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The influence of diel period on fish assemblage in the unstructured littoral of reservoirs

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Abstract Diel changes in littoral fish assemblage were studied in four reservoirs in the Czech Republic (Central Europe). The sampling was performed by beach seining in an unstructured littoral zone. Perch, *Perca fluviatilis* L., roach, *Rutilus rutilus* (L.), bream, *Abramis brama* (L.), carp, *Cyprinus carpio* L., ruffe, *Gymnocephalus cernua* (L.), pikeperch, *Sander lucioperca* (L.), eel, *Anguilla anguilla* (L.) and *A. brama* × *R. rutilus* hybrids exhibited higher densities at night. Only bleak, *Alburnus alburnus* (L.) exhibited higher densities during the day. The number of species was higher in night hauls, and mean body size of roach and bleak was also higher at night. Diel changes in fish densities resulted in the change in species composition between day and night. The study has implication for the sampling design to assess littoral fish assemblages using beach seine netting and recommends night sampling for a representative assessment or sampling during both diel periods for a robust assessment.

KEYWORDS: beach seining, diel migration, Římov Reservoir, sampling, species composition.

Introduction

The littoral zones of lakes, rivers and reservoirs are the most complex and productive parts of these water bodies (Winfield 2004). The majority of fish species use the littoral zone during at least a part of their ontogenetic development (Duncan & Kubečka 1995; Winfield 2004). Thus, representative assessment of littoral zone fish assemblages is desirable for ecological studies, such as spatial fish distribution, habitat preference or evaluation of the ecological status of the water body.

Beach seining is an effective method for capturing fish in the unstructured littoral zone of lakes and rivers. It is widely used for littoral zone sampling in marine and freshwater environments (Pierce *et al.* 1990; Cowx *et al.* 2001; Johnson *et al.* 2007). This method combines many advantages over other sampling methods, such as simplicity of use, low selectivity during the day and night, a large sampled area and

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capture of live samples with minimal trauma (Pierce *et al.* 1990; Johnson *et al.* 2007; Říha *et al.* 2008; Bonar *et al.* 2009). However, the method can only be used in unstructured littoral habitats, i.e. places without obstacles, rough substratum or dense macrophytic vegetation on the bottom (Johnson *et al.* 2007; Bonar *et al.* 2009).

The representativeness of littoral fish assemblages obtained from beach seining can be influenced by diel fish movement between habitats. The diel shift between structured and unstructured littoral or open water has been widely documented for juvenile fishes (e.g. Gliwicz & Jachner 1992; Lewin *et al.* 2004; Holker *et al.* 2007). Juveniles seek refuge in littoral structures during the day and migrate to the unstructured littoral habitat and open water at night (Lewin *et al.* 2004). Until now, however, little attention has been given to sub-adult and adult fish diel movements. Diel changes of adult fish assemblages in the unstructured littoral zone were evaluated using beach seining in some lakes in the North America (Blackwell & Brown 2005; Reid & Mandrak 2009), with fish preferring the unstructured littoral zone at night, although the pattern varied across lakes. In European lentic waters, detailed studies of diel changes in littoral fish assemblages are lacking. Only Kubečka (1993) and Říha *et al.* (2008) have provided evidence that beach seine catches differ between day and night.

In addition to knowledge about the ecology of fishes, there is also a need for representative sampling of fish communities in all freshwater habitats, to meet obligations under the European Community Water Framework Directive (Schmutz *et al.* 2007; Bonar *et al.* 2009). This requires representative sampling of fish abundance and species and size structure in certain habitats. As a consequence, it is essential to understand diel patterns in fish distribution in the littoral zone.

This study examined differences in the diel composition of fish assemblages in the littoral zone of four Czech Republic reservoirs assessed using beach seine netting. The study aimed: (1) to examine diel changes in littoral zone fish assemblage abundance, biomass, species composition and size structure in these reservoirs and (2) to determine which period is the best for sampling littoral fish communities by beach seine netting in reservoirs.

