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Communities and species of Isoëto-Nanojuncetea in Poland – syntaxonomic classification, distribution and current state of research

by

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Abstract: The current state of research on phytosociology and phytogeography of the Isoëto-Nanojuncetea class in Poland is discussed. In the aspect of syntaxonomic research, the recognition of communities of the class has been found unsatisfactory, whereas the distribution of the character species of the class seems to be sufficiently known. There are eight types of communities belonging to the Isoëto-Nanojuncetea class in Poland, but only three of them have appropriate phytosociological documentation. All communities of the class growing in Poland have the depauperated appearence, which is presumably a result of their development on the limits of their ranges and/or their occurrence in unstable habitats. The phytogeographical study has provided description of several types of distribution of character species of the Isoëto-Nanojuncetea class in Poland. The paper also provides a table of syntaxonomic classification of the communities in Poland and maps of distribution of certain species.

Introduction

In Poland, communities and species belonging to the Isoëto-Nanojuncetea class Br.-Bl. et Tx. 1943 have been objects of interest for many years. Studies have mainly concerned two issues: (1) recognition and classification of communities, and (2) description of distribution of the character species.

KORNAŚ (1960) and WÓJCIK (1968) have started the phytosociological research and were the first to publish the phytosociological relevés from southern and central Poland and give some methodical suggestions concerning both field work and classification. Communities of the Isoëto-Nanojuncetea class do not play a significant role in the vegetation of Poland. That reason as well as difficulties in carrying out the field study probably affected the extent of research and only a few papers concerning them as a whole have been published. Recently numerous relevés of the communities have appeared (e.g. WARCHOLIŃSKA 1974, 1981; LOSTER 1976; BRZEG & RATYŃSKA 1983; BORYSIAK & RATYŃSKA 1984; BORYSIAK & RATYŃSKA-NOWAK 1986; WNUK 1989; TRĄBA 1991), however generally they

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document depauperated (degenerated) communities only or communities representing the Radiolion alliance, growing exclusively in arable fields. Communities of the Elatini-Eleocharition ovatae were not well documented, for example the data on the Heleocharetum ovatae association were published only once – from the Oświęcim Basin (ZAJĄC M. & ZAJĄC A. 1988).

Phytogeographical research on the species representing various units of the Isoëto-Nanojuncetea class started before WW2. The pioneer of those studies was CZECZOTTOWA (1928), who prepared maps of distribution of species belonging to the Atlantic element, among others: *Illecebrum verticillatum*, *Elatine hexandra*, *Hypericum humifusum*, *Radiola linoides* and *Sagina subulata*. In the post-war years maps of other species from the class were published successively (e.g. ŻUKOWSKI 1969, 1975; ZAJĄC E.U. & ZAJĄC A. 1974; ZARZYCKI & KAŻMIERCZAKOWA 1993).

In 1997 the first attempt at numerical classification of communities of the Isoëto-Nanojuncetea class was made (POPIELA 1997). It was based on the above data and own results of the author concerning the communities of the Elatini-Eleocharition ovatae alliance (POPIELA 1996a). Simultaneously, on the request of the editors of the "Atlas of distribution of the vascular plants in Poland (ATPOL)" a study on the distribution of the character species of each syntaxonomic unit of the class was launched (see POPIELA 1996b, 1998a, b, 1999a, b).

The purpose of this paper is to present the present state of knowledge of the Isoëto-Nanojuncetea class in Poland and to point out the main problems related to occurrence of communities of the class as well as their syntaxonomical position.

Methods

The results of the syntaxonomic study reported in this paper have been obtained on the basis of numerical classification based on all available relevés of communities of the Isoëto-Nanojuncetea class, taken in Poland till 1994 (see POPIELA 1997) and later (POPIELA & FUDALI 1996). Detailed methods of numerical classification and the list of all relevés used are given in (POPIELA 1997).

At present the phytosociological data on the communities include about 800 relevés. Unfortunately, most of them are of low quality and of minor syntaxonomic significance, the areas of sampling plots were too vast and the whole group of bryophytes was disregarded. Since many relevés do not satisfy the methodological criteria, particular syntaxonomic units were distinguished and characterized on the basis of selected relevés. The criteria of their choice were: the area covered (1-3 m^2 on average, and 8 m^2 maximum), plot uniformity and the fact of taking into account the bryophytes.

