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Fish Assemblages and Fishery Analysis at the Mare aux Hippopotames in Burkina Faso

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Abstract: Fish populations and the exploitation of water bodies data are essential for the implementation of sustainable fisheries management strategies. Thus, fish diversity, fisheries production and fishermen's income in the «Mare aux Hippopotames» located in western Burkina Faso were studied. This study aims to characterise the fish fauna and fisheries in this natural lake. From 12 to 16 May 2020, experimental fishing was conducted using gillnets with mesh sizes of 10, 20, 35 and 40 mm and cast-nets in five stations. Supplementary data were collected within 22 commercial fishing landings. In total, 1642 fish individuals belonging to 29 species were collected. Twenty-two genera and 13 families were identified. *Sarotherodon galilaeus* is the dominant species (46.83%) followed by *Oreochromis niloticus* (11.02%), *Brycinus nurse* (10.66%). The fish fauna is quite varied and reflects the characteristics of the tropical fish fauna. Length-weight relationship revealed that some fish species have allometric growth while others have isometric growth. The density of fishermen, which is between 0.18 and 0.36 fishers per hectare shows a moderate pressure on the reservoir. The total production of the lake is estimated at 47.85 tonnes per year, i.e. an average yield of 398.78 kg. ha^{-1}. The average annual income of the fisherman is estimated at 528,000 FCFA.

Keywords: Fish Fauna, Fishing, Condition Factor, Income

1. Introduction

Aquatic ecosystems are both diverse and sensitive to anthropogenic activities [1]. Thus, natural lakes, artificial lakes and rivers from Africa have been studied extensively [2-4]. Also, some intensive projects [5, 6] made deep researches. However, in the African continent, scientific information has remained scarce, fragmentary, difficult to access, and the statistical methodologies used are often not harmonized [7]. For fish production, as example, yields often seem to be calculated intuitively by empirical procedures or, more recently, by applying indices based on data for other similar water bodies [8].

In the fields, only part of the production is declared and recorded in official statistics [9]. The productions like those of subsistence fisheries are devoted to family consumption and are not taken into account in the statistics. The quantities caught in these fisheries are likely to be very large [10]. According to Béarez [9], the actual fish landings from running waters are about twice higher than those that appear in the catch statistics in Burkina Faso. However, the fisheries administration believes that only 1/3 of the catches are not weighed.

Burkina Faso is not provided with large natural water bodies and rivers. Nowadays, the production of capture fisheries tends to stabilize and even decrease, as the stocks are fully or over exploited to satisfy the high demand of fish products and also due to bad environmental, climatic and hydrological conditions. However, hopes of increasing production by opening new

reservoir fisheries and/or aquaculture implementation are jeopardised by the rapid deterioration of aquatic environments influencing negatively certain fisheries [7]. In Burkina, in a few exceptional water bodies, a good fishery management could lead to a further increase in local production and generate substantial income for populations.

In Burkina Faso the Hippopotamus Pond or "Mare aux Hippopotames" is one of these aquatic ecosystems. It is a natural lake opened to commercial fishing between 1955 and 1958 [11]. Actually, it is part of a multi-status conservation area. The assessment of wetland ecosystems and their vulnerability pointed out, the disappearance of vegetal and animal species as a result of climate change and human activities [12]. Hence, listing animal and plant species of this ecosystem as well as their relationships is critical for its sustainable use [12]. In order to characterize the Hippopotamus Pond as well as its fish population, several studies such as Blanc and Daget [13], Béarez [9] and Compaoré et al. [14] have been carried out. These different studies have reported the presence of several fish species, belonging to different trophic levels. However, information regarding the morpho-metric characteristics of the fish and the exploitation of the fishery were scarce. Therefore, the present study was conducted to fill this gap.

The overall objective of this study is to characterize the fishery of the Mare aux Hippopotames of Balla. The specific objectives are (i) describe the structure of the fish fauna; (ii) analyse the dynamics of the exploitation of the fish resources and (iii) estimate the production and the income from the fishery.

2. Materials and Methods

2.1. Study Area

The Mare aux Hippopotames of Balla or Hippopotamus Pond of Balla is a natural lake about 60 Km far from Bobo-Dioulasso and located in the Department of Satiri. It is a depression in the floodplain of the right hand side of the Mouhoun River bank and fed by numerous phreatic resurgences [9]. The lake is about 2.6 km long (direction northwest-southeast) and 700 m wide. However different sources give different estimates of its size: 80 to 350 ha according to Béarez [9] and 120 to 660 ha according to UCFHB [15]. The last source mentions that the water is 3 m deep.

The Hippopotamus pond has several national and international conservation status. It is a classified forest since 1937, a Biosphere Reserve since 1987, a Ramsar site since 1991 and then a Wildlife Conservation Unit in 2003 [16]. It hosts a population of hippos whose protection status could be beneficial to other species dependent on the lake.

2.2. Fish Sampling and Fish Species Determination

Fish were sampled from May 12 to 16, 2020 in five stations chosen according to their accessibility. We used gillnets of 10 mm, 20 mm, 30 mm, 35 mm and 40 mm mesh side and a cast net of 40 mm mesh side to catch fish. The fishes were identified to species level using Paugy et al. [17, 18]. Then, each specimen was weighed (total weight W) to the nearest 0.1 g using an electric balance (CONSTANT brand / model 14192-33) and its total length (L_T) was measured to the nearest mm. The names of the fish in bobo, a local language of the area, were also given by the local fishermen. Fish specimens whose determination was uncertain were sent to the Laboratory of Animal Biology and Ecology of the University Joseph Ki-Zerbo in Ouagadougou for confirmation.

We also observed the commercial landings, in search for species and fish size that we were not catching.

