Pre-Impoundment Fish Stock Assessment of the Black Volta: A Contribution to Fisheries Management of Bui Reservoir in Ghana

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Abstract

A length-based fish stock assessment of the Black Volta River in Ghana was undertaken prior to its damming at Bui in 2011. The approach involved estimation of the population parameters and exploitation rates of dominant fish stocks using TropFish R. The targeted species were: *Alestes baremoze, Hydrocynus forskalii, Hemisynodontis membranaceus* and *Labeo coubie*. The estimated asymptotic length (L_∞) ranged from 30.8 – 48.2 cm standard length (SL) with derived longevity of 11 – 27 years for the assessed species. The estimated growth coefficient (K) value ranged from 0.10 – 0.25 yr^{1} which suggested slow growth rates. The estimated length at first capture (Lc_{50}) was lower than the length at first maturity (Lm_{50}) for all the assessed fish species which suggests the presence of recruitment overfishing within the fish stocks. The total mortality rate (Z) was relatively high ranging between 0.51 and 1.34 yr^{1} suggesting that the stocks were over-exploited during the pre-impoundment period. The exploitation rate (E) for the assessed fish species were lower than the maximum exploitation rate (E_{max}) which indicates that the species are far from collapse. These estimates are baseline scientific information for designing a Fisheries Management Plan for the Bui reservoir. Meanwhile, alternative livelihood and employment opportunities such as cage fish culture are to be explored to reduce the fishing pressure on the reservoir.

Keywords: Black Volta; Bui reservoir, fish stocks, exploitation rate, growth and mortality rates, TropFish R

Introduction

Globally, small-scale fisheries provide an important source of animal protein, micronutrients, income and employment. It constitutes a unique source of livelihood (fishing, processing, marketing and distribution) for fisher folks of resettled communities in particular, and contributes to the food and nutritional security in the riparian communities (Ofori-Danson et al. 2012; Asiedu et al. 2017). To ensure the continuity of the aquatic environment supporting the livelihood and wellbeing of dependent households, there is the need to conduct scientific studies on the stock status and biology of fish species for the development and implementation of sustainable fisheries policies. In Ghana, several authors have provided information on various aspects of the fisheries of the Volta Basin. The information provided includes Roberts' (1967) provisional checklist of freshwater fish and their possible economic importance; Braimah's (1995) study on developments in the fisheries of Volta Lake such as lake dependents and fish catch decline; Ofori-Danson and Ntow's (2004) work on the state of limno-chemistry and potential fish yield of the Lake Volta; and Bene's (2007) study on fisheries potential of the Volta Basin. Though several studies have been conducted as indicated above, little or no information pertaining to the stock status of commercially important fish species within the Black Volta, Ghana exists.

The key fish species identified during October 1989 to September 1990 sampling period in the Black Volta at Bamboi in relation to the Onchocerciasis Control Programme (OCP) were *Petrocephalus bovei*, *Hydrocynus forskalii*, *Brycinus nurse*, *Brycinus leuciscus*, *Labeo senegalensis*, *Schilbe mystus*, *Synodontis ocellifer*, *Synodontis gambiensis*, and *Eutropius niloticus* (Samman and Abban, 1991). However, during the October, 1993 to September, 1994 sampling period, no catches were made for *Petrocephalus bovei* in the river (Dankwa et al., 1995). Another fish survey conducted on the Black Volta within the Bui National Park identified 46 species of fish from 17 families (Bennett and Basuglo, 1998). Surveys in 2001 and 2002 at the Bui dam site, the possible reservoir inundation area, recorded a total of 49 species of fish belonging to 26 genera and 14 families (Gordon et al., 2003). Surveys in 2011 and 2012 on the Bui dam section of the Black Volta recorded sixty-three (63) fish species, thirty-eight (38) genera and twenty (20) families (Alhassan et al., 2015). The following species were recorded as the most abundant in the catches: *Synodontis sorex*, *Schilbe mystus*, and *Heterobranchus bidorsalis* representing 12.46%, 7.47 % and 6.44%, respectively by number. *Bagrus docmak*, *Synodontis sorex*, and *Labeo coubie* dominated the fish catches representing 7.12%, 5.83 % and 4.47 %, respectively by weight. These were however, higher than that recorded by earlier works (Bennett and Basuglo, 1998; Gordon et al., 2003) in the same area.

The major anticipated environmental impact that is expected to affect the flora and fauna in the Volta basin would be the effect of lacusterization on the Black Volta, as a result of the construction of the Bui dam. Construction of the Bui dam and associated structures, and the creation of the reservoir, will cause both loss and alteration of habitats, with resulting impacts on ecology and biodiversity (ERM, 2007). It is also expected that the Bui dam will block upstream movements of potamodromous fish (species of fish that requires movement through the freshwater system to complete life cycle) such as *Alestes sp*. and *Labeo sp*., disrupting spawning activities and ultimately leading to a possible decrease in gene flow and genetic variation between isolated populations in the river (ERM, 2007). The entire life cycle of this potamodromous fish species occurs within freshwaters of a river system (Northcote, 1998). In addition, the blockage and altered downstream flows after completion of the Bui dam could affect the fish communities in Lake Volta. During May and September, certain potamodromous fish species (e.g. of the genera *Hydrocynus, Labeo*, *Chrysichthys*, *Bagrus* and *Synodontis*) migrate from Lake Volta upstream to spawn in the Black Volta tributaries (Samman et al., 1992). If suitable spawning sites for these species do not occur between Lake Volta and the Bui dam site, then these species could be lost from this part of the Black Volta system.