Distribution maps were made using the 10 x 10 ATPOL grid square system (ZAJĄC 1978) on the basis of revised herbarium material and literature, using both published and unpublished data. The list of floristic data was sent to the ATPOL database (Laboratory of Computer Chorology, Institute of Botany, Jagiellonian University, Kraków, Poland).

In this paper we assumed the syntaxonomic system and syntaxon nomenclature proposed by (PIETSCH 1973), except for the Heleocharetum ovatae association described after MOOR (1936) and the Ranunculo-Myosuretum minimi association described after DIEMONT W., H. SISSINGH G. & WESTHOFF, V. (1940). In order

to avoid risky syntaxonomic distinctions, the phytocoenoses not well recognized yet or devoid of exclusive character species were referred to as the community accompanied with the name of the dominant species (e.g. the community *Centaurium pulchellum-Pottia truncata*, the community with *Elatine alsinastrum*).

Plant species nomenclature follows MIREK et al. (1995), ROTHMALER (1990) for vascular species, and CORLEY et al. (1981) and GROLLE (1977) for bryophytes.

Syntaxonomic study

Results of syntaxonomic research show, that eight types of communities of the class belonging to two alliances the Radiolion linoidis and the Elatini-Eleocharition ovatae occur in Poland. Syntaxonomy of the Isoëto-Nanojuncetea class in Poland is as follows:

Class: Isoëto-Nanojuncetea Br.-Bl. et Tx. 1943
Ch. Cl. *Juncus bufonius, J. tenageia, J. capitatus, Centaurium pulchellum, Lythrum hyssopifolia, Plantago intermedia, Mentha pulegium*

Order: Cyperetalia fusci (Klika 1935) Müller-Stoll et Pietsch 1961
Ch. O. *Gnaphalium luteo-album, G. uliginosum, Isolepis setacea, Potentilla supina*

Alliance: Radiolion linoidis (Rivas Goday 1961) Pietsch 1965
Ch. All. *Hypericum humifusum, Radiola linoides, Spergularia rubra, Gypsophila muralis, Riccia sorocarpa, Riccia bifurca, Fossombronia wondraczekii, Pohlia annotina*
1. Ass. Centunculo-Anthoceretum punctati Koch 1926
Ch. Ass. *Centunculus minimus, Anthoceros punctatus, A. agrestis, Phaeoceros laevis*
2. Ass. Spergulario-Illecebretum verticillati Sissingh 1957
Ch. Ass. *Spergularia rubra, Illecebrum verticillatum*
3. Ass. Ranunculo-Myosuretum minimi Diem., Siss. et Westh. 1940
Ch. Ass. *Myosurus minimus, Ranunculus sardous*
4. The community *Centaurium pulchellum-Pottia truncata*

Alliance: Elatini-Eleocharition ovatae Pietsch 1965
Ch. All. *Limosella aquatica, Cyperus fuscus, Eleocharis acicularis, Riccia cavernosa*
5. Ass. Heleocharetum ovatae (Hay.) Moor 1936
Ch. Ass. *Carex bohemica, Eleocharis ovata, Elatine triandra, E. hexandra, E. hydropiper, Lindernia procumbens*
6. The community *Cyperus fuscus-Limosella aquatica*
(?) 7. The community with *Elatine alsinastrum*
(?) 8. Ass. Cyperetum flavescentis Koch 1926
Ch. Ass. *Cyperus flavescens, Carex oederi, Sagina nodosa*

The communities are characterized by strong habitual and floristic differentiation (Table 1). The phytocoenoses of the Radiolion linoidis occur on anthropogenic sites like stubble fields only, on the other hand the communities of the Elatini-Eleocharition ovatae grow on the bottom of dried out ponds and exposed river or lake banks.

Table 1: Classification of the Isoëto-Nanojuncetea Br.-Bl. et Tx. 1943 class communities in Poland on the basis of selected relevés, follows Popiela 1997, changed.