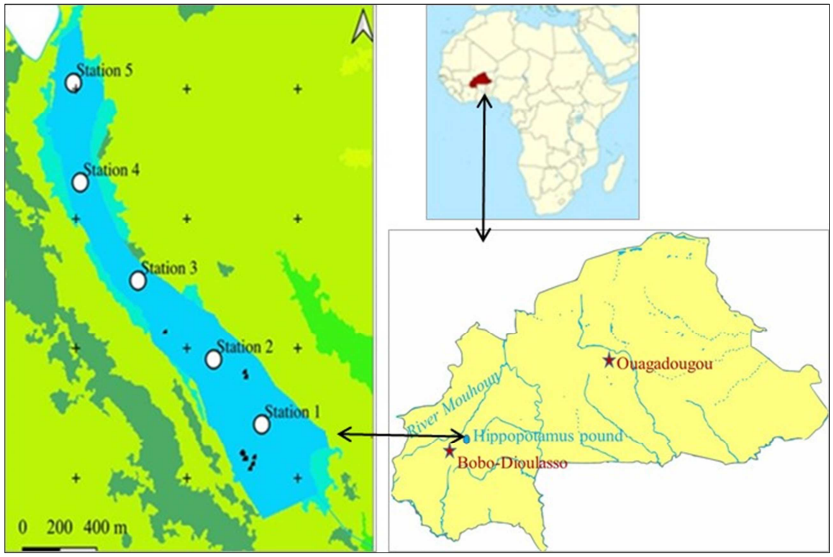

Figure 1. *Localisation of the Hippopotamus Pond.*

2.3. Data on Fishermen's Production and Income

A questionnaire was carried out during fish sampling period. The purpose of this survey was to collect data about the number of fishermen, the types of fishing gears, the gears cost and their lifespan, the seasonality of fishing, the prices of fish,

other income-generating activities.

2.4. Statistical Analysis

The fish fauna diversity was expressed by the total specific richness (S) [19], the Shannon diversity index H' [20] and the Pielou evenness index E determined to account for this diversity. The frequency of occurrence (F) of Dajoz [21] was used to assess fish species occurrence.

$$H' = -\sum_{i=1}^{S} p_i \, lnp_i \quad (1)$$

p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and s is the number of species

$$E = \frac{H'}{H_{max}} \quad (2)$$

$$F = \frac{e}{E} \times 100 \quad (3)$$

e: sample where the taxon is present, E: total number of samples).

The values of F were set as:

1. F ≥ 50%, then the taxa is "very frequent";
2. 25% ≤ F <50%, then the taxon is "frequent";
3. F < 25% the taxon is "rare".

The length-weight relation $W = a * L^b{}_T$ [22] was used to estimate the relationship between the weight (g) and the total length (cm) of the fish. The parameters a and b representing respectively the intercept and the slope of the relationship were deduced using the linear regression of the log-transformed equation: log (W) = log (a)+blog (L_T).

The condition factor K was established to assess the degree of wellbeing of fish species. The statement is that heavier fishes are in better condition than lean ones. So, Good growth condition of the fish is deduced when K≥1, while the fish is in poor growth when K<1. K was calculated based on the following formula: $K = \frac{W}{L_S^b} \, x \, 100$, [23] W is the total weight, L_S is the standard length.

In order to have valid result, only fish species having relative abundances greater or equal to 1%, and/or having a frequency of occurrence greater or equal to 10% were taken into account for the analysis of the relationship.

We also estimated the net revenue generated by fishing after collecting data on the investment, the running costs and the gross revenue.

3. Results

3.1. Fish Fauna Characterisation

A total of 655 cast net throws and 3 gillnet fishing were carried out and 13 commercial landings searched. As a results, 1642 fish specimens were observed. These included 974 specimens for experimental fishing and 668 specimens for commercial fisheries. Twenty-nine (29) species of fish were identified. They were dominated by *Sarotherodon galileaus* (46.83%) followed by *Oreochromis niloticus* (11.02%) and *Brycinus nurse* (10.66%) (Table 1). Very low frequencies were observed for some fish species, such as *Synodontis clarias* (0.06%), *Auchenoglanis occidentalis* (0.06%) and *Mormyrus rume* (0.06%).

The interview with the fishermen showed that several species or families of fish have the same vernacular name in the Bobo language. These names are given by the fishermen according to the biology, morphology and ethology of the species. However, the names in bobo of some species have not been found yet (Table 1).

Table 1. *List, frequencies and species names in Bobo, the locale language.*

	Species	Relative frequencies	Names in Bobo language	
			Name	Meaning of the name
1	*Sarotherodon galilaeus*	46.83%	Pagale fourou	Jump in the water
2	*Oreochromis niloticus*	11.02%	Pagale Gjoun	Jump in the water
3	*Brycinus nurse*	10.66%	Kôlnon	Fish of clear water
4	*Synodontis nigrita*	7.49%	Kikônon	Fish with spine
5	*Hemichromis fasciatus*	6.88%	Sougoudienon	---
6	*Coptodon zillii*	2.92%	Pagale pènè	---
7	*Hemichromis. bimaculatus*	2.68%	Sougoudiénon	---
8	*Enteromius macrops*	1.77%	---	---
9	*Schilbe intermedius*	1.52%	Yilénon	Fish poisonous spine
10	*Synodontis membranaceus*	1.04%	Kikônon	Fish with spine
11	*Gymnarchus niloticus*	0.85%	Gnini	Silly or stubborn fish
12	*Synodontis schall*	0.85%	Kikônon	Fish with spine
13	*Heterotis niloticus*	0.79%	Zonkiè	---
14	*Clarias anguillaris*	0.73%	Makèlè	Slipping fish
15	*Hyperopisus bebe*	0.73%	Bôrônon	Fish with reproduction
16	*Polypterus senegalus*	0.67%	Kalga	Spine
17	*Ctenopoma kingsleyae*	0.49%	---	---
18	*Parachanna obscura*	0.37%	Tianon	Sleeper fish
19	*Coptodon dageti*	0.30%	Pagale pènè	---
20	*Chrysichthis sp*	0.24%	Kpirèdotalé	Powerful venom fish
21	*Synodontis punctifer*	0.24%	Kikônon	Fish with spine
22	*Labeo coubie*	0.18%	Dayagabou	Fish with a lot of bones in the boby
23	*Marcusenius senegalensis*	0.18%	Bôrônon	Fish with reproduction

