Abundance and distribution of fish in the lower Mnembo River, Malawi-Mozambique

Leanda M. Delaney[1], Daniel M. Jamu[2] and Christine E. Campbell[1]*

[1]*Environmental Science, Memorial University of Newfoundland, Corner Brook, NL, Canada A2H 6P9 and* [2]*WorldFish Center, PO Box 229, Zomba, Malawi*

Abstract

Endorheic Lake Chilwa is one of the most productive lakes for fisheries in Africa. High human population densities and agricultural practices in the Chilwa catchment have been linked to observed declines of the annual fish catch in the lake. The Mnembo River is a major inflow into Lake Chilwa which has received little scientific study to date. In 2003/2004, fish diversity, abundance and distribution were monitored monthly at three sites in the Mnembo River. Twelve fish species were collected, a subset of the fourteen fish species present in Lake Chilwa. Although *Barbus* spp. were the most abundant species sampled in the Mnembo, total biomass was higher for *Labeo cylindricus* (6709 and 10,434 g, respectively). Total biomass of *Pareutropius longifilis* (1741 g) and *Brycinus imberi* (1174 g) were also high in the river. Catches of *Barbus* and *Labeo* were highly correlated ($r = 0.763$). Compared with other inflows into Lake Chilwa (Likangala and Domasi), the Mnembo River appears to be less adversely influenced by human populations, with high abundance of *Barbus* and strong presence of the riverine species *Labeo*, *Pareutropius* and *Brycinus*.

Key words: Barbus, biomass, Chilwa, diversity, fish, river

Résumé

Le lac Chilwa est endorhéique. C'est un des lacs les plus productifs d'Afrique. De fortes densités de population humaine et les pratiques agricoles du bassin de Chilwa sont liées au déclin des prises annuelles de poisson que l'on a observé. La rivière Mnembo est un des affluents majeurs du lac; elle a fait l'objet de peu d'études scientifiques jusqu'à présent. En 2003–2004, on a surveillé la diversité, l'abondance et la distribution du poisson de façon régulière, chaque mois, à trois endroits le long de la Mnembo. On a récolté douze espèces de poissons, une partie des quatorze espèces trouvées dans le lac Chilwa. Même si *Barbus* spp. était l'espèce la plus abondante récoltée dans la Mnembo, la biomasse totale était plus forte pour *Labeo cylindricus* (6.709 g et 10.434 g, respectivement). La biomasse totale de *Pareutropius longifilis* (1.741 g) et de*Brycinus imberi* (1.174 g) était aussi élevée dans la rivière. Les prises de *Barbus* et de *Labeo* étaient en forte corrélation ($r = 0{,}763$). Comparée aux autres affluents du lac Chilwa (Likangala et Domasi), la Mnembo semble moins souffrir de l'influence des populations humaines, avec la grande abondance de *Barbus* et une présence affirmée des espèces de rivage que sont *Labeo, Pareutropius* et *Brycinus*.

Introduction

Endorheic Lake Chilwa is one of the most productive lakes for fisheries in Africa, contributing on average 24% of the total annual fish production of Malawi (Furse, Morgan & Kalk, 1979a). Lake Chilwa has five major influent rivers – the Domasi, Likangala, Mnembo, Phalombe and Sombani. It is suspected that the Mnembo which flows from Mozambique is the lake's major source of water (Jamu, Delaney & Campbell, 2006). The lake is relatively shallow and, because of evaporation and unpredictable rainfall, can experience extreme annual fluctuations in water level and water quality (Msiska, 2001). Possibly as a result of the extreme conditions, Lake Chilwa is low in fish species diversity and contains only fourteen species, of which tilapias, clariids and small barbs (cyprinids of the genus *Barbus*) dominate. These species are prominent in the lake and in its tributaries because they can withstand harsh conditions by developing drought-resistant strategies (Msiska, 2001). Each species exploits Lake Chilwa's rivers

