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VERTICAL MIGRATION OF CRUSTACEAN PLANKTON IN PIBURGER SEE (TYROL, AUSTRIA) (M.R. USTAOĞLU)

Zusammenfassung: Vertikalwanderung der Crustaceen im Piburger See (Tirol, Österreich)

Anhand von 8 Vertikalprofilen, die in 3-stündigen Intervallen über der tiefsten Stelle des Sees entnommen wurden, wurde die Vertikalwanderung der Crustaceen beobachtet. Zugleich sind Temperatur und Sauerstoffgehalt untersucht worden.
Die im Epilimnion auftretende und das Zooplanktonbild bestimmende *Ceriodaphnia quadrangula* wies dabei eine maximale Amplitude von 3,5 m auf, während die unterhalb der Thermokline lebende *Daphnia longispina* kaum Wanderungstendenzen aufwies. Diese Wanderungsbeobachtung wurde in Hinsicht auf eine optimale Aberntung von Zooplankton zur Fischfütterung mit Hilfe des Olszewski-Rohres durchgeführt.

Introduction

Most crustaceans, some rotifers and a few other freshwater zooplankters perform considerable vertical movements in the course of a twentyfour hour period. Diel vertical migration by limnetic zooplankters has been extensively investigated (HUTCHINSON, 1967; WETZEL, 1975). The typical migratory pattern of zooplankton is to move upwards at night (nocturnal migration) or at dawn and sunset (twilight migration). Rare cases in which the animals behave like autotrophic plankton (reverse migration) have been recorded (HUTCHINSON, 1967).

haft

nten der
schaft

Schilfbereich (auch innerhalb anderer Bestände)

Carex elata-Horste

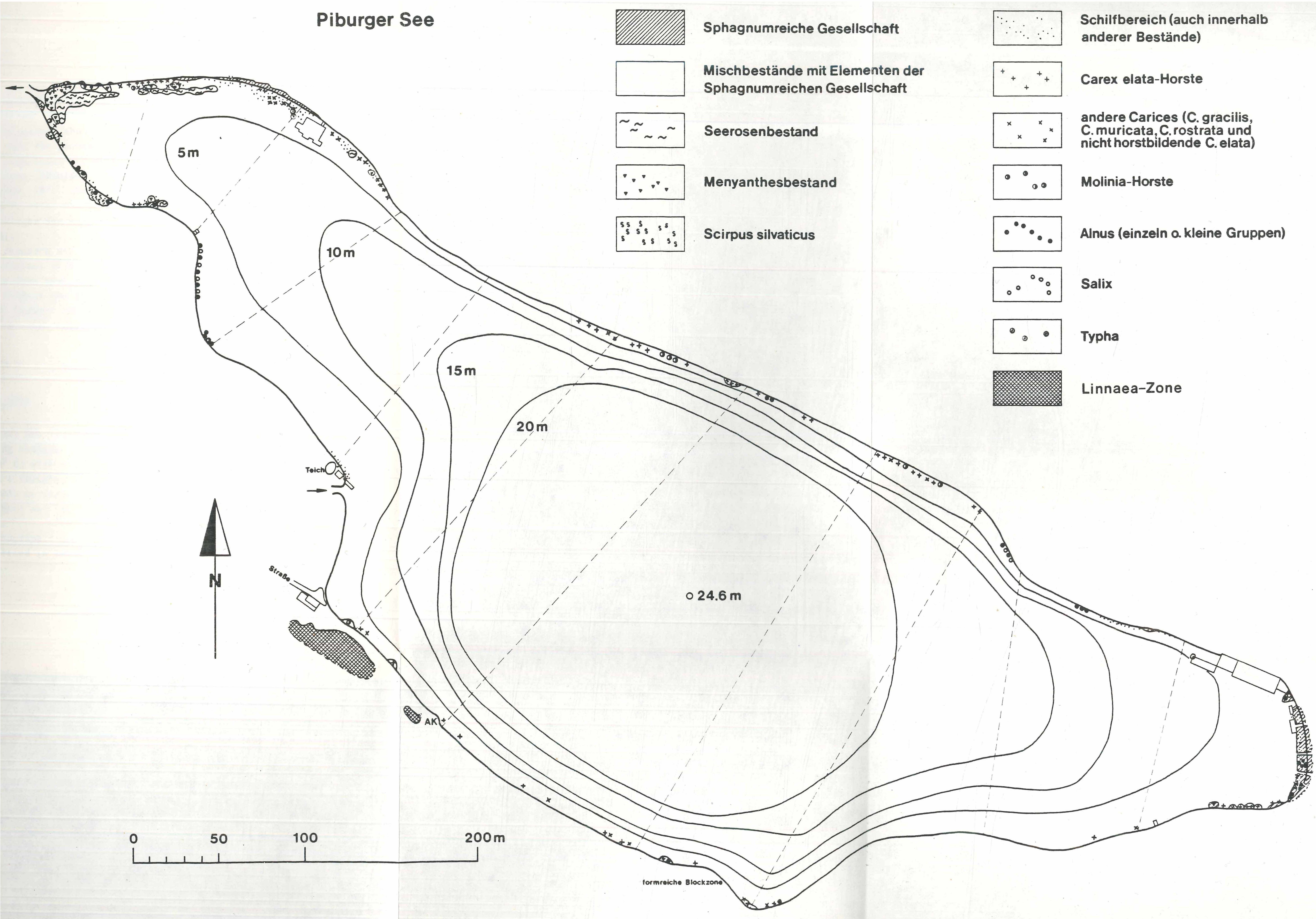
andere Carices (C. gracilis, C. muricata, C. rostrata und nicht horstbildende C. elata)

