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Limnologica 37 (2007) 311–322
LIMNOLOGICA
www.elsevier.de/limno

Spatio-temporal changes in the abundance of the populations of the gastrotrich community in a shallow lake of tropical Africa
Variations spatio-temporelles de l'abondance des populations d'une communauté de Gastrotriches d'un lac peu profond d'Afrique tropicale

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Received 26 April 2006; received in revised form 20 May 2007; accepted 29 June 2007

Abstract

Studies on the biodiversity and population dynamics of freshwater planktonic Gastrotricha have been carried out in conjunction with a physical–chemical analysis of the water in the Yaounde Municipal Lake (Cameroon, Central Africa) over a 14 months period (November 1996–December 1997). The results obtained allow to consider the Yaounde Municipal Lake as an eutrophic lake. It harbours eight species of Gastrotricha belonging to four genera (*Chaetonotus*, *Dasydytes*, *Neogossea* and *Polymerurus*) of the order Chaetonotida. This community was characterized by high abundances of populations, and was dominated by the genus *Neogossea* and *Chaetonotus* reaching up to 2000 ind. L^{-1}. *Polymerurus* was mostly abundant at the almost anoxic bottom layers. The highest abundances were found mostly during the rainy season, when there is an important sedimentation process of organic matter, and were influenced by several different environmental factors such as dissolved oxygen, temperature and pH of the water.

Finally this community which may play an important role in the water bodies, is a potential water quality indicator.

Résumé

Des analyses physico-chimiques de l'eau ainsi que l'étude de la biodiversité et la dynamique des populations de Gastrotriches planctoniques ont été effectuées dans le Lac Municipal de Yaoundé (Cameroun, Afrique Centrale) pendant une période de 14 mois (de novembre 1996 à décembre 1997). Les résultats obtenus permettent de conclure que le Lac Municipal de Yaoundé est un lac eutrophe qui héberge 8 espèces de Gastrotriches appartenant à 4 genres (*Chaetonotus, Dasydytes, Neogossea* et *Polymerurus*), tous de l'ordre des Chaetonotida.

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0075-9511/$ - see front matter
doi:10.1016/j.limno.2007.06.003

Cette communauté dont les abondances sont élevées est dominée par les genres *Neogossea* et *Chaetonotus* dont les densités peuvent atteindre 2000 ind. L^{-1}. *Polymerurus* est plus abondant dans les fonds presque anoxiques. Les fluctuations d'abondance des espèces présentent des pics surtout pendant la saison des pluies, lorsque le milieu est riche en matières organiques, et sont influencées par plusieurs variables environnementales, principalement par le taux d'oxygène dissous, la température et le pH. Ces espèces qui peuvent jouer un rôle important dans les milieux aquatiques dulcicoles, se sont avérées potentiellement indicatrices de la qualité des eaux.

Mots clés: Limnologie tropicale; Gastrotriches; Lac Municipal de Yaoundé; Plancton; Répartition spatio-temporelle et Corrélations

Keywords: Tropical limnology; Gastrotricha; Yaounde Municipal Lake; Plankton; Spatio-temporal variations and Correlations

Introduction

Gastrotrichs are triploblastic, microscopic, acoelomate metazoans and form a phylum divided into two orders: Macrodasyida and Chaetonotida (Hochberg & Litvaitis 2000). They are characterized by worm-like or ten-pin body shape covered by a multilayered cuticle that often forms spine-bearing scales, a muscular pharynx with a triradiate lumen and by the cuticle covering all cilia (Balsamo & Todaro 2002; Grünspan 1910; Schwank 1990; Strayer & Hummon 2001; Zelinka 1889). Order Chaetonotida contains the greatest number of freshwater species within the Gastrotricha (Schwank 1990; Strayer & Hummon 2001), yet chaetonotidans are among the most poorly known freshwater microinvertebrates (Balsamo & Todaro 2002).

Historically, Gastrotricha was placed as a class within the Aschelminthes, a now defunct assemblage of various microinvertebrates with not known synapomorphies (Wallace, Ricci, & Melone 1996). Despite advances in knowledge on gastrotrich systematic (Hochberg & Litvaitis 2000, 2001; Ruppert 1988; Todaro, Guldi, Leasi, & Tongiorgi 2006; Todaro, Telford, Lockyer, & Littlewood 2006; Travis 1983), much remains to be elucidated about gastrotrich ecology (Todaro, Leasi, Bizzarri, & Tongiorgi 2006). Remane (1936) provided information on several marine species, but freshwater gastrotrichs were mostly neglected until Beauchamp (1965) showed importance on structure and functioning of limnic ecosystems. Even today, most hydrobiological research is focused on other microinvertebrates such as Rotifera, Cladocera, Copepoda and the Protozoa (mostly ciliates). The taxonomy and ecology of several microinvertebrate taxa are well documented in Europe and America including various monographs of Gastrotricha (Grünspan 1908, 1910; Hummon 1982; Kisielewski 1998; Remane 1936; Ruppert 1988; Schulze 1923; Schwank 1990; Zelinka 1889). Studies on African microinvertebrates, however, still remain in their infancy, Gastrotricha have seldom been studied. This is curious because Strayer and Hummon (2001) reported that gastrotrichs are ubiquitous in the benthos and periphyton of lakes, ponds and wetlands (Balsamo & Todaro 2002; Nesteruk 1996a, 1996b; Strayer & Hummon 2001), with densities ranging from 100 000 to 1 000 000 ind. m^{-3}. Since some species of the Neogosseidae and Dasydytidae are good swimmers, they may be abundant in the plankton, and have been reported in the plankton of some shallow weedy lakes (Hutchinson 1967; Kisielewski 1991).

