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Plant Species Richness of Riverbed Elevations—the Pripyat River Valley Case Study[1]

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Abstract—Flora of the still unchanged or slightly modified floodplains is particularly valuable. Such are the natural, periodically flooded riparian ecosystems within the Mid–Pripyat river valley in Belarus. Distinctive elements of that area are 'periodic islands', which arise from the most elevated parts of the riverbed during flooding and have a specific microtopography. The aim of the research was to recognize floristic composition and ecological conditions of the 'islands.' Noted plants were mainly photophilous, by clearly varied in soil moisture, acidity and fertility requirements.

Keywords: species diversity; floodplain area; river; Belarus

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INTRODUCTION

Belarusian Polesie altogether with the Pripyat river valley is part of the largest in Eastern Europe complex of wetlands, peatlands and swamps, which cover ca. 200000 km^2 (Kondracki 1992, Masing et al. 2010). Within the area there is the Turov Meadow—one of the nowadays uncommon wetlands, which are barely changed by human. It is the best preserved fragment of the Pripyat river valley, under law protection in the local scale and a place of international importance as the Mid–Pripyat State Landscape Zakaznik Ramsar site (Kozulin et al. 1997, 2002, Samusenko 2000).

Many authors point that natural ecosystems occur in European river valleys only fragmentarily (Grevilliot and Muller 2002, Kamp et al. 2004, Krause et al. 2011). Still, their remnants, especially those well preserved and traditionally managed, are characterized by high species richness of plants (Norderhaug et al. 2000) and they are refuges for valuable and threatened taxa (Selinger–Looten et al. 1999, Luoto 2000, Gerard et al. 2008, Stępień 2009). A good example is *Gratiola officinalis*, plant common in the Pripyat valley and endangered in central Europe (Grevilliot and Muller 2002, Geissler and Gzik 2010).

In the spring the Pripyat river forms backwaters with riverbed elevations, located above the water level. Those places, called in this paper 'periodic islands'. The aim of the research was to characterize floristic composition and habitat conditions of the 'islands'.

STUDY AREA

The study was carried out in the fragment of natural, riparian meadows, in the right-bank of middle part of the Pripyat river valley, located close to Turov town (S Belarus, 52°04′ N, 27°44′ E, Gomel region, Zhitkovichi district) (Fig. 1).

Study area is located in south-eastern part of the 'Mid-Pripyat' nature reserve, established in 1999 and covering the area of 90 447 ha and also within the 'Turov Meadow' area (500 ha), which has international protection status and is a Ramsar site (Kozulin et al. 1997, 2002). The middle part of the river altogether with its tributaries belongs to the central part of the Polesie Lowland. Along that stretch, river is characterized by a strong meandering (meandering index from 2.1 to 2.8), with many distributaries and oxbows.

The slope of the riverbed in the vicinity of Turov is 0.11 m/km and its width varies from 100 to 175 m. Every year the river valley is inundated during the spring flood (Mongin and Pinchuk 1999). Appearing backwaters are widespread and they are characterized by a relatively low water level (Kozulin et al. 2002). The flooding period in the Pripyat valley usually lasts 3.5 to 4 months. In the floodplains close to Turov town water usually remains for 62 days and the water level in

