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Composition, abundance and feeding guilds of macroinvertebrates in lake Kenyatta, Kenya

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Abstract: In an attempt to describe the benthic macroinvertebrate assemblage of Lake Kenyatta and recommend possible interventions for sustainable management, sampling was done at different stations using an Eckman grab and a scoop net. At each station, six samples were taken (three grabs and three scoops). The samples were washed using a 300µm sieve, sorted live and identified to genus level and where possible to species level using appropriate keys. The specimens were further categorized into functional feeding guilds. The data were then analysed for diversity, evenness, abundance and dominance. Forty two species in 25 families and 13 orders were recorded. The organisms were further grouped into 4 functional feeding groups. The order Pulmonata dominated the macroinvertebrates sampled with 34.3% relative abundance while the lowest were Rhynchobdellida and Lepidoptera with 0.3% each. The high abundance of mollusks in the lake is probably an indication of absence of a predator. It is thus recommended that a fish species be introduced to convert these mollusks into fish biomass. This will enhance the economic gains and reduce the risk of bilhazia infestation since the host snail exists within the lake.

Keywords: Diversity, Tolerance, Feeding Guilds

1. Introduction

Freshwater benthic macroinvertebrates are small animals that live on and under submerged rocks, logs, sediment, debris and aquatic plants during the entire or part of their life cycle (Brittain, 1982). They include mature and immature forms of aquatic insects as well as crustaceans such as crayfish, mollusks such as clams and snails, and aquatic worms (Karr and Chu, 1997). Benthic macroinvertebrates represent an extremely diverse group of aquatic animals, with a wide range of responses to stressors including organic pollutants, sediments, and toxic materials. The presence of only a few types of benthic macroinvertebrates, or the presence of primarily the insensitive groups to disturbed systems in particular place maybe indicative of the existence of some stress (Mason, 2002).

Benthic macroinvertebrate metrics that have been widely used by scientists and researchers include taxa richness and diversity, specific taxa pollution sensitivities/ tolerances, and taxon abundances (Raburu, 2003; Masese *et al*., 2008; Aura *et al*., 2009). These metrics have been used as bioindicators of water quality, providing integrated information on toxic chemical concentrations, DO levels, nutrients, and habitat quality. Benthic macroinvertebrates are themselves an important part of aquatic food chains, especially for fish by transferring carbon from algae and bacteria (which are on the bottom of the food chain) to the upper trophic levels. They in addition shred and eat leaves and other organic matter in the water thus facilitating the process of organic matter mineralization. Because of their abundance and position in the trophic hierarchy, benthic macroinvertebrates play a critical role in the natural flow of energy and aquatic nutrients in aquatic systems. .

2. Materials and Methods

2.1. Study Area

Lake Kenyatta is a freshwater lake located in Mpeketoni Division of Lamu County at the Kenyan north coast. It is adjacent to Kipini Conservancy and lies 60km across from

Lamu Island on the mainland (Fig. 1). The lake is located in a remote area with little infrastructure development and the region is argued to be rich in wildlife and natural forest. The area also has an expansive population of neem tree forest believed to have been introduced in the 1970s. It is positioned between 2˚24′55″S and 40˚40′45″E.

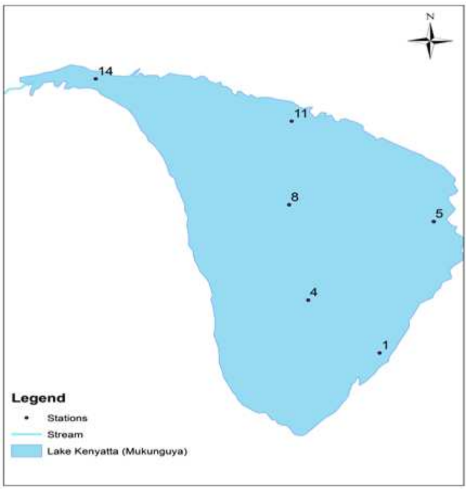

Figure 1. *Map showing Lake Kenyatta in Lamu County.*

2.2. Sampling

Macroinvertebrate sampling was done using a 500µm scoop net for littoral zones and an Eckman grab for sediments. At each station six replicates were taken, three with the grab and three with the scoop net. The samples were washed through a sieve, sorted live and preserved in 70% ethanol. In the laboratory, the samples were identified to genus level and where possible species according to Merritt and Cummins (1996); Gerber and Gabriel (2002); Samways (2008); and http://extension.usu.edu/water quality. The identified taxa were further categorized into functional feeding guilds using their mouth morphology and existing literature.

