Research in
AGRICULTURE, LIVESTOCK and FISHERIES
ISSN : P-2409-0603, E-2409-9325
An Open Access Peer-Reviewed International Journal

Article Code: 0314/2020/RALF
Article Type: Research Article

Res. Agric. Livest. Fish.
Vol. 7, No. 3, December 2020: 545-551.

COEFFICIENT OF ALGEBRAIC RELATIONSHIP BETWEEN LINEAR DIMENSIONS AS GROWTH DEDUCTION FOR RAINBOW SARDINE *Dussumieria acuta* IN THE BAY OF BENGAL

Zoarder Faruque Ahmed*, Mst. Kaniz Fatema, Umme Habiba Az Zohora, Mansura Akter Joba and Ferdous Ahamed[1]

Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh; [1]Department of Fisheries Management, Patuakhali Science and Technology University, Patuakhali-8602, Bangladesh.

***Corresponding author:** Zoarder Faruque Ahmed; E-mail: zoarder@bau.edu.bd

ARTICLE INFO

Received
01 June 2020

Revised
14 July 2020

Accepted
18 July 2020

Online
12 January 2021

Key words:
length-length relationship
Growth pattern
D. acuta
Bay of Bengal

A B S T R A C T

The intercept as the coefficient of algebraic relationship between standard length (SL) and total length (TL), the two predominantly used linear dimensions of fin fish species, was referred to growth pattern deduction for rainbow sardine *Dussumieria acuta* population in the Bay of Bengal. Monthly rainbow sardine samples were collected from the industrial fishing vessel in the Bay of Bengal over a period of a calendar year. The length-length relationship was formed algebraically as y=a+ bx. Linear relationship between SL and TL for male, female and unsexed populations was constructed separately. Chi-squared test affirmed that sex ratio between male and female did not deviate from the parity (P>0.05). The SL and TL ranges of male were 13.1-16.8and 16.4-20.7 cm respectively, they for female were13.4-17.2 and 16.5-20.9 cm respectively. Slope and intercept showed variation monthly in all length-length relationships regardless of sexes. The generalized SL-TL relationships of male, female and unsexed populations employing pooled data over the study period were TL=1.130SL+1.571 (R=0.908), TL=1.106SL+1.925 (R=0.911), and TL=1.114SL+1.825 (R=0.908) respectively. The correlation coefficients of all monthly and generalized regression analyses of all sex categories were very high (R≥0.786), a fact that explained the associations between two length dimensions were strongly related. Study revealed isometric growth for male in all months, while algometry was apparent for female and unsexed populations in a few months. Present findings of length-length relationship and growth pattern for *D. acuta* population in the Bay of Bengal would remain useful for future references.

To cite this article: Ahmed Z. F., M. K. Fatema, U. H. A. Zohora, M. A. Joba and F. Ahamed, 2020. Coefficient of algebraic relationship between linear dimensions as growth deduction for rainbow sardine *Dussumieria acuta* in the Bay of Bengal. Res. Agric. Livest. Fish., 7 (3): 545-551.

INTRODUCTION

Changes of linear dimension describe animal growth and are often used in growth study of fish (King, 1995). Several works emphasized the importance of length-length relationships in fisheries biology (Pauly, 1993; Petrakis and Stergiou, 1995; Binohlan and Pauly, 2000; Binohlan *et al.* 2000; Froese and Pauly, 2000; Froese, 2006). Length-length relationships are important for comparative growth studies (Moutopoulos and Stergiou, 2002), and are used as the corollary of growth pattern. Fish from birth undergo physiological process having isometric or allometric as a natural consequence over life cycle. Though data on length-length relationships are available for almost all European and North American freshwater and marine fishes (e.g., Petrakis and Stergiou, 1995; Sinovcic *et al.* 2004), but they are still lacking in most tropical and sub-tropical fish species (Martin-Smith, 1996; Harrison, 2001; Ecoutin *et al.* 2005). The length-length relationship has been employed as input data in fish population dynamics and fish stocks assessment (Ricker, 1968). Length-length relationships have been used frequently to estimate unknown lengths readily at later period from equations modelled erstwhile since field data recording is often seemed impossible (Sinovcic et al. 2004). The rainbow sardine *Dussumieria acuta* (Valenciennes, 1847) (Fig. 1), Clupeiformes: *Dussumieriidae*, locally known as Colombo ilish is an important fish species, commonly caught by industrial from the Bay of Bengal in Bangladesh. Present research was undertaken to provide pilot information of growth pattern of *D. acuta* deduced from length-length monthly data analysis.

