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An Assessment on Population Parameters of the African Catfish, *Clarias gariepinus* (Burchell, 1822) from Burullus Wetland, Egypt

Mohammed G. Desouky[1]*, Ahmad M. Azab[2], Emrah Şimşek[3], Aydin Demirci[3], Ahmed F. Makkey[1]

[1]Fisheries Division, National Institute of Oceanography and Fisheries (NIOF), Egypt
[2]Zoology Department, Faculty of Science, Al-Azhar University, Cairo, Egypt
[3]İskenderun Technical University, Faculty of Marine Sciences, Department of Marine Technologies, Hatay, Türkiye

***Corresponding author:** dr.mgaberniof@gmail.com

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ABSTRACT

The present study aimed to determine some population parameters of the African catfish, *Clarias gariepinus* (Burchell, 1822) from Burullus Wetland, Egypt. Samples (N=431) were collected with gillnets between January and December 2022. Their lengths ranged between 18.8 and 76.7cm, and their weights ranged between 40 and 3905g. The sex ratio (1:1.18) were slightly biased toward females. The value of length-weight ratio (LWR) coefficient (*b*) was calculated as 3.14, 3.25, and 3.18 for females, males, and combined sex, respectively. Therefore, positive allometric growth was recorded. Mean values of condition factors were calculated as K= 0.737± 0.005 and K_n= 0.396± 0.002. The von Bertalanffy growth parameters were estimated as L_∞=86.4cm, K=0.25 year^{-1}, t_0= -0.35, φ=3.27 for all samples. The first maturity length (L_{m50}) was estimated at 28.61 and 30.83cm for females and males, respectively. In conclusion, although African catfish have good growth performance in this region, the *C. gariepinus* stocks in this Wetland are overexploited.

INTRODUCTION

Burullus Wetland has a diverse array of biodiversity, including both fish and aquatic flora, with a total fish output of around 91,852 in the year 2020. *Clarias gariepinus* ranks fourth in production in Burullus Wetland, with a total yield of around 2886 tons according to **GAFRD (2020)**. A multitude of studies have been conducted to investigate and delineate the physical, chemical, geological, and biological attributes of Burullus Wetland **(Manohar *et al*., 1974; Beltagy, 1985; Maiyza *et al*., 1988, 1991; Maiyza, 1992; Said & Moati, 1992; Hussain, 1994; El-Geziry, 2004; Dewidar & Khedr, 2005; Hereher *et al*., 2010; Abayazid & Al-Shinnawy, 2012; Donia & Farag, 2012; El-Adawy *et al*., 2013; El-Geziry *et al*., 2014; Assar *et al*., 2015; Hossen & Negm, 2016; El-Sayed *et al*., 2017, 2019; Shalby *et al*., 2020)**. Numerous studies have been conducted on the ecology, biology, and limnology of Burullus Wetland; nevertheless, there is a paucity of research on stock assessment and fisheries management. The concepts of "overfishing" and "sustainable ecosystem" have long been prevalent in fisheries research. Research on demographic characteristics is essential for sustainable management **(Can & Demirci, 2012; Mehanna *et al*., 2018)**.

The African catfish, *Clarias gariepinus* (Burchell, 1822), is a tropical and subtropical species capable of thriving in many environmental situations **(Turan & Turan, 2016; Şimşek *et al*., 2022)**. **Konings *et al*. (2019)** evaluated the status of *C. gariepinus* as "Least Concern" on the IUCN Red List of Threatened Species. *Clarias gariepinus* is a notable tropical freshwater fish species suitable for aquaculture **(Şimşek *et al*., 2022; Turan *et al*., 2022)**. Since 2004, *C. gariepinus* has emerged as a significant rival to the Nile tilapia (*Oreochromis niloticus*) as a principal fish species in aquaculture in Africa **(FAO, 2012)**. Recently, there has been a resurgence of interest in the commercial culture of African catfish. The African catfish's resilient traits and air-breathing ability make it an excellent option for cultivation in intensive recirculating systems.

