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REVIEW ARTICLE

AGE, GROWTH AND EXPLOITATION PARAMETERS OF *Chelon dumerili* (Steindachner, 1870) FROM SALOUM ESTUARY, SENEGAL

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ABSTRACT

This study estimated the growth, mortality and exploitation parameters of *Chelon dumerili*. The aim of this study was to estimate the growth parameters and determine the mortality and exploitation coefficients. The *C. dumerili* specimens used for this study were caught in the Sangomar Marine Protected Area during experimental fishing carried out monthly from June 2016 to May 2017. The weight and length of the individuals were measured respectively using an electronic scale and an ichthyometer. The results obtained show that the allometric coefficient (b = 3) was equal to 3, indicating an isometric growth for *C. dumerili*. The asymptotic length ($L\infty$) and the growth rate (K), were respectively equal to 37 cm and 0.33 yr^{-1}. This study also showed that for *C. dumerili*, fishing mortality (3.49 $year^{-1}$) is much higher than natural mortality (M = 1.22 $year^{-1}$). The exploitation rate (E = 0.51) obtained in this study is higher than the optimum reference rate (E = 0.5); this indicates the beginning of overexploitation of the C. dumerili stock in the waters of the Saloum Delta.

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INTRODUCTION

Fish of the Mugilidae family are abundant and widely distributed in estuaries in tropical and temperate regions where they represent a major commercial resource (Blaber, 1997; Pombo *et al*., 2005; Honorine, 2019). In West Africa, only the genera Mugil and Liza are known from this family (Honorine, 2019). In Senegal, the Mugilidae family is one of the most abundant taxa (Pandaré and Capdeville, 1986). Due to its commercial, nutritional importance (Pandaré and Capdeville, 1986) and ecological (Diouf and Bousso, 1988), the Mugilidae family deserves special attention (Diouf, 1991). *Chelon dumerili* is one of the most abundant species of this family in the Saloum delta waters. However, studies on the growth biology of *C. dumerili* are insufficient. In Senegal, a few studies, focusing on descriptive aspects (Diouf, 1991) and growth aspects (Ndiaye *et al*., 2020), have been carried out on *C. dumerili* while it is particularly intensively exploited in the Saloum delta. Moreover, knowledge of growth is an essential step for the study of the dynamics of a fish population. It allows a better understanding of the evolution of stocks according to the modifications made in their exploitation (Sidibé *et al*., 2003). Thus, the objective of this work was to estimate the growth parameters from size frequency data and determine the mortality and exploitation rates of *C. dumerili* in Saloum Delta waters in order to improve knowledge on the biology of this species for its rational exploitation in Senegal.

MATERIALS AND METHODS

Study area: This study was carried out in the Marine Protected Area (MPA) of Sangomar located in the Saloum Delta (13° 35' and 14° 10' north and 16° 50' and 17° 00'). With an area of 87,437 ha, a large part of the Sangomar MPA is included in the Saloum Delta Biosphere Reserve (RBDS) in Senegal. The Sangomar MPA is bounded to the north by the Joal-Fadiouth MPA, to the south by the Saloum Delta National Park, to the east by the Palmarin Community Nature Reserve (RNCP) and the municipalities of Djirnda and Bassoul and to the West by the Atlantic Ocean (Ba, 2019). A total of 5 fishing stations were chosen and distributed in the different parts of the Sangomar MPA. Thus, the Sofna and Bakina stations are located in the area of the mouth of the Saloum, the Mariniane and Djimsane stations were located on the main arm of the Saloum and the Sarema station is in a salt water channel (Figure 1).

Sampling protocol: A total of twelve 12 experimental fishing campaigns were carried out monthly from June 2016 to May 2017. The fishing operations were carried out using a 250 m long, 20 m height and with a 14 mm mesh size experimental purse seine. 360 individuals of *C. dumerili* were sampled.

