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Distribution, abundance and diversity of macrozoobenthos in Aiba Reservoir, Iwo, Nigeria

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Spatial and seasonal variation in macrozoobenthic composition, abundance and diversity in Aiba Reservoir were investigated bimonthy between June 2004 and April 2005 using a van Veen grab. A depauperate fauna of nine taxa was recorded. Generally, larger numbers of taxa were recorded during the dry season than in the wet season. *Melanoides tuberculata* and chironomid larvae dominated the macrozoobenthos and showed wide spatial distribution. Diversity and evenness were lower during the wet season than in the dry season, when densities of the major species were low. *Melanoides tuberculata* and chironomid larvae were recorded from maximum depths of 3.9 m and 2.6 m, respectively. Both taxa were also recorded from all substrate texture types, regardless of the amount of macrophyte material present. The benthic fauna is characterised as being poor in terms of density, taxonomic richness and diversity.

Keywords: *Chironomus* sp., *Melanoides tuberculata*, spatio-temporal variation, substrate

Introduction

Available literature shows that the benthic organisms of Nigerian inland freshwaters, especially lentic waters, are few and poorly documented (Egborge 1994, Saliu and Ovuorie 2007). There has been no documentation of the macroinvertebrates of Aiba Reservoir since its creation in 1957. Previous studies on this reservoir covered its biological productivity (Akinyemi and Nwankwo 2006), zooplankton fauna in relation to physico-chemical water quality, drainage hydrology and basin characteristics (Ayodele and Adeniyi 2006) and seasonal physico-chemistry (Atobatele and Ugwumba 2008). The present study aims to supplement the information on macrozoobenthic organisms of lentic freshwaters in south-western Nigeria by describing the distribution, abundance and diversity of the macrozoobenthic fauna of Aiba Reservoir.

Aiba Reservoir, a small tropical man-made reservoir, lies between longitudes 4°11′–4°13′ E and latitudes 7°38′–7°39′ N (Figure 1). The dry season extends from November to March and the wet season from April to October. The average monthly rainfall ranges from about 254 mm in July to 25.4 mm in December–January (Alamu 1992). Aiba Reservoir, which has a catchment area of 54.39 km^2, is the second oldest impoundment of the Osun River Basin and officially came into full operation on 1 June 1957. The dam is 11.58 m high and 455.2 m long, and the reservoir had an original storage capacity of approximately 1.91 billion m^3. The reservoir has a mean depth of 0.75 m and a maximum depth of 7.5 m. The mean Secchi disc transparency ranges from 0.97 m during the dry season to 0.90 m during the wet season (Ayodele and Adeniyi 2006). The reservoir is regarded as being eutrophic (Akinyemi and Nwankwo 2006, Atobatele and Ugwumba 2008).

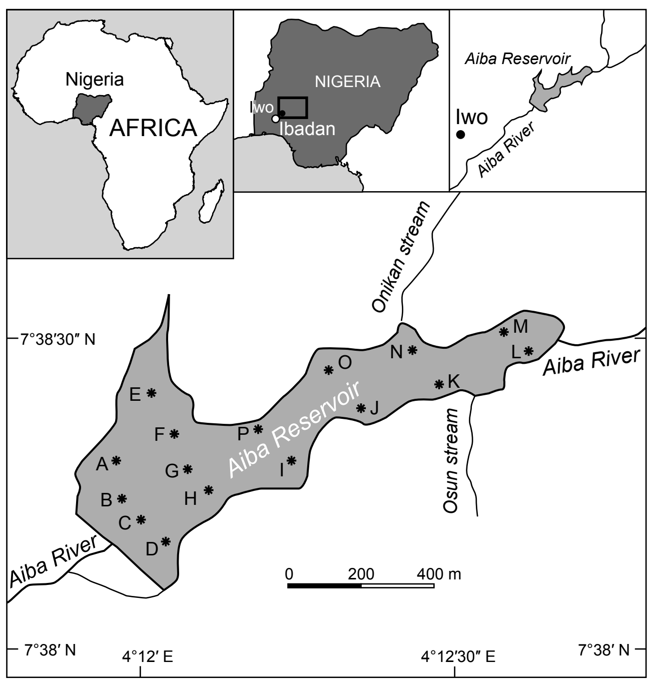

Figure 1: Map of Aiba Reservoir showing locations of macrozoobenthos sampling points

