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Composition and seasonal variations in abundance of Copepod (Crustacea) populations from the northern part of Lake Tanganyika

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Copepod has an important ecological role as a main food of several fishes on which commercial fisheries are based in Lake Tanganyika. However, very little multi-annual monitoring programs have been conducted for this group of crustacean zooplankton. This study was conducted in the northern part of Lake Tanganyika by weekly sampling at both pelagic and littoral sites over three consecutive years (2012–2014). The analyzed samples showed that Lake Tanganyika copepod was essentially composed of three suborders including Calanoida (30% by number) with a single endemic species, Cyclopoida (69%) with four dominant species and Harpacticoida (1%). These taxa showed variations in their abundance respectively at pelagic and littoral sampling sites. The average densities of copepods did slightly vary during the sampling period in both areas although higher peaks were observed in 2013. For the post-nauplii stage, Tropocyclops tenellus predominated while the nauplii of T. simplex predominated at both sampling sites. Seasonal fluctuations of copepod densities showed higher peaks in September/October and April/May, respectively, for the three most common species. T. simplex and M. aequatorialis ovigerous females showed higher peaks in the rainy season in 2013. These results can benefit pelagic fisheries research and lake environmental management efforts as the copepod abundance seems to be closely correlated to that of sardines in Lake Tanganyika.

Keywords: copepod diversity, zooplankton ecology, density, development stage

Introduction

Lake Tanganyika is remarkable in its large biodiversity and high fish production (Mannini, 1999; Phiri and Shirakihara, 1999). Commercial fisheries mainly target two pelagic clupeids, *Stoilothrissa tanganicae* (Regan) and *Limnothrissa miodon* (Boulenger), and four latids, especially *Lates stappersii* (Boulenger) (Roest, 1992; Sarvala et al., 1999). Clupeids feed mainly on

copepods which occupy a key position in both food chain and energy transfer between primary producers (phytoplankton) and superior taxa (Langenberg et al., 2003). In Lake Tanganyika, copepod spatial distribution is mainly due to the increase in phytoplankton biomass closely driven by hydrodynamics and water mixing (Plisnier et al., 1999, 2009). Nevertheless, copepod populations have been the subject of few environmental studies in Lake Tanganyika.

Earlier studies on their ecology (e.g. seasonal variations in abundance) were also limited by difficulties linked to the determination of many endemic species still requiring revision (Dussart et al., 1984). The description of Lake Tanganyika copepod species was previously conducted by Sars (1909), Gurney (1928) and Lindberg (1951). The Copepoda group is more diversified than other zooplankton groups and only harpacticoids, cyclopoids and calanoids are well represented in Lake Tanganyika (Lindberg, 1951; Dussart et al., 1984). Thirty nine cyclopoid species are present in Lake Tanganyika with three dominant species in the open waters: *Mesocyclops aequatorialis aequatorialis* (Kiefer), *Tropocyclops tenellus* (Sars) and *Microcyclops cuningtoni* (Sars) (Coulter, 1991). The cyclopoids are the most diverse group with a high endemism while *Tropodiptomus simplex* (Sars) is the unique endemic calanoid species known, widely distributed in Lake Tanganyika open waters (Lindberg, 1951; Mgana et al., 2014). The harpacticoid are reported but poorly known in Lake Tanganyika. Most species of this group seem to be parasites and benthic (Coulter, 1991). Previous researches on zooplankton have highlighted the vertical distribution of copepods in relation to planktivorous fish in the lake (Mulimbwa, 1988; Kurki et al., 1999; Vuorinen et al., 1999). Not much attention was paid to species diversity. Calanoids were noted to be more abundant in the south whereas cyclopoids were observed to dominate in the north (Kurki et al., 1999). Fluctuations in copepod abundance between both pelagic and littoral zones and the different life cycle stages (nauplii and post-nauplii) were not well investigated in Lake Tanganyika previously, despite their high biomass and relation with fish distribution. Densities and biomass of copepod taxa observed previously were preliminary and did not permit conducting comprehensive analyses due to the diversity of sampling methods used in the lake (Sarvala et al., 1999). Although zooplankton is sensitive to climate change (Richardson, 2008), it has not been used for this type of analyses in Lake Tanganyika. To overcome this knowledge gap, the present study performed regular monitoring to evaluate copepod populations in both pelagic and littoral waters and analyzed their inter-annual, seasonal and spatial variations in the northern part of Lake Tanganyika.

