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1. THE NATURE OF THE BARRIER SEPARATING THE LAKE MALAWI AND ZAMBEZI FISH FAUNAS

by

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2. AN ANNOTATED CHECKLIST OF THE FISH FAUNA OF THE RIVER SHIRE SOUTH OF KAPACHIRA FALLS, MALAWI

by

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ABSTRACT

The nature of the barrier separating the 'Lake Malawi' from the 'Lower Zambezi' fish faunas was investigated by electrofishing the 145 km stretch of the Shire River surrounding the Murchison cataracts. The study shows that the lowermost element of the cataracts, the Kapachira Falls, is an absolute physical barrier to upstream movement of 'Lower Zambezi' species. The barrier to downstream movement by 'Lake Malawi' species is largely ecological and has two components, the fluviatile nature of the Upper and Middle Shire and especially the torrential nature of the cataracts, which are unsuitable for lacustrine species, and competition with the 'Lower Zambezi' fauna of the Lower Shire by the few species which succeed in negotiating the cataracts.

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INTRODUCTION

A number of authors including Worthington (1933), Jackson (1961) and Bell-Cross (1972) have noted that the Murchison cataracts on the Shire River serve as a barrier separating the 'Lower Zambezi' fauna of the Lower Shire from the mainly endemic fish fauna of Lake Malawi, Lake Malombe and the upper and middle reaches of the Shire River. This paper presents the result of the first detailed study of the nature of the barrier separating the two faunas.

Our conclusions are based primarily upon the results of an extensive electrofishing survey covering the region from Liwonde, some 50km above the uppermost cataract, to Chikwawa, 15km below the last of the falls. The faunas of a number of tributaries of the Shire which enter the river in this region were also sampled.

The Murchison cataracts cover a distance of approximately 80km extending from Matope to the Kapachira Falls (formerly Livingstone Falls) (Fig. 1). Within this stretch of river are 10 rapids and 5 major waterfalls of which Kapachira with two drops of 15m separated by 25m of fast rapids is the largest. The physiography of the Middle Shire Valley is described by Lister (1976) as being '...characterised by youthful Quaternary erosion: the river bed is marked by numerous sets of rapids and the valley is narrow and steep-sided, features which are clearly visible at the Murchison Falls (Matope bridge) and the Mpatamanga Gorge. The river course in this section has been largely superimposed.' Fig. 2, adapted from Halcrow *et al.* (1954), indicates a total drop of more than 50m at Kapachira and drops of approximately 30m at Mpatamanga, Tedzani, Nkula and Kholombidzo. Although referred to as falls the latter four are in fact very steep rapids where the river is funnelled through narrow gorges.

MATERIALS AND METHODS

The equipment used for the electrofishing programme consisted of:-

Generator: 3KVA Titan Kombi, producing at full power single-phase A.C., 220V.

Transformer and Rectifier: Producing full-wave rectified single-phase A.C., undulation rate 47%, peak voltage 420V.

Anode: Circular aluminium or copper frame 40cm diameter, mounted on 2m bamboo pole.

Cathode: Wire mesh gauze of 1.5m^2 area.

With this equipment all accessible points between Liwonde and Chikwawa were sampled in September and October 1975. (See Fig. 1) Additional samples were taken at Chikwawa and Mpatamanga Gorge (August 1976), North Matope and Liwonde (October 1976) and the Mwanza River (August 1976). On July 17th 1977 a new barrage across the Shire River at Tedzani, built to regulate water flow for a hydroelectric power station, was completely closed for testing. The river was electrofished as the water was falling and, when the flow had been arrested, fish stranded in pools in the river bed were collected by hand. By comparing the species diversity and relative species abundance of these samples with the electrofished samples previously collected it was possible to assess the reliability of the electrofishing technique (see Appendix).

DESCRIPTION OF SAMPLING SITES (grid reference in brackets; numbers running downstream).

1. MAIN RIVER

(1) Liwonde: Kamuzu Barrage (YU 3834). Sampling dates October 1975 and October 1976. Upstream of barrage flow rate nil on west bank, dense emergent vegetation; fast flow and rocky bank on east. Downstream of barrage fast flow, broken flow through exit at gate, rocky bottom, gabions. The barrage was constructed at the site of the very first set of minor rapids downstream of Lake Malombe and was therefore a most suitable upstream limit for the survey.

(2) Masaula: (YU 2711) October 1975. Backwater of the main river. Much decaying vegetation. Shallow, less than 0.5m deep with sandy/muddy bottom. Conductivity high, 590 uS/cm, pH low, 6.5.

(3) North Matope (Chigaru): (YU 0901) October 1975 and October 1976. Main river 80m wide. Side channels and parts of main river fished. Channels 1 - 1.5m deep, sandy/muddy bottom, occasional rocks. Broken water and fast flow. Much *Phragmites* and *Cyperus*.

(4) Matope: (YT 0598) October 1975. 200m above road bridge. Rocky river bed 30 - 60m wide. Sandy/muddy bottom, broken water, no vegetation.

(5) Walkers Ferry: (XT 9685) October 1975. Water intake of Blantyre Water Board. River 30 - 50m wide with moderate flow, overhanging vegetation. Mud bottom with steep sides.

(6) Tedzani Upstream: (XT 9179) October 1975. River 40 - 60m wide, muddy bed shelving steeply. Much emergent vegetation along sides. Also one isolated oxbow lagoon with much rotting vegetation. This area is now inundated when the Tedzani Barrage downstream is closed.

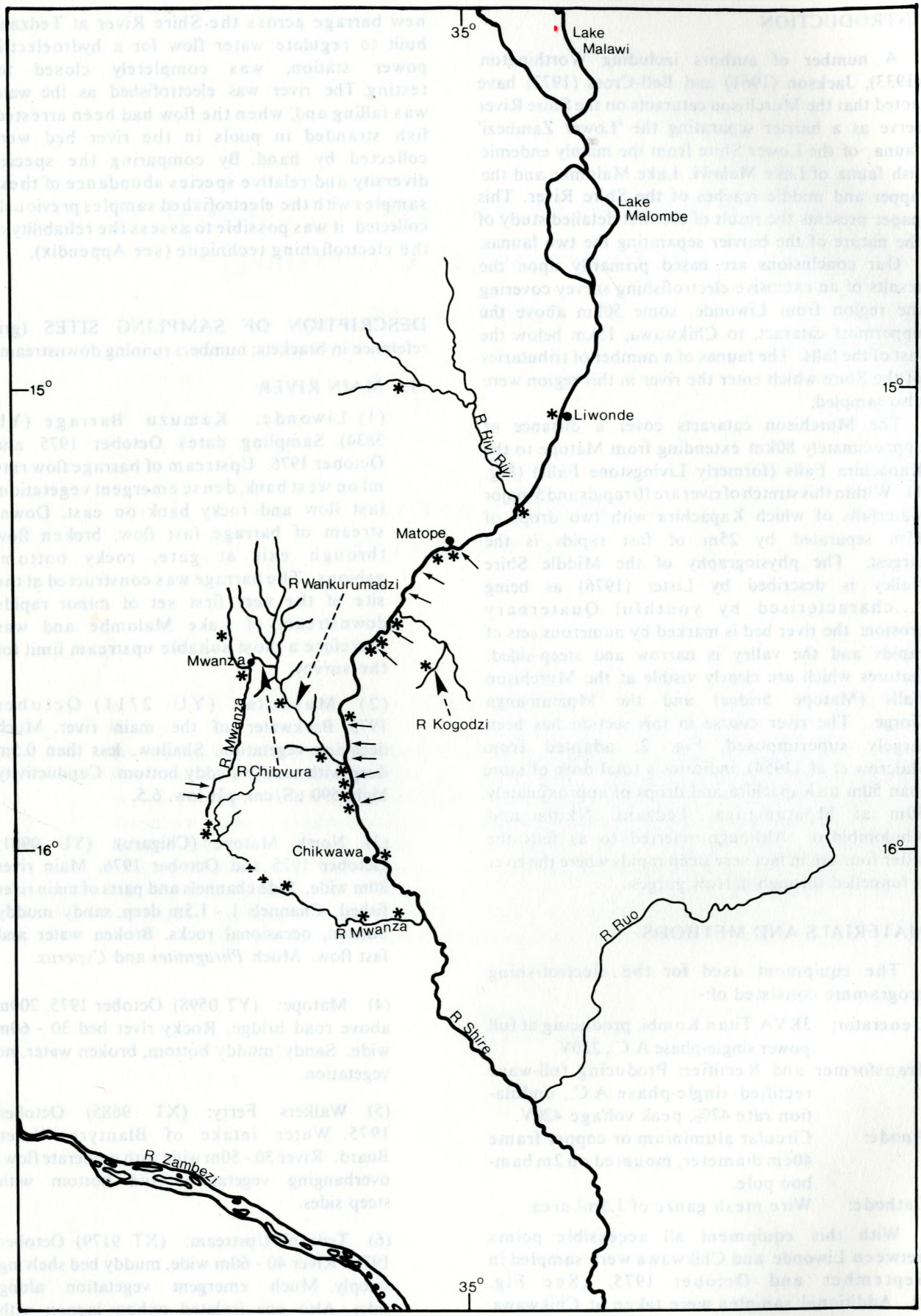

Fig 1. River Shire, showing area covered by electrofishing survey. Sample sites indicated by asterisks, major falls and rapids by arrows.