Materials and methods

Sixteen sampling points were chosen to cover the entire area of Aiba Reservoir. Sites A–D were located in the lower reaches of the reservoir near the dam, Sites E–I and P were located in the middle region of the reservoir and Sites J–O were located in the upper region of the reservoir (Figure 1). Benthic samples were collected bimonthly between June 2004 and April 2005 using a van Veen grab (surface area 0.03 m^2). Temporal and spatial dimensions were incorporated into the environmental design (stratified random sampling) to enable the detection of spatial and seasonal variation in benthic macroinvertebrate composition, abundance and diversity. Three random replicate hauls were taken from each site. Water depth was measured using a calibrated rope tied to the van Veen grab. Each benthic sample was diluted with water and swirled. The slurry was gently poured into sieves with mesh sizes 2 mm, 1 mm and 0.5 mm. The residues retained on the screens of the sieves were washed into a shallow white tray with water for sorting. The sorted benthic organisms were preserved in 5% buffered formalin in small glass jars. Individual organisms were identified using a stereoscopic microscope and identification guides such as APHA (1992) and Egborge (1994). Subjective methods (Table 1) were used to assess substrate texture and the amount of plant debris present after sorting the benthic organisms from each sample.

Results

Occurrence, density and diversity

Nine different taxa belonging to three phyla were recorded; two oligochaetes (*Dero* sp. and *Tubifex* sp.), one gastropod (*Melanoides tuberculata*), one ostracod, one hydracarine, and four groups of insect larvae (Chironomidae, *Chaoborus* sp., Coleoptera and one unidentified insect). Only three taxa (*M. tuberculata,* chironomid larvae and *Tubifex* sp. larva) occurred during August and October (Table 2), while the largest number of taxa (seven) was recorded in April. Generally, more taxa were recorded during the wet season (April–October) than in the dry season (November–March).

Table 1: Descriptions of subjective methods used to assess substrate texture and amount of plant material present

Sample no.	Substrate texture [a]	Description
1	Muddy	All the substrate passes through a 0.5 mm mesh sieve, and cannot be felt between the fingers
2	Silty	All the substrate passes through a 0.5 mm mesh sieve, but can be felt between the fingers
3	Fine sandy	Less than 50% of the substrate is retained by a 0.5 mm mesh sieve
4	Sandy	More than 50% of the substrate is retained by a 0.5 mm mesh sieve
5	Coarse sandy	More than 50% of the substrate is retained by a 1 mm mesh sieve
6	Gravelly	More than 50% of the substrate is retained by a 2 mm mesh sieve
Sample no.	**Amount of plant material [a,b]**	**Description**
1	Absent	No plant material found in the substrate
2	Little	Volume of plant material retained by sieves is between 5% and 15% of the volume of substrate
3	Moderate	Volume of plant material retained by sieves is between 20% and 30% of the volume of substrate
4	Large	Volume of plant material retained by sieves is >30% of the volume of substrate

[a] A measuring cylinder was used to assess the volume of substrate retained and the volume of plant material retained in relation to the substrate sample

[b] Plant material comprised mainly dead and decaying macrophytes, although living plants were also present. Microscopic plants were evident by the greenish colour of some of the substrate samples, but were not quantified

Table 2: Mean density (± standard error), overall range, diversity and evenness values of macrozoobenthic organisms in Aiba Reservoir during the study period

Organism	Mean number of organisms m^{-2} (± standard error)							Overall range (no. of orgs m^{-2})
	June 2004	August 2004	October 2004	December 2004	February 2005	April 2005	Total	
Melanoides tuberculata	254 (± 99)	211 (± 107)	70 (± 22)	91 (± 36)	42 (± 12)	63 (± 18)	122 (± 26)	0–2 520
Chironomid larvae	25 (± 8)	65 (± 18)	4 (± 2)	24 (± 8)	49 (± 17)	77 (± 27)	40 (± 7)	0–840
Dero sp.	11 (± 8)	0 (± 0)	0 (± 0)	5 (± 4)	0 (± 0)	10 (± 5)	4 (± 2)	0–350
Chaoborus sp.	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)	1 (± 1)	<1 (± 0)	0–35
Tubifex sp.	1 (± 1)	1 (± 1)	1 (± 1)	0 (± 0)	1 (± 1)	1 (± 1)	1 (± 0)	0–70
Ostracoda	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)	1 (± 1)	1 (± 1)	<1(± 0)	0–35
Diptera larvae	0 (± 0)	0 (± 0)	0 (± 0)	2 (± 1)	0 (± 0)	0 (± 0)	<1 (± 0)	0–35
Coleoptera larvae	0 (± 0)	0 (± 0)	0 (± 0)	1 (± 1)	0 (± 0)	0 (± 0)	<1 (± 0)	0–35
Hydracarina	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)	0 (± 0)	1 (± 1)	<1 (± 0)	0–35
Total	291 (± 110)	277 (± 112)	74 (± 23)	123 (± 42)	92 (± 25)	153 (± 48)	168 (± 29)	
Diversity	0.47	0.58	0.25	0.76	0.77	1.01		
Evenness	0.34	0.52	0.23	0.47	0.56	0.52		

