342	0,5152	0,5507	0,5021	0,4373	0,4453	0,5162	0,3867	0,5020	0,5025
44 Sil2-B2-P22	0,5070	0,4368	0,5376	0,4840	0,4666	0,4678	0,5144	0,4726	0,4756	0,4880	0,4264	0,4343	0,4342	0,3812	0,4731	0,4637
45 Sil2-B3-P27	0,4173	0,3783	0,5463	0,4392	0,3779	0,4168	0,4339	0,4058	0,5072	0,4320	0,3728	0,3736	0,4296	0,3859	0,4906	0,4507
46 Sil2-B3-P28	0,4377	0,3990	0,5191	0,4976	0,3989	0,3982	0,3995	0,4337	0,4884	0,4428	0,3455	0,3550	0,4498	0,3991	0,5067	0,4697
47 Sil2-B4-P31	0,3973	0,3558	0,5182	0,4865	0,3811	0,4386	0,4478	0,4266	0,5218	0,4529	0,3498	0,3515	0,4259	0,3641	0,4900	0,4137
48 Sil2-C4-P42	0,4713	0,4040	0,5143	0,4627	0,4259	0,4333	0,4495	0,4454	0,4840	0,4100	0,3678	0,3696	0,3674	0,3648	0,4463	0,4954
49 Keulrod TH	0,5026	0,5192	0,5340	0,5648	0,4445	0,5368	0,5400	0,4741	0,5221	0,4194	0,4583	0,5051	0,3998	0,5000	0,4511	0,4727
50 Kl Gleichberg TH	0,5527	0,5097	0,5618	0,6131	0,4495	0,5973	0,5661	0,5465	0,5415	0,4563	0,4795	0,4873	0,4947	0,5560	0,5020	0,4697
51 Berchtesgade I	0,4551	0,4389	0,5457	0,4973	0,3804	0,4532	0,4623	0,4441	0,4468	0,3636	0,4366	0,4446	0,4365	0,3949	0,4375	0,4099
52 Berchtesgade II	0,5113	0,4802	0,5525	0,5463	0,4174	0,4952	0,5566	0,4790	0,4953	0,4933	0,4512	0,4999	0,4572	0,4750	0,4865	0,4414
53 Salzburg	0,5152	0,4807	0,5158	0,5539	0,4270	0,5334	0,5368	0,5458	0,5612	0,5095	0,4486	0,4725	0,4475	0,4435	0,5308	0,4283

Jacc\SM	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1 Saarm1-A1-P1	0,3176	0,2799	0,3427	0,2925	0,3205	0,3013	0,3206	0,3271	0,3206	0,3206	0,3178	0,3492	0,2924	0,3141	0,2803	0,3395	0,2987	0,3240	0,3277
2 Saarm1-A1-P2	0,3522	0,3082	0,3585	0,3019	0,3049	0,2926	0,3051	0,3047	0,2987	0,2857	0,3084	0,3522	0,2956	0,3304	0,2831	0,3176	0,2893	0,2640	0,2673
3 Saarm1-A2-P5	0,3648	0,3584	0,3708	0,3270	0,3173	0,3116	0,3176	0,2863	0,3237	0,3117	0,3272	0,3395	0,3210	0,3052	0,3145	0,3493	0,3207	0,2954	0,2982
4 Saarm1-B2-P16	0,3051	0,3364	0,3366	0,3427	0,4088	0,3900	0,4083	0,3522	0,4088	0,3776	0,3741	0,3868	0,3491	0,3771	0,3929	0,3770	0,3239	0,3867	0,3959
5 Saarm1-B2-P15	0,2768	0,2579	0,2891	0,2201	0,3045	0,2864	0,3046	0,2486	0,2865	0,2487	0,2389	0,3080	0,2578	0,2922	0,2580	0,2737	0,2327	0,2893	0,2799
6 Saarm1-C1-P23	0,3553	0,3993	0,3364	0,3493	0,3394	0,3336	0,3393	0,3025	0,3400	0,3084	0,2866	0,3241	0,3366	0,3524	0,3236	0,3144	0,3114	0,3428	0,3332
7 Saarm1-C1-P24	0,3461	0,3778	0,3525	0,2960	0,3307	0,3236	0,3302	0,2987	0,3110	0,3238	0,2644	0,2892	0,3399	0,3115	0,2891	0,2987	0,2893	0,3146	0,3050
8 Saarm1-C2-P25	0,2898	0,2894	0,2892	0,2389	0,3305	0,3244	0,3300	0,3055	0,3690	0,3117	0,3147	0,3391	0,3082	0,3620	0,3842	0,3427	0,2892	0,3719	0,3630
9 Saarm1-C2-P26	0,3334	0,3397	0,3522	0,3083	0,4056	0,3873	0,4053	0,3873	0,4121	0,3867	0,3898	0,4024	0,3774	0,3741	0,3914	0,4178	0,3647	0,4104	0,4136
10 Saarm1-C3-P29	0,2986	0,2801	0,3115	0,2105	0,3642	0,3462	0,3646	0,3205	0,3461	0,3142	0,3051	0,3112	0,3117	0,3391	0,3367	0,3458	0,3365	0,3488	0,3397
11 Saarm1-C4-P30	0,2767	0,2327	0,3208	0,2264	0,2799	0,2672	0,2799	0,2925	0,2735	0,2738	0,2702	0,3270	0,2579	0,2422	0,2702	0,3177	0,2767	0,2515	0,2422
12 Saarm1-C4-P31	0,2924	0,3490	0,3554	0,2421	0,3023	0,2841	0,3019	0,2641	0,2954	0,2456	0,2605	0,3114	0,2233	0,2956	0,2681	0,2587	0,2735	0,2860	0,2895
13 Saarm1-D2-P35	0,2953	0,3022	0,3140	0,2701	0,2605	0,2425	0,2610	0,2485	0,2368	0,2675	0,2716	0,3085	0,2453	0,2414	0,2571	0,2994	0,2828	0,2394	0,2428
14 Saarm1-E3-P49	0,3148	0,3020	0,2956	0,2767	0,2921	0,2801	0,2931	0,2486	0,2618	0,2608	0,2327	0,2639	0,2266	0,2230	0,2644	0,2483	0,2641	0,2395	0,2430
15 Harz N	0,3269	0,3207	0,3334	0,2518	0,3807	0,3740	0,3806	0,3741	0,3804	0,3804	0,3711	0,3773	0,2893	0,3240	0,3584	0,3928	0,3650	0,3836	0,3866
16 Nennsdorf TH	0,2295	0,2169	0,2548	0,2229	0,3207	0,3147	0,3207	0,2952	0,2831	0,2827	0,3113	0,3678	0,2547	0,3334	0,2736	0,3143	0,2798	0,2863	0,2890
17 Geraberg I TH	-	0,1572	0,2579	0,2013	0,2421	0,2357	0,2416	0,2734	0,2799	0,2926	0,2830	0,3145	0,2704	0,2737	0,2830	0,3049	0,2642	0,2955	0,2864
18 Geraberg II TH	0,2747	-	0,2390	0,2327	0,2669	0,2737	0,2674	0,2546	0,2672	0,2676	0,2703	0,2830	0,2767	0,2484	0,2895	0,2990	0,2579	0,2832	0,2736
19 Rennsteig TH	0,4184	0,3838	-	0,2956	0,3054	0,3053	0,3051	0,2673	0,2988	0,2422	0,3018	0,3082	0,2642	0,3304	0,2955	0,2986	0,2704	0,3144	0,3051
20 Inselsberg TH	0,3478	0,3814	0,4653	-	0,2861	0,2799	0,2862	0,3178	0,3050	0,2738	0,3082	0,3522	0,2579	0,2924	0,2828	0,3302	0,2893	0,2955	0,2858
21 Sil1-A1-P1	0,3811	0,4026	0,4512	0,4353	-	0,0191	0,0000	0,1763	0,2136	0,2208	0,1925	0,2234	0,2546	0,2335	0,2170	0,2395	0,2168	0,2359	0,2264
22 Sil1-A1-P2	0,3749	0,4125	0,4530	0,4297	0,0339	-	0,0192	0,1769	0,2140	0,2208	0,1985	0,2420	0,2485	0,2334	0,1987	0,2529	0,2233	0,2424	0,2325
23 Sil1-A2-P3	0,3812	0,4024	0,4508	0,4353	0,0000	0,0337	-	0,1767	0,2137	0,2208	0,1924	0,2231	0,2545	0,2337	0,2171	0,2398	0,2171	0,2358	0,2267
24 Sil1-A3-P4	0,4265	0,3930	0,4122	0,4787	0,2796	0,2820	0,2797	-	0,1697	0,1585	0,0723	0,1415	0,2044	0,2333	0,1913	0,1325	0,1037	0,1986	0,1883
25 Sil1-A4-P5	0,4217	0,3973	0,4378	0,4511	0,3211	0,3223	0,3202	0,2670	-	0,1511	0,1603	0,2233	0,1918	0,2074	0,1037	0,2138	0,2233	0,0410	0,0379
26 Sil1-A4-P6	0,4387	0,3988	0,3721	0,4161	0,3298	0,3317	0,3298	0,2514	0,2350	-	0,1604	0,2170	0,1602	0,2333	0,1478	0,2016	0,2232	0,1793	0,1703
27 Sil1-A5-P7	0,4350	0,4092	0,4506	0,4643	0,2987	0,3090	0,2993	0,1263	0,2527	0,2541	-	0,0880	0,1826	0,2102	0,1885	0,1104	0,1069	0,1764	0,1664
28 Sil1-A5-P8	0,4630	0,4167	0,4495	0,5045	0,3337	0,3581	0,3331	0,2282	0,3288	0,3225	0,1473	-	0,2453	0,2171	0,2263	0,1353	0,1509	0,2390	0,2295
29 Sil1-B2-P9	0,4300	0,4272	0,4158	0,4141	0,3872	0,3814	0,3871	0,3284	0,3020	0,2597	0,2957	0,3714	-	0,2229	0,1887	0,2043	0,2327	0,2077	0,2107
30 Sil1-B2-P10	0,4242	0,3833	0,4839	0,4471	0,3519	0,3533	0,3524	0,3572	0,3157	0,3488	0,3266	0,3283	0,3512	-	0,2167	0,2079	0,2420	0,2106	0,2202
31 Sil1-B3-P11	0,4327	0,4299	0,4412	0,4329	0,3308	0,3077	0,3301	0,3012	0,1702	0,2346	0,2961	0,3380	0,3031	0,3333	-	0,2113	0,2266	0,1135	0,1170
32 Sil1-B4-P12	0,4687	0,4504	0,4542	0,4976	0,3650	0,3826	0,3651	0,2227	0,3286	0,3136	0,1882	0,2212	0,3316	0,3289	0,3304	-	0,1229	0,2171	0,2264
33 Sil1-B4-P13	0,4375	0,4184	0,4388	0,4694	0,3520	0,3621	0,3518	0,1881	0,3550	0,3570	0,1922	0,2553	0,3854	0,3886	0,3653	0,2221	-	0,2140	0,2171
34 Sil1-C1-P14-1	0,4496	0,4246	0,4652	0,4497	0,3551	0,3649	0,3553	0,3123	0,0711	0,2791	0,2797	0,3553	0,3299	0,3267	0,1880	0,3396	0,3502	-	0,0095
35 Sil1-C1-P14-2	0,4373	0,4123	0,4532	0,4375	0,3432	0,3523	0,3426	0,2983	0,0657	0,2660	0,2667	0,3426	0,3338	0,3384	0,1921	0,3515	0,3535	0,0172	-
36 Sil1-C1-P14-3	0,4374	0,4124	0,4606	0,4376	0,3510	0,3594	0,3511	0,3075	0,0657	0,2745	0,2752	0,3508	0,3414	0,3379	0,2016	0,3429	0,3540	0,0174	0,0117
37 Sil1-C1-P15	0,4452	0,4206	0,4465	0,4601	0,3521	0,3610	0,3521	0,3249	0,0704	0,2935	0,2946	0,3517	0,3269	0,3241	0,1864	0,3370	0,3635	0,0449	0,0612
38 Sil1-C2-P16	0,4292	0,4120	0,4450	0,4726	0,3444	0,3534	0,3440	0,3172	0,1047	0,2700	0,3028	0,3441	0,3351	0,3316	0,1700	0,3288	0,3549	0,1020	0,1169
39 Sil1-C3-P17	0,3997	0,4221	0,4483	0,3750	0,3968	0,3919	0,3965	0,3949	0,3368	0,3059	0,3809	0,4398	0,3052	0,3689	0,3297	0,4379	0,4451	0,3565	0,3510
40 Sil1-C4-P18	0,4637	0,4526	0,4788	0,4782	0,3284	0,3382	0,3285	0,1991	0,3319	0,2996	0,1828	0,2698	0,3601	0,3241	0,3251	0,1807	0,1418	0,3272	0,3384
41 Sil2-A2-P5	0,4809	0,4911	0,5616	0,4660	0,4661	0,4686	0,4660	0,4369	0,4465	0,3978	0,4447	0,4913	0,4105	0,4415	0,4355	0,4634	0,4852	0,4298	0,4330
42 Sil2-B1-P18	0,3852	0,3753	0,4029	0,3848	0,3758	0,3777	0,3756	0,3332	0,3315	0,2761	0,3186	0,4043	0,3006	0,4012	0,3413	0,3842	0,3807	0,3428	0,3299
43 Sil2-B1-P20	0,4787	0,5091	0,5136	0,5275	0,4713	0,4731	0,4710	0,4567	0,4648	0,4529	0,4357	0,4692	0,4887	0,4750	0,4408	0,4749	0,4760	0,4359	0,4383
44 Sil2-B2-P22	0,4545	0,4735	0,5354	0,4622	0,4974	0,4996	0,4977	0,4694	0,4559	0,4366	0,4549	0,5091	0,4280	0,4594	0,4300	0,4730	0,4821	0,4545	0,4574
45 Sil2-B3-P27	0,4019	0,4388	0,4587	0,3937	0,4439	0,4452	0,4433	0,4200	0,3772	0,3634	0,3821	0,4354	0,3757	0,4547	0,3882	0,4244	0,4060	0,3583	0,3535
46 Sil2-B3-P28	0,4833	0,4647	0,5113	0,4537	0,4329	0,4483	0,4328	0,3786	0,4125	0,3690	0,3797	0,4318	0,4351	0,4585	0,4238	0,3905	0,4350	0,4098	0,3976
47 Sil2-B4-P31	0,4398	0,4521	0,4949	0,4233	0,4712	0,4584	0,4709	0,4090	0,4051	0,3409	0,3934	0,4622	0,3702	0,4678	0,3840	0,4132	0,4279	0,4176	0,4051
48 Sil2-C4-P42	0,4497	0,4749	0,5135	0,4497	0,4709	0,4591	0,4709	0,4362	0,4311	0,4329	0,4438	0,4697	0,4608	0,4409	0,4419	0,4323	0,4835	0,4290	0,4249
49 Keulrod TH	0,4301	0,4105	0,4796	0,3409	0,4479	0,4430	0,4482	0,4315	0,4786	0,4437	0,4320	0,4906	0,4592	0,4449	0,4605	0,4972	0,4681	0,5071	0,4953
50 Kl Gleichberg TH	0,4603	0,3991	0,4531	0,3466	0,5044	0,5215	0,5051	0,4901	0,5116	0,4485	0,5048	0,5024	0,4798	0,4946	0,4951	0,5028	0,5130	0,5261	0,5139
51 Berchtesgade I	0,3383	0,3133	0,3658	0,3873	0,3784	0,3876	0,3777	0,3822	0,4017	0,3439	0,3839	0,3699	0,4084	0,4110	0,3822	0,4238	0,4146	0,4280	0,4160
52 Berchtesgade II	0,4107	0,4084	0,2276	0,4838	0,4145	0,4161	0,4142	0,3830	0,4018	0,3665	0,4208	0,4677	0,4377	0,4868	0,4331	0,4799	0,4299	0,4417	0,4304
53 Salzburg	0,4202	0,3926	0,4136	0,4612	0,4459	0,4410	0,4462	0,4054	0,3941	0,4039	0,3908	0,4523	0,4495	0,4037	0,4126	0,4020	0,3723	0,4072	0,4183