**Correspondence:* Tel.: (709) 637 6200 (ext. 6478); Fax: (709) 639 8125; E-mail: ccampbel@swgc.mun.ca

and swamps, including its major river inflows, as potential spawning areas and refugia during periods of lake desiccation (Jamu & Brummett, 1999). Small barbs and clariids migrate seasonally between the lake and its tributaries, but during periods of lake level recession, some are trapped near the outer edge of the lake in the marshlands, floodplains and rivers (Jamu & Brummett, 1999). Fish families existing in Lake Chilwa are Alestiidae [*Brycinus imberi* (Peters, 1852) and *Hemigrammopetersius barnardi* (Herre, 1936)], Cichilidae [*Pseudocrenilabrus philander philander* (Weber, 1897), *Oreochromis shiranus chilwae* (Trewavas, 1966), *Tilapia rendalli* (Boulenger, 1897) and *Haplochromis callipterus* (Günther, 1894)], Clariidae [*Clarias gariepinus* (Burchell, 1822) and *Clarias theodorae* Weber, 1897], Cyprinidae [*Barbus paludinosus* Peters, 1852, *B. trimaculatus* Peters, 1852 and *Labeo cylindricus* Peters, 1862], Mormyridae [*Marcusienis macrolepidotus* (Peters, 1852) and *Petrocephalus catastoma* (Günther, 1866)] and Schilbeidae [*Pareutropius longifilis* (Steindachner, 1914)].

Prior studies have been conducted on two of Lake Chilwa's river catchments in Malawi: the Domasi and the Likangala. These catchments support a human population of over half a million (catchment density of 93 persons km^{-2}; Ngulube, Mwabumba & Makungwa, 1999; United Nations, 2004). Both rivers have been extensively diverted for smallholder and commercial purposes, and large quantities of natural vegetation have been removed for urbanization, land cultivation and charcoal production. Jamu & Brummett (1999) studied watershed processes, land use activities, river system dynamics and the reproductive state of *Barbus* spp. in the two rivers. The study suggested that *Barbus* spp., which are economically very important in the Lake Chilwa fishery, may also be useful indicators of watershed health. Jamu, Chimphamba & Brummett (2003) estimated soil erosion losses in the Likangala catchment and indicated that sediment yield, river flow, electrical conductivity and total suspended solids (TSS) were significant predictors of *Barbus* reproductive state.

To date, no studies have evaluated fish populations in the Mnembo River, potentially the major influent to the lake, as scientific research was extensively curtailed by the Mozambican civil war which lasted from 1972 to 1992. While the Mnembo River has also been diverted for agricultural purposes, we hypothesize that it could be less affected by human population as a consequence of lower population density (catchment density of 17 persons km^{-2}; Department of Agriculture, 2004). Therefore, from July 2003 to June 2004, a study was conducted on the Mnembo River to collect baseline data on fish species abundance, diversity and distribution in the river.

Materials and methods

Lake Chilwa is located in the southern portion of Malawi and is bordered by Mozambique to the east. The total area of the lake and its surrounding wetland is 2400 km^2; one-third of which is open water, one-third swamp and marsh and one-third composed of floodplains. The total area for the lake catchment is 8349 km^2 of which 30% is in Mozambique (Lancaster, 1979). The Mnembo River catchment, located on the eastern side of Lake Chilwa, is located primarily in Mozambique.

Sampling on the river was conducted once a month from July 2003 to June 2004. Three sampling sites (Mnembo sample sites 1, 2 and 3; henceforth designated as MSS1, MSS2 and MSS3) were selected: all three sites were approximately 4 km apart with differing vegetation cover. MSS1 (UTM 0802225 8309918) was located within Malawi and was approximately 1.8 km north-east of the river mouth, whereas MSS2 (UTM 0806543 8309790) and MSS3 (UTM 0811404 8305750) were located further inland in Mozambique. MSS1 was situated within the Lake Chilwa wetland. The vegetation consisted of short grasses and shrubbery around the river's edge with an abundance of instream vegetation. MSS2 was densely vegetated along the bank of the river with vegetation comprised mainly of tall grasses, large shrubs and trees. MSS3 was near the main road and the bridge that connects the district of Mecanhelas with the T/A (Traditional Authority) of Messossomera. Tall grasses dominated the periphery of the river's edge and there was some instream vegetation. Bank slopes were steeper here than at the other two sites.

