Fishery methods and fish diversity in the Kilombero River in south-eastern Tanzania

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ABSTRACT

Assessment of common fishery methods and of fish diversity was undertaken in two fishing camps on the Kilombero River in south-eastern Tanzania in surveys towards the end of the dry season, 1994. Fishermen identified 23 different types of fish that they caught on a regular basis. Only 19 species of fish, belonging to 17 genera and 11 families were, however, identified according to Linnean taxonomy. Hooks, nets, traps and spears were used to catch fish. Fish were either sold fresh, or preserved for storage and long-distance transport by smoking or frying. Based on frequency distributions of the numbers of fish landed over a 4 day period at one of the camps, a Shannon-diversity index of 1.95 was calculated. The fork (or total) length of 480 fish and the weight of 413 fish were measured and length frequency distributions as well as length-weight relationships determined for the six most common species. It is concluded that local fishing methods applied in the Kilombero River allow for sustainable fish production.

INTRODUCTION

In the 1960's, the Kilombero River in south-eastern Tanzania, charmed the producers and stars of the film 'African Queen' and, as GEIGY (1976) reported "on the sandspits and banks hippos, crocodiles, monitor lizards, and swarms of all kinds of aquatic birds [can be observed]". Even today visitors to the Kilombero cannot fail to be impressed by it. It is one of the most important rivers in East Africa.

The river is of great biological interest because it acts as the source of water for an extremely diverse terrestrial fauna which, in the dry season includes a large proportion of the elephants and buffaloes otherwise resident in the Selous game reserve into which it flows. Above the Selous it also supports the largest population of puku *(Kobus vardoni* Livingstone) in Africa (RODGERS, 1984). It provides an immense habitat for a diverse avifauna, including 'vast numbers' of pelicans (WILLIAMS and ARLOTT, 1980) and at least one endemic species of weaver.

The river is of great economic value because fishing is one of the main activities of villagers who live in the Kilombero valley and fish provide an important source of cash income. In an extensive household s rvey in Kikwawila, a village lying at the edge of the fertile basin of the river, 14% ofthe villagers interviewed stated that fishing during the dry season was one of their main non-agricultural sources of income (ZEHNDER *et al.,* 1987a; ZEHNDER *et al.,* 1987b). Fish is a major source of high quality protein for villagers in the Kilombero valley, as there is only limited cattle-breeding because both east-cost fever and trypanosomiasis are endemic (JATZOLD and BAUM, 1968; LUKMANJI and TANNER, 1985, ZEHNDER *et al.,* 1987a,

TANNER *et al*, 1991). In Kikwawila, fish were observed to be a daily item of the diet for most families in August, the dry and post-harvest season (LUKMANJI and TANNER, 1985; TANNER and LUKMANJI, 1987). Nevertheless, despite its biological and economic importance the river and the Kilombero valley as a whole are poorly described. Access is difficult and the area was considered of limited value for development in the past (JATZOLD and BAUM, 1968; RODGERS, 1984).

In the present study we describe the traditional fisheries and provide an assessment of fish diversity, based on both the local and formal taxonomy. The length-weight relationship of the most common species is also given. Particular emphasis was placed on rapid assessment procedures (SCRIMSHAW and HURTADO, 1987) and the application of social science techniques to collect the relevant data (DENZIN and LINCOLN, 1994; CLAY and MC GOODWIN, 1995).

MATERIAL AND METHODS

Study area

The Kilombero River and its tributaries form a nexus of waterways running through the middle of a seasonally inundated plain in south-eastern Tanzania (S: 7°44' - 9°26'; E: 35°33' - 36°56'). It is situated some 300 km from the Indian Ocean and lies at an altitude of about 230-260 m above sea level (asl). The river is approximately 250 km long and the plain up to 52 km wide, covering a total of 626,500 ha at high water. The Kilombero valley is oriented SW-NE, between the densely forested escarpment of the Udzungwa Mountains, which rise to 2,576 m asl on the north-western side and the grass covered Mahenge Mountains, which rise to 1,516 m asl on the south-eastern side (RODGERS, 1984). The characteristic features of the valley have been described in detail elsewhere (JATZOLD and BAUM, 1968; TANNER *et al.*, 1991, CHARLWOOD, 1997). The area is characterized by two distinct seasons: a rainy season from November until the middle of May, with maximum rainfall usually recorded in March or April when the river is in flood and a dry season from June until October (FREYVOGEL, 1960). The river is characterised by strong meandering, indicative of the low altitude above sea level and a low water gradient (FREYVOGEL, 1960). The meandering river and its annual rhythm of floods, have been suggested as leading factors for the wide variety of soil types in the Kilombero valley (ZEHNDER *et al.*, 1987a).

