Effect of Sunken Decomposing Water Hyacinth (*Eichhornia crassipes*) Biomass on Dissolved Oxygen and Food of Major Inshore Fish Species in Northern Lake Victoria, Uganda

RUKUUNYA E[1], TWONGO[2] T. & MAKANGA[3] B.

[1] *Water Hyacinth Unit,*
P. O. Box 4,
Entebbe, Uganda.

[2]*Fisheries Resources Research Institute,*
P. O. Box. 343
Jinja, Uganda.

[3] *Zoology Department,*
Makerere University,
P. O. Box 7062,
Kampala, Uganda.

ABSTRACT

This study examined the effect of the sunken decomposing water hyacinth biomass on dissolved oxygen and food of two major inshore fish species *Lates niloticus* and *Oreochromis niloticus* in the northern Lake Victoria, Uganda. Sampling was done in Thruston Bay where weed collapse occurred and Fielding Bay used as a control. Results reveal significant differences in dissolved oxygen concentration between the two bays ($p<0.05$). Dissolved oxygen fluctuated between 4.6 mg/l and 7.5 mg/l in Thruston Bay compared to 6.2 mg/l to 11.3 mg/l in Fielding Bay. The composition of food items varied in the two bays with *O. niloticus* from Thruston Bay feeding on a wider variety of phytoplankton genera than in Fielding Bay. The Chlorophyceae dominated the diet of *O. niloticus* in both bays, followed by Cyanobacteria, Bacilariophyceae and macro-invertebrates. Significant differences ($p<0.05$) were also observed in the frequency of occurrence of these phytoplanktons in the diet of *O. niloticus* within the two bays. Relative importance of food items to the diet of *O. niloticus* was higher in the inshore fish samples from Thruston Bay than in Fielding Bay indicating increased food availability. Overall, the relative importance of food items ingested by *L. niloticus* was higher in offshore fish from both bays but higher in Thruston than in Fielding Bay. The sunken water hyacinth can be considered as having increased the algal biomass favoring phytoplanktivores. Continued monitoring is recommended so as to understand fully the mortality, dynamics and resurgence potential of water hyacinth for proper guidance of effective weed control.

Keywords: Sunken, Decomposing, Water Hyacinth.

INTRODUCTION

Water hyacinth, *Eichhornia crassipes* Mart. Solms - Laubach is a floating aquatic weed native to some countries in Latin American. The weed first appeared on the African Continent in Egypt between 1879 and 1892 (Gopal and Sharma, 1981) and was reported in South Africa in 1910, Zimbambwe in 1930s, Democratic Republic of Congo (Congo River) in 1952 (Gopal, 1987), Sudan in 1956, Benin and Nigeria in 1980's. In Uganda (Lake Victoria) it was reported in 1989 entering via Kagera River (Taylor, 1993) but the first siting of the weed was in Lake Kyoga in 1988 (Twongo, 1991). The water weed spread rapidly attaining maximum cover between 1994 and 1995 when the Ugandan portion of Lake Victoria had an estimated stationery weed cover of about 80% of the shoreline area (EAC document, 1998). Thruston Bay is believed to have had a weed cover of between 800 to 1000 ha and Radarsat images of 1997 show clearly that the relatively large bay (1650 ha.) was completely filled with water hyacinth (Schouten, *et al.,* 1999).

The ecological and socio-economic impacts of water hyacinth proliferation occurred mostly in the littoral zones that provide nursery, feeding and spawning habitats for a variety of fish (Welcome, 1964 & Balirwa, 1998) including *Oreochromis niloticus* and *Lates niloticus.* The impact of water hyacinth on these commercial fish stocks of Lake Victoria were envisaged to be more severe on the Nile tilapia that thrives best in waters less than 10 m (Kudhongania & Cordone, 1974). The fish species also frequents environments that are susceptible to water hyacinth infestation for food and shelter particularly at fry or juvenile stage (Twongo, 1991). Nile tilapia is also reported to avoid very low oxygen environments (Welcome, 1967) a case that was common under the water hyacinth mats (Balirwa, 1998) and likely in the areas with sunken weed biomass. The impacts of water hyacinth infestation on Nile perch were envisaged to be felt more by juveniles, which frequented indigenous submerged and floating macrophytes in search of food and shelter. Smaller juveniles feed primarily on invertebrates hence the effect of water hyacinth proliferation and its subsequent sinking on macro invertebrates can affect the most important development stage in the Nile perch fishery.