1 – the community with *Elatine alsinastrum*
2, 3, 5, 6 – Heleocharetum ovatae (Hay.) Moor 1936
4 – the community *Cyperus fuscus-Limosella aquatica*
7 – Spergulario-Illecebretum verticillati Sissingh 1957
8 – Centunculo-Anthoceretum punctati Koch 1926
9 – Ranunculo-Myosuretum minimi Diem. Siss. et Westh. 1940
10 – The community *Centaurium pulchellum-Pottia truncata*
11 – Cyperetum flavescentis Koch 1926

Successive number	1	2	3	4	5	6	7	8	9	10	11
Number of relevés	5	14	31	30	21	19	23	39	15	17	10
I Radiolion linoidis											
Centunculus minimus	-	-	-	-	-	-	I	V	-	-	-
Anthoceros punctatus	-	-	-	-	-	-	I	III	-	-	I
Anthoceros laevis	-	-	-	-	-	-	-	II	-	-	I
Anthoceros punctatus ssp.*agrestis*	-	-	-	-	-	-	-	I	-	-	-
Illecebrum verticillatum	-	-	-	-	-	-	V	I	-	-	-
Spergularia rubra	-	-	-	I	-	-	V	I	II	I	-
Myosurus minimus	-	-	-	-	-	-	-	-	V	-	-
Ranunculus sardous	-	-	-	-	-	-	-	I	IV	-	I
Hypericum humifusum	-	-	-	-	-	-	V	II	-	-	-
Radiola linoides	-	-	-	-	-	-	V	III	-	-	I
Gypsophila muralis	-	-	-	I	-	-	II	IV	II	I	I
Fossombronia wondraczekii	-	-	-	-	-	-	I	II	-	-	-
Pohlia annotina	-	-	-	-	-	-	I	II	-	-	-
Riccia sorocarpa	-	-	-	-	-	-	I	I	-	II	-
Riccia bifurca	-	-	-	-	-	-	-	I	-	II	-
II Elatini-Eleocharition ovatae											
Eleocharis ovata	-	V	-	-	V	-	-	-	-	-	-
Elatine hexandra	-	I	-	-	-	V	-	-	-	-	-
Elatine hydropiper	-	II	IV	-	I	II	-	-	-	-	-
Lindernia procumbens	-	III	-	I	II	-	-	-	-	-	-
Carex bohemica	-	II	-	-	II	-	-	-	-	-	-
Elatine triandra	-	-	-	-	-	II	-	-	-	-	-
Limosella aquatica	-	IV	V	V	II	II	-	-	-	-	-
Cyperus fuscus	-	-	IV	V	IV	-	-	-	I	-	II
Eleocharis acicularis	-	-	IV	II	V	V	-	-	-	-	-
Riccia cavernosa	V	-	III	II	III	I	-	-	-	-	-
Elatine alsinastrum	V	-	-	-	-	-	-	-	-	-	-
Cyperus flavescens	-	-	-	-	-	-	-	-	I	-	V
Sagina nodosa	-	-	-	-	-	-	-	I	I	-	IV
Carex oederi	-	-	-	-	-	-	-	I	-	-	III
III Cyperetalia fusci											
Gnaphalium uliginosum	II	I	II	IV	V	II	IV	IV	IV	II	II
Peplis portula	IV	IV	I	I	III	II	II	II	III	-	II
Gnaphalium luteo-album	-	-	-	-	-	-	II	I	-	-	-
Riccia sp.	-	-	I	I	-	I	-	II	II	-	-
Riccia glauca	-	I	-	I	-	-	-	I	-	I	I

