Assessment of Zooplankton Community Structure of the Bahir Dar Gulf of Lake Tana, Ethiopia

***Imoobe, T. O. T. and **Akoma O. C.**

Abstract

The zooplankton composition of the Bahir Dar gulf of Lake Tana was studied in June and July, 2007. A total of forty four zooplankton species made up of 16 species of rotifers, 16 species of cladocerans and 12 species of copepods and their developing stages were recorded in the following order of dominance; Rotifera > Cladocera > Cylopoida > Calanoida. The number of species was not too different among the three sampling Stations, however, average zooplankton abundance, was significantly higher (P<0.05) at the littoral stations 3 and 2 than the open water Station 1 due to the small-bodied nauplii stages, small rotifers and cladocerans particularly Bosmina longirostris. In general, species richness, evenness, and diversity increased as average abundance increased in the littoral zones of the lake. The dominant zooplankton were Bosmina longirostris, Daphnia lumholtzi, Thermodiaptomus galebi, Thermocyclops ethiopiensis, Diaphanosoma sarsi, Keratella sp., Brachionus sp., Filinia sp. and Trichocerca longiseta. The rotifers particularly, the brachionids consistently occurred at all stations and was the most dominant zooplankton group in terms of abundance and diversity. This study showed that the lake is not polluted, and has a high potential for thriving fishery.

Key words: *Zooplankton, Bahir Dar Gulf, Lake Tana, Ethiopia.*

Introduction

The dominant zooplankton in freshwater ecosystems are rotifers and micro-crustaceans made up of cladocerans and copepods. Generally, zooplankton occupies a central position in the trophic link between primary producers and higher trophic levels; they are also good bio-indicators of the physical and chemical conditions of aquatic environments which cause changes in the qualitative and quantitative composition of zooplankton and influence their densities (Gliwicz, 1974; Radwan 1973, 1976; Hillbricht-Ilkowska, 1977; Karabin, 1985; Matveeva, 1991).

In Lake Tana, zooplankton has been reported as an essential component of the biodiversity. A few existing investigations of the zooplankton in Lake Tana have been those by Brunelli & Cannicci (1940), Rzóska (1976), and Wudneh (1998). Recently Dejen *et al.* (2002) reported the importance of micro-crustaceans in the diet of two 'small barbs', *Barbus tanapelagius* and *B. humilis* which are the basis for the commercial fish production in the Lake, while Dejen *et al*. (2004) investigated the temporal and spatial distribution of micro-crustacean zooplankton in relation to turbidity and other environmental factors in the lake, and Wondie & Mengistou (2006) investigated the duration of development, biomass and rate of production of the dominant copepods (calanoida and cyclopoida).

In this paper we examined the zooplankton community structure and the physico-chemical conditions in the Bahir Dar gulf of Lake Tana, because the abundance of major zooplankton divisions (e.g., Rotifera, Copepoda) are important to show changes in trophic state of a water body (Gannon & Stemberger, 1978; Pace, 1986).

Materials and Methods

Study sites

The location of Lake Tana in Ethiopia, its catchment area and its shape is shown in Fig 1. Lake Tana is located in the north-western range of the Ethiopian highlands in the Amhara region of the Federal Democratic Republic of Ethiopia. It straddles the provinces of Gojjam and Gondar and it is Ethiopia's largest lake and the source of the Blue Nile. At approximately 1,800 m above sea level, it is a high altitude lake. According to Mohr (1961) the Tana-rift in which Lake Tana lies is a shallow trough which is not directly connected to the main Eastern Rift Valley but is certainly related to it. From geological evidences the lake probably formed through volcanic blocking of the Blue Nile in early Pleistocene times. Subsequently the lake basin filled up and now covers an area of approximately 3150 km^2. The lake is bordered by low plains in the north, east and south-west that are often flooded in the rainy season forming extensive wetlands and some steep rocky shores in the west and north-west (Nagelkerke, 1997).

