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The benthic communities of the saline lakes Abijata and Shala (Ethiopia)

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Abstract

Lake Abijata lies in a shallow depression (maximum depth 8–9.5 m); the water is green with phytoplankton and it supports large fish and bird communities. Lake Shala lies in a deep caldera (maximum depth reputedly 260 m); phytoplankton is sparse and fish and bird communities scanty.

Lakes Abijata and Shala, sampled in January, 1985, had conductivities of 14000 and 21000 microSiemens cm^{-1} at 25 °C respectively, mainly due to high sodium, carbonate and chloride ions. Calcium concentrations are very low.

The benthic fauna was studied with an Ekman grab to a depth of 8.5 m in Abijata and 15.5 m in Shala and was found to be dense in both lakes but varying greatly in composition at different depths. In Abijata the benthos consisted mainly of Ostracoda and Chironomidae, and in Shala mainly of Tubificidae, Ostracoda and Chironomidae. There were very few Nematoda. No true halophilic species were found but the community consisted of euryhaline forms found also in non-saline waters. Predatory invertebrates were absent and many of the dominant species, notably of the Chironomidae, were different from those of non-saline lakes nearby.

Introduction

Very few studies of the benthos in tropical African lakes have been done. The most comprehensive are those on non-saline lakes Chad (Carmouze, Durand & Leveque, 1983) and Chilwa (Kalk, McLachlan & Howard-Williams, 1979), but there have been no complete descriptions of benthic populations of Afrotropical saline lakes. This paper describes the benthic fauna of two saline lakes in the Ethiopian Rift Valley and forms part of the first study on benthic populations of Ethiopian lakes, both saline and non-saline.

Lakes Abijata and Shala lie between 7°25′ and 7°45′N and 38°25′ and 38°45′W at altitudes of approximately 1580 m and 1540 m respectively (Fig. 1). During pluvial periods these two lakes were united with Lakes Langano and Ziway (Fig. 1) to form the large Lake Gala which had a northern outflow into the Awash River (Gasse & Street, 1978). After the last pluvial the water level dropped until the outflow into the Awash was lost, and now Ziway and Langano drain into Abijata which is a terminal lake. Lake Shala is no longer connected to the other lakes.

Lake Abijata lies in a shallow basin about 18 km long and its greatest depth is about 8 – 9.5 m (Wodajo & Belay, 1984, and authors' data). It receives as its main inflows the Bulbula River from Lake Ziway and the Hora Kelo River from Lake Langano. It also receives inflows from local drainage channels during the rainy season but these must be small as rainfall is low on the valley floor. Wodajo & Belay (1984) report that Abijata is a very productive lake, and this is borne out by the abundant phytoplankton and fish and bird life as noted by the authors.

Lake Shala lies in a caldera almost surrounded by high hills; it is about 26 km long and reputed to have a greatest depth of 260 m (von Damm & Edmond, 1984). It is fed by the Digo River from the west of the Rift Valley and by mountain streams from the east (Fig. 1). There are also a number of hot springs around the shore and possibly some below the surface. It has no outlet at present and appears to be less productive than Abijata as the authors noted that

