Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 25(3): 1045 – 1057 (2021)
www.ejabf.journals.ekb.eg

Length-Weight Relationships of Ten Small Pelagic Fishes along the Coastal Waters of Karnataka, Southeastern Arabian Sea, India

Rajesh K. Mallegowda[1]*, Mridula Rajesh[2] and Prathibha Rohit[1]

[1]ICAR-Central Marine Fisheries Research Institute, Mangalore Regional Centre, P.B. No. 244, Hoige Bazar, Mangaluru-575 001, Karnataka, India

[2]Department of Fisheries Resources and Management, College of Fisheries Mangaluru – 575 002, Karnataka, India

***Corresponding Author**: rajeshmkm3@rediffmail.com

ARTICLE INFO

Article History:
Received: Dec. 15, 2020
Accepted: May 27, 2021
Online: June 29, 2021

Keywords:
Length-weight relationship,
Small pelagic fish,
Karnataka,
Isometric growth,
Allometric growth.

ABSTRACT

Information on length and body weight of fish is the foremost requirement for regulation of catch and estimation of biomass as they are the pre-requisites for conservation and management of fish. Length-weight relationships were estimated for ten major marine small pelagic fish species landed along Karnataka coast, southeastern Arabian Sea. Specimens were collected on weekly basis from various gears such as purse seines, ring seines, trawl nets and gillnets landed at two major fishing harbors (Mangalore and Malpe) located along the Karnataka coast during January 2018 to December 2019. The estimated allometric coefficient *b* ranged between 2.513 and 3.205, falling within the expected range (2.5-3.5). The LWRs were highly significant ($P<0.001$; $r^2 \geq 0.90$) for all the species and ranged from 0.90 to 0.99. The analysis divulged isometric growth ($b=3$) for *Sardinella albella* (female), *Sardinella fimbriata* (female), *Sardinella gibbosa* (male and pooled) *Decapterus macrosoma* (pooled) and *Stolephorus commersonii* (pooled). However, *Sardinella albella* (male and pooled), *Sardinella gibbosa* (female), *Escualosa thoracata* (pooled), *Decapterus tabl* (pooled), *Stolephorus waitei* (pooled) showed positive allometeric growth ($b>3$) while *Sardinella fimbriata* (male and pooled), *Seriolina nigrofasciata* (male, female and pooled) and *Encrasicholina devisi* (pooled) showed negative allometric growth ($b<3$). The present study reported new maximum size for *Sardinella fimbriata*, *Escualosa thoracata*, *Encrasicholina devisi* and *Stolephorus waitei*. In addition, this study would contribute in providing the first estimate of LWRs of *Decapterus tabl* from Indian waters. The basic biological information provided in this study in the form of length-weight estimates for 10 commercially important small pelagic fish species from southeastern Arabian Sea filling important knowledge gaps in population studies and stock assessment and further assists in sustainable management and conservation of fisheries.

INTRODUCTION

A length weight relationship (LWRs) is an important parameter required to identify the health state of an animal (**Possamai *et al*., 2019**). It is also useful in estimating the average weight for a given length group, and conversion of length measurements into

weight where measurement of both length and body weight of each specimen is practically cumbersome, time consuming, expensive and difficult to weigh large-sized fishes in the field or on-board vessels (**Froese, 2006; Froese *et al*., 2011; Karna, 2017; Rajesh *et al*., 2020**). The LWRs is required for the elaboration of stock and growth models and with the allometric coefficient *b*, it helps to verify the type of fish growth, whether allometric or isometric (**Carvalho *et al*., 2017**). Information on length and body weight of fish is the foremost requirement for regulation of catch and estimation of biomass as they are the pre-requisites for conservation and management of fish (**Froese *et al*., 2014**).

The nutritional profile of small prey fish is extensive and plays a key role in promoting the health of people as it contains essential vitamins, minerals, coenzymes and fatty acids, all beneficial for optimal health (**Rajesh & Rohit, 2012**). The widely distributed and abundantly available cheap small pelagic fishes are undoubtedly the best nutritional rich food source that can meet the challenge of food security facing most of the developing countries. Consumption of small quantities of these species of fish, associated with basic foods, can significantly improve the nutritional value of food and the biological value of the diet. The small pelagic fishes mostly belonging to the families Clupeidae, Carangidae, Engraulidae and Scombridae constitute the bulk of fish landings in tropical countries (**Rajesh & Rohit, 2012**). In India, the small pelagic fish forms 32.68% of the total marine fish landings of the country (**CMFRI, 2020**).

The basic information on LWRs of small pelagic fish remains scanty and not studied in detail. Some of the available information from FishBase on length weight relationships being tentative and / or older, hence not representative for the present situation. In addition, the estimated LWRs parameters from local populations are usually preferred while calculating fish weights from lengths (**Giakoumi & Kokkoris, 2013**). Therefore, the present study investigated the LWRs of ten commercially important small pelagic fishes landed along Karnataka coast, southeastern Arabian Sea.

MATERIALS AND METHODS

Fishes captured using wide variety of fishing gears such as purse seines, ring seine, trawl nets and gill nets were collected on weekly basis from the landing centres of Mangaluru (12°853’N, 74°833’E) and Malpe (13°347’N, 74°701’E) Fishing Harbour along the south-eastern Arabian Sea, India for the period between January 2018 to December 2019. The fishes collected were identified up to the species level (**Fischer & whitehead, 1974; Fischer & Bianchi, 1984; Uibilein & Heemstra, 2010**) and the scientific names were verified following **Froese and Pauly (2020)**. Total length (TL) of each fish specimen was taken to the nearest 0.1 cm and individual total body weight (TW) was recorded to the nearest 0.1 g. The LWRs were determined for male, female and combined sexes for the species *Sardinella gibbosa, Sardinella fimbriata, Sardinella albella* and *Seriolina nigrofasciata*. LWRs of *Decapterus macrosoma, Decapterus tabl,*

Stolephorus waitei, Stolephorus commersonii, Encrasicholina devisi and *Escualosa thoracata* were determined for combined sexes.

