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THE VEGETATION OF CHANNELS AND FLOODPLAINS OF SŁUPIA (POLAND) AND STRIZHEN (UKRAINE) RIVERS IN URBANIZED TERRITORIES

ROŚLINNOŚĆ KANAŁÓW I TERAS ZALEWOWYCH RZEK SŁUPI (POLSKA) I STRIZHEN (UKRAINA) NA TERENACH ZURBANIZOWANYCH

***Abstract*:** The vegetation of the channels and floodplains of the Słupia and Strizhen rivers, located in a close latitudinal range within the cities of Slupsk (Poland) and Chernihiv (Ukraine) and with average indicators of habitation, was investigated. Both for the Słupia River within the city of Słupsk and for the Strizhen River within the Chernihiv city, the composition and dynamics of the plant quatic macrophytes communities are determined by changes in weather and hydrological conditions, as well as anthropogenic pressure. The vegetation of the channels and depressions of the floodplains of both rivers is represented by typical communities of the classes *Lemnetea minoris*, *Potametea*, *Phragmito-Magnocaricetea*. Temporarily flooded and highly zooanthropogenic nutrient-rich upland floodplains occupied by the *Agropyro-Rumicion* communities. Due to the higher velocity of the Słupia River in its channel free-floating plants communities poorly represented. The vegetation cover of the Strizhen River floodplain is more ruderalized, as compared to the Słupia River floodplain, as evidenced by the greater syntaxonomic diversity of phytocenoses of summer annuals on soils rich in nitrates (class *Bidentetea*). The grey alder forests are the phytocoenotic value of the Słupia floodplain within the city of Słupsk.

***Keywords*:** floodplain, macrophytes, phytocenos, Słupia River, Strizhen River
***Słowa kluczowe*:** fitocenoza, makrofity, równina zalewowa, rzeka Słupia, rzeka Strizhen

Introduction

Vegetation is an important topic in the research and practice of managing ecosystems in zones of water level fluctuations, not only in reservoirs, as Jiang W. et al. [2021] demonstrated in their article, but also in other rivers, lakes, and adjacent territories.

The vegetation of water bodies and waterlogged areas, in particular riverine areas (to a greater extent) and river floodplains (to a lesser extent), differs from other types of vegetation in its intrazonality, as well as in specific features of structure and functioning. The main factor of changes in the development of communities of aquatic macrophytes in water bodies and floodplains is the fluctuation of water level, which determines the morphological variability of plant species and associated plant communities. It should be noted that the development of higher aquatic vegetation in waters is caused, along with other factors, by wave and waste water movements [Kirvel 2005]. Also, the degree of anthropogenic pressure affects the state of the vegetation of the channel, coastal strips and floodplains of rivers.

For the purpose of studying the vegetation were chosen rivers Slupia and Strizen near the cities of Słupsk (Poland) and Chernihiv (Ukraine), located in a close latitudinal range (geographic coordinates 54°27′50″, 17°01′43″ and 51°30′19″, 31°17′05″) and moderate urbanization or the so-called residential load (urban population density 2,250 men/ км² and 3,632 men/км²). The climate of Slupsk is maritime, Chernigov is moderately continental. In both rivers, water level fluctuations occur with a certain regularity in time and during the entire vegetation of plants.

Study areas

The Słupia River is one of Baltic coastal rivers and is located in the region of Central Pomerania (North of Poland). It originates in a peatland in the vicinity of locality Sierakowice and flows into the Baltic Sea in locality Ustka. It flows through several lakes, including Lake Tuchlińskie, Trzebocińskie and Węgorzyno. The river is 138.6 km long and its catchment consists mainly of farmlands and forests, and encompasses 1623 km^2. The channel is about 12 m wide in the upper course of the river and rises downstream to about 20 m. Mean depth ranges from 0.7–1.2 m to 1.6 m in the upper and lower course, respectively. Maximal depth reaches 6 m. Banks are generally well defined. Typical discharge, averaged for the year, ranges from 17 to 18 m^3. There are no anoxygenic episodes [Krzysztof 2009]. The Słupia River within the urban zone is more fleeting than the Strizhen River along the entire interval of its current.