Materials and methods

Study site

Lake Tanganyika is located in Eastern Africa and is bordered by Burundi, Tanzania, Zambia and the Democratic Republic of Congo. The Democratic Republic of Congo covers over 14,800 km² (45%) of the surface of the lake and 795 km (43%) of its perimeter. Monitoring of copepods was carried out in the open waters off Uvira at the extreme northwest of Lake Tanganyika. Two sites and two different sampling approaches were chosen: in pelagic site (03°24'56.7, 29°10'38.1"E) at 5 km from the shore and at an estimated depth of over 60 m; and in littoral site (03°25'01.2"S, 29°02'56.9"E) nearly 10 m from the shores with a variable depth estimated from 1 to 2.5 m. These sites were accessible from the Centre of Research on Hydrobiology (CRH, Uvira) and the pelagic site was very close to that of the LTR/FAO/FIN-NIDA project (Plisnier et al., 1999). In littoral areas we sampled at a site characterized by mixed substrates (rock-sand) with strong influence of human activities.

Data collection and sampling design

Sampling was conducted following two levels: spatial (pelagic and littoral) and temporal (weekly) from January 2012 to August 2014. At each site, a double and regular sample was taken weekly (every Tuesday) between 8–10 a.m. using a plankton net (100 µm aperture mesh, 25 cm diameter). Each sample was collected in a plastic pot and adjusted to a volume of 50 ml and immediately preserved in 4% formalin (Haney, 1988). The net was ballasted with a lead seal and raised slowly (0.5 m/s) on a vertical haul from 60–0 m in the pelagic zone or attached on floaters and pulled horizontally over a distance of 20 m slightly below the lake surface in the littoral site. The identification of copepod groups and species was conducted mainly in the laboratory of Biology at the CRH, Uvira (DR Congo) and complemented in laboratories at the Royal Museum for Central Africa and Royal Institute of Natural Science of Belgium. For this, each sample was transferred into 70% ethanol and isolated specimens were dissected into 10% glycerin solution onto slides using fine forceps (Type brucelle Dumont clockmaker). To perform copepod preparations, we followed patterns given

in Kiefer (1956) and revised by Dussart (1980). For copepod species identification, a sound knowledge of their morphology was required and for this we used both light-microscopic observations and scanning electron microscopy (SEM) methods according to the scheme proposed by Dussart and Defaye (2001), Hernandez-Chavarria and Schaper (2000) and Fiers (Unpublished data). These procedures permitted broader view of specimen appendices of copepod taxa. Microscopic counting (OLYMPUS CH30RF200 and DIALUX 20) was carried out by sub-samples of 1 ml from the entire adjusting sample using a pipette (4 mm opening) (Isumbisho et al., 2006a,b). Counting taxa according to their development stages (nauplii and post-nauplii) was conducted following the methods described in Kurki (1993, 1997) and Vuorinen (1993). Copepods were determined to species level except for harpacticoids (group level).

Data analysis (descriptive statistics, One-way ANOVA and t-test) was performed using Excel 2007, StatView and SPSS 16.0 software to test for differences in temporal and spatial abundance. Differences between means were considered significant at $p < 0.1$.

