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Length-weight relationship, relative condition factor and growth of *Oratosquilla anomala* (Tweedie, 1935) (Crustacea: Stomatopoda) off Visakhapatnam, east coast of India

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ABSTRACT

The length-weight relationship of males and females of Oratosquilla anomala collected at Visakhapatnam were $W = 0.003368992\ L^{1.7336}$ *and* $W = 0.002779713\ L^{1.7801}$ *respectively. A single length-weight relationship is given for both the sexes as* $W = 0.002932243\ L^{1.7801}$. *Analysis of covariance conducted to test the difference between the regression slopes of males and females of O. anomala showed significant differences* ($P < 0.05$)*. Relative condition factor for males and females was given for this study. The age and growth were estimated by applying ELEFAN 1 method; it confirmed the longevity of the stomatopod to be 124 months. The growth rate was high during the first year and then it declines during subsequent years. The Von Bertalanffy's growth parameters were* $L\infty = 124.95$, $K = 1.0$, $t_0 = 0.11$ *and* $Ø = 4.1935$*/yr respectively.*

INTRODUCTION

Stomatopods belonging to order stomatopoda, class crustacea are referred as 'Squilla' or mantis shrimp. Stomatopods are common member of benthic ecosystems in tropical, subtropical marine and brackish waters throughout the world. Few species are known from temperate seas. There are 412 species of known to inhabit the world oceans [7], 54 species of stomatopods inhabiting in the sea around India [14, 15].

In the fishery point of view stomatopods are important resources in global fishery especially in Asia [12]. In these communities, many species are commercially valuable species, such as *O. oratoria* [9], *Squilla* species [16] and *H. raphidea* [26]. As fisheries product, mantis shrimp can be found regularly in fish markets of several countries, such as Spain, Italy, Egypt and Morocco [2]. In many Asian countries, mantis shrimps are considered a delicacy and commonly eaten by middle and upper class people. Basically, mantis shrimps are an important commercial species, especially in Hong Kong [10]. In India, especially in Andhra Pradesh, stomatopods are non-target species incidentally or accidentally caught by benthic trawl operations. They are treated as by-catch and not used for human consumption.

Stomatopods landed in considerable quantities in almost all maritime states of India. 26 species of stomatopods occurring at Visakhapatnam fishing harbour (Lat: 17º 41' N Long: 83º 18' E). Among the 26 species *O. anomala* an important component of by-catch of the shrimp trawl at Visakhapatnam fishing harbour [25]. The present study focused on account of length-weight relation, relative condition factor and growth of *O. anomala* represented in the trawl net by-catches at Visakhapatnam.

MATERIALS AND METHODS

The present study is based on 1316 specimens of *O. anomala* (573 males in size range of 58-119 mm TL and weight 3-16 g; 743 females in size range of 54-117 mm TL and weight 2-20 g) collected from commercial trawl catches at Visakhapatnam fishing harbour thrice in a month during January 2008 to December 2009. The samples were not available in the month of May due to fishing holidays from April 15th to May 31st, which were implemented for conservational purpose.

The random samples of *O. anomala* collected in fresh condition from trawl catches at Visakhapatnam fishing harbour. The collected samples were stored in crushed ice and immediately brought to the laboratory for further analysis after removing the excess of moisture by blotting paper, the total length (nearest 1mm) and weight (nearest 1g) of each specimen were measured. The three samples in a month were pooled and treated as a single sample of the month. The length–weight relationship (LWR) was calculated employing hypothetical formula $W = aL^b$ (11). Where W is body weight (g), L is total length (mm), 'a' is coefficient related to body form and 'b' is an exponent indicating isometric growth when equal to 3 [24]. The equation can be expressed in the logarithmic form as log W = log a + b. log L. For testing the difference between regression slopes of males and females, analysis of covariance was employed [23]. The relative condition factor, $Kn = W/\hat{W}$ was calculated following [11, 13]. Where W= observed weight, $\hat{W}$ = calculated weight according to the regression equation.