Figure 1. Rainbow sardine *Dussumieria acuta* (Valenciennes, 1847). Sampled on 15 July 2019 SL 15 cm

MATERIALS AND METHODS

Study area and fish sample collection

Samples of *D. acuta* were collected once a month over an entire calendar year from January to December from an industrial fishing vessel going to the Bay of Bengal from Chittagong fish landing center. Trawl net with 4 cm-meshed codend was used to catch the fish. All specimens were preserved with crushed ice in a fish box, and subsequently transported to laboratory.

Recording of lengths

Linear dimension of fish as linear distance of body length which is measured by scale. To carry out present research two linear dimensions of standard length and total length were considered. Standard length was measured from the tip of the snout (mouth closed) to the last vertebrae, and total length from the tip of the snout to the end of caudal fin. Both lengths were taken to the nearest cm with the help of a measuring board. Data were input on the spreadsheet of the computer software, Microsoft Excel.

Gonad collection and sex determination

The body cavity of a fish was cut open carefully by scissors, and gonads were extracted with forceps carefully. Fishes were sexed as male and female observing the gonads with naked eye.

Length-length relationship

A linear relationship between standard length (SL) and total length (TL), which can be represented by equation: TL = a+bSL where ‘a’ and ‘b’ are coefficients as intercept and slope respectively. Estimates of ‘a’ and ‘b’, and their 95% confidence limits were computed statistically.

Growth deduction

Somatic growth of fish increases at the same rate in all linear dimensions, and as a matter of fact, standard length and total length are proportional to each other. Identical proportionate growth rate over life cycle implies isometric growth; otherwise, it is termed as allometric. Intercept, the coefficient 'a' in the y=a+bx describes growth type. The 95% confidence intervals for the population intercept of the length-length straight line equation deduce isometry and allometry in this study. If the zero remains within confidence limits of population intercept, then the growth was deduced as isometric.

RESULTS

Fish size

The investigation dealt with a total of 500 rainbow sardine individuals. Among them, 308 were male and 292 were female. The standard length and total length of male measured from 13.1 to 16.8cm, and from 16.4 to 20.7cm respectively. The standard length and total length of female recorded from 13.4to 17.2cm, and from 16.5 to 20.9cm respectively (Table 1).

Table 1. Collection details for monthly samples of rainbow sardine *D. acuta* population collected from the Bay of Bengal

Month	Male			Female		
	Obs.	SL (cm)	TL (cm)	Obs.	SL (cm)	TL (cm)
January	28	13.4-16.8	16.5-20.6	22	13.5-17.0	16.6-20.4
February	24	14.0-16.6	17.3-20.3	26	14.4-17.0	17.5-20.7
March	30	14.0-16.6	16.7-19.9	20	14.0-17.0	17.6-20.8
April	24	13.8-16.8	17.0-20.4	26	14.0-17.0	17.2-20.5
May	25	14.2-16.7	17.5-20.5	25	14.6-16.4	18.2-20.5
June	24	14.0-16.3	17.5-20.2	26	13.4-16.5	16.5-20.7
July	29	13.1-16.6	16.4-20.5	21	14.4-16.8	17.6-20.2
August	28	14.3-16.2	17.5-20.0	22	14.3-16.8	17.1-20.6
September	27	14.0-16.8	17.5-20.7	23	13.7-16.5	16.6-20.5
October	21	13.8-16.0	17.2-19.7	29	14.6-16.4	18.2-20.2
November	25	15.2-16.3	16.8-20.1	25	14.3-16.5	17.8-20.4
December	23	15.2-16.6	18.5-20.5	27	15.0-17.2	18.4-20.9