The majority of global fish stocks lack adequate catch, survey, and other biological data with only 5 to 20% of stocks in developing countries assessed (Costello et al., 2012; Carruthers et al., 2014).

The Black River of Lake Volta falls into the perceived often "data-poor status" of many tropical waters (Fitzgerald et al., 2018), even though it plays ecological and socio-economic roles. This limitation in stock status (catch and biological) may pose challenges for the sustainable management of fish stocks in the Black River of Lake Volta and the created Bui reservoir. The Bui Dam currently located on the Black Volta River at the Bui Gorge is designed primarily to generate hydropower with a lower magnitude of 400 MW. In addition to this, the 444 km2 reservoir area created will provide water for irrigation agriculture and an estimated 30,000-hectare land for massive mechanized farming (BPA, 2011). The reservoir which covers part of the Bui National Park also presents an opportunity for enhanced eco-tourism and artisanal fisheries. Given the impact of the Dam on fish resources of the Black River of Lake Volta, the main objective of this study was to assess the stocks of important fish species inhabiting the Black River of Lake Volta, which will serve as a baseline for management of these species after the construction of the Bui Dam. Ghana continues to be fish insecure with about 43% fish self-sufficiency (MoFAD, 2017), thus, it is necessary to sustainably manage the fishery resources by relying on sound scientific information. The Black Volta fishery may effectively contribute to food and nutrition security, income generation, poverty reduction and sustainable livelihood. However, it has not been given the needed attention and recognition especially in Ghana's inland fisheries policies and dialogue.

Materials and Methods

Description of the study area

The Black Volta Basin (BVB) is one of the most important basins in West Africa. It is estimated to be a home for about 8 million people by 2025 (Allwaters, 2012). Figure 1 shows the outline of the Black Volta River where sampling was done. The Black Volta is one of the major rivers that flow into the Volta Lake. It takes its source from Burkina Faso and drains into the Volta Lake in Ghana. It is located in north-western Ghana, forming partially the border between Ghana and Burkina Faso and also between Ghana and Cote d'Ivoire. Within Ghana, the Black Volta forms the border between the Savannah region and Bono region.

The portion of Black Volta in Ghana is estimated to be 650 km long with a catchment area of 35,105 km^2 (Vanden Bossche and Bernacsek 1990).

For the purpose of this study, four communities were selected, namely Bui and Bator (the Bui dam site area and currently submerged); and Bamboi and Agbelekama (below the Bui dam site area) within latitudes 8° 09′–8° 16′ N and longitudes 2° 01′–2° 15′ W, covering a distance of about 37.5 km. Seven communities namely, Bui (Bui village and Bui Camp), Batore Akanyakrom, Dokokyina, Lucene, Agbegikuro, Dam Site and Agbelekame (North and South) were displaced during the dam construction. However, due to the resettlement programme, these villages and camp have been grouped into three according to resettlement phases A, B and C. Phase A had already been settled as Gyama new settlement which includes the villages of Brewohodi, Agbegikuro, Dam Site, Agbelikame (North and South) and Lucene. Phase B includes the villages of Bui, Bator Akanyakrom and Dokokyina whiles Phase C covers Bui Camp (Atindana et al., 2015). The inhabitants are predominantly peasant farmers, fishermen, fish processors and others engage in petty trading.

In all the studied locations, data were collected from two sources namely, artisanal commercial fishing (fishery-dependent data) and experimental fishing (fishery-independent

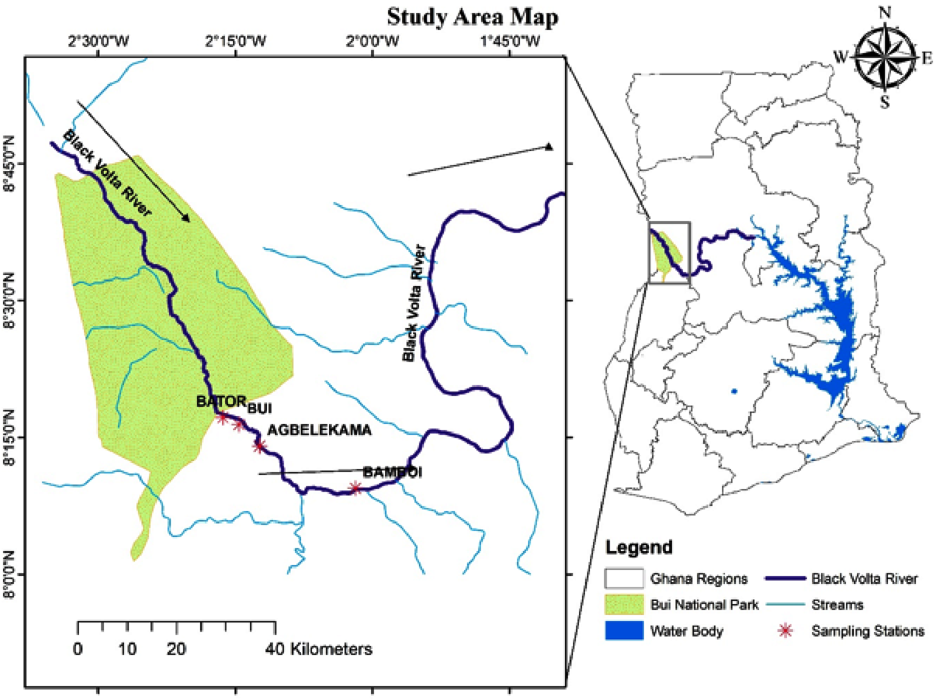

Figure 1 Map of the study area showing sampling locations

data).