Burullus Wetland is situated northeast of the Rosetta branch, occupying a central location along the Nile's shore and delta. It spans over 70 kilometers in length and has a breadth ranging from 6 to 17 kilometers. The present area is around 460km². The wetland is linked to the River Nile by the Bermbal Channel and to the Mediterranean Sea via the Burullus **(GAFRD, 2020)**.

The Burullus Wetland has around 30 islets adorned with abundant greenery. By 1974, agricultural land reclamation in the southern region may have reduced the wetland's area to around 460km² (110,000 feddan), and this reduction persisted **(Dumont & El-Shabrawy, 2007)**. The reduction is attributed to ongoing land reclamation initiatives along the Wetland's southern and eastern sides, as well as aquaculture activities **(Younis & Nafea, 2012)**. The Brullus Wetland is delineated from the Mediterranean Sea by a land strip including sandbars and dunes of varying widths and elevations **(Beltagy, 1985)**.

Given the economic importance of the African catfish, it is crucial to assess fish populations and implement effective management strategies in Burullus Wetland. The current research sought to ascertain several population factors of the African catfish, *Clarias gariepinus* (Burchell, 1822) from Brullus Wetland, Egypt.

MATERIALS AND METHODS

1. Data collection

Samples were weekly collected using gillnets from January 2022 to December 2022. Total lengths were measured to the closest 1.0mm, and wet weights were recorded to the nearest 0.01g. The specimens were examined, and the genders were identified.

The otoliths of the fish were then removed. Ages of all individuals were determined based on otolith measurements. Otoliths were read using transmitted light under a binocular stereoscope with 25x magnification. The length from the otolith focus rostrally (maximum radius) and radius (distance from the otolith focus to the border of the opaque region in the same direction as the maximum radius) of each ring were measured using an optical micrometer.

2. Length-weight relationship (LWR)

The length-weight relationship (LWR) of *Clarias gariepinus* was determined for females, males, and all specimens according to **Ricker (1975)** using the following equation:

$$W = aL^b$$

Where, **W** is the weight; **L** is the total length; and **a** and **b** are constants. If ***b*** is equal to 3, >3, or <3, this shows an isometric, positive allometry, and a negative allometry growth type, respectively.

The monthly length frequencies of each sample were grouped into classes of 1 interval and were laid out sequentially over one year to estimate the growth **(Froese, 2006)**.

3. Condition factors

The condition factor is used to assess the health or adiposity of fish **(Froese, 2006)**. The formulae used to determine Fulton's condition factor (K) and relative condition factor (Kn) were as follows:

$$K = \frac{W}{L^3} \times 100 \qquad \textbf{(Fulton, 1904)}$$

$$K_n = \frac{W}{aL^b} \qquad \textbf{(Le Cren, 1951)}$$

Where, **K** represents Fulton's condition factor, **W** denotes total weight (g), **L** signifies total length (cm); K_n indicates the relative condition factor; **a** is the intercept, and **b** is the slope derived from the length-weight connection.

4. Growth parameters

Growth curves for all individuals were fitted using the least-squares approach in accordance with the von Bertalanffy growth equation:

$$L_t = L_\infty * (1 - e^{-K(t-t_0)}) \qquad \textbf{(Von Bertalanffy, 1938)}$$

Where, L_t represents the total length at age t, L_∞ denotes the asymptotic length, **k** signifies the body growth coefficient, and t_0: indicates the theoretical age at zero length **(Beverton & Holt, 1959)**. The solver functions of Microsoft Office Excel 2016 were used to elucidate growth curves.

The growth performance index (Phi Prime, **φ**) was established using the given equation:

$$\varphi = \log(K) + 2\log(L_\infty) \qquad \textbf{(Pauly \& Munro, 1984)}$$

Where, **K** and L_∞ are von Bertalanffy's growth model parameters.