Material and methods

The study was carried out in four Czech reservoirs: Římov, Orlík, Želivka and Žlutice. Characteristics of these reservoirs are given in Table 1. All reservoirs are canyon shaped (with similar morphology, Duncan & Kubečka 1995) and dimictic with well-developed thermal stratification during the summer. Water-level management of all reservoirs is similar with seasonal rather than daily fluctuations. The water levels are usually high at spring and early summer and slowly decline during the middle to late summer and autumn. The littoral area (inshore zone in a depth range of 0–4 m) represents 10–25% of the area in the reservoirs. The unstructured littoral zone suitable for beach seining covers approximately 2–7% of the shoreline of each reservoir. The rest of the shoreline is structured littoral habitat or steep banks with a very limited littoral zone.

Table 1. Basic characteristics of the studied reservoirs

Characteristics	Římov	Orlík	Želivka	Žlutice
Year of filling	1978	1963	1976	1968
Area (ha)	210	2637	1432	138
Volume (10^6 m^3)	33	703.8	246	10.9
Max. depth (m)	45	72	55.7	21
Mean. depth (m)	16	26	17	7.7
Length (km)	12	55	38	3.4
Retention time (days)	100	105	539	119

Sampling was conducted on suitable shores with a slight slope (2–8°) and a bottom surface consisting of a fine substrate without mud or obstructions. Catches from hauls when the net became snagged were excluded. Submerged macrophytes only occurred at sampling sites in the Želivka and Žlutice reservoirs. In the former, terrestrial macrophytes were flooded during sampling because of high water level. These macrophytes occurred only to a depth of 0.5 m. In Žlutice Reservoir, soft aquatic macrophytes (*Batrachium* sp. and *Myriophylum spicatum*) occurred rarely along the whole shoreline of the reservoir but covered no more than 5% of the shoreline in total.

Sampling was performed using beach seine nets. The nets were simple walls of netting with floats on the top line and lead weights on the bottom line. Two different dimensions of nets were used, each with a different method of hauling. The first net was 200 m long, 4 m high and had a 10-mm (knot-to-knot) mesh size. The net was set in a rectangle from the shoreline to the open water (to isobaths of 3.5–4 m) using a rowboat. The area enclosed by the net was measured using a measuring tape to calculate sampled area and was then hauled to the shore. This net was used to sample the Římov, Orlík and Želivka reservoirs. The second net was 40 m long, 3 m high, had a 6-mm (knot-to-knot) mesh size, and 50-m-long haul ropes were attached to ends of the net. The net was set parallel with the shore (to isobaths of 2.5–3 m) using a rowboat and pulled to

Table 2. Sampling effort carried out in all reservoirs and the total fish catch (abundance and biomass) investigated during this study

	Římov		Orlík		Želivka		Žlutice	
	Day	Night	Day	Night	Day	Night	Day	Night
No. of sites	4	4	2	2	5	5	6	6
No. of hauls	8	8	5	5	5	5	6	6
Sampled area (ha)	2.47	2.43	0.90	1.00	1.75	1.78	0.43	0.45
Total catch (ind.)	1789	4896	697	2323	6773	2436	385	467
Total catch (kg)	53.2	250.55	26.26	278.51	141.89	85.8	8.15	48.49

the shore using the haul ropes. The net was used to sample Žlutice Reservoir. The area hauled by both nets was calculated according to Říha *et al.* (2008).

Both methods of seining are effective for sampling during the day and night. The first seining method has low selectivity on a non-structured bottom because the whole area is enclosed and thus limits the escape of fish during hauling of the net to shore (Pierce *et al.* 1990). Říha *et al.* (2008) showed that the second seining method (used only in the Žlutice Reservoir) has more selectivity against larger fish, although the selectivity did not bias results of the size of net used in this study. Thus, the second seining method gives comparable results to the first seining method.

The experiments were carried out over the summer season from June to August in 2003 and 2005 in Římov Reservoir, 2004 in Orlík Reservoir, 2005 in Želivka Reservoir and 2006 in Žlutice Reservoir (Table 2). Sampling in each reservoir was performed during the day and repeated at the same site during the following night. Day sampling was between 11:00 and 16:00 h and night sampling between 22:00 and 03:00 h.

