Species abundance and distribution of mbuna in Lake Malawi National Park and other areas of Lake Malawi

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Abstract

Malawi generally and the lakeshore areas in particular are experiencing ecological and environmental degradation, because of a very dense and increasing human population whose livelihoods depend on utilisation of a limited and diminishing resource base. Because of Lake Malawi's unique aquatic biome, the Government of Malawi established the Lake Malawi National Park (LMNP) in 1980 with the principal objective of conserving colourful rock-dwelling cichlids known as mbuna. This study was carried out to determine the abundance and distribution of mbuna. Species diversity of mbuna was high in both protected and non-protected areas. Most of the sites that were close together tended to cluster together based on species distribution, suggesting that unique species combinations were found in specific areas of the lake. The major threat to mbuna population with and outside LMNP was fishing for food by the fishermen who were resident in some of the islands.

Key words: Lake Malawi National Park, mbuna, cichlids, abundance, distribution, threats

Introduction

The cichlids of Lake Malawi are internationally recognized as an outstanding example of rapid speciation, with a potential to provide greater insight into the understanding of evolutionary processes. Of these are the colourful rock-dwelling cichlids locally known as *mbuna*. Because of their sedentary habits, most of these mbuna rarely migrate long distances from their locality. The resultant isolation of communities has created species endemic not only to the lake but to certain restricted areas within the lake itself. In turn, this aspect has led to adaptive speciation of fish species, which is more diverse than the Darwin finches of the Galapogas Islands (Meyer, *et al.*, 1990).

The Government of Malawi through the Department of National Parks and Wildlife established Lake Malawi National Park (LMNP) in 1980. The park is located at the southern part of the lake in Mangochi and Salima districts. It comprises 13 islands, rocks and reefs, most of which are within Traditional Authority (TA) Nankumba in Mangochi district. Chinyamwezi and Chinyankhwazi reefs are in TA Makanjila, while Boadzulu Island is in TA Mponda. The three Maleri Islands, namely Maleri, Nakantenga and Nankoma are within TA Maganga in Salima district. The primary objective for the establishment of the park was to protect representatives of Lake Malawi's aquatic communities and their habitats with special reference to the rocky lakeshore and its specialist cichlid communities.

Since the establishment of LMNP, the major comprehensive study of rock dwelling was the survey conducted by Ribbink *et al.* (1983). The study provided an inventory and abundance descriptions of specific taxa within the rocky areas of the lake. However, the study did not provide the numerical abundance of fishes. The current study was therefore carried out to assess the species abundance and distribution of the mbuna species.

Materials and Methods

Sampling

Underwater observations with the aid of SCUBA diving were employed during the months of March and April 2002. SCUBA surveys were undertaken in the 100 m zone of the following areas of LMNP: two of the Maleri islands namely, Maleri (5 sites) and Nakantenga(1), Chinyamwezi Island (1), Chinyankhwazi Island (1), Mumbo Island (3), Thumbi West Island (6), Otter Point (1), Zimbawe Rock (1), Domwe Island (2), Ilala Gap (1), Thumbi East Island (1), Nkhudzi Spit(1), and Boadzulu Island (2). We selected sites covered by Ribbink *et al.* (1983) and where necessary few sites were added to obtain extra information. Eight other sites outside the national park, four in Salima and another four in Nkhata Bay, were surveyed for comparison of fish abundance inside and outside the protected areas. Selection of sites was based on the need to assess human activities such as impact of fishing on mbuna stocks and diversity; assess whether there has been a change on fish species composition since the last study by Ribbink *et al.* (1983), and compare fish densities inside and outside protected areas.

Mbuna species were identified from descriptions and published colour pictures of Konings (1990, 1995), Ribbink *et al.* (1983) and original papers of fish description. Fish colour has been widely used for identification of fish (McElroy, Kornfield & Everett, 1991; Snoeks 1991 and Ribbink *et al.,* 1983). While we recognised that some species have been formally described following the study of Ribbink *et al.* (1983), we used the temporally fish names of Ribbink *et al.* (1983) for ease of comparison.