Human population

The human population consists of several Bantu tribes (mainly Ndamba, Pogoro, Bena, Ngindo, Mbunga) most of whom are subsistence farmers (rice, maize and cassava) and fishermen (JATZOLD and BAUM, 1968). The main anthropogenic influences on the river ecosystem are due to relatively intensive poaching of the game (CHARLWOOD, 1997) and to deforestation of the surrounding hills which may result in increased flooding in the wet season and reduced flow in the dry season.

Throughout the length of the river there are a number of fishing camps of varying sizes. In the upper reaches, where flooding is an annual occurrence, these are often small and seasonal whereas closer to the Selous game reserve they are permanent villages. The fishing camps also serve as the base for illegal hunters.

Study sites

The present study was carried out in two camps, Liguliau and Funga (Fig. 1), in October and November 1994. Liguliau (S: 8°142'; E: 36°352') is a seasonally inundated camp some 15 km upstream from the ferry crossing at Kivukoni close to the town of Ifakara (the Kilombero district's main town). It can only be reached by pirouge, the journey upstream taking between five to six hours. Although it is on the main river there are numerous water channels of varying depths in the vicinity of Liguliau. This enables different methods of fishing to be used.

Funga camp (S: 8°100'; E: 36°467') is located some 10 km downstream from the ferry. It is usually reached by pirouge but in the dry season can also be reached by foot or bicycle. Funga is much larger than Liguliau and remains inhabited throughout the year. It has many of the features of a small village.

