Formalized classification of ephemeral wetland vegetation (Isoëto-Nanojuncetea class) in Poland (Central Europe) (#55719)

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Formalized classification of ephemeral wetland vegetation (Isoëto-Nanojuncetea class) in Poland (Central Europe)

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Reliable and formalized classification of the class Isoëto-Nanojuncetea has not been performed in Poland. Thus, the objective of this study is to classify rare ephemeral wetland vegetation found in the eastern boundary of their geographical distribution in Europe. We used a set of 69562 relevés data stored in Polish Vegetation Database and selected 43 species to be analysed for the class Isoëto-Nanojuncetea. Unequivocal classification was applied in this work according to Cocktail method. A set of characterizations was established using a combination of logical operators of total cover of species in case of high-rank syntaxa while sociological species groups and cover of particular species were used for logical formulas describing associations level. An Expert system was created and 1340 relevés were classified into the class Isoëto-Nanojunceteaon alliance and association. From the final dataset, 46% of the relevés were assigned to the association level. 13 associations among them identified as Coleanthetum subtilis was proposed as a new syntaxon. Vegetations of the Isoëto-Nanojuncetea class occur in central and southern part of Poland with scattered stands in northern part. According to DCA analysis, the most explanatory determining factors of the vegetation of class Isoëto-Nanojuncetea in Poland is moisture and temperature. The presented classification consist of concepts of higher syntaxa accepted in the EuroVegChecklist and provide protocols for newly described syntaxa.

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- 31 Key words: distribution, syntaxonomical revision, Eleocharition ovatae, Verbenion, Radiolion
- 32 Abstract
- Reliable and formalized classification of the class Isoëto-Nanojuncetea has not been performed
- in Poland. Thus, the objective of this study is to classify rare ephemeral wetland vegetation
- found in the eastern boundary of their geographical distribution in Europe. We used a set of
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- operators of total cover of species in case of high-rank syntaxa while sociological species groups
- and cover of particular species were used for logical formulas describing associations level. An



Expert system was created and 1340 relevés were classified into the class Isoëto-Nanojuncetea 41 alliance and association. From the final dataset, 46% of the relevés were assigned to the 42 association level. 13 associations among them identified as Coleanthetum subtilis was proposed 43 as a new syntaxon. Vegetations of the Isoëto-Nanojuncetea class occur in central and southern 44 part of Poland with scattered stands in northern part. According to DCA analysis, the most 45 explanatory determining factors of the vegetation of class Isoëto-Nanojuncetea in Poland is 46 moisture and temperature. The presented classification consist of concepts of higher syntaxa 47 accepted in the EuroVegChecklist and provide protocols for newly described syntaxa. 48

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Introduction

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The classification of plant communities in Poland is not fully conducted, although studies on 52 vegetations has a long tradition and several comprehensive studies has been published 53 (Matuszkiewicz 2007, Kącki, Czarnecka & Swacha 2013). There are syntaxonomic units, due to 54 seasonal dynamic, unique habitat requirements and species poor layout, that have not been 55 defined. examples are vegetation of the class Isoëto-Nanojuncetea. These annual, pioneer 56 ephemeral awarf-cyperaceous vegetation, occurs in Central Europe in mid-field hollows, at the 57 bottoms of drying puddles, drained ponds, oxbows, lakes and rivers, in regularly flooded places, 58 available for vegetation in a short period of time. Many species found on these locations are rare, 59 although they usually have a wide distribution (Deil 2005, Lampe 1996). The communities of 60 Isoëto-Nanojuncetea class in Europe and Africa were first identified and reported at the 61 beginning of the 20th century (Koch 1926, Braun-Blanquet 1931, 1936). Later on, an important 62 contribution to the knowledge of diversity and classification of Isoëto-Nanojuncetea in Europe 63 were provided by Moor (1936, 1937), Pietsch (1965, 1969, 1973); Pietsch & Müller-Stoll (1968, 64 1974), Rivas Goday (1970), Tüxen (1973), Popiela (1997), Brullo & Minisalle 1998), Täuber 65 (2000), Deil (2005), Šumberová & Hrivnák (2013). 66

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the length of time of ground exposure or agricultural intensity and the soil seed bank (eg. Poschlod et al. 2013). At initial development stage, an impoverishment in diagnostic species are often observed or the species are found in small patches among other complex annual vegetation, especially from classes Bidentetea and Papaveretea. Additionally, some studies indicated that these same species are linked to different and distinctively defined plant associations. Hence, the classification of ephemeral wetland vegetation is confusing both on the level of associations and the whole class (Popiela 2005, Šumberová & Hrivnák 2013).

Plant communities of Isoëto-Nanojuncetea class in Polish territory reaches out to the northeastern distribution boundaries and most of these diagnostic species are rare and are vanishing (Popiela 2005, Kaźmierczakowa at al. 2016). For the first time in Poland they were described by Kornaś (1960), Wójcik (1968) and Zając (1988). The first comprehensive classification based on large dataset was proposed by Popiela (1997), however, in recent decades, new regional studies

The species diversity and communities structure of ephemeral vegetation often depends on



on the syntaxonomy and ecology of Isoëto-Nanojuncetea class vegetation have been published 81 (e.g. Spałek & Nowak 2006, Krawczyk et al. 2016) and new communities were identified and 82 reported (Fabiszewski & Cebrat 2003, Drabnik & Buchalik 2004, Dajdok 2009). All this data 83 suplemented by unpublish data are stored in national phytosociological database Polish 84 Vegetation Database (Kacki & Śliwiński 2012). Large vegetation-plot databases are currently 85 available worldwide (Dengler et al. 2011; Chytrý et al. 2016, Nowak at al. 2017) which make 86 possible a comprehensive classification of vegetation at different spatial scales (Dengler et al. 87 2013; De Cáceres & Wiser 2012). To achieve consistency in classification across large regions, 88 the Cocktail method proposed by Bruelheide (1995, 2000) is used in classification of different 89 vegetation types in Europe (e.g. Šilc & Čarni 2007, Douda at al. 2016, Willner at al. 2019). 90 Formalized approach uses definitions, by which particular relevé is classified into vegetation 91 units in a reproducible way but the classification results is independent of the origin of the data 92 set (Bruelheide & Chytrý 2000). The first attempt in the classification of Isoëto-Nanojuncetea 93 vegetation by the use of Cocktail method was made by Šumberová & Hrivnák (2013) for Czech 94 and Slovakia territory. Authors have described formal definitons at the association level. In this 95 study we applied multilevel formalized classification (Janišová & Dúbravková 2010) which was 96 successfully introdued in classification of *Molinia* meadows in Poland (Swacha at al. 2016). 97 This work is aimed at solving the inconsistencies in the Polish classification of ephemeral 98 vegetation of the Isoëto-Nanojuncetea class. We provided a formalized classification procedure 99 and synthesis of Isoeto-Nanojuncetea class units for alliance and associations level. The 100 classification takes into account, as much as possible, the accepted and valid syntaxa described 101 formerly in Europe. 102

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Material and Methods

- 106 Data set and classfication method
- We used 69562 relevés stored in Polish Vegetation Database PVD (Kacki & Śliwiński 2012) for
- this study. In accordance with professional knowledge (Matuszkiewicz 2007, Popiela 1997,
- Kacki, Czarnecka & Swacha 2013), we selected 43 diagnostic species for the Isoëto-
- Nanojuncetea class (Table 1). Then we defined groups of diagnostic species into class and
- alliances as reported from Central Europe (Matuszkiewicz 2007, Mucina et al. 2016). Using this
- group of species, we created total cover groups (#TC) separately for the class and alliances
- according to Landucci et al. (2015) approach. Sociological groups of species were
- simultaneously determined using the fidelity phi coefficient (Chytrý et al. 2002). We applied
- unequivocal classification in accordance with Cocktail method (Bruelheide 1997). Formulas
- were created using the formal operators AND, OR, NOT available in Juice sofware Tichý
- 2002). The structure of the formulas for alliance level was based on total cover groups #TC,
- while the association level was modelled by a combination of sociological species groups or
- cover treshold of particular diagnostic species associated with total cover group of the alliance.
- This enable is to keep the syntaxonomical hierarchy, which means that releves classified to



- particular association was all o included into the appropriate alliance (Landucci et al. 2020, Kacki
- et al. 2020 in press). An Expert System was prepared and applied in the classification of the
- whole data set of PVD and 1340 relevés and were classified both at alliance and association
- levels. Relevés without geographical coordinates and with surface area smaller than 1 m² or
- greater than 100 m² were excluded. We also removed cultivated plants from the analyses. Next,
- three relevés were randomly selected from each unit of grid square of 1.25 longitude x 0.75
- latitude (ca. 1.5 x 1.4 km) from each alliance. Finally we used data set of 816 relevés to prepare
- synthetic tables, distribution maps and descriptions of the syntaxa.
- For each syntaxon diagnosis, constant and dominant species were determined and a combined
- synoptic table with frequency and fidelity was created. More so, diagnostic species were defined
- using phi coefficient (Sokal & Rohlf 1995, Chytrý et al. 2002). Species were considered a
- diagnostic for association at phi ≥ 0.25 and Fisher's exact test significance level p<0.001 (Chytrý
- et al. 2002). We considered only diagnostic species which were included in the list of Expecies
- for Isoëto-Nanojunceta class, while the others we indicated as a differential species.
- 135
- 136 Statistics, map preparation, nomeclature
- Ecological gradients of detected associations were evaluated by Detrended Correspondence
- Analysis (DCA) using Juice 7.0.213 and ordination methods available in R for Windows with
- VEGAN module (Oksasen et al. 2011). For interpretation of the main environmental gradients,
- average non-weighted Ellenberg indicator values for light, temperature, continentality, soil
- reaction, moisture and nutrients (Elleberget al. 1992) were used as supplementary variables.
- Ellenberg indicator values were calculated for weighted relevés by species cover
- 143 (CWM). Ordination (DCA) was conducted with data transformation b=(Xi,j)^p (p=0.5) and
- scaling by 26 segments.
- Distribution maps of all associations were prepared using PostgreSQL 11.0 database with
- PostGIS 2.6 extension. Visualisation of the result was prepared on QGIS3.2 and
- results showed on digital elevation map with accuracy 100x100 m by pixel.
- We used Euro-Med-Plant+ nomenclature for species names (access 11.2018). Taxonomically
- critical taxa were merged into aggregates following the syntaxonomy proposed by Mucina et al.
- 150 (2016).
- 151
- 152 **Table 1**.
- 153 Results
- Three alliances with 13 plant association were identified in Poland (Tab. 2). 610 relevés were
- assigned to particular associations, representing 74% of 816 relevés used and 205 were classified
- at the alliance level only (161 for Eleocharition ovatae, 4 for Verbenion and 41 for Radiolion
- linoidis). Further more, we identified a new association Coleanthetum subtilis placed in the
- Eleocharition alliance and a community with *Montia arvenisi* included into the Radiolion
- alliance. According to DCA analysis the most influential factors determining the species
- composition are moisture and temperature (Fig.1).



