ANNALES
UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA
LUBLIN – POLONIA
VOL. LX SECTIO C 2005

MARTA KOWALECZKO

Department of Hydrobiology and Ichtiobiology, University of Agriculture
Akademicka 13, 20-950 Lublin, Poland

# Preliminary investigations on the dependence between the day-time and vertical migrations of rotifers in Piaseczno during summer stagnation

Badania wstępne dotyczące zależności pomiędzy porą dnia a pionowymi migracjami wrotków w jeziorze Piaseczno w okresie letniej stagnacji

SUMMARY

Diurnal, vertical migrations of the rotifers (*Rotifera*) in the mesotrophic lake were observed. Throughout all the cycle of research some variations of migrations were analyzed. *Filinia maior* showed a nocturnal pattern of migration. On the contrary, *Filinia longiseta* and *Keratella quadrata* represented a reverse pattern of vertical movements. *Polyarthra vulgaris* and *Keratella cochlearis* showed a stationary pattern of migrations. Temperature and oxygen requirements of several species were analyzed and discussed.

STRESZCZENIE

Obserwowano dobowe, pionowe migracje wrotków (*Rotifera)* w mezotroficznym jeziorze. W ciągu całego cyklu badań analizowano pewne typy migracji. *Filinia maior* przedstawiała nocny wzorzec migracji. Przeciwnie, *Filinia longiseta* i *Keratella quadrata* reprezentowały odwrócony wzorzec pionowych wędrówek. *Polyarthra vulgaris* i *Keratella cochlearis* przedstawiały stacjonarny wzorzec migracji. Bazowano na wybranych środowiskowych czynnikach, wśród których temperaturowe i tlenowe wymagania kilku gatunków opisano i przedyskutowano.

Key words: *Rotifera,* vertical migrations, Piaseczno lake.

List of abbreviations: DVM — diurnal vertical migration, D — mean residence depth.

## INTRODUCTION

While analyzing the hydrobiological literature a number of works can be found concerning the vertical tests on zooplankton migration both in fresh and sea waters (7). The research material for these works is usually crustacean zooplankton. Many such research works have been carried out in laboratory conditions. The phenomenon of vertical daily migrations in the natural conditions has been described only by few researches. The above-mentioned researchers dealt with the analyses of vertical migrations in shallow eutrophic and hypereutrophic lakes (16). They also tested *Rotifera* migrations in hypolimnion layer and in alpine lakes. No papers have been written so far which would describe vertical migrations of *Rotifera* in mesotrophic, dimictic type of lakes in the temperate geographical zone. That is why the preliminary tests concerning the discussed migrations phenomenon were started just in the dimictic, mesotrophic Piaseczno lake, situated in the Łęczyńsko-Włodawskie Lake District. The present paper aimed at examination of the *Rotifera* species structure, characterized by special migration types or by standing still in a water column. An attempt was made at the determination of an influence of light, oxygen and temperature on the migration habits of *Rotifera* during the diurnal cycle.

Light is generally regarded as the most important factor influencing the vertical migration of rotifers. Daily changes in light intensity can act both as a stimulus for initiating vertical migration and a means of controlling the speed and amplitude of movement (15). The phenomenon of DVM is controlled by other proximate and ultimate factors such as food concentration and distribution, predator pressure, and probably other as yet unidentified factors (8, 10, 11, 12). Besides, combined effect of temperature and oxygen concentration exerts influence on migration of rotifers (8). The patterns of diurnal movements are distinct for different species. (1, 2, 8, 10, 11, 12, 15).

## MATERIAL AND METHODS

The plankton was sampled from 22 July to 25 July 1999 at the deepest point of the lake (38.6 m). Duplicate samples were collected using a 10 liter "Toń" sampler. Zooplankton samples were condensed in the 40 μm plankton net. Temperature, pH, oxygen concentration, were also measured using the "HYDROLAB"-sounder. DVM were studied over 24 hours. The samples were taken at 5h, 9h, 12h, 16h, 20h and 24h, at 1-meter intervals in the epilimnion, at 2-meters intervals in the metalimnion and at 3-meters intervals in the hypolimnion. The biological samples were immediately preserved in 4% formalin solution. At least three subsamples were counted in the laboratory using an inverted microscope at 20× and 40× magnification. Vertical migration were estimated using the (D) — mean residence depth formula (3):

$$D=\Sigma N_i N^* d_i/\Sigma N_i$$

$d_i$ — depth of $i^{th}$ sample.
$N_i$ — concentration of individuals at $d_i$ depth.