5. Length at first maturity (L_{m50})

The average length of first reproduction (L_m) is the height group in which 50% of the individuals are mature, separated according to the sexes, and was estimated by the formula below:

$$P = 1/\,(1 + \exp[-r\,(L - L_m)]$$

While equations preparing this equation, height groups with 4cm intervals, were created, and the numbers of mature and immature individuals corresponding to these height groups were proportioned. The equation variables and the confidence interval were estimated by the least squares method with MS Excel Solver **(King & Mcfarlane, 2003)**.

6. Mortality parameters

The natural mortality (**M**) rate (year^{-1}) in Burullus Wetland was determined using the following equation:

$$\log_{10} M = -0.0066 - 0.279 \log_{10} L\infty + 0.6543 \log_{10} K + 0.4634 \log_{10} T$$ **(Pauly, 1980)**

Fishing mortality (**F**) was determined by subtracting natural mortality (**M**) from total mortality (**Z**). To calculate natural mortality (M), a mean annual water temperature of 23°C was used, derived from the temperature range reported for Burullus Wetland during 2020–2021 **(Egyptian Ministry of Environment, 2021)**.

Fishing mortality (F) was then calculated by subtracting natural mortality (M) from total mortality (Z).The exploitation rate was determined using the accompanying formula:

$$E = (F/Z)*100$$

RESULTS

In the present study, 233 female and 198 male catfish specimens were studied. The results of age determination showed that seven age groups were detected (Fig. 1). Age groups II and III dominated these specimens. The sex ratios were found to be high in favor of females in all age groups except VI age, which is 1.76 in total. The average length of all samples was 39.1cm. The small individual measured 18.8cm and the longest individual measured 76.7cm. At the same time, the average individual weight was 741g, the smallest individual measured 4g and the largest individual weight was 3905g, respectively (Table 1 & Fig. 2).

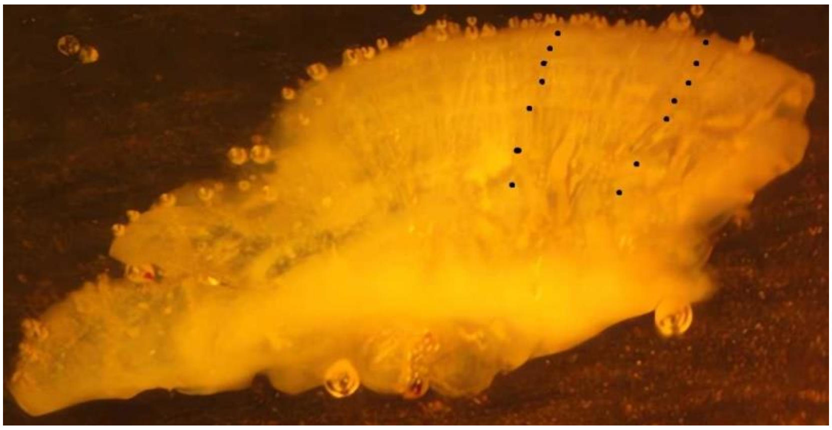

Fig. 1. Image of otolith rings observed for age estimation in a sample collected from Burullus Wetland (TL = 76 cm and 7 years old)

Table 1. Sex, age, length, and weight distribution of *Clarias gariepinus* in Burullus Wetland, Egypt

