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Population Parameters of *Clarias gariepinus* (cat fish) in Gubi dam, Bauchi State,Nigeria

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1 SUMMARY

Studies on the population parameters of *Clarias gariepinus* (cat fish) in Gubi dam, Nigeria was carried out to determine the curvature parameter, asymptotic length, mortality rates and exploitation rate of the fish in the dam. Length-frequencies data of 272 *Clarias gariepinus* obtained from six fishermen ranged from 8 – 41cm (total length to the nearest cm. Selection ogive curve was used to adjust length-frequencies data for the interphase months from which monthly catches from January to December, 2008 were estimated using proximate catch and population analysis (PCPA). The assessment revealed that asymptotic length ($L\infty$) = 43cm, growth coefficient (K) = 0.65/year, growth performance (Φ) = 3.08, age at zero length (to) = -1.37 years and natural, fishing and total mortality rates were found to be 1.20/year, 0.22/year and 1.42/year, respectively. Over 88 % of the landings were below minimum exploitable sizes (L_{opt} = 27cm) and for that "close area" (spawning ground) fishing far from the spawning grounds is recommended. Increase of current fishing effort (7300 man days/year) by 29 percent will enable the fishermen attain maximum sustainable yield (MSY) of 16.53 tons compared to current yield of 12.81 tons per annum, this can be achieved if the policy makers enforced the minimum legal length (Lg) of 15cm. of the fish to be caught in the dam.

2 INTRODUCTION

Nigeria is blessed with numerous inland water bodies. There are over 323 man-made lakes in the country occupying 137,802 hectares of the land (Ita, 1993). The need for sustainability of fishing resources prompted researchers to investigate the potentials of the water bodies for fish production (Abdul & Omoniyi, 2007). Stock assessment of fish in the tropics has been carried out by researchers such as Pauly, (1980) and (1984), Saila and Reedel, (1980), Pauly and David, (1981), Munro (1983) and recently, King (1997), Sparre and Venema (1998), Cubillos, (2003) and Abdul and Omoniyi 2007. Despite these studies, there is still insufficient information on stocks of lentic water bodies of the tropics as compared to the extensive literature available on temperate regions (Spearre & Venema, 1998).

Gubi Dam was constructed to provide water to Bauchi metropolis. Abdullkarim *et al* (2005) identified eight (8) fish species in the dam – *Alestes nurse* (tiger fish) , *Oreochromis niloticus* (Nile perch) , *Barilus senegalensis* (carp), *Clarias gariepinus* (cat fish), *Distinnchodus engycephalus, Labeo senegalensis* (carp), *Schilbe mystus* (butter fly fish) *and Hemichromis faciatus*(golden fish)i Fishing activities at the dam are mainly traditional, characterized by the use of traditional fishing gears such as *Birgi*, *Mari* (nets), *Kugiya* (lines), *Mali* and *Undurtu* (fishing traps). This current study was carried out to assess the stock of *Clarias gariepinus* (North African Catfish) in the dam.

There is paucity (insufficient) of information on the stocks of Gubi dam except the work of Abdulkarim *et al,* 2005who reported that *Clarias gariepinus* is among the commercial fishes caught in the dam. According to Sparre and Venema (1998) dynamic pool models of fish stock assessment are initially developed on age dependent data, aging tropical fish species from hard parts requires special skills and equipments that have proven difficult to obtain especially in rural areas. This has led to the development of length frequencies based approaches for estimating growth and mortality parameters (Rosenberg & Beddington, 1988).

3 MATERIALS AND METHODS

3.1 Study Area: Bauchi State is located between latitude 10°17' and longitude 9°49' with a mean annual rainfall of 1099 millimeters (mm) and mean water temperature of 27.4°C (FAO, 1988). The vegetation comprises mainly of shrubs interspersed with trees. The state has a projected total surface area of reservoirs and lakes of 5259.0 ha (Ita & Sado, 1985). Gubi dam is an earth fill dam with clay core. It has a total storage capacity of 3.84 x 10^6 m^3. The maximum height of the dam is 27 m, length of the embankment 3.8 km, freeboard 3m and spill way 70m. The dam has a catchment area of 590 ha and an expected yield from the reservoir of approximately 90,000 m^3/day.