The density of *M. tuberculata* ranged from 0 to 2 520 organisms m^{-2} in the 288 samples collected, with an overall mean of 122 ± 26 organisms m^{-2} (Table 2). *Melanoides tuberculata* was most abundant (254 ± 99 organisms m^{-2}) during June and least abundant (42 ± 12 organisms m^{-2}) during February. The density of chironomid larvae in individual grab samples ranged from 0 to 840 organisms m^{-2} with a mean of 40 ± 7 organisms m^{-2}. The highest mean density (77 ± 27 organisms m^{-2}) was recorded during April while the lowest (4 ± 2 organisms m^{-2}) was recorded during October. No other macrozoobenthic taxa had a total mean density of >5 organisms m^{-2}.

No benthic invertebrates were captured at the two deep sites (B and C) near the dam and these sites were excluded from subsequent analyses. Variation in total density among sites (Figure 2) was greatest in August (0–1 645 organisms m^{-2}), and least in October (0–257 organisms m^{-2}). The highest densities were recorded from the lower reaches (Site A) during December and April and the upper region of the reservoir (Sites K and M during June and August, respectively). Shannon-Wiener diversity of macrozoobenthos during the study period ranged from 0.25 in October to 1.01 in April. Diversity was relatively lower during the wet season compared to the dry season. Evenness varied from 0.23 in October to 0.56 in February.

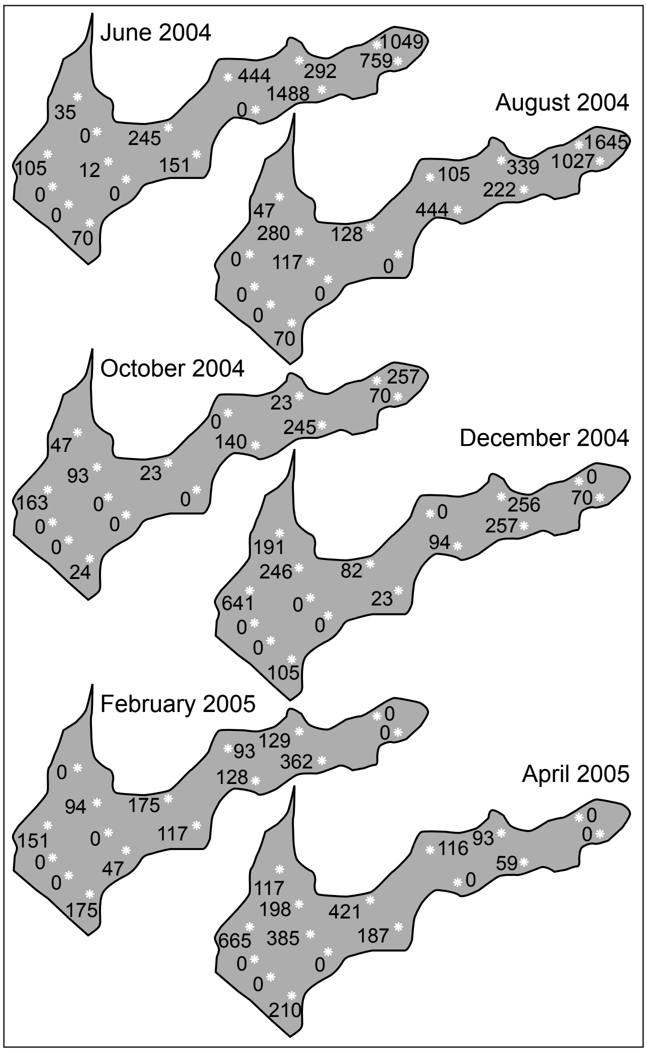

Figure 2: Spatial density (number of organisms m^{-2}) of macrozoobenthos in Aiba Reservoir from June 2004 to April 2005. Values are mean densities of all macrozoobenthic organisms in three replicate benthic samples

