

MOSS DIVERSITY PATTERNS ON THE TERRITORY OF THE FORMER USSR

ОСОБЕННОСТИ РАЗНООБРАЗИЯ ФЛОР МХОВ НА ТЕРРИТОРИИ БЫВШЕГО СССР

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Abstract

The moss diversity on the territory of the former USSR is analyzed on the basis of recently published check-list. Oceanic sides of Eurasia and mountain areas appears to be much more rich in species number, than continental lowlands, especially in comparison with quite a different situation in vascular plants. Specifics of regions of the former USSR are demonstrated and the total species diversity is expanded on 9 main geographic elements, and their significance is evaluated.

Резюме

На основе анализа списка видов мхов территории бывшего Советского Союза (Arctoa, vol. 1) рассматривается видовое богатство моховых флор Северной Евразии. При этом прибрежные и горные районы оказываются существенно богаче видами, чем континентальные равнины, что сильно отличает характер видового разнообразия мхов от такового сосудистых растений. Показана специфика флор мхов отдельных регионов бывшего СССР, а также предложена схема, представляющая общее разнообразие как результат суперпозиции 9 основных типов ареалов, с оценкой вклада каждого из них.

INTRODUCTION

In 1975 L. I. Malyshev has published an interesting paper on the spatial diversity of vascular plants and their richness in regional floras. There was provided a map where isolines indicate the number of species for an area of 100 000 km². This size of area is especially useful since many lists or floras deal with approximately such an area.

As one can assume from that map (partly reproduced on Fig. 1) isolines within Northern Eurasia are mostly parallel to the equator. Some centers of floristically enriched regions are in mountains of South Ural and especially in Central European - Mediterranean regions.

Analyzing data from the territory of the former USSR, and, to a less extent, from other parts of Holarctic, I have found that the situation with the spatial diversity of mosses is considerably different: oceanic and mountain areas (O, M) being more rich in

species number than inland lowlands (IL), have the rate between them ("O & M : IL") sufficiently higher in mosses than in vascular plants. The main reason for this is, probably due to the relatively high diversity of vascular plants in steppes and deserts where bryophytes are poorly represented both in number of species and in number of individuals. So isolines on the map of moss diversity in Northern Eurasia typically are not parallel to the equator, but surround the regions with more wet and mild climate (Fig. 2). To argument this observation and the map is the task of the present paper.

RELATIONSHIP BETWEEN AREA AND SPECIES NUMBER

Some methodological questions should be answered first: 1) what is the appropriate area for such a comparison; 2) how is the number of species in a moss flora affected by the area investigated?

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The answer to the first question depends to a great extent on current practice of floristic investigation. Floras usually are elaborating for two types of territories. The first are of 0.1 to 100 km² (National Parks, different kinds of Reserves, territories of botanical gardens, special interesting places, surroundings of cities) - such areas, in many cases, can be explored in several days to weeks, or by a number of periodical visits. The second area size is from 10 000 to 1 000 000 km² - it is the average area of many European countries, many states, provinces, territories in big countries like former USSR, USA, Canada, China, etc. The results of investigations of such areas are usually present in handbooks, complete "Floras" or, in recent time, also in numerous check-lists. The problem with the usage of data of smaller areas (0.1 to 100 km²) is that most of them are territories more or less outstanding with respect to bryophytes. For example, in the lowland European part of Russia, one can find in the valley of a more or less big river 2-3 times more species than in more flat area without rivers / big creeks. And bryodiversity here depends on the diversity of relief, height of slopes, kind of rocks, level of human impact (occurring too strongly in many provinces) and many other factors. In mountain area with very diverse natural conditions, the number of species, as I can assume, strongly depends on the time, a bryologist can devote to do the field work. I know only few localities of high mountains in the former USSR territory, which can be said to be explored enough to provide the basis for comparative studies. By these reason, I think that comparison of local floras (so common in floristics of vascular plants), is premature for bryophytes.

What about bryofloras of areas of 10 000 - 1 000 000 km², it seems that they are more evenly investigated, comparatively with the smaller area variant. So, I believe that their comparison can elucidate the main characteristics of the relationship between number of species/area studied, even when comparison is made for different regions of Holarctic.

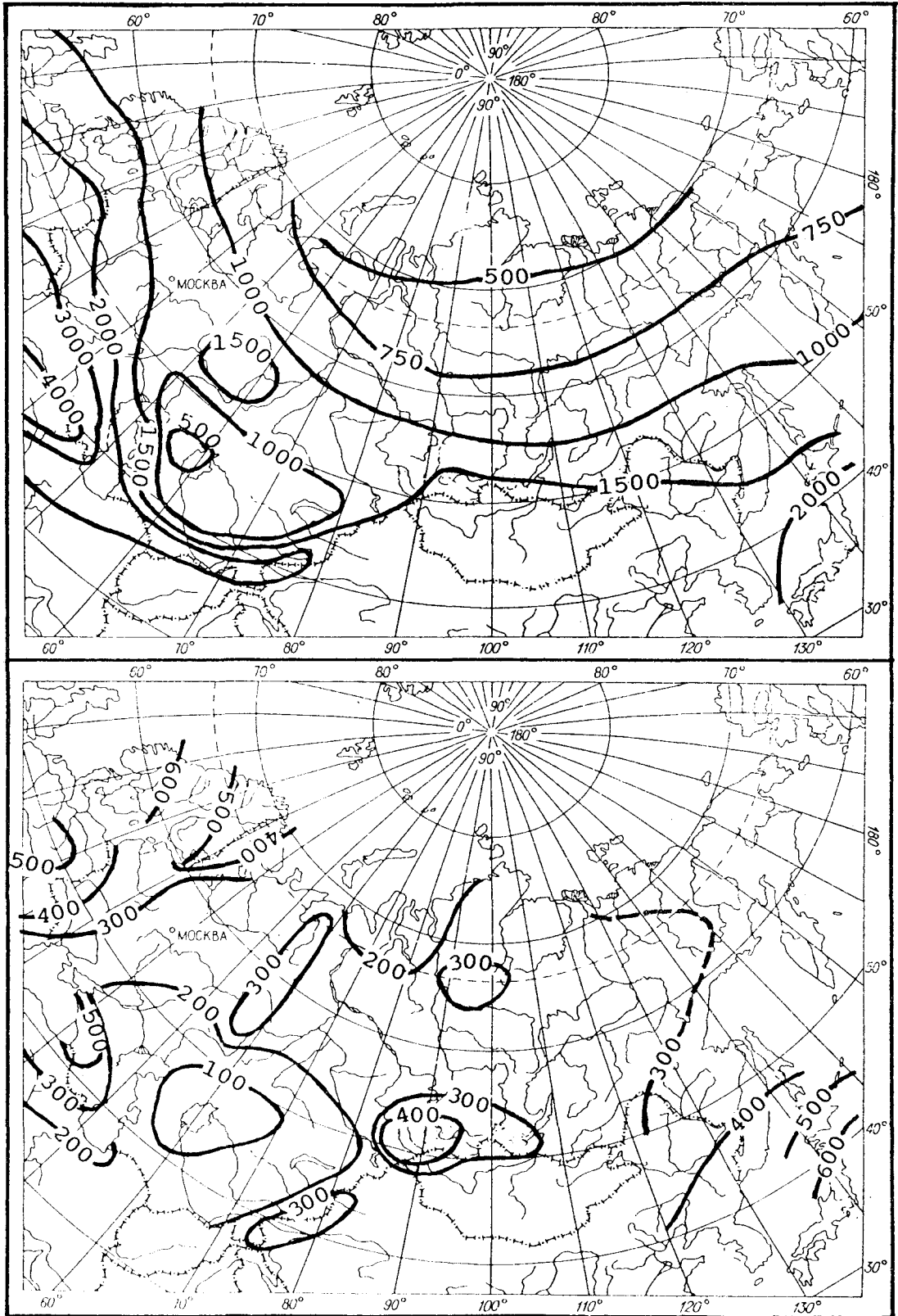
As it can be seen from Table 1 (graph-

ically displayed on Fig. 3), the relationship between the area investigated and the number of species is though positive, but comparatively with vascular plants the line of regression is nearly horizontal¹ (Fig. 3). So it is clear that differences in quality of exploration and the taxonomical concepts ("splitter / lamper") are maybe more important, at least today, than the differences caused by the area size under exploration in the interval of 10 000-1 000 000 km². So, in evaluating of the theoretical number of species of 100 000 km² for the map of moss diversity (Fig. 2), I took into consideration all these factors, especially the level of exploration of an area. The resulting picture of moss diversity on the territory of the former USSR in Fig. 2 is based, therefore, on data taken from Tables 1 & 2, with my own indexing. And though my subjectivity remains unrecoverable here, I believe that such an evaluation is, at least, no less inaccurate than mathematical calculation based on presently available data. For the outline of some regions for Fig. 2, the maps of distribution of some moss species, as well as general maps of physiography and vegetation were also useful (Atlas SSSR, 1984).

The overall picture of moss diversity pattern was investigated in the course of preparing of the "Check-list of mosses of the former USSR" (*Arctoa*, 1). Some practical consequences derived from Fig. 2 are:

1) the division of "Flora Europaea" (Tutin & al. 1964 - 1980) repeated by Duell (1984, 1985) for the European part of the USSR, uses regions with latitudes much smaller than longitudes (especially Northern and Central regions of the European part of former USSR). Maybe it is naturally for vascular plants with their well-established

¹ - This difference can be illustrated with some examples: in Moscow Province there are known ca. 5% of species of vascular plants of the entire USSR (Woroschilov & al., 1966; Czerepanov, 1981), while for mosses this number is ca. 25% (Ignatov & Ignatova, 1990; Ignatov & Afonina, 1992); or Swedish vascular flora is ca. 20 % of that of Europe (Hulten, 1971; Lid, 1963; Tutin, 1964-1980), while for mosses - ca. 70% (Hallingbaeck & Soederstroem, 1987; Corley & Crundwell, 1991). Selected small area can contain up to half of the moss flora of a very much larger territory. For example, in Kunzevo in Moscow, on a 100 ha (0.000 02% of territory of Moscow Province) there are represented 130 species of mosses, or half of the number for the Province; or in South Wales (Hill, 1988) there is found about half of the moss flora of Europe on about 0.1% of territory of the latter, etc.



Figs. 1 - 2. Number of species in floras of vascular plants (1), and of mosses (2) on the territory of the former USSR and neighboring areas (approximation to area of 100 000 km²). Fig. 1 - after Malyshev (1975).

Table 1. Number of moss species in regional floras.

Territory	Number of species	Area, km ²	Reference
Arabian Peninsula	51	2985	Frey, 1986
Trans-Jordan Area	110	ca.90	El-Oqlah & al., 1988
Moldova (within ex-USSR)	143	34	Simonov, 1978
Iraq	145	435	Agnew & Wondracek, 1975
Darvaz Mt Range, Middle Asia	156	ca.10	Mamatkulov, 1975
Afganistan	182	647	Frey, 1986
Pridneprovskaya Upland, Ukraine	188	ca.40	Virchenko, 1989
Lebanon + Syria + Jordan	199	293	Frey, 1986
Don River Basin in Middle Course, Russia	203	60	Khmelev & Popova, 1988
Saskatchevan, Canada	208	570	Ireland & al., 1987
Tomsk Province, Russia	220	314	Muldiyarov, 1990
Arctic Archipelago, Canada	230	ca.1000	Ireland & al., 1987
Lithueva (Litva)	231	65	Yukonene, 1991
Israel	232	14	Herrnstadt & al., 1991
Gorkij Province, Russia	238	75	Vorobjov, 1983
Sakhalin Island (southern part)	238	ca.30	Ardeeva, 1969
South-East Armenia	243	8	Manakyan, 1989b
Iran	259	1648	Frey, 1986
Krym (Crimea) Peninsula	268	26	Partyka, 1989
Manitoba, Canada	269	650	Ireland & al., 1987
Moscow Province, Russia	269	47	Ignatov & Ignatova, 1990
Bashkiria, South Ural Mts.	302	143	Ignatova & Ignatov, 1992
Belorussia	315	208	Rykovskiy, 1980
Pamiro-Alaj Mts., Middle Asia	320	ca.100	Mamatkulov, 1989
North-West Territories, Canada (continental part)	321	ca.2400	Ireland & al., 1987
Yakutian tundras, Northern Siberia	322	394	Stepanova, 1986
Mongolia	329	1565	Abramov & Abramova, 1983
Eastern Sayan Mts., South Siberia	332	ca.100	Bardunov, 1974
Western Sayan Mts., South Siberia	339	ca.100	Bardunov, 1974
Intermountain West, USA	342	ca.500	Spence, 1988
Leningrad Prov., Russia	343	86	Vjyunova, 1980
Armenia	355	30	Manakyan, 1989a
Estonia	361	45	Kannukene, 1986
Chukotka Peninsula	361	ca.90	Afonina, 1989
Azerbaidjan	364	87	Lyubarskaya, 1986
Latvija	368	65	Abolina, 1968
Yukon Territories, Canada	364	536	Ireland & al., 1987
Netherlands (without <i>Sphagnum</i>)	389	41	Touw & Rubers, 1989
Komi Republic, Russia	411	416	Zheleznova, 1991
Iceland	414	103	Johannsson, 1983

Table 1 (concluded).

Territory	Number of species	Area, km ²	Reference
South Primorskiy Prov., Russian Far East	420	ca.50	Bardunov & Czerdantseva, 1982
Hungary	422	93	Boros, 1968
Alberta, Canada	422	661	Ireland & al., 1987
Greece	424	132	Preston, 1984
Murmansk Prov., Russia	437	145	Schljakov & Konstantinova, 1982
Altai Mts. within ex-USSR	452	ca.100	personal data
Denmark	461	43	Dirske & al., 1988
Ontario, Canada	467	1068	Ireland & al., 1987
Turkey + Cyprus	470	781	Frey, 1986
North-East China	472	ca.800	Gao & Chang, 1983
Makaronesia	485	ca.11	Eggers, 1982
Georgia	496	70	Chikovani, 1986
Rheinland-Pfalz	499	ca.15	Duell & al., 1983
Bulgaria	502	111	Petrov, 1975
Quebeck, Canada	506	1540	Ireland & al., 1987
Northern Wales	546	13	Hill, 1988
Finland	591	337	Koponen & al., 1977
British Columbia, Canada	655	949	Ireland & al., 1987
Spain	668	505	Casas, 1981
Poland	677	313	Ochyra & al, 1992
Britain & Ireland	692	316	Smith, 1978
Eastern North America	752	ca.7000	Crum & Anderson, 1981
Sweden	753	449	Hallingbaeck & Soederstroem, 1987
Japan	ca.900	372	Noguchi, 1987
Canada	965	9976	Ireland & al., 1987
Former USSR	1157	22400	Ignatov & Afonina, 1992
Europe	1154	11600	Corely & Crundwell, 1991
USA & Canada	1320	17815	Anderson & al., 1990
China	2004	9597	Redfearn & Wu, 1986
World	7000	149000	Touw, 1974
World	9000	149000	Crosby, 1980

latitudinal boundaries. But in mosses, longitudinal limits are much more important, so it is necessary to divide the territory along the oceanic-continental gradient. However "Flora Europaea" borders are mostly accepted, with a few weak shifts. The principal one is that St.-Petersburg (Leningrad) Province was removed from the Central Region and included in the oceanic alliance of provinces (NW, B, BLR, W, K).