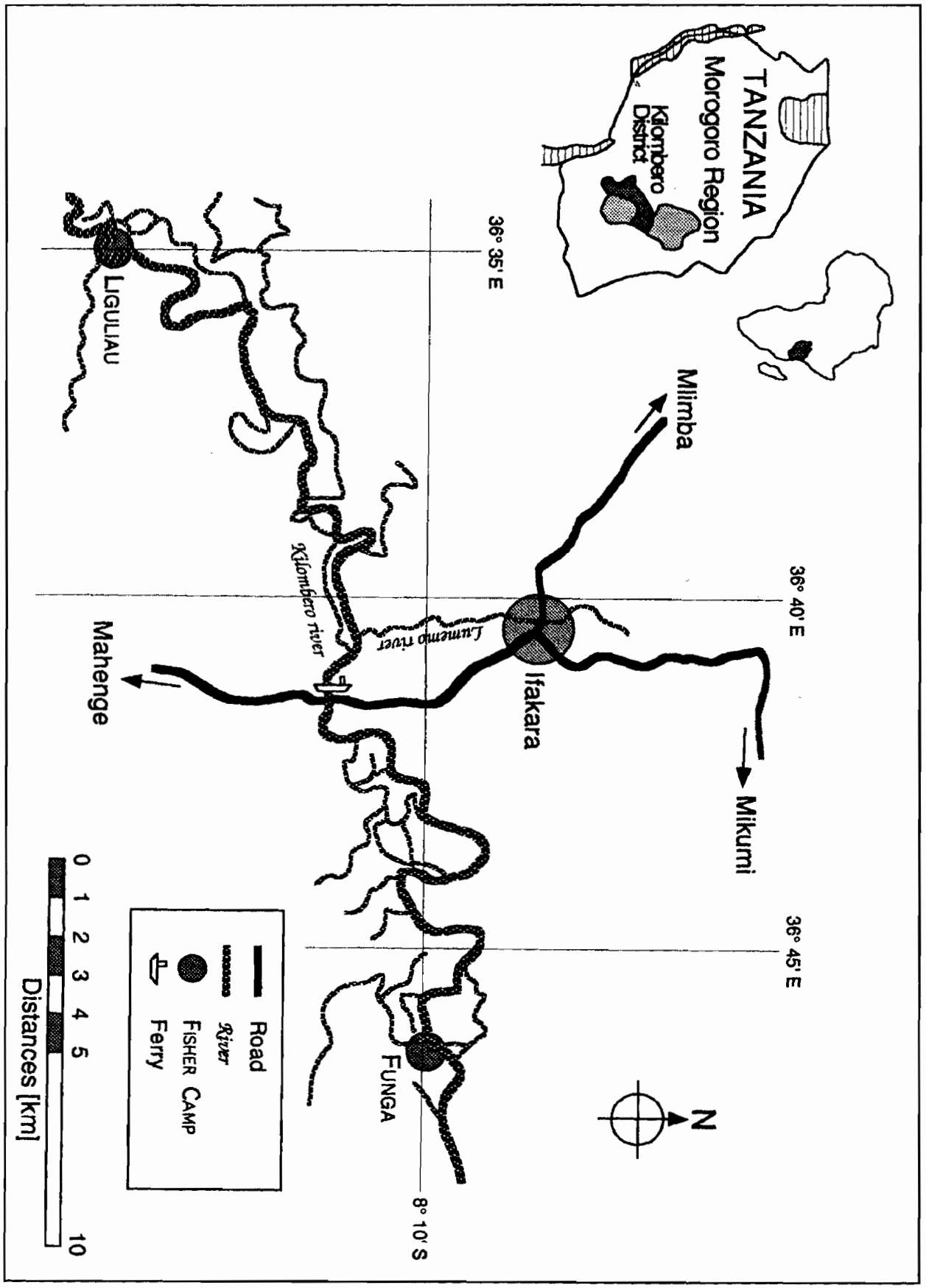

Fig. 1 Location of the two fishing camps Liguliau and funga, where the two fish baseline surveys were undertaken

Data collection

The different fishing methods, the techniques of preparing fish for storage and transport and the fishermen's knowledge of the different fish species (appraised by their Kiswahili names) were assessed by direct observation and by discussions with the fishermen. In addition, two in-depth interviews were carried out with two fishermen according to methods outlined in DENZIN and LINCOLN (1994). During the survey at Liguliau all fish caught over a period of six days were identified according to the local taxonomy. The fork length (distance between fish snout and fork of caudal fin) or total length (for those fish with non-forked caudal fin e.g. *Clarias gariepinus*), was measured to the nearest 5 mm. The weight of intact fish of over 100 g was measured to the nearest 25 g, using a kitchen balance. During the survey in Funga, the fish were identified according to family, genus and, where possible, to species, using FAO identification sheets (ECCLES, 1992). Diversity was calculated according to the Shannon-diversity index (KREBS, 1994; BEGON *et al.*, 1996). For the six most common species, the length-weight relationship was analysed after logarithmic transformation, which gives a straight line relationship (BAGENAL, 1978):

$$log\ W = log\ a + b\ log\ L$$

where W = weight, L = length, b = regression coefficient and log a = intercept of the line of the y-axis.

Data analysis

Fork lengths (or total lengths) and weights of fish were entered onto a personal computer using StatView software and cross-checked with the original field forms. The range (minimum and maximum), mean and the standard deviation for both length and weight was determined per species.

Results

Two fishing camps and characterization of its population

The population of Liguliau consisted only of adult men, aged 20 years and older, while in Funga, women and children were also recorded. In both camps a distinct division of labour was observed into three or four different activities: (i) fishing, (ii) preparing and preserving the fish, (iii) transporting and selling the fish and, in Funga, (iv) brewing beer, cooking food and selling those products within the camp. Fishing was performed by men. In Liguliau, the majority of fishermen were of the Ndamba and Mbunga tribes, the original inhabitants of the Kilombero valley (JATZOLD and BAUM, 1968), while in Funga most ofthe fishermen were Nyakyusa (recent immigrants from Lake Nyasa). Fishermen did not hunt and generally left the local game undisturbed. No differences were found between fishing methods with respect to tribe and age.

Liguliau was usually inhabited from the beginning of the dry season (June) until the beginning of the heavy rains (February) when the camp was abandoned because of the rising water level. Individual fishermen spent periods of 7 to 10 days living in the camp with breaks of 2 to 4 days in Ifakara or in their home villages. At the time of the survey, the human population consisted of 20 to 42 men. The camp consisted of seven temporary field huts, constructed with a wooden or bamboo wattle covered with grass. Huts were used for sleeping places (always 2 to 3 people) and offered protection from the sun during the day. Around half of the inhabitants slept outside, on twisted matting on the sand shore with only a blanket for cover. Some of the inhabitants, even those sleeping outside, used nets to protect themselves against the many mosquitoes biting at night. In Funga, there are permanent residents, a *'balozi'* (ten cell leader), small shops and restaurants. *'Pombe'*, a locally brewed maize beer, was available and consumed on a regular basis.