The LWRs were estimated following the equation $TW=aTL^b$ (**Huxley, 1932; Le Cren, 1951**) where *TW* represents the total body weight (g) and *TL* represents the total length (cm), *a* is the intercept and *b* is the slope (growth co-efficient). The equation may also be expressed as $LogTW= Loga + bLogTL$ (**Le Cren, 1951; Ricker, 1975**). The parameters *a* and *b* of LWRs were determined by linear regression analysis (least square method) on log transform data. By performing a log-log plot of the length weight pairs, extreme outliers were removed from the regression analysis. Coefficient of determination (r^2) and 95% confidence limit (CL) of parameters *a* and *b* were estimated. The growth of fish was assessed as isometry when b=3 (**Ricker, 1975; Quinn & Deriso, 1999**); negative allometric growth when b<3 and is defined as hypo-allometry, indicating more length than predicted by its weight; positive allometric growth when b>3 and is defined as hyper-allometry, indicating more in weight than predicted by its length (**Shingleton *et al*., 2009**). To test the *b* value of all the species against the value of 3, student's *t*-test was used to predict any significant deviation (**Snedecor & Cochran, 1967**). Analysis of Co-Variance (ANCOVA) was performed to determine the difference between the *b* values of LWRs of males and females (**Snedecor & Cochran, 1967**).

RESULTS

Length-weight relationships (LWRs) of ten small pelagic fish species belonging to three families were analyzed. Details of sample size (N), length range (cm), mean length (cm), weight range (g), mean weight (g), parameters of LWRs with 95% confidence interval (CI) of *a* and *b*, coefficient of determination and type of growth for each species are depicted in Table (1). The LWRs of ten small pelagic fishes are expressed in Figs. (1-10). The LWRs were highly significant (P<0.001; $r^2 \geq 0.90$) for all the species. The r^2 values (pooled sexes) ranged between 0.90 for *Escualosa thoracata* to 0.99 for *Decapterus tabl*. The analysis of ANCOVA indicated that there was no significant difference (P<0.05) in the LWRs between the sexes for *Sardinella gibbosa* (F=1.53, d.f. =575, P=0.22), *S. fimbriata*, (F=2.49, d.f. =317, P=0.12) *S. albella* (F=2.67, d.f. =372, P=0.10) and *Seriolina nigrofasciata* (F=1.29, d.f. =648, P=0.28). The growth co-efficient *b* estimated for all the fishes were within the expected range of 2.5-3.5 (**Froese, 2006**). The *b* values ranged between 2.513 for male *Seriolina nigrofasciata* and 3.205 for male *Sardinella albella*. The growth type (positive or negative allometry or isometry) was detected for each species following student's *t*-test. The analysis divulged that the growth of *S. albella* (female), *S. fimbriata* (female), *S. gibbosa* (male and pooled), *Decapterus macrosoma* (pooled) and *Stolephorus commersonii* (pooled) was isometric growth (*b*=3) whereas for all other species, *b* value was significantly different from 3 (*t*-test, P<0.05). *Sardinella albella* (male and pooled), *S. gibbosa* (female), *Escualosa thoracata* (pooled), *D. tabl* (pooled), *Stolephorus waitei* (pooled) showed positive allometeric growth (*b*>3)

Table 1. Descriptive statistics and estimated parameters of length-weight relationships (LWRs) for small pelagic fishes along Karnataka coast, southeastern Arabian Sea, India during 2018-19.

Family	Species	Sex	N	TL range (cm)	Mean ± SE	TW range (g)	Mean ± SE	Parameters of LWRs				r^2	Growth
								a	95% CI	*b*	95% CI		
Clupeidae	*Sardinella albella* (Valenciennes, 1847)	M	194	10.5-19.2	15.25±0.15	10.0-65.0	32.67±0.99	0.0049	0.004-0.007	3.205	3.088-3.323	0.94	A^+
		F	181	9.7-20.2	15.08±0.16	8.2-78.4	32.33±1.05	0.0072	0.005-0.009	3.072	2.966-3.178	0.95	I
		P	375	9.7-20.2	15.17±0.11	8.2-78.4	32.51±0.72	0.0061	0.005-0.008	3.129	3.051-3.208	0.94	A^+
	Sardinella fimbriata (Valenciennes, 1847)	M	146	10.6-**21.2**	15.09±0.18	12.5-84.0	34.10±1.20	0.0157	0.012-0.019	2.812	2.726-2.897	0.97	A^-
		F	174	12.0-21.0	15.42±0.14	17.8-83.5	35.49±1.04	0.0122	0.009-0.016	2.901	2.791-3.011	0.94	I
		P	320	10.6-**21.2**	15.27±0.11	12.5-83.5	34.86±0.79	0.0152	0.013-0.018	2.822	2.753-2.891	0.95	A^-
	Sardinella gibbosa (Bleeker, 1849)	M	274	11.8-18.3	15.48±0.08	12.1-54.2	31.69±0.45	0.0080	0.006-0.011	3.018	2.911-3.124	0.92	I
		F	304	11.9-18.3	15.88±0.08	12.2-51.4	34.35±0.51	0.0062	0.005-0.008	3.109	3.017-3.202	0.94	A^+
		P	578	11.8-18.3	15.69±0.06	12.2-54.2	33.09±0.35	0.0068	0.006-0.008	3.076	3.007-3.144	0.93	I
	Escualosa thoracata (Valenciennes, 1847)	P	1222	7.6-**12.7**	10.17±0.03	3.2-20.9	9.24±0.08	0.0058	0.005-0.006	3.163	3.104-3.222	0.90	A^+
Carangidae	*Decapterus macrosoma* Bleeker, 1851	P	72	14.5-33.5	20.14±0.46	18.5-321.2	84.93±7.52	0.0077	0.005-0.011	3.060	2.947-3.173	0.98	I
	Decapterus tabl Berry, 1968	P	156	11.2-18.4	17.73±0.42	13.6-340.0	93.46±7.33	0.0097	0.009-0.011	3.095	3.060-3.129	0.99	A^+
	Seriolina nigrofasciata (Rüppell, 1829)	M	307	16.6-44.0	28.23±0.33	66.0-1130	323.32±10.35	0.0671	0.053-0.085	2.513	2.441-2.585	0.94	A^-
		F	344	16.3-52.0	28.27±0.34	57.0-1650	337.85±11.68	0.0574	0.047-0.071	2.567	2.503-2.629	0.95	A^-
		P	651	16.3-52.0	28.25±0.24	57.0-1650	331.08±7.87	0.0631	0.054-0.074	2.535	2.488-2.583	0.94	A^-
Engraulidae	*Encrasicholina devisi* (Whitley, 1940)	P	1099	7.0-**11.1**	8.86±0.20	2.15-9.10	4.73±0.03	0.0084	0.007-0.009	2.897	2.843-2.951	0.91	A^-
	Stolephorus commersonii Lacepède, 1803	P	100	5.3-12.6	7.46±0.15	1.20-16.10	6.26±0.34	0.0141	0.010-0.020	2.984	2.813-3.155	0.92	I
	Stolephorus waitei Jordan and Seale, 1926	P	901	4.2-**13.0**	8.49±0.05	1.40-25.0	7.53±0.13	0.0089	0.008-0.010	3.103	3.065-3.142	0.97	A^+