Results

Composition and relative abundance of taxa

The three identified copepod suborders (Calanoida, Cyclopoida and Harpacticoida) show unequal proportions in their abundance ($F = 80.3$,

$p < 0.001$) in Lake Tanganyika (Figure 1). Total densities indicate that cyclopoids with four common species predominate with ascending percentages of *T. tenellus* (52%) > *M. aequatorialis* (14%) > *Thermocyclops oblongatus* (2%) > *M. cunningtoni* (1%), respectively, followed by calanoid *T. simplex* (30%) and harpacticoids (1%) throughout the sampling period (Figure 1). Copepods are more abundant in the pelagic ($n = 142$, mean of 2069 ind.m^{-3} , 66%) than in the littoral ($n = 142$, mean of 1060 ind.m^{-3} , 34%) sites sampled here ($F = 61.5$, $p < 0.001$). Harpacticoids, although observed in both sites, were rare in the pelagic site. Average densities of copepods has varied slightly during the study period ($r = 0.086$, $F = 7.4$, $p = 0.001$).

Distribution and abundance of Copepod populations

The variations in total abundance of copepods by stages show that copepodids and nauplii are more dominant respectively for *T. tenellus* and *T. simplex* (Table 1). The male individuals of post-nauplii (mean number = 545 ind.m^{-3} , 23%) are slightly dominant over females (mean number = 503 ind.m^{-3} , 21%) ($t = 3.9$, $r = 0.924$, $p < 0.001$). The ovigerous females are less abundant (mean number = 38 ind.m^{-3} , 1.6%) and increasingly rare in the littoral site for all taxa. Differences in abundance of copepod taxa indicate that *T. tenellus* prevails at all stages except for nauplii for which *T. simplex* dominates in both habitats.

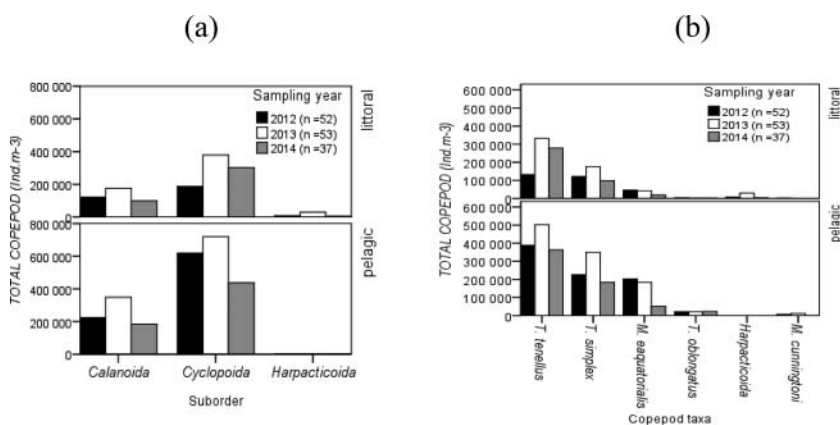


Figure 1. Total densities (individuals m^{-3}) of copepod according to their suborders (a) and species (b) in both pelagic and littoral sampling sites and study period in the northern Lake Tanganyika. n = number of samples.

Table 1. Average densities (Individuals number $m^{-3} \pm$ Standard Deviation) followed by the number of samples and percentages (in brackets) of copepod taxa in pelagic and littoral sampling sites according to stages in life cycle. N = nauplii, C = copepodid, F = female, M = male, OV, F = ovigerous female and T. COP. = total copepod.