In Africa, few known researches concerning freshwater Gastrotricha are the taxonomic works of Daday (1910) and Beauchamp (1932). In Cameroon, no work to our knowledge has been carried out concerning this phylum. The principal objective of this paper is to document the diversity and spatio-temporal distribution of planktonic Gastrotricha in the Municipal Lake of Yaounde (Cameroon), jointly with some physical–chemical factors that may govern gastrotrich distribution.

Material and methods

Study site

The Yaounde Municipal Lake is a large artificial pond, created in 1951 on the Mingoa streams. It is located in the heart of the capital, at 3°51′37″N and 11°31′4″E, at 710.8 m altitude (Fig. 1(I)). The lake has a maximum depth of 4 m (Fig. 1(II)) with an average depth of about 2.4 m and a surface of some 6.5 ha (Zébazé Togouet 2000).

Sampling

Sampling was carried out on a weekly basis, from November 1996 to December 1997, at three stations (A, B and C) in the pelagic zone, using a 6 l dark Van Dorn sampling bottle mounted horizontally. Water sample (12 l) was concentrated, using a 40 μm mesh size sieve plankton net. In the littoral zone, sampling was done by agitation, squeezing, scooping of vegetation and concentration using the same technique for qualitative studies. At stations A (entrance of the lake), B (middle of the lake) and C (posterior part of the lake),

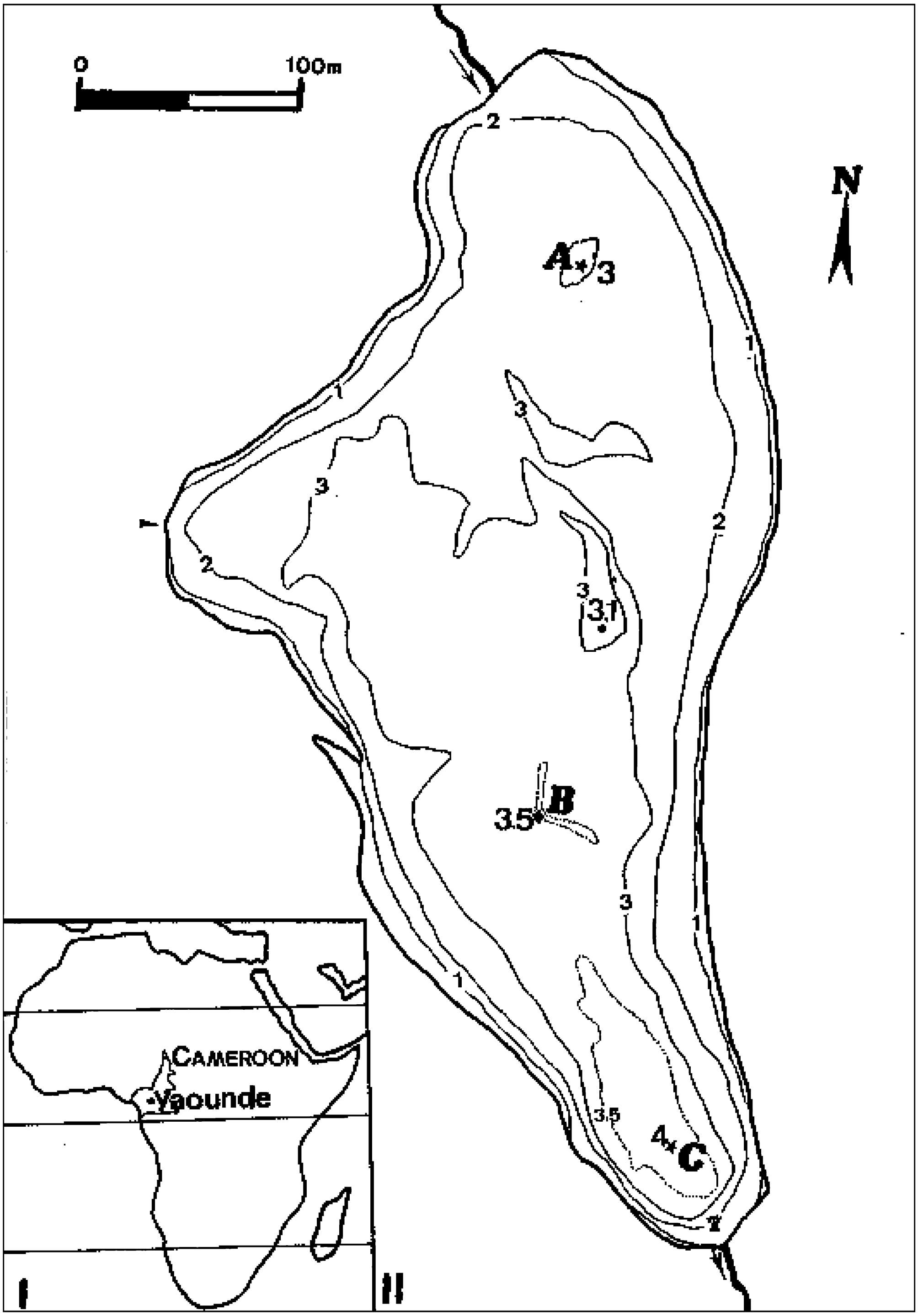

Fig. 1. Geographical location of Yaounde inside Cameroon and inside Africa (I) and location of the three pelagic sampling sites A, B and C in the lake with their different dephts (II).

the samples were taken at five different depths: 0, 0.5, 1.0, 1.5 and 2.5 m (Fig. 1(II)).