M, Male; *F*, Female; *P*, Pooled; *N*, number of specimens studied; *a*, intercept of relationship; *b*, slope of relationship; *CI*, confidence interval; *r2* , coefficient of determination; *TL*, total length; TW, Total weight; I: isometric growth; A+: positive allometric growth; A-: negative allometric growth. Bold font represents new maximum size recorded.

Table 2. Length-weight parameters of small pelagic fishes reported from various regions.

Species	Authors	Location	Length-weight parameters					
			a			*b*		
			Male	Female	Pooled	Male	Female	Pooled
Sardinella albella	Sekharan, (1968)	Mandapam, India	0.00805	0.00019	-	3.052	3.176	-
	Perkins *et al*. (2019)	Hong Kong	-	-	0.01470	-	-	2.773
Sardinella fimbriata	Ghosh *et al*. (2013)	Paradeep, Vishakhapatnam and Kakinada, India	0.01315	0.01299	-	2.888	2.918	-
	Kudale *et al*. (2016)	Karwar, India	0.000026	0.000021	-	2.858	2.913	-
Sardinella gibbosa	Ghosh *et al*. (2013)	Paradeep, Vishakhapatnam and Kakinada, India	0.00567	0.00549	-	3.138	3.149	-
	Hussain *et al*. (2010)	Indus delta, Northern Arabian Sea, Pakistan	-	-	0.0780	-	-	3.058
Escualosa thoracata	Abdurahiman *et al*. (2004)	Southern coast of Karnataka, India	0.0060	0.0060	-	3.213	3.187	-
	Dar *et al.* (2014)	Mumbai, India	-	-	0.0048	-	-	3.236
	Gurjar *et al*. (2017)	Ratnagiri, Maharashtra, India	0.0174	0.0133	0.0162	2.7521	2.8567	2.8537
	Srihari *et al*. (2018)	Mandovi-Zuary estuary, India	-	-	0.0055	-	-	3.090
	Abdussamad *et al*. (2018)	Kerala, southwest coast of India	-	-	0.00459	-	-	3.295
Decapterus macrosoma	Sousa and Gj-saeter, (1987)	Mozambique	-	-	0.00383	-	-	3.258
	Pauly *et al*. (1996)	Western Indonesia	-	-	0.00760	-	-	3.005
	Pattikawa *et al*. (2017)	Eastern waters of Ambon Island, Indonesia	-	-	0.0020	-	-	3.592
Decapterus tabl	Iwasaki and Aoki, (2001)	Suruga Bay, Central Japan	0.00979	0.00995	-	3.185	3.117	-
	Narido *et al*. (2016)	Camotes Sea, Central Philippines	-	-	0.00970	-	-	2.986
Seriolina nigrofasciata	Qamar and Panhwar (2017)	Northern Arabian Sea coast of Pakistan	-	-	0.040	-	-	2.766
	Rajesh *et al*. (2019)	South-west coast of India	0.00021	0.00013	-	2.504	2.595	-
Encrasicholina devisi	Andamari *et al.* (2002)	Bima Bay, Sumbawa, Nusa Tenggara, Indonesia	-	-	0.00708	-	-	2.850
	Abdurahiman *et al*. (2004)	Southern coast of Karnataka, India	0.03100	0.03500	-	2.307	2.249	-
Stolephorus commersonii	Andamari *et al*. (2002)	Bima Bay, Sumbawa, Nusa Tenggara, Indonesia	-	-	0.00465	-	-	3.190
	Abdurahiman *et al*. (2004)	Southern coast of Karnataka, India	0.00400	0.00400	-	3.351	3.326	-
	Nair *et al*. (2015)	Kerala coast, India	0.0070	0.00756	-	3.16	2.99	-
Stolephorus waitei	Luther *et al.* (1992)	West coast of India	-	-	0.0000073	-	-	2.98
Sardinella albella	Luther *et al*. (1992)	East coast of India	-	-	0.0000046	-	-	3.11

- denotes data not available.

and *S. fimbriata* (male and pooled), *Seriolina nigrofasciata* (male, female and pooled) and *Encrasicholina devisi* (pooled) showed negative allometric growth (*b*<3).

