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Age and Growth Parameters of African Catfish (*Clarias gariepinus* Burchell, 1822) From Asi River, Turkey

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ABSTRACT

This study aimed to determine the age and growth parameters of the African catfish *Clarias gariepinus* (Burchell, 1822) from the Asi River. A total of 185 fish samples have been collected from the Asi River, located in the Eastern Mediterranean region of Turkey, from December 2018 to March 2019. Samplings were carried out with fyke-nets. Lengths and weights of samples ranged from 20.47 to 62.46 cm and 74.4 to 1874.2 g, respectively. The sex ratio (1:1.06) was biased toward males (p>0.05). In terms of length-weight relationship, b-values were calculated as 2.98, 2.83, and 2.94 for female, male, and whole samples, respectively. Isometric growth was determined. The Fulton condition factor (CF) value for all samples was calculated as 0.7591±0.009. The ages of fish samples ranged from I to IV, and the dominant age and total length (TL) groups of the population were the I and II age groups. The von Bertalanffy growth parameters were estimated as L_∞=58.5 cm, K=0.41 year^{-1}, $t_0 = -0.7$, Φ′=3.15 for females; L_∞=68.3 cm, K=0.35 year^{-1}, $t_0 = -0.6$, Φ′=3.21 for males and L_∞=58.2 cm, K=0.39 year^{-1}, $t_0 = -0.4$, Φ′=3.12 for whole collected samples. As a result, climate change and its effects, especially the construction of dams in certain parts of the river for agricultural irrigation purposes and the resulting lack of management negatively affect the natural living stocks of the Asi River. Therefore, it can be said that the *C. gariepinus* stocks in these areas are overexploited. Legal arrangements should be made in this region to correct these conditions.

INTRODUCTION

Freshwater fishing provides the main food source and it is an important part of the ecosystem approach. However, research and legal regulations in wetlands are limited as compared to general fishery worldwide (Zhang et al., 2020). The Asi River enriches the protein source alternatives of the people of the region, and

Clarias gariepinus has an important place as a food source. The aquatic biodiversity of the river is at serious risk, since, its geographical location was severely impacted by the global climate change (Smith et al., 2014).

C. gariepinus (Burchell, 1822) is a tropical and subtropical catfish species. *C. gariepinus* lives in various water resources such as lakes, ponds and streams both in deep and shallow waters (Turan & Turan, 2016). In present, *C. gariepinus* has been reported in four continents namely Africa, Asia, Europe and South America, and in sixty-nine countries. However, this species spreads in sixty-three countries (Froese & Pauly, 2019). This species has been evaluated as "Least Concern (LC)" according to the IUCN Red List of Threatened Species since 2019 (Konings et al., 2019). At Turkey, it is widely distributed in the southern and the central Anatolian freshwaters i.e., Ceyhan, Seyhan, Göksu, Aksu, Sakarya, and Asi rivers, where it has commercial importance (Yalçın et al., 2002; Turan et al., 2005; Genç et al., 2006). TurkStat (2018) reported that *C. gariepinus* had its annual catching capacity of 2 tonnes in the Asi River and 206 tonnes in the Turkish freshwaters in 2018. Also, this species has been reported to be reared in several areas in the world (Turan et al., 2022).

The Asi River, which flows into the Eastern Mediterranean Sea after passing through Syria from the Samandağ district of Hatay, after crossing Syria, originating from the Bekaa valley of Lebanon, is an essential resource for agricultural irrigation and fishing (Demirci et al., 2020). *Clarias gariepinus*, *Anguilla anguilla* Linnaeus, 1758 and several Cyprinid species (*Cyprinus carpio* Linnaeus, 1758, *Capoeta capoeta* Güldenstädt, 1773, *Capoeta trutta* Heckel, 1843, *Capoeta damascina* Valenciennes, 1842, *Capoeta barroisi* Lortet, 1894, *Capoeta angorae* Hankó, 1925, *Barbus lorteti* Sauvage, 1882, *Garra rufa* Heckel, 1843) have been reported in previous studies in the Asi River (Demirci & Yalçın, 2010, 2015; Özcan & Altun, 2015; Demirci et al., 2016a; Alagöz & Turan, 2017; Bayçelebi, 2020; Alagöz, 2021a; Alagöz, 2021b; Demirci & Yalçın, 2021). Fishing in this river is done with set nets, fyke nets and various types of handlines (Demirci & Demirci, 2009, Şimşek et al., 2021; 2022).

