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Diel migration and spatial distribution of fish in a small stratified lake

Ain Järvalt*, Teet Krause & Anu Palm
Institute of Zoology and Botany, Estonian Agricultural University, Võrtsjärv Limnological Station, 61101, Rannu, Tartu County, Estonia
*(*Author for correspondence: E-mail: ajarvalt@zbi.ee)*

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Abstract

The diel migration and spatial distribution of fish were explored using six sequential 4-h sample gillnettings in the pelagic and littoral zones of Lake Verevi (Estonia, 12.6 ha, max. depth 11 m, hard-water, deoxygenated hypolimnion) in August 2001 and July 2002. Considering abundance, two-thirds of the total fish moved to the littoral zone. The biomass of fish was distributed evenly between the littoral and pelagic zones, where the topmost epilimnion accounted for 80–85% leaving 10–15% for the lower epilimnion in the pelagic zone. Just above the thermocline only some large specimens of perch *Perca fluviatilis* (L.) and roach *Rutilus rutilus* (L.) (1–5%) during the daytime were captured. No fish movements were recorded under the thermocline. Rudd *Scardinius erythrophtalmus* (L.) inhabited only the littoral zone; all the other species were captured in both zones. Juvenile perch stayed in the littoral zone, whereas juvenile roach was caught in both zones and was active over a 24-h period. Piscivores, perch and pike *Esox lucius* L., were inactive in the dark. Perch inhabited mostly the littoral zone and the duration of its activity increased with age. In summer-stratified Lake Verevi, sharp change in the values of oxygen in the metalimnion along with species interaction affected the spatial distribution of fish, while diel migration was light-dependent.

Introduction

In lakes, the biota is mostly determined by water quality and lake morphometry, while fish composition and biomass are related to the content of dissolved solids *per* mean depth of the water column (Ryder et al., 1974; Moss, 1998). The catchability of passive fishing gears is directly related to moving activity of fish. The activity of fish depends on season, light conditions and temperature, besides mutual interaction of fish species (Davenport & Sayer, 1993; Rowe, 1994; Jurvelius & Sammalkorpi, 1995; Persson et al., 1996; Ekloev, 1997; Horppila, 1998; Dörner et al., 1999; 2001; Jepsen et al., 1999; Hölkner & Breckling, 2002). Vegetated sites had higher densities of fish, specially smaller fish and greater species richness than unvegetated sites (Randall et al., 1996; Jacobsen et al., 2002a). Inter-annual variation in fish community structure, in biomass–size distributions of benthic lake fish communities, in mutual interaction of species and in activity are well-known (Holmgren, 1999; Holmgren & Appelberg, 2000; Olin et al., 2002). The dominant fish species in Lake Verevi as in most eutrophic small Estonian lakes were roach and perch (Mäemets, 1977; Pihu 1993). Our goal was to study the diel migration and spatial distribution of fish in this small hard-water lake at the time of sharp summer stratification.

Material and methods

Verevi (South Estonia) is a small (12.6 ha), slightly exorheic, sheltered, and hence a stratified lake with

a steep thermocline, and a small drainage basin of 1.1 km^2. The maximum depth is 11 m, and the average depth 3.6 m. At the time of the study, the Secchi disc transparency of water in Lake Verevi was 3 m, bottom was covered with submerged plants to a depth of 3.5 m, and values of pH ranged from 8.2 in the upper epilimnion to 7.5 at 4 m, and to 7.0 at 5 m.

According to the literature data, 12 fish species inhabited L. Verevi (Eesti järved, 1968; Mäemets, 1977). Roach and perch are still the most abundant in the lake, while pike, rudd, tench *Tinca tinca* (L.) and crusian carp *Carassius carassius* (L.) are of second-rate abundant. The common benthophagous species, bream *Abramis brama* (L.) and ruffe *Gymnocephalus cernuus* (L.) of L. Verevi between 1950 and 1980, have obviously disappeared by now.

The fish composition was explored on 2–3 August in 2001, and on 8–9 July in 2002. We used Danish type of multi-mesh nylon monofilament gillnets (of 14 randomly placed 3 × 1.5-m mesh panels). The gillnets were arranged to catch at depths of 0–1.5 , 2.5–4 , 4.5–6 , and 6.5–8 m in the pelagic zone. In every depth one gillnet was used. Two gillnets were placed at a depth of 1–2.5 m in the littoral zone. This zone was characterised by the *Typha–Phragmítes–Chara–Potamogeton–Nuphar* complex. All captured fish were sorted by mesh size and species, and measured by total length (TL, to the nearest 1 mm), and total weight (TW, to the nearest 0.1 g); sex and consumed prey (fish) were identified. The age of perch by *operculum* and of roach by scales was determined.

Since noon, the gillnets were checked in sequential 4 h over a 24-h period (altogether six times). In both years, the days of experiment were sunny. The specific feature of weather in the morning of the experiment day in 2001 was a weak thunderstorm. In both years, the mornings were foggy and direct sunlight irradiated the water column for 14 h in 2001 (the morning was foggy from 4 to 8 a.m.), and only for 11.5 h in 2002 (clouds dispersed at 10 a.m.) out of possible 16–17 h characteristic of the season. The water temperature of the topmost epilimnion was 22.4 °C in August 2001 and somewhat lower (21.6 °C) in July 2002. The temperature and oxygen gradients over the water column in the pelagial at gillnetted depths are presented in Figure 1.

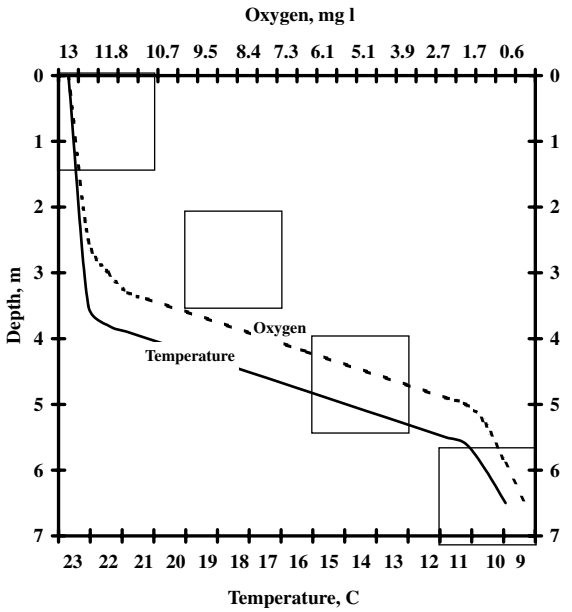

Figure 1. Temperature and oxygen gradients over a water column at the gillnetted (transparent squares) station.

Results

In August 2001, the total landing of 24-h gillnetting (13.8 kg) at two stations (littoral and pelagic) comprised 376 fish from five species: roach, perch, tench, rudd, and pike. The biggest captured fish were a 1188 g tench and a 1090 g pike (accounting 18% for total catch). In July 2002, 301 fish (9.9 kg) were captured at the same stations. In comparison with the catches of the previous year, rudd and juvenile tench were absent, and a juvenile pike and a 1407 g tench were captured.

Spatial segregation

Rudd inhabited only the littoral zone; all the other species were captured in both zones. Roach and perch outweighed the other species accounting for 80% of the total catch. The lengths of the captured perch and roach were distributed evenly in both years (Fig. 2), as did the catches between the net panels of different mesh size (Fig. 3). In the littoral zone, juvenile roach and perch were caught as shoals; rudd and juvenile pike were captured in places with opulent water-plants, while tench inhabited shallow