The Government of Uganda, being aware of the serious economic, social and environmental impacts of water hyacinth adopted an integrated control system, involving manual, mechanical and biological control. By late 1998, the effects of biological control and possibly other environmental factors such as hydrological changes had caused massive collapse of the mobile and resident water hyacinth biomass in Thruston Bay. This left many questions unanswered about the dynamics of the sunken organic debris. Detailed ecological research was started in November 1998 by the Fisheries Resources Research Institute (FIRRI) to determine the impact of the sunken biomass of water hyacinth on water quality, biodiversity and fisheries. This study which started in July 1999, built on the research by FIRRI with the purpose of establishing the residual extent of the impacts of the sunken waterweed.

MATERIALS AND METHODS

Study area,

The study area covered two bays in the Northern Lake Victoria namely Thruston and Fielding. Thruston Bay has an estimated area of about 1,650 hactares and maximum depth of 11 meters, is highly sheltered and accumulated water hyacinth since 1994 which built up to large quantities of resident water hyacinth of about 950 ha that died and sunk in 1998. Fielding Bay has an estimated area of about 700 ha and maximum depth of 7 meters, is lightly sheltered and did not have continuous cover of permanently resident weed. Thruston Bay had three sampling sites namely Kafunda, Buluba and Forest while Fielding Bay also had three sites namely Kakira Forest, Kakira Papyrus and Wairaka Rocky (Fig. 1). The sites were chosen based on similarities in shoreline vegetation cover and bottom sediment.

Sampling for fish was done at the six selected sites between July 1999 - Nov 2000 using gill net fleets with sizes ranging from 1-8 inch set at inshore and offshore. In both bays nets were set at around dusk, left overnight and retrieved the following morning before 8.00 a.m. On retrieval fish was first sorted into their taxonomic groups to species level and biometric data collected. Stomach fullness was estimated according to Hynes 1950 (Table I.) and stomachs with substantial food contents were preserved in 10% formaldehyde solution, labelled and taken to FIRRI laboratory for food analysis. Sampling for dissolved oxygen was done at the three sampling sites in each bay using automated electronic metre probes. Readings were taken before mid day for bottom and surface water at various points (lake edge, 20 m and 300 m from the edge) along three transects labelled A, B and C. Due to the shallowness and fluctuations in water level in the bays bottom readings were mainly taken at 20 m and 300 m, and at times only at 300 m from the edge towards open water.