**Department of Animal and Environmental Biology,University of Benin, Benin-City, Nigeria.*
***Department of Biology, Bahir Dar University,Bahir Dar, Ethiopia. osonduakoma@yahoo.com*

At the southernmost tip of the lake is the city of Bahir Dar and the gulf extends for approximately 10 km from the shore line.

In the present study, samples were collected from three points in the Bahir Dar gulf area; two shoreline stations and one pelagic station as follows:

- Station 1 is on the open water about 10 km from the southernmost point of the lake at the 'Mango Park' in Bahir Dar City.
- Station 2 is at the shoreline by Tana Hotel/Shum-Abo Resort. The shoreline vegetation comprise predominantly of the following macrophytes - *Ceratophyllum demersum* L. (Ceratophyllaceae), *Typha latifolia* L.(Typhaceae) *Nymphaea* sp. (Nymphaeaceae), *Potamogeton heterophyllus* Schreb. (Najadaceae) and *Lemna* sp.
- Station 3 is at the shoreline by the Bahir Dar Resort area. The station is adjacent to one of the lake wetlands used extensively for livestock grazing and subsistent vegetable farming. *Typha latifolia* and *Nymphaea* sp. were observed as the dominant vegetation.

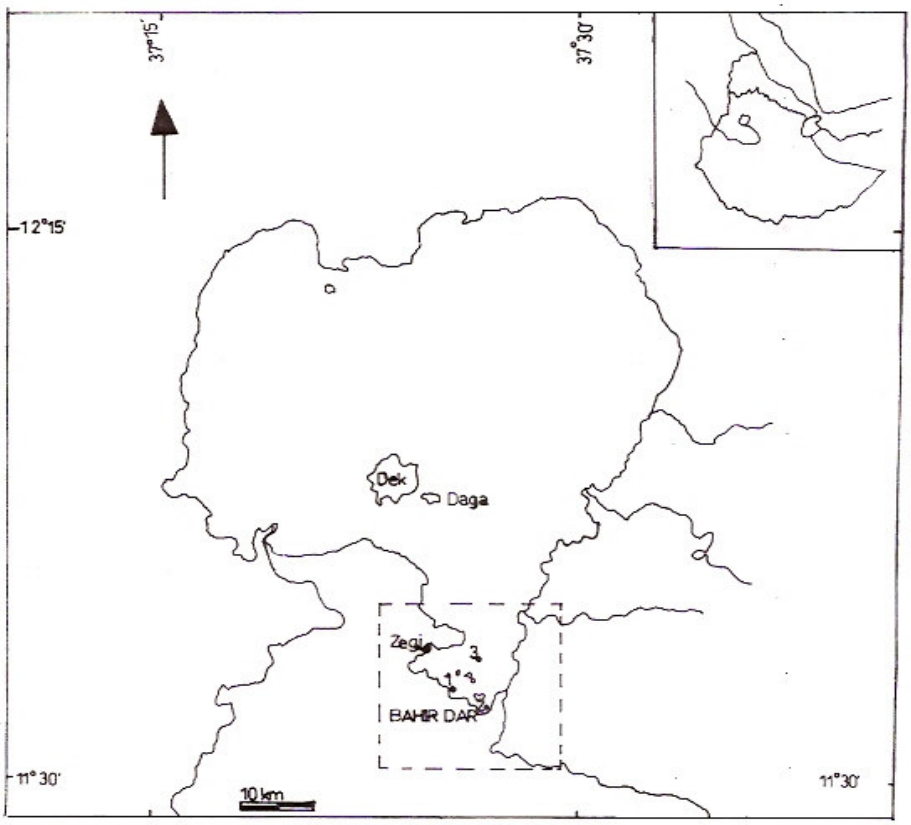

FIG. 1 MAP OF LAKE TANA SHOWING BAHIR DAR GULF AND SAMPLE STATIONS

Environmental conditions

Generally, water temperature ranged between 22.2 and 25 ^{o}C throughout the study with the highest mean temperature value (24.13±0.59 ^{o}C) recorded in station 2. Depth ranged between 0.96 and 4 m across the sampling stations, the pelagic zone of station 1 was significantly ($P<0.001$) deeper than other sections of the lake in the study area. Secchi transparency ranged from a minimum of 0.4 m (station 3) to a maximum of 0.9 m (recorded in station 2). Generally, the lake water was relatively turbid at all the stations.

