BRIEF COMMUNICATIONS

Diel migration and site fidelity in a stream-dwelling cyprinid, *Leuciscus leuciscus*

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During May and June 1995, radio-telemetry was used to record diel movements between different, clearly defined daytime and night-time habitats in dace *Leuciscus leuciscus*. The frequent and often rapid return of individuals to previously occupied locations at dawn and dusk suggests differential habitat suitability according to light intensity, and appears similar in some respects to roosting behaviour in birds.

Key words: daily migration; dace; radio-tracking; telemetry; stream fish habitat; homing; roosting.

Although there have been many studies of group dynamics of fish shoals, it is only relatively recently that technological innovations such as radio- and acoustic-tracking have permitted detailed observations to be made of fish activity patterns in natural surroundings. Movements and migrations can now be tracked over periods ranging from minutes to months, including periods of low light intensity, at night or in turbid water conditions. Daily migrations in marine- and lake-dwelling species are well documented (Helfman, 1993); however, there is little information in the literature concerning diel migrations of stream-dwelling species.

The present study describes in the dace *Leuciscus leuciscus* (L.), a small, shoaling, riverine cyprinid, a behaviour pattern which involves daily migrations between discrete day and night habitats. In the past, it has been observed that various river fish species may be strictly nocturnal or diurnal feeders (Reebs et al., 1995) and indeed may spend periods of relative quiescence in certain favoured localities (Young, 1995). Diel movements to and from feeding positions have been observed in adult stream-dwelling salmonids (Clapp et al., 1990), and in juveniles of smelt *Osmerus eperlanus* (L.), perch *Perca fluviatilis* L., and roach *Rutilus rutilus* L., in Polish lakes (Gliwicz & Jachner, 1992). However, the present study is believed to be the first recorded instance of regular, daily, homing by shoaling adult cyprinids.

Radio-tracking studies were carried out on a southern chalk stream, the River Frome, and the East Stoke Millstream, a side channel taking c. 30% of the discharge of the River Frome. The work was conducted during May and June 1995. The main river study area had an average width of 10 m and had a sinuous course. Depths ranged from 3 m in the deepest pools to only a few cm in the shallowest riffles. The substratum was mainly sand and gravel, with a rich flora of instream, submerged macrophytes, mainly *Ranunculus penicillatus* and *Potamogeton* spp.

Study fish were caught, using rod and line, from the East Stoke Millstream, and were retained in a through-flow channel fed by the Millstream until the following day. Radio tags were sutured onto the dorsal musculature of three fish (22.2, 23.7 and 24.8 cm fork length) on 20 May 1995.
lengths), approximately one-quarter of the fish’s total body depth below the dorsal fin, using the technique detailed in Beaumont et al. (1996). Tagged fish were allowed to recover, along with several untagged fish, in a cage in the Millstream for 24 h. The fish were released lowering a hinged door on the cage remotely and allowing the fish to swim out with a minimum of disturbance. The first fish was tracked 3–14 May 1995, the second 3–19 May 1995 and the third between 25 May and 18 June 1995, totalling 51 days of observations. Movements of radio-tagged fish were monitored regularly using both mobile and fixed position listening stations.

An incident light meter, positioned 300 m upstream of the release point, was used to determine the times of dawn and dusk. Dawn was defined as when the incident light level rose above 0 units, and corresponded to 26 min before sunrise. Dusk was deemed to have ended when incident light levels fell to 0 units, and corresponded to 25 min after sunset.

During daylight, the three fish occupied the same short section of the East Stoke Millstream on 42 days. This area was 6 m wide and had a maximum depth of 0.6 m. The substratum was mainly sand with very little instream cover. Normal flow velocity in this area was 0·2–0·3 m s$^{-1}$. For a detailed description of daytime habitat use by dace in the Millstream see Garner & Clough (1996). Water clarity was usually excellent, and visual observation in this area showed that the tagged fish were associated with shoals of dace, often in excess of 50 individuals, of mixed sizes. Neither tagged fish nor their shoalmates appeared to be foraging actively, although occasionally items in the drift were investigated.

Regularly, at or shortly before dusk, the three fish moved upstream and occupied one of two positions in the main river. The first area was a pool of maximum depth of 1·3 m, 345 m upstream of the site used during the day. This site was used on 29 nights. Flow velocity in the pool was 0·3 m s$^{-1}$ and the substratum was composed of sand and gravel. Instream macrophytes covered c. 20% of the area. The second position was used by only one fish, on seven nights, 680 m upstream of the Millstream site. Flow velocities in this area ranged from <0·1 to >1·0 m s$^{-1}$ with substratum composition varying from silt in the slack through to cobbles in the main flow. Depths ranged from 0·4–1·2 m. Both of these nocturnally used sites were situated immediately downstream of extensive areas of riffle.

At dawn, the fish left their nocturnal site on 38 occasions, returning to the position they had occupied during the previous days on 29 occasions. This return journey usually required the fish to find and select the mouth of the Millstream, and was often rapid.
with the fish covering 260 m in <5 min. Visual observations showed that tagged dace were able to home to the same small area of river as used the previous day, and suggested that they occupied the same position within the shoal relative to other recognisable individuals. In total, complete diel migrations (Fig. 1) were observed on 34 days.

Presumably, the potential benefits of such a daily migration outweigh the costs. Possible factors influencing differential habitat use of this type include differences in predation pressure, temperature, oxygen and food availability between sites. It appears that neither site, on its own, meets all the requirements of the dace during a complete 24-h cycle. The key to advancing our understanding of this behaviour pattern lies in discovering which factor or factors make one site more suitable than another at a particular time of day. Helfman (1993) states that ‘many fishes appear to separate the day into an active, food gathering phase and a relatively inactive, resting phase that is intimately linked with predator avoidance.’ Some birds, too, are known to separate their day in this way, with the inactive, resting phase being referred to as roosting. Eiserer (1984) suggests that communal roosting may serve anti-predator functions, and diel migrations between feeding and roost sites have been demonstrated (Stouffer & Caccamise, 1991). If the daily migrations of dace detailed in this paper are found to be between feeding and safe resting sites, then there are clear similarities between the two behaviour patterns.

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References