Abdulkarim *et al.,* (2005) identified the four main rivers recharging Gubi dam as Gora, Makaranta, Ran and Tagwaye with their respective discharge points as Kumi, Kwarinkiri, Lakarina and Tatumari. Six fishing spots were identified: Chinbi, Dutesen tatumari, Gindin giginya, Kwarinkira, Larkarina and Malugubi as well as six landing sites: Bayala, Kumi, Kwari, Tatumari, Tsamiya and yashi. Kwari also known as kwata is the most popular and busiest landing site of all.

3.2 Sampling techniques: Total catch per landing of *C. gariepinus* was taken from six (6) randomly selected fishermen once a week for two months (September and October), the total catch for the entire period was 272.

The fish were counted after landing at Kwari landing site. Total length of fish (measured to the nearest 1 cm) in a sub-sample was taken concurrently within the study period. The weight of the fish was taken using 20kg weighing balance.

Based on an interview conducted with the fishermen and census taken, it was found that there is an average of 30 fishermen per day during the rainy season and 10 fishermen per day during dry season in the dam. They were used as a constant unit of effort for the respective seasons. Under the assumption of a unified landing site, the sampled catches for two months (September and October were used as interphase months for rainy and dry seasons respectively) and used to estimate average catches per fisherman per day as catch per unit effort (CPUE) for each month. The formula of Sparre and Venema (1998) was used to calculate estimated catch.

Effort x CPUE = Estimated catch

To estimate the economic value of the catches, interviews were conducted with fishermen at three different landing sites (Kwari, Yashi and Tatumari) as well as observations of their trading pattern.

3.3 Adjustment of sub-sample length-frequencies data: The length-frequencies data were adjusted using the selection curve as suggested by Sparre and Veneme (1998), with modifications as follows:

L ∞ was estimated using method of Pauly (1983):

$L_\infty = L_{max} / 0.95$

Where L max is the maximum length of fish in the sample.

The length – frequencies are corrected for selection using value of 1.0 for curvature parameter (K) and estimated L ∞.

3.4 Estimation of curvature parameter (K) and growth performance index (ǿ): The Adjusted length-frequencies were used to calculate percentages of each length group frequencies. Using the percentages, the values are raised to the total catches for the two interphase months. The raised catch frequencies are used to estimate K using the combined deductions of Cubillos (2003) and Pauly (1980), similar to that of Abdul and Omoniyi, (2007).

$$K = 0.9849 \frac{\times \ T^{0.463} \times w^{2.8927}}{L_\infty^{0.297} \times \ 3(1-w)}$$

Where T ° is annual mean environmental temperature (°c) and w = ratio of critical length (L*) to asymptotic length (L_∞) i.e. L*/L∞ and according to Cubillos (2003), w is assumed to be a constant for all species given as 0.62.

Growth performance index (ó) was determined according to Pauly (1979) using the formula:

$$\phi = \text{Log } K + 2 \text{ Log } L_{\infty}.$$

3.5 Estimation of mortality rates, optimum size (L_{opt}) and length at first spawning (Lm): Natural mortality rate (M) was estimated using Cubillos (2003) empirical model

$$M = (3K (1-w))/w.$$

Total mortality rate (Z) was estimated using Linearized length converted catch curve as described by Sparre and Venema (1998) using the equation below

$$\ln (Ct/ t) = a - Z t$$

Where: Ct is catch at age t, t is age corresponding to mid length, a is Constant and Z = Constant and total mortality rate:

$$t = (1/K) \times \ln [(L_{\infty} - L1) / (L\infty - L2)]$$

Fishing mortality rate (F) was estimated using the equation $Z = F + M$ Beverton (1992).

Using Beverton (1992) equation L_{opt} in cm was estimated: $L_{opt} = L\infty \times [3/ (3+M/K)]$ based on Beverton and Holt (1959) suggestions that $Lm/L_{\infty} = 2/3$ thus $Lm = (2 \times L_{\infty})/3$ where Lm is the length at first maturity.

3.6 Estimation of Exploitation Rate (E), Yield per Recruit (Y/R) and Biomass per Recruit (B/R): Exploitation rate (E) was estimated using the equation $E = F/Z$ and Yield per recruit (Y/R) was estimated according to the method adopted by Beverton and Holt (1966).

$$Y/R = F/K \times A \times W\infty \times [(1/Z) - (3u/Z+1) + (3u2 /Z+2) - (u3/Z+3)]$$ and $$A = [(L_{\infty} Lc)/(L_{\infty} - Lr)]^{M/K}$$

Where F is fishing mortality rate, K is curvature parameter, W_{∞} is asymptotic body weight, $L\infty$ = asymptotic length, Lc is Length – at First Capture, Lr = Length at Recruit, Z is the Total mortality rate and M is Natural mortality rate.

