GCP/RAF/271/FIN–TD/64 (En) July 1997

RESULTS OF ZOOPLANITON SAMPLING FROM JULY 1995 TO JULY 1996 AND COMPARISON WITH THE RESULTS FROM JULY 1993 TO JUNE 1995

by
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FINNISH INTERNATIONAL DEVELOPMENT AGENCY

FOOD AND AGRICULTURAL ORGANIZATION
OF THE UNITED NATIONS

Bujumbura, July 1997

The conclusions and recommendations given in this and other reports in the Research for the Management of the Fisheries on the Lake Tanganyika Project series are those considered appropriate at the time of preparation. They may be modified in the light of further knowledge gained at subsequent stages of the Project. The designations employed and the presentation of material in this publication do not imply the expression of any opinion on the part of FAO or FINNIDA concerning the legal status of any country, territory, city or area, or concerning the determination of its frontiers or boundaries.

PREFACE

The Research for the Management of the Fisheries on Lake Tanganyika project (LTR) became fully operational in January 1992. It is executed by the Food and Agriculture Organization of the United Nations (FAO) and funded by the Finnish International Development Agency (FINNIDA) and the Arab Gulf Program for the United Nations Development Organization (AGFUND).

LTR's objective is the determination of the biological basis for fish production on Lake Tanganyika, in order to permit the formulation of a coherent lake—wide fisheries management policy for the four riparian States (Burundi, Tanzania, Republique D6mocratique du Congo, Zambia).

Particular attention is given to the reinforcement of the skills and physical facilities of the fisheries research units in all four beneficiary countries as well as to the build-up of effective coordination mechanisms to ensure full collaboration between the Governments concerned.

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For bibliographic purposes this document should be cited as follows:

E. M. Bosma, A. Kalangali, S. Muhoza, K. Kaoma, and I. Zulu, 1997 Results of zooplankton sampling from July 1995 to July 1996 and comparison with the results from July 1993 to June 1995. FAO/FINNIDA Research for the Management of the Fisheries of Lake Tanganyika. **GCP/RAF/271/FIN-TD/64 (En): 15p.**

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SUMMARY

This report presents the zooplankton data collected from January 1996 to July 1996 which are combined with that of the previous six months for comparison with the data collected in the preceding years.

During the third sampling year (SSP3: July 1995 - July 1996) the distribution of Copepoda differed from the previous 2 years (SSPl: July 1993 - June 1994, SSP2: July 1994 - June 1995). The lowest Copepoda dry weight biomass was found off Kigoma, whereas previously it was lowest off Mpulungu. The Copepoda dry weight biomass was highest off Bujumbura during all sampling years.

The relationship between the biomass of phytoplankton and zooplankton was not clear. Bacteria production could supply an alternative food source, supporting the abundance of zooplankton at the north end of the Lake. The peaks in abundance of zooplankton during the SSP3 coincided with high gonado-somatic index values of the pelagic fish species.

1 INTRODUCTION

Because of its high transparency, Lake Tanganyika has been described as an oligotrophic lake (e.g. Coulter, 1991); high transparency indicating a low plankton abundance. Although the standing crop of alga is indeed low, it was shown that the algae growth rates are very rapid and levels of primary production surprisingly high in this lake (Burgis 1984; Sarvala and Salonen, 1995; Järvinen *et al.,* 1996).

The abundance of clupeids (Coulter, 1991) indicates either a very efficient transfer of energy between the trophic levels of phytoplankton, zooplankton and fish, or the presence of energy sources other than phytoplankton (Hecky & Fee, 1981; Burgis, 1984)

The main pelagic fish species rely heavily on zooplankton during parts of their life cycle. An understanding of zooplankton dynamics and the role of zooplankton in energy transfer through the food chain is necessary for estimates of the potential production of the fishery.

2 OBJECTIVES

The regular sampling program of zooplankton, part of the Scientific Sampling Program (SSP), was executed by the Lake Tanganyika Research Project (LTR) from July 1993 to July 1996.

The results of the first two and a half years of zooplankton sampling, from July 1993 to December 1995, were presented by Vuorinen & Kurki (1994), Kurki & Vuorinen (1995) and Kurki (1996)

Here data from the last half year of zooplankton sampling, January 1996 to July 1996, are compared with the results given in Kurki (1996).

