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THE INFLUENCE OF INCREASING UNCONTROLLED RECREATION ON THE STRUCTURE OF PLANKTON AND MACROPHYTE COMMUNITIES IN THE TUNNEL-VALLEY LAKES LOCATED IN AGRICULTURAL CATCHMENT AREA

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ABSTRACT. In the years 1993-1995 biological research was carried out on three lakes, which are situated in a typical agricultural catchment area, along the Gołaniecka River. The hydrobiological examination carried out in 1993 revealed a stable state of eutrophy on these lakes. At that time neither of the Bukowieckie lakes was used for recreation, while at the Kobyleckie lake there were a number of buildings, including private holiday homes and holiday camps. In 1995, the year finishing the examination, recreation housing began to develop at the Bukowieckie Duże lake and also an acceleration of tourism was observed on the Kobyleckie lake. In the spring and summer of 2000 hydrobiological research was repeated in order to find out whether the changes in the neighbourhood of the lakes had affected the chemical condition of lake waters. Although the building area by the lakes was still unfinished, particular changes of many parameters of water were already observed. Negative effects of trophic status were noted in the decrease of the visibility of water, increase of the nutrients concentration, in the outstanding blue-green algae character of the spring phytoplankton (*Aphanizomenon issatschenkoi* (Ussac.) Proschkina-Lavrenko; *Planktothrix agardhii* (Gom.) Anagn. et Kom.; *Limnothrix redekei* (Van Goor) Meffert) and zooplankton (*Keratella cochlearis* f. *tecta* (Lauterborn), *K. quadrata* (O.F. Müller), *Anuraeopsis fissa* (Gosse), *Bosmina longirostris* (O.F. Müller) and *Chydorus sphaericus* (O.F. Müller)), the increase of the total densities of zooplankton with the dominance of rotifers, the impoverishment of the phytolittoral, as well as quality and quantity changes in the structure of macrophytes.

Key words: eutrophic lakes, phytoplankton, blue-green algae, zooplankton, phytolittoral, quality and quantity changes in hydrobiocenosis

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Introduction

The Wielkopolska region is of great agricultural importance to Poland. In recent years, long-term changes in the water ecosystems connected with transformation in their catchment area have become more visible. The trophic characteristics of lakes in this area, mostly including blooms of blue-green algae have been the subject of various studies because of their negative effect in changing the quality of water (**Messyasz** 1999, 2000). Therefore, it appears reasonable to assume that changes in phytoplankton composition could account for the observed variations in zooplankton structure. The next problem is connected with finding out whether maximal development of phytoplankton in the water column can reduce the extent of macrophytes or not. The changes in plankton and macrophyte communities in the Bukowieckie Duże, Bukowieckie Małe and Kobyleckie lakes within all the years of the examination may be described as remodelling of species structure and loss of their richness, which is probably due to the increasing eutrophication. However, these differences might be attributable to natural factors such as lake morphometry, hydrological features, nutrient concentrations or changes in the catchment area. One of the major problems in these lakes seems to be a considerable increase of recreation and tourism.

In 1995 recreational housing began to develop at both of the Bukowieckie lakes and increased gradually at lake Kobyleckie. Based on the physical and chemical properties of the water, the lakes have been classified as eutrophic reservoirs. Since the year 2000 water quality has deteriorated and plankton concentrations have increased, while the number and dispersion of submerged and emergent macrophyte communities have decreased significantly. Therefore, the objective of the present study was to emphasise the effects of the acceleration of tourism on lakes and their relation to fluctuations in the phytoplankton, zooplankton and macrophyte structures.

This work was undertaken in order to:

1. Determine quality and quantity changes in the structure of phytoplankton, zooplankton and macrophytes after the development of recreation.
2. Find out whether the increase of recreation has resulted in an acceleration of eutrophication in lakes.

Materials and methods

The Bukowieckie Duże, Bukowieckie Małe and Kobyleckie lakes are situated in a typical agricultural catchment area (in the northern part of the Wielkopolska region, Poland). The complex of lakes has one tributary, which varies in size – the river Struga Gołaniecka. The polymictic Bukowieckie Duże and Bukowieckie Małe lakes (mean depth 4.5 and 3.3 m) are situated among forests and fields (**Jańczak** et **al.** 1996). Between 1993-1995 neither was used for recreation. Stratification and anoxic hypolimnion develop in May and persist into October in the third lake Kobyleckie (max. depth 14.3 m) which has been used for recreation for many years. The trophic degree of these lakes is eutrophic in terms of chlorophyll-a, phytoplankton biomass and total phosphorus and nitrogen concentrations (**Messyasz** 2000).

