Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 24(4): 281 – 292 (2020)
www.ejabf.journals.ekb.eg

Growth pattern, condition and prey-predator status of 9 fish species from the Arabian Sea (Baluchistan and Sindh), Pakistan

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ARTICLE INFO

Article History:
Received: June 4, 2020
Accepted: June 13, 2020
Online: June 21, 2020

Keywords:
Growth pattern ;
Fulton's condition factor;
Relative weight;
Arabian Sea;
Pakistan

ABSTRACT

The present study aimed to estimate the growth pattern through length-weight relationships (LWRs), condition (Fulton's condition factor, K_F) and prey-predator status through relative weight (W_R) of 9 fish species e.g. *Netuma thalassina*, *Epinephelus coioides*, *Acanthopagrus berda*, *Acanthopagrus latus*, *Acanthopagrus bifasciatus*, *Parastromateus niger*, *Aluterus monoceros*, *Sphyraena putnamae*, and *Lates calcarifer* belong 7 families from the Arabian Sea of Pakistan. Occasionally samples were collected from marine waters of the Arabian Sea connected to Baluchistan and Sindh province from June 2018 to May 2019 by **bottom and midwater trawl nets**, gill nets, and trammel nets. Individual whole body weight (BW) and total length (TL) were measured. The growth pattern either allometric (+/-) or isometric was calculated as LWR: $BW = a \times TL^b$. *a* and *b* were the LWR parameters. Condition factor was calculated as $K_F = (BW/TL^3) \times 100$ and prey-predator status was as $W_R = (W/W_S) \times 100$, where $W_S = a \times TL^b$. This study recorded a new maximum TL (150.0 cm) for *S. putnamae*. The *b* values of LWR ranged from 2.02 to 2.76 with $r^2 \geq 0.95$ that indicated a negative allometric growth pattern. Additionally, the study estimated K_F mostly above 1.0 except *A. bifasciatus*, *A. monoceros*, and *S.putnamae*. The prey-predator status was mostly balanced except for *L. calcarifer*. The findings of this study will be valuable for fishery managers to impose sustainable fishery management in the Arabian Sea (Baluchistan and Sindh), Pakistan, and adjacent ecosystems.

INTRODUCTION

The Arabian Sea at the coast of Sindh and Baluchistan has rich fish deposits of commercial importance. This coast is divided into two zones, *i.e.* the northwestern rock and rough region or Makran coast and the southeastern sandy or sandy-muddy region or Sindh coast. Pakistan has a coastline that extended 1050 km of which Sindh province

belonged 250 km and Baluchistan 800 km. Pakistan coast is the habitat of considerable diversity including marine flora and fauna, with numerous commercially important fish species inhabiting the intertidal, near-shore and off-shore areas **(Siddiqui *et al.*, 2008)**.

Growth pattern of fishes are effective for management both in basic and applied use for estimation of weight from length observations **(Hossain *et al.*, 2009)**, calculation of biomass and production of a fish population **(Hossain *et al.*, 2016)**, and provide information on stocks condition **(Hossen *et al.*, 2020)**. In addition, the condition factors of fish are quantitative parameter that reflects physical and biotic circumstances, and varies with interaction among physiological factors, feeding conditions and parasitic infections **(Le Cren, 1951)**. It determines population success by the effect on survival, growth and reproduction **(Sabbir *et al.*, 2020)**. Furthermore, prey predator status is very essential to know the habitat suitability of any species **(Hossain *et al.*, 2013).**

A few works on fisheries aspect **(Farooq *et al.*, 2017)** was carried out in the Arabian Sea, Pakistan but none of them covered growth pattern, condition and prey-predator status. Thus, this study was carried out to estimate the growth pattern, condition and prey predator status in the Arabian Sea connected to Baluchistan and Sindh province, Pakistan.

