DIURNAL AND NOCTURNAL VERTICAL MIGRATION OF ZOOPLANKTON IN WADI EL RAYAN LAKES (EL FAYOUM, EGYPT)

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ABSTRACT

Samples of zooplankton were collected at two-hour intervals during the twenty-four hours cycle of 26-27 July 1997. The samples were collected from fixed depths of the water column at a fixed station at the first lake of Wadi El Rayan Lakes (El Fayoum, Egypt).

The results obtained indicate that large number of organisms in the epilimnion characterized the general trend of zooplankton vertical migration. Each group had a special style of diel vertical migration. Crustacean organisms were correlated negatively with temperature and light. They migrated downward during daytime and upward during night. Rotifera showed a reverse trend with a significant positive correlation with light intensity.

INTRODUCTION

Zooplankton is known to show diel vertical migration during the twenty-four hours cycle (Onbe and Ikeda, 1995; Paggi, 1995; Makino *et al*, 1996; and Steele & Henderson, 1998). There is very little field evidence that zooplankton stay within a particular water layer over a daily cycle (Boden & Kampa, 1967). Roe (1983) showed that zooplankton are capable of attaining the swimming speed necessary to follow a narrow isolume during sunrise or sunset. Kerfoot (1970) concluded that the effect of light might be a fundamental environmental parameter determining the adaptive significance of vertical migration. Buikemo (1975) reported that the effects of light intensity are independent of temperature and wavelength. Buchanan and Haney (1980) stated that the absolute light intensity in the form of a preferred or optimal zone is not the proximal cause of diel vertical migration. Buskey *et al* (1989) studied the effects of light in regulating the daytime position of vertical migration of adult oceanic copepods and concluded other exogenous factors might influence diurnal vertical migration as temperature, salinity, and hydrostatic pressure. Liebold (1990) noticed that vertical migration of zooplankton vary substantially among species or even within species among lakes and at different times.

Numerous published studies of zooplankton counts were depending on samples collected during the daytime. The results of these studies must be interpreted with caution, understanding that samples collected at night may produce higher numbers.

The present study was conducted at the first lake of Wadi El Rayan Lakes (El Fayoum, Egypt), aiming to study the diel vertical migration of zooplankton for the twenty-four hours cycle, and to correlate them with water temperature, and light intensity of the same site and time of collection.

MATERIAL AND METHODS

Study area:

Wadi El Rayan Lakes (30° 23′ E and 20° 28′ N) are located southwest of Cairo in the western desert of Egypt. They are new lakes (started in 1973), divided into two distinct lakes at different elevations during the present time (Fig. 1). The connecting canal between the two lakes is characterized by shallow water (about 2 meters depth) covered by emergent aquatic macrophytes. The first lake is completely filled with water with a maximum depth of about 25m and covers an area of about 52 km^2. The second one has an area of about 110 km^2, with a maximum depth of about 30 m, where the water level is changing with time, and new flooded areas are continuously added at the south western side of the lake. The main water source of Wadi El Rayan Lakes is the agricultural drainage water of El Fayoum Governorate. It discharges to the first lake through one branch from El Wadi drain (one of the biggest two drains in El Fayoum). The study was carried out at the deepest area of the first lake.

Field and laboratory analysis:

The field collection of zooplankton was conducted on July 26-27, 1997. The bathymetry of the first lake was determined using Eco-sounder recordings (Lowrance model) to locate the deepest area in the lake.

Zooplankton samples were collected by an opening/closing plankton net (12 cm in diameter, 55μm mesh). It was towed vertically from 20 m deep up to the surface at intervals of 20-15m, 15-10m, 10-5m, 5-2m, and 2m-surface in addition to filtration of 50 liters from the surface water. The samples were collected at two-hours interval, and were preserved upon collection in 5% neutral formalin. The samples were adjusted to 100 ml before enumeration and identification of zooplankton species. Five subsamples of three ml were settled in a plankton tray. The counting and identification were carried out by light microscope at 100X magnification (sometimes 400X for rotifers). Zooplankters were expressed as number of organisms per cubic meter.

Light intensity was measured as quantum ($\mu mol s^{-1} m^{-2}$) using LI-COR Quantum/Radiometer/Photometer Model LI-189 at one meter interval at the water column. Water samples (5 litre) were collected at the same time and space of zooplankton sampling for measuring water temperature (°C) by ordinary thermometer.

RESULTS

Light intensity during the study was bright in the period of 7a.m. to 5p.m. with maximum intensity during 11am (Fig.2). The penetration of light through the water column reached to about 15 meters depth in 11a.m. The compensation level (1% light depth) did not exceed about 8 meters (Fig.3).

Water temperature decreased gradually with depths from 7p.m. on the day 27 to 5 p.m. on 28 July 1997 (Fig. 4). The maximum water temperature was recorded at 5 p.m. where the difference between surface water temperature and 20m depth was 8.1°c, whereas the lowest difference was at 7a.m. (3.8°c).