Most of the fish were sold in Ifakara, or Mahenge (70 km south of Ifakara). Other important destinations included Mkamba (50 km north-east of Ifakara), Mikumi (110 km north-east of Ifakara) Morogoro (220 km north-east of Ifakara) and Dar es Salaam (300 km north-east of Ifakara).

Fishing methods

Four main fishing methods were observed. First, fishing by hook-and-line which was done both by hand or passively, by fixing the line on a pole or stone and checking after a few hours. Hooks used were 2-6 cm in size and the method was accordingly designed to catch larger fish. The fishermen practised hook-and-line fishing either from the river bank or from pirouges at all times of the day. Very often, long line fishing was performed. Fishermen attached up to 30 hooks on short (circa 0.3 m) lines at regular intervals on one long line which was strung across the width of the river and left overnight. Different baits such as worms, meat or pieces of fish were used.

Gill nets with different mesh widths (range: 5-20 mm), seines and cast nets (mesh size: 2-5 cm) were the most common method of fishing observed. Casting weighted nets from the prow of a canoe was perhaps the most specialised form of fishing. This was performed by two fishermen, one of whom threw the net whilst the other guided the canoe. Small fish, in shallow and slow flowing water, were often caught with scoop nets with tiny mesh sizes (range: 2-10 mm).

A wide range of traps, especially basket traps, were also used. The smaller waterways were partially blocked with a barrier of local bamboo stalks and a basket trap placed in the opening that remained. As the dry season progressed and the water level dropped fish were caught in the traps. Along the river banks the use of nets and traps was often combined.

Fishermen also used spears randomly thrust close to the shore line, where the water was shallow and where there was dense floating aquatic vegetation.

Fish preparation and preservation for storage and transport

Only occasionally were fresh fish taken to the markets to be sold. This tended to depend on the nature and number of the fish caught. For example, if a fisherman at Liguliau had a particularly good day then he would take his catch downstream (where prices were higher) and combine the trip with a home visit.

Different ways of preservation were used according to fish size. Large fish were cut laterally on the dorsal side and, after removal of the intestines, were opened like a book, pickled and smoked for several hours. Smaller fish were either smoked or dried in the sun without cleaning. Fish were also fried to preserve them. They were cleaned, cut into pieces and then deep fried in cooking oil for at least a quarter of an hour.

Fishermen's knowledge of the different fish

Fishermen gave a total of 23 different local names for the fish which they caught on a regular basis. During our surveys at the two fishing camps we assessed the abundance on a semi-quantitative basis for 13 and 16 of those species, respectively (Table 1). The fishermen's taxonomy, as assessed by the local Kiswahili fish names, however, does not reflect the Linnaean classification down to the level of species since at least two species of Ndipi (*Mormyridae* sp.) and two species of Perege (*Oreochromis* sp.) are recognized by the field guide but only one each by the fishermen (Table 2).

During the two surveys 19 different species, belonging to 17 different genera and 11 different families (Table 2) were identified using the FAO field guide to the freshwater fishes of Tanzania (ECCLES, 1992). Three types of fish could not be distinguished with the identification sheets. In addition the identification sheets were poor for *Barbus* classification and the *Labeo congoro* (local name, Mtuku) on the Kilombero had eleven instead of the specified ten branched rays on the dorsal fin. This may be a local variant or a new

species within this genus. Furthermore, both Surusuru and Ngogo (local names) may each be a composite of more than one species (Table 2).

Large fish (mean weight > 500 g) occurring in the Kilombero River are catfish; local name: Kitoga (*Bagrus orientalis*), Kambale (*Clarias gariepinus*), Ndungu (not known), Njege (*Hydrocynus goliath*) and Ntuku (*Labeo congoro*).

In the survey at Liguliau, we measured the fork or total length of 480 and the weight of 413 fish. The fish were classified according to the fishermen's taxonomy. The range, mean and standard deviation of both length and weight are given in Table 3. The total weight of all fish caught during the six days of the survey at Liguliau was 360 kg. *Bagrus orientalis* (Kitoga) was the most common fish caught and contributed 49% to the total biomass. *Clarias gariepinus* (Kambale) contributed another 24%, whilst Perege (> 1 species, see Table 2) and Ndungu contributed 10% and 9%, respectively. Although both Surusuru (*Mormyrus longirostris*) and Ngogo (*Synodontis maculipinna*) were common they contributed only marginally to the total harvest (3% each species). This was also the case for small species, such as Ndipi (*Hippopotamyrus discorhynchus, Marcusenius stanleyanus*) and Dagaa (*Barbus* spp).