Fish catches were identified to species level, measured (standard length, nearest 5 mm) and weighed (nearest g). Catches of young of the year fishes were ignored, and only fish older than 1 year were considered for the study. Each sample was standardised before analysis to the same unit of area and expressed as the number of individuals per ha. Biomass was expressed in kg ha^{-1}.

Differences between day and night were compared according to the following fish assemblage characteristics: abundance and biomass of particular species, total fish abundance and biomass, number of species and species composition. The general pattern of diel change across all reservoirs was found using the following model. In each reservoir, the previously described characteristics were obtained from the study sites during the day and following night. This treatment is considered as a repeated measurement with one factor, the reservoir. Data were non-normally distributed as half the records were zeros, signifying no catch of the target species at the study site. Neither the Poisson model of data distribution nor hierarchical double Poisson model was optimal for use. The best-fitting model was a non-parametric ANOVA that compared mean rank of both day and night observations (following Brunner *et al.* 2002). The test statistic was the sum of the square of the differences between the mean day rank and overall mean rank and the difference between mean night rank and overall mean rank. In the next step, the sum was normalised by variance of the statistic, and the distribution of the test statistic was approximated by the central $F(1,\infty)$ function, which is recommended for small and medium data sizes (Brunner *et al.* 2002). The test was carried out on species that were caught in at least two reservoirs.

If a significant difference in abundance was found between diel periods, comparison of the ratio between night and day abundances was used to test whether the pattern of diel change was consistent in all reservoirs. This approach omitted the influence of differences in the abundances of certain species in a given reservoir and revealed whether the observed pattern of higher abundance in one diel period was valid for all reservoirs. The ratio was derived as night abundance divided by day abundance from the same sampling site. The resulting ratio signifies how many times the night catch was more abundant than the day catch. A slight adjustment of the data set was used to account for species caught only during one diel period. In this case, the zero value was replaced by the lowest abundance obtained at the reservoir divided by two. This approach only slightly underestimated the real ratio. Conversely, this small modification allowed inclusion of all data in the analysis with no dramatic increase in the data set variability. The non-parametric Kruskal–Wallis test was used to detect any variation in ratios among reservoirs and was performed only among reservoirs where certain species where caught during both diel periods.

Canonical correspondence analysis was used to test the effect of diel period on change in species composition (CANOCO software; Biometrics–Plant Research International, Wageningen, the Netherlands). Two

Table 3. Comparison of fish abundance (ind ha^{-1}) and biomass (in brackets; kg ha^{-1}), number of species and average fish weight between day and night in all reservoirs

