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Estimating sampling bias when using electrofishing to catch stone loach

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Point abundance sampling, using electrofishing, for stone loach *Barbatula barbatula* in two habitats, riffle and pool, showed that there was no difference in density between the two habitats. The density of fish increased significantly (1·8 fold; $P < 0{\cdot}001$) when the substratum of small cobbles (128–256 mm) was removed and electrofishing repeated.

Key words: *Barbatula barbatula*; benthic fish; electrofishing; sampling bias; stone loach.

The efficiency of electrofishing can be influenced by fish behaviour. Cowx & Lamarque (1990) noted that differences in the catchability of species are observed when comparing benthic and nectonic species. Some benthic fishes can be difficult to capture with electrofishing, particularly those species that sink to the substratum when stunned. Furthermore, benthic fishes often colonize different habitats within a sampling site (Zweimüller, 1995), so their catchability may differ from one habitat type to another. Thus factors such as substratum composition, water depth or velocity may be important determinants influencing capture.

Stone loach *Barbatula barbatula* (L.) is a small benthic fish species belonging to the Balitoridae. It is widespread throughout much of Europe, from the Pyrenees to Russia. It appears to be absent from northern and southern areas, including much of Scotland and northern Scandinavia, central and southern Spain, and Italy (Keith & Allardi, 2001). The stone loach is inactive during the day, sheltering within the substratum, and emerging to feed at dusk, with activity peaking a few hours after sunset (Burdeyron & Buisson, 1982; Fischer, 2000*a*, *b*).

Since the stone loach is benthic and nocturnal, it is probable that many individuals are missed when electrofishing is used to sample them. The aim of this study was to develop a method for estimating sampling bias when using this technique.

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The study was conducted in the River Garonne (43°05′ N; 0°33′ E; south-west France). Previous work by Reyjol *et al.* (2001) indicated that an abundant population of stone loach existed in the river.

Two habitat types were defined within the sampling site, one riffle and one pool. The substratum composition of both habitats was strongly dominated by small cobbles (range of the smallest particle diameter from 128 to 256 mm; Cummins, 1962). In the riffle, water depth ranged from 10 to 30 cm and water velocity from 60 to 100 cm s^{-1}. In the pool, water depth ranged from 10 to 40 cm and water velocity from 10 to 20 cm s^{-1}.

Fishing operations took place in July 2003, during the day. The point abundance method developed by Nelva *et al.* (1979) was used. The method involves plunging the anode into the river, holding it stationary and collecting every fish observed. In the present study, a ballasted plastic hoop was placed in the river in order to visually delimit the sampling point. To ensure that samples were taken randomly, the person carrying the hoop walked in the river from downstream to upstream and from one bank to another, and placed the hoop when told to stop by a second person. Immediately, the anode (10 cm diameter) of the power source (DEKA® 7000, EFKO, Leutkirch, Germany) was placed in the centre of the plastic hoop and the fish within each sampling point captured. Once all fish were captured, the substratum was carefully removed from the surface defined by the hoop and new fish present under the substratum captured. Because stone loach sometimes quickly recover from electrofishing, short plunges with the anode were made during the removal of the substratum to ensure that the fish did not escape.

Enclosures were not used to delimit the sampling points and limit escape because the coarse substratum did not allow them to be correctly installed in the river bed. Instead, the voltage and amperage used were adjusted after preliminary sampling, so that the stone loach were shocked immediately after immersion of the anode in the water (320 V, 2·5 A). The radius of the plastic hoop corresponded to the maximum distance the stone loach was shocked in each habitat *c.* 40 cm (Y. Reyjol, pers. obs.).

To determine the sampling bias associated with stone loach, the total density of fish captured at each point after substratum removal was compared to the density captured without removal (expressed as the number of individuals per m^2).

The density observed before and after substratum removal for each sample was compared using a *t*-test for paired samples (Scherrer, 1984). A *t*-test for separate groups was performed to compare the mean density observed in the riffle and the pool.

During this study, 54 samples were made in the riffle, 60 in the pool. Densities of 2·8 and 2·3 individuals per m^2 were caught before substratum removal in the riffle and the pool, respectively. Following removal, a density of 4·4 individuals per m^2 was found in both habitats. The densities after removal were significantly higher than the densities before removal for each habitat (*t*-test, riffle: d.f. = 53, $P < 0·001$; pool: d.f. = 59, $P < 0·001$). Overall at the sampling site, the density calculated without removing the substratum was 2·4 individuals per m^2, and after removal was 4·4 individuals per m^2 (density increased by 1·8; *t*-test, d.f. = 113, $P < 0·001$). These results are similar to those observed for sculpin *Cottus gobio* L., another benthic fish species, using the same methodology but with an enclosure instead of a hoop (*c*. 40% of fish were missed; D. Pont, unpubl. data). In the present study, no statistical difference was found for the total density observed in the riffle and the pool. There may have been fewer stone loach in the riffle but the higher flow in this habitat may have enabled a greater capture rate relative to the pool habitat. The substratum composition of both habitats, predominantly composed of small cobbles, was large enough to allow stone loach to fall between the intestices after being stunned. Therefore, the ratio between catches before and after removal of the substratum obtained in the present study is probably valid for small cobbles only, and would have probably been different for a smaller particle diameter.

When attempting to estimate the bias associated with sampling of stone loach at a given site, it is important that habitat types with homogenous environmental conditions are defined. Then the voltage and amperage of the fishing apparatus should be adjusted so that the fish will be shocked immediately after immersion of the anode in water to limit escape movements. The evaluation of the maximum distance within which stone loach is shocked then serves to determine the radius of the plastic hoop. The number of anode plunges needs to be proportional to the area of each habitat type. This procedure can be used to estimate the sampling bias associated with stone loach when electrofishing in streams with many sampling sites, and to correct for the densities observed.

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