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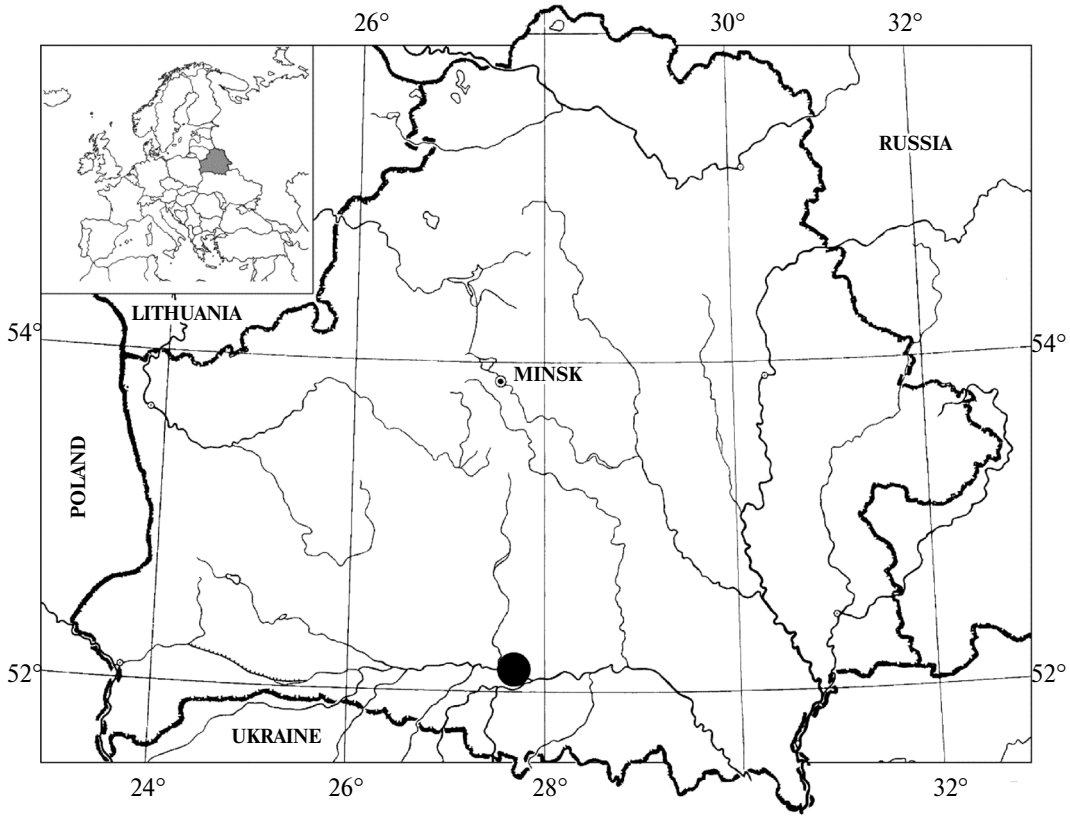

Fig. 1. Location of the study area (marked with a black dot).

the riverbed elevates on average for 3.5 to 4 m (Kozulin et al. 1997). The highest parts of the flooded meadows transform into so-called 'islands'. The area of those islands is determined by the water level of the backwater area. In the turn of April, when islands are inaccessible from the land, their area varies from 3 to 5 ha (A. Szurlej–Kielańska, unpubl.). The highest water level is observed every year in the turn of March and it may also vary during the season after intense rains (Kozulin et al. 2002). At the lowest water level the islands' height does not exceed 1 m (Kozulin et al. 1997).

The study area is located within the southern, warm climate region with changeable moisture. The continental climate, with mild and short winters and relatively long and warm summer, comparing to other regions of Belarus, prevails here (Kozulin et al. 1997). Mean temperatures of the coldest and warmest months of the year (January/July) are –5.3°C and 18.6°C respectively (data according to the meteorological station in Pińsk).

MATERIAL AND METHODS

The field research was carried out at the end of May 2008, in within all 6 'islands' located in the vicinity of Turov town. During the study a floristic inventory was made within the whole area of the islands altogether with the flooded margin, where stagnant water did not exceed of 0.5 m in depth.

The analysis of the flora included division of taxa into various sociological-ecological groups, established on the basis of species affiliation to particular vegetation units, given by Matuszkiewicz (2008). The following groups of plants were distinguished: aquatic, species of marshes and silted grounds, rushes, wet meadows, fresh meadows, peatlands, forests, dry grasslands and heatlands, ruderal and segetal plants and species of wide ecological scale. Life forms followed Raunkiaer (1934). Habitat conditions were characterized with the use of Ellenberg's bioindicator method (Ellenberg 1992).

Species were grouped according to their habitat preferences with the use of Principal Correspondence Analysis (PCA) method, as the first axis showed a gradient length of 2.49 (Jongman et al. 1995, Lepš and Šmilauer 2004). For species the present/absent data were used, while the number of species in particular sociological-ecological groups and mean values of Ellenberg's indicators were treated as supplementary variables. The multivariate analysis was performed with the use of CANOCO ver. 4.5 (ter Braak and Šmilauer 2002).