The perception of fisheries has changed every day in accordance with the "sustainable ecosystem" (Şimşek & Demirci, 2018). Studies on fisheries biology and population dynamics are crucial issues for fisheries management (Can & Demirci, 2012; Demirci et al., 2018). Therefore, growth parameters have been an essential indicator to evaluate fishing pressure on fish stocks (Demirci et al., 2016b; Turan et al., 2021). Age and growth factors of *C. gariepinus* from different regions have been reported previously (Idumah Okogwu, 2011; Bokhutlo et al., 2015; Mehanna et al., 2018; Behmene et al., 2021; Nsapu, 2021). In addition, the latest information about the growth parameters of this species was reported in the region approximately 20 years ago (Yalçın et al., 2002). Therefore, there is an urgent need for the current information about this species' age and growth parameters in the region. Therefore, this study aims to estimate the growth parameters of this species in terms of length, weight and age factors for the Asi River Basin fishery.

MATERIAL AND METHOD

The Asi River originates on the threshold of Baalbek in Bekaa, Lebanon, heading north and entering Syria (Figure 1). After merging with the streams Burc and Karasu, the river passes through Antakya and reaches the Mediterranean Sea in the south of Samandağ, Turkey (Demirci & Demirci, 2009; Kılıç & Can, 2017). The total length of the Asi River is approximately 400 km, and approximately 94 km of Asi River flows through the Turkish territory (Yalçın Özdilek et al., 2006; Kılıç & Yücel, 2019). The river is located in the Mediterranean climate zone which practices hot and arid summers (Kılıç, 2018). Annual precipitation of the Asi River Basin is recorded as 816 mm, mean temperature is noted as 16.8°C and annual total flow of the river is reported as 1.17 km^3/year (Kılıç et al., 2018).

Samples were collected between December 2018 and March 2019 using fyke-nets (mesh size 12-18 mm, Polyamide (PA) material). Although this fish species is distributed along the Asi River, only Güzelburç has been determined as a location. Because, the Güzelburç region has a higher catching capacity since having less river current (Demirci & Demirci, 2009).

The sampled fish were placed in boxes and then immediately brought to the laboratory. Total lengths (TL) to the nearest 1.0 mm and wet weights (W) to the nearest 0.01 g were measured (Lin et al., 2011). The specimens were dissected, and sexes were determined aiming to test for differences in sex ratio, a chi-square test for goodness of fit was also used. Vertebrae were used for age determination and readings were carried out twice by the first reader and independently by a second reader.

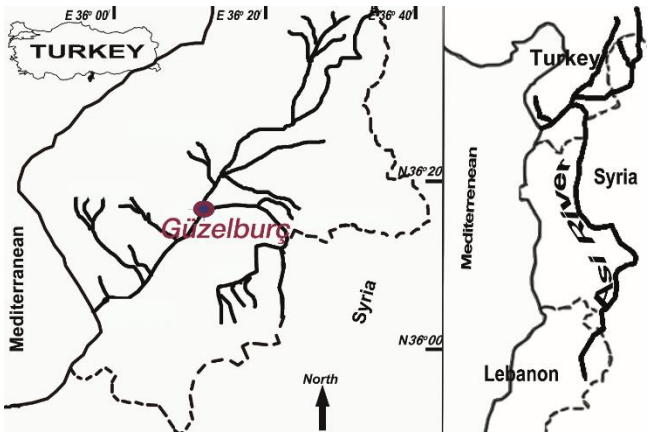

Figure 1. Study area in the Asi River basin (*Left side:* Asi River tributaries in the territory of Turkey, Sampling location is indicated, *Right side*: Total area of Asi River, also covering the international territories)

Relationships between the length and weight of *C. gariepinus* were calculated for female, male, and all individuals with Eq. (1) according to Ricker (1975).

$$W = aL^b \quad (1)$$

The parameters of the Eq. (1) were estimated on the log-transformed data (Eq. (2)):

$$\log W = \log a + b \log L \quad (2)$$

where W is the weight, L is the total length, and a and b are constants.