Data collection and analysis
Experimental fishing was done using a mixed battery of multifilament gillnets with 15, 17.5, 20, 22.5, 25, 30 and 40 mm nominal stretched mesh size (lateral stretched). All the nets were set by a hired pre-trained fisher using a paddled canoe in the evening (17.00 h -18.00 h) and retrieved the following morning between 06.00 h and 08.00 h (Ofori-Danson et al., 2012). For commercial fishing, monthly fish sampling was undertaken from February to November, 2011 based on the designated rainfall season[1] in the study area. The sampling unit was regarded as a canoe normally with gillnets. Fish caught by each canoe was sorted into species and total weight per species was recorded. Fish species were identified using keys by Paugy et al. (2003), Dankwa et al. (1999). Fish were measured individually for standard length (SL) to the nearest 0.1 cm. The data of commercial and experimental fishery were combined and grouped into length–frequency (class interval = 1cm) for the analysis. The data were processed for the following variables:

Growth parameters
The growth parameters estimate of the species was obtained from the monthly length-frequency distribution data of the species.
The growth of each of the major fish species was assumed to conform to the Von Bertalanffy growth equation (Sparre and Venema, 1998), which is given by the formula:

$$L_t = L_\infty (1 - \exp^{-K(t - t_o)}]$$

where L_t = length at age t, L_∞ = asymptotic length, K = growth coefficient and t_o = theoretical age at zero length. Using Pauly's (1984) empirical equation, t_o was calculated using the formula:

$$\mathrm{Log}_{10}(-t_0) = -0.3922 - 0.2752 \log_{10} L_\infty - 1.038 \log_{10} K$$

The longevity (t_{max}) of the species was estimated from the equation:

$$t_{max} = 3/K \text{ (Pauly, 1984)}$$

The growth performance index was calculated using the formula:

$$\Phi' = 2\log L_\infty + \log K \text{ (Pauly and Munro, 1984)}$$

Mortality Parameters
Total mortality (Z) was computed using linearized length converted catch curve (Pauly and David 1981; Spare and Venema 1992). The natural mortality rate (M) was calculated using the equation:

$$M = 4.118K^{0.73}L_\infty^{-0.333} \text{ (Then et al., 2015)}$$

Fishing mortality (F) was calculated as:

$$Z - M \text{ (Qamar et al., 2016)}$$

The exploitation rate (E) was calculated using:

$$F/Z \text{ (Georgiev and Kolarov, 1962)}$$

Length at First Capture (Lc_{50})
The probability of capture was estimated by backward extrapolation, of the descending limb of the length-converted catch curve. A selectivity curve was generated using linear regression fitted to the ascending data points from a plot of the probability of capture against length, which was used to derive values of the lengths at capture at probabilities at 50%, 75% and 95% (Pauly 1987).

Length at first maturity
The length at first maturity was estimated using the procedure by Hoggarth et al. (2006) which is as follows:

$$2/3 * (L_\infty)$$

Biological reference points
The biological reference points including the maximum exploitation rate (E_{msy}) and its corresponding fishing mortality rate (F_{msy}) as well as exploitation at 50% ($E_{0.5}$) and its

[1]

(i)	Dry season	(January to March)
(ii)	Pre-rainy season	(April to June)
(iii)	Rainy season	(July to September)
(iv)	Post-rainy season	(October to December)

corresponding fishing mortality rate ($F_{0.5}$) were estimated using TropFish R (Taylor and Mildenberger 2017).

Data analysis

Minitab version 19 was applied in estimating the descriptive statistics (i.e., including mean, minimum and maximum) of the length measurement. The TropFish R developed by Taylor and Mildenberger (2017) was used in estimating the population parameters of the assessed fish species.

Results

Length frequency distribution

Table 1 shows the length distribution of the assessed fish species. The mean length of the fish species ranged between 19.4 ± 1.39 cm SL and 25.4 ± 1.4 cm SL. The skewness of the fish species ranged from -0.65 to 0.96 which shows the uniform presence of both small-sized and large-sized specimen of the species investigated.

