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FISH COMMUNITY STRUCTURE OF WEIJA RESERVOIR AFTER 28 YEARS OF IMPOUNDMENT

T. Quarcoopome and F.K.Y. Amevenku
Council for Scientific & Industrial Research, Water Research Institute,
P. O. Box AH 38, Achimota, Ghana

ABSTRACT

The fish community structure of Weija Reservoir after twenty eight (28) years of impoundment was investigated to formulate management strategies and interventions for sustainable fisheries development. Monthly fish sampling was undertaken with gill nets of various mesh sizes from March to December 2005. Sixteen species representing 11 genera and 7 families were recorded, indicating declining fish species richness due to disappearance of marine species and restructuring of the fish community in response to change from riverine to lacustrine conditions. Cichlid, mainly, *Tilapia guineensis* and *Hemichromis fasciatus* and Cyprinids, mainly *B. macrops* supported about 69.6 % of total weight (mass) and 93.8 % of total number. About 37.14 % of all fish species ever recorded from the reservoir have disappeared and about 6 % have appeared, indicating that the fish community is undergoing restructuring. Semi-pelagic omnivores and aufwuchs-detritus herbivores constituted the most important trophic groups accounting for about 65 % of both total weight and number. The Forage/Carnivores (F/C) ratio of 4.97 and 2.43 in terms of weight and numbers indicated acceptable ecological balance among the fish population. For effective fisheries development, regular biological monitoring of the major fish species, control of unapproved fishing practices and anthropogenic activities that accelerate habitat destruction and environmental degradation must be instituted.

1. INTRODUCTION

Water reservoirs are rich in aquatic resources and provide suitable environment for fish production. The Weija Reservoir was created 28 years ago to supply potable water for domestic and industrial purposes. Studies on pre-impoundment ecology and inventory of fish species, feeding habits, yield, community structure and growth parameters of commercial important fish species have been conducted [1 - 5], as well as the socio-economics of fishes in the reservoir [6]. Since the last study on the fish fauna 14 years ago, changes have occurred in the ecology and fish biodiversity which might have implications for management of the fishery resources of the reservoir.

In this paper, the situational analysis on fish community structure with particular reference to species composition, relative abundance, diversity, ecological balance and status of fish species in the Weija reservoir is presented. The information would contribute to formulation of management interventions for sustainable development of the fishery resources of the reservoir.

2. STUDY AREA

The Weija Reservoir, created by construction of a dam on the River Densu in 1977, is located 17 km west of Accra, between 0^{o} 20' to 0^{o} 25' W and 5^{o} 30' to 5^{o} 45' N (Fig. 1), in the coastal savanna thicket and grassland vegetation zone. At maximum water level, the reservoir is 14 km long and 2.2 km wide, with a mean depth of 5 m covering approximately 3361 ha [7]. The maximum surface elevation is 15.24 km [8]. The reservoir area is low lying with undulating topography and isolated ridges. Rainfall is erratic with 2 peaks occurring in May to June and in October. The soils are sodium vleisols, coastal savanna ochrosols and lithosols which are low in nutrients, especially,

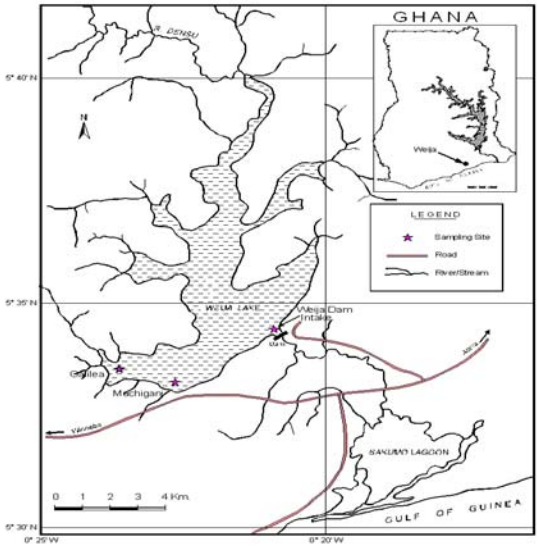

Fig. 1. Map of Weija Reservoir showing sampling stations

phosphorous and nitrogen [9, 10].