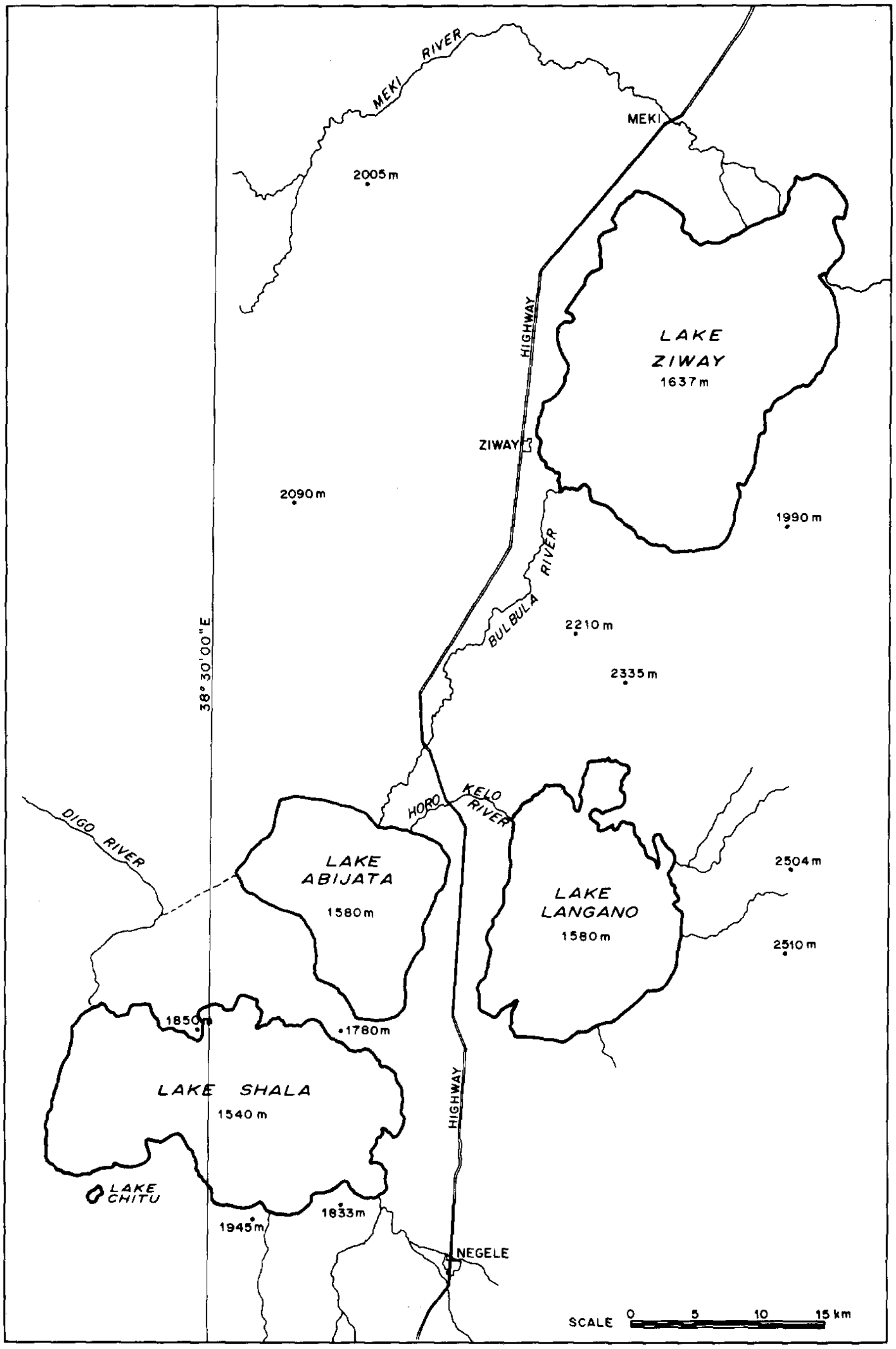

Fig. 1. Map of Lake Abijata and Shala with their principal sources of water.

algal- and fish-eating birds were rare.

The two lakes differ markedly from the non-saline lakes nearby in that they lack any form of aquatic macrophytes. In fact, during periods of rising water levels their water rapidly kills off all shoreline vegetation.

Wodajo & Belay (1984) give a short description of the climate of the region; most rain falls between

June and mid-September but there is also a shorter wet period between March and May. They also report that water levels in the lakes seldom vary by more than 1 m during the year; there are no figures for Lake Shala.

Methods

The lakes were sampled for zoobenthos on the 17th and 18th January, 1985, and water samples for chemical analyses were taken in April, 1983.