Abiotic variables

Water temperature, transparency (z_{SD}) and the pH were measured *in situ* respectively with a mercury thermometer (1/10 °C), a Secchi disc and a portable pH meter (Schött C.G. 818). The euphotic depth (z_{eu}) was computered from the water transparency using the relationship $z_{eu} = 2.42 z_{SD}$, assuming that there is a maximum of 15% transmission of light at the depth of the Secchi disc transparency (Wetzel & Likens 1995). The light availability was measured with a luxmeter and the euphotic depth to mixing depth ratio (z_{SD}/z_{mix}) was calculated. The attenuation coefficient was calculated according to the law of Beer Lambert ($I_z = I_o e^{-\varepsilon z}$). The colour and ammonium nitrogen concentration were measured by spectrophotometry (HACH DR/2000) using Nessler reagent for ammonium nitrogen. The suspended solids (SS) were quantified by filtration on a 0.45 μm pore size Whatmann GF/C. The dissolved oxygen was determined by the classical method of Winkler.

Biotic variables

Specimens were examined and identified using a binocular stereomicroscope Wild M5 and a Leitz Orthoplan microscope with camera lucida. The described specimens were fixed in 5% formalin and mounted on glass slides in glycerine. Slides were sealed with nail polish and deposited in the Queensland Museum (Australia). Taxonomic identification was carried out with the aid of keys by Brunson (1950, 1959), Schwank (1990), Kisielewski (1998), Strayer and Hummon (2001) and Balsamo and Todaro (2002). Quantitative counts were carried out according to Legendre and Watt (1972) in the Dolfuss chamber. For the ecological analysis, biomass was evaluated in an indirect manner by the method of bio-volumes (Ruttner-Kolisko 1977). Some fixed specimens were photographed with an Olympus BH2 microscope with DIC/Nomarski optics and a Sanyo HiRes Color CCD camera at the Queensland Museum (Australia).

To evaluate the relationship between gastrotrich biomass and physical–chemical variables, the rank correlation of Spearman corrected according to Bonferroni approach was performed.

Results

Abiotic factors

Fluctuation of physical–chemical variables was roughly similar among the three stations of the pelagic zone. The water temperature remained around 25 °C in the water column with annual variation of about 2.5 °C (Fig. 2A). Suspended solids and the colour were inversely proportional to the depth (Fig. 2B and C). The water transparency varied between 60 and 80 cm (Fig. 2D). The ratio z_{SD}/z_{mix} ranged from 40% to 100% with a 66% mean. The underwater light attenuation varied from 2.6 to 5.7 with a mean of 3.9 (Fig. 2E). The dissolved oxygen, which was higher at the surface at all stations (from 4.1 to 18.4 mg L^{-1} corresponding to 47% and 235% of saturation), approached 0 at 2.5 m depth (Fig. 2F). Ammonium nitrogen concentration was higher at lake bottom than in the surface (Fig. 2G). The pH varied around the neutrality (Fig. 2H).

Biotic factors

Taxonomic note

Since taxonomic work has not been done so far on the freshwater gastrotrichs of the region, it was difficult to identify at the species level a certain number of specimens.

Family Chaetonotidae Ehrenberg, 1850

Chaetonotus formosus Stokes, 1887

Specimens were 140–185 μm long with an oval trunk and slightly rectangular head flanked by two tufts of cilia per side. The body was covered dorsally with 24–32 rows of curved spines and ventrally with two rows of locomotor cilia. The spines in the posterior region were larger. The caudal furca bore an adhesive tube on each ramus (Fig. 3). We noted the presence of two tactile bristles on the furca. These specimens were enough similar to those observed by Sharma (1980) in India and Brunson (1950, 1959) in USA, but they were shorter in length, bore more spines and the head was largely rectangular.

Chaetonotus sp.

This species measured 195–298 μm long and 55 μm wide. The body was covered with 16–32 rows of curved spines. The head, flanked with two tactile ciliary tufts, was flattened on the fore side and the rim of the mouth was highly indented. The neck was not well differentiated and did not bear spines. The hind part of the body bore a simple furca with adhesive tubes and two tactile bristles. These specimens approach *Chaetonotus gastrocyaneus* Brunson, 1950 but differed from the original description of the species by the body length and the number of ciliary tufts in the head region. Cameroon specimens were significantly shorter (195–298 μm long compared to 347–485 μm in the original description) and bore only two ciliary tufts on the head when there are four tufts in the original description. The Cameroonian specimens are very likely representatives of a related species new for science to be described in the future.

Polymerurus sp.

The scarcity of the species of the genus *Polymerurus* did not enable us to carry out sufficient measurements. *Polymerurus* sp. was an elongate species with a long furca. The furca was completely segmented, approximately long as the half of the body and bore two tactile bristles. The trunk was covered with numerous small spines that were dispersed without any particular order. The head was elongated, rectangular, anteriorly flattened and flanked with four discrete ciliary tufts. The pharynx length was approximately 1/3 of the body length. These specimens, which were close to *Polymerurus callosus* described by Brunson (1950), were however distinguishable by the absence of refringent granules in the gut and by the entirely segmented furca which, in the original description, was not segmented up to the extremity.