Obs, observations; SL, standard length; TL, total length

Size relationships and growth pattern

Male population

Relationships between standard length vs. total length of monthly samples showed variations in both constants ('a'' and 'b') and correlation coefficients (R) of the linear equations. Results of analyses are given in Table 2. The lowest value of 'a' was -0.916calculated in September, and the highest 3.486 in December. The minimum value of 'b' was 1.021estimated in December, and the maximum 1.315 in April. The generalized relationship of the pooled data over the study period is TL=1.130SL+1.571; R=0.908 (Fig. 2). The minimum and maximum correlation coefficients ranged from 0.786 to 0.977, and calculated in March and June,

respectively. Very high correlation coefficient values indicated strong association between the two variables in all monthly data. Corollary of monthly growth pattern for the species based on 95% confidence interval of intercept are documented in Table 2. Results showed that growth of *D. acuta* in the Bay of Bengal according to SL-TL relationship was isometric in all months.

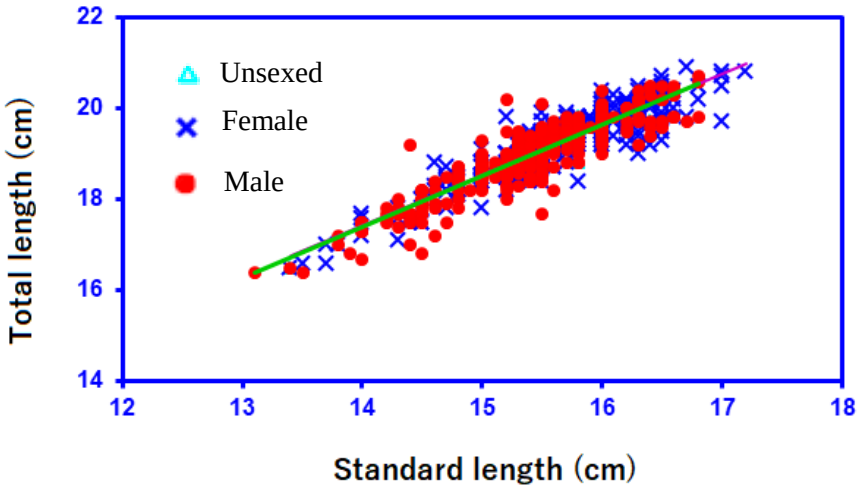

Figure 2. Generalized relationships between standard length and total length. For equations see text.

Female population

Relationships between standard length vs. total length of monthly samples showed variations in both constants (‘a’’ and ‘b’) and correlation coefficients (R) of the linear equations. Results of analyses are given in Table 2. The lowest value of ‘a’ was -0.761 found in September, and the highest 4.236 found in January. The minimum value of ‘b’ was 0.124calculated in February, and the maximum 1.280 in September. The generalized relationship of the pooled data over the study period is TL=1.106SL+1.925; R=0.911 (Fig. 2). The minimum and maximum correlation coefficients ranged from 0.874 to 0.980, and were estimated in August and June respectively. Very high correlation coefficient values indicated strong association between the two variables in all monthly data. Corollary of monthly growth pattern for the species based on 95% confidence interval of intercept are documented in Table 2. Results showed that growth of *D. acuta* in the Bay of Bengal according to SL-TL relationship was allometric in January, June, October and December, while it was isometric in other months.

Unsexed population

Relationships between standard length vs. total length of monthly samples showed variations in both constants (‘a’’ and ‘b’) and correlation coefficients (R) of the linear equations. Results of analyses are given in Table 2. The lowest value of ‘a’ was 0.707occurred in April, and the highest 3.383 in January. The minimum value of ‘b’ was 0.094computed in March, and the maximum 1.182 in April. The generalized relationship of the pooled data over the study period is TL=1.114SL+1.825; R=0.908 (Fig. 2). The minimum and maximum correlation coefficients ranged from 0.851 to 0.954, and were calculated in March and June respectively. Very high correlation coefficient values indicated strong association between the two variables in all monthly data. Corollary of monthly growth pattern for this species based on 95% confidence interval of intercept are documented in Table 2. Results showed that growth of *D. acuta* in the Bay of Bengal according to SL-TL relationship was allometric in January, October and December, while it was isometric in other months.