$U = 1 - (Lc/L_{\infty})$ defined as fraction of growth to be completed after entering into exploitation Phase.

According to Beverton and Holt (1954)

$$B/R = Y/R \times 1/F$$

3.7 Estimate of yield (Y) from total Catches, estimate of relative population per annum and estimate of mean Biomass (B) per annum: Yield (Y) and relative population were estimated using proximate catch and population analysis (PCPA) as a method developed in this study.

- Mean Biomass (B) was estimated from the following equation

$$Y = F \times B \Rightarrow B = Y / F$$

3.8 Estimation of Maximum Sustainable Yield (MSY) and Economic Value of Yield per annum: MSY was estimated using Cadima's formula (in Troadec, 1977),

$$MSY = 0.5 \times Z \times B$$

Where B is average annual biomass and Z is total mortality rate.

However, the "0.5" was replaced by "0.2" as suggested by Beddington and Cooke (1983).

Maximum sustainable yields of fishing mortality (F_{MSY}) and effort (F_{MSY}) was estimated using results obtained form yield (Y) and mean annual biomass (B):

$$MSY = F_{MSY} \times B \Rightarrow F_{MSY} = MSY/B$$

$$F = q \times f \text{ then } F_{MSY} = q \times fmsy \Rightarrow fmsy = F_{MSY} /q$$

The economic value of yield per annum was estimated based on the following criteria

a. Fishes are traded in number at Gubi Dam

b. Observed pattern of trade shows that fish of length less than 25 cm are classified to be small while from 25cm above are large sizes.

c. Live *Clarias gariepinus* are economically more valuable than dead ones, and the ratio of live to dead caught is approximately 7:3 out of every 10 catches.

3.9 Estimation of other important parameters

1. Using the inverse Von Bertalanffy growth $t = t_0 - 1/K \times \ln [1 - (L(t) / L\infty)]$ and from results of Lm, L_{opt} their corresponding tm, t opt are estimated by putting $t_o = 0$.

2. Age at zero length (t o) was estimated using Pauly's (1979) Method:

$$\text{Log} (- t_o) = 0.392 - 0.275 \log (L_{\infty}) - 1.038 \text{ Log} (K)$$

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3. From the empirical method developed in this study asymptotic weight (W∞) shall be estimated as follows: $W\infty = (W\,max / L^3\,max)\,L^3\infty$
Where W max is the Weight of maximum length of *C. gariepinus* in the sample.
4. The mid-weights (W) corresponding to mid-length (L) was estimated using weight – based Von Bertalanffy growth equation; however by using their corresponding ages t

$$W(t) = W\infty\,(1 - \exp(-K \times (t - t_o)))^{s}$$

Where to = 0 and t = age of mid – length (L)
5. Age at recruitment (Tr) was estimated using inverse weight base Von Bertalanffy equation;

$$t = to - 1/k \times \ln(1 - (w(t) / W_\infty)^{1/3})$$

Putting t o = 0 and W (t) = Y/R
6. Corresponding length at recruitment (Lr) was estimated using length based Von Bertalanffy growth equation:

$$L(t) = L\infty \times (1 - \exp(-K(t - t_o)))$$

7. Growth per year as a measure of change in length per year was estimated using the formula below:

$$t = K(L_\infty - L(t))\ \text{cm/year.}$$

Where
L is L2 – L1 i.e. upper limit of length – lower limit within a length class interval.
t is the change in time from length L1 to L2, L (t) is mid - length of L1 and L2 i.e.

$$(L1 + L2) / 2$$

8. Maximum age (tmax) using Pauly (1980) method was estimated as; t max = approximately 3/K

4 RESULTS

Table 1: Sub-sample of length – frequencies of *Clarias gariepinus* of Gubi dam, adjusted for selectivity using selection ogive curve. L∞ = 43cm, K = 1.0 per year, t50% = 0.975 year and to = 0 year.