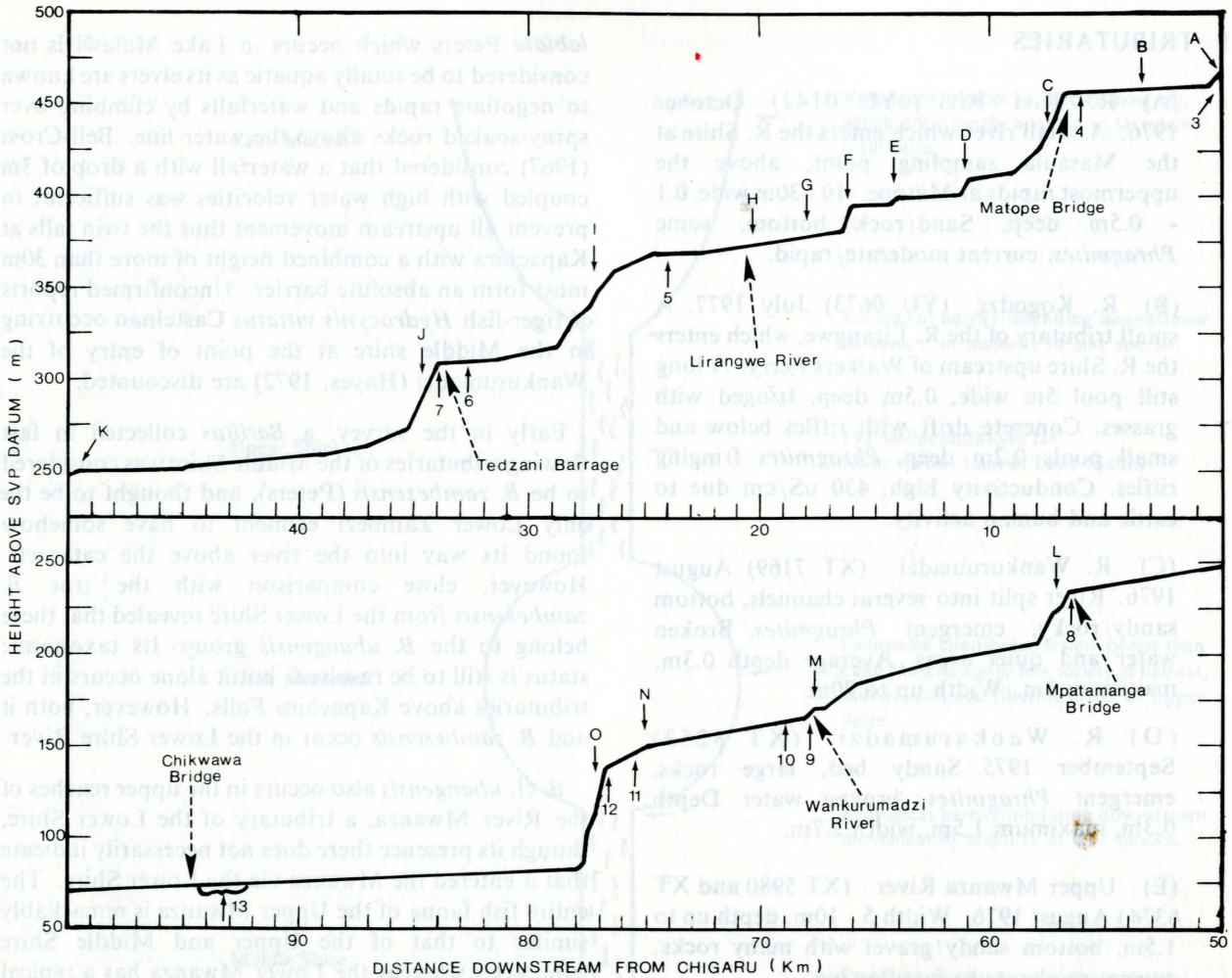

Fig 2. Profile of Murchison Cataracts, Middle Shire River. Shire Valley Project (SVP) Datum = mean sea level at Beira. Numbers indicate sample sites as in text. Letters refer to rapids as follows:- A - Chigaru Rapids, B - Thima Rapids, C - Kholombidzo Falls, D - Toni Rapids, E - Chimbalame Rapids, F - Nachimbeya Rapids, G - Chilemba Rapids, H - Mbinjewanda Rapids, I - Nkula Falls, J - Tedzani Falls, K - Namiwawa Rapids, L - Mpatamanga Gorge, M - Wankurumadzi/Majete Rapids, N - Hamilton Rapids, O - Kapachira Falls.

(7) Tedzani Downstream: (XT 9179) July 1977. Rapids below barrage. Bottom rocky, no vegetation. Electrofishing undertaken whilst barrage was being closed. Hand collection also made from pools on river bed after closure of barrage.

(8) Mpatamanga: (XT 8562) October 1975 and August 1976. Under and downstream of Bailey Bridge, upstream of gorge. Fast flowing river over rocks/boulders, sandy bottom below bridge with some *Phragmites*.

(9) Junction R. Shire/R.Wankurumadzi: (XT 8651) September, 1975. Bed of Wankurumadzi sandy with large rocks. Depth less than 1m, average 0.2m, width 10 - 20m, split into several channels. *Hydrostachys* on rocks in fast water, and *Phragmites* along banks in shallow water. Also backwater of R. Shire, sandy bottom 2 - 3m wide, less than 1m deep, no current, overhanging bank with *Phragmites*.

(10) Majete Rapids: (XT 8650) September 1975. Just south of the Wankurumadzi junction. Eddy in river caused by exposed rocky outcrop. Bottom muddy/rocky. Also rapids of main river at outer end of outcrop.

(11) R. Shire Backwater: (XT 8744) September 1975. Width 10m, depth up to 3m. Rocky/muddy bottom with overhanging vegetation. broken water at one end, deep pools and relatively still at other end.

(12) Kapachira Falls: (XT 8842) September 1975. Rocky pool at head of falls. No. vegetation, sandy bottom, overhanging rocks and fairly strong current.

(13) Chikwawa (XT 9228) September 1975 and August 1976. Samples taken along banks from a boat. Banks with lots of overhanging vegetation, and rooted vegetation in many places. Current variable.

II TRIBUTARIES

(A) R. Rivi Rivi: (YU 0142) October 1976. A small river which enters the R. Shire at the Masaula sampling point, above the uppermost rapids at Matope. 10 - 30m wide, 0.1 - 0.5m deep, Sand/rock bottom, some *Phragmites*, current moderate/rapid.

(B) R. Kogodzi: (YU 0673) July 1977. A small tributary of the R. Lirangwe, which enters the R. Shire upstream of Walkers Ferry. A long still pool 5m wide, 0.5m deep, fringed with grasses. Concrete drift with riffles below and small pools 0.2m deep. *Phragmites* fringing riffles. Conductivity high, 430 uS/cm due to cattle and human activity.

(C) R. Wankurumadzi: (XT 7169) August 1976. River split into several channels, bottom sandy/rocky, emergent *Phragmites*. Broken water and quiet areas. Average depth 0.3m, maximum 1m. Width up to 20m.

(D) R. Wankurumadzi: (XT 8253) September 1975. Sandy bed, large rocks, emergent *Phragmites*, broken water. Depth 0.3m, maximum 1.5m, width 2.7m.

(E) Upper Mwanza River (XT 5980 and XT 6374) August 1976. Width 5 - 10m, depth up to 1.5m, bottom sandy/gravel with many rocks, current moderate to fast flowing.

(F) Lower Mwanza River: (XT 5534, XT 6920, XT 9012 and XT 9713) August 1976. Flow gentle, bottom sand/gravel, overhanging vegetation in some places. Depth variable, average 0.3m, maximum at XT 5534 approx. 3m. No physical barriers between these sampling sites and the Lower Shire River.

SPECIES RECORDED

The species recorded from the River Shire sampling sites are listed in Table I. The species are grouped in three categories, 'Lake Malawi', 'ubiquitous' and 'Lower Zambezi'. Species from the various tributaries sampled are listed in Table II. An indication of relative abundance is given for all species. A complete species list for the Lower Shire is given by Tweddle and Willoughby (1979).

DISCUSSION

It is immediately apparent from the data presented in Table I that the lowermost elements of the Murchison Cataracts, the Kapachira Falls, constitutes a total barrier to upstream movement of all the totally aquatic 'Lower Zambezi' species of the Lower Shire River. The ubiquitous species *Anguilla nebulosa labiata* Peters which occurs in Lake Malawi is not considered to be totally aquatic as its elvers are known to negotiate rapids and waterfalls by climbing over spray-soaked rocks above the water line. Bell-Cross (1967) considered that a waterfall with a drop of 3m coupled with high water velocities was sufficient to prevent all upstream movement thus the twin falls at Kapachira with a combined height of more than 30m must form an absolute barrier. Unconfirmed reports of tiger-fish *Hydrocynis vittatus* Castelnau occurring in the Middle shire at the point of entry of the Wankurumadzi (Hayes, 1972) are discounted.

Early in the survey, a *Barilius* collected in fast flowing tributaries of the Middle Shire was considered to be *B. zambezensis* (Peters), and thought to be the only Lower Zambezi element to have somehow found its way into the river above the cataracts. However, close comparison with the true *B. zambesensis* from the Lower Shire revealed that these belong to the *B. ubangensis* group. Its taxonomic status is still to be resolved, but it alone occurs in the tributaries above Kapachira Falls. However, both it and *B. zambesensis* occur in the Lower Shire River.

B. cf. *ubangensis* also occurs in the upper reaches of the River Mwanza, a tributary of the Lower Shire, though its presence there does not necessarily indicate that it entered the Mwanza via the Lower Shire. The entire fish fauna of the Upper Mwanza is remarkably similar to that of the Upper and Middle Shire tributaries whereas the Lower Mwanza has a typical Lower Shire fauna (see Table II). This suggests that the upper reaches of the Mwanza originally drained into the Middle Shire, a contention which is supported by geological evidence. Rising near the town of Mwanza is the small River Chibvura, a tributary of the Wankurumadzi which itself runs into the Middle Shire. The source of the Chibvura (Grid ref.: XT 6374) is very close to the Mwanza at a point where the latter changes its course sharply from East to South. The valley of the Chibvura is unusually large in relation to the size of the stream. It seems quite likely that the river capture may have occurred at this point by the Mwanza River cutting back through the Majete escarpment and capturing the upper reaches of the Chibvura. Separation of the Upper and Lower Mwanza faunas is maintained by the numerous rapids over the escarpment section, and by the swampy section at the foot of the escarpment which is unsuitable for the species of the upper reaches which favour fast flowing stream conditions.