Table 1, continued

Successive number	1	2	3	4	5	6	7	8	9	10	11
Number of relevés	5	14	31	30	21	19	23	39	15	17	10
Pottia truncata	-	-	-	I	-	-	-	I	-	III	-
Pottia davaliana	-	-	-	-	-	-	-	-	-	III	-
Riccia cfr. cavernosa	-	-	-	I	-	I	-	-	-	-	-
Physcomitrium pyriformae	-	I	-	I	-	-	-	-	-	-	-
Physcomitrella patens	-	-	I	II	-	-	-	-	-	-	-
IV Isoëto-Nanojuncetea											
Plantago intermedia	II	-	I	V	II	-	I	IV	III	V	I
Juncus bufonius	-	-	I	IV	-	-	IV	V	V	V	III
Juncus capitatus	-	-	I	-	I	-	III	IV	-	-	-
Centaurium pulchellum	-	-	-	-	-	-	-	-	-	V	I
Juncus tenageia	III	-	-	-	-	-	-	-	I	-	-
V others											
Polygonum hydropiper	-	-	-	-	-	-	III	III	III	-	-
Spergula arvensis	-	-	-	-	-	-	V	IV	-	-	-
Mentha arvensis	-	-	-	-	-	-	III	III	III	III	-
Equisetum arvense	-	-	-	-	-	-	-	III	III	III	-
Polygonum aviculare	-	-	-	-	-	-	-	IV	-	V	-
Cerastium holosteoides	-	-	-	-	-	-	-	III	-	III	-
Rumex acetosella	-	-	-	-	-	-	IV	III	-	-	-
Rorippa palustris	V	IV	V	IV	-	-	-	-	-	-	-
Juncus bulbosus	-	I	II	I	I	III	-	-	-	-	I
Calitriche verna	-	IV	IV	-	-	-	-	-	-	-	-
Oenanthe aquatica	V	IV	-	-	III	-	-	-	-	-	-
Alisma plantago-aquatica	IV	-	-	-	-	III	-	-	-	-	-
Ranunculus flammula	-	-	-	-	III	-	-	-	-	-	IV
Dreplanocladus aduncus	-	-	-	-	III	III	-	-	-	-	-
Bryum argenteum	II	-	-	-	-	-	-	-	-	III	-

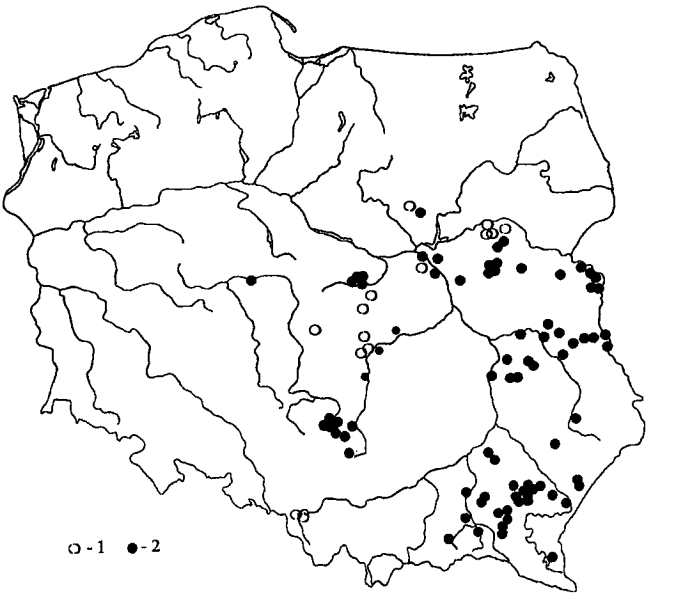
Sporadic species

III: *Blasia pusilla* 8(I), *Dicranella rufescens* 8(I), *Isolepis setacea* 8(I), *Potentilla supina* 4(I), *Riccia beyrichiana* 8(I), *Riccia ciliata* 8(I), *Riccia fluitans* 8(I), *Sagina ciliata* 4(I).

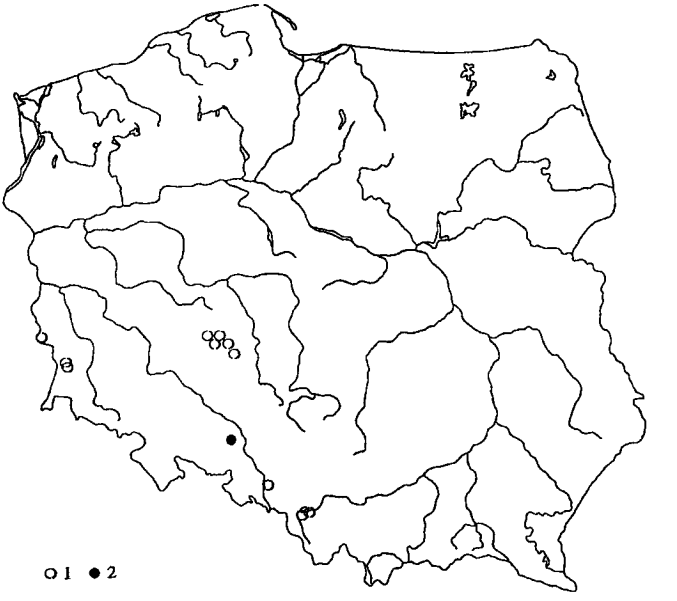
IV: *Lythrum hyssopifolia* 8(I), *Mentha pulegium* 4(I).