Molinia-Horste

Alnus (einzeln o. kleine Gruppen)

Salix

Typha



Piburger See
Sphagnumreiche Gesellschaft
Mischbestände mit Elementen der Sphagnumreichen Gesellschaft
Seerosenbestand
Menyanthesbestand
Scirpus silvaticus
Schilfbereich (auch innerhalb anderer Bestände)
Carex elata-Horste
andere Carices (C. gracilis, C. muricata, C. rostrata und nicht horstbildende C. elata)
Molinia-Horste
Alnus (einzeln o. kleine Gruppen)
Salix
Typha
Linnaea-Zone
5 m
10 m
15 m
20 m
24.6 m
Teich
Straße
AK
formreiche Blockzone
N
0
50
100
200 m

Most studies suggest the dominant environmental factor acting as the stimulus for vertical migration is light (SIEBECK, 1960; RINGELBERG, 1964).
Investigations about vertical migration of zooplankton establish that the phenomenon is greatly widespread, particularly for cladocerans and copepods (KIKUCHI, 1930, 1931; WORTHINGTON, 1931; CUSHING, 1951; HEALEY, 1967; DUMONT, 1968; HART & ALLANSON, 1976; CRUZ-PIZARRO, 1978; GOPHEN, 1979; REDFIELD & GOLDMAN, 1978, 1980). Previous zooplankton investigations in Piburger See were made by SCHABER (1974) and HEHENWARTER (1980).
This research was carried out with the purpose of assessing the vertical distribution and migration of crustacean zooplankton, as this knowledge was necessary to perform zooplankton sampling through the Olszewski tube whose inlet was to be fixed at the highest zooplankton abundance depth. This crop will be used for fish feeding.

Study area

Piburger See is a small meromictic softwater lake (alkalinity ranging between 0.4 and 0.8 meq/1, conductivity 50 - 90 microhms at 20^{o} C) with natural eutrophication (PECHLANER, 1979; PECHLANER & FRICKER, 1980). It has a small catchment area (265 ha) entirely on silicious rocks, only one surface inlet entering from West and subsurface springs and seepage inflows (roughly 50 %).
The geographic position and morphometry of Piburger See are summarized in Table 1.

Table 1 - Morphometric parameters of Piburger See.
(from PSENNER, 1978)

Geographic position, latitude	$47^{o}12'$N
Geographic position, longitude	$10^{o}53'$E
Elevation (m.a.s.l.)	915
Area (m^2)	133690
Length (m)	806
Width (m)	260
Shoreline (m)	1900
Volume (m^3)	$1.835x10^6$
Maximum depth (m)	24.6
Mean depth (m)	13.7
Relative depth (%)	5.96
Critical depth (m)	19.1

Piburger See is mesotrophic with a mean Secchi disc depth of 7.40 m in 1976 (PECHLANER & FRICKER, 1980). The monimolimnion starts at 19.1 m (PECHLANER, 1979).
An artificial hypolimnetic outlet through an Olszewski tube (diameter 10 cm) constantly siphons eleven l/sec of water. It was constructed in 1970 to eliminate both nutrients and reduced substances from the lake (PECHLANER, 1975).

Materials and methods

Zooplankton samples were collected from a fixed station indicated by a buoy near the point of maximum depth (24.6 m) according to the bathymetric map (Fig. 1).

