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Diurnal Changes in Fish Assemblages in the Danube River Section Upstream of Budapest and Its Tributaries

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Abstract: Consideration of diurnal changes of fish distribution is one of the basic requirements of standard monitoring of fluvial fish assemblages. Sampling results of day and night electrofishing were evaluated in different types of watercourses, in a very large river, that is the Danube River, as well as in a tributary of a large stream (Ipel River) and in a tributary of a small stream (Sződrákosi stream). A total of 4859 individuals belonging to 39 species were caught during the period 2012-2013. Species richness and fish abundance in the night samples was significantly higher than in the day samples at low water level in the Danube River. Diurnal variability of fish samples in the large stream was less than in the very large river. Difference between the day and the night samples was not significant in the small stream. Preliminary observations indicate an impact of running water quantity on diurnal changes in riparian fish assemblages.

Keywords: Day and night sampling, river fish survey, electric fishing

Introduction

Long-term changes in abundance and composition of fish stocks are good indicators of alterations of fluvial ecosystems, therefore, the assessments of fish populations are becoming more important for the evaluation of ecological status of the Danube River system, especially since the implementation of the EU Water Framework Directive (Angermeier, Karr 1986, Karr *et al.* 1987, EC 2000, Schmutz *et al.* 2007). In the monitoring of long-term dynamics of riverine fish populations, consideration should be given to sampling variability, because of the spatial and temporal changes in fish distribution (Ericksen, Marshall 1997, Specziár 2001, Zalewski, Cowx 1990), as well as to consistency of long-term sets of data (Guti 2002).

Quick and easily feasible methods, as the application of electric fishing are preferred in the study of riverine fish assemblages (Buijse *et al.* 2002, Cowx, Lamarque 1990, Harvey, Cowx 1996, Hendricks *et al.* 1980, Reynolds 1993, 1996), however their efficiency depends on several factors.

Consideration of diurnal changes of sampling results is an important issue in the development of a sampling strategy for representative surveys. The night sampling by electrofishing usually results in a higher number and abundance of species than the day sampling, because of the daily dynamics of spatial fish distribution (Erős *et al.* 2008, Gaygusuz *et al.* 2010, Graham 1986, Paragamian 1989, Sanders 1992, Witt, Cambell 1959).

A standardised methodology for fish monitoring depends on the type and size of the monitored streams and rivers. However, the sampling procedures are not unified in the main national monitoring systems in Hungary. The day sampling by electrofishing is implemented in streams and rivers according to the national monitoring protocol of the Water Framework Directive (Halasi-Kovács, Tótmérész

2007), while the night sampling, which is required in large rivers, is implemented according to the protocol of the National Bio-monitoring System (Sallai *et al.* 2008). The evaluation of diurnal changes in the fish assemblages with consideration of the watercourse types is a critical issue in the development of standard fish survey methods.

Material and Methods

Diurnal distribution of fish assemblages and samples of day and night electrofishing were studied in three different types of watercourses: in a very large river, that is the Danube River at Szob (rkm 1709-1707), in a large stream (Ipel River at rkm 2-3) and in a small stream (Sződrákosi stream – 250 m from the Danube) (Fig. 1).

The sampling was implemented three times: in September and November 2012 at low water level (Szob 89 cm and 94 cm) and in May 2013 at medium water level (Szob 285 cm). The sampling sites were characterised by natural and modified shorelines.

A medium size (5 kW) electrofishing equipment (Hans Grassl EL-63) with a dip net was used from a boat for sampling in shallow waters (< 1.5 m) along the riverbanks in the Danube River and the Ipel River. A small (600 W) backpack electrofishing unit (Hans Grassl IG-600) was used by wading in the Sződrákosi stream.

The abundance of fish in the day and night samples was compared by paired t-test and Wilcoxon signed rank test. Species richness for a given number of individual samples was assessed by rarefaction analysis. Species diversity and cumulative number of species as a function of the number of samples was demonstrated by rarefaction analysis. The diurnal difference in the number of detected species was illustrated by boxplots. The statistical analysis was performed using the PAST 1.9 (Hammer *et al.* 2001) and R 2.15.2 (R Core Team 2012) software.