Communities of the Isoëto-Nanojuncetea class occur in the central and southern parts of Poland, 161 so far they were not found in north-eastern Poland and are rarely found in northern parts (Fig. 2). 162 Localities of the Eleocharition ovatae stands are distributed mainly in western and south-eastern 163 part of Poland in big river valleys and fish pond regions (Fig.3A). The communities of the 164 Verbenion alliance are the rarest, sparcely distributed in the midlle part of Poland, mostly in the 165 Lubelska Upland and the Wielkopolska Lowland (Fig. 3B). Localities of Radiolion linoidis 166 alliance were found mostly in the central and the south-eastern part of Poland (Fig. 3C). 167 168 Table 2. 169 170 Figure 1 171 172 Figure 2 173 174 Figure 3 175 176 177 List of syntaxa and species composition 178 179 Synoptic list of species shows diagnostic species with phi coefficient value ≥ 0.25 , constant 180 species with percentage frequency ≥40% and dominant species with cover at least 25% in at least 181 5% of the cluster. 182 183 Eleocharition ovatae Philippi 1968 184 Diagnostic species: Eleocharis acicularis, Cyperus fuscus, Eleocharis ovata, Carex bohemica, 185 Limosella aquatica, Elatine hexandra, Rorippa palustris, Elatine hydropiper, Elatine triandra 186 187 Differential species: Callitriche palustris s. l., Alisma plantago-aquatica, Leersia oryzoides Constant species: Cyperus fuscus, Gnaphalium uliginosum, Limosella aquatica, Eleocharis 188 acicularis 189 Dominant species: Cyperus fuscus, Eleocharis acicularis, Limosella aquatica, Eleocharis ovata, 190 Elatine hexandra, Lythrum portula, Carex bohemica, Plantago major subsp. intermedia, Elatine 191 hydropiper 192 193 In Poland, the Eleocharition ovatae alliance includes three plant communities 194 (Appendix 2, 3): 195 1. Polygono-Eleocharitetum ovatae Eggler 1933 196 2. Cyperetum micheliani Horvatić 1931 197 3. Coleanthetum subtilis ass. nova hoc loco 198 They develop on moderately fertile habitats, mainly on the drying-out bottom of fish ponds, the 199 margins of mid-field ponds and periodically exposed banks of river channels, mostly in the 200 western part of Poland (Fig. 4). Moisture, nutrients and temperature are factors determining the 201 vegetation of the Eleocharition alliance according to DCA analysis (Fig. 5). 202 203

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Figure 4.



- 206 Polygono-Eleocharitetum ovatae Eggler 1933
- 207 Diagnostic species: Eleocharis ovata, Carex bohemica, Elatine hexandra, Eleocharis acicularis,
- 208 Elatine triandra, Lindernia procumbens
- 209 Differential species: Alisma plantago-aquatica, Physcomitrium eurystomum, Oenanthe aquatica
- 210 Constant species: Eleocharis ovata, Eleocharis acicularis, Carex bohemica, Alisma plantago-
- 211 aquatica,
- 212 Dominant species: Eleocharis ovata, Elatine hexandra, Eleocharis acicularis, Carex bohemica,
- 213 Juncus bulbosus

- Distribution: Polygono-Eleocharetum ovatae occurs on scattered sites in the south-western and
- south-eastern parts of Poland, it does not occur in the north of the country due to scarcity of the
- 217 typical habitat the fish pond complexes (Fig. 4).
- 218 Physiognomical layout: The individual patches show a single-layer structure and form a low turf-
- 219 like, with varying degrees, vegetation coverage. The association often develop patchy structure,
- with typical plots composed of diagnostic species dispersed between stands of Phragmito-
- 221 Magnocaricetea and Bidentetea vegetation (Fig. 6).
- Habitat requirements. The Polygono-Eleocharitetum ovatae is associated mostly with ponds (old
- facilities), where regular, extensive fishery management was conducted for a long time. It does
- 224 not appear on natural water bodies across Poland. It is mostly found on a fine-grained, wet, moist
- or drying sandy-loamy or silty substrate, rich in mineral compounds. Within the Eleocharition
- alliance this association is usually in the wettest habitats (Fig. 5).

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- 228 Cyperetum micheliani Horvatić 1931
- 229 Diagnostic species: Cyperus fuscus, Limosella aquatica, Eleocharis acicularis
- 230 Differential species: Rumex maritimus, Salix fragilis
- 231 Constant species: Cyperus fuscus, Gnaphalium uliginosum, Limosella aquatica, Plantago major
- subsp. intermedia, Rumex maritimus, Rorippa palustris, Juncus bufonius
- Dominant species: Cyperus fuscus, Limosella aquatica, Plantago major subsp. intermedia,
- 234 Eleocharis acicularis

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- Distribution: The Cyperetum micheliani occurs in the western part of Poland, mainly in the river
- valleys (Odra, Warta, Vistula), and in regions with large and old fish ponds complexes (Valleys:
- 238 Żmigrodzka, Milicka, Oświęcimska and Sandomierska) Fig. 4.
- 239 Physiognomical layout: The association develops more or less compact turf, usually at the end of
- summer. It is distinguished by the abundant occurrence of *Cyperus fuscus* and *Limosella*
- 241 aquatica (Fig. 6).
- Habitat requirements: In Poland, patches of the Cyperetum micheliani develop periodically on
- flooded habitats, located on gently sloping banks, coastal mudslides, margins of oxbow lakes and
- small water-filled hollows on the flooded terraces. They are also found on freshly exposed
- bottom of water reservoirs, e.g. lakes, small mid-field depression at the bottom of drained fish
- ponds and dam reservoirs. These possesses the highest requirements with regards to nutrients and
- has less demand for moisture within the alliance communities (Fig. 5).

248249

250 Figure 5.



- Figure 6. 252 Coleanthetum subtilis ass. nova hoc loco 253 Lectotypus hoc loco designatus: Dajdok et al. (2017), Appendix B, Table B1, relevé no. 9. 254 255 Diagnostic species: Coleanthus subtilis, Limosella aquatica, Riccia cavernosa, Myosurus 256 257 minimus Differential species: Veronica peregrina, Callitriche palustris s. l., Ranunculus trichophyllus, 258 Cardamine parviflora, Persicaria lapathifolia s. 1. 259 Constant species: Coleanthus subtilis, Veronica peregrina, Myosurus minimus, Limosella 260 aquatica, Persicaria lapathifolia s. 1., Callitriche palustris s. 1., Persicaria hydropiper, Juncus 261 bufonius 262 Dominant species: Coleanthus subtilis, Persicaria lapathifolia s. l., Veronica peregrina, 263 Callitriche palustris s. l., Myosurus minimus, Riccia cavernosa, Limosella aquatica 264 265 266 267 Distribution: So far the association was found only in the south-western part of Poland, in fish-268 pond complexes in Lower Silesia (Fig. 4). 269 Physiognomical layout: The association is well distinguished by its dominance of short grasses 270 mostly the diagnostic species *Coleanthus subtilis* (Fig. 7). 271 Habitat requirements: Generally, plots of the Coleanthetum subtilis develop in ponds used in 272 annual or biennial cycle (stocking ponds). So far, plots developing in autumn or during seasonal 273 summer water deficit have been recorded much less frequently. 274 275 Figure 7. 276 277 278 Verbenion supinae Slavnić 1951 279 Diagnostic species: Pulicaria vulgaris, Elatine alsinastrum, Pycreus flavescens, Schoenoplectus 280 281 Differential species: Alisma lanceolatum, Atriplex prostrata, Persicaria amphibia, Xanthium 282 orientale subsp. italicum, Agrostis stolonifera 283 284 Constant species: Plantago major subsp. intermedia, Agrostis stolonifera, Juncus bufonius Dominant species: Pulicaria vulgaris, Alisma lanceolatum, Elatine alsinastrum, Juncus 285 bufonius, Schoenoplectus supinus, Pycreus flavescens, Plantago major subsp. intermedia, Juncus 286 ranarius 287 288
- According to the formal classification of our data set, the Verbenion alliance includes four associations (Appendix 2, 3):
- 1. Veronico anagalloidis-Lythretum hyssopifoliae Wagner ex Holzner 1973
- 292 2. Cyperetum flavescentis Koch 1926
- 293 3. Pulicario vulgaris-Menthetum pulegii Slavnić 1951
- 4. Eleocharito aciculari Shoenoplectetum supini Soo & Ubrizsy 1948