Common name	Scientific name	Římov		Orlík		Žlutice		Želivka	
		Day	Night	Day	Night	Day	Night	Day	Night
Cyprinidae									
Roach***	*Rutilus rutilus* (L.)	64.57 (2.74)	524.33 (36.90)	237.61 (6.71)	934.15 (46.11)	9.25 (0.04)	194.17 (32.48)	304.17 (4.83)	263.43 (11.64)
Bream**	*Abramis brama* (L.)	59.47 (9.04)	439.60 (39.99)	100.79 (7.44)	676.76 (24.11)	–	–	235.89 (14.10)	480.70 (12.03)
Hybrid***	*A. brama* × R. rutilus	3.72 (0.05)	18.60 (0.94)	0.70 (0.02)	7.14 (4.97)	–	–	0.00 (0.00)	1.12 (0.05)
Carp**	*Cyprinus carpio* L.	1.24 (2.76)	1.86 (5.97)	2.32 (1.63)	23.61 (50.48)	–	–	–	–
Bleak**	*Alburnus alburnus* (L.)	72.85 (0.91)	42.32 (1.47)	143.06 (3.04)	76.81 (1.01)	–	–	1931.11 (22.47)	555.69 (10.80)
Rudd	*Scardinus erythrophthalmus* (L.)	15.85 (0.21)	5.82 (0.25)	13.96 (0.11)	4.65 (0.16)	862.23 (7.04)	758.21 (12.77)	38.47 (1.12)	44.35 (1.22)
Asp	*Aspius aspius* (L.)	25.97 (1.48)	21.68 (1.05)	101.37 (2.68)	65.23 (5.49)	9.25 (5.47)	50.86 (33.14)	3.90 (5.45)	0.49 (0.15)
Dace	*Leuciscus leuciscus* (L.)	186.03 (1.03)	176.72 (1.48)	63.87 (0.25)	98.15 (0.16)	–	–	0.00 (0.00)	0.46 (0.00)
Ide	*Leuciscus idus* (L.)	–	–	24.22 (0.42)	20.96 (0.99)	–	–	–	–
Chub	*Squalius cephalus* (L.)	3.34 (0.02)	5.95 (0.40)	14.94 (0.04)	11.00 (0.54)	–	–	0.36 (0.01)	0.00 (0.00)
Gudgeon	*Gobio gobio* (L.)	1.66 (0.01)	12.76 (0.16)	3.38 (0.00)	16.00 (0.01)	–	–	–	–
Tench	*Tinca tinca* (L.)	0.00 (0.00)	0.51 (0.13)	15.13 (2.35)	10.52 (1.09)	–	–	–	–
Topmouth gudgeon	*Psudorasbora parva* (Temminck & Schlegel, 1846)	0.29 (0.13)	0.37 (0.11)	24.00 (0.05)	11.73 (0.02)	–	–	–	–
Crucian carp	*Carassius auratus* (L.)	0.00 (0.00)	2.31 (0.33)	0.00 (0.00)	0.92 (0.74)	–	–	–	–
Silver bream	*Blicca bjoerkna* (L.)	–	–	0.00 (0.00)	40.79 (5.08)	–	–	–	–
Grass carp	*Ctenopharyngodon idella* (Valenciennes, 1844)	1.05 (3.19)	0.00 (0.00)	1.71 (0.16)	0.97 (3.31)	–	–	0.29 (1.52)	0.00 (0.00)
Percidae									
Perch***	*Perca fluviatili* L.	15.64 (1.28)	56.85 (6.76)	31.86 (2.07)	238.48 (51.06)	0.00 (0.00)	27.74 (3.39)	30.21 (2.09)	36.05 (1.56)
Ruffe***	*Gymnocephalus cernua* (L.)	17.95 (0.18)	253.24 (2.18)	25.87 (0.25)	439.37 (3.35)	0.00 (0.00)	18.49 (0.14)	0.00 (0.00)	8.37 (0.09)
Pikeperch***	*Sander lucioperca* (L.)	12.36 (0.63)	51.93 (1.92)	7.37 (0.11)	57.91 (12.35)	0.00 ()	16.18 (0.98)	0.00 (0.00)	6.87 (1.47)
Esocidae									
Pike	*Esox lucius* L.	0.52 (0.21)	2.94 (9.95)	7.71 (3.95)	9.30 (12.30)	9.25 (6.28)	13.87 (29.21)	12.48 (4.99)	32.60 (9.33)
Anguillidae									
Eel***	*Anguilla anguilla* (L.)	0.00 (0.00)	2.00 (0.77)	0.00 (0.00)	15.67 (3.79)	–	–	–	–
Siluridae									
European catfish	*Silurus glanis* L.	–	–	0.00 ()	5.61 (4.72)	–	–	–	–
Total fish abundance** (biomass***)		482.52 (23.87)	1619.81 (110.79)	831.58 (31.26)	2765.74 (231.86)	889.97 (18.83)	1079.52 (112.09)	2556.88 (56.48)	1430.13 (48.36)

Asterisks beside species names indicate significant difference in abundance of all the studied reservoirs together ($*P = 0.05$, $**P = 0.01$, $***P < 0.001$).

Table 4. Comparison of the day and night total number of species, average number of species per haul (in brackets) and sum of all species detected during both periods in each reservoir

	Day	Night	Sum of species
Římov	16 (9.63)	19 (12.25)	20
Orlik	19 (11.8)	22 (14.6)	22
Žlutice	4 (2.33)	7 (6.6)	7
Želivka	9 (6.6)	11 (8.0)	13

types of explanatory variables were used: reservoir and diel period. Two analyses were performed. The first analysis tested the effect of a given reservoir on the species composition when the diel period was used as a covariate; the second tested the effect of the diel period when reservoir was used as a covariate. All factors were coded as dummy variables. All hauls were standardised to percentage species composition before analyses. Rare species, defined as those found in < 5% of samples, were excluded because it is unlikely that they significantly influenced the dynamics of the fish community. Furthermore, multivariate statistical techniques are sensitive to rare species, which could distort meaningful, significant trends (Kwak & Peterson 2007). Biplot scaling using inter-species distance was used for the analysis. The statistical significance of the diel period to species composition was analysed using a Monte Carlo permutation model. A total of 999 permutations were performed with blocks defined by covariates (Lepš & Šmilauer 2003).