Condition factor is used with the aim of correlating the health or fatness of the fish (Froese, 2006). Fulton's coefficient of condition factor (CF) was calculated by Eq. (3).

$$CF = \frac{W}{L^3} \times 100 \quad (3)$$

where; L is the total length (cm) and W is the weight (g) (Bagenal & Tesch, 1978).

Growth curves were fitted using the least-squares method for all subjects using the von Bertalanffy growth equation (Eq. (4)) (Von Bertalanffy, 1938).

$$L_t = L_\infty\left(1 - e^{-K(t-t_0)}\right) \quad (4)$$

where L_t is the total length at age t, L_∞ is asymptotic length, K is the body growth coefficient and t_0 is the theoretical age at zero length (Beverton & Holt, 1959). The solver routines in Microsoft Excel Program 2016 were used to define length growth curves.

The growth performance index, phi prime (Φ') was calculated by Eq. (5) (Pauly & Munro, 1984).

$$\Phi' = \log(K) + 2\log(L_\infty) \quad (5)$$

where K and L_∞ are Von Bertalanffy Growth model parameters.

RESULTS

A total of 185 individuals of *C. gariepinus* were sampled from the Turkish part of the Asi River. 87 individuals were female and 92 were male. The remaining 6 samples could not be able to distinguish by gender. The sex ratio (F:M=1:1.06) was biased toward males and there was no statistically significant difference between the sexes ($p>0.05$) as shown in Table 1.

Table 1. Sex distribution of *C. gariepinus* from Asi River sampling (December 2018-March 2019)

Sex	N	Ratio (%)	Mean TW (g)	Mean TL (cm)
Female	87	47.03	109.7	57.7
Male	92	49.73	105.7	59.3
Undetermined	6	3.24	124.9	73.4
Total	**185**	**100**	**108.1**	**58.5**

Table 2. The age-total length key for the *C. gariepinus* caught from Asi River (December 2018 to March 2019)

Total Length (cm)	Age Groups (Year)				Total
	I	II	III	IV	
20.0-24.9	16	12			28
25.0-29.9	25	35	1		61
30.0-34.9	17	31	6	1	55
35.0-39.9		24	3		27
40.0-44.9		1	6	1	8
45.0-49.9		3	1		4
50.0-54.9			1		1
55.0-59.9					
60.0-64.9				1	1
Total	58	106	18	3	185
$TL_{min-max}$	20.47-33.53	22.29-49.96	25.30-51.42	34.14-62.46	20.47-62.46
TL_{mean}± SD (cm)	27.49±0.43	31.31±0.54	37.58±1.59	46.81±8.31	30.98±0.46
$TW_{min-max}$	73.50-416.20	78.50-866.81	114.40-1082.80	252.60-1874.20	73.50-1874.20
TW $_{mean}$± SD (g)	166.42±8.49	252.81±15.26	475.24±69.14	918.40±69.14	256.54±15.69