Jacc\SM	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
1 Saarm1-A1-P1	0,3332	0,3240	0,3456	0,2926	0,3112	0,2770	0,2764	0,3082	0,3238	0,2550	0,2764	0,2295	0,3111	0,3049	0,3458	0,3018	0,3521	0,3207
2 Saarm1-A1-P2	0,2736	0,2892	0,3114	0,3019	0,2767	0,2799	0,2549	0,2736	0,2830	0,2389	0,2615	0,2138	0,2704	0,3396	0,3302	0,3050	0,3428	0,3113
3 Saarm1-A2-P5	0,3052	0,3081	0,3427	0,3324	0,3329	0,3170	0,3377	0,3805	0,3410	0,3534	0,3379	0,3158	0,3409	0,3206	0,3429	0,3740	0,3805	0,3114
4 Saarm1-B2-P16	0,3962	0,3996	0,4403	0,3430	0,3426	0,3081	0,3153	0,3649	0,2927	0,2618	0,3158	0,2870	0,2933	0,3428	0,3837	0,3270	0,3711	0,3396
5 Saarm1-B2-P15	0,2805	0,3019	0,3110	0,2766	0,2457	0,2860	0,2545	0,3491	0,3080	0,2391	0,2613	0,2329	0,2893	0,2768	0,2798	0,2555	0,2863	0,2673
6 Saarm1-C1-P23	0,3395	0,3303	0,3582	0,3300	0,3053	0,3203	0,2522	0,3331	0,2990	0,2612	0,2511	0,2671	0,2865	0,3429	0,3964	0,3082	0,3461	0,3461
7 Saarm1-C1-P24	0,3117	0,3143	0,3430	0,3021	0,2956	0,3300	0,2682	0,3676	0,3347	0,2715	0,2489	0,2717	0,2964	0,3401	0,3616	0,3115	0,3993	0,3426
8 Saarm1-C2-P25	0,3689	0,3724	0,4182	0,3157	0,3211	0,3297	0,2741	0,3554	0,3020	0,2521	0,2803	0,2586	0,2963	0,2889	0,3491	0,2985	0,3301	0,3564
9 Saarm1-C2-P26	0,4197	0,3975	0,4133	0,3532	0,3584	0,3486	0,2934	0,3933	0,3083	0,3408	0,3313	0,3406	0,3345	0,3333	0,3488	0,3047	0,3491	0,3741
10 Saarm1-C3-P29	0,3457	0,3621	0,3963	0,3054	0,3614	0,3393	0,2778	0,3519	0,3240	0,2807	0,2963	0,2870	0,2745	0,2547	0,2832	0,2396	0,3523	0,3333
11 Saarm1-C4-P30	0,2484	0,2642	0,2987	0,2515	0,2766	0,2234	0,2171	0,2861	0,2640	0,2263	0,2105	0,2013	0,2327	0,2767	0,2924	0,2925	0,3050	0,2736
12 Saarm1-C4-P31	0,2954	0,3112	0,3331	0,2930	0,2669	0,2076	0,1949	0,2955	0,2734	0,2297	0,2202	0,2045	0,2362	0,3176	0,3018	0,3020	0,3522	0,2956
13 Saarm1-D2-P35	0,2427	0,2519	0,2611	0,2776	0,2636	0,2295	0,2741	0,3554	0,2711	0,2716	0,2928	0,2571	0,2332	0,2322	0,3064	0,2938	0,3115	0,2734
14 Saarm1-E3-P49	0,2491	0,2526	0,2989	0,3157	0,2516	0,2490	0,2178	0,2486	0,2325	0,2398	0,2556	0,2143	0,2334	0,3144	0,3613	0,2610	0,3300	0,2736
15 Harz N	0,3866	0,3836	0,3743	0,3583	0,3897	0,3173	0,3370	0,3488	0,3083	0,3272	0,3488	0,3147	0,3020	0,2768	0,3179	0,2988	0,3428	0,3489
16 Nennsdorf TH	0,2899	0,2985	0,3018	0,2926	0,3302	0,2895	0,2324	0,3270	0,2799	0,2731	0,2954	0,2359	0,3245	0,2738	0,2707	0,2579	0,2831	0,2462
17 Geraberg I TH	0,2864	0,2959	0,2862	0,2452	0,3019	0,3176	0,2422	0,3176	0,2833	0,2452	0,3177	0,2642	0,2958	0,2516	0,2737	0,2106	0,2673	0,2485
18 Geraberg II TH	0,2737	0,2830	0,2799	0,2705	0,3021	0,3364	0,2419	0,3554	0,3081	0,2831	0,3111	0,2829	0,3271	0,2453	0,2359	0,1981	0,2735	0,2358
19 Rennsteig TH	0,3112	0,3017	0,3051	0,2901	0,3206	0,3995	0,2612	0,3554	0,3585	0,2954	0,3491	0,3143	0,3584	0,2956	0,2737	0,2359	0,1354	0,2484
20 Inselsberg TH	0,2862	0,3082	0,3239	0,2267	0,3145	0,3055	0,2425	0,3617	0,2893	0,2391	0,2924	0,2517	0,2956	0,1887	0,1918	0,2485	0,3303	0,2799
21 Sil1-A1-P1	0,2331	0,2356	0,2327	0,2606	0,2116	0,3283	0,2519	0,3345	0,3426	0,2989	0,2960	0,3117	0,3368	0,2864	0,3333	0,2580	0,2893	0,2894
22 Sil1-A1-P2	0,2391	0,2423	0,2392	0,2542	0,2174	0,3283	0,2513	0,3345	0,3430	0,2988	0,3084	0,2987	0,3241	0,2800	0,3456	0,2645	0,2894	0,2829
23 Sil1-A2-P3	0,2326	0,2354	0,2327	0,2606	0,2118	0,3282	0,2521	0,3345	0,3424	0,2988	0,2953	0,3110	0,3366	0,2862	0,3333	0,2583	0,2892	0,2895
24 Sil1-A3-P4	0,1954	0,2106	0,2079	0,2553	0,1163	0,2957	0,2146	0,3141	0,3115	0,2727	0,2457	0,2549	0,2984	0,2677	0,3144	0,2580	0,2579	0,2514
25 Sil1-A4-P5	0,0378	0,0410	0,0629	0,2176	0,2169	0,3144	0,2204	0,3334	0,3110	0,2482	0,2831	0,2610	0,3050	0,3176	0,3460	0,2827	0,2831	0,2516
26 Sil1-A4-P6	0,1766	0,1917	0,1763	0,1914	0,1916	0,2707	0,1757	0,3212	0,2922	0,2356	0,2456	0,2107	0,3048	0,2863	0,2894	0,2329	0,2516	0,2576
27 Sil1-A5-P7	0,1726	0,1888	0,1982	0,2454	0,1076	0,3060	0,2050	0,2997	0,3015	0,2457	0,2482	0,2453	0,3083	0,2703	0,3303	0,2610	0,2927	0,2424
28 Sil1-A5-P8	0,2361	0,2390	0,2359	0,3019	0,1698	0,3553	0,2796	0,3365	0,3583	0,2956	0,2986	0,3082	0,3395	0,3270	0,3365	0,2547	0,3427	0,2988
29 Sil1-B2-P9	0,2171	0,2076	0,2169	0,1827	0,2265	0,2672	0,1857	0,3364	0,2704	0,2326	0,2864	0,2200	0,3143	0,2830	0,2988	0,2735	0,2987	0,2799
30 Sil1-B2-P10	0,2200	0,2103	0,2200	0,2361	0,2040	0,3021	0,2708	0,3329	0,3049	0,3045	0,3141	0,3049	0,3048	0,2799	0,3207	0,2832	0,3520	0,2511
31 Sil1-B3-P11	0,1234	0,1134	0,1040	0,2082	0,2080	0,2984	0,2228	0,3053	0,2830	0,2514	0,2863	0,2396	0,3080	0,2957	0,3239	0,2610	0,3050	0,2612
32 Sil1-B4-P12	0,2198	0,2171	0,2136	0,2861	0,1043	0,3153	0,2513	0,3281	0,3110	0,2734	0,2518	0,2545	0,2925	0,3175	0,3207	0,2892	0,3397	0,2455
33 Sil1-B4-P13	0,2168	0,2264	0,2233	0,2771	0,0755	0,3179	0,2359	0,3114	0,3019	0,2453	0,2734	0,2515	0,3205	0,2767	0,3113	0,2673	0,2799	0,2107
34 Sil1-C1-P14-1	0,0095	0,0253	0,0600	0,2279	0,2072	0,2924	0,2229	0,2989	0,3019	0,2264	0,2734	0,2642	0,2955	0,3336	0,3492	0,2987	0,3116	0,2549
35 Sil1-C1-P14-2	0,0064	0,0347	0,0694	0,2245	0,2173	0,2957	0,2138	0,3016	0,3048	0,2229	0,2644	0,2549	0,2926	0,3237	0,3396	0,2895	0,3020	0,2644
36 Sil1-C1-P14-3	-	0,0348	0,0630	0,2247	0,2109	0,3020	0,2201	0,3083	0,3050	0,2231	0,2708	0,2611	0,2861	0,3237	0,3397	0,2892	0,3081	0,2579
37 Sil1-C1-P15	0,0611	-	0,0473	0,2281	0,2202	0,3053	0,2357	0,3112	0,2891	0,2392	0,2867	0,2639	0,3205	0,3333	0,3615	0,2988	0,2985	0,2422
38 Sil1-C2-P16	0,1070	0,0807	-	0,2241	0,1919	0,3270	0,2580	0,3333	0,3112	0,2865	0,3209	0,3115	0,3428	0,3237	0,3334	0,2767	0,2891	0,2201
39 Sil1-C3-P17	0,3513	0,3531	0,3449	-	0,2520	0,3236	0,2235	0,3673	0,3015	0,2520	0,3049	0,2893	0,3458	0,2517	0,2483	0,2355	0,2988	0,2683
40 Sil1-C4-P18	0,3299	0,3393	0,2990	0,3936	-	0,3124	0,2619	0,3312	0,2830	0,2643	0,2800	0,2637	0,3143	0,3019	0,3114	0,2801	0,2987	0,2359
41 Sil2-A2-P5	0,4401	0,4406	0,4597	0,4783	0,4582	-	0,2205	0,2524	0,2117	0,2048	0,1707	0,1794	0,1854	0,3365	0,3588	0,3334	0,3585	0,3146
42 Sil2-B1-P18	0,3382	0,3550	0,3781	0,3525	0,3951	0,3433	-	0,2456	0,2175	0,1806	0,1829	0,1737	0,2304	0,3115	0,3085	0,2077	0,2390	0,2637
43 Sil2-B1-P20	0,4454	0,4452	0,4648	0,5241	0,4773	0,3847	0,3730	-	0,2358	0,2295	0,2200	0,2358	0,2358	0,3992	0,4152	0,2891	0,3398	0,3206
44 Sil2-B2-P22	0,4568	0,4363	0,4562	0,4678	0,4389	0,3453	0,3498	0,3768	-	0,1957	0,2236	0,1884	0,2012	0,3021	0,3176	0,2734	0,3174	0,2484
45 Sil2-B3-P27	0,3529	0,3705	0,4235	0,4025	0,4119	0,3332	0,2956	0,3650	0,3314	-	0,1737	0,1134	0,1831	0,2829	0,3556	0,2548	0,2798	0,2862
46 Sil2-B3-P28	0,4059	0,4213	0,4554	0,4594	0,4232	0,2796	0,2940	0,3462	0,3636	0,2912	-	0,1295	0,1671	0,3556	0,3335	0,2892	0,3460	0,3399
47 Sil2-B4-P31	0,4118	0,4139	0,4648	0,4620	0,4237	0,3076	0,2959	0,3847	0,3326	0,2114	0,2328	-	0,1709	0,3019	0,3305	0,3051	0,3113	0,2989
48 Sil2-C4-P42	0,4169	0,4531	0,4720	0,4974	0,4564	0,2967	0,3508	0,3605	0,3285	0,2992	0,2720	0,2903	-	0,3083	0,3616	0,3176	0,3679	0,3176
49 Keulrod TH	0,4952	0,5021	0,4858	0,4212	0,4776	0,5165	0,4827	0,5826	0,4923	0,4639	0,5405	0,5028	0,4781	-	0,2296	0,2673	0,3175	0,2798
50 Kl Gleichberg TH	0,5140	0,5347	0,4977	0,4170	0,4901	0,5426	0,4802	0,5997	0,5126	0,5509	0,5170	0,5383	0,5398	0,4146	-	0,2705	0,3395	0,2580
51 Berchtesgade I	0,4161	0,4238	0,3947	0,3642	0,4120	0,4709	0,3188	0,4199	0,4159	0,3890	0,4235	0,4620	0,4488	0,4230	0,4278	-	0,1823	0,2391
52 Berchtesgade II	0,4379	0,4242	0,4089	0,4392	0,4336	0,4973	0,3579	0,4756	0,4673	0,4198	0,4865	0,4690	0,5019	0,4833	0,5094	0,2815	-	0,2642
53 Salzburg	0,4098	0,3863	0,3536	0,4359	0,3884	0,4856	0,4199	0,4907	0,4175	0,4616	0,5164	0,4919	0,4831	0,4759	0,4478	0,3818	0,4137	-

