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Decrease of faunal diversity in a disturbed lake, as exemplified by Tanytarsini chironomids (Diptera: Chironomidae) of Jezioro Żarnowieckie

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Abstract: Diversity of the Tanytarsini chironomids (Diptera: Chironomidae) collected on the Żarnowieckie Lake (northern Poland) in the early 1980s and in 2008–2009 was compared. The analysis demonstrated a significant impoverishment of the Żarnowieckie chironomid fauna. Within less than 30 years, the number of Tanytarsini species dropped from 21 to 14, and the fauna became dominated by common eurytopic species *Cladotanytarsus atridorsum* Kieffer (more than 73% of all individuals collected in 2008), *C. mancus* (Walker) (more than 8%), and *Paratanytarsus inopertus* (Walker) (more than 9%). The four species rare in Poland [*Tanytarsus niger* Andersen, *Rheotanytarsus muscicola* Thienemann, *Stempellinella brevis* (Edwards), *Paratanytarsus tenellulus* (Goetghebuer)], recorded in the area in the 1980s, were absent in 2008–2009. The reduction in the Tanytarsini diversity is interpreted as an effect of unstable environmental regime of the lake following its artificial modification in 1983 to serve the needs of the "Żarnowiec" pumped storage power station, and interventions related to the planned construction of a nuclear power plant on the lake.

Key words: Diptera, Chironomidae, Tanytarsini, Lake Żarnowieckie, biodiversity

INTRODUCTION

The Tanytarsini form one of the largest tribes of the family Chironomidae, represented by about 200 species known from Europe, including 105 species recorded in Poland (Sæther & Spies 2004; Giłka 2006, 2009; Giłka & Dominiak 2007). The Tanytarsini reproduce primarily in fresh water and inhabit almost all types of freshwater aquatic habitats. A substantial number of species in the tribe and their varying tolerance to destabilising factors affecting their habitats make the Tanytarsini good candidates for indicators in environmental assessment of aquatic habitats.

This paper is a part of series of studies addressing biodiversity and directions of changes in the Tanytarsini fauna of the largest and most important freshwater reservoirs of the Gdańsk Lakeland. Data on the Tanytarsini fauna of the region have been reported in a number of recent publications (Giłka 1997, 2001b, 2001c, 2002, 2009; Giłka & Dominiak 2007).

Within less than 30 years, the aquatic habitat of the Żarnowieckie Lake changed as a result of human interventions related to the planned construction of a nuclear power plant and due to the „Żarnowiec" S.A. pumped storage power plant being put into operation in 1983. Materials analysed in this study, collected in the early 1980s and in 2008–2009, made it possible to follow changes in the composition of the Tanytarsini fauna of the Żarnowieckie Lake.

STUDY AREA

The Żarnowieckie Lake (Fig. 1), Poland's largest and northernmost inland water body (54°46'N, 18°35'E) originally covered 1443 ha and contained 124 million m^3 water at the altitude of 1.50 m above sea level (as documented by measurements performed in 1960 by the Inland Fisheries Institute in Olsztyn; Wiśniewolski & Malinowski 2004). In the 1980s, the lake's characteristics changed as a result of interventions associated with power plant construction, which involved burying the south-eastern part of the lake, damming its water, and regulating

the lake's discharge into the Baltic Sea. Measurements commissioned by the "Żarnowiec" pumped storage power station (Elektrownia Wodna „Żarnowiec", EWŻ) in 2000 showed the lake to cover now 1388 ha, with the volume of up to 123.2 million m^3, and the mean and maximum depths of 8.4 and 19.4 m, respectively (Wiśniewolski & Malinowski 2004). EWŻ uses the lake as a source of water and the site of its discharge after pumping; as a consequence, the lake's water is cyclically mixed. The EWŻ operation induces changes in water level of up to 1 m per day (Dubrawski et al. 2003, Wiśniewolski & Malinowski 2004).