Results

Danube River

A total of 31 fish species were collected in the Danube River. Some species, *e.g.* bream (*Abramis brama*), white bream (*Blicca bjoerkna*), schraetzer (*Gymnocephalus schraetser*), white-finned gudgeon (*Romanogobio vladykovi*), ide (*Leuciscus idus),* Volga pikeperch (*Sander volgensis*)*,* vimba bream (*Vimba vimba),* and zingel (*Zingel zingel*), were caught only in the night samples. Other species, such as bleak (*Alburnus alburnus),* chub (*Squalius cephalus),* round goby (*Neogobius melanostomus*), etc., were found both in the day and night samples, and some of them had a higher abundance in the daytime period.

The species richness was significantly higher at night in the autumn period of low water level (89 cm in September and 94 cm in November at Szob), while its diurnal change was not significant in spring time at medium water level (285 cm at Szob in May) (Table 1, Fig. 2).

Table 1. Species richness and abundance of fish in the day (D) and night (N) samples at low (LWL) and medium water level (MWL). * indicates significant differences

	Number of species		Mean number of species		Number of individuals		Mean abundance of fish in the samples	
	D	N	D	N	D	N	D	N
Danube River								
Sep (LWL)	14	23	5.50±1.85*	10.00±2.62*	370	476	37.00±20.29	47.60±26.10
Nov (LWL)	10	21	3.00±1.45*	7.00±1.51*	79	162	7.90±6.52	16.20±10.44
May (MWL)	18	17	8.00±2.50	9.00±1.20	474	310	94.80±34.30*	62.00±32.20*
Ipel River								
Sep (LWL)	13	19	5.00±2.14*	11.00±1.79*	173	369	34.60±22.34*	73.80±15.84*
Nov (LWL)	16	18	5.00±3.16	6.00±1.02	460	294	92.00±110.71	58.80±32.99
May (MWL)	18	19	8.00±2.14	8.00±1.79	184	257	36.80±5.49	51.40±4.92
Sződrákosi stream								
Sep (LWL)	12	14	5.00±2.61	7.00±1.67	89	157	17.80±9.74	31.40±21.96
Nov (LWL)	12	10	5.40±1.36	4.80±0.75	127	161	25.40±11.00	32.20±18.90
May (MWL)	8	7	1.80±0.75	2.60±0.49	20	26	4.00±4.52	5.20±1.17

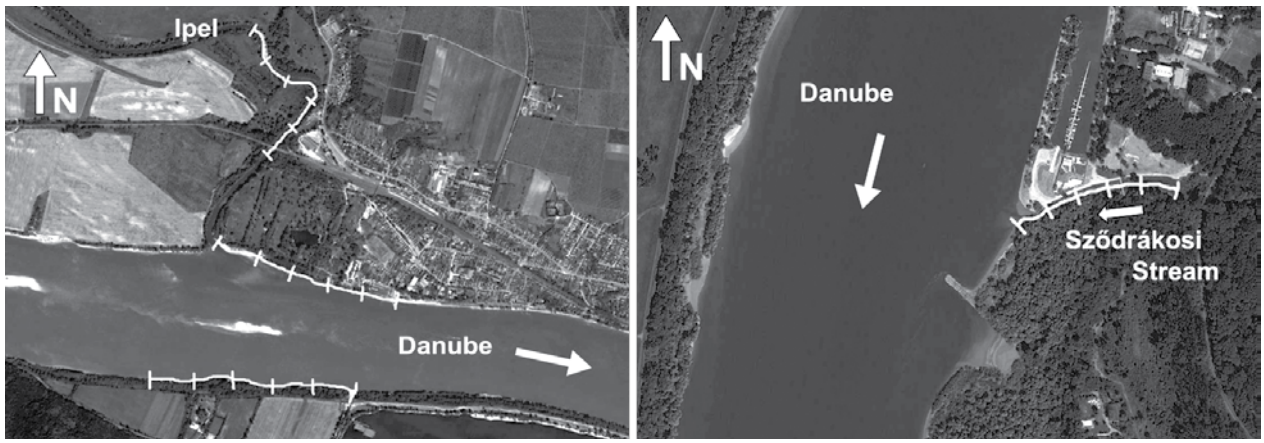

Fig. 1. Sampling sites in the Danube River, in the Ipel River (left) and in the tributary of the Sződrákosi stream (right)