Age and growth was estimated by applying the ELEFAN I (Electronic Length Frequency Analysis) method, FiSAT II Software package, version 1.2.2 to get the estimate of asymptotic length ($L\infty$) and growth coefficient (K) [17]. By using the value t_o was calculated by Pauly's equation [19]. The Von Bertalanffy's growth model was used to fit growth curve to the length frequency data [4]. The equation was expressed as:

$$L_t = L\infty\,(1 - e^{-k\,(t-to)})$$

Where, L_t = length at age t, $L\infty$ = asymptotic size, K = growth coefficient and t_o = age of the individual mantis shrimp at '0' size.

The growth performance index ($\text{Ø}'$) was estimated according to [18] as:

$$\text{Ø}' = \log K + 2 \log L\infty$$

Where, K = Growth constant/yr, $L\infty$ = Asymptotic length

RESULTS

Length-weight relationship

The regression equation for the length-weight relationship of males and females were calculated as:

Males	:	log W = 0.003368992 $L^{1.7336}$ (r = 0.6917)
Females	:	log W = 0.002779713 $L^{1.7801}$ (r = 0.7489)

The length-weight data of males and females can be pooled to obtained common regression equation for both the sexes as W = 0.002932243 $L^{1.7801}$ (r = 0.7291). The comparison lines in Table 1 showed significant difference ($p < 0.05$) between the slopes of two sexes at 5% level and showed negative allometric growth for individual sexes. The scattered diagram of observed weight against to length of the stomatopods reveals curvi-linear relation between the two variables for both the sexes in Figures 1 and 2.

Relative condition factor

Variations in the relative condition factor in the different months and in different size groups were studied for *O. anomala* (Figure 3, 4 and 5). The higher values were recorded during Jul to Aug and again Oct to Nov in both the sexes due to indicating the spawning seasons. Lowest values were observed during March to April and December to January in *O. anomala* due to accumulation of fat in these species at Visakhapatnam.

Study of relative condition factor corresponds to different length groups in both the sexes showed that peak value was observed at 71-80 mm and a steep fall observed at 81-90 mm TL in males. Peak value was observed at 71-80 mm and low value was observed at 91-100 mm TL in females of *O. anomala* at Visakhapatnam.

Age and growth studies

The best fit estimate of asymptotic length (L∞) and growth constant (K) were estimated by ELEFAN I. L∞ was 124.95 mm and K was 1.0yr^{-1} with highest Rn value 0.175 in Figure 6. Calculated growth performance index (($Ø'$) was 4.1935 and t_0 was 0.11. The length of the mantis shrimp at specific time in *O. anomala* was expressed as:

$$L_t = 124.95\ (1\text{-}e^{-1.0(t-0.11)})$$

On the basis of this formula, growth curves were drawn in Figure 6 according to Von Bertalanffy growth equation. The length attained in mm at ages of 3, 6, 9 and 12 months were 18.140, 36.820, 55.230 and 73.646 respectively.

Basing on the ELEFAN I method *O. anomala* attained a total length of 73.646 mm during 1st year, 106.07 mm during 2nd year, 118.08 mm during 3rd year, 122.40 mm during 4th year and 124.01 mm during 5th year. The longevity of *O. anomala* was 124 months was show in Figure 7 and Table 2.

Table 1: Comparison of regression lines of length-weight relationship in males and females of *O. anomala*

	DF	X^2	Y^2	XY	Regression coefficient Intercept (log a)	Slope (b)	Deviation from Regression DF	SS	MSS
Within Males	573	3.5416	0.635	1.4877	0.003368992	1.7336	572	0.0067	
Females	743	3.5745	0.6661	1.5299	0.002779713	1.7801	742	0.0095	
							1314	0.0162	0.0000123
Pooled	1316	7.1161	1.3011	3.0176	0.002932243	1.7669	1315	0.0167	0.0000126
		Difference between slope					1	0.0005	0.0005
	Slope F= 40.650406				**D.F.1,1314**		**Significant at 5% level**		