2.3. Data Analysis

The data was then analysed for diversity, abundance and evenness. The results were presented in frequency tables, and graphs. Spatial variation was tested using a log transformed one way ANOVA at $p < 0.05$.

3. Results and Discussion

3.1. Macroinvertebrate Composition

A total of 421 macroinvertebrate individuals falling in 13 orders, 25 families and38 genera were identified (Table 1). The order Pulmonata was the most dominant accounting for over 30% of the total abundance followed by Hemiptera (s) with a relative abundance of 11.2%. All the remaining orders had proportions less than 10% while orders Lepidoptera and Rhynchobdellida had the lowest relative abundance of 0.3% each (Fig. 2). This result indicates existence of several organisms in terms of diversity and abundance in a relatively small area. This high diversity and abundance of macroinvertebrate taxa in a small area is an indication of conducive environment within Lake Kenyatta promoting co-existence of different taxa with various life traits. Higher taxa diversity has been attributed to good ecosystem health and ability of the resident taxa to adapt to the prevailing conditions (Karr and Chu, 1997; Mason, 2002).

The order Pulmonata had the highest number of families (5) followed by Odonata and Hemiptera each with 4 families. The order Odonata, however, recorded the highest number of genera and species with 8 and 13, respectively (Table 1). Among Odonata, predatory Libellulidae was the most dominant with 5 genera and 9 species. The order Coleoptera was dominated by family Dytiscidae with 4 genera out of the six. Even though Pulmonata had the highest number of families, each family was only represented by one species except Planorbidae that was represented by 4 species.

Table 1. *List of Invertebrates sampled in Lake Kenyatta.*

Order	Family	Genera	Species	Common name
Araneae	Lycosidae	-	-	Wolf spider
Coleoptera	Dytiscidae	Bidessonotus	Bidessonotus sp	
		Dytiscus	Dytiscus sp	Large diving beetles
		Ilybius	Ilybius sp	Predacious beetles
		Neoporus	Neoporous sp	Water tigers (larvae)
	Gyrinidae	Gyrinus	Gyrinus sp	Whirligig beetle
Decapoda	Potamonautidae	-	-	Freshwater crab
Diptera	Chironomidae	Chironomus	Chironomus sp	Midgefly
	Culicidae	Anopheles	Anopheles sp	A. mosquito
		Culicida	Culicida sp	Mosquito
	Tabanidae	Tabanus	Tabanus sp	Horsefly
Ephemeroptera	Baetidae	Baetis	Baetis sp	Minnow mayflies
Hemiptera	Nacouridae	Macrocoris	M. flavocolis	Creeping bugs
	Corixidae	Micronecta	Micronecta sp	Water boatman
		Corixa	C. punchata	Water boatman
	Belostomatidae	Sphaerodema	S. nephroides	Giant bugs
	Notonectidae	Notonecta	Notonecta sp	Backswimmer
Hirudinida	Hirudinidae	Hirudo	H. medicinalis	Medicinal leech

Order	Family	Genera	Species	Common name
Lepidoptera	Crambidae	Nymphula	Nymphula sp	Aquatic moth
Odonata	Aeshnidae	Anax	A. imperator	Blue emperor
		Aeshna	A. ellioti	Elliot's hawker
	Gomphidae	Ictinogomphus	I. forox	Tigertail
	Libellulidae	Brachythemis	B. leucosticta	
		Chalcostephia	C. flavirons	
		Sympetrum	S. fonscolombii	Red-veined darter
		Trithemis	T. aurora	Marsh glider
			T. aconita	
			T. annulata	
			T. bifida	
			T. dorsalis	
		Urothemis	U. assignata	Red basker
	Platycnemididae	Platycnemis	Platycnemis sp	
	Lymnaeidae	Lymnae	L. natalensis	
	Physidae	Physa	Physa sp	
	Pomatiopsidae	Oncomelania	Oncomelania sp	
Pulmonata	Planorbiidae	Biomphalaria	Biomphalaria sp	
		Bulinus	B. trancatus	Ramshorn snail
		Planorbella	Planorbella sp	
		Planorbis	Planorbis sp	
	Thiariidae	Melanoides	M. tuberculata	
Rhynchobdellida	Glossophonidae	Glossophonia	Glossophonia sp	
Unionoida	Unionidae	Anadonta		Duck mussels
Total	25	38	42	