Plankton studies in the Bukowieckie Duże, Bukowieckie Małe and Kobyleckie lakes were carried out at three stations between 1993 and 1995 and were controlled in 2000. All the stations were situated in the deepest part of each lake. In order to analyse the physico-chemical properties of the water samples were taken from the surface and the bottom layer (**Elbanowska** et **al.** 1999, **Dojlido** 1995). Algae analysis was made in accordance with Starmach's generally established methods (**Starmach** 1989, **Rott** 1982). Chlorophyll–a was measured following the method of Lorenzen (**Lorenzen** 1967). Samples for zooplankton were thickened using a planktonic net with a mesh of 45 μm and then preserved with 4% formalin. Macrophyte communities were identified with the use of the Braun-Blanquet method (**Fukarek** 1967, **Tomaszewicz** 1979).

Results and discussion

Although all the examined lakes were situated in an agricultural region, they differed in some characteristics (Table 1).

Table 1
Characteristics of the direct catchment area of the Bukowieckie Duże, Bukowieckie Małe and Kobyleckie lakes (according to Messyasz 1999)
Charakterystyka zlewni bezpośredniej jezior Bukowieckie Duże, Bukowieckie Małe i Kobyleckie (za Messyasz 1999)

Lake Jezioro	The surface of catchment area (ha) Powierzchnia zlewni (ha)	Agricultural area (% of the surface) Zlewnia rolnicza (% powierzchni)	Forests (% of the surface) Lasy (% powierzchni)	Dense building (% of the surface) Gęsta zabudowa (% powierzchni)	Character of direct catchment area Charakter zlewni bezpośredniej
Bukowieckie Duże	98.6	38.59	60.00	0.01	agricultural--forestry rolniczo-leśna
Bukowieckie Małe	29.4	82.98	17.01	0.01	agricultural rolnicza
Kobyleckie	314.3	79.95	7.32	12.73	recreation--agricultural rekreacyjno--rolnicza

The hydrobiological examination carried out in 1993-94 revealed a stable state of eutrophy on these lakes (**Messyasz** 1999). At that time neither of the Bukowieckie lakes were used for recreation, while at Kobyleckie lake there were a number of buildings, including private holiday homes and holiday camps. In 1995, the final year of the initial examination, recreational housing began to develop at Bukowieckie Duże lake and also the acceleration of tourism was observed on Kobyleckie lake. In the spring and summer of 2000 hydrobiological research was repeated in order to find out whether the changes

in the neighbourhood of the lakes had affected the condition of the lake waters. Although the building area around the lakes was still unfinished, particular changes of many parameters of water have already been observed.

Dissolved nutrient concentrations were higher in lakes under study in 2000 compared to 1994-1995. Grater concentrations of phosphatic phosphorus than 0.020 mg $P\text{-}PO_4$/l in Bukowieckie lakes and 0.010 mg $P\text{-}PO_4$/l in the epilimnion of the Kobyleckie lake over the spring months, and less than 0.010 mg $P\text{-}PO_4$/l and 0.008 mg $P\text{-}PO_4$/l respectively over the summer months were noted (**Messyasz** 2000). Dissolved inorganic nitrogen concentrations fluctuated in average values from 3.17 to 4.13 mg N/l in polymictic lakes and from 2.04 to 4.40 mg mg N/l in the epilimnion of Kobyleckie lake (in the spring period); and respectively 1.25-2.17 mg N/l and 1.45-1.95 mg N/l (in the summer) (**Messyasz** 2000). In 2000 the increase of ammonia nitrogen concentrations from 0.40 mg N/l to 0.7 mg N/l in Bukowieckie Małe lake and from 0.55 mg N/l in 1994 via 1.20 mg N/l in 1995 to 1.70 mg N/l in the hypolimnion of Kobyleckie lake were recorded (**Kuczyńska-Kippen** et **al.** 2000). At the same time increase of phosphatic phosphorus concentrations were observed. The increase in the P concentration in the water column in many shallow eutrophic lakes during the summer period is known as internal loading (**Ryding** 1985). These results indicated a high trophic status in these lakes.