Copepod taxa	PELAGIC (n = 142)										LITTORAL (n = 142)									
	N	C	F	M	OV, F	T. COP.	N	C	F	M	OV, F	T. COP.	N	C	F	M	OV, F	T. COP.		
<i>Tropodiatomus simplex</i>	1784 ± 130 (47)	1321 ± 909 (26)	1117 ± 109 (25)	1162 ± 114 (24)	149 ± 303 (34)	5535 ± 386 (30)	1700 ± 272 (57)	598 ± 973 (20)	257 ± 475 (17)	255 ± 474 (15)	4 ± 22 (14)	2890 ± 366 (30)								
<i>Tropocyclops tenellus</i>	1512 ± 1499 (38)	2608 ± 1400 (52)	2471 ± 1821 (55)	2664 ± 1678 (55)	0 ± 0 (0)	9155 ± 4288 (49)	1053 ± 167 (36)	1904 ± 199 (64)	1066 ± 147 (70)	1199 ± 149 (70)	0 ± 0 (0)	5424 ± 493 (57)								
<i>Mesocyclops aequatorialis</i>	586 ± 900 (15)	902 ± 1013 (18)	752 ± 1082 (17)	812 ± 1132 (17)	142 ± 328 (33)	3193 ± 3716 (17)	169 ± 436 (6)	373 ± 814 (12)	98 ± 269 (6)	130 ± 367 (8)	5 ± 47 (21)	788 ± 1570 (8)								
<i>Thermocyclops oblongatus</i>	0 ± 0 (0)	133 ± 271 (3)	126 ± 232 (3)	151 ± 260 (3)	142 ± 211 (33)	470 ± 767 (3)	0 ± 0 (0)	28 ± 79 (1)	24 ± 72 (2)	17 ± 47 (1)	17 ± 111 (65)	75 ± 164 (1)								
<i>Microcyclops cunningtoni</i>	0 ± 0 (0)	33 ± 114 (1)	57 ± 169 (1)	47 ± 125 (1)	0 ± 0 (0)	148 ± 432 (1)	0 ± 0 (0)	3 ± 27 (0)	16 ± 84 (1)	2 ± 19 (0)	0 ± 0 (0)	39 ± 228 (0)								
<i>Harpacticoida</i>	1 ± 10 (0)	1 ± 11 (0)	0 ± 0 (0)	1 ± 9 (0)	0 ± 0 (0)	3 ± 21 (0)	51 ± 139 (2)	91 ± 250 (3)	57 ± 167 (4)	97 ± 248 (6)	0 ± 0 (0)	309 ± 605 (3)								

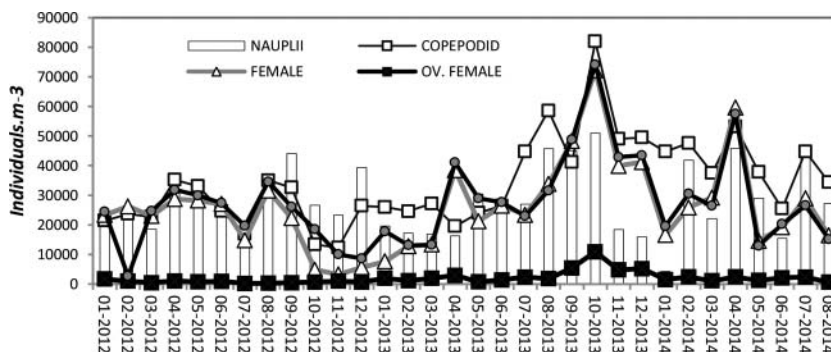


Figure 2. Total copepod number (individuals m^{-3}) according to the stages of development in the northern Lake Tanganyika (pelagic and littoral sampling waters) during the study period.

Seasonal variations of copepods

Seasonal variations in total copepod abundance by developmental stages indicate higher peaks in September/October 2013 at the beginning of the rainy season respectively for copepodids > males > females > nauplii > ovigerous females in both sampling sites (Figure 2). These peaks are followed by that of post-nauplii (male and female adults) in April throughout the sampling period (Figure 2).

The changes in total seasonal abundance of copepod taxa are most noteworthy in 2013 compared to other periods with higher peaks respectively for the three most dominant species (*T. tenellus*, *T. simplex* and *M. aequatorialis*) in October 2013 (start of the rainy season) and second peaks in April/May (end of the rainy season) in both sites (Figure 3a). Ovigerous females in pelagic waters have increasing longer duration peaks from October 2013 for *T. simplex* and *M. aequatorialis* (Figure 3b).

Variations in seasonal and monthly abundance of total nauplii by copepod taxa indicate increasing peaks in the dry season (August/September) and the end of the rainy season (April/May). These peaks are more pronounced with longer duration in the littoral site in 2013 throughout the dry season (Figure 3c). *T. simplex* nauplii are predominant with higher and prolonged peaks throughout the dry season and the beginning of the rainy season in 2013 in the littoral site. In the pelagic one, these peaks are observed towards the end of the rainy season. Copepodids are abundant in 2013 with higher peaks in October and secondary ones in April/May and September/October in both sites. Unlike nauplii, copepodid peaks are headed by *T. tenellus* in both study sites (Figure 3d).