The barrier to upstream migration by 'Lower Zambezi' species imposed by the Kapachira Falls is entirely physical, but the almost total absence of Lake Malawi species from the Lower Shire cannot be explained so simply. Jubb (1976) amassed a considerable body of evidence indicating that many fish are capable of surviving passage through hydroelectric power turbines and subsequently

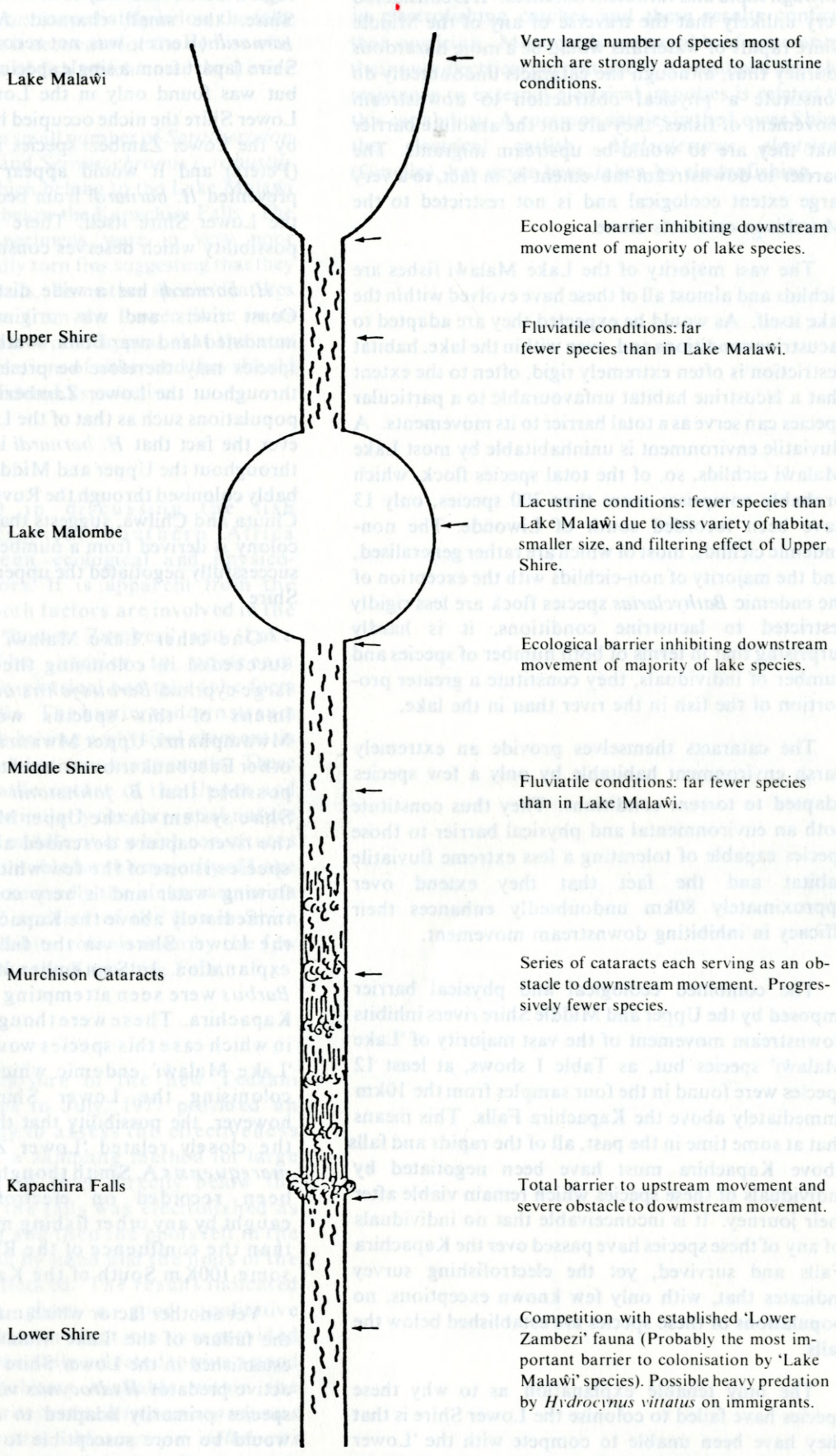

Fig 3. The nature of the barrier separating the Lake Malawi and the Lower Zambezi fish faunas.

through rapid and turbulent tail races. It is considered very unlikely that the traverse of any of the Middle Shire rapids of waterfalls would be a more hazardous journey thus, although the cataracts undoubtedly do constitute a physical obstruction to downstream movement of fishes, they are not the absolute barrier that they are to would-be upstream migrants. The barrier to downstream movement is, in fact, to a very large extent ecological and is not restricted to the Murchison cataracts alone.

The vast majority of the Lake Malawi fishes are cichlids and almost all of these have evolved within the lake itself. As would be expected they are adapted to lacustrine conditions and, even within the lake, habitat restriction is often extremely rigid, often to the extent that a lacustrine habitat unfavourable to a particular species can serve as a total barrier to its movements. A fluviatile environment is uninhabitable by most Lake Malawi cichlids, so, of the total species flock, which probably comprises more than 300 species, only 13 have been recorded south of Liwonde. The non-endemic cichlids, most of which are rather generalised, and the majority of non-cichlids with the exception of the endemic *Bathyclarias* species flock are less rigidly restricted to lacustrine conditions, it is hardly surprising that in terms of both number of species and number of individuals, they constitute a greater proportion of the fish in the river than in the lake.

The cataracts themselves provide an extremely harsh environment habitable by only a few species adapted to torrent conditions. They thus constitute both an environmental and physical barrier to those species capable of tolerating a less extreme fluviatile habitat and the fact that they extend over approximately 80km undoubtedly enhances their efficacy in inhibiting downstream movement.

The combined ecological and physical barrier imposed by the Upper and Middle Shire rivers inhibits downstream movement of the vast majority of 'Lake Malawi' species but, as Table I shows, at least 12 species were found in the four samples from the 10km immediately above the Kapachira Falls. This means that at some time in the past, all of the rapids and falls above Kapachira must have been negotiated by individuals of these species which remain viable after their journey. It is inconceivable that no individuals of any of these species have passed over the Kapachira Falls and survived, yet the electrofishing survey indicates that, with only few known exceptions, no populations of these species are established below the falls.

The only tenable explanation as to why these species have failed to colonise the Lower Shire is that they have been unable to compete with the 'Lower Zambezi' fauna which is better adapted to fluviatile conditions. The contention is substantiated by the fact that one of the species thought to have colonised the region below the Kapachira Falls from the Middle Shire, the small characid *Hemigrammopetersius barnardi* (Herre), was not recorded from the Lower Shire (apart from a single specimen from Chikwawa), but was found only in the Lower Mwanza. In the Lower Shire the niche occupied by *H. barnardi* is filled by the Lower Zambezi species *Micralestes acutidens* (Peters) and it would appear that the latter has prevented *H. barnardi* from becoming established in the Lower Shire itself. There is however a second possibility which deserves consideration.

H. barnardi has a wide distribution in the East Coast rivers and was originally described from inundated land near Beira, south of the Zambezi. The species may therefore be present in small numbers throughout the Lower Zambezi, with a few thriving populations such as that of the Lower Mwanza. However the fact that *H. barnardi* is extremely common throughout the Upper and Middle Shire, which it probably colonised through the Ruvuma system via Lakes Chiuta and Chilwa, suggests that the Lower Mwanza colony is derived from a number of specimens which successfully negotiated the upper reaches of the Lower Shire.

One other 'Lake Malawi' species which has succeeded in colonising the Lower Shire is the large cyprinid *Barbus johnstonii* Boulenger. Specimens of this species were caught in the Mwamphanzi, Upper Mwanza and in a number of other East bank tributaries of the Lower Shire. It is possible that *B. johnstonii* reached the Lower Shire system via the Upper Mwanza as a result of the river capture described above, though as this species is one of the few which favours very rapid flowing water and is very common in the rapids immediately above the Kapachira Falls, entry into the Lower Shire via the falls is the most likely explanation. In September 1975 numerous large *Barbus* were seen attempting to ascend the falls at Kapachira. These were thought to be *B. johnstonii* in which case this species would be the only known 'Lake Malawi' endemic which has succeeded in colonising the Lower Shire itself. There is, however, the possibility that the fish observed were the closely related 'Lower Zambezi' species *B. marequensis* A. Smith though this species has not been recorded on electrofishing surveys or caught by any other fishing method further North than the confluence of the Rivers Ruo and Shire some 100Km South of the Kapachira Falls.

Yet another factor which may have contributed to the failure of the 'Lake Malawi' species to become established in the Lower Shire is the presence of the active predator *Hydrocynus vittatus*. It is likely that species primarily adapted to a lacustrine existence would be more susceptible to predation when subjected to an alien riverine environment and their susceptibility would be increased by the damage or disorientation suffered by the passage through the

Kapachira Falls. There is known to be a large population of *H. vittatus* immediately below the falls and it is probable that it accounts for the demise of a significant proportion of fish which enter the Lower Shire by this route.

As Table I shows, a small number of *Sarotherodon shiranus* (Boulenger) and *Serranochromis r. robustus* (Gunther), both of which belong to the Lake Malawi fauna, were recorded below the Kapachira Falls. The majority of these specimens were in very poor condition and had badly torn fins suggesting that they had passed over the falls. As neither species features in commercial catches from the Lower Shire or its surrounding marshes it would appear that the area does not support populations of either and they should therefore not be considered as colonists.