Table 2: Von Bertalanffy equation to the growth data in *O. anomala*

L∞ = 124.95 mm K = 1.0 t_0 = 0.11 years

t (years)	t-t0	K(t-t0)	e-k(t-to)	1- e-k(t-to)	Lt = L∞(1- e-k(t-to))
0.17	0.06	0.06	0.9417	0.06	7.2846
0.33	0.22	0.22	0.8025	0.2	24.678
0.5	0.39	0.39	0.677	0.32	40.359
0.66	0.55	0.55	0.67705	0.32	40.353
0.83	0.72	0.72	0.4867	0.51	64.137
1	0.89	0.89	0.4106	0.59	73.646
1.16	1.05	1.05	0.3499	0.65	81.23
1.33	1.22	1.22	0.2952	0.7	88.065
1.5	1.39	1.39	0.2491	0.75	93.825
1.66	1.55	1.55	0.2122	0.79	98.436
1.83	1.72	1.72	0.179	0.82	102.58
2	1.89	1.89	0.1511	0.85	106.07
2.16	2.05	2.05	0.1287	0.87	108.87
2.33	2.22	2.22	0.1086	0.89	111.38
2.5	2.39	2.39	0.0916	0.91	113.5
2.66	2.55	2.55	0.0781	0.92	115.19
2.83	2.72	2.72	0.0658	0.93	116.73
3	2.89	2.89	0.055	0.95	118.08
3.16	3.05	3.05	0.0473	0.95	119.04
3.33	3.22	3.22	0.0399	0.96	119.96
3.5	3.39	3.39	0.0337	0.97	120.74
3.66	3.55	3.55	0.02878	0.97	121.35
3.83	3.72	3.72	0.0242	0.98	121.93
4	3.89	3.89	0.0204	0.98	122.4
4.16	4.05	4.05	0.0174	0.98	122.78
4.33	4.22	4.22	0.0146	0.99	123.13
4.5	4.39	4.39	0.0124	0.99	123.4
4.66	4.55	4.55	0.0105	0.99	123.64
4.83	4.72	4.72	0.00891	0.99	123.84
5	4.89	4.89	0.00752	0.99	124.01
5.08	4.97	4.97	0.006943	0.99	124.08

5.17	5.06	5.06	0.006345	0.99	124.16
5.25	5.14	5.14	0.005857	0.99	124.22
5.33	5.22	5.22	0.005407	0.99	124.27
5.42	5.31	5.31	0.004941	1	124.33
5.5	5.39	5.39	0.004561	1	124.38
5.58	5.47	5.47	0.004211	1	124.42
5.67	5.56	5.56	0.003848	1	124.47
5.75	5.64	5.64	0.003552	1	124.51
6	5.89	5.89	0.002766	1	124.6
6.08	5.97	5.97	0.002554	1	124.63
6.17	6.06	6.06	0.002334	1	124.66
6.25	6.14	6.14	0.002154	1	124.68
6.33	6.22	6.22	0.001989	1	124.7
6.42	6.31	6.31	0.001818	1	124.72
6.5	6.39	6.39	0.001678	1	124.74
6.58	6.47	6.47	0.001549	1	124.76
6.67	6.56	6.56	0.001415	1	124.77
6.75	6.64	6.64	0.001307	1	124.79
6.83	6.72	6.72	0.001206	1	124.8
6.92	6.81	6.81	0.001102	1	124.81
7	6.89	6.89	0.0010179	1	124.82
7.08	6.97	6.97	0.0009396	1	124.83
7.17	7.06	7.06	0.0008587	1	124.84
7.25	7.14	7.14	0.0007927	1	124.85
7.33	7.22	7.22	0.0007318	1	124.86
7.42	7.31	7.31	0.0006688	1	124.87
7.5	7.39	7.39	0.0006173	1	124.87
7.58	7.47	7.47	0.0005699	1	124.88
7.67	7.56	7.56	0.0005208	1	124.88
7.75	7.64	7.64	0.0004808	1	124.89
7.83	7.72	7.72	0.0004438	1	124.89
7.92	7.81	7.81	0.0004056	1	124.9
8	7.89	7.89	0.0003744	1	124.9
8.08	7.97	7.97	0.0003456	1	124.91
8.17	8.06	8.06	0.0003159	1	124.91
8.25	8.14	8.14	0.0002916	1	124.91
8.33	8.22	8.22	0.0002692	1	124.92
8.42	8.31	8.31	0.000246	1	124.92
8.5	8.39	8.39	0.0002271	1	124.92
8.58	8.47	8.47	0.0002096	1	124.92
8.67	8.56	8.56	0.0001916	1	124.93
8.75	8.64	8.64	0.0001768	1	124.93
8.83	8.72	8.72	0.0001632	1	124.93
8.92	8.81	8.81	0.0001492	1	124.93
9	8.89	8.89	0.0001377	1	124.93
9.08	8.97	8.97	0.0001271	1	124.93
9.17	9.06	9.06	0.0001162	1	124.94
9.25	9.14	9.14	0.00010728	1	124.94
9.33	9.22	9.22	0.00009903	1	124.94
9.42	9.31	9.31	0.00009051	1	124.94
9.5	9.39	9.39	0.00008355	1	124.94
9.58	9.47	9.47	0.00007713	1	124.94
9.67	9.56	9.56	0.00007049	1	124.94
9.75	9.64	9.64	0.00006507	1	124.94
9.83	9.72	9.72	0.00006007	1	124.94
9.92	9.81	9.81	0.00005489	1	124.94
10	9.89	9.89	0.00005067	1	124.94
10.08	9.97	9.97	0.00004678	1	124.94
10.17	10.1	10.1	0.00004107	1	124.94
10.25	10.1	10.1	0.00004107	1	124.94
10.33	10.2	10.2	0.00003717	1	124.95