The aims of this study were to investigate temporal and spatial changes of the crustacean micro-, meso- and macrozooplankton. North to south differences in the structure of the crustacean planktonic community in the pelagic were investigated.

3 MATERIAL AND METHODS

The sampling sites are shown in igure 1. Details of each sampling site are given in Table 1.

Table 1. The distance from shore, depth, latitude, longitude and number of samples taken at the sample sites at Lake Tanganyika during the period July 1995 to July 1996.

Station	Distance (km)	Depth (m)	Latitude	Longitude	N° of samples
Bujumbura	5.5	120	03°28″00′S	29°17″00′E	156
Kigoma	2.5	250-500	04°51″00′S	29°35″00′E	150
Mpulungu	6.5	120	08°43″00′S	31°02″43′E	153

Every week, three replicate samples were taken by towing a net (diameter 25 cm, hauling speed <0.5 ms^{-1}) from 100 meters depth to the surface at all three sampling sites. The samples were preserved in 4% formalin. From each sample a subsample of at least 100 micro- and mesoplankters was taken for identification and counting using an inverted microscope and counting chambers. The remaining sample was examined under a dissecting microscope in a counting tray to identify and count at least 300 macroplankters. The zooplankton number per cubic meter was calculated assuming that the filtration efficiency of the net was 100%.

Sampling, subsampling, identification and counting followed Vuorinen (1993) and Kurki (1993). Data analysis followed Kurki (1996)

In the zooplankton samples the following identified taxa were counted:

Micro- and mesozooplankton	
- cyclopoids	*Microcyclops cunningtoni*
	Thermocyclops oblongatos
	Tropocyclops tenellus
	Mesocyclops aequatorialis aequatoriails
- Calanoids	*Tropodiaptomus simplex*
Macrozooplankton	
- Shrimps	Palaemonidae and Atyidae
- Medusae	*Limnocnida tanganyicae*
- Fish larvae	centropomids and clupeids

For abundance analyses the data were grouped into nauplii and post-naupliar stages although egg carrying females were kept separately. For dry weight biomass calculations the copepodid and adult stages, including the ovigerous females, were pooled. See Table 2 for dryweight values which were used to convert number of Copepoda to Copepoda dry weight.

Table 2. Dry weight values of Copepoda according to Schindler & Noven (1971) and Bottrell *et al.* (1976)

	Adult	Copepodid	Nauplii
calanoids	4.5 µg	2.6 µg	0.4 µg
cyclopoids	4.0 µg	1.5 µg	0.3 µg

The data in previous reports (Vuorinen & Kurki, 1994; Kurki & Vuorinen, 1995; Kurki, 1996) were divided in two solar years, July 1993 to June 1994 (SSPl) and July 1994 to June 1995 (SSP2). The data of July 1995 to December 1995 were presented by Kurki (1996). They are included here in order to be able to compare data of SSP3 (July 1995 to July 1996) with the data from SSPl and SSP2.

4 RESULTS

4.1 Micro- and mesozooplankton

4.1.1 Spatial abundance

Table 3 lists values of mean density, standard deviation, coefficient of variation, number of samples and the percentage contribution to the total Copepoda component of the pelagic crustacea off Bujumbura, Kigoma and Mpulungu. Copepoda were densest off Bujumbura and sparsest off Kigoma. The cyclopoid component of the copepod zooplankton was around 70% at each site.

Nauplii numbers were low compared to the later stages, i.e. around 30 % at all stations. Also the ovigerous female density of both calanoids and cyclopoids was low in all three stations during 55P3. It was highest off Bujumbura (0.5% of total Copepoda) and lowest off Kigoma (0.2%).

Table 3: Mean density (number m^{-3}, standard deviation (SD), coefficient of variation (CV), number of sample dates (n) and percentage contribution to the total Copepoda (% of TOTCOP) of the pelagic mesozooplankton off Bujumbura, Kigoma and Mpulungu.
NAUPTR, COPADTR, OVTR and TOTTR = nauplii, copepodids + adults, ovigerous females and total number of *Tropodiaptomus simplex* respectively.
NAUPCY, COPADCY, OVCY and TOTCY = nauplii, copepodids + adults, ovigerous females and total number of cyclopoids respectively.
NAUPLII, COPAD and TOTCOP nauplii, copepodids + adults + ovigerous females, and total number of calanoids and cyclopoids combined, respectively.