	Species	Relative frequencies	Names in Bobo language	
			Name	Meaning of the name
24	*Chromidotilapia guntheri*	0.12%	---	---
25	*Siluranodon auritus*	0.12%	Yilénon	Poisonous spine
26	*Synodontis ansorgii*	0.12%	Kikônon	Fish spine
27	*Auchenoglanis occidentalis*	0.06%	Sobarikikonon	Donkey fish
28	*Mormyrus rume*	0.06%	Bôrônon	Fish with reproduction
29	*Synodontis clarias*	0.06%	Kikônon	Fish with spine

Seven fish species were found at station 1, near the source, 12 twelve at station 2 and 17 at stations 3 and 4. The Shannon diversity and Pielou Evenness indices followed the same trend as the species richness. From upstream to downstream, the Shannon index ranged from 1 to 1.81 and the Pielou Evenness ranged from 0.52 to 0.64 (Figure 2).

Table 2I. *Occurrence of fish species in the Mare aux Hippopotames.*

Species	Occurrence frequencies (%)	Frequencies signification
Sarotherodon galilaeus	100.00	Very frequent species
Oreochromis niloticus	85.71	Very frequent species
Coptodon zillii	52.38	Very frequent species
Hemichromis fasciatus	47.62	Frequent species
Heterotis niloticus	38.10	Frequent species
Gymnarchus niloticus	38.10	Frequent species
Clarias anguillaris	38.10	Frequent species
Brycinus nurse	38.10	Frequent species
Synodontis schall	28.57	Frequent species
Synodontis nigrita	28.57	Frequent species
Synodontis membranaceus	23.81	Rare species
Parachanna obscura	23.81	Rare species
Schilbe intermedius	19.05	Rare species
Polypterus senegalus	19.05	Rare species
Hemichromis bimaculatus	19.05	Rare species
Ctenopoma kingsleyae	19.05	Rare species
Synodontis punctifer	14.29	Rare species
Marcusenius senegalensis	14.29	Rare species
Hyperopisus bebe	14.29	Rare species
Enteromius macrops	14.29	Rare species
Chrysichthis sp	9.52	Rare species
Chromidotilapia guntheri	9.52	Rare species
Synodontis clarias	4.76	Rare species
Synodontis ansorgii	4.76	Rare species
Siluranodon auritus	4.76	Rare species
Mormyrus rume	4.76	Rare species
Labeo coubie	4.76	Rare species
Coptodon dageti	4.76	Rare species
Auchenoglanis occidentalis	4.76	Rare species

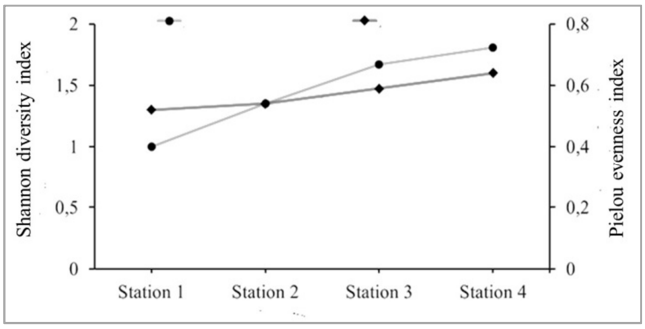

Figure 2. *Diversity indices along the sampling stations.*

Regarding fish species occurrences, 10.34% of the recorded species were very frequent. These species belong to the Cichlidae family and listed as *C. zillii, O. niloticus and S. galilaeus*. Frequent species represented 24.14% of species; they were *B. nurse, C. anguillaris, G. niloticus, H. fasciatus, H. niloticus, S. nigrita and S. schall*. During this study, 65.52% of the species caught were rare. Species with lowest frequencies of occurrence (4.76% each one) included *S. clarias, A. occidentalis and M. rume* (figure 3).

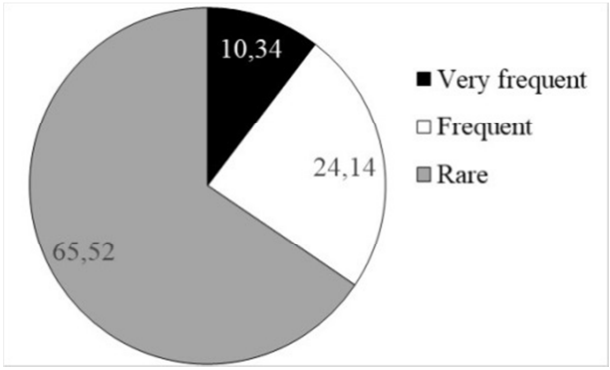

Figure 3. *Fish species distribution according to their occurrence (%) in the Hippopotamus Pond.*

