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Two Approaches to Lake-Naturalness Determination - a Case Study from Four Mid-Forest Polish Lakes

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Abstract

This study aimed at evaluate the ecological states of four protected, mid-forest lakes located in mid-western Poland. Two means of evaluation were used and compared: biodiversity (expressed by phytocoenotic diversity of macrohydrophyte vegetation) and habitat diversity (resulting from abiotic conditions and biota activity). The first method was based on the type and number of plant associations present in the studied lakes. The contribution of naturally and anthropogenically induced plant assemblages to lake vegetation was considered. The other method concerned morphometric, mictic and trophic features of the lakes and their water purity classes. The study results, especially a large number of plant assemblages and natural character of vegetation, evidenced a high degree of naturalness of all the reservoirs. However, results obtained with the use of both methods were to a certain degree inconsistent. With respect to the type of catchment and mid-forest location as well as still limited anthropopressure, the phytocoenotic diversity more clearly differentiated the reservoirs and more accurately reflected their ecological status than the habitat diversity whose use - especially as the only or main method - seems to be rather limited.

Keywords: naturalness, macrophytes, habitat diversity, phytocoenotic diversity, lakes

Introduction

Biodiversity and habitat diversity and interrelation between them reflect ecological status of the lake ecosystem. Nowadays, apart from global and local natural factors influencing the above-mentioned ecosystem features, human impact becomes more and more important. In accordance with this, biodiversity and habitat diversity, representing two different but not separated approaches, are to be used when evaluating the ecological state of lakes and intensity of their disturbance and preservation, which might be understood as lake "naturalness".

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Due to numerous literature data on the studies of biodiversity expressed in plant cover, not only the recognition of species composition and estimation of structure of dominance on a given territory are taken into account, but also phytocoenotic attempt (the type and number of plant associations) is reflected by published works, among others [1-5].

Habitat diversity of lakes might be understood in accordance with the concept of patchy or mosaic structure following habitat differentiation among macrophyte communities [6-8] but, in a broader sense, it could be estimated from such important factors as the morphometry, mictic and trophic types of a lake, water purity classes, etc. [9].

Table 1. Characteristics of the lakes studied.

Features	Lakes			
	Pławno	Kociołek	Czarne Duże	Czarne Małe
Area (ha)	11	0.9	6	4
Max. depth (m)	10.0	3.0	5.1	5.0
Littoral type	phytolittoral	typical of ponds	phytolittoral	phytolittoral
Mixing	D	P	D	D
Transformation degree	5	5	4	5
Trophic status	E	M	E	M
Water quality class	I	I	I	I
Fishery type	perch-roach	perch-roach	perch-roach	perch-roach
Land use	Forest and meadow	Forest	Forest and transitional bog	Forest and transitional bog

Explanations: type of lakes: D - dimictic, P - polymictic, trophic status: E - eutrophic, M - mesotrophic, transformation degree: 0-5 (0 - the highest transformation degree; 5 - the lowest transformation degree).

Table 2. Criteria for estimation of the lake's habitat diversity used in the present paper; after Radwan and Sender [9].

Features	Number of points					
	0	1	2	3	4	5
Area (ha)		<20		<40		>60
Depth (m)		<5		<10		>10
Littoral type		artificial	atrophic	type of ponds	typical of small lake	phytolittoral
Fishery type		crucian carp	bream-pikeperch	tench-pike		bream-whitefish
Mixing		polymictic		dimictic		
Transformation degree*		0-1	2-3	4-5	>5	
Trophy		eutrophy			mesotrophy	dystrophy
Water quality class	out of classification	III class		II class		I class

* - 0 - the highest transformation degree; 5 - the lowest transformation degree

The study reported aimed at:
(i) evaluating the degree of naturalness of four protected, mid-forest lakes, and
(ii) comparison of the results obtained with the use of two means of evaluation: biodiversity (expressed by phytocoenotic diversity of macrophyte vegetation) and habitat diversity (resulting from abiotic conditions and biota activity).

Material and Methods

Four reservoirs located in the Zielonka Primeval Forest Landscape Park (mid-western Poland), which are protected as strict reserves, were studied. They are differentiated with respect to the area, depth, trophical status and the character of vegetation. All of them are located in the same tunnel-valley and separated from each other by small pond-like reservoirs and wetlands. The reservoirs' detailed characteristics, based on the literature data [10] and our own observations, are in Table 1.

In the present study, phytocoenotic diversity concerned the type and number of plant associations of the lakes vegetation, which were distinguished with the use of the mid-European phytosociological method of Braun-Blanquet. Syntaxons were classified in accordance with the system given by Brzeg and Wojterska [11]. With respect to the origin of particular associations and their floristic composition as well as to the presence of patches in a given territory (syngenesis and coenogenesis), contribution of naturally and anthropogenically induced plant associations to the lakes

Table 3. Syntaxonomical composition of vegetation of the lakes under study.