The water of the reservoir was slightly alkaline with high dissolved oxygen and though the ionic dominance pattern had not changed since impoundment, the proportions of various ions were approaching that of fresh water [11. The reservoir currently provides and supplies water to Western parts of Accra-Tema Metropolitan Area, and offers facilities for irrigation and fishing. The main economic activities of the people in the catchment area are fishing, animal rearing and crop farming.

3. FIELD STUDIES

3.1. Fish Sampling and Data Collection

Monthly fish sampling was undertaken from March to December 2005 in offshore and inshore areas at three existing and easily accessible sampling stations in the Weija Reservoir; at Dam Intake, Machigani and Galilea. Sampling was undertaken with two sets of multifilament gill nets of laterally stretched meshes of 12.5, 15.0, 17.5, 20.0, 22.5, 25.0 30.0 and 40.0 mm and two sets of monofilament gill nets of meshes 50.8, 63.5, 69.85, 76.2, 88.9 and 101.6 mm. All the nets were set between 1600 and 1730 h and retrieved the next morning between 0600 and 0800 h. Sampled fishes were individually identified based on standard keys [12], and measured for length ± 0.1 mm and weight (mass) ± 0.1 g.

3.2. Data Analysis

3.2.1. Fish species, relative abundance and diversity

The fish species composition of the reservoir was obtained from pooled monthly checklist of fishes obtained at the various sampling stations. The relative abundance of fish families and species were computed as percentages of the pooled data of weight and number.

The fish diversity of the Reservoir was described by Margalef's Index (D) for species richness [13], Shannon-Wiener Index (H) for species diversity [14] and Pielou Index (J) for species evenness [15].

For species richness,

$$D = \frac{S-1}{lnN} \quad (1)$$

where S is number of species and N is number of individuals. For species diversity,

$$H = -\sum P_i \ln P_i \quad (2)$$

where P_i is proportion of the total number of individuals occurring in species i. For species evenness,

$$J = \frac{H}{lnS} \quad (3)$$

where H is species diversity index and S is number of species.

3.2.2. Ecological balance

Fishes recorded were grouped into 4 trophic categories [16], for estimation of ecological balance for species evenness as Forage-Carnivore ratio (F/C ratio) in terms of weight and number [17], where

F/C (weight) = (Total weight of Foragers (Herbivores + Omnivores))/Total Carnivores.

F/C (number) = (Total number of Foragers (Herbivores + Omnivores))/Total Carnivores.

3.2.3. Status of fish species

The status of fish species from the reservoir was described by 5 legends or attributes: (a). Disappeared (recorded in pre impoundment study but have not been recorded from all subsequent studies), (b). Declined (reported previously [5], but are absent [6]), (c). Important (constituting at least 4 % of the total fish weight and number), (d). Permanent (reported continually), and (e). Appeared (reported in the reservoir for first time).

4. RESULTS

4.1. Fish Species Composition, Relative Abundance and Diversity

Seventeen species of fin fish representing 12 genera and 8 families of freshwater origin were sampled, as shown in Table 1. Comparison of the fish species composition previously reported showed that the number of fish species had declined from 21 to 16 as shown in Table 2. The dominant fish species with respect to pooled weight and number were *Tilapia guineensis* (22.3 % and 27.8 %), *Barbus macrops* (21.3 % and 30.0 %) and *Hemichromis fasciatus* (14.1 % and 23.5 %) (Table 3). Cichlidae and Cyprinidae together contributed most to the fish community, comprising 69.6 % and 93.8 % of pooled weight and number (Table 3). The estimated fish diversity indices, of species richness, species diversity and species evenness were 5.44, 1.87 and 0.65, respectively.

Table 1. Fish species of Weija Reservoir (Mar/Dec 2005)

Family	Genera	Species
1. Channidae	*Parachanna*	*Parachanna obscura*
2. Cichlidae	*Hemichromis*	*Hemichromis bimaculatus*
		Hemichromis fasciatus
	Oreochromis	*Oreochromis niloticus,*
	Sarotherodon	*Sarotherodon galileus*
		Sarotherodon melanotheron
	Tilapia	*Tilapia guineensis*
		Tilapia zillii
3. Clariidae	*Clarias*	*Clarias anguillaris*
		Clarias gariepinus
	Heterobranchus	*Heterobranchus longipinnis*
4. Claroteidae	*Chrysichthys*	*Chrysichthys nigrodigitatus*
5. Clupeidae	*Cynothrissa*	*Cynothrissa mento*
6. Cyprinidae	*Barbus*	*Barbus macrops*
		Barbus trispilos
7. Mormyridae	*Brienomyrus*	*Brienomyrus brachyistus*
8. Polypteridae	*Polypterus*	*olypterus endlicheri*
8	12	17