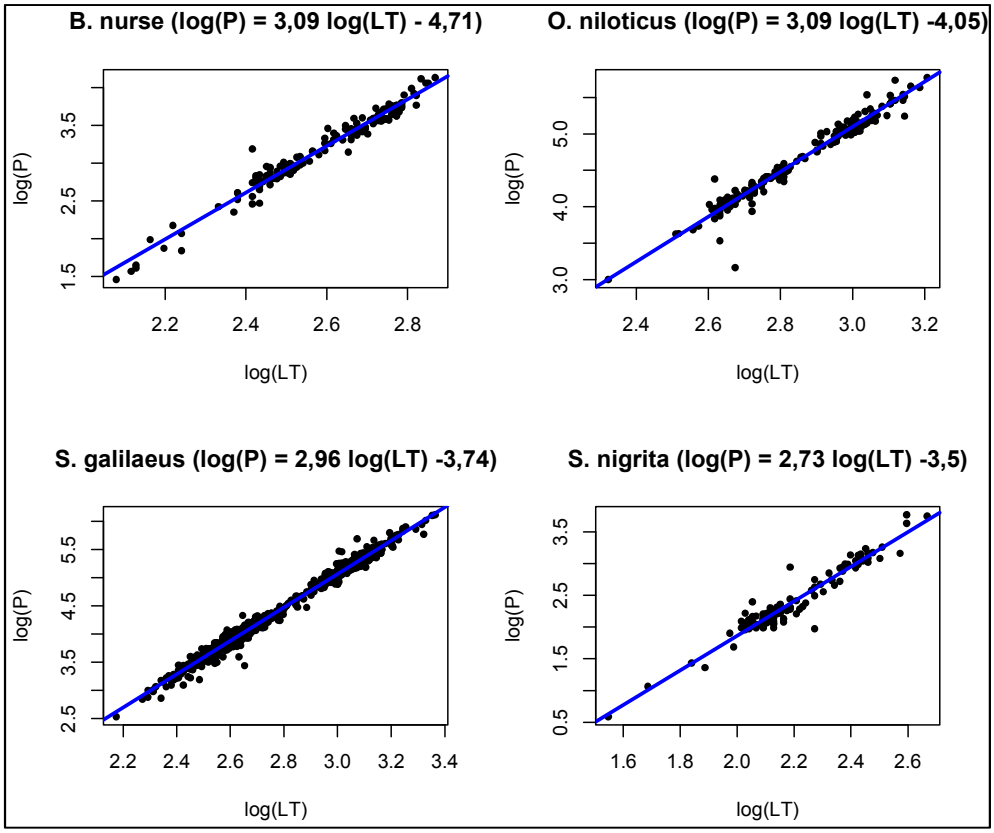

Figure 4. *Length-weight relationship of four dominant fish species.*

Table 3. *Descriptive parameters and Length-weight relationship parameters of fishes.*

N°	Species	Abundance	a	b	R^2	Growth type	K_{means}	K Standard deviation	Growth condition
1	*Brycinus nurse*	175	0.008	3.087	0.97	I	0.826	0.08	Poor
2	*Clarias anguillaris*	12	0.003	3.191	0.99	A+	0.343	0.027	Poor
3	*Coptodon zillii*	48	0.012	3.184	0.97	A+	1.182	0.183	Good
4	*Ctenopoma kingsleyae*	8	0.021	2.986	0.99	I	2.096	0.079	Good
5	*Enteromius macrops*	29	0.022	2.615	0.65	A-	2.239	0.283	Good
6	*Gymnarchus niloticus*	14	0.05	2.202	0.80	A-	5.395	2.119	Good
7	*Hemichromis bimaculatus*	44	0.137	2	0.77	A-	13.685	1.025	Good
8	*Hemichromis fasciatus*	113	0.015	2.998	0.97	I	3.122	6.559	Good
9	*Heterotis niloticus*	13	0.321	2.101	0.78	A-	35.198	19.435	Good
10	*Hyperopisus bebe*	12	0.033	2.508	0.99	A-	3.274	0.199	Good
11	*Oreochromis niloticus*	181	0.016	3.088	0.96	I	1.462	0.393	Good
12	*Parachanna obscura*	6	0.009	3.072	0.77	I	1.037	0.62	Good
13	*Polypterus senegalus*	11	0.0007	3.622	0.94	A+	0.069	0.006	Poor
14	*Sarotherodon galilaeus*	769	0.022	2.96	0.99	I	2.154	0.36	Good
15	*Schilbe intermedius*	25	0.002	3.433	0.98	A+	0.226	0.023	Poor
16	*Synodontis membranaceus*	17	0.032	2.64	0.81	A-	3.219	0.368	Good
17	*Synodontis nigrita*	123	0.028	2.725	0.93	A-	2.699	0.456	Good
18	*Synodontis schall*	14	0.019	2.673	0.98	A-	1.956	0.245	Good

R^2 = Coefficient of determination; a = Intercept of regression; b = Slope of regression; Kmeans= Condition factor; I= Isometric growth; A- = Negative allometric growth, A+ = Positive allometric growth.

3.2. Length-weight Relationships

The weight-length relationship showed a strong correlation between these two variables ($p < 0.05$) with R^2 values greater than 0.90 in twelve species, $0.70 \leq R^2 \leq 0.9$ in five species and $R^2 = 0.65$ for one species (figure 4, Table 3). The values of the constant b revealed three types of growth in the species encountered in Mare aux Hippopotames. The growth trend for four species, namely *C. anguillaris, C. zillii, S. intermedius* and *P. senegalus* is positive allometric growth (Table 3), while *B. nurse, C kingsleyae, H. fasciatus, O. niloticus, P. obscura* and *S. galilaeus* showed isometric pattern. Conversely, eight species including *G. niloticus, E. macrops, H. bimaculatus, H. niloticus, H. bebe, S. membranaceus, S. nigrita and S. schall*

presented a negative allometric growth.

The values of the condition factor are shown in the table 3, fourteen of the 18 fish species showed well-being with the recorded mean values of K greater than 1, while the other 4 showed poor shape (Table 3).

3.3. Number of Fishermen and Fish Production

A focus group was held with 11 fishermen, and was implemented with individual interviews with 8 fishermen. They indicated that the total number of fishermen is 61, but on average 22 fishermen are active every day. They are all from villages bordering the lake. The survey showed that agriculture and livestock are the primarily activities, fishing being the third most important economic activity. The fishermen tend to reduce fishing in order to go for farming during the rainy season (June to and October). Anyhow they fish less from July to September that corresponds to the maximum level of water in the lake, because the production of fishing is low.