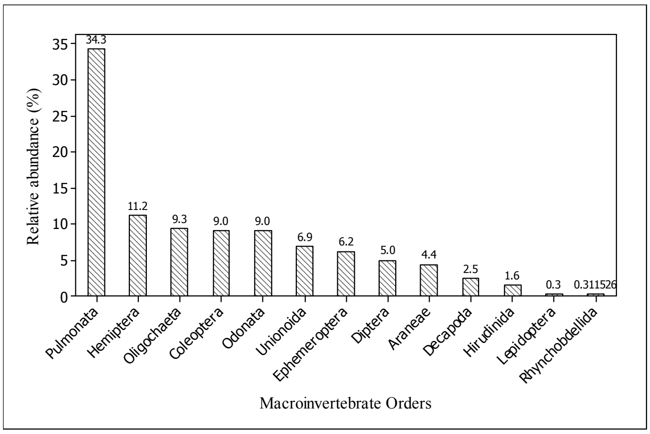

Figure 2. *Relative abundance of macroinvertebrate orders.*

The dominance of mollusks in this lake could probably be attributed to resource availability or lack of predation or both. Past studies (e.g. Iskaro and Dardin, 2010) have attributed dominance of a taxa to suitable abiotic factors, availability of sufficient food and lack of competition and predation. Just like Baetis, Pulmonata are scrapers and therefore abundance in food items could also enhance the abundance of the former. Baetis are probably controlled by predation from Hemiptera and Odonata while molluscks probably lack predators. Molluscks have been reported to be a major food item for African lung fish, Protopterus aethiopicus in Lake Baringo (Omondi et al., 2013) and thus affects its abundance in a system. Abundance of P. aethiopicus significantly reduces abundance of mollusck in an aquatic system since it forms part of their food (Adeyemi, 2010). P. aethiopicus feeds at the bottom of aquatic systems, regions inhabited by molluscks and as such potentially affecting their successful survival (Muli et al., 2007) thus the relationship is possibly inverse.

3.2. Spatial Variation in Composition

Results on abundance changed with changes in depth. There were fewer macroinvertebrates in deeper stations compared to the shallow ones (Fig. 3). Station 14 which had the lowest depth of 30 cm recorded the highest abundance of 145 organisms/m2 while stations 11 and 8 which were the deepest among sampled stations (100 cm each) had the lowest abundance of 42 and 38 organisms/m2, respectively. One way ANOVA using log-transformed total abundance data revealed significant differences between the stations ($F = 8.42$, $p < 0.01$). This variation in diversity and abundance between stations could partly be attributed to variation in water depth. Water depth has been reported to have a significant negative relationship with macroinvertebrate diversity and abundance (Masese et al., 2008)

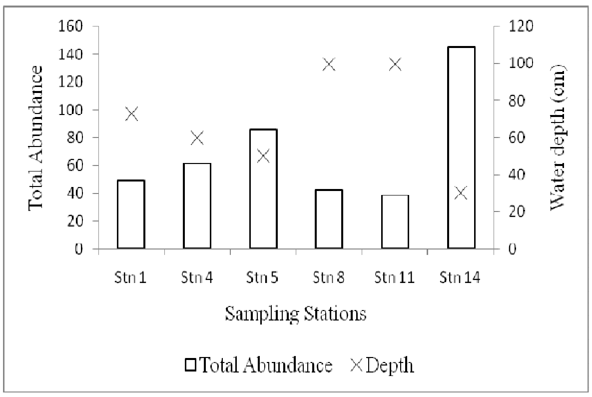

Figure 3. *Relationship between Total abundance and sampling depth within the Lake Kenyatta.*

Station 14 had the highest number of species (39 species) as whereas stations 8 and 11 only had 8 species and 7 species, respectively. Shannon-Weiner diversity index (HI) ranged from 1.67 ± 0.07 in station 8 to 3.28 ± 0.04 in station 14 (Table 2). The evenness index was high in Lake Kenyatta with values ranging from 0.69 ± 0.09 in station 14 to 0.91 ± 0.08 in station 11. In contrast to evenness index, dominance was generally low and ranged from 0.053 ± 0.001 in station 14 to 0.233 ± 0.005 (Table 2). The high abundance and diversity in Station 14 could be as a result of food availability. The sation was closer to the river mouth and as a result receives allochthonous food from the catchment. Food availability has been shown to have a positive correlation with diversity and abundance (Mason, 2002) while research has shown that river mouths have a lot of organic matter compared to other sections within the lake (Resh, 1995; Karr and Chu, 1997).