2) more diverse and peculiar with respect to bryophytes South Siberia is separated from the flattened northward territories. At the same time Altai Mts. and Sayan Mts., which usually were separated by traditional division into Western and Eastern Siberia, are combined here: altaian additional diversity in vascular plants (because of many xerophytic groups) is practically absent in regard to mosses.

NUMBER OF SPECIES AND PECULIARITIES OF REGIONS OF THE EX-USSR

According to the recently published check-list of mosses of the former USSR (Ignatov & Afonina, 1992) on its territory there are known 1157 species and 74 infraspecific taxa, including, however, 43 species and 1 variety considered as dubious. The territory was divided into 6 main regions - Arctic, European part, Caucasus, Siberia, Far East and Middle Asia, in general following the main division using for vascular plants in the Flora of the USSR (Komarov, 1934-66). In most regions (except Caucasus and Middle Asia) there are subdivisions, and the total number of recognized geographical entities is 21. The number of taxa, known for these divisions is represented in Table 2.

Though the correlation in number of species in common between of the regions of Holarctic is at about 85 % (cf. Schofield 1988b; Ignatov 1992), the number of species in common among all the six principal divisions of the former USSR is unexpectedly low - only 17%, or 200 species (listed below). And only ca. 3% of species (36) are known in all the 21 subdivisions of the former USSR (marked with * in this list): **Abietinella abietina*, *Amblystegium serpens*, *A. varium*, *Amphidium lapponicum*, *A. mougeotii*, *Andreaea rupestris*, *Anomobryum julaceum*, *Anomodon viticulosus*, *Aulacomnium palustre*, *Barbula convoluta*, *B. ungu-*

iculata, *Bartramia ithyphylla*, *B. pomiformis*, *Brachythecium albicans*, *B. campestre*, **B. mildeanum*, *B. plumosum*, *B. populeum*, *B. reflexum*, *B. rivulare*, **B. salebrosum*, *B. starkei*, *B. velutinum*, **Bryoerythrophyllum recurvirostrum*, *Bryum algovicum*, **B. argenteum*, **B. caespiticium*, *B. capillare*, *B. creberrimum*, *B. funckii*, *B. intermedium*, *B. pallens*, *B. pallescens*, **B. pseudotriquetrum*, *B. schleicheri*, *B. weigeli*, *Calliergon cordifolium*, *C. giganteum*, *C. stramineum*, *Calliergonella cuspidata*, *Campylium polygamum*, **C. stellatum*, **Ceratodon purpureus*, *Cirriphyllum cirrosum*, **Climacium dendroides*, *Coscinodon cribrosus*, **Cratoneuron filicinum*, *Ctenidium molluscum*, *Cynodontium tenellum*, *Desmatodon latifolius*, *Dicranella subulata*, *Dicranella varia*, *Dicranoweisia crispula*, *Dicranum bonjeanii*, *D. brevifolium*, *D. congestum*, *D. elongatum*, *D. muehlenbeckii*, *D. polysetum*, **D. scoparium*, *D. spadiceum*, *Didymodon fallax*, *D. rigidulus*, *D. vinealis*, **Distichium capillaceum*, *D. inclinatum*, *Ditrichum flexicaule*, **Drepanocladus aduncus*, **D. sendtneri*, *Encalypta ciliata*, *E. rhaptocarpa*, *E. streptocarpa*, *E. vulgaris*, *Entodon concinnus*, **Eurhynchium pulchellum*, *Fissidens adianthoides*, **F. bryoides*, *F. osmundoides*, *Fontinalis antipyretica*, *F. hypnoides*, **Funaria hygrometrica*, *Grimmia alpestris*, *G. donniana*, *G. elatior*, *G. elongata*, *G. montana*, *G. ovalis*, *Gymnostomum aeruginosum*, *Hedwigia ciliata*, *Helodium blandowii*, *Hygrohypnum duriusculum*,

Fig. 3. Relationship between number of moss species in some regions and area of these regions (see also Tab. 1).

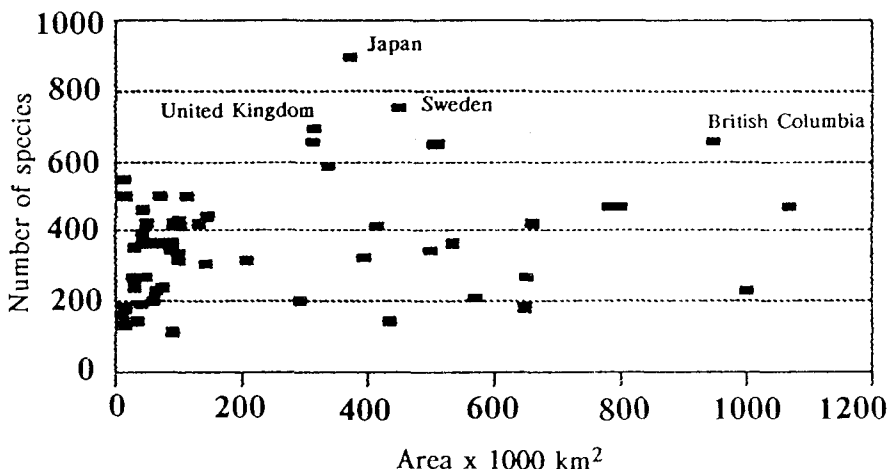


Table 2. Number of moss species in the regions of the former USSR (the names of regions are in some cases shortened; for their precise definitions see *Arctoa*, vol 1).

Regions of the former USSR	Abbreviations	Number of species (+infraspecific taxa)	Area, km ² x 10 ³
Arctic	ARC	506 (+34)	1250
European Arctic	EURO	361 (+22)	250
West-Siberian Arctic	WS	237 (+8)	200
East-Siberian Arctic	ES	371 (+27)	500
Beringian Arctic	BE	390 (+24)	300
European part	EUR	782 (+49)	4310
North-West	NW	554 (+24)	370
North-East	NE	374 (+25)	700
North Ural	N-UR	311 (+6)	150
Baltic Countries	B	453 (+23)	190
Belorussia	BLR	334 (+12)	210
Central Russia	C	351 (+18)	1300
West (Ukraine & Moldova)	W	572 (+28)	610
Krym (Crimea)	K	253 (+13)	30
East (South-East)	E	243 (+13)	500
South Ural	S-UR	363 (+12)	250
Caucasus	CAUC	627 (+42)	350
Siberia	SIB	625 (+40)	9300
West Siberia	W	286 (+11)	1900
East Siberia	E	399 (+19)	4900
South Siberia	S	560 (+35)	2500
Far East	FAR EAST	635 (+29)	3100
northern part	N	321 (+17)	1900
southern part	S	555 (+19)	1200
Middle Asia	MID AS	489 (+40)	3980
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total		1157 (+74)	22400

**H. luridum*, *H. ochraceum*, **Hylocomium splendens*, *Hymenostylium recurvirostre*, **Hypnum cupressiforme*, *H. lindbergii*, *H. revolutum*, *H. vaucheri*, *Isopterygiopsis pulchella*, *Leptobryum pyriforme*, *Leptodictyum humile*, *L. riparium*, *Lescurea saxicola*, *Leskea polycarpa*, *Leskeella nervosa*, *Leucodon sciuroides*, *Limprichtia cossoni*, *L. revolvens*, *Meesia uliginosa*, *Mnium ambiguum*, *M. marginatum*, *M. spinosum*, *M. spinulosum*, *M. stellare*, *M. thomsonii*, *Molendoa sendtneriana*, *Myurella julacea*, *M. tenerrima*, *Oncophorus virens*, *O. wahlenbergii*, *Orthotrichum anomalum*, *O.*

obtusifolium, *O. speciosum*, *Oxystegus tenuirostris*, *Paludella squarrosa*, *Palustriella commutata*, *P. decipiens*, *Paraleucobryum enerve*, *P. longifolium*, **Philonotis fontana*, *Plagiobryum zieri*, *Plagiomnium cuspidatum*, **P. ellipticum*, **P. medium*, *Plagiopus oederiana*, *Plagiothecium denticulatum*, *P. laetum*, *Platydictya jungermannioides*, *P. subtilis*, *Platygyrium repens*, **Pleurozium schreberi*, **Pogonatum urnigerum*, **Pohlia cruda*, *P. elongata*, *P. filum*, *P. longicollis*, **P. nutans*, **P. wahlenbergii*, *Polytrichastrum alpinum*, *Polytrichum commune*, **P. juniperinum*, **P. piliferum*, *P. strictum*,

Pseudobryum cinclidioides, *Pseudeskeia incurvata*, *P. radicata*, *Pseudeskeella catenulata*, *P. tectorum*, *Pterigynandrum filiforme*, *Ptilium crista-castrensis*, *Pylaisiella polyantha*, *Racomitrium canescens*, *Rhizomnium pseudopunctatum*, *R. punctatum*, *Rhodobryum roseum*, **Rhytidiadelphus triquetrus*, *Rhytidium rugosum*, *Saelania glaucescens*, **Sanionia uncinata*, *Sarmentypnum sarmentosum*, *Schistidium agassizii*, **S. apocarpum*, *S. rivulare*, *S. strictum*, *Sphagnum capillifolium*, *S. centrale*, *S. contortum*, *S. flexuosum*, *S. fuscum*, *S. girgensohnii*, **S. magellanicum*, *S. platyphyllum*, *S. russowii*, *S. squarrosum*, *S. subsecundum*, *S. teres*, *S. warnstorffii*, *Tetraxis pellucida*, *Thuidium philibertii*, *Timmia megapolitana*, *T. norvegica*, *Tortella fragilis*, *T. inclinata*, *T. tortuosa*, *Tortula mucronifolia*, *T. norvegica*, **T. ruralis*, *Trichostomum crispulum*, *Ulota curvifolia*, *Warnstorffia exannulata*, *W. fluitans*. It is interesting that only 9 genera out of 99 in the above list have more than three species: *Sphagnum* (13), *Bryum* (12), *Brachythecium* (10), *Dicranum* (8), *Mnium* (6), *Grimmia* (6), *Pohlia* (6), *Schistidium* (4), *Hypnum* (4).

On the peculiarity of bryophyte flora of accepted regions it is possible to note the following. The most particular area in the former USSR is the region of Far East, where are known 130 species which are absent in all the other parts of the USSR, and among them 119 are known only from its southern part. There is a considerable number of genera, occurring in the former USSR only here: *Actinothuidium*, *Atractylocarpus*, *Bartramiopsis*, *Boulaya*, *Brachymenium*, *Brotherella*, *Bryochenea*, *Dolichomitriopsis*, *Dozya*, *Drummondia*, *Fauriella*, *Glyphomitrium*, *Homaliadelphus*, *Hondaella*, *Hylacomitriopsis*, *Hypopterygium*, *Macromitrium*, *Mamillariella*, *Miyabea*, *Oedipodium*, *Okamuraea*, *Pleuroziopsis*, *Pseudeskeopsis*, *Rauiella*, *Rigodiadelphus*, *Schwetschkeopsis*, *Vesicularia*. There are also a lot of interesting and peculiar species here - *Anomodon giraldii*, *A. solovjovii*, *Aulacomnium heterostichum*, *Camptothecium auriculatum*, *Claopodium crispifolium*, *Climacium japonicum*, 3 species of *Cyrtohypnum* (*C. pyg-*

maeum, *C. sparsifolium*, *C. vestitissimum*), 8 species of *Entodon* (*E. diversinervis*, *E. giraldii*, *E. luridus*, *E. rubicundus*, *E. rufescens*, *E. scabridens*, *E. sinense*, *E. sullivantii* var. *versicolor*), *Fissidens adelphinus*, *F. nobilis*, 3 species of *Forsstroemia* (*F. japonica*, *F. stricta*, *F. trichomitria*), *Gollania ruginosa*, *Haplohymenium flagelliforme*, *Homomallium connexum*, *H. plagiangium*, *Homalothecium laevisetum*, *Isothecium hakodense*, *Leucodon pendulus*, *Lindbergia japonica*, *Neckera yesoana*, *Oligotrichum aligerum*, *O. parallelum*, *Plagiothecium obtusissimum*, 4 species of *Pogonatum* (*P. contortum*, *P. inflexum*, *P. japonicum*, *P. spinulosum*), 4 species of *Pylaisiella* (*P. brotheri*, *P. intricata*, *P. obtusa*, *P. subcircinata*), *Rhizomnium nudum*, *R. striatulum*, 3 species of *Taxiphyllum* (*T. alternans*, *T. aomoriense*, *T. taxirameum*), *Tetraxis geniculata*, 4 species of *Thamnobryum* (*T. coreense*, *T. plicatum*, *T. subseriatum*, *T. vorobjovii*), 5 species of *Thuidium* (*T. cymbifolium*, *T. glaucinum*, *T. kanedae*, *T. molkenboeri*, *T. submicropteris*), *Trachycystis flagellaris*, *T. microphyllus*, etc. - this is just an incomplete list, including the most phytogeographically interesting taxa and groups. Again it is worthwhile to note that Russian Far East is still rather incompletely explored.

The 2 species confined only to Northern part of Far East are of rather dubious taxonomic status (*Pseudeskeella korjakorum* and *Timmia corniculata*, the latter probably is conspecific with the widespread in Western North America *T. crassinervia*). Only 9 species of those confining to the Russian Far East, are known both in its Northern and Southern parts. And most of them occur also in Western North America, representing well-known pattern of North Pacific Arc (*Bartramiopsis lescurii*, *Bryhnia hultenii*, *Oligotrichum parallelum*, *Pleuroziopsis ruthenica*, *Pogonatum contortum*, *Polytrichum sphaerothercium*, *Rhizomnium nudum*).

The number of species limited in the former USSR only in Far East and Beringian Arctic, is unexpectedly low - only 2 species, (*Bryoxiphium norvegicum* and *Herzogiella ascendens*). Moreover both are known in the Northern Europe and in the North America.

The number of species in common between Far East and South Siberia which are, however, unknown from any other part of USSR, is much greater - 21: *Anacamptodon latidens*, *Anomodon minor* ssp. *integerrimus*, *A. thraustus*, *Brachythecium buchananii*, *Brothera leana*, *Bryohaplocladium angustifolium*, *Buxbaumia minakatae*, *Eurohypnum leptothallum*, *Grimmia pilifera*, *Haplohymenium longinerve*, *Helodium paludosum*, *Herpetineuron toccocae*, *Hyophila involuta*, *Lepidontium styriacum*, *Neckera borealis*, *Plagiomnium maximoviczii*, *Plagiomnium vesicatum*, *Ptychomitrium sinense*, *Pylaisiadelphatenuirostris*, *Rhizomnium parvulum*, *Zygodon conoideus*. And it is interesting that no one of them is distributed in the northern part of the Far East. Obviously, most of these species could be understood as the more resistant portion of the East Asian route, concentrating mostly in Far East. Many of them represent classical disjunction between East Asia and Eastern North America.