Note: *TL*: total length, *TW*: total weight, *SD*: standard deviation

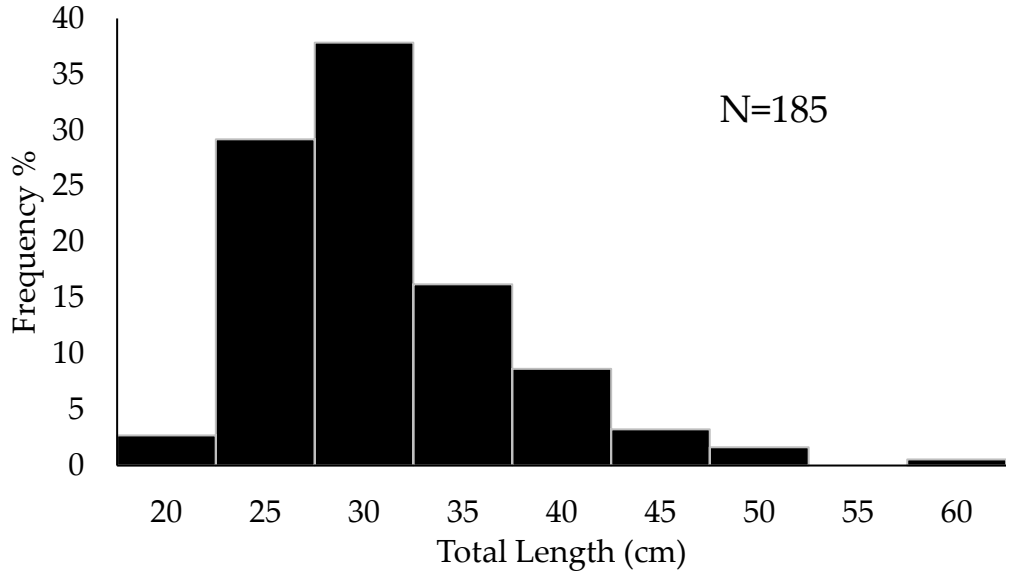

Figure 2. The length-frequency distribution of *C. gariepinus* from Asi River

The fish size ranged from 20.47 to 62.46 cm (TL) and weighed between 73.5 and 1874.2 g. (Figure 2). Standard deviation values of mean TL and mean TW of samples caught from the Asi River were calculated as 30.98±0.46 cm and 256.54±15.69 g, and the ages ranged from I to IV. The dominant age and TL groups of the population were found in the I and II age groups (Table 2).

The length-weight relationship (LWR) regression was calculated for female, male and all sampled individuals of *C. gariepinus*, and it was shown in Figure 3. The length-weight relationships of *C. gariepinus* for female, male and all individuals were recorded as $W=0.0079\times TL^{2.98}$, $W=0.013\times TL^{2.83}$, and $W=0.0092\times TL^{2.94}$, respectively. The exponents of the length-weight relationship, *b*, showed an isometric growth.

Fulton condition factor (CF) value ranged from 0.5583 to 1.3490 for females, 0.3742-1.6043 for males and 0.374-1.604 for all individuals and the mean value with standard deviations was calculated as 0.765±0.011, 0.751±0.015 and 0.7591±0.009 for female, male, and all sampled individuals, respectively.

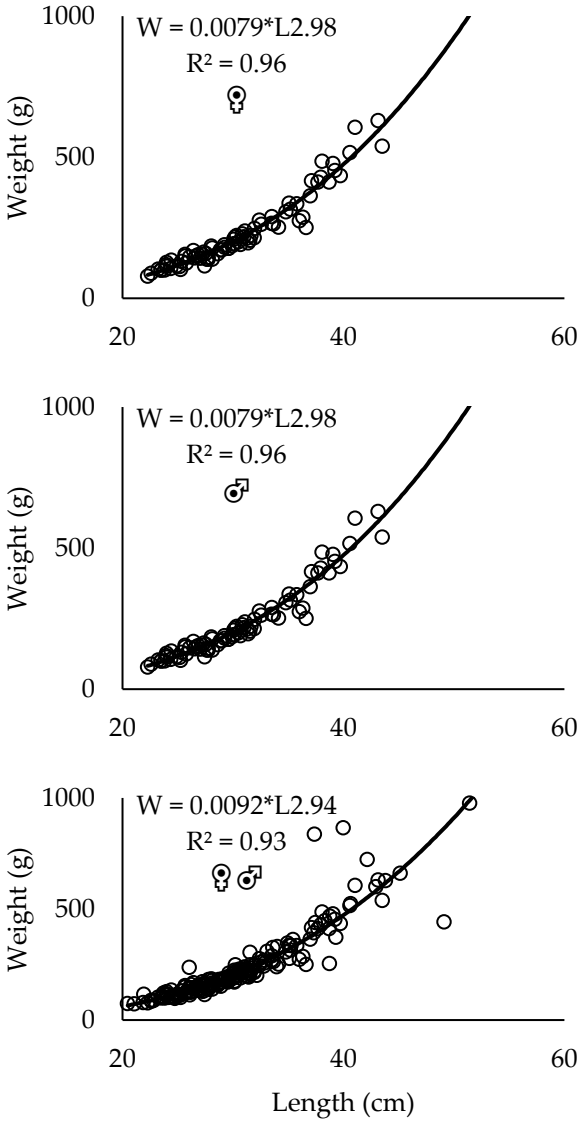

Figure 3. The length-weight relationship of *C. gariepinus* collected from Asi River (December 2018 to March 2019).

