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Small – but not easy: Evaluation of sampling methods in floodplain lakes including whole-lake sampling

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ABSTRACT

We tested the efficiency of electrofishing and beach seining with several sampling strategies in small (<1 ha) floodplain borrow pits of the Dyje River (Danube basin). The study sites were characterized as rectangular-shaped with maximum depths of 2 m, having uniform habitat with minimal shelters and gravel bottom with organic sediment. We conducted point abundance sampling and continual electrofishing along the shoreline and also sampled in a zigzag pattern in the mid-zone from a boat. Sub-sampling and whole-lake sampling was conducted using a beach seine (40 m length, 10 mm mesh size). Each of the four sampling strategies (point sample electrofishing, continuous electrofishing, seining sub-samples, and whole-lake seining) was conducted on separate days in two sampling events in November 2005 and May 2007. A total of 22 species was registered in both sites. Electrofishing was more efficient for determining species richness in both sites compared to seining in the November sampling, but this finding was reversed in May 2007. Some species (chub, weatherfish) were recorded only by electrofishing, while other species (perch, bitterling, tench) were recorded mainly by electrofishing. Asp and blue bream were recorded only by seining. Pelagic species (bleak, bream, white bream) were highly underestimated by electrofishing in both sites and sample periods. The accurate representation of the fish community using just one sampling method and strategy is not feasible even in a small floodplain lake. Whole-lake seining through the entire borrow-pit site was more representative for pelagic species but less efficient for shelter-seeking species. Regarding the ability to capture representative samples, the behaviour of particular fish species seems to be a more significant factor than fish size.

1. Introduction

The number and abundance of fish species occurring at a particular site and time are of considerable interest to fish biologists and fisheries managers. Results are often dependent on how sufficiently species richness and composition of fish assemblages are characterized by sampling (Cao et al., 2001). Many sampling methods have been designed to achieve reliable estimates; however, each sampling method has its own shortcomings (Brosse et al., 2001). For example, many studies attempted to find the most representative sampling method for lake habitats and to evaluate the accuracy of electrofishing (e.g. Perrow et al., 1996; Fago, 1998; Cao et al., 2001; Meador, 2005; Lapointe and Corkum, 2006b), beach seining (Lyons, 1986; Fago, 1998; Pierce et al., 1990; Bayley and Herendeen, 2000; Lapointe and Corkum, 2006a), visual observation (Brosse et al., 2001; MacRae and Jackson, 2006), various traps (Jackson and Harvey, 1997; Lapointe and Corkum, 2006a; MacRae and Jackson, 2006) fyke nets (Weaver, 1993) or gill nets (Weaver, 1993; Jackson and Harvey, 1997).

Although there is a wide range of approaches to sampling and the type of data collected, there is little information to guide researchers as to whether the degree of sampling is sufficient to provide good quantitative or even qualitative estimates of fish abundance. Many studies underestimate the species composition within lakes due to insufficient effort and restricted use of sampling gears (Jackson and Harvey, 1997). Most studies conclude that no single method describes the full species richness, nor do single methods adequately describe the fish assemblage composition. These problems with estimating fish community structure are not restricted to large lakes; unbiased estimates of fish community structure are problematic even in small standing water bodies (Basler and Schramm, 2006) and in small streams and rivers (Hankin and Reeves, 1988).

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Beach seining is a common method for assessing abundance and species composition of fish in the littoral zone (Murphy and Willis, 1996). Despite many advantages of the method, physical obstructions such as rocks, macrophytes, stumps and tree branches are a major source of bias limiting the effectiveness of seining (Pierce et al., 1990).

Electrofishing is generally unsuccessful in open water areas, probably due to fish avoidance behaviour, irrespective of fish abundance. In shallow water and/or vegetated areas, electrofishing is possible and may be very efficient, depending on fish species and habitat (Bohlin et al., 1989). Electrofishing is used mainly in the littoral zone of lakes (Brind'Amour and Boisclair, 2004; Diekmann et al., 2005) or in small ponds (Perrow et al., 1996; Copp et al., 2005).

It is difficult to sample fish in a representative manner even when study sites are rather small (<1 ha) and characterized by homogenous habitat without abundant refuge habitat. According to our previous studies of young-of-the-year fishes, we found that two commonly used methods—electrofishing (Bartošová and Jurajda, 2001) and fry beach seining (Jurajda et al., 2004), were not fully comparable even in small floodplain borrow pits.

The objectives of this study were to compare species richness, qualitative community structure (i.e. assemblage composition) and size structure of fish assemblages obtained by two sampling methods and four strategies. Whole-lake sampling should provide our most accurate picture of the total fish species richness and "real" assemblage structure. The overall aim of the study was to evaluate several sampling techniques in small, man-made ponds as contrasted with a comprehensive sampling strategy of whole-lake sampling, so that efficient and representative techniques can be used in further monitoring programmes.