296	In Poland, plots of this alliance occur rarely, mainly in the big river valleys and in the Lublin
297	Upland (Fig. 3). According to DCA analysis and Ellenberg values Verbenion alliance in Poland
298	has higher demand of the temperature and nutrient content (Fig. 8).
299	
300	Figure 8.
301	
302	Veronico anagalloidis-Lythretum hyssopifoliae Wagner ex Holzner 1973
303	Diagnostic species: Juncus ranarius
304	Constant species: Juncus ranarius, Oxybasis rubra, Oxybasis glauca, Juncus compressus,
305	Atriplex prostrata, Argentina anserina, Agrostis stolonifera
306	Dominant species: Juncus ranarius, Carex secalina, Bolboschoenus maritimus
307	•
308	Distribution: There are only three known sites of the Veronico anagalloidis-Lythretum
309	hyssopifoliae in Poland located in the lowland belt of Wielkopolska, Kujawy and Mazury
310	regions (Fig. 9).
311	Physiognomical layout: The association is well defined by the cus ranarius and the presence
312	of halophilous species. It has a transitional characteristic to halophilous communities of the
313	Festuco-Puccinellietea class.
314	Habitat requirements: In saline habitats.
315	
316	
317	Cyperetum flavescentis Koch 1926
318	
319	Diagnostic species: Pycreus flavescens
320	Differential species: Sagina nodosa, Calliergonella cuspidata, Carex flava agg., Triglochin
321	palustris, Ranunculus flammula, Poa trivialis
322	Constant species: Pycreus flavescens, Sagina nodosa, Ranunculus flammula, Juncus articulatus,
323	Calliergonella cuspidata, Agrostis stolonifera, Juncus bufonius, Carex flava agg.
324	Dominant species: Pycreus flavescens
325	
326	Distribution: The Cyperetum flavescentis is distributed in the south-eastern part of Poland (Fig.
327	9).
328	Physiognomical layout: They form very low and loose turfs, on a sandy or sandy-loam substrates
329	with weak acidity. The plant communities are usually clearly dominated by <i>Pycreus flavescens</i>
330	(Fig. 10).
331	Habitat requirements: The communities develop periodically on flooded and grazed lakesides as
332	well as peaty hollows. According to DCA analysis Cyperetum flavescentis requires lower
333	humidity compared to Pulicario vulgaris-Menthetum pulegii and Elatino-Juncetum tenageiae
334	(Fig. 8).
335	
336	Figure 9.
337	Deliania and ania Mandarton malarii Classii (1051
338	Pulicario vulgaris-Menthetum pulegii Slavnić 1951
339	Diagnostic species: Pulicaria vulgaris



- Differential species: Xanthium orientale subsp. italicum, Phalaroides arundinacea, Rorippa
- amphibia, Atriplex prostrata, Inula britannica, Alopecurus haussknechtianus, Bidens frondosus,
- 342 Persicaria lapathifolia s. l., Persicaria amphibia, Agrostis stolonifera
- 343 Diagnostic species: Pulicaria vulgaris, Mentha pulegium
- 344 Differential species: Xanthium orientale subsp. italicum, Phalaroides arundinacea, Rorippa
- 345 amphibia, Atriplex prostrata, Rumex maritimus, Inula britannica, Alopecurus haussknechtianus,
- 346 Bidens frondosa, Matricaria discoidea, Glyceria maxima, Persicaria lapathifolia s. l., Persicaria
- 347 amphibia, Agrostis stolonifera
- 348 Constant species: Pulicaria vulgaris, Plantago major subsp. intermedia, Juncus bufonius,
- 349 Gnaphalium uliginosum, Persicaria lapathifolia s. l., Agrostis stolonifera, Rumex maritimus,
- Persicaria hydropiper, Bidens tripartitus, Bidens frondosa, Atriplex prostrata, Xanthium
- 351 orientale subsp. italicum, Rorippa amphibia
- Dominant species: Pulicaria vulgaris, Juncus bufonius, Plantago major subsp. intermedia,
- 353 Oxybasis rubra, Lysimachia nummularia, Eleocharis acicularis, Chenopodium album agg.

- Distribution: In Poland, the association occurs on scattered sites, mainly in the valleys of Odra
- and Warta rivers (Fig. 9).
- Physiognomical layout: It is a community found mostly in the flood zone of big rivers. In
- addition to the dominating diagnostic species, important part to this vegetation is composed of
- species from the class Bidentetea.
- Habitat requirements: The association reveal relatively high requirement for nutrients (Fig. 8).

361362

Eleocharito-Schoenoplectetum supini Soo & Ubrizsy 1948 nomina inversa prop.

364

- Diagnostic species: Elatine alsinastrum, Schoenoplectus supinus, Lythrum hyssopifolia,
- 366 Differential species: Alisma lanceolatum, Persicaria amphibia, Typha latifolia
- 367 Constant species: Alisma lanceolatum, Elatine alsinastrum, Limosella aquatica, Schoenoplectus
- 368 supinus, Persicaria amphibia
- Dominant species: Alisma lanceolatum, Elatine alsinastrum, Schoenoplectus supinus, Plantago
- 370 major subsp. intermedia, Lythrum portula, Juncus bufonius

371

- Distribution: Eleocharito-Schoenoplectetum supini is are receively seen in Poland. The majority of
- records come from uplands of Lublin region, but it was also sporadically found in north-w estern
- part of Poland (Fig. 9).
- Physiognomical layout: In the initial phase, it is a distinctive pioneer vegetation type and was
- encountered in, both, the terrestrial and aquatic habitats. In its optimal phase, it is characterized
- by a high cover and relatively high height (up to half a meter) (Fig. 10).
- Habitat requirements: The associacion wellop most often in temporary pools in arable field
- depressions. Some of them occur episodically only during periods with abundant precipitation.
- The association is the most demanding as regards humidity and temperature within the
- Verbenion alliance (Fig. 8).

382

383 Figure 10.

384

385 Radiolion linoidis Pietsch 1973



- Diagnostic species: Hypericum humifusum, Radiola linoides, Anagallis minima, Gypsophila
- 388 muralis, Anthoceros punctatus s. l., Spergularia rubra, Juncus capitatus, Juncus bufonius,
- 389 Illecebrum verticillatum, Phaeoceros laevis, Riccia glauca, Isolepis setacea, Gnaphalium
- 390 uliginosum, Riccia sorocarpa
- 391 Differential species: Spergula arvensis, Rumex acetosella, Scleranthus annuus, Sagina
- 392 procumbens, Equisetum arvense, Elytrigia repens, Setaria pumila, Stellaria media s. l., Viola
- 393 arvensis, Fallopia convolvulus, Veronica serpyllifolia, Veronica arvensis, Achillea millefolium,
- Mentha arvensis, Polygonum aviculare s. l., Erigeron canadensis, Myosotis arvensis, Anthemis
- 395 arvensis, Raphanus raphanistrum, Cyanus segetum, Anagallis arvensis, Cerastium fontanum
- subsp. vulgare, Apera spica-venti, Teesdalia nudicaulis, Vicia hirsuta, Stachys palustris, Oxalis
- 397 fontana, Arnoseris minima, Vicia sativa s. l., Convolvulus arvensis, Capsella bursa-pastoris,
- Ranunculus repens, Galeopsis tetrahit s. l., Holcus mollis, Erodium cicutarium, Cirsium arvense
- 399 Constant species: Juncus bufonius, Gnaphalium uliginosum, Rumex acetosella, Plantago major
- subsp. intermedia, Polygonum aviculare s. l., Sagina procumbens, Hypericum humifusum,
- Radiola linoides, Gypsophila muralis, Spergula arvensis, Anagallis minima, Spergularia rubra,
- 402 Equisetum arvense
- Dominant species: Juncus bufonius, Isolepis setacea, Illecebrum verticillatum, Montia arvensis,
- 404 Anthoceros punctatus s. l.

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- There are six associations of the Radiolion alliance distiguished by a formal classification (Appendix 2, 3):
 - 1. Stellario uliginosae-Isolepidetum setaceae Libbert 1932
 - 2. Centunculo-Anthoceretum punctati Koch ex Libbert 1932
 - 3. Hyperico humifusi-Spergularietum rubrae Wójcik 1968
 - 4. Digitario ischaemi-Illecebretum verticillati Diemont & al. 1940 nom. mut. propos.
 - 5. Cerastio dubii-Ranunculetum sardoi Oberdorfer 1957 emend. Vicherek
- 6. Community with *Montia arvensis*

414

- According to DCA analysis and Ellenberg indicator values, communities of the Radiolion
- linoidis alliance are differentiated in accordance with habitat requirements in terms of moisture,
- light, nutrients and soil reaction (Fig. 9).

418 419 420

- Stellario uliginosae-Isolepidetum setaceae Libbert 1932
- Diagnostic species: *Isolepis setacea*
- Differential species: Stellaria alsine, Juncus articulatus, Juncus effusus, Leontodon saxatilis,
- Bryum pseudotriquetrum, Blasia pusilla, Calamagrostis epigejos
- 424 Constant species: Isolepis setacea, Juncus articulatus, Juncus bufonius, Gnaphalium uliginosum,
- 425 Stellaria alsine, Sagina procumbens, Juncus effusus
- Dominant species: Isolepis setacea, Juncus bufonius, Trichodon cylindricus, Juncus articulatus,
- 427 Calliergonella cuspidata

- Distribution: Stellario-Isolepidetum ocurrs rarely in Poland, mostly in the river valleys in the
- western part of the country (Fig. 11).



- Physiognomical layout: It occurs in the form of low turf with varying degrees of vegetation
- cover. The communities have a considerable amount of diagnostic species for the Bidentetea,
- 433 Molinio-Arrhenatheretea and Scheuchzerio-Caricetea (Fig. 12).
- Habitat requirements: This plant community was recorded on extensively used forest roads, as
- well as mid-field depressions and pond margins. According to DCA results Stellario-
- 436 Isolepidetum has higher demand of humidity and lower soils reaction requirements compared to
- other communities of the Radiolion alliance (Fig. 13).