RESULTS

Spring flora of the studied 'periodic islands' comprises 98 vascular plants. Among them the highest frequency had species of fresh meadows, which constituted 16% of all taxa (Table 1). They were represented mostly by grasses, with dominating species: *Poa pratensis, Festuca rubra* and *Phleum pratense*. From dicotyledones, *Cardamine pratensis, Cerastium holosteoides* and *Rumex acetosa* occurred most often. The next group consisted of wet meadow species (14%), among which the most frequent were: *Alopecurus pratensis, Deschampsia caespitosa, Filipendula ulmaria* and *Lysimachia vulgaris*. Similarly numerous (14%) was representation of plant connected with dry grasslands and heathlands, especially: *Corynephorus canescens, Hieracium pilosella, Nardus stricta, Rumex acetosella, Scleranthus perennis* and *Sedum acre*. Species of marshes and silted grounds comprised 11% of the total flora. The most often noted were species: *Agrostis stolonifera, Alopecurus geniculatus, Lysimachia nummularia, Potentilla anserine* and *Ranunculus repens*. The following, equally large (11%) group consisted of rushes' species, with dominating: *Eleocharis palustris, Phalaris arundinacea, Rorippa amphibian* and *Veronica beccabunga*. Among the aquatic plants, which represented 7% of the total, the most frequent were: *Lemna trisulca* and *Polygonum amphibium* f. *natans*.

Group of ruderal and segetal plants was not numerous (5%), however species belonging to it, such as: *Cirsium arvense, Glechoma hederacaea* and *Xanthium strumarium*, were common components noted on 'islands'. The other plants represented forests, peatlands and the group of species with a wide ecological scale. Among them, *Carex nigra, Stellaria graminea* and *Achillea salicifolia* were often noted in the studied area.

The distinguished sociological-ecological groups (Table 1) may be classified into three main categories. The first one comprises hydrophytes and helophytes and represents almost 33% of the total flora. Analogous participation showed plants belonging to the group of hygro– and mesophytes, while the third category consisted of sclerophytes and plants growing in dry places. Species of first two categories were found mainly on the flooded shores, in terrain depressions and in the lowest located flat fragments of the 'islands', while plants of dry and sandy places occupied the most elevated fragments of the 'islands'.

The highest participation in the studied flora had hemicryptophytes. They were mainly represented by short-leaved semi-rosette perennial plants (56%) (Table 1). Among the rest, over 15% were hydrophytes and almost 13%—therophytes. Chamaephytes and geophytes were infrequent—6% each. Nanophanerophytes were represented by only 1 species—*Salix cinerea*, which formed singular, slender stems of ca. 50 cm height.

Table 1. Synecological groups and life forms of plants of the analyzed flora

	Group symbol	No. of species	Share, %
SYNECOLOGICAL GROUP			
Aquatic	I	7	7.1
Marshes and silty grounds	II	11	11.2
Rushes	III	11	11.2
Wet meadows	IV	14	14.3
Fresh meadows	V	16	16.3
Peatlands	VI	3	3.1
Forests	VII	2	2.0
Dry grasslands and heatlands	VIII	14	14.3
Ruderal and segetal	IX	5	5.1
Others	X	15	15.3
LIFE FORM			
Hemicryptophytes		57	55.9
Hydrophytes		15	15.3
Therophytes		13	12.7
Chamaephytes		6	5.9
Geophytes		6	5.9
Nanophanerophytes		1	1.0

Ecological characteristics of the species, expressed by the Ellenberg's indicators allowed valorising habitat conditions of the 'islands'. Distribution of the indicators' values is given at Fig. 2. Most of species of the studied flora belong to the group of photophilous plants (7th and 8th degree). Those are mainly herb species connected with open areas. Few taxa with minor light requirements represent aquatic or partially submerged plants (Fig. 2a).

Almost half of all species, which grew on 'islands', was characterized by the wide tolerance or lack of preferences to thermal conditions (Fig. 2b). Other plants represented group of moderate climate species. Most of the noted taxa is attached to Central Europe or is regarded as suboceanic *s. l.* (Fig. 2c). There were also some species not related to any group, due to their azonal character. As regards the moisture, 'islands' plants showed high (and moderately even) diversity, as they represented dry, fresh, moist, wet or even aquatic habitats (Fig. 2d). Similar distribution is observed in case of other two indicators: acidity (Fig. 2e) and nitrogen (Fig. 2f). It is probably connected with variety of microhabitats within each studied island.