Table 2. Fish species recorded in the Weija Reservoir during Pre-impoundment [2], 14 years [5] and 28 years [6] Post-impoundment Studies

Species	Pre-	14 yrs	28yrs
Marine Fishes			
Gerres melanopterus	*		
Elops lacerta	*		
Citharichthys stapflii (sole)	*		
Mugil strongyloephalus	*		
Ethmalosa fimbriata	*		
Freshwater Fishes			
Heterotis niloticus	*		
Hepsetus odoe	*		
Pellonula afzeluisi	*		
Brycinus nurse		*	
Brycinus longipinnis	*	*	
Brycinus leuciscus	*	*	
Barbus sublineatus	*		
Barbus trispilos		*	*
Barbus macrops		*	*
Barbus eburnensis	*		
Sarotherodon galileus	*	*	*
Tilapia heudeloti	*		
Tilapia zillii	*	*	*
Hemichromis fasciatus	*	*	*
Hemichromis bimaculatus	*	*	*
Tilapia guineensis		*	*
Sarotherodon melanotheron		*	*
Oreochromis niloticus		*	*
Chromidotilapia guntheri	*		
Epiplatys senegalensis	*		
Parachana obscura	*	*	*
Brienomyrus brachyistius		*	*
Chrysichthys nigrodigitatus		*	*
Chrysichthys furcatus		*	
Clarias anguillaris		*	
Clarias senegalensis		*	
Clarias gariepinus			*
Polypterus endlicheri			*
Heterobranchus longifilis	*		*
Odaxothrissa mento			*
Total	21	18	16

Table 3. Relative Abundance of fish families and species of Weija Reservoir in terms of Weight (W g) and Numbers (N) and corresponding percentages (%) (March – December 2005)

Species	W (g)	(%)	N	(%)
Channidae	**98.8**	**0.7**	**2**	**0.3**
Parachanna obscura	98.8	0.7	2	0.3
Cichlidae	**7196.3**	**48.2**	**502**	**63.5**
Hemichromis bimaculatus	301.9	2.0	42	5.3
Hemichromis fasciatus	2100.6	14.1	187	23.6
Oreochromis niloticus	771.5	5.2	14	1.8
Sarotherodon galileus	7.5	0.1	1	0.1
Sarotherodon melanotheron	478.2	3.2	18	2.3
Tilapia guineensis	3328.8	22.3	221	27.9
Tilapia zillii	207.8	1.4	19	2.4
Clariidae	**1930.8**	**12.9**	**4**	**0.5**
Clarias anguillaris	154.3	1.0	2	0.3
Clarias gariepinus	26.5	0.2	1	0.1
Heterobranchus longipinnis	1750	11.7	1	0.1
Clarotidae	**1833.9**	**12.3**	**28**	**3.5**
Chrysichthys nigrodigitatus	1833.9	12.3	28	3.5
Cyprinidae	**3191.1**	**21.4**	**240**	**30.3**
Barbus macrops	3181.7	21.3	239	30.2
Barbus trispilos	9.4	0.1	1	0.1
Mormyridae	**47.5**	**0.3**	**3**	**0.4**
Brienomyrus brachyistus	47.5	0.3	3	0.4
Polypteridae	**625.4**	**4.2**	**12**	**1.5**
Polypterus endlicheri	625.4	4.2	12	1.5
Total	14,923.8	100	791	100

4.2. Ecological Balance

The data on relative abundance of trophic groups and ecological balance of the reservoir are presented in Table 4. The most important trophic group for weight was semi pela-

Table 4. Relative Abundance of trophic groups and forage-carnivore ratio of fishes of Weija Reservoir in terms of Weight (W g) and Numbers (N) and corresponding percentages (%) (March – December 2005)