439 Figure 11.

440

- Centunculo minimi-Anthoceretum punctati Koch ex Libbert 1932
- Diagnostic species: Anagallis minima, Anthoceros punctatus s. l., Radiola linoides, Juncus
- 443 capitatus, Phaeoceros laevis, Fossombronia wondraczekii
- Differential species: Rumex acetosella, Sagina procumbens
- 445 Constant species: Anagallis minima, Juncus bufonius, Gnaphalium uliginosum, Radiola linoides,
- Anthoceros punctatus s. l., Polygonum aviculare s. l., Sagina procumbens, Plantago major
- subsp. intermedia, Rumex acetosella, Juncus capitatus, Gypsophila muralis, Equisetum arvense,
- 448 Spergula arvensis, Hypericum humifusum
- Dominant species: Juncus bufonius, Anthoceros punctatus s. l., Anagallis minima

450

- Distribution: The Centucu Anthoceretum occurs mostly in the south-eastern part of the
- country: the Masovian Plain, the Malopolska Upland, the Podlasie Lowland and the Beskid
- Foothills. Additionally, a single site was noted in the western Poland Fig. 11.
- Physiognomical layout: The communities are characterized by a small annual vascular plants and
- significant share of bryophytes. (Fig. 12)
- Habitat requirements: The community develops on arable fields, in the second half of summer
- and early autumn. A prerequisite for its development is the presence of an exposed and moist
- substrate. In such places, rainwater stays longer and there are no dense high weeds communities.
- These are furrows and mid-field depressions, drying edges of puddle margins, wet spots among
- clay or sandy soil that is slightly acidic. These association has lower humidity and higher
- temperature demands within the Radiolion alliance (Fig. 13).

462

463 Figure 12.

464

465 Figure 13.

- Hyperico humifusi-Spergularietum rubrae Wójcik 1968
- Diagnostic species: Spergularia rubra, Gypsophila muralis, Anagallis minima, Anthoceros
- punctatus s. l., Hypericum humifusum, Laphangium luteoalbum,
- Differential species: Scleranthus annuus, Anthemis arvensis, Rumex acetosella, Convolvulus
- 471 arvensis, Erigeron canadensis, Setaria pumila, Veronica serpyllifolia, Elytrigia repens,
- Raphanus raphanistrum, Anagallis arvensis, Oxalis fontana, Vicia grandiflora, Artemisia
- vulgaris, Myosotis arvensis, Viola arvensis, Sagina procumbens, Polygonum aviculare s. l.,
- 474 Crepis tectorum
- 475 Constant species: Spergularia rubra, Gypsophila muralis, Juncus bufonius, Gnaphalium
- 476 uliginosum, Rumex acetosella, Polygonum aviculare s. l., Scleranthus annuus, Sagina



- 477 procumbens, Plantago major subsp. intermedia, Erigeron canadensis, Elytrigia repens,
- 478 Anagallis minima, Setaria pumila, Hypericum humifusum, Veronica serpyllifolia, Anthemis
- 479 arvensis, Spergula arvensis, Viola arvensis, Equisetum arvense
- Dominant species: Gypsophila muralis, Persicaria hydropiper, Spergularia rubra, Rumex
- $ace to sella, Persicaria\ minor, Juncus\ bufonius,\ Gnaphalium\ uliginosum,\ Anthoceros\ punctatus\ s.$

482 *l*.

483

- Distribution: The Hyperico humifusi-Spergularietum rubrae occurs in the south-eastern part of Poland (Fig. 11).
- Physiognomical layout: The association is dominated by small annual vacular plants, mostly—
- diagnostic for Radiolion alliance with considerable constancy and also have species diagnostic of
- Artemisietea, Papaveretea and Molinio-Arrhenathereta classes (Fig. 12).
- Habitat requirements: The Hyperico-Spergularietum occurs in condition requirements y similar to
- Centunculo-Anthocetetum and is found in wet depression in arable fields, as well as in wet
- furrows and in the vicinity of mid-field water reservoirs. Likewise, results of the the DCA
- analysis showed similarity in habitat demand as Centunculo-Anthoceretum (Fig. 15).
- 493

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- Digitario ischaemi-Illecebretum verticillati Diemont & al. 1940 nom. mut. propos.
- Diagnostic species: *Illecebrum verticillatum, Hypericum humifusum, Spergularia rubra, Radiola* linoides
- Differential species: Teesdalia nudicaulis, Arnoseris minima, Spergula arvensis, Scleranthus
- annuus, Holcus mollis, Rumex acetosella, Digitaria ischaemum, Raphanus raphanistrum, Setaria
- 501 pumila, Aphanes microcarpa, Galeopsis tetrahit s. l., Fallopia convolvulus, Anthoxanthum
- aristatum, Stachys palustris, Rhinanthus angustifolius, Setaria viridis, Persicaria hydropiper,
- Mentha arvensis, Bidens tripartitus, Myosotis arvensis, Stellaria media s. l.
- 504 Constant species: Illecebrum verticillatum, Spergula arvensis, Scleranthus annuus, Rumex
- 505 acetosella, Persicaria hydropiper, Spergularia rubra, Juncus bufonius, Hypericum humifusum,
- 506 Gnaphalium uliginosum, Teesdalia nudicaulis, Radiola linoides, Mentha arvensis, Bidens
- 507 tripartitus, Arnoseris minima, Setaria pumila, Stellaria media s. l., Fallopia convolvulus,
- 508 Equisetum arvense, Agrostis stolonifera, Polygonum aviculare s. l., Elytrigia repens, Stachys
- 509 palustris, Raphanus raphanistrum, Persicaria lapathifolia s. l., Holcus mollis
- 510 Dominant species: Illecebrum verticillatum, Agrostis stolonifera

511

- Distribution: Digitario ischaemi-Illecebretum verticillati occurs under similar conditions as
- Centunculo-Anthoceretum and Hyperico-Spergularietum, in the south-eastern part of Poland
- 514 (Fig. 11).
- Physiognomical layout: It develops at the end of summer, in the form of small patches, on moist
- soil in crop stands or on stubble. Compared to Centunculo-Anthoceretum, it differs in its
- abundant occurrence of *Illecebrum verticillatum* and *Spergula arvensis* with the negligible
- amount of bryophytes.
- Habitat requirements: The soil is more acidic; according to DCA, it also has lower humidity and
- 520 higher temperature requirements (Fig. 13).



- 523 Cerastio dubii-Ranunculetum sardoi Oberdorfer ex Vicherek 1968
- 524 Diagnostic species: Ranunculus sardous, Myosurus minimus, Centaurium pulchellum,
- 525 Differential species: Bryum dichotomum, Bryum caespiticium, Capsella bursa-pastoris, Bryum
- 526 ruderale, Thlaspi arvense, Barbula unguiculata, Tortula modica, Papaver rhoeas, Barbula
- 527 convoluta agg., Dicranella varia, Phascum cuspidatum, Galium aparine, Veronica persica,
- Veronica hederifolia, Tripleurospermum inodorum agg., Marchantia polymorpha, Stellaria
- media s.l., Sherardia arvensis, Oxyrrhynchium hians, Linaria spartea, Lamium amplexicaule,
- Euphorbia exigua, Ceratodon purpureus, Aethusa cynapium, Geranium pusillum, Erodium
- cicutarium, Leptobryum pyriforme, Vicia sativa s. l., Brachythecium rutabulum, Plantago major
- 532 **subsp**. *intermedia*
- 533 Constant species: Plantago major subsp. intermedia, Myosurus minimus, Ranunculus sardous,
- Juncus bufonius, Tripleurospermum inodorum agg., Gnaphalium uliginosum, Stellaria media s.
- 1., Ceratodon purpureus, Capsella bursa-pastoris, Bryum dichotomum, Bryum caespiticium,
- Bryum ruderale, Thlaspi arvense, Sagina procumbens, Polygonum aviculare s.l., Leptobryum
- 537 pyriforme, Dicranella varia
- Dominant species: Ranunculus sardous, Myosurus minimus, Juncus bufonius, Riccia glauca,
- 539 *Gnaphalium uliginosum*
- Distribution: The association are found on scattered localities mainly in river valleys (Fig. 11).
- Physiognomical layout: The communities develop at the beginning of the summer in June and
- July. The amount of species from the Isoëto-Nanojuncetea class is insignificant and plants of the
- 544 Stellarietea class and the diagnostic species of these association are important (Fid. 12).
- Habitat requirements: It occurs in damp places in mid-field furrows, on fallow fields and their
- margins. It is a short-term seasonal community, composed exclusively of annuals. Analysis of
- 547 Ellenberg indicator values showed that Cerastio dubii-Ranunculetum sardoi has higher demand
- for moisture and nutrient content (Fig. 13).

- 551 Community of *Montia arvensis*
- 552 Diagnostic species: Montia arvensis, Riccia sorocarpa
- 553 Differential species: Dicranella staphylina, Holcus lanatus, Epilobium ciliatum, Lotus
- pedunculatus, Bryum subapiculatum, Lathyrus pratensis, Bryum violaceum, Lysimachia
- vulgaris, Myosotis discolor, Arabidopsis thaliana, Vicia hirsuta, Cerastium glomeratum,
- Eupatorium cannabinum, Poa trivialis, Pohlia annotina, Solidago gigantea, Bidens frondosus,
- 8557 Ranunculus repens, Myosurus minimus, Lamium purpureum, Veronica arvensis, Galium palustre
- agg., Stellaria palustris, Pleuridium acuminatum, Glyceria declinata, Rumex crispus,
- Leptobryum pyriforme, Tripleurospermum inodorum agg., Brachythecium rutabulum
- Constant species: Montia arvensis, Juncus bufonius, Myosurus minimus, Lotus pedunculatus,
- Holcus lanatus, Vicia hirsuta, Tripleurospermum inodorum agg., Ranunculus repens,
- Gnaphalium uliginosum, Epilobium ciliatum, Dicranella staphylina, Bidens frondosus, Agrostis
- 563 stolonifera, Veronica arvensis, Rorippa palustris, Persicaria hydropiper, Lysimachia vulgaris,
- Polygonum aviculare s.l., Poa trivialis, Plantago major subsp. intermedia, Persicaria
- lapathifolia s.l., Mentha arvensis, Ceratodon purpureus, Bryum subapiculatum
- Dominant species: Montia arvensis, Juncus bufonius, Pohlia annotina, Argentina anserina

567

Distribution: This community was recorded in the west part of Poland in the Lubuskie Region



- 569 only (Fig. 11)
- Physiognomical layout: Montia arvensis is most often accompanied by Myosurus minimus and
- common segetal weeds of the class Papaveretea (Fig. 12).
- Habitat requirements: Community with *Montia arvensis* stands were found in moist, sandy
- arable fields, most often near backwaters after spring thaws, silts, drainage ditches and spring
- areas. Less often found in the fields of wastelands. According to DCA, the association showed
- 575 higher soil reaction and moisture (Fig. 13).