The only recorded zooplankton groups were Rotifera, Cladocera, and Copepoda. Rotifera species appeared as rare and scattered group. They were represented by *Keratella cochlearis*, *K. valga*, *Brachionus plicatilis*, *Lecane luna*, *Monstilla bulla*, *Hexarthra oxyuris*, *Polyarthra vulgaris*, and *Asplanchna priodonta*. Generally, these rotifers were attracted to light during the daytime (Fig. 5). *H. oxyuris* was the most abundant rotiferan species. It disappeared totally from the depth of 20m but mostly concentrated in the upper five meters, especially the surface layer during afternoon (2p.m. and 5p.m.) and in 2m depth at other times except at 9p.m. At this time, *H. oxyuris* was concentrated at 5m and 10m depths only (Fig. 6).

Cladocera was represented during this study by only three species; *Diaphanosoma excisum*, *Ceriodaphnia cornuta*, and *Bosmina longirostris*. The first one was the most dominant species. Cladocera showed distinct diurnal variations with maximum counts at 2m depth. They started their migration towards the subsurface layer at night. After sunrise, they started to move downward and their majority departed from the surface after 5p.m. and then the cycle was repeated (Fig. 5). The first two cladoceran species were nearly similar in their trend of daily vertical migration; whereas the third one migrated from the subsurface layer during the daytime (11a.m. - 5p.m.) to the depth of 5m (Fig. 7).

The cyclopoids *Thermocyclops neglectus* and *Megacyclops viridis*, and the calanoid *Thermodiaptomus galebi* represented adult copepods. *T.*

neglectus was the most abundant copepod species. Both males and females mostly migrated downward from the surface during the daytime and moved upward during night with little difference between them in migration (Fig. 8). The juvenile stages of Copepoda (nauplius and copepodite stages) attained their maximum counts in the subsurface layer at the day and night with lower numbers at the subsurface during the daytime (Fig. 9).

In summary, fairly large numbers in the epilimnion showed a general trend of vertical migration of zooplankton, while very few individuals were collected at the hypolimnion (below the compensation level). During daytime, zooplankton organisms migrated from the surface water layer to the depth of 2m or below, whereas during night, they migrated to the surface water layer again. Each group had a special trend as discussed above.

DISCUSSION

Most of the crustacean organisms, some of the rotifers and a few other members of the freshwater plankton perform considerable vertical movements in the course of the twenty-four hours period which are consistent with observations made by Hutchinson (1967). These zooplankters showed a clear trend in dial variations where, their small numbers at midday in subsurface water layer coincided with results of Jolly (1965).

A strong negative correlation between zooplankton number and surface water temperature was recorded (-0.886). This means that zooplankton migrated downwards when the surface water temperature increases. Dumont (1968) has already pointed out the strong negative correlation between water temperature and zooplankton migration.

The crustacean groups had the same pattern of total zooplankton. The midnight abundance and midday scarcity of adult copepods found here accord well with observations made by Michael (1966), Mathew (1977), and Mageed (1996) that there is an inverse relationship between temperature and phototaxis. The rise of surface water temperature during day time leads to decrease in the water density. So, the organisms sink according to their weight, but some organisms resist sinking. According to Hutchinson (1967), the resistance of organisms to sinking depends largely on their shape. Some organisms may be provided with oil droplets or gas vacuoles that reduce their density. Rudjakov (1970, 1973) has suggested that the downward vertical migration of crustacean zooplankton could be due entirely to passive sinking.

Light appeared as a controlling factor in the diurnal vertical distribution of zooplankton. Reid (1961), Hutchinson (1967), and Buskey *et al* (1989) suggested that at great light intensities, a negative phototaxis involving a change of posture relative to light, and swimming away from the source. These movements characteristically take the organisms near surface regions at midnight and to the depths during midday. Buikema (1975) concluded that, three possible effects of light intensity act singly or in combination. First, avoidance of high light intensity may be adaptive because high intensities may decrease the net efficiency of growth of the species. Second, feeding may occur at a specific light intensity, where the efficiency of converting food to growth and young is maximal. Third, the animals may remain in a zone of optimum light intensity, where assimilation and the conversion of food into growth and young are maximal.

In contrast to other zooplankton groups, rotifers have shown positive responses to light intensity ($r = 0.533$), they migrated to near the surface water during the daytime. These observations are consistent with the results of Arora (1967), Szlauer (1969), and Menzel and Roth (1972). The predation effect of adult copepods on the rotifers may cause migration of these small organisms. George (1961) observed daytime abundance of rotifers in Delhi ponds. On the contrary, Paggi (1995) observed increases in numbers of the rotifer populations only during night hours. Mathew (1977) recorded the maximum counts of rotifers at varying times during the different parts of the day. He concluded that, rotifers as a group failed to show any fixed trend in their diurnal migration.