L1 – L2	L(cm) (L1 + L2)/2	T(Years) (L1 +L2)/2	C(L1,L2) Obs.	St Est	C(L1,L2) Est
Total			**272**		**1243**
8 – 12	10	0.265	49	0.10	490
12 – 16	14	0.394	35	0.14	250
16 – 20	18	0.542	28	0.21	133
20 – 24	22	0.717	69	0.31	223
24 – 28	26	0.928	32	0.46	70
28 – 32	30	1.196	26	0.65	40
32 – 36	34	1.564	19	0.85	23
36 – 40	38	2.154	12	0.97	12
40 – 44	42	3.761	2	1.00	2

L∞ = Asymptotic length, K = Growth coefficient, t50% = Age whereby 50% of the stock caught are retained in the gear, to = Age at zero length, C (L1, L2) obs = observed catches in numbers (L1, L2 length frequencies)
L1 - L2 = upper and lower limits of length class., L = mid – length, t = Age of mid-length
C (L1, L2) est. = Adjusted L1, L2 length frequencies, St est. = estimated selection ogive curve.
St est. = 1/ [1 + exp (T1 – T2 x t)] Where = T1 = 2.96 and T2 = 3.00

Table 2: Interphase months (September and October, 2008) total catches of *Clarias gariepinus* in Gubi dam expressed as length frequencies.

L1 – L2 (cm)	C (L1, L2) est.	C (L1, L2) est. Percentage	Sept. – Oct. C (L1, L2).
8 – 12	490	39.42	11645
12 – 16	250	20.11	5941
16 – 20	133	10.70	3159
20 – 24	223	17.94	5300
24 – 28	70	5.63	1663
28 – 32	40	3.22	951

32 – 36	23	1.85	547
36 – 40	12	0.97	287
40 – 44	2	0.16	47
Total	**1243**	**100.00**	**29,540**

C (L1, L2) = number caught for each length class.
C (L1, L2) est. = Adjusted L1, L2 length frequencies

Table 3: Table: Relative population per length group with respect to annual catches of *Clarias gariepinus* in Gubi dam for the year 2008.

L1-L2	**t**	**Percentage**	**Annual**	**Cumulative**	**Relative**
(L1+L2)/2	C (L1, L2)		C (L1, L2)	percentage	population
8-12	0.407	39.42	97,108	39.42	105,552
12-16	0.606	20.11	49,539	59.53	56,294
16-20	0.834	10.70	26,359	70.23	31,758
20-24	1.103	17.94	44,194	88.17	55,942
24-28	1.257	5.63	13,869	93.80	18,249
28-32	1.840	3.22	7,932	97.02	11,839
32-36	2.406	1.85	4,557	98.87	7,724
36-40	3.310	0.97	2,390	99.84	4,979
40-44	5.786	0.16	394	100.00	1,407
Total		100.00	246,342		293,744

Where L1 – L2 is the length interval, t is average age of the fish with the length interval, Ct is catch at certain age and CT is the cumulative catch for the age.

Table 4: Population parameters of *Clarias gariepinus* in Gubi dam

Parameters	Value
Maximum length caught (L max) TL*	41cm
Length at – first – capture (Lc) TL	8cm
Legal length (L)	15cm
Asymptotic length (L∞) TL	43cm
Length at first maturity (Lm) TL	29cm
Length at recruitment (Lr) TL	9cm
Optimum size or length (Lopt) TL	27cm
Asymptotic weight (W∞)	636g
Growth performance index (Φ)	3.08
Growth coefficient or curvature (K)	0.65 per year
Natural mortality rate (F)	1.20 per year
Total mortality rate (Z)	0.22 per year
M / K ratio	1.42 per year
L_{opt} / L_∞	1.85
Lm / L_∞	0.61
Age at zero length (to)	0.67
Age at maturity (tm)	- 1.37 year
Age at first capture (Tc)	1.69 year
Age at recruitment (Tr)	0.317 year
Age at optimum size (Lopt)	1.23 year
topt / tmax	0.27
Condition factor (q)	0.008g. cm^3

*TL = Total length
L_{opt}/L_∞ is the ratio between optimum catch and asymptotic length
Lm / L_∞ is the ratio between length at fist maturity and asymptotic length of the fish species

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Table 5: Age, corresponding length and growth rate of *Clarias gariepinus* in Gubi dam.

Age Years	Corresponding Length (cm) / Age	Growth rate / Length/ Age
1	20.55	14.59
2	31.28	7.62
3	36.88	3.98
4	39.81	2.07
5	41.33	1.09
6	42.13	0.57
7	42.55	0.29

As fish gets older the rate of growth reduces. The highest growth rate (14.59cm / year) wasrealized at 1 year old and lowest growth rate (0.29cm / year) at 7 years old.