Fish relative abundance was investigated by underwater strip or point transect counts of fish (Table 1) depending upon the slope and configuration of the

Table 1. Sampling sites and abundance of mbuna species.

District	Place	Site	Abbreviation	Point/line transect	Number of mbuna species	PIE	Dominance
Inside of Lake Malawi National Park							
Salima	Maleri	C	MLC	Line	23	0.73	0.49
Salima	Maleri	D	MLD	Line	30	0.80	0.42
Salima	Maleri	E	MLE	Line	20	0.91	0.16
Salima	Maleri	F	MLF	Line	18	0.87	0.25
Salima	Maleri	F&C	MLFC	Line	17	0.80	0.41
Salima	Nakantenga	B	NGA	Line	33	0.52	0.69
Mangochi	Chinyamwezi		CMZ	Line	12	0.41	0.77
Mangochi	Chinyankhwazi		CKZ	Line	12	0.80	0.28
Mangochi	Mumbo	A	MBA	Line	20	0.89	0.26
Mangochi	Mumbo	B	MBB	Point	19	0.88	0.24
Mangochi	Mumbo	C	MBC	Point	18	0.92	0.14
Mangochi	Thumbi West	A	TWA	Line	25	0.89	0.22
Mangochi	Thumbi West	B	TWB	Line	22	0.81	0.38
Mangochi	Thumbi West	C	TWC	Line	26	0.81	0.32
Mangochi	Thumbi West	D	TWD	Line	26	0.92	0.17
Mangochi	Thumbi West	E	TWE	Line	28	0.83	0.35
Mangochi	Thumbi West	F	TWF	Line	30	0.76	0.41
Mangochi	Otter Point		OP	Point	8	0.85	0.29
Mangochi	Zimbawe Rock		ZR	Point	9	0.32	0.82
Mangochi	Domwe	E(1)	DE1	Line	17	0.45	0.74
Mangochi	Domwe	E(11)	DE2	Point	15	0.33	0.82
Mangochi	Ilala Gap		IG	Line	11	0.83	0.32
Mangochi	Thumbi East	A	TEA	Line	18	0.76	0.42
Mangochi	Nkhudzi Spit	A	NKZ	Line	16	0.88	0.21
Mangochi	Boadzulu	A: West	BZA	Line	15	0.71	0.51
Mangochi	Boadzulu	B: East	BZB	Line	14	0.88	0.23
Outside of Lake Malawi National Park							
Salima	Mbenji Island	A	MJIA	Line	21	0.90	0.25
Salima	Mbenji Island	B	MJIB	Line	5	0.65	0.59
Salima	Mbenji Island	C	MJIC	Line	20	0.88	0.24
Salima	Mbenji Island	D	MJID	Line	29	0.85	0.35
Nkhata-Bay	Nkhata Bay	Nkhata-Bay	NBA	Line	31	0.86	0.27
Nkhata-Bay	Nkhata Bay	Mayoka Peninsula	NBB	Line	18	0.86	0.29
Nkhata-Bay	Nkhata Bay	Malemba	NBC	Line	22	0.71	0.46
Nkhata-Bay	Nkhata Bay	Nkhata Bay Peninsula	NBD	Line	21	0.80	0.34

rocky bottom substratum (Ribbink *et al.*, 1983). The transects were each 25 by 2 metre covering a total area of 50 square metres while the radius of the point transects varied depending upon the distance at which individuals of all fish species could accurately be identified. The numbers of fish counts covered by point transects were also expressed per 50 square metres. The depths sampled were 2 m, 5 m, 10 m and 15 m where majority of mbuna are restricted (Ribbink *et al.*, 1983).

The data on mbuna abundance and distribution were subjected to several analyses in order to draw inferences. Means and percentages were calculated to determine species composition per depth per genus for all the sampling sites. Species diversity was measured in terms of species richness and species evenness using the EcoSim version 7 software (Gotelli and Entsminger, 2001). Species number in rarefied samples was calculated as an indicator of species richness. The probability of an interspecific encounter (PIE) was calculated as an index of species evenness which gives the probability that two randomly sampled individuals from an assemblage represent two different species.