Pww Distance values between world-wide *Pleurozium schreberi* samples. Simple matching distances in the upper right, Jaccard distances in the lower left part.

Jacc\SM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Jägerhof MV	-	0,1316	0,2098	0,2232	0,2188	0,2009	0,2388	0,2366	0,2545	0,2210	0,2500	0,2723	0,2188	0,2366	0,2411	0,2500
2 Neuehütte BB	0,3391	-	0,1540	0,1853	0,1897	0,1540	0,2679	0,2076	0,1808	0,2321	0,2300	0,2433	0,1898	0,2255	0,2746	0,2567
3 Summt BB	0,4796	0,4010	-	0,2009	0,1696	0,1518	0,2299	0,2054	0,2232	0,2567	0,2188	0,1964	0,1786	0,2143	0,2634	0,2545
4 Saarm1-A1-P1	0,4854	0,4462	0,4639	-	0,2098	0,1563	0,2434	0,1920	0,2366	0,2254	0,2321	0,2188	0,1920	0,2277	0,2679	0,2589
5 Köthen BB	0,4900	0,4670	0,4176	0,4747	-	0,1339	0,2835	0,1875	0,2232	0,2657	0,2188	0,2321	0,1875	0,2321	0,2545	0,2545
6 Löbten BB	0,4500	0,3878	0,3736	0,3684	0,3333	-	0,2389	0,1696	0,2054	0,2388	0,2188	0,1875	0,1786	0,2054	0,2098	0,2366
7 Harz N	0,4977	0,5713	0,5000	0,5046	0,5773	0,5001	-	0,2834	0,2835	0,2237	0,2789	0,3013	0,2924	0,2567	0,2389	0,2388
8 Nennsdorf TH	0,5000	0,4792	0,4646	0,4257	0,4286	0,3878	0,5571	-	0,1875	0,2120	0,2188	0,2143	0,2143	0,2500	0,2723	0,2723
9 Geraberg TH	0,5327	0,4356	0,5000	0,5048	0,4950	0,4554	0,5618	0,4158	-	0,2120	0,2009	0,2500	0,2411	0,2768	0,2902	0,2723
10 Inselsberg TH	0,4782	0,5251	0,5531	0,4856	0,5613	0,5095	0,4695	0,4567	0,4612	-	0,2522	0,2656	0,2388	0,2835	0,2389	0,2031
11 Rennsteig TH	0,5490	0,5479	0,5158	0,5200	0,5104	0,5000	0,5787	0,4900	0,4639	0,5487	-	0,2188	0,1920	0,2277	0,2500	0,2768
12 Vesser TH	0,5648	0,5503	0,4583	0,4804	0,5149	0,4286	0,5922	0,4660	0,5283	0,5510	0,5000	-	0,2232	0,2232	0,2545	0,2277
13 Sil1-B4-P13	0,4900	0,4671	0,4348	0,4433	0,4468	0,4211	0,5901	0,4752	0,5243	0,5195	0,4624	0,5000	-	0,1696	0,2634	0,2723
14 Dietzhausen TH	0,5146	0,5258	0,4948	0,5000	0,5200	0,4646	0,5324	0,5283	0,5741	0,5826	0,5204	0,4950	0,4086	-	0,2634	0,2634
15 Keulrod TH	0,5143	0,5970	0,5673	0,5556	0,5481	0,4653	0,4976	0,5545	0,5856	0,5071	0,5490	0,5377	0,5619	0,5566	-	0,2054
16 Kl Gleichberg TH	0,5333	0,5750	0,5588	0,5472	0,5534	0,5146	0,5023	0,5596	0,5648	0,4528	0,5962	0,5000	0,5810	0,5619	0,4600	-
17 Marienberg S	0,4774	0,5416	0,5256	0,4542	0,5495	0,4799	0,4976	0,5425	0,5476	0,4927	0,6203	0,5389	0,5777	0,5857	0,5220	0,4975
18 Bayreuth BY	0,5098	0,5210	0,5052	0,4950	0,4688	0,4105	0,5550	0,5096	0,4700	0,5381	0,4681	0,4592	0,4526	0,4796	0,4800	0,5149
19 Frankenau H	0,5098	0,4561	0,4574	0,4167	0,4362	0,3936	0,5280	0,4653	0,5288	0,5519	0,5306	0,4433	0,4194	0,4479	0,5660	0,5714
20 Mönchberg BW	0,5208	0,4465	0,5000	0,4894	0,5426	0,4333	0,5952	0,4737	0,4947	0,5505	0,5435	0,5158	0,4778	0,5213	0,6214	0,6139
21 Waldenbuch B	0,4653	0,4570	0,5347	0,4951	0,4694	0,4286	0,5921	0,4510	0,5688	0,5509	0,5000	0,5333	0,4694	0,4330	0,5096	0,5701
22 Berchtesgaden I BY	0,4495	0,4857	0,4571	0,4495	0,4078	0,3689	0,4827	0,3925	0,4685	0,4912	0,4519	0,4299	0,4815	0,4909	0,5044	0,5351
23 Salzburg	0,5588	0,5272	0,4946	0,5152	0,5053	0,4632	0,5879	0,4848	0,5051	0,5149	0,4725	0,4792	0,4565	0,5455	0,5728	0,5354
24 Norway	0,5259	0,4952	0,5091	0,5259	0,5812	0,5088	0,6102	0,5738	0,5424	0,5976	0,5575	0,5714	0,5310	0,4865	0,6210	0,6033
25 Sweden I	0,5437	0,4261	0,4947	0,4848	0,4896	0,4316	0,6117	0,4388	0,4747	0,5290	0,4731	0,5673	0,4896	0,5300	0,5714	0,5631
26 Sweden II	0,5536	0,5668	0,5377	0,5405	0,5596	0,4953	0,5685	0,5398	0,5315	0,5002	0,5333	0,5495	0,5596	0,5413	0,5913	0,5455
27 Scotland	0,5872	0,5155	0,4526	0,5049	0,5100	0,4851	0,5887	0,4608	0,4951	0,6478	0,6095	0,5429	0,5100	0,4900	0,5872	0,6429
28 England I	0,5327	0,4844	0,5294	0,5189	0,5660	0,5283	0,5870	0,5185	0,5505	0,5975	0,6330	0,5818	0,5098	0,4902	0,5982	0,6404
29 England II	0,5377	0,5207	0,5051	0,4804	0,5577	0,4752	0,5670	0,4952	0,5688	0,6150	0,6000	0,5192	0,4848	0,4490	0,5780	0,6216
30 Poland	0,4573	0,5361	0,5638	0,5097	0,5440	0,4901	0,4489	0,5643	0,5425	0,4878	0,5594	0,5748	0,5858	0,5936	0,4416	0,4774
31 Slovakia	0,5046	0,5001	0,5283	0,5046	0,4952	0,4860	0,5840	0,4909	0,4954	0,5570	0,4951	0,5273	0,5370	0,5185	0,5948	0,6000
32 Italy	0,4510	0,4740	0,5196	0,5094	0,5429	0,4608	0,5783	0,4811	0,4712	0,5365	0,4043	0,4904	0,4388	0,5096	0,5094	0,5946
33 Spain I	0,5429	0,4784	0,4468	0,4063	0,4421	0,4167	0,5591	0,4554	0,4902	0,5559	0,5354	0,4490	0,4898	0,5149	0,5429	0,5619
34 Spain II	0,5431	0,5142	0,5273	0,5175	0,5225	0,4865	0,6040	0,5546	0,5470	0,5671	0,5495	0,5763	0,5357	0,5565	0,5556	0,6198
35 Russia I	0,7523	0,7099	0,7714	0,7290	0,7642	0,7383	0,8354	0,8017	0,7768	0,8197	0,8468	0,8462	0,7524	0,8018	0,8760	0,8142
36 Russia II	0,4537	0,5603	0,4906	0,4679	0,5536	0,4340	0,4666	0,4404	0,5133	0,4325	0,5140	0,4909	0,5138	0,5225	0,5089	0,4434
37 Russia III	0,6174	0,6018	0,6429	0,5804	0,5872	0,5636	0,6945	0,6154	0,6555	0,6626	0,6396	0,6379	0,6126	0,6316	0,6639	0,6466
38 Russia IV	0,5631	0,4662	0,5313	0,4742	0,4787	0,4362	0,5917	0,5340	0,4949	0,5198	0,5714	0,5865	0,4947	0,4896	0,5769	0,5825
39 Russia V	0,6033	0,5616	0,6034	0,5798	0,5983	0,5000	0,6368	0,5785	0,5593	0,6361	0,5752	0,6000	0,5614	0,5565	0,6480	0,6746
40 Russia VI	0,6293	0,6215	0,6182	0,6174	0,6372	0,6140	0,6787	0,6154	0,5714	0,6790	0,6396	0,6496	0,6250	0,6071	0,7073	0,6695
41 USA Alaska I	0,5505	0,5051	0,5196	0,5505	0,5288	0,5327	0,5595	0,5495	0,5545	0,5566	0,5849	0,5596	0,5429	0,5780	0,6379	0,5688
42 USA Alaska II	0,5528	0,5134	0,5000	0,5042	0,5086	0,4609	0,5551	0,5520	0,5565	0,6193	0,5714	0,5840	0,5462	0,5294	0,6094	0,6250
43 Ecuador	0,5887	0,5594	0,5133	0,5169	0,5714	0,5254	0,6114	0,4655	0,5333	0,5767	0,5726	0,5620	0,5714	0,5424	0,6328	0,6160