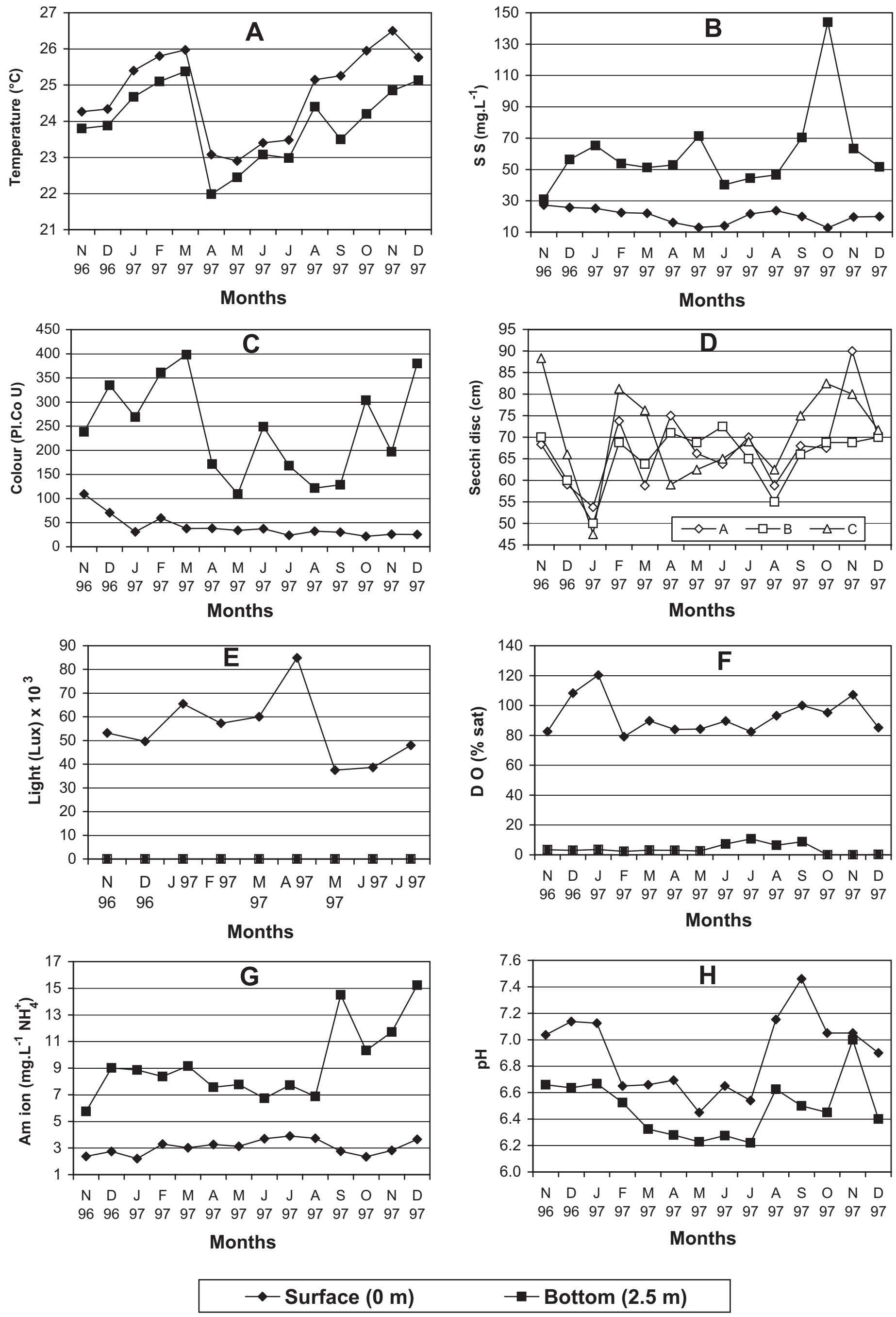

Fig. 2. Spatio-temporal variations of some physical–chemical variables of water at the surface and in the bottom in the Yaounde Municipal Lake during the study period. (A) Temperature, (B) suspended solid (SS), (C) colour, (D) depth of disappearance of Secchi disc, (E) penetration of light, (F) dissolved oxygen (DO), (G) ammoniacal nitrogen (Am ion) and (H) pH.

Polymerurus rhomboides (Stokes, 1887)

This highly elongated species was distinguished from *Polymerurus* sp. by the structure of the cuticle and the presence of numerous cilia on the body, especially along the ventral surface (Fig. 4). The head of *P. rhomboides* was largely rectangular-like shape, anteriorly flattened and bore a strong sub-terminal mouth lined with numerous bristles (Fig. 4A and B). Locomotor cilia were present below the mouth and along two columns on the ventral body wall. A dorsal cephalion, a ventral hypostomium, and lateral pleuria were present. Cilia formed a transverse line just behind the hypostomium ridge. The pharynx extended to the neck (Fig. 4B). The cuticle was highly ornamented and composed of flattened ovoid scales, with short peduncles and without spines. The caudal end bore two furcal extensions which were entirely segmented and reached 3/5 of the total body length (Fig. 4C). Cameroon specimens were very

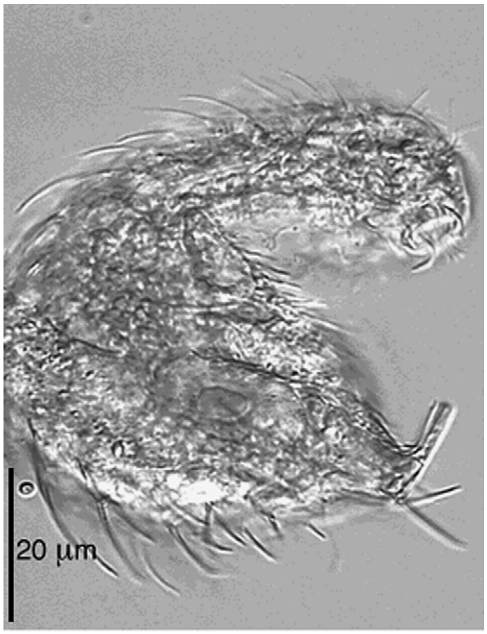

Fig. 3. Photograph of *Chaetonotus formosus* Stokes, 1887 (fixed specimen).

similar to the specimens described from Brazil by Kisielewski (1991), and considered by this author as already found in the USA by Stokes (1887, in Kisielewski 1991).