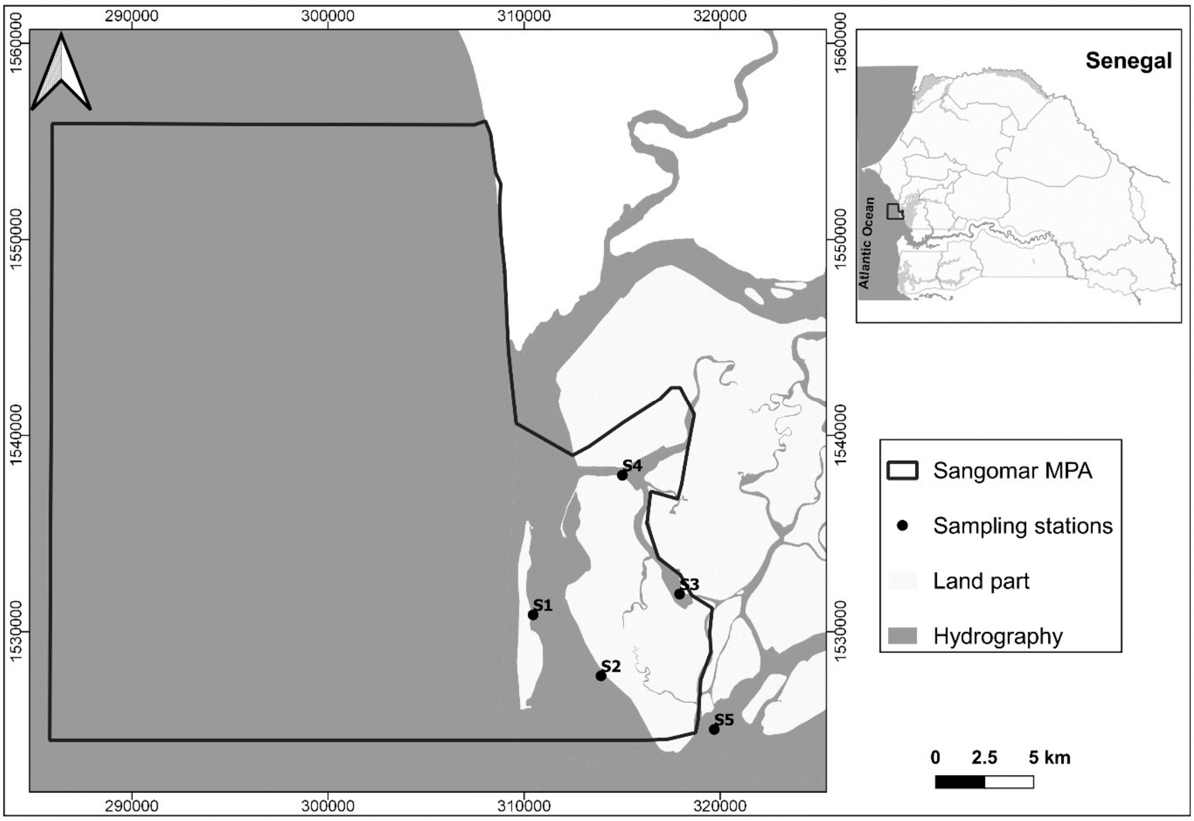

Figure 1. Map showing the location of the sampling stations

These individuals were caught using purse seines and beach seines during experimental fisheries. For each individual, the total weight and the eviscerated weight were determined using a 0.1 g precision electronic scale. Total length and were measured with a 1 mm precision ichthyometer.

Length- weight relationship: The relationship between total length (L) and total weight (W) for almost all fish species was expressed by the following equation (Le Cren, 1951) : $W = a \times L^b$, where W = Weight (g) of fish in grams, L = Total length of fish in centimeters, a = Exponent describing the rate of change of weight with length, b = The slope of the regression line (also referred to as the allometric coefficient). The values of the constants a and b were estimated by least squares linear regression from the logarithmically transformed length and weight values (Sivashanthini *et al* 2009): $\log W = \log(a) + b \times \log(L)$. The 95% confidence limits for b (CL 95%) were computed using the equation (Tah *et al*., 2012): $CL = b \pm (1.96 \times SE)$, Where SE = the standard error of b. In order to check if the value of b was significantly different from 3, the Student's t-test was conducted as expressed by the equation according to Sokal and Rohlf (1987):$ts = \frac{(b-3)}{SE}$, where ts = The t-test value, b = The slope and SE = The standard error of the slope b. Growth is isometric (I) if b equal or very close to 3 and allometric if b significantly different from 3; negative allometric (A^-) if b 3 and positive allometric (A^+) if b > 3 (Mehanna and Farouk, 2021).