The copepod male and female individuals show almost similar seasonal fluctuation profiles and are predominant in 2013 with ascending peaks in April and September/October, i.e. towards the end and beginning of the rainy season in both pelagic and littoral zones (Figures 3e and f).

Discussion

Copepods are extremely abundant in freshwater (from five orders) and comprise a major component of most planktonic, benthic and groundwater communities. This diversity is reflected in the enormous range of life styles adopted, and in sub-Saharan Africa, the major contributors are the Cyclopidae, especially *Eucyclops* and *Thermocyclops*, and the Diaptomidae, especially *Tropodiatomus*, followed by the Lernaecidae (Boxshall and Halsey, 2004; Boxshall and Defaye, 2008). Cyclopoids are the most diversified copepod group in both Lake Tanganyika (Coulter, 1991) and Victoria (Gophen et al., 1993; Mwebaza-Ndawula, 1994). Our results are compared to some earlier works on Tanganyikan copepods, broadly related to limnology and pelagic fisheries management, for the five common species identified including *T. simplex*, *T. tenellus*, *M. aequatorialis*, *T. oblongatus* and *M. cunningtoni*, respectively (Narita et al., 1986; Kondo and Hori, 1986; Coulter, 1991; Kurki, 1993; Kurki et al. 1999; Vuorinen, 1993; Vuorinen et al., 1999; Dumont, 2006; Langenberg et al., 2008; Mgana et al., 2014). As Lake Baikal, around 49% of copepod species are endemic in Lake Tanganyika (Coulter, 1991; Boxshall and Defaye, 2008). Globally, the abundance of zooplankton follows a cycle closely related to the seasonal cycle of rainfall and phytoplankton