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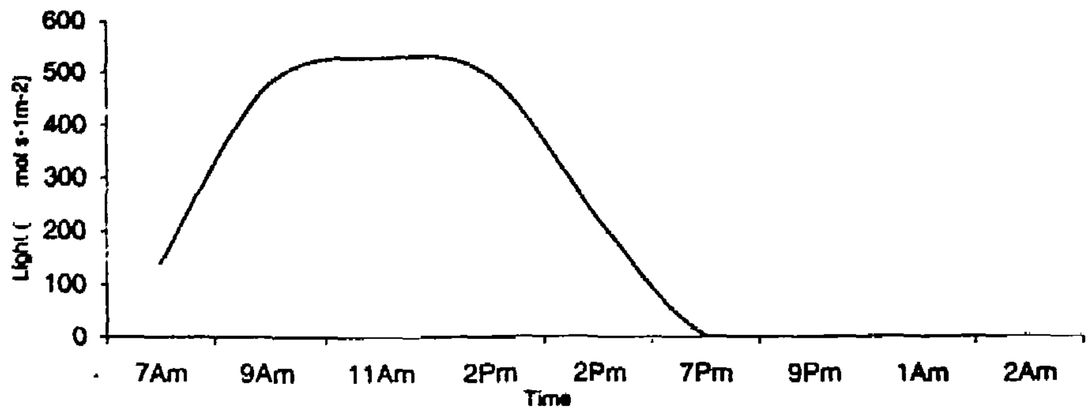


Fig. 2: Light intensity (μ mol s-1m-2) at the surface water of the first lake of Wadi El Rayan Lakes

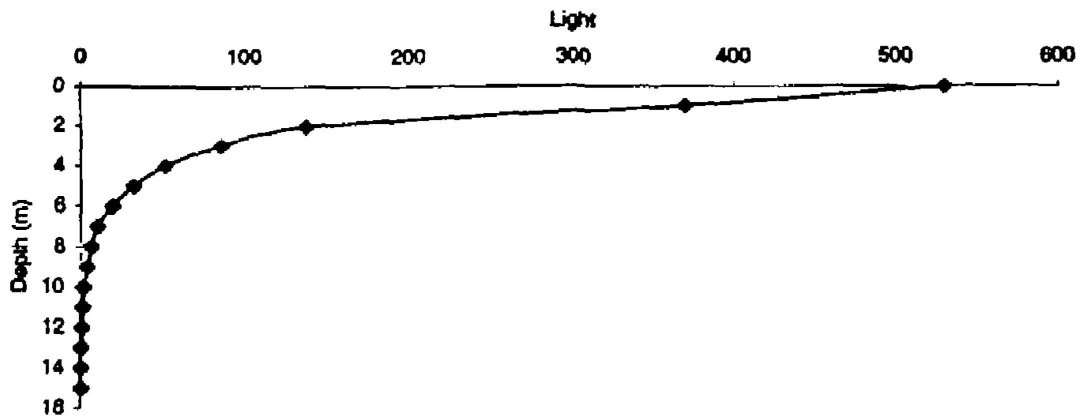


Fig. 3: Maximum light intensity (μ mol s-1 m-2) in the water column during 11a.m.