CONCLUSION

Jackson (1962) in discussing the fish distribution in tropical Southern Africa differentiated between ecological and physico-environmental factors. It is apparent from the present study that both factors are involved in the separation of the 'Lower Zambezi' and 'Lake Malawi' fauna. The barrier to upstream movement is entirely physical and takes the form of the Kapachira Falls. The barrier to downstream movement, although having a physical element, is largely ecological and has two components. These are firstly the fluviatile nature of the Upper and Middle Shire and particularly the torrential nature of a large part of the middle river which constitutes an environment unsuitable for the majority of Lake Malawi species and secondly the niche saturation by 'Lower Zambezi' species of the Lower Shire which effectively inhibits colonisation by the few species which negotiate the Kapachira Falls.

APPENDIX

The complete closure of the new Tedzani Barrage for 4 hours in July, 1977 provided an excellent opportunity to assess the effectiveness of electrofishing as a sampling method for large rivers. The stretch of river directly below the barrage and above the falls was electrofished as the river was falling and then the pools left in the river bed were fished by hand and the finds of the local people were checked. The results indicated that electrofishing gives a good qualitative estimate of the species present in a river provided sampling sites are carefully selected to give a good cross section of habitats available within the river. Three mormyrids, *Hippopotamyrus discorhynchus* (Peters), *Mormyrops deliciosus* (Leach), and *Mormyrus longirostris* Peters were found in the pools but were not represented in the electrofishing catches. It had been suspected in the past that mormyrids were under-represented in electrofishing catches and these results confirm that suspicion. Mormyrids are capable of generating their own electrical current and it is presumed that the resistence to external electrical impulses is related to this capability. A common species in the Lower Shire, the electrical catfish, *Malapterurus electricus* (Gmelin), has never been taken by electrofishing.

TABLE I 'Lake Malawi', 'ubiquitous' and 'Lower Zambezi' species caught at each sampling site. Sample site numbers as in text. Present ++ = Fairly Common +++ = Very Common.

SPECIES	SITE NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	13
LAKE MALAWI SPECIES													
Marcusenius nyasensis	+												
Hemigrammopetersius barnardi[1]	+++	+++	+++	++	+++	+	+	+					+
Barbus cf. *arcislongae*	+++		+++	++	+		++						
B. atkinsoni[1]	+		+										
B. johnstonii	++		++	++	+		++	++	+++	+	+	+	
Barbus species	++		+++	+	++	+	++		++	+			
Barilius microcephalus	+++		+++	++	++		+++	+++	++	+	+	++	
B. cf. *ubangensis*									++				+
Synodontis njassae	++	++	++	++			+						
Aplocheilichthys johnstonii	+++	+++	+++	+	++	++	++		+				
Chilotilapia rhoadesii	+												
Cyathochromis obliquidens	+												
Haplochromis kirkii	++	+	+		++					++	++	+	
H. kiwinge					+								
H. placodon									++	+			
H. rostratus	+						+						
H. strigatus	+												
H. tetraspilus	+												
H. tetrastigma		+			++						+		
H. triaenodon					+								
Haplochromis species	++												
Hemitilapia oxyrhynchus										+			
Sarotherodon shiranus	++	+++	++	++	++	++	++	++	+++	+++	++	+	++
S. squamipinnis/saka									+				
Serranochromis robustus	+	+	++	++	+	++			++				+
Mastacembalus shiranus	++	++	++	+									
UBIQUITOUS SPECIES													
Anguilla nebulosa labiata							+			+	+		
Hippopotamyrus discorhynchus			+	+			++						
Marcusenius macrolepidotus													+
Mormyrops deliciosus			+				+						
Mormyrus longirostris			+	+			+						
Alestes imberi	++	+	++	++									++
Barbus kerstenii	+		++		+								
B. cf. *lineomaculatus*	++	+++	+++		+++	++	+++	++		++	++	++	++
B. macrotaenia[2]	+++	+++	+++				++	++		+	++		
B. paludinosus	+	++	+++	++	++	+	+++		++		+		
B. radiatus													+
B. trimaculatus	+		+++	++	++		++						+
Labeo cylindricus	++		++	++	+		+++	++	++			+	+
Amphilius platychir									+				
Clarias gariepinus	+	+	++	++	+	++	+		++				++
C. ngamensis			+										
C. theodorae	+		+										
Chiloglanis neumanni	+++		+++	+++	++		+++	+	+++				++
Haplochromis callipterus	+++	+++	+++	+++	+++	++	+++	++	++	+++	+++	+	++
Tilapia rendalli	++			+	+	++	++						
LOWER ZAMBEZI SPECIES													
Hydrocynus vittatus													++
Micralestes acutidens													+++
Barbus afrohamiltoni													+
Barilius zambezensis													++
Labeo altivelis													+
Eutropius depressirostris													+
Synodontis nebulosus													+
Aplocheilichthys katangae													++
Sarotherodon mossambicus													++
S. placidus													++

NOTES TO TABLE I

[1] *Barbus atkinsoni* and *Hemigrammopetersius barnardi* are members of the 'East Coast River' fauna, which are believed to have invaded the Upper Shire from the Ruvuma via Lakes Chiuta and Chilwa. They are categorised here as 'Lake Malawi' species for convenience.

[2] *Barbus macrotaenia* is a common species both in Lake Malawi and the Lower Shire. It is a member of a group of closely-related species, the distribution of which has still to be satisfactorily defined. Although it is possible that *B. macrotaenia* originally colonised the Lower Shire from Lake Malawi, it is categorised here as an ubiquitous species.

TABLE II Species found in Middle Shire tributaries and the Mwanza River

SPECIES	SITE					
	R. Rivi Rivi A	R. Kogodzi B	R. Wankurumadzi C	R. Wankurumadzi D	Upper Mwanza E	Lower Mwanza F
Marcusenius macrolepidotus						+
Hemigrammopetersius barnardi						++
Barbus johnstonii	+++	+++	+++	+++	+++	
B. kerstenii			+			++
B. cf. *lineomaculatus*						+++
B. macrotaenia						+++
B. paludinosus	+	+++		++		+
B. radiatus						++
B. trimaculatus	+++	++	+	+	+++	+
B. cf *viviparus*						+++
Barilius cf. *ubangensis*	++		++	++	++	
Labeo cylindricus	+++				++	++
Leptoglanis rotundiceps					++	
Eutropius depressirostris						+
Amphilius platychir	+		++		+	
Clarias gariepinus	+	+	++	+	+	++
C. theodorae						+
Chiloglanis neumanni	+++		+++	+++	+++	
Aplocheilichthys katangae						+++
Haplochromis callipterus					+	+++
Pseudocrenilabrus philander						++
Sarotherodon mossambicus						++
S. placidus						++
S. shiranus shiranus		+++	+	+		
Tilapia rendalli						+

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2. AN ANNOTATED CHECKLIST OF THE FISH FAUNA OF THE RIVER SHIRE SOUTH OF KAPACHIRA FALLS

by

D. TWEDDLE AND N.G. WILLOUGHBY

ABSTRACT

The Shire River drains Lake Malawi and is a major tributary of the Lower Zambezi River. Sixty-one species of fish have been recorded in the lower reaches which are separated from the lower Shire basin by the Kapachira Falls and from the 'East Coast River' fauna present in the Upper Ruo River by the Zoa Falls. The fauna is essentially similar to that of the Lower Zambezi, although some Lake Malawi endemics occur sporadically in the upper part of the flood plain.

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INTRODUCTION

The upper and central watersheds of the River Zambezi have been extensively studied, and their fish faunas examined and described in detail by Jubb (1967) and Bell-Cross (1972,1976). The lower reaches of the Zambezi have received less attention and the distribution of fish species in this region is relatively poorly known. Bell-Cross (1972) published the most recent lists for the Lower Zambezi, based largely on collections by Guy and Maar which are housed in the Queen Victoria Museum, Salisbury, while Bowmaker *et al.* (1978) discuss the zoogeography of the area.

Sampling of a major tributary of the Lower Zambezi, the Lower Shire river, and its associated marshes over the past three years has revealed the presence of many more fish species in the area than have previously been recorded by *e.g.* Ratcliffe (1972) and Hastings (1973). Several of these species are new records for the Lower Shire system.

Brief notes on the abundance and distribution of all species recorded in the Lower Shire area are given here.

DESCRIPTION OF THE AREA

The River Shire is the only outlet from Lake Malawi. The Upper and Middle Shire (separated by the large, shallow Lake Malombe) contain a fauna fairly typical of inshore sheltered areas of Lake Malawi, with several species of cichlids endemic to Lake Malawi predominating. The Middle Shire is separated from the Lower Shire by a series of rapids and falls stretching for a distance of 80 km collectively known as the Murchison Cataracts. The most southerly of these, Kapachira Falls, is a barrier to the upstream movement of Lower Zambezi fauna. The Middle Shire River and the effectiveness of the rapids and falls as an environmental and ecological barrier are the subject of a separate paper (Tweddle *et al.*, 1979). Below Kapachira Falls the river follows a meandering course through the Shire River floodplain (Fig I) for a distance of approximately 200kg to its confluence with the Lower Zambezi River. The total fall is only 50m over that distance. There are two main areas of marsh on the Shire Valley floodplain, the Elephant Marsh (500km^2) to the north and the Ndinde Marsh (150km^2) to the south. These marshes support an important fishery, yielding more than 10,000 tons of fish per year. Three species, *Clarias gariepinus* (Burchell) *Clarias ngamensis* (Castelnau) and *Sarotherodon mossambicus* (Peters) comprise about 90% of the commercial catch.