Mean body size was used to evaluate changes in the size structure of dominant fish species such as perch *Perca fluviatilis* L., roach *Rutilus rutilus* (L.), bream *Abramis brama* (L.), bleak *Alburnus alburnus* (L.) and rudd *Scardinius erythrophthalmus* (L.) between the day and night. Two-way ANOVA with two factors, reservoir and diel period, was used for comparison.

Results

A total of 19 766 individual fish from 22 species (older than age 0+) were caught in the littoral zones of the

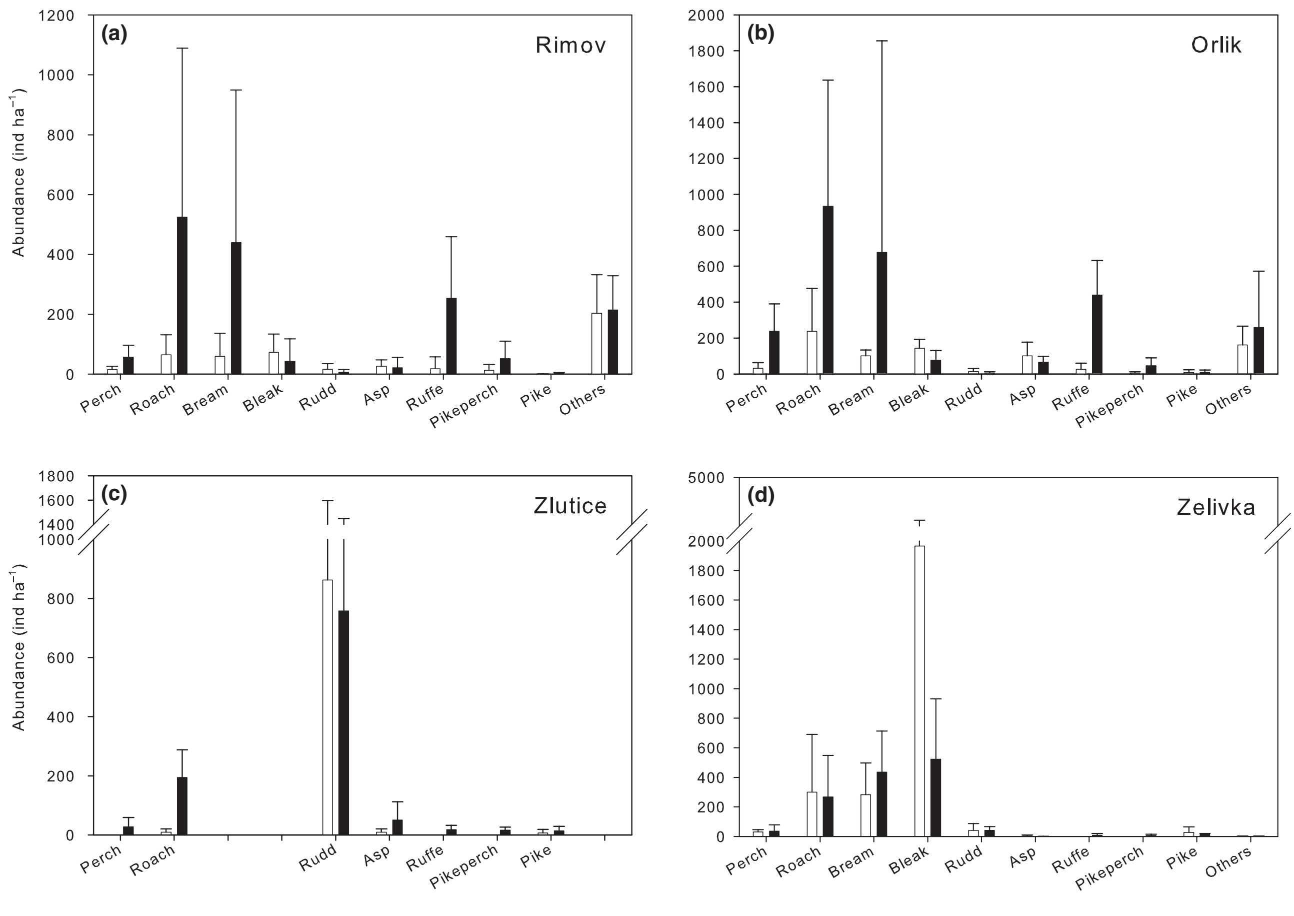

Figure 1. The comparison of day (□) and night (■) mean abundance (means are indicated by boxes, standard deviations are indicated by whiskers) of dominant species in each reservoir separately (a – Římov, b – Orlík, c – Žlutice, d – Želivka).

Table 5. Comparison of the ratio between night and day abundance of species with a significant change of abundance between day and night. The ratio was determined for each species and reservoir separately. Species detected only in the night assemblage in a given reservoir are indicated as NO (night only). The test was not performed for eel because this species was detected only at night (NT – not tested)

	Roach	Bream	Hybrid	Carp	Bleak	Perch	Ruffe	Pikeperch	Eel
Římov	8.1	7.4	5.0	1.5	0.6	3.6	14.1	4.2	NO
Orlík	3.9	6.7	10.2	10.2	0.5	7.5	17.0	7.9	NO
Žlutice	21.0	–	–	–	–	NO	NO	NO	–
Želivka	0.9	2.0	–	–	0.3	1.2	NO	NO	–
P-level	0.008	0.08	0.659	0.024	0.801	0.004	0.242	0.77	NT

studied reservoirs. Cyprinids and percids were the dominant species in all four reservoirs (Table 3).