Linear growth: The most widely used model for modeling fish growth is that of Von Bertalanffy (1938) whose equation is written as follows:$Lt = L_\infty\left(1 - e^{-K(t-t0)}\right)$, where Lt = Fish length at time t; L∞ = Theoretical asymptotic length if the individual grew indefinitely; K = Growth coefficient; t_0 =Nominal age when the length is zero. The growth parameters (L∞, K) were obtained from the ELEFAN in R software which was a new stock assessment tool based on size frequencies. This new ELEFAN version was re-released in a modern (R) programming language. From the corresponding size-frequency data, the routines allowed estimating the growth parameters (L∞, K) of the Von Bertalanffy's equation, taking into account the seasonal variations in growth (Pauly and Greenberg, 2013). The size frequency data of captured individuals were organized into size classes of 1 centimeter intervals. t_0 was estimated using the empirical equation of Pauly (1979): Log ($-t_0$) = -0.3922-0.275×log (L∞) -1.038×K. The growth performance index (Φ') was used to assess the growth performance of the species (Pauly and Munro, 1984). This index was defined by correlating K and L∞ (Pauly, 1980): (Φ') = Log (k) + 2×Log (L∞).

Exploitation parameters: A stock of a species undergoes an evolution characterized by gains (inputs) and losses (outputs). Gains are represented by annual recruitment and growth of fish while losses are due to total mortality (Z). Total mortality (Z) was the sum of fishing mortality (F) generated by the various fishing operations and natural mortality (M) which expressed mortality from any cause other than fishing (Bouaziz, 2007). Total mortality was estimated from catch curves converted into length using the modified catch curve method from age-structured catch curves with ELEFAN in R software (Pauly and Greenberg, 2013). The different methods for estimating total mortality, which used the linearized catch curve according to size classes, were derived from the age-based catch curve method (Ricker, 1980). For the estimation of natural mortality, several methods can be used. In the present work, the method of Pauly (1984), which was recommended for pelagic fish, was used. The natural mortality (M) was calculated by Pauly's empirical equation (Pauly 1980), where the mean habitat temperature was 26.25°C. Log(M) = -0,0066-0,279×Log (L∞) + 0,6543×Log (K)+0,4634 Log (T°), where M = natural mortality; L∞ = Asymptotic length; K = Growth coefficient; T° = average annual temperature of the environment. Fishing mortality expressed the quantity of *C. dumerili* taken by fishing activity in one year. Knowing naturel mortality (M) and total mortality (Z), the fishing mortality (F) rate was deduced: F = Z-M. The exploitation rate (E) was obtained using the relationship (Pauly, 1985): E = F/(F+M) = F/Z. This exploitation ratemade it possible to know whether a stock was overexploited or not depending on whether its value was greater or less than 0.5 (optimal value of E (E_{opt}) was close to 0.5).

RESULTS

Length-weight relationship: The length-weight relationship of *C. dumerili* was shown in Figure 2. The parameters of this length-weight relationship (a and b), the 95% confidence interval for b, the correlation coefficient r^2, min-max length, min-max weight and growth type were recorded in Table 1. It was found that the length-weight relationship of *C. dumerili* was highly correlated and the correlation coefficient was r^2 = 0.968. The coefficient b was not significant (Student's t-test: p>0.05) and differs from 3 for *C. dumerili*, indicating that the growth was isometric.

Linear growth: The analysis of the size frequencies made it possible to estimate the parameter L∞, K from the ELEFAN in R software. The asymptotic length (L∞) estimated from the size frequencies by the ELEFAN in R software for *C. dumerili* was 37 cm. The growth coefficient K obtained from the K-scan procedure of the program ELEFAN in R was 0.33 yr^{-1}. The growth performance index (Φ') of *C. dumerili* was equal to 2.65 when t_0 was estimated to be -0.47 yr^{-1}. The analysis of the linear growth carried outindicated that *C. dumerili* exhibited rapid growth during its juvenile phase, particularly during the first three years (Figure 3). The average length at 6 months was 10.6 cm and became 18 cm at 18 months. At 3 years old, the species could reach an average size of 25 cm. From the fourth year, however, growth in length slowed down. It could be estimated at a few centimeters per year.

Fishing mortality (F) andexploitation rate (E) were 0.83 yr^{-1} and 0.51, respectively.