The Lower Shire is fed by a number of tributaries which have some habitats not found in the main river. Tributaries on the west bank are temporary, only flowing for short periods during the rainy season. Many east bank streams have larger catchment areas with higher rainfall than those on the west bank and as a result are perennial. All the tributaries are subject to flash floods. The largest tributary is the River Ruo, which drains Mulanje Mountain. This has a dry season flow of as little as 3m^3/sec, but during flash floods resulting from storms on Mulanje it can carry 3,000m^3/sec, flooding low lying countryside in the area near its confluence with the River Shire. In this paper the River Ruo is included as far upstream as the Zoa Falls, a 60m high barrier separating the upper reaches from the lower. The fauna of the Upper Ruo is quite different from the Lower Ruo, with several elements of the Lake Chilwa fauna and also affinities with the faunas of rivers south of the Zambezi. The Upper Ruo fauna will be the subject of a separate paper.

Samples were obtained at three sites typical of the different habitats in the Lower Shire Valley: (1) at Chiromo, where the River Ruo joins the Shire, the habitat is mainly riverine with the vegetation along the banks being dominated by grasses of the genus *Echinochloa*. (2) at Mchacha there are large open lagoons usually less than 4m deep containing dense beds of *Ceratophyllum* and *Nymphaea*. The lagoons are separated by small channels and the area is normally subjected to low rates of flow. (3) at Ndombo, on the eastern shore of the Elephant Marsh, both riverine and marsh habitats are found, the dominant vegetation being *Typha*, with *Ceratophyllum* abundant in the lagoons.

SAMPLING METHODS

The following fishing methods were used at each station every month:

a) Gillnets with stretched mesh sizes 1″ (2.5cm) to 4″ (10.2cm) in $^1/_2$″ (1.2cm) increments. 5″, 6″ and 7″ nets were also used occasionally.
b) Longlines.
c) Castnets.
d) 1″ (2.5cm) mesh netting traps with funnel side entrance.
e) Mosquito netting covered traps of similar design.
f) Perspex 'Breder' traps.
g) Local basketwork traps.

In addition electrofishing equipment, described by Tweddle *et al.* (1979), was used on several occasions at each station. It was also used to sample the fish populations in the Shire River at Chikwawa, approximately 15km south of the Kapachira Falls which is the upper limit of the floodplain, and tributaries of the Shire River, including the Mwanza, Thangadzi, Mwamphanzi and Ruo Rivers.

SPECIES ABUNDANCE AND DISTRIBUTION

Table I includes all species whose abundance has been confirmed by the recent survey. The notes on individual species below give reasons for the exclusion

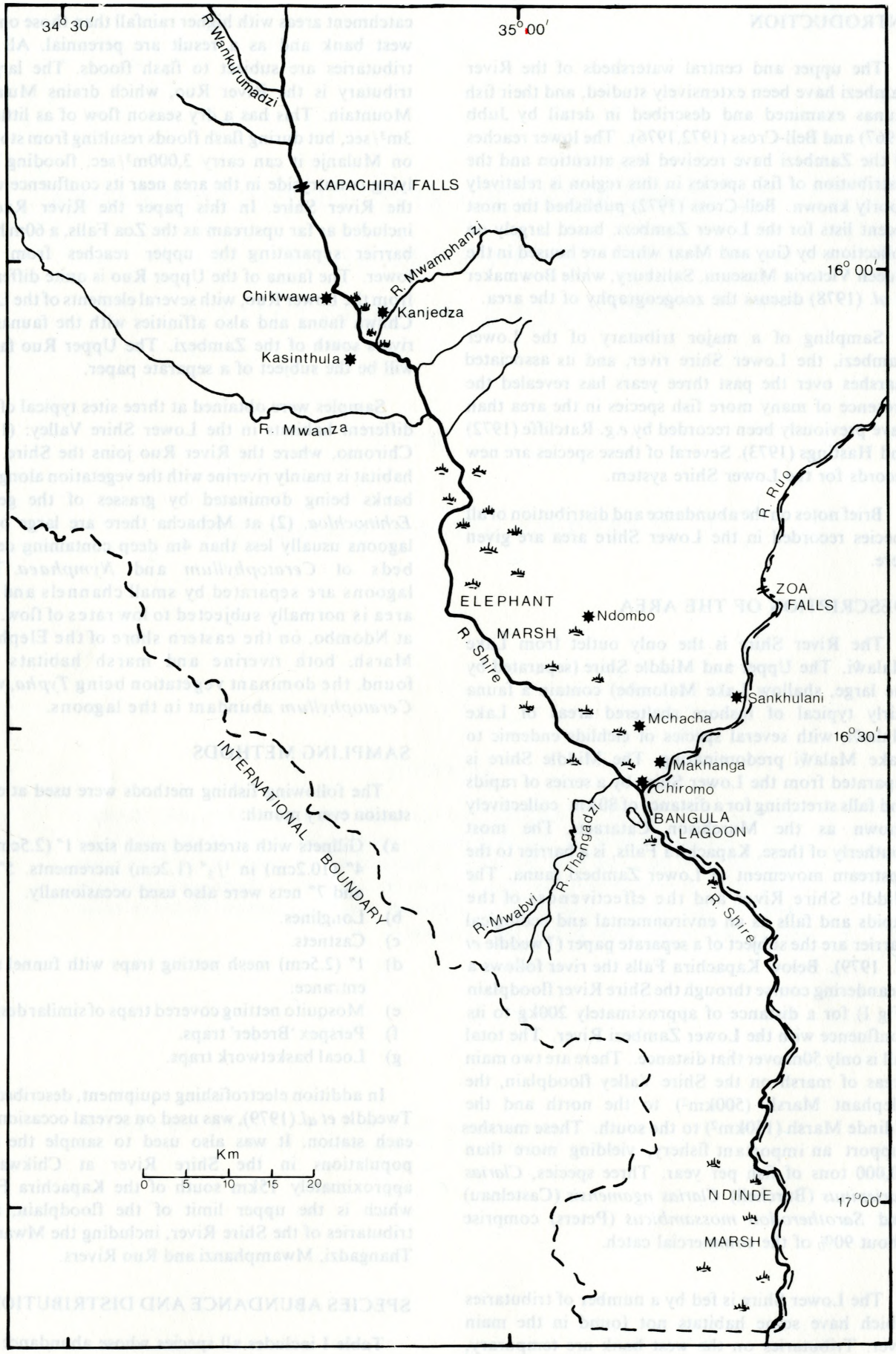

Figure 1. The River Shire, indicating tributaries and place names mentioned in the text.

of other species recorded by Ratcliffe (1972) and Hastings (1973).

The general classification in Table I shows the system adopted by Bell-Cross (1976), in which orders and families follow Greenwood *et al.* (1966), with the genera and species listed for convenience in alphabetical order.

Bell-Cross (1976) and Jubb (1967) may be consulted for more detailed information on the various species and keys to their identification. In Table I, common names, where given, are those suggested by Jackson (1975). A list of local Lower Shire names for the commoner species was given by Ratcliffe (1972).

Investigations into the taxonomy of the small *Barbus* species in Malawi have not yet been completed and therefore the characters by which the uncertain species are separated are included here for the benefit of future investigators.

INDIVIDUAL SPECIES NOTES

Protopterus annectens brieni Poll

Fairly common in the marsh areas, especially in Bangula Lagoon, but of no commercial importance. They are seldom eaten by the local people, most of whom consider them to be snakes. The average weight of specimens in Bangula Lagoon was less than 1kg, although occasional specimens reached 3kg.

Megalops cyprinoides (Broussonet)

Occasionally caught in gillnets near the Shire/Ruo confluence, but not in large numbers. Jubb (1967) recorded a specimen of 2kg on rod and line at this point.

Anguilla bicolor bicolor McClelland

A single specimen of this species, weighing 2kg, was taken in a seine net in Bangula Lagoon in 1974. It is preserved in the Fisheries Department collection.

Anguilla nebulosa labiata Peters

Fairly common throughout the River Shire and its tributaries and not uncommon in Lake Malawi. Spear fishermen in the Shire Valley sometimes catch specimens of up to 5kg while the eels are basking in shallow water near the river banks.

Hippopotamyrus discorhynchus (Peters)

Caught in sufficient quantities with the small mesh gillnets in the Shire during the rains to be considered of economic importance. Found almost exclusively in the main river channels.

Marcusenius macrolepidotus (Peters)

The fourth most important commercial species, being caught in large quantities in the Shire/Ruo area from September to December i.e. before and during the early part of the rainy season. Also commonly caught in the open lagoon at Mchacha, but uncommon in the northern marsh at Ndombo.

Mormyrops deliciosus (Leach)

Present throughout the River Shire in small numbers. Frequently caught in the Shire at Chiromo, but not in the marshes at Mchacha and Ndombo. A juvenile of 3cm total length taken by poison in the Ruo at Sankhulani in June 1972 had a body depth/total length ratio of 0.18, compared with an average of 0.15 for a collection of 13 larger specimens, suggesting allometric growth, but the data are insufficient to be conclusive. In Lake Malawi juveniles of up to 20cm are common on rocky shores affording plenty of cover. Larger specimens up to 8kg are occasionally caught trawling in shallow water off weedy shores. The capture of the juvenile in the rocky area of the Ruo at Sankhulani, and the capture of larger specimens in quiet reedy areas of the main river suggest similar habitat preferences in the River Shire population.

Mormyrus longirostris Peters

Found throughout the River Shire and caught fairly regularly at Chiromo, but rarely at the marsh stations. It is of little commercial importance, and seldom reaches more than 500g in the River Shire, although larger specimens are found in Lake Malawi. It is one of the few species which inhabit the centre of the main river bed rather than keeping to the edges.

Alestes imberi Peters

Caught in small numbers in the Shire and Ruo Rivers, but not in sufficient numbers to be considered of economic importance. Rare at Mchacha and Ndombo. Specimens from Bangula Lagoon have a colour very similar to *Alestes lateralis* Boulenger i.e. the caudal spot extends onto the caudal fin rays, and the dark lateral stripe develops in formalin, but all scale counts and other characteristics indicate that they are *Alestes imberi*. This unusual colour pattern led Ratcliffe (1972) erroneously to record *A. lateralis* as common in Bangula Lagoon. Ratcliffe's specimens have been re-examined and found to be *A. imberi*.