The Stryzhen River is located in the Chernihiv region (North of Ukraine). It belongs to the basin of the Desna river and is a right-bank tributary of the first order. Natural vegetation covers 42.7% of the total pool. The river flows through the territory of Chernihiv region. The length of the river is 32.4 km, the catchment area is 158 km^2; 8.0% of the river basin is covered with woods, 0.28% – with swamps and 57.3%

– with arable lands. The source of the river, which is located 2.5 km to the west of the village Veliky Osniaky, Ripky district, Chernihiv region, is 150.00 m above sea level. Flow rate of the river is 14.0 million m^3, shallow stack year supply of 75 and 95% – respectively 9.39 million m^3 and 5.53 million m^3. Rriver's flow is regulated poorly. The total number of ponds and reservoirs that regulate the local flow is 5, and their total volume is 1.531 million m^3. The river water belongs to the calcium bicarbonate class, its hardness is 4.2–4.9 mgEq/l, its total mineralization is 290–320 mg/l. By its regime the Stryzhen river refers to the East European type. The river is fed mostly by snow and rain. The Stryzhen' river basin is highly cultivated: 7 villages and the city of Chernihiv are within the basin. The state of some environmental factors and orientation of the occurring processes cause the overall ecological situation in the basin of the Stryzhen river, which at present in general is unsatisfactory [Lukash et al. 2016].

Matherial and methods

Studies of vegetation of channels and floodplains of small rivers in urbanized territories were held in Słupsk city (Słupia River) and Chernihiv city (Strizhen River). Materials (phytosociological relevés and herbarium) for the article were collected during 2017–2021. The field study of the vegetation was carried out by geobotanical methods (Korchagin, Lavrenko 1976). The 54 phytosociological relevés were carried out during the optimum of vegetation period in the areas of 4–50 m^2.

Syntaxa were identified according to Matuszkiewicz [2019], Dubyna [2006], and Mucina et al. (2016). Syntaxa names are ordered according to Mucina et al. [2016].

Results and their discussion

The classification scheme of vegetation of the Słupia and Strizhen rivers respectively in the Słupsk city and Chernihiv city was drawn up based on the results of field studies, after the identification of syntaxa. It is presented in the Table.

Table

Syntaxonomic composition of vegetation of channels and floodplains
of small rivers in urbanized territories

Tabela

Skład syntaksonomiczny roślinności kanałów i teras zalewowych
małych rzek na terenach zurbanizowanych

Syntaxa	Słupia River (in Słupsk)	Stryzhen River (in Chernihiv)
Lemnetea O. de Bolos et Masclans 1955	+	+
Lemnetalia minoris O. de Bolos et Masclans 1955	+	+
Lemnion minoris O. de Bolos et Masclans 1955	+	+

Syntaxa	Słupia River (in Słupsk)	Stryzhen River (in Chernihiv)
Lemnetum minoris [Oberd. 1957] Th. Müller et Görs 1960	+	+
Lemno minoris-Spirodeletum polyrrhizae W. Koch 1954	+	+
Salvinio-Spirodeletum (polyrrhizae) Slavnic 1956	-	+
Potamogetonetalia Koch 1926	+	-
Nymphaeion albae Oberd. 1957	+	-
Nuphareto lutei-Nymphaeetum albae Nowinski 1930 et Tomaszewicz 1977	+	-
Isoëto-Nanojuncetea Br.-Bl. et Tx. in Br.-Bl. et al. 1952	-	+
Nanocyperetalia Klika 1935	-	+
Eleocharition soloniensis Philippi 1968	-	+
Transitive phytocoenosis between *Eleochario-Caricetum bohemicae* Klika 1935 em. Pietsch 1961 and *Dichostylidi--Helochloetum alopecuroidis* [Timar 1950] Pietsch 1973	-	+
Phragmito-Magnocaricetea Klika in Klika et Novák 1941	+	+
Phragmitetalia Koch 1926	+	+
Phragmition communis Koch 1926	+	+
Phragmitetum communis [Gams 1927] Schmale 1939	+	+
Scirpetum lacustris Schmale 1939		+
Typhetum angustifoliae [Allorge 1922] Soó 1927	+	+
Typhetum latifoliae Soó 1927	+	+
Oenanthetalia aquaticae Hejny ex Balatova-Tulackova et al. 1993	+	+
Carici-Rumicion hydrolapathi Passarge 1964	+	+
Butometum umbellati [Konczak 1963] Philippi 1973	+	+
Butomo-Sagittarietum sagittifoliae Losev in Losev et V. Golub 1988	-	+
Sagittario-Sparganietum emersi R.Tx. 1953	-	+
Molinio-Arrhenatheretea Tx. 1937	+	+
Potentillo-Polygonetalia avicularis Tx. 1947	+	+
Agropyro-Rumicion Nordhagen 1940	+	+
Ranunculo-Alopecuretum geniculati R.Tx. 1937	+	+
Alno glutinosae-Populetea albae P. Fukarek et Fabijanic 1968	+	-
Alno-Fraxinetalia excelsioris Passarge 1968	+	-
Alnion incanae Pawłowski et al. 1928	+	-
Alnetum incanae Lüdi 1921	+	-