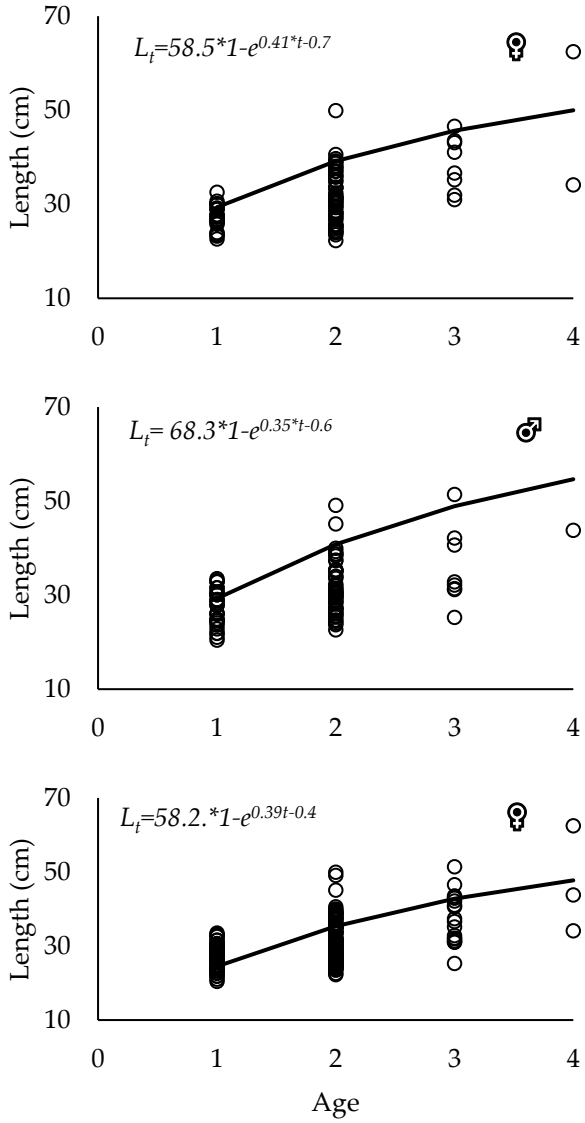

Figure 4. Length at age, with von Bertalanffy curve, of *C. gariepinus* collected from Asi River (December 2018 to March 2019).

The von Bertalanffy growth model has been used for estimating the age, length and growth parameters which were recorded as L_∞ =58.5 cm, K=0.4 year^{-1}, $t_0 = -0.7$ for females, L_∞ =68.3 cm, K=0.35 year^{-1}, $t_0 = -0.6$ for males and L_∞ =58.2 cm, K=0.39 year^{-1}, $t_0 = -0.4$ for whole sampled individuals (Figure 4). Moreover, the growth performance index (phi prime value, Φ′) for female, male and whole sampled individuals have been calculated as 3.15, 3.21, and 3.12, respectively.

DISCUSSION

Asi River is an important resource in terms of fisheries dynamics due to its species diversity. However, the Asi River also flows through intensely urbanized areas and agricultural lands which increases the contamination by agricultural and domestic sources (Genç et al., 2008). At the same time, the construction of dams on the Asi River for agricultural irrigation reduces the water flow in summers, even though the cut of some tributaries. All these activities negatively affect the survival of aquatic animals living in the Asi River. In addition to water scarcity, overfishing also creates important problems for fish stocks (Demirci & Demirci, 2009). Furthermore, the spawning season of *C. gariepinus* found in the Asi River was reported from May to August when the temperature of water ranged between 21°C and 30°C (Yalçın et al., 2001). The present study delivered up-to-date data on the age and growth parameters of *C.*

gariepinus from the Turkish part of the Asi River. Unfortunately, there were no biological data reported in the region since 2003.