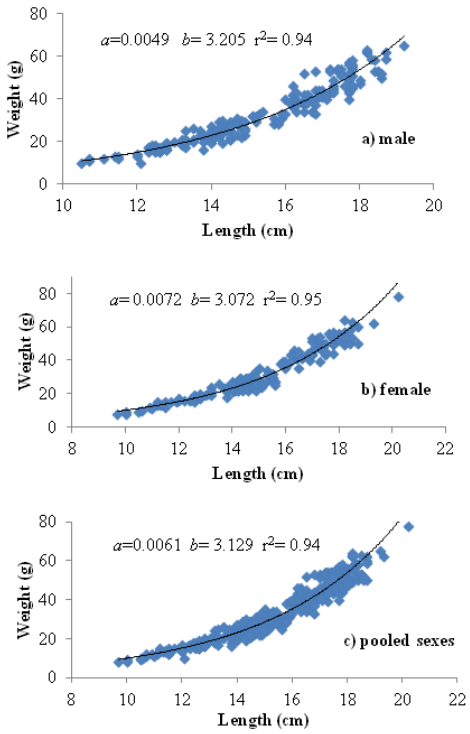

Fig. 1. Length–weight relationships in *sardinella albella* a) male, b) female and c) pooled sexes along Karnataka coast, southeastern Arabian Sea, India during 2018–2019.

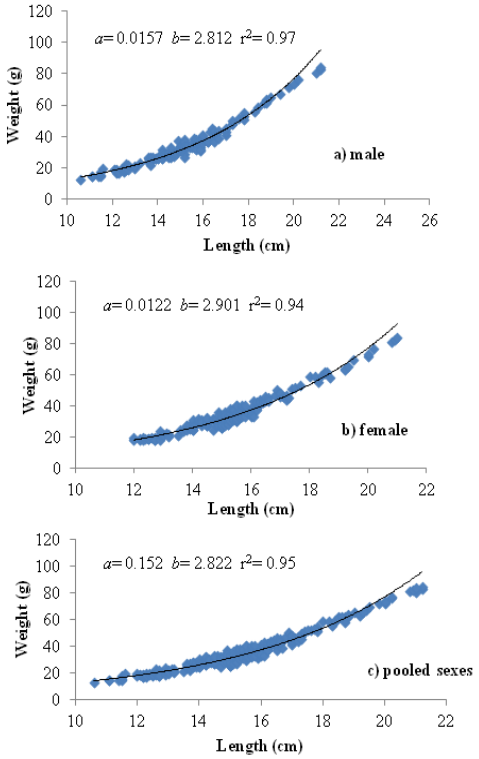

Fig. 2. Length–weight relationships in *sardinella fimbriata* a) male, b) female and c) pooled sexes along Karnataka coast, southeastern Arabian Sea, India during 2018–2019.

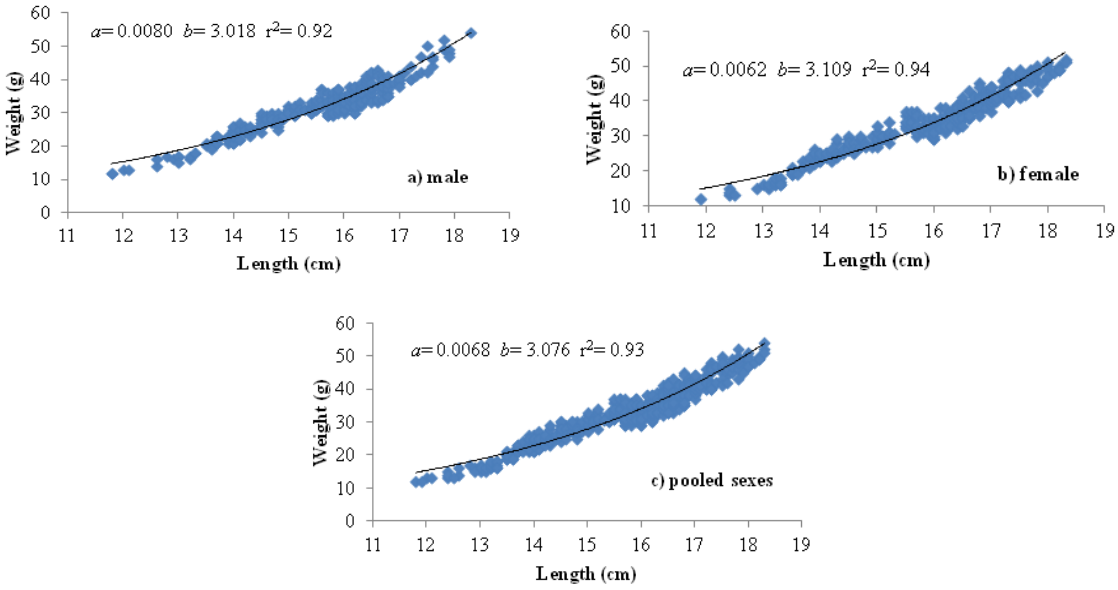

Fig. 3. Length–weight relationships in *sardinella gibbosa* a) male, b) female and c) pooled sexes along Karnataka coast, southeastern Arabian Sea, India during 2018–2019.

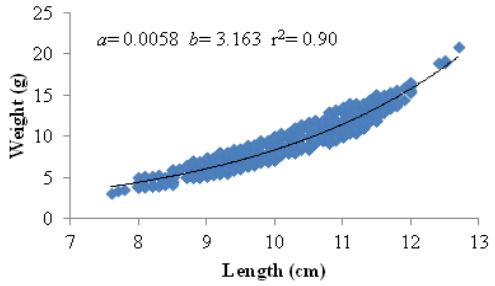

Fig. 4. Length–weight relationships in *Escualosa thoracata* for the pooled sexes along Karnataka coast, southeastern Arabian Sea, India during 2018–2019.