Measurements of temperature and oxygen concentration were made in the field with a YSI Model 57 oxygen-temperature meter, conductivities with a YSI Model 43 conductivity meter corrected to 25 °C, and pH with a portable pH meter; oxygen saturations were derived from the table supplied with the meter. Water samples were collected by the authors and analysed in the Department of Earth Sciences, University of Waterloo, Canada, by the following methods: cations by atomic absorption analysis, chloride and sulfate by ion chromatography, using a Dionex System 12 ion chromatograph, and bicarbonate by tritating with standard acid to a pH end-point of 4.3.

Bottom deposits and benthic fauna were sampled with a standard Ekman grab with a 15 cm square opening. Two biological samples were taken at each sampling station and results are reported as a means of these. Particle size analysis was carried out according to Folk (1968). Faunal samples were first washed in a Nitex net with 0.20 mm mesh and then analysed in the laboratory by means of a binocular dissecting microscope. Identification of chironomid larvae and adults netted around the lakes or caught emerging from the lake surface was done using the complete African literature. All larvae were correlated by rearing in the laboratory. Nematoda were sent to A. Zullini (Milan) and Ostracoda to K. Martens (Ghent).

Results

Table 1 gives the results of the water analyses and field measurements. Some results are also given for

Table 1. Analysis of surface waters of Ethiopian Rift Valley saline lakes.

	Abijata	Shala	Chitu
Altitude m	1578	1558	1560
pH	9.55	9.50	9.50
Conductivity μS cm^{-1} at 25 °C	14000	21000	-
Ions, mg l^{-1}			
Na^+	4510	6250	12600
K^+	233	248	935
Ca^{2+}	0.70	<2	<2
Mg^{2+}	0.15	<1	-
HCO_3^-/CO_3^{2-}	10070	12800	14600
Cl^-	2250	3010	5975
SO_4^{2-}	167	275	320
Transparency m (Secchi disk)	0.3	3.0	-

Lake Chitu, a small crater lake on the southern shore of Shala (Fig. 1, see discussion). All three are "soda lakes" with high pH, sodium, carbonate and chloride values and very low calcium and magnesium values. The pH values over 9.4 and high alkalinity lead to precipitation of calcium and magnesium carbonate and account for the very low levels of these cations; the chemical processes taking place are described by von Damm & Edmond (1984). Our results are very similar to those listed by Talling & Talling (1965).

The high turbidities in Abijata were related to dense phytoplankton (Wodajo & Belay, 1984) and the relatively low transparency in Shala was due to the slightly brown color of the water.

Figure 2 gives the temperature and oxygen profiles; both lakes were calm at the time. Shala was measured only down to 15.5 m, the length of the available cables and the greatest depth at which benthic samples were taken. Abijata was probed to the bottom near the centre of the lake. In both lakes the surface waters were markedly warmer than the deeper waters, but the deeper waters of Abijata were cooler (18.5 °C) than those of Shala (21.5 – 22.5 °C). The surface waters of Abijata were supersaturated with oxygen and high oxygen values continued to the bottom. In Shala the values were lower but were still nearly 60% of saturation at 15.5 m.