Relatively high chlorophyll-a and phytoplankton biomass concentrations have been observed (Table 2). The highest values of phytoplankton biomass and chlorophyll-a were noted in the Bukowieckie lakes. Lastly, the dimictic Kobyleckie lake was characterised by clearly lower values of these parameters. A high chlorophyll-a concentration in 2000, indicated a highly productive period in May when the blue-green algae were developing

Table 2

Mean values of chlorophyll-a and phytoplankton biomass concentration in three lakes in 1994-1995 and 2000
Średnie wartości koncentracji chlorofilu a i biomasy fitoplanktonu w trzech jeziorach w latach 1994-1995 i 2000

Parameter Parametr	Bukowieckie Duże	Bukowieckie Małe	Kobyleckie (epilimnion)
Chlorophyll-a ($mg \cdot m^{-3}$) Chlorofil a			
Spring – Wiosna 1994-1995*	42.36	46.33	25.67
Summer – Lato 1994-1995**	37.90	42.67	21.84
7.05.2000	59.02	73.15	52.63
26.06.2000	12.61	38.81	15.55
Total phytoplankton biomass ($mg \cdot m^{-3}$) Całkowita biomasa fitoplanktonu			
Spring – Wiosna 1994-1995*	19.992	16.775	19.816
Summer – Lato 1994-1995**	17.695	53.509	13.582
7.05.2000	76.362	68.502	64.098
26.06.2000	36.100	33.959	41.875

* n = 5, ** n = 6.

abundantly. At the end of June the level of concentrations decreased (Table 2). Due to the relatively high concentration of phytoplankton biomass, water transparency was greatly reduced (about 0.1 m). Chlorophyll-a may also be a direct physiological indicator of photosynthetic capability of the water ecosystem (**Kawecka** and **Eloranta** 1994). Analysis of its concentrations from the years 1994-1995 and 2000 revealed the negative tendency in the trophy level of all the examined lakes – the increase from eutrophy to strong eutrophy was recorded.

Distributions of some of the more abundant algae groups and the changes in their dominance are shown in Figure 1. The blue-green algae, which can regulate their position in the water column and tend to be concentrated in the surface layer of water in the Bukowieckie lakes and Kobyleckie lake, showed an increase in abundance in 2000. This was particularly marked for *Planktothrix agardhii* (Gom.) Anagn. et Kom. in May (Fig. 1). Individual algal species mostly showed a clear trend of decreasing densities during the bloom of filamentous cyanobacterium *Planktothrix*. The presence of some eutrophic algae species with high biomass concentration was recorded during the studies on these reservoirs. Species, such as: *Limnothrix redekei* (Van Goor) Meffert, *Aphanizomenon issatschenkoi* (Ussac.) Proschkina-Lavrenko, *Peridinium incospicuum* Lemm., *Trachelomonas intermedia* Dang., *Euglena pisciformis* Klebs, *Cyclotella radiosa* (Grun.) Lemm were present in all the lakes. On 26 June, when the wind had been blowing strongly (for several days) a trend of increasing biomass values for *Cryptomonas marssonii* Skuja, *Ceratium hirundinella* (O.F. Müller) Schrank, *Dinobryon sociale* Ehr., *Microcystis aeruginosa* Kütz., *M. wesenbergii* Kom. was evident (Fig. 1). The first peak in the Bukowieckie Duże and Bukowieckie Małe lakes, in May 2000, corresponded with high densities of *Planktothrix agardhii* (above 90%). There is a clear seasonal norm with *Planktothrix*, a typical summer taxa, which grows longer when the water column is mixed and achieves high densities vary when the water column is stable, creating a monoculture in the phytoplankton biomass (**Royo** and **Cobelas** 1994, **Izaguirre** and **Vinocur** 1994). These facts seem to agree with the obtained results, since during the May examination the temperatures were very high and the water column in the lakes was stable. Later, in July dinoflagellates, chrysophyceans and diatoms dominated the phytoplankton community. Wind-induced turbulent mixing improves circulation in the surface layer of water, returning *Ceratium hirundinella*, *Fragilaria ulna* var *acus* (Kütz.) Lange-Bertalot to the photic zone from which they otherwise might settle out.