Figure 1: Scattered diagram showing relationship between length and weight in males of *O. anomala*

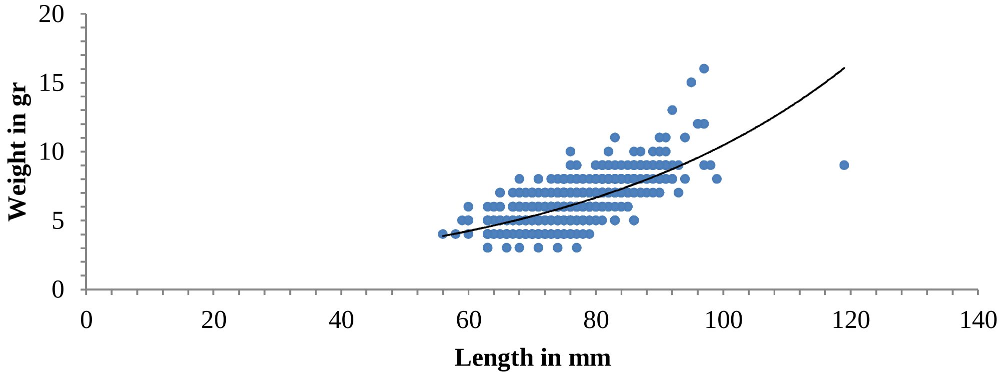


Figure 2: Scattered diagram showing relationship between length and weight in females of *O. anomala*

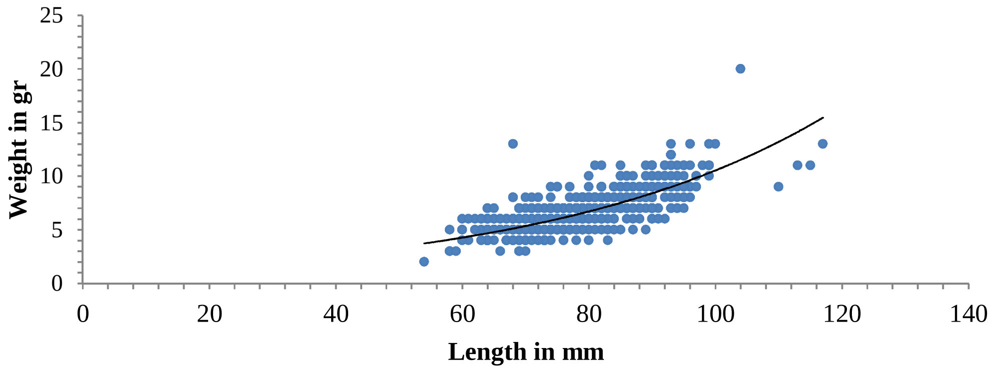


Figure 3: Comparison of relative condition factor of *O. anomala* in relation to months during January – December 2008