Growth parameters

The growth parameters of the fish species assessed is shown in Table 2. The growth rate (K) ranged from 0.10 per year to 0.25 per year. *H. membranaceus* had the highest K at 0.25 per year while *A. baremoze* had the lowest K (0.10 per year). The length at infinity (L_∞) ranged from 30.8 cm to 48.2 cm. *L. coubie* had the highest length at infinity (48.2 cm SL). The longevity of the assessed fish species was between 11 years to 27 years (Table 2). The growth performance index ranged from 2.206 per year to 2.405 per year. *L. coubie* recorded the highest growth performance index (2.405 per year) while *A. baremoze* had the least growth performance index (2.206 per year). The theoretical age at length zero (t_o) were all negative for the assessed fish species (Table 2). The estimated Rn for all the species were above 0.50, which indicates a high reliability of data points. Figure 2 shows the reconstructed length distribution frequency

TABLE 1

Descriptive statistics of length measurement of assessed fish species

Variable	N	Mean	SE	Minimum	Maximum	Skewness
Alestes baremoze	87	22.42	0.71	8.5	39.5	0.34
Hydrocynus forskalii	55	25.37	1.39	9.5	51.5	0.96
Labeo coubie	107	19.48	0.31	11.5	25.5	-0.65
Hemisynodontis membranaceus	20	22.05	1.68	10.5	33.5	0.10

SE = Standard Error

TABLE 2

Growth parameters of the assessed fish species

Species	Linf	K	to	Phi	Rn	t_{max}
Alestes baremoze	41.8	0.10	-1.52	2.260	0.709	27.3
Hydrocynus forskalii	42.6	0.11	-1.79	2.311	0.728	25.2
Labeo coubie	48.2	0.11	-1.41	2.405	0.613	26.1
Hemisynodontis membranaceus	30.8	0.25	-0.67	2.372	0.616	11.3

Linf = Asymptotic length

K = Growth rate

t_o = Theoretical age at zero-length

Phi = Growth performance index

Rn

t_{max} = Longevity

plot of the assessed fish species.

Probability of capture and length at first maturity

The length at first capture (Lc_{50}) ranged from 17.3 cm SL to 22.0 cm SL. *L. coubie* had the highest Lc_{50} (22.0 cm SL) while *H. forskalii* had the lowest Lc_{50} of 17.3 cm SL (Table 3). Figure 3 shows the probability of capture in terms of age for all the assessed fish species.

The highest length at first maturity was recorded by *H. forskalii* (Lm_{50} = 28.4 cm SL) while *H. membranaceus* recorded the least Lm_{50} (20.5 cm SL) as indicated in Table 3.

Exploitation rates

Table 4 shows the mortality parameters of the fish species assessed. The instantaneous total mortality rate (Z) ranged from 0.506 ± 0.206 per year to 1.340 ± 0.148 per year with *H. membranaceus* having the highest Z of 1.340 ± 0.148 per year while *A. baremoze* had the lowest mortality of 0.506 ± 0.206 per year. Figure 4 shows the instantaneous total mortality rate (Z) estimated for all the assessed fish species. The instantaneous