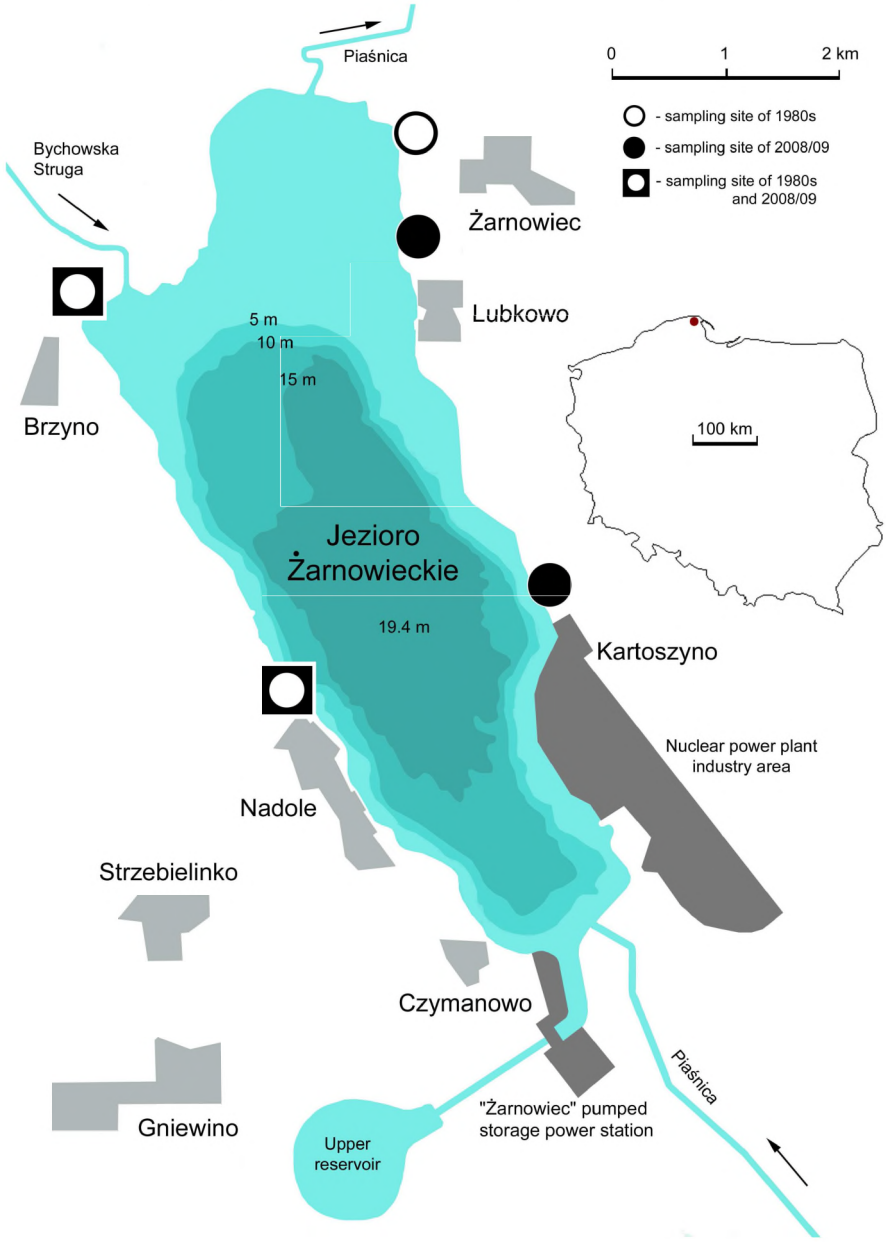

Fig. 1. Study area and distribution of sampling sites.

The mean annual water temperature in the surface layer is 9°C, the mean summer temperature amounting to about 18°C (Dubrawski et al. 2003). At present, the trophic status of the Żarnowieckie Lake can be described as intermediate between β mesotrophic and eutrophic, eutrophication tending to intensify. The entire lake shows very good oxygen regime; however, mechanical and hydrodynamic destruction of the shallow littoral, devoid of water for several hours per day, results in, i.a., changes in the biomass of macrobenthos and macrophytes (Dubrawski et al. 2003). A prolonged stagnation and strong increase in water fertility in the flooding zone, brought about by accumulation of abundant organic matter, results in irreversible changes associated with regressive succession, degradation of plant communities, and complete disappearance of some rare species (Pliński & Wnorowski 1993).

Materials and methods

The materials used in this work consisted of a total of 3869 adult males of 25 Tanytarsini species collected in 1980–1983 and 2008–2009. The 1980s collection consisted of 429 chironomid individuals sampled from the three sites near the villages of Brzyno, Nadole and Żarnowiec (15 samples) between April and August. The remaining samples (51) were collected regularly, at least once a month in 2008 (April–November) and at the beginning of 2009 (April) from four sites distributed uniformly around the lake (Brzyno, Kartoszyno, Lubkowo and Nadole) (Fig. 1). The chironomids were captured with a sweep net during swarming or by "mowing" from herbaceous plants, shrubs, and trees near the lake; some individuals were caught with light traps. The sampling methods were the same in 1980s and 2008/2009. The adult males were assigned to species with use of the keys by Lehmann 1970, Reiss & Fittkau 1971, Säwedal 1976, Reiss & Säwedal 1981, Giłka 2001a, 2001c, Stur & Ekrem 2006, Ekrem 2007. The materials collected in 1980–1983 by Professor Ryszard Szadziewski and in 2008–2009 by the junior author are available at the Department of Invertebrate Zoology, University of Gdańsk.

