EGYPTIAN JOURNAL OF AQUATIC RESEARCH 1687-4285
VOL. 32 NO. 1, 2006: 158- 167.

BIOMASS, PRODUCTION, AND TURNOVER RATE OF ZOOPLANKTON IN LAKE MANZALA (SOUTH MEDITERRANEAN SEA, EGYPT)

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Keywords: Zooplankton, biomass, secondary production, turnover rate, Lake Manzala.

ABSTRACT

Biomass, production, and biomass turnover rate (productivity, P/B) of zooplankton were calculated from monthly zooplankton samples in Lake Manzala to estimate the carrying capacity of zooplanktivore fish. The estimated mean biomass was 0.158 g Carbon m^{-3}. Spring followed by summer was the highest productive seasons due to the flourishing of rotifers during this period. The mean secondary production in Lake Manzala was 4.198 g C m^{-3} Yr^{-1}. This production can increase zooplanktivore yield in Lake Manzala by 24.13 % of the actual total catch of the fish yield per year.

1. INTRODUCTION

Zooplankton is important food sources for the larvae and some adult fish of many fish communities (Mavuti & Litterick, 1981). The impact of fish predation on zooplankton abundance is indicated by Serruya and Pollingher (1983), where significantly lower plankton density was associated with the presence of the planktivore fish, *Gambussia affinis*, in Lake Mariut. In Lake Manzala, zooplankton are mainly preyed upon by tilapias fry and grey mullets (Shaheen *et al.,* 1980; Lemoalle, 1987; and Abdel-Baky *et al*., 1989).

Zooplankton of Lake Manzala made the object of numerous studies. Its species composition, distribution, abundance and seasonal changes are well known (El-Maghraby *et al*., 1963; Guergess, 1979; MacLaren, 1982; Khalifa & Mageed, 2002; and Mageed, under publication). The zooplankton of Lake Manzala is composed of organisms of varying size: crustaceans (as; Copepoda, Cladocera, and Decapoda) and rotifers (mostly small forms like *Keratella*) as well as larvae of Mollusca (veliger) and Cirripedia (nauplius). The biomass and production of these organisms differ according to their size (Wiktor, 1990).

The estimate of zooplankton secondary production is one of the goals of studies on ecological dynamics in aquatic ecosystems (Kimmerer & McKinnon, 1987 and Guerrero & Rodriguez, 1997), since zooplankton is on a principal pathway in the energy flow in the ecosystem, viz., which constitutes the link between primary production on one hand, and fish, as secondary consumers, on the other hand.

Carbon biomass of zooplankters are essential for the evaluation of secondary production and the construction of models on energy and carbon flux through the zooplankton (Culver & De Mott, 1978; Serruya *et al.,* 1980; and Manca & Comoli, 2000). Zooplankton biomass as carbon can be used to track changes in the trophic status of Lake Manzala and is important as fish food. On the other side, no body tried to calculate secondary production. Thus the aim of this study is an attempt to estimate the zooplankton production and evaluation of the carrying capacity for zooplanktivore fish. It will help in calculation of the productive power of the lake and its efficiency as a fishing ground.

2. MATERIAL AND METHODS

Monthly field trips per annum were carried out for collection of zooplankton samples. Ten sampling stations were selected to represent different microhabitats of the lake (Fig. 1). Zooplankton samples were collected by filtration of thirty liters of lake surface water filtered through 55 µm mesh size plankton net. Samples were fixed with 5% formalin solution and examined under a binocular research microscope. Three successive sub-samples were examined and the average count was taken. The abundance of zooplankton is taken from Mageed (in press).

The carbon content (g C m^{-3}) of zooplankton was estimated from the individual species densities, according to Edmondson & Winberg (1971), Mavuti (1983 & 1990), Wiebe (1988). The relationship between production (P, g C m^{-3} yr^{-1}) and biomass (B, g C m^{-3}) for zooplankton species were estimated by Morgan *et al.* (1980).