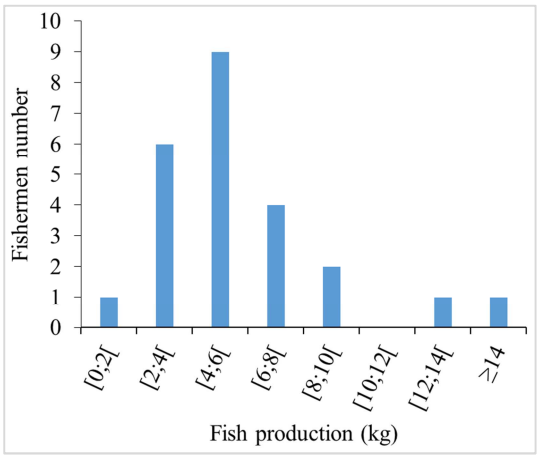

Figure 5. *Daily production of fish in the Hippopotamus Pond.*

Four types of fishing gear are used: gillnet, cast net, traps and longlines. All fishermen (100%) use the gillnet in combination with the longlines, traps or harpoon. The cast net is occasionally used in shallow waters free of vegetation. It appears that 12.5% of the fishermen combine a maximum of three gears. Some fishermen use harpoons to handle large size fishes caught by the gillnet, but still alive.

The fishing gears can be used from 2 to 12 months. The minimum investment for gears that was recorded was 12000 FCFA and the maximum 74000 FCFA. Some fishermen have canoes which individually costs at least 75000 FCFA.

No species is particularly targeted, but the most expensive ones and large size specimen are simply preferred.

On average, the fisherman works 240 days a year, and the mean catches per day is 5.96 kg (Min. 3; Max. 14) as illustrated by figure 5.

The annual production of the Mare aux Hippopotames is estimated at 30.94.85 tonnes per year, i.e. an average yield of 257.84 $kg.ha^{-1}$ if we consider that the water surface is 120 ha [9] and 51.568 $kg.ha^{-1}$ if we consider an area of 600 ha.

3.4. Income from Fishing

The cost of a ready-to-use gillnet is estimated at 39,468.75 FCFA. To make a longline, the packet of hooks is purchased at 1500 FCFA and the assembly cost varies according to the size and number of the hooks. The canoe costs 35,000 to 100,000 FCFA. Operational expenses per fishing day include fuel costs to reach the lake, food and hot drinks and other miscellaneous (cola nuts, cigarettes, …) cost 1,081.25 FCFA.

After being landed, the catches are all immediately bought by fishmongers from the village of Satiri or the town of Bobo-Dioulasso. The most expensive fishes are sold at 1,500 FCFA/kg and include *G. niloticus*, *L. niloticus* and *H. niloticus* (i.e. 9% of catches). Any other species is sold at 700 FCFA/kg. Self-consumption is estimated at 3.40% of catches. Thus, on average the daily gross income of the fisherman is around 4044.40 FCFA. The fisherman must save FCFA 1,795.36 per fishing day for the amortisation of his fishing equipment. The fishing license and all taxes that the fisherman faces cost 10,500 FCFA per year. By deducting all the expenses, the net daily income of the fisherman is 2200 FCFA. The survey revealed that fisherman works 240 days a year and so his annual net income is 528,000 FCFA.

4. Discussion

The 29 fish species that we recorded contribute for less than 25% of total diversity of Mouhoun sub-catchment compiled by Minoungou [24]. Although this compilation has to be improved, this suggests that the Hippopotamus Pond probably hosts more many species of fish. Actually, the present study took place during season only, but more many species could have been found if the fish were sampled during the rainy season as stated by Baijot et al. [11] and Ouédraogo [6]. However, more often the differences of species richness between these two seasons are not significant after statistical test [25].

Some former studies already conduced in the Mare aux Hippopotames revealed different species richness. Among which the maximum diversity was recorded by Blanc and Daget [13] who identified 42 species. However, in these study many species names are invalid, therefore the reliability of the result is questionable. Recently, Sanon [26], Béarez [9] and Compaoré et al. [14] studied fish diversity of the lake and came respectively to a list of 34, 30 and 24 species, which is not significantly different to our findings.

The recorded fishes included species with various ecological guilds among others ubiquitous species from continental African waters (*Synodontis schall, Labeo coubie, Synodontis membranaceus*), species from wetlands and swamps (*Clarias anguillaris, Ctenopoma kingsleyae, Synodontis nigrita*), fluvial species (*Siluranodon auritus*), *Polypterus senegalus*) and especially ubiquitous species swarming aquatic systems of Burkina Faso (*Oreochromis niloticus, Sarotherodon galilaeus, Brycinus nurse*). These large ecological guilds combined to the presence of intolerant species such as *G. niloticus, H. niloticus, H. fasciatus, P.*

obscura and Mormyrid species (*M. rume and H. bebe*) suggests that the aquatic ecosystem is somehow healthy as explained by Ouédraogo [6] and Mano [27], and this is confirmed by the good values of Shannon index.

Diversity increased from upstream to downstream, which is in accordance with the results of several authors including Minoungou et al. [28] in the new Samandéni reservoir, Burkina Faso.

Regarding the investigation of length-weight relationship, some of our results are in agreement with other national findings, others are not. Furthermore, the positive allometric growth recorded in the genus Clarias was in agreement with the results observed in the fisheries of Lake Bam and the Kompienga reservoir by Da et al. [29] and in the Sourou reservoir by Coulibaly [30]. However, Sirima et al. [31] obtained an isometric growth for *C. gariepinus* in the Comoe River. The isometric growth obtained for *Oreochromis niloticus* is in accordance with the results of a former study already conducted in the lake [32]. The positive allometric growth observed for *S. galilaeus* in this study is not in accordance with the results of previous studies carried out in Lake Bam [29], Lake Higa [33], Samandéni Reservoir and in Bama Pond [32]. Finally, the negative allometry observed in *H. niloticus* is consistent with the results obtained by Coulibaly [34].