Alestes cf. **lateralis** Boulenger

A single specimen was taken from a trap at Chiromo, and is lodged at the Albany Museum, Grahamstown. Jubb (in litt.) considers that in the present state of our knowledge it must be referred to *A. lateralis*. the specimen is, however, very similar to the population which become abundant in Lake Kariba after impoundment, and might be conspecific with *Alestes humilis* Boulenger 1905, at present known only from the type. The status of these species is being re-examined at the Albany Museum (Jubb, 1976).

Hemigrammopetersius barnardi (Herre)

Very common in the Upper and Middle Shire, but only one specimen has been recorded so far in the Lower Shire, taken by electrofishing at Chikwawa. However it is very common in the lower reaches of the Mwanza River near its confluence with the Lower Shire. It is possible that this species is unable to

become established in the Lower Shire as a result either of predation by young tigerfish *(Hydrocynus vittatus*, or of competition with the related and very common *Micralestes acutidens*. The distribution of *H. barnardi* is discussed in detail by Tweddle *et al.* (1979).

Hydrocynus vittatus Castelnau

Common throughout the Lower Shire River, especially in the fast flowing stretches below the Kapachira Falls, the uppermost limit of its distribution, and near the confluence of the inflowing rivers, in particular the River Ruo at Chiromo. It does not penetrate far into the marshes and is therefore not of major commercial importance in the area.

Micralestes acutidens (Peters)

Very common in the Shire River in the fringing vegetation, from which large numbers can be caught by electrofishing. Not represented in commercial catches.

Distichodus mossambicus Peters

Appears spasmodically throughout the year in gillnet catches in the Shire and Ruo Rivers, but not in sufficient quantities to be considered economically important. Much less common than the following species, and very seldom encountered other than in the main river channels.

Distichodus schenga Peters

Caught regularly at Chiromo, especially in the dry season low water conditions, but not in commercial quantities. It is also restricted to the main river channels, seldom venturing to the marsh environment.

Both species of *Distichodus* are popular angling fish, especially in the stretches of river below Kapachira Falls. A specimen of *D. mossambicus* of 5.47kg was taken at Chiromo on legered oxheart in October, 1978.

Barbus afrohamiltoni Crass

Common in 2.5cm mesh gillnet and electrofishing catches in the Ruo and Shire Rivers. Uncommon in the marshes. This species has also been found in dry season pools in the bed of the Thangadzi River in Mwabvi Game Reserve. This river flows during the rains for a few days at a time. It is possible that *B. afrohamiltoni* ascend the river at this time for breeding purposes.

Barbus choloensis Norman

This species has been found in the Shire Valley only in the Mwabvi River, a tributary of the Thangadzi. The river stops flowing in the dry season, but water is retained in the gorge in which the species occurs by a series of rock sills. The only other species in the pools are *Barbus trimaculatus* and *Labeo cylindricus*, both species being very widely distributed in Southern Africa. It is presumed that the fish are a relict population, protected from competition by the narrowness of the gorge exit (1m) when the river is in spate and by the rock sills and waterfalls when the river subsides. The pools are protected from human interference as they are well within the boundaries of Mwabvi Game Reserve.

The type locality of *B. choloensis* is the River Nswadzi which rises on the eastern side of Thyolo escarpment, and flows into the River Ruo upstream of Zoa Falls. The species is quite common in the River Ruo above Zoa Falls, but has not been found below the falls which constitute a major environmental and ecological barrier between the Upper Ruo and the Shire system. Jubb (pers. comm., 1978) has pointed out that *B. choloensis* is very similar to specimens of *Barbus argenteus* (Gunther) from the Transvaal. However, Banister (in litt. to D.T.) pointed out differences in gillraker counts and scale striation patterns between *B. choloensis* and the Angolan type specimens of *B. argenteus*. Until more material is available and more work can be done on the relationship between two species, we are referring our specimens to *B. choloensis*.

Barbus haasianus David

A very small species which is common throughout the marshes in shallow water, being caught by electrofishing and mosquito net and perspex traps.

Barbus johnstonii Boulenger

Found in the River Mwamphanzi and other fast flowing tributaries on the Thyolo escarpment. It is a large species (up to 4kg) which is endemic to the Lake Malawi system, and its distribution in the River Shire has been discussed in some detail by Tweddle *et al.* (1979). Large numbers have been seen attempting to jump Kapachira Falls.

Barbus kerstenii Peters

A species which is here referred to *B. kerstenii*, otherwise known from east coast rivers north of the Zambezi, Kenya and Uganda is found throughout the Lower Shire in vegetation fringing the main channels. It does not occur in lagoons or any other quiet water. Specimens in the valley lack the red spot on the operculum, characteristic of the majority of populations of this species, but a red flush is apparent and in Lower Mwanza specimens a suggestion of a spot is present. It has not been possible to relate the presence or intensity of this spot to the physical or chemical characteristics of the water bodies.

R.A. Jubb (in litt.) has commented that 'the excellent material, notes and colour photographs supplied by Mr Tweddle make it quite clear that the status of *B. tangandensis* Jubb must be re-examined. To me (i.e. Jubb) *B. tangandensis* is either a synonym of *B. kerstenii* or very closely related; an interesting zoogeographical issue as Bell-Cross (1976) gives the Okavango, Upper Zambezi, Kafue and Zambian Zaire system in his distribution of *B. tangandensis*...'

Barbus macrotaenia Worthington

Specimens of this species were originally assigned to *Barbus barnardi* Jubb, 1965, a species with which it shares many similarities. Scale counts are similar and in both species the male is smaller and more slender than the female, with numerous conical tubercles on the snout. However, the barbels on R. Shire specimens are longer than in *B. barnardi* and unlike the latter there are pit lines on the cheek. Barbel length and coloration can be somewhat variable, especially in small isolated populations such as those found in roadside pools. K.E. Banister (pers. comm., 1978) has confirmed that our specimens are referable to *B. macrotaenia*, described by Worthington from a single Lake Malawi specimen. This species is very common throughout the marsh system.

Barbus marequensis A. Smith

A large species which grows to more than 3kg, although specimens of more than 500g are seldom encountered in the River Shire. Occasionally caught in gillnets set near the Shire/Ruo confluence, and juveniles have been taken by electrofishing in rocky, fast flowing stretches of the River Ruo. It has not been taken north of the Shire/Ruo confluence, while small specimens of the related 'Lake Malawi' species *B. johnstonii* are common in most of the permanent streams to the north of the R. Ruo on the western side of the Thyolo escarpment. The two species differ in lateral line scale counts; *B. marequensis* 29 - 31, *B. johnstonii* 33 - 36; and in the caudal peduncle length/depth ratio, *B. marequensis* 1.13, *B. johnstonni* 1.19 - 1.6.

Barbus paludinosis Peters

Widely distributed and fairly common in the Lower Shire, appearing in trap and electrofishing catches at all three stations and also in the tributaries. Although not of commercial importance in the Shire Valley, this species forms a large proportion of the commercial catch in Lake Chilwa, Malawi.

Barbus radiatus Peters

Uncommon in the marshes, but it occurs in small numbers in the Shire and Ruo Rivers and is quite common in tributaries, although not abundant anywhere. It appears that this species seldom forms shoals even in suitable habitats.

Barbus trimaculatus Peters

Very uncommon in the marshes, but it occurs in small numbers in the main river and is very common in small, clear, fast flowing tributaries, where it may often be the largest component of the fish biomass. This confirms the clearwater preferences of this species first noted by Jackson (1961).

Barbus cf. **lineomaculatus** Boulenger

This species is very common throughout the River Shire, the lower reaches of the Lake Malawi affluent streams and Lakes Chiuta and Chilwa. It is a small species with affinities to *B. lineomaculatus*, from which it differs in lateral scale counts (23 - 25 against 27 - 32 for *B. lineomaculatus*) and in maximum size, the largest specimen recorded being 5cm total length against 8cm for *B. lineomaculatus*. Also, it lacks the iridescent sheen on specimens from northern Malawi rivers positively identified as *B. lineomaculatus* by K.E. Banister (pers. comm., 1978).

Barbus cf. **toppini** Boulenger

A small species with affinities to both *B. macrotaenia* and *B. toppini*. Lateral line tubules are restricted to the first 4 - 6 scales as in *B. toppini*, but the mid-lateral line scale count is lower, 22 - 27 against 27 - 30 for *B. toppini*. This character also separates it from *B. macrotaenia*. The scales are easily dislodged, hence this species has been confused with *B. macrotaenia* in all samples until recently, and the distribution is still unclear. It has appeared in catches both at Mchacha and Ndombo.

Barbus cf. **viviparus** Weber

The exact identity of the specimens from this area has still to be discovered, but R.A. Jubb(pers. comm., 1978) is of the opinion that they can be referred to *B. viviparus*. They differ from 'typical' *B. viviparus* in that the upper lateral stripe is in the form of three elongated spots which merge together, rather than being a complete or broken stripe. The three spot pattern is common to all Malawi populations in the Lower Shire, Lake Chiuta and Lake Chilwa. Two golden-coloured specimens were taken from a fast flowing stretch of the R. Ruo at Sankhulani. The species in general is rare in the marshes, but is found in small quantities in the main river channel and, like *B. radiatus* and *B. trimaculatus*, is common in tributaries, in particular the River Mwanza.

Barilius zambezensis (Peters)

Fairly common in fast flowing stretches of the River Ruo, and has also appeared in catches at Chikwawa at the north end of the Shire Valley. Not found in the marshes.

Barilius cf. **ubangensis** Pellegrin

Occurs in the Shire River above Chikwawa, and also in some east bank streams. It was confused with the closely related *B. zambesensis* and it is therefore not known how abundant the species is in the Shire Valley. *B.* cf. *ubangensis* is very common in the affluent streams of Lake Malawi.