Fish were sampled monthly at each site over a 3-day period with one site sampled per day. During the evening hours, a multi-mesh gill net (survey nets type 'Norden'; Lundgrens Fiskredskapsfabrik AB, Stockholm, Sweden) with mesh sizes ranging from 5 to 43 mm was placed across the river and left overnight. A variety of mesh sizes was used to reduce species and size selectivity characteristic of gillnets (van der Mheen, 1995). The net was removed the following morning after approximately 10 h, and all the fish collected were placed in plastic buckets containing water from the river. All fish that appeared to be on the lake side of the net were placed in a bucket labelled 'Lake to River' and fish that were on the river side were placed in a bucket labelled 'River to Lake'. The purpose of separating the fish was to determine if there was a tendency for species to be moving upstream or downstream.

Once all the fish had been removed from the net, they were anaesthetized using sodium bicarbonate (Peake, 1998) and were then identified, weighed using a portable scale (digital meter, Kern and Sohn GmbH, Balingen, Germany) and their total and standard lengths determined using a portable metric measuring board. As fishing time varied between sites (from 8 to 10 h), catch per unit effort (CPUE) was calculated for each species as fish biomass caught per hour. CPUE was determined for each sampling date and on a seasonal basis; no samples were collected in May because of researcher illness. Four seasons were delineated: (i) Dry/Hot from August to October with 26 mm total monthly rainfall and an average air temperature of 30°C, (ii) Wet/Hot from November to January with 148 mm total monthly rainfall and average temperature 28°C, (iii) Wet/Warm from February to April with 108 mm total monthly rainfall and average temperature 26°C, and (iv) Dry/Cool from May to July with 0 mm of rain and 21°C average temperature.

A one-way ANOVA was applied to *B. paludinosus* and *B. trimaculatus* CPUE data to determine if there were significant differences in catch between the two *Barbus* species. Pearson product–moment correlations were applied using Minitab (2000) statistical package 13.2 to ascertain if monthly abundances (CPUE data) of all fish exhibited any seasonal relationships between species. Prior to the correlation analysis, data for each species were tested for normality by a Kolmogorov–Smirnov test and visual inspection of residuals. Where necessary, data were log-transformed to improve normality.

Results

Fish diversity, abundance and distribution in the Mnembo River

All six families found in Lake Chilwa were present in the Mnembo River, however only twelve species were represented of the fourteen found in the lake (Table 1). Four of these are predominantly riverine species (*Labeo cylindricus*, *Pareutropius longifilis*, *Brycinus imberi* and *Marcusenius macrolepidotus*; Skelton, 1993). For all species collected, the abundance of fish oriented upriver in the nets was highly correlated with the abundance of fish oriented downriver ($r > 0.850$ in all cases, abundance determined as CPUE). Thus for further analysis, CPUE of those oriented upriver were pooled with those oriented downriver (i.e. total of upriver + downriver fish). There was also no statistically significant difference in abundance between the two *Barbus* species, *B. paludinosus* and *B. trimaculatus*, as assessed by

Table 1 Total abundance (no. collected) and total biomass (g) of fish species collected from the Mnembo River from July 2003 to June 2004. Families are listed in order of abundance

Scientific name	Common name	Total abundance (#)	% collected	Total biomass (g)	% biomass
Family Cyprinidae					
Barbus paludinosus + B. Trimaculatus (Peters, 1852)	Matemba	2,478	50.3	6709	24.9
Labeo cylindricus Peters, 1868	Chonjo	1312	26.7	10,434	38.7
Family Cichlidae					
Haplochromis callipterus (Günther, 1894)	Makwale	201	4.1	680	3.9
Oreochromis shiranus chilwae (Trewavas, 1966)	Chambo	93	1.9	1630	4.4
Tilapia rendalli (Boulenger, 1897)	Chilinguni	21	0.4	1225	6.5
Family Mormyridae					
Petrocephalus catastoma (Günther, 1866)	Kanenele	174	3.5	838	4.7
Marcusenius macrolepidotus (Peters, 1852)	Mphuta	126	2.6	1084	3.2
Family Schilbeidae					
Pareutropius longifilis (Steindachner, 1914)	Namwembeya	300	6.1	1741	6.0
Family Alestiidae					
Brycinus imberi (Peters, 1852)	Nghalala	201	4.1	1174	4.5
Family Clariidae					
Clarias gariepinus (Burchell, 1822)	Mlamba	12	0.2	1271	2.5
C. theodorae (Weber, 1897)	Mlamba	7	0.1	188	0.7