MATERIALS AND METHODS

Geographically, the study area in the Arabian Sea was located at 61°30' E to 68°10' E (Figure 1). Samples were collected with the help of local fishermen during June 2018 to May 2019 by using different types of fishing gear namely nets (bottom and mid water trawl nets**,** gill nets, trammel nets) and long-lines. Size of gill nets was about 44×10 square meter. Samples were collected by wooden ship from the different sites.

Total length (TL) was measured using measuring tape in cm and whole body weight (BW) was taken using an electronic weighing balance in g for each individuals. The growth pattern was calculated by length-weight relationship: $BW = a \times TL^b$. a and b were the LWR parameters estimated by linear regression analysis based on logarithms: $log(W) = log(a) + b\ log\ (L)$. The Fulton's condition factor (K_F) was calculated by the equation of **Fulton (1904)**: $K_F = (BW/TL^3) \times 100$. The prey predator status was calculated by the relative weight (W_R) using the equation of Froese (2006): $= (W/W_S) \times 100$, where W is the weight of a particular individual and W_S is the predicted standard weight for the same individual as calculated by $W_S = a \times L^b$.

For statistical analyses GraphPad Prism 6.5 software was used. A *t* test was used to determine any significant difference from the isometric value ($b = 3$) for LWRs. All statistical analyses were considered significant at 5% ($p<0.05$).

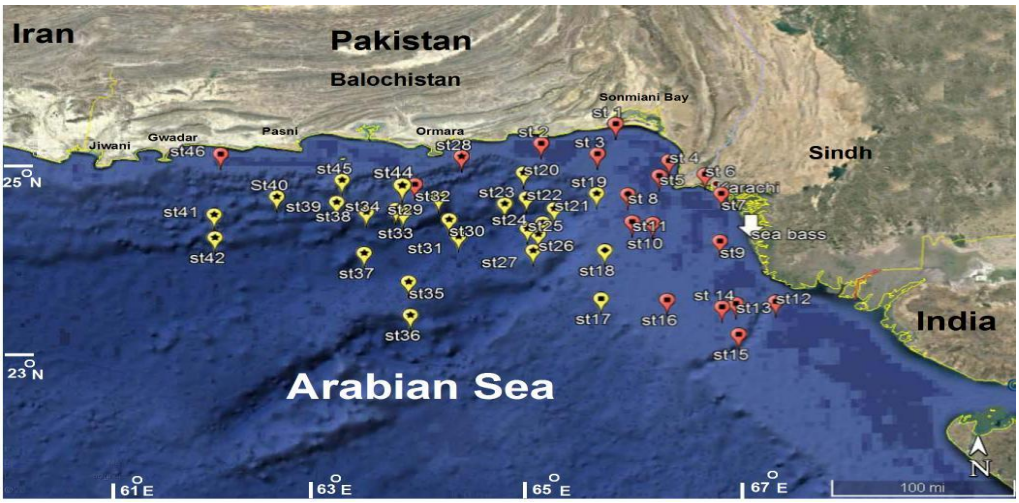

Fig.1.Sampling sites in the Arabian Sea connected to Baluchistan and Sindh province Pakistan (red indicate shallow water sampling site and yellow indicate deep water sampling site).

RESULTS

A total number of 1325 individuals of 9 fish species e.g., *Netuma thalassina*, *Epinephelus coioides*, *Acanthopagrus berda*, *Acanthopagrus latus*, *Acanthopagrus bifasciatus*, *Parastromateus niger*, *Aluterus monoceros*, *Sphyraena putnamae* and *Lates calcarifer* from seven families were collected from the Arabian Sea, Pakistan during this study. The minimum TL observed for *A. latus* (8.0 cm) corresponding to weight 22.0 g. The maximum captured TL was 150.0 cm (10000.0 g) for *S. putnamae* which was higher than available literatures. The *b* value of LWR ranged from 2.02 to 2.76 with $r^2 \geq 0.95$ that specify the growth pattern as negative allometric (Figure 2, Table 1).