Table 2. *Macroinvertebrate community attributes at each sampling station.*

Attributes	Station 1	Station 4	Station 5	Station 8	Station 11	Station 14
No of species	14	14	16	8	7	39
Diversity index (HI)	2.53 ± 0.15	2.43 ± 0.17	2.52 ± 0.15	1.67 ± 0.07	1.85 ± 0.13	3.28 ± 0.04
Evenness index	0.89 ± 0.07	0.81 ± 0.05	0.78 ± 0.09	0.76 ± 0.01	0.91 ± 0.08	0.69 ± 0.09
Dominance	0.09 ± 0.01	0.11 ± 0.01	0.10 ± 0.01	0.23 ± 0.01	0.17 ± 0.01	0.05 ± 0.00

3.3. Macroinvertebrate Tolerance Status

Majority of the macroinvertebrates recorded in Lake Kenyatta were the tolerant groups such as Glossophonia, Melanoides, and Lymnae. These accounted for 71.9%while the remaining were the semi-tolerant (28.1%). The sensitive taxa like Plecoptera were not represented in the samples obtained from the Lake. This may suggest that the lake is highly disturbed thus of poor ecosystem health. Lack of sensitive taxa in lake cannot be attributed only to pollution or disturbance but also other factors. Presence of macroinvertebrate taxa in a system is a function of disturbance, availability of microhabitats, climate, and food availability. The lake was relatively shallow with fewer microhabitats. The sediment was mainly sandy and thick forest around the lake could have trapped allochthonous food sources from getting into the lake. There was further high number of hippos that could further destroy the available microhabitats through trampling. Due to the presence of swamps around the lake, the sensitive taxa probably spent their larval stages in the swamps and only came to the lake as adults to forage.

3.4. Functional Feeding Groups

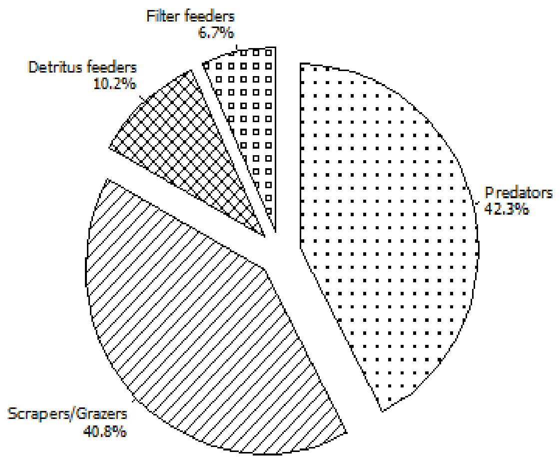

Figure 4. *Proportions of macroinvertebrates functional feeding groups in Lake Kenyatta.*

Four feeding guilds were identified from the macroinvertebrates recorded in Lake Kenyatta. The macroinvertebrates were dominated, in terms of total abundance, by predators (42.3%) followed by Scrapers/grazers (40.8%) while the filter feeders accounted for 6.7% (Fig. 4).

Considering number of taxa per feeding guild, predators had 21 genera which was the highest while filter feeders were the lowest with only 3 species. The dominance of predators in a system is usually an indication of water clarity (low turbidity). Predators flourish in a system where there is adequate prey and clear water for good visibility (Adeyemi, 2010). In comparison to the low depth of Lake Kenyatta, the allochthonous influx in the lake is relatively low hence low representation of filter feeders that depend on TSS and TDS for food.

4. Conclusion and Recommendations

From the results above it is evident that the lake is dominated by mollusks due to lack of predation to control their population. The absence of sensitive taxa in the lake is probably as a result of high numbers of hippos depositing feces and urine apart from destruction of microhabitats. Based on these conclusions the following are recommended;

- Introduction of African Lungfish to convert the mollusks into high biomass to improve economic gain of the fishermen and the local community
- Culling of the hippos to avoid microhabitat destruction and high concentrations of urine and fecal deposits consequently increasing diversity of sensitive taxa that are also food for other cichlids.

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