Similarity of species composition between sites was determined using Dice coefficient. The species data were coded into presence - absence and Dice Coefficient was calculated using the formula:

$$Dc = 2a/(2a + b + c)$$

where Dc is Dice Coefficient for sites i and j,

a is the number of species present in both sites i and j,

b is the number of species present in site i but not available in site j,

c is the number of species present in site j but not available in site i.

The index varies from 0 (no similarity) to 1.0 (complete similarity), the coefficient values were subjected to cluster analysis using the SAHN programme of NTSYS-pc (Rohlf, 1993). The Unweighted Pair Group Method (UPGMA) was used to generate the dendograms.

Results and Discussion

Species composition

In total, 10 genera were observed and in their order of abundance *Pseudotropheus* (65.64%), *Cyanotilapia* (12.22%), *Melanochromis* (8.56%), *Petrotilapia* (5.67%), *Labeotropheus* (3.42%), *Labidochromis* (2.97%), *Genyochromis* (0.79%), *Iodotropheus* (0.57%) *Cyathochromis* (0.13%), *Gephyrochromis* (0.03%) (Table 1). Within the genus *Pseudotropheus*, *P. zebra* was the most abundant (24.27%) while within the *Cynotilapia* genus, *C. afra* comprised about 55% of individuals observed in the genus followed by *C.* chinyamwezi (42.3%) (Table 2). The species which were endemic and limited to specific sampling sites depicted low total relative abundance while those which were widespread and found in large numbers at most of the sampling sites showed high abundance values. *Pseudotropheus* is the commonest genus of mbuna and as such it has highest abundance (Reinthal, 1993).

Overall, the distribution of the genera by depth indicated that *Cynotilapia* was common at 5 m for *C. afra* and 15 m for *C.* Chinyamwezi. *Labeotropheus*, *Labidochromis*, *Melanochromis*, and *Petrotilapia* genera were most abundant in shallow bottoms (2 and 5 m) than in the deeper water (10 and 15 m). Among the *Pseudotropheus*, *P. zebra* and *P. zebra* "cobalt" decreased in their numbers with depth while *P. zebra* "red top" increased in numbers with depth (Table 2). Similar observations were noted by Ribbink *et al.* (1983).

Species diversity

The number of species observed varied considerably among the sites (Table 1). Thumbi West Island harboured more species than any of the sites sampled in Mangochi District. Although located in remote area from the Department of National Parks and Wildlife offices, Maleri and Nakantenga Islands have maintained high number of species comparable to those of Cape Maclear. Similar observations were made for the Nkhata Bay populations. Population sizes of mbuna in the protected areas are comparable to those of non-protected areas using Nkhata Bay and Mbenji Island as case studies. Among the sites surveyed on Mbenji Island, Site B had the lowest species diversity and population density of mbuna. This is the site that is on the side of the island where there is settlement by fishermen during the open season for fishing. Mbuna is caught for onsight consumption by the community on the island when popular food fish species are scarce. Similar observations were made on Chinyamwezi Island where fishermen caught mbuna for food. Such sites were also associated with accumulation of litter on the bottom substrate which probably contributed to reduction in species diversity. Few of the mbuna species reported by Ribbink *et al.* (1983) were not found at some of the sites during this study. This can be attributed to differences in sampling intensity whereby our data are based on transect observations alone which are likely to miss rare species of fish while Ribbink *et al.* (1983) supplemented transect data with observations from exploratory dives. Moreover the present study was restricted to a maximum of 15 metre depth while Ribbink *et al.* (1983) went up to 40 m depth.