The water is fresh with conductivity values ranging from 152 to 232µScm^{-1} with a progressive increase from station 1 to station 3. Lowest ionic content of the lake water was recorded in station 1 (156.3±1.93 µScm^{-1}), while the highest record was for station 3 (185.5±15.2). A weak alkaline pH range of 7.3 – 8.5 was observed across the stations. Dissolved oxygen concentration values (1.667mgl^{-1} - 7.7mgl^{-1}) recorded in the Bahir Dar gulf of Lake Tana were significantly lower ($P<0.05$) in station 3 than other stations. The essential primary productivity nutrient, nitrate was comparatively higher (0.92 - 4.18mgl^{-1}) than phosphate (0.1 to 0.61mgl^{-1}). A summary of some physical and chemical conditions of the study stations is presented in Table 1.

Sampling and analysis

Fortnightly sampling of the Bahir Dar gulf of Lake Tana was carried out in the early wet season months of June and July 2007 to investigate physico-chemical conditions, and plankton assemblages. Samples were collected from the three stations using a 3.5 liter capacity Van Dorn water sampler. Triplicate samples were collected with the water sampler at different depth intervals and homogenized before being sub sampled for physico-chemical analyses. Temperature, depth and Secchi disc transparency were taken *in-situ* during the survey. Conductivity, dissolved oxygen and pH were also recorded *in-situ* using a WTW water sampler probe. Nitrate and phosphate were determined colometrically using Palintest analytical kit.

Vertical plankton hauls were made at each of the sample stations using a 55µm net and immediately fixed in 4% formaldehyde solution. Observation and identification of zooplankton to species level was done with an Olympus model microscope and classification was with the aid of relevant literatures (Korinek, 1999; Flössner, 2000; Smirnov, 1996; Defaye, 1988; Van de Velde, 1984), in the zooplankton Laboratory of the Department of Animal and Environmental Biology, University of Benin, Benin City Nigeria.

Results

Zooplankton Composition, Abundance, Diversity and Spatial Distribution

Table 2 shows the zooplankton species encountered in Bahir Dar Gulf of Lake Tana and their relative abundance at the sampled stations. Forty four zooplankton species made up of 16 species of rotifers, 16 species of cladocerans and 12 species of copepods and their developing stages were recorded. The number of species was not too different among the three sampling Stations, generally ranging between 33 in the open water (Station 1) and 40 in the Littoral Station 2. Average zooplankton abundance, was significantly higher ($P<0.05$) at stations 3 and 2 than Station 1. The highest average zooplankton abundance (in station 3) was about 1.5x the average abundance in the most sparsely populated Station 1 (open water). In general, species richness, evenness, and diversity increased as average abundance increased in the littoral zones of the lake (Table 3).

The cyclopoid copepods which constituted 75% of the copepod species found in the lake were of relatively high densities at the three stations particularly the littoral stations 2 and 3. Out of the nine cyclopoid copepod species, *Thermocyclops ethiopiensis and Mesocyclops aequatorialis similis* were the most abundant. Calanoids, nauplii and copepodites were also abundant at all three stations. The calanoid copepod *Thermodiaptomus galebi lacustris* was the dominant calanoid copepod. Most of the cladocerans were in the families bosminidae, sididae and daphnidae. Chydorids, and moinids were found in relatively fewer numbers at all three stations while macrothricids were found only at the littoral Stations 2 and 3. *Bosmina longirostris*, *Daphnia hyalina, Daphnia lumholtzi* and *Diaphanosoma sarsi* were the most abundant cladoceran species. The rotifers particularly, the brachionids consistently occurred at all stations and was the most dominant zooplankton group in terms of abundance and diversity. The zooplankton groups occurred in

the following order of dominance; Rotifera > Cladocera > Cylopoida > Calanoida.