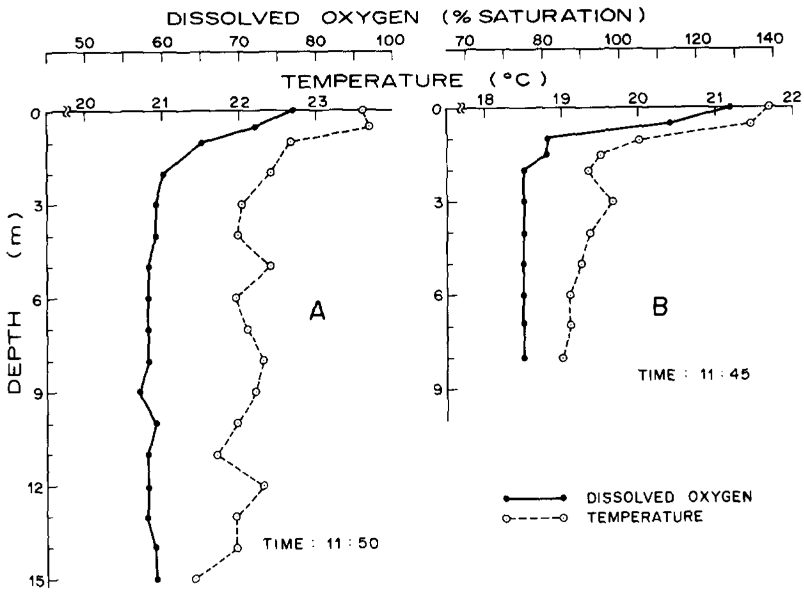

Fig. 2. Depth profiles for temperature and dissolved oxygen (% saturation) in Lake Shala (A) and Lake Abijata (B) on 17 and 18 January, 1985, respectively.

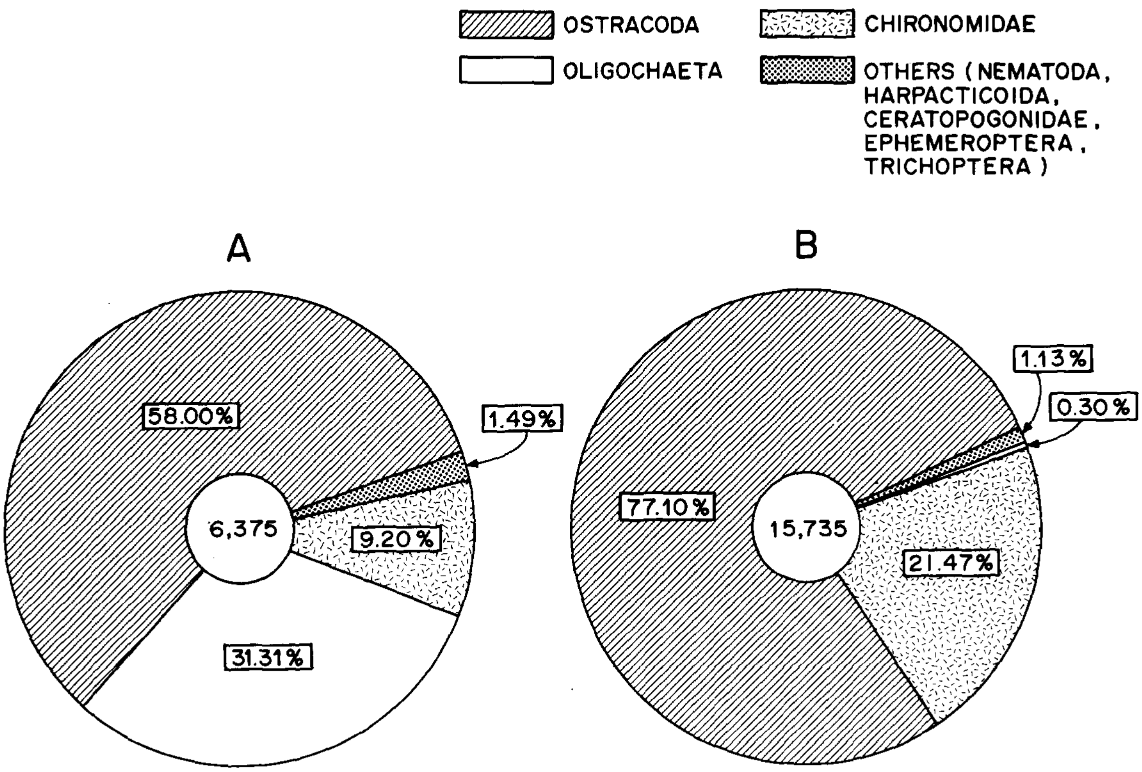

Fig. 3. Per cent abundance of benthic organisms in Lake Shala (A) and Lake Abijata (B) in January, 1985. The total number of individuals collected from the lakes is shown in the middle of the circles.