Length classes (cm)		Age groups														Total	
		I		II		III		IV		V		VI		VII			
		F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
20		14	9													14	9
25		19	18	29	23											48	41
30				37	37	18	16									55	53
35						27	35									27	35
40				1	1	12	3									13	4
45				7	3	10	3	1								18	6
50					1	6	1	5	2							11	4
55								2								2	0
60								1	2	8	2	5	3			14	7
65											3	10	15	2		12	18
70										1	1	9	8	9	1	19	10
75											1		2		8		11
Total number		**33**	**27**	**74**	**65**	**73**	**58**	**9**	**4**	**9**	**7**	**24**	**28**	**11**	**9**	**233**	**198**
Total length (cm)	**Min**	18.8	19.6	24.0	24.9	29.8	31.0	44.8	50.5	58.3	56.0	61.0	60.9	71.9	71.5	**18.8**	
	Max	25.2	25.4	47.5	48.2	51.0	49.3	60.1	58.3	72.3	71.2	70.9	75.0	76.1	76.7	**76.7**	
	Mean (L)	**22.7**	**23.0**	**29.8**	**29.5**	**37.5**	**34.8**	**52.1**	**54.5**	**61.4**	**61.3**	**65.7**	**66.5**	**74.3**	**74.6**	**39.1**	
	SD	**1.7**	**1.7**	**5.7**	**4.9**	**5.9**	**3.6**	**3.9**	**4.1**	**4.2**	**5.0**	**3.1**	**3.6**	**1.5**	**1.8**	**16.1**	
Total Weight (g)	**Min**	40	45	90	95	170	180	595	930	1340	1325	1635	1655	2985	2890	**40**	
	Max	120	135	940	875	1221	815	1545	1475	3195	3005	2780	3685	3850	3905	**3905**	
	Mean (W)	**81.8**	**85.4**	**218.9**	**197.8**	**446.4**	**306.9**	**1141.7**	**1232.5**	**2006.7**	**1807.1**	**2196.0**	**2382.3**	**3450.5**	**3517.2**	**741.0**	
	SD	**19.6**	**25.6**	**184.9**	**151.2**	**261.7**	**119.9**	**255.9**	**253.5**	**628.4**	**564.3**	**403.9**	**550.3**	**260.9**	**327.6**		

SD: Standerd deviation

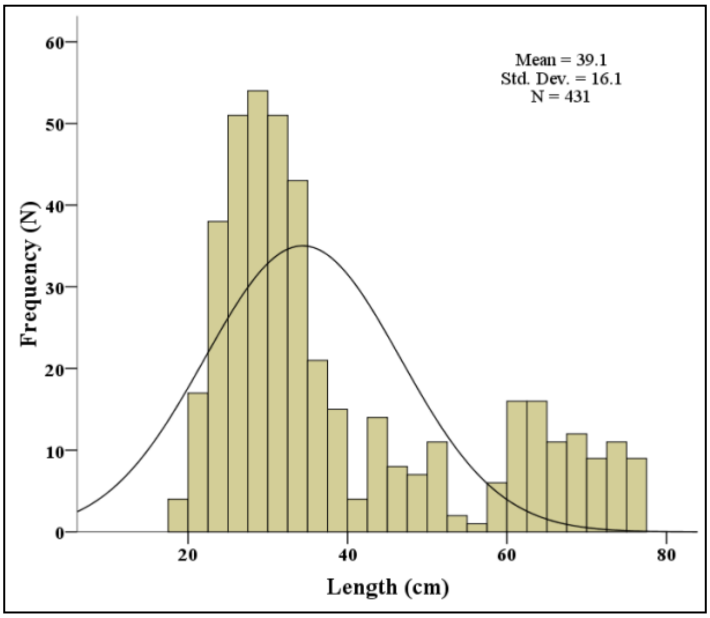

Fig. 2. Length frequencies of all samples of *C. gariepinus* collected from Burullus Wetland

The results in Fig. (3) illustrate length-weight relationships of the African catfish for female, male, and overall. Positive allometric growth was detected in female (3.14), male (3.25) and combined sex (3.18).