An interesting feature was the high concentration of *Microcystis aeruginosa* recorded in June 2000 in all the lakes, the taxa which was absent in phycological structure in 1994-95. **Takamura** and **Yasuno** (1984) and also **Tarczyńska** (1998) have described the physiological responses of this blue-green alga to gaining the best light conditions and nutrient concentrations in periods of low water visibility.

The pattern of phytoplankton variation across the five-year study was not regular. In 1994-95 blue-green algae appeared mainly during summer, but in 2000 the increase of densities was observed during May. The Kobyleckie lake was characterised by greater variability within the subdominant and accompaniment taxa.

As a result of the examination carried out in the years 1995 and 2000 – 55 species of zooplankton were recorded – 41 species in the Bukowieckie Duże lake (29 species of rotifers, 8 of cladocerans and 4 of copepods), 33 species in Bukowieckie Małe (24, 6 and 3 respectively) and 47 species in Kobyleckie lake (34, 10 and 3 respectively). The number of zooplankton species has not differed significantly throughout the five years.

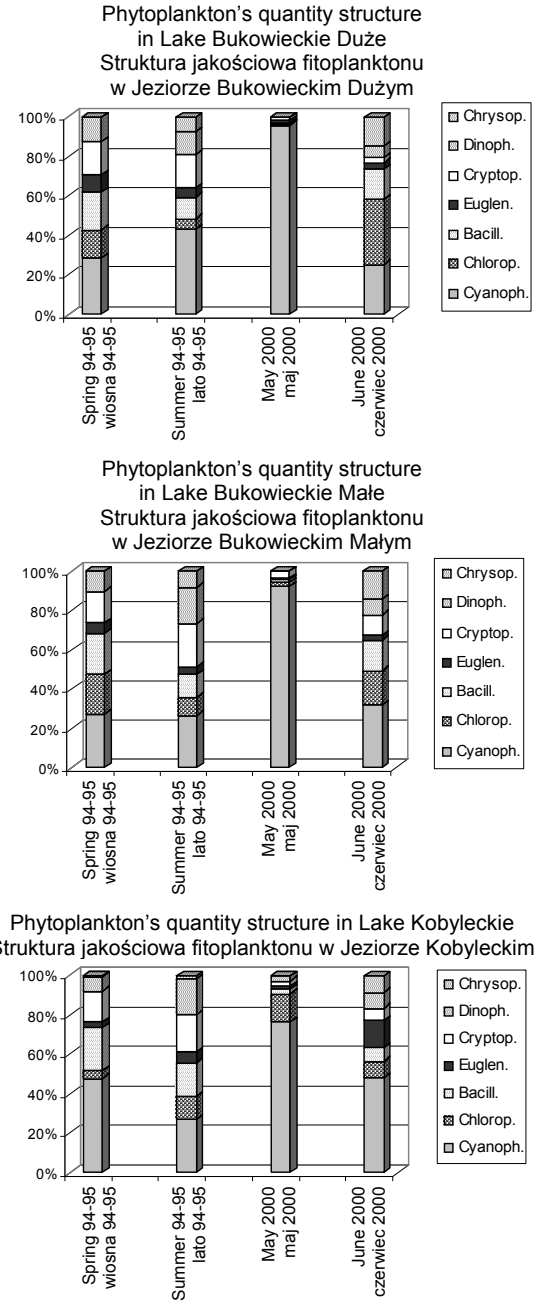

Fig. 1. Changes in the biomass proportion of the main phytoplankton groups in the Bukowieckie Duże, Bukowieckie Małe and Kobyleckie lakes in 1995 and 2000

Ryc. 1. Zmiany w udziale biomasy poszczególnych grup fitoplanktonu w jeziorach: Bukowieckim Dużym, Bukowieckim Małym i Kobyleckim w 1995 i 2000 roku