The condition factor is influenced by many factors, the main ones being the individual's own morphology, the state of fattening, the sexual stage of the gonads, the specific density and the state of fullness of the digestive tract [35]. The condition factor $K \geq 1$ for the majority of the species studied clearly showed the 'well-being' of the fish and therefore a relatively good quality of the aquatic ecosystem of the Hippopotamus Pond [36, 37]. If we consider the number of 61 fishermen in the lake, we have a density of 10.17 to 76.25 fishermen per km^2. This number is very high in comparison to the recommendation of FAO [38] and may compromise the sustainability of the fishery in the lake. It urges to take effective management and development measures in the near future to avoid the depletion of the fishery as it happened in Lac Bam, which is currently undergoing rehabilitation [6]. However, since only 21 of the 61 fishermen fish each day due to other occupations, our statement is slightly moderated.

Most of the fish in Mare aux Hippopotames have a name in local language. However, these names are not specific for one species. More often they refer to a group of species, genus or even families with common traits as reported by previous studies [6, 30]. These findings revealed that local actors pay an attention to fish ecological guilds.

The average annual net income of fisherman observed in this study is 528,000 FCFA or 44,000 FCFA per month. This amount is well above the guaranteed minimum monthly inter-professional of 32,218 FCFA in Burkina Faso [39], the poverty threshold of 153530 FCFA in 2014 [39]. Referring to Ouédraogo [6], which reported that fishing brings about 37% of the total annual income earned by the fisherman practicing agriculture and breeding as priority activities, each fisherman would have a net annual income of 1427027.03 FCFA. Analysing this findings, one can say that theoretically, even considering fishing as their sole income-generating activity, the fishermen of Balla are not poor, even if in Burkina, INSD [40] considers fishermen to be the second socio-professional category, which has the highest proportion of poor people (48.3%) after subsistence farmers (50.1%).

5. Conclusions

The Hippopotamus Pond has an appreciable diversity of fish species. Although three species (*S. galileaus, O. niloticus* and *B. nurse*) highly dominate the fish fauna, the presence of intolerant species and many large size specimens suggests that the environment is not greatly impacted compared to other fisheries in Burkina Faso. The values of the diversity indices and the conditions factor also tend to confirm this.

The number of active fishermen seems quite high, but access to the fishery is regulated due to the practice of other activities, mainly agriculture and livestock breeding. So every day, the lake is frequented by 22 fishermen. Fishing provides an annual net income of 528,000 FCFA, which is consistent and suggests that fishermen are not poor but further studies can establish the profile of poverty.

Conflict of Interests

The authors declare that they have no competing interests.

Authors' Contribution

OR, DV and SYMF conceived, designed and performed the fieldwork. DV and SYMF participated in the data analysis and manuscript editing. OR, MK and OA participate to the manuscript editing and revision.

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References

[1] McInnes R, Ali M, Pritchard D, 2017. Ramsar et la Convention du patrimoine mondial: au confluent du succès [Ramsar and the World Heritage Convention: at the crossroads of success]. Secrétariat de la Convention de Ramsar.

[2] Lévêque C, Paugy D, Teugels GG. éd., 1990. *Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest [Freshwater and brackish water fish fauna of West Africa]*. Paris, Orstom/MRAC, Faune tropicale, 28, vol. I, 384 p.

[3] Lévêque C, Paugy D, Teugels GG. éd., 1992. *Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest [Freshwater and brackish water fish fauna of West Africa]*. Paris, Orstom/MRAC, Faune tropicale, 28, vol. II, 526 p.

[4] Lévêque C, Didier P, et Teugels GG, 2003. *Faune des poissons d'eaux douces et saumâtres de l'Afrique de l'Ouest*, 2e édition. Collection Faune et Flore tropicales 40 [fish fauna of the fresh and brackish water of West Africa, 2nd edition. Tropical Fauna and Flora Collection 40], Paris, 2003. Tomes 1 & 2.

[5] Melcher A, Ouedraogo R, Oueda A, Somda J, Toe P, Sendzimir J., Slezak G, Voigt C, 2020. SUSFISHBook -*Sustainable Fisheries and Water Management. Transformation Pathways for Burkina Faso*. SUSFISH+ Project Consortium - http://susfish.boku.ac.at/ ISBN: 978-3-9504470-9-5

[6] Ouédraogo R, 2010. *Fish and fisheries prospective in arid inland waters of Burkina Faso, West Africa.* PhD thesis, University of Natural Resources and Life Sciences, Vienna Austria, p. 232.

[7] FAO, 2017. La pêche dans les zones arides d'Afrique subsaharienne « le poisson vient avec la pluie »: favoriser la résilience dans les zones arides pour la sécurité alimentaire et la nutrition des populations qui dépendent de la pêche. Organisation des Nations Unies pour l'Alimentation et l'Agriculture, Circulaire sur les pêches et l'aquaculture n°1118 [Fishery in the arid zones of sub-Saharan Africa "the fish comes with the rain": fostering resilience in the arid zones for the food security and nutrition of the populations who depend on fishing. Food and Agriculture Organization of the United Nations, Fisheries and Aquaculture Circular No. 1118]. Rome, FIAF/C1118 (Fr).

[8] Da Costa KS. et Dietoa YM, 2008. Production halieutique du lac Fae (bassin du San-Pedro) en région sud-ouest de la Cote d'Ivoire [Fish production from Lake Fae (San-Pedro basin) in the southwest region of Cote d'Ivoire]. *Agronomie Africaine* 20 (3): 313 - 329 (2008).