Labeo altivelis Peters

Quite common at Chiromo where it is of some economic importance, especially during the dry season low water conditions, but it is uncommon in the marshes.

Labeo congoro Peters

Caught frequently throughout the year in the main river near Chiromo, but not in sufficient numbers to be considered of economic importance. Neither of the

above *Labeo* species grows to as large a size in the River Shire as in other parts of the Zambezi system. The largest *L. altivelis* and *L. congoro* seen have weighed less than 1kg, while Bell-Cross (1976) gives weights of over 3kg for the former, and more than 4kg for the latter.

Labeo cylindricus Peters

Very common in rocky, fast flowing stretches of the majority of tributaries, and found in small numbers in the fast flowing stretches of the main river, but not found in the marshes.

Leptoglanis rotundiceps (Hilgendorf)

Common in shallow, sandy bottomed stretches of many tributaries, but not yet found in the main river.

Eutropius depressirostris (Peters)

Very common throughout the Lower Shire River, especially in dry season (May - December) gillnet catches in the Ruo and Shire Rivers at Chiromo. Also caught in small numbers at Mchacha, but very uncommon in the marshes in the Ndombo area. This species is piscivorous from a very small size, with specimens of only 10cm total length feeding on young cichlids.

Amphilius platychir Gunther

Found in rocky, fast flowing stretches of many tributaries, but not yet taken from the Shire itself, even in areas apparently ideal for it, such as the Middle Shire rapids. It is postulated that water quality is the reason for this, as the species is most common in water of very low conductivity compared with that of the Shire (220/240 uS/cm). One specimen was taken in the R. Wankurumadzi within metres of the junction with the Shire.

Clarias gariepinus (Burchell)

The most important species in the fishery, representing approximately 50% of the annual harvest of 10 000 tons. Found throughout the river and marshes and in all the tributaries. The largest specimens are taken from the main river, but overall catches are greater from the marsh stations. The ecology of this and the following species in the Shire Valley are discussed by Willoughby and Tweddle (1978). The largest specimen seen was 9kg, but the average size in commercial catches was less than 1kg.

Clarias ngamensis Castelnau

An important commercial species representing over 20% of the annual harvest. Found throughout the marshes, but does not appear to penetrate as far up tributaries as *C. gariepinus*. It is a smaller species than *C. gariepinus*. The largest specimen encountered was 1kg, and the average size in commercial catches was 500g.

Clarias theodorae Weber

A small species of no commercial importance which appears in small numbers in gillnets and traps in the marshes.

Heterobranchus longifilis Cuvier & Valenciennes

This species is restricted to deep stretches and pools of the main river channels. It is the largest species in the Shire and specimens of over 15kg are often taken by anglers. Smaller specimens are sometimes taken on long-lines, but the species is of no commercial importance.

Malapterurus electricus (Gmelin)

Found in small numbers in the river and marshes. Four juveniles from 5.2 to 5.7cm total length were taken in a fast flowing rocky section of the R. Ruo at Sankhulani by means of poison in June 1972.

Chiloglanis neumanni Boulenger

Common in rocky, fast flowing perennial tributaries, but absent from the marshes and slow stretches of the river.

Synodontis nebulosus Peters

Occasionally taken by electrofishing along the banks of the main river, but not in any quantity. Appears to favour habitats with more vegetation than the following species.

Synodontis zambezensis Peters

A very common species, caught in large numbers in small meshed gillnets in the main river, especially when the water level is low during the dry season. This species also appears in small numbers in catches at the marsh stations.

Aplocheilichthys hutereaui (Boulenger)

Very common in the marshes at the end of the rains, large numbers been taken by electrofishing in April. This is the first record of this species for the Lower Zambezi system.

Aplocheilichthys katangae (Boulenger)

Another very common species throughout the marshes and lagoons and in vegetation fringing the main river.

Nothobranchius orthonotus (Peters)

Appears in isolated pools around the edge of marshes during the rains and occasionally in shallow areas in the marsh itself when the water level is very high. Specimens were taken by electrofishing at Ndombo in such circumstances in March, 1976.

Haplochromis callipterus (Gunther)

Very common throughout the area in all habitats especially in beds of *Ceratophyllum* in the marshes. Caught in large quantities in 1" (2.5cm) stretched mesh gillnets at Mchacha.

Pseudocrenilabrus philander (Weber)

A very common species in sheltered environments, though not often encountered in the main river channels.

Sarotherodon mossambicus (Peters)

Ranks second in importance in the commercial fishery, being caught in large quanities in gillnets, fish

traps, castnets and encircling fish fences. Generally prefers the quiet waters of the marsh lagoons and channels, but moves into the main river at times of low water levels. This is a fairly small species of *Sarotherodon*, with specimens normally maturing at 13 - 14cm total length. Fry and juveniles are abundant throughout the year in the marshes, while the larger fish are more often found in the deeper water of the main channels.

Sarotherodon placidus (Trewavas)

Not caught in sufficient quantities to be considered economically important. Large specimens prefer the main river and groups of up to a dozen fish up to 1kg in weight are often attracted from the cover of exposed tree roots or overhanging bushes when electrofishing along the bank of the Shire river.

Sarotherodon squamipinnis (Gunther)/**S.saka** (Lowe)

These two species are difficult to distinguish unless the male is in breeding colour. Emaciated specimens are occasionally caught at the northern end of the valley, having presumably made their own way down through the Middle Shire rapids from Lake Malombe.

Sarotherodon shiranus shiranus (Boulenger)

Another Lake Malawi endemic species which appears occasionally at the northern end of the valley. An electrofishing trip at Chikwawa in September 1975 yielded 12 specimens of this species, 11 *S. placidus* and 9 *S. mossambicus*. However, specimens are almost invariably emaciated, with torn fins, presumably as a result either of damage suffered while going over the falls or of inability to compete with other species in the Lower Shire.

Serranochromis robustus robustus (Gunther)

A single specimen of this Lake Malawi species was taken by electrofishing in the Shire at Chikwawa.

Tilapia rendalli rendalli (Boulenger)

Appears frequently in gillnet catches, but not in commercial quantities. However, in January 1976, at a time of rapidly rising water levels, a seine net in Bangula Lagoon yeilded 5kg of *T. rendalli* out of a total catch of 5.38kg. The fish were presumed to be feeding on the newly inundated terrestrial vegetation, as the majority had stomachs full of newly-ingested green plant material. Two distinct year classes were present, one with a modal length of 7cm and the other 16cm. All fish in the first year class were immature while the others were all in breeding condition.

Glossogobius giuris (Hamilton & Buchanan)

Present in small numbers in Bangula Lagoon and Kanjedza Lagoon. An irrigation pond at Makhanga fed by water pumped from the River Ruo has a thriving population of this species.

Ctenopoma ctenotis (Boulenger)

Caught in small numbers in traps in the marshes, and also taken by electrofishing.

Ctenopoma multispinis Peters

A slightly larger species than the above and consequently occasionally appears in 1" (2.5cm) and $1^1/_2$" (3.8cm) stretched mesh gillnets in the marshes and the main river. Sexual dimorphism occurs in this species. The genital aperture of the male is a small slit, in the female it is round and wider than the vent.

Mastacembelus shiranus Gunther

Not recorded by the authors, but probably occurs in the rocky stretch of river immediately below Kapachira Falls. A specimen in the reference collection at Kasinthula fish farm is believed to have been taken from the irrigation intake channel, but unfortunately no collection data are available.

Carcharhinus leucas (Muller & Henle)

Small specimens up to 10kg are occasionally taken by gillnet and also by angling. Five were recorded in 1974, but none since.

Pristis microdon Latham

Not recorded in recent years, but Jubb (1967) stated that River Shire fishermen know of this species.

OTHER SPECIES REPORTED

The following species were recorded by Hastings (1973), but are considered doubtful.

Petrocephalus catostoma (Gunther)

This species has not been recorded anywhere in the river, marsh or tributaries despite extensive sampling. At the start of the present sampling programme, it was found that juvenile *H. discorhynchus* were being recorded as *P. catostoma* at all stations. *P. catostoma* is common in Lake Malawi streams, Lake Chilwa and Lake Chiuta. *P. catostoma* has been recorded from the Lower Zambezi (Bell-Cross, 1972), but these specimens came from tributaries and not from the main river (Bell-Cross, *pers. comm.*, 1977).

Alestes lateralis Boulenger

Specimens of *A. imberi* from Bangula Lagoon have a colour pattern more like that of *A. lateralis*, hence these specimens were misidentified.

Clarias carsonii Boulenger

This species occurs in Malawi only in high altitude northern Lake Malawi affluent streams. Lower Shire specimens are *C. theodorae*.

Barbus lineomaculatus Boulenger

Specimens are now referred to *Barbus* cf. *lineomaculatus*.

Barbus barnardi Jubb

Now refered to *B. macrotaenia*.

Haplochromis darlingi (Boulenger)

All Lower Shire specimens are now considered to be *Haplochromis callipterus*.

Tilapia sparrmanii A. Smith

Not seen by the authors. Electrofishing surveys throughout Malawi have shown it to be common in the lower reaches of northern and central Lake Malawi streams, but it has not been found anywhere south of Chia Lagoon, Nkhotakota. Records from Chilwa, Chiuta and the Lower Shire are considered very doubtful. Juvenile *T. rendalli* have pattern bars more typical of *T. sparrmanii* than *T. rendalli* and misidentification of juveniles is considered to be a possibility.

Aplocheilichthys johnstonii (Gunther)

This species occurs in the middle Shire as far south as Kapachira Falls, but does not occur below the falls, where it is replaced by *A. hutereaui* and *A. katangae*, both of which are very common though neither has been recorded previously. The recording of *A. johnstonii* as common in Bangula Lagoon is an obvious misidentification of one of the two species, both of which occur in the lagoon.