The densities of zooplankton differed when comparing both years of the study – there was a high increase observed for all three lakes. The highest numbers were recorded for Bukowieckie Małe lake, reaching 5506 ind·l^{-1}. Zooplankton of all the lakes was highly dominated by rotifers (Fig. 2), which is often characteristic of eutrophic lakes and is connected with the food availability. The food base consists of planktonic algae, detritus, bacteria and also periphyton (**Moore** et **al.** 1994, **Jürgens** et **al.** 1994, **Theil-Nielsen** and **Søndergaard** 1999). In the case of eutrophic lakes the presence of blue-green algae, inedible for zooplankton, numerous bacteria and detritus stimulate the development of small forms of zooplankton – rotifers. Also the dominating species indicated the eutrophic character of the lake waters. An increase of the species described as characteristic for high trophy (**Karabin** 1985, **Mäemets** 1983, **Saksena** 1987) was observed, especially in the Bukowieckie Duże lake (*Filinia longiseta* (Ehrenberg), *K. cochlearis* f. *tecta* (Lauterborn), *Polyarthra vulgaris* Carlin, *Trichocerca pusilla* (Lauterborn), *Bosmina longirostris* (O.F. Müller), *Daphnia cucullata* Sars). In the case of the Kobyleckie lake the disappearance from the structure of dominance of the species characteristic for water of lower trophy (*Kellicottia longispina* Kellicott and *Polyarthra major* Burckhardt) was observed in the year 2000 (**Karabin** 1985, **Radwan** 1973).

In the last of the examined lakes – Bukowieckie Małe – there were no significant changes among the dominating species within five years. The constant dominance of the 'eutrophic' species was recorded (Table 3).

Table 3

The dominant zooplankton taxa (more than 10% in the total number of specimens) in lakes situated along the Struga Gołaniecka river
Gatunki dominujące zooplanktonu (powyżej 10% całkowitej liczby osobników) w jeziorach usytuowanych wzdłuż Strugi Gołanieckiej

Lake Jezioro	Species – Gatunki		
	September 1995 wrzesień 1995	May 2000 maj 2000	June 2000 czerwiec 2000
Bukowieckie Duże	*Keratella cochlearis* *Pompholyx sulcata* *Daphnia cucullata* *Eudiaptomus gracilis*	*Keratella cochlearis* *K. cochlearis* f. *tecta* *Polyarthra vulgaris* *Bosmina longirostris*	*Filinia longiseta* *K. cochlearis* f. *tecta* *Polyarthra vulgaris* *Trichocerca pusilla* *Daphnia cucullata*
Bukowieckie Małe	*Keratella cochlearis* *K. cochlearis* f. *tecta* *Keratella quadrata* *Pompholyx sulcata* *Bosmina longirostris*	*Keratella cochlearis* *Keratella quadrata* *Polyarthra vulgaris* *Bosmina longirostris*	*Filinia longiseta* *K. cochlearis* f. *tecta* *Polyarthra vulgaris* *Bosmina longirostris*
Kobyleckie	*Kellicottia longispina* *Keratella quadrata* *Polyarthra major* *Pompholyx sulcata* *Bosmina longirostris*	*Keratella cochlearis* *Bosmina longirostris*	*Collotheca mutabilis* *Conochilus unicornis* *K. cochlearis* f. *tecta* *Chydorus sphaericus* *Daphnia cucullata*