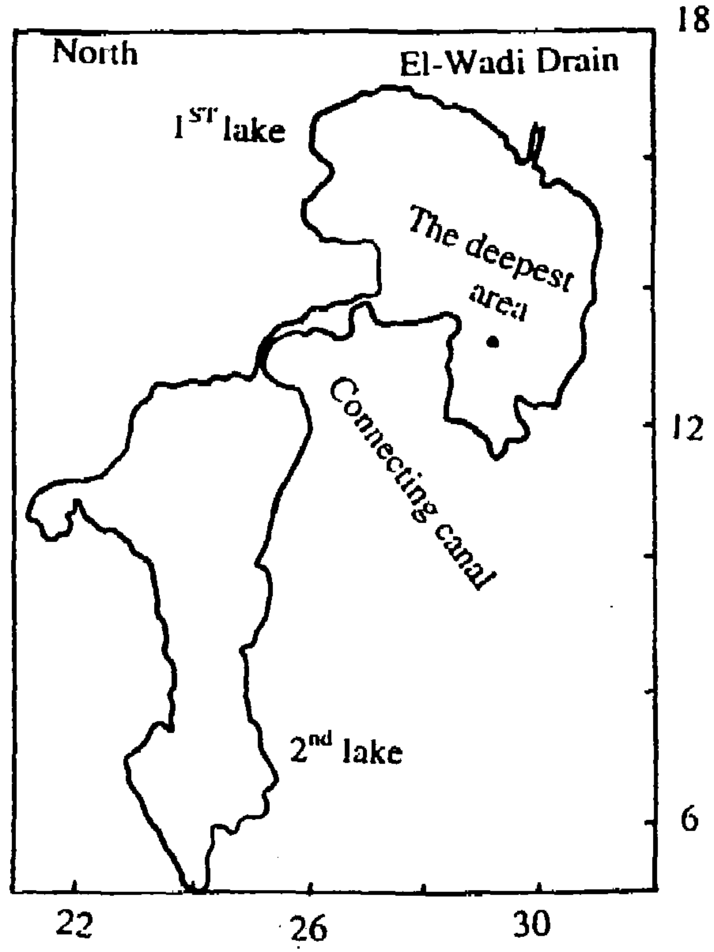
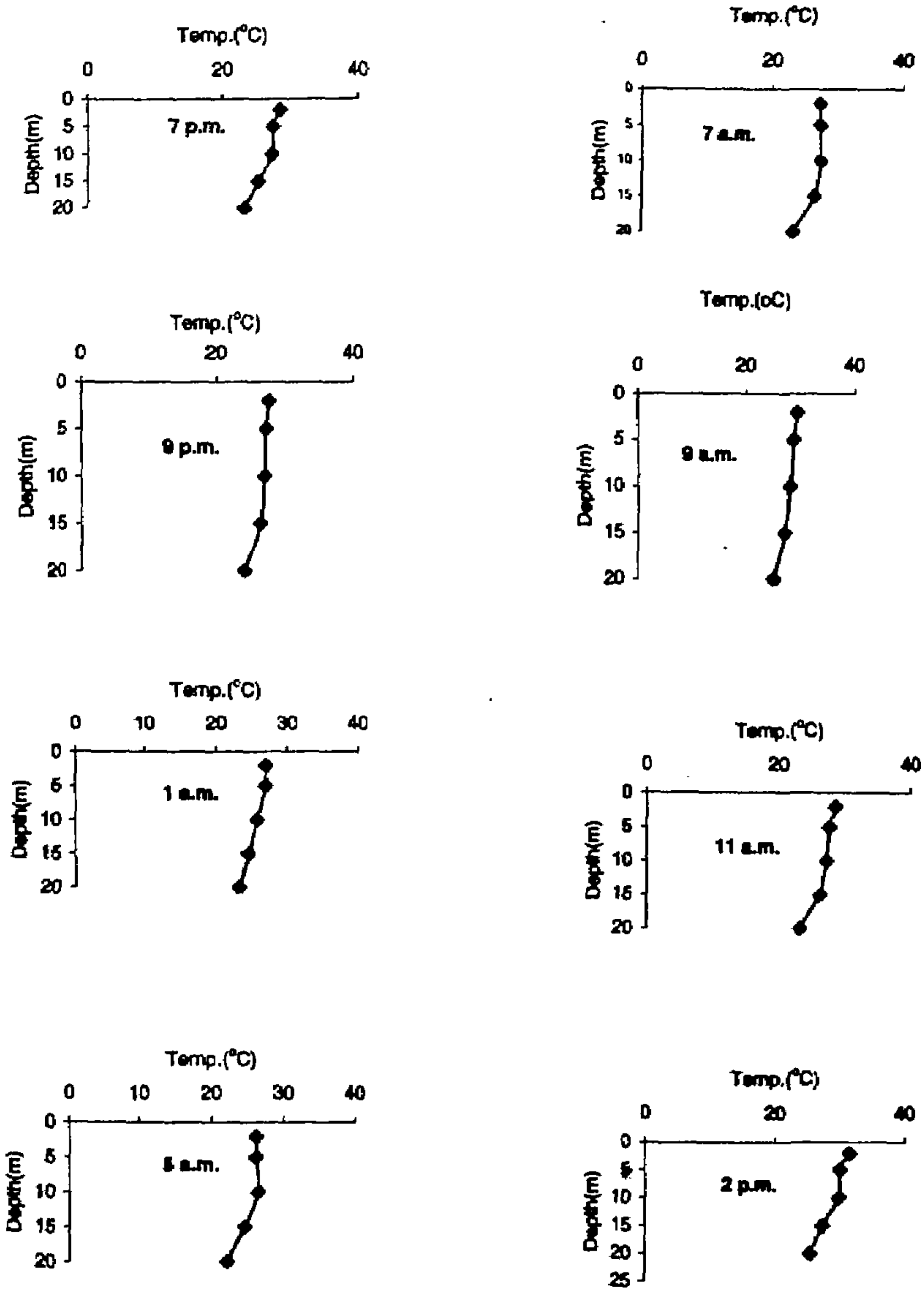


Fig. 1: Showing site of sampling collection at the first lake of Wadi El Rayan Lakes