Communities	Syngenesis coeno-genesis	Lakes			
		Pławno	Kociołek	Czarne Duże	Czarne Małe
Cl. *Phragmitetea australis* (Klika in Klika et Novák 1941) R. Tx. et Preising 1942					
Cladietum marisci (Allorge 1922) ex Zobrist 1935	NP	+	+	+	+
Scirpetum lacustris (Allorge 1922) Chouard 1924	NA	+	+	+	+
Typhetum angustifoliae Soó 1927 ex Pignatti 1953	NA	+	+	+	+
Phragmitetum communis (W. Koch 1926) Schmale 1939	NA	+	+	+	+
Thelypterido–Phragmitetum Kuiper 1958	NP	+	+	+	+
Caricetum rostratae Rübel 1912 ex Osvalg 1923	NA	+	-	+	+
Cicuto-Caricetum pseudocyperi Boer et Sissingh in Boer 1942	NP	+	+	+	+
Caricetum ripariae Soó 1928	NA	+	+	-	+
Caricetum paniculatae Wangerin 1916 ex von Rochow 1951	NP	+	+	+	-
Sparganietum erecti Roll 1938	NA	+	+	-	-
Typhetum latifoliae Soó 1927 ex Lang 1973	NA	+	-	-	-
Equisetetum fluviatilis Steffen 1931	NA	-	-	+	-
Acoretum calami Eggler 1933 ex Kobendza 1948	X	-	-	+	-
Community built by *Eleocharis uniglumis* (Link) Schultes	nd	-	-	-	+
Cl. *Potametea* R. Tx. et Prsg. 1942 ex Oberd. 1957					
Nymphaeo albae-Nupharetum luteae Nowiński 1928	NP	+	+	+	+
Myriophylletum verticillati Gaudet 1924	NA	-	+	+	+
Potametum natantis Soó 1927 ex Podbielkowski et Tomaszewicz 1978	NA	-	+	-	+
Najadetum marinae Fukarek 1961	NA	+	-	-	-
Cl. *Charetea fragilis* Fukarek 1961 ex Krausch 1964					
Charetum tomentosae Corillion 1957	N	+	+	-	+
Charetum contrariae Corillion 1957	N	-	+	+	+
Charetum intermediae (Corillion 1957) Fiajałkowski 1960	N	-	+	-	+
Cl. *Lemnetea minoris* (R. Tx. 1955) de Bolós et Masclans 1955					
Lemno-Spirodeletum polyrrhizae W. Koch 1954 ex Th. Müller et Görs 1960	NA	+	-	+	-
Lemno-Utricularietum vulgaris Soó 1928 ex 1947	NA	+	-	+	-
Lemno-Hydrocharitetum morsus-ranae (Oberd.1957) Pass. 1978	N	-	+	-	+
Cl. *Fontinaletea antipyreticae* Hüb. 1957					
Fontinaletum antipyreticae Kaiser 1936	nd	+	-	-	-
CL. *Littorelletea uniflorae* Br.–Bl. et R. Tx. 1943					
Littorello-Eleocharitetum acicularis (Baumann 1911) Jouanne 1925	N	-	-	+	-
Sparganietum minimi Schaaf 1925	NP	-	-	+	+
Community built by *Utricularia minor* L.	nd	-	-	+	+
Cl. *Scheuchzerio-Caricetea fuscae* (Nordhhagen 1936) R. Tx. 1937					
Sphagno recurvi-Eriophoretum angustifolii Hueck 1925	NP	-	-	+	+
Community built by *Menyanthes trifoliata* L.	nd	+	-	-	-
Total number of communities		18	16	19	19
Number of natural communities (N)		1	4	2	4
Number of natural auxochoris communities (NA)		9	7	8	7
Number of natural perdochoric communities (NP)		6	5	7	6
Number of xenospontaneous communities (X)		-	-	1	-
Number of communities with no detailed data on syngenesis and coenogenesis (nd)		2	-	1	2

vegetation was worked out [11]. All the lakes studied in the present work were compared with respect to the composition of macrophyte vegetation.

Another important aspect used in evaluating lake naturalness was habitat diversity [9] counted from such important factors as the morphometry (area and depth of the studied lakes), mictic, trophic and fishery types, type of littoral, transformation degree and water quality classes. Such criterion as transformation degree reflects the intensity of anthropogenic pressure and degradation. Point estimation of lake habitat diversity acquired in the present study was based on the criteria and 5-score scale proposed by Radwan and Sender [9] and enclosed in Table 2. Results acquired in both ways were compared and discussed in the context of their potential usefulness in lake evaluation and management.

