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Fish activity as determined by gillnet catch: A comparison of two reservoirs of different turbidity

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ABSTRACT

Fish activity was monitored analyzing the catches of gillnets exposed for short time intervals at night. Experiments were done in two Central European reservoirs with different turbidity and fish density. Cyprinids dominated in both reservoirs. The aims of the study were to describe and model a pattern of fish activity in general and on species and age group levels, and in turbid and clear water. Fish activity showed two distinct peaks around sunset and sunrise and was low during night. This pattern was the same in clear and turbid reservoirs, as well as for all species and age groups tested. This study established some justifications and standards for gillnet sampling: (i) it is possible to compare overnight gillnet catches between different lowland European species and waterbodies, as the pattern of fish activity is general; (ii) gillnets should be set 2–3 h before sunset and lifted 2–3 h after sunrise to cover activity peaks, thus getting reliable and comparable results; (iii) depicting gillnet catches per average hour of exposition produces biased and incomparable results.

1. Introduction

Fish activity plays major role in the efficiency of passive fishing gear like gillnets and varies during the diel cycle. In order to explain diel activity, fish biologists have described fish species to be diurnal, nocturnal or crepuscular according to the period of the day in which they exhibit the highest activity (Helfman, 1993). The pattern of diel activity may change with season (Prchalová et al., 2006), turbidity (Reichard et al., 2001), predation pressure (Pettersson et al., 2001), age of the fish (Järvalt et al., 2005), breeding (Helfman, 1993), food availability or intraspecific competition (Reebs, 2002).

It is crucial to be aware of the diel activity pattern for reliable interpretations of gillnet catches. It is recommended to set gillnets as long a time as possible to ensure that the activity peaks of each fish species are sampled, while also ensuring they do not degrade and are protected from predators while being caught (CEN, 2005). To fulfill this requirement, gillnets should be and traditionally are set overnight. The catch per unit of effort (CPUE) is then expressed as catch per night. In cases of shortened or prolonged soak time, the CPUE should be expressed as catch per one hour of exposition (CEN, 2005). But how do we know that we cover the activity peaks of all target species and what catch per average hour of exposition actually reveals?

In order to answer these questions, we carried out a simple experiment with gillnets exposed for short periods of time from sunset to sunrise in two reservoirs. Both reservoirs have a stable fish community dominated by cyprinids (Prchalová et al., 2009a,b). The Římov Reservoir is deep and relatively clear while the Nové Mlýny I is shallow and turbid. Our aims and assumptions were:

i. To describe and model a general pattern of fish activity. We expected lower catches during the night and higher catches at dusk and dawn, as indicated by previous studies (Olin and Malinen, 2003; Olin et al., 2004; Vašek et al., 2009). We wanted to use the created model of fish activity for the definition of effective soak times and recommendations for gillnet sampling.
ii. To describe the pattern of fish activity for species caught. We assumed that the pattern would be different for diurnal and nocturnal species. Among the common European species, roach *Rutilus rutilus* (L.) (Hautala, 2008) and perch *Perca fluviatilis* L. (Zamora and Moreno-Amich, 2002) have been described as diurnal species while pikeperch *Sander lucioperca* (L.) (Brabrand and Faafeng, 1993) and ruffe *Gymnocephalus cernuus* (L.) (Ylönen et al., 2007) as nocturnal species.
iii. To describe the pattern of fish activity for young-of-the-year (YOY) and older fish. We hypothesized that the fish activity of YOY and older fish would be uniform, as it is driven by the twilight migrations between day and night habitats (Vašek et al., 2009).

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iv. To describe the pattern of fish activity in turbid and clear water. We supposed together with others (Jacobsen et al., 2004; Andersen et al., 2008; Hazelton and Grossman, 2009) that fish would be more active under turbid conditions. Identification of prey in the turbid water is more difficult and increased activity can compensate for this situation (see Andersen et al., 2008).

2. Materials and methods

2.1. Study areas

Experiments were carried out in two reservoirs located in the Czech Republic, Central Europe. The Římov Reservoir is a deep canyon-shaped reservoir with a surface area 210 ha and maximum and average depths of 45 and 16 m, respectively. The trophic status is classified as eutrophy (Vašek et al., 2008). The fish community is represented mainly by cyprinids (family Cyprinidae), with roach *Rutilus rutilus* (L.), common bream *Abramis brama* (L.) and bleak *Alburnus alburnus* (L.) being the most abundant species. For details on reservoir characteristics and the residing fish community see Prchalová et al. (2009a). The fish biomass at the location of the experiment in the upper part of the reservoir was 201 kg ha^{-1} (horizontal hydroacoustic survey in August 2004; Draštík et al., 2008).

The Nové Mlýny I Reservoir is a shallow pond-like reservoir with a surface area of 528 ha and maximum and average depths of 4.3 and 1.8 m, respectively. The trophic status is classified as hypertrophy (Žáková et al., 2006). The fish community is represented mainly by cyprinids, with white bream *Blicca bjoerkna* (L.), roach *R. rutilus* (L.), bleak *A. alburnus* (L.) and common bream *A. brama* (L.) being the most abundant species (Prchalová et al., 2009b). The fish biomass in the location of the experiment in the upper part of the reservoir was 538 kg ha^{-1} (horizontal hydroacoustic survey in September 2008; Prchalová et al., 2009b).