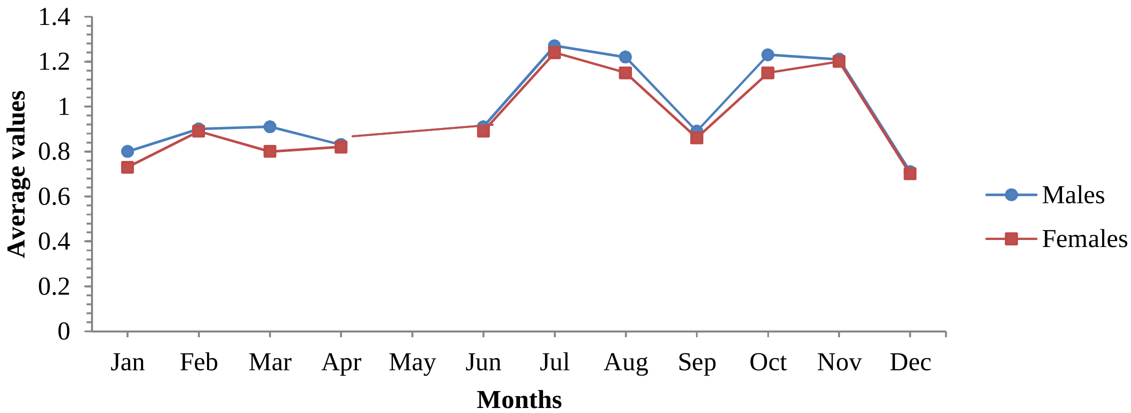


Figure 4: Comparison of relative condition factor of *O. anomala* in relation to months during January – December 2009

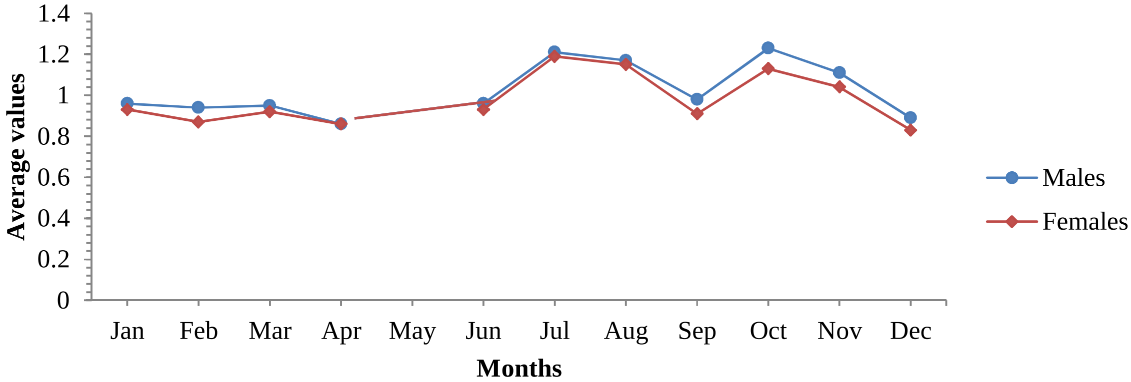


Figure 5: Comparison of relative condition factor of *O. anomala* in relation to lengths during January 2008 to December 2009.