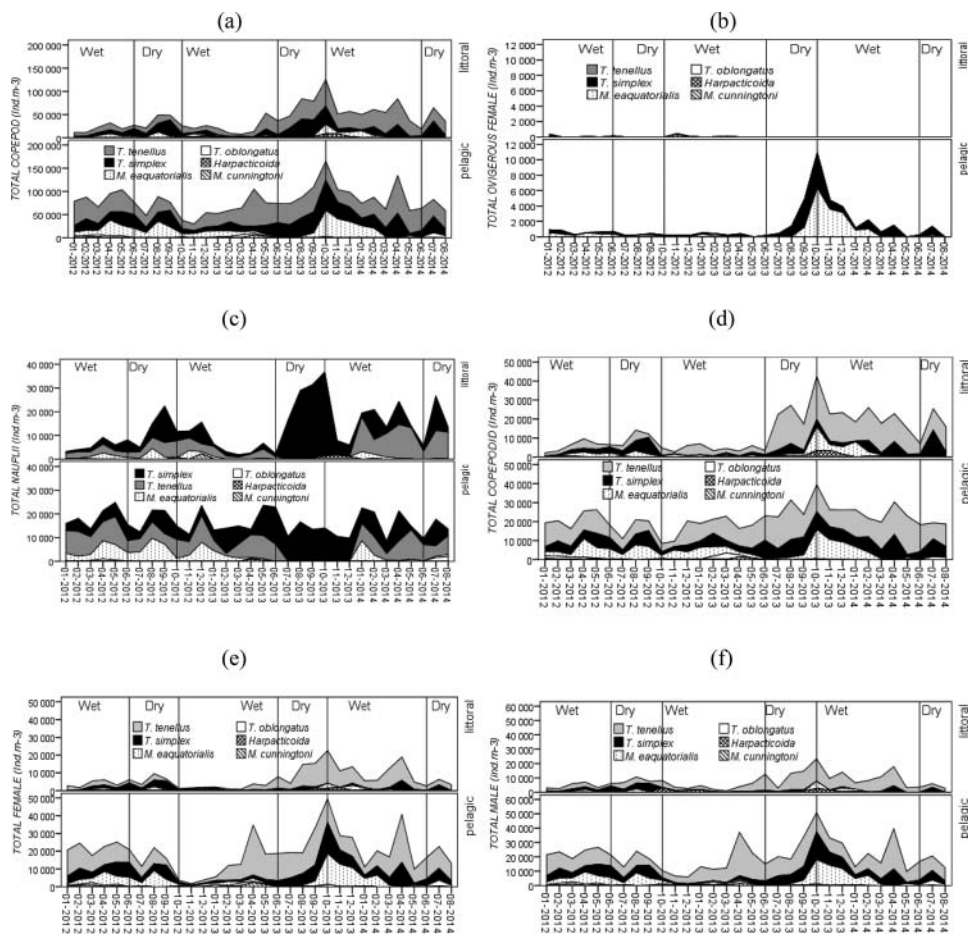


Figure 3. Number (individuals m^{-3}) of total copepod (a), ovigerous female (b), nauplii (c), copepodid (d), female (e) and male (f) in pelagic and littoral sites and by species in the northern Lake Tanganyika during the study period. Wet and dry seasons are indicated.

populations in Lakes Tanganyika (Plisnier et al., 1999; Mulimbwa et al., 2014a) and Victoria (Cocquyt et al., 1994). Recently, a tight positive correlation between monthly rainfall and copepod biomass was reported in the north of Lake Tanganyika (Mulimbwa et al., 2014b). This could be linked to river discharges into the lake and higher nutrients in coastal areas particularly during the rainy season due to surface runoff and increased groundwater flow from the lake basin (Coulter, 1991). Similarly, peaks in total abundance of copepod zooplankton appeared to follow this pattern in the rainy season (September/October and April, respectively) through our results. The success of clupeids, therefore, appeared to be linked to rainfall and abundance of copepods in the lake (Mulimbwa et al., 2014b). This seasonality is correlated to phytoplankton biomass as in other Great

Lakes such as lakes Malawi and Kivu. In Lake Tanganyika zooplankton biomass appears to be generally lower in contrast to Lake Malawi possibly because of the presence of specialized clupeids in Lake Tanganyika while in Lake Malawi, *Chloroborus* are present and there seems to be little efficient zooplankton utilization by e.g. *Engraulicypris sardella* (Hecky, 1984; Bootsma and Hecky, 1993).

T. simplex is the only calanoid species known and widely distributed in Lake Tanganyika with differences in densities along the north and south axis of the lake. Unlike in the north, *T. simplex* is distributed over a larger water column in the south of Lake Tanganyika and becomes increasingly rare in upper layers (Vuorinen et al., 1999). The copepod species globally have shown variations in their littoral-pelagic abundances according to their