DVM were calculated at each sampling time. The calculations obtained according to the above formula permitted to establish a speed of migration for the bulk of the population.

## RESULTS AND DISCUSSION

### Abiotic environment

During the prescribed sampling period the weather was sunny, warmly and windless. The mean air temperature was 25°C. The water of the lake was slightly alkaline with pH values between 7.87 at the surface and 6.34 near the bottom. At

0–6 m depth, the water temperature was between 22.7–24.5°C. The thermocline was at 6–10 m depth. The lowest water temperature (4.56°C) was near the bottom. The transparency was measured with a Secchi disc. These values varied between 2.5–3.5 m.

## Community composition and migrations

In the most heterogenous as to the physico-chemical factors epilimnion, the greatest density and distribution changes in *Rotifera* were noted daily. Similar changes in *Rotifera* fauna were found out in metalimnion, in spite of the fact that the biological material was taken every 2 meters in the above-mentioned layer. While taking the biological material from 6, 8 and 10 meters depth some differences were noted in the *Rotifera* distribution between the upper and lower metalimnion. Only few species occurred in the more homogenous environment of hypolimnion, especially its lower layers (Fig. 1).

During laboratory investigations 28 species of *Rotifera* were found. The rotifers noted in all periods of the year in Piaseczno Lake were among them (14). To this group belonged: *Keratella cochlearis, Polyarthra vulgaris, Conochilus unicornis* and *Kellicottia longispina.* All-year rotifers, as *Conochilus unicornis, Keratella cochlearis* and *Polyarthra vulgaris* occurred during presented research in the greatest number in the epi- and metalimnion. The highest density of rotifer species was noted for *Keratella cochlearis* at 5 meters of depth (near thermocline) (Tab. 1), (Fig. 1). Generally mentioned perennial species tended to be eurythermal. This fact can be confirmed by Radwan's opinion (14). He stated that the perennial species can tolerate a wide range of temperature within which they find optimum conditions for populations growth. They tolerate temperatures from less than 1°C to more than 20°C (8). The other noted species like *Ascomorpha ovalis* and *Collotheca mutabilis* were concentrated at depths from 0–11 meters. These two species appeared at warm and day-lighting surficial. Radwan (14) confirms that *Ascomorpha ovalis* and *Collotheca mutabilis* prefer warm waters at the temperature above 18°C. The other species like *Conochilus unicornis* was found in the epi- and metalimnion too, though it did not avoid the deep layers. During all the cycle of the research *Gastropus stylifer* and *Keratella cochlearis f. tecta* tended to remain in the epi- and metalimnion. *Gastropus stylifer* was found in the layers with high oxygenation (70–115%). These environmental requirements are confirmed by Ruttner-Kolisko (15), that *Gastropus stylifer* needs high oxygen concentration. In the case of *Kellicottia longispina* the individuals appeared in wide range of vertical profile. Whereas egg-carrying females of *Kellicottia longispina* were located deeper than the other individuals. This behaviour of egg-carrying females may be explained by increased weight of these rotifers (1). *Filinia maior* occupied cold and dark hypolimnion (Tab. 1, Fig. 1) during all time of research. (water temperature 4.3–7.3). Radwan classifies this rotifer as cold-water stenotherm (14). Moreover, *Filinia maior* occurred in layers with low oxygen concentration (14–18%). Similar distribution represents *Filinia maior* in other lakes (15).

Table 1. The mean residence depth (D) (meters) of selected rotifer species in Piaseczno Lake

| Species/Time | 4 p.m. | 8 p.m. | Midnight | 5 a.m. | 9 a.m. | Midday |
|---|---|---|---|---|---|---|
| *Keratella cochlearis* | 6.32 | 7.88 | 6.88 | 7.18 | 7.24 | 7.71 |
| *Keratella quadrata* | 8.88 | 12.89 | 19.79 | 16.85 | 8.29 | 4.98 |
| *Filinia longiseta* | 5.33 | 11.46 | 17.12 | 7.62 | 5.32 | 4.5 |
| *Filinia maior* | 24.96 | 21.29 | 18.98 | 22.34 | 23.93 | 25.78 |
| *Polyarthra vulgaris* | 7.49 | 10.25 | 8.07 | 8.74 | 7.31 | 0.22 |