Fish diversity, length frequency distribution and length-weight relationship

The species of fish caught depended to a large extent on the method used. The Shannondiversity index calculated for the fish collected during the survey at Liguliau was 1.95. The length frequency distributions are given for the six most common species: Kitoga, Kambale, Perege, Ngogo, Ndungu and Surusuru (local taxonomy, Figure 2). The length-weight relationship was also analysed for these six species and the corresponding values (log a and b, according to BAGENAL, 1978) are given in Table 3.

Table 1: Local Kiswahili names of Kilombero River fish and semi-quantitative assessment of the fish studied during the two surveys in Liguliau and Funga (+++: very common, ++: common, +: rare, –: not observed).

No	Local name	semi-quantitative assessment		No	Local name	semi-quantitative assessment	
	(Kiswahili)	Liguliau	Funga		(Kiswahili)	Liguliau	Funga
1	Ndipi	+++	+++	13	Bula	+	+
2	Surusuru	++	+	14	Kambale	+++	+++
3	Mkunga	+	+	15	Ngogo	++	++
4	Ngurufi	–	+	16	Perege	+++	+++
5	Mtuku	+	++	17	Mjongwa	–	–
6	Dagaa	–	+	18	Nguyu	–	–
7	Ndungu	++	++	19	Ningu	–	–
8	Mbala	–	++	20	Kibenamdenge	–	–
9	Mgundu	+	+	21	Njuji	–	–
10	Mbewe	+	+	22	Sheta	–	–
11	Njege	+	+	23	Benasongo	–	–
12	Kitoga	+++	+++				

Table 2: The local taxonomy of Kilombero River fish (Kiswahili names) and their corresponding Linnaean classification

No	Local name (Kiswahili)	Linnaean Classification		
		Family	Genus	
1	Ndipi	Mormyridae	*Hippopotamyrus*	*Hippopotamyrus discorhynchus* (Peters, 1852)
2	Ndipi	Mormyridae	*Marcusenius*	*Marcusenius stanleyanus* (Boulenger, 1897)
3	Surusuru	Mormyridae a)	*Mormyrus*	*Mormyrus Longirostis* (Peters, 1852)
4	Mkunga	Anguilliae	*Anguilla*	*Anguilla bengalensis labiata* (Peters, 1852)
5	Ngurufi	Cyprinidae	*Labeo*	*Labeo coubie* (Ruppell, 1832)
6	Mtuku	Cyprinidae	*Labeo*	*Labeo congoro* (Peter, 1852) b)
7	Dagaa	Cyprinidae	*Barbus*	*Barbus lumiensis* c)
8	Ndungu	Distichodontidae	*Distichodus*	not known d)
9	Mbala	Citharinidae	*Citharinus*	not known d)
10	Mgundu	Characidae	*Alestes*	*Alestes stuhlmanni* (Pfeffer, 1896)
11	Mbewe	Characidae	*Brycinus*	not known d)
12	Njege	Characidae	*Hydrocynus*	*Hydrocynus goliath* (Boulenger, 1898)
13	Mbewe	Characidae	*Petersius*	*Petersuis conserialis* (Hilgendorf, 1894)
14	Kitoga	Bagridae	*Bagrus*	*Bagrus orientalis* (Boulenger, 1902)
15	Bula	Schilbeidae	*Schilbe*	*Schilbe moebiusii* (Pfeffer,1896)
16	Kambale	Clariidae	*Clarias*	*Clarias gariepinus* (Burchell, 1815)
17	Ngogo	Mochokidae a)	*Synodontis*	*Synodontis maculipinna* (Norman, 1922)
18	Perege	Cichlidae	*Oreochromis*	*Oreochromis jipe* (Lowe,1955)
19	Perege	Cichlidae	*Oreochromis*	*Oreochromis urolepsis* (Normann, 1922)

a) Most likely additional species within this family
b) 11 instead of 10 branched rays on dorsal fin
c) Identification sheets poor for *Barbus* classification
d) Identification not possible based on the field guide. Either local variation or new species

Table 3: Fork length (FL) or total length (TL; if specified) and weight of the most common species of fish (above 100g weight) landed between 10 and 15 October 1994 at Linguliau fishing camp (fish classified according to the local taxonomy; SD = standard deviation).