The zooplankton population showed a significant spatial variation with the highest densities in the littoral, and the lowest densities in the pelagic zone. Stations 2 and 3 always recorded the highest zooplankton abundance, with an average of 759 and 876 individuals/m^3 in Stations 2 and 3 respectively. The open water station 1 recorded comparatively lower abundance of an average of 588 individuals/m^3. The high values recorded at these stations were mostly due to the small-bodied nauplii stages, small rotifers and cladocerans particularly *Bosmina longirostris*. Densities of large bodied Cladocera and Calanoida were low during the period of investigation.

Discussion

The forty four zooplankton species reported in this study is a mixture of tropical and temperate species, most of which have earlier been reported from the lake (Wudneh, 1998**;** Dejen *et al.,* 2004). The presence of temperate species is most probably due to the generally low water temperature of the lake as a result of its location in a high altitude. The number of zooplankton species reported here can be described as high when compared with previous reports from the area. Brunelli & Cannicci (1940) had listed a total of 26 zooplankton species, consisting of 3 copepods, 11 cladocerans and 12 rotifers. *Bosmina longirostris*, *Thermodiaptomus galebi*, *Diaphanosoma excisum*, *Ceriodaphnia bicuspidata*, *Daphnia longispina*, *Moina dubia*, *Mesocyclops leuckarti*, *Ceriodaphnia sp*, *C.cornuta*, *Cyclops albidus*, being the predominant species; while A total of 17 species, which include 3 Copepoda, 7 Cladocera, and 7 Rotifera was reported by Wudneh (1998) with the predominant species in the community being *Thermodiaptomus galebi*, *Thermocyclops sp. Mesocyclops sp*, *Bosmina longirostris, Diaphanosoma excisum*, *Keratella quadrata*, *K. crassa* and *Brachionus falcatus*. Dejen *et al.* (2004) reported a total of 13 species, four copepods and nine cladocerans, the calanoid copepod *Thermodiaptomus galebi lacustris*, dominated the zooplankton community, while *Thermocyclops ethiopiensis* was the most abundant cyclopoid. *Bosmina longirostris*, *Daphnia hyalina, Daphnia lumholtzi* and *Diaphanosoma sarsi* were the most abundant cladoceran species. In the present study *Bosmina longirostris*, *Daphnia lumholtzi, Thermodiaptomus galebi*, *Thermocyclops ethiopiensis, Diaphanosoma excisum, Keratella sp*. and *Brachionus sp*. *Filinia sp. and Trichocerca longiseta,* have been found to still be important among the zooplankton in Bahir Dar Gulf of Lake Tana. The rotifer family Brachionidae which constituted 29% of the zooplankton population is dominant and this conforms to generally known fact as the most dominant in terms of species in freshwater ecosystems in other parts of the world (Egborge & Chigbu, 1988; Akinbuwa & Adeniyi 1991; Fernando, 1980a; Arcifa, 1984; Sendacz, 1984). Diversity of the limnetic cladocerans is relatively high because of the co-occurence of both tropical and temperate species particularly the daphniids as compared with other African Lakes and reservoirs (Dumont, 1994; Marshall, 1997).