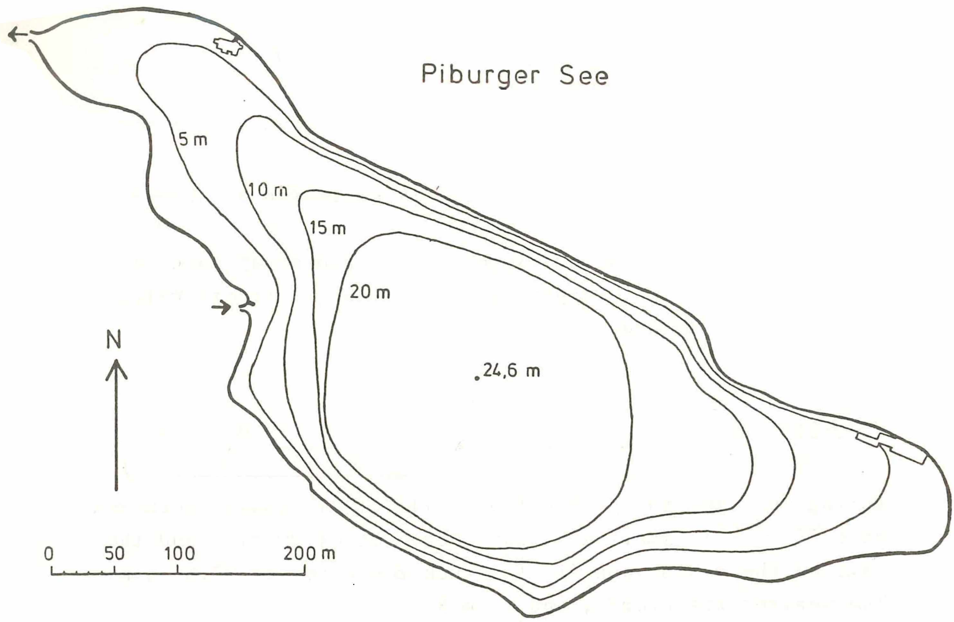


Fig. 1 - Bathymetric map of Piburger See.
(from PSENNER, 1978)

Samples were taken with a self-closing modified Schindler-trap (volume 5 liters), at every meter from the surface to 15 meters of depth, in consideration to the vertical distribution of the zooplankters (SCHABER, 1974; HEHENWARTER, 1980). The samples were filtered through a sieve (mesh size 47 µm) to be concentrated. They were preserved in 4 % formaldehyde.
Collections started at 1.00 p.m. (13.7.1981) and continued every 3 hours till 1.00 p.m. of the next day (14.7.1981).
Crustaceans were sorted and counted in a petri dish with guide lines ruled on the bottom, under a dissecting microscope.
Movements of populations have been estimated from mean depths (d) according to the equation:

$$d = \sum n_i d_i \ / \ \sum n_i$$

where n_i = number of individuals at the depth d_i (CRUZ-PIZARRO, 1978).
On the diagrams, numerical density is expressed as number of individuals per 5 liters.
Temperature and dissolved oxygen were measured at each depth every sampling time. Oxygen was determined titrimetrically using Winkler method.

Results

During the sampling period (13. - 14.7.1981) sunset occurred at 6.30 p.m. (summertime), dawn began at 04.00 a.m. and the rays of the rising sun first struck the water at 07.30 a.m. The weather was cloudy, and from 8.00 to 12.00 p.m. it was raining. Moonshine was covered by clouds. The Secchi depth was 8.5 meter.
The lake showed a distinct thermal stratification. The epilimnion reached down to 4 m depth, the sharp metalimnion was situated between 4 m and 11 m with a temperature decrease from 19.5° C to 7.0° C . In 15 m, the deepest point of sampling, the temperature reached 5.1° C. During the investigation period the highest variations of temperature occurred in the metalimnion between 6 and 10 m, which might have been caused by internal seiches.

Oxygen showed a metalimnetic maximum, depending on the photosynthesis of algae. The highest value of oxygen (14.4 mg/l) was measured in 7 m, which amounts to a relative saturation of 152 %. From the surface down to 13 m of depth an oversaturation was found. Below this depth a sharp decrease of the oxygen concentration occurred. In 21 m depth no oxygen could be found. The mean, maximum and minimum values are given in (Table 2).

Table 2 - Minimum, mean and maximum values of temperature, dissolved oxygen and oxygen saturation during the sampling period.