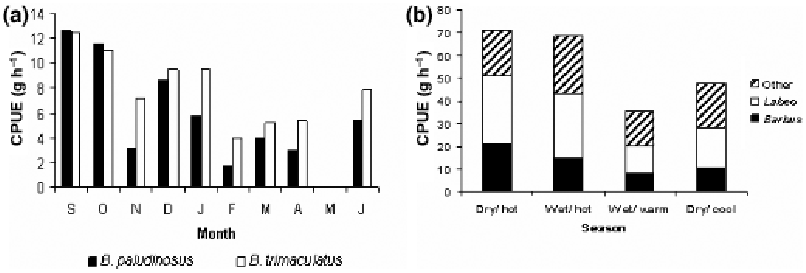

Fig 1 (a) Monthly catch per unit effort (CPUE) of *Barbus paludinosus* and *B. trimaculatus* in the Mnembo River from July 2003 to June 2004. (b) Seasonal CPUE of *Barbus* spp., *Labeo* and all other species combined in the Mnembo River from July 2003 to June 2004

one-way ANOVA (CPUE data, $F_{1,17} = 1.29$, $P = 0.273$), even though *B. trimaculatus* was more abundant than *B. paludinosus* by approximately 25%, except during the September and October (dry/hot season) when CPUE of *B. paludinosus* was slightly higher (Fig. 1a). Therefore, all further analysis of *Barbus* spp. will consider both *B. paludinosus* and *B. trimaculatus* together. Both species are morphologically very similar and it was difficult to distinguish between them as fry. *Barbus paludinosus* and *B. trimaculatus* are also distributed throughout eastern and southern Africa, prefer similar environmental conditions and are not separated in the Lake Chilwa fishery (Skelton, 1993).

Highest catches for each species were observed consistently at MSS1 near the river mouth (Fig. 2). The most abundant species were *Barbus* spp. and *Labeo cylindricus*. As shown in Table 1, however, *Labeo* had the highest total biomass (10,434 g), followed by *Barbus* (6709 g), *Pareutropius* (1741 g) and *Oreochromis* (1630 g). In the lake, the most abundant and commercially important species are *O. s. chilwae*, *C. gariepinus* and *Barbus* spp. (Bourn, 1974; Jamu & Brummett, 1999), however *Oreochromis*

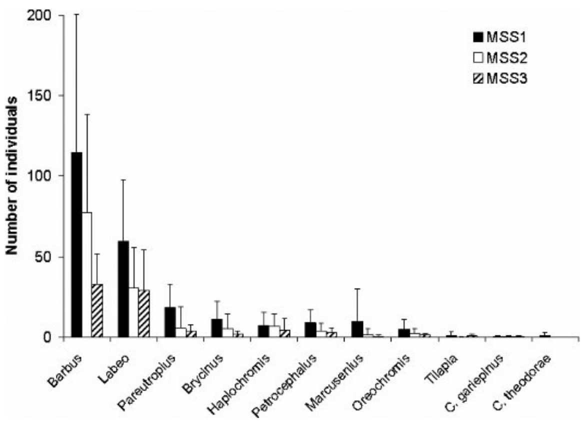

Fig 2 Mean number of fish per month sampled at each site in the Mnembo River from July 2003 to June 2004. Error bars represent standard deviations around the mean

and *C. gariepinus* were not abundant in the Mnembo River, nor were they viewed as important to the Mnembo fishing community (based on surveys of local villagers; Delaney, 2006). Nonetheless, their combined biomass (2901 g) did contribute over 10% to the total biomass collected from the Mnembo River (Table 1). The total number of fish decreased by approximately 50% from MSS1 to MSS2 for the majority of the species sampled.

Tilapia rendalli, *C. gariepinus* and *O. s. chilwae* are relatively large fish which, while not abundant in the Mnembo, together represented 14% of the total fish biomass in the river (Table 1). Maximum total length (TL) measured for *Tilapia*, *C. gariepinus* and *Oreochromis* were 35, 31 and 28 cm, respectively (Table 2), while the more abundant fish in the Mnembo, *Barbus* and *Labeo*, had maximum TLs of 13 and 20 cm, respectively.