Species availability

The relationship among the various islands and sites based on Dice coefficient of species presence or absence data is presented in Figure 1. There are two clusters for the Monkey Bay-Cape Maclear sites; (1) all the Thumbi West Island sites formed a single cluster, and (2) Thumbi East, Domwe, Ilala Gap formed a subcluster with Mumbo Island sites. Nkhudzi Bay and Zimbawe rock sites also belonged to this major cluster. Boadzulu Island sites clustered together as they haboured common endemic species. Otter Point did not form close cluster with any of its nearest sites. The Salima sites also formed two clusters with (1) Maleri Island sites clustering together with Nakantenga site and (2) Mbenji Island sites clustered together except for site B which was an outgroup. The Nkhata-Bay sites clustered together and indeed a similar pattern is observed for the islands of Chinyankhwazi and Chinyamwezi. The Dice coefficient and its resultant dendogram suggest that species distribution was closely related to proximity of the sites. Each of the areas surveyed haboured unique species. The close relationship between Thumbi West and Nkhata-Bay sites in terms of species abundance supports the fact that translocated species have established themselves in the Cape Maclear region which is more fertile than the northern part of the lake where they originated from (Munthali, 1996).

Table 2: Species relative abundance (number per 50 m2) and distribution at four sampling depths

Species name	2m	5m	10m	15m	Total	%
Cyanotilapia afra	107	1140	208	97	1552	6.76
Cyanotilapia axelrodi	7	3	0	1	11	0.05
Cyanotilapia sp. chinyamwezi	1	86	85	1014	1186	5.16
Cyanotilapia sp. maleri	1	13	1	0	15	0.07
Cyanotilapia sp. mbamba	8	8	0	9	25	0.11
Cynotilapia sp. black dorsal	1	0	0	3	4	0.02
Cynotilapia sp. yellow dorsal	0	1	6	6	13	0.06
Subtotal	***125***	***1251***	***300***	***1130***	***2806***	***12.22***
Cyathochromis obliquidens	4	17	9	0	30	0.13
Genyochromis mento	62	43	37	40	182	0.79
Gephyrochromis lawsi	2	4	0	1	7	0.03
Iodotropheus sprengerae	55	36	32	7	130	0.57
Subtotal	***123***	***100***	***78***	***48***	***349***	***1.52***
Labeotropheus fuelleborni	295	267	50	12	624	2.72
Labeotropheus trewavasae	48	82	10	21	161	0.70
Subtotal	***343***	***349***	***60***	***33***	***785***	***3.42***
Labidochromis caeruleus	5	8	10	5	28	0.12
Labidochromis freibergi	0	36	0	0	36	0.16
Labidochromis gigas	0	33	7	0	40	0.17
Labidochromis heterodon	39	5	20	1	65	0.28
Labidochromis maculicanda	36	6	4	0	46	0.20
Labidochromis mylodon	10	8	9	0	27	0.12
Labidochromis pallidus	17	43	4	0	64	0.28
Labidochromis shiranus	3	15	0	0	18	0.08
Labidochromis strigatus	0	2	1	0	3	0.01
Labidochromis vellicans	104	137	33	31	305	1.33
Labidochromis ianthinus	8	7	2	5	22	0.10
Labidochromis sp. mbenji	12	11	6	0	29	0.13
Subtotal	***234***	***311***	***96***	***42***	***683***	***2.97***

Table 2: Species relative abundance (number per 50 m2) and distribution at four sampling depths