DEPTH	TEMPERATURE (°C)			DISSOLVED OXYGEN (mg/l)			OXYGEN SATURATION (%)		
(m)	MIN.	MEAN	MAX.	MIN.	MEAN	MAX.	MIN.	MEAN	MAX.
0	19.0	19.7	20.3	8.8	9.0	9.3	107	109.8	114
1	19.0	19.7	20.3	8.8	9.0	9.3	107	109.8	114
2	19.0	19.8	20.3	7.7	8.8	9.1	95	108.0	112
3	19.6	19.9	20.3	8.6	8.9	9.6	107	110.5	120
4	19.0	19.5	19.9	9.0	9.5	9.7	114	115.9	119
5	17.6	18.4	18.8	10.3	10.5	10.7	123	125.3	128
6	14.7	15.9	17.1	11.5	12.5	13.0	133	141.8	146
7	12.0	13.0	14.3	13.4	13.8	14.4	140	147.1	152
8	9.7	11.2	12.1	13.3	13.8	14.3	132	141.6	147
9	8.4	9.1	10.0	12.9	13.8	14.1	123	133.5	138
10	7.5	7.9	9.2	12.7	13.4	13.8	119	126.8	135
11	6.2	7.0	7.9	12.5	13.1	13.7	116	120.8	130
12	6.0	6.4	7.0	12.4	13.1	13.5	112	119.1	124
13	5.5	5.8	6.1	10.1	11.9	13.1	90	107.1	118
14	5.1	5.3	5.5	5.0	7.6	10.1	44	67.3	89
15	4.9	5.1	5.3	3.0	4.9	6.7	26	43.1	59

Five species of crustaceans were observed (Table 3), but only the abundance of *Ceriodaphnia quadrangula* and *Daphnia longispina* were sufficient to study the diurnal migration.

Table 3 - Species composition of crustaceans in Piburger See during the sampling period

A) CLADOCERA
Daphnia longispina O.F.MÜLLER, 1785
Ceriodaphnia quadrangula (O.F.MÜLLER, 1785)
Bosmina longirostris (O.F.MÜLLER, 1785)
Scapholeberis mucronata (O.F.MÜLLER, 1785)
B) COPEPODA
CYCLOPOIDA
Cyclops vicinus ULJANIN, 1875

Diurnal migrations

Ceriodaphnia quadrangula showed a pure nocturnal migration (Fig.2). At first sampling (1.00 p.m.), the mean depth of the population was 7.2 m and most individuals of the population (762 Ind/5 l) were present at 5 m. Ascension of the population began at 1.00 p.m. and at 10.00 p.m. it reached a mean depth of 3.7 m. At this time the maximum of the individuals of the population (935 Ind/5 l) was present at 3 m. After this ascent, the population remained at the same mean depth until 4.00 a.m. At this time the mean depth of the population was 3.8 m and the maximum individual density of the population (831 Ind/5 l) was in 1 m of depth. The population began to descend at 4.00 a.m. At 10.00 a.m. the mean depth of the population reached 6 m and the maximum individual density of the population (655 Ind/5 l) was present at 3 m of depth.

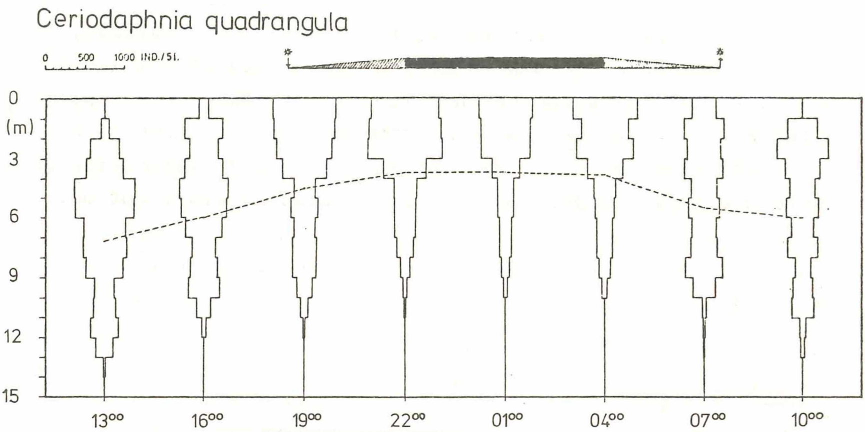


Fig. 2 - Diel vertical migration pattern for *Ceriodaphnia quadrangula*. Dashed lines link the mean depths.