	NAUPT	COPAD	OVTR	TOTTR	NAUPCY	COPADCY	OVCY	TOTCY	NAUPLII	COPAD	TOTCOP
BUJUMBURA											
n=52 Mean	1881	1919	65	3865	2517	9175	30	11721	4399	11189	15587
SD	1489	1158	57	2225	1678	6753	33	7816	2895	7609	9650
CV	0.72	0.64	0.89	0.50	0.61	0.57	0.99	0.53	0.59	0.53	0.49
% of TOTCOP	11.0%	16.8%	0.4%	28.2%	17.2%	54.5%	0.1%	71.8%	28.2%	71.8%	
Kigoma											
n=50 mean	1069	1062	18	2148	966	4746	4	5715	2034	5829	7863
SD	1401	1016	22	2036	1409	3107	5	3473	2312	3580	5072
CV	1.31	0.96	1.25	0.95	1.46	0.65	1.31	0.61	1.14	0.61	0.64
% of TOTCOP	13.6%	13.5%	0.2%	27.3%	12.3%	60.4%	0.0%	72.7%	25.9%	74.1%	
Mpulungu											
n=51 mean	871	2266	18	3155	2643	4340	6	6989	3514	6619	10144
SD	495	725	16	877	1604	1546	7	2706	1869	2037	3321
CV	0.57	0.32	0.91	0.28	0.61	0.36	1.23	0.39	0.53	0.31	0.33
%of TOTCOP	8.6%	22.3%	0.2%	31.1%	26.1%	42.8%	0.1%	68.9%	34.6%	65.2%	

4.1.2 Spatial distribution based on dry weight calculations

Table 4 provides values of mean dry weight, standard deviation, coefficient of variation, number of samples and the percentage contribution to the total Copepoda dry weight biomass of the pelagic crustacea off Bujumbura, Kigoma and Mpulungu. The highest dryweight biomass of Copepoda was found off Bujumbura and the lowest off Kigoma. At the three stations from north to south the dry weight biomass of cyclopoids was times 4, times 3 and times 1.5 that of calanoids respectively.

Dryweight of calanoids decreased at the sampling sites in the order Bujumbura **>** Mpulungu **>** Kigoma. Dryweight of cyclopoids decreased at the sampling sites in the order Bujumbura **>** Kigoma **>** Mpulungu. The nauplii of calanoids and cyclopoids contributed to the total dry weight by less then 4% for each sampling site.

Table 4: Mean dry weight biomass (mg dw m^{-2}), standard deviation (SD) , coefficient of variation (CV), number of sample dates (n) and percentage contribution to the total Copepoda (% of TOTCOP) of the pelagic mesozooplankton off Bujumbura, Kigoma and Mpulungu. Abbreviations used are explained in Table 3.

	NAUPTR	COPADTR	TOTTR	NAUPCY	COPADCY	TOTCY	TOTCOP
BURUNDI							
n=52 Mean	71	595	667	67	3220	3286	3953
stdev	58	516	551	50	2682	2711	3162
cv	0.74	0.79	0.75	0.74	0.77	0.76	0.72
of TOTCOP	1.7%	19.7%	21.3%	1.8%	76.8%	78.7%	
TANZANIA							
n=50 Mean	43	365	408	29	1231	1260	1668
stdev	56	361	386	42	756	756	986
cv	1.31	0.99	0.95	1.46	0.61	0.60	0.59
of TOTCOP	2.6%	21.9%	24.4%	1.7%	73.8%	75.6%	
ZAMBIA							
n=51 Mean	35	818	853	79	1149	1229	2082
stdev	20	234	231	48	338	358	508
cv	0.57	0.29	0.27	0.61	0.29	0.29	0.24
of TOTCOP	1.7%	39.3%	41.0%	3.8%	55.2%	59.0%	

4.1.3 Temporal abundance patterns

Weekly abundance of post-naupliar stages of calanoids and cyclopoids for each sampling site during 55P3 are presented in Figures 2 and 3, respectively.

Off Bujumbura, the abundance of Copepoda was higher from July 1995 to December 1995 than from January 1996 to July1996, with maxima of 8922 n m^{-3} calanoids and 58077 n m^{-3} cyclopoids on 19 July 1995. After this peak, four more calanoid abundance peaks were observed off Bujumbura, in August and December, 1995 and in May and July, 1996.