Species name	**2m**	**5m**	**10m**	**15m**	**Total**	**%**
Melanochromis auratus	270	277	113	91	751	3.27
Melanochromis sp. black-white johanni	5	71	18	0	94	0.41
Melanochromis brevis	4	18	20	5	47	0.20
Melanochromis sp chinyamwezi	8	1	0	0	9	0.04
Melanochromis sp. chinyankhwazi	15	7	9	12	43	0.19
Melanochromis chipokae	20	27	15	11	73	0.32
Melanochromis crabro	2	4	6	1	13	0.06
Melanochromis joanjohnsonae	17	23	0	0	40	0.17
Melanochromis labrosus	4	9	2	1	16	0.07
Melanochromis melanopterus	33	39	23	45	140	0.61
Melanochromis parallelus	7	28	16	3	54	0.24
Melanochromis sp. brown	3	9	13	1	26	0.11
Melanochromis sp. slab	9	5	17	11	42	0.18
Melanochromis sp.blue	1	3	2	0	6	0.03
Melanochromis vermivorous	199	229	121	63	612	2.66
Subtotal	***597***	***750***	***375***	***244***	***1966***	***8.56***
Petrotilapia genalutea	308	241	102	112	763	3.32
Petrotilapia sp. gold	29	20	14	29	92	0.40
Petrotilapia sp. mumbo blue	32	12	4	2	50	0.22
Petrotilapia sp. mumbo yellow	14	10	16	9	49	0.21
Petrotilapia nigra	105	13	5	5	128	0.56
Petrotilapia novemfasciatus	3	7	7	1	18	0.08
Petrotilapia sp. small blue	4	13	5	11	33	0.14
Petrotilapia sp fuscus	9	14	12	4	39	0.17
Petrotilapia tridentiger	42	34	29	26	131	0.57
Subtotal	***546***	***364***	***194***	***199***	***1303***	***5.67***
Pseudotropheus sp. aggressive blue	70	20	4	8	102	0.44
Pseudotropheus sp. aggressive brown	2	23	7	0	32	0.14
Pseudotropheus sp. aggressive grey head	82	7	0	0	89	0.39
Pseudotropheus sp. aggressive yellow head	22	5	6	0	33	0.14
Pseudotropheus sp. aggressive zebra	31	43	19	0	93	0.40
Pseudotropheus aurora	34	117	48	61	260	1.13
Pseudotropheus barlowi	27	36	61	463	587	2.56
Pseudotropheus sp. burrower	10	14	4	4	32	0.14
Pseudotropheus sp. chinyankhwazi	0	43	81	52	176	0.77
Pseudotropheus sp. dumpy	1	3	0	0	4	0.02
Pseudotropheus elegans	0	4	0	0	4	0.02
Pseudotropheus sp elegans 'boadzulu'	3	9	2	12	26	0.11
Pseudotropheus elongatus	14	12	7	7	40	0.17
Pseudotropheus sp. elongatus aggressive	45	34	57	42	178	0.78
Pseudotropheus sp. elongatus bar	2	17	0	9	28	0.12
Pseudotropheus sp. elongatus black (Ps ater)	7	6	12	3	28	0.12
Pseudotropheus sp. elongatus 'boadzulu'	1	8	0	0	9	0.04
Pseudotropheus sp. elongatus chinyamwezi	5	11	12	4	32	0.14
Pseudotropheus sp. elongatus dinghani	12	8	35	124	179	0.78

Table 2: Species relative abundance (number per 50 m2) and distribution at four sampling depths