No	Local name (Kiswahili)	N measured	Length [mm]		Weight [g]		Length-weight relationship	
		Length/Weight	Range	Mean ± SD	Range	Mean ± SD	log a	b
1	Kitoga	119/119	285-850	440 ± 105	300-9700	1100 ± 1084	-5.01	3.05
2	Kambale (TL)	111/111	275-900	440 ± 76	175 - 5400	700 ± 382	-4.61	2.82
3	Perege (TL)	70/68	190-415	253 ± 61	250 - 1350	463 ± 255	-2.87	2.30
4	Ngogo	45/45	140-255	210 ± 23	100 - 350	250 ± 58	-2.58	2.14
5	Ndungu	37/37	195-475	320 ± 80	200 - 2325	688 ± 664	-4.06	2.97
6	Surusuru	28/28	240-470	328 ± 82	150 - 1050	488 ± 250	-3.69	2.51
7	Ndipi	51/0	65 - 165	105 ± 22				
8	Mbewe	12/0	125-145					
9	Bula	4/4	295-315		400 - 475			
10	Mgundu	1/0		195				
11	Njege	1/0		500				
12	Ntuku	1/1		315	775			

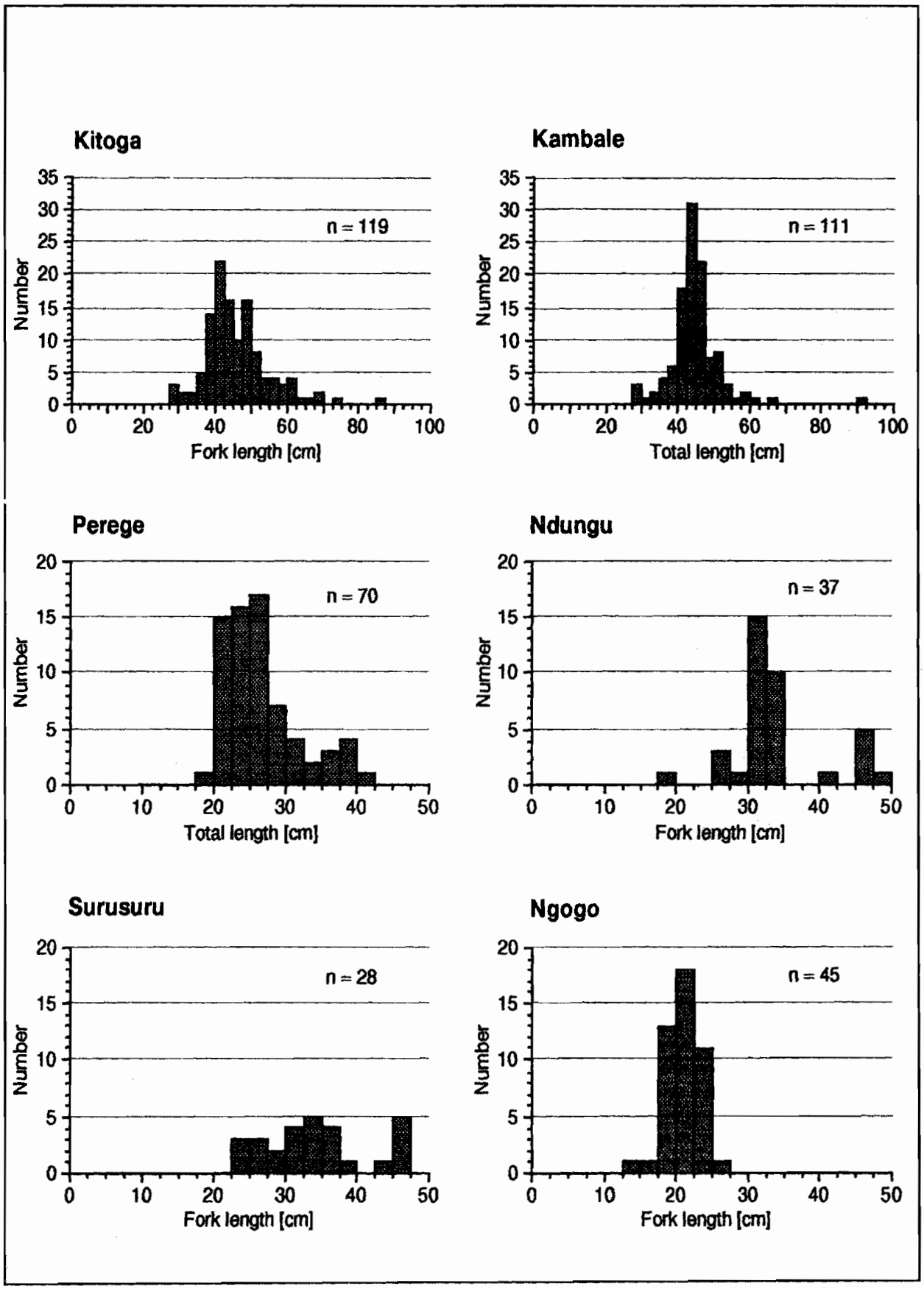

Fig. 2. Length frequency distribution of the six most common fish species, classified according to their local taxonomy

DISCUSSION

In many areas of the world fishing is a specialised traditional occupation. Thus, all the members of a particular tribe are fishermen rather than some members of all tribes being so. This is the case in the Kilombero where fishermen either belonged to tribes with a long history in the area or to tribes that elsewhere are known to be fishermen. The major centres of population of the Wandamba are in the middle of the valley alongside major tributaries of the Kilombero to the west of Ifakara town (Mofu and Merera). They made use of their knowledge of the nexus of waterways to escape from tribal enemies or early colonial taxgatherers. People belonging to the Nyakyusa tribe, originating from Mbeya region, are relatively recent immigrants into the Kilombero valley. Before, they used to fish on Lake Nyasa but moved to the Kilombero because of the good fishing grounds. They show the tendency to stay on their own in Funga and other camps to the east of the ferry crossing whereas the Wandamba tended to predominate upstream to the west of the crossing. Both groups applied similar fishing methods.

Notwithstanding the many conceptual and practical difficulties associated with their application (LUDWIG and REYNOLDS, 1988) diversity indices can provide information about species richness in samples (SPELLERBERG, 1991). We used the Shannon-diversity index and calculated a value of 1.95 for the diversity of fish in the Kilombero. It is probably too low and strictly speaking, it should be used only on random samples drawn from a large community in which the total number of species is known (KREBS, 1994). Our data were probably biased because the fish analysed depended on the places fished, the size of hook or net mesh and