Family Neogosseidae Remane, 1927

Neogossea sp. 1

This gastrotrich was the most abundant species sampled in the Yaounde Municipal Lake. *Neogossea* sp. 1 was characterized by a slight ovoid body shape and two posterior protuberances of the body wall, pointed somewhat medially; the species exhibited four to six very long caudal bristles. The head was largely triangular and flanked with a pair of tentacles; the body was more oval than that of other chaetonotidans and covered with numerous small spined scales. The mouth was terminal and bounded by bristles. The pharynx was voluminous and nearly circular-like shape. Maximum body length was 120 μm and the width was 60 μm. The observed specimens differed in a few respects from *Neogossea fasciculata* describded by Daday (1905). In fact, *Neogossea* sp. 1 bore fewer caudal spines (four to six and not eight), exhibited a slightly different pharynx

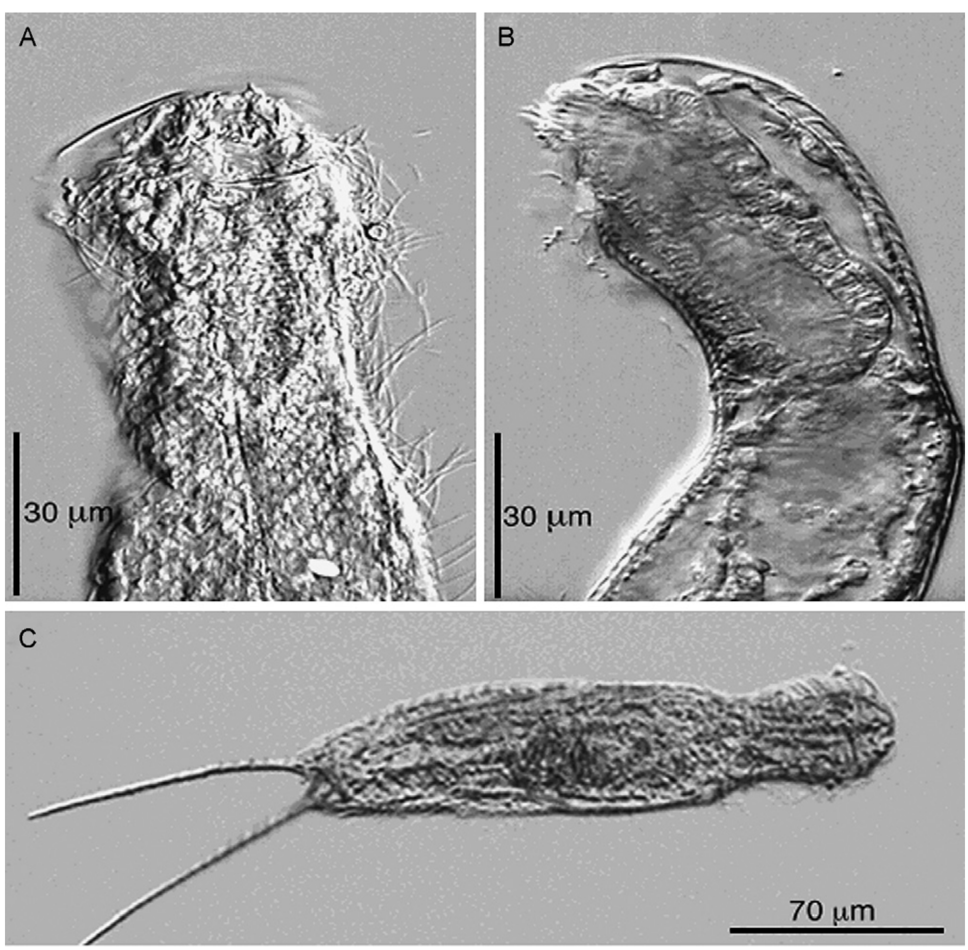

Fig. 4. Photographs of fixed specimen of *Polymerurus rhomboides* (Stokes, 1887): ventral view of anterior part (A), lateral view of anterior part showing the pharynx (B) and habitus (C).

shape, and cilia were present not only on the ventral part of the body but also on the dorsal part.

Neogossea sp. 2

This scarce species was 110 µm long; pharynx was 24 µm long. The head bore lateral cilia 10–11 µm long distributed in three distinct tufts. A pair of club-shaped tentacles protruded from between the tufts and the pharynx was circular-like sharpe (Fig. 5A and B). Small, lateral pair of ciliary tufts were present at approximately 2/3 of body length on the ventrolateral body margin. The caudal end bore six posterior spines on each side but without the characteristic body wall protuberances (Fig. 5C and D).

Neogossea sp. 2 exhibited resemblance in general body shape with *N. acanthocolla* and *N. voigti*. Compared to *N. acanthocolla*, the specimens from Cameroon lacked the neck spines and the presence of pedunculated scales was not observed. Thus they also possessed a greater number of posterior spines than *N. voigti* (six compared to four in the original description). *Neogossea* sp. 2 was likely to be new to science but requires great care with respect to the cuticle before any determination or description will be possible.

Family Dasydytidae Daday, 1905

Dasydytes sp.

Two different species of this genus were collected. They were similar in appearance, with a stocky shape body and a round-like caudum without protuberances or furca. Both remain unidentified.