V: *Agropyron repens* 9(III), *Agrostis stolonifera* 11(III), *Anagallis arvensis* 8(II), *Arnoseris minima* 7(IV), *Bidens tripartita* 7(III), *Chenopodium rubrum* 4(III), *Cirsium arvense* 10(III), *Conyza canadensis* 10(IV), *Fallopia convolvulus* 7(III), *Juncus articulatus* 2(IV), *Matricaria maritima* subsp. *inodora* 10(III), *Medicago lupulina* 10(III), *Melandrium noctiflorum* 10(III), *Physcomitrium eurystomum* 2(V), *Polygonum persicaria* 10(4), *Potentilla anserina* 9(III), *Rumex maritimus* 4(III), *Scleranthus annuus* 7(IV), *Setaria pumila* 7(IV), *Sonchus arvensis* 10(III), *Stellaria media* 10(III), *Sagina procumbens* 8(V), *Sonchus asper* 10(III), *Teesdalea nudicaulis* 7(IV), *Trifolium repens* 8(III), *Veronica arvensis* 8(III), *Veronica serpyllifolia* 8(III).

The species from group V (others), whose occurrence is characterised by the I and II degree of constancy, are not included in the Table.



a



b

Fig 1: Location of the phytosociological relevés of (a) the Centunculo-Anthoceretum punctati Koch 1926, and (b) Heleocharetum ovatae (Hay.) Moor 1936 in Poland (follows POPIELA 1997).
1 – the selected relevés; 2 – the other relevés.

Taking into regard the number and quality of relevés, only three communities are well documented in Poland – the Heleocharetum ovatae, the Centunculo-Anthoceretum punctati and the *Cyperus fuscus-Limosella aquatica*. As the phytosociological data on the communities of the Isoëto-Nanojuncetea originated only from some parts of Poland (Fig. 1) it is difficult to establish whether the picture of localisation of the relevés reflects the actual geographical distribution of the communities, or is a result of insufficient botanical documentation. The other distinguished phytocoenoses: the Spergulario-Illecebretum verticillati, the Ranunculo-Myosuretum minimi, the community *Centaurium pulchellum-Pottia truncata*, the Cyperetum flavescentis are represented only by a few correctly executed relevés. Similarly, the community with *Elatine alsinastrum*, currently recorded in northern Poland, also belongs to the group of phytocoenoses not suffieciently recognized (KĘPCZYŃSKI & RUTKOWSKI 1993; POPIELA & FUDALI 1996). These communities demand further studies in the future which should concentrate on collecting more relevés from the whole area of Poland and analysis of their syntaxonomic status.

Associations of the Isoëto-Nanojuncetea class occurring in Poland show floristic similarity to the associations described from Western Europe, but they have depauperated appearance. In Poland many species recorded in Western Europe's communities of the class do not occur. Some of them (e.g. *Cicendia filiformis, C. pusilla, Veronica acinifolia*) are the taxa with the western types of geographical distribution in Europe which do not reach the borders of Poland, other as: *Crassula aquatica, Corrigiola litoralis, Dichostylis micheliana, Isolepis supina, Marsilea quadrifolia, Pilularia globulifera* used to appear in Poland but their appearance has not been recently reconfirmed or is extremely rare. (ZARZYCKI & KAŻMIERCZAKOWA 1993). Special attention should be paid to the Heleocharetum ovatae association in the wide sense of MOOR (1936, 1937). In Poland the association reaches the easternmost limits of its geographical range, is rarely met and develops in a much poorer form than the phytocoenoses recorded in the western part of Europe (e.g. PIETSCH 1973; PIETSCH & MÜLLER-STOLL 1968, 1974). The *Cyperus fuscus-Limosella aquatica* community is rather common in Poland, however, it has no exclusive character species, which prevents its classification as an association.