Jacc\SM	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1 Jägerhof MV	0,2121	0,2321	0,2321	0,2232	0,2098	0,2188	0,2545	0,2723	0,2500	0,2768	0,2857	0,2545	0,2545	0,2030	0,2455	0,2054	0,2545	0,2813	0,3661
2 Neuehütte BB	0,2321	0,2210	0,1852	0,1674	0,1897	0,2254	0,2165	0,2343	0,1674	0,2656	0,2210	0,2076	0,2255	0,2323	0,2255	0,2032	0,1987	0,2433	0,3058
3 Summt BB	0,2299	0,2188	0,1920	0,2009	0,2411	0,2143	0,2054	0,2500	0,2098	0,2545	0,1920	0,2411	0,2232	0,2566	0,2500	0,2366	0,1875	0,2589	0,3616
4 Saarm1-A1-P1	0,1987	0,2232	0,1786	0,2054	0,2277	0,2188	0,2277	0,2723	0,2143	0,2679	0,2321	0,2455	0,2188	0,2343	0,2455	0,2411	0,1741	0,2634	0,3482
5 Köthen BB	0,2478	0,2009	0,1830	0,2277	0,2054	0,1875	0,2143	0,3036	0,2098	0,2723	0,2277	0,2679	0,2589	0,2478	0,2321	0,2545	0,1875	0,2589	0,3616
6 Löbten BB	0,2121	0,1741	0,1652	0,1741	0,1875	0,1696	0,1964	0,2589	0,1830	0,2366	0,2188	0,2500	0,2143	0,2210	0,2321	0,2098	0,1786	0,2411	0,3527
7 Harz N	0,2327	0,2701	0,2523	0,2790	0,3013	0,2477	0,2835	0,3460	0,3058	0,2970	0,2970	0,3013	0,2835	0,2058	0,3103	0,2968	0,2746	0,3371	0,4531
8 Nennsdorf TH	0,2567	0,2366	0,2098	0,2009	0,2054	0,1875	0,2143	0,3125	0,1920	0,2723	0,2098	0,2500	0,2321	0,2747	0,2411	0,2277	0,2054	0,2946	0,4152
9 Geraberg TH	0,2567	0,2098	0,2455	0,2098	0,2768	0,2321	0,2232	0,2857	0,2098	0,2634	0,2277	0,2679	0,2768	0,2567	0,2411	0,2188	0,2232	0,2857	0,3884
10 Inselsberg TH	0,2237	0,2522	0,2612	0,2434	0,2656	0,2478	0,2299	0,3281	0,2433	0,2433	0,3327	0,3013	0,3103	0,2237	0,2835	0,2611	0,2656	0,3014	0,4264
11 Rennsteig TH	0,2880	0,1964	0,2321	0,2232	0,2188	0,2098	0,1920	0,2813	0,1964	0,2500	0,2857	0,3080	0,2813	0,2523	0,2277	0,1696	0,2366	0,2723	0,4196
12 Vesser TH	0,2477	0,2009	0,1920	0,2188	0,2500	0,2054	0,2054	0,3036	0,2634	0,2723	0,2545	0,2857	0,2411	0,2745	0,2589	0,2277	0,1964	0,3036	0,4420
13 Sil1-B4-P13	0,2656	0,1920	0,1741	0,1920	0,2054	0,2321	0,1875	0,2679	0,2098	0,2723	0,2277	0,2321	0,2143	0,2746	0,2589	0,1920	0,2143	0,2679	0,3527
14 Dietzhausen TH	0,2746	0,2098	0,1920	0,2188	0,1875	0,2411	0,2411	0,2411	0,2366	0,2634	0,2188	0,2232	0,1964	0,2835	0,2500	0,2366	0,2321	0,2857	0,3973
15 Keulrod TH	0,2388	0,2143	0,2679	0,2857	0,2366	0,2545	0,2634	0,3438	0,2679	0,3036	0,2857	0,2991	0,2813	0,1942	0,3080	0,2411	0,2545	0,2902	0,4732
16 Kl Gleichberg TH	0,2210	0,2321	0,2679	0,2768	0,2723	0,2723	0,2366	0,3259	0,2589	0,2679	0,3214	0,3259	0,3080	0,2121	0,3080	0,2946	0,2634	0,3348	0,4107
17 Marienberg S	-	0,2344	0,2076	0,2344	0,2477	0,2388	0,2656	0,2924	0,2344	0,2880	0,2523	0,2657	0,2210	0,2058	0,2924	0,2254	0,2478	0,2924	0,3907
18 Bayreuth BY	0,5250	-	0,2232	0,1875	0,2098	0,1920	0,1920	0,2902	0,2500	0,2589	0,2768	0,2902	0,2545	0,2701	0,2366	0,1875	0,2009	0,2723	0,4107
19 Frankenau H	0,4797	0,5051	-	0,1964	0,2188	0,2098	0,2366	0,2366	0,2232	0,2768	0,2232	0,2098	0,1741	0,2523	0,2455	0,2321	0,1563	0,2455	0,3571
20 Mönchberg BW	0,5525	0,4667	0,4835	-	0,1652	0,2545	0,2188	0,2366	0,1875	0,2321	0,2679	0,2723	0,2455	0,2612	0,2366	0,1964	0,2098	0,2813	0,3036
21 Waldenbuch B	0,5388	0,4747	0,4900	0,4157	-	0,1875	0,2232	0,2321	0,1920	0,2545	0,2723	0,2589	0,2411	0,2745	0,2411	0,2009	0,2411	0,2768	0,3705
22 Berchtesgaden I BY	0,4910	0,4135	0,4434	0,5377	0,4000	-	0,1964	0,2768	0,2366	0,2455	0,2634	0,2679	0,2679	0,2568	0,2589	0,2098	0,2143	0,2857	0,4420
23 Salzburg	0,5889	0,4624	0,5408	0,5385	0,5102	0,4314	-	0,3125	0,2188	0,2545	0,2634	0,3125	0,2946	0,2388	0,2321	0,2098	0,2411	0,2679	0,3973
24 Norway	0,5648	0,5603	0,4818	0,5048	0,4685	0,5041	0,6034	-	0,2455	0,2545	0,2902	0,2857	0,2679	0,2834	0,2679	0,2455	0,2589	0,2321	0,3795
25 Sweden I	0,5302	0,5545	0,5102	0,4719	0,4479	0,4907	0,5158	0,5000	-	0,2054	0,2321	0,2902	0,2723	0,2433	0,2455	0,2232	0,2455	0,2813	0,3393
26 Sweden II	0,5811	0,5370	0,5636	0,5200	0,5229	0,4783	0,5429	0,4872	0,4554	-	0,3125	0,2991	0,3170	0,2612	0,2545	0,2768	0,2723	0,3170	0,4196
27 Scotland	0,5485	0,5849	0,5000	0,6000	0,5701	0,5221	0,5784	0,5556	0,5200	0,6087	-	0,1830	0,1741	0,2969	0,2991	0,2500	0,2009	0,3080	0,3929
28 England I	0,5613	0,5963	0,4700	0,5980	0,5421	0,5217	0,6422	0,5424	0,6019	0,5826	0,4184	-	0,1339	0,3013	0,3036	0,2366	0,1964	0,2946	0,3884
29 England II	0,4950	0,5481	0,4105	0,5612	0,5192	0,5263	0,6226	0,5217	0,5810	0,6121	0,4063	0,3226	-	0,2835	0,2857	0,2455	0,1964	0,2768	0,3884
30 Poland	0,4718	0,5762	0,5485	0,5911	0,5746	0,5134	0,5405	0,5474	0,5395	0,5365	0,6101	0,6081	0,5880	-	0,2477	0,2433	0,2567	0,3013	0,4175
31 Slovakia	0,5848	0,5000	0,5140	0,5248	0,5000	0,4957	0,5049	0,5042	0,5189	0,5044	0,5877	0,5862	0,5664	0,5139	-	0,2545	0,2232	0,2500	0,3795
32 Italy	0,4951	0,4286	0,5049	0,4681	0,4455	0,4312	0,4796	0,4825	0,4950	0,5487	0,5283	0,5000	0,5189	0,5190	0,5135	-	0,2277	0,2277	0,3929
33 Spain I	0,5442	0,4639	0,3804	0,5054	0,5243	0,4486	0,5455	0,5133	0,5446	0,5545	0,4592	0,4444	0,4490	0,5529	0,4762	0,4951	-	0,2232	0,3705
34 Spain II	0,5696	0,5398	0,5000	0,5780	0,5391	0,5203	0,5455	0,4407	0,5575	0,5772	0,5847	0,5593	0,5391	0,5768	0,4828	0,4595	0,4630	-	0,3616
35 Russia I	0,7991	0,8214	0,7547	0,7158	0,7615	0,7984	0,8241	0,7203	0,7379	0,7966	0,7928	0,7768	0,7838	0,8238	0,7456	0,7788	0,7685	0,7043	-
36 Russia II	0,4883	0,5315	0,4766	0,5146	0,5179	0,4071	0,5094	0,5440	0,5093	0,4690	0,5652	0,5391	0,5439	0,4258	0,4870	0,5044	0,5225	0,5484	0,7217
37 Russia III	0,6565	0,6522	0,6161	0,5500	0,5893	0,6349	0,6364	0,5378	0,6339	0,6364	0,6917	0,6667	0,6723	0,6624	0,5439	0,5625	0,6316	0,5299	0,6635
38 Russia IV	0,5205	0,5306	0,5000	0,4598	0,4526	0,5229	0,5521	0,4907	0,4565	0,4752	0,5825	0,5534	0,5588	0,5450	0,5238	0,5149	0,5052	0,5364	0,7327
39 Russia V	0,6516	0,6017	0,5398	0,5377	0,5517	0,5440	0,5965	0,4667	0,5446	0,5417	0,5966	0,6290	0,6341	0,5889	0,5333	0,5130	0,5690	0,5323	0,7155
40 Russia VI	0,6506	0,6283	0,5780	0,6058	0,6018	0,6016	0,6486	0,5128	0,6696	0,6134	0,6695	0,6555	0,6379	0,6681	0,5565	0,5625	0,5556	0,5424	0,7364
41 USA Alaska I	0,4878	0,6250	0,5333	0,5743	0,5856	0,5000	0,5534	0,5214	0,5660	0,5614	0,5688	0,5278	0,5327	0,5399	0,5776	0,4906	0,4951	0,5385	0,7788
42 USA Alaska II	0,5043	0,6080	0,4870	0,5983	0,5492	0,4841	0,6260	0,4803	0,5299	0,5625	0,5085	0,5083	0,4741	0,5734	0,5769	0,4874	0,4649	0,4841	0,7154
43 Ecuador	0,5792	0,5750	0,4867	0,6000	0,5378	0,4715	0,6050	0,5039	0,5304	0,5403	0,5583	0,5691	0,5738	0,6523	0,5556	0,5372	0,5043	0,5197	0,7500