There was a clear spatial pattern in the zooplankton distribution in this study, densities per litre being high in the littoral zone and reduced toward the deeper open water areas. This supports the findings of Sladecek (1983), Egborge & Chigbu (1988), Wudneh (1998) and Akinbuwa & Adeniyi (1991) that the bulk of the zooplankton often occur at the littoral zones. This is however, in contrast with Dejen *et al.* (2004), who reported that in Lake Tana the cladocerans were most abundant in the sublittoral zone and least abundant in the littoral zone because the littoral zones sampled were devoid of aquatic macrophytes. Large lakes have been reported (Patalas & Salki, 1993) to have greatest abundance at the littoral zones, and Lake Tana is a large lake. However, a possible factor explaining the low abundance of zooplankton in the deeper part of the lake could be the high predation pressure in the open water. According to Dejen *et al*. (2004) adult *Clarias gariepinus*, *Barbus brevicephalus* and *Barbus trispilopleura*, are important predators on zooplankton, and are more abundant in the open water. The impact of predation on zooplankton abundance is also indicated by Serruya & Pollingher (1983), where significantly lower plankton density was associated with the presence of the planktivore fish, *Gambussia affinis,* in Lake Mariut, Egypt.

The relative percentage compositions of the various groups of zooplankton show that the small sized zooplankton dominated the community. These high values were mostly due to small-bodied nauplii stages, high densities of small rotifers and cladocerans which are characteristic of lakes with planktivorous fishes. Densities of large bodied Cladocera and Calanoida were low during the period probably as a result of predation pressure. The size range in this study was similar to that found in other tropical freshwater bodies in Africa, South-East Asia and Latin America (Burgis *et al.* 1973; Fernando, 1980b; Zaret, 1980; Arcifa, 1984).

Conclusions

The zooplankton community structure of Bahir Dar Gulf of Lake Tana is a mixture of tropical and temperate species, thus resulting in the relatively high biodiversity of limnectic zooplankton in this lake. Majority of the zooplankton are small-bodied nauplii stages, high densities of small rotifers and cladocerans found in larger number in the littoral zone than the pelagic zone an indication of the presence of abundance of planktivorous fishes in the open water.

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Table 1 Summary of Physico-Chemical Properties in the Bahir Dar Gulf of Lake Tana.

	Station 1		**Station 2**		**Station 3**	
Parameters	**Range**	**X±SE**	**Range**	**X±SE**	**Range**	**X±SE**
Temperature ^{o}C	22.2-24	23.03±0.37	23.5-24.9	24.13±0.59	23-25	23.7±0.44
Depth m	3.5- 4.00	3.73± 0.10	1.58-2.25	1.91±0.15	0.96-1.8	1.27±0.19
Transparency m	0.4-0.57	0.49 ± 0.03	0.4-0.9	0.58±0.11	0.4-0.56	0.51±0.04
Conductivity µScm^{-1}	152-160	156.3±1.93	153-165	160.5±2.72	169-232	186.5±15.2
pH	8.3-8.4	8.45± 0.02	8.2-8.5	8.31±0.07	7.3-8.2	7.78±0.18
Nitrate mgl^{-1}	0.92-3.3	1.92 ± 0.50	0.97-3.5	2.31±0.56	0.97-4.18	2.61±0.80
D.O mgl^{-1}	5.9 -7.7	6.66 ± 0.53	3.5-7.2	5.50±1.06	1.66-5.06	2.84±1.11
Phosphate mgl^{-1}	0.14-0.16	0.16± 0.00	0.22-0.61	0.43±0.11	0.1-0.18	0.15±0.03

Table 2: Composition and Distribution of Zooplankton in the Bahir Dar Gulf of Lake Tana.