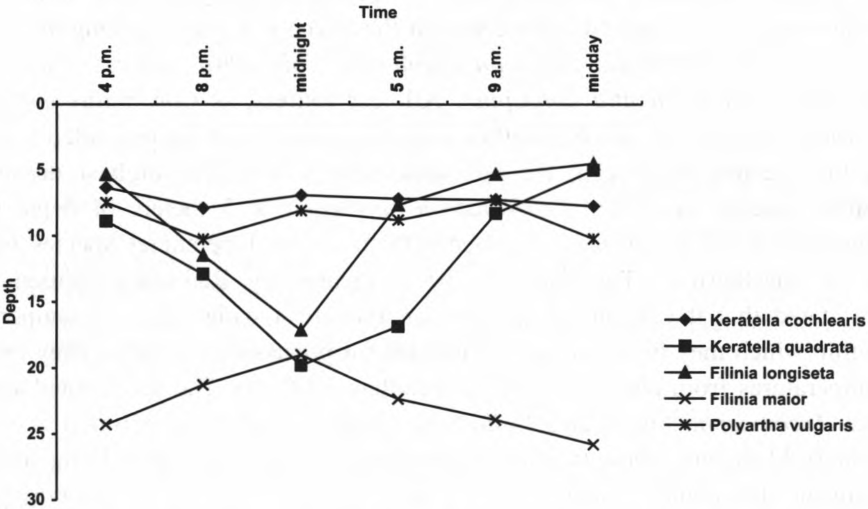


Fig. 1. The mean residence depth (D) (meters) of selected rotifer species in Piaseczno Lake during the summer

The rotifers tended to occupy narrowly delimited layers in the vertical profile and they generally remain within them during the diurnal cycle (Tab. 1). Generally, the number and species composition in Piaseczno Lake were comparable to these of among natural, deep lakes in the temperate region (3, 8, 9, 12, 13).

Daily changes in rotifers vertical distribution, migration and their different modifications can be observed in Piaseczno Lake. Besides the usual daily vertical movements of descent during day-light and ascent at night, reverse type of migration occurred too.

The speed of ascent and descent was calculated from (D) (Tab. 1) on different sampling hours. The speed of movement of particular rotifer species was varied and relatively high (Tab. 2). The received values of speed were comparable with the analogical values originated from other lakes of temperate region (3).

Table 2. Maximum speed of ascent and descent moving (meters per hour) for the selected rotifer species between 22.07 to 25.07.1999, as calculated from the mean residence depth of population. Period when maximum speed was reached is given in brackets. Migration type: N = nocturnal, R = reverse, S = stationary

| Species | Maximum speed | | Migration type |
|---|---|---|---|
| | Ascent | Descent | |
| *Keratella cochlearis* | 0.35 (12.00–16.00) | .–0.39 (16.00–20.00) | S |
| *Keratella quadrata* | 2.14 (5.00– 9.00) | .–1.37 (20.00–24.00) | R |
| *Filinia longiseta* | 1.9 (24.00– 5.00) | .–1.53 (16.00–20.00) | R |
| *Filinia maior* | 0.92 (16.00–20.00) | .–0.67 (24.00– 5.00) | N |
| *Polyarthra vulgaris* | 0.68 (12.00–16.00) | .–0.97 (9.00–12.00) | S |

The daily movements of *Filinia maior* showed a normal upward nocturnal migration (Tab. 2), (Fig. 1). That pattern of vertical migration often occurs in lakes of temperate region (3, 13). Supposedly, this type of migrations is caused by the direct harmfulness of day light, especially UV, to *Rotifera* (11). Moreover, it can be assumed that the above-mentioned type of migration occurs with the *Rotifera* which avoid predators (especially planctonophagous fish), inhabiting the well lit epilimnion (4, 7, 11).

*Keratella cochlearis* and *Polyarthra vulgaris* showed no clear pattern of movement but tended to aggregate at constant definite depths during all the sampling period (Tab. 1), (Fig. 1).

It can be concluded that *Keratella cochlearis* and *Polyarthra vulgaris* represented stationary type of migration (Tab. 2). The same type of migration of the species appeared in other lakes of temperate region (3, 5). Presumably, the non--migrating in water column *Rotifera*, or those moving slowly there, are generally less sensitive to change of abiotic and biotic factors (i.e. light, radiation, oxygen concentration, abundance of food), occurring in particular, vertical water areas (4, 7, 11).