- Discussion
- The distribution of the Isoëto-Nanojuncetea class in Poland clearly reflects the following
- patterns: it is quite common in the central and southern part of Poland, rarely found in the central
- and eastern Pomerania and absent in Warmia and Mazury regions. This is due to the fact that 25
- 581 (65.7%) characteristic taxa of the class extended to the eastern distribution boundary of their
- European range (Popiela 2005). Moreover, a large part of these communities in Poland has no
- characteristic feature and could be classified into alliances only.
- In accordance with the syntaxonomic concept of Mucina et al. (2016), the order Nanocyperetalia
- Klika 1935 includes six alliances, of which three occur in Central Europe: Radiolion linoidis
- Pietsch 1973, Eleocharition ovatae Philippi 1968 and Verbenion supinae Slavnic 1951 and all of
- which occur in Poland (Kacki, Czarnecka & Swacha 2013). Two alliances are are the most
- common the Eleocharition ovatae 61.3% of these relevés fall into this alliance and the
- Radiolion linoidis alliance is made up of 32.2% of relevés. The Verbenion supinae alliance
- represents only 6.5% of the relevés. Our results showed that vegetation of Radiolion is more
- frequent in Poland than in south part of Europe, especially in the Czech Republic and Slovakia
- 592 (Šumberová & Hrivnák 2013). The Radiolion linoidis is widely distributed in the Atlantic part of
- Europe along with others in moist depressions in heaths (Moor 1936, Pietsch 1973). Habitats of
- this vegetation are almost exclusively moistened by precipitation or rarely by flood, as reported
- by Pietsch (1973). According to Deil (2005) and Šumberová & Hrivnák (2013), high amount of
- 596 precipitation before growing season of its characteristic species is crucial for the development of
- this vegetation. Our results showed that communities of the Radiolion requires less humidity
- compared to communities of the other two alliances. The opposite pattern showed distribution of
- Verbenion supinae which is reported to be more common in southern parts of Europe
- 600 (Šumberová & Hrivnák 2013) and limited number of diagnostic species are found in Poland. The
- occurrence of communities of Verbenion supinae was uncertain in Poland so far (Popiela 1997,
- Matuszkiewicz 2007). However, plant communities of this alliance have been recently classified
- into the alliance Nanocyperion considered by Mucina at al. (2016) as synonym of Verbenion
- 604 supinae
- Altogether, 13 assemblages were distinguished using the formal definition in Poland. The most
- widespread are associations Polygono-Eleocharitetum ovatae and Cyperetum micheliani. Similar
- result was obtained by Šumberová & Hrivnák (2013) in the Czech Republic and Slovakia. This
- also corresponds with the observations from other European countries (e.g. Philippi 1977,
- 609 Müller-Stoll & Pietsch 1985, Bagi 1988, Täuber 2000).
- Our results indicated that the new association of the Eleocharition alliance, namely
- 611 Coleanthetum subtilis which occur preferably in ponds that are used in annual or biennial cycle
- (stocking ponds), with emptying in late autumn, and filling at the turn of April and May. The
- 613 habitat conditions of plant communities with *Colenathus subtilis* showed that it develops on
- organic soils with a pH of 6.4 7.8, rich in N, K, Mg, Ca and Na, and poor in P (Dajdok et al.



2017). In Europe there is no uniform approach to the classification of patches with *Coleanthus* subtilis. They were included in Polygono-Eleocharitetum, Cypero-Limmoselletum and Stellario uliginosae-Isolepidetum setaceae (Pietsch 1973, Brullo & Minissale 1998, Šumberová & Hrivnák 3, Richert et al. 2016), but according to our results and the different nature of vegetation dominated by *Coleanthus subtilis* were distinguished as a new association. Among the Radiolion alliance the Centunculo-Anthoceretum punctan, the Digitario ischaemi-Illecebretum verticillati and the Hypericum humifusi-Spergularietum rubrae are widespread associations. All of them are distributed in the south-eastern part of Poland and develop mostly in wet furrows on arable fields. The Hyperico humifusi-Spergularietum rubrae was described by Wójcik (1968) but Popiela (1997) pointed out that this association was similar to the Digitario ischaemi-Illecebretum verticillati. In the Czech Rebubl et ll this cociation were incuded in Centunculo-Anthoceretum punctati associtation (Šumberová 2011). According to our results which uses formal definition both associations were well separated in Poland, however, share many diagnostic in common. From Radiolion alliance, we found a new community with Montia arvensis that have developed on arable fields in west part of the country. Vegetation with Montia arvensis and Myosurus minimus have been classified so far within Centunculo-Anthoceretum punctate Gicendietum filimormis and Molineriello-Illecebretum verticillate (Pietsch 1973, Brullo & inisalle 1998). This community is well separeted mn Radiolion linoidis, however, further research is required to describe the environmental condition of the stands and distribution pattern as a well defined association.

Communities of Verbenion alliance were rarely reported from Poland. The Pulicario-Menthetum were presented mainly by Strech (1941) and Borysiak (1994) and included, by these authors, in Bidentetea class, but in the Czech Republik and Slovakia communities with species of Isoëto-Nanojuncetea has been included into the Verbenion supinae alliance (Šumberová & Hrivnák 2013). Veronico anagalloidis-Lythretum hyssopifoliae is still poorly recognized in Poland, probably has a transitional character to halophitic communities of the Festuco-Puccinellietea class and requires further research.

Cyperetum flavescentis is classified differently in the phytosociological literature (Moor 1936, Pietsch 1973, Pietsch & Müller-Stoll 1974, Oberdorfer 1983). Due to data scarcity, Popiela (1997) temporarily included this association into the alliance Verbenion supinae. Cyperetum flavescentis was rarely found in Poland, however, a proposition of Pycreus flavescens have recently been reported from South Poland and the North-Eastern Poland (Marciniuk et al. 2020).

The Eleocharito-Schoenoplectus supinus and Alisma lanceolatum has a distinct floristic and ecological characteristic. Our results coresspond with the results produced by the formal classification of the Isoëto-Nanojuncetea communities for the Czech Republic and Slovakia, where communities with Elatine alsinastrum were included into the Verbenion supinae alliance (Šumberová & Hrivnák 2013). We also used in name Eleocharito-Schoenoplectetum supini because of the priority of the valid name published by Ubrizsy (1948). This association were found on temporary ponds of mid-field depressions that occurred frequently on the uplands of Lublin region in Poland (Krawczyk et al. 2016). Formerly communities with Elatine alsinastrum associated with Juncus tenageia were classified to Elatini alsinastrum-Juncetum tenageiae Tausch 1963 and placed in the Eleocharition ovatae alliance (e.g. Pietsch 1973; Täuber, Bruns & Steinhoff 2007) or remained rankless (Kępczyński & Rutkowski 1991; Popiela & Fudali 1996; Krawczyk et al. 2016). In Pannonian Basin association Eleocharito-Schoenoplectetum supini and



- Elatinetum alsinastri (Nagy et al. 2009; Hrivnák & Slezák 2017) were reported. The 661 classification and differences between Junco tenageiae-Radioletum linoidis and Eleocharito-662 Schoenoplectetum supini is still problematic. The Eleocharito-Schoenoplectetum supini in Poland 663 is characterized by a high constancy of *Alisma lanceolatum*, however this species is related to 664 Eleocharito palustris-Alismatetum lanceolati, which is a littoral community (Hrivnák et al. 665 2015). According to the formal definition of the association Eleocharito-Schoenoplectetum 666 supini the relevés with high amount of Alisma lanceolatum and without species from Isoëto-667 Nanojuncetea were excluded and considered as marsh vegetation. In general, communities of this 668 type are scarcely known in Europe, resulting from the fact that they occur irregularly and most 669 often in arable fields. Studies to date have shown that they can remain dormant for a very long 670 time, even for several decades (Täuber et al. 2007; Lukács, Sramkó & Molnár 2013). Their fast 671 development during favorable conditions is possible due to a very durable and abundant soil seed 672 bank (Albrecht et al. 2019). The communities of this group are more associated with continental 673 climate, for example in Hungary, they are more common and more diverse (Lukács, Sramkó & 674 Molnár 2013). In Poland, they occur significantly on the north-western range limit, and most of 675 the sites have been documented from the Volhynian Upland, which is included by 676
- biogeographers into the forest-steppe zone. 677 The first formal classification of the Isoëto-Nanojuncetea class in Poland revealed a high 678
- diversity of ephemeral vegetation found on their distribution boundary in Europe. We described 679 new association and plant community within Eleccharition and Radiolion alliance. Although, we 680
- based our analysis on large data set, some very rare vegetation units were recognized based on 681
- relatively small number of relevés, however, species composition and formal definition used 682
- made it possible to distinguish them. 683
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Table 1(on next page)