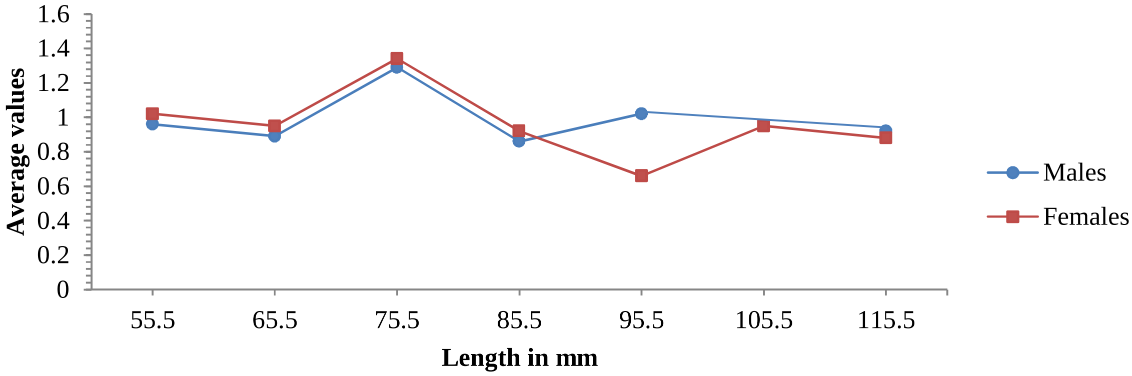
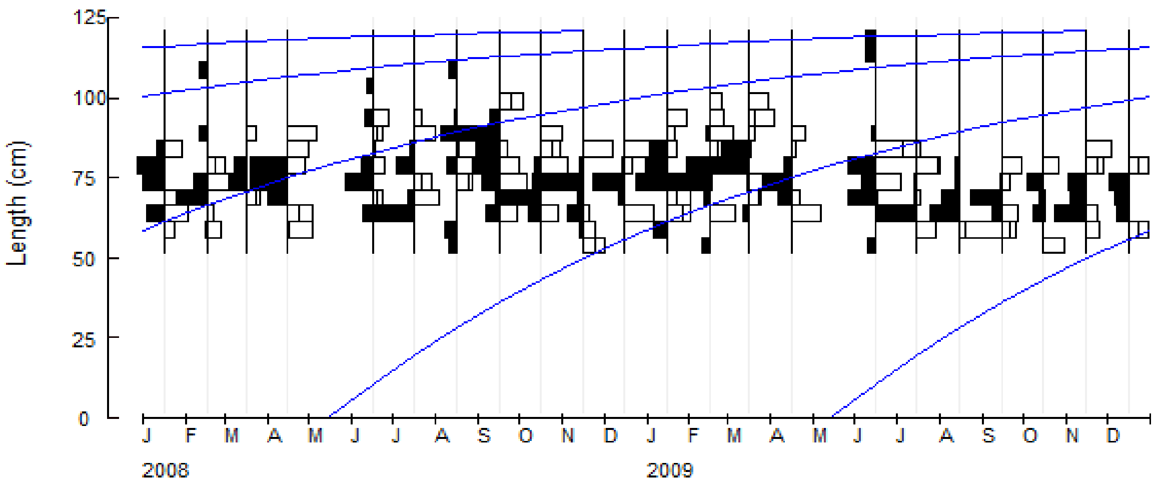
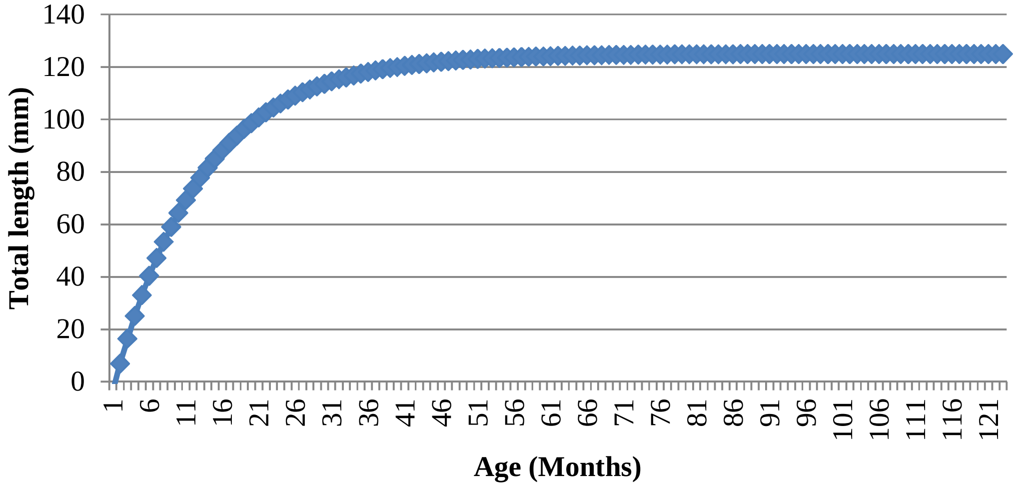