The mean residence depth (D) of *Keratella quadrata* and *Filinia longiseta* at the surface in the middle of the day was higher than during the night (Tab. 1). That pattern of movements exhibited reverse type of migration (Tab. 2). The received results concerned migration corresponded with effects of rotifers examination carried out by Stewart and George (16).

The dominant group of rotifers showed little tendency to vertical moving or did not migrate at all. Among them were *Asplanchna priodonta, Trichocerca similis, Trichocerca capucina, Pompholyx sulcata, Conochilus unicornis* and the other less abundant species. Miracle (13) stated that movement of individuals and the mean residence depth were distorted to a certain degree of rotifers moving, because individuals from different depths might not go up and down synchronously. Biernacka (2) confirmed that migratory or non-migratory strategy of rotifers might be an individual choice of each member of a population.

## CONCLUSIONS

Despite the fact that the preliminary tests have already been carried out on the vertical *Rotifera* migrations, it is possible to make an attempt at saying that:

1. An analysis of DVM of rotifers in Piaseczno Lake indicated that some environmental factors, such as temperature, oxygen and light influenced vertical movements fundamentally.

2. The metalimnion prevented or delayed movements, resulting in characteristic accumulations of individuals just above or below its upper or lower limit.

3. Vertical migrations should be analyzed during the whole year, within the context of seasonality.

## REFERENCES

1. Axelson J. 1958. Zooplankton and impoundment of two lakes in Northern Sweden (Ransaren and Kultsjön). Rept. Inst. Freshw. Res. Drottningholm, 39: 80–170.
2. Biernacka A. 1992. Dobowe migracje pionowe zooplanktonu: kompromisowa strategia przetrwania. Wiad. Ekol., XXXVIII: 153–171.
3. Bogaert G. and Dumont H. 1989. Community structure and coexistence of the rotifers of an artificial crater lake. Hydrobiol., 186/187: 167–179.
4. Dawidowicz P. 1999. Koszty behawioralnej obrony przed drapieżnictwem: model dobowych migracji pionowych zwierząt planktonowych. Wiad. Ekol., XLV: 3–16.
5. Forsyth D. J. 1991. Seasonal abundance and dial vertical dynamics of zooplankton in Lake Okaro. Arch. Hydrobiol., 121: 419–429.
6. Galkovskaya G. and Mityanina I. 1989. Morphological structure and functional patterns of *Keratella cochlearis* (Gosse) populations in stratified lakes. Hydrobiol., 186/187: 119–128.
7. Hays G., Proctor A., John W. and Warner A. 1994. Interspecific differences in the diel vertical migration of marine copepods. Limnol. Oceanogr., 39: 1621–1629.
8. Herzig A. 1987. The analysis of planktonic rotifer populations: A plea for long-term investigatons. Hydrobiol., 147: 163–180.
9. Hofmann W. 1987. Population dynamics of hypolimnetic rotifers in the Pluss-See (North Germany). Hydrobiol., 147: 197–201.

10. Lampert W. 1989a. Efekty kaskadowe w ekosystemach jeziornych: znaczenie dobowych migracji zooplanktonu. Wiad. Ekol., 34: 123–141.
11. Lampert W. 1989b. The adaptive significance of dial vertical migration of zooplankton. Funct. Ecol., 3: 21–27.
12. Lampert W., Sommer U. 1996. Ekologia wód śródlądowych. PWN, Warszawa.
13. Miracle M. R. 1977. Migration, patchiness and distribution in time and space of planktonic rotifers. Arch. Hydrobiol. Beih. Ergebn. Limnol., 8: 19–37.
14. Radwan S., Popiołek B., Paleolog A. 1989. The effect of temperature on vertical distribution of rotifers in a mesotrophic lake. Pol. Arch. Hydrobiol., 36: 113–121.
15. Ruttner-Kolisko A. 1977. Population dynamics of rotifers as related to climatic conditions in Lunzer Obersee and Unter See. Arch. Hydrobiol. Beih., 8: 135–137.
16. Stewart J., George D. G. 1987. Environmental factors influencing the vertical migration of planktonic rotifers on a hypereutrophic tarn. Hydrobiol., 147: 203–208.