Jacc\SM	36	37	38	39	40	41	42	43
1 Jägerhof MV	0,2188	0,3170	0,2589	0,3259	0,3259	0,2679	0,3036	0,3259
2 Neuehütte BB	0,2701	0,2835	0,1853	0,2746	0,2969	0,2209	0,2567	0,2834
3 Summt BB	0,2321	0,3214	0,2277	0,3125	0,3036	0,2366	0,2545	0,2589
4 Saarm1-A1-P1	0,2277	0,2902	0,2054	0,3080	0,3170	0,2679	0,2679	0,2723
5 Köthen BB	0,2768	0,2857	0,2009	0,3125	0,3214	0,2455	0,2634	0,3036
6 Löbten BB	0,2054	0,2768	0,1830	0,2500	0,3125	0,2545	0,2366	0,2768
7 Harz N	0,2343	0,3906	0,2878	0,3638	0,3773	0,2834	0,3148	0,3549
8 Nennsdorf TH	0,2143	0,3214	0,2455	0,3125	0,3214	0,2723	0,3080	0,2411
9 Geraberg TH	0,2589	0,3482	0,2188	0,2946	0,2857	0,2723	0,3080	0,2857
10 Inselsberg TH	0,2076	0,3549	0,2343	0,3548	0,3684	0,2746	0,3594	0,3192
11 Rennsteig TH	0,2455	0,3170	0,2500	0,2902	0,3170	0,2768	0,3036	0,2991
12 Vesser TH	0,2411	0,3304	0,2723	0,3214	0,3393	0,2723	0,3259	0,3036
13 Sil1-B4-P13	0,2500	0,3036	0,2098	0,2857	0,3125	0,2545	0,2902	0,3036
14 Dietzhausen TH	0,2589	0,3214	0,2098	0,2857	0,3036	0,2813	0,2813	0,2857
15 Keulrod TH	0,2545	0,3527	0,2679	0,3616	0,3884	0,3304	0,3482	0,3616
16 Kl Gleichberg TH	0,2098	0,3348	0,2679	0,3795	0,3527	0,2768	0,3571	0,3438
17 Marienberg S	0,2344	0,3371	0,2255	0,3550	0,3325	0,2209	0,2612	0,3102
18 Bayreuth BY	0,2634	0,3348	0,2321	0,3170	0,3170	0,3125	0,3393	0,3080
19 Frankenau H	0,2277	0,3080	0,2143	0,2723	0,2813	0,2500	0,2500	0,2455
20 Mönchberg BW	0,2366	0,2455	0,1786	0,2545	0,2813	0,2589	0,3125	0,3080
21 Waldenbuch B	0,2589	0,2946	0,1920	0,2857	0,3036	0,2902	0,2991	0,2857
22 Berchtesgaden I BY	0,2054	0,3571	0,2545	0,3036	0,3304	0,2545	0,2723	0,2589
23 Salzburg	0,2411	0,3125	0,2366	0,3036	0,3214	0,2545	0,3438	0,3214
24 Norway	0,3036	0,2857	0,2366	0,2500	0,2679	0,2723	0,2723	0,2857
25 Sweden I	0,2455	0,3170	0,1875	0,2723	0,3438	0,2679	0,2768	0,2723
26 Sweden II	0,2366	0,3438	0,2143	0,2902	0,3259	0,2857	0,3214	0,2991
27 Scotland	0,2902	0,3705	0,2679	0,3170	0,3527	0,2768	0,2679	0,2991
28 England I	0,2768	0,3571	0,2545	0,3482	0,3482	0,2545	0,2723	0,3125
29 England II	0,2768	0,3571	0,2545	0,3482	0,3304	0,2545	0,2455	0,3125
30 Poland	0,1987	0,3461	0,2432	0,3102	0,3505	0,2567	0,3147	0,3728
31 Slovakia	0,2500	0,2768	0,2455	0,2857	0,2857	0,2991	0,3348	0,3125
32 Italy	0,2545	0,2813	0,2321	0,2634	0,2813	0,2321	0,2589	0,2902
33 Spain I	0,2589	0,3214	0,2188	0,2946	0,2679	0,2277	0,2366	0,2589
34 Spain II	0,3036	0,2768	0,2634	0,2946	0,2857	0,2813	0,2723	0,2946
35 Russia I	0,3705	0,3080	0,3304	0,3705	0,3616	0,3929	0,3929	0,4152
36 Russia II	-	0,3304	0,2723	0,2857	0,3482	0,2902	0,2902	0,2411
37 Russia III	0,6066	-	0,2902	0,3125	0,3036	0,3080	0,3438	0,3393
38 Russia IV	0,5545	0,6019	-	0,2277	0,2813	0,2321	0,2411	0,2991
39 Russia V	0,5246	0,5785	0,4811	-	0,2946	0,2902	0,2902	0,2946
40 Russia VI	0,6290	0,5913	0,5888	0,5546	-	0,2813	0,3170	0,3214
41 USA Alaska I	0,5556	0,6000	0,5149	0,5508	0,5625	-	0,2054	0,3080
42 USA Alaska II	0,5118	0,5969	0,4821	0,5078	0,5635	0,4071	-	0,2723
43 Ecuador	0,4500	0,5984	0,5726	0,5197	0,5760	0,5610	0,4729	-

Plot Saarm1
Plot Sil1
Plot Sil2

A5.3 *Rhytidiadelphus squarrosus*

Rger Distance values between German *Rhytidiadelphus squarrosus* samples. Simple matching distances in the upper right, Jaccard distances in the lower left part.