There are 12 species confined to the Siberia + Arctic + Far East: *Aulacomnium acuminatum*, *Cinclidium latifolium*, *Hypnum subimponens*, *Lyellia aspera*, *Oligotrichum falcatum*, *Orthotrichum sordidum*, *Podperaea krylovii*, *Racomitrium panschii*, *Scouleria aquatica*, *Sphagnum orientale*, *S. perfoliatum*, *Trichostomum arcticum*, many of them occur also in America, being connected via the North Pacific Arc.

There are 27 species known only from Siberia. This number, however, includes 9 species, described from Eastern Siberia by Lindberg & Arnell (1890), and known mostly by their type collections, so their status needs confirmation (*Bryum calcicola*, *B. jeniseense*, *B. planiusculum*, *B. sibiricum*, *Cinclidium minutifolium*, *Myurella acuminata*, *Pohlia alba*, *P. brevinervis*, *P. viridis*). The only endemic species of Eastern Siberia, whose taxonomic rank seems unquestionable, is *Myuroclada rotundifolia* (= *Myrinia rotundifolia*). It is a very interesting, distinct moss known from a few localities in the lower course of Lena River, near the border of Arctic region.

There is no species known only from Western Siberia. This lowland territory of

steppe vegetation to the south and discontinuous *Sphagnum* bogs to the north is very poor in bryophytes. So the absence of specificity here is quite natural.

Fifteen species occur in the former USSR only in South Siberia: **Bryerythrophyllum inaequalifolium*, **Aongstroemia orientalis*, **A. julacea*, **Barbula amplexifolia*, **Brachythecium wichurae*, *Bryum altaicum*, *Didymodon perobtusus*, *Entodon transbaicalensis*, **Forsstroemia noguchii*, **Gollania turgens*, *Grimmia cavifolia*, *Jaffueliobryum latifolium*, *Orthodontopsis bardunovii*, *Schistidium liliputanum*, **Struckia argentata* ssp. *zerovii*. Nearly all of these species are well-reputed taxa. Many are strongly disjunctive with the remote southern regions (marked by asterisk *), or (*Barbula*, *Gollania*) also with Arctic.

There are as many as 61 species, restricted in their distribution in the former USSR only to Middle Asia. This number, however, is strongly affected by many dubious species, which badly need a revision. Especially it is concerning to 23 species of *Bryum*, mostly described by Philibert. Among other species there are *Dicranella howei*, 3 species of *Entostodon* (*E. angustifolius*, *E. attenuatus*, *E. handelii*), *Grimmia pitardii*, *G. mesopotamica*, 16 (!) species of *Tortula*, 4 *Weissia*, 3 *Hydrogonium* (*H. ehrenbergii*, *H. arcuatum*, *H. mamatkulovii*), *Trichostomopsis aaronii*, *Anacolia webbii*. The three latter genera are known in the former USSR only from Middle Asia.

The specificity (i. e. species, known in the former USSR only from this region) of the European part of the former USSR includes 55 species. This group is rather heterogeneous. Thirteen species are known only from North-West, especially from Kola Peninsula (*Andreaea crassinervia*, *Bryum culmannii*, *B. murmanicum*, *B. savicziae*, *B. saxatile*, *B. tardum*, *B. tenuisetum*, *B. umbratum*, *Ditrichum zonatum*, *Pseudocalliergon angustifolium*, *Sanionia nivalis*, *Seligeria subimmersa*, *Warnstorfia h-schulzei*). As it is clear from this enumeration, the specificity of the Kola Peninsula largely depends on better studies of *Bryum* and *Drepanocladus*-group. Twelve species are confined to the "West",

and in reality - to the Carpatian Mts.: *Barbula crocea*, *Campylopus schwarzii*, *Campylostelium saxicola*, *Ephemerum recurvifolium*, *E. sessile*, *Grimmia apiculata*, *Hypnum jutlandicum*, *Molendoa horns-chuchiana*, *Pohlia ambigua*, *Rhytidiadelphus loreus*, *Tetradontium ovatum*, *Weissia rostellata*. Only 6 species are known only from Baltic republics, now countries (this region includes also Kaliningrad Province of Russia) - *Tortella rigens*, *T. flavovirens*, *Schistidium trichodon*, *Orthodontium lineare*, *Bryum marratii*, *B. mamillatum*. But some of them are known only by old and unconfirmed records. Most species of only European distribution within the former USSR are known in several regions near the western borders - North-West, Baltic, West, Belorussia, in different combinations: *Bryum klinggraeffii*, *B. violaceum*, *Cinclidotus danubicus*, *Cynodontium suecicum*, *Dicranodontium asperulum*, *Encalypta mutica*, *Fissidens fontanus*, *F. rufulus*, *Physcomitrium arenicola*, etc. The only four species, confined to European part of the former USSR are more or less widely distributed on its territory (*Cyrto-hypnum minutulum*, *Sphagnum molle*, *Pseudephemerum nitidum*, *Ephemerum serratum*).

The peculiarity of Caucasus appears to be less than could be expected, 30 species, but among them there are many interesting, well-known by their "revealing" distribution: *Anomodon rostratus*, *Bartramia stricta*, *Bryohaplodadium virginianum*, *Crumia latifolia*, *Cryphaea heteromalla*, *Encalypta microstoma*, *Epipterygium tozeri*, *Eurhynchium pumilum*, *Hookeria acutifolia*, *Leptobarbula berica*, *Philonotis rigida*, *Ptychomitrium incurvum*, *Rhynchostegiella teesdalei*, *Taxiphyllum densifolium*.

So, the peculiarities of European part of the former USSR and Caucasus seem rather poor if they are considered alone. However, if to combine these regions, their specificity appears to be much more considerable, and exceeds the number of species confined to Far East (and even Far East + South Siberia) - 156 species. The species common for both European part of the former USSR and Caucasus (absent in the other parts of ex-USSR) are: *Anacamptodon splachnoides*, *Antitrichia*

curtipendula, *Atrichum angustatum*, *Aulacomnium androgynum*, *Brachyodontium trichoides*, *Buxbaumia viridis*, *Campylopus flexuosus*, *C. fragilis*, *Cinclidotus aquaticus*, *Cirriphyllum tommasinii*, *Diphyscium foliosum*, *Eurhynchium crassinervium*, *E. flotovianum*, *E. striatulum*, *Fissidens rivularis*, *Heterocladium heteropterum*, *Hookeria lucens*, *Hygroamblystegium fluviatile*, *Isothecium alopecuroides*, *I. myosuroides*, *Leptodon smithii*, *Metaneckera menziesii*, *Neckera complanata*, *N. crispa*, *N. pumila*, *Plagiomnium undulatum*, *Plagiothecium plathyphyllum*, *P. undulatum*, *Pogonatum aloides*, *P. nanum*, *Pseudoleskea saviana*, *Pterogonium gracile*, *Ptychodium plicatum*, *Racomitrium affine*, *R. elongatum*, *R. macounii* ssp. *alpinum*, *Rhynchostegiella tenella*, *Rhynchostegium murale*, *R. rotundifolium*, *Scorpiurium circinatum*, *Sporledera palustris*, *Thamnobryum alopecurum*, *Tortula latifolia*, *T. papillosa*, *T. vahliana*, *Ulota coarctata*.

However, the number of genera limited to Europe and Caucasus is, nevertheless, smaller, than that of the Far East. These are 20: *Campylostelium*, *Ephemerum*, *Orthodontium*, *Pseudephemerum*, *Crumia*, *Epipterygium*, *Cryphaea*, *Hookeria*, *Leptobarbula*, *Rhynchostegiella*, *Antitrichia*, *Brachyodontium*, *Diphyscium*, *Leptodon*, *Metaneckera*, *Pterogonium*, *Ptychodium*, *Rhynchostegium*, *Scorpiurium*, *Sporledera* (in Far East - 27, or if one counts the genera for Far East + South Siberia - 31).

The further addition to this group of generally European species can be made by 44 species known from Europe + Caucasus + Middle Asia (ambiguous and critical taxa are not listed): *Acaulon triquetrum*, *Barbula enderesii*, *Bartramia halleriana*, *Brachythecium geheebii*, *Camptothecium lutescens*, *Cinclidotus fontinalioides*, *Dicranoweisia cirrata*, *Didymodon tophaceus*, *Encalypta spathulata*, *Entostodon fascicularis*, *Eurhynchium speciosum*, *Fissidens crassipes*, *F. exiguus*, *Grimmia crinita*, *G. orbicularis*, *Herzogiella seligeri*, *Homalothecium aureum*, *H. philippianum*, *H. sericeum*, *Hypnum imponens*, *Orthotrichum diaphanum*, *O. lyellii*, *O. patens*, *O. tenellum*, *Palamocladium euchloron*, *Pleurochaete squarrosa*, *Pottia*

bryoides, *Pseudoscleropodium purum*, *Rhynchostegium megapolitanum*, *Schistidium flaccidum*, *Tortula canescens*, *T. handelii*, *T. inermis*, *T. intermedia*, *T. lingulata*, *T. ruraliformis*, *T. subulata*, *T. virescens*. Also, there are 12 species known in the former USSR only for Caucasus and Middle Asia, the most of them, however, are known also in the Mediterranean part of West Europe: *Crossidium crassinerve*, *C. griseum*, *Encalypta intermedia*, *Entostodon pallescens*, *Fabronia pusilla*, *Fissidens grandifrons*, *Funaria aequidens*, *Leucodon immersus*, *Phascum vlassovii*, *Pleuroweisia schliephackei*, *Tortula atrovirens*, *T. princeps*.

In the Arctic there are 31 species known in the former USSR only from this region. However, most of these taxa need further study. The most interesting are **Didymodon subandraeoides*, *Funaria polaris*, **Pseudoleskea chilensis*, **Rhizomnium gracile*, **Seligeria oelandica*, **Sphagnum arcticum*, *Arctoa anderssonii*, **Heterocladium procurrans*, *Plagiothecium berggrenianum*, *Schistidium tenerum*, **S. cryptocarpum*, *Voitia hyperborea*, and *Geheebia gigantea*, the latter represents the only genus, specific for Arctic region in the territory discussed (but it occurs outside the Arctic in the mountains of Central Europe, Himalayas, Japan and Rocky Mts. of North America). Among the species enumerated above, there is a considerable number, known so far only from the Beringian Arctic (marked by *), which is the best explored part of the Russian Arctic.

However, if one considers the arctic region in a somewhat broadened sense, including species known also from the neighboring regions (Kola Peninsula, Polar Ural Mts., Putorana Plateau), the group of arctic species can be supplemented with *Andreaea blyttii*, *A. nivalis*, *Aongstroemia longipes*, *Aplodon wormskjoldii*, *Brachythecium coruscum*, *B. udum*, *Bryum axel-blyttii*, *Calliargon megalophyllum*, *Cinclidium latifolium*, *C. subrotundum*, *Dicranum angustum*, *Distichium hagenii*, *Funaria arctica*, *Hamatocaulis lapponicus*, *Hypnum subimponens*, *Kiaeria glacialis*, *Molendoa tenuinervis*, *Oligotrichum falcatum*, *Orthotrichum pylaisii*, *Plagiomnium medium*

ssp. curvatulum, *Pseudocalliargon brevifolius*, *Psilopilum cavifolium*, *Racomitrium ericoides*, *Sanionia orthothecioides*, *Schistidium andreaeopsis*, *Tortella arctica*, etc.

The negative specificity (species occurring in all other main regions except this) of the above mentioned regions is as follow. There are practically no "negative species" for Siberia and Europe, except *Brachythecium trachypodium* for Siberia and *Trachycystis ussuriensis* for Europe. Rather moderate is the negative specificity of Caucasus, 13 species, and Far East, where there are no data about 22 species, known however from the all five other main divisions of the former USSR. However, these "negative" groups surely will be reduced by further collections.

The negative specificity of the Arctic is reasonably greater - 39 species, representing obvious southern elements (*Atrichum flavisetum*, *A. undulatum*, *Brachythecium rutabulum*, *Bryum elegans*, *B. subelegans*, *B. uliginosum*, *Dicranella heteromalla*, *Didymodon vinealis*, *Eucladium verticillatum*, *Eurhynchium hians*, *Fabronia ciliaris*, *Funaria muehlenbergii*, *Grimmia tergestina*, *Homalia trichomanoides*, *Hygroamblystegium tenax*, *Hypnum fertile*, *H. pallescens*, *Lescurea mutabilis*, *Mnium heterophyllum*, *M. hornum*, *Orthodicranum flagellare*, *O. montanum*, *Orthotrichum affine*, *O. striatum*, *Physcomitrium pyriforme*, *P. sphaericum*, *Plagiothecium latebricola*, *Pohlia melanodon*, *Racomitrium heterostichum*, *Rhynchostegium riparioides*, *Sphagnum palustre*, *Splachnum ampullaceum*, *Timmiella anomala*, *Tortula laevipila*, *T. sinensis*, *Ulota crispa*, *Weissia brachycarpa*, *W. controversa*).

But the greatest number of negative specificity is in the Middle Asia - 76 species (*Aulacomnium turgidum*, *Blindia acuta*, *Brachythecium latifolium*, *Bryum cryophilum*, *B. imbricatum*, *Buxbaumia aphylla*, *Callicladium haldanianum*, *Calliargon richardsonii*, *Campylium chrysophyllum*, *C. halleri*, *C. hispidulum*, *C. sommerfeltii*, *Catocopium nigratum*, *Cinclidium arcticum*, *Cynodontium polycarpon*, *C. strumiferum*, *Cyrtomnium hymenophylloides*, *Dichodontium pellucidum*, *Dicranella cerviculata*, *D. grevilleana*, *D.*

rufescens, *D. schreberiana*, *Dicranodontium denudatum*, *Dicranum fuscescens*, *D. majus*, *Ditrichum cylindricum*, *D. pusillum*, *Encalypta brevicollis*, *E. procera*, *Grimmia incurva*, *G. muehlenbeckii*, *Hamatocaulis vernicosus*, *Heterocladium dimorphum*, *Hydrogrimmia mollis*, *Hylocomiastrum pyrenaicum*, *Hypnum callichroum*, *H. recurvatum*, *Isopterygiopsis muellerana*, *Kiaeria falcata*, *K. starkei*, *Meesia longiseta*, *M. triquetra*, *Neckera pen-nata*, *Oligotrichum hercynicum*, *Plagiothecium cavifolium*, *P. piliferum*, *Pohlia drummondii*, *P. prolifera*, *Polytrichum formosum*, *P. longisetum*, *P. sexangulare*, *Pseudocalliergon lycopodioides*, *P. trifarium*, *Racomitrium aciculare*, *R. fasciculare*, *R. lanuginosum*, *R. sudeticum*, *Rhytidiadelphus squarrosus*, *R. subpinnatus*, *Sphagnum angustifolium*, *S. balticum*, *S. compactum*, *S. cuspidatum*, *S. fallax*, *S. fimbriatum*, *S. imbricatum*, *S. obtusum*, *S. papillosum*, *S. riparium*, *S. rubellum*, *Splachnum rubrum*, *Tayloria lingulata*, *Thuidium delicatulum*, *Timmia austriaca*, *Tomentypnum nitens*). This enumeration clearly indicates the poority in bogs and wetlands, at least in the area investigated.