The particle size analysis showed that in Abijata the bottom between 0.15 and 3 m is sandy, and the values of the sorting coefficients (Folk, 1968) suggest a poorly sorted sediment. From 5 m to 9 m the bottom consisted of clay, moderately well sorted. In Shala the bottom at the shallow eastern shore stations (0.2, 0.3 and 0.9 m) was sandy with poorly sorted sediments; at 15 m, where the bottom slopes gently, it consisted of well-sorted clay. Near the north shore at 15.5 m, where the bottom slopes steeply, it consisted of sand and gravel.

Figure 3 gives the percentage abundance of taxonomic groups in both lakes, based on figures from all depths. In Shala (A) Ostracoda predominated but Oligochaeta (*Tubifex*) and Chironomidae formed important constituents. In Abijata (B) Ostracoda and Chironomidae comprised the bulk of the fauna and *Tubifex* were very few in number.

Table 2 gives the densities of the various taxonomic groups in Shala. Ostracoda and *Tubifex* were abundant down to 15.5 m but Chironomidae were more abundant in shallower water. There was not much difference between the communities on mud at 15 m and on sand and gravel at 15.5 m. The latter

Table 2. Densities of taxa m^{-2} at various depths in Lake Shala (means of 2 samples).

Depth m	0.2	0.3	0.9	11.0	15.0	15.5
Nematoda	0	222	44	22	0	200
Oligochaeta	978	13111	5311	6378	9133	16000
Ostracoda	133	8889	25000	9089	12644	30844
Harpacticoida	667	1867	0	0	0	0
Chironomidae	800	5156	7622	667	733	622
Heteroptera	0	44	44	44	0	0
Ephemeroptera	0	44	0	0	0	0
Trichoptera	0	44	0	0	0	0

Notes: Oligochaeta = *Tubifex;* Ostracoda = Limnocytherinae; Harpacticoida = *Nitocra* sp.; Heteroptera = *Laccocoris* cf. *limigenus*.

Table 3. Densities of the Chironomidae m^{-2} at various depths in Lake Shala (mean of 2 samples).

Depth m	0.20	0.30	0.90	11.0	15.0	15.5
Microchironomus deribae	0	0	1311	444	89	422
Einfeldia disparilis	22	133	822	222	644	200
Cladotanytarsus pseudomancus	778	5022	5467	0	0	0
Tanytarsus horni	0	0	0	22	0	0

Table 4. Densities of taxa m^{-2} at various depths in Lake Abijata (mean of 2 samples).

Depth	0.15	0.5	3.0	5.0	8.0	9.5
Nematoda	2889	200	133	0	0	0
Oligochaeta	1000	0	0	0	0	0
Ostracoda	39378	5600	220889	3711	22	0
Chironomidae	2067	422	61711	7578	911	2400
Heteroptera	489	22	44	0	0	0
Ceratopogonidae	156	0	44	0	0	0

Notes: Oligochaeta = *Tubifex;* Ostracoda = mostly Limnocytherinae; Heteroptera = *Micronecta compar*.

Table 5. Densities of the Chironomidae m^{-2} in Lake Abijata (mean of 2 samples).

Depth m	0.15	0.5	3.0	5.0	8.0	9.5
Microchironomus deribae	1756	44	52044	7533	911	1578
Einfeldia disparilis	22	44	8600	44	0	822
Cladotanytarsus psudomancus	267	333	1067	0	0	0

station was on a steeply sloping bottom near the northern shore and there was a lot of fresh leaf detritus present. Table 3 gives details of the benthic chironomids in Shala; only four species were found and one, *Tanytarsus horni* Goetghebeur, was rare. *Cladotanytarsus pseudomancus* Goet. was abundant in the shallows but disappeared at 11 m and below.