Table 2. Parameters of SL vs TL relationships for rainbow sardine *D. acuta* population collected monthly over the study period with growth deduction

Month	Gender	Obs.	r	b	(±)Se_b*t	a	(±)Se_a*t	Growth
	M	28	0.920	1.083	0.185	2.362	2.909	Isometric
January	F	22	0.900	0.956	0.216	4.236	3.360	Allometric
	U	50	0.908	1.015	0.136	3.383	2.130	Allometric
	M	24	0.933	1.063	0.182	2.468	2.863	Isometric
February	F	26	0.890	0.124	0.256	0.633	3.984	Isometric
	U	50	0.909	1.102	0.147	1.921	2.300	Isometric
	M	30	0.786	1.061	0.323	2.388	5.039	Isometric
March	F	20	0.925	1.034	0.210	1.578	3.315	Isometric
	U	50	0.851	0.094	0.189	2.523	2.960	Isometric
	M	24	0.930	1.315	0.230	1.315	0.230	Isometric
April	F	26	0.885	1.018	0.226	3.347	3.563	Isometric
	U	50	0.907	1.182	0.160	0.707	2.501	Isometric
	M	25	0.909	1.133	0.224	1.633	3.395	Isometric
May	F	25	0.923	1.197	0.215	0.708	3.373	Isometric
	U	50	0.926	1.171	0.138	1.094	2.137	Isometric
	M	24	0.977	1.272	0.123	-0.396	1.832	Isometric
June	F	26	0.980	1.155	0.097	1.662	1.533	Allometric
	U	50	0.954	1.158	0.106	1.234	1.602	Isometric
	M	29	0.971	1.231	0.119	0.123	1.817	Isometric
July	F	21	0.926	1.112	0.218	1.734	3.377	Isometric
	U	50	0.950	1.159	0.110	1.127	1.692	Isometric
	M	28	0.918	1.182	0.206	0.748	3.131	Isometric
August	F	22	0.874	1.119	0.291	1.689	4.563	Isometric
	U	50	0.911	1.143	0.150	1.337	2.318	Isometric
	M	27	0.923	1.296	0.222	-0.916	3.417	Isometric
September	F	23	0.977	1.280	0.127	-0.761	1.981	Isometric
	U	50	0.899	1.177	0.167	0.927	2.587	Isometric
	M	21	0.927	1.173	0.227	1.019	3.457	Isometric
October	F	29	0.931	1.015	0.164	3.532	2.554	Allometric
	U	50	0.935	1.110	0.125	2.025	1.927	Allometric
	M	25	0.846	1.092	0.296	2.098	4.532	Isometric
November	F	25	0.874	1.140	0.273	1.397	4.263	Isometric
	U	50	0.870	1.124	0.185	1.632	2.860	Isometric
	M	23	0.806	1.021	0.340	3.486	5.387	Isometric
December	F	27	0.941	1.066	0.158	2.731	2.542	Allometric
	U	50	0.885	1.032	0.158	3.294	2.515	Allometric

U, unsexed; M, male; F, female; Obs, observations; r, correlation coefficient; b and a, slope and intercept of equation (TL=a+bSL); Se_b and Se_a, standard error of b and a; t, value for 95% confidence level from t table

DISCUSSION

Works pertinent to present study as on length-frequencies, length-length and length-weight relationships, age and growth, and otolith of the species are available (Nansen, 1984; Fishbase, 2020; Kulbicki et al., 1993; Dalzell, et al., 1987; Corpuz et al., 1985; Rivaton, 1999). Abdurahiman et al. (2004) reported total length range of male *D. acuta* of 11.0 - 20.4 cm, and that of female 11.4 - 20.2 cm from the southern coast of Karnataka in India. Mousavi-Sabet et al. (2016) documented standard length of unsexed population having range from 7.5 to 11.6 cm caught from the Persian Gulf and Oman sea. Total length ranges of the species from two other marine waters of eastern Mediterranean Sea and western Indonesia at place as 14.0 - 16.9 cm and 6.0 - 20.5 cm respectively (Taskavak and Bilecenoglu, 2001; Pauly, et al. 1996). Size ranges in terms of standard length and total length irrespective of genders of the species mentioned by the above authors are in accord to our length data. Fishbase (2020) referred to several studies on length-length relations of D. acuta. The relevant page of the global biodiversity information system on finfishes depicted the relationship between standard length vs total length as SL=0.809TL and TL=1.154SL for unsexed populations, while current effort estimated relationship between two length variables was TL=1.114SL+1.825. Growth pattern deduced by the present study could not be examined since references to similar works are absent. The reason, however, why growth pattern happened to be allometric in a few months over the year for female and unsexed populations would be a pressing subject for future inquiry. The research was intended to produce initial information so as to relevant future works may be compared.

