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Changes in relative abundance of zooplankton in northern Lake Victoria, East Africa

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Abstract

The zooplankton community of Lake Victoria was studied between March 1990 and February 1991 with the aim of identifying its constituent groups/species, their distribution, abundance, and long term changes in community structure. Zooplankton samples were taken from four stations using plankton nets (75–300 μm mesh size) hauled vertically through the water column. The plankton comprised mainly Crustacea and to a lesser extent early stages of aquatic insects. Cyclopoid copepods, their nauplii and copepodites constituted the most frequent group at all stations. Calanoid copepods, Cladocera and *Caridina nilotica* (Roux), though widely distributed, contributed a small proportion. *Chaoborus* larvae and pupae and mites were occasionally present. A comparison of the relative proportions of the main zooplanktonic groups from three sources revealed remarkable changes in community structure since 1931. These changes are discussed with respect to predation, eutrophication and other changes in the food web structure of the lake.

Introduction

The role of zooplankton in functioning and productivity of aquatic ecosystems is vital (Matthias, 1971; Downing, 1984; Wright & O'Brien, 1984). This role arises from its influence on nutrient dynamics and from its trophic position in aquatic food chains. As major primary consumers many zooplankters convert algal production into animal material for carnivorous invertebrates and fishes further up the food chain. There is, therefore, a strong direct relationship between the dynamics of zooplankton populations and fishery production.

In Lake Victoria, the obligate zooplanktivorous fishes include *Rastrineobola argentea*, a major commercial species. Other zooplanktivorous fishes such as several species of *Haplochromis*, have been reduced to low levels following the establishment of the Nile perch, *Lates niloticus* in the lake. Many facultative zooplanktivores including larval/juvenile fishes and invertebrate predators such as *Chaoborus* larvae, mites and flatworms also incorporate zooplankton in their diets.

Relatively little research work has so far been done on the ecology of zooplankton in the inland lakes of Africa; and the contribution of zooplankton in the functioning of aquatic systems and fishery production remains largely unassessed. In Lake Victoria, the current knowledge on the zooplankton is largely qualitative, originating from fish stomach analyses during routine fish ecology studies. As noted by Mavuti (1990), the exploitation of the fisheries in most African lakes has proceeded in absence of knowledge of fish food organisms. The few studies which specifically deal with zooplankton in Lake Victoria include Worthington (1931) who investigated vertical movements of zooplankton, Rzoska (1956), on species composition and distribution, Kateyo (1984), on zooplankton population dynamics; Mavuti & Litterick (1991) on composition, distribution and the ecological role of zooplankton, and Mwebaza-Ndawula (1990a) on composition, distribution, abundance, and importance of zooplankton as food for fish.