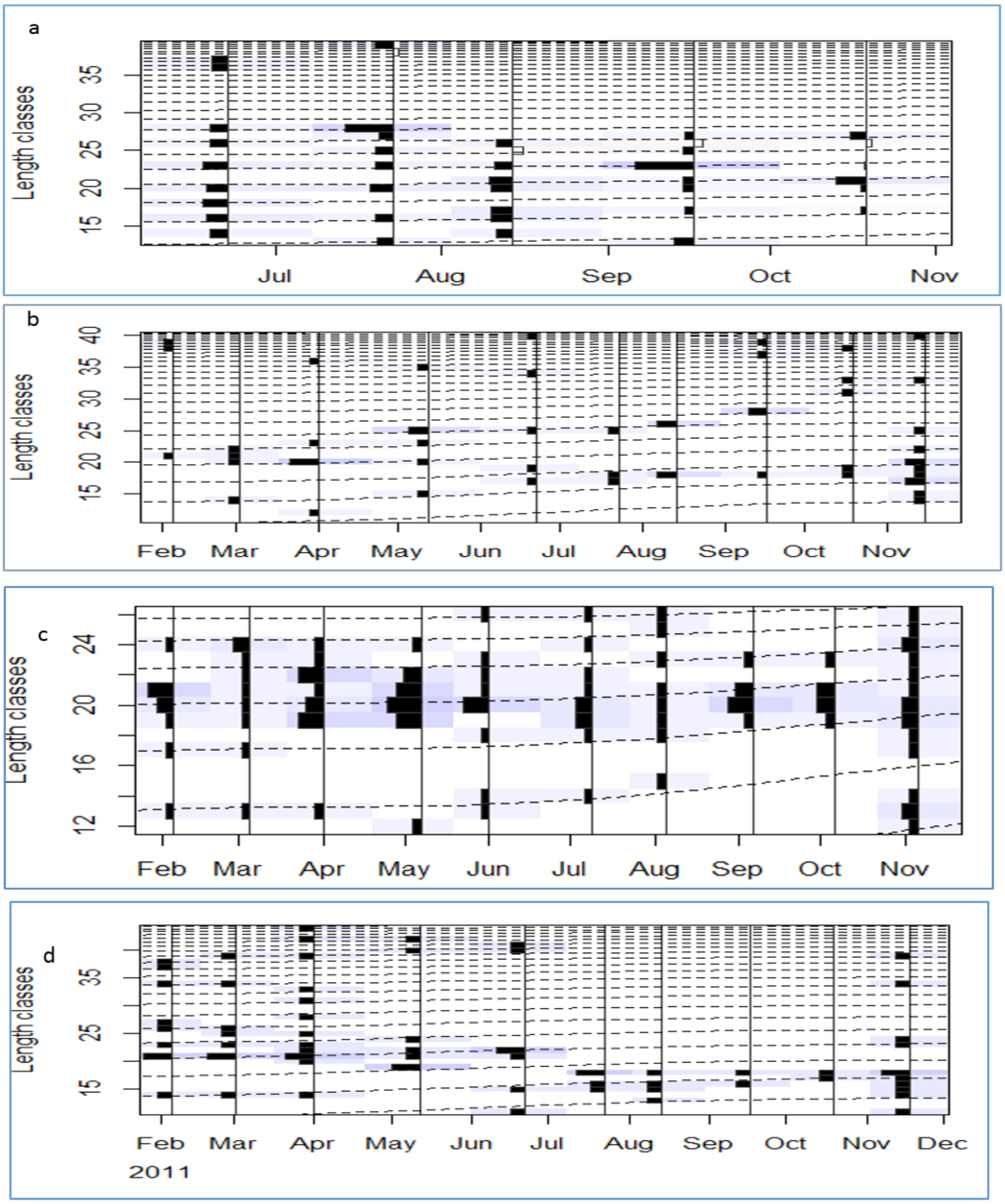

Figure 2 Reconstructed length-frequency distribution of a) *Alestes baremoze*, b) *Hydrocynus forskalii*, c) *Hemisynodontis membranaceus* and d) *Labeo coubie*

TABLE 3

Probability of capture and length at first maturity of the assessed fish species

Species	Length at first capture			Age at first capture			Length at first maturity
Variable	L_{50}	L_{75}	L_{95}	t_{50}	t_{75}	t_{95}	Lm_{50}
Alestes baremoze	20.6	22.7	26.2	6.4	7.5	9.5	27.9
Hydrocynus forskalii	17.3	19.8	23.5	4.6	5.6	7.1	28.4
Labeo coubie	22.0	24.9	29.1	5.6	6.7	8.5	32.1
Hemisynodontis membranaceus	20.8	22.1	23.9	4.5	5.1	6.0	20.5