DISCUSSION

In this study, the allometric coefficient of the length-weight relationship of *C. dumerili* equal to 3 indicated isometric growth. This meant that the species maintained the same shape or body contour throughout its life (Le Cren, 1951; Tesh, 1971). The results of the present study were in agreement with those of Marais (1976) in Swartkops Estuary in South Africa, King (1996) in the Qua Iboe Estuary in Nigeria, Harrison (2001) in South African estuaries, Dankwa (2011) in the Pra estuary in Ghana and Ndiaye*et al* (2020) in the Marine Protected Area of Joal-Fadhiuth in Senegal. However, positive allometric growth of *C. dumerili* was obtained in the Volta estuary in Ghana by Dankwa (2011) (Table 2). The observed differences in b values could be due to factors such as different environmental conditions in geographic areas (Warren *et al*., 2008; Ergden, 2021), habitat including seasonal effects, and food abundance

Table 1. Descriptive statistics and estimated parameters of the length-weight relationship for *C. dumerili* from the Saloum Estuary

Length range (cm) Min- Max	Weight range (g) Min- Max	Regressionparameters			95% CL ofb	r^2	Growth type
		a	b	SE of *b*			
16.1-33.8	38.3-323.9	0.008	3.00	0.056	2.94-3.06	0.968	I

Min=minimum; Max=maximum; a = Exponent describing the rate of change of weight with length, b = The slope of the regression line (also referred to as the allometric coefficient); CL=confidence limits; r^2=Correlation coefficient; I = Isometric

Tableau 2. The table showed the parameters of length-weight relationship for C. *dumerili* from various regions

Conutries	Type of Length	Parameters			Growth type	Authors
		a	b	r^2		
Senegal	TL	0.008	3.00	0.968	I	Presentestudy
Senegal	TL	0.0001	3.00	-	I	Ndiaye *et al* (2020)
South Africa	SL	0.0269	2.858	0.994	I	Harrison (2001)
Ghana	SL	0.0223	2.918	0.977	I	Dankwa (2011)
Ghana	SL	0.0098	3.236	0.983	A^+	Dankwa (2011)
South Africa	SL	0.0156	3.034	-	I	Marais (1976)
Nigeria	TL	0.0070	3.043	0.956	I	King (1996)

a = Exponent describing the rate of change of weight with length, b = The slope of the regression line (also referred to as the allometric coefficient); r^2=Correlation coefficient; I= Isometric; A^+ = Positive allometric

Tableau 3. Paramtres de croissance de *C. dumerili*de diverses régions

Countries	Type of Length	Growthparameters			Authors
		L∞ (cm)	K (an^{-1})	(Φ')	
Sénégal (Saloum Estuary)	TL	37	0.33	2.65	Presentstudy
Sénégal (Joal MPA)	TL	39.55	0.37	2.76	Ndiaye *et al* (2020)
Ghana (Pra Estuary)	SL	23.3	0.42	2.36	Dankwa (2011)
Ghana (Volta Estuary)	SL	23.3	0.55	2.48	Dankwa (2011)

L∞ = Asymptotic length; K = growth coefficient; (Φ') = growth performance index

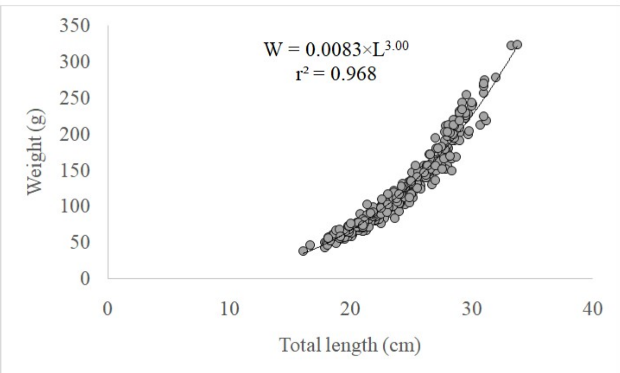

Figure 2. Length-weight relationship for *C. dumerili*

Figure 3. Linear growth curve of Von Bertalanffy for *C. dumerili*

Mortality and exploitation rate: From the size frequency distribution of *C. dumerili*, the estimated total mortality coefficient (Z) was 1.63 yr^{-1}. Based on the growth parameters and the average temperature of 26.56 °C, the natural mortality (M) value was estimated at 0.8 $year^{-1}$.