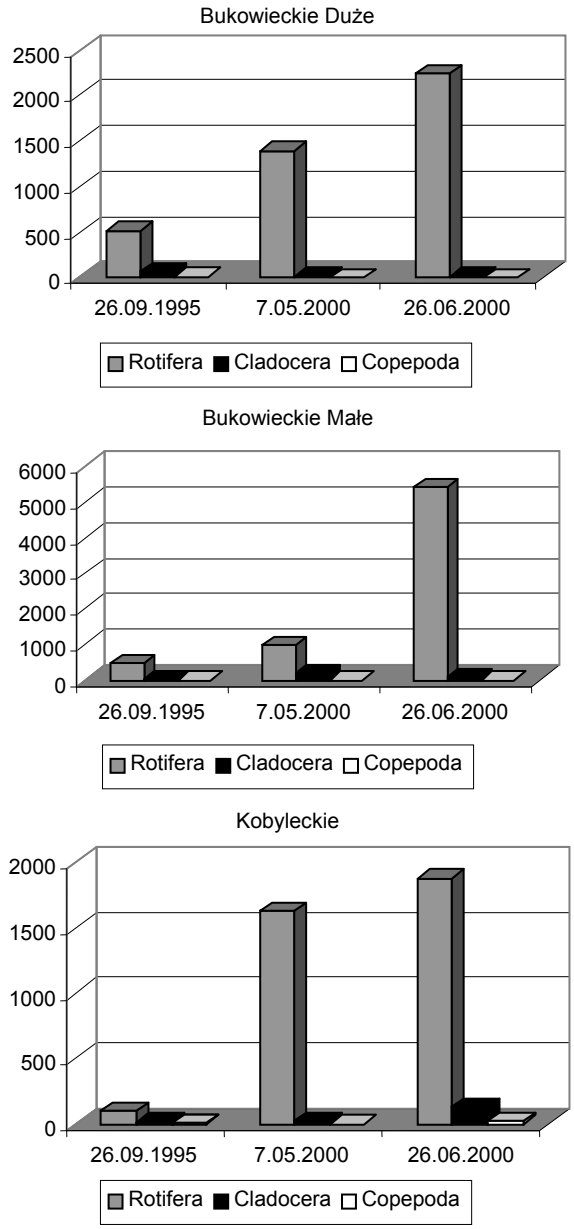

Fig. 2. The numbers of zooplankton communities (ind l^{-1}) in the lakes Bukowieckie Duże, Bukowieckie Małe and Kobyleckie in the years 1995 and 2000

Ryc. 2. Liczebność zespołów zooplanktonu (os. l^{-1}) w jeziorach: Bukowieckim Dużym, Bukowieckim Małym i Kobyleckim w latach 1995 i 2000

The level of participation of *Keratella cochlearis* f. *tecta* compared to *K. cochlearis* f. *typica* was between 0 and 89% in particular years. The lowest values of this indicator were observed in spring 2000, however the examination carried out in the summer period revealed much higher values (89% for Kobyleckie and Bukowieckie Duże lakes). For highly eutrophic lakes this participation is included between 70 and 100% (**Hillbricht-Ilkowska** 1972), which confirms the high trophy state in the lakes along the Golaniecka Struga river.

The resarch conducted in 1993-94, the presence of 20 phytocenosis of rush and submerged macrophyte communities in assembly range in three lakes was noted. In the Bukowieckie Duże Lake 15 macrophyte communities, in Kobyleckie Lake 14 and in Bukowieckie Małe Lake 12 ones were stated (**Nagengast** 1998). From 20 communities according to **Brzeg** and **Wojterska** (1996) five belong to endangered in the Wielkopolska region. Among them are *Potametum lucentis*, *Myriophylletum spicati*, *Nupharo-Nymphaeetum albae*, *Thelypterido-Phragmitetum* and *Cicuto-Caricetum pseudocyperi.*

In the years 1993-1994 *Typhetum angustifoliae* dominated the rush communities on the Bukowieckie Duże lake. At the same time *Phragmitetum* occupied smaller areas of this zone. The remaining phytocoenosis of the associations from *Phragmitetea* class: *Typhetum latifoliae*, *Glycerietum maximae*, *Acoretum calami*, *Eleocharitetum palustris* and *Caricetum ripariae* formed a mosaic structure in the middle part of the east bank of the Bukowieckie Duże lake. However, they did not occupy a large space. A *Nupharo--Nymphaeetum albae* patch was well developed at the north and south part of the lake. In the zone of elodeids five associations: *Potametum lucentis*, *Potametum pectinati*, *Potametum perfoliati*, *Myriophylletum spicati* and *Ceratophylletum demersi* were identified. The pond-weed (*Potamogeton*) communities created single agglomerations contrary to *Myriophylletum spicati* and *Ceratophylletum demersi* which developed in the narrow and long patches along the rushes.

The second Bukowieckie Małe lake, the smallest out of the three examined lakes, differed from others by the domination of *Ceratophylletum demersi* association, which covered more than half the bottom surface. The residual submerged macrophyte communities such as *Myriophylletum spicati*, *Potametum lucentis* and *Potametum perfoliati* created much smaller patches. In the west bay, near the outflow of Bukowieckie Małe lake, two large clusters with *Nuphar luteum* were noted. At the edge of this bay the presence of a *Cicuto-Caricetum pseudocyperi* patch was observed. The rush zone of this lake consisted of *Phragmitetum* and *Typhetum latifoliae* associations.