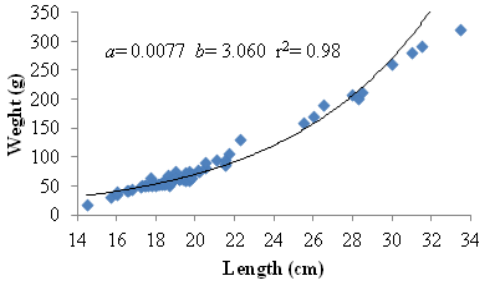

Fig. 5. Length–weight relationships in *Decapterus macrosoma* for the pooled sexes along Karnataka coast, southeastern Arabian Sea, India during 2018–2019.

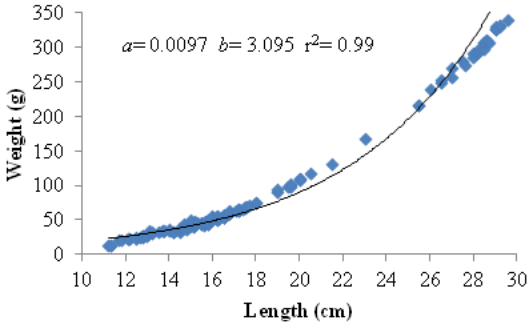

Fig. 6. Length–weight relationships in *Decapterus tabl* for the pooled sexes along Karnataka coast, southeastern Arabian Sea, India during 2018–2019.

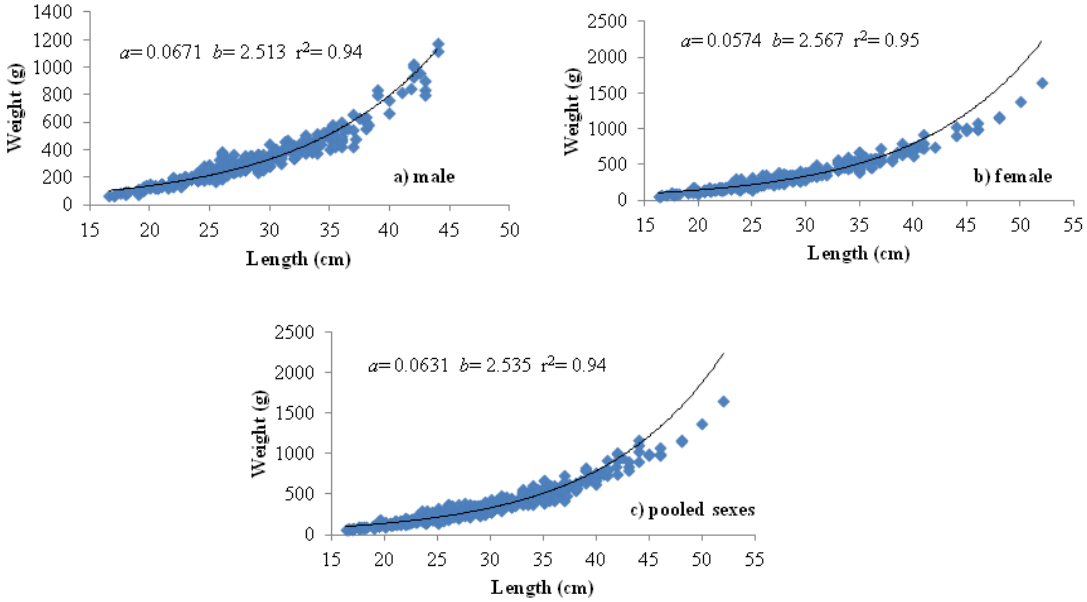

Fig. 7. Length–weight relationships in *Seriolina nigrofasciata* a) male, b) female and c) pooled sexes along Karnataka coast, southeastern Arabian Sea, India during 2018–2019.

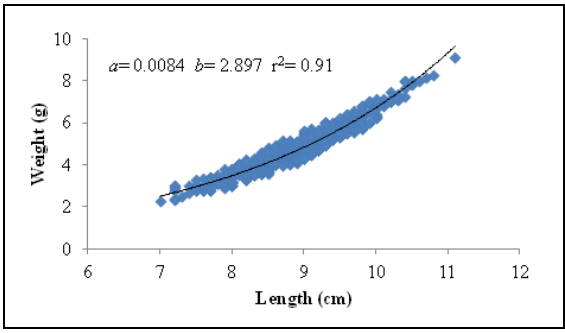

Fig. 8. Length–weight relationships in *Encrasicholina devisi* for the pooled sexes along Karnataka coast, southeastern Arabian Sea, India during 2018–2019.

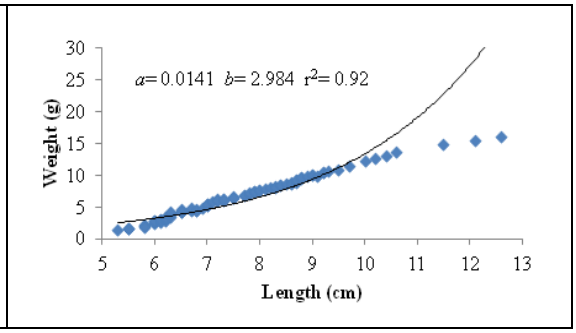

Fig. 9. Length–weight relationships in *Stolephorus commersonii* for the pooled sexes along Karnataka coast, southeastern Arabian Sea, India during 2018–2019.

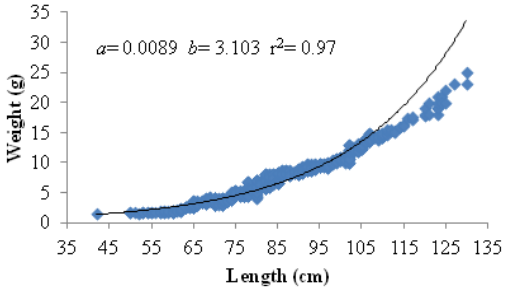

Fig. 10. Length–weight relationships in *Stolephorus waitei* for the pooled sexes along Karnataka coast, southeastern Arabian Sea, India during 2018–2019.