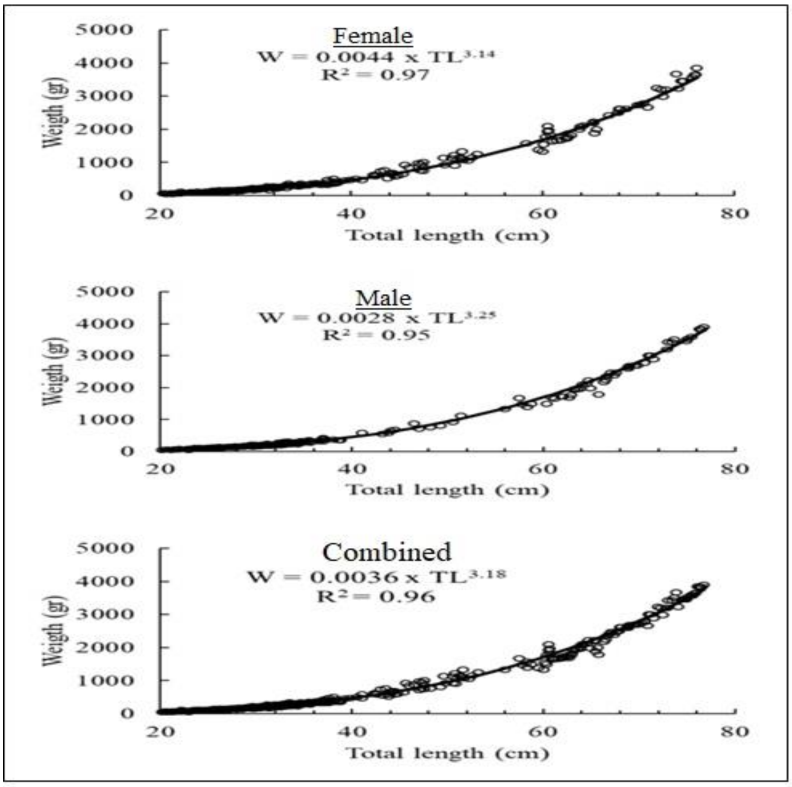

Fig. 3. Length-weight relationships of the African catfish, *C. gariepinus* in Burullus Wetland, Egypt

Fulton's condition factor (K) ranged from 0.517 to 1.252, from 0.411 to 1.631, and from 0.411 to 1.631 for females, males, and whole samples, respectively. Average K was calculated as 0.750±0.006, 0.722±0.007, and 0.737±0.005 for females, males, and all samples, respectively. The average relative condition factor (K_n) was calculated as 0.403±0.003, 0.388±0.004, and 0.396±0.002 for females, males, and combined sexes, respectively (Table 2).

Table 2. Condition factors of the African catfish, *C. gariepinus* collected from Burullus

Sex	Fulton's Condition Factor (K)		Relative Condition Factor (K_n)	
	Range	Average ±SE	Range	Average ±SE
Female	0.517 - 1.252	0.750±0.006	0.291 - 0.646	0.403±0.003
Male	0.411 - 1.631	0.722±0.007	0.230 - 0.841	0.388±0.004
Combined sex	0.411 - 1.631	0.737±0.005	0.230 - 0.841	0.396±0.002

SE: Standard error

The growth curves of the African catfish according to von Bertalanffy equation for female, male, and overall are presented in Fig. (4). Length infinity (L_∞) for females, males, and combined sex was 85.7, 97.41, and 86.4cm, respectively. The (*k)* values were found for female, male, and combined sex at 0.27, 0.22, and 0.25, respectively. The calculated growth performanc index (**φ**) values were 3.30, 3.32, and 3.37 for female, male, and combined sex, respectively.