(Gonzalez *et al*., 2004; Ruiz-Campos *et al*., 2006 and Hossain *et al*., 2015) and the breeding season (Bagenal and Tesch, 1978; Alp *et al*., 2005). Growth parameters from this study revealed that *C. dumerili* had an asymptotic length (L∞) of 37 cm and a growth coefficient (K) of 0.33 yr^{-1}. This indicated that the species was developing at a relatively rapid growth rate. Indeed, according to Branstetter (1987) a species grew slowly when $0.05 \leq K \leq 0.10\ yr^{-1}$, growth was intermediate for $0.10 \leq K \leq 0.20\ yr^{-1}$ and for fast-growing species $0.2 \leq K \leq 0.50\ yr^{-1}$. Moreover, the asymptotic length (L∞) and the growth rate (K) estimated in the present study were lower than those obtained by Ndiaye*et al* (2020) in the MPA of Joal-Fadiouth in Senegal. On the other hand, lower values of asymptotic lengths and higher growth rates of *C. dumerili* have been reported in the Pra and Volta Estuaries in Ghana (Dankwa, 2011) (Table 3). According to Pauly and Moreau (1997), competition for food, space and sexual competition also induced high values of K and contribute to decreasing growth and in particular asymptotic size. The differences could be due to the diversity of the methods used to estimate the growth parameters but also to the sampling methods (commercial fishing or experimental fishing). In the evaluation of linear growth, when different sets of parameters were available, it was not recommended to compare them individually (Sparre and Venema, 1996). For this reason, some authors recommended comparing linear growth performance indices (Φ') by combining several parameters of the Von vonBertalanffy equation (Pauly and Munro, 1984; Chauvet, 1988; Chakroun-Marzouk and Ktari, 2003). The growth performance index (Φ'), which showed very similar values within neighboring taxa, proved to be the best overall growth performance index in the sense of having minimal variance (Chakroun-Marzouk and Ktari, 2003). Growth performance indices (Φ') found in the literature for *C. dumerili* varied from 2.36 to 2.76 (Table 3).

Thus, the growth performance index (Φ') calculated in the present study (2.65) fell within this range, indicating relatively a rapid linear growth for *C. dumerili*. The slight differences between growth performance indices (Φ') could be related to factors such as temperature, food availability, metabolic activity, and reproductive activity. The fishing mortality ($F=3.49\ yr^{-1}$) estimated in the present study was higher than the natural mortality ($M=1.22\ yr^{-1}$), contrary to the results reported by Ndiaye*et al* (2020) ($F=1.99\ yr^{-1}$; $M=0.62\ yr^{-1}$). This observation could be due to the fact that the fishing for *C. dumerili* was more intense in the Saloum Delta than in the Fadiouth coastal waters; making the species more sensitive to natural mortality conditions than to fishing gear. The high growth rate ($K=0.33yr^{-1}$) coupled with high fishing mortality ($F=3.49\ yr^{-1}$) testified to the r-type demographic strategy adopted by the species. The exploitation rate found in the present study (E=0.51) was slightly higher than the optimal reference rate defined by Gulland (1971) (0.5); which indicates abeginning ofoverexploitation of the *C. dumerili* stock.

CONCLUSION

The present study provided information on the growth of *C. dumerili*. These growth parameters were fundamental to the development of effective management and conservation strategies for the species. The length-weight relationship results showed that the growth of *C. dumerili* was isometric. Thus, study of linear growth showed that this species had rapid growth and high mortality. The exploitation rateabove the optimal reference rate (0.5) confirmed the overexploited state in which the *C. dumerili* stock was. In order to ensure sustainable management of the *C. dumerili* stock, it was therefore necessary to reduce fishing effort and regulate the mesh size of the nets used to catch this species.

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Conflict of Interest statement: There is no conflict of interest for the publication of this article.

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REFERENCES

Alp, A., Kara, C.H., Büyükçapar, M. and Bülbül, O. 2005. Age, growth and condition of *Capoetacapoetaangorae*, Hanko 1924 from the upper water systems of the River Ceyhan, Turkey. *Turk. J. Vet. Anim. Sci.,* 29: 665-676.