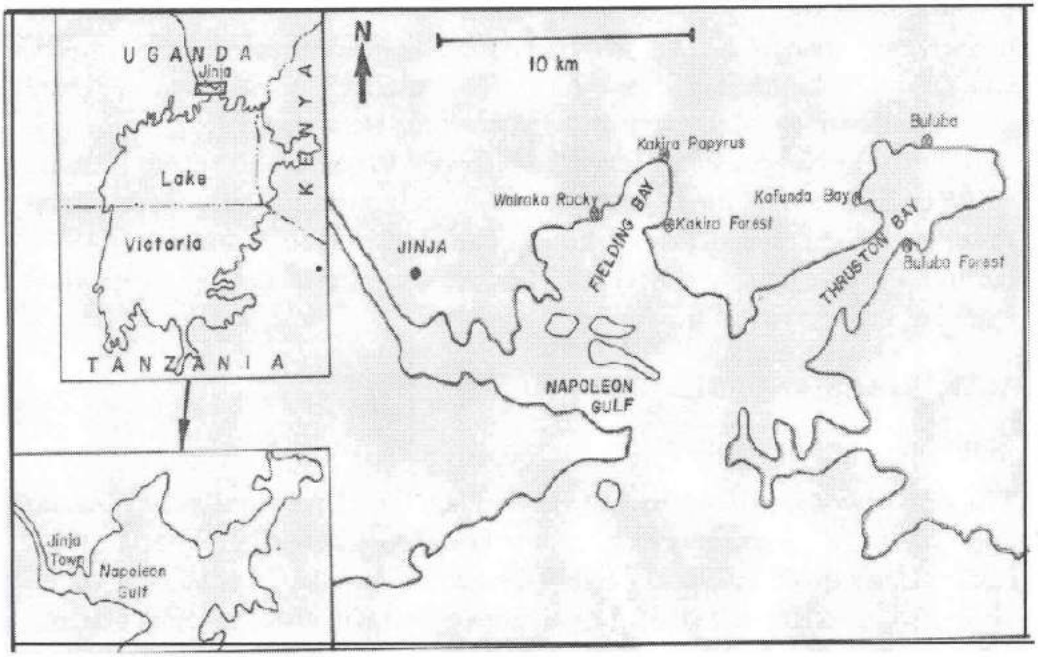


Figure 1 A map of the Northern portion of Lake Victoria showing the sampling sites in Thruston and Fielding bays

Table I Degree of fullness versus stomach state ratings

Fullness	Stomach fullness
F	fully distended
T	> 75% full < 100%
H	> 50% full < 75%
Q	> 25% full > 50%
E	No recognisable contents

In the laboratory, stomach contents of fish were emptied into a petri dish and both binocular (x10x80) and compound (x600) microscopes were used to identify the contents. Food items were grouped into broad categories, quantified and points alloted based on Hynes (1950) i.e. empty stomach fullness (E) was given 0 points, quarter stomach fullness (Q) 2 points, half stomach fullness (H) 4 points, three quarter stomach (T) 8 points and full stomach (F) 16 points. The relative importance of the different food categories was estimated by multiplying the percentage volume estimate by the points on a stomach, for example a food item contributing 30% in a three quarter full stomach scores 30 divided by 100 times 8 = 2.4. During data analysis the points scored for each food category in a bay were summed and scaled down to percentage composition of food of all the fish species examined from the two bays. For purposes of data comparability with works done earlier, the frequency of occurrence method used by Welcome, (1967) and Balirwa, (1990) was also used for *O. niloticus* on top of the points method. Two-way ANOVA-test was used to compare food of the two species between and within the bays at 95 % confidence limit. Dissolved oxygen readings at various distances along the transects A, B and C were averaged to get mean dissolved oxygen for surface, bottom, shoreline, 20 m and 300 m from the shoreline for the various sampling sites. Data were analysed in SPSS and AVOVA test carried out to find out differences within and between bays and sampling sites.

RESULTS

Food composition

The composition of food items ingested varied in the two bays with fish especially *O. niloticus* ingesting a wider range of food items in Thruston Bay than in Fielding Bay. The fish stomachs examined had varying degrees of stomach fullness ranging from full to quarter full.

Lates niloticus

Lates niloticus from inshore waters of Fielding Bay had a diet composed of Ephemeroptera, fish remains, *Odonata*, *Caridina nilotica*, chironomids, molluscs, detritus, ostracods, *Rastrineobola argentea* and haprochromines while offshore *Lates* had fish remains, *Odonata*, *C. nilotica*, chironomids, molluscs, *Chaoborus* and *R.. argentea.* Detritus was only found in inshore samples while *Chaoborus* larvae only appeared in offshore samples. *L. niloticus* from inshore waters of Thruston Bay fed on Ephemeroptera, fish remains, *Odonata*, *Caridina nilotica*, Chironomids, Molluscs, *R.. argentea* and haprochromines while offshore *Lates* had fish remains, *Odonata*, *C. nilotica*, Chironomids and *R.. argentea*. Detritus, *Chaoborus* and Ostracods were absent in the diet of both inshore and offshore samples. Fish from inshore waters of both bays had a higher count of food items appearing in the stomach compared to offshore but Fielding Bay had a generally higher count than Thruston Bay ($\chi^2 = 0.596$).