The migration amplitude of *Ceriodaphnia quadrangula* was 3.5 m. The extent of migration was from 3.7 m to 7.2 m of depth. In Piburger See the reported amplitude of *Ceriodaphnia quadrangula* was 3.4 m in August 04-05, 1973 (SCHABER, 1974). In this investigation, *Ceriodaphnia quadrangula* showed two peaks of maximum individual numbers at each sampling time. The cause of this phenomenon could have been that the population consisted of two communities, adapted to different depths or also two different age classes of individuals (SCHABER, personal communication). In the present investigation, C. *quadrangula* showed only one peak of maximum individual numbers.

HEHENWARTER (1980) investigated the vertical distribution and migration of C. *quadrangula* in Piburger See at the same time at two different stations, from 6.20 a.m. to 6.50 p.m., on 5th August, 1978. In this study, C. *quadrangula* descended during the day time, similar to the present observations. Descent was more pronounced at station 6 than at station 8, which is earlier shadowed than the other. The present sampling point was between these two stations. Individual numbers of C. *quadrangula* at both stations were different. These differences were due to inhomogeneities of the horizontal distribution.

Daphnia longispina did not show clear nocturnal migration (Fig.3).

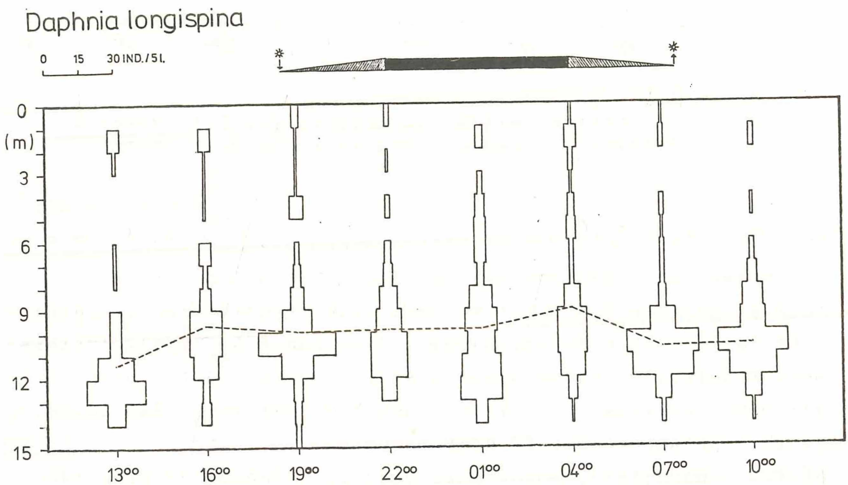


Fig.3: Diel vertical migration pattern for *Daphnia longispina*. Dashed lines link mean depths.

In the first sampling time, the mean depth of the population was 11.4 m and the maximum individual density of the population (26 Ind/5 l) was present in 13 m depth. At 4.00 p.m., it reached the mean depth of 9.7 m. The population remained at the same mean depth until 1.00 a.m. After this time it began to ascend and at 4.00 a.m. it reached the mean depth of 9 m.
The maximum individual density of the population (13 Ind/5 l) was present at 10 and 11 m of depth. After 4.00 a.m. the population began to descend and reached the mean depth of 10.7 m at 7.00 a.m. At this time the maximum individual density of the population (32 Ind/5 l) was present at 11 m of depth.
The migration amplitude of *D. longispina* was 2.4 m. The extent of migration was from 9.0 m to 11.4 m.
Past studies of diel vertical migration indicate that the amplitude of vertical movement characteristic for *Daphnia* may vary greatly from lake to lake as well as from day to day and season to season (McNAUGTH & HASLER , 1964). Reported amplitudes range from 0.6 m (observed by PENNAK (1944) for *D. longispina* in Bear Lake, Colorado, due to lack of dissolved oxygen) to 33 - 50 m reported by WORTHINGTON (1931) for the same species in Lake Victoria, Africa.

In Piburger See, the main population of *D. longispina* was stable at the boundary between metalimnion and hypolimnion (between 8.0 m and 14.0 m). In this layer, the range of the mean temperature lies between 9.1° C and 5.8° C and dissolved oxygen between 13.8 mg/l and 11.9 mg/l.

D. longispina seemed to avoid to cross the metalimnion.
In Japanes lakes, KIKUCHI (1930) found that *D. longispina* remained below the thermocline. But other studies show *D. longispina* crossing a very sharp thermocline (WORTHINGTON, 1931).
D. longispina prefers to live in the greater depths of Piburger See (SCHABER, pers. comm.). Reasons for this behaviour could be predation pressure of zooplanktophagous fish in the upper

layers and / or food conditions.

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