Ba, A., Chaboud, C., Schmidt, J., Diouf, M., Fall, M., Deme, M. and Brehmer, P. 2019. The potential impact of marine protected areas on the Senegalese sardinella fishery. *Ocean Coast Manag,* 169: 239-246.

Bagenal, T.B. and Tesch, F.W. Age and growth (pp. 101- 136). In: Bagenal, T. (Ed.), Methods for assessment of fish production in fresh waters. (3rd ed.), IBP Handbook, 1978, No. 3, UK: Blackwell Scientific Publications, Oxford.

Blaber, S.J.M. Fish and fisheries of tropical estuaries. Chapman & Hall, London; 1997.

Bouaziz, A. The Sardinella (*Sardinellaaurita*Valenciennes, 1847) of the Algerian coasts: Distribution, Biology and estimation of biomasses. Doctorate thesis; U.ST.H.B., Algiers, 2007.

Branstetter, S. 1987. Age and growth estimates for blacktip, *Carcharhinuslimbatus*, and spinner, *C. brevipinna*, sharks from the northwestern Gulf of Mexico. Copeia, 1987 :964-974.

Chakroun-Marzouk, N. and Ktari, M.H., 2003. The crow of the Tunisian coasts, Sciaena umbra (Sciaenidae): sexual cycle, age and growth. Cybium, 27: 211-225.

Chauvet, C. 1988. Study of the growth of *Epinephelusguaza* (Linne, 1758) off the Tunisian coast. Aquat. Living Resour., 1: 277-288.

Dankwa, H.R. 2011. Length-weight relationship and growth parameters of grey mullets (Pisces: Mugilidae) in two estuaries in Ghana. W. Afr. J. Appl. Ecol., 18 : 53-61.

Diouf, P.S. and Bousso, T. Senegal River-Aquatic environment and fishing. Doc. Scient. Cent. Rech. Océanogr. Dakar-Thiaroye, 1988, Final report 108.

Diouf, P.S. Senegalese estuary mullets quick identification guide, Dakar, Doc. Scient. Centre Rech. Océanogr. Dakar -Tiaroye, 1991, Final report 129.

Erguden, S.A. 2016. Length-weight relationships for six freshwater fish species from the Seyhan Reservoir (south-eastern Anatolia, Turkey). J. Appl. Ichthyol., 32: 141-143.

Goncalves, J.M.S., Bentes, L., Lino, P.G., Ribeiro, J., Canario, A.V.M. and Erzini, K. 1997. Weight-length relationships for selective fish species of the small scale demersal fisheries off the South and Southwest coast of Portugal. *Fish. Res.,* 30: 253-256.

Gulland, J. 1971. The fish resouces of the ocean. West Byfleet, Surrey, Fishing News (Books), Ltd., for FAO, 255p. Rev. ed. Of FAO Fish. Tech. Pap., 97.

Harrison, T.D. 2001. Length-weight relationships of fishes from South African estuaries. *J. Appl. Ichthyol*., 17: 46-48.

Honorine, A.E.Y.G., Fidèle, K.K., Dagou, S. and Béatrice, A.A. 2019. Reproductive biology of the fish Liza dumerili (Steindachner, 1870) in the Ebrié lagoon (South-Eastern Côte d'Ivoire, West Africa). *Int. J. Fish. Aquat.,* 7: 521-527.

Hossain, M.Y., Sayed, S.R.M., Rahman, M.M., Ali, M.M., Hossen, M.A., Elgorban, A.M. and Ohtomi, J. 2015. Length-weight relationships of nine fish species from the Tetulia River, southern Bangladesh. *J. Appl. Ichthyol.,* 31: 967-969.

King, R.P. 1996. Length-weight relationships of Nigerian coastal water fishes. Naga ICLARMQ, 19: 53-58.

Le Cren, C.D. 1951. The Length-Weight Relationship and Seasonal Cycle in Gonad Weight and Condition in Perch, *Percafluviatilis*. *J. Appl. Ecol.,* 20: 201-219.

Marais, J.F.K. The nutritional ecology of mullets in the Swartkops estuary. PhD thesis, University of Port Elizabeth, Port Elizabeth, 1976

Mehanna, S.F. and Farouk, A.E. 2021. Length-Weight Relationship of 60 Fish Species from the Eastern Mediterranean Sea, Egypt (GFCM-GSA 26). *Front. Mar. Sci.,* 8: 1-7.