Oreochromis niloticus

Oreochromis niloticus from inshore waters of Fielding Bay had a phytoplankton diet composed of seven genera of Cyanobacteria namely *Planktolyngbya, Merismopedia, Microcystis, Oscillatoria, Raphidium, Aphanocapsa* and *Anabaena,* five genera of Bacillariophyceae namely *Navicula, Cyclotella, Syrrirella, Synedra and Nitzschia* and twelve genera of Chlorophyceae namely *Scenedesmus, Ankistrodesmus, Pediastrum, Botryococcus, Sphaerocystis, Coelastrum, Anthrodesmus, Cylidrisperma, Closterium, Monoraphidium, Selenastrum* and *Chlorococcus.* Other food items included macro invertebrates (Ephemeroptera, Leeches, *Caridina nilotica,* Chironomids and Molluscs), higher plant material, fish eggs, fish remains and detritus. *O. niloticus* from inshore waters of Thruston Bay had a phytoplankton diet composed of eight genera of Cyanobacteria namely *Gompharium, Planktolyngbya, Merismopedia, Microcystis, Coelospharium, Oscillatoria, Aphanocapsa* and *Anabaena,* six genera of Bacillariophyceae namely *Navicula, Merosira, Syrrirella, Cyclotella, Synedra and Nitzschia* and ninenteen genera of Chlorophyceae namely *Scenedesmus, Ankistrodesmus, Pediastrum, Botryococcus, Coelastrum, Staurastrum, Sphaerocystis, Anthrodesmus, Gonatozyton, Crucigenia, Ocystis, Peridium, Cosmarium,* filamentous algae, *Tetraedron, Closterium, Monoraphidium, Selenastrum* and *Chlorococcus.* Other food items included macro invertebrates (Ephemeroptera, *Caridina nilotica,* chironomids, and insect remains) higher plant material and detritus. Inshore samples of both bays had the highest count of food items appearing in the fish stomach than offshore. Thruston Bay had higher counts than Fielding Bay ($\chi^2 = 0.253$).

Both forms of algae were more dominant in the stomachs of fish from inshore waters of both bays although Thruston Bay had the highest representation. The blue green algae dominated, followed by blue-green and lastly the diatoms. Significant differences ($p<0.05$) were observed in the frequency of occurrence of these phytoplankton in the diet of *O. niloticus* with in the two bays. The highest frequencies were observed in Thruston Bay.

Relative Importance

The results of relative importance of various food items to the diet of *Lates niloticus* from the inshore and offshore waters of Thruston and Fielding bays is shown in Table 2 and that of *Oreochromis niloticus* in Table III.

Table II. Relative importance (%) of various food items to the diet of *Lates niloticus* in Thruston and Fielding bays

Food item	Fielding		Thruston	
	Inshore (N=128)	Offshore (N=106)	Inshore (N=65)	Offshore (N=103)
Ephemeroptera	3.8	1.2	7.6	-
Fish remains	25.7	23.8	22.2	28.2
Odonata	20.0	5.7	11.5	0.2
Caridina	37.3	32.5	29.6	50.7
Chironomid	1.3	2.9	3.8	2.7
Molluscs	0.7	0.2	0.1	-
Higher plant material	0.4	-	0.7	0.3
Detritus	0.6	-	-	-
Chaoborus	-	0.2	-	-
Ostracods	0.6	-	-	-
Rastrineobola	7.1	32.3	3.0	9.3
Haplochromines	2.5	-	21.6	8.5