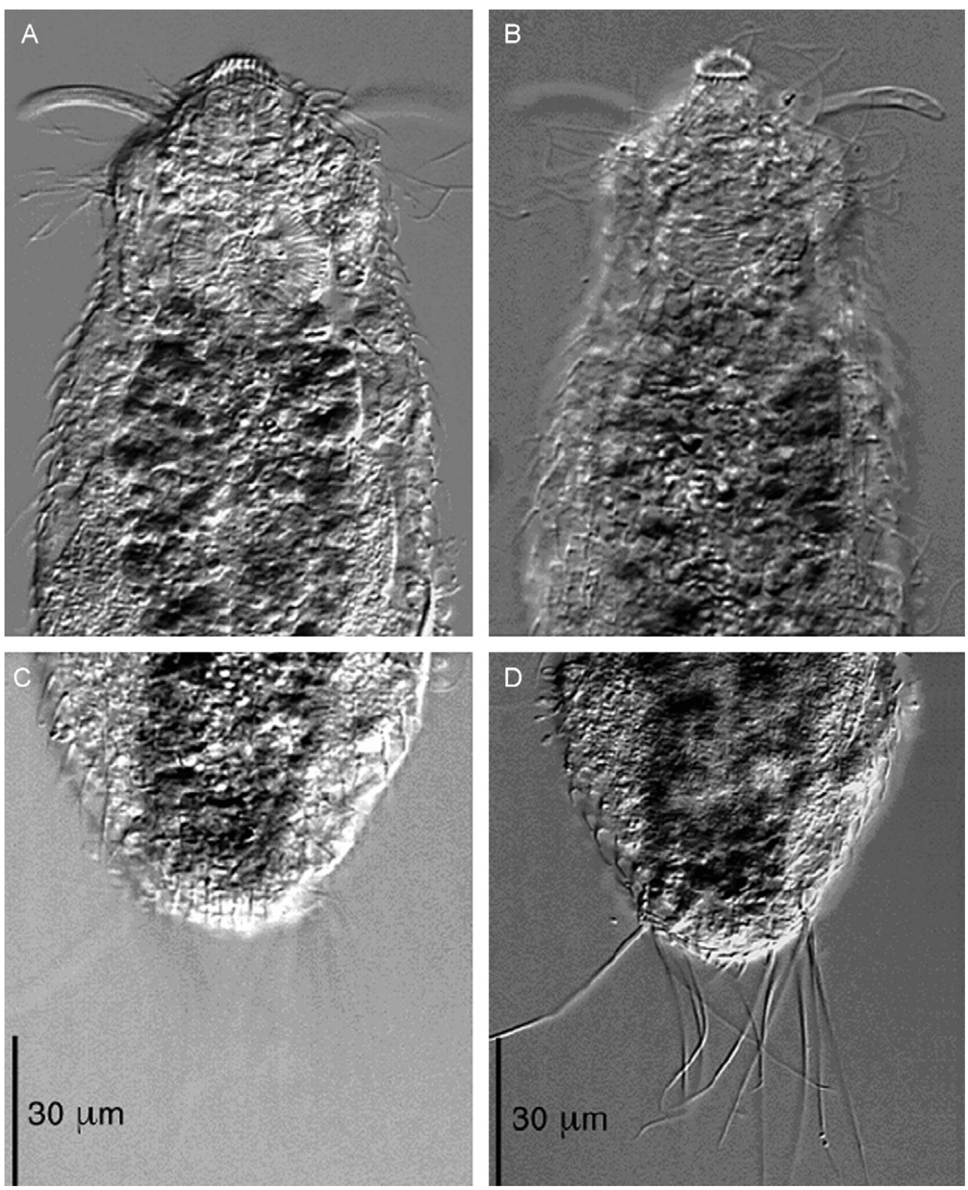

Fig. 5. Anterior region of *Neogossea* sp.2 (fixed specimen): anterior part, dorsal view (A) and ventral view (B); posterior part, dorsal view (C) and ventral view (D).

Dasydytes sp. 1: This species had a monolobed head with three to four long bristles disposed in a circular manner, while the body was adorned with two to four groups of four to six bristles. Each bristle was long and fixed at the base of a clearly differentiated neck. In the posterior part of the body, we observed four to six short bristles disposed in a circular manner. Length: 110 μm, width: 34 μm.

Dasydytes sp. 2: Of smaller size than *Dasydytes* sp.1, generally measuring 100 μm long, its head was round and flanked with two circular ciliary tactile tufts. This species was characterized by the presence at the base of the neck of a crown formed of four pairs of bristles. Each bristle was longer than the trunk. This species was rare during the study period.

Population dynamics

The population dynamics of gastrotrich in the water column of the Yaounde Municipal Lake from November 1996 to December 1997 showed different patterns. In fact, only *N. fasciculata* was present during the whole year with its highest abundance at 1.5 m depth (Fig. 6). The greatest abundance occurred on the beginning of February at all the three stations. This species presented a serrated variation from November 1996 to December 1997. The same variation pattern was observed at all the three pelagic stations A, B and C. *Dasydytes* was present from January 1997. These populations at station A show a serrated variation marked by a disappearance in November 1997. At stations B and C the population gradually increased from January 1997 until the end of the study period. At the three stations, *Chaetonotus* was mainly present in November 1996 (Fig. 7), while *Polymerurus* was confined to station A, mostly in September 1997. This last genus generally presented its highest densities between 1.5 and 2.5 m depth.

Correlation analysis

Table 1 presented a summary of Spearman correlation coefficients between species biomass of Gastrotricha and the measured physical–chemical variables. There were no significant correlations between any measured physical–chemical variable and the biomass of neither *Chaetonotus* nor *Polymerurus*. Conversely the biomass of *Dasydytes* and *Neogossea*, were negatively correlated (at 95%–99%) with dissolved oxygen, temperature and pH of water.