Results

Tanytarsini collections examined were found to consist of 26 species representing 6 genera (Table 1). The 1980–1983 collection consisted of 429 individuals representing 21 species, whereas the 2008/2009 collection numbered 3440 individuals assigned to 14 species. The 2008/2009 collection contained 9 of the 21 species recorded in 1980–1983; 5 species had not been recorded before, while 12 species present in 1980–1983 were missing. The 2008/2009 collection was dominated by a single species, *Cladotanytarsus atridorsum* Kieffer, which accounted for more than 73% individuals and was present in all samples collected in 2008 (except in April) from all sites (Tables 1 & 2).

Adult Tanytarsini were present on the Żarnowieckie Lake as of April. The first to appear were individuals representing species of the genera *Micropsectra* and *Tanytarsus*, including the early-spring single-generation *Tanytarsus sylvaticus*. The highest number of individuals was collected in May, whereas the highest number of species was recorded in September. In the 2008 season, the last sample, consisting of male *Cladotanytarsus atridorsum*, *C. mancus* and *M. atrofasciata*, was collected on November, 12th (Table 2).

Discussion

The species recorded on the Żarnowieckie Lake account for slightly more than 25% of the Polish Tanytarsini fauna. Considering the size of the study area, the number of the species found should be regarded as relatively low. A total of 33 species were found on the Raduńskie lakes (an area of a comparable size) (Giłka & Dominiak 2007).

Table 1. Numbers of individuals of Tanytarsini (n) and the percentage (%) of species recorded on the Żarnowieckie Lake.

Sampling period	1980–1983		2008–2009		1980–2009	
Species	n	%	n	%	n	%
C. atridorsum Kieffer	43	10.02	2523	73.34	2566	66.06
C. mancus (Walker)	31	7.23	291	8.46	322	8.32
M. apposita (Walker)	-	0	8	0.23	8	0.21
M. atrofasciata (Kieffer)	10	2.33	90	2.62	100	2.58
M. junci (Meigen)	-	0	14	0.41	14	0.36
M. notescens (Walker)	-	0	3	0.09	3	0.08
M. recurvata Goetghebuer	1	0.23	-	0	1	0.03
P. inopertus (Walker)	24	5.59	322	9.36	346	8.94
P. laccophilus (Edwards)	-	0	1	0.03	1	0.03
P. lauterborni (Kieffer)	1	0.23	-	0	1	0.03
P. tenellulus (Goetghebuer)	14	3.26	-	0	14	0.36
P. tenuis (Meigen)	1	0.23	-	0	1	0.03
R. muscicola Thienemann	3	0.70	-	0	3	0.08
S. brevis (Edwards)	1	0.23	-	0	1	0.03
T. bathophilus Kieffer	10	2.33	15	0.44	25	0.65
T. brundini Lindeberg	32	7.46	2	0.06	34	0.88
T. dibranchius Kieffer	1	0.23	-	0	1	0.03
T. lestagei Goetghebuer	23	5.36	5	0.15	28	0.72
T. ex gr. lestagei	14	3.26	-	0	14	0.36
T. mendax Kieffer	2	0.47	-	0	2	0.05
T. niger Andersen	1	0.23	-	0	1	0.03
T. pallidicornis (Walker)	8	1.86	66	1.92	74	1.91
T. sylvaticus (van der Wulp)	-	0	76	2.21	76	1.96
T. usmaensis Pagast	2	0.47	-	0	2	0.05
T. verralli Goetghebuer	206	48.02	24	0.70	230	5.94
T. volgensis Miseiko	1	0.23	-	0	1	0.03
Total	429	100%	3440	100%	3869	100%
Number of species	21		14		26	

The Tanytarsini fauna of both areas differs substantially, Jaccard's faunistic similarity index being as low as 37%. Margalef's diversity index for the Raduńskie Tanytarsini was as high as 3.79, in contrast to the values 3.13 and 1.35 that were found on the Żarnowieckie Lake in 1980–1983 and 2008, respectively. Even if one takes into account the dependence of the index on the number of individuals, the difference in values of the index is considerable and it shows that the Tanytarsini fauna of the Żarnowieckie Lake become impoverished.

The experiences with the Żarnowieckie Lake point the changes in trophic status as a consequence of sewage discharge inflow, i.e. from the discharge of sewage treatment plant collector at Nadole and from untreated sewage discharge from the village of Lubkowo (the village without a treatment plant). The power station's operation generates water currents and induces cyclic mixing of the entire water volume in the lake. Consequently, water of the upper pelagial and the littoral (down to 5 m depth) is oxygen-saturated. On the other hand, processes taking place in the shallow littoral are typical for eutrophic water bodies. Under such unstable conditions, it is mainly the eurytopic species that are able to develop and persist (Table 1). Almost 84% of the specimens caught in 2008 represent two *Cladotanytarsus* species, common in Poland and tolerant of heavily eutrophic lentic water bodies.