Species grouping according to microhabitat conditions was presented on the PCA diagram (Fig. 3). The amount of variance explained by the first 2 axes is 62.3%. Eigenvalues of the axes showed that the first and second axes had the greatest input in the explaining of variation in the analysed data set (eigenvalue of

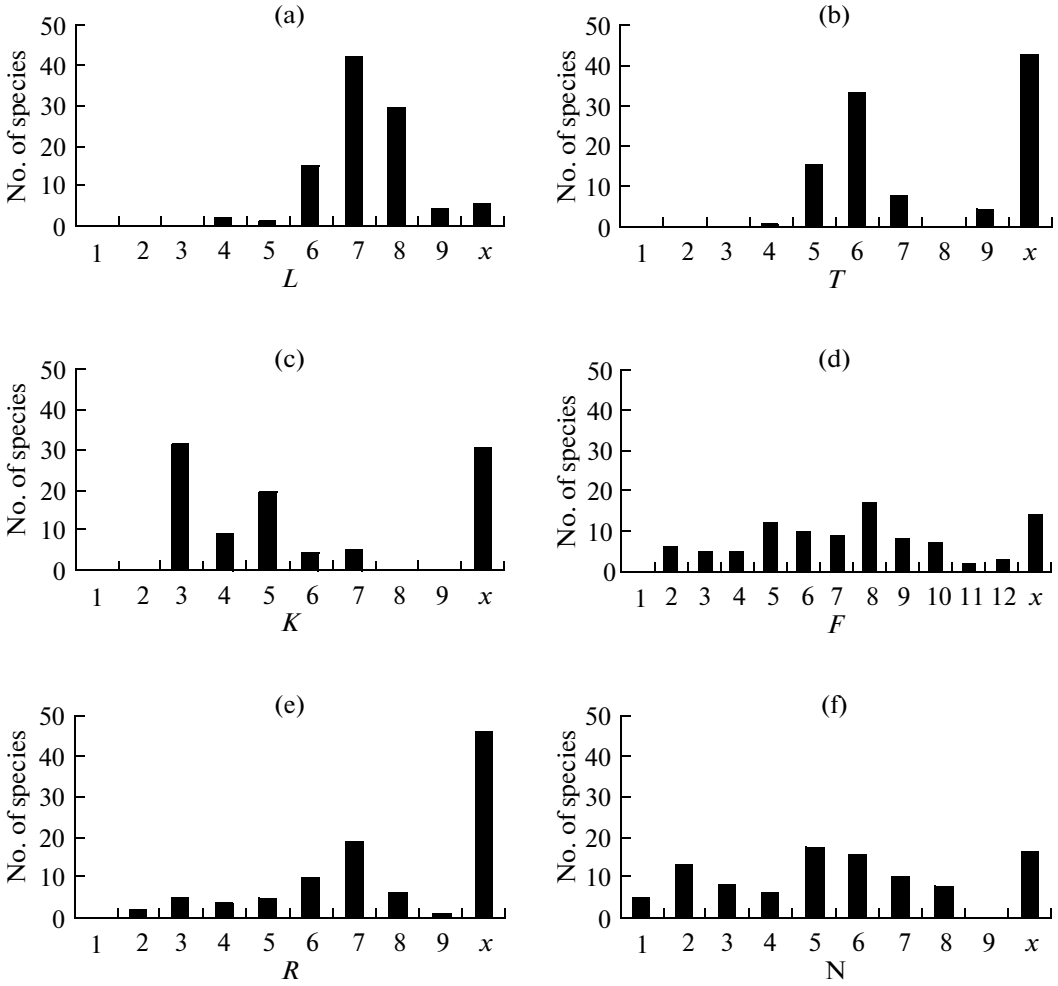

Fig. 2. Ellenberg's indicator values for light (*L*), temperature (*T*), continentality (*K*), moisture (*F*), acidity (*R*) and nitrogen (N) within total flora of the study area. *x*—species of undefined indicator value.

the first axis is 0.342 and the second is 0.281). Gradients of moisture, trophy and acidity are connected with axis 1.

Within the highest values of the first axis there is a group of species of low moisture ($F = 2$ and $F = 3$) and nitrogen requirements (N = 1 to N = 3) and those attached to acidic habitats ($R = 2$ to $R = 4$) (Fig. 3, species assemblage 'C'). Those plants were noted at more elevated parts of 'islands' and belonged to the group of dry grasslands, heathlands (VIII), fresh meadows (V) and species of wide synecological scale (X). The most frequent were species: *Scleranthus perennis, Sedum acre, S. sexangulare, Corynephorus canescens, Potentilla argentea, Rumex acetosella, Nardus stricta, Cerastium holosteoides, Prunella vulgaris, Ranunculus acris, Trifolium dubium* and *T. montanum*.