Feeding Type	N	W	N (%)	W (%)
Aufwuchs-detritus & herbivores	**273**	**4793.8**	**34.5**	**32.1**
Oreochromis niloticus	14	771.5	1.8	5.2
Sarotherodon galileus	1	7.5	0.1	0.1
Sarotherodon melanotheron	18	478.2	2.3	3.2
Tilapia guineensis	221	3328.8	27.9	22.2
Tilapia zillii	19	207.8	2.4	1.4
Semi pelagic omnivores	**242**	**4967.6**	**30.6**	**33.3**
Barbus macrops	239	3181.7	30.2	21.2
Barbus trispilos	1	9.4	0.1	0.1
Clarias gariepinus	1	26.5	0.1	0.2
Heterobranchus longifilis	1	1750.0	0.1	11.7
Benthic omnivores	**45**	**2661.1**	**5.7**	**17.8**
Brienomyrus brachyistius	3	47.5	0.4	0.3
Chrysichthys nigrodigitatus	28	1833.9	3.5	12.3
Clarias anguillaris	2	154.3	0.3	1.0
Polypterus endlicheri	12	625.4	1.5	4.2
Carnivores	**231**	**2501.3**	**29.2**	**16.8**
Hemichromis fasciatus	187	2100.6	23.6	14.1
Hemichromis bimaculatus	42	301.9	5.3	2.0
Parachanna obscura	2	98.8	0.3	0.7
Total	**791**	**14923.2**	**100**	**100**

* F/C (weight) = (4793.8 + 4967.6 + 2661.1)/2501.3 = 4.97;
F/C (number) = (273 + 242 + 45)/231 = 2.42

Table 5. Attributes of status of fish species of Weija Reservoir after 28 years of impoundment

	Disappeared	Declined	Appeared	Important	Permanent
	H. odoe	*C. furcatus*	*C. gariepinus*	*T. guineensis*	*H. fasciatus*
	H. niloticus	*C. senegalensis*	*P. endlicheri*	*B. macrops*	*S. galileus*
	P. afzeluisi	*C. anguillaris*		*H. fasciatus*	*T. zillii*
	B. sublineatus	*B. leuciscus*		*C. nigrodigitatus*	*H. bimaculatus*
	C. guntheri	*B. longipinnis*		*S. melanotheron*	*P. obscura*
	E. senegalensis	*B. nurse*		*H. bimaculatus*	
		H. longifilis		*P. endlicheri*	
	T. heudelotti			*O. niloticus*	
	B. eburnensis			*H. longifilis*	
	Marine species				
	C. stapfli				
	E. fimbriata				
	E. lacerta				
	G. melanopterus				
	M. tronglycephalus				
Total	13	7	2	8	5

gic omnivores (33.3 %) followed by aufwuchs detritus herbivores (32.1 %), benthic omnivores (17.8 %) and carnivores (16.8 %).

For numbers, aufwuchs-detritus herbivores (34.5 %) were the most important trophic group followed by semi pelagic omnivores (30.6 %), carnivores (29.2 %) and benthic omnivores (5.7 %) respectively. The most important semi pelagic omnivore was *Barbus Macrops*, while the most important aufwuchs-detritus herbivore was *Tilapia guineensis*. The F/C ratio of ecological balance of the reservoir in terms of weight and number were 4.97 and 2.43 respectively.

4.3. Status of Fish Species

At the time of classification, the status of fish species from the reservoir is presented in Table 5. Five species namely *Parachanna obscura, Sarotherodon galileus, Tilapia zillii* and 2 *Hemichromis spp* were categorised as 'Permanent'. Thirteen species categorized as 'Disappeared' included all 5 reported marine species, as well as, some freshwater species, namely, *Hepsetus odoe*, *Heterotis niloticus*, *Pellonula afzeluisi*, *Tilapia heudelotti* and 4 others. Three *Brycinus spp* and 2 *Clarias spp* are among the 7 which constituted the 'Declined' category. *Clarias gariepinus* and *Polypterus endlicheri* were categorised as 'Appeared'. Nine species categorized as 'Important' included 4 Cichlids, 1 Cyprinid and 4 others.

5. DISCUSSION

5.1. Fish population

The damming of Densu River has resulted in conversion from a riverine or lotic state to a lacustrine or lentic condition, affecting the fish assemblage of the reservoir. The phenomenon could partly be explained by the decline and disappearance of certain species, such as, *Hepsetus odoe*, *Heterotis niloticus* and *Brycinus nurse*, as well as, proliferation of others, such as, *Barbus macrops*. The steady decline in number of fish species in the reservoir could also be attributed to disappearance of marine species from the reservoir after impoundment, as well as the restructuring of fish communities due to changes in environmental conditions.