Distribution

Melanoides tuberculata and chironomid larvae were recorded from all parts of the reservoir, except from the two deep sites, B and C, near the dam (Figure 3) and were the only macrozoobenthic organisms recorded from Site H, which yielded macrozoobenthos only once throughout the study period. *Melanoides tuberculata* occurred in greater numbers in the upper region of the reservoir (Sites I to P) and in the lower reaches of the reservoir (Sites A and D), while chironomid larvae occurred in greater numbers in the middle region (Sites F and P) and in the lower reaches of the reservoir (Sites A and D). Small numbers of *Dero* sp. were found in the upper region of the reservoir (Sites K, M and N) and in the middle region (Sites E, F, G and P), but only at Site A in the lower reaches of the reservoir. All other macrozoobenthic organisms were represented by only a few individuals. Only four of the sixteen sites (D, K, N and P) yielded benthic invertebrates during every sampling visit.

Interrelationship of physical environmental variables with macrozoobenthos occurrence

Only *Melanoides tuberculata*, chironomid larvae and *Tubifex* sp. were found at depths >2 m (Table 3). *Melanoides tuberculata*, chironomid larvae and *Tubifex* sp. were recorded from maximum depths of 3.9 m, 2.6 m and 2.2 m, respectively. In contrast, *Chaoborus*, Ostracoda and Hydracarina were found only at depths <1 m. *M. tuberculata* and chironomid larvae were recorded from all substrate texture types, whereas *Chaoborus*, Ostracoda, Coleoptera larvae and Hydracarina were found only on sandy substrata. The occurrences of *M. tuberculata* and chironomid larvae appeared to be independent of the amount of macrophytes present. *Dero* sp. was absent from substrates with a large amount of macrophyte material while the other insect larvae and Hydracarina were recorded from substrate with little or no macrophytes.

Melanoides tuberculata was most abundant on silty substrate (170 ± 97 organisms m^{-2}) and gravel (136 ± 100 organisms m^{-2}), but was less frequently found on gravel (Figure 4); and least common on mud (17% of samples, 57 ± 36 organisms m^{-2}). Chironomids were most common and abundant on coarser substrata, and rarely collected on mud. *M. tuberculata* was collected most frequently on substrata with little plant material, but mean densities did not vary with the amount of plant material in the samples (Figure 5). Chironomids occurred most frequently and abundantly in samples with little to moderate amounts of plant material (Figure 5).