Within the lowest and mean values of the axis 1 there is a concentration of plants with the highest requirements of moisture ($F = 10$ to $F = 12$), nitrogen (N = 6 to N = 8) and associated with slightly acidic and neutral habitats ($R = 5$ to $R = 8$) (Fig. 3a). Those species, found at the 'islands' margins and within local depressions, represented: rushes' (III), marshes' (II), aquatic (I) and forest plants (VII). Among them, frequent were: *Alisma plantago-aquatica, Carex vulpina, Eleocharis palustris, Galium palustre, Agrostis stolonifera, Lycopus europaeus, Gratiola officinalis, Rorippa amphibia, Rumex acetosa* and *Achillea salicifolia*, less often occurred e.g. *Lemna trisulca*.

The third group (Fig. 3b) is connected with positive values of the axis 2. It is formed by the mixture of species representing wet meadows (IV), peatlands (VI) with ruderal and segetal (IX), which have intermediate requirements comparing to species from groups 'A' and 'C'. The most frequent within the group 'B' are: *Lysimachia nummularia, Poa pratensis, Potentilla anserina, Ranunculus repens, Alopecurus pratensis, Carex hirta, Stellaria palustris* and *Cirsium arvense*.

The analysis of ecological requirements of plants growing on 'islands' altogether and grouping of those species with the use of PCA method allowed to distinguished three types of habitats (Table 2). Aquatic and