Table III. Relative importance (%) of phytoplankton and other food categories in the stomachs of *Oreochromis niloticus* from Thruston and Fielding bays

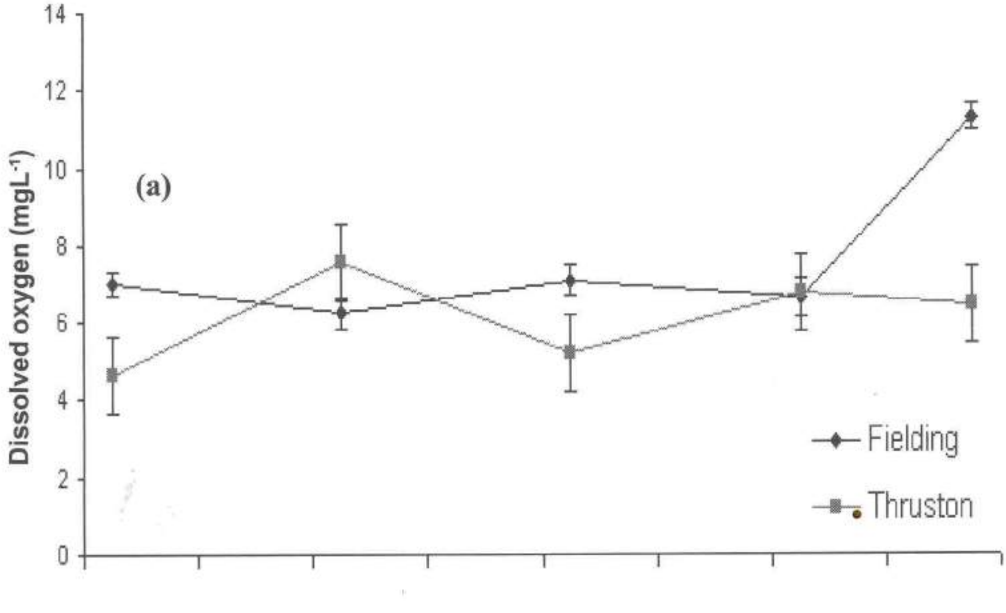
Food category	Fielding		Thruston	
	Inshore (N=69)	Offshore (N=4)	Inshore (N=98)	Offshore (N=8)
Cyanobacteria (Blue green algae)	28.8	5.5	30.0	32.4
Bacillariophyceae (Diatoms)	9.1	1.3	7.6	4.4
Chrolophyceae (Green algae)	6.9	1.2	11.6	2.5
Macro-invertebrates	17.1	75.8	2.9	11.4
Fish eggs	0.1	-	-	-
Higher plant material	5.1	-	3.3	1.7
Detritus	31.2	16.3	44.9	36.7
Fish remains	1.7	-	-	1.0

Dissolved oxygen concentration

The observed temporal changes in shoreline (0 m) surface, offshore (300 m) bottom and overall surface dissolved oxygen concentrations in Thruston and Fielding bays are illustrated in Figure 2. Surface dissolved oxygen fluctuated between 4.6 mg/l and 7.5 mg/l in Thruston Bay compared to 6.2 mg/l to 11.3 mg/l in Fielding Bay during July 1999 and November 2000 (Fig 2a). In Thruston Bay bottom water dissolved oxygen concentration declined from 1.93 mg/l in July to 1.4 mg/l in November 1999 following the sinking of large hyacinth biomass. It however started recovering and increased up to 4.5 mg/l in July 2000 while that of Fielding Bay was about 4.0 mg/l. Bottom dissolved oxygen in Fielding Bay showed a progressive decline but was always higher than that of Thruston Bay except during July to October 2000. During the sampling period bottom dissolved oxygen fell lower than 2 mg/l in Thruston Bay when that of Fielding Bay was about 5 mg/l (Fig 2b). Overall dissolved oxygen concentration in Thruston Bay increased between July and November 1999 from 5.7 mg/l to 6.4 mg/l but declined up to March 2000. That of Fielding Bay showed an opposite trend starting with a decline and then an increase to 5.8 mg/l. After March 2000 dissolved oxygen in Fielding Bay increased to 9.4 mg/l and that of Thruston Bay to 8.3 mg/l (Fig. 2c). Anova test shows a statistically significant difference in surface and bottom-dissolved oxygen between the two bays with $F_{1, 12} = 4.722$, $p < 0.05$.

