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# Diel shifts in community composition and feeding of juvenile fishes in the pelagic area of a large shallow lake

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## Abstract

Diel cycles of changing ambient illumination have been shown to have strong influence on fish community composition in freshwater systems, mainly due to diel habitat shifts of fish between sheltered and more exposed, but profitable sites. Low information is available, however, from diel patterns of fish community composition and feeding in the central areas of large shallow lakes where lake depth and diameter may hamper diel migrations. We studied whether there are diel differences in species abundance and shifts in feeding modes of the juvenile pelagic fish species over an 8 months sampling period in a shallow lake. The strong decline of perch numbers towards the night suggests low nocturnal activity for this species. In contrast, the nearly constant numbers of roach over the full diel cycle points to pronounced activity under changing light intensities. Increased ruffe numbers at night reflect the good adaptation of this species to feed efficiently at low light intensities. Niche segregation of fish species along the diet axis was low. There was low evidence that diel shifts in the fish community composition were attributed to diel horizontal migrations of species into or out of the pelagic zone. Because availability of preferred zooplanktonic prey was high, differential diel activity patterns of species reflect their genetically fixed, albeit varying adaptations to feed under low-light conditions, instead of being an active avoidance to reduce competition.


***Keywords:*** Species replacement; Perch; Roach; Ruffe; Planktivory; Benthivory

## Introduction

Diel cycles of changing ambient illumination have been shown to influence species-specific feeding activities and fish community composition in several aquatic ecosystems. A clear replacement pattern between diurnally active species and their nocturnal counterparts in almost all functional groups was described in particular from tropical and temperate coral reefs (Ebeling & Bray, 1976; Hobson & Chess, 1978; Bohl, 1980; Helfman, 1993).

The diel pattern is less pronounced in temperate freshwater systems. The distinction between either diurnal or nocturnal activity is less clearly expressed for many freshwater fish, and thus there are no complete replacement sets of species which cover all trophic guilds from herbivores to piscivores (Helfman, 1981, 1993). However, distinct differences in fish community

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composition and abundance has been found in freshwater lakes and rivers as a consequence of diel migrations of fish between safe resting sites and more profitable, but often also more risky feeding sites (Werner, Gilliam, Hall, & Mittelbach, 1983; Gliwicz & Jachner, 1992). Since individual predation risk declines with increasing fish size, diel horizontal migrations have often been described for juvenile fish. As an example, young cyprinids and percids migrate between the main channel during dark periods and the shallow lentic habitats in rivers or adjacent floodplain lakes during daytime (Garner, Clough, Griffiths, Deans, & Ibbotson, 1998; Baras & Nindaba, 1999; Borcherding, Bauerfeld, Hintzen, & Neumann, 2002).

Similarly, young fish perform diel horizontal migrations between littoral areas covered with complex structures and the adjacent open water habitats in shallow, non-turbid lakes (Jacobsen & Berg, 1998; Okun & Mehner, 2005). Diel vertical migrations of coregonids were found in deep lakes where the fish stay mainly in deep, cold layers during the day and ascend into warmer layers with higher zooplankton densities during the night (Rudstam & Magnuson, 1985; Hamrin 1986). All these studies have in common that the diel habitat shifts of fish were explained by a trade-off between an increased use of sheltered sites at daylight to reduce feeding risk from day-active predators, and the opportunity to feed in the more exposed but also more profitable habitats during twilight periods and at night (compare Gliwicz & Jachner, 1992; Hölker, Haertel, Steiner, & Mehner, 2002).

No information is available, however, from diel patterns of fish community composition and feeding in the central areas of shallow temperate lakes. Whereas the majority of the bottom of shallow lakes can be covered by submerse macrophytes thus allowing for short-range diel horizontal migrations of fish between inside and outside the macrophyte beds (Jacobsen & Berg, 1998), higher plants cannot settle and grow under the low-light conditions at the bottom in the deepest region of those lakes. Thus, the pelagic area of shallow lakes does not offer structured hiding places and is rather homogeneous for young fish with respect to food availability and predation risk. The low lake depth may not allow for effective vertical migrations into deep and dark water layers. In addition, if the lake has a large surface area and diameter, even diel horizontal migrations between littoral and pelagic areas may be hampered.

Therefore, we studied whether there are at all diel differences in the juvenile fish community in the pelagic area of a large shallow lake. We focused on changes in species abundance and shifts in feeding modes of the dominant species along the day–night cycle over an 8 months sampling period. The patterns found are discussed with respect to species-specific adaptations of feeding to changing illumination strength, and to the resulting patterns of niche segregation between potentially competing fish species.

## Study site

Lake Müggelsee is a shallow eutrophic, polymictic lake in Berlin, Germany. Surface area is 7.3 $km^2$, mean water depth is 4.9 m (Fig. 1). Despite a decline of nutrient loads since 1990, the lake is still eutrophic (Köhler, Behrendt, & Hoeg, 2000). Up to the 1960s, extensive zones of the lake bottom were covered with submerged vegetation, but as a result of an increased turbidity, they disappeared almost completely. From the 1990s on, macrophytes were observed again, but with currently less than 2% coverage of lake area (Körner,

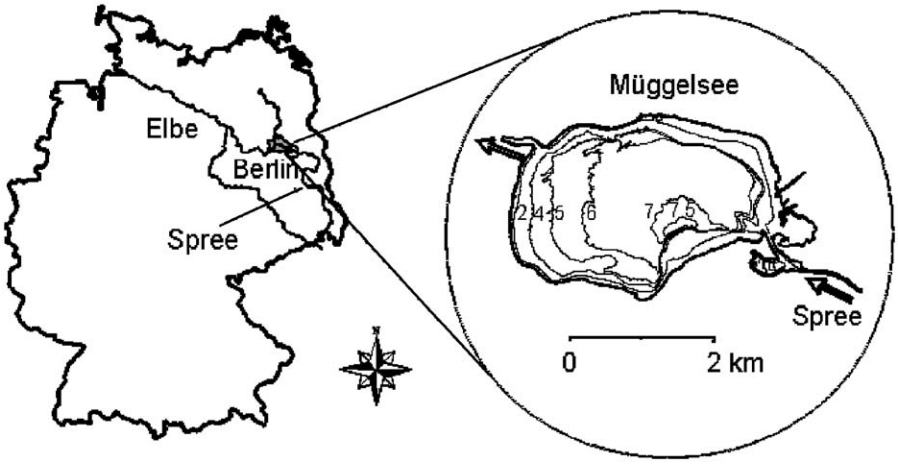


**Fig. 1.** Lake Müggelsee and its location in Germany.