Seasonal distribution of species

All of the twelve fish species collected in this study were found at each site, except for *C. theodorae* which was only taken at MSS1 in February during the wet/wet season (Table 3). Catches of *Barbus*, *Labeo*, and the other 10 species combined were all highest during the dry/hot and wet/hot seasons when air temperatures were above 29°C (Fig. 1b). Similar seasonal trends were evident for *Barbus* and *Labeo* with monthly CPUE values for the two species positively correlated ($r = 0.763$, $P = 0.006$; Table 4). CPUE values for *Petrocephalus catastoma* and *Marcusenius macrolepidotus* from the family Mormyridae were also positively correlated ($r = 0.895$, $P < 0.001$). *Petrocephalus catastoma* and *Marcusenius macrolepidotus* were very abundant during the sampling in January at MSS1, but otherwise were not numerous during the remainder of the year. *Brycinus imberi* was most abundant at site MSS1 from January to May 2004, while *Haplochromis callipterus* was more numerous during the drier seasons (August to October). CPUE values for these two species were

Table 2 Mean (±1 standard deviation), maximum and minimum total lengths (TL, cm) of each species sampled and the sites in which they were collected within the Mnembo River from July 2003 to June 2004 (*Barbus* spp. = *B. paludinosus* + *B. trimaculatus*)

Species	Mean	Maximum	Site (MSS#)	Minimum	Site (MSS#)
Barbus spp.	6 ± 1.7	13	1	3	3
Brycinus imberi	7 ± 2.2	17	2	4	2
Clarias gariepinus	22 ± 5.1	31	1	13	3
Clarias theodorae	18 ± 2.0	20	1	15	1
Haplochromis callipterus	6 ± 1.6	12	1	3	1
Labeo cylindricus	9 ± 2.1	20	2	4	1
Marcusenius macrolepidotus	8 ± 2.2	19	1	5	2
Oreochromis shiranus chilwae	10 ± 4.1	28	1	3	3
Pareutropius longifilis	8 ± 2.9	16	1	4	3
Petrocephalus catastoma	8 ± 2.8	20	1	5	2
Tilapia rendalli	12 ± 5.7	35	1	3	3

Table 3 Seasonal distribution of species sampled in the Mnembo River at each site from July 2003 to June 2004

	MSS1				MSS2				MSS3			
Species	D/H	W/H	W/W	D/C	D/H	W/H	W/W	D/C	D/H	W/H	W/W	D/C
Barbus spp.	+	+	+	+	+	+	+	+	+	+	+	+
Brycinus imberi	+	+	+	+		+	+	+	+	+	+	+
Clarias gariepinus	+				+	+	+		+	+		+
Clarias theodorae			+									
Labeo cylindricus	+	+	+	+	+	+	+	+	+	+	+	+
Haplochromis callipterus	+	+	+	+	+	+	+	+	+	+	+	+
Marcusenius macrolepidoptus	+	+	+	+		+	+				+	
Oreochromis shiranus chilwae	+	+	+	+	+	+	+	+	+	+	+	+
Pareutropius longifilis	+	+	+	+		+	+		+		+	
Petrocephalus catastoma	+	+	+	+		+		+	+	+		+
Tilapia rendalli	+			+	+				+		+	+

D/H = dry/hot, W/H = wet/hot, W/W = wet/warm, D/C = dry/cool, + = presence of species in gill nets, *Barbus* spp. = *B. paludinosus* + *B. trimaculatus*.

Table 4 Pearson product–moment correlation coefficients (r) and associated P-values of catch per unit effort (CPUE) data for species sampled monthly in the Mnembo River from July 2003 to June 2004. CPUE data are the mean values of all three sites. Only correlations having $P < 0.05$ are shown (*Barbus* spp. = *B. paludinosus* + *B. trimaculatus*)

Species 1	Species 2	r	P
Barbus spp.	*Labeo cylindricus*	0.763	0.006
	Marcusenius macrolepidotus	0.710	0.014
	Haplochromis callipterus	0.622	0.041
Brycinus imberi	*Haplochromis callipterus*	−0.644	0.032
Labeo cylindricus	*Petrocephalus catastoma*	0.726	0.012
	Marcusenius macrolepidotus	−0.663	0.026
Marcusenius macrolepidotus	*Petrocephalus catastoma*	0.895	0.001

negatively correlated based on mean Mnembo data ($r = -0.644$, $P = 0.032$; Table 4).