L_{50}= length at first capture

L_{75}= Length at 75% capture

L_{95} = Length at 95% capture

t_{50}= Age at first capture

t_{75}= Age at 75% capture

t_{95} = Age at 95% capture

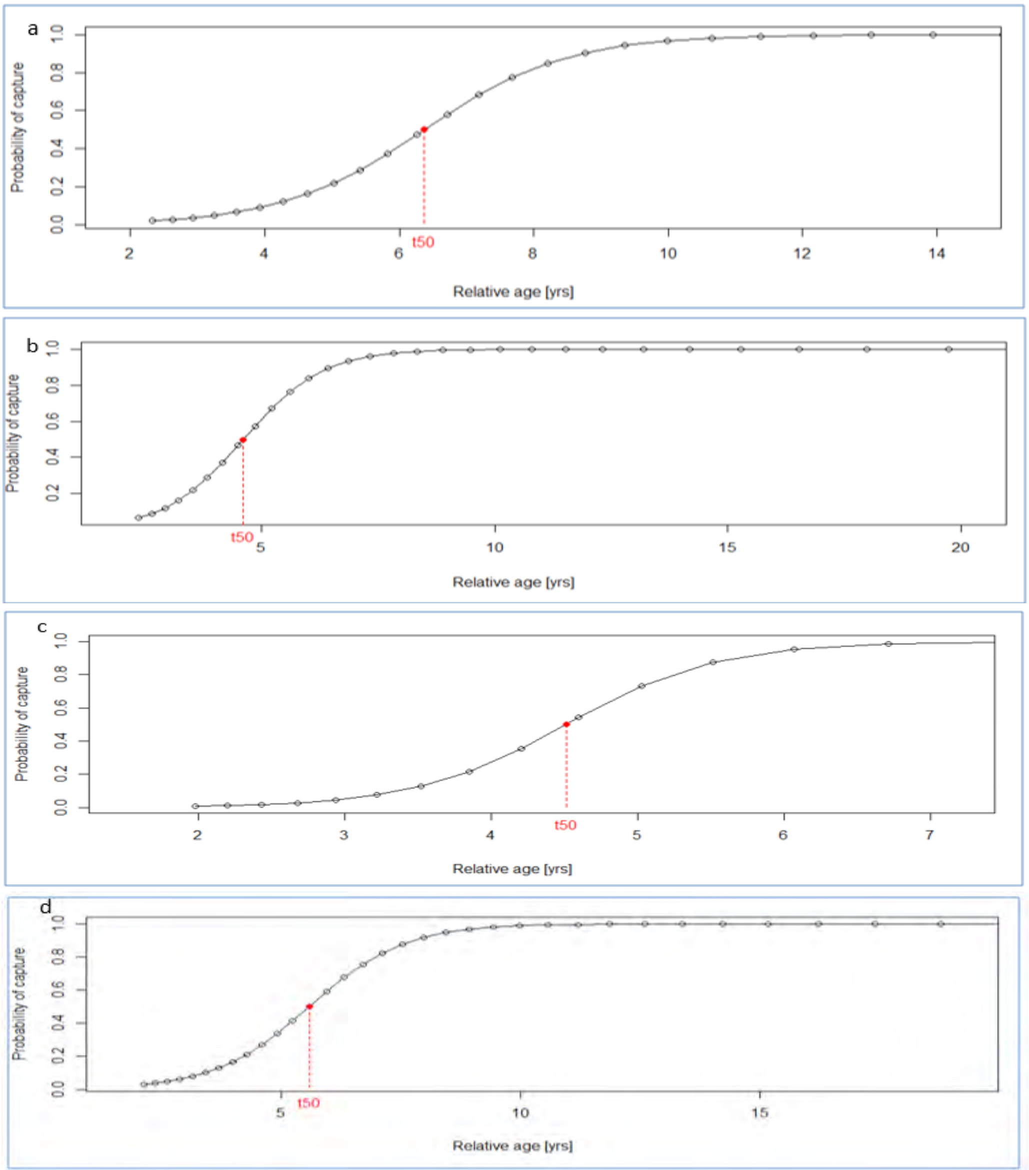

Figure 3 Probability of capture (in years) of a) *Alestes baremoze*, b) *Hydrocynus forskalii*, c) *Hemisynodontis membranaceus* and d) *Labeo coubie*

natural mortality rate (M) ranged from 0.230 per year to 0.480 per year. The instantaneous fishing mortality (F) rate ranged from 0.276 per year to 0.857 per year. *A. baremoze* had the lowest natural mortality rate of 0.230 per year while *H. membranaceus* had the highest M value of 0.480 per year. *A. baremoze* experienced the lowest fishing mortality rate (F = 0.276 per year) while *H. membranaceus* had the highest rate of fishing mortality (F = 0.857 per year). The exploitation rate (E) was within the range of 0.545 to 0.732. *L. coubie*

TABLE 4
Mortality parameters of the assessed fish species

Species	M	F	Z	E
Alestes baremoze	0.230	0.276	0.506 ± 0.222	0.545
Hydrocynus forskalii	0.243	0.299	0.542 ± 0.206	0.552
Labeo coubie	0.227	0.619	0.846 ± 0.171	0.732
Hemisynodontis membranaceus	0.480	0.857	1.340 ± 0.148	0.640

M= Natural mortality rate

F= Fishing mortality rate

Z= Total mortality rate

E = Exploitation rate

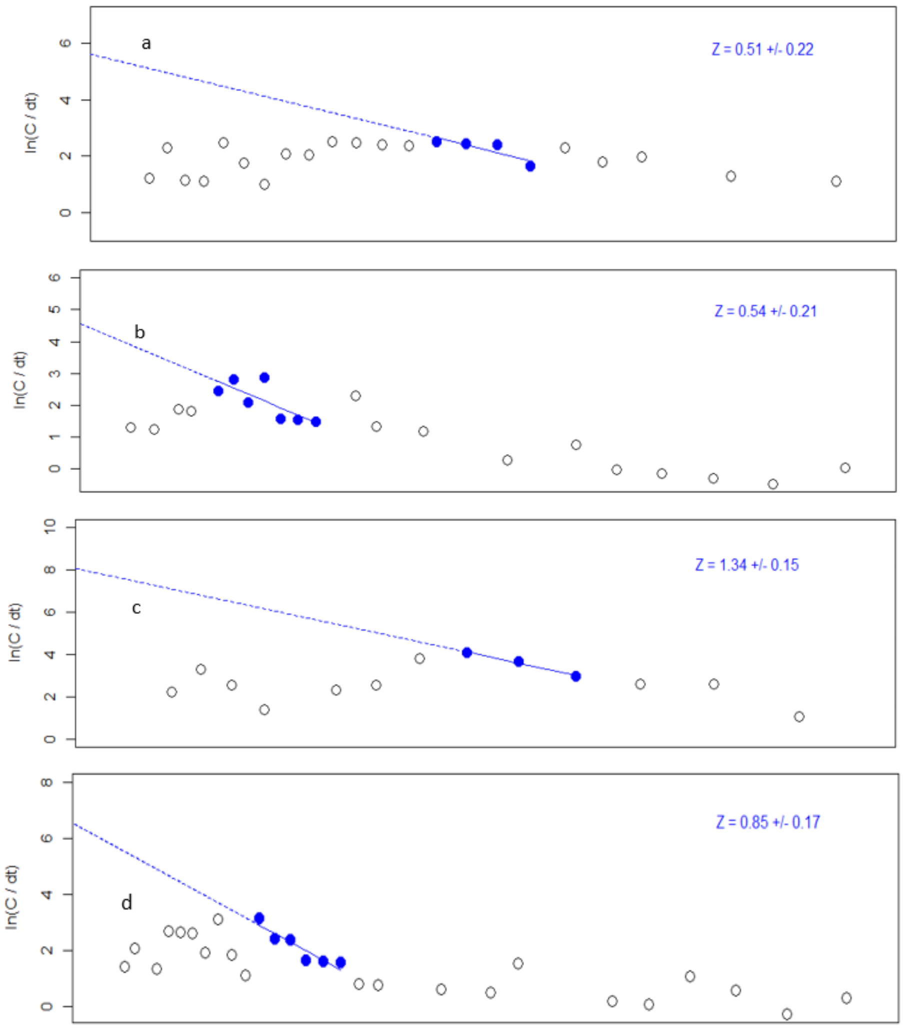

Figure 4 Length catch curve for total mortality rate a) *Alestes baremoze*, b) *Hydrocynus forskalii*, c) *Hemisynodontis membranaceus* and d) *Labeo coubie*

had the highest level of exploitation (0.732) while *A. baremoze* had the lowest E (Table 4).