Figure 6: Estimate of L∞ in *O. anomala* using ELEFAN I method



L∞ (Asymptotic length) [124.95]
K (Growth constant) [1.0]
SS (Starting sample) [22.00]
SL (Starting length) [121.50]

Figure 7: Von Bertalanffy growth curves of *O. anomala*



DISCUSSION

A separated equation for on length-weight relationship is given as log W = 0.003368992 $L^{1.7336}$ (r = 0.6917) for males; log W = 0.002779713 $L^{1.7801}$ (r = 0.7489) for females and log W = 0.002932243 $L^{1.7801}$ (r = 0.7291) for combined sexes in the present study. From these equations it is clear that the "b" values of males and females were less than 3, indicated that negative allometric growth in these species.

Rocket *et al*., [22] estimated that the length-weight relationship for *S. empusa*, where they conclude that the species shown as isometric growth pattern as the 'b' value (2.9574) for males and (2.9362) for females. James and Thirimilu [8] reported the length-weight relationship has been given as log W = - 2.226907 + 1.623622 log L for males, log W = - 2.023819 + 1.50877 log L for females and log W = - 4.8665 + 2.9661 log L for combined sexes of *O. nepa*. Analysis of covariance showed not significant at 5% level and showed negative allow metric growth. Lyla *et al.*, [13] reported that length-weight relationship as log W = - 3.18 + 2.21 log L for males and log W = - 2.98 + 2.12 log L for females of *H. melanoura*. Abdurahiman [11] reported that length-weight relationship parameters, i.e intercept (a) and slope (b) and correlation coefficient (r) for the stomatopod *O. nepa* are 0.017, 2.786 and 0.97 respectively. Antony *et al.*, [3] given a length-weight relationship as log W = - 3.6479 + 2.3758 log x for males, log W = - 3.4826 + 2.3024 log x for females and log W = - 3.5589 + 2.336 log x for combined sexes of *H. harpax*. Yusli & Ali [26] reported the length-weight relationship of *H. raphidea*. The length-weight relationship has been given as W = 3E-$05L^{2.743}$ and 'b' value 2.686-2.800 (r = 0.936) for males and W = 4E-$05L^{2.678}$ and 'b' value 2.643-2.731 (r = 0.941) for females in the intertidal area; W = $0.0003L^{2.356}$ and 'b' value 2.322-2.390 (r = 0.947) for males and W = $0.0002L^{2.413}$ and 'b' value 2.366-2.460 (r = 0.883) for females.

Lyla *et al.*, [13] reported that the regression co-efficient varied from 1.43 to 3.03. Males and females showed significant differences in length–weight relationship of *H. melanoura*. Antony *et al.*, [3] reported that analysis of covariance showed no significant difference between the regression lines in males and females of *H. harpax* at 5% level. The Comparison of regression lines showed a significant difference (P ‹ 0.05) between slopes of two sexes in the present study.

Rajeswari [20] reported that the Kn values were found high during July to April and again November to December in *O. nepa*. This is agree with present study Kn values were high during Jul to Aug and again Oct to Nov. Reddy and Shanbhogue [21] reported Kn values against size class indicated that the stomatopod mature at 95-96 mm size. In the present study Kn value were high during 71-80 mm length groups.