Significantly higher abundances (A) and biomasses (B) (non-parametric ANOVA) were found at night for perch (A and B: $P < 0.001$), roach (A and B: $P < 0.001$), bream (A: $P = 0.001$, B: $P < 0.001$), ruffe, *Gymnocephalus cernua* (L.) (A and B: $P < 0.001$), pikeperch, *Sander lucioperca* (L.) (A and B: $P < 0.001$), carp, *Cyprinus carpio* L. (A: $P = 0.01$, B: $P = 0.002$), eel, *Anguilla anguilla* (L.) (A and B: $P < 0.001$) and the hybrid *A. brama* × *R. rutilus* (A and B: $P < 0.001$) in all reservoirs. Only bleak had significantly higher abundance during the day ($P = 0.005$), although the differences in biomass were not significant between day and night ($P = 0.135$). Total fish abundance (TA), biomass (TB) and the number of species across all reservoirs were significantly higher at night (TA – $P = 0.006$, TB and number of species – $P < 0.001$; Tables 3 and 4).

Significant differences in the ratio of diel abundance were found for perch, roach and carp. Perch and roach had high ratios in all reservoirs except for Želivka Reservoir, where their abundances were similar during both diel periods; thus, the ratio was close to unity (Fig. 1, Table 5). A similar pattern was found for carp that had a high ratio in Orlík Reservoir but a ratio close to unity in Římov Reservoir (Table 5).

Both reservoir and diel period influenced species composition ($P < 0.001$ for both factors). Reservoir explained 46.4% of the variability, while diel period contributed 7.4% of the variability. In the ordination diagram (Fig. 2), the horizontal axis corresponds to the day–night gradient and highlights the diel changes in abundance of the fish. Dominant species with higher abundance at night, such as ruffe, pikeperch, bream, roach and perch, grouped close to the night centroid and species with higher abundance during the day, such as bleak, or similar abundance during both periods, like dace or rudd, grouped closer to the day centroid. This predominance of different species during the night and day is highlighted in the percentage composition of samples during each period (Fig. 3).