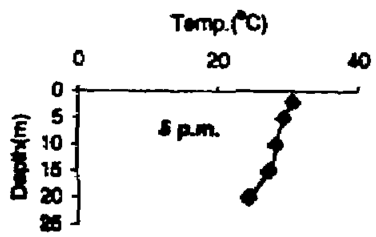
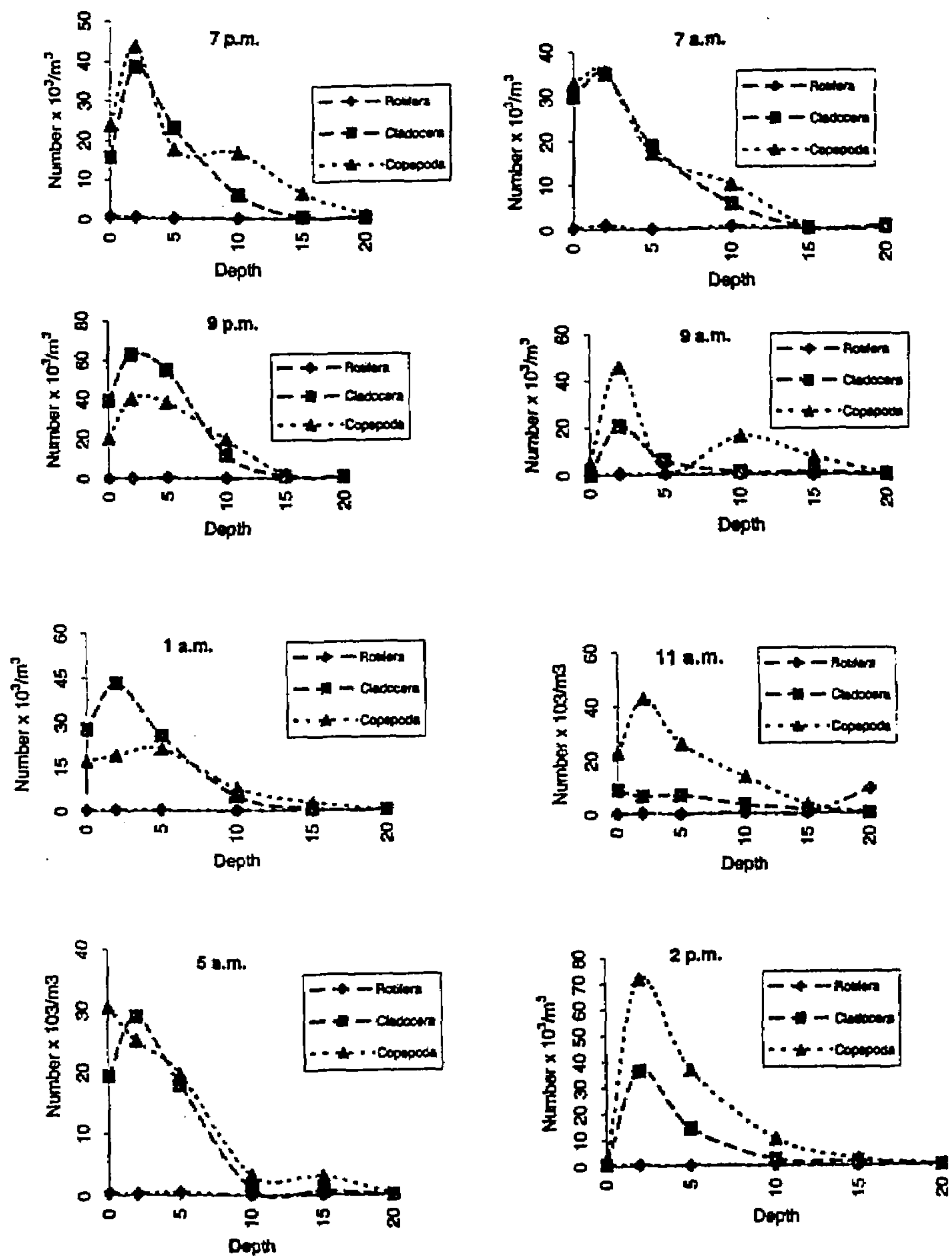


Fig 4: Dial variations of water temperature (°C) at the different depths of first lake of Wadi El Rayan Lakes during 27-28/7/1997



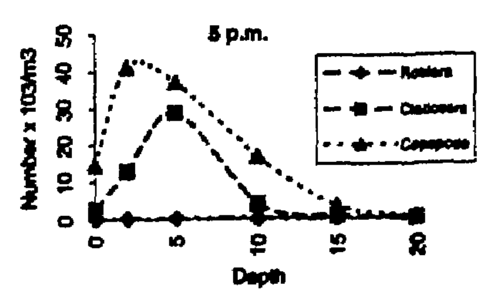


Fig 5: Dial migration of zooplankton groups (organisms/m³) at the first lake of Wadi El Rayan Lakes.