Species name	**2m**	**5m**	**10m**	**15m**	**Total**	**%**
Pseudotropheus sp. elongatus nkhata brown	8	5	3	1	17	0.07
Pseudotropheus sp. elongatus slab	34	36	30	20	120	0.52
Pseudotropheus sp. elongatus 'yellow tail'	43	64	17	9	133	0.58
Pseudotropheus gracilior	32	80	102	102	316	1.38
Pseudotropheus heteropictus	11	30	23	397	461	2.01
Pseudotropheus sp. livingstonii likoma	4	0	0	16	20	0.09
Pseudotropheus livingstonnii	3	9	19	33	64	0.28
Pseudotropheus sp. lucerna	6	3	1	2	12	0.05
Pseudotropheus sp. lurcena 'brown'	1	0	0	0	1	0.00
Pseudotropheus microstoma	36	5	32	12	85	0.37
Pseudotropheus minutus	4	8	3	6	21	0.09
Pseudotropheus socolofi	0	0	0	1	1	0.00
Pseudotropheus sp. tropheops aggressive	3	13	7	15	38	0.17
Pseudotropheus sp. tropheops band	9	1	3	0	13	0.06
Pseudotropheus sp. tropheops black	42	6	2	33	83	0.36
Pseudotropheus sp. tropheops 'boadzulu'	0	0	0	40	40	0.17
Pseudotropheus sp. tropheops chinyamwezi	31	32	35	24	122	0.53
Pseudotropheus sp. tropheops deep	5	3	5	2	15	0.07
Pseudotropheus sp. tropheops gold otter	0	0	3	2	5	0.02
Pseudotropheus tropheops intermediate	13	24	0	2	39	0.17
Pseudotropheus tropheops 'lilac'	8	31	4	8	51	0.22
Pseudotropheus sp. tropheops lilac maleri	17	39	0	0	56	0.24
Pseudotropheus sp. tropheops lilac mumbo	28	44	23	6	101	0.44
Pseudotropheus sp. tropheops maleri blue	6	2	0	0	8	0.03
Pseudotropheus sp. tropheops Maleri yellow	64	30	0	0	94	0.41
Pseudotropheus sp. tropheops mauve	18	25	20	17	80	0.35
Pseudotropheus sp. tropheops no band	4	1	4	1	10	0.04
Pseudotropheus sp. tropheops olive	38	27	3	20	88	0.38
Pseudotropheus sp. tropheops 'orange chest'	103	156	52	39	350	1.52
Pseudotropheus sp. tropheops rust	7	24	30	14	75	0.33
Pseudotropheus sp. tropheops broad mouth	18	22	9	24	73	0.32
Pseudotropheus sp. tropheops 'red cheek'	86	85	16	2	189	0.82
Pseudotropheus sp. williamsi Maleri	2	12	0	0	14	0.06
Pseudotropheus sp. williamsi 'nkhudzi	6	55	18	0	79	0.34
Pseudotropheus xanstomachus	21	5	2	0	28	0.12
Pseudotropheus sp. yellow chin	24	18	27	0	69	0.30
Pseudotropheus zebra	1315	1765	1460	1034	5574	24.27
Pseudotropheus sp zebra "red top"	27	521	125	474	1147	4.99
Pseudotropheus sp. zebra black dorsal	30	8	2	8	48	0.21
Pseudotropheus sp. zebra blue	80	478	45	67	670	2.92
Pseudotropheus sp. zebra 'cobalt'	963	486	95	28	1572	6.84
Pseudotropheus sp. zebra gold	10	18	27	41	96	0.42
Pseudotropheus sp. zebra mumbo	19	38	36	58	151	0.66

Species name	**2m**	**5m**	**10m**	**15m**	**Total**	**%**
Pseudotropheus sp. zebra patricki	2	7	7	30	46	0.20
Pseudotropheus sp. blue mbenji	3	0	0	0	3	0.01
Pseudotropheus sp. elongatus mbenji brown	15	8	8	6	37	0.16
Pseudotropheus lombardoi	1	15	87	42	145	0.63
Pseudotropheus sp. lucerna mbenji	6	0	0	3	9	0.04
Pseudotropheus sp. zebra red dorsal	0	15	30	0	45	0.20
Pseudotropheus sp. tropheops mbenji blue	8	25	17	0	50	0.22
Pseudotropheus sp. tropheops mbenji yellow	21	41	22	13	97	0.42
Pseudotropheus sp. tursiops mbenji	4	7	7	0	18	0.08
Pseudotropheus sp. williamsi mbenji	0	2	0	0	2	0.01
Pseudotropheus sp. zebra mbenji	3	176	237	39	455	1.98
	3612	***4929***	***3053***	***3480***	***15074***	***65.64***
Total number observed	**5580**	**8054**	**4156**	**5176**	**22966**	

Synthesis of the results indicate that Mbuna species diversity is high in both protected and non-protected areas. This finding suggests that exploitation of mbuna for aquarium fish trade outside the protected area does not probably have negative effect on most of the mbuna fish. However, since the mbuna have high degree of endemism catches by the aquarium trade. operators is selective and this may affect rare species. Catching mbuna for food seem to be detrimental to conservation of the fishes as was observed on site B of Mbenji Island.