There was no clear abundance pattern of cyclopoids off Bujumbura between July 1995 and December 1995. From January 1996 the abundance was lower, with a peak in April.

The abundance pattern of calanoids was similar to that of cyclopoids off Kigoma. Calanoid and cyclopoid abundance was highest in August and November 1995 and in February and May 1996.

Calanoid abundance off Mpulungu was highest in August and October - November, 1995 and March, May and July, 1996. The abundance of cyclopoids off Mpulungu was also highest in August. No clear periodicity was found for the rest of SSP3.

4.2 Macrozooplankton

Figures 4 and 5 present the mean density of medusae and shrimps respectively at each sampling site. At all stations the mean density of medusae was higher than that of shrimps. Lowest values for both occured off Kigoma. Medusae were densest off Bujumbura and shrimps off Mpulungu. Other relative abundances can be found in the figures.

5 DISCUSSION AND CONCLUSIONS

Off Bujumbura, the dryweight biomass of Copepoda increased considerably during SSP3 compared to SSP1 and 2. This was due to the high density of Copepoda found during the first half of SSP3. Before and after this half year, no such high level of Copepoda density was found. It is recommended to be cautious with interpreting this data. Due to civil unrest at the north coast of the lake, different people sampled and handled this data which may have led to unintended differences in methods.

In general, a low amount of nauplii was caught at all three sampling sites. This was a bias caused by the selectivity of the used sampling gear. Small nauplii pass through a zooplankton sampling net with a mesh size of 100µm. A net with a smaller mesh size could indeed collect all nauplii, but the net would clog when sampling up from 100 meters depth. For the discussion, only post-naupliar stages are considered.

Comparison with preceding years and other research components.

In general, the abundance of phytoplankton is considered to be a poor indicator for zooplankton abundance. However, Narita *et al.* (1986) found that in Lake Tanganyika the abundance of zooplankton varies positively with the phytoplankton abundance. The phytoplankton abundance seems to be correlated to the Secchi disk depth, especially in the south of the Lake (Langenberg, 1996). Mean annual transparency, measured with a Secchi disk, was lower off Bujumbura/Uvira (8.5 m) and off Mpulungu (11.8 m) than off Kigoma (13.4 m) during SSPl and 2 (Plisnier, 1996; Plisnier *et al.,* 1996). This shows that during this period phytoplankton abundance was highest off Bujumbura and lowest off Kigoma. The dryweight biomass of Copepoda from July 1993 to July 1996 at each station is presented in Figure 6. Copepoda became less dense (as implied by dryweight analysis) from the north of Lake Tanganyika to the south end during SSPl and 2 (Kurki, 1996). This pattern changed during SSP3, when the mean dryweight biomass of Copepoda off Mpulungu was higher than off Kigoma. For July 1993 to June 1995 the results do not agree with the suggested link with relative phytoplankton abundance estimated from Secchi disk results.

An alternative source of energy besides phytoplankton which is available to secondary producers, is supplied by bacteria (Järvinen *et al.,* 1996; Hecky *et al.,* 1979, 1981). The contribution of bacteria production to the total primary production in Lake Tanganyika was estimated at 25-50% (Järvinen *et al.,* 1996), which is probably an underestimation according to Langenberg (1996). Bacterial production increased with nutrient concentrations, especially of phosphorus and nitrogen (J&rvinen *et al.,* 1996). The mean annual nutrient concentration from July 1993 to June 1995 was highest off Bujumbura and Kigoma and lowest off Mpulungu. As this provides the zooplankton community with an important food source, zooplankton should be more abundant in the north of the Lake, and less in the south as was found during SSPl and 2.

In Lake Tanganyika, the fishery concentrates on clupeids in the north, the centropomid *Lates stappersii* in the south and on both, clupeids and centropomids in the Kigoma area (Mannini *et al.,* 1996). Rufli (1976) suggested that the life cycles of clupeids and consequently that of their predators are ultimately dependant on the main phases of zooplankton production, as indicated by growth rate, by annual change of ichthyomass, by main spawning period, and by recruitment to offshore stock (Van well & Chapman, 1975, 1976; Chapman, 1975; Coulter, 1975; Ndugumbi *et al.,* 1976).