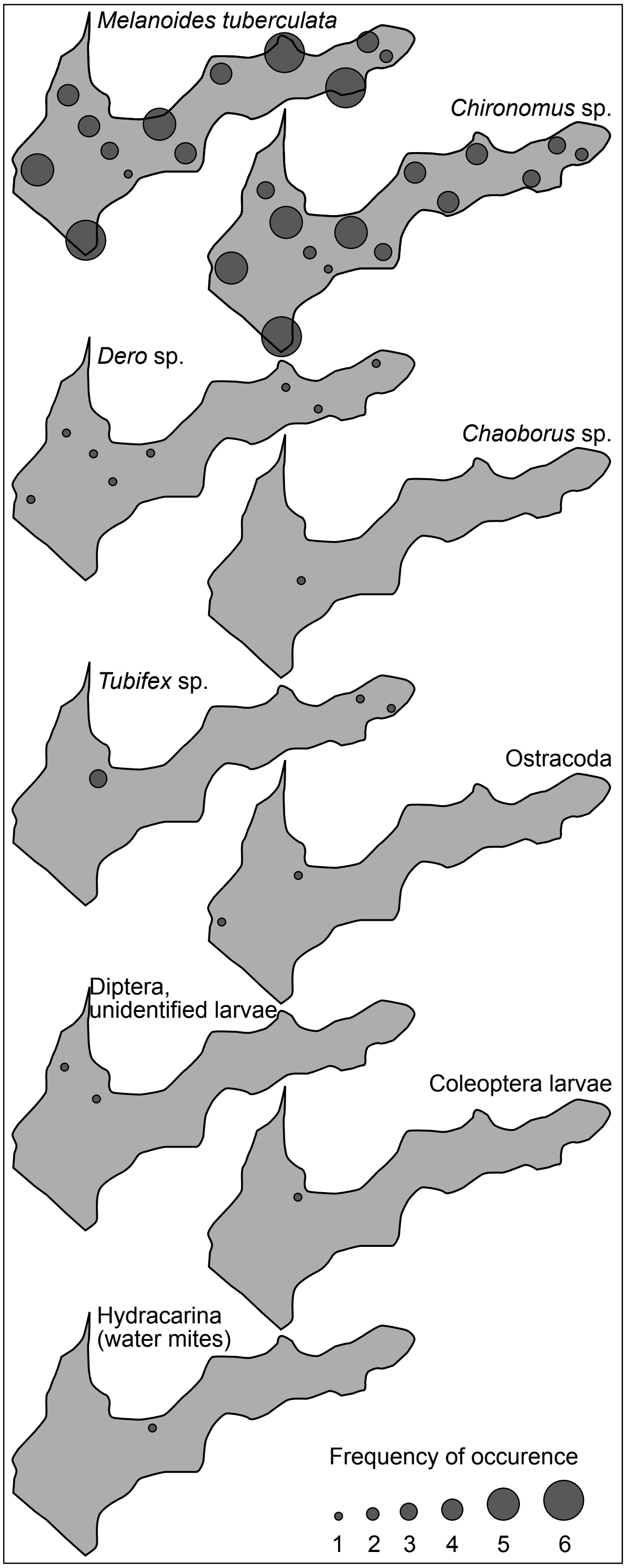

Figure 3: Distribution of macrozoobenthos in Aiba Reservoir from June 2004 to April 2005. Each location was sampled six times during the study period. Frequency of occurrence (number of times each taxon was recorded during the six sampling occasions) is shown for each taxon

Discussion

The largest number of taxa was recorded in April during the early rainy season. Higher taxonomic richness of macrozoobenthos during the rainy season compared with the dry season has been reported in Brazil (Moreno and Callisto 2006). The greatest macrozoobenthic density was found in the lower reaches of the reservoir towards the dam, the area with the highest human activity, and in the upper region of the reservoir near the inflow of the Aiba River. The major human activity in the lower reaches of the reservoir, which is the landing area for artisanal fishermen, is fish processing. The offal and scales of processed fish are returned into the reservoir at Sites A and D. The Aiba River is also a source of input from human activities into the reservoir, especially during the rainy season. *Melanoides tuberculata* and chironomid larvae occurred throughout the study period and showed widespread spatial distribution. They were recorded from all parts of the reservoir except towards the two deepest sites (B and C) near the dam, which had a muddy substrate. The absence of macrozoobenthos from this part of the reservoir may be due to a combination of factors including the lack of or inadequate food or plant materials, unsuitability of the substrate, or very likely the water depth which was >7 m, suggesting anoxic conditions. *Melanoides tuberculata* and chironomid larvae were relatively more abundant in the upper region of the reservoir, except during October when the latter were more abundant in the lower part of the reservoir. This may be attributed to the greater mobility of chironomids compared to that of the gastropod, enabling them to propagate themselves quickly by re-colonising sites suitable for larval development. Organic inputs from allochthonous sources are likely to promote benthic secondary production, while deoxygenation from microbial processing of organic inputs, and predation pressure by fish could result in the near absence of macrozoobenthos during the dry season.

The gastropod *M. tuberculata* was the most abundant benthic organism and was distributed throughout Aiba Reservoir. Its success can be attributed to its toughness, its horny operculum protecting it against drought and predators. The snail can easily survive months of drought hidden in the substrate, while the strength and thickness of its shell prevents most fish and other predators from crushing it. Even predators that swallow them whole will not always benefit from their meal as these snails can sometimes survive passing through the intestines (Ghesquiere 2007). One of the most remarkable features of this snail is its parthenogenetic reproduction (Samadi et al. 1999, Genner et al. 2004, Facon et al. 2005, Gregoric et al. 2007). *Melanoides tuberculata* has been reported to be of public health importance, as it can serve as first intermediate host for the human lung flukes *Paragonimus westermani* and *Clonorchis sinensis* (Paz et al. 1995, Supian and Ikhwanuddin 2002, Gregoric et al. 2007, Reeves et al. 2008).