Up to now, the studies on the communities of the Isoëto-Nanojuncetea class occurring in Poland have made it possible to establish a tentative list of their character species among vascular plants. The problem of participation of the bryophytes in the communities and their supposed syntaxonomic role still exist. Many authors of relevés did not mention the bryophytes, which aroused great difficulties in determining which of them are characteristic of individual units. The next topic demanding further study is the problem of nativity of the communities classified within the Radiolion linoidis alliance, growing in Poland only in arable fields. It seems that they have a seminatural character, with the presence of native species in anthropogenic habitats.

Phytogeographical research

From the phytogeographical point of view, the species of the Isoëto-Nanojuncetea class make an interesting group of plants. Among them, the taxa cha-

racterized by wide disjunctive ranges are prevalent. A great number of the species belong to the connective elements of the flora ("éléments de liaison", cf. PAWŁOWSKA 1966: 186). In Europe they often represent the western types of distribution with a main centre of occurrence in the western, southern and central parts of the continent. In the eastern part of Europe the taxa are absent, they occur only on dispersed sites or their localities are scattered. In Poland many of these species are classified as the taxa of "rare" and "endangered" category (ZARZYCKI & SZELĄG 1992, ŻUKOWSKI & JACKOWIAK 1995) and some of them reach the eastern or the north-eastern limits of their geographical range here. The phenomenon of shrinking of the ecological scale of the species is clearly notable. They are divided into two groups according to their ecological demands: the species which grow on bottoms of dried out ponds and exposed river or lake banks (in communities of the Elatini-Eleocharition ovatae alliance) and the taxa occurring in arable fields (in communities of the Radiolion linoidis alliance).

A map of *Elatine hexandra* is an example of one type of distribution of the species from the first group (Fig. 2a). Other species from this group are: *Carex bohemica, Elatine alsinastrum, Elatine triandra, Juncus tenageia, Lindernia procumbens.* The plants occur in Western Poland and reach the limits of their range there. The taxa are rarely found in Poland and are threatened with extinction. A great number of their sites have not been reconfirmed since 1945. Devastation of habitats caused by man (especially progressive contamination of waters) is presumably the main reason for disappearance of the species on river and lake banks. Nowadays they are found on the temporarily flooded bottoms of the ponds. A map of *Limosella aquatica* (Fig. 2b) shows the second type of distribution of species belonging to this group, which cover a net of ways of the main rivers in Poland. The maps of *Lythrum hyssopifolia, Cyperus fuscus* and *Mentha pulegium* look similar. The species reach a sociological and ecological optimum of their occurrences in the *Cyperus fuscus-Limosella aquatica* community associated with valleys of the big rivers as well as in other parts of Europe (e.g. ALLORGE 1922; LIBBERT 1938; WENDELBERGER-ZELINKA 1952; KORNECK 1960). Regression of the taxa in Poland is presumably caused by damage or disapperance of their habitats. The most interesting and at the same time the most difficult to analyse are maps of the species rarely collected and without phytosociological documentation. Among these taxa is *Sagina subulata* (Fig. 2c) reaching the extreme limits of its northeastern range in Poland, and is therefore directly in danger of extinction.

In Poland the other group of taxa are plants growing exclusively on the anthropogenic sites, in communities occurring in arable fields. The map of *Illecebrum verticillatum* shows the type of distribution of such species (Fig. 2d). *Centunculus minimus* and *Radiola linoides* belong also to this group. In Poland contemporary sites of the taxa concentrate in the south-eastern part of the country. In the northern and western parts they are rather absent – occurring rarely or having not been reconfirmed since 1945. Information about observation of the species outside arable fields could be found only in older literature (e.g. KLINGGRAEFF 1882, DECKER 1911, LIBBERT 1938). The data suggests that the species are native elements in the Polish flora but nowadays they have a status of an apophyte. The problem of the origin of these taxa requires further investigation. The question is if it is possible that, according the suggestion of MOOR (1936), the species were able to colonize and survive on arable fields after the disappearence of their natural sites like heaths and bare places.