Reproduction patterns of clupeids and centropomids were investigated by Mannini *et al.* (1996) . From March 1994 to December 1995, the gonado-somatic index, GSI, of *Stolothrissa tanganicae* off Bujumbura and off Kigoma peaked at intervals of 3-4 months. Abundance peaks of calanoids and cyclopoids occured at the same periods when relatively high GSI values for *S. tanganicae* were found. These high GSI values indicate increased spawning (Mannini *et al.,* 1996). However, to evaluate properly the seasonal allocation of reproductive output of the clupeids, a fecundity index correlated with an index of the spawning population abundance should be used (Craig and Mannini, in prep.)

Kurki (1996) and Mannini *et al.* (1996) suggested that the northern pelagic ecosystem could be characterized as a clupeid - medusa - cyclopoids community, while the southern pelagic ecosystem could be characterized as a *L. stappersii* - shrimps - calanoids community. The results of the macrozooplankton analyses for SSP3 confirm this. As in the preceding years, medusae were abundant at the north end of the Lake and shrimps at the south end of the Lake. However, it should be noted that the sampling gear used is actually inappropriate for sampling shrimps. High speed towing of nets with bigger diameter and mesh size, such as the Gulf-net, will give more reliable results.

A simultanous global gathering of information on the main components of the ecosystem (physical parameters, nutrients, primary production, secondary production and fish concentration) could provide essential information on the controlling mechanism of the ecosystem. Another area which needs more research is the contribution of bacterial production and its role as an energy source to the pelagic ecosystem, which, in this lake, may be more important than it was previously considered.

ACKNOWLEDGMENTS

First I would like to thank the zooplankton sampling and analyzing teams of LTR Bujumbura: Messrs. Mulimbwa and Bwebwa, LTR Kigoma: Messrs. Kalangali and Muhoza and LTR

Mpulungu: Messrs. Kaoma and Zulu. The encouragement and support of the Project Coordinator, Dr. G. Hanek is greatly acknowledged. And I want to sincerely thank my colleagues P. Mannini and P. Verburg for their constructive help during the writing of this report. Last but certainly not least I want to thank Dr. K. Banister for editing this report.

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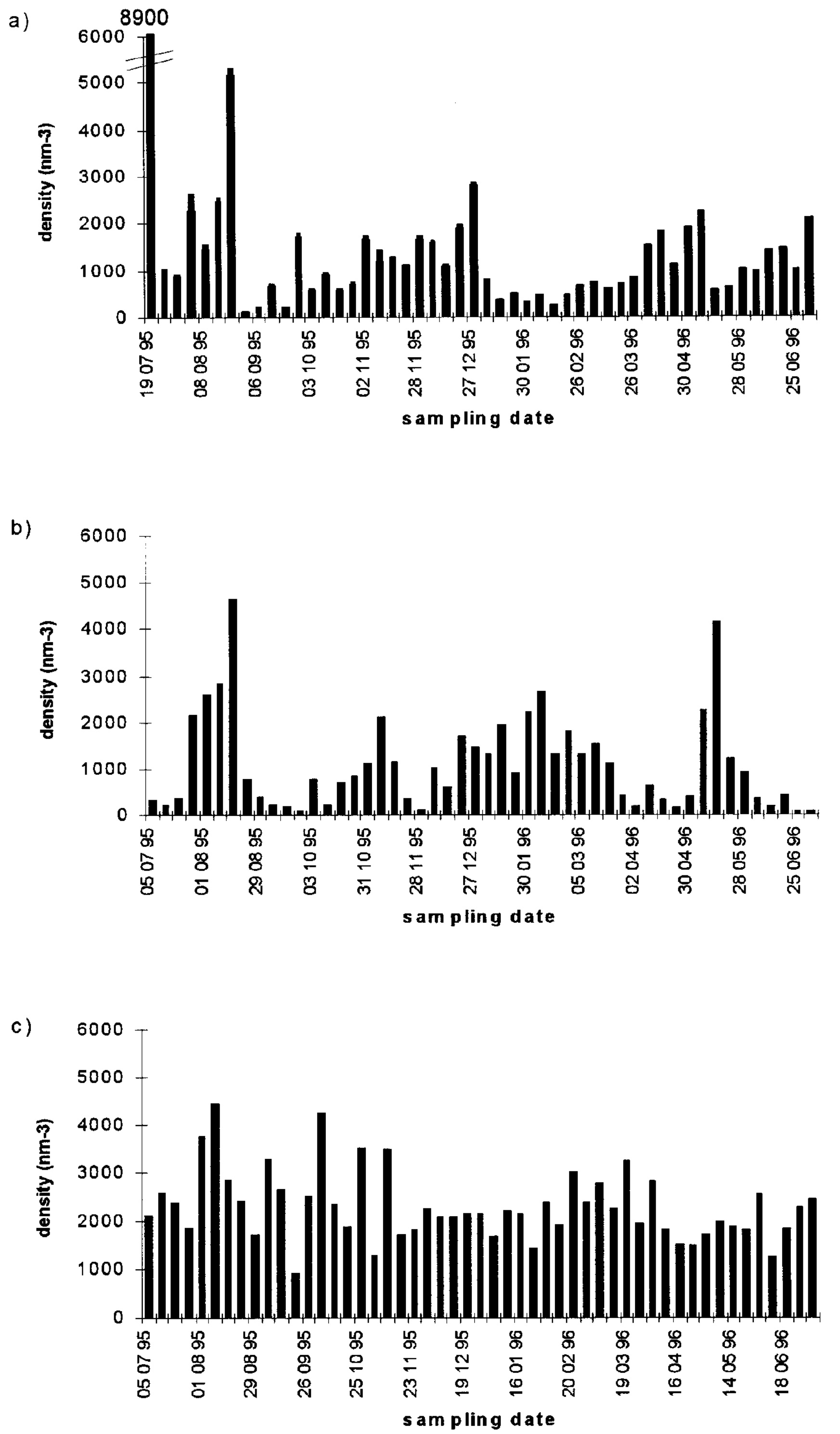