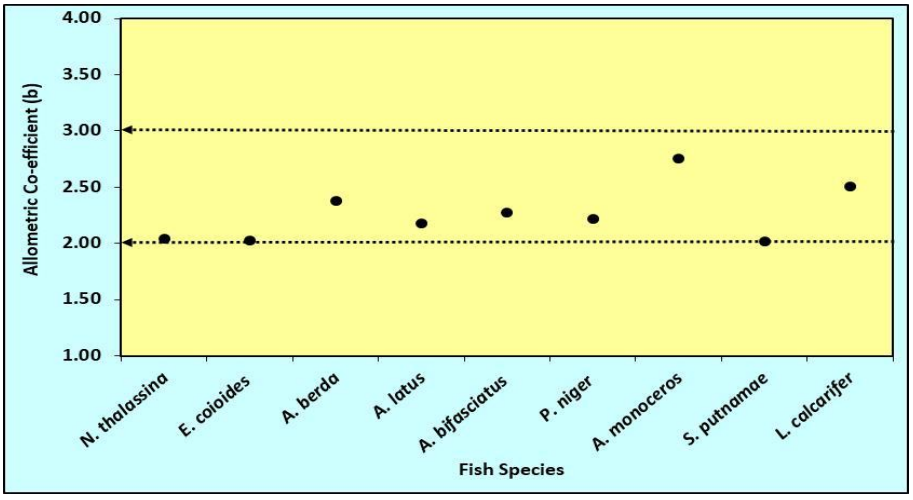

Figure 2. Allometric co-efficient (*b*) values of 9 fish species from the Arabian Sea (Baluchistan and Sindh), Pakistan.

Table 1: Descriptive statistics and estimated length–weight relationships ($BW = a \times TL^b$, BW in g and TL in cm) parameters for 9 species from Arabian Sea (Baluchistan and Sindh), Pakistan

Family	Species	*n*	TL (cm)		BW (g)		*a*	*b*	95% CL of *a*	95% CL of *b*	r^2	GT
			Min	Max	Min	Max						
Ariidae	*Netuma thalassina*	156	20.0	40.0	300.0	1300.0	0.6257	2.04	0.1440 - 2.7195	1.62 - 2.47	0.98	A-
Serranidae	*Epinephelus coioides*	142	30.0	47.0	700.0	1600.0	0.6834	2.03	0.0618 - 7.5549	1.37 - 2.68	0.95	A-
	Acanthopagrus berda	157	15.0	38.0	100.0	900.0	0.1691	2.38	0.0669 - 0.4274	2.10 - 2.65	0.99	A-
Sparidae	*Acanthopagrus latus*	115	8.0	32.0	22.0	400.0	0.1715	2.18	0.0385 - 0.7627	1.65 - 2.70	0.96	A-
	Acanthopagrus bifasciatus	156	17.0	38.0	49.0	270.0	0.0697	2.27	0.0097 - 0.5012	1.66 - 2.88	0.95	A-
Carangidae	*Parastromateus niger*	191	15.0	42.0	200.0	2000.0	0.4560	2.22	0.0906 - 2.2937	1.76 - 2.68	0.97	A-
Monacanthidae	*Aluterus monoceros*	164	30.	70.0	200.0	2500.0	0.0219	2.76	0.0016 - 0.2998	2.11 - 3.41	0.96	A-
Sphyraenidae	*Sphyraena putnamae*	115	55.0	150.0*	1300.0	10000.0	0.4015	2.02	0.3022 - 0.5333	1.96 - 2.08	0.99	A-
Centropomidae	*Lates calcarifer*	129	13.0	120.0	40.0	8000.0	0.0533	2.51	0.0114 - 0.2485	2.07 - 2.94	0.99	A-

BW, body weight; TL, total length; *n*, sample size; Min, minimum; Max, maximum; CL, confidence limit for mean value; GT, growth type; A-, negative allometric; *, Maximum TL found than previous study

The first quartile, median, third quartile and IQR were shown in Figure 3 where extreme outliers were omitted from the analysis. Fulton's condition factor (K_F) revealed balance condition (~ 1) for *E. coioides, A. latus* and *L. calcarifer,* underweight (< 1) for *A. bifasciatus, A. monoceros* and *S. putnamae* while *N. thalassina, A. berda* and *P. niger* showed over weight (> 2) compared to their length (Table 2). This study indicated the Arabian Sea as a balanced habitat for all studied marine species except *L. calcarifer* (Table 2).