Biological references points

Table 5 shows the biological reference points for the assessed fish species. Figure 5 shows the F_{msy} and $F_{0.5}$ of the assessed fish species. The biological reference points estimated for the F_{msy} 2.08 per to 4.48 per year with *H. membranaceus* recording the highest F_{msy} and *H. forskalii* recorded the least. The maximum exploitation rate (E_{msy}) was highest

TABLE 5

Biological reference points for the assessed fish species

Species	F_{msy}	$F_{0.5}$	E_{msy}	$E_{0.5}$
Alestes baremoze	3.32	1.24	0.935	0.844
Hydrocynus forskalii	2.08	0.64	0.895	0.725
Labeo coubie	3.80	1.64	0.944	0.878
Hemisynodontis membranaceus	4.48	1.28	0.903	0.726

F_{msy} = Fishing mortality rate at maximum sustainable yield

$F_{0.5}$ = Fishing mortality rate at 50% exploitation of virgin stock

E_{msy} = Exploitation rate at maximum sustainable yield

$E_{0.5}$ = Exploitation rate at 50% exploitation of virgin stock

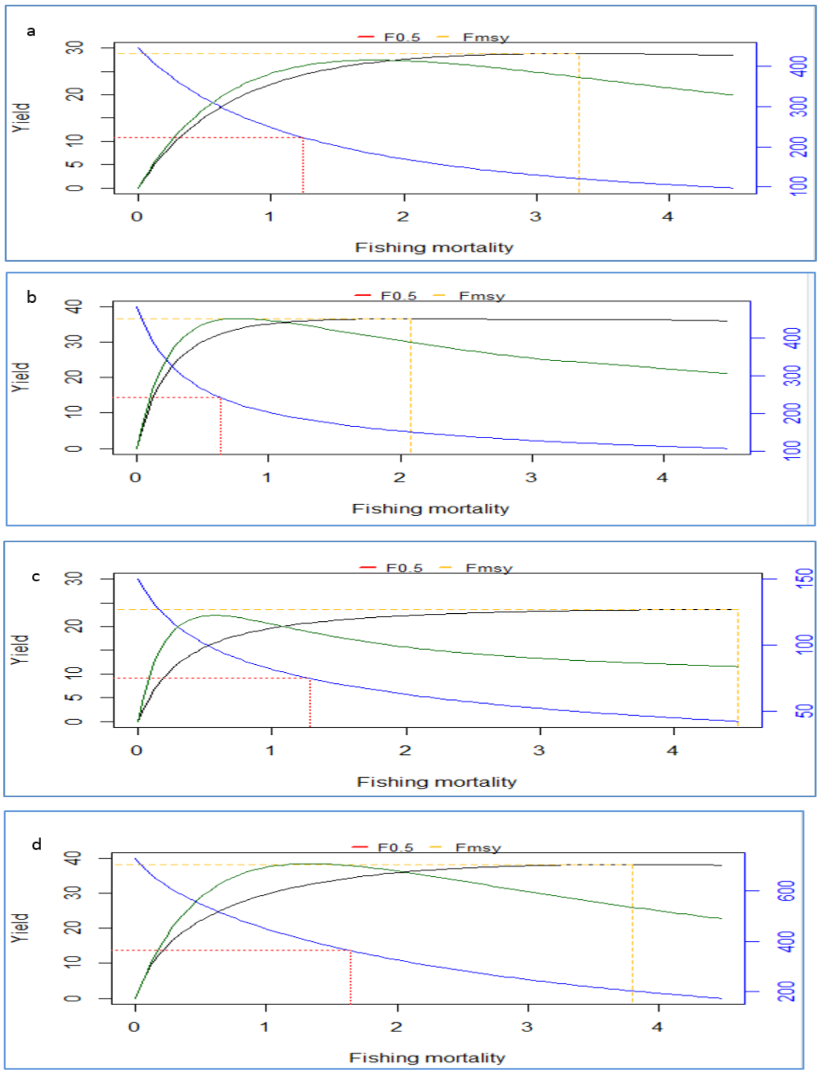

Figure 5 Yield plot for biological references points a) *Alestes baremoze*, b) *Hydrocynus forskalii*, c) *Hemisynodontis membranaceus* and d) *Labeo coubie*

for *L. coubie* (0.944) and lowest in *H. forskalii* (0.895).

Discussion

The estimated asymptotic length for species was invariance to estimates as documented by other studies such as Abobi and Ekau (2013) from the White Volta and Ofori-Danson (1999) and de Graaf & Ofori-Danson (1997) from stratum VII of Lake Volta. The variation in length at infinity for the assessed fish species in relation to other studies could be due to differences in the mesh size of the fishing gear used, the level of fishing pressure, the genetic makeup of the organisms and environmental parameters (Ahmed and Tagago 2013; Berg et al., 2018). The estimated growth rate (k) of the investigated fish species was lower than 0.34 per year, suggesting that these species are portraying slow growth rate, which is reflected in the longevity of these fish species (Kienzle 2005). In terms of growth performance, the growth performance index per year for all species in the current study was lower compared to other studies (such as de-Graaf and Ofori-Danson 1997 from stratum VII of Lake Volta which is also part of the Volta Basin). Changes in the growth performance index could be due to differences in the physical and chemical composition as well as the biological factors in the studied locations such as temperature, dissolved oxygen, abundance of feeding items, etc. Furthermore, the low growth performance index for the assessed fish species suggests that these species are showing signs of slow growth rate (Kalhoro et al., 2014). Further to this, should the stock of these fish species be depleted, the rate of rebuilding will be slow as well, with the consequences being more of biological than economical. Generally, changes in growth rates could relate to ecological differences, feeding variability and fishing pressure (Olopade et al. 2019).