Discussion

The Mnembo River is suspected to be the largest source of fresh water to Lake Chilwa (Jamu *et al.*, 2006) and based on the abundance of *B. trimaculatus*, *B. paludinosus* and other fish species, the river is potentially in much better condition than the other catchment basins of Lake Chilwa. Connections can be made between this putative better condition and the lower population density, less intensive cultivation and deforestation in the Mnembo catchment when compared with the more degraded Likangala and Domasi catchments (Delaney, 2006; Jamu *et al.*, 2006).

Fish species richness in the Mnembo River is low, dominated by the cyprinids *B. paludinosus*, *B. trimaculatus*, and *Labeo cylindricus*, which are widely distributed throughout most small water bodies in Africa (Marshall & Maes, 1994). Twelve fish species were collected in the Mnembo, a subset of the fourteen fish species present in Lake Chilwa (lake fish *Hemigrammopetersius barnardi* and *Pseudocrenilabrus philander philander* were not found in the river). During July 2003 to June 2004, the majority of the commercially important Lake Chilwa species were found at least 10 km upriver (at MSS3) several times throughout the sampling period even when lake levels were observed to be high. This suggests that fish could be accessing the Mnembo River for spawning and that some may be resident there. The Mnembo should be a suitable environment for spawning by lake and riverine species, including *Barbus*, *Clarias* and *Labeo*. *Clarias*, for example, prefer shallow grassy edges of rivers or recently flooded land for spawning (Furse *et al.*, 1979b), while *Barbus* prefer slow-moving, highly vegetated areas (Skelton, 1993). *Labeo* characteristically prefer clear running water in rocky habitats (Reid, 1985) and it was interesting that this species was found in higher numbers at MSS1, the only site that displayed measurable river current all year round.

Labeo spp. are considered commercially important in many African water bodies (Weyl & Booth, 1999), yet *L. cylindricus* does not contribute significantly to the Lake Chilwa commercial fisheries (Jamu & Brummett, 1999). However, it is important to the Mnembo catchment community as it is predominantly a riverine species (Weyl & Booth, 1999). For villagers near the Mnembo River, *Labeo* can be as abundant and as important a food source as *Barbus* spp., depending on the time of the year and environmental conditions (Delaney, 2006).

Only in Malawi's Lake Chilwa has *Barbus* been recognized as an important part of an African fishery (Bourn, 1974). *Barbus paludinosus* is generally found in muddy waters and appears to be more tolerant of higher concentrations of TSS than is *B. trimaculatus* (Jackson, 1961). In the Likangala River of Lake Chilwa, *B. paludinosus* was more abundant than *B. trimaculatus*. In the Mnembo River, *B. trimaculatus* was the more abundant of the two species, while TSS concentrations (maximum 0.07 mg l^{-1}) were not as high as had been recorded in the Likangala River (maximum 0.14 mg l^{-1}) and were not correlated with fish abundance (Delaney, 2006). Lower TSS coupled with *B. trimaculatus* abundance could suggest that the water quality of the Mnembo River was potentially better than that of the Likangala for human use.

While *Barbus* and *Labeo* were the most abundant contributors to the river's total catch, *Barbus* is potentially more important to the lake fishery because of its higher capacity for population growth (Skelton, 1993). *Labeo* can take 4.5–14 years to double its population whereas *Barbus* can take <15 months (Reid, 1985; Skelton, 1993). Collected riverine species *Brycinus imberi*, *Marcusenius macrolepidotus*, *Pareutropius longifilis* and *Petrocephalus catastoma* also have rapid growth rates similar to that of *Barbus* (Skelton, 1993). However, *Barbus* species were markedly more abundant than these fish species in the Mnembo River and in Lake Chilwa, possibly because the small barbs are extremely hardy, have flexible feeding habits and can adapt to a wide range of habitats (Furse *et al.*, 1979b). Such attributes, coupled with high fecundity, likely aided *Barbus* in rapid re-colonization (within 2 years) after a drying phase of the lake (Furse *et al.*, 1979b).

Another explanation for the high number of *Barbus* caught in the Mnembo River could be related to gear type and net location. A multi-mesh gillnet (5–43 mm mesh size) was used in this study and sampling sites were selected where impacts of gear selectivity were thought to be minimal. While gillnets can be very selective for size and species (Mattson, 1994; van der Mheen, 1995), selectivity was most likely reduced by using the multi-mesh gillnet with a wide range of mesh sizes. Net location can also affect gear selectivity. Placement of nets within areas of high instream vegetation, for example, could tend to select for species that only reside in those areas, whereas placement of nets in deep water could facilitate fish escapes under the net (van der Mheen, 1995).