Chironomid larvae dominated the macrozoobenthos during the late dry season and the early wet season (February–April). Chironomid larvae have also been reported to be prominent in Lakes Edward and George (Beadle 1974). Many chironomid larvae are collectors and are usually confined to

Table 3: Macroinvertebrate habitat characteristics during the study period

Organism	Depth range (m)	Substrate texture	Amount of plant material
Melanoides tuberculata	0.1–3.9	Muddy, silty, fine sandy, sandy, coarse sandy, gravelly	Absent, little, moderate, large
Chironomid larvae	0.1–2.6	Muddy, silty, fine sandy, sandy, coarse sandy, gravelly	Absent, little, moderate, large
Dero sp.	0.3–1.4	Silty, sandy, gravelly	Absent, little, moderate
Chaoborus sp.	0.6	Sandy	Little
Tubifex sp.	0.1–2.2	Muddy, coarse sandy, gravelly	Absent, large
Ostracoda	0.4	Coarse sandy	Moderate
Diptera larvae	1.3–1.4	Silty, sandy, coarse sandy	Absent
Coleoptera larvae	1.4	Sandy	Absent
Hydracarina	0.5	Fine sandy	Little

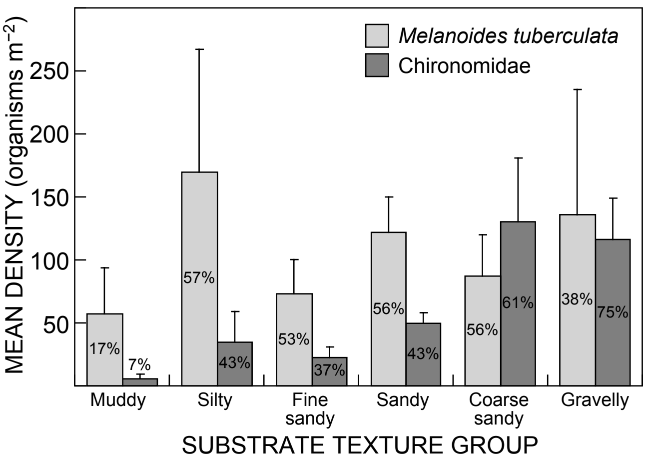

Figure 4: Mean density and standard error of *Melanoides tuberculata* and Chironomidae found on different substrate groups in Aiba Reservoir from June 2004 to April 2005. The percentage frequency of occurrence of each taxon for each substrate texture group is given in each bar

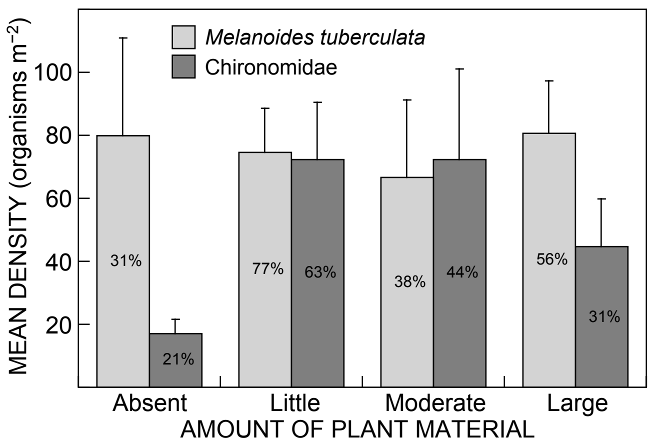

Figure 5: Mean density and standard error of *Melanoides tuberculata* and Chironomidae in relation to the amount of substrate plant material in Aiba Reservoir from June 2004 to April 2005. The percentage frequency of occurrence of each taxon for each substrate texture group is given in each bar

the bottom mud, where they feed on detritus and associated microorganisms, thereby assisting in the general process of decomposition and in remobilising nutrients into the water column (Beadle 1974, Anyaele 2005). *Chaoborus* larvae had a low density and distribution in the benthic samples, while the ostracod was recorded only during the dry season month. Both of these groups are common in African lakes, and form a major portion of the diet of some fish species in the reservoir, such as *Chrysichthys* spp. (Atobatele 2008). The abundance of ostracods was probably underestimated due to the 0.5 mm mesh of the sieve used being too coarse to retain some species.