Figure 2 Abundance of post-naupliar stages of Calanoida off a) Bujumbura, b) Kigoma and c) Mpulungu

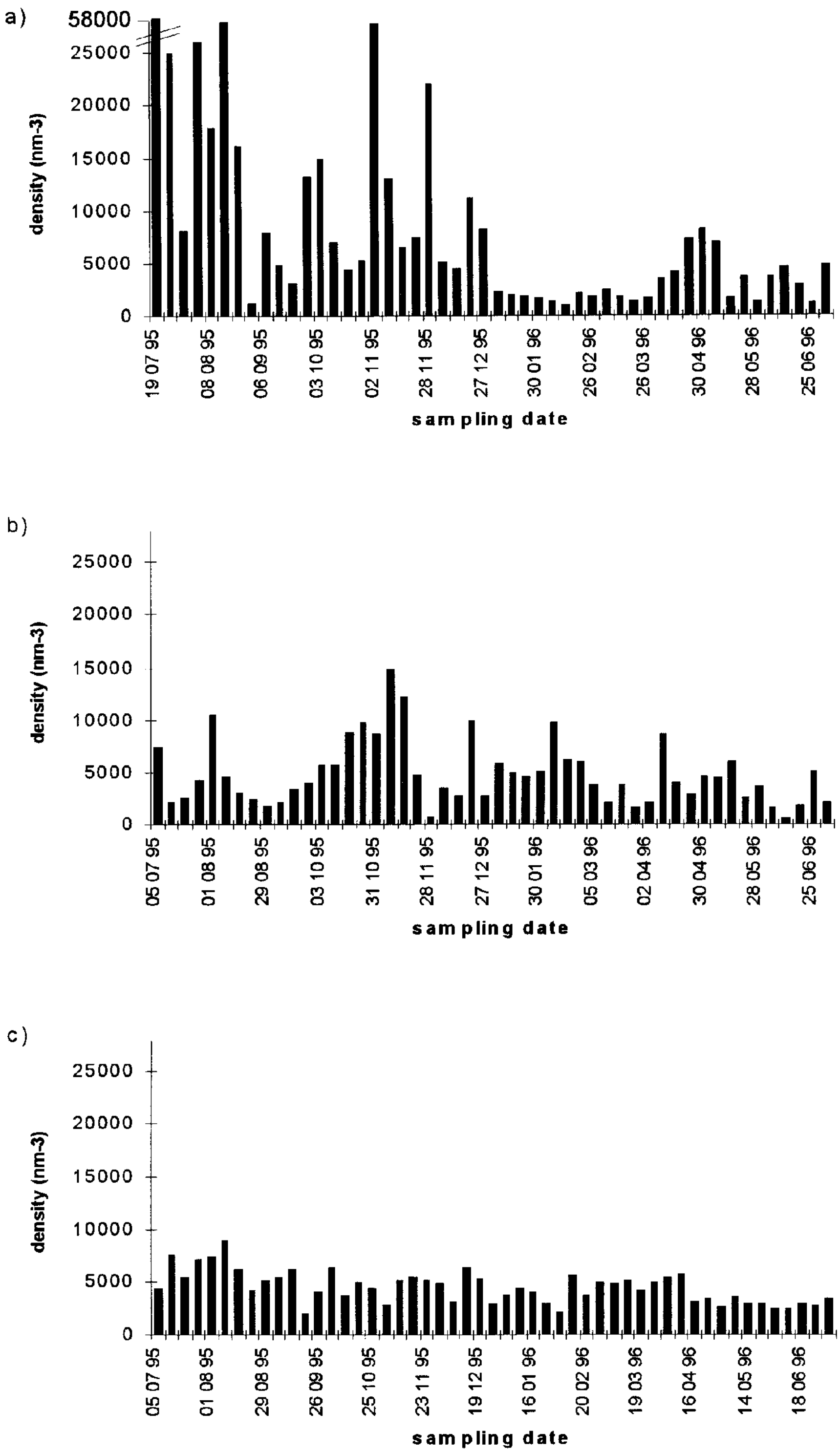

Figure 3 Abundance of post-naupliar stages of Cyclopoida