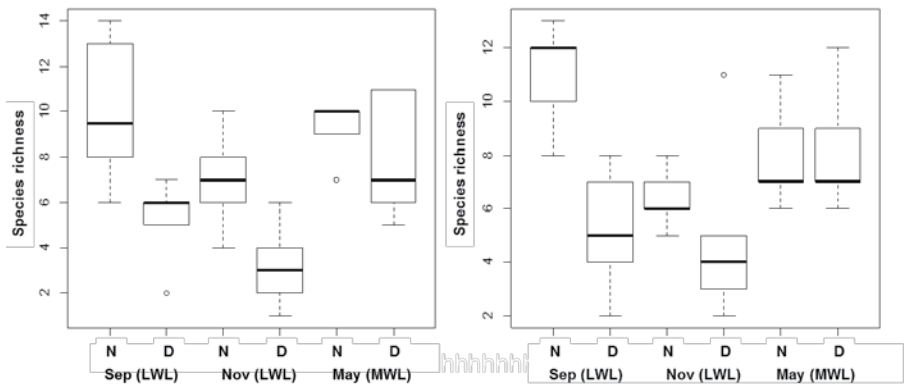

Fig. 2. Species richness of the day (D) and night (N) samples in the Danube River (left) and the Ipel River (right) in September and November 2012, at low water level (LWL), as well as in May 2013 at medium water level (MWL)

The obvious separation of the day and night curves in the rarefaction analysis (Fig. 3) indicates a significant diurnal difference in the cumulative number of species and significantly higher species richness in the night samples during the autumn period of low water level. However, the day and the night curves were overlapping in the late spring time at medium water level.

The diurnal change of fish abundance was not significant in September and November, but it was significantly higher (t-test $p<0.05$) in the day samples collected in May (Table 1).

Ipel River

A total of 32 fish species were collected in the Ipel River. Some of the species, such as bream, asp (*Aspius aspius*), white bream, ide, roach (*Rutilus rutilus*), and pikeperch (*Sander lucioperca*), were detected mainly in the night samples, while others, *e.g.* stone moroko (*Pseudorasbora parva),* bighead goby (*Ponticola kessleri*), and western tubenose goby (*Proterorhinus semilunaris*), occurred in the day samples.

The species number in the night samples was significantly higher (t-test $p<0.05$) at low water level in September. However, the diurnal change of species richness was not significant at low water level in November and at medium water level in May (Table 1, Fig. 2). The rarefaction analysis (Fig. 3) proved a significant diurnal difference and a higher cumulative number of species in the night samples in September, while the day and the night curves of the species richness were similar in November and May.

The diurnal change of fish abundance was significant only in September. The abundance of stone moroko was extremely high at one sampling point in November, but these data were excluded from the statistical analysis. The mean abundance of fish in the night samples was significantly higher (t-test $p>0.05$) in September (Table 1).

Sződrákosi stream

A total of 24 fish species were collected in the Sződrákosi stream. Some species, *e.g.* bream, schraetzer white-finned gudgeon, pikeperch, etc., were