The Kobyleckie lake, the deepest lake, was divided into two parts: deep north and shallow south basins. In the shallow part *Thelypterido-Phragmitetum* dominated the rush zone and the phytocoenosis of *Typhetum latifoliae*, *Caricetum ripariae* and *Cicuto--Caricetum pseudocyperi* were recorded. Nymphaeids were represented by *Nupharo--Nymphaeetum albae* and *Hydrocharitetum morsus-ranae* communities. The bottom was covered by *Ceratophylletum demersi*, *Myriophylletum spicati* and *Parvopotameto--Zanichellietum* comminities. The deep basin of the Kobyleckie lake was of a different character. Along the west side of this basin the beach, lakeside resort, wood and steel platforms as well as private holiday homes were located. At the east bank of the lake the wild tent field with numerous trampled paths in the direction of the water and platforms, causing the devastation of the phytolittoral or its absence, was observed. *Phragmitetum* patches covered parts of the bank only partially. Among elodeids *Myriophylletum spicati*, *Ceratophylletum demersi* and *Potametum perfoliati* communities were noted (**Kuczyńska-Kippen** et **al.** 2000).

Table 4

A comparison of the plant association composition in Bukowieckie Duże (B.D.), Bukowieckie Małe (B.M.) and Kobyleckie (K.) lakes in 1995 and 2000
Porównanie struktury zbiorowisk roślinnych w jeziorach Bukowieckim Dużym (B.D.), Bukowieckim Małym (B.M.) i Kobyleckim (K.) w latach 1995 i 2000

Macrophyte communities Zbiorowiska makrofitów	B. D.	B. M.	K.
Lemno-Spirodeletum W. Koch 1954	+	+	.
Potametum lucentis Hueck 1931	+/a	+/a	.
Potametum perfoliati W. Koch 1926 em Pass. 1964	+	+	+/a
Potametum pectinati Carstensen 1955	+/a	.	.
Myriophylletum spicati Soó 1927	+/b	+/b	+/b
Ceratophylletum demersi Hild 1965	+/b	+/b	+/b
Parvopotameto-Zanichellietum W. Koch 1926	.	.	+
Nuphareto-Nymphaeetum albae Tomaszewicz 1977	+/c	+/c	+/c
Hydrocharitetum morsus-ranae Langendonck 1935	.	+	+
Scirpetum lacustris (Allorge 1922) Chouard 1924	.	.	+
Typhetum angustifoliae (Allorge 1922) Soó 1927	+	+	+
Phragmitetum (Gams 1927) Schmale 1939	+	+	+
Typhetum latifoliae Soó 1927	+	.	+
Glycerietum maximae Hueck 1931	+	.	.
Acoretum calami Kobendza 1948	+	.	+
Thelypterido-Phragmitetum Kuiper 1957	.	.	+
Eleocharitetum palustris Schennikow 1919	+	+	.
Caricetum acutiformis Sauer 1937	+	+	.
Caricetum ripariae Soó 1928	+	.	+
Cicuto-Caricetum pseudocyperi de Boer 1942	.	+	+

Legend:
+ – macrophyte communities present in 1995,
a – macrophyte communities absent in 2000,
b – macrophyte communities, in which area and depth of stands decreased in 2000,
c – macrophyte communities, in which area and the number of stands decreased in 2000.
Legenda:
+ – zbiorowiska makrofitów stwierdzone w 1995 roku,
a – zbiorowiska makrofitów nie stwierdzone w 2000 roku,
b – zbiorowiska makrofitów, w których powierzchnia i głębokość występowania zmniejszyła się w 2000 roku,
c – zbiorowiska makrofitów, w których powierzchnia i liczba stanowisk zmniejszyła się w 2000 roku.

After seven years the same examination took place (in 2000). The greatest devastation was observed on the Bukowieckie Duże lake. With the build up of a new lakeside resort and new private holiday homes the rush zone and the fragments of trees espalier (*Alnus glutinosa*) were removed. At the same time the submerged macrophyte beds were raked out along the beach. The increase in tourist numbers was reflected by the many new angler's platforms and accesses to the water. All the destroyed parts of the littoral zone were of an anthropogenic character. The quality and quantity changes in the syntaxonomic structure of the rushes and submerged macrophytes were stated. In 2000 *Myriophylletum spicati*, *Ceratophylletum demersi* and *Potametum perforiati* communities were only noted, while *Potametum lucentis* and *Potametum pectinati* were absent. Moreover, the *Myriophylletum spicati* and *Ceratophylletum demersi* patches were of a smaller volume and decrease of their range of extent was also observed. The stated phytocenoses consisted of only one or two species. In the area of Struga Gołaniecka inflow and outflow the area of *Nupharo-Nymphaeetum albae* phytocoenosis was smaller.