off a) Bujumbura, b) Kigoma and c) Mpulungu

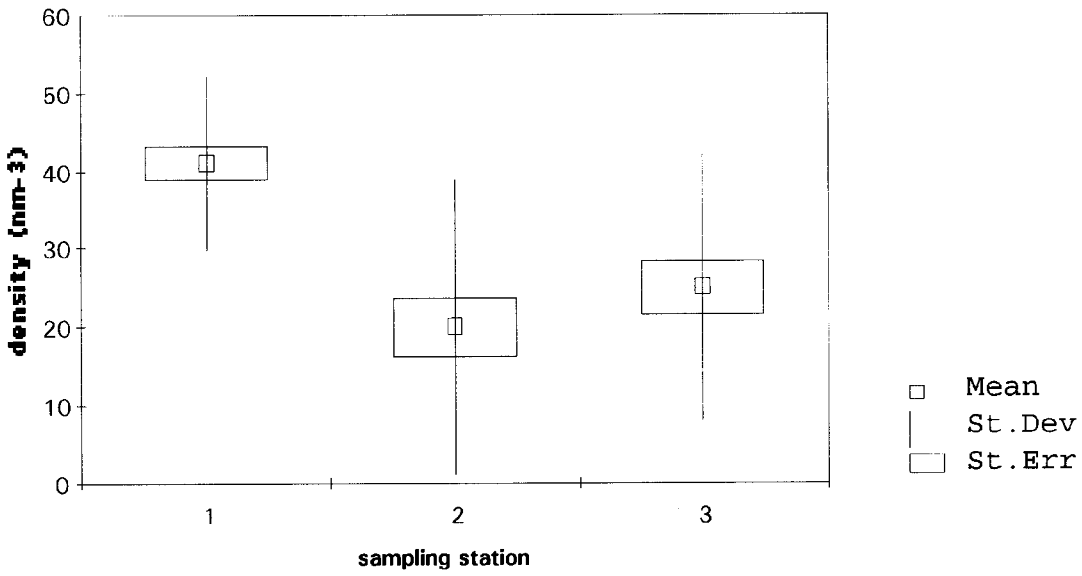

Figure 4 Mean number of medusae sampled from January to July 1996 off 1) Bujumbura, 2) Kigoma and 3) Mpulungu.