Syntaxa	Słupia River (in Słupsk)	Stryzhen River (in Chernihiv)
Polygono-Poetea annuae Rivas-Mart. 1975	+	+
Polygono arenastri-Poetalia annuae Tx. in [Gehu et al. 1972] corr. Rivas-Mart. et al. 1991	+	+
Polygono-Coronopodion Sissingh 1969	+	+
Prunello-Plantaginetum Faliński 1963	+	+
Bidentetea Tx. et al. ex von Rochow 1951	+	+
Bidentetalia Br.-Bl. et Tx. ex Klika et Hadac 1944	+	+
Bidention tripartitae Nordhagen ex Klika et Hadac 1944	+	+
Polygono-Bidentetum [Koch 1926] Poli et J. Tx. 1960	+	+
Chenopodion rubri [Tx. in Poli et J. Tx. 1960] Hilbig et Jage 1972	+	+
Chenopodietum glauco-rubri Lohm. 1950	+	+
Xanthio riparii-Chenopodietum Lohm. et Walther 1950	+	+

Source: own research according to [Korchagin, Lavrenko 1976; Matuszkiewicz 2019; Dubyna 2006; Mucina et al. 2016].
Źródło: badania własne według [Korchagin, Lavrenko 1976; Matuszkiewicz 2019; Dubyna 2006; Mucina i in. 2016].

Coastal and aquatic vegetation of the Słupia and Strizen rivers develops in their coastal zone, forming discontinuous stripes, which are often parallel to the coast, are 1–10 m long and up to 2 m wide. Find and pinpoint boundaries communities of macrophytes is not always possible due to partial mixing.

Communities of the coastal aquatic plants, like other groups of organisms, undergo targeted changes – successions. Modern successions of coastal aquatic vegetation of the Slupia and Strizen rivers within the urban zones of Slupsk and Chernigov are predominantly allogeneic, occurs due to external factors. For example, the first stage of overgrowing of the watercourse of the Sterzen river is marked by the dominance of such free-swimming species as *Lemna trisulca*, *L. minor*, *Hydrocharis morsus-ranae*, *Ceratophyllum demersum*, *Elodea canadensis*, *occasionally Stratiotes aloides* whose participation in cenoses is 25–50%. Phytocenoses at the initial stage of overgrowing in the watercourse of the Slupia River were not found.

In the coastal water strips of both rivers, we observed phytocenoses with monodominance *Phragmites australis*, *Glyceria maxima*, *Typha latifolia* (*in the river Sterzen Typha angustifolia*). Their projective cover in different communities is 60–80% (total grass cover 80–100%). These species form a grouping of perennial grasses *Glycerietum maximae*, *Phragmitetum communis*, *Scirpetum lacustris Schmale*, *Typhetum latifoliae*, *Typhetum angustifoliae*. These communities belong to the most widespread class of aquatic vegetation in Pomeranian and Polesie – *Phragmito – Magnocaricetea*. In stagnant water in these cenoses, the dominant species *Lemna minor and L. trisulca* are found with a cover of no more than 15%. In the floodplains of the Slupia and Strizen rivers, there are meadow communities of rich, sometimes slightly saline, soils of heavy texture, which are periodically flooded or submerged. They belong to the order *Potentilla-Polygonetalia avicularis*. These natural communities alternate with areas of phytocenoses of the *Polygono-Poetea annuae* (unlike the previous ones, they have a greater number of annuals), which are formed under the influence of trampling and in places where waterfowl are concentrated.

Our research [Lukash et al. 2016] shows that under the influence of meteorological factors (mainly rainfalls) edaphic and hydrological conditions in the riverside alluvial sediment near the Stryzhen estuary has been changed. Ecological and coenotic sequence of succession is the following: *nitrophile community Chenopodietum glauco-rubri → community of therophytes*, *transitive from Eleochario-Caricetum bohemicae to Dichostylidi-Helochloetum alopecuroidis → halophilous community Ranunculo-Alopecuretum geniculati + ruderal community Prunello-Plantaginetum + water-terrestrial community Sagittario-Sparganietum emersi*.