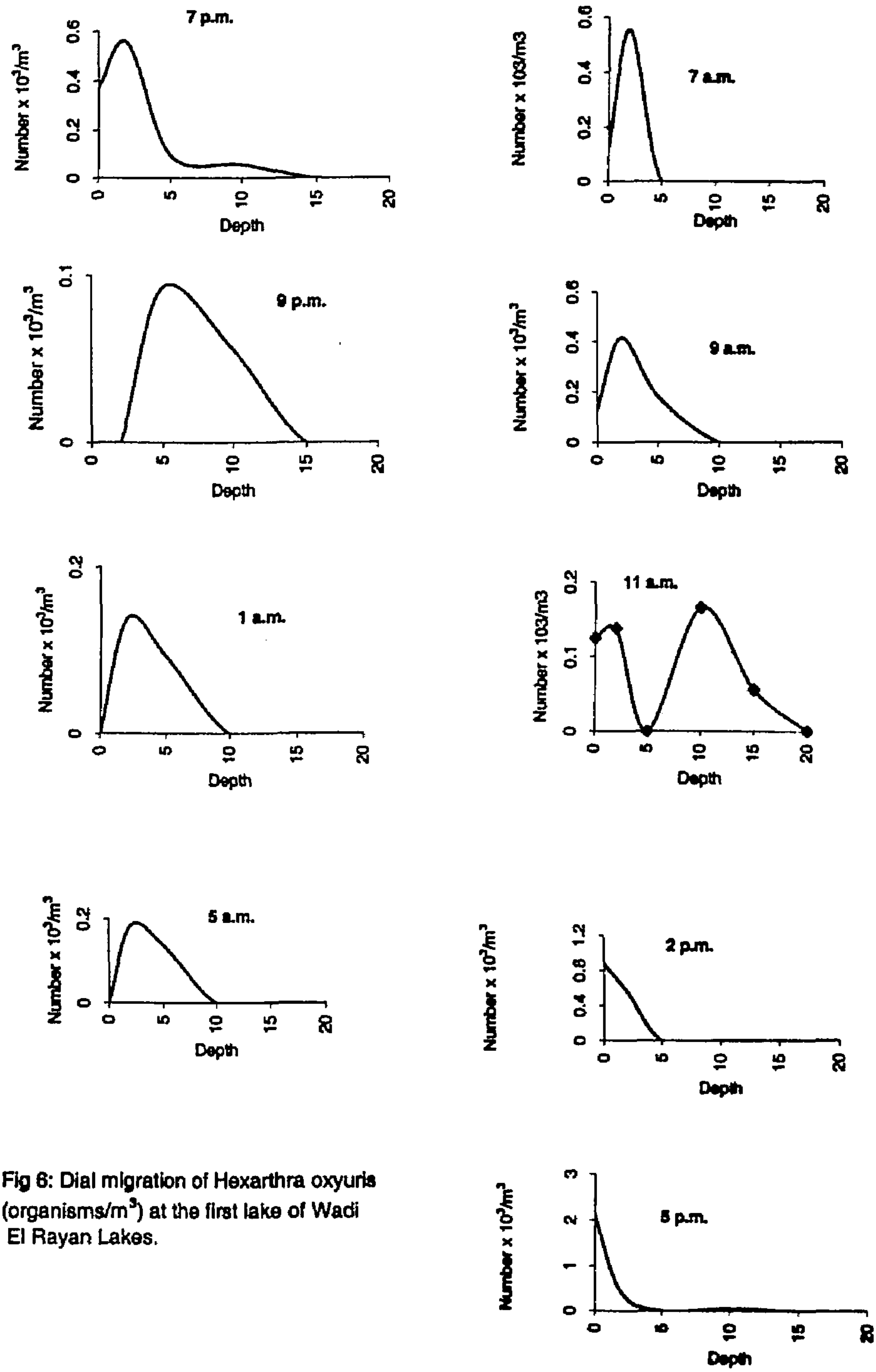
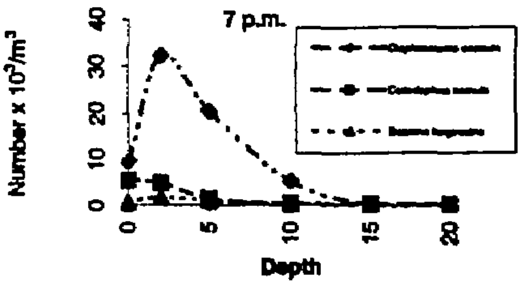
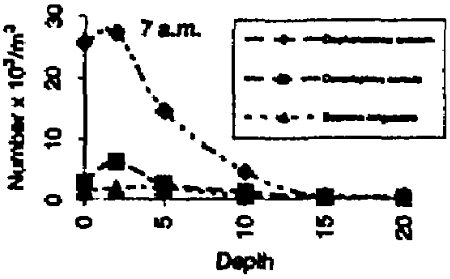
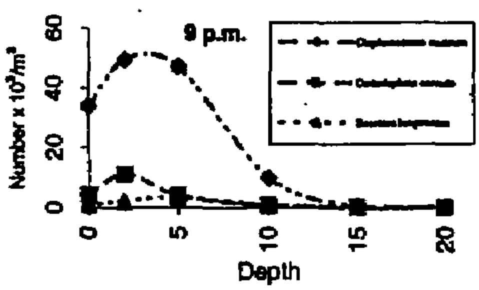
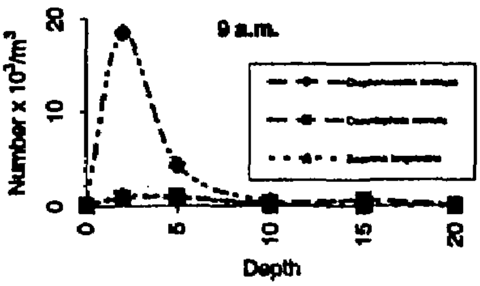


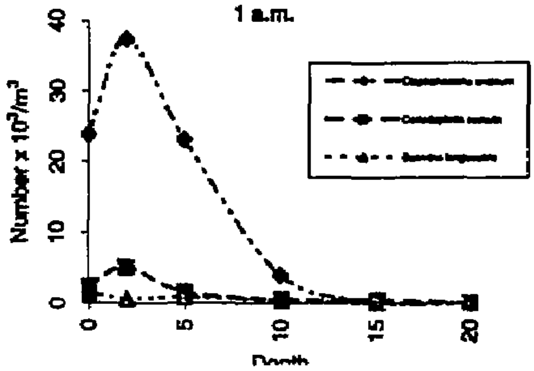
Fig 6: Dial migration of Hexarthra oxyuris (organisms/m^3) at the first lake of Wadi El Rayan Lakes.