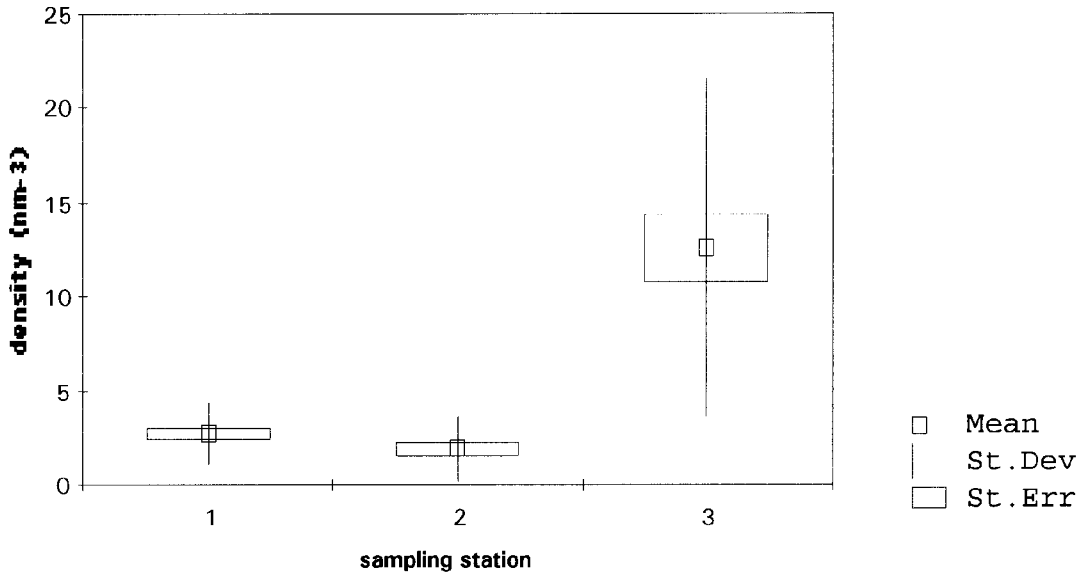

Figure 5 Mean number of shrimps sampled from January to July 1996 off 1) Bujumbura, 2) Kigoma and 3) Mpulungu.

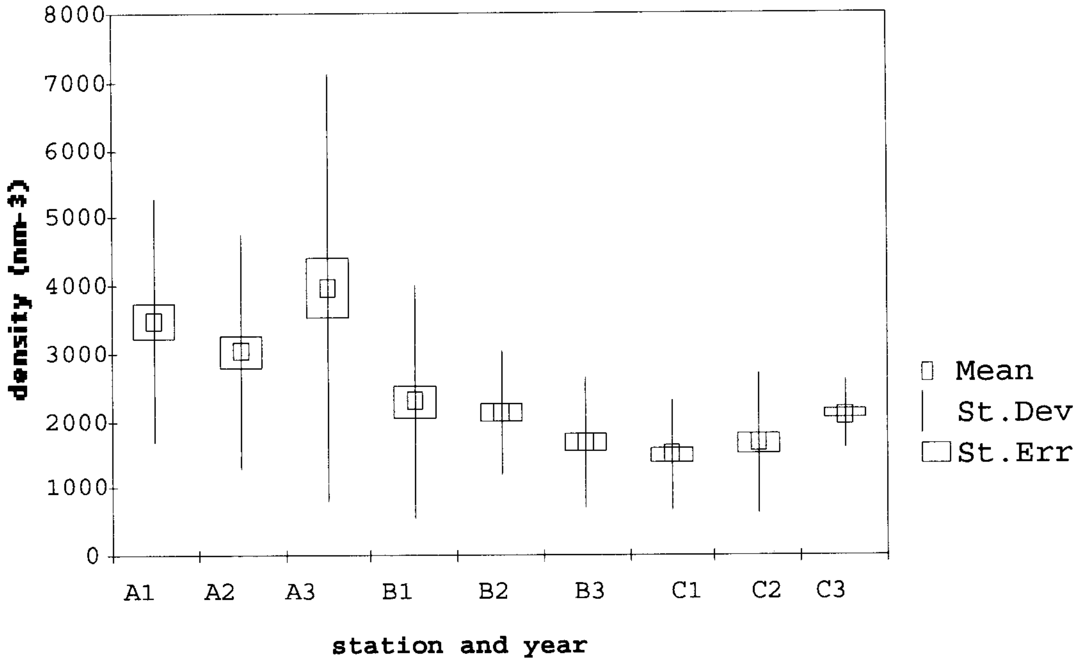

Figure 6 Yearly (1 - 3) mean dry weight of Copepoda off Bujumbura (A), off Kigoma (B) and off Mpulungu (C).