This paper, which constitutes part of a wider

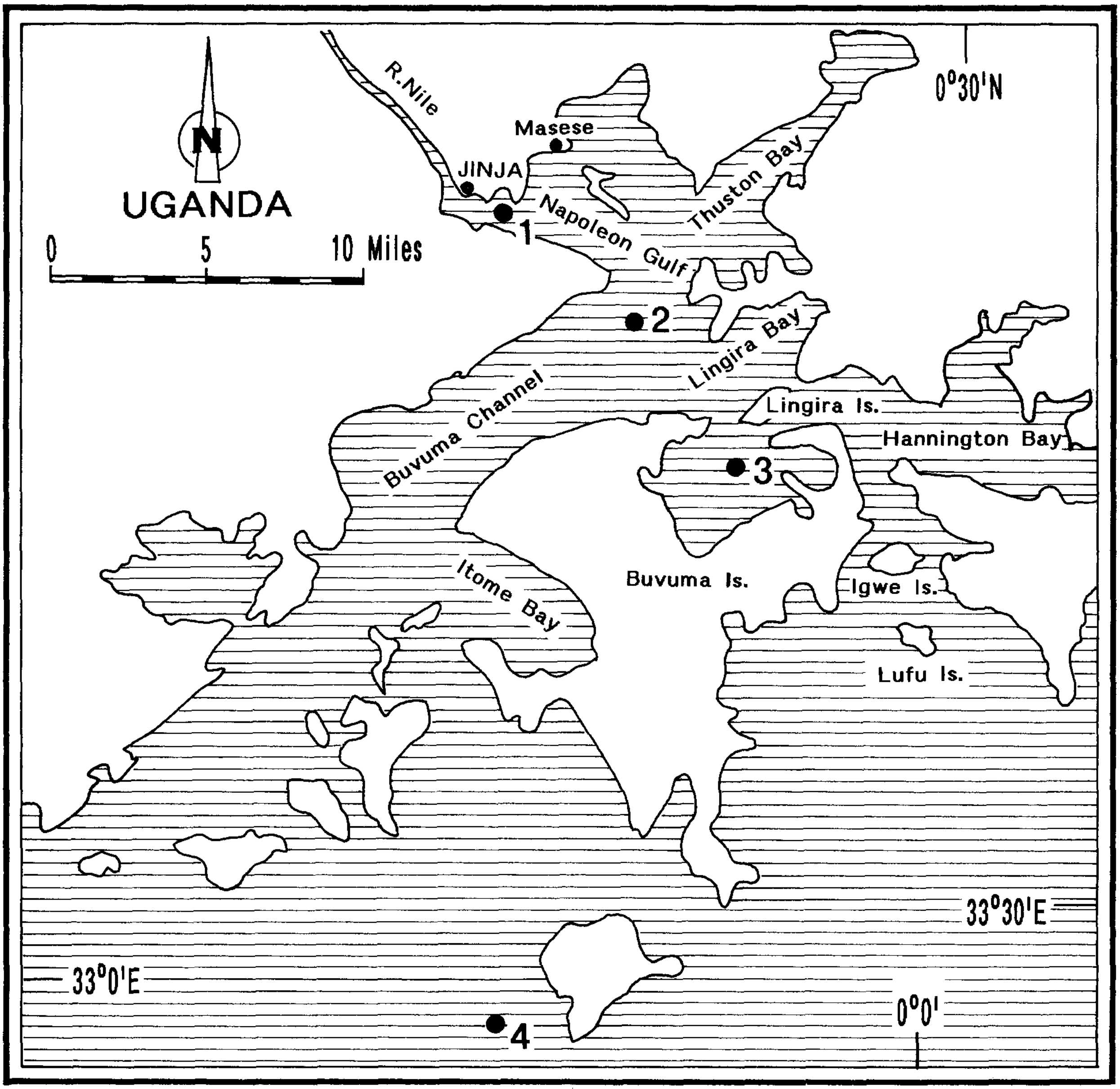

Fig. 1. The northern part of Lake Victoria showing sampling stations: 1. Napoleon Gulf, 2. Buvuma Channel, 3. Pilkington Bay, 4. Bugaia.

investigation of the biology, ecology and production of zooplankton highlights the changes in relative abundance of the major groups in Lake Victoria since 1931 and attempts a discussion of the factors likely to have caused the observed changes.

Materials and methods

Monthly samples of the zooplankton were taken at each of four stations in northern Lake Victoria, between March 1990 and February 1991. The stations represent shallow inshore waters (Napoleon Gulf and Pilkington Bay), an open water corridor (Buvuma Channel), and deep offshore waters (Bugaia) (Fig. 1). Samples were taken using Nansen type plankton nets with mesh sizes between 75 and 300 μm, hauled vertically through the water column. A detailed description of the sampling stations, methods of collection, preservation and analysis of samples has been given in Mwebaza-Ndawula (1990b).

Results

The zooplankton of Lake Victoria was dominated by Crustacea which constituted over 99% of the plankton (Table 1). Copepods, and their early life stages (copepodites and naupliar larvae) were dominant. Cyclopoids were the most abundant copepods constituting between 13.9 and 29.9% of the total zooplankton, with *Thermocyclops*

Table 1. Percentage composition (numerical) of the zooplankton species in the northern Lake Victoria (+ trace presence; – not encountered).