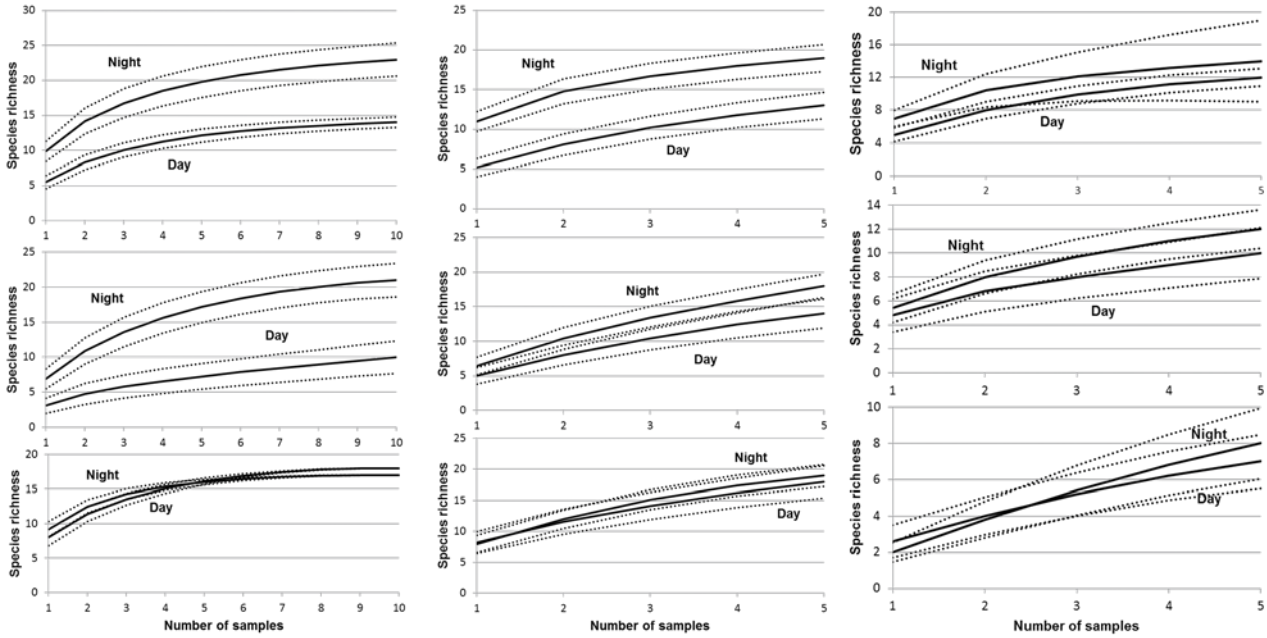

Fig. 3. Rarefaction analysis curves of cumulative number of species in the day and night samples in the Danube River (left column), in the Ipel River (middle column) and in the Sződrákosi stream (right column), in September 2012 (top row), in November 2012 (middle row), and in May 2013 (bottom row)

caught only in the night, but the diurnal change of species richness was not significant (t-test $p>0.05$). The diurnal difference of the mean species number per sample was also not significant (Table 1).

The rarefaction analysis (Fig. 3) indicated similar species richness by the overlapping confidence intervals of the day and the night curves at low water level (September and November) and at medium water level (May).

The diurnal difference in the fish abundance was not significant (t-test $p>0.05$) at the sampling site (Table 1).

Discussion

The diurnal changes in species richness and fish abundance in the samples caught by electrofishing can be explained by a daily fluctuation in habitat use of fish and by fish movements between feeding grounds and refuges. The sampling was directed to the shallow shoreline habitats, where the electrofishing was more effective. In daytime, most of the fluvial fish species avoid the shallow and sunny areas of the riverbed (Gaygusuz *et al.* 2010, Hayward *et al.* 1989, Sanders 1992) and shift to the deep and dark medial zone, outside of the shoreline zone. In night time, feeding activity of several fish species increases and their individuals move to the shallow shoreline zone. Some fish species can find refuges in caves among rip-rap rocks used to armour shorelines and the diurnal change in occurrence of these species is low in electrofishing samples.

The diurnal variations in species richness and abundance of the fish assemblages were moderate in the Ipel River, which is considerably smaller than the Danube River. The width of its channel is one order of magnitude narrower and the range of lateral movement of fish between the deep medial zone and shallow shoreline zone is more limited. The daytime efficiency of electrofishing was higher in the smaller river due to the relative rarity of deep areas in its channel. The diurnal change in the fish assemblages in the Sződrákosi stream was insignificant. This stream has an even smaller watercourse, and its fishes are easy to catch by electrofishing both at night and day. Some species were recorded only at night, but these migrated from the Danube River, using the lower section of the stream as an overnight feeding habitat.

The results of the fish surveys show an increase in the diurnal fluctuation in species richness and abundance of shoreline electrofishing samples with the increase in the size of the watercourses. The diurnal change was more significant at low water levels, in the autumn period. The highest values of species

richness of fish were observed at night and during low water levels. The impact of the water regime on the daily dynamics of fish assemblages (change of distribution and composition) is less known in the Danube River and its tributaries. Therefore, more detailed surveys may contribute to the explanation of the diurnal behaviour of fishes and the formation of their assemblages.

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