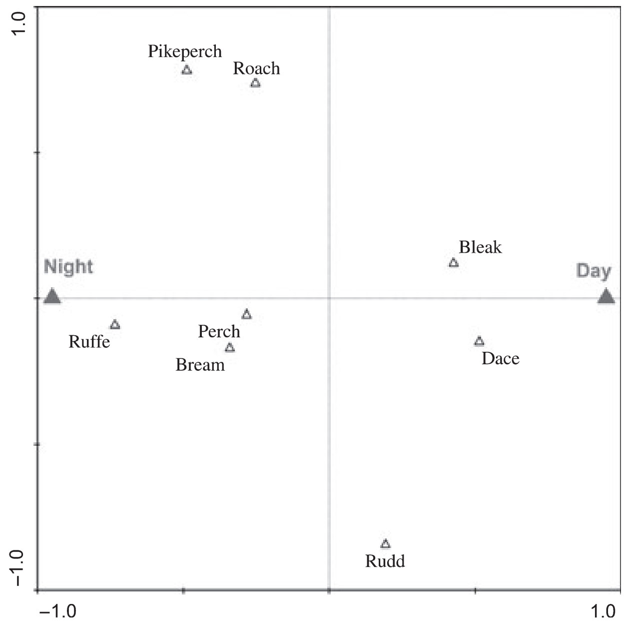

Figure 2. Biplot of the species composition response to diel period based on a canonical correspondence analysis. Species are indicated by open triangles, while day and night centroids are shown by filled triangles.

A significant change in mean body size found for roach and bleak between day and night sampling (Table 6). Roach with larger body sizes were found in the night assemblage ($P = 0.001$), while bleak with a larger body size were found in the day assemblage ($P = 0.046$).

Discussion

Distinctive diel changes in fish assemblage were found between day and night in the unstructured littoral zone of all reservoirs studied. Differences were found in the densities of certain species, species composition and number of detected species. Larger-sized roach were found in the night assemblage, while larger bleak were caught during the day. These findings are in agreement with those of Kubečka (1993) and Říha

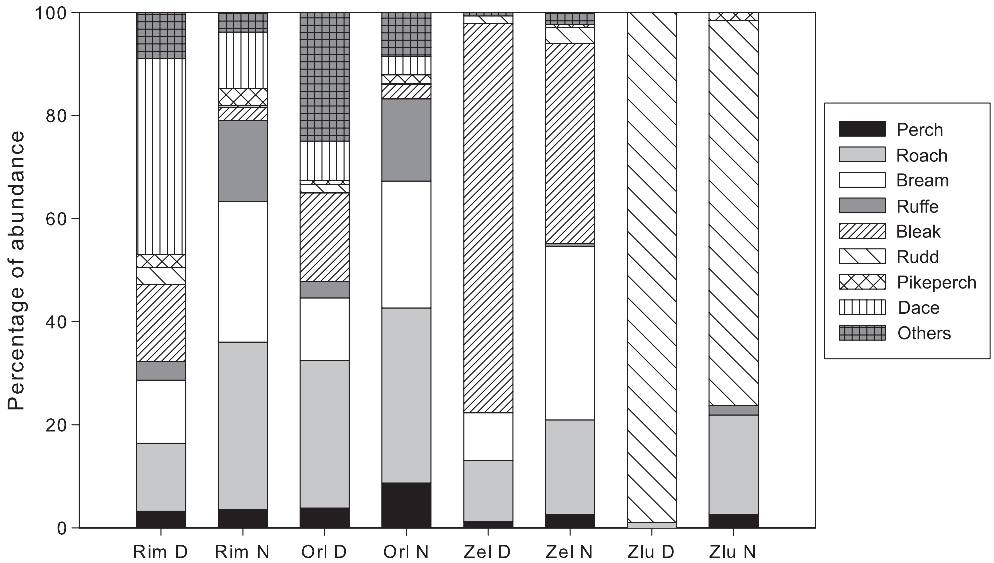

Figure 3. Change of proportion of dominant species in the assemblage between day and night in all sampled reservoirs.