GENERAL DISTRIBUTION NOTES

Table II indicates the number of specimens of each species caught in the research gillnets over one year from October 1976 to September 1977, fishing twelve days of every month at each station. It can be seen from the Table that Chiromo catches, from a riverine environment, showed the greatest diversity and Ndombo, furthest from the main river, the least. Catches at Ndombo consisted almost entirely of *C. gariepinus, C ngamensis, S. mossambicus, S. placidus* and *M. macrolepidotus. H. callipterus* and *C. multispinis* are also common in the marshy areas, *H. callipterus* being particularly common in the *Ceratophyllum* beds at Mchacha.

B. afrohamiltoni, D. mossambicus, D. schenga, E. depressirostris and *S. zambesensis* are all clearly fish which prefer the main river channels.

The majority of fish in the rivers hug the bank in areas where weed, tree roots, etc. provide shelter, a fact easily demonstrable by electrofishing. A haul with a small electrified trawl up the middle of the Shire yielded only *E. depressirostris, S. zambezensis* and small numbers of the mormyrids, *H. discorhynchus* and *M. longirostris*. Bell-Cross (1976) discussed the relationship between *Hydrocynus* and *Synodontis* and suggested that the bottom living habits of *Synodontis*, together with the dorsal and pectoral spine armament, act as a deterrent to predation by tigerfish and render *Synodontis* less vulnerable than other species would be in the open water. *Eutropius* also have dorsal and pectoral spines coated with poisonous mucus, which may give some protection. *Synodontis* are eaten by tigerfish, but not to the extent that their availability would indicate, and out of approximately 50 specimens of *H. vittatus* examined out of the Lower Shire none have been found with *Synodontis* remains in the stomach.

The small *Barbus* species, *B. haasianus, B. macrotaenia, B.* cf. *toppini, B.* cf *lineomaculatus* and *B. paludinosus* are common in quiet waters in the marshes, with *B. afrohamiltoni* and *B. kerstenii* in the main river channels and *B. radiatus, B. trimaculatus* and *B.* cf. *viviparus* in small tributaries.

Several marine and estuarine species are regular visitors up to Chiromo and beyond. *M. cyprinoides, G. giuris* and *C. leucas* have been recorded on several occasions recently and *P. microdon* was reputedly recorded in the past.

At the northern end of the valley several Lake Malawi species occasionally appear including *S. squamipinnis/saka, S. shiranus shiranus* and *S. robustus robustus. B. johnstonii* and *Barilius* cf. *ubangensis* are present in the east bank tributaries of the R. Shire and *H. barnardi* (see Tweddle *et al.*1979) in the Mwanza River. Other Lake Malawi species undoubtedly find their way down occasionally, and *Aplocheilichthys johnstonii, Haplochromis kirkii* (Gunther), *H. placodon* (Regan), *H. rostratus* (Boulenger), *H. testrastigma* (Gunther) and *Hemitilapia oxyrhynchus* (Boulenger) have all been recorded in the Middle Shire rapids near the upper limit of the Lower Shire.

Apart from the Lake Malawi species mentioned above, the following are new records for the Lower Zambezi system since Bell-Cross (1972): *Alestes* cf. *lateralis* (distinct from *A. lateralis* sensu stricto) *Barbus haasianus, Barbus kerstenii, Barbus macrotaenia, Barbus* cf. *lineomaculatus* (listed previously as *B. lineomaculatus* (Bell-Cross, *pers. comm.*, 1977)), *Barbus* cf. *toppini, Clarias ngamensis* and *Alpocheilichthys hutereaui.*

The following species (excluding a long list of marine and estuarine species) were recorded from the Lower Zambezi system by Bell-Cross (1972), but have not been recorded from the Lower Shire River: *Barbus fasciolatus* Gunther, *B. unitaeniatus* Gunther, *Varicorhinus nasutus* Gilchrist & Thompson, *Labeo molybdinus* du Plessis, and *L. rubropunctatus* Gilchrist & Thompson. Two other listed species, *Barbus eutaenia* Boulenger and *Kneria auriculata* (Pellegrin) are fishes of highland tributaries and *B. eutaenia* is common in the Upper Ruo, a highland tributary of the Lower Shire River.

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TABLE I

Species known to occur in the Lower Shire area.

LEPRIDOSIRENIDAE

Protopterus annectens brieni Poll, 1961; lungfish

MEGALOPIDAE

Megalops cyprinoides (Broussonet, 1782); oxeye tarpon

ANGUILLIDAE

Anguilla bicolor bicolor McClelland, 1844; shortfin eel

Anguilla nebulosa labiata Peters, 1852; African mottled eel

MORMYRIDAE

Hippopotamyrus discorhynchus (Peters, 1852); Zambezi parrotfish

Marcusenius macrolepidotus (Peters, 1852); bulldog

Mormyrops deliciosus (Leach, 1818); Cornish jack

Mormyrops longirostris Peters, 1852; eastern bottlenose

CHARACIDAE

Alestes imberi Peters, 1852; imberi

Alestes cf. lateralis Boulenger, 1900

Hemigrammopetersius barnardi (Herre, 1936)

Hydrocynus vittatus Castelnau, 1861; tigerfish

Micralestes acutidens (Peters, 1852); silver robber

DISTICHIDINTIDAE

Distichodus mossambicus Peters, 1852; nkupe

Distichodus schenga Peters, 1852; chessa

CYPRINIDAE

Barbus afrohamiltoni Crass, 1960; Hamilton's barb

Barbus choelensis Norman, 1925; rosefin barb

Barbus haasianus David, 1936; sicklefin barb

Barbus johnstonii Boulenger, 1907

Barbus kerstenii Peters, 1868

Barbus macrotaenia Worthington, 1933

Barbus marequensis A. Smith, 1841; large scale yellowfish

Barbus paludinosis Peters, 1852; straightfin barb

Barbus radiatus Peters, 1953; Beira barb

Barbus trimaculatus Peters, 1852; threespot barb

Barbus cf. *lineomaculatus* Boulenger, 1903

Barbus cf. *toppinni* Boulenger, 1916

Barbus cf. *viviparus* Weber, 1897; bowstripe barb

Barilius zambezensis (Peters, 1852); barred minnow

Barilius cf. *ubangensis* Pellegrin, 1901

Labeo altivelis Peters, 1852; Hunyani labeo

Labeo congoro Peters, 1852; purple labeo

Labeo cylindricus Peters, 1852; redeye labeo

BAGRIDAE

Leptoglanis rotundiceps (Hilgendorf, 1905); spotted catlet

SCHILBEIDAE

Eutropius depressirostris (Peters, 1852); butter catfish

AMPHILIDAE

Amphilius platychir Gunther, 1864; Rhodesian mountain catfish

CLARIIDAE

Clarias gariepinus (Burchell, 1822); sharptooth catfish

Clarias ngamensis Castelnau, 1861; blunttooth catfish

Clarias theodorae Weber, 1897; snake catfish

Heterobranchus longifilis Cuvier & Valenciennes, 1840; vundu

MALAPTERURIDAE

Malapterurus electricus (Gmelin, 1789); electric catfish

MOCHOKIDAE

Chiloglanis neumanni Boulenger, 1911; Neumann's rock catlet

Synodontis nebulosis Peters, 1852; clouded squeaker

Synodontis zambezensis Peters, 1852; brown squeaker

CYPRINODONTIDAE

Aplocheilichthys hutereaui (Boulenger, 1913)

Aplocheilichthys katangae (Boulenger, 1912); striped topminnow

Nothobranchius orthonotus (Peters, 1844); spotted killifish

CICHLIDAE

Haplochromis callipterus (Gunther, 1893); eastern happy

Pseudocrenilabrus philander (M. Weber, 1893); southern mouthbrooder

Sarotherodon mossambicus (Peters, 1952); Mizambique tilapia

Sarotherodon placidus (Trewavas, 1941); black tilapia

Sarotherodon squamipinis (Gunther, 1864) / *S. saka* (Lowe, 1952)

Sarotherodon shiranus shiranus (Boulenger, 1896)

Sarotherodon robustus robustus (Gunther, 1964)

Tilapia rendalli rendalli Boulenger, 1896; northern redbreast tilapia

GOBIIDAE

Glossoglobius giuris (Hamilton & Buchanan, 1822); tank gobi

ANABANTIDAE

Ctenopoma ctenotis (Boulenger, 1919); blackspot climbing perch

Ctenopoma multispinis Peters, 1844; manyspined climbing perch

MASTACEMBELIDAE

Mastacembalus shiranus Gunther, 1896

CARCHARHINIDAE

Carcharhinus leucas (Miller & Henle, 1841); Zambezi shark

PRISTIDAE

Pristis microdon Lathan, 1794; smalltooth sawfish

TABLE II

Number of specimens of each species caught in graded fleets of gillnets at each station, October, 1976 - September, 1977

SPECIES	CHIROMO	MCHACHA	NDOMBO
Protopterus annectens brieni	-	17	-
Megalops cyprinoides	1	-	-
Hippopotamyrus discorhynchus	188	3	-
Marcusenius macrolepidotus	443	320	156
Mormyrops deliciosus	14	-	-
Mormyrus longirostris	5	6	-
Alestes imberi	20	-	2
Hydrocynus vittatus	25	37	-
Distichodus mossambicus	1	-	-
Distichodus schenga	21	-	-
Barbus afrohamiltoni	66	1	-
Labeo altivelis	80	-	3
Labeo congoro	20	1	-
Eutropius depressirostris	513	142	-
Clarias gariepinus	286	410	432
Clarias ngamensis	116	356	189
Clarias theodorae	-	11	-
Synodontis zambezensis	400	5	5
Haplochromis callipterus	50	1039	19
Sarotherodon mossambicus	405	2957	521
Sarotherodon placidus	8	27	55
Tilipia rendalli	1	5	-
Ctenopoma multispinis	7	22	8

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