Jacc\SM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
1 Sil1-B2	-	0,3000	0,2000	0,1471	0,2059	0,1765	0,1647	0,1471	0,1882	0,1529	0,1706	0,1647	0,2296	0,2647	0,1941	0,2059	0,1647	0,1471	0,1529	0,1471	0,1176	0,1059	0,1529	0,1647	0,1353	0,1706	0,2647	0,1882	0,3000	0,1471	0,1706	0,2118	0,1941	0,1824	0,1706	0,1824	0,2059	0,2294	0,2176	0,1941	0,2824	0,2059	0,2176	0,2118	0,1882
2 Sil1-A5	0,6145	-	0,2765	0,3647	0,3529	0,3471	0,3588	0,3529	0,3588	0,3353	0,3412	0,3824	0,3117	0,3647	0,3294	0,3647	0,3353	0,3412	0,3471	0,3176	0,3471	0,3353	0,3588	0,3235	0,3059	0,3294	0,3765	0,3941	0,3765	0,2824	0,3529	0,3941	0,3529	0,3176	0,3294	0,3529	0,3294	0,3529	0,3412	0,3765	0,2882	0,3412	0,3176	0,3471	0,3000
3 Sil3-A1-R1	0,3953	0,6267	-	0,2765	0,2765	0,2706	0,2588	0,2529	0,2706	0,2588	0,2647	0,2706	0,2825	0,2765	0,2647	0,2412	0,2353	0,2412	0,2588	0,2412	0,2353	0,2118	0,2706	0,2824	0,2647	0,2529	0,3588	0,2824	0,3706	0,2529	0,2647	0,2941	0,2765	0,2765	0,2647	0,2765	0,3118	0,2882	0,2882	0,2882	0,2824	0,2647	0,2765	0,2941	0,2471
4 Sil3-A1-R6	0,2747	0,6739	0,4896	-	0,1176	0,0882	0,1000	0,1059	0,2059	0,1471	0,1176	0,1941	0,2707	0,2588	0,2000	0,2000	0,1471	0,1529	0,1588	0,1412	0,1353	0,1353	0,1824	0,1824	0,1882	0,1882	0,2706	0,2412	0,3882	0,1765	0,2824	0,2882	0,2706	0,2235	0,2118	0,2353	0,2353	0,2353	0,2353	0,2588	0,2882	0,2353	0,2588	0,2412	0,2294
5 Sil3-A1-R7	0,3723	0,6742	0,5000	0,2222	-	0,0765	0,1000	0,1176	0,2294	0,1118	0,1059	0,2176	0,2412	0,2588	0,2000	0,1765	0,1471	0,1412	0,1588	0,1412	0,1588	0,1706	0,1706	0,1588	0,1765	0,1412	0,2588	0,2412	0,3765	0,1412	0,2588	0,3000	0,2471	0,2118	0,2000	0,2706	0,2353	0,2471	0,2000	0,2588	0,3118	0,1765	0,1882	0,1941	0,2059
6 Sil3-A1-R10	0,3226	0,6556	0,4842	0,1685	0,1512	-	0,0588	0,0765	0,2118	0,1059	0,1000	0,1882	0,2178	0,2294	0,1706	0,1588	0,1412	0,1353	0,1529	0,1118	0,1176	0,1176	0,1529	0,1529	0,1588	0,1353	0,2529	0,2000	0,3824	0,1588	0,2412	0,2588	0,2294	0,1941	0,1824	0,2412	0,2176	0,2412	0,1941	0,2647	0,2706	0,2176	0,2059	0,2118	0,2118
7 Sil3-A1-R11	0,3011	0,6630	0,4632	0,1868	0,1910	0,1149	-	0,0412	0,2000	0,0706	0,0765	0,1765	0,2173	0,2059	0,1706	0,1706	0,0941	0,1000	0,1059	0,0765	0,1059	0,1059	0,1059	0,1176	0,1471	0,1353	0,2529	0,2000	0,3706	0,1471	0,2294	0,2471	0,2294	0,1824	0,1588	0,2294	0,2294	0,2412	0,1706	0,2529	0,2706	0,2059	0,2059	0,2118	0,2118
8 Sil3-A1-R12	0,2747	0,6593	0,4574	0,1978	0,2222	0,1477	0,0814	-	0,1824	0,0882	0,1059	0,1588	0,2238	0,2118	0,1647	0,1529	0,1000	0,0941	0,1235	0,0941	0,1000	0,1000	0,1235	0,1118	0,1412	0,1529	0,2706	0,1824	0,3529	0,1412	0,2235	0,2412	0,2471	0,1882	0,1765	0,2118	0,2118	0,2353	0,1882	0,2235	0,2882	0,2000	0,2000	0,2176	0,2176
9 Sil3-A2-R15	0,3368	0,6630	0,4792	0,3500	0,3900	0,3600	0,3400	0,3163	-	0,1882	0,1941	0,2118	0,2472	0,2765	0,2176	0,2294	0,2000	0,2176	0,2000	0,2059	0,2000	0,1647	0,2000	0,2118	0,2529	0,2529	0,3706	0,2353	0,3471	0,2176	0,2765	0,2706	0,2529	0,2647	0,2647	0,2647	0,2882	0,2882	0,2529	0,2294	0,3176	0,2412	0,2882	0,2824	0,2706
10 Sil3-A2-R16	0,2857	0,6404	0,4681	0,2660	0,2135	0,2000	0,1364	0,1685	0,3265	-	0,0647	0,2000	0,2056	0,2059	0,1588	0,1941	0,1059	0,0882	0,0941	0,1000	0,1176	0,1176	0,0824	0,1059	0,1471	0,1235	0,2647	0,2118	0,3353	0,1353	0,2176	0,2588	0,2176	0,1941	0,1706	0,2294	0,2176	0,2529	0,1941	0,2647	0,2941	0,1824	0,2059	0,2235	0,2118
11 Sil3-A3-R22	0,3222	0,6667	0,4891	0,2247	0,2093	0,1954	0,1512	0,2045	0,3438	0,1310	-	0,1941	0,2000	0,2235	0,1647	0,1647	0,1000	0,1176	0,1000	0,0941	0,1353	0,1235	0,1235	0,1235	0,1529	0,1176	0,2471	0,2059	0,3412	0,1176	0,2235	0,2412	0,2000	0,1765	0,1765	0,2235	0,2118	0,2118	0,1647	0,2706	0,2647	0,1647	0,1882	0,1941	0,2059
12 Sil3-A4-R23	0,2979	0,6842	0,4742	0,3300	0,3700	0,3232	0,3030	0,2784	0,3529	0,3400	0,3402	-	0,2706	0,2529	0,2412	0,2176	0,2235	0,2059	0,2235	0,2059	0,2000	0,1529	0,2000	0,2118	0,2294	0,2294	0,3235	0,2353	0,3588	0,2294	0,2647	0,2706	0,2412	0,2529	0,2647	0,2529	0,2647	0,3000	0,2765	0,2529	0,2941	0,2529	0,2765	0,2588	0,2706
13 Sil3-A4-R24	0,4326	0,6669	0,5418	0,4745	0,4429	0,4020	0,3979	0,4084	0,4400	0,3849	0,3868	0,4670	-	0,3236	0,2176	0,2529	0,2178	0,2237	0,2180	0,2003	0,2177	0,2176	0,2414	0,2470	0,2293	0,2353	0,3115	0,2704	0,3942	0,2235	0,2591	0,3170	0,2651	0,2589	0,2709	0,3060	0,2584	0,2940	0,2530	0,3177	0,2650	0,2470	0,2355	0,2467	0,2412
14 Sil3-A5-R29	0,4327	0,6526	0,4747	0,4112	0,4190	0,3750	0,3398	0,3495	0,4312	0,3431	0,3762	0,3981	0,5260	-	0,2706	0,2706	0,2059	0,2471	0,2176	0,2000	0,2294	0,2294	0,2412	0,2412	0,2824	0,2588	0,3882	0,3000	0,4118	0,2588	0,3059	0,3235	0,2824	0,3059	0,2824	0,3059	0,3176	0,3529	0,2941	0,3412	0,3471	0,3059	0,3176	0,3353	0,3353
15 Sil3-B1-R37	0,3626	0,6588	0,4945	0,3579	0,3656	0,3152	0,3118	0,3043	0,3814	0,2967	0,3146	0,4100	0,4188	0,4423	-	0,2000	0,1588	0,1765	0,1706	0,1765	0,1471	0,1588	0,2294	0,2294	0,2235	0,2235	0,3059	0,2176	0,3529	0,2000	0,2824	0,3235	0,2706	0,2706	0,2706	0,2824	0,2706	0,2588	0,2471	0,2824	0,3471	0,2588	0,2706	0,2882	0,2647
16 Sil3-B1-R38	0,3723	0,6889	0,4505	0,3505	0,3226	0,2903	0,3053	0,2796	0,3900	0,3438	0,3077	0,3700	0,4593	0,4340	0,3656	-	0,1471	0,1882	0,2059	0,1765	0,1706	0,1588	0,2294	0,2059	0,2000	0,2118	0,3294	0,2529	0,3529	0,1882	0,2588	0,3000	0,2471	0,2824	0,2706	0,2941	0,2588	0,2824	0,2353	0,3059	0,3118	0,2588	0,2706	0,2647	0,2765
17 Sil3-B2-R40	0,3111	0,6552	0,4444	0,2717	0,2778	0,2637	0,1818	0,1932	0,3505	0,2045	0,2000	0,3800	0,4109	0,3500	0,3034	0,2778	-	0,0765	0,0588	0,0529	0,1176	0,1176	0,1412	0,1412	0,1588	0,1706	0,3000	0,2235	0,3824	0,1353	0,2176	0,2588	0,2176	0,1941	0,1824	0,2176	0,2294	0,2176	0,1706	0,2647	0,3059	0,2059	0,2176	0,2235	0,2000
18 Sil3-B3-R50	0,2841	0,6667	0,4556	0,2826	0,2697	0,2556	0,1932	0,1839	0,3776	0,1744	0,2326	0,3571	0,4218	0,4078	0,3333	0,3441	0,1566	-	0,0647	0,0824	0,1000	0,1000	0,1118	0,1235	0,1529	0,1647	0,2706	0,1941	0,3529	0,1294	0,2000	0,2176	0,2118	0,1647	0,1529	0,1765	0,1765	0,2118	0,1882	0,2000	0,3000	0,1882	0,1765	0,2059	0,1941
19 Sil3-B4-R56	0,2857	0,6556	0,4681	0,2842	0,2903	0,2766	0,1978	0,2283	0,3434	0,1798	0,1954	0,3725	0,4027	0,3592	0,3152	0,3608	0,1190	0,1310	-	0,0647	0,1059	0,1059	0,0941	0,1294	0,1588	0,1471	0,3000	0,2000	0,3706	0,1353	0,2059	0,2235	0,2176	0,1706	0,1588	0,1941	0,2059	0,2176	0,1824	0,2412	0,2941	0,1824	0,1941	0,2235	0,1882
20 Sil3-B5-R66	0,2809	0,6279	0,4505	0,2609	0,2667	0,2135	0,1494	0,1818	0,3571	0,1932	0,1882	0,3535	0,3827	0,3400	0,3297	0,3226	0,1098	0,1667	0,1294	-	0,0765	0,0882	0,1235	0,1353	0,1529	0,1412	0,2824	0,1941	0,3765	0,1294	0,2000	0,2529	0,2118	0,1765	0,1765	0,2235	0,2235	0,2353	0,1765	0,2588	0,2765	0,2000	0,1765	0,2176	0,1941
21 Sil3-C1-R70	0,2247	0,6484	0,4301	0,2447	0,2872	0,2174	0,1957	0,1868	0,3400	0,2174	0,2527	0,3366	0,3974	0,3714	0,2747	0,3053	0,2222	0,1932	0,1978	0,1494	-	0,0706	0,1412	0,1765	0,1706	0,1706	0,3118	0,1647	0,3588	0,1706	0,2294	0,2471	0,2412	0,2176	0,2176	0,2294	0,2059	0,2294	0,2176	0,2294	0,3176	0,2059	0,2059	0,2353	0,2118
22 Sil3-C2-R77	0,2045	0,6333	0,3956	0,2447	0,3053	0,2174	0,1957	0,1868	0,2887	0,2174	0,2333	0,2680	0,3987	0,3714	0,2935	0,2872	0,2222	0,1932	0,1978	0,1705	0,1348	-	0,1294	0,1529	0,1588	0,1471	0,2882	0,1412	0,3353	0,1471	0,2059	0,2235	0,2176	0,2059	0,2059	0,2059	0,2059	0,2176	0,1824	0,2176	0,2824	0,2059	0,2059	0,2235	0,2000