Similar seasonal trends in abundances were observed in some species. Positive correlations in CPUE were observed between cyprinids *Labeo* and *Barbus* and between mormyrids *Marcusenius* and *Petrocephalus*. Catches of both *Barbus* and *Labeo* were high in the dry/hot season and low in the wet/warm season. This suggests that these cyprinids are likely responding to similar environmental cues, such as discharge, to trigger movement up and down the river (Weyl & Booth, 1999; Delaney, 2006). The observation that *Marcusenius* and *Petrocephalus* tend to school with each other (Gosse, 1984) could explain the high positive correlation between these two species. Such schooling behaviour may be a defence against *C. gariepinus*, one of their major predators (Merron, 1993).

During periods of lake level recession, Lake Chilwa's river catchments become significantly more important to the sustainability of the lake fisheries. Species such as *Barbus* spp., *O. s. chilwae* and the catfish, *C. gariepinus*, use the rivers and swamps of Lake Chilwa as a refuge during periods of lake desiccation, and as sites for feeding and spawning (Furse *et al.*, 1979b; Jamu & Brummett, 1999). During periods of extreme lake level decrease and increased salinity, *C. gariepinus*, *B. paludinosus*, *B. trimaculatus* and *O. s. chilwae* can likely adapt to changes in food availability, becoming nonspecialized opportunistic feeders (Furse *et al.*, 1979b). For example, *Oreochromis* are primarily herbivorous; however, within Lake Chilwa they also consume zooplankton during the drying phases of the lake (Bourn, 1974). *Clarias gariepinus* is tolerant of harsh environmental conditions by virtue of specific morphological adaptations (Furse *et al.*, 1979b). For instance, the species can withstand periods of anoxia because of accessory respiratory organs in the branchial cavity (Furse *et al.*, 1979b). *Clarias theodorae*, the other clariid species sampled in the Mnembo River, was only caught once and that was when discharge was at its peak (February, wet/warm season). *Clarias theodorae* prefer slow-moving waters and lagoonal floodplains along river banks for spawning (Skelton, 1993). Absence of *C. theodorae* in the gillnets at other seasons may be related to reduction in discharge and lack of rainfall leading to decreasing lagoonal habitat.

Catches of *Clarias* in the Mnembo could also have been low due to the gear type used. In Lake Chilwa, long-lines are the most effective gear for catching *Clarias* spp., followed by seines and then gillnets (Nyasulu, Namoto & Mponda, 2001). As the probability of encountering gillnets is directly proportional to fish swimming speed and river flow rate (Mattson, 1994; van der Mheen, 1995), such nets are less likely to catch slow-moving, bottom dwelling fish such as *Clarias* (Nyasulu *et al.*, 2001), especially during periods of low flow in the river.

Overall, sizes of fish species in the Mnembo River seemed to be smaller than the same species in the lake. Both *Tilapia rendalli* and *C. gariepinus* in Lake Chilwa can reach lengths substantially greater than those caught in the Mnembo (Teugels, 1986; Teugels & Thys van den Audenaerde, 1991). The maximum size for *Labeo cylindricus* (20 cm) in the Mnembo was also smaller than in other African rivers (25 cm; Skelton, 1993). Reasons for this are unclear. Based on Skelton (1993), the maximum size of *Barbus* caught in Lake Chilwa was 15 cm whereas in the Mnembo the maximum size was marginally smaller (13 cm). While it does not appear that size in *Barbus* has changed substantially over the last 12 years, fish sellers report that the average size of *Barbus* is decreasing in the local city markets and in the daily fish catch at Kachulu Harbour on Lake Chilwa (L.M. Delaney, pers. obs.). Reduction in *Barbus* size does appear to be a concern for the entire lake watershed and this apparent trend needs to be further examined. Decrease in fish size in the river could be a result of overfishing and removal of larger spawners. Alternatively, perhaps the larger fish are less likely to be utilizing the river for spawning, preferring instead to spawn in the swamps around the lake and hence not migrate upriver. Links between the health of fish stocks in the Mnembo and the sustainability of the Lake Chilwa fishery need to be examined further.

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