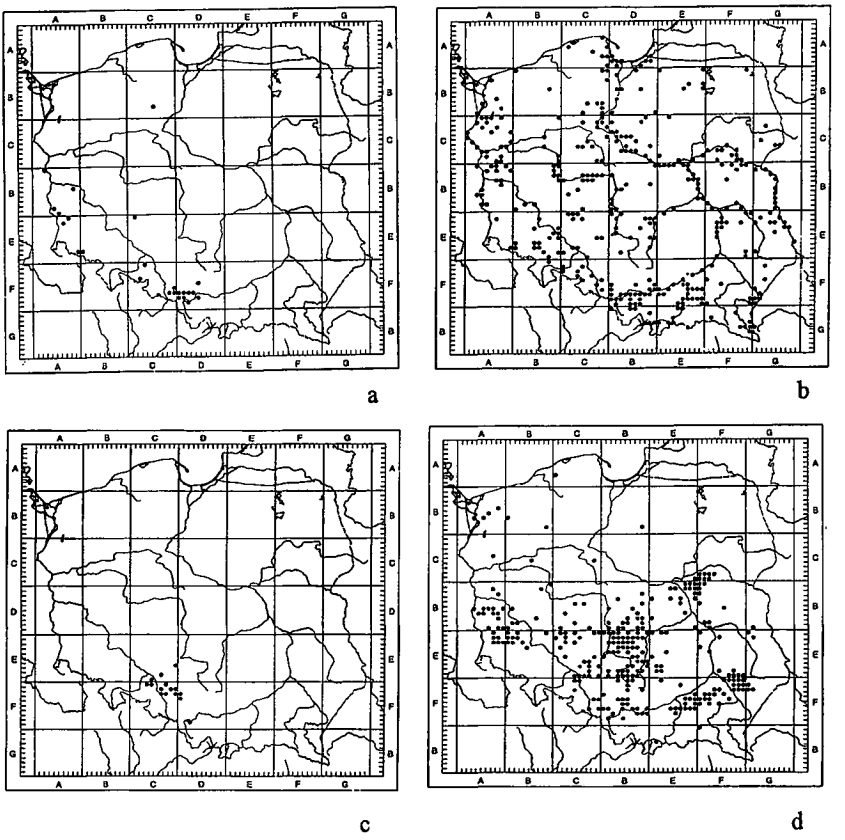


Fig. 2: The distribution of (a) *Elatine hexandra* (Lapierre) Dc., (b) *Limosella aquatica* L., (c) *Sagina subulata* (Sw.) Presl, and (d) *Illecebrum verticillatum* L. in Poland.

Conclusion

The level of knowledge of the communities of the Isoëto-Nanojuncetea class occurring in Poland is insufficient. The total number of the phytosociological relevés carried out in these communities is large but most of them are not methodically correct. The great difficulties in research on the communities occur at the stage of field-investigations and later while classifying the phytocoenoses. The phytocoenoses are very hard to find, they exist rarely and in small areas only. Generally, one can find the communities without the character species of the associations, which could be classified to the class Isoëto-Nanojuncetea or to the order Cyperetalia fusci only or as fragments of the associations. The depauperated appearance of these communities may be a result of their development on the limits of their ranges and/or their occurrence in unstable habitats. For this reason a comparison of the relationship of the communities occurring in Poland to the ones from the centre of their range in Western Europe and an attempt at their classification poses many problems. In addition, some associations are not distinguished in the phytosociological

literature with respect to habitat and to species combination, but with respect to a quantitative domination of single taxa (see PIETSCH 1973), which makes it even more difficult to perform comparisons.

The most important tasks in research on the communities of the Isoëto-Nanojuncetea class in Poland, are as follows:

- to improve the phytosociological data basis and to explain the syntaxonomic position of certain communities, as the Cyperetum flavescentis; the Spergulario-Illecebretum verticillati, the Ranunculo-Myosuretum minimi, the *Centaurium pulchellum-Pottia truncata*, the community with *Elatine alsinastrum*;
- to resolve the problem of nativity of communities growing in arable fields;
- to establish limits of occurrences of the communities (connected with the collection of the phytosociological data from all parts of Poland);
- to give a list of character species among bryophytes.

On the other hand, the studies on the distribution of the vascular character species of the Isoëto-Nanojuncetea have achieved a satisfactory level. Distribution maps of each species will be finished in the next few months, to be published in the first edition of the "Distribution atlas of vascular plants in Poland (ATPOL)" (ZAJĄCA., ZAJĄC M. 1992).

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