DISCUSSION

The parameter *b* of LWRs is generally found within the expected range of 2.5-3.5 (**Froese, 2006**) or 2-4 (**Bagenal & Tesch, 1978**) for fishes. The estimated LWRs of 10 fish species in the present study were found well within these expected ranges. In terms of growth pattern, *S. fimbriata* (male and pooled), *Seriolina nigrofasciata* (male, female and pooled) and *Encrasicholina devisi* (pooled) showed negative allometric growth ($b<3$); indicating that these fishes grows faster in length compared to weight. On the contrary, *Sardinella albella* (male and pooled), *S. gibbosa* (female), *Escualosa thoracata* (pooled), *D. tabl* (pooled), *Stolephorus waitei* (pooled) showed positive allometeric growth ($b>3$); suggesting these fishes grows faster in weight than length. However, in case of *Sardinella albella* (female), *Sardinella fimbriata* (female), *Sardinella gibbosa* (male and pooled), *Decapterus macrosoma* (pooled) and *Stolephorus commersonii* (pooled) showed isometric growth ($b=3$), the increase in weight with length was isometric. The estimated *b* value of *S. albella* was 3.205, 3.072 and 3.129 for male, female and pooled sexes respectively which is in accordance with the observations of **Sekharan (1968)** from Mandapam waters, India (3.052 for male and 3.176 for female) but differed from that of **Perkins *et al.* (2019)** from Hong Kong (2.773 for pooled sexes). The *b* values of *S. fimbriata* of male (2.812), female (2.901) and pooled sexes (2.822) in the present study almost coincides with that from east coast (**Ghosh *et al.*, 2013**) and

Karwar, west coast of India (**Kudale *et al*., 2016**) (Table 2). The growth coefficient '*b'* of *S. gibbosa* reported for male (3.138) and female (3.149) from east coast of India (**Ghosh *et al*., 2013**) and for pooled sexes (3.058) along Indus delta, Pakistan (**Hussain, *et al*., 2010**) are in concurrence with the values estimated in the current study (3.018, 3.109 and 3.076 for male, female and pooled sexes respectively). The estimated *b* value of *E. thoracata* for pooled sexes (3.163) is in agreement with the observations from southwest coast of Karnataka (**Abdurahiman *et al*., 2004**), Mumbai (**Dar *et al*., 2014**), Mandovi-Zuary estuary (**Srihari *et al*., 2018**) and Kerala (**Abdussamad *et al*., 2018**) while comparatively lower values were reported from Ratnagiri, Maharashtra, India (**Gurjar *et al*., 2017**) (Table 2).

The isometric growth (*b*=3.060) for *D. macrosoma* in this investigation is found to be similar to that reported by **Pauly *et a*l., (1996)** from Western Indonesia (*b*=3.005). However, allometric growth was reported by **Sousa and Gj-saeter, (1987)** and **Pattikawa *et al*., (2017)** from Mozambique (*b*= 3.258) and eastern waters of Ambon Island, Indonesia (*b*=3.592) respectively. The growth coefficient *b* for *D. tabl* documented was slightly higher (3.185 and 3.117 for male and female respectively) from Suruga Bay, Central Japan (**Iwasaki & Aoki, 2001**) and lower (2.986 for pooled sexes) from Camotes Sea, central Philippines (**Narido *et al*., 2016**) compared to the present study (3.095 for pooled sexes). The negative allometric growth observed for *S. nigrofasciata* in the present study (*b*= 2.513, 2.567 and 2.535, respectively for male, female and pooled sexes) is in line with the reports of **Qamar and Panhwar (2017)** from Northern Arabian Sea coast of Pakistan and **Rajesh *et al*. (2019)** from South-west coast of India (Table 2).

The estimated *b* value of *E. Devisi* from the present study (2.897 for pooled sexes) is similar to that of **Andamari *et al.* (2002)** from Bima Bay, Indonesia (2.850 for pooled sexes) and higher than that of **Abdurahiman *et al*. (2004)** from Southern coast of Karnataka, India (2.307 for males and 2.249 for females). The growth coefficient (*b*) documented for *S. commersonii* in the current investigation (2.984 for pooled sex) is comparable with **Nair *et al*. (2015)** from Kerala coast (2.99 for female) while it was lower than that reported by **Andamari *et al*. (2002)** from Bima Bay, Indonesia and **Abdurahiman *et al*. (2004)** from southern coast of Karnataka, India (Table 2). The estimated b values of this study (3.103) for *Stolephorus waitei* is almost in agreement with the results of **Luther *et al*. (1992)** from east (3.11) and west coast (2.98) of India.

The difference in the *b* values in LWRs for some of the species in this study with earlier reports may be attributed to various factors such as sample size, length range covered, the habitat in which the fish live, fish physiology, ontogenetic development, season, population, sex, gonadal maturity, stomach fullness, health, disease and parasite loads (**Le Cren, 1951; Tesch, 1971; Ricker, 1975; Froese *et al*., 2011; Mondol *et al*., 2017**). The fishes collected in the present study were from diverge group of gears such as purse seines, ring seines, trawlers and gillnets operating in different depths. Further, in

this study, the sample size was large as it was collected throughout the year including small size to large size groups which helped to minimize the error in calculating LWRs. Remarkably, the present study reported a new maximum size for *S. fimbriata*, *Escualosa thoracata*, *Encrasicholina devisi* and *Stolephorus waitei* (**Froese & Pauly, 2020**). The maximum size recorded earlier for *S. fimbriata* (**Ghosh *et al*., 2013**), *E. thoracata* (**Abdurahiman *et al*., 2004**), *E. devisi* (**Abdurahiman et al., 2004**) and *Stolephorus waitei* (**Doddamani *et al*., 2002**) was 19.9, 10.0, 11.5 and 11.0 cm, respectively, and are comparatively lesser than the size recorded in the present study (Table 1). In addition, this study would contribute in providing the first estimate of LWRs for *Decapterus tabl* from Indian waters.