	S	Open Water (STN 1)	Littoral Zone (STN 2)	Littoral Zone (STN 3)
CLADOCERA				
Family : Bosminidae Sars, 1865	1			
Bosmina longirostris O.F.Muller, 1785		35	55	60
Family : Chydoridae Stebbing, 1902	5			
Sub family : Chydorinae Stebbing, 1902				
Chydorus eurynotus Sars, 1901		5	-	15
Chydorus reticulatus Daday, 1898y		-	5	10
Chydorus sphaericus sphaericus O.F. Müller, 1785		10	5	15
Pleuroxus hamatus Birge, 1879			5	-
Sub family : Aloninae Frey, 1967				
Alona quadrangularis O.F.Muller, 1785		4	-	8
Family : Daphniidae Straus, 1820	5			
Ceriodaphnia cornuta Sars, 1885		5	9	-
Ceriodaphnia rigaudi Richard, 1897		-	5	10
Daphnia hyalina lacustris Sars, 1862		10	15	20
Daphnia longispina Müller, 1785		10	5	10
Daphnia lumholtzi (F. monacha)		15	20	20
Family : Macrothricidae Baird, 1843	2			
Echinisca triserialis Brady, 1886		-	5	9
Macrothrix laticornis (Jurine, 1820)		-	4	5
Family : Moinidae Goulden, 1967	1			
Moina micrura Kurz, 1874		5	5	-
Family :Sididae Sars, 1865	2			
Diaphanosoma excisum Sars, 1885		5	5	10
Diaphanosoma sarsi Richard, 1895		10	15	20
Copepoda				
Order Cyclopoida	9			
Cryptocyclops linjanticus Kiefer, 1928		5	15	20
Ectocyclops phaleratus Koch, 1838		2	-	5
Mesocyclops aequatorialis similis		16	29	20
Mesocyclops bodanicola Kiefer 1928		5	15	15
Microcyclops minutus		-	6	-
Microcyclops varicans Sars, 1863		5	5	10
Thermocyclops ethiopiensis		15	25	30
Thermocyclops hyalinus		-	10	12
Thermocyclops neglectus Sars, 1901		8	-	8

Order Calanoida	3			
	S	**Open Water (STN 1)**	**Littoral Zone (STN 2)**	**Littoral Zone (STN 3)**
Eudiaptomus gracilis Sars, 1863		10	5	15
Thermodiaptomus galebi lacustris		30	35	40
Tropodiaptomus neumaniia		-	9	5
Developing Stages				
Copepodite larvae		40	40	35
Nauplius larvae		65	50	60
Rotifera				
Class Monogononta; Order Ploima				
Family Asplanchnidae	1			
Asplanchna brightwelli Gosse, 1850		10	15	10
Family Brachionidae	6			
Brachionus calyciflorus Pallas, 1776		25	30	40
Brachionus caudatus caudatus Barrois & Daday, 1894		15	20	30
Brachionus diversicornis Daday, 1885		8	6	-
Brachionus falcatus falcatus Zacharias, 1898		20	25	30
Keratella cochlearis cochlearis Gosse, 1851		60	75	70
Keratella tropica tropica (Apstein, 1907)		55	60	75
Family Euchlanidae	1			
Euchlanis dilatata (Ehrenberg, 1932)		-	5	8
Family Gastropodidae	1			
Ascomorpha ovalis (Bergendahl, 1892)		-	5	3
Family Lecanidae	1			
Lecane bulla Gosse, 1886 (Monostyla)		-	5	4
Family Synchaetidae	1			
Polyarthra remata		6	8	5
Family Trichocercidae	3			
Trichocerca cylindrica chattoni Imhof, 1891		9	10	6
Trichocerca longiseta (Schrank, 1802)		25	35	30
Trichocerca similis Wierzejski, 1893		10	8	8
Class Monogononta; Order Floscullariacea				
Family Filinidae	2			
Filinia longiseta Ehrenberg, 1834		20	30	35
Filinia opoliensis Zacharias, 1898		10	20	35

S = Total number of species in each family

Table 3. Total number of species.

	S	N	D	E	H'
Open water Station 1	33	588	5.178	0.9114	3.1867
Littoral Zone Station 2	40	759	5.995	0.9059	3.3418
Littoral Zone Station 3	39	876	5.705	0.9158	3.3553

(S), Average number of individuals/m^3 (N), Margalef richness (D), Evenness (E), and Shannon diversity (H') for each Station averaged over all sampling dates.