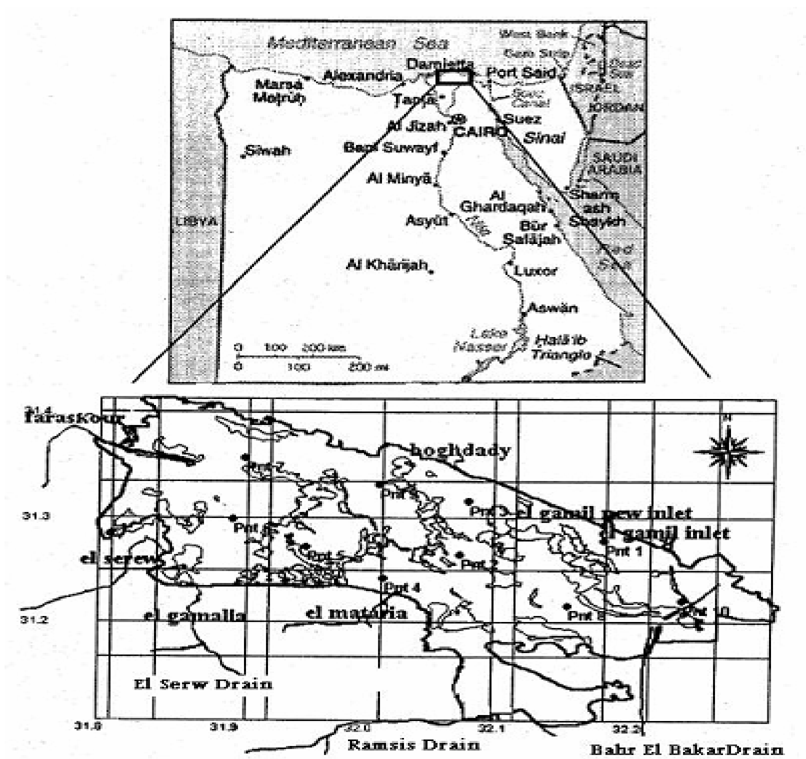

Fig. (1): Percentage frequency of zooplankton biomass as carbon in Lake Manzala

3. RESULTS

3.1. Biomass of zooplankton as carbon:

In Table (1), the carbon temporal variations of zooplankton groups are shown. The carbon content of zooplankton was represented by 60% rotifers, 22% copepods, and 12% cladocerans in addition to 6% of the others (Fig. 2).

Rotifera, ranked the first group with mean carbon of 0.095 g C m^{-3}. The maximum rotifer carbon concentration was noticed during April and June (0.233 and 0.205 g C m^{-3} respectively), while the lowest value was noticed during November (0.010 g C m^{-3}). *Brachionus plicatilis* was the main bulk of rotifer biomass.

Carbon content of copepods was lower than rotifers. The carbon concentrations ranged from 0.004 to 0.115 g C m^{-3} with a mean of 0.035 g C m^{-3}. In spite of the maximum number of copepods was recorded during July (489 g C m^{-3}), the carbon of copepods was 0.080 g C m^{-3}. The maximum value of the copepods carbon was found during February (0.115 g C m^{-3}).

Cladocera showed a density range of 1 to 12 individual L^{-1} and were composed of predominance of *Moina rectirostris*, which was relatively more important in numbers. In Mageed (under publicaion), the composition of cladocerans is described in more detail. Their carbon ranged from 0.002 to 0.059 g C m^{-3} and their mean concentration was 0.019 g C m^{-3} (12% of zooplankton carbon).

Other groups were dominated by Cirripedia. They gave 0.009 g C m^{-3} to the carbon pool in Lake Manzala.

3.2. Secondary production and biomass turnover rate (P/B ratio):

Production and biomass turnover rate of zooplankton in Lake Manzala were monthly variable, ranging from 0.569 to 8.927 g Carbon m^{-3} yr^{-1} for secondary production and from 55 to 96 yr^{-1} for productivity (P/B). The average of biomass turnover rate for zooplankton was 76 yr^{-1} (2.5 day^{-1}). The highest production and turnover for biomass was calculated for rotifers (Table 2).

Production of rotifers was high from March to August (avg. 4.625 g C m^{-3} yr^{-1}) and low during autumn and beginning of the year. Production of Crustacea (copepods and cladocerans) was high during February and March, while the lowest values were calculated during January, June, October and December.

For Biomass turnover rate, rotifer P/B ranged between 16 and 34 yr^{-1} while it was between 13 & 28 for copepods and 11 & 24 yr^{-1} for cladocerans.