[9] Béarez P, 2003. La Mare aux Hippopotames (Burkina Faso): aspects hydrobiologiques et halieutiques [Hippopotamus Pond (Burkina Faso): hydrobiological and halieutic aspects] In Palomares, M. L. D., B. Samb, T. Diouf, J. M. Vakily and D. Pauly (eds.), 2003. Fish biodiversity: Local studies as basis for global inferences. ACP-EU Fish. Res. Rep., (14): 281 p.

[10] Kaboré M, Bako D, Guissou R, 2014. Méthodologie d'enquête statistique par sondage probabiliste sur la pêche: cas du Burkina Faso [Statistical survey methodology by probabilistic survey on fishing: case of Burkina Faso]. *STATECO N°108, 2014.*

[11] Baijot E, Moreau J, Bouda S, 1994. *Aspects hydrobiologiques et piscicoles des retenues d'eau en zone soudano-sahélienne [Hydrobiological and fish-farming aspects of water reservoirs in the Sudano-Sahelian zone]*. Ede; Bruxelles: Centre Technique de Coopération Agricole et Rurale (CTA); Commission des Communautés Européennes (CCE), 1994. 250 p.; 56 dl.; 274 réf.-ISBN 92 9081 124 2.

[12] GIRE, 2006. Le bilan des écosystèmes humides et de leur vulnérabilité: fiches techniques [Assessment of wet ecosystems and their vulnerability: technical sheets]. Gestion Intégrée des Ressources en Eau du Burkina Faso. Rapport technique n° RT-OTEG-R 1.6.

[13] Blanc M, Daget J, 1957. Les eaux et les poissons de Haute Volta [The waters and fish of Upper Volta]. Mem. *De l'IFAN.* 50: 110-112.

[14] Compaoré I, Sanogo S, Tankoano B, Tama K, Nacro BH, Kabre TA, 2021. Specific richness, size classes and growth parameters of the main fish species in the upper Mouhoun River basin in Burkina Faso. *International Journal of Fisheries and Aquatic Studies*. IJFAS; 9 (1): 195-203. DOI: https://doi.org/10.22271/fish.2021.v9.i1c.2402.

[15] UCFHB, 2006. *Plan d'aménagement et de gestion de la Réserve de Biosphère de la Mare aux Hippopotames [Development and management plan of the Hippopotamus Pond Biosphere Reserve]. Unité de Conservation de la Faune des Hauts Bassins*. Novembre 2005. 81 p.

[16] Ramsar, 2017. Burkina Faso. La Mare aux hippopotames. https://rsis.ramsar.org/ris/491. Formulaire FDR créé par le SISR V. 1.6 - 27 March 2017 [Burkina Faso. The Hippopotamus Pond. https://rsis.ramsar.org/ris/491. FDR form created by the SISR].

[17] Paugy D, Lévêque C, Teugels GG, 2003a. Poissons d'Eaux Douces et Saumâtres de l'Afrique de l'Ouest [Fresh and brackish water fish from West Africa], Tome 1. IRD: Paris, France.

[18] Paugy D, Lévêque C, Teugels GG, 2003b. Poissons d'Eaux Douces et Saumâtres de l'Afrique de l'Ouest, [Fresh and brackish water fish from West Africa] Tome 2. IRD: Paris, France.

[19] Blondel J, 1975. L'analyse des peuplements d'oiseaux, élément d'un diagnoctic écologique. I. La méthode des échantillonnages fréquentiels progressifs [Analysis of bird populations, part of an ecological diagnosis. I. The progressive frequency sampling method]. (EFP) *Terre et Vie*, 29: 533-589.

[20] Shannon CE, Weaver W, 1949. The Mathematical Theory of Communication. Urbana: *University of Illinois Press.*

[21] Dajoz R, 1985. *Précis d'Ecologie [Precise of Ecology]*. Edition. Dunod: Paris.

[22] Pauly D, 1982. *Une sélection de méthodes simples pour l'estimation des stocks de poisson [A selection of simple methods for estimating fish stocks]*. FAO circulaire sur les pêches n°729, 63p.

[23] Bagenal TB, Tesch AT, 1978. Conditions and Growth Patterns in Fresh Water Habitats. *Blackwell Scientific Publications*, Oxford, 75-89.

[24] Minoungou M, 2020. *Caracteristiques Physico-Chimiques et piscicole du lac de barrage de Samandeni avant l'ouverture de la pêche au Burkina Faso [Physico-Chemical characteristics and fish fauna characteristics of the Samandeni dam lake before the opening of fishing in Burkina Faso]*. Mémoire de Master II, Université Joseph Ki-Zerbo, Burkina Faso, 74p.

[25] Yao AA, Konan KM, Doumbia L, Ouattara A, Gourene G, 2019. Diversité et Structure du Peuplement Ichtyologique du Bassin Inférieur du Fleuve Comoé (Côte d'Ivoire) [Diversity and Structure of the Ichthyological Population of the Lower Comoe River Basin (Côte d'Ivoire)]. *European Scientific Journal*; 15 (6): 244-268.

[26] Sanon ZL, 1995. *Inventaire et dynamique de quelques espèces de poissons dans la réserve de la biosphère de la mare aux hippopotames et dans le lac de la vallée du Kou.* Mémoire de fin d'études présenté en vue de l'obtention du diplôme d'Ingénieur du Développement Rural: option·Eaux et Forêts. p. 80. *[Inventory and dynamics of some fish species in the hippopotamus pond biosphere reserve and in the lake of the Kou valley. Thesis presented in view of obtaining the diploma of Rural Development Engineer: option Waters and Forests. p. 80]*.

[27] Mano K, 2016. *Fish Assemblages and Aquatic Ecological Integrity in Burkina Faso,* PhD thesis, University of Natural Resources and Life Sciences, Vienna Austria, p. 283.