Different values of sex ratio can be encountered with the effect of some environmental factors (Bohlen et al., 2008). This variation could be based on several reasons, such as the number of samples, location, season, feeding and maturation phases, different growth rates, mortality, etc. (Innal et al., 2015). This ratio (Female: Male) was reported in previous studies as 1:1.04 (Yalçın et al., 2002); 1:0.47 (Narin, 2003) in the same region and 1:0.77 (Mehanna et al., 2018); 1:0.68 (Behmene et al., 2021); 1:1.24 (Wartenberg et al., 2013); 1:0.47 (Abera et al., 2014) in different areas in the world.

The length distribution of previous studies conducted in the Asi River and other regions was similar (Yalçın et al., 2002; Narin, 2003). Mean length at first sexual maturity has been reported as (L_m) 25.05 cm at first age for *C. gariepinus* in the Asi River (Yalçın et al., 2001). However, the minimum catching capacity for this species is recorded as 35 cm in Turkey's commercial fishery regulations (MAF, 2020). When we evaluate the size of fish according to their age and weight, the smallest individual weight is noted as 73.50 g, and the largest individual weight is 1.87 kg. A very important part of the sampled population varies between 200-400 g as individual weights.

Table 3. Length-weight relationship parameters of *C. gariepinus* reported from different areas

Area	Sex	N	a	b	r^2	Reference
Elands River, South Africa	M	195	0.0070	2.99	-	Van der Waal (1972)
Asi River, Turkey	F	351	0.0100	2.90	-	Yalçın et al. (2002)
	M	366	0.0160	2.74	-	
	A	720	0.0127	2.82	-	
Gölbaşı Lake, Turkey	F	330	0.0075	2.99	0.95	Narin (2003)
	M	154	0.0097	2.91	0.95	
	A	566	0.0076	2.99	0.96	
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	-	Macharia et al. (2017)
Manzalah Lake, Egypt	F	701	0.0045	3.13	0.98	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)
Sakaryabaşı, Turkey	A	559	0,0093	2.92	-	Başkurt (2020)
Oued Takhamalte, Algeria	F	50	0.0482	2.49	0.93	Behmene et al. (2021)
	M	34	0.0509	2.46	0.90	
	A	84	0.0608	2.42	0.89	
Asi River, Turkey	**F**	**87**	**0.0079**	**2.98**	**0.96**	**Present study**
	M	**92**	**0.0013**	**2.83**	**0.91**	
	A	**185**	**0.0092**	**2.94**	**0.93**	

Note: *dash* means no data available; *F*: Female; *M:* Male; *A*: All; *N*: number of samples; *a*: intercept of the relationship; *b*: slope of the relationship; r^2: coefficient of correlation.

Table 4. Parameter's comparisons (L_∞, K, t_0) of the von Bertalanffy growth curve and growth performance indices (Φ') for female, male and all individuals reported from different areas