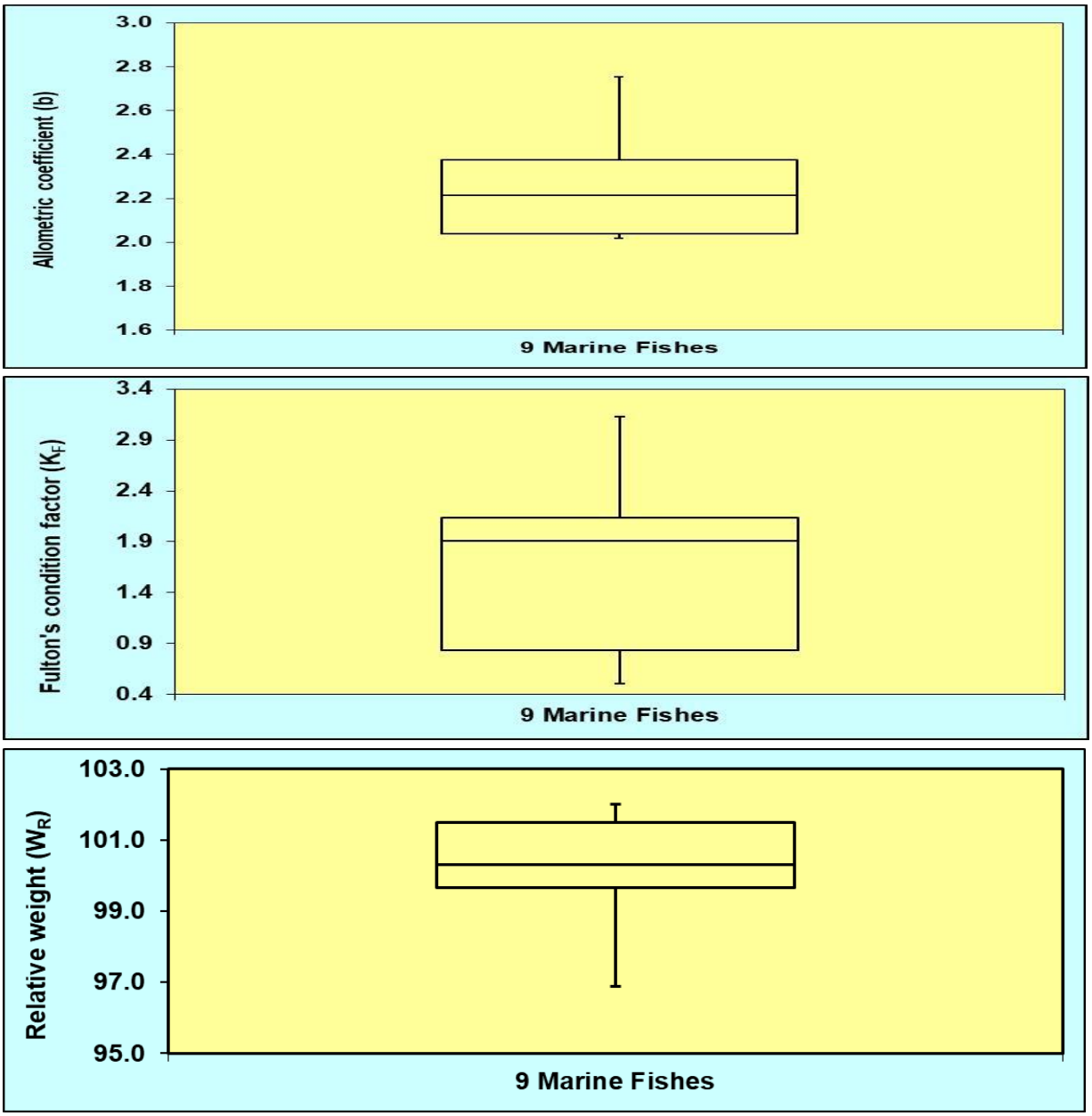

Figure 3. Box plot of allometric co-efficient (*b*) values, Fulton's condition factor (K_F) and relative weight (W_R) of 9 fish species from the Arabian Sea (Baluchistan and Sindh), Pakistan.

Table 2: Descriptive statistics on Fulton's condition factor (K_F) and relative weight (W_R) measurements and their 95% confidence limits of 9 species from Arabian Sea (Baluchistan and Sindh), Pakistan

Species	K_F				W_R			
	Min	**Max**	**Mean ± SD**	**95% CL of K_F**	**Min**	**Max**	**Mean ± SD**	**95% CL of W_R**
Netuma thalassina	1.8224	3.7500	2.3579 ± 0.6979	1.6255 - 3.0903	92.99	112.04	100.32 ± 7.80	92.12 - 108.51
Epinephelus coioides	1.5411	2.5926	1.9278 ± 0.3706	1.5388 - 2.3167	89.00	110.43	102.02 ± 7.87	93.76 - 110.27
Acanthopagrus berda	1.6402	2.9630	2.1386 ± 0.4491	1.7232 - 2.5540	92.52	108.26	99.22 ± 7.28	92.49 - 105.96
Acanthopagrus latus	0.9155	4.2969	1.9096 ± 1.1673	0.8300 - 2.9892	72.49	140.50	101.50 ± 26.81	76.70 - 126.30
Acanthopagrus bifasciatus	0.4921	1.0177	0.6901 ± 0.1909	0.5135 - 0.8666	80.83	122.80	101.80 ± 15.66	87.31 - 116.29
Parastromateus niger	2.3324	5.9259	3.1316 ± 1.2592	1.9670 - 4.2962	81.88	115.67	99.66 ± 14.04	86.65 - 112.67
Aluterus monoceros	0.7289	1.2500	0.8336 ± 0.1974	0.6511 - 1.0162	77.88	141.02	101.47 ± 20.57	82.45 - 120.50
Sphyraena putnamae	0.2963	0.7814	0.5085 ± 0.1995	0.2991 - 0.7178	97.78	103.03	99.71 ± 1.89	97.73 - 101.69