DISCUSSION

The value of phytoplankton in the diet of *O. niloticus* was emphasized by Welcome, (1967). The frequent occurrence of large quantities of detritus and invertebrates in the diet of adult *O. niloticus* in Lake Victoria was noted by



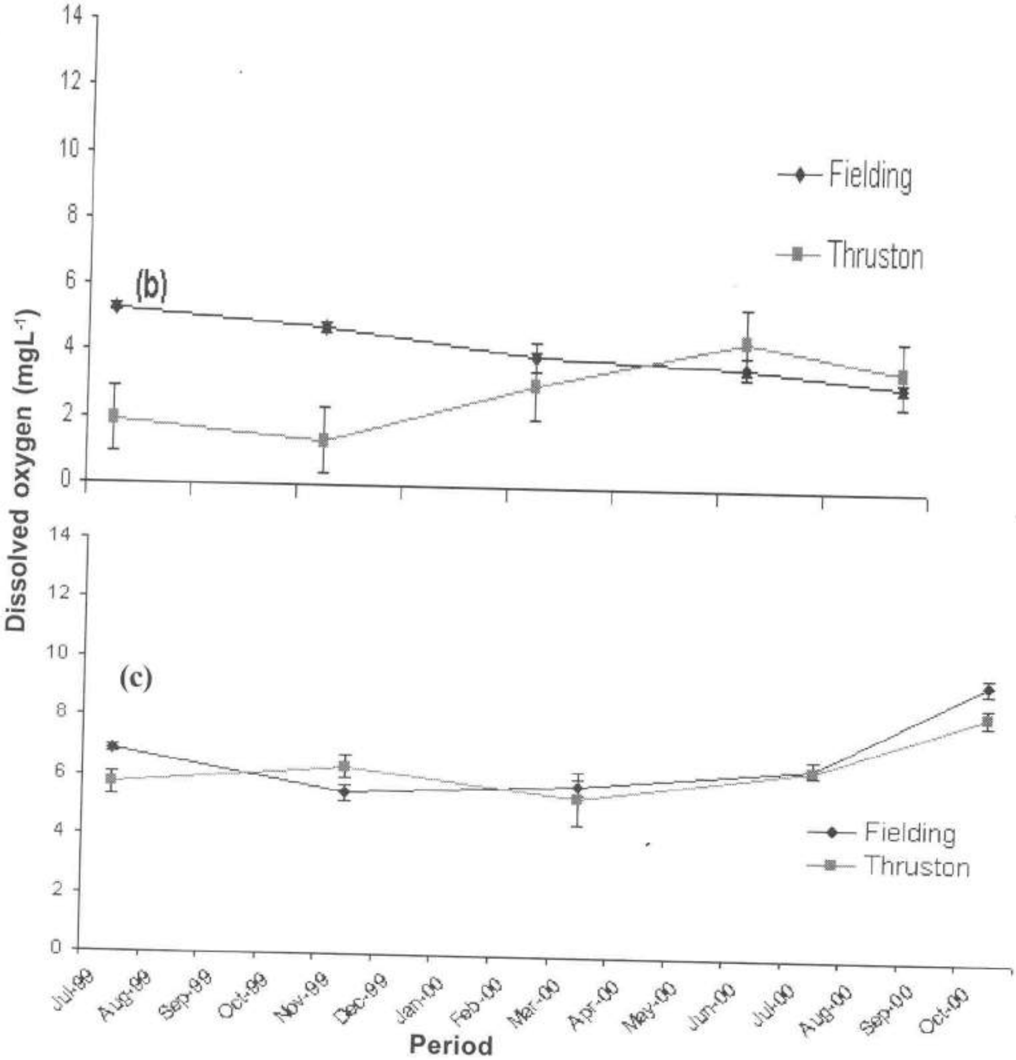
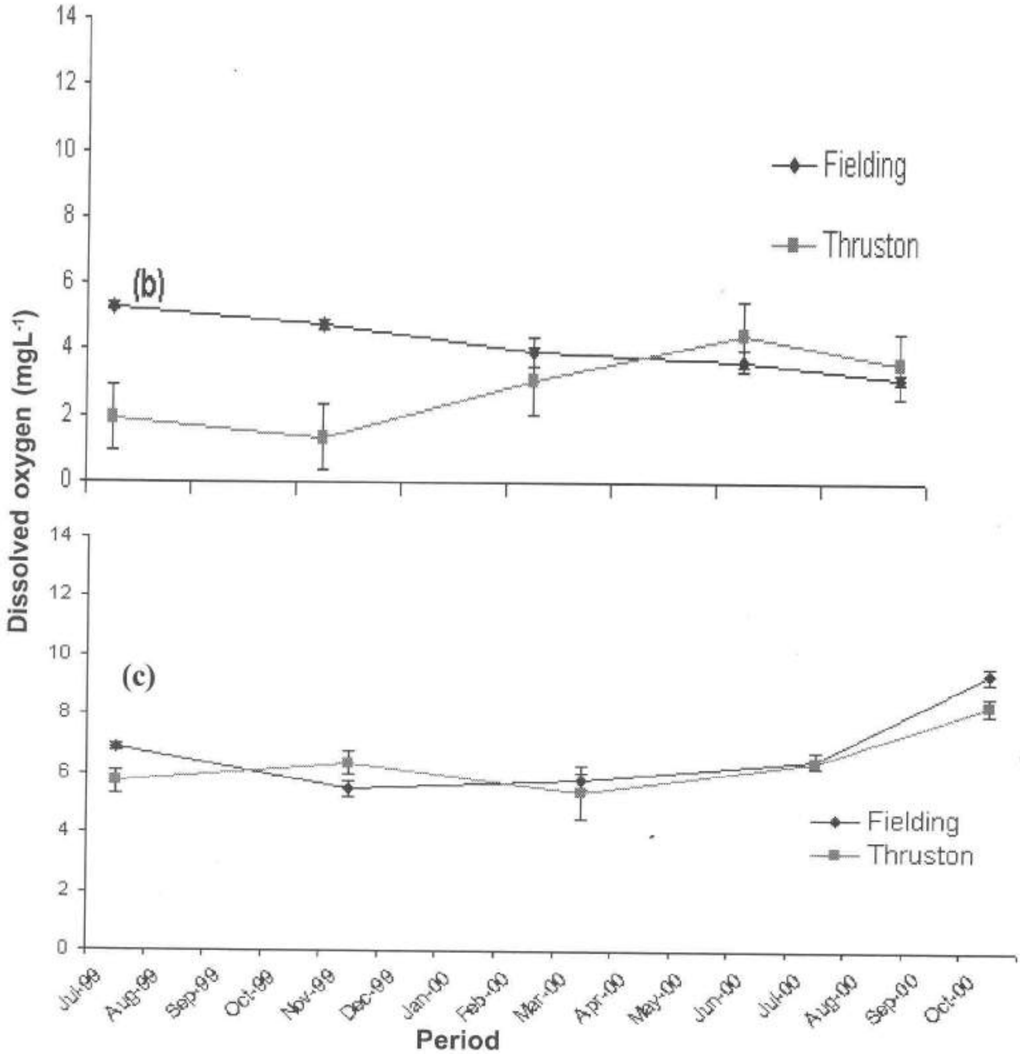


Figure 2. The general trend in dissolved oxygen (a) shoreline (0 m) surface, (b) offshore (300 m) bottom and (c) overall (surface) in Thruston and Fielding bays (Lake Victoria)