The coastal psammophyton communities (transitive between *Eleochario-Caricetum bohemicae and Dichostylidi-Helochloetum alopecuroidis* of the Strizhen River are of the greatest scientific interest. Its formation was influenced by weather conditions, which indirectly freed habitat and favorable edaphic factors (moderate salinity and high nitrate content) [Lukash et al. 2016].

The vegetation of the floodplains of the Slupia and Strizen 'rivers has even more differences. The floodplain phytocenoses of the city of Sterzen in Chernigov are represented mainly by ruderal groups, in particular, phytocenoses from the class Bidentetea. Within the city of Slupsk (park of culture and recreation), in shallow water (1.0–1.5 m) in the floodplain reservoirs of the Slupia river, there are cenoses of attached vegetation with leaves floating on the water surface in particular communities belonging to the Nuphareto lutei-Nymphaeum albae association. These phytocenoses have 70–80% coverage, mainly due to dominant species (60–80%).

In the floodplain of the River Sterzen within the urban zone of Chernigov, floodplain forests have not survived. In the floodplain of the Slupia river within the city of Slupsk, we can find fragments of hygrophilic non-boggy forests belonging to the *Alnetum incanae* association. The secondary forest is formed by *Alnus incana* (L.) Moench., which has a crown density of 0.7–0.8 and a height of 12–16 m. The secondary forest includes *Ulmus laevis and Fraxinus excelsior*. *Humulus lupulus* L. occasionally winds along the tree trunks. The underbrush was not found, only single specimens are found *Rubus caesius*, *Salix cinerea* L., *Ribes nigrum* L., *Prunus padus*, *Sorbus aucuparia*. The layer of grasses has a projective cover of 50–70%. The herbaceous layer contains characteristic species *Alnion incanae* (*Carex remota*, *Chrysosplenium alternifolium*, *Circaea lutetiana*, *Festuca gigantea*, *Ficaria verna*, *Gagea lutea*, *Stellaria nemorum*, *Rubus caesius*, *Equisetum sylvaticum*, *Galium palustre*, *Iris pseudacorus*, *Lycopus europaeus*, *Lysimachia vulgaris*, *Solanum dulcamara*, *Athyrium filix-femina*, *Thelypteris palustris Schott*). The *Alnetum incanae* association is diagnosed by species such as *Brachypodium sylvaticum*, *Chaerophyllum hirsutum*, *Deschampsia cespitosa*, *Equisetum hyemale*, *Filipendula ulmaria*, *Geum urbanum*, *Geum rivale*, *Impatiens noli-tangere*, *Ranunculus repens*, *Stachys sylvatica*, *Thalictrum aquilegiifolium*, *Urtica dioica*, *Valeriana excelsa*.

The distribution of these forests in Pomerania is natural, because the European range of Alnus incana covers this territory (Figure).