23 Sil3-C3-R86	0,2796	0,6559	0,4742	0,3131	0,3021	0,2708	0,1935	0,2234	0,3366	0,1556	0,2308	0,3333	0,4271	0,3832	0,3939	0,3861	0,2581	0,2111	0,1758	0,2283	0,2500	0,2316	-	0,0471	0,1235	0,1235	0,2765	0,1765	0,3353	0,1235	0,2059	0,2353	0,2294	0,1706	0,1235	0,1941	0,1941	0,2529	0,1941	0,2059	0,3059	0,1471	0,1941	0,1882	0,1765
24 Sil3-C4-R94	0,3111	0,6395	0,5106	0,3263	0,2967	0,2826	0,2222	0,2135	0,3673	0,2045	0,2414	0,3636	0,4540	0,3981	0,4105	0,3684	0,2697	0,2414	0,2444	0,2584	0,3158	0,2796	0,0941	-	0,1000	0,1235	0,2529	0,1765	0,3000	0,0765	0,1941	0,2235	0,2294	0,1588	0,1118	0,1706	0,1588	0,2059	0,1706	0,1824	0,2941	0,1353	0,1706	0,1765	0,1765
25 Sil3-C5-R107	0,2738	0,6420	0,5056	0,3478	0,3371	0,3034	0,2809	0,2727	0,4388	0,2841	0,3023	0,4021	0,4455	0,4660	0,4176	0,3736	0,3103	0,3023	0,3034	0,2989	0,3187	0,3000	0,2386	0,2073	-	0,0941	0,2235	0,1706	0,2941	0,1059	0,1529	0,2059	0,1647	0,1176	0,1059	0,2000	0,1647	0,1882	0,1647	0,1765	0,2529	0,1412	0,1529	0,1471	0,1471
26 Sil-R114	0,3187	0,6437	0,4674	0,3333	0,2667	0,2527	0,2500	0,2796	0,4216	0,2333	0,2299	0,3861	0,4346	0,4190	0,4000	0,3750	0,3152	0,3077	0,2717	0,2667	0,3053	0,2688	0,2283	0,2386	0,1951	-	0,2000	0,1471	0,3176	0,1176	0,1882	0,2412	0,2000	0,1647	0,1529	0,2353	0,2118	0,2000	0,1529	0,2235	0,2647	0,1529	0,1647	0,1824	0,1824
27 Sil-R113	0,4592	0,7111	0,6100	0,4510	0,4444	0,4300	0,4257	0,4510	0,5676	0,4455	0,4330	0,5093	0,5431	0,5739	0,5149	0,5333	0,5000	0,4646	0,4904	0,4752	0,5000	0,4712	0,4519	0,4388	0,4130	0,3617	-	0,2294	0,3059	0,2235	0,2706	0,3235	0,2706	0,2588	0,2706	0,2941	0,2824	0,2824	0,2588	0,3059	0,3706	0,2706	0,2471	0,2412	0,2647
28 Sil-R115	0,3368	0,7053	0,4948	0,3981	0,4059	0,3434	0,3400	0,3163	0,3883	0,3600	0,3608	0,3846	0,4720	0,4595	0,3814	0,4216	0,3838	0,3438	0,3434	0,3402	0,2887	0,2526	0,3030	0,3158	0,3187	0,2688	0,3939	-	0,2529	0,1588	0,2176	0,2000	0,2412	0,1941	0,2059	0,1824	0,2059	0,1824	0,1471	0,1706	0,3294	0,1824	0,1824	0,1882	0,1882
29 Sil-R116	0,4951	0,6957	0,6117	0,5789	0,5766	0,5752	0,5575	0,5405	0,5315	0,5229	0,5421	0,5398	0,6288	0,5882	0,5607	0,5505	0,5856	0,5556	0,5625	0,5766	0,5446	0,5182	0,5135	0,4904	0,5000	0,5094	0,5000	0,4175	-	0,3059	0,3059	0,2765	0,3176	0,3059	0,3176	0,2824	0,3176	0,3294	0,3059	0,2941	0,3824	0,3412	0,3294	0,3353	0,3471
30 Dietzhausen TH	0,3049	0,6316	0,5059	0,3409	0,2892	0,3140	0,2907	0,2824	0,4022	0,2738	0,2500	0,4149	0,4521	0,4490	0,3953	0,3678	0,2805	0,2716	0,2738	0,2683	0,3295	0,2907	0,2471	0,1688	0,2368	0,2469	0,4270	0,3103	0,5306	-	0,1529	0,2412	0,2000	0,1529	0,1294	0,2000	0,1765	0,1882	0,1412	0,2000	0,2529	0,1294	0,1412	0,1471	0,1471
31 B1-A1-R1	0,3152	0,6667	0,4787	0,4571	0,4356	0,4059	0,3861	0,3800	0,4476	0,3737	0,3918	0,4286	0,4626	0,4727	0,4752	0,4356	0,3814	0,3579	0,3571	0,3542	0,3861	0,3535	0,3500	0,3474	0,2955	0,3368	0,4554	0,3700	0,4906	0,3059	-	0,1588	0,1059	0,1294	0,1412	0,1765	0,2235	0,2471	0,2000	0,2118	0,2882	0,2118	0,1765	0,1941	0,1824
32 B1-A1-R3	0,3673	0,6979	0,5051	0,4537	0,4766	0,4190	0,4000	0,3942	0,4299	0,4190	0,4059	0,4259	0,5270	0,4825	0,5140	0,4766	0,4272	0,3737	0,3725	0,4175	0,4000	0,3689	0,3810	0,3800	0,3684	0,4020	0,5093	0,3366	0,4434	0,4316	0,2813	-	0,1471	0,1235	0,1471	0,1000	0,1706	0,1706	0,1353	0,1588	0,2941	0,2294	0,2059	0,2353	0,2235
33 B1-A1-R5	0,3587	0,6818	0,5054	0,4510	0,4286	0,3980	0,3939	0,4200	0,4257	0,3814	0,3656	0,4059	0,4812	0,4528	0,4694	0,4286	0,3895	0,3830	0,3814	0,3789	0,4100	0,3776	0,3900	0,4063	0,3218	0,3617	0,4646	0,4100	0,5143	0,3908	0,2069	0,2688	-	0,1059	0,1412	0,1882	0,2235	0,2471	0,1882	0,2118	0,2529	0,2000	0,1529	0,1706	0,1941
34 B1-A2-R7	0,3523	0,6585	0,5222	0,4000	0,3913	0,3587	0,3370	0,3478	0,4545	0,3587	0,3409	0,4343	0,4886	0,4952	0,4842	0,4898	0,3667	0,3218	0,3222	0,3371	0,3895	0,3723	0,3152	0,3103	0,2500	0,3182	0,4632	0,3548	0,5149	0,3250	0,2558	0,2386	0,2195	-	0,0588	0,1059	0,1529	0,1647	0,1294	0,1529	0,2294	0,1647	0,1059	0,1471	0,1471
35 B1-A2-R8	0,3258	0,6588	0,4945	0,3750	0,3656	0,3333	0,2935	0,3226	0,4455	0,3152	0,3333	0,4412	0,4942	0,4571	0,4742	0,4646	0,3407	0,2955	0,2967	0,3297	0,3814	0,3646	0,2333	0,2235	0,2222	0,2921	0,4694	0,3646	0,5192	0,2750	0,2697	0,2717	0,2759	0,1299	-	0,1294	0,1765	0,2118	0,1647	0,1647	0,2412	0,1529	0,1412	0,1353	0,1353
36 B1-A2-R10	0,3333	0,6667	0,4947	0,3960	0,4510	0,4059	0,3861	0,3636	0,4327	0,3900	0,3918	0,4135	0,5257	0,4727	0,4752	0,4808	0,3814	0,3226	0,3402	0,3878	0,3861	0,3535	0,3333	0,3118	0,3696	0,4040	0,4854	0,3196	0,4615	0,3820	0,3158	0,1868	0,3404	0,2143	0,2500	-	0,1059	0,1529	0,1529	0,1529	0,3000	0,2000	0,1765	0,2059	0,1824
37 B1-A3-R12	0,3804	0,6588	0,5579	0,4082	0,4167	0,3854	0,3980	0,3750	0,4757	0,3854	0,3871	0,4412	0,4782	0,5000	0,4742	0,4490	0,4105	0,3333	0,3684	0,4000	0,3646	0,3646	0,3438	0,3034	0,3256	0,3830	0,4848	0,3646	0,5192	0,3571	0,3958	0,3085	0,4043	0,3059	0,3371	0,2093	-	0,1294	0,1412	0,1647	0,3000	0,1647	0,1529	0,1941	0,1824
38 B1-A3-R13	0,4194	0,6977	0,5326	0,4124	0,4375	0,4227	0,4184	0,4124	0,4804	0,4388	0,3913	0,4904	0,5318	0,5455	0,4632	0,4848	0,3978	0,3913	0,3895	0,4211	0,4021	0,3854	0,4300	0,3804	0,3678	0,3696	0,4898	0,3333	0,5385	0,3810	0,4330	0,3118	0,4421	0,3294	0,3956	0,2921	0,2619	-	0,0941	0,1882	0,3118	0,1882	0,1882	0,2294	0,2176
39 B1-A3-R16	0,4022	0,6824	0,5326	0,4124	0,3696	0,3548	0,3152	0,3441	0,4343	0,3548	0,3182	0,4608	0,4753	0,4762	0,4468	0,4211	0,3258	0,3556	0,3370	0,3333	0,3854	0,3333	0,3474	0,3258	0,3294	0,2955	0,4583	0,2778	0,5098	0,3000	0,3656	0,2556	0,3556	0,2683	0,3218	0,2921	0,2824	0,2000	-	0,1882	0,2647	0,1647	0,1412	0,1706	0,1706
40 B1-R20	0,3511	0,6957	0,5104	0,4272	0,4356	0,4369	0,4175	0,3800	0,3861	0,4369	0,4554	0,4135	0,5401	0,5133	0,4752	0,4952	0,4455	0,3579	0,4059	0,4356	0,3861	0,3700	0,3500	0,3298	0,3333	0,3878	0,5000	0,3021	0,4762	0,3820	0,3673	0,2813	0,3750	0,2955	0,3077	0,2796	0,3077	0,3478	0,3478	-	0,3000	0,1529	0,1882	0,1824	0,1824
41 B1-R23	0,5393	0,6806	0,5783	0,5269	0,5699	0,5055	0,5000	0,5269	0,5625	0,5376	0,5114	0,5263	0,5422	0,5842	0,6277	0,5699	0,5652	0,5604	0,5376	0,5222	0,5625	0,5161	0,5417	0,5495	0,5119	0,5056	0,6495	0,5773	0,6500	0,5309	0,5326	0,5263	0,4943	0,4756	0,4824	0,5484	0,5667	0,5889	0,5233	0,5484	-	0,2647	0,2647	0,2706	0,2471
42 B1-R24	0,3846	0,6824	0,5000	0,4124	0,3333	0,3895	0,3684	0,3617	0,4184	0,3370	0,3182	0,4300	0,4663	0,4906	0,4632	0,4536	0,3804	0,3556	0,3370	0,3696	0,3684	0,3684	0,2747	0,2674	0,2892	0,2955	0,4742	0,3333	0,5524	0,2785	0,3830	0,3980	0,3736	0,3294	0,3023	0,3656	0,3218	0,3636	0,3256	0,2921	0,5233	-	0,0824	0,0882	0,0882
43 Pankow Schloßpark	0,4157	0,6750	0,5341	0,4583	0,3636	0,3846	0,3804	0,3736	0,4949	0,3846	0,3678	0,4747	0,4653	0,5192	0,4946	0,4842	0,4111	0,3488	0,3667	0,3448	0,3804	0,3804	0,3587	0,3372	0,3210	0,3256	0,4565	0,3444	0,5545	0,3117	0,3409	0,3763	0,3095	0,2338	0,2927	0,3409	0,3133	0,3765	0,2963	0,3596	0,5422	0,1842	-	0,0882	0,1118
44 Pankow Heimsuchung	0,4045	0,7108	0,5556	0,4316	0,3708	0,3913	0,3871	0,3978	0,4848	0,4086	0,3750	0,4490	0,4795	0,5377	0,5158	0,4737	0,4176	0,3933	0,4086	0,4066	0,4211	0,4043	0,3478	0,3448	0,3086	0,3523	0,4457	0,3516	0,5588	0,3205	0,3667	0,4167	0,3372	0,3086	0,2805	0,3846	0,3793	0,4382	0,3452	0,3483	0,5476	0,1948	0,2027	-	0,0471
45 Pankow Bürgerpark	0,3678	0,6456	0,4884	0,4149	0,3889	0,3913	0,3871	0,3978	0,4694	0,3913	0,3933	0,4646	0,4711	0,5377	0,4839	0,4896	0,3820	0,3750	0,3556	0,3708	0,3871	0,3696	0,3297	0,3448	0,3086	0,3523	0,4787	0,3516	0,5728	0,3205	0,3483	0,4000	0,3750	0,3086	0,2805	0,3483	0,3605	0,4205	0,3452	0,3483	0,5122	0,1948	0,2500	0,1127	-