List of sociological species groups used for formal definitions of syntax



Species group	Species		
# TC Isoëto-Nanojuncetea	Anagallis minima, Anthoceros punctatus s. l., Carex bohemica,		
class	Centaurium pulchellum, Coleanthus subtilis, Crassula aquatica,		
	Cyperus fuscus, Cyperus michelianus, Elatine alsinastrum, Elatine		
	hexandra, Elatine hydropiper, Elatine triandra, Eleocharis		
	acicularis, Eleocharis ovata, Fossombronia wondraczekii,		
	Gnaphalium uliginosum, Gypsophila muralis, Hypericum		
	humifusum, Illecebrum verticillatum, Isolepis setacea, Juncus		
	bufonius, Juncus capitatus, Juncus ranarius, Juncus tenageia,		
	Laphangium luteoalbum, Limosella aquatica, Lindernia dubia,		
	Lindernia procumbens, Lythrum hyssopifolia, Lythrum portula,		
	Mentha pulegium, Montia arvensis, Myosurus minimus, Phaeoceros		
	laevis, Plantago major subsp. intermedia, Potentilla supina,		
	Pulicaria vulgaris, Pycreus flavescens, Radiola linoides, Ranunculus		
	sardous, Riccia canaliculata, Riccia cavernosa, Riccia glauca,		
WEG EL 1 ::	Riccia sorocarpa, Schoenoplectus supinus, Spergularia rubra		
#TC Eleocharition ovatae	Carex bohemica, Coleanthus subtilis, Crassula aquatica, Cyperus		
	fuscus, Cyperus michelianus, Elatine hexandra, E. propiper, E.		
	triandra, Eleocharis ovata, Limosella aquatica, Linaernia dubia, L.		
	procumbens, Lythrum portula, Potentilla supina, Riccia canaliculata, Riccia cavernosa		
#TC Radiolion	Anagallis minima, Anthoceros punctatus s.l., Fossombronia		
#1C Radionon	wondraczekii, Gypsophila muralis, Hypericum humifusum,		
	Illecebrum verticillatum, Isolepis setacea, Juncus capitatus, Juncus		
	tenageia, Montia arvensis, Phaeoceros laevis, Radiola linoides,		
	Ranunculus sardous, Spergularia rubra		
#TC Verbenion	Centaurium pulchellum, Elatine alsinastrum, Juncus ranarius,		
	Lythrum hyssopifolia, Mentha pulegium, Pulicaria vulgaris, Pycreus		
	flavescens, Schoenoplectus supinus		
### Cyperus fuscus	Cyperus fuscus, Potentilla supina, Limosella aquatica		
### Elatine alsinastrum	Alisma lanceolatum, Elatine alsinastrum, Schoenoplectus supinus		
### Elatine hexandra	Elatine hexandra, Elatine triandra, Elatine hydropiper		
### Eleocharis ovata	Carex bohemica, Eleocharis ovata, Lindernia procumbens		
### Myosurus minimus	Bryum ruderale, Myosurus minimus, Ranunculus sardous		
### Centunculus mini			
	Radiola linoides		
### Gypsophila muralis	Gypsophila muralis, Laphangium luteoalbum, Spergularia rubra		
### Isolepis setacea	Isolepis setacea, Juncus tenageia, Stellaria alsine		



Table 2(on next page)

Number of relevés of identified plant communities of the Isoëto-Nanojuncetea class in Polan



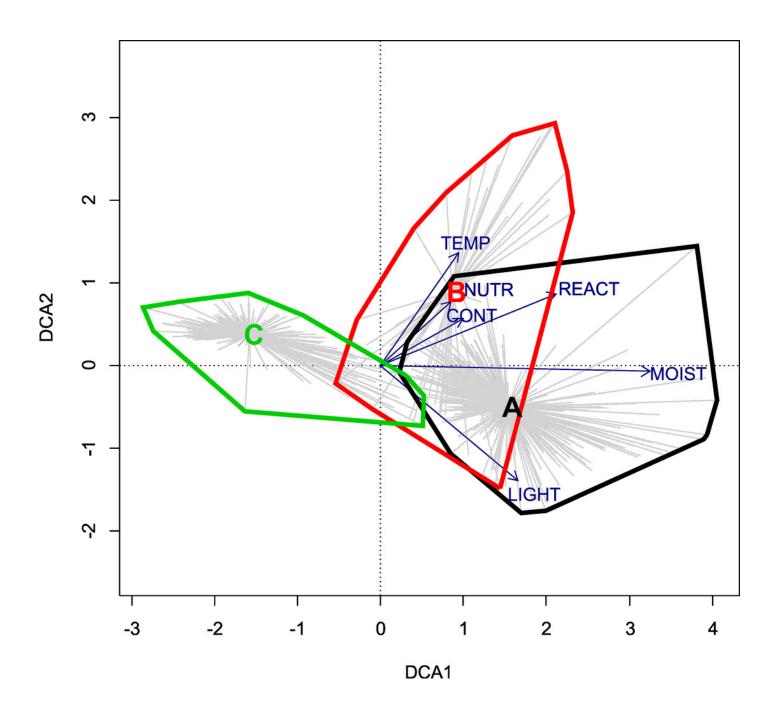
Cluster	Syntaxon	Nr of
		relevé
		S
A	Eleocharition ovatae Philippi 1968	161
1	Polygono-Eleocharitetum ovatae Eggler 1933	142
2	Cyperetum micheliani Horvatić 1931	184
3	Coleanthetum subtilis ass. nova	13
В	Verbenion supinae Slavnić 1951	4
4	Veronico anagalloidis-Lythretum hyssopifoliae Wagner ex Holzner 1973	3
5	Cyperetum flavescentis Koch 1926	9
6	Pulicario vulgaris-Menthetum pulegii Slavnić 1951	16
7	Eleocharito-Schoenoplectetum supini Soo & Ubrizsy 1948	21
С	Radiolion linoidis Pietsch 1973	41
8	Stellario uliginosae-Isolepidetum setaceae Libbert 1932	21
9	Centunculo minimi-Anthoceretum punctati Koch ex Libbert 1932	89
10	Hyperico humifusi-Spergularietum rubrae Wójcik 1968	41
11	Digitario ischaemi-Illecebretum verticillati Diemont & al. 1940 nom. mut. propos.	46
12	Cerastio-Ranunculetum sardoi Oberdorfer 1957 emend. Vicherek	10
13	Community with <i>Montia arvensis</i>	15



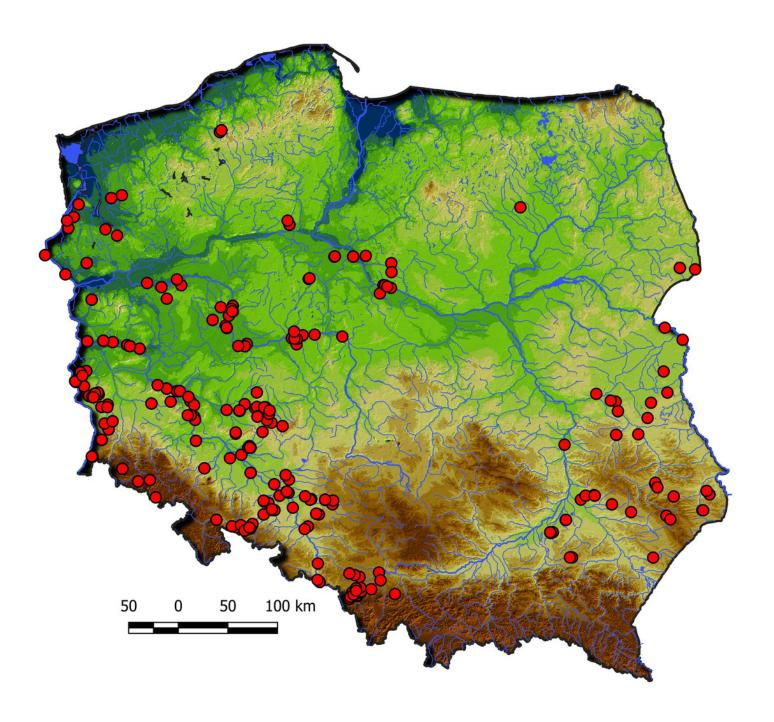
DCA ordination diagram of samples of Isoëto-Nanojuncetea communitie



The first two ordination axes explain 34.1% and 36.9% total species-environment relations variability, and explain 2.9% and 5.1% of the total species variability (n=610). The center of centroids is marked by colored number. A - Eleocharition ovatae, B - Verbenion supinae, C -Radiolion linoidis. The Elleneberg # dicators - LIGHT - Light; TEMP - Temperature; CONT -Continentality; MOIST - Moisture; REACT - Soil Reaction; NUTR - Nutrient - were plotted as a supplementary variables



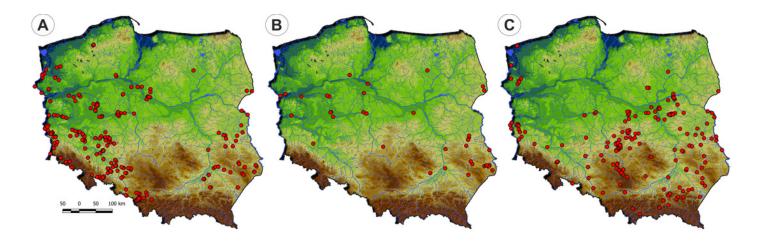
Distribution of plant communities of the Isoëto-Nanojuetea class in Poland





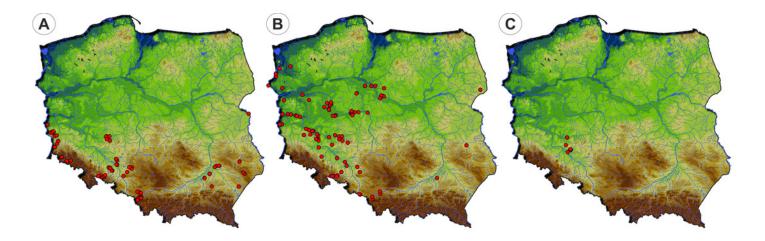
The ranges of alliances of Isoëto-Nanojucetea class in Poland