Discussion

Gastrotricha biodiversity

Eight species of Gastrotricha belonging to four genera and two families of the order Chaetonotida were found in the Municipal Lake of Yaounde, Cameroon. The largest family in the order, the Chaetonotidae, was represented by four species (*Chaetonotus formosus*, *Chaetonotus* sp., *Polymerurus* sp. and *P. rhomboides*),

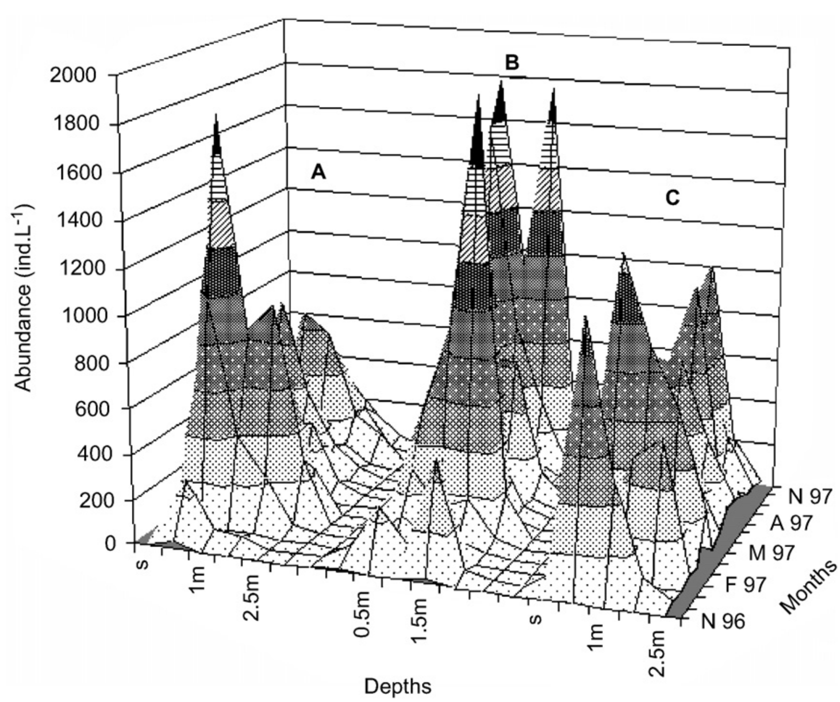

Fig. 6. Spatio-temporal variations of abundance of *Neogossea* species (during the 14 months of the study period, at the five different depths, in the three sampling sites A, B and C).

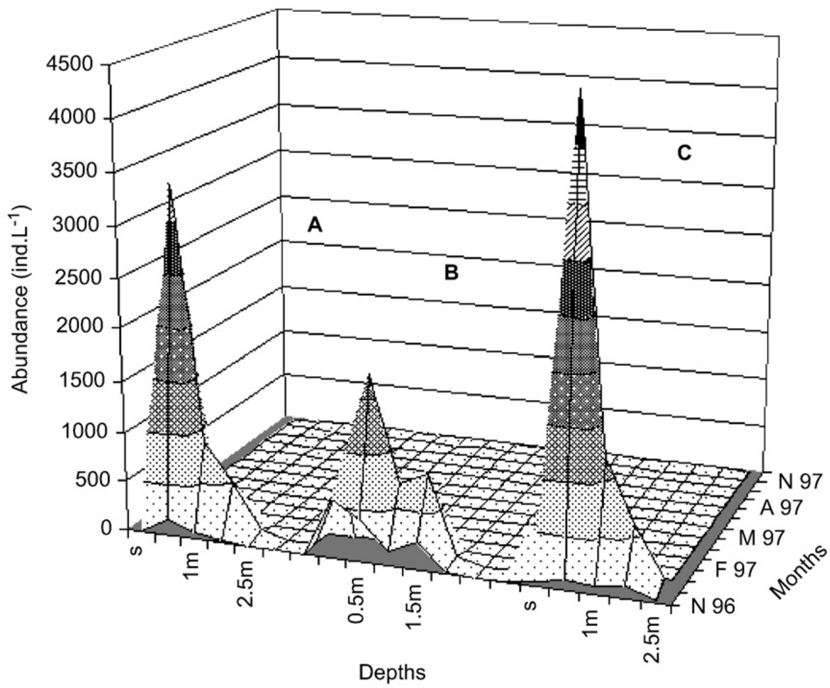

Fig. 7. Spatio-temporal variations of abundance of *Chaetonotus* species (during the 14 months of the study period, at the five different depths, in the three sampling sites A, B and C).

Table 1. Spearman correlation coefficients (r) between the biomass of Gastrotricha genera and the physical–chemical variables of the water in the Yaounde Municipal Lake ($n = 57$)

Water characteristics:	*Chaetonotus*	*Dasydytes*	*Neogossea*	*Polymerurus*
Temperature (°C)	0.0499	0.6440*	0.6802*	0.1518
pH	0.0994	0.6681*	0.7250**	0.2894
Dissolved oxygen (mg L^{-1})	0.2552	0.7176**	0.7867**	0.1754
Conductivity (μS cm^{-1})	0.0704	0.1438	0.3039	0.0615
Colour (Pl.Co units)	0.1212	0.1533	0.3594	0.1124
Suspended solids (mg L^{-1})	0.0913	0.2425	0.4038	0.0594

*Significant correlation at 5% (= "significant"); **Significant correlation at 1% (= "highly significant").

the Neogosseidae by two species (*Neogossea* sp. 1 and *Neogossea* sp. 2) and the Dasydytidae by two species (*Dasydytes* sp. 1 and *Dasydytes* sp. 2). Only two species of Chaetonotidae were reliably identified, the remaining species were scarce and require additional observations. Kisielewski (1991) reported also the occurrence of the same three families of the order Chaetonotida in several collecting sites of tropical/equatorial, shallow weedy lakes in Brazil. He observed a total of 38 species with 26 species of Chaetonotidae (including 14 species of *Chaetonotus*), 10 species of Dasydytidae and two species of Neogosseidae. We anticipated that the Cameroon lake harbour more species than those reported so far, as we mainly sampled to catch planktonic specimens when it is known that gastrotrichs are adapted for benthic life (Nesteruk 1996a, 1996b; Strayer & Hummon 2001). Despite the relatively low species richness, the gastrotrichs reached high abundances in the pelagic area of the lake. *Neogossea* reached 2000 individuals per litre (Fig. 6) and *Chaetonotus* more than 4000 individuals per litre (Fig. 7) in our samples. This result resembles the observation of Kisielewski (1986) and of Nesteruk (1996b) where high densities of Gastrotricha were found in eutrophic water bodies in Poland. In general, these results also confirm the fact that Gastrotricha are abundant worldwide in lakes and ponds (Strayer & Hummon 2001), at least in the tropical freshwaters (Kisielewski 1991), even in the pelagic water. However, in contrast to observations suggesting that species of *Chaetonotus* are dominant gastrotrichs (Strayer &

Hummon 2001), the population of gastrotrichs in the Municipal Lake of Yaounde was generally dominated by *Neogossea* though the highest density was observed in *Chaetonotus,* reaching 4084 individuals per litre at 0.5 m in November at station C.