Rww Distance values between world wide *Rhytidiadelphus squarrosus* (1-36) and *R. subpinnatus* (37-40) samples. Simple matching distances in the upper right, Jaccard distances in the lower left part.

Jacc\SM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
1 Jägerhof MV	-	0,0654	0,1121	0,1168	0,1075	0,1121	0,1028	0,1121	0,1075	0,0981	0,1028	0,1028	0,1589	0,1636	0,1215	0,1215	0,0981	0,1168	0,2991	0,2383	0,2056	0,2991	0,1963	0,2056	0,2026	0,2402	0,1495	0,1262	0,1402	0,2570	0,2850	0,2243	0,2430	0,1729	0,1636	0,2523	0,3411	0,3505	0,3505	0,3692
2 Bohndorf NI	0,1489	-	0,0748	0,0888	0,0794	0,1121	0,0561	0,0748	0,0607	0,0607	0,0561	0,0748	0,1402	0,1542	0,0841	0,0748	0,0701	0,0701	0,2617	0,2290	0,1776	0,2897	0,1589	0,1963	0,1560	0,1893	0,1028	0,0794	0,1028	0,2196	0,2664	0,1869	0,2336	0,1542	0,1449	0,2336	0,3224	0,3224	0,3037	0,3505
3 Haselünne NI	0,2353	0,1667	-	0,0981	0,1168	0,1402	0,0935	0,1121	0,0888	0,1168	0,1028	0,0935	0,1495	0,1729	0,1308	0,1028	0,0888	0,1075	0,2804	0,2383	0,2243	0,3084	0,1963	0,2336	0,1695	0,2147	0,1308	0,1168	0,1402	0,2757	0,2850	0,2056	0,2617	0,1636	0,1636	0,2617	0,3598	0,3318	0,3131	0,3505
4 Harz NI	0,2451	0,1959	0,2079	-	0,1028	0,1355	0,0794	0,1075	0,1028	0,1028	0,0888	0,1168	0,1355	0,1776	0,1355	0,1075	0,1121	0,1121	0,2757	0,2336	0,2290	0,3131	0,2103	0,2477	0,2078	0,2088	0,1075	0,1028	0,1355	0,2523	0,2897	0,1729	0,2664	0,1682	0,1589	0,2477	0,3458	0,3364	0,3084	0,3551
5 Lindow BB	0,2277	0,1771	0,2427	0,2178	-	0,1168	0,0981	0,0794	0,1028	0,0935	0,1168	0,1262	0,1542	0,1776	0,1262	0,1355	0,1215	0,1308	0,2757	0,2617	0,2103	0,3131	0,2103	0,2383	0,1804	0,2256	0,1262	0,1215	0,1262	0,2617	0,2710	0,1916	0,2383	0,1589	0,1776	0,2570	0,3271	0,3178	0,3084	0,3271
6 B1-A3-R12	0,2330	0,2376	0,2804	0,2736	0,2404	-	0,1215	0,1121	0,1355	0,1262	0,1402	0,1308	0,1589	0,1636	0,1682	0,1495	0,1168	0,1542	0,2897	0,2570	0,1869	0,2897	0,2523	0,2056	0,1839	0,2456	0,1869	0,1636	0,1495	0,2850	0,2850	0,2056	0,2617	0,1636	0,1916	0,2897	0,3411	0,3318	0,3224	0,3692
7 Pankow Heimsuchung BE	0,2200	0,1290	0,2000	0,1735	0,2100	0,2500	-	0,0935	0,0701	0,0888	0,0654	0,1028	0,1215	0,1636	0,1121	0,0935	0,0794	0,0794	0,2523	0,2196	0,1869	0,2430	0,1589	0,1869	0,1764	0,2067	0,1308	0,1075	0,1308	0,2290	0,2757	0,1776	0,2430	0,1636	0,1542	0,2523	0,3318	0,3318	0,3224	0,3598
8 Lindena BB	0,2330	0,1649	0,2308	0,2233	0,1700	0,2286	0,1980	-	0,0701	0,0794	0,1121	0,1308	0,1495	0,1449	0,1121	0,1215	0,1262	0,1168	0,2710	0,2477	0,1869	0,3178	0,1869	0,2336	0,1854	0,2208	0,1308	0,1075	0,1308	0,2477	0,2850	0,1963	0,2523	0,1729	0,1449	0,2804	0,3318	0,3037	0,2944	0,3505
9 Bleicherode TH	0,2277	0,1383	0,1900	0,2178	0,2178	0,2736	0,1546	0,1515	-	0,0561	0,0794	0,0981	0,1355	0,1589	0,1075	0,0888	0,0841	0,0841	0,2664	0,2430	0,1822	0,2850	0,1729	0,2009	0,1785	0,2197	0,1168	0,0935	0,1262	0,2336	0,2897	0,1822	0,2383	0,1682	0,1402	0,2664	0,3084	0,2897	0,2617	0,3178
10 Treffurt TH	0,2100	0,1383	0,2427	0,2178	0,2000	0,2571	0,1919	0,1700	0,1250	-	0,0701	0,0888	0,1355	0,1495	0,1168	0,1168	0,1028	0,1121	0,2944	0,2710	0,1916	0,3037	0,2009	0,2196	0,1709	0,2208	0,0981	0,0935	0,1168	0,2430	0,3178	0,2009	0,2383	0,1589	0,1402	0,2664	0,3364	0,3271	0,2991	0,3364
11 Nennsdorf TH	0,2222	0,1304	0,2200	0,1939	0,2475	0,2857	0,1474	0,2353	0,1753	0,1563	-	0,0654	0,1215	0,1636	0,0935	0,0841	0,0888	0,0607	0,2617	0,2383	0,1963	0,2804	0,1495	0,1963	0,1756	0,2055	0,1121	0,1075	0,1308	0,2196	0,2850	0,1776	0,2056	0,1542	0,1355	0,2523	0,3131	0,3318	0,3224	0,3505
12 Saalburg TH	0,2222	0,1702	0,2020	0,2475	0,2647	0,2692	0,2222	0,2692	0,2121	0,1939	0,1489	-	0,1308	0,1542	0,1121	0,1028	0,0888	0,0981	0,2523	0,2290	0,2056	0,3084	0,1963	0,1963	0,1738	0,2127	0,1402	0,1168	0,1495	0,2570	0,2944	0,1963	0,2336	0,1636	0,1636	0,2804	0,3224	0,3224	0,3131	0,3318
13 Sil3-A1-R10 TH	0,3063	0,2804	0,2883	0,2661	0,2973	0,3009	0,2430	0,2857	0,2661	0,2661	0,2453	0,2617	-	0,1262	0,1495	0,1402	0,1449	0,1449	0,2523	0,2477	0,1682	0,2804	0,2243	0,2150	0,2032	0,2638	0,1589	0,1262	0,1682	0,2009	0,2757	0,1682	0,2430	0,1822	0,2009	0,2991	0,3692	0,3411	0,3411	0,3131
14 Sil3-C2-R77 TH	0,3043	0,2946	0,3162	0,3248	0,3248	0,2991	0,3043	0,2696	0,2957	0,2807	0,3070	0,2920	0,2328	-	0,1729	0,1636	0,1682	0,1589	0,2477	0,2523	0,1636	0,3037	0,2290	0,2196	0,2267	0,2744	0,1822	0,1682	0,1916	0,2804	0,2897	0,2757	0,2850	0,1963	0,2056	0,3318	0,3645	0,3364	0,3551	0,3832
15 Lengfeld TH	0,2574	0,1895	0,2718	0,2816	0,2647	0,3333	0,2400	0,2353	0,2300	0,2475	0,2062	0,2424	0,2936	0,3217	-	0,0561	0,0888	0,0888	0,2710	0,2290	0,2150	0,3178	0,1402	0,2243	0,1950	0,2157	0,1215	0,1075	0,1215	0,2103	0,2570	0,1963	0,2336	0,1822	0,1636	0,2617	0,2944	0,2850	0,2757	0,3505
16 Frankenau HE	0,2600	0,1720	0,2222	0,2323	0,2843	0,3048	0,2062	0,2549	0,1959	0,2500	0,1895	0,2268	0,2804	0,3097	0,1304	-	0,0514	0,0701	0,2617	0,2196	0,1963	0,2897	0,1682	0,2056	0,1942	0,2168	0,1215	0,0981	0,1495	0,2383	0,2664	0,1963	0,2710	0,1729	0,1542	0,2523	0,2850	0,2664	0,2664	0,3411
17 Bayreuth BY	0,2121	0,1596	0,1919	0,2376	0,2549	0,2427	0,1753	0,2596	0,1837	0,2200	0,1959	0,1959	0,2844	0,3130	0,1959	0,1196	-	0,0841	0,2570	0,2150	0,1916	0,2757	0,1822	0,2103	0,1801	0,2172	0,1262	0,0935	0,1262	0,2430	0,2804	0,1729	0,2477	0,1589	0,1402	0,2570	0,3271	0,2897	0,2897	0,3364
18 Ruppicht NW	0,2525	0,1630	0,2323	0,2424	0,2772	0,3143	0,1789	0,2475	0,1875	0,2424	0,1413	0,2188	0,2897	0,3036	0,2000	0,1630	0,1895	-	0,2290	0,2056	0,1822	0,2757	0,1542	0,2009	0,1797	0,1974	0,1168	0,1121	0,1449	0,2430	0,2897	0,1916	0,2383	0,1869	0,1495	0,2383	0,2897	0,2991	0,2991	0,3551
19 Norway	0,5246	0,4828	0,4959	0,4917	0,4917	0,5041	0,4615	0,4793	0,4790	0,5164	0,4786	0,4655	0,4426	0,4240	0,4915	0,4828	0,4701	0,4375	-	0,1822	0,1776	0,2523	0,2804	0,2056	0,2737	0,2823	0,2710	0,2664	0,2710	0,2477	0,2477	0,2523	0,2897	0,2664	0,2477	0,3271	0,3598	0,3411	0,3785	0,3972
20 Sweden I	0,4359	0,4298	0,4322	0,4274	0,4667	0,4545	0,4087	0,4417	0,4407	0,4793	0,4397	0,4261	0,4309	0,4252	0,4261	0,4159	0,4035	0,3964	0,3482	-	0,1542	0,2290	0,2570	0,2103	0,2835	0,2564	0,2383	0,2150	0,2570	0,2243	0,2336	0,2290	0,2944	0,2523	0,2336	0,3224	0,3551	0,3178	0,3551	0,4112
21 Sweden II	0,3826	0,3455	0,4068	0,4153	0,3879	0,3478	0,3540	0,3478	0,3451	0,3596	0,3717	0,3860	0,3103	0,2941	0,4000	0,3750	0,3628	0,3545	0,3363	0,2946	-	0,2430	0,2617	0,1589	0,2133	0,2583	0,2243	0,2009	0,2150	0,1916	0,2009	0,2056	0,2710	0,2290	0,2103	0,3178	0,3318	0,3224	0,3505	0,3785
22 Belgium	0,5289	0,5254	0,5366	0,5447	0,5447	0,5082	0,4522	0,5440	0,5083	0,5328	0,5085	0,5455	0,4839	0,5000	0,5574	0,5254	0,5000	0,5086	0,4615	0,4224	0,4370	-	0,3178	0,2523	0,3192	0,3282	0,3178	0,2944	0,2804	0,2664	0,2850	0,2897	0,3458	0,3224	0,3131	0,3738	0,3879	0,3785	0,4159	0,4439
23 Austria	0,3590	0,3063	0,3559	0,3782	0,3782	0,4320	0,3009	0,3390	0,3217	0,3644	0,2883	0,3621	0,3840	0,3798	0,2727	0,3214	0,3391	0,3000	0,4724	0,4365	0,4375	0,5231	-	0,2430	0,2488	0,2770	0,1495	0,1449	0,1682	0,2477	0,2757	0,2336	0,2336	0,2196	0,1822	0,2991	0,3785	0,3785	0,3505	0,4065
24 Poland	0,3793	0,3717	0,4167	0,4380	0,4250	0,3729	0,3509	0,4132	0,3707	0,3983	0,3684	0,3684	0,3770	0,3730	0,4103	0,3860	0,3879	0,3805	0,3761	0,3782	0,2957	0,4463	0,4094	-	0,2646	0,3048	0,2430	0,2196	0,2336	0,2103	0,2290	0,2056	0,2523	0,2664	0,2196	0,2897	0,3131	0,3411	0,3224	0,3972
25 Russia I	0,4180	0,3438	0,3589	0,4237	0,3773	0,3809	0,3744	0,3806	0,3775	0,3641	0,3724	0,3773	0,4025	0,4238	0,4104	0,4096	0,3824	0,3895	0,5191	0,5246	0,4184	0,5861	0,4627	0,4895	-	0,1840	0,1936	0,1967	0,1888	0,2592	0,2970	0,2349	0,2900	0,2356	0,2338	0,3022	0,3107	0,3001	0,3212	0,3705
26 Russia II	0,4728	0,4093	0,4345	0,4360	0,4629	0,4728	0,4306	0,4371	0,4536	0,4407	0,4272	0,4356	0,4860	0,4932	0,4499	0,4511	0,4476	0,4163	0,5337	0,5061	0,5008	0,6121	0,5112	0,5466	0,4099	-	0,2442	0,2275	0,2504	0,2996	0,3253	0,2729	0,3335	0,2898	0,2674	0,2963	0,3388	0,3301	0,3687	0,3895
27 England I	0,3019	0,2222	0,2667	0,2255	0,2596	0,3571	0,2692	0,2642	0,2427	0,2079	0,2376	0,2885	0,3036	0,3305	0,2549	0,2574	0,2621	0,2500	0,4833	0,4322	0,4068	0,5484	0,2832	0,4298	0,3986	0,4780	-	0,0514	0,0841	0,2477	0,2944	0,1963	0,2523	0,1729	0,1729	0,2617	0,3411	0,3131	0,2850	0,3505
28 England II	0,2596	0,1753	0,2404	0,2157	0,2500	0,3182	0,2255	0,2212	0,1980	0,1980	0,2277	0,2451	0,2477	0,3077	0,2277	0,2121	0,2000	0,2400	0,4750	0,3966	0,3707	0,5164	0,2743	0,3950	0,4047	0,4574	0,1134	-	0,0701	0,2150	0,2617	0,1729	0,2383	0,1402	0,1495	0,2664	0,3364	0,3084	0,2897	0,3271
29 Spain I	0,2857	0,2222	0,2830	0,2762	0,2596	0,2963	0,2692	0,2642	0,2596	0,2427	0,2718	0,3048	0,3186	0,3445	0,2549	0,3077	0,2621	0,3010	0,4833	0,4583	0,3932	0,5000	0,3130	0,4167	0,3905	0,4947	0,1800	0,1515	-	0,2290	0,2664	0,1869	0,2150	0,1542	0,1636	0,2617	0,3411	0,3411	0,3224	0,3598
30 Spain II	0,4622	0,4159	0,4836	0,4538	0,4667	0,4919	0,4224	0,4417	0,4274	0,4407	0,4123	0,4661	0,3644	0,4615	0,3982	0,4435	0,4444	0,4522	0,4454	0,4068	0,3534	0,4750	0,4240	0,3782	0,4932	0,5517	0,4454	0,3966	0,4188	-	0,1682	0,1822	0,2196	0,2897	0,2617	0,3037	0,3645	0,3551	0,3271	0,3832
31 Azores	0,4841	0,4672	0,4803	0,4882	0,4640	0,4766	0,4720	0,4766	0,4882	0,5231	0,4880	0,5000	0,4538	0,4593	0,4508	0,4672	0,4800	0,5000	0,4309	0,4065	0,3554	0,4841	0,4470	0,3920	0,5269	0,5645	0,4922	0,4480	0,4560	0,3103	-	0,2196	0,2290	0,2897	0,2991	0,3411	0,3551	0,3645	0,3645	0,4019
32 Canada	0,4034	0,3540	0,3729	0,3246	0,3534	0,3697	0,3333	0,3559	0,3391	0,3675	0,3363	0,3652	0,3051	0,4436	0,3652	0,3684	0,3274	0,3628	0,4390	0,4016	0,3636	0,4921	0,3937	0,3607	0,4476	0,5028	0,3590	0,3217	0,3448	0,3333	0,3760	-	0,1776	0,1916	0,1916	0,2710	0,3785	0,3692	0,3411	0,3224
33 Alaska USA	0,4160	0,4098	0,4375	0,4453	0,4080	0,4341	0,4160	0,4219	0,4080	0,4080	0,3667	0,4065	0,4000	0,4420	0,4065	0,4603	0,4240	0,4180	0,4733	0,4737	0,4394	0,5441	0,3817	0,4122	0,4976	0,5602	0,4252	0,4048	0,3740	0,3760	0,3769	0,3065	-	0,2290	0,2290	0,2897	0,3598	0,4159	0,3598	0,3785
34 Australia	0,3304	0,3056	0,3125	0,3214	0,3063	0,3097	0,3153	0,3246	0,3214	0,3063	0,3028	0,3182	0,3305	0,3415	0,3482	0,3364	0,3091	0,3604	0,4634	0,4390	0,4016	0,5391	0,3790	0,4488	0,4513	0,5342	0,3274	0,2727	0,2973	0,4882	0,4733	0,3417	0,3828	-	0,1495	0,2757	0,3832	0,3458	0,3458	0,3364
35 New Zealand I	0,3043	0,2793	0,3017	0,2957	0,3248	0,3417	0,2895	0,2696	0,2655	0,2655	0,2613	0,3070	0,3468	0,3438	0,3070	0,2946	0,2679	0,2883	0,4240	0,4000	0,3629	0,5115	0,3145	0,3730	0,4348	0,4881	0,3162	0,2783	0,3017	0,4375	0,4706	0,3306	0,3712	0,2712	-	0,2196	0,3832	0,3551	0,3551	0,3832
36 New Zealand II	0,4821	0,4630	0,4912	0,4732	0,4867	0,5254	0,4821	0,5128	0,5000	0,5000	0,4865	0,5263	0,5246	0,5504	0,5000	0,4909	0,4911	0,4722	0,5785	0,5656	0,5528	0,6400	0,5161	0,5124	0,5826	0,5851	0,4912	0,4957	0,4912	0,5417	0,5703	0,4833	0,4921	0,4958	0,4017	-	0,3879	0,3598	0,3692	0,4159
37 Russia III	0,6239	0,6106	0,6417	0,6271	0,6034	0,6134	0,6121	0,6017	0,5789	0,6154	0,5929	0,6053	0,6320	0,6094	0,5676	0,5596	0,6087	0,5688	0,6417	0,6281	0,5917	0,6803	0,6328	0,5630	0,6202	0,6697	0,6186	0,6102	0,6186	0,6393	0,6080	0,6378	0,5969	0,6508	0,6308	0,7034	-	0,1963	0,2150	0,3178
38 Russia IV	0,6148	0,5897	0,5868	0,5950	0,5714	0,5820	0,5917	0,5462	0,5345	0,5833	0,5966	0,5847	0,5794	0,5581	0,5351	0,5135	0,5391	0,5614	0,5984	0,5620	0,5610	0,6480	0,6136	0,5794	0,5861	0,6351	0,5630	0,5546	0,5984	0,6080	0,6000	0,6077	0,6403	0,5873	0,5802	0,6471	0,4330	-	0,1028	0,2710
39 Russia V	0,6098	0,5603	0,5583	0,5546	0,5546	0,5656	0,5750	0,5294	0,4912	0,5424	0,5798	0,5678	0,5748	0,5758	0,5175	0,5089	0,5345	0,5565	0,6378	0,6032	0,5906	0,6846	0,5769	0,5520	0,6044	0,6724	0,5214	0,5254	0,5702	0,5691	0,5954	0,5703	0,5746	0,5827	0,5758	0,6529	0,4600	0,2391	-	0,2710
40 USA	0,6270	0,6148	0,6000	0,6080	0,5738	0,6172	0,6160	0,5952	0,5620	0,5854	0,6098	0,5868	0,5360	0,6029	0,6098	0,6033	0,5902	0,6230	0,6538	0,6617	0,6183	0,7090	0,6350	0,6343	0,6646	0,6927	0,6000	0,5691	0,6111	0,6308	0,6324	0,5433	0,5912	0,5669	0,6029	0,7008	0,6071	0,5225	0,5179	-

Bärental TH
Plot Sil3
Berlin Pankow
Plot B1

Curriculum Vitae

Der Lebenslauf ist in der Online-Version

aus **G**ründen des **D**atenschutzes nicht enthalten

Hiermit erkläre ich, dass ich die vorliegende Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel verwendet habe.

Berlin, den 21.12.2009

Sebastian Fritz