Lates calcarifer	0.4630	1.8207	1.0607 ± 0.4719	0.5655 - 1.5559	64.95	118.05	91.50 ± 25.30	64.95 - 118.05

Min, minimum; Max, maximum; SD, standard deviation; CL, confidence limit for mean value

DISCUSSION

Production or biomass of any fish population can be calculated with the help of growth pattern (LWR) (Hossain *et al*., 2017a, b). To estimate growth pattern condition and prey predator status, a total number of 1325 individualss of 9 fish species from the Arabian Sea, Pakistan were collected. All the collected species are smaller (*N. thalassina* **(Bykov, 1983)**, *E. coioides* **(Assadi and Dehghani, 1997)**, *A. berda* **(Smith and Smith, 1986)**, *A. latus* **(Wang *et al*., 2016)**, *A. bifasciatus* **(Taher, 2010)**, *P. niger* **(Sousa and Dias, 1981)**, *A. monoceros* **(Claro, 1994)**, *L.calcarifer* **(Kottelat *et al*., 1993)** than previous findings except *A. bifasciatus* **(Iwatsuki and Heemstra, 2011)**. The difference may be attributed as the selectivity of fishing gears **(Hossain *et al*., 2019)** or fishermen did not go or harvest fish in that area where large specimens were available (**Khatun *et al*., 2019)**. Fishbase record was 90.0 cm for *S. putnamae* **(Randall *et al*., 1990)** while we found maximum TL (150.0 cm). Information on maximum length is essential to assessment the population parameters including growth coefficient and asymptotic length, which is important for fisheries resource management and planning **(Hossen *et al*., 2019; Rahman *et al*., 2019)**.