(A) Eleocharition ovatae. (B) Verbenion supinae. (C) Radiolion linoidis



Distribution of plant communities of the Eleocharition ovatae alliance in Polan

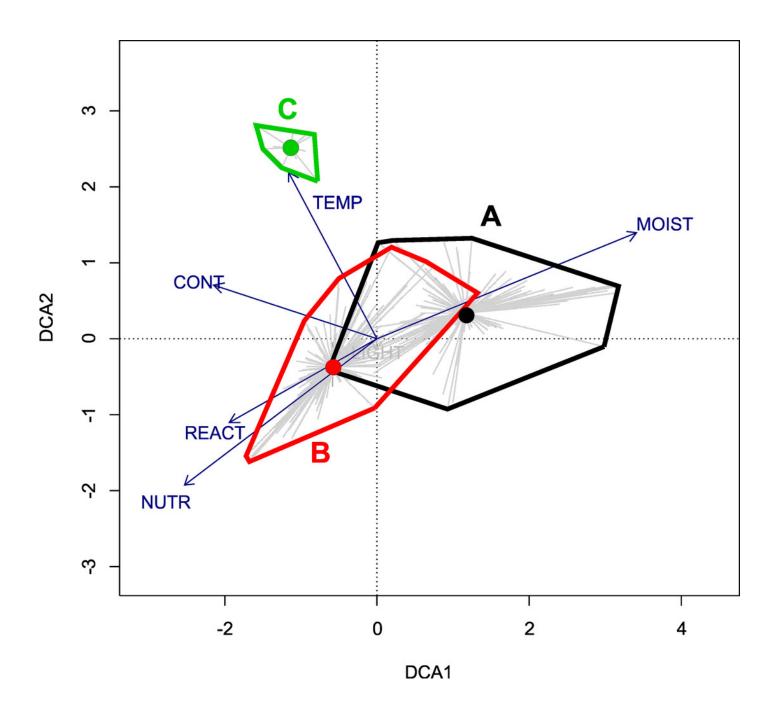
(A) Polygono-Eleocharitetum ovatae. (B) Cyperetum micheliani. (C) Coleanthetum subtilis.





DCA ordination diagram of samples of Eleocharition ovatae plant communities

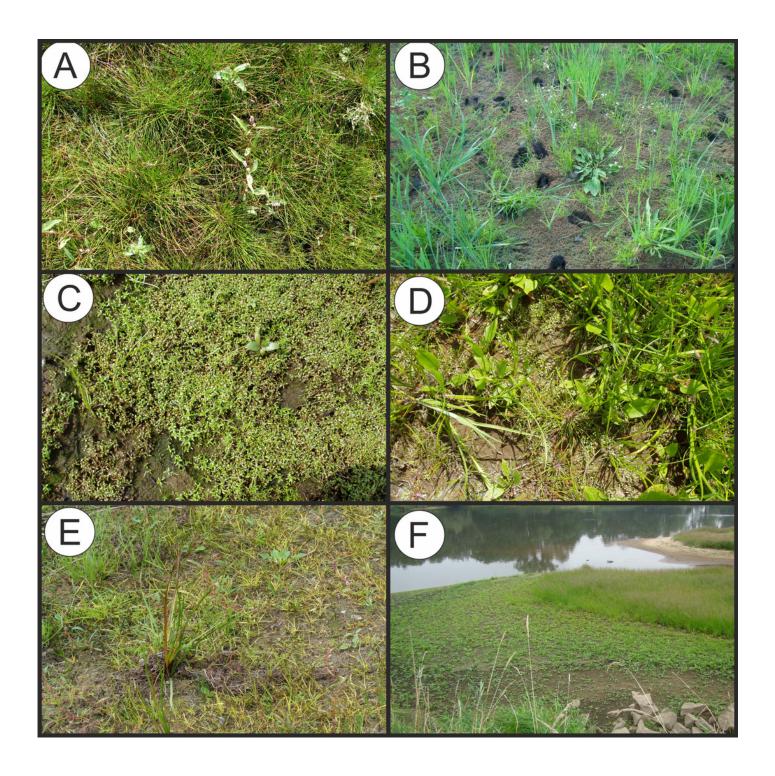
The first two ordination axes explain 25.9% and 40.6% of the total species-environment relations variability, and additional explain 3.5% and 6.7% of the total species variability (n=339). The center of centroids are marked by colored dots. (A) Polygono-Eleocharitetum ovatae. (B) Cyperetum micheliani. (C) Coleanthetum subtilis ass. nova. The Elleneb indicators: LIGHT - Light; TEMP - Temperature; CONT - Continentality; MOIST - Moisture; REACT - Soil Reaction; NUTR - Nutrient were plotted as a supplementary variables.





Vegetation of the Eleocharition soloniensis liance

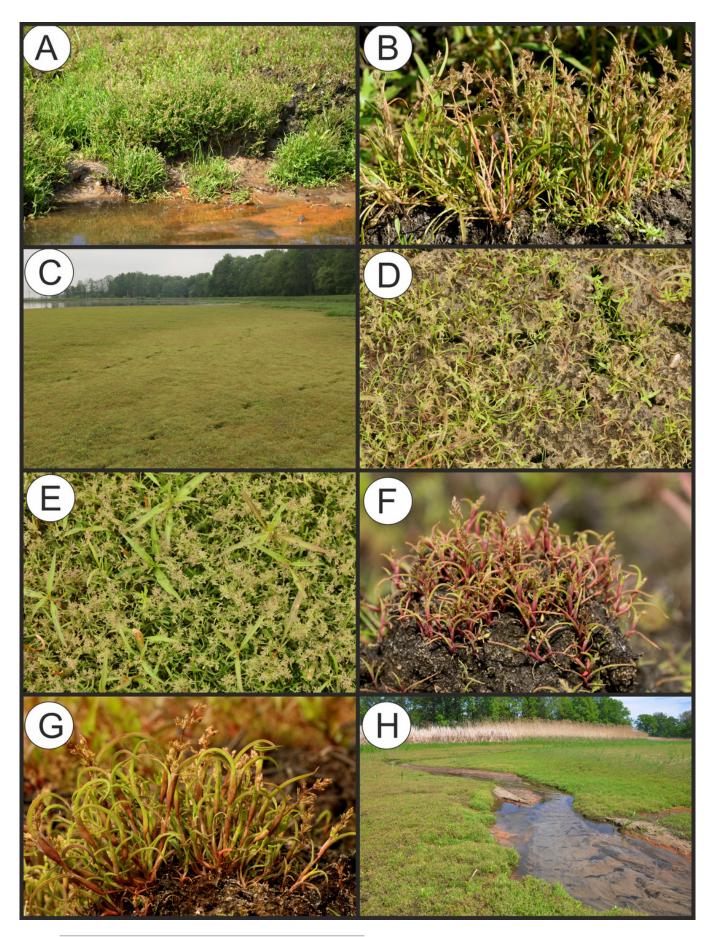
(A, B, C, D) phytocoenoses of the Polygono-Eleocharetum ovatae in different stages of development (Photos by R. Krawczyk, S. Rosadziński, A. Popiela); (E, F) phytocoenoses of Cyperetum micheliani (Photos by S. Rosadziński).





Coleanthus subtilis and phytocoenoses of the Colenathetur ubtilis

(A, D, E) phytocoenoses of the Coleanthetum subtilis association. (B, F, G) individuals of the species at various development stages. (C) the view of the community patches at the bottom of one of the ponds in the vicinity of Borowa Oleśnicka, (H) the patches of the community in the complex of ponds in the area of Ruda Sułowska (Photos by Z. Dajdok)



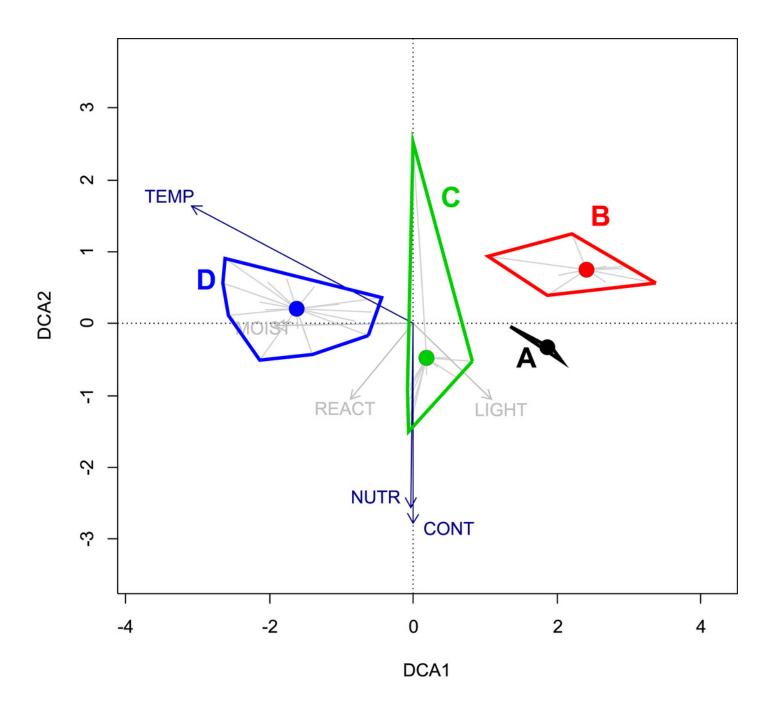
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DCA ordination diagram of samples of Verbenion supinae plant communities