With the exception of *H. membranaceus*, the ratio of the length at first capture to the asymptotic length (Lc) of the remaining species was slightly lower than 0.50 while that of *H. membranaceus* was 0.50. According to Pauly and Munro (1984), Lc lower than 0.50 signifies abundance of small sized fishes and vice versa. Thus, from the current study, the composition of assessed fish species barely comprised of small-sized individuals which suggests that the rate of growth overfishing is not too intense within the stock of the assessed fish species. The estimated length at first maturity (Lm_{50}) which is taken as a function of the asymptotic length was higher than the estimated length at first capture for all the assessed fish species. This implies that species become vulnerable to fishing gears before they even reach maturity, which has massive repercussions on the recruitment potential. This observation may result in recruitment overfishing which could collapse the fishery in the future if no management strategies are put in place.

Mortalities, fishing (F) and natural (M) rates are important for understanding the rate of population decay (Pauly 1983; Sparre and Venema 1998). The fishing mortality for *A. baremoze* and *L. coubie* were lower than estimates reported by Abobi and Ekau (2013) from the White Volta and DeGraaf and Ofori-Danson (1997) from stratum VII of Lake Volta. Nonetheless, the estimate of natural mortality rate for *A. baremoze* was higher than estimates recorded by Yousif and Ahmed (2012), Abowei and Hart (2009) and Villanueva et al. (2006) from the Nile River, Niger Delta and Bargre Reservoir, respectively. Even though these mortality rates are from different water bodies, there is much to be gained by sharing ideas in pro-poor inland fisheries system in Africa (Cooke et al., 2014). In Africa, most fisheries are open access with social and economic factors as driving forces. The Black Volta goes beyond the territory of Ghana, hence many institutions, stakeholders and interest come to play. This calls for collaborative fisheries data sharing. The natural mortality for *A. baremoze*, with the exception of estimates by Yousif and Ahmed (2012), was lower than the values reported by studies by Abobi and Ekau (2013), Abowei and Hart (2009) and Villanueva et al. (2006). For *L. coubie*, the natural mortality value from the current study was lower than the estimate provided by deGraaf and Ofori-Danson (1997). Comparatively, the variation in mortality rates for the assessed fish species may be due to differences in computation procedure, the intensity of fishing activities and the severity of environmental factors. The reliability of M values obtained was verified using M/K ratios which are reported to be within 1.2 to 2.5 (Sparre and Venema 1998), for the values to be valid for scientific interpretations and deductions. The M/K ratios were within the accepted range of accuracy and indicate that the values are accurate and reliable for scientific inferences and prescription of management measures. Comparatively, the fishing rate from the current study was relatively higher than the estimated natural mortality which suggests that the assessed fish species are more prone to fishing activities than naturally induced morality situations such as predation, competition and diseases. Potential explanation for this observation is the gradual increase in fishing activities since 1997. Furthermore, the estimated fishing mortality was lower than the biological reference points (F_{msy}) which could suggest that the assessed fish is not under intense fishing pressure.

Other studies such as that of Abobi and Ekau (2013), Yousif and Ahmed (2012) as well as Abowei and Hart (2009) all recorded lower levels of exploitation for *A. baremoze*. However, deGraaf and Ofori-Danson (1997), documented that *L. coubie* is slightly overexploited in the Stratum VII of Lake Volta. Furthermore, the exploitation rate of the assessed fish species from the current study was greater than the optimal level of exploitation reported by Pauly (1983). According to Pauly (1983), the optimum level of exploitation of fish species is 0.5 which implies that the fishery of the assessed fish species is overexploited. Nonetheless, the estimated maximum exploitation rate (E_{msy}) was relatively higher than the calculated current exploitation rate for all the assessed fish species. This finding denotes that even though the species are currently over-exploited, their fishery is far from collapse. Nonetheless, to reduce the fishing pressure on these commercial species, there is the need to institutionalize appropriate fisheries management options.

Conclusions

From the study, the species assessed from the Black Volta before its impoundment were identified as slow growing species. Furthermore, all the assessed fishes are experiencing recruitment overfishing as more individuals get caught before reaching the maturity stage. Growth overfishing was found not to be too intense within the stock of the fish species assessed. Again, all the assessed fish species are currently overexploited, which could lead to a possible collapse in the future. Therefore, it is recommended that i) fishing effort and fishing gear control, ii) closing areas to fishing and iii) protection of the aquatic environment should be instituted by the Bui Power Authority, Environmental Protection Agency and Water Resources Commission.

Limitation

The data points for assessing the stock status of the species were very small hence application of the results in other studies should be done with caution.

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