Nearly all species encountered in Cameroon were generally of smaller size than those of the closest taxon. This smaller body size, when accompanied by high densities, may generally be assumed to result from an adaptive mechanism in the eutrophic waters (Green 1977) or a mechanism of protection against predators (Pourriot 1983). Green (1977) has shown that Rotifera dwarfing was an adaptation to the enrichment of the habitat. In fact, the Municipal Lake of Yaounde was a rich water body, ranging from eutrophic to hyper-eutrophic (Kemka 2000; Niyitegeka 2001; Zébazé Togouet 2000).

Spatio-temporal variations

During all the study period, it was observed that the pelagic gastrotrich community of the Municipal Lake of Yaounde had a simple structure consisting of only two genera occurring together. In November 1996 and December 1996, this community included *Neogossea* and *Chaetonotus*. The species of the latter genus are replaced by that of *Dasydytes* from January 1996 to December 1997. At station A, this community included species of *Neogossea* and *Polymerurus* in November 1997. At the end, *Neogossea* was present throughout the study period with *Chaetonotus* from November 1996 to December 1996 and with *Dasydytes* from January 1997 to December 1997.

The abundances of Gastrotricha were high (Figs. 6 and 7). The highest abundances were found mostly at the beginning and during the rainy season when there is an important sedimentation of organic matter with recirculation (Zébazé Togouet 2000). High abundance of Gastrotricha is often the result of the eutrophication of the milieu (Angeli 1980; Kisielewski 1986). Kisielewski (1986) showed that the density of the Gastrotricha is positively correlated with the habitat productivity. Since Kemka et al. (2004) showed the Municipal Lake of Yaounde was highly eutrophic and very likely this can explain the high observed abundances. In the eutrophic ecosystems, there is generally a reduction of the number of species and an increase in the number of individuals per species. Similar results by Moss (1998) confirm these observations for Rotifera, Cladocera, Copepoda and Ciliophora. That station D (littoral zone) was richer than the other stations throughout the study period can be explained by the richness of diversified microhabitats due to the abundance and diversity of macrophytes and by the affinity of this zone with the benthos. In fact many gastrotrichs are benthic.

Concerning the vertical distribution, *Polymerurus* was mostly abundant at the bottom layers (1.5 and 2.5 m) while the three other genera generally attained their maxima at 0.5 or 1 m, a depth which corresponds to the euphotic zone. Balsamo and Todaro (2002) reported this genus as epibenthic and periphytic. We also noted that at these depths there was an increase in organic matter and algae (Tadonléké, Jugnia, Sime-Ngando, Zébazé Togouet, & Nola 1998). This apparent correlation can be explained by the fact that gastrotrichs feed on bacteria, algae, protozoans, detritus and small inorganic particles. Gastrotricha can thus be considered as first-order consumers (Beauchamp de 1965; Ruppert 1988; Strayer & Hummon 2001).

Correlation analysis

Significant correlations were observed between the biomass of species of *Dasydytes* and *Neogossea* and various physical–chemical variables. The significant negative correlation between dissolved oxygen and species biomass indicated that these species can tolerate low oxygen tensions, perhaps avoiding predators more abundant and active in shallow well-oxygenated waters. However, only the species of *Polymerurus* were consistently found at the nearly anoxic bottom, indicating that most other species may have metabolic constraints that limit their ability to respire in the benthos. Morphologically, the species of *Dasydytes* and *Neogossea* seem to be well adapted for a semi-pelagic existence, with short rotund bodies covered with large flexible spines that facilitate floatation, and so perhaps it was not surprising these species were rarely found at the bottom. Species of *Polymerurus*, however, possessed a general chaetonotidan body plan that was adapted for benthic life: slender body, complete scale covering, and furca with adhesive tubes. Species of *Polymerurus* are well documented to have a benthic or periphytic existence on submerged vegetation (Balsamo & Todaro 2002; Kisielewski 1991). These results corroborate the conclusions of Strayer (1985) who states that Gastrotricha are among the few animals commonly found in the anaerobic environment. Also, perhaps it was not surprising to find negative correlations between biomass and temperature and pH, since these two physical–chemical variables are linked to water depth and likely influence oxygen tension and therefore invertebrate abundance. These significant correlations suggest these fluctuations in abundance of *Dasydytes* and *Neogossea* may be highly influenced by several different environmental factors. These two genera in general and their representative species in particular are adapted to pelagic area and may therefore have potential to be indicators of water quality in future freshwater body assessments.

Acknowledgements

The authors thank Pr. Roger Pourriot of the University of Paris VI and Dr. Joseph Gangoue of the IMPM Yaounde for their efficient assistance. We also thank Dr. Rosette Megnekou for the computer assistance and the "IRD-Cameroun" for their logistic assistance. We are grateful to the anonymous reviewers for their constructive and valuable comments. This work was partly supported by the grant of AUF no. P6-420/3090/216/BAC 2005 and the grant no. 01-2-CMR-31-1 of "AIRE développement".

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