the type of bait used. In addition, the two surveys were carried out over a relatively short time so that some species of fish were missed. For a comprehensive assessment of the magnitude of fish diversity, investigations would need to be done throughout at least one year using an unselective method of catching the fish, for example by electrofishing. The advantage of the method used in the present study, however, is that no sophisticated equipment is needed to catch the fish. Despite our misgivings, the index may not be too far from an absolute index for a number of reasons. Fishermen are unlikely to throw away any fish that they catch (if they are not to be used for human consumption then they will serve as bait) and an optimum division of labour among fishermen is likely to have arisen over the generations such that the relative effort to catch the different sized fish available at any one time is minimized. We did not find comparable studies of fish diversity in the literature, therefore we are unable to compare our value with those derived from elsewhere.

Large and common fish in the Kilombero River were Kitoga, Ndungu and Kambale (local names). These might be of importance if a rural aquaculture-project were to be established in the Kilombero valley. In Africa freshwater aquaculture is a comparatively new development, but as fish prices continue to rise, it is expected to expand at an annual rate of 5.5% (HUNTER et al., 1993). We were unable to obtain clear evidence on the age structure of the different fish species because it is likely that the youngest and smallest fish were missed and were never caught by the fishermen. Such fish are of less economic interest and the size of both hooks and net mesh might be chosen so that the smallest size classes remain in the river. Such fishing techniques could assure sustainable use of the fish resources in the long term. This will only happen if the environment remains unchanged. In 1989 there were an estimated 8,414 hippopotami in the Kilombero, but at the time of the survey these had been hunted almost to extinction in the upper reaches of the river (CHARLWOOD, 1997). Whilst many fishermen were happy that the river was a safer place to fish the older men bemoaned its demise. They said that in the past the fish were larger, especially in the pools frequented by the hippos who presumably created fertile refuges for the larger fish. Since they eat on the land but defecate in the river the loss of fertiliser may also have an adverse effect on fish growth rates in general.

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