THE RELATIONSHIP OF THE MOSS FLORA OF THE REGIONS OF FORMER USSR WITH EACH OTHER

As it was shown above (Table 2), there are five regions within the former USSR where the number of species exceed 500. They are European North-West, European West (most of Ukraine and Moldova), Caucasus, South Siberia and southern part of Far East. In Table 3 are represented the percentage of species in common among each of these five regions, and also Beringian Arctic, with each other regions (number of species in common : number of species in the latter region)¹:

Some considerations can be drawn from

¹ - this simplest coefficient is selected here because it is not affected by differences in number of species in bryofloras, if consider the values *within the single serie* (i.e. in relation to one, selected bryoflora - for example *SIB:S* has 67.8% in common with *EUR: W* (572 species) and nearly the same value, 71.7%, with *EUR: BLR* (334 species); or 85.3% with *ARC: EURO* (361) and 85.2% with *ARC: WS* (237), etc.); the values of different series, however, are uncomparable.

this table by looking at the decreasing of percentage in each column:

1) European North-West has a rather high percentage (> 80%) with most regions, except European West, Crimea (Krym), Caucasus, Middle Asia, South Siberia and southern Far East (72.3 - 59.8 %);

2) European West has a rather strong species relation (> 85 %) with nearby European subdivisions (Central Russia, Belorussia, Baltia, Krym) and also European East, South Ural and Western Siberia. The percentage of species in common is gradually decreases in relation to place farther away (North Ural - 81.4%, European North-East - 78.3%, Caucasus - 77.4%);

3) Caucasus also has a strong connections (> 84.8%) with regions of southern and central parts of European ex-USSR: Krym, European West, Belorussia, Central Russia, European East, South Ural. It gradually decreases in the percentage of common species toward West Siberia (83.2%), Baltia (80.8%), North Ural (80.7%), etc.;

4) South Siberia has a rather high relationship (> 80%) with most of the regions, except the most oceanic (European North-West, Baltia, Belorussia, European West, Krym, Caucasus, southern Far East), and also with Middle Asia (despite the neighboring position of the latter);

5) Southern part of Far East has a weak relation with nearly all the regions, except West Siberia (86.4%) and East Siberia (82.0%). Even with neighboring Northern part of Far East (75.7%) and South Siberia (67.3%) have only a rather weak relation with Southern Far East. The higher percentage for West and East Siberia can be explained by their rather poor and unspecific moss flora (mainly, as I understand, because of under-exploration);

6) Beringian Arctic is connected with other Arctic regions stronger than with any other (80.4 - 83.6%), somewhat weaker with Northern Far East (76.3%) and so on.

These six relationships can be grouped into 2 natural patterns - some regions have stronger relations with nearby regions/weaker with remote, while other - stronger with relatively remote regions (belonging

Table 3. Percentage of species in common between regions of the former USSR (see also Figs. 4-9).

Region (in brackets - number of species)	Percent of species in common with:					
	EUR:NW	EUR:W	CAUC	SIB:S	FAR EAST:S	ARC:BE
ARC						
EURO (361)	<u>90.0</u>	70.7	72.6	<u>85.3</u>	70.4	<u>80.7</u>
WS (237)	<u>89.9</u>	71.0	71.7	<u>85.2</u>	71.4	<u>83.6</u>
ES (371)	<u>82.7</u>	64.3	68.5	<u>83.0</u>	62.2	<u>80.4</u>
BE (390)	<u>80.5</u>	62.3	66.7	<u>81.5</u>	58.8	<u>100</u>
EUR						
NW (554)	<u>100</u>	74.5	74.4	72.9	59.9	56.7
NE (374)	<u>89.8</u>	78.3	77.0	<u>85.8</u>	73.0	64.4
N-UR (311)	<u>93.9</u>	81.4	80.7	<u>91.6</u>	76.5	74.6
B (453)	<u>85.7</u>	<u>86.3</u>	80.8	71.3	64.0	47.2
BLR (334)	<u>85.3</u>	<u>94.6</u>	<u>88.0</u>	71.7	70.1	45.8
C (351)	<u>87.5</u>	<u>91.7</u>	<u>86.0</u>	<u>80.0</u>	73.2	50.4
W (572)	72.2	<u>100</u>	<u>84.8</u>	67.8	58.0	43.2
K (253)	71.1	<u>91.7</u>	<u>98.0</u>	66.8	70.8	39.1
E (243)	<u>85.2</u>	<u>97.5</u>	<u>96.3</u>	<u>86.4</u>	77.8	57.6
S-UR (363)	<u>88.9</u>	<u>88.7</u>	<u>87.3</u>	<u>89.3</u>	78.5	59.5
CAUC (627)	64.8	77.4	<u>100</u>	64.0	53.4	41.5
SIB						
W (286)	<u>93.7</u>	83.6	83.2	<u>93.4</u>	<u>86.4</u>	69.9
E (399)	<u>84.7</u>	69.2	70.9	<u>85.0</u>	<u>82.0</u>	70.7
S (560)	72.3	67.5	71.6	<u>100</u>	67.3	58.6
FAR EAST						
N (321)	<u>87.2</u>	73.2	72.9	<u>85.0</u>	75.7	76.3
S (555)	59.8	59.8	60.4	67.4	<u>100</u>	42.0
MID AS (489)	59.3	67.3	76.3	66.9	50.1	43.4

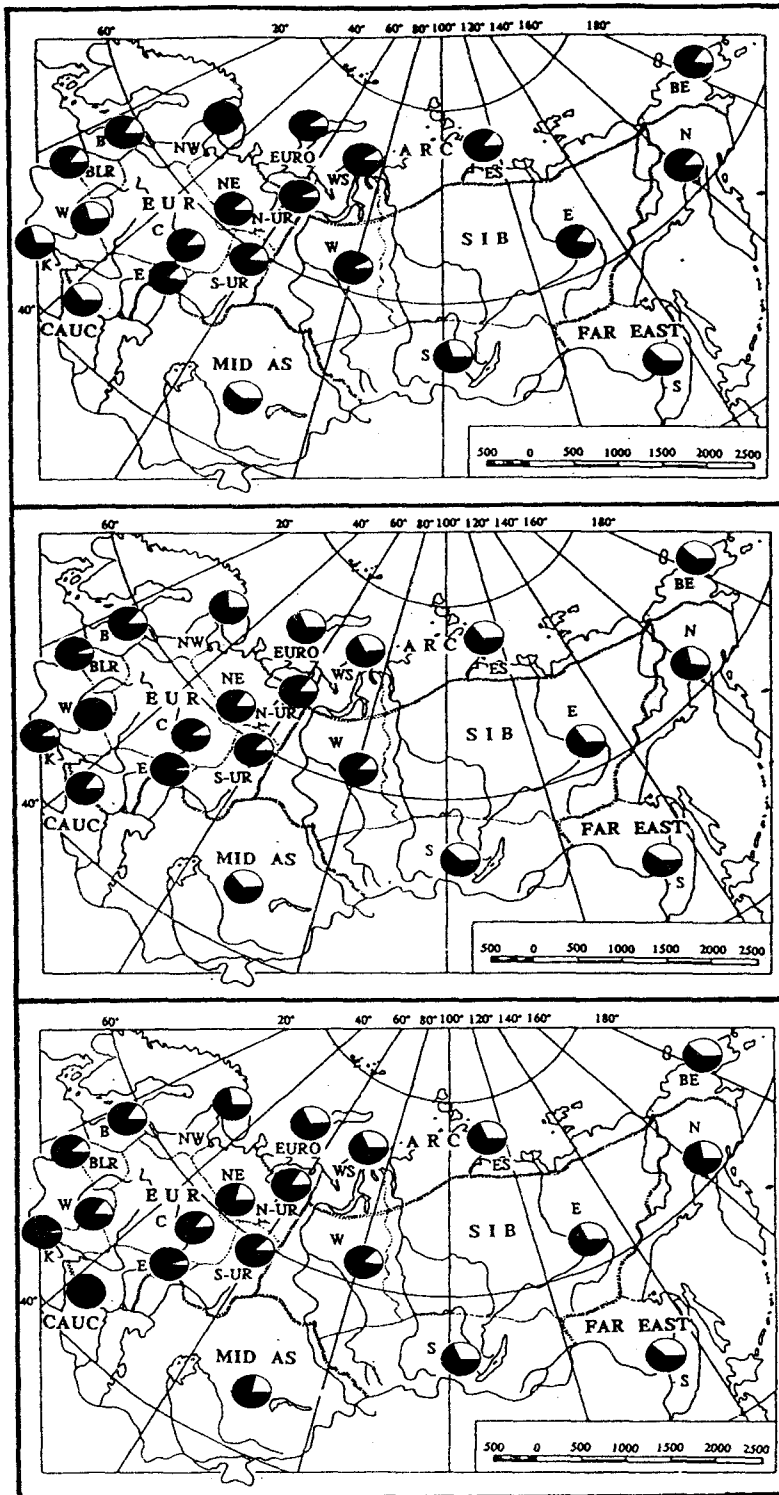
to the same zone)/ and weaker with nearby (belonging to another zone):

1) European West and Caucasus (Figs. 5 - 6) have stronger connections with nearby regions, and a much weaker connections with more remote places; the South of Russian Far East (Fig. 8) probably also belongs to this group, but it has weak connections with any region of the former USSR, except West and East Siberia;

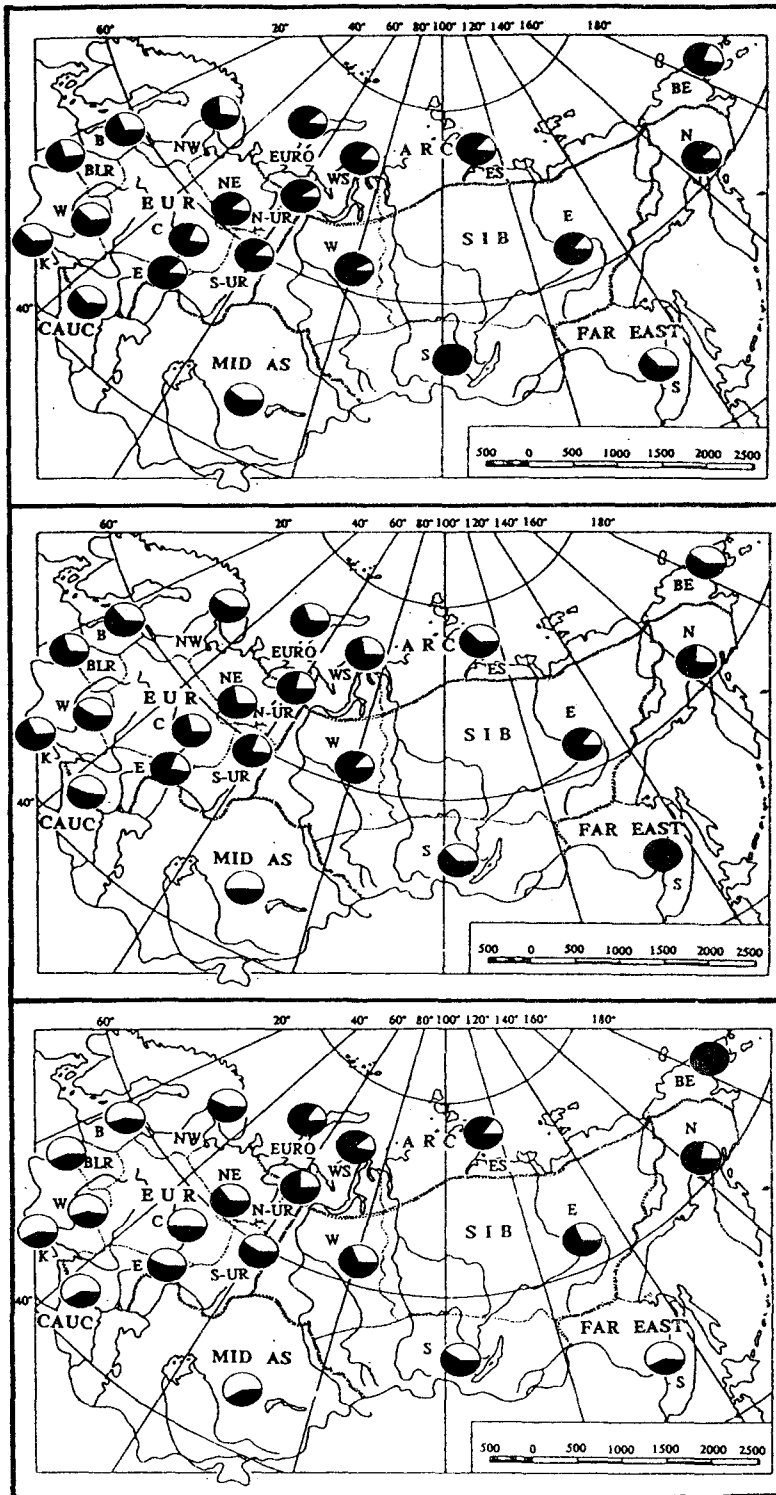
2a) European North-West (Fig. 4) and South Siberia (Fig. 7) have rather uniformly high correlations with many relatively remote regions in the boreal and arctic zones, including ARC: EURO, WS, ES, BE; EUR: NE, N-UR, C, E, S-UR; SIB: W, E; FAR

EAST: N. Other zone has less in common with European North-West and South Siberia; it includes the regions where deciduous forests are widespread: EUR: B, BLR, W, K; CAUC; MID AS; FAR EAST: S. It is usually considered as nemoral, or temperate. Though this zone is not so consistent as the boreal one, moss floras of its regions have rather much in common with each other, but often at the level higher than species. The main nucleus of this nemoral flora was discussed by Lazarenko (1944), when he analyzed the moss flora of the Soviet Far East;

2b) Beringian Arctic also has stronger connections with more remote zonal arctic floras and weaker - with nearby



Figs. 4 - 6. Percent of moss species in common with moss flora of (4) European North-West, (5) European West, (6) Caucasus. See also Tab. 3.



Figs. 7 - 9. Percent of moss species in common with moss flora of (7) South Siberia, (8) southern Russian Far East, (9) Beringian Arctic. See also Tab. 3.

boreal floras. The fact that arctic floras have the high percentage of similarity with *EUR: NW* and *SIB: s* means just that most of the arctic environmental diversity is represented in these two regions, where mountains occupy a considerable territories. Therefore, delimitation of Arctic zone from Boreal zone is based on its rather negative specificity.

Summarizing, three zonal types of moss floras can be segregated, basing on above analysis: Arctic, Boreal and Nemoral, or Temperate. It is important, however, that nearly a half of species of boreal floras have very wide ranges of distribution, well exceeding the Holarctic. So, despite the fact that moss floras of the most part of the former USSR are classifying as boreal, the number of really boreal species, more or less strongly limited to boreal biota, is rather low.

ELEMENTS OF BRYODIVERSITY

After the above overview we can try to expand on the moss diversity across the territory of the former Soviet Union (Fig. 2) and group moss species into a number of elements (which are illustrated by some characteristic species on Figs. 10-49). The most of them can be classified into four groups:

- I. Widespread throughout the former USSR;
- II. Alpine and mountain species;
- III. "Circum-zonal species", limited in their geographical distribution to some zone (arctic, boreal, nemoral (temperate), arid), but occurring within these zones more or less evenly throughout the Holarctic or Eurasia;
- IV. Western and Eastern species, limited in their range or strongly preferring one of oceanic sides of Eurasia.