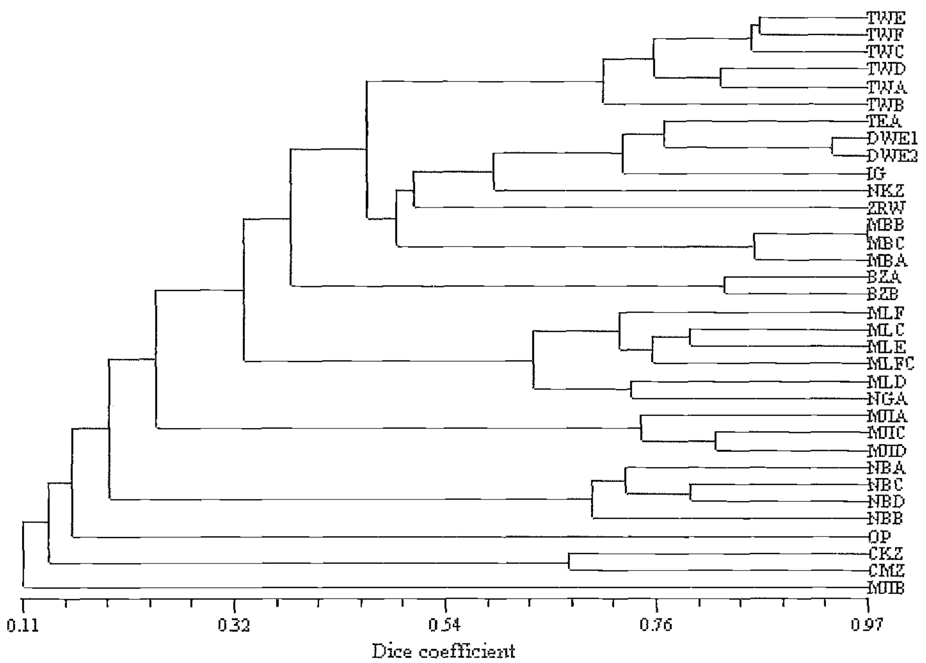

Figure 1: Dendogram of Dice coefficient for species distribution in 34 sampling sites covered in this survey. Refer to Table 1 for site abbreviations.

References

Gotelli, N.J. and Entsminger, G.L., 2001. EcoSim: Null models software for ecology. Version 7.0. Acquired Intelligence Inc. & Kesey-Bear. http://homepages.together.net/~gentsmin/ecosim.htm.

Konings A., 1990. *Konings book of cichlids and all the other fishes of Lake Malawi T.F.H.* Publication 495 pp.

Konings A., 1995. *Malawi Cichlids in their natural habitats.* Cichlid Press 352 pp.

Meyer A., Kocher, T.D., Basasibwaki, P., & Wilson, A.C., 1990. Monophyletic origin of Lake Victoria cichlid fishes suggested by mitochondrial DNA sequence. *Nature*, 347:550-553.

McElroy, D.M., Confield, I. & Everett, J., 1991. Colouration in African Cichlids: diversity and constraints in Lake Malawi Endemics. *Netherlands Journal of Zoology* 4(4):250-168.

Munthali, S.M., 1996. Territoriality and nutritional condition in *Cynotilapia afra* (Gunther) and *Pseudotropheus zebra* (Boulenger), cichlidae in Lake Malawi National Park, Malawi. *Journal of Applied Ichthyology*, 12:131-134.

Reinthal, P., 1993. Evaluating biodiversity and conserving Lake Malawi's cichlid fish fauna. *Conservation Biology* 7(3):712-718.

Ribbink, A.J., Marsh, B.A., Ribbink, A.C., & Sharp, B.J., 1983. A Preliminary Survey of the cichlid fishes of rocky habitats in Lake Malawi. *South African Journal of Zoology* 18 (3): 140-310.

Rohlf F.J., 1993. *NTSYS-pc. Numerical Taxonomy and Multivariate Analysis System.* Exeter Software, Setauket, NY.

Snoeks J., 1991. The use of standard colour guide and subtle morphological difference in Lake Kivu Haplochromine taxonomy. *Ann Mus. Roy. Afr. Centr.Sc. Zool. Biol of cichlid Proc of the 5th Euro Congress "Biology of cichlids" State University of Antwerp 24-26 Jan 1990.* (ed) M. H.J. Neilson.