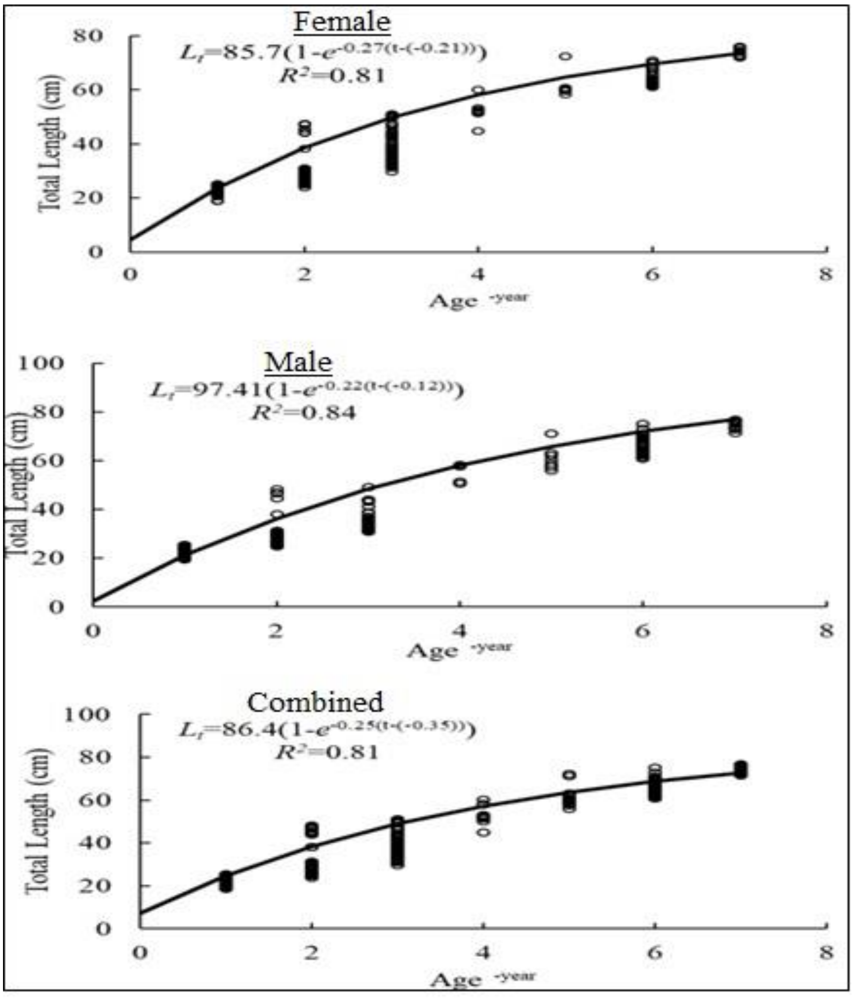

Fig. 4. Age length growth curves of *C. gariepinus* in Burullus Wetland, Egypt

Sexual differentiation was not preferred when estimating the African catfish mortality rates in Burullus Wetland. Fishing and natural mortality losses for this stock were 0.7 and 1.1, respectively. The first maturity length of the African catfish, which constitues half of the members of all samples, was found to be 25.61 and 37.83cm in females and males, respectively. The logistic curves of the first maturity length are illustrated in Fig. (5).

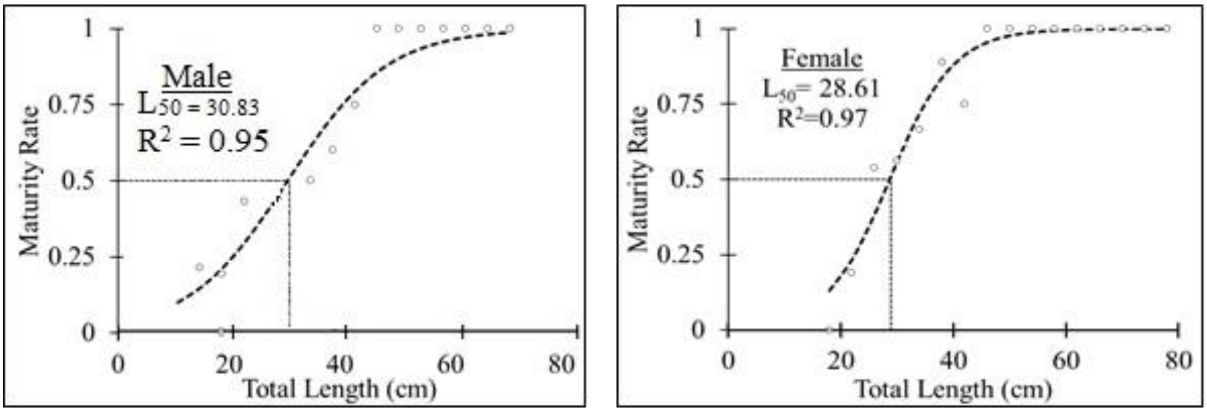

Fig. 5. The logistic curves of the first maturity length in (A) male and (B) female of *C. gariepinus* in Burullus Wetland, Egypt

DISCUSSION

Fisheries resources throughout Egypt are important and an essential source of nutrients holding an economic importance. Burullus Wetland is home to many aquatic species regionally. The annual fish composition of Burullus Wetland reveals that the African catfish is a significant species both economically and for the sustainability of the ecosystem.