I. **WIDESPREAD SPECIES** of average conditions of forest zone form a medium, which makes most of moss floras of all the territories to be of no less than 100-150 species rich, except some xeric areas of the South-East Europe (region of the Lower Volga River), Middle Asia, some parts of Eastern Caucasus. Most of species of this group occur also in tundra, though some of them are not so common there. In total, about 200 species.

Examples: *Abietinella abietina*, *Brachythecium rivulare*, *Bryoerythrophyllum recurvirostrum*, *Cratoneuron filicinum*, *Dicranum scoparium*, *Drepanocladus aduncus*, *Leskeella nervosa*, *Orthotrichum obtusifolium*, *O. speciosum*.

Examples: *Aongstroemia julacea*, *A. orientalis*, *Campylopus schimperi*, *C. schwarzii*, *Arctoa fulvella*, *Hylocomiastrum umbratum*, *Loeskeobryum brevirostre*, *Andreaea obovata*, *Amblyodon dealbatus*, *Tetradontium repandum*, *Bryoerythrophyllum inaequalifolium*, *Plagiobryum zieri*, *Coscinodon cribrosus*, *Cnestrum schistii* (Figs. 10-12).

II. **MONTANE AND ALPINE SPECIES** - this group includes species of different vegetational zones, but obviously limited in their distribution to mountains (with somewhat broader distribution in oceanic climates). The explanation of their range obviously relate to more diverse and in average more mild climatic conditions, favouring the surviving of these species, which are considered as relicts in many areas. In total, about 100 species.

III. **CIRCUM-ZONAL SPECIES.**

III. A. ARCTIC AND ARCTO-ALPINE SPECIES.

III. A. 1. **Arctic species**, confined in their distribution to the Arctic Floristic Province (Yurtsev & al., 1978) only, or occurring also in neighboring regions of Kola Peninsula, Polar Ural Mts., Putorana Plateau in Eastern Siberia. In total, ca. 50 species.

Examples: *Plagiothecium berggrenianum*, *Schistidium tenerum*, *Voitia hyperborea*, *Aplodon wormskjoldii*, *Cinclidium latifolium*, *C. subrotundum*, *Dicranum angustum*, *Hamatocaulis lapponicus*, *Kiaeria glacialis*, *Oligotrichum falcatum*, *Pseudocalliergon brevifolius*, *Psilopilum cavifolium*, *Schistidium andreaeopsis* (Fig. 15).

III. A. 2. **Arcto-Alpine species**. The well-known pattern. It is, important to note are that the considerable part of species, typically growing in high mountains above timber-line, occur sporadically in same mountains on lower altitudes in deep canyons, on cliffs, and so on. In total, about 100 species.

Examples: *Dicranella subulata*, *Cono-*

stomum tetragonum, *Andreaea rupestris*, *Bartramia ithyphylla*, *Desmatodon latifolius*, *Dicranoweisia crispula*, *Lescuraea saxicola*, *Orthothecium chryseon*, *Paraleucobryum enerve*, *Polytrichastrum alpinum*, *Racomitrium lanuginosum*, *Sarmentypnum sarmentosum* (Figs. 13-14).

III. B. BOREAL SPECIES. Though traditionally the main part of species in foras of boreal zone was considered as boreal, I think that the number of species with distribution more or less confined to boreal zone is probably no more than 30.

Examples: *Tetraphis pellucida*, *Tetraplodon angustatum*, *Splachnum rubrum*, *S. ampullaceum*, *Buxbaumia aphylla*, *Schistostega pennata*, *Rhytidiadelphus subpinnatus*, *Brachythecium oedipodium* (Figs. 16-18).

III. C. PAN- OR EURASIAN NEMORAL (temperate) species have usually the latitudinal northern limit, at about 58-62° N. In total, about 70 species.

Examples: *Homalia trichomanoides*, *Dicranum viride*, *Anomodon longifolius*, *Dicranella heteromalla*, *Callicladium haldanianum*, *Atrichum undulatum* s.l., *Fissidens taxifolius*, *Eurhynchium angustirete*, *E. hians*, *Platygyrium repens* (Figs. 19-21).

III. D. XERIC SPECIES are mostly confined in the former USSR to the desert zone of Middle Asia, but some species have wider distribution, penetrating to steppe and forest zones by xeric rocky slopes and other suitable habitats. In total, ca. 70 species.

Examples: *Tortula atrovirens*, *T. handelii*, *T. inermis*, *T. pagorum*, *T. caninervis*, *Entostodon fascicularis*, *E. handelii*, *E. hungaricus*, *Crossidium squamiferum*, *C. crassinerve*, *Pterygoneurum ovatum*, *P. subsessile*, *Grimmia tergestina*, *G. plagiopodia*, *G. pitardii*, *Aloina rigida*, *Anacolia webbii*, *Fabronia ciliaris* (Figs. 22-24).

IV. OCEANIC SPECIES. In zonal aspect most of the representatives of this group are a temperate species, but contrary to the previous circum-zonal group, these species are limited or strongly preferring one of the oceanic sides of Eurasia. Many species are comprising the classical disjunctions between Europe and Western North America, and between East Asia and Eastern North

America. These disjunctions need some comments. Usually lists of these bicentric disjuncts are carefully rectifying from species known from other regions, even by a single collection (cf. Iwatsuki, 1992). Indeed, it is an important account. But here I'd like to underline more similarities between western sides of Eurasia and North America, as well as between eastern sides of both continents. Many species of formally tri- or polycentric distribution are very common in either Western North America & Europe, or Eastern North America & East Asia, being much rarer in all the other regions. For example, *Aulacomnium androgynum*, *Isothecium myosuroides*, *Grimmia pulvinata* are very common in Western North America and Europe, being very rare in the East of both Eurasia and North America. In parallel way *Bryhnia novae-angliae*, *Grimmia pilifera* are common species in Russian Far East, Japan and China and Eastern North America, but extremely rare or absent in Europe and Western North America. My conception of Wests and Easts in such broadened sense can be illustrated by pairs of *Grimmia pulvinata*/*G. pilifera* (Figs. 46 - 47) and *Hookeria lucens*/*H. acutiloba* (Figs. 48 - 49). In many cases Eastern (within Holarctic) species are widespread in tropical zone (cf. *Herpetineuron toccoae*), while Western - known from many regions of Southern Hemisphere.

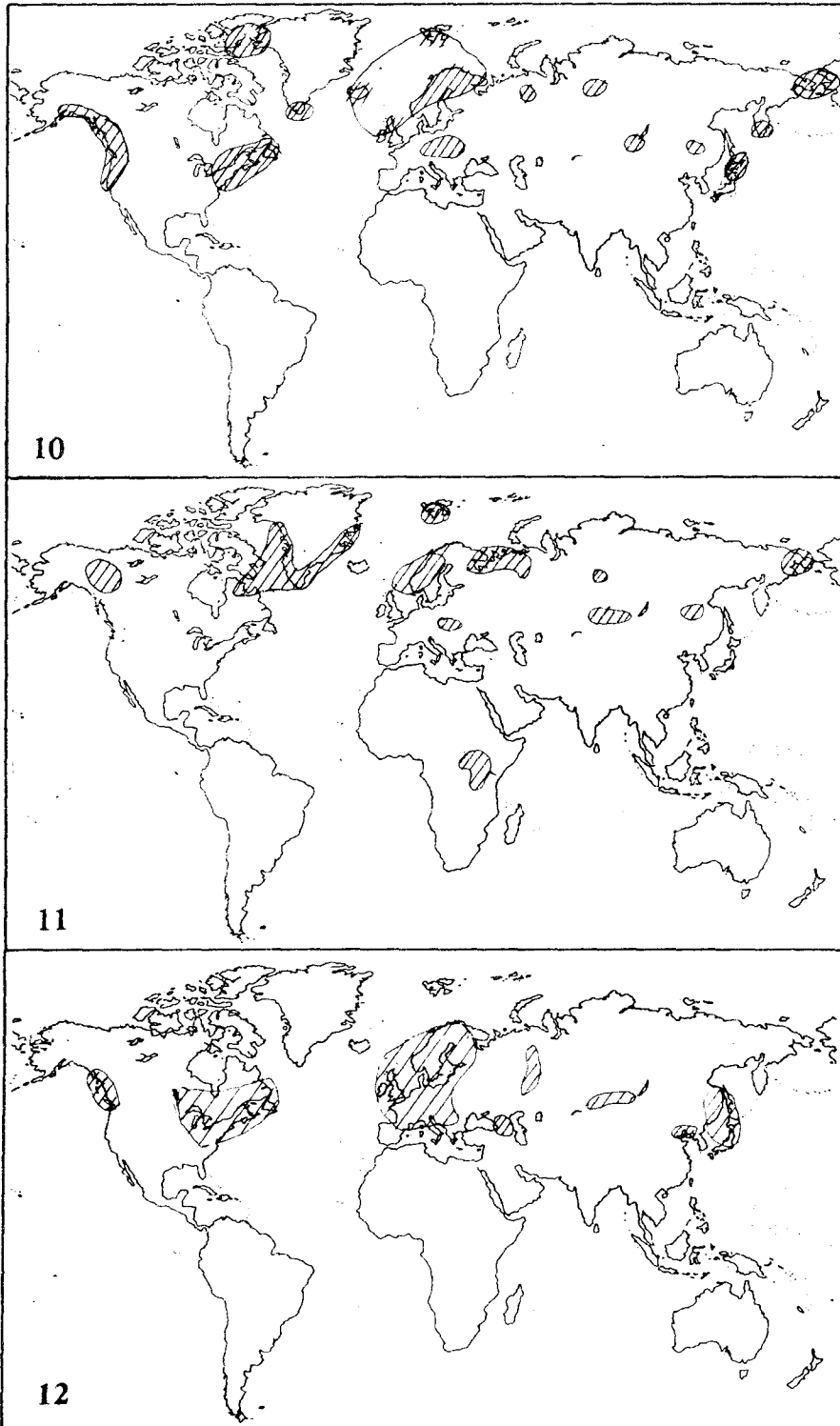
IV. A. WESTERN SPECIES. Diverse group, composed of at least four distinct subgroups. In total, about 200 species.

IV. A. 1. European endemics or subendemics (occurring in neighboring North Africa and West Asia).

Examples: *Cinclidotus danubicus*, *Cryphaea heteromalla*, *Eurhynchium pumilum*, *E. crassinervium*, *E. striatulum*, *Rhynchostegiella tenella*, *R. teesdalei*, *Cirriphyllum tommasinii*, *Neckera pumila*, *Scorpiurium circinatum*, *Brachythecium geheebii* (Figs. 25-27).

IV. A. 2. Amphiatlantic species.

Examples: *Anomodon rostratus*, *Anacamptodon splachnoides*, *Diphyscium foliosum*, *Neckera complanata*, *Homalothecium sericeum*, and a very few others (Figs. 28-30).



Figs. 10 - 12. Distribution of (10) *Arctoa fulvella* (in part after Schofield, 1972), (11) *Andreaea obovata* (after Murray, 1987, completed), (12) *Hylocomiastrum umbratum* (after Ochyra & al., 1992b).