Similar changes, due to the absence of trees, shrubs and the lack of great parts of rush vegetation, were recorded on Bukowieckie Małe lake. The *Potametum lucentis* patch was not noted, owing to the decision of the lakeside resort management to clear it away. The phytocoenosis of *Ceratophylletum demersi*, which dominated in 1994, decreased the depth and occurrence extent (by about 30%).

In the Kobyleckie lake the presence of the phytocoenosis of *Potametum perforiati* was not recorded after seven years. The extent of *Myriophylletum spicati* decreased its area (Table 4). The already devastated rush zone was even more slitted by new built platforms and expanding holiday camps.

The negative effects of trophic status were reflected in the decrease of the visibility of water, in the outstanding blue-green algae character of the spring phytoplankton (*Aphanizomenon issatschenkoi*; *Planktothrix agardhii*; *Limnothrix redekei*) and zooplankton (*Keratella cochlearis* f. *tecta*, *K. quadrata*, *Anuraeopsis fissa*, *Bosmina longirostris* and *Chydorus sphaericus*), the increase of the total densities of zooplankton with the dominance of rotifers, the impoverishment of the phytolittoral as well as the quality and quantity changes in the structure of macrophytes. In the catchment area of these lakes no changes connected with expanding industry or changes in agricultural production were observed within the five years between both examinations.

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WPŁYW WZROSTU NIEKONTROLOWANEJ REAKCJI NA STRUKTURĘ PLANKTONU I ZBIOROWISK MAKROFITÓW W JEZIORACH RYNNOWYCH LEŻĄCYCH W ZLEWNI ROLNICZEJ

S t r e s z c z e n i e

W latach 1993-1995 przeprowadzono badania biologiczne na jeziorach: Bukowieckim Dużym, Bukowieckim Małym i Kobyleckim, położonych w obrębie typowej zlewni rolniczej, wzdłuż Strugi Gołanieckiej.

Badania hydrobiologiczne przeprowadzone w 1993 roku świadczyły o stabilnym stanie eutrofii w tych jeziorach. W tym czasie żadne z jezior Bukowieckich nie było wykorzystywane rekreacyjnie, podczas gdy nad Jeziorem Kobyleckim występowała zabudowa obejmująca domki letniskowe i kempingi. W 1995 roku, po zakończeniu badań, rozpoczęła się budowa domków rekreacyjnych nad Jeziorem Bukowieckim Dużym, zaobserwowano także wzrost rekreacji nad Jeziorem Kobyleckim.

W okresie wiosennym i letnim 2000 roku powtórzono badania hydrobiologiczne w celu stwierdzenia, czy zmiany w sąsiedztwie jezior miały wpływ na parametry chemiczne ich wód. Chociaż zabudowa nad jeziorami nie była jeszcze zakończona, zaobserwowano zmiany kilku parametrów wody badanych jezior (tab. 2). Głównym celem przeprowadzonych badań był opis istotnych zmian jakościowych i ilościowych parametrów fizyczno-chemicznych i biologicznych, ze szczególnym odniesieniem do aspektów dotyczących wzrostu poziomu trofii badanych zbiorników.

Negatywne efekty w stanie trofii były związane ze zmniejszającą się przezroczystością wody, wzrostem koncentracji biogenów, wybitnie sinicowym charakterem fitoplanktonu wiosennego (*Aphanizomenon issatschenkoi* (Ussac.) Proschkina-Lavrenko; *Planktothrix agardhii* (Gom.) Anagn. et Kom.; *Limnothrix redekei* (Van Goor) Meffert) i zooplanktonem (*Keratella cochlearis* f. *tecta* (Lauterborn), *K. quadrata* (O. F. Müller), *Anuraeopsis fissa* (Gosse), *Bosmina longirostris* (O.F. Müller) and *Chydorus sphaericus* (O.F. Müller)), wzrostem całkowitej liczebności zooplanktonu z dominacją wrotków (tab. 3, ryc. 1, 2), zniszczeniami w strefie fitolitoralu i zmianami jakościowymi i ilościowymi w strukturze makrofitów (tab. 4).