Froese (2006) stated that the expected natural mortality rate (M) of wild fish populations is typically between 0.001 and 0.050 per year, depending on the species' life history and environmental conditions. This range reflects the variability in mortality rates due to predation, disease, and other natural factors that affect fish populations.

The natural mortality rate (M) for African catfish (*Clarias gariepinus*) has been reported to vary between 0.0023 and 0.07 year^{-1}, based on research conducted across different locations. In the current study, the estimated value was found to be consistent with or slightly below the overall average reported in the literature. Additionally, the parameter bb (from the length-weight relationship) for fish generally falls within the range of 2.5 to 3.5, as suggested by **Carlander (1977)**, reflecting the expected growth patterns for this species. However, in this investigation, the bbb-value exceeded 3, indicating positive allometric growth. This result was further compared with values reported in the literature, which supported the observed deviation and highlighted potential influences of environmental and biological factors.

The length-weight relationship parameters of *Clarias gariepinus* from various regions, combined with the von Bertalanffy growth parameters ($L\infty$, K, and t_0), provide a comprehensive model for evaluating and managing exploited fish populations. These parameters are essential for understanding growth dynamics and are widely used in fisheries biology to assess stock health and productivity **(Froese, 2006)**. The inclusion of the growth performance index (φ) further ensures a standardized and an accurate comparison across studies, as it integrates multiple growth parameters into a single metric **(Pauly & Munro, 1984; Şimşek *et al.*, 2022)**.

Divergences among populations of the same species arise from several factors, including growth conditions, sample characteristics (such as size range and sample size), and geographical variations. For instance, studies have shown that *C. gariepinus* populations from nutrient-rich waters exhibit faster growth rates and higher bbb-values in their length-weight relationship compared to populations from resource-limited environments **(Bruton, 1979; Adebayo & Fagbenro, 2004)**. Additionally, differences in aging methodologies significantly contribute to variability in growth parameter estimates, with misinterpretation of age being a common issue in fisheries studies **(Beamish & McFarlane, 1983)**.

Environmental factors, such as water temperature and nutrient availability, play a pivotal role in shaping growth patterns. Water temperature influences metabolic rates and, consequently, growth and mortality rates **(Pauly, 1980)**. Nutrient availability affects food supply and fish condition, leading to regional variations in growth rates and length-weight relationships **(Hogendoorn, 1981)**. These environmental and biological factors are reflected in the disparities observed in Table (3), aligning with expectations based on the known ecology and life history of *C. gariepinus*.

Such variations emphasize the importance of regional studies and the need for localized management strategies to ensure sustainable exploitation of fish stocks. By incorporating robust growth models and addressing the factors influencing disparities, fisheries managers can better evaluate and conserve *C. gariepinus* populations across diverse habitats.

When age and length parameters in a population are analyzed alongside mortality rates, they provide crucial information for assessing the dynamics of fish stocks. This integration allows for the estimation of natural losses within the population and the determination of exploitation levels, serving as a basis for understanding the balance between natural mortality (M) and fishing mortality (F). By combining principles of population dynamics with stock assessment techniques, such analyses enable the identification of overexploited or underutilized stocks. For instance, the von Bertalanffy growth parameters (L_∞ , K, t_0) provide insights into growth patterns, while length-at-age data contribute to understanding recruitment and growth variability **(Pauly, 1980)**. When paired with mortality estimates, these parameters allow for the calculation of exploitation rates (E), which indicate the level of fishing pressure relative to natural population turnover **(Beverton & Holt, 1957)**. Such analyses are integral to sustainable fisheries management as they help predict stock responses to varying exploitation pressures. By identifying optimal levels of harvest and ensuring that fishing mortality does not exceed natural replenishment rates, fisheries managers can maintain population stability and ecosystem health. This approach underscores the importance of integrating biological and ecological data into fisheries management strategies for long-term sustainability **(Jennings *et al*., 2001; Froese, 2006)**.