Taxonomic group	Napoleon Gulf	Buvuma Channel	Pilkington Bay	Bugaia
Copepoda:				
Cyclopoida				
Thermocyclops emini	9.3	8.9	6.8	8.8
T. oblongatus	+	0.7	0.9	2.0
T. neglectus	4.3	2.8	15.0	2.0
T. incisus	0.7	0.6	3.4	1.1
Mesocyclops spp.	1.4	–	–	+
Tropocyclops confinis	1.4	5.5	3.4	+
Eucyclops agiloides	+	–	–	–
Calanoida				
Thermodiaptomus galeboides	+	0.7	0.8	2.0
Tropodiaptomus stuhlmanni	+	+	1.7	2.7
Nauplii & Copepodites	82.8	80.0	66.7	81.2
Cladocera				
Daphnia lumholtzi	+	+	+	+
D. longispina	+	+	–	–
Ceriodaphnia cornuta	+	+	1.0	0.1
Bosmina longirostris	+	+	–	–
Diaphanosoma excisum	+	+	+	+
Decapoda				
Caridina nilotica	+	+	+	+
Diptera				
Chaoborus larvae/pupae	0.2	0.1	0.3	+
Chironomid larvae/pupae	+	+	+	+
Acarid mites	+	+	+	+
Rotifers	+	+	+	+

emini and *T. neglectus* as the main species. Calanoids and Cladocera contributed relatively small proportions at all stations. Nauplii and copepodites showed persistently high proportions at all stations. *Caridina nilotica* and *Chaoborus* larvae were insignificant. In addition, water mites, chironomid larvae and pupae were occasionally encountered. Rotifers were not assessed because of the large mesh size (300 μm) of the nets used to collect the bulk of the samples.

Long-term changes in relative abundance of zooplankton

Table 2 compares the relative proportions of the main zooplankton groups at two areas of northern Lake Victoria from three sources: Worthington (1931), Rzoska (1956) and the present study. The data of Worthington indicate a predominance of calanoids (50.1%) (*Diaptomus galeboides* and *D. stuhlmanni*) at an offshore station (north-eastern corner of the lake, 67 meters deep), followed by Cladocera (39.0%) (*Daphnia longispina*, *Ceriodaphnia dubia*, *Diaphanosoma excisum* and *Simocephalus vetulus*). Cyclopoids contributed 5.4% and *Caridina nilotica* 5.0%. Rzoska's data collected 25 years later at an open water station in the north-western corner of the lake showed a predominance of cyclopoids (45.0%) (largely *T. neglectus*, *T. emini* and *Mesocyclops* spp.) followed by Cladocera (30.0%); calanoids contributed only 25.0% of the total zooplankton. The present study shows cyclopoids still as the dominant group with *T. emini* and *T. neglectus* as the main species at Bugaia, an offshore deep water station (65 meters) (Fig. 1). Calanoids and Cladocera are down to <5.0% and <1.0% respectively. At Pilkington Bay, a shallow inshore station, the proportion of cyclopoids does not seem to have changed much between 1956 and 1990 (31.3% and 29.5%, respectively). Calanoids (from 33.0% to 2.5%) and Cladocera (from 35.0% to 1.0%) have declined. *C. nilotica*, not mentioned by Rzoska, was encountered during the present study in small numbers.

Discussion

The ecological role of zooplankton and aquatic invertebrates in general has been reviewed and discussed for Lake Victoria by Mwebaza-Ndawula (1990b). Prior to the introduction of *Lates niloticus* in the lake, several haplochromine zooplanktivores were present. At present, a single obligate zooplanktivore, *Rastrineobola argentea* exists. The two other major fish species: *Oreochromis niloticus* and *L. niloticus* also incorporate zooplankton in their diets during their juvenile stages. *L. niloticus* remains indirectly dependent on zooplankton during adulthood through predation on *R. argentea* (Ogutu-Ohwayo, 1985). Adult *O. niloticus* have also been found to supplement their diet with elements from the zooplankton, particularly daphnids (personal observation).

During the 1950s Lake Victoria lost some of its distinctive fish species through overfishing

Table 2. Percentage composition of zooplankton groups between 1931 and 1990.

	Worthington (1931)	Rzoska (1956)		Present study	
	Open Lake Station	Open Lake Station	Pilkington Bay	Open Lake	Pilkington Bay
Cyclopoids*	5.4	45.0	31.3	13.9	29.5
Calanoids	50.1	25.0	33.0	4.7	2.5
Cladocera	39.0	30.0	35.0	0.1	1.0
Caridina nilotica	5.0	–	–	+	–
Naupliar larvae, copepodites, minor groups	0.5 (*Corethra*)				

* Constituent species as in Table 1.