2. Study area

The borrow pits in this study (sensu Cowx and Welcomme, 1998) were situated in the River Dyje floodplain (Danube basin, Czech Republic). The borrow pits were created during the 1980s when the flood protection dikes were built from the excavated material. We used the opportunity of the presence of three adjacent borrow pits, allowing the use of the middle pond as a site for fish translocations when large numbers of fish needed to be stored. The distance between sites was less than 60 m. The two outer sites were surveyed; the smaller one (0.2 ha) locally named Čapí dolní and the bigger one (0.8 ha) named Čapí horní.

Both sites were of rectangular shape, having steep banks and sandy-gravel bottoms covered with a thin layer of organic mud, providing limited shelter for fish. There were only four tree stumps near the bank of one site (Čapí dolní) and several stumps present in one corner of the other site (Čapí horní) that created potential shelters for fish and prevented efficient seining in these particular locations. In both sites, live unionid mussels (necessary for ostracophilic species) and empty shells (utilizable by speleophilic species) were present.

Water level fluctuation corresponded with the discharge in the adjacent Dyje River, due to permeable gravel subsoil. The study was conducted during two seasons: November 2005 and May 2007 with different water levels (maximum depth was 1.5 m and 2.0 m, respectively). In 2006, the study sites were flooded for several months, preventing sampling but allowing fish to migrate between sites and also between the main channel and the sites, which essentially reset the system in terms of fish distribution and allowed us to resample the study sites for an additional season.

3. Material and methods

3.1. Data collection

Two traditional sampling methods (electrofishing, beach seining) and four strategies [point abundance sampling by electrofishing (PAS), continual sampling by electrofishing (CS), subsampling by beach seining (SS), and whole-lake sampling by beach seining (WL)] were used to sample fish in the borrow pits in two sampling events in November 2005 and May 2007. Each of the four strategies (PAS, CS, SS and WLS) was conducted on a separate day. Though it was not expected that fish would be influenced by previous sampling, strategies were conducted in a given order, from least to most intensive (i.e. PAS, CS, SS, and WLS). All sampling was conducted during daylight hours.

Many other sampling approaches were not suitable for these study sites. Low visibility (30 cm Secchi) prohibited the use of visual census (MacRae and Jackson, 2006), while gill nets are known to cause high mortality in fish (Hubert, 1996). Acoustic surveys would be impractical in such small shallow sites and various traps are too selective for individual fish species and size classes, and too time-intensive and/or expensive (Jackson and Harvey, 1997).

According to previous studies (Halačka et al., 1998; Jurajda et al., 2004), we expected a total species richness between 18 and 25 species, with fish sizes ranging from 4 to 100 cm. Electrofishing and beach seining are commonly used in similar habitats and are efficient for the type of fish community we expected to encounter, and thus were compared in this study. For the most comprehensive sampling approach we were not able (nor did we desire) to use destructive methods such as rotenone or explosives (Halyk and Balon, 1983; Lappalainen and Urho, 2006). In the present study, our approach of whole-lake sampling by beach seine was chosen as the method arriving at the most comprehensive picture of fish community structure relative to the other, less-comprehensive methods.

In the case of electrofishing, we compared point abundance sampling strategy (PAS) and continual sampling strategy (CS) along the shoreline and in a zigzag pattern in mid-zone sites from a small boat. Electrofishing gear ML3 (fa. Bednář, Czech Republic; pulsed DC, 2 kW, 230 V, 1.5–2 A, 80 Hz) was used for both sampling strategies. The anode was composed of a stainless steel ring of 30 cm diameter with a switch located in the 2.5 m long safety handle.

During PAS, the boat was paddled along the bank and zigzagged through the middle zone of the entire sampling site. At each sampling point, the activated anode was rapidly immersed. Each sample point was located approximately 5 m apart to achieve sample independence (corresponding to approximately 50 points at Čapí dolní and 80 points at Čapí horní). For a detailed description of PAS, see Persat and Copp (1990). The active range of the anode was estimated as a circle with a radius of 60 cm, twice as large as the anode radius. The area electrofished using PAS was estimated as the sum of areas of points (i.e. active ranges).

The continual sampling with electrofishing strategy (CS) was conducted using the same equipment as PAS, but the activated anode was positioned continuously around the bank and zigzagged through the middle zone of the site. All fishes were identified, measured (standard length-SL) and released back to the borrow pit. A three-person team was able to carry out both electrofishing strategies. The area electrofished using CS was estimated as a rectangle having the width of the active range diameter (i.e. 60 cm) on one side and the length covered by boat on the other.

Beach seining was used in two of the sampling strategies, sub-sampling (SS) and whole-lake sampling (WLS). We used a 40 m length, 4 m maximum height knotless nylon beach seine with 10 mm mesh and a continuous lead-cored bottom line with polystyrene floats along the top line.