According to **Carlander** (1969), the allometric coefficient (*b*) values of LWRs may vary between 2.0 to 4.0. Findings of this study were within this range. The allometric coefficient (*b*) values of *A. monoceros* and *L. calcarifer* was within the edge stated by **Froese (2006)**. We found negative allometric growth for all species while other study found positive allometric growth for some species including *N. thalassina* **(Bawazeer, 1987)**, *E. coioides* **(Grandcourt *et al*., 2005)**, *A. latus* **(Wang *et al*., 2016), *P. niger* (Pauly *et al*., 1996)** and isometric growth for *E. coioides* **(Mathews and Samuel, 1991; Letourneur *et al*., 1998; Kandula *et al*., 2014; Gumanao *et al*., 2016)**, *A. berda* **(Samuel and Mathews, 1987; Harrison, 2001; Hussain *et al*., 2010; Lubna *et al*., 2013)**, *A. latus* **(Heydarnejad, 2009; Hussain *et al*., 2010)**, *A. bifasciatus* **(Samuel and Mathews, 1987; Grandcourt *et al*., 2004)**, *P. niger* **(Rao, 1972)**. Some study also support our findings including *N. thalassina* **(Al Sakaff and Esseen, 1999; Farooq *et al*., 2017)**, *A. latus* **(Raeisi *et al*., 2010; Alavi-Yeganeh *et al*., 2016; Awan *et al*., 2017; Vahabnezhad *et al*., 2017)**, *A. bifasciatus* **(Edwards *et al*., 1985)**, *P. niger* **(Abdurahiman *et al*., 2004; Saleh and Soegianto, 2017)**, *A. monoceros* **(Wang *et al*., 2011; Yagi *et al*., 2015)**, *S. putnamae* **(Letourneur *et al*., 1998; Kulbicki *et al*., 2005; Roul *et al*., 2020)**, *L. calcarifer* **(Patnaik and Jena, 1976; Awan *et al*., 2017; Ramses *et al*., 2020)**. The variation of growth pattern may be ascribed by several factors including sex, gonadal development **(Hossain and Ohtomi, 2008; Hossain *et al*., 2010)**, food availability, seasonal effect **(Hossain *et al*., 2012)**, health, habitat and preservation techniques **(Parvin *et al*., 2018)**, which are not counted during this study.

Condition factor dependent on the LWR pointed out general fish health as an indicator of the changes in food reserves **(Nima *et al*., 2020)**. But a very few study was conducted on condition factors of these species. Fulton's condition factor for *E. coioides* **(Raeisi *et al*., 2011)** and *A. latus* **(Awan *et al*., 2017)** were smaller than our current findings. Rests of the species have no available data on K_F. Relative weight data were not available except *L. calcarifer* **(Ramses *et al*., 2020)**. The relative weight (W_r) index allows easy interpretation of condition for fish of various species and lengths and provides an indirect means of evaluating ecological relations and the effects of various management strategies. The habitat considered as balanced if the value W_R is 100 **(Rahman *et al*., 2012)**. Any deviation of 100 is considered as unbalance for fish population **(Hossain *et al*., 2018).**

CONCLUSION

This study has delivered valuable information on the growth as well as length-weight relationship that are useful to determine stock or biomass of fish population, condition factors and prey predator status would be convenient to fishery managers for sustainable fishery management in the Arabian Sea (Baluchistan and Sindh), Pakistan and also else-where.

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