developmental stages. In the littoral area, variations of taxa were remarkable for *T. simplex*, in ascending order of nauplii > copepodids > post-nauplii (male and female) > ovigerous females, respectively, and almost the opposite in the pelagic zone. This means that the proportion of post-nauplii globally decreased in the littoral site for this species. *T. simplex* nauplii have dominated in both study sites compared to other taxa. This could be due to both the sampled water column (60–0 m) and the vertical migration profiles of *T. simplex* in the pelagic zone where post-nauplii inhabit deeper layers during daytime and ascend into the upper layers at night (Vuorinen et al., 1999). Perhaps also in order to escape predation by *S. tanganyicae* and to graze on phytoplankton increasingly abundant in the upper layers during the daytime and known as seasonally regulated by the hydrodynamic cycles of the lake (Plisnier et al., 1999). Larval and juvenile clupeids in Lake Tanganyika feed essentially on copepod with preference for larger organisms (e.g. *T. simplex*, *M. aequatorialis* or *T. oblongatus*) when available (Mannini et al., 1996; Sarvala et al., 2002). So, the monthly catches of clupeids are known to fluctuate with cohort peaks shortly originated after those of copepods, mainly determined by the catches of *S. tanganyicae* and *L. miodon* towards July and October and April–May in the north parts of Lake Tanganyika (Mulimbwa et al., 2014a). We must also take into account the significant differences in body size between *T. simplex* and cyclopoids such as a *T. simplex* nauplius whose size is comparable to a *T. tenellus* adult (Kurki et al., 1999). Coulter (1991) stated that in the pelagic zone, *T. simplex* is the most affected species by predation of clupeids and Chéné (1975) found that *S. tanganyicae* fed largely on this species (72.9%) in the north of the lake. Kurki et al. (1999) suggested that *T. simplex* is the most vulnerable species preyed upon because of its larger size. Kondo and Hori (1986) collected zooplankton vertically and horizontally near the coasts (between 0–5 m in depth) in a rocky area off Luhanga, South of Uvira (DRC) during both day- and nighttime. Their results indicated that the nauplii and cyclopoid copepodids predominated; this confirmed partially our results at the littoral site off Uvira but the planktivory by littoral cichlid diversity of Lake Tanganyika has not yet demonstrated in details. A positive correlation between phytoplankton chlorophyll in Kigoma area (Kimirei and Mgaya, 2007) or

spatio-temporal phytoplankton blooms (Plisnier et al., 2009) and the abundance of *S. tanganyicae* (catches) have been already mentioned in Lake Tanganyika. However, clear abundance links of both copepods and clupeids remain unproven for fisheries management although data from experimental trawl catches of pelagic fish were positively correlated with post-naupliar copepod abundance in the south basin of Lake Tanganyika (Kurki, 1998); but sometimes strong fish cohorts could arise even under poor food conditions in the north basin (Mulimbwa et al., 2014a) and the timing of reproductive activities in clupeids species is likely to be subject to strong year-to-year variation.

T. tenellus is a small species (female: 0.32–0.36 mm; male: 0.30–0.33 mm of total length, TL). Since the original description by Sars (1909), various revisions of this species took place (Kiefer, 1956; Dumont, 2006). *T. tenellus* predominated in our samples and was well distributed throughout the water column although there were differences between littoral (54%) and pelagic (49%) areas. This species was much more abundant compared to *T. simplex* and other cyclopoid taxa with dominance males. The slight dominance of males against their respective females may be due to a better capability in the feeding competition (e.g. grazing mode, selection and size of phytoplankton cell available) or the predation by fish. Tanganyikan clupeids are known as visual predators and their feeding mode are related with the prey sizes. In our observations, the males were relatively smaller than females and might be less visible by sardines. This was more noticeable in the most common *T. tenellus* due to its small size and maybe its grazing/feeding habit in the study area unlike other copepod species. The high abundance of cyclopoids could be explained by the fact that most of them live in the littoral zone (Kondo and Hori, 1986). *T. tenellus* has shown also high densities of post-nauplii, followed by relevant copepodids in littoral and pelagic waters. However, the average density of individuals was generally higher in pelagic, almost twice the values for post-nauplii of this species. This larger proportion of *T. tenellus* could be due to the vertical distribution of copepod populations during the daytime in the lake. Our sampling was focused in the first 60 meters where *T. tenellus* is supposed to be more abundant, unlike other species (Sarvala and Salonen, 1995). The cyclopoids confined in upper

layers (Vuorinen et al., 1999; Kurki et al., 1999) were mainly *T. tenellus* (Dumont, 2006). The hypothesis was that *T. tenellus* rarely occurs deeper than 40 m where species like *M. aequatorialis* and *Thermocyclops* spp. are abundant to avoid competition and maybe also predation (Dumont 2006). Otherwise, Mulimbwa et al. (2014b) sampled zooplankton in closely similar pelagic site (0–100 m) off Uvira as in this study in 2007–2008 and found *T. simplex* and *M. aequatorialis* to predominate while smaller cyclopoids (probably *T. tenellus*) were very low in density. This was different from Kurki et al. (1999), Vuorinen et al. (1999), Dumont (2006) and our own observations study. Sampling at different moments might explain variability in observations.