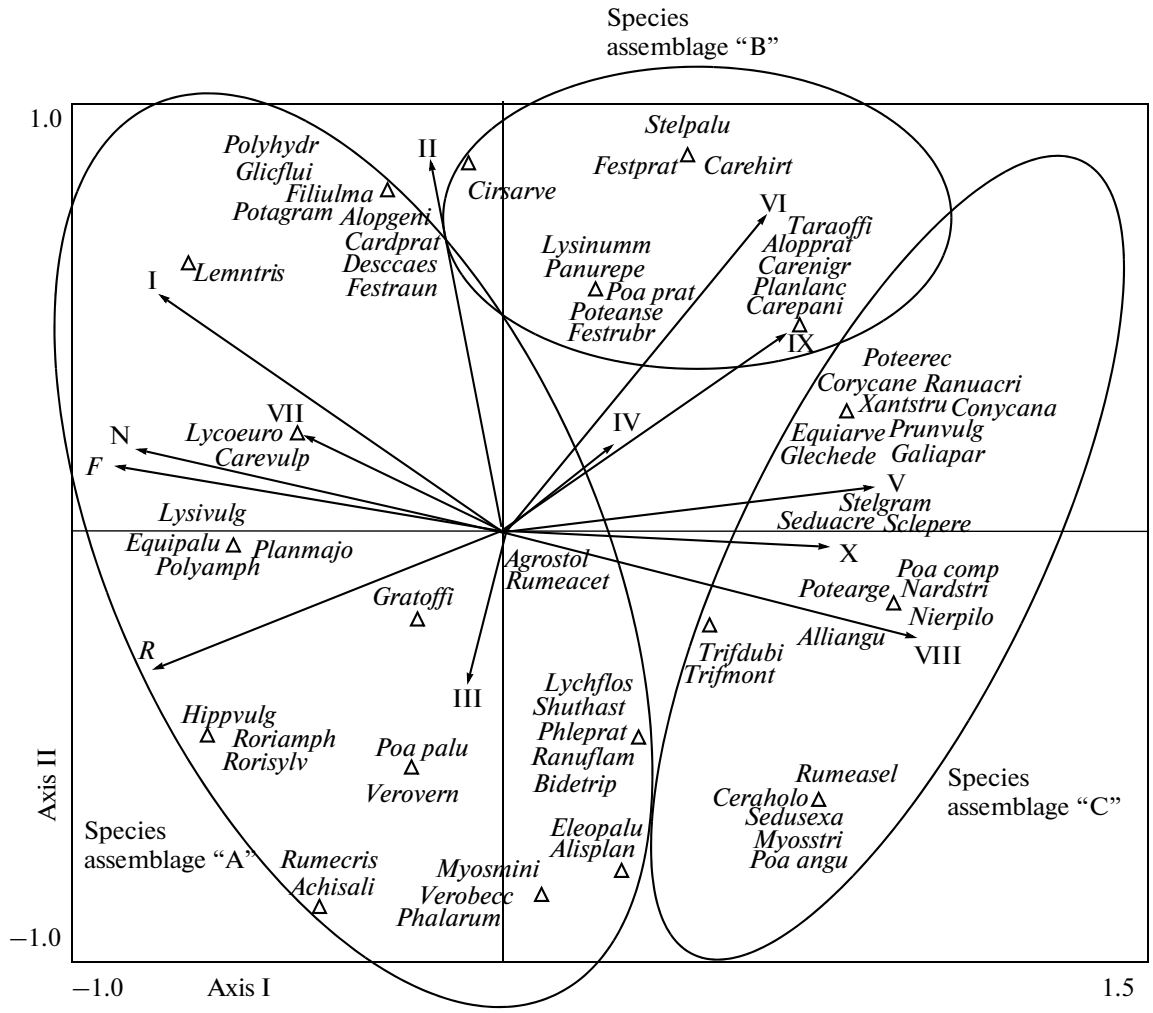

Fig. 3. PCA ordination diagram of species for the first and second axes (species with a frequency of more than 25% in the sampling plots are showed). Arrows represent supplementary variables—Ellenberg's indicators: *F*—moisture, *L*—light, N—nitrogen, *R*—acidity, numbers I–X—synecological groups, as in Table 1.

Achisali—Achillea salicifolia, Agrostol—Agrostis stolonifera, Alisplan—Alisma plantago-aquatica, Alliangu—Allium angulosum, Alopgeni—Alopecurus geniculatus, Alopprat—Alopecurus pratensis, Bidetrip—Bidens tripartita, Cardprat—Cardamine pratensis, Carehirt—Carex hirta, Carenigr—Carex nigra, Carepani—Carex panicea, Carevulp—Carex vulpina, Ceraholo—Cerastium holosteoides, Cirsarve—Cirsium arvense, Conycana—Conyza canadensis, Corycane—Corynephorus canescens, Desccaes—Deschampsia caespitosa, Eleopalu—Eleocharis palustris, Equiarve—Equisetum arvense, Equipalu—Equisetum palustre, Festarun—Festuca arundinacea, Festprat—Festuca pratensis, Filiulma—Filipendula ulmaria, Galiapar—Galium aparine, Glechede—Glechoma hederacea, Glycflui—Glyceria fluitans, Gratoffi—Gratiola officinalis, Hierpilo—Hieracium pilosella, Hippvulg—Hippuris vulgaris, Lemntris—Lemna trisulca, Lychflos—Lychnis flos-cucculi, Lycoeuro—Lycopus europaeus, Lysinumm—Lysimachia nummularia, Lysivulg—Lysimachia vulgaris, Myosstri—Myosotis stricta, Myosmini—Myosurus minimus, Nardstri—Nardus stricta, Phalarun—Phalaris arundinacea, Phleprat—Phleum pratense, Planlanc—Plantago lanceolata, Planmajo—Plantago major, Poa angu—Poa angustifolia, Poa comp—Poa compressa, Poa palu—Poa palustris, Poa prat—Poa pratensis, Polyamph—Polygonum amphibium, Polyhydr—Polygonum hydropiper, Potagram—Potamogeton gramineus, Poteanse—Potentilla anserina, Potearge—Potentilla argentea, Poteerec—Potentilla erecta, Prunvulg—Prunella vulgaris, Ranuacri—Ranunculus acris, Ranuflam—Ranunculus flammula, Ranurepe—Ranunculus repens, Roriamph—Rorippa amphibia, Rorisylv—Rorippa sylvestris, Rumeacet—Rumex acetosa, Rumeasel—Rumex acetosella, Rumecris—Rumex crispus, Sclepere—Scleranthus perennis, Scuthast—Scutellaria hastifolia, Seduacre—Sedum acre, Sedusexa—Sedum sexangulare, Stelgram—Stellaria graminea, Stelpalu—Stellaria palustris, Taraoffi—Taraxacum officinale, Trifdubi—Trifolium dubium, Trifmont—Trifolium montanum, Verobecc—Veronica beccabunga, Verovern—Veronica verna, Xantstru—Xanthium strumarium.

wetland habitats were characterized by neutral soil reaction and moderate fertility. Similarly, mesic habitats were neutral or slightly acidic and relatively fertile. Unlike the above-described, dry habitats were poor and strongly acidic.