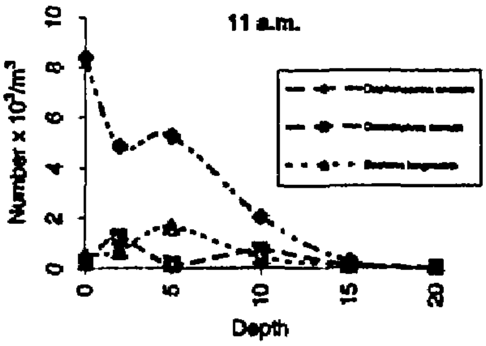


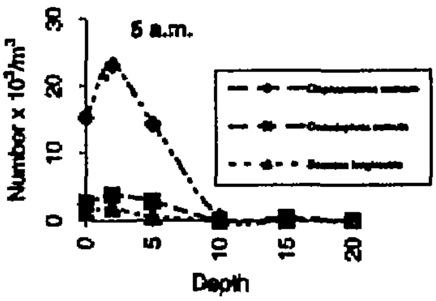


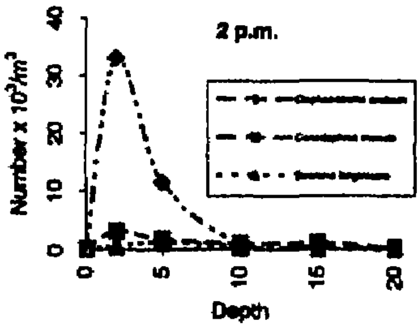












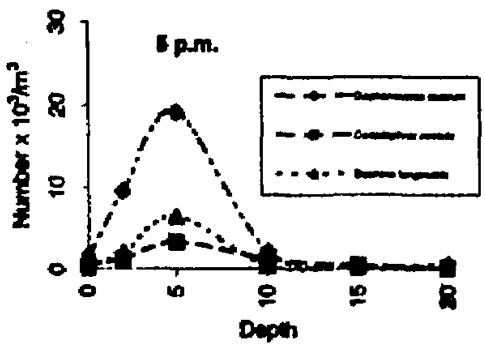
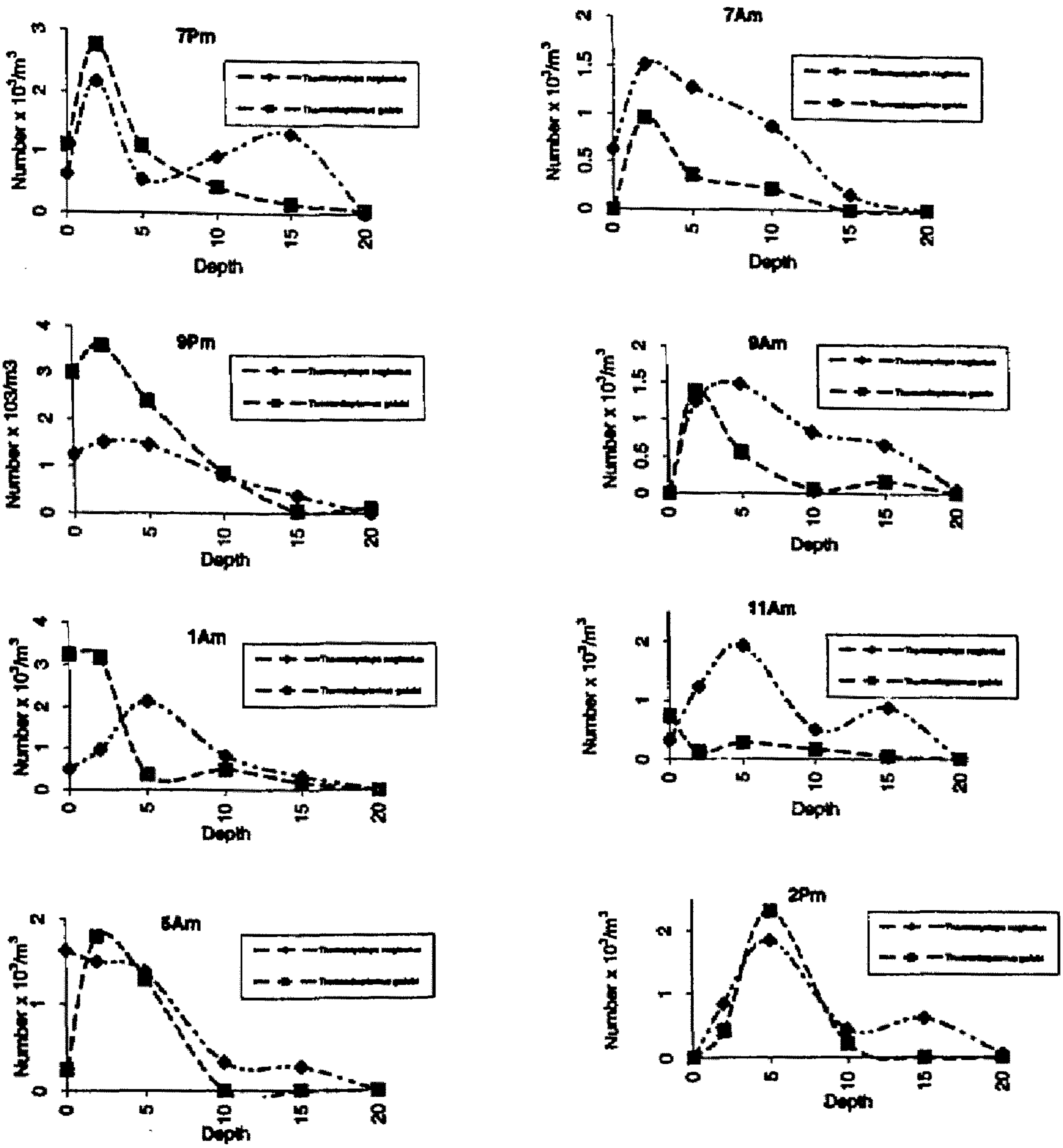


Fig 7: Dial migration of Cladocera species (organisms/m^3) at the first lake of Wadi El Rayan Lakes.