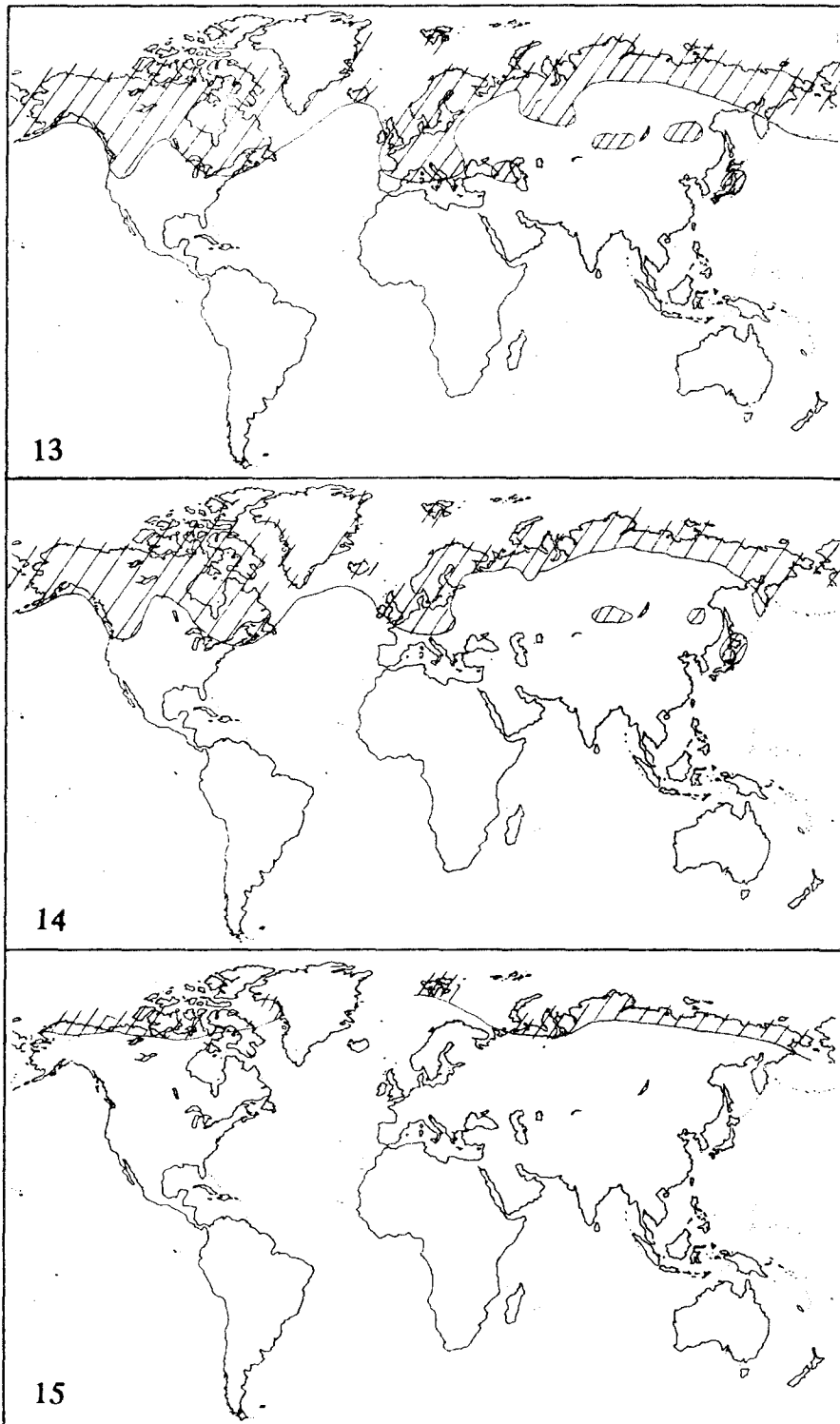
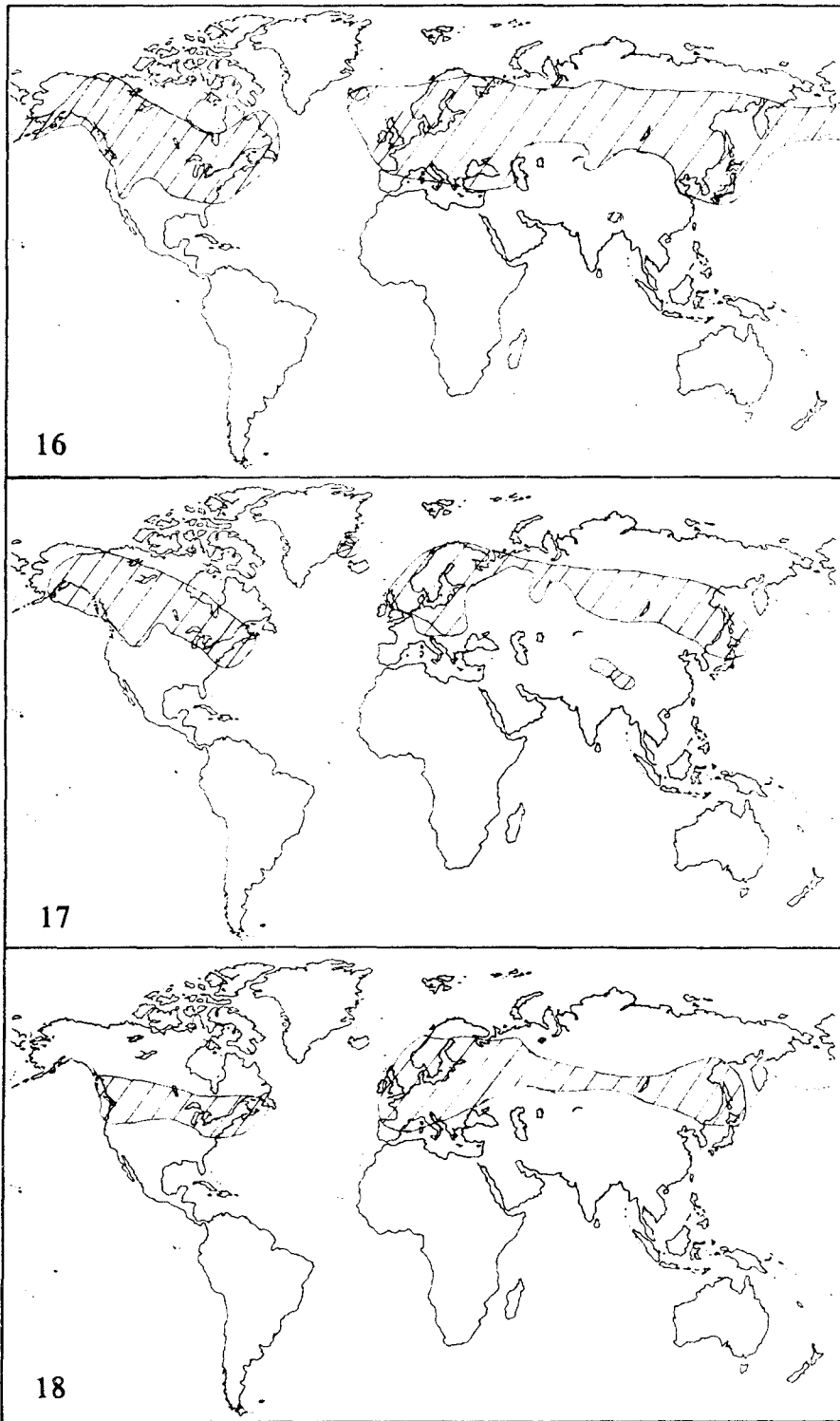
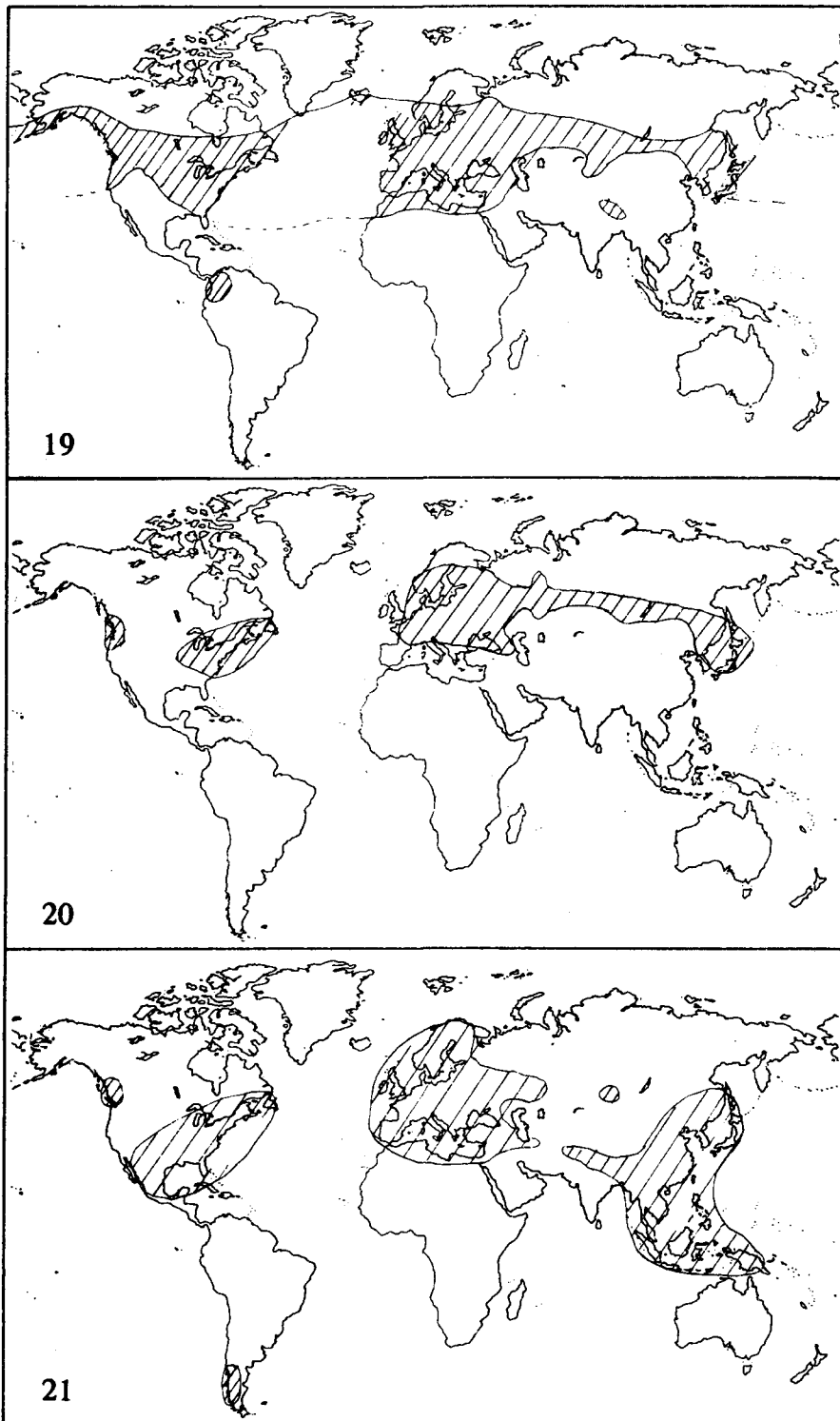


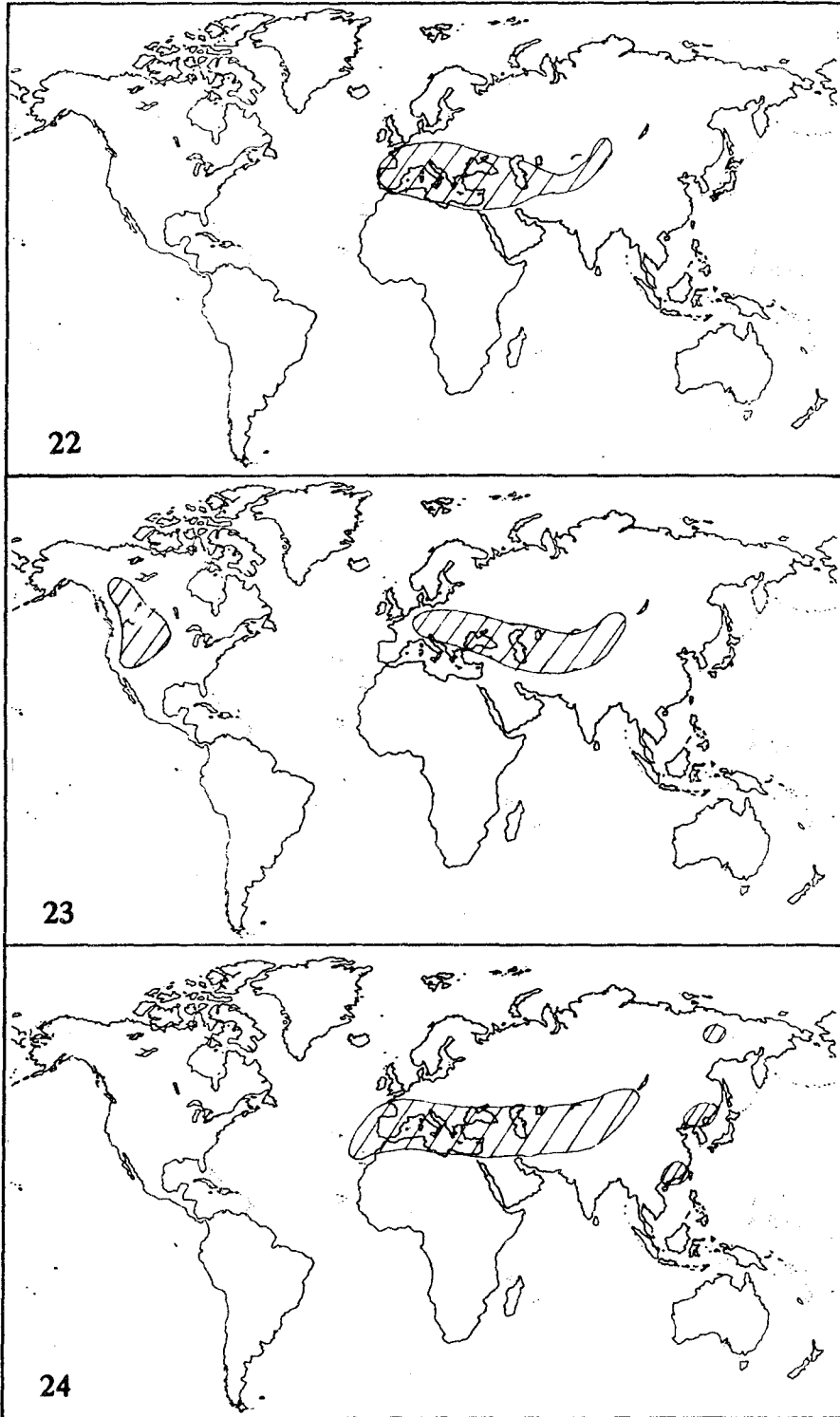
Fig. 13 - 15. Distribution of (13) *Dicranella subulata*, (14) *Conostomum tetragonum*, (15) *Plagiothecium berggrenianum* (in part after Ireland, 1986).



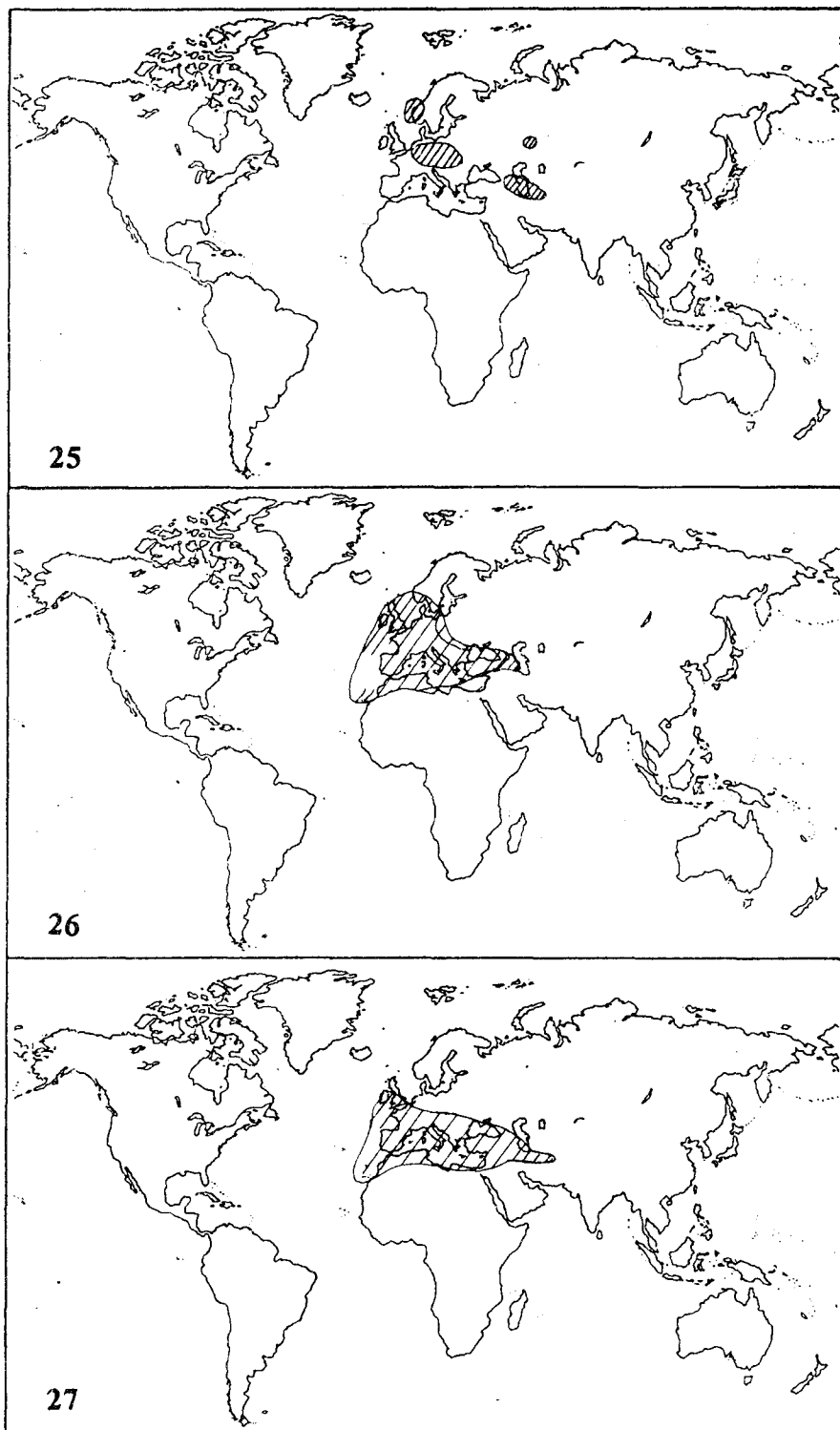
Figs. 16 - 18. Distribution of (16) *Tetrapiodon pellucida* (in part after Schofield, 1972), (17) *Tetrapiodon angustatum* (after Szmajda & al. 1991, completed), (18) *Schistostega pennata*.