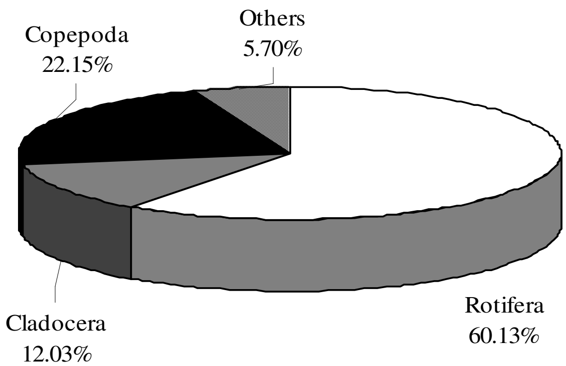

Fig. (2): Percentage frequency of zooplankton biomass as carbon in Lake Manzala

Table (1): Temporal variations in biomass of rotifers, cladocerans, copepods, and other groups as carbon (mg Carbon m^{-3}) in Lake Manzala.

	Rotifera	**Copepoda**	**Cladocera**	**Others**	**Total**
January	0.026	0.015	0.007	0.042	0.090
February	0.019	0.115	0.009	0.012	0.154
March	0.126	0.074	0.059	0.013	0.272
April	0.233	0.042	0.006	0.005	0.286
May	0.085	0.019	0.047	0.007	0.158
June	0.205	0.013	0.003	0.014	0.234
July	0.142	0.030	0.003	0.003	0.178
August	0.109	0.059	0.022	0.003	0.193
September	0.071	0.033	0.042	0.002	0.148
October	0.021	0.006	0.006	0.001	0.033
November	0.010	0.009	0.022	0.003	0.044
December	0.099	0.004	0.002	0.002	0.107
Average	0.095	0.035	0.019	0.009	0.158

Table (2): Annual production (g Carbon m^{-3} $Year^{-1}$) and biomass turnover rate (P/B, yr^{-1}) of rotifers, cladocerans, copepods, and other groups in Lake Manzala.

	Rotifera		Copepoda		Cladocera		Others		Total	
	P	P/B	P	P/B	P	P/B	P	P/B	P	P/B
January	0.525	20	0.26	17	0.097	15	0.946	22	1.828	74
February	0.342	18	3.257	28	0.135	15	0.198	17	3.932	79
March	3.664	29	1.9	26	1.428	24	0.223	17	7.214	96
April	7.845	34	0.928	22	0.085	14	0.069	13	8.927	83
May	2.255	27	0.345	18	1.074	23	0.105	15	3.779	83
June	6.685	33	0.216	17	0.03	11	0.231	17	7.162	78
July	4.244	30	0.623	21	0.03	11	0.043	12	4.94	74
August	3.056	28	1.438	24	0.432	19	0.031	12	4.957	83
September	1.802	25	0.693	21	0.947	22	0.02	11	3.461	79
October	0.403	19	0.081	14	0.08	14	0.005	8	0.569	55
November	0.156	16	0.199	22	0.417	19	0.04	12	0.811	69
December	2.699	27	0.054	13	0.024	11	0.022	11	2.799	62
Avg.	2.806	26	0.833	20	0.398	17	0.161	14	4.198	76

4. DISCUSSION

The seasonal pattern of the zooplankton organisms in Lake Manzala shows a cycle characterized by an increase in carbon from the beginning of spring to September, followed by a consistent decrease during winter.

Lake Manzala is highly productive, with a mean zooplankton production of 4.198 g C m^{-3} $year^{-1}$. This value is one order of magnitude higher than those found for the oligotrophic sub-tropical systems, Lake Sybaia-South Africa (Hart & Allanson, 1975); and tropical Awasa Lake-Ethiopia (Mengistou 1989); but lower than those reported for the temperate lakes, Lake Nakuru (Vareschi & Jacobs, 1984) and Flosek Lake (IBP, in Saunders & Lewis 1988) (Table 3). Levels of biomass and secondary production in Lake Manzala are closely reflecting its advanced eutrophicated conditions and dominance of small zooplankon forms (rotifers).

The zooplankton organisms are classified according to their feeding habits as filter-feeders, raptorial-feeders or suspension-feeders (Kankaala, 1987 and Hansen *et al*., 1994). Filter-feeding species are able to feed on bacterial sized food (Hessen *et al*., 1986 and Koski *et al*., 1999), while suspension feeders prefer slightly larger prey, and raptorial feeders are able to grab individual particles, such as large diatoms or ciliates (Hansen *et al*., 1994). The proportion of filter-feeding rotifers and cladocerans to raptotial and carnivore copepods has been noticed to increase with increasing trophic status and increasing bacterial production of an area (Kankaala, 1987 and Johansson, 1992). The total viable bacterial counts were much high in Lake Manzala, ranging between 0.2 x 10^8 to 45.7 x 10^8 ml^{-1} at 22ºC and 0.14 x 10^8 to 49.5 x 10^8 ml^{-1} at 37ºC (Sabae, 2000). Phytoplankton in Lake Manzala was dominated by Cyanophyceae at the effluent of Bahr El-Bakar drain (45.8% of total crop) and diatoms & Chlorophyceae at the other sites with a conspicuous bloom in April (El-Sherif and Gharib, 2001). Lake Manzala considered eutrophic lake (Donia and Hussein, 2004). Therefore, rotifers can always find sufficient food for growth at maximum rate. The pool of alive zooplankton carbon flux in Lake Manzala is mostly of the rotifers with their richness during spring.