Balirwa, (1990) with all the foods ingested associated with detritus (present in 100% of the guts). Welcome, (1967) had come up with 42.8% detritus ingestion. In the present study a wider range of food items was encountered in the stomachs of *O. niloticus* confirming the high feeding plasticity of the species (Lowe-Mcconnel, 1958) or availability of the food items to the fish. Detritus was found in 87% of the stomachs examined from Thruston Bay and 78.1% of the stomachs from Fielding Bay. Fish from Thruston Bay had a wider variety of



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Among the blue-green algae *Anabaena, Microcystis* and *Planktolyngby* were the most abundant in both bays but frequency of occurrence in the fish stomachs was higher in Thruston than Fielding Bay. Comparing with the result of Welcome, (1967) and Balirwa, (1990), the diversity of phytoplanktons especially the green algae, in the diet seems to be increasing with more algal species appearing in gut contents of *O. niloticus*. The following eight algal genera namely, *Peridium, Oocystis, Cosmarium, Sphaerocystis, Cylindrosperma, Anthrodesmus, Gonatozyton* and *Dinobryon* which did not occur in earlier studies by Balirwa (1990) and Welcomme (1967) occurred in *O. niloticus* from Thruston Bay during this study. This high diversity could have been induced by nutrient release into the bay by the sinking water hyacinth biomass. Benthic macro invertebrates i.e. Chironmids and Odonata were also encountered in *O. niloticus* especially from offshore samples in both bays. The low relative importance especially in the inshores of Thruston Bay compared to Fielding Bay could be attributed to accumulation of debris from dead water hyacinth mats whose decomposition could have affected the distribution of macro-invertebrates as earlier found by Willoughby *et al.,* (1993). Although detritus contributed more to the diet of *O. niloticus* in inshore samples than offshore ones in both bays, its contribution in Thruston Bay was higher compared to Fielding Bay. This could be attributed to the sinking of a larger weed mass in Thruston compared to Fielding Bay. There were no Oligochaetes in the diet of all the size class samples examined in the two bays contrary to what was reported by Balirwa, (1998) that smaller *O. niloticus* (0-15 cm TL) ingest little detritus but more Molluscs and Oligochaetes than large fish. Molluscs only contributed to samples of 20-30 cm TL from Fielding Bay.

Considering that Nile perch reaches sexual maturity at between 60-80cm TL at three or four years old (Ogutu-Ohwayo, 1994), the current study has mainly delt with juvenile Nile perch (0-50cm TL) whose feeding ecology has received limited attention (Hamblyn, 1966). *Caridina nilotica* dominated the diet of Nile perch in both inshore and offshore samples in the two bays but was more dominant in offshore samples from Thruston Bay compared to Fielding Bay where it dominated in inshore samples. Odonata, another favorite food for Nile perch, was more important in inshore fish samples in both bays but its relative importance in Nile perch diet was higher in Fielding Bay. *Chaoborus* and Ostracoda were limited in the diet of Nile perch only appearing in samples from Fielding Bay inshore and offshore respectively. The acquisition of these food items could have been hampered by the low oxygen concentrations experienced in Thruston Bay. The present study has shown that the death and subsequent sinking and decomposition of water hyacinth has had some effect on the trophic ecology of inshore fish species and water quality in Lake Victoria. It has increased the algal biomass in the bays as observed during the survey and evidenced by their high frequency of occurrence, in the guts of the fish especially in Thruston Bay. However some preferred food for the fish that used to be common in the hyacinth roots i.e. Odonata and Oligochaetes were rare in the stomachs.

It is therefore recommended that continued regular monitoring of the lake ecosystem be undertaken to clearly understand the dynamics of sunken decomposing water hyacinth and its long-term impacts on the lake ecosystem and the fishery. A water quality model should be developed to guide proper management of the Lake Victoria ecosystem.

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