M. aequatorialis (male: 0.6–0.7 mm and female: 0.8–1 mm) occurs in both Lakes Tanganyika and Kivu though the genus *Mesocyclops* Sars, 1914 is well distributed in many aquatic systems of Africa (for revision see Dahms and Fernando [1992]; Ueda and Reid [2003]; Isumbisha et al. [2006b]). This species was found in both littoral (8% of total density) and pelagic (17%) sites with lower densities than *T. tenellus* and *T. simplex*. This could be also attributed to the water column sampled during the study period. Like *T. simplex* and their predators (Clupeidae), *M. aequatorialis* is more abundant in the lower layers (40–80 m) during the daytime (Dumont, 2006). Nauplii and copepodids of this species were more prevalent in littoral site compared to post-nauplii individuals. It is known that *M. aequatorialis* and *Thermocyclops* spp. adult individuals may predate *T. tenellus* individuals which, in turn, are in competition with their nauplii and copepodids in Lake Tanganyika (Chéné, 1975; Dumont, 2006). *M. aequatorialis* nauplii were very rare at the beginning of rainy season (September/October) and reappeared during December/January. Mulimbwa et al. (2014) found this species to be most abundant around November/October and April in pelagic waters in Uvira in agreement with our own results. Kurki et al. (1999) have investigated the seasonal changes in three localities off Bujumbura, Kigoma and Mpulungu and they also obtained comparable results in Kigoma.

The genus *Thermocyclops* Kiefer, 1927 is represented by four species in Lake Tanganyika (Lindberg, 1951; Kiefer, 1956) (see Babwingure et al. (2001); Ueda and Reid (2003); Dussart and Dufaye (2006) for revisions). Only *T. oblongatus*

was observed (respectively, 1 and 3% of total copepods in the littoral and pelagic waters) during this study in Lake Tanganyika. By cons the genus is rather represented by *T. consimilis* (Kiefer) in Lake Kivu where it is dominant in the pelagic waters with *M. aequatorialis* (Kiefer) and *T. confinis* (Kiefer) (Isumbisha et al., 2006a). Although *T. oblongatus* was not more detailed in previous studies in Lake Tanganyika, Dumont (2006) reported that it lives in deeper open waters during the daytime like *M. aequatorialis*. In our results, *T. oblongatus* was observed more frequently in March and July throughout the study period except in 2014. The genus *Microcyclops* Claus, 1893, is represented by five taxa in Lake Tanganyika among which *M. cunningtoni* lives in open waters (Lindberg, 1951). This species was less abundant in our results (1% of total copepod in pelagic and almost absent in littoral). *M. cunningtoni* was often observed in the April/May rainy season in 2012 and 2013 but absent at the same period in 2014.

The *Harpacticoida* are poorly known in Lake Tanganyika basin. Five genera and 16 species and subspecies of this group are reported (Lindberg, 1951). We have sporadically observed them in littoral waters at the start of rainy season but rarely in pelagic waters. This could be explained by the fact that this copepod group is essentially associated with the littoral and benthic environment in Lake Tanganyika.

Conclusions

Monitoring of Copepods was carried out in the north of Lake Tanganyika during three years in pelagic and littoral waters. Copepods were more abundant in pelagic than littoral with disparities for different taxa identified. These changes in copepod abundance have fluctuated depending on development stages of each taxon. *T. simplex* nauplii were most abundant in the littoral site compared with those of other taxa. *T. tenellus* was dominant in both sampling sites and throughout the study period for post-nauplii. Seasonally, copepods were dominant at the beginning (higher peaks) and the end (slightly lower peaks) of rainy season in the north of Lake Tanganyika. Diversity and ecology of copepod species, especially cyclopoids are still largely understudied in littoral waters characterized by cichlid fish diversity. The accurate identification of zooplankton species is a

domain where further studies are highly desired to allow additional progress in environmental and fisheries research on Lake Tanganyika.

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