Copepod (as a carnivore organisms) production during February is assumed to control the abundance of rotifers biomass, while the decline of the copepod production during spring is accompanied by rotifer production. This agrees with results of Lignell *et al.* (1993) and Koski *et al.* (1999).

Zooplankton had considerable biomass turnover rates or P/B ratio, with turnover time of 2.53 day^{-1} (76 yr^{-1}). It was comparable with Darss Zingest estuary in DDR (2.5day^{-1}). (Schiewer *et al*., 1990). In Lake Awasa, it was 0.14 day^{-1}, for crustacean community (Mengestou & Fernando 1991). Rotifers had the maximum turnover rates during the present study, with turnover time of 0.87 day^{-1}.

Abdel-Baky *et al.* (1989) found that zooplankton (especially rotifers) were the most abundant food organisms in the gut of *T. zillii* and *O. aureus* during their studies on the feeding habits of cichlid fishes in Lake Manzala. The highest feeding activity occurred at summer and spring. In spite of this predation on zooplankton, the production of zooplankters is still high.

From GADFR (General Authority for Development of Fish Resources-Egypt), the annual fish production from Lake Manzala during the study period was 65,015 Tons y^{-1}. The annual production of zooplankton for Lake Manzala as Carbon was estimated at, P= 4.198 g C m^{-3} yr^{-1}. Assuming a 10% conversion efficiency from zooplankton production to fish production (Sheldon *et al*., 1977; Borgmann *et al*., 1984), the zooplankton stock can sustain an annual production of zooplanktivore in Lake

Manzala (*ca.* 29,000 feddan) equal to 15,689 Tons Yr^{-1}.

The zooplankton composition implicitly showed that most zooplankton community is not utilized by the higher trophic level consumers, it sink and become not available; thus it is a potential food resource for fish and could be exploited to increase fishery production from the lake. Therefore, the standing crop biomass and production of the zooplankton is sufficient to make worthwhile the introduction into the lake of a commercially suitable and a planktivorous fish to exploit the uncropped zooplankton. Thus, we can add 24.13% of the actual fish yield to Lake Manzala.

With such introduction, however, many important points to be taken into account in the event of any zooplanktivorous fish introduction in Lake Manzala. Of these points; selective predation may lead to a shift in species composition of the zooplankton, increased phytoplankton biomass due to reduced grazing, and the introduced fish species might compete with fry of the juveniles of the other fish species already established in the lake for food and so depress the production of the existing commercial fishery.

Table (3): Mean biomass (B, g $C.m^{-3}$), production (P, g $C.m^{-3}$ yr^{-3}) and turnover rate productivity (P/B ratio, yr^{-1}) for zooplankton in some tropical and temperate lakes.

Lakes	Lat.	B	P	P/B	References
Sibaya	27.0´S	0.033	1.3	40.6	Hart and Allanson (1975)
Awasa	6.3´N	0.040	2.2	55.8	Mengistou (1989)
Tana	11-12´N	0.174	6.7	38.5	Wudneh (1998)
George	0´	0.249	7.2	28.7	Burgis (1974)
Chad	12-14´N	0.380	26.5	69.7	Carmouze *et al.* (1983)
Lanao	8´N	0.668	27.3	41.0	Lewis (1979)
Tjeukemeer		0.700	20.0	26.0	Vijverberg & Richter (1982)
Valencia	10´N	1.025	39.1	38.1	Saunders & Lewis (1988)
Nakuru	0´	1.135	136.0	119.9	Vareschi & Jacobs (1984)
Flosek (IBP)	54´N	1.450	41.9	28.9	Saunders & Lewis (1988)
Manzala	31°15´N	0.158	4.198	76	Present study

IBP, results from International Biological Programme in Saunders & Lewis (1988)

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