CONCLUSION

The reported LWRs available for most of the small pelagic fishes are of old decades and are not representatives for today. Therefore, the basic biological information such as LWRs and a length-weight key for 10 major commercially important small pelagic fish species landed from Indian waters would be useful for filling important knowledge gaps in population studies and stock assessment and might further assist in sustainable management and conservation of fisheries.

ACKNOWLEDGEMENT

Authors are thankful to the Director, ICAR-CMFRI for the support and the facilities provided to take up this study. The technical staff: Nataraja, G.D., Sathyavathi and Abdul Hakeem, ICAR-CMFRI, Mangaluru are acknowledged for their support to analyse the samples in the field and laboratory.

REFERENCES

Abdurahiman, K.P.; Nayak, T.H.; Zacharia, P.U. and Mohamed, K.S. (2004). Length-weight relationship of commercially important marine fishes and shellfishes of the southern coast of Karnataka, India. NAGA, World Fish Centre Quart, 27(1&2): 9–14.

Abdussamad, E.M.; Mini, K.G.; Gireesh, R.; Prakasan, D.; Retheesh, T.B.; Rohit P. and Gopalakrishnan, A. (2018). Systematics, fishery and biology of the white sardine *Escualosa thoracata* (Valenciennes, 1847) exploited off Kerala, south-west coast of India. Indian J. Fish., 65(1): 26-31.

Andamari, R.; Milton, D. and Zubaidi, T. (2002). Reproductive biology of five species of anchovies (Engraulidae) from Bima Bay, Sumbawa, Nusa Tenggara. Indonesian J. Agri. Sci., 3(2): 37-42.

Bagenal, T.B. and Tesch, F.W. (1978). Age and growth. In: "Methods for assessment of fish production in fresh waters." Bagenal, T.B. (Ed.). IBP Handbook No. 3. Blackwell, Oxford, England. pp. 101–136.

Carvalho, B.M.; Barradas, J.R.S.; Fontoura, N.F. and Spach, H.L. (2017). Growth of the silverside *Atherinella brasiliensis* in a sub tropical estuary with some insights concerning the weight length relationships. An. Acad. Bras. Cienc., 89(3): 2261-2272.

CMFRI (2020) Marine Fish Landings in India (2019). Technical Report. ICAR-Central Marine Fisheries Research Institute, Kochi.

Dar, S.A.; Thomas, S.N.; Chakraborty, S.K. and Jaiswar, A.K. (2019). Length-weight relationships for five species of Clupeidae caught from Mumbai coast, India. Fish. Technol., 51: 291-294.

Doddamani, M.; Ramesha, T.J.; Laxmipathi, M.T.; Annappaswamy, T.S. and Shanbhogue, S.L. (2002). Reproductive potential and growth of *Stolephorus batavensis* from Daksina Kannada coast. Indian J. Fish., 49(3): 321-325.

Fischer, W. and Bianchi, G. (1984). FAO species identification sheets for fishery purposes: Western Indian Ocean; (Fishing Area 51). Prepared and printed with the support of the Danish International Development Agency (DANIDA). Rome, Food and Agricultural Organization of the United Nations, vols. 1–6.

Fischer, W. and Whitehead, P.J.P. (1974). FAO species identification sheets for fishery purposes.Eastern Indian Ocean (fishing area 57) and Western Central Pacific (fishing area 71). Vols 1–4. Rome, FAO.

Froese, R. (2006). Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. J. Appl. Ichthyol., 22: 241–253.

Froese, R. and Pauly, D. (2020). FishBase 2020, version (February, 2020).World Wide Web electronic publication. Retrieved from http://www.fishbase.org

Froese, R.; Tsikliras, A.C. and Stergiou, K.I. (2011). Editorial note on weight–length relations of fishes. *Acta Ichthyol. Piscat.,* 41: 261–263.

Froese, R.; Thorson, J.T. and Reyes, Jr. R.B. (2014). A Bayesian approach for estimating length – weight relationships in fishes. J. Appl. Ichthyol., 30(4): 78-85.

Ghosh, S.; Rao, M.V.H.; Sumithrudu, M.S.; Rohit, P. and Maheswarudu, G. (2013). Reproductive biology and population characteristics of *Sardinella gibbosa* and *Sardinella fimbriata* from north west Bay of Bengal. Indian J. Mar. Sci., 42 (6): 758-769.

Giakoumi, S. and Kokkoris, G. D. (2013). Effects of habitat and substrate complexity on shallow sublittoral fish assemblages in the Cyclades Archipelago, North-eastern Mediterranean sea. Mediter. Mar. Sci., 14(1): 58-68.

Gurjar, U.R.; Sawant, M.S.; Takar, S.; Pawar, A.; Nirmale, V.H. and Pawase, A.S. (2017). Biometric analysis of white sardine, *Escualosa thoracata* (valenciennes, 1847) along the Ratnagiri coast of Maharashtra, India. J. Exp. Zool. India, 20(2): 845-849.

Hussain, S.M.; Paperno, R. and Khatoon, Z. (2010). Length-weight relationships of fishes collected from the Korangi-Phitti Creek area (Indus delta, northern Arabian Sea). J. Appl. Ichthyol., 26: 477-480.

Huxley, J. S. (1932). Problems of relative growth. Methuen and Co., London.

Iwasaki, Y. and Aoki, M. (2001). Length-weight relationship, maturity and spawning season of the northern mackerel scad *Decapterus tabl* Berry in Suruga Bay, central Japan. Bull. Inst. Oceanic Res. & Develop., Tokai Univ., 22: 93-100.

Kudale, R.G.; Rathod, J.L. and Kudale, S.R. (2016). Analysis of length-weight relationship of sardinella fimbriata (Cuv. & Val.) from Karwar coast. Proceedings of the National Conference on Environment and Development, 9-10 September, 2016, Lonaval, Goa, India.