DISCUSSION

Natural or slightly changed river valleys such as of the Pripyat or Lena rivers are particularly important for the occurrence of various ecosystems (riverbeds with oxbows, adjacent open floodplains and peat-

Table 2. Type of habitats and mean Ellenberg's indicator values for moisture (*F*), nitrogen (N) and acidity (*R*)

Habitats	Mean values	Ellenberg's	Indicator
	F	N	*R*
Aquatic and Wetland	10.7	5.2	7.0
Mesic	7.1	5.9	6.3
Dry	2.4	2.1	3.2

lands, as well as riparian forests and shrubs) (Mirkin et al. 1992, Kozulin et al. 1997). In many European river valleys those types of ecosystems are fragmented, as a result of river banks' regulations, canalizing and draining the adjacent areas (Tockner and Stanford 2002, Kamp et al. 2007). Quantitative and qualitative changes in meadow phytocoenoses are observed also as a result of the intensification of agriculture, e.g. in Germany the area of wet and species-rich mesic meadows was reduced by 80% (Krause et al. 2011) and the species richness dropped to 10–50% (Wesche et al. 2012).

Simplification of habitat structure, lack of phytocoenoses' variety and habitat fragmentation cause changes in floristic composition and decrease of species diversity (Dufíková and Lexa 2001, Critchley et al. 2003, Leyer 2005, Gerard et al. 2008, Prajs and Antkowiak 2010). Within one of the well preserved fragments of West European floodplain grassland in the Middle Elbe River, vegetation patches comprised 245 plant species (Leyer 2004), while in 'Mid-Pripyat' reserve 725 species were noted (Kozulin et al. 1997). On the river islands within floodplains of the Lena river valley 104 plants were observed (Mirkin et al. 1992) and the flora of studied 'islands' in the Pripyat river consisted of 98 taxa.

Apart from the anthropogenic factors, number of species in phytocoenoses of riparian meadows is also related to natural conditions, such as: soil moisture and degree of shade (Pausas and Austin 2001, Pykälä et al. 2005). Water level in river valleys often determines the floristic composition, in which the main role is played by grasses and other species typical for wet and floodplain grasslands, e.g. *Alopecurus pratensis, Agrostis stolonifera* and *Rumex acetosa* (Touzard et al. 2002, Härdtle et al. 2006, Vercoutere et al. 2007), similarly as on the analyzed Pripyat 'islands'.

The majority of perennials, especially hemicryptophytes, hydrophytes and chamaephytes and a lack of phanerophytes in the studied flora is connected with slight elevation of the 'islands' above the water level (from 0.5 to 1.0 m) and their tidal flooding. Domination of hemicryptophytes in meadow and tall grass phytocoenoses within alluvial plains of the Polesie Province was observed by Gusev (2009). In the flora of islands in the Lena valley, apart from a significant participation of hemicryptophytes, a group of phanerophytes was also noted, as a result of higher elevation of river islands above the water level (from 0.5 to 13 m) (Mirkin et al. 1992). In the analyzed flora of Pripyat valley there was a small participation of therophytes. Similar smaller share of annual and biennial plants comparing to perennials were observed by Nilsson et al. (1991) at the margins of natural, not regulated rivers.

Specific feature of the 'periodic islands' of the Pripyat valley is co-occurrence of contrasting in terms of moisture and fertility microhabitats: (a) neutral, fertile aquatic and wetland habitats, (b) fertile and slightly acidic mesic ones and (c) poor and acidic dry ones, within the small area of each 'island'. The joint occurrence of dry and wet habitats was reported from other river valleys, although only in case of the Lena river those habitats formed relatively close located complexes (Mirkin et al. 1992). In the river valleys in France such habitats are spatially distant and occupy riverbanks and the flood plains (Selinger–Looten et al. 1999). Habitats diverse according to moisture were noted also in flood plains with significant relief (Prach 1996, Lenssen et al. 1999, Koning 2005).

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