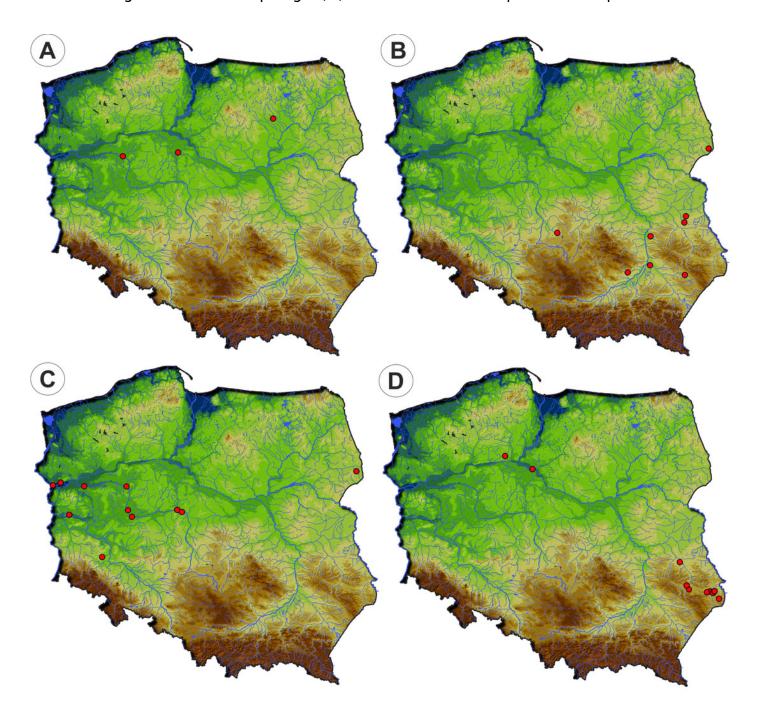
The first two ordination axes explain 21.2% and 32.7% of the total species-environment relations variability, and explain 8.5% and 14.6% of the total species variability (n=49). The centers of centroids are marked by colored dots. (A) Veronico anagalloidis-Lythretum hyssopifoliae. (B) Cyperetum flavescentis. (C) Pulicario vulgaris-Menthetum pulegii. (D) Eleocharito acicularis-Schoenoplectetum supini. The Elleneber ndicators - LIGHT - Light; TEMP - Temperature; CONT - Continentality; MOIST - Moisture; REACT - Soil Reaction; NUTR - Nutrient - were plotted as a supplementary variables.





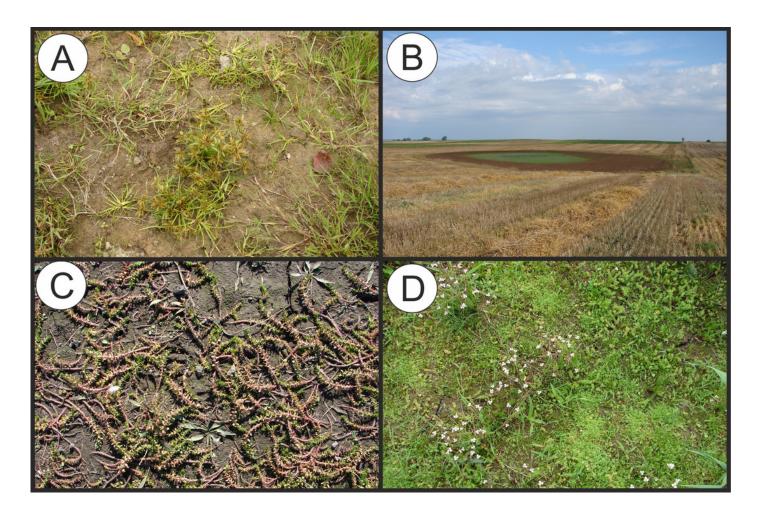
Distribution of plant communities of the Verbenion supinae alliance in Poland

(A) Veronico anagalloidis-Lythretum hyssopifoliae. (B) Cyperetum flavescentis Koch 19 (C) Pulicario vulgaris-Menthetum pulegii. (D) Eleocharito-Schoenoplectetum supini.



Vegetation of the Verbenion alliance

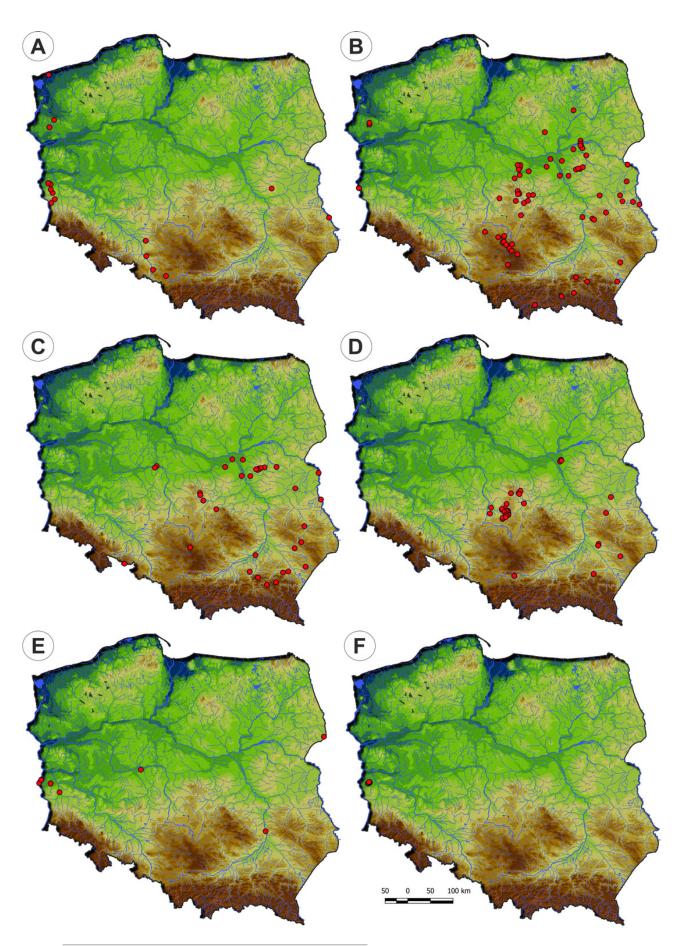
(A) phytocoenose of the Cyperetum flavescentis association. (B) a temporary pool in arable field depressions with patches of the Eleocharito-Schoenoplectetum supini (brown belt). (C, D) phytocoenoses of the Eleocharito-Schoenoplectetum supini in different stages of development (Photo by R. Krawczyk)





Distribution of the plant communities of the Radiolion linoidis alliance in Poland

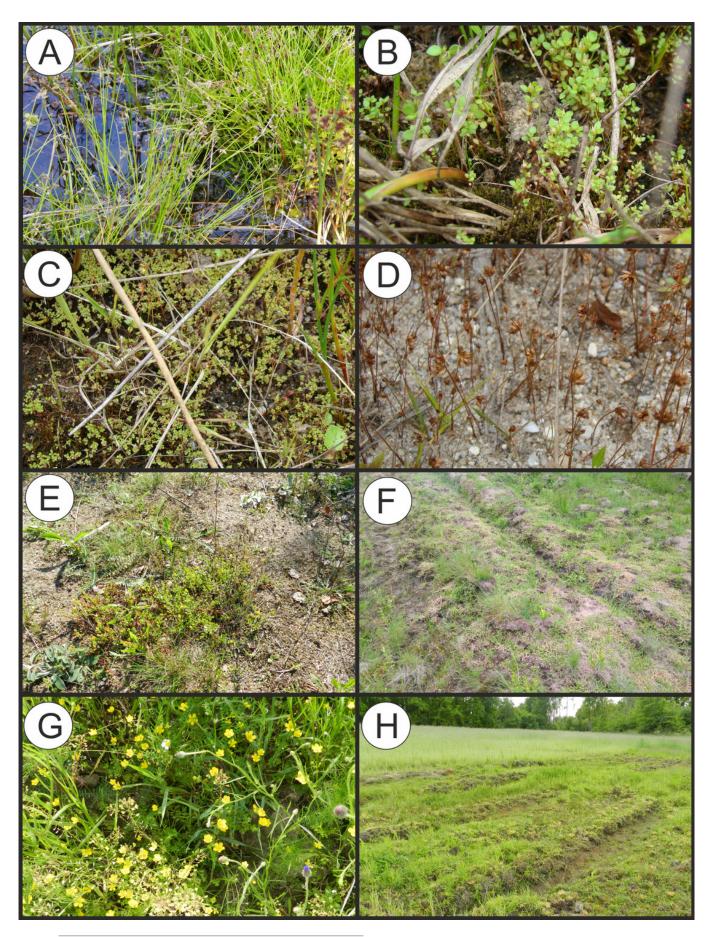
- (A) Stellario uliginosae-Isolepidetum setaceae. (B) Centunculo minimi-Anthoceretum punctati.
- (C) Hyperico humifusi-Spergularietum rubrae. (D) Digitario ischaemi-Illecebretum verticillati.
- (E) Cerastio dubii-Ranunculetum sardoi. (F) Community with Montia arvensis.





Vegetation of the Radiolion alliance

(A) phytocoenose of the Stellario uliginosae-Isolepidetum setaceae association. (B, C, D, E, F) phytoceonoses of the Centunculo-Anthoceterur ssociation: a patch of the Hyperi Spergularietum, phytocoenose of the Digitario ischaemi-Illecebretum verticillati association. (G) a patch of Cerastio dubii-Ranunculetum sard (H) a community of Montia arvensi (Photos by S. Rosadziński)



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DCA ordination diagram of samples of Radiolion linoidis plant communities

The first two ordination axes explain 25.8% and 36.3% total species-environment relations variability, and explain 5.7% and 9.3% of the total species variability (n=222). The centroids are marked by colored dots. (A) Stellario uliginosae-Isolepidetum setaceae. (B) Centunculo-Anthoceretum punctati. (C) Hyperico-Spergularietum. (D) Digitario ischaemi-Illecebretum verticillati. (E) Cerastio-Ranunculetum sardoi. (F) Community with *Montia arvensis*.