(Beauchamp, 1955; Cadwalladr, 1964). The introduction of *L. niloticus* in the early 1960s led to profound changes in the lake's food web structure (Ligtvoet *et al.*, 1989). During the establishment of *L. niloticus* many trophic groups of fish were lost including the haplochromine zooplanktivores. These changes may have caused shifts in grazing and predation pressure upon different fish food components of the lake, which could later be manifested in community restructuring of the type shown in Table 2. Although methods of sample collection and location of sample sites may have varied among workers, the ecological events which took place in the lake basin since 1931 provide sufficient justification to reflect upon a possible interplay of factors operating within the system. Two major factors can be recognised: predation by fish and invertebrate predators, and the onset of eutrophication.

Generally, persistent heavy predation by fish upon zooplankton community leads to impoverished zooplankton assemblages composed of small species. For this reason, fish are seen as the chief architects of the zooplankton community structure (Hrbacek, 1962; Brooks & Dodson, 1965; Wright & O'Brien, 1984; Dumont, 1986). The changes in Lake Victoria fish species during recent decades have produced a three-pronged predation force upon the zooplankton community, visualized in form of the three commercial fish species: *Lates niloticus*, *Oreochromis niloticus* and *Rastrineobola argentea*. All three have progressively increased in their abundance throughout the 1980s (IDRC Tech. Reports 1989/90; 1990/91). The sum-total of effects of the three predators can be sizeable if sustained for a long time. It has been demonstrated that the probability of capture by predatory fish is highest for cladocerans, copepod nauplii and lowest for calanoid copepods and chaoborid larvae (Lazzaro, 1987). In Lake Albert, Green (1967) found that the horizontal distribution of the large non-helmeted *Daphnia lumholtzi* relative to that of the smaller helmeted form was governed by predation imposed by zooplanktivorous fish. Clearly, size of prey, in addition to ability to escape is important for survival of prey organisms. These observations may explain the decline of cladocerans in Lake Victoria while cyclopoids and chaoborid larvae have thrived. The latter, together with *C. nilotica*, when taken with a net sampler designed by Nero (1982) have been found to be much more abundant than suggested by the present samples (IDRC Report, 1990/91). Calanoid copepods may have declined due to unfavourable competitive interactions with grazing fishes as reported in Lazzaro (*op. cit*).

Invertebrate predators such as *Chaoborus* larvae, some copepods, mites and flatworms may also inflict considerable predation pressure upon zooplankton communities (Rocha *et al.*, 1990; Janicki & De Costa, 1990; Blaustein & Dumont, 1990). Acarid mites are an occasional component of the zooplankton in northern Lake Victoria and together with *Chaoborus* larvae and *Mesocyclops* spp. constitute the main invertebrate predation force upon small zooplankton. Flatworms, though not encountered in the samples, have been reported elsewhere in the lake (Mavuti & Litterick, 1990).

There are indications of eutrophication, particularly in the inshore waters of Lake Victoria (IDRC Tech. Reports 1989/90; 1990/91; Mavuti & Litterick, *op. cit*). Changes in lake trophy are generally accompanied by changes in composition and cell size distribution of phytoplankton which may in turn create new niches and competitive interactions among herbivores (Einsle, 1988). In such cases, poor competitors may be suppressed. Green (1976) attributed the disappearance of some species of zooplankton in three lakes in western Uganda to eutrophication, pollution and fish predation. The riparian and catchment areas of Lake Victoria have in recent decades been intensively and extensively cultivated in response to human demographic increases in the region. Use (misuse?) of a wide range of agrochemicals has been on the increase and therefore the chances of residual chemicals ending in the lake are rather high. This possibility, in part, explains the observed eutrophication which may have repercusions on the biological diversity. Maas *et al.* (1986) have associated the massive occurrence of *Tropodiaptomus lateralis* in Oguta

Lake to low pH, conductivity, but also decline in planktivorous fish relative to other lakes in the same area. Thus, in cases involving spatial and temporal changes in the community structure of biological populations, both biotic and abiotic factors are important, singly and in combination.

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