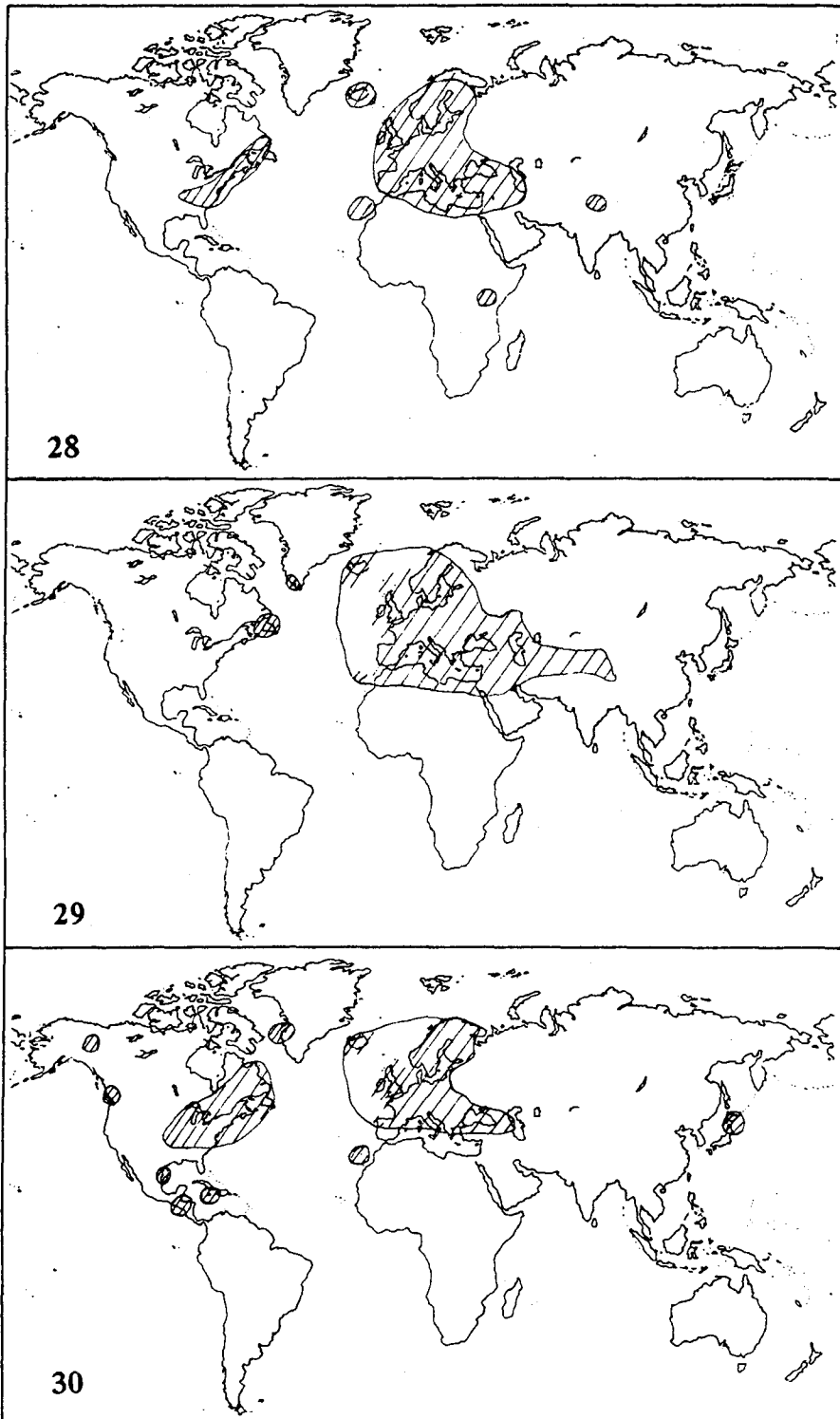
Figs. 19 - 21. Distribution of (19) *Dicranella heteromalla*, (20) *Callicladium haldanianum*, (21) *Fissidens taxifolius*.



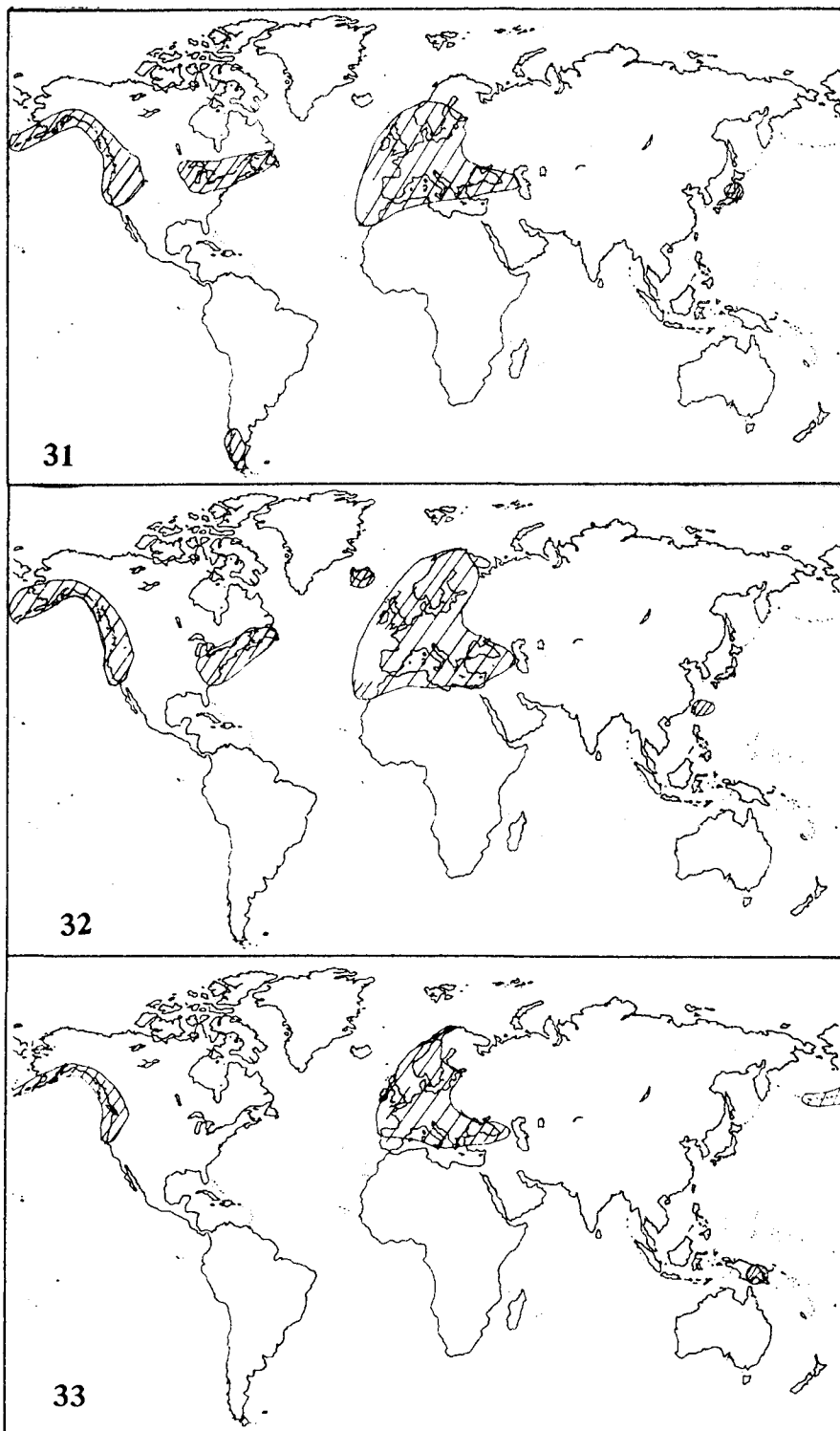
Figs. 22 - 24. Distribution of (22) *Homalothecium philippeanum*, (23) *Grimmia plagiopodia*, (24) *Grimmia tergestina*.



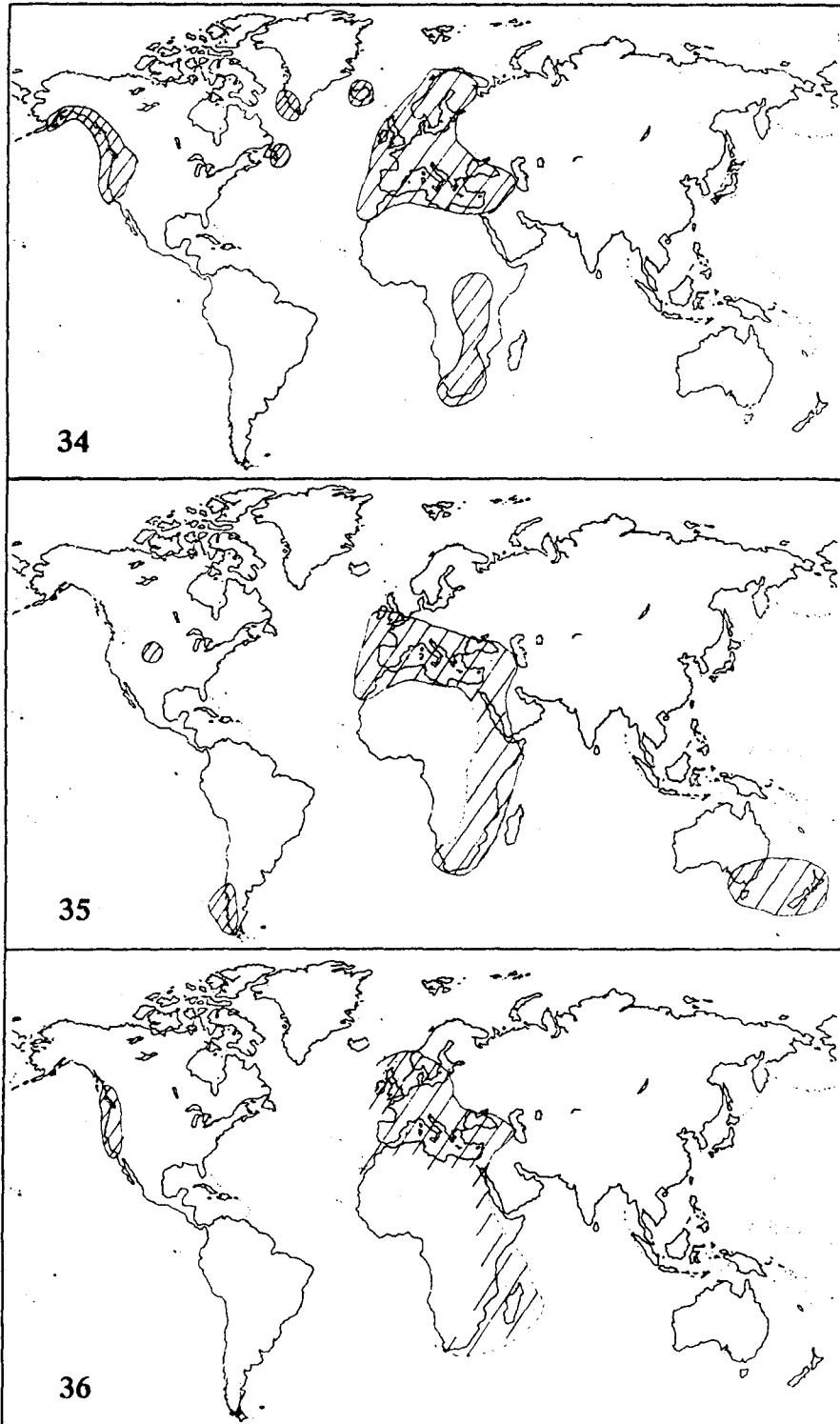
Figs. 25 - 27. Distribution of (25) *Brachythecium geheebii* (after Ochyra & Szmajda, 1983, completed), (26) *Eurhynchium pumilum* (after Stoermer, 1969, completed), (27) *Scorpiurium circinatum*.



Figs. 28 - 30. Distribution of (28) *Neckera complanata* (after Ochyra & al., 1988, completed), (29) *Homalothecium sericeum*, (30) *Diphyscium foliosum* (after Ochyra & al., 1990, completed).



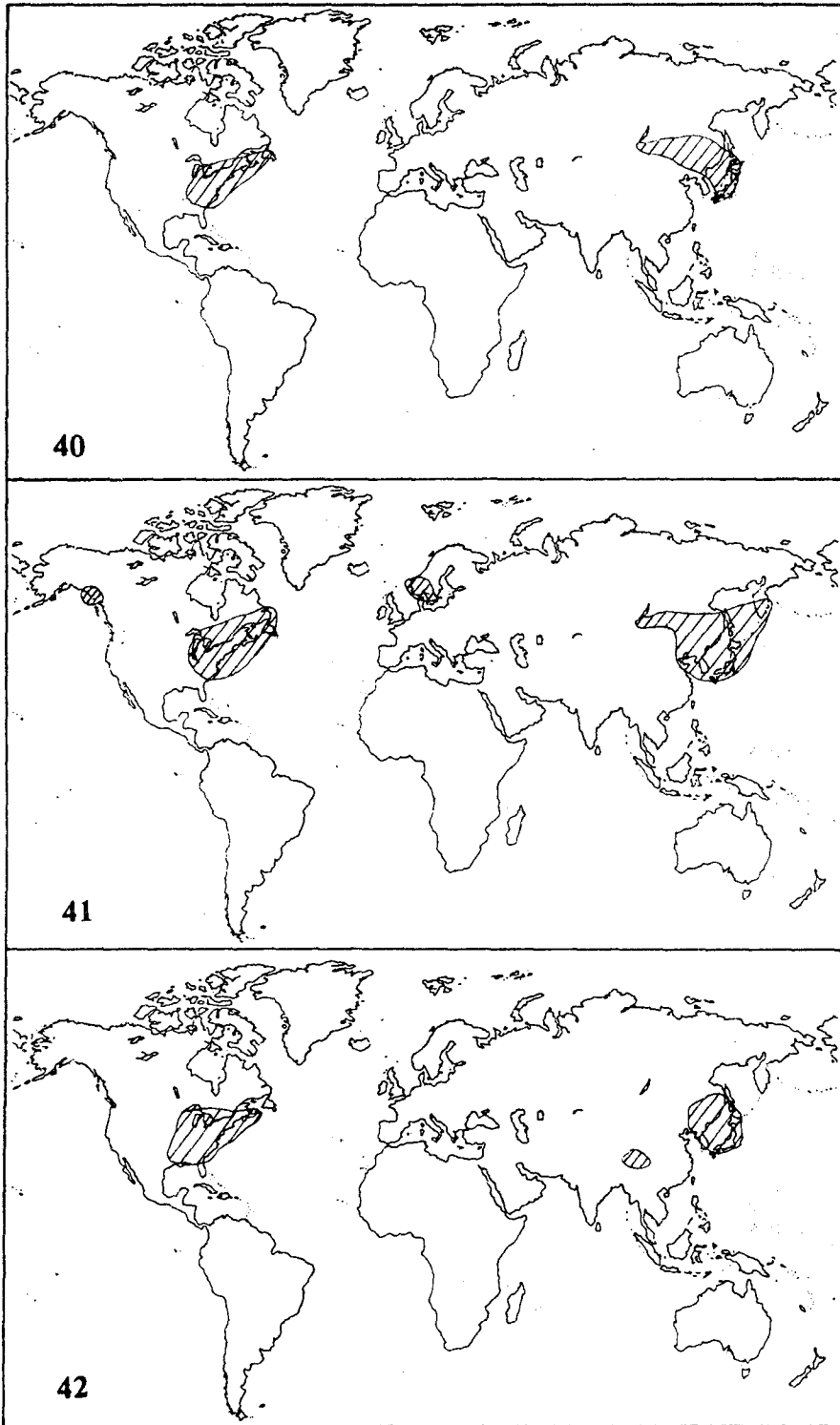
Figs. 31 - 33. Distribution of (31) *Aulacomnium androgynum* (in part after Stoermer, 1969), (32) *Isoetecium myosuroides* (Stoermer, l.c. and others), (33) *Plagiothecium undulatum* (after Ireland, 1986 and Ochyra & al., 1990).