Ndiaye, M., Sarr, S.M., Diouf, M. and Touré, A. 2020. Growth and exploitation of Liza dumerili (Steindachner, 1870), by the use of length frequencies in Joal-Fadiouth Marine Protected Area in Senegal. *Int. J. Innov. Appl. Res.,* 28 : 652-665.

Pandare, D. and Capdeville, B. 1986. "Ichthyological fauna of Casamance": 59-88, in EPEEC, Study of the estuaries and lagoons of Senegal: Casamance and Joal Fadiouth, Dakar, Unesco.

Pauly, D. 1985. The population dynamics of short-lived species, with emphasis on squids. NAFO Sci. Council Stud., 9: 143-154.

Pauly, D. A selection of simple methods for the assessment of tropical fish stocks. 1980. FAO Fish. Circ., 729.

Pauly, D. and Moreau, J. Methods for the assessment of fisheries resources. Polytech collection of the I.N.P. of Toulouse, Cépaduès-Edutions, France, 1997.

Pauly, D. and Munro, J.L. 1984. Once more on the comparison of growth in fish and invertebrates. ICLARM Fishbyte, 2: 1-21.

Pauly, D. Gill size and temperature as governing factors in fish growth: a generalization of von Bertalanffy's growth formula. Doctoral thesis, Berichte des Institutfür Meereskunde an der Universität, 1979.

Pauly, D., Greenberg, A. 2013. ELEFAN in R: A new tool for length-frequency analysis. Fisheries Centre Research Reports. University of British Colombia, 21:1198-6727.

Pombo, L., Elliott, M. and Rebelo, J.E. 2005. Environmental influences on fish assemblage distribution on an estuarinecoastallagoon, Ria de Aveiro (Portugal). *Sci. Mar.*, 69: 143-159.

Ricker, W.E. Calculation and interpretation of biological statistics of fish populations. *J Fish Res Board Can.,* 191E, 1980, Ottawa

Ruiz-Campos, G., González Acosta, A.F. and De La Cruz Aguero, J. 2006. Length-weight and length-length relationships for some continental fishes of northwestern Baja California, Mexico. *J. Appl. Ichthyol.,* 22 : 314-335.

Sidibé, A., Gascuel, D. and Domain, F. Assessment and diagnosis using the structural approach: Application to four coastal demersal fish stocks (Galeoidesdecadactylus, Pseudotolithuselongatus, P. senegalensis and P. typus) from Guinea. In: Gascuel, D.; Barry, M.; Laurans, M.; Sidibé, A. (eds.) Assessments of demersal stocks in North-West Africa. Work of the “Monospecific analyses” group of the SIAP project. CECAF/PACE Series. No.03/65. Rome, FAO. 2003.

Sivashanthini, K., Gayathri, G. and Gajapathy, K. 2009. Length-weight relationship of *Sphyraenaobtusata*cuvier, 1829 (Pisces: perciformes) from the Jaffna Lagoon, Sri Lanka. *J Fish Aquat Sci.,* 4: 111-116.

Sokal, R.R. andRohlf, F.J. Introduction to Biostatistics. W.H. Freeman, New York, New York, USA; 1987.

Sparre, P. and Venema, S.C. Introduction to tropical fish stock assessment. Part One: FAO Manual, 1996. *Fisheries Technical Paper. Rev.*1, Rome: 306(2).

Tah, L.G., Gooré, B.G. and Da Costa, K.S. 2012. Length-weight relationships for 36 freshwater fish species from two tropical reservoirs: Ayamé I and Buyo, Côte d’Ivoire. *Rev. Biol. Trop.,* 60: 1847-1856.

Tesch, F.W. Age and growth (pp. 98-103). In: Ricker, W. E. (Ed.), Methods for assessment of fish production in fresh waters. (1st ed.). Oxford, UK: Blackwell Scientific Publications, 1971.

Von Bertalanffy, L. 1938. A Quantitative theory of organic growth. *Hum. Biol.,* 10 : 181-213.

Warren, D.L., Glor, R.E., and Turelli, M. 2008. Environmental niche equivalency versus conservatism: quantitative approaches to niche evolution. Evolution: *International Journal of Organic Evolution,* 62: 2868-2883.

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