Area	Sex	N	L_∞(cm)	K year^{-1}	t_0	Φ'	Reference
Asi River, Turkey	F	351	82.94	0.15	-1.72	-	Yalçın et al. (2002)
	M	366	85.32	0.14	-0.69	-	
Gölbaşı Lake, Turkey	F	330	56.98	0.23	-1.70	-	Narin (2003)
	M	154	64.85	0.19	-1.72	-	
	A	566	60.24	0.21	-1.61	-	
Laing River reservoirs, Eastern Cape	A	101	140.67	0.17	-0.16	-	Potts et al. (2008)
Kat River reservoirs, Eastern Cape	A	134	93.02	0.19	-0.28	-	
Mid-Cross River, Nigeria	A	1421	80.24	0.49	-3.93	3.10	Idumah Okogwu (2011)
Darlington Dam, Eastern Cape	F	78	86.79	0.17	-2.08	-	Wartenberg et al. (2013)
	M	97	99.96	0.13	-2.72	-	
	A	175	93.17	0.15	-2.43	-	
Lower Okavango Delta, Botswana	A	106	52.87	0.72	-1.35	-	Bokhutlo et al. (2015)
Baringo Lake, Kenya	A	2272	114.30	0.37	-	-	Macharia et al. (2017)
Manzalah Lake, Egypt	A	1241	86.88	0.31	-0.39	-	Mehanna et al. (2018)
Oued Takhamalte, Algeria	A	84	53.84	0.28	-	-	Behmene et al. (2021)
Mai-Ndombe Lake, DRC	A	2001	55.65	0.28	-0.50	-	Nsapu (2021)
Asi River, Turkey	**F**	**87**	**58.5**	**0.41**	**-0.70**	**3.15**	**Present study**
	M	**92**	**68.3**	**0.35**	**-0.60**	**3.21**	
	A	**185**	**58.2**	**0.39**	**-0.40**	**3.12**	

Note: dash means no data available; *F*: Female; *M*: Male; *A*: All; L_∞: Asymptotic length; *K*: body growth coefficient; t_0: Theoretical age at zero length; *Φ'*: phi prime value; *DRC*: Democratic Republic of the Congo.

The length-weight relationship (LWR) has a valuable means of fish stock assessment (Keyombe et al., 2015). If the *b* value, which is an allometric coefficient, is 3.0 then the growth is isometric. In the same manner, if this value is larger or smaller than 3.0 then it means a positive or negative allometric growth can exist (Bagenal & Tesch, 1978). In this study, the growth of *C. gariepinus* was evaluated as an isometric accordingly to the *b* value which is similar to previous studies conducted in similar regions. A comparison between the length-weight relationships for the species was done by using the results of previous studies (Table 3).

The condition factor (CF) is an index reproducing relations between biotic and abiotic elements in the physiological situation of fishes. Le Cren (1951) stated that CF values larger than 1 indicate the suitable condition for fish, but a value lower than 1 was showing the existence of unsuitable environmental conditions. In addition, Perry et al. (1996) informed that fishes with a low condition index are probably understood to have experienced a severe physical environment or lacking nutrition. In this study, it has been calculated that the mean condition factor for female, male and all sampled individuals of *C. gariepinus* were of values of lower than l which showed that *C. gariepinus* are under environmental stress in the Asi River.

The low number of elderly individuals brings to mind the idea that the fishing of *C. gariepinus* creates fishing pressure. Several factors can affect growth parameters i.e., location, season, etc. (Avşar, 1995). Thus, VBGF growth parameters were compared with the literature in different areas (Table 4). The growth coefficient (K=0.39 year^{-1}) found in this study was one of the highest values when comparing previous studies. Nevertheless, the asymptotic length (L_∞=58.2 cm) found in this study was one of the lowest values.

In addition, Yalçın et al. (2002) reported this value as 82.94 and 85.32 for females and males, respectively. Therefore, it can be said that the *C. gariepinus* stocks in the Asi River are under intense pressure. The phi prime (Φ') values calculated for *C. gariepinus* had similar results to previous studies on *C. gariepinus* from different areas (Table 4).

CONCLUSION

In conclusion, this study updated the information on the length distribution, length-weight relationship, age and growth of *C. gariepinus* from the Asi River. In the river, as in all Turkish inland waters, commercial fishing is restricted except for leased areas. However, unfortunately, illegal fishing is carried out intensively. As a result, climate change and its effects, especially the construction of dams in certain parts of the river for agricultural irrigation purposes and the resulting lack of management negatively affect the natural living stocks of the Asi River. Therefore, it can be said that the *C. gariepinus* stocks in these areas are overexploited. Legal arrangements should be made in this region to correct these conditions.

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Compliance With Ethical Standards

Authors' Contributions

EŞ and OS designed the study. EŞ, ZAG and OS analysed the data, performed the experiments. EŞ wrote, revised the manuscript. All authors have read and approved the final version of the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required. Even so, the authors followed all applicable international, national, and/or institutional guidelines for the care and use of animals.

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