CONFLICT OF INTEREST

No conflict of interest among authors exists for publishing the article.

ACKNOWLEDGEMENT

We are thankful to the Ministry of Science and Technology, Government of the People's Republic of Bangladesh for funding the research.

REFERENCES

1. Abdurahiman KP, T Harishnayak, PU Zacharia and KS Mohamed, 2004. Length-weight relationship of commercially important marine fishes and shellfishes of the southern coast of Karnataka, India. Naga WorldFish Center Q. 27(1&2): 9-14.
2. Binohlan C, Pauly D 2000: The length-weight table. In: Froese R, Pauly D, eds. Fishbase 2000: concepts, design and data sources. ICLARM, Manila, 121-123.
3. Corpuz A, J Saeger and V Sambilay, 1985. Population parameters of commercially important fishes in Philippine waters. Tech. Rep. Dep. Mar. Fish. Univ. Philipp. Visayas, (6): p99.
4. Dalzell P and RA Ganaden, 1987. A review of the fisheries for small pelagic fishes in Philippine waters. Tech. Pap. Ser. Bur. Fish. Aquat. Resour. (Philipp.) 10(1): p58.
5. Ecoutin JM, Albaret JJ, Trape S 2005: Length-weight relationships for fish populations of a relatively undistributed tropical estuary the Gambia. Fisheries Resource, 72: 347–351.
6. Fishbase 2020. https://www.fishbase on 18 December 2020.
7. Froese R, 2006. Cube law, condition factor and weight length relationships: history, meta-analysis and recommendations. Journal of applied Ichthyology, 22: 241-253.
8. Froese R, Pauly D 2000: Fishbase: concepts, design and data sources. ICLARM, Manila.
9. Harrison TD 2001. Length–weight relationships of fishes from South African estuaries. Journal of Applied Ichthyology, 17: 46-48.
10. King M. 1995. Fisheries Biology, Assessment and Management, Fishing News Books, 341p.
11. Kulbicki M, G MouTham, P. Thollot and L Wantiez, 1993. Length-weight relationships of fish from the lagoon of New Caledonia. Naga ICLARM Q. 16(2-3): 26-29.

12. Martin-Smith KM, 1996. Length-weight relationships of fishes in a diverse tropical fresh-water community, Sabah, Malaysia. Journal of Fish Biology, 49: 731-734.
13. Mousavi-Sabet H, H Homayouni, M Marjani and A Heidari, 2016. Length-weight relationships for five Clupeiformes species from the Persian Gulf and Oman sea. Journal of Applied Ichthyology, 32: 169-170.
14. Moutopoulos DK, Stergiou KI 2002: Length-weight and lengthlength relationships of fish species from Aegean Sea (Greece). Journal of Applied Ichthyology, 18: 200-203.
15. Nansen F, 1984. Fisheries resources survey Pakistan. NORAD/UNDP/FAO Programme GLO/82/001.
16. Pauly D 1993. Fishbyte Section. Editorial. Naga, the ICLARM quarterly 16-26.
17. Pauly D, A Cabanban and FSB Torres Jr., 1996. Fishery biology of 40 trawl-caught teleosts of western Indonesia. p. 135-216. In D. Pauly and P. Martosubroto (eds.) Baseline studies of biodiversity: the fish resource of western Indonesia. ICLARM Studies and Reviews, 23.
18. Petrakis G and Stergiou KI 1995: Weight-length relationships for 33 fish species in Greek waters. Fisheries Research, 21: 465-469.
19. Rivaton J and P Bourret, 1999. Les otolithes des poissons de l'Indo-Pacifique. IRD. Doc. Sci. Tech. II 2, 378pp.
20. Taskavak E and M Bilecenoglu, 2001. Length-weight relationships for 18 Lessepsian (Red Sea) immigrant fish species from the eastern Mediterranean coast of Turkey. Journal of the Marine Biological Association of the United Kingdom, 81(5): 895-896.