Table 4 shows that in Abijata the ostracods were abundant over most of the bottom except in the deepest region in the centre of the lake; chironomids were abundant there. The oligochaetes (*Tubifex*) and the corixid, *Micronecta compar* Horvath, occurred only in the shallows. Only three chironomid species were found in Abijata (Table 5) and *Microchironomus deribae* Freeman was abundant in almost every sample. *Cladotanytarsus pseudomancus* was found only down to three metres, a much shallower distribution than in Shala.

Discussion

The waters of these saline lakes are unsuitable for many aquatic species because of their high osmotic pressure, their high pH and their unusual ionic balance. The sodium concentrations are very high, whereas the calcium concentrations are exceedingly low. Nevertheless a limited fauna is present and some of the species are very abundant. Wodajo & Belay (1984) found much the same with the zooplankton of Abijata.

Nearly all the benthic species found in the saline lakes have also been found in non-saline lakes or smaller waterbodies nearby. *Micronecta compar*, the only known exception, was very abundant around the shallow margins of Abijata in handnet samples; it was previously reported from this lake by Hutchinson (1930), but he found it in no other samples from Ethiopia; the authors found it in no other lakes.

The chironomid species which are so abundant in Shala and Abijata were only rarely found at lights near the freshwater lakes, and these may have been arriving from nearby smaller freshwater bodies. The only exception is *Cladotanytarsus pseudomancus* which is abundant in both saline and non-saline lakes. The distribution of chironomids in the lakes of the Central Ethiopian Rift Valley is discussed by Harrison (in press).

Many benthic forms common in nearby freshwater lakes are absent from the saline lakes; these include all molluscs, Ephemeroptera, such as *Caenis spp.* and the predatory tanypodine chironomids, such as *Procladius brevipetiolatus* Geotghebeur. Thus the composition of the benthic community of these saline lakes is unique, but the component species are euryhaline organisms found also in freshwater.

The composition of the zooplankton of Abijata follows the same pattern (Wodajo & Belay, 1984) and the same appears to be the case with the fish. The tilapia, *Oreochromis niloticus*, is the only species reported from Abijata where it is very abundant. The authors noted only this species and the cyprinidont minnow, *Aplocheilichthys* sp., in Shala.

The density of the benthos is greater in the saline lakes than in the nearby freshwater lakes of Ziway, Langano and Awasa (authors' observations). This is not surprising in the case of Abijata which has a dense phytoplankton as a food source, but Shala has poor phytoplankton and yet supports dense benthic organisms. One obvious factor is the lack of predators in these lakes. The fish found so far are not benthic feeders; *O. niloticus* feeds on phytoplankton and *Aplocheilichthyes* sp. on zooplankton. Similarly, there are few predatory invertebrates; the main one, *Laccocoris* sp., in Shala, is not found in deeper water and is only locally abundant under stones in very shallow water.

The small crater lake Chitu (Fig. 1 and Table 1) is even more strongly saline than Shala but is a more precarious habitat, as it has an anoxic zone close to the surface and which may even reach the surface at times (Amha Belay, private communication). Nevertheless, the same four chironomid species which are found in Shala have also been found emerging from this lake, as well as a large number of *T. horni* in one of nine Ekman grabs. Nevertheless, bottom samples collected in the same way as in the other lakes have shown no ostracods, nematodes or Tubificidae. These may not be able to survive anoxic periods and therefore would not be able to recolonize the lake as quickly as the chironomids.

Hutchinson (1932) did not find *Micronecta compar* but a similar species, *M. jenkinae* Hutch. in Lake Nakuru, Kenya. Vareschi and Jacobs (1985) found *Microchironomus deribae* (reported as *Leptochironomus deribae*) from the same lake, but noted no ostracods or tubificids. One of the authors (ADH) noted large numbers of *Tanytarsus horni* emerging from Lakes Elmenteita and Bogoria, Kenya, in September, 1985; there were also a few at lights in the town of Nakuru, not far from the lake. Therefore, there is evidence that the Kenyan soda lakes may support a benthic community similar to that of the Ethiopian soda lakes.

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