Table 6: Monthly estimated catches of *Clarias gariepinus* of Gubi dam using proximate catch and population analysis (PCPA).

Month	Proximate Catch
January	4747
February	4642
March	4782
April	5225
*May	20,159
*June	74,058
*July	56,670
*August	38,702
* *September	25,200
October	4,340
November	3885
December	3932
Total	246,342

*Months of rainy season. Others are in the dry season.

Table 7: Stock status of *Clarias gariepinus* in Gubi dam (December, 2008)

Stock Status	Values
Yield per recruit (Y/R)	34.60g / R
Biomass per recruit (B/R)	157.27g /R
Annual biological yield (Y)	12.808 tons
Mean Annual Biomass (B)	58.21 tons
Yield recruit (R' per year)	370141
Annual Economic yield (₦)	14,791,830
Biological maximum sustainable yield (MSY)	16.53 tons
Current effort (man days per year)	7,300
*MSY effort (man days per year)	9,420
Annual catch (in number)	246340
Exploitation rate (E)	0.16

5 DISCUSSION

The stock assessment of *Clarias gariepinus* in Gubi dam revealed that over 88% of the landed fish in terms of length frequencies data are below the exploitable size 27cm. Ita (1993) reported that Nigerian inland water law stipulated that *Chrysichthys nigrodigitatus* (Bagrid catfish) should attain the minimum standard length of 26cm before it is caught. It is obvious that the fishermen in the dam have been fishing in spawning grounds; which implies adverse pressure on potential spawners. Upstream and downstream migration of *C. gariepinus* may be responsible for the Catch Per Unit Effort of 28 *Clarias gariepinus* per fisherman in the rainy season and 14 fish in the dry season. This resulted into reduction from 30 man days for fishing activities in the rainy season to 10 man days in dry season.

The growth coefficient (K) value from this study was determined to be high (0.65 per year) compared to the low value reported elsewhere in Asia (fishbase.org, 2003) of 0.09 per year for the same species. This may probably be due to high mean annual water temperature (27^{o}c)in Bauchi, Northern Nigeria and partly as a result of dominance of juveniles in the catches. Furthermore, fish growing in different water bodies have different K values. It is observed that K value is higher in young fish (1 year old) with growth rate of 14.59cm per year compared to older fish (5 years old) with 1.09cm per year. M/K ratio is the measure of validity of mortality estimate and it is found to be 1.85, it is within the range of 1.5 to 2.5 recommended by Beverton and Holt (1959).

The optimum body size (Lopt) to asymptotic length (L∞) ratio ($L_{op}t/L_\infty$) was found to be 0.61 which is in line with the findings of Cubillos (2003) that assumed the optimum body size (L_{opt}) to asymptotic length (L∞) ratio (L_{opt}/L_∞) to be constant with an average of 0.62 and minimum and maximum values of 0.323 and 0.938, respectively, for all fish species.

The low value of fishing mortality (F = 0.22) obtained in Gubi dam compared to high value of total mortality (Z = 1.42) resulted in low exploitation rate of *C. gariepinus* (E=0.16). E value obtained in the study is an indication that fishery in Gubi is not being optimally exploited as recommended Gulland (1971). For optimally exploited stock, F = M, resulting in a fixed E = 0.5. However, in the determination of the maximum sustainable yield (MSY) the suggestion of Beddington and Cooke (1983) is used by replacing "0.5" with "0.2" in the Cadima formula so as to avoid overestimation of MSY (Troadec, 1977). Generally, the growth parameters (K and L∞) and mortality rates (M, F and Z) are the basic inputs for determination of the stock status as shown in Table 7. Since these parameters compare favorably with what is established in published literature, then the stock status data is also reliable.

The population estimate of *C. gariepinus* (Table 3) was a relative population within the range of what is termed "fishable stock" and not the actual population of fish in the dam for the year because PCPA estimates catches, relative population and "ideal population". The latter corresponds to the population in the dam but that was not within the scope of this study.

The stock assessment of *Clarias gariepinus* in Gubi dam revealed that there was fishing pressure on fish below the optimum sizes and catches were highest during the rainy season. This indicated that the fishermen were probably fishing in spawning grounds. There is great need, therefore, of regulatory body to judiciously monitor the activities of fishermen operating in the dam. This will eventually boost fish production potentials of the dam.

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