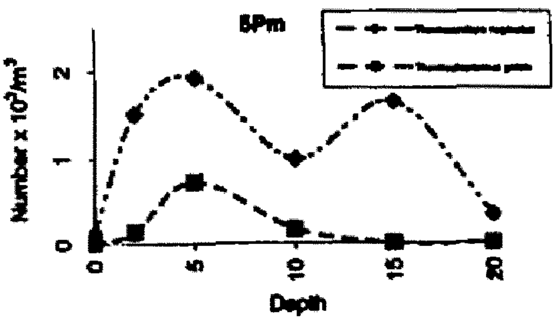


Fig 8: Dial migration of the dominant copepod species (organisms/m3) at the first lake of Wadi El Rayan Lakes.

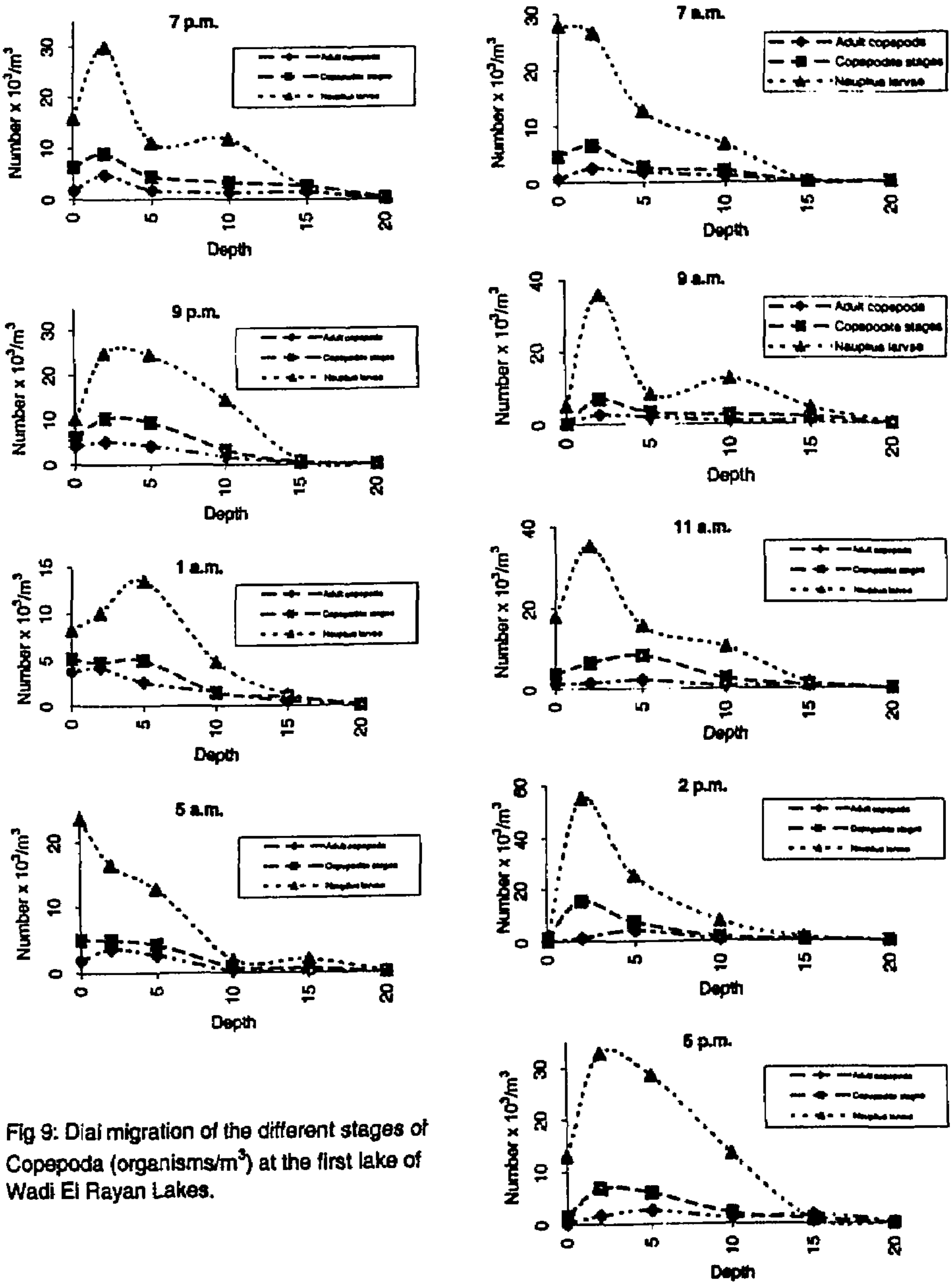


Fig 9: Dial migration of the different stages of Copepoda (organisms/m^3) at the first lake of Wadi El Rayan Lakes.