Table 4. Point estimation of lake habitat diversity.

Criteria for estimation	Lakes			
	Pławno	Kociołek	Czarne Duże	Czarne Małe
	Scores			
Area	1	1	1	1
Maximum depth	3	1	3	1
Littoral type	5	3	5	5
Mixing	3	1	3	3
Transformation degree	3	3	3	3
Trophic status	1	4	1	4
Water quality class	5	5	5	5
Total	21	18	21	22

Explanations: number of points for each criterion is given in Table 2

Results

Phytocoenotic Diversity

As a result it was stated that the total number of communities was similar in all the lakes under study and ranged from 16 to 19 (Table 3). It seems to be noteworthy that in each lake all ecological groups of phytolittoral zoning, including the charophyte zone, were represented.

In each lake the same communities dominated in the helophyte zone and shaped the same character of the emergent vegetation (dominance of *Cladietum marisci* Allorge 1922 *ex* Zobrist 1935). By contrast, the submerged hydrophytes and transitional bog communities were the main factors to told the lakes from each other (Table 3).

In all lakes the phytolittoral was built by phytocoenoses of natural associations with respect to their origin and floristic composition. Associations built by native species, occurring on undisturbed habitats (=natural perdochoric associations), revealed a significant contribution to lake vegetation (Table 3). It was observed in both the number of such associations (with the exception of Lake Pławno) as well as the area covered by their phytocoenoses. In Lake Kociołek, quite similar share revealed associations called natural auxochoric (it means: built by native species but occupying mostly anthropogenically-induced habitats), especially when the number of associations is considered. These associations revealed a smaller share in Lakes Czarne Duże and Czarne Małe. On the contrary, in Lake Pławno phytocoenoses of natural auxochoric associations dominated as far as the number of syntaxons is taken into account. However, in the lakes studied phytocoenoses of such associations covered smaller areas in comparison to those of natural perdochoric character. In general, the character of the lakes vegetation is natural with the significant share of associations covering natural habitats. Only one anthropogenically induced association, (=xenospontaneous association), was found (*Acoretum calami* Eggler 1933 *ex* Kobendza 1948), but its phytocoenoses were observed only in one lake - Lake Czarne Duże (Table 3), and covered small areas of the phytolittoral.

Habitat Diversity

Habitat diversity of the lakes studied, counted on the basis of their abiotic conditions and biota activity, ranged from 18 to 22 points (Table 4), so it could be stated that the lakes were not clearly differentiated amongst each other. Lake Kociołek scored 18 points, which suggests its lowest habitat diversity in this group of lakes.

Discussion

In comparison to the data obtained by Radwan and Sender [9] for 22 lakes of the Łęczyńsko-Włodawskie Lakeland (eastern Poland), the studied lakes could be characterized by rather medium habitat diversity. On the other hand, phytocoenotic diversity observed in all the lakes under study could be recognized as very high even in a larger than regional scale and suggests high naturalness of the investigated ecosystems, especially when the contribution of natural associations to lake vegetation is taken into account. The number of plant assemblages was comparable to that obtained by Ciecierska and Radwan [12] in lakes of the Łęczyńsko-Włodawskie Lakeland. By contrast, a significantly lower number of plant assemblages were found in urban lakes of Ostróda in the Masurian Lake District (northeastern Poland, [4]) and in lakes of varied trophy and forms of protection in Wielkopolski National Park [13].

Based on all that above, the results obtained in both ways are to a certain degree inconsistent. With respect to the type of catchment and mid-forest location as well as still limited anthropopressure, the phytocoenotic diversity more accurately differentiates the studied lakes and reflects their state than habitat diversity. Such observation is confirmed by Ciecierska and Radwan [12], who found only 10 plant assemblages in Lake Piaseczno. This lake represents the highest habitat diversity (point estimation: 32) among lakes investigated in the Łęczyńsko-Włodawskie Lakeland by Radwan and Sender [9]. As it could be seen from the results presented in the present paper, estimated habitat diversity is to a significant extent naturally conditioned. Therefore, it should rather be treated as a reflection of a lake's resourcefulness and not the level of naturalness.

Our research is based on a few examples so it is not statistically sound. In the case of the paper by Radwan and Sender [9], biological diversity, expressed by species diversity characterized on the basis of the total number of species composing the zoocoenoses, reflected to a significant extent the habitat one. This implies necessity to carry on such investigation on the phytocoenotic level in more lake ecosystems, which will be undertaken with the appropriate statistical analyses.

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