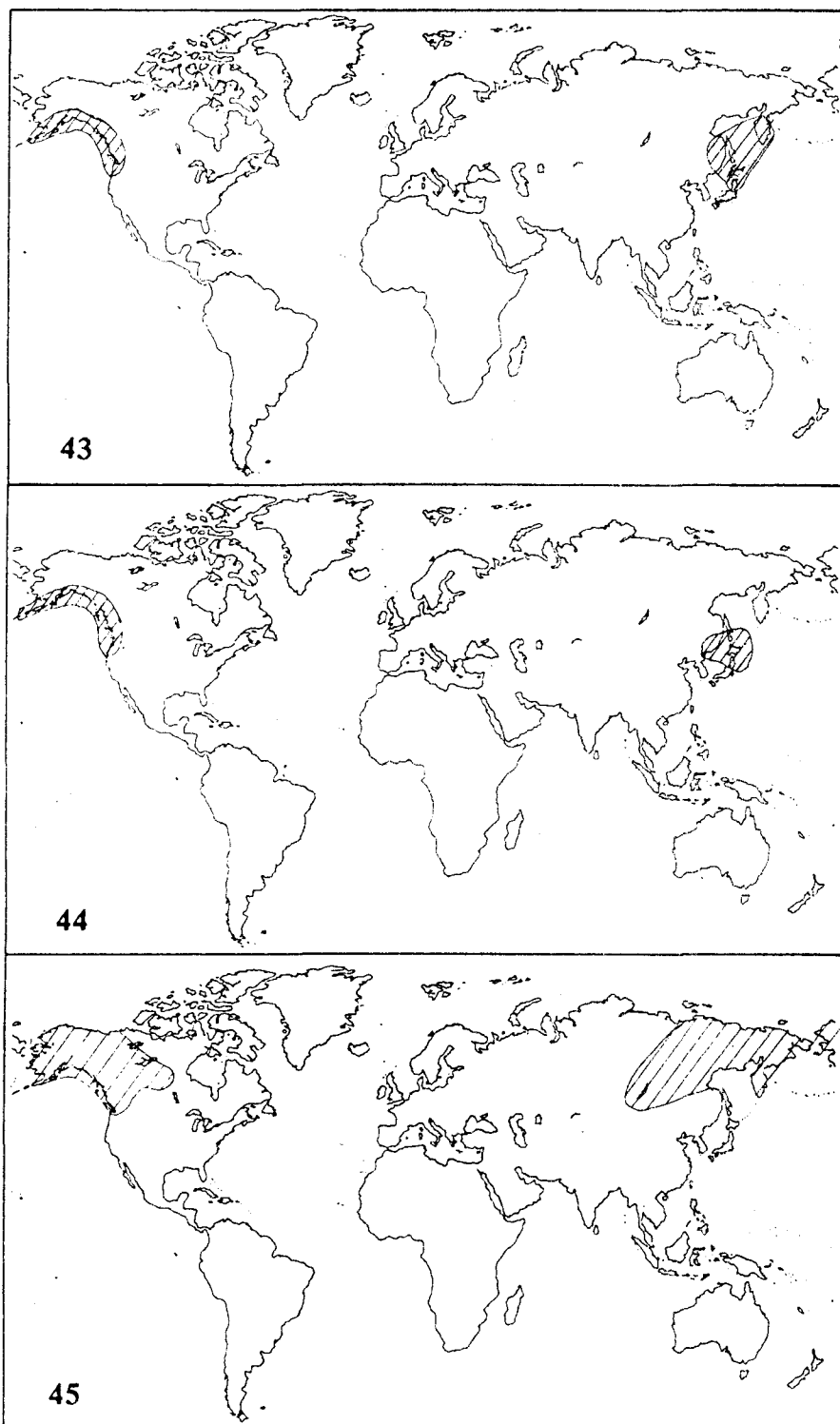
Figs. 34 - 36. Distribution of (34) *Antitrichia curtispindula* (in part after Schofield, 1972 and Stoermer, 1969, completed), (35) *Leptodon smithii*, (36) *Pterogonium gracile* (in part after Stoermer, 1969).



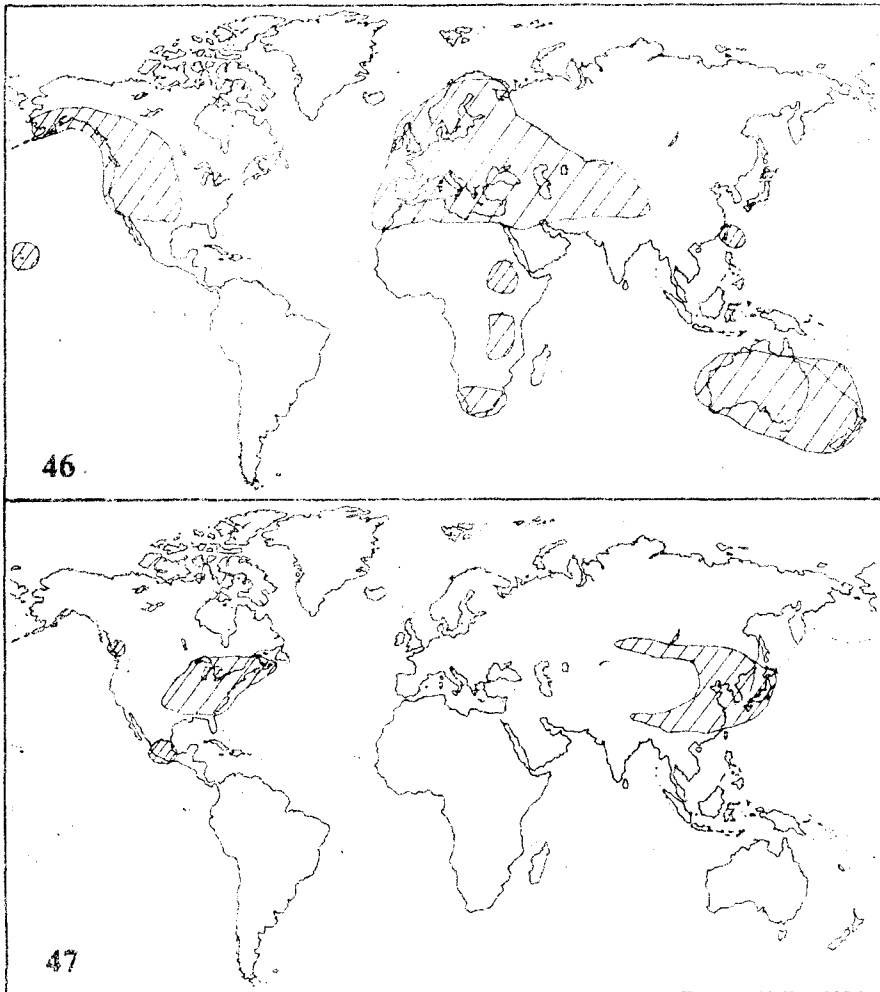
Figs. 37 - 39. Distribution of (37) *Eurohypnum leptothallum* (in part after Wu, 1992 and Abramov & Abramova, 1983), (38) *Brachythecium wichurae*, (39) *Actinothuidium hookeri* (in part after Wu, 1992).



Figs. 40 - 42. Distribution of (40) *Pylaisiadelpha tenuirostris*, (41) *Bryhnia novae-angliae*, (42) *Aulacomnium heterostichum* (after Janssens & al., 1979).



Figs. 43 - 45. Distribution of (43) *Oligotrichum parallelum*, (44) *Pleuroziopsis ruthenica*, (45) *Aulacomnium acuminatum*.



Figs. 46 - 47. Distribution of (46) *Grimmia pulvinata*, (47) *Grimmia pilifera* (after Iwatsuki, 1972 and Cao & Vitt, 1986, completed).

IV. A. 3. European - Western North American disjuncts

Examples: *Dicranoweisia cirrata*, *Crumia latifolia*, *Buxbaumia viridis*, *Hookeria lucens*, *Metaneckera menziesii*, *Encalypta spathulata*, *E. mutica*, *Herzogiella seligeri*, *Orthotrichum lyellii* (Figs. 31-33).

IV. A. 4. Widespread species, but in Holarctic their main areas are on the West of Eurasia (a) or on the Wests of Eurasia and North America (b)

Examples: (a) *Philonotis rigida*, *Bartramia stricta*, *Leptodon smithii*, *Plagiomnium undulatum*; (b) *Aulacomnium androgynum*, *Plagiothecium undulatum*, *Bartramia halleriana*, *Antitrichia curtispindula*, *Pterogonium gracile*, *Isothecium myosuroides*

(Figs. 34-36).

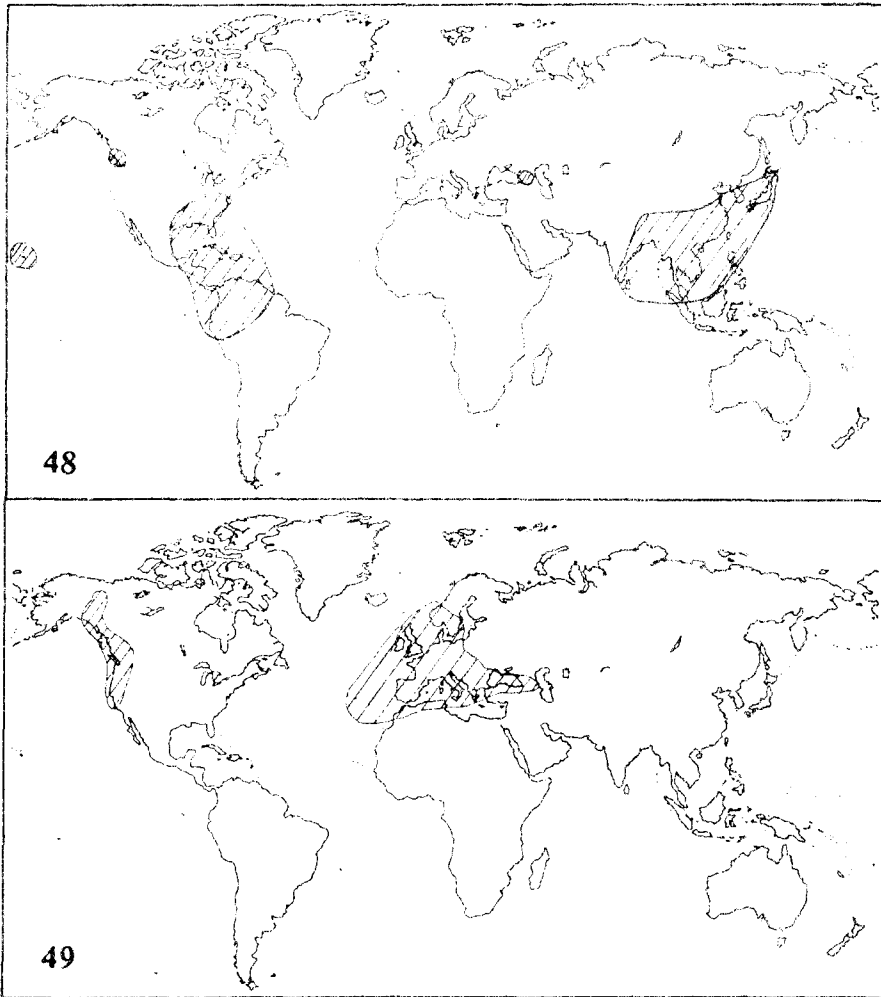
IV. B. EASTERN SPECIES also represent at least four distinct groups. In total about 180 species.

IV. B. 1. East Asian Species.

Examples: *Actinothuidium hookeri*, *Fauriella tenuis*, *Dozya japonica*, *Climacium japonicum*, *Leucodon pendulus*, *Anacamptodon latidens*, *Eurohypnum leptothallum*, *Plagiothecium obtusissimum*, *Rhizomnium striatulum*, *R. parvulum*, *Pseudoleskeopsis zippellii* (Figs. 37-39).

IV. B. 2. East Asian - Eastern North American disjuncts.

Examples: *Aulacomnium heterostichum*, *Brothera leana*, *Buxbaumia minakatae*, *Ano-*



Figs. 48 - 49. Distribution of (48) *Hookeria lucens* (in part after Schofield, 1972 and Stoermer, 1969), (49) *Hookeria acutifolia* (after Iwatsuki, 1972, completed).

modon minor, *A. thraustus*, *Helodium paludosum*, *Entodon sullivanii* *Pylaisiadelphina tenuirostris*, *Forsstroemia trichomitria* (Figs. 40, 42). For complete list see Iwatsuki (1992).

IV. B. 3. North-Pacific species.

Examples: *Bartramiopsis lescurii*, *Oligotrichum parallelum*, *O. aligerum*, *Rhizomnium nudum*, *Pleuroziopsis ruthenica*, *Leptopterigynandrum austro-alpinum*, *Scouleria aquatica*, *Claopodium crispifolium*, *C. pellucinerve*, *Gollania turgens* (Figs. 43-45). For more examples see Iwatsuki (1972).

IV. B. 4. More widespread species, occurring in Holarctic generally on East of both Eurasia and North America.

Examples: *Bryhnia novae-angliae*, *Grimmia*

pilifera, *Hookeria acutiloba*, *Taxiphyllum alternans*, *T. taxirameum*, *Herpetineuron toccoae* (Figs. 42, 49).

V. ENDEMIC SPECIES. At present there are known only two endemic genera from the territory of the former USSR: *Mamillariella*, with a single species, distributed in several localities of the South Far East, and *Orthodontopsis*, also monotypic, strictly confined to the upper taiga zone in Altai and Sayan Mts., South Siberia. The most of endemic species, at present, need to be additionally revised, since very few recent studies were undertaken on them. As the "good" species I can mention now *Myuroclada rotundifolia*, *Forsstroemia stricta*, *Cinclidium minutifolium*, and a few others. It

is worthy to note, that these species belong to small, recently revised genera and are known so far from a few localities in forest zone of Asian part of the former USSR.

About 10 % of species are difficult to link to either one of the above groups. They can be attributed to various smaller groups, but here I'm leaving them unclassified.

Overlapping the above types of distribution one can see the general pattern of diversity shown on Fig. 2 (p. 15). Some less diverse area in respect to mosses, however, can not be detected by using such a rather general method only.

A more detailed and more formal model of the bryodiversity of the territory of the former USSR would need additional explorations of the mosses, especially in its Asiatic part. Also it hardly can be successful without a correlation of all the taxa throughout the whole Holarctic, and also without considering all of its territory.

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