Diversity was higher during the dry season months, when the densities of the major taxa were low. This may be attributed to an increase in substrate habitat diversity during the dry season, when the reservoir water is relatively clear and the water level is low as a result of the absence of disturbance from rain and from inflow. This may also result in increased predation, resulting in the lower densities of major taxa. Atobatele and Ugwumba (2008) reported a significant seasonal difference in turbidity in the reservoir, with clearer water during the dry season. Inflow of water from the catchment area of the reservoir and the direct impact of rain on the reservoir during the rainy season increase the water level and disturbance, reducing the clarity of the water.

The very low densities of macrozoobenthos recorded (overall mean 168 ± 29 organisms m^{-2}), although a common phenomenon in tropical lakes, is in sharp contrast to the high densities recorded in north temperate lakes. A study of 30 arctic and subarctic lakes recorded total benthic densities ranging from 660 to >25 000 organisms m^{-2} (D Barton, University of Waterloo, Canada, pers. comm.). The maximum density of *M. tuberculata* recorded was 2 520 organisms m^{-2}, well below the maximum density of 10 000 organisms m^{-2} reported in St Johns River, Florida (Benson et al. 2001). This snail was the only macroinvertebrate collected from depths >2.6 m, consistent with observations by Benson et al. (2001) that it can be found in relatively deep pools (3.0–3.7 m deep). Substrate type has been reported to play a major role in structuring macroinvertebrate assemblages. Ziser (1985) and Silveira et al. (2006) reported that sandy substrates are unstable and limit benthos colonisation, resulting in reduced densities and diversity. Saliu and Ovuorie (2007) reported that microinvertebrate preference for gravels is because of gravel size and physical stability, providing abundant microhabitats for colonisation and ability to trap organic matter. *Melanoides tuberculata* and chironomid larvae were recorded from all substrate types in Aiba Reservoir, regardless of the amount of macrophyte material present. However, it preferred silty and gravelly substrates to muddy substrates, whereas chironomids showed preference for coarser substrata, occurring in high frequency on coarse sandy and gravelly substrates. *Melanoides tuberculata* seems not to show a preference for the amount of substrate plant material, although it occurs more commonly on substrates with little plant material. Chironomids seem to prefer substrates with little or moderate amounts of plant material, especially the former. Chironomids showed less tolerance for substrates with no plant material. This suggests that, although the two dominant taxa showed preferences for certain substrate types, they tolerate a wide range of substrata down to a certain water depth.

Conclusion

This study recorded the paucity, sporadic occurrence, low density and low diversity of macrozoobenthos in Aiba Reservoir. The depauperate nature of the benthic macrofauna may be attributed to the fact that most samples were taken from sediment in open water, away from emergent macrophytes. Only four of the 16 sites studied yielded benthic invertebrates during every sampling visit, and one of the sites yielded two taxa only once during the sampling period. No macrozoobenthos was found at depths greater than 3.7 m. The upper region of the reservoir seems to be unfavourable to macroinvertebrates during the dry season, but favourable during the wet season. However, the opposite applies in the lower reaches of the reservoir. This may suggest that hydrologic factors influence the density and suitability of habitat for macrozoobenthic colonisation. Water depth and substratum texture also seem to be predictive of macrozoobenthic abundance in the reservoir. The low and high mean densities recorded during dry and wet season months, respectively, for the three most abundant macrozoobenthic organisms (*M. tuberculata,* chironomid larvae and *Dero* sp.) may suggest that the abundance of food from allochthonous sources aids in the proliferation of these organisms, while predation pressure plays an important role during the dry season.

The dominance of *M. tuberculata* and chironomid larvae, in terms of distribution, density and their ability to colonise a wide range of depths and substrate types, suggests that they are hardy species. *Melanoides tuberculata* is native to subtropical and tropical regions of Africa, Asia and Australia. However, its hardy nature has enabled it to become established in numerous countries outside its native range (Benson et al. 2001, Derraik 2008), and it is therefore regarded as a cosmopolitan species (Elkarmi and Ismail 2007).

Since this was only a baseline study of the macrozoobenthos of Aiba Reservoir, it will be necessary to carry out further research on the physico-chemical and biotic characteristics of the reservoir that determine the presence and abundance of these species, and to determine the biology and specific role of the abundant macrozoobenthic species.

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