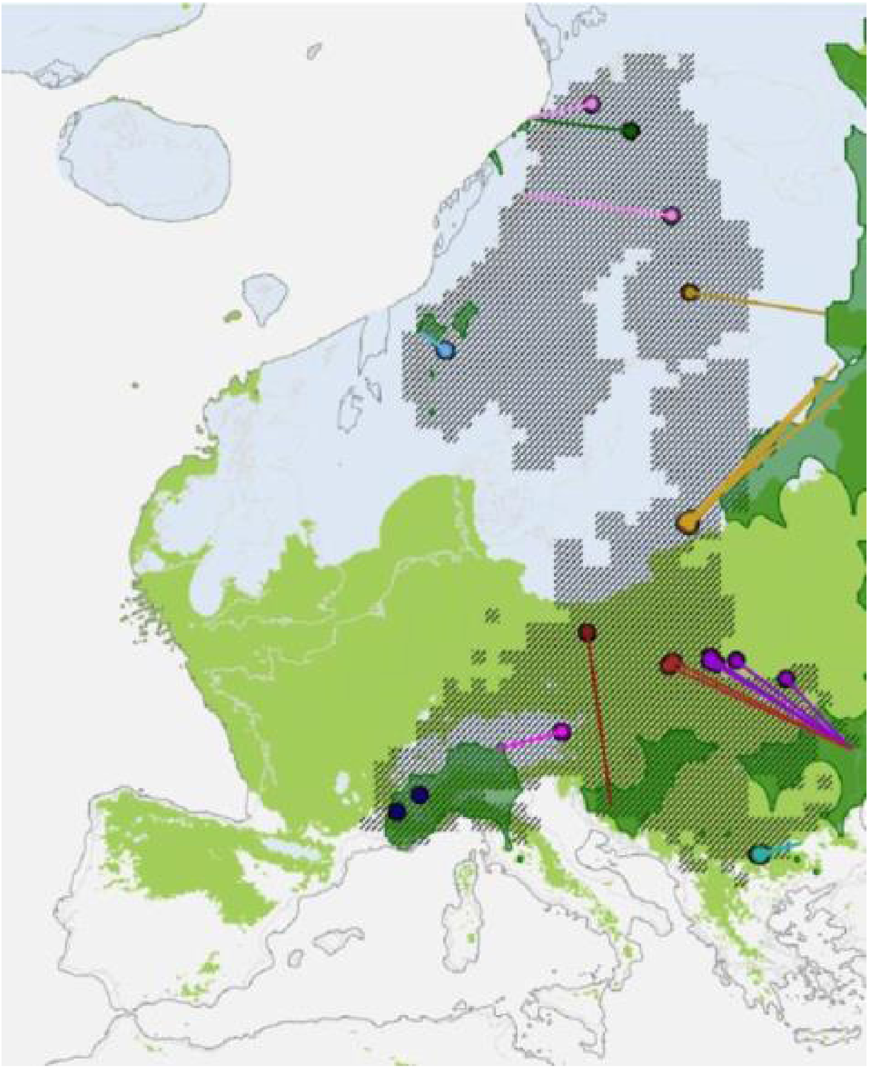

Fig. Distribution of *Alnus incana* in Europe
Ryc. Rozmieszczenie *Alnus incana* w Europie
Source: comp. based on [Kurtto et al. 2018].
Źródło: oprac. na podst [Kurtto et al. 2018].

Alnus incana (L.) Moench is native to western Europe. Gray alder prefers moist to mesic sites throughout its distribution but occurs in a wide variety of plant communities within that moisture gradient. Speckled alder occurs in forest, shrub, and herbaceous communities. It also occurs in elm-ash-cottonwood (*Ulmus-Fraxinus-Populus* spp.) galleries and forests and can be found on stream banks, lake shores and damp meadows and also in bogs and nutrient-rich swamp communities. Instead, Chernihiv Polesie, within which the floodplain of the Stryzhen River is located, is outside the continuous distribution of *Alnus incana*.

Conclusions

Both for the Słupia River within the city of Słupsk and for the Strizhen River within the Chernihiv city, the composition and dynamics of the plant quatic macrophytes communities are determined by changes in weather and hydrological conditions, as well as anthropogenic pressure. Due to the higher velocity of the Słupia River in its channel free-floating plants communities of the Lemnetea minoris class poorly represented.

At the same time, such communities, along with eu- and mesotrophic phytocenoses of the *Potametea* class, formed by plants completely submerged in water and with floating leaves, are found in floodplain water bodies. Communities of the *Phragmito-Magnocaricetea* class have formed in the coastal strips of both rivers, as well as in areas of the floodplain with wide fluctuations in water level, rich in mineral elements and silt deposits.

Temporarily flooded and highly zooanthropogenic nutrient-rich upland floodplains occupied by the *Agropyro-Rumicion* communities. On the hill with nitrificated sandy, dry, hardened substrate we found the ruderal *Prunello-Plantaginetum* communities. However, the vegetation cover of the Strizhen River floodplain is more ruderalized, as compared to the Słupia River floodplain. It has the greater syntaxonomic diversity of phytocenoses of summer annuals on soils rich in nitrates (class *Bidentetea*).

Fragments of hygrophilous wetlands belonging to the *Alnetum incanae* association are the phytocoenotic value of the Słupia floodplain within the city of Słupsk. The spread of these forests is due to the availability of optimal climatic conditions in Pomerania (unlike Polesie) for the growth of the dominant *Alnus incana*.

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Streszczenie

Badano roślinność koryt i teras zalewowych rzek Słupi i Strizhen, położonych w bliskim pasie równoleżnikowym w obrębie miast Słupsk (Polska) i Czernihów (Ukraina) o średnich wskaźnikach siedliskowych. Zarówno dla rzeki Słupi w obrębie miasta Słupsk, jak i rzeki Strizhen w obrębie miasta Czernihów skład i dynamika zbiorowisk roślinnych makrofitów wodnych są determinowane przez zmiany warunków pogodowych i hydrologicznych, a także presję antropogeniczną. Roślinność koryt i zagłębień teras zalewowych obu rzek reprezentowana jest przez typowe zbiorowiska klas *Lemnetea minoris*, *Potametea*, *Phragmito-Magnocaricetea*. Czasowo zalewane i wysoce zooantropogeniczne, wyżynne tereny