The most important fish species in both weight and abundance during the sampling were *Tilapia guineensis, Barbus macrops* and *Hemichromis fasciatus,* while, *Sarotherodon melanotheron, Sarotherodon galileus* and *Tilapia zillii,* which were among the 5 significant species in the reservoir have diminished in importance [5]. *Tilapia guineensis* alone contributed about a quarter of the total weight and abundance recorded during sampling, while *Tilapia zillii* contributed less than 3 % of recorded weight and numbers showing a decline from previous level of 20.5 % and 16.3 % respectively [5]. The reason for the observation is unclear and therefore, constitutes subject for further study. In addition, the effects of change from lotic to lacustrine conditions require investigation.

Oreochromis niloticus, which might have entered the reservoir accidentally from fish farm stocks in the catchment area in 1985 [5], constituted about 5 % and 2% of pooled weight and numbers recorded. The absence of *Odaxothrissa mento* from the sampling was that selective mesh sizes of nets used for sam-

pling were for catching bigger-sized fishes.

5.2. Fish Diversity

The uses of the watershed affect the biological diversity of a reservoir. Stone quarrying, building construction, agriculture, industries and urbanization which could impact negatively on the reservoir fish populations were observed in the watershed and might have contributed to sedimentation of the reservoir resulting in the loss of feeding, breeding and spawning grounds for benthophagus species and the lower numbers of benthic omnivores recorded.

5.3. Status of Fish Species

With the exception of *Parachanna obscura,* the rest of the species categorised as 'permanent' were relatively abundant and frequently occurred in the catches of fishermen. The disappearance or absence of *Hepsetus odoe* and *Heterotis niloticus* could be attributed to the change in conditions from riverine to lacustrine conditions, and the inability to sample the northern and more riverine section of the Weija Reservoir for which the species were commonly found.

Factors accounting for disappearance of *Barbus sublineatus* and *Barbus eburnensis* from the reservoir are unclear. Gill net fishing and intensive capture of predatory fishes by using hooks and long line with live baits in the early years of the impoundment had, however, been found to encourage the buildup of dense populations of small fishes [19]. The all year round continuous fishing on the headpond of the Weija Reservoir had induced high prevalence of *Barbus macrops.*

5.4. Habitat and Ecological Balance

With the exception of numbers of benthic omnivores, all the feeding groups identified in the Reservoir constituted important components of the fish community. The representation of fish species in each feeding group had not changed much from what pertained in 1993 [5]. The notable change was that most of the semi pelagic omnivores were not recorded in the previous study, except for *Barbus spp.* The record of *Hemichromis bimaculatus* was one notable change in the representation of carnivorous species. The F/C ratio for both weight and numbers were within the 1.4 to 10.0 acceptable range for ecologically balanced fish populations indicating that predator-prey relationships were suitable [17].

Regular monitoring of major fish species to provide information on changes in population characteristics, such as population size, age and size structure, maturation, reproduction, growth rates and feeding habits would contribute to sustainable management interventions. The main challenges to maintaining and enhancing reservoir fisheries and associated social and economic benefits include fish habitat and environmental degradation [20]. For successful conservation of Weija Reservoir fish resources, stone quarrying, building construction, use of illegal fishing gears and methods, such as explosives and chemicals (dichlorodiphenyltrichloethane) and proper waste management should be adequately addressed.

6. CONCLUSIONS

All 17 species of fin fish representing 12 genera and 8 families recorded were of freshwater origin indicating disappearance of marine species and decline of species richness over time. Cichlids mainly *Tilapia guineensis* and *Hemichromis fasciatus* and Cyprinids, mainly *B. macrops* supported about 69.6 % of total weights and represented nearly the total numbers (93.8 %). With 37.1 % of all fish species ever reported from the reservoir disappearing and about 6 % appearing, was indicative that the fish community is undergoing restructuring.

Semi pelagic omnivores and aufwuchs detritus herbivores were the most abundant trophic groups in terms of weight and numbers. The F/C ratios for weight and numbers show that fish populations in the reservoir were ecologically balanced. About 37.1 % of all fish species ever recorded from the reservoir had disappeared and about 6 % have appeared indicating that the fish community structure is changing.

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