[28] Minoungou M, Ouédraogo R, Da N, Ouéda A, 2020. Relation longueur-poids et facteur de condition de sept espèces de poisson du réservoir de Samandeni avant son ouverture à la pêche (Burkina Faso) [Length-weight relationship and condition factor of seven fish species from the Samandeni reservoir before it opened to fishing (Burkina Faso)]. *J. Appl. Biosci*. 151: 15559 – 15572.

[29] Da N, Ouédraogo R, Ouéda A, 2018. Relation poids-longueur et facteur de condition de Clarias anguillaris et Sarotherodon galilaeus pêchées dans le lac Bam et le réservoir de la Kompienga au Burkina Faso [Weight-length relationship and condition factor of *Clarias anguillaris* and *Sarotherodon galilaeus* fished in Lake Bam and the Kompienga reservoir in Burkina Faso]. *Int. J. Biol. Chem. Sci.* 12 (4): 1601-1610, August 2018. ISSN 1997-342X. http://www.ifgdg.org

[30] Coulibaly ND, 2003a. Noms communs des poissons commerciaux des hauts bassins du fleuve Volta au Burkina Faso [Common names of commercial fish from the upper Volta River basins in Burkina Faso] In Palomares, M. L. D., B. Samb, T. Diouf, J. M. Vakily and D. Pauly (eds.), 2003. *Fish biodiversity: Local studies as basis for global inferences*. ACP-EU Fish. Res. Rep., (14): 281 p.

[31] Sirima O, Toguyeni A, Zoungrana/Kaboré CH, 2009. Faune piscicole du bassin de la Comoé et paramètres de croissance de quelques espèces d'intérêt économique [Fish fauna of the Comoe basin and growth parameters of some species of economic interest]. *Int. J. Biol. Chem. Sci.* 3 (1): 95-106. ISSN 1991-8631. http://dx.doi.org/10.4314/ijbcs.v3i1.42740

[32] Tama K, 2019. *Inventaire de l'ichtyofaune et étude de la structure des populations de six principales espèces du bassin versant supérieur du fleuve Mouhoun au Burkina Faso: cas des mares de Balla, de Bama et le barrage de Samendéni*. Institut du Développement Rural. Mémoire de fin de cycle en vue de l'obtention du diplôme d'ingénieur du développement rural, option: Eaux et Forêts [Inventory of ichthyofauna and study of the population structure of six main species of the upper Mouhoun basin in Burkina Faso: case of the Balla and Bama ponds and the Samendéni reservoir. Institute of Rural Development. Thesis presented in view of obtaining the diploma of rural development engineer, option: Water and Forests].

[33] Ouédraogo R, Soara AE, Oueda A, 2015. Description du peuplement piscicole du lac sahélien de Higa, un site Ramsar du Burkina Faso, Afrique de l'Ouest [Description of the fish fauna of the Sahelian lake of Higa, a Ramsar site in Burkina Faso, West Africa]. *Journal of Applied Biosciences* 95: 8958 – 8965; ISSN 1997–5902.

[34] Coulibaly ND., 2003b. Relation taille-poids de 11 espèces de poissons du Burkina Faso [Length-weight relationship of 11 fish species from Burkina Faso] In Palomares, M. L. D., B. Samb, T. Diouf, J. M. Vakily and D. Pauly (eds.), 2003. Fish biodiversity: Local studies as basis for global inferences. ACP-EU Fish. Res. Rep., (14): 281 p.

[35] Fréon P, 1979. Relations tailles-poids, facteurs de condition, et indices de maturité sexuelle: rappels bibliographiques, interprétations, remarques et applications [lenght-weight relationships, condition factors, and indices of sexual maturity: bibliographical reminders, interpretations, remarks and applications]. In: La reproduction des espèces exploitées dans le golfe de Guinée. Dakar: CRODT, (68), 144-171. (Document Scientifique - CRODT; 68). La Reproduction des Espèces Exploitées dans le Golfe de Guinée: Groupe de Travail ISRA-ORSTOM, Dakar (SN), 1977/11/07-12.

[36] Baby F, Tharian J, Abraham KM, Ramprasanth MR, Ali A, Raghavan R, 2011. Length-weight relationship and condition factor of an endemic stone sucker, Garra gotyla stenorhynchus (Jerdon, 1849) from two opposite flowing rivers in southern Western Ghats. *Journal of Threatened Taxa* 3 (6): 1851–1855.

[37] Alhassan EH, Abobi SM, Mensah S, Boti F, 2014. The spawning pattern, length weight relationship and condition factor of elephant fish, Mormyrus rume from the Bontanga reservoir, Ghana. *International Journal of Fisheries and Aquatic Studies*; 2 (2): 109-114.

[38] Batiéné M, 2016. *Caractérisation des modes de gestion de d'exploitation des ressources piscicoles du Lac de Barrage de Kompienga, au Burkina Faso*. Mémoire de Fin de Cycle présenté en vue de l'obtention du Diplôme d'Inspecteur des Eaux et Forêts. Ecole Nationale des Eaux et Forêts. Burkina Faso. 120 p. Année scolaire 2015-2016 [Characterization of management methods for the exploitation of fish resources in the Kompienga reservoir, in Burkina Faso. Thesis presented in view to obtain the Diploma of Inspector of Water and Forests. National School of Water and Forests. Burkina Faso. 120 p. 2015-2016].

[39] Gouvernement du Burkina Faso, 2016. Plan national de développement économique et social [National economic and social development plan] (PNDES) 2016-2020. 97 p.

[40] INSD, 2014. Profil de pauvreté et d'inégalités. Rapport Enquête multisectorielle continue (EMC) 2014. Novembre 2015. Institut national de la statistique et de la démographie (INSD). 90 p. [Poverty and Inequality Profile. Report Continuous multisectoral survey (EMC) 2014. November 2015. National Institute of Statistics and Demography (INSD). 90 p].