Karna, S. K. (2017). Length- weight and length-length relationship of *Thryssa purava* (Hamilton 1822), *Thryssa polybranchiolis* (Wongratana, 1983) and *Thryssa mystax* (Bloch and Schneider, 1801) from Chilka lagoon, India. J. Appl. Ichthyol., 33: 1284-1286.

Le Cren, E. D. (1951). The length–weight relationship and seasonal cycle in gonad weight and condition in the perch (*Percafluviatilis*). J. Anim. Ecol., 20: 201–219.

Luther, G.; Rao, K.V.N.; Gopakumar, G.; Muthiah, C.; Pillai, N.G.; Prathibha R.; Kurup, K.N.; Reuben, S.; Devadoss, P.; Rao, S.G.; Bennet, P.S. and Radhakrishnan, N.S. (1992). Resource characteristics and stock assessment of whitebaits. Indian J. Fish., 39 (3,4): 152-168.

Mondol, M.R.; Hossen, M.A. and Nahar, D.A. (2017). Length–weight relationships of three fish species from the Bay of Bengal, Bangladesh. J. Appl. Ichthyol., 33: 604–606.

Nair, P.G.; Joseph, S. and Pillai, V.N. (2015). Length-weight relationship and relative condition factor of *Stolephorus commersonii* (Lacepede, 1803) exploited along Kerala coast. J. Mar. Biol. Assoc. India, 57(2): 27-31.

Narido, C.I.; Palla, H.P.; Argente, F.A.T. and Geraldino, P.J.L. (2016). Population dynamics and fishery of roughear scad *Decapterus tabl* Berry 1968 (Perciformes: Carangidae) in Camotes Sea, Central Philippines. Asian Fish. Sci., 29: 14-27.

Pattikawa, J.A.**; Tetelepta, J.M.S.; Ongkers, O.T.S.; Uneputty, P.A. and Lewerissa, H.** (2017). Size distribution, length-weight relationship and age group of *Decapterus macrosoma* in eastern waters of Ambon Island, Indonesia. AACL Bioflux, 10(4): 969-976.

Pauly, D.; Cabanban, A. and Torres Jr. F.S.B. (1996). Fishery biology of 40 trawl-caught teleost of western Indonesia. In: "Baseline studies of Biodiversity: the fish resource of western Indonesia". Pauly, D. & Martosubroto, P. (Eds.) ICLARM Studies and Reviews 23, pp. 135-216.

Perkins, M.J.; Mak, Y.K.Y.; Law, C.S.W.; Tao, L.S.R.: Yau, J.K.C. and Leung, K.M.Y. (2019). Length-weight relationships of 79 marine fish species from the coastal waters of Hong Kong. J. Appl. Ichthyol., 35: 1-10.

Possamai, B.; Zanlorenzi, D.; Machado, R.C. and Favaro, L.F. (2019). Length weight relationships for estuarine fishes in South Brazil. J. Appl. Ichthyol., 35: 608-613.

Qamar, N. and Panhwar, S. K. (2017). Length-weight relationship of nine rarely occurring carangids in the northern Arabian Sea coast of Pakistan. J. Appl. Ichthyol., 34: 221-223.

Quinn, I.I.T. and Deriso, R.B. (1999). Quantitative Fish Dynamics. Oxford University Press, New York

Rajesh, K.M. and Rohit, P. (2012). Small pelagic fishes: Role in alleviating poverty, combating malnutrition and contributing to food security. In: "Global Symposium on Aquatic Resources for Eradicating Hunger and Malnutrition- Opportunities and Challenges." The book of abstracts, Asian Fisheries Science, Indian branch, India, pp. 66-67.

Rajesh, K.M. ; Rohit, P.; Mini, K.G.; Sathyavathi, T. and Hakeem, A.M. M. (2019). Seriolina nigrofasciata (Ruppel, 1829), its fishery and biological aspects off south-west coast of India. Indian J. Fish., 66(1): 9-16.

Rajesh, K.M.; Rohit, P. and Roul, S.K. (2020). Length-weight relationships (LWRs) of fourteen marine pelagic fish species in the Southeastern Arabian Sea. Thalassas, 36(1): 371-374.

Ricker, W. (1975). Computation and interpretation of biological statistics of fish population. Bull. Fish. Res. Board Can., 191: 1–382.

Sekharan, K. V. (1968). *Length-weight relationship in Sardinella albella (Val.) and Sardinella gibbosa (Bleek.).* Indian J. of Fish., 15 (1&2): 166-174.

Shingleton, A.W.; Estep, C.M.; Driscoll, M.V. and Dworkin, I. (2009). Many ways to be small: different environmental regulators of size generate distinct scaling relationships in *Drosophila melanogaster*. Proc. R. Soc. B., 276: 2625–2633.

Snedecor, G. W. and Cochran, W. G. (1967). Statistical methods, 6th edn. New Delhi, India: Oxford and IBH Publishing Co. pp. 593.

Sousa, M. I. and Gj_saeter J. (1987). Reproduction, age and growth of the round scad, *Decapterus macrosoma* (Bleeker, 1851) (Carangidae) from Mozambique. Rev. Invest. Pesq. (Maputo), 16: 1-18.

Srihari, M.; Sreekanth, G.B. and Jaiswar, A.K. (2018). Length-weight relationships of seven finfish species from Mandovi-Zuari estuarine system, Goa, India. J. Appl. Ichthyol., 34: 1384-1386.

Tesch, F. W. (1971). Age and growth. In: "Methods for assessment of fish production in fresh waters." Ricker W.E. (Ed). Blackwell Scientific Publications, Oxford, pp. 99–130.

Uiblein, F. and Heemstra, P. C. (2010). A taxonomic review of the Western Indian Ocean goatfishes of the genus *Upeneus* (Family Mullidae), with descriptions of four new species. Smithiana Bull., 11: 35–71.