2.2. Gillnetting and data analyses

Benthic, bottom mounted gillnets were used for the experiments. Gillnets were made according to the European standard EN 14 757 (CEN, 2005), i.e. with 12 mesh sizes in the range of 5–55 mm, knot to knot, each mesh size in panels 2.5 m long and 1.5 m high (Pokorny-site, Brloh, Czech Republic).

In the Římov Reservoir, the experiment was performed at a location close to the tributary (48°48′52″N and 14°28′50″ E), where the highest abundances of fish were found (Prchalová et al., 2009a; the maximum depth at the site was 9 m). Three anchored gillnets were exposed to a 1.6 m depth in the littoral zone from 19:00, 9 August 2008, to 7:00 the next day. Gillnets were cleared every hour during the exposition. It resulted in 36 individual samples. Sunset was at 20:37 and sunrise at 5:47.[1] The intensity of visible light was measured above the water surface in lx using the MDLX lux meter. The transparency measured as the Secchi depth was 100 cm (this reservoir is called clear in the text). The surface water temperature was 23 °C and the concentration of surface dissolved oxygen was 11.3 mg l^{-1}.

In the Nové Mlýny I Reservoir, the experiment was performed at a location close to the tributary, approximately 50 m from the shore (48°53′45″N and 16°32′33″E). Three gillnets were exposed to a 1.6 m depth from 16:00, 16 September 2008, to 9:30 the next day. Gillnets were replaced by new ones every half an hour during periods of high catches, i.e. from 16:30 to 20:30 in the evening and from 6:30 to 9:30 in the morning. During periods of lower catches, gillnets were anchored and cleared every hour. It resulted in 72 individual samples. Sunset was at 18:57 and sunrise at 6:35.[1] The intensity of visible light was measured as described previously. The transparency measured as the Secchi depth was 35 cm (this reservoir is herein called turbid). The surface temperature was 13 °C and the concentration of surface dissolved oxygen was 8.8 mg l^{-1}.

We did our best in order to bias the fish activity and our results by the study design in a minimal possible way. We tried to replace the survey gillnets as quickly and silently as it was possible to do not disturb fish more that it was inevitable.

All fish were identified to species. Standard lengths were measured with 5 mm accuracy in case of older fish. YOY fish were measured with 1 mm accuracy. Size ranges of YOY and age 1+ fish were defined according to a size-frequency distribution with the help of scale reading. The age groups of 1+ fish in white bream and bleak were used in analyses instead of YOY fish because of the absence of YOY of these species in catches at the Nové Mlýny I Reservoir. Small fish are highly underestimated in gillnet sampling (Prchalová et al., 2009c), thus we tested them only in cases where their numbers were high.

Catches per time intervals of the experiments are referred as 'fish activity' or 'activity' in the text.

The differences among catches in particular time intervals were tested using factorial ANOVA and Tukey HSD tests in STATISTICA (StatSoft). The nonparametric correlations were calculated using the Spearman correlation coefficients in STATISTICA (StatSoft). The models and figures were created using Mathematica software (Wolfram Research).

The catches in individual time periods were found to be independent on each other. This was proved by positive or zero correlation coefficients between following catch residuals. If the catches were dependent, the correlation would be negative—when the value was higher than the mean, i.e. the residual was positive, the value and the residual of the following catch should be negative and vice versa. However, this was not valid for our data sets. Thus, the ANOVA for independent samples was used.

3. Results

A distinct pattern of fish activity was found. In both reservoirs, the activity had evening and morning peaks with night plateau between peaks (Fig. 1). The average catches during the night plateau were similar in both reservoirs (Římov: 0.885 fish gillnet^{-1} 0.5 h^{-1}, SD 0.814; Nové Mlýny I: 0.970 fish gillnet^{-1} 0.5 h^{-1}, SD 0.749). The peak catches were around 13.2-fold (SD 8.7) and 13.8-fold (SD 6.2) higher than the average plateau catches in the Římov and Nové Mlýny I reservoirs, respectively. The heights of the evening and morning peaks were comparable in each reservoir.

The patterns of gillnet activity were similar in both reservoirs for all species and also for YOY and older fish, corresponding to the general activity pattern (Tables 1–4, Fig. 2). In the Římov Reservoir, all species and age groups tested were positively correlated with each other (Table 3). The exception was bleak, which was positively correlated only with the sum of all species. The reason was that bleak did not reach peak values during the evening peak of general fish activity and thus its activity pattern was not significant (Table 1). In the Nové Mlýny I Reservoir, all species and age groups tested were positively correlated (Table 4). The exceptions were YOY bream and age 1+ bleak, which were not positively correlated with other species. However, they were positively correlated with the sum of YOY fish and their older conspecific fish.

The activity pattern of the peaks and the night plateau was modeled separately by two independent mathematical models. The peaks were fitted using a quadratic model

$$y = a * x^2 + b * x + c \quad (1)$$

[1] Sunsets and sunrises were calculated using the spectral calculator at http://www.spectralcalc.com/solar_calculator/solar_position.php.