The Tanytarsini fauna of the Żarnowieckie Lake comprised some species that are seldom observed in Poland: *Tanytarsus niger* Andersen, so far known from the single site in Poland (Giłka 2002); *Rheotanytarsus muscicola* Thienemann, found – in addition to the Żarnowieckie Lake – at three sites in Cracow (Lehmann 1970), in the Masurian Lakeland and in the Bieszczady Mountains (Giłka 2002); *Stempellinella brevis* (Edwards), known from the Jura Krakowsko-Częstochowska region (Giłka 2002) and from three dubious identifications based on larvae collected in the Pieniny Mountains (Kownacki 1982), on the Babia Góra Mountain (Dratnal 1970)

and in the Beskidy Mountains (Sowa 1965); *Paratanytarsus tenellulus* (Goetghebuer), recorded in the Masurian (4 sites) and Kashubian (1 site) Lakelands (Giłka 2002); and *Paratanytarsus laccophilus* (Edwards), so far reported from two sites in the Masurian Lakeland (Giłka 2002) and from a single site in the Tatra Mountains (Giłka 2007). The species mentioned above were recorded in Brzyno and Nadole, except for *P. laccophilus* collected in Lubkowo. Unfortunately, four of the five species listed (except for *P. laccophilus*) were not found in 2008–2009.

Table 2. Numbers of individuals and species of the Tanytarsini ccollected in different months of the year 2008 on the Żarnowieckie Lake.

Species \ month	April	May	June	July	Aug	Sep	Oct	Nov
C. atridorsum	-	1254	691	190	188	158	21	21
C. mancus	-	149	12	7	33	81	8	1
M. apposita	3	-	-	-	-	2	1	-
M. atrofasciata	8	-	-	-	-	1	48	16
P. inopertus	-	1	-	73	83	165	-	-
P. laccophilus	-	-	-	-	-	1	-	-
T. bathophilus	6	-	-	-	-	-	9	-
T. brundini	-	-	-	-	-	1	1	-
T. lestagei	-	-	-	-	1	4	-	-
T. pallidicornis	13	-	-	-	7	31	2	-
T. sylvaticus	41	-	-	-	-	-	-	-
T. verralli	3	-	-	-	7	14	-	-
Total	74	1404	703	270	319	458	90	38
Number of species	6	3	2	3	6	10	7	3

The pattern of seasonal dynamics of appearance of the adult Tanytarsini was distinctly different than these described earlier for the Tanytarsini of the Kashubian Lakeland (Giłka & Dominiak 2007) and entire Poland (Giłka 2002) with 4 or 5 peaks of appearance: early and late spring, summer, late summer and autumn, lasting until the second decade of October. As few as two marked peaks of abundance and species richness were observed in the Żarnowieckie Tanytarsini fauna in 2008: one in April–May and the other in September–October (Table 2). Interestingly, the adult males of *Cladotanytarsus atridorsum*, *C. mancus*, and *Micropsectra atrofasciata* were observed to form swarms as late as in early November.

The non-typical pattern of the dynamics of appearance was, doubtless, influenced by intensive mixing of the entire water volume of the lake, cyclic changes in water level, and drying out of a part of the shallow littoral.

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STRESZCZENIE

[Spadek różnorodności faunistycznej w zaburzonym środowisku Jeziora Żarnowieckiego na przykładzie ochotkowatych z plemienia Tanytarsini (Diptera: Chironomidae)]

Prezentowana analiza objęła muchówki z rodziny ochotkowatych i plemienia Tanytarsini (Diptera: Chironomidae), grupę hydrobioindykatorów o zróżnicowanej tolerancji. Materiał zebrano nad Jeziorem Żarnowieckim na początku lat 80-tych oraz w latach 2008 i 2009. Zestawienie uzyskanych wyników wskazuje na wyraźne ubożenie fauny jeziora. Liczba gatunków Tanytarsini notowanych w okresie niespełna 30 lat spadła z 21 do 14. Faunę zdominowały pospolite gatunki eurytopowe: *Cladotanytarsus atridorsum* Kieffer (ponad 73% okazów zebranych w 2008 r.), *C. mancus* (Walker) (ponad 8%), *Paratanytarsus inopertus* (Walker) (ponad 9%), natomiast czterech rzadkich gatunków, notowanych na badanym obszarze w latach 80-tych, obecnie nie stwierdzono (*Tanytarsus niger* Andersen, *Rheotanytarsus muscicola* Thienemann, *Stempellinella brevis* (Edwards), *Paratanytarsus tenellulus* (Goetghebuer)). Spadek bioróżnorodności Tanytarsini zinterpretowano jako skutek niestabilnych parametrów jeziora, sztucznie uregulowanego na potrzeby elektrowni szczytowo-pompowej „Żarnowiec" w 1983 roku, a także inwestycji związanych z budową elektrowni jądrowej, wdrażanych w latach 80-tych.

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