Table (3): A comparison of population parameters of African catfish from different areas

Area	Sex	N	a	b	r^2	L_8 (cm)	k	t_0	φ	Author
Asi River, Turkey	F	351	0.0100	2.90	-	82.94	0.15	-1.72	-	Yalçın Özdilek *et al.*, 2002
	M	366	0.0160	2.74	-	85.32	0.14	-0.69	-	
Gölbaşı Lake, Turkey	F	330	0.0075	2.99	0.95	56.98	0.23	-1.70	-	Narin, 2003
	M	154	0.0097	2.91	0.95	64.85	0.19	-1.72	-	
	A	566	0.0076	2.99	0.96	60.24	0.21	-1.61	-	
Epe Lagoon, Nigeria	A	1944	0.0160	2.88	0.97	-	-	-	-	Fafioye & Oluajo, 2005
Abu-Zaabal Lakes, Egypt	A	-	0.0785	2.37	0.97	-	-	-	-	Shalloof & El-Far, 2009
Baringo Lake, Kenya	A	54	0.0060	2.93	-	-	-	-	-	Nyamweya *et al.*, 2010
Langano Lake, Ethiopia	A	537	0.0123	2.99	0.94	-	-	-	-	Bongie, 2013
Babogaya Lake, Ethiopia	F	528	0.0143	2.95	0.96					Abera *et al.*, 2014
	M	420	0.0174	2.90	0.97					
	A	948	0.0156	2.93	0.94					
Naivasha Lake, Kenya	F	-	0.0018	3.30	0.90					Keyombe *et al.*, 2015
	M	-	0.0031	3.16	0.86					
	A	139	0.0023	3.23	0.88					
Baringo Lake, Kenya	A	2272	0.0147	2.81	-	114.30	0.37	-	-	Macharia *et al.*, 2017
Manzalah Lake, Egypt	F	701	0.0045	3.13	0.98	86.88	0.31	-0.39	-	Mehanna *et al.*, 2018
	M	540	0.0037	3.18	0.99					
Lugo Lake, Ethiopia	A	81	0.0157	2.80	0.90	-	-	-	-	Mekonnen *et al.*, 2019
Offin River, Ghana	A	353	0.0198	2.71	0.97	-	-	-	-	Dogah, 2020
Oued Takhamalte, Algeria	A	84	0.0608	2.42	0.89	53.84	0.28	-	-	Behmene *et al.*, 2021
Asi River, Turkey	F	87	0.0079	2.98	0.96	58.5	0.41	-0.70	3.15	Şimşek *et al.*, 2022
	M	92	0.0013	2.83	0.91	68.3	0.35	-0.60	3.21	
	A	185	0.0092	2.94	0.93	58.2	0.39	-0.40	3.12	
Brullus Lake, Egypt	F	233	0.0044	3.14	0.97	85.7	0.27	-0.21	3.30	Present study
	M	198	0.0028	3.25	0.95	97.4	0.22	-0.12	3.32	
	A	431	0.0036	3.18	0.96	86.4	0.25	-0.35	3.27	

- : no data available; **F**: Female; **M**: Male; **A**: combined sex; **N**: number of samples; **a**: intercept of the relationship; **b**: slope of the relationship; $\mathbf{r^2}$: coefficient of correlation; $\mathbf{L_8}$: Asymptotic length; **K**: body growth coefficient; $\mathbf{t_0}$: Theoretical age at zero length; **φ**: Phi prime value

CONCLUSION

This research offers significant insights into the population characteristics of African catfish *C. gariepinus* from Burullus Wetland, Egypt. The results indicate that *C. gariepinus* exhibited a positive allometric growth, suggesting that this location is highly conducive to the species' development. Consequently, these data would provide essential context for further biological research and local fisheries management approaches. However, further studies are needed to better understand the population dynamics of this species since study on ichthyology is crucial for assessing the state of fish populations across various environments.

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