Table 6. Comparison of the differences in the mean body length of dominant fish between day and night. Insufficient numbers of rudd and perch were caught in some reservoirs; thus, the difference in the mean body size was not tested (NT) in these cases

	Roach	Bream	Bleak	Rudd	Perch
Římov	103.2–128.4	192.3–139.9	86.6–117.2	NT	232.6–221.4
Orlík	102.9–121.5	116.1–154.6	105.8–102.8	NT	130.7–200.8
Žlutice	63.3–161.2	–	–	66.6–87.5	NT
Želivka	90.9–110.8	107.7–91.5	107.1–96.2	86.1–111.9	133.3–115.5
P-level	0.001	0.600	0.046	0.082	0.564

et al. (2008). Contrary to Kubečka (1993) and Říha *et al.* (2008), bleak was more abundant in the unstructured littoral zone during the day and the diel pattern of occurrence in this zone varied for roach, perch and carp among reservoirs. Moreover, the diel period influenced the fish assemblage structure obtained from beach seining.

Sub-adults and adults of a wide species spectrum were found in higher numbers in the unstructured littoral zone at night, a phenomena documented for a variety of species in European lowland (Kubečka & Duncan 1998; Wolter & Freyhof 2004; Eros *et al.* 2008) and regulated rivers (Vehanen *et al.* 2005). The migration of fish from structured habitat in the littoral zone can also influence the assemblage of the unstructured littoral zone. However, the association of adults with different littoral habitats is poorly understood in European lentic water bodies. Brosee *et al.* (2007) described the association of adults of different species between different littoral zone habitat types in Lake Pareloup (France) and found adult fish prefer open littoral habitat with no vegetation cover during the day, whilst juveniles favour structured habitat. Unfortunately, the habitats considered by Brosee *et al.* (2007) are different to those found in reservoirs, and the Pareloup study lacks the diel aspect.

Submerged terrestrial macrophytes could contribute to the observed lack of diel change in perch and roach abundance in Želivka reservoir. Macrophyte beds are used as a cover against predators by juvenile perch and roach (Jacobsen & Berg 1998; Holker *et al.* 2007). The majority of roach and perch from the day catches were sub-adults (Table 6) that likely have similar behaviour to juveniles, i.e. using littoral macrophytes as cover. However, the mean body size of roach was larger at night than during the day in Želivka, as in other reservoirs. This suggests a greater occurrence of adult roach in the littoral zone at night; a similar behavioural pattern was found in the other reservoirs. Conversely, ruffe, pikeperch, bream, the hybrid and eel exhibited a similar behavioural pattern in all reservoirs. This observation suggests that the migration pattern of the above-mentioned species to the littoral zone is more stable than for sub-adult roach and perch.

Sampling methods that detect more species and higher abundance of fish could be considered more representative (Draštík *et al.* 2009; Copp 2010). The average number of species per haul and total number of species were higher in all reservoirs in the night assemblages. Diel patterns in fish abundances differed across species; most species exhibited greater abundance at night or similar abundances during both periods – the notable exception being bleak. Day sampling appeared to underestimate the abundance and biomass of many species, while night sampling underestimated only bleak (Table 3). Thus, when sampling is performed only during the day, number of species and abundance of dominant species (bream and most likely also roach and perch) would be lower. Moreover, important species occupying this habitat exclusively or predominantly during the night (ruffe, pikeperch) would be underestimated or completely missed in the daytime assessment. Therefore, the information from night seining is considered more representative for the unstructured littoral zone than day seining, and it is recommended for sampling to provide a true representation the fish community of this habitat. However, the behaviour of bleak and inconsistencies in the diel change in abundance in some species suggest that a comprehensive assessment should include both day and night sampling. However, sampling at night requires extra cost and has safety implications. Safety concerns can be minimised through strict attention to hazards, proper equipment (lights, lifejackets) and good organisation of the sampling process (Berry 1996).

A number of methodical guidelines consider beach seining as a suitable approach for regular monitoring of the ecological status of water bodies (Bonar *et al.* 2009). It is therefore important to know how representative the results from beach seining in the unstructured littoral zone are for the littoral fish community as a whole. Unfortunately, this cannot be answered without further research on differences between unstructured and structured habitat during the day and night. A combination of seining in unstructured habitats and other sampling methods in structured habitats both during the day and night is recommended for accurate assessment of the whole fish community.

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