James and Thirumilu [8] estimated the growth using Von Bertalanffy parameters for males and female of *O. nepa*. Growth coefficient was (K) 3.9871 for males and 2.7173 for females; while L∞ was 96 mm for males and 114 mm for females. Males and females of *O. nepa* such a length of 92.23 mm and 95.81 mm; 95.99 mm and 107.82 mm; 113.59 mm and 113.97 mm at the end of 1,2 and 3 years respectively. Hamano [6] estimated growth using Von

Bertalanffy's growth models were Lt = 57.2 (1 - exp (0.0190 (t + 8.25))) for males and Lt = 55.8 (1-exp (0.0191 (t + 8.45))) for females of *O. oratoria*. Yusli and Ali [26] estimated the growth parameters (K & L∞) and t_o for both sexes, using Ford-walford plot analysis from Von Bertalanffy's equation; K = 0.14 for males and 0.11 for females; L∞ = 381.68 for both sexes. Then the values of growth parameters are used as basis to get the *H. raphidea* Von Bertalanffy equation, i.e. Lt = 381.68* (1-e $^{[-0.11(t + 0.5533]]}$)]) for males and Lt = 381.68* (1-e $^{[-0.11(t + 0.3802]]}$)]) for females.

In the present study age and growth of *O. anomala* has been estimated by using ELEFAN–1 programme of FISAT software. The parameters of the Von Bertalanffy growth models were L_∞ = 124.95, K = 1.0 /yr, t_0 = 0.11 and Ø = 4.1935/Yr. The estimated length of the *O. anomala* was 73.64 mm, 106.07 mm, 118.08 mm, 122.40 mm and 124.01 mm at 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and 5^{th} yrs respectively. The rate of growth was high during initial months and then it slows down with advancement of age.

Life span of *O. anomala* was 124 months. Life span *O. anomala* was higher than that of some other types of mantis shrimps: such as *S. mantis* was 1.5 yrs Abello and Martin [2]; *O. oratoria* from 3-3.5yrs Dell and Sumpton [5] and *O. stephensoni* 2.5-3 yrs. *H. raphidea* was 6.7-8.5yrs Yusli and Ali [26]. The asymptotic size (L∞) in *S. mantis* reported was 200mm Abello and Martin [2]; *O. stephensoni* 163mm Dell and Sumpton [5] and in *H. raphidea* 381.68mm Yusli and Ali [26].

REFERENCES

[1] Abdurahiman K.P, Nayak T.H, NAGA P.U, *W. Fish Cen. Qua*, **2004**, 27 (1&2), pp. 9-14.
[2] Abello P and Martin P, *Fisheries Research*, **1993**, 16:131–145.
[3] Antony P.J, Eldose P.M, Lyla P.S and Ajmalkhan S, *J. Aq. Bio*, **2004**, 19 (2), pp. 39-42.
[4] Bertalanffy Von L, *Hum. Bio*, **1938**, 10 (2): 181-213.
[5] Dell Q and Sumpton W, *Asian Fisheries Science*, **1999**, Vol. 12, pp. 133-144.
[6] Hamano T, *Nippon Suisan* Gakkaishi, **1990**, 56 (9): 1529.
[7] Hans-georg müller, *Laboratory for Tropical Ecosystems, Research & Information Service,* P.O. Box 2268, **1994**, D-35532, Wetzlar, Germany.
[8] James D.B and Thirumilu P, *J. Bio. Asst*. India, **1993**, Vol. 35 (1&2), pp. 135-140.
[9] Kodama K, Shimuzu T, Yamakawa T and Aoki I, *Fishries Science*, **2004,** 17: 734-745.
[10] Lai W.C and Leung K, *Invertebrate*, **2003**, 3-4.
[11] Le Cren C.P, *J. An. Eco*, **1951**, 20(2): 201-219.
[12] Lui K.K.Y, Ng J.S.S and K.M.Y, *Coastal Shelf Science*, **2007**, 72: 635-647.
[13] Lyla P.S, Panchatcharam K and Khan S.A, *Soc. Fish. Tech*, India, **1998**, pp 44-47.
[14] Manning, *Proc. Biol. Soc,* **1968a**, *Wash,* **81**, 241-250.
[15] Manning, *Contri*. **1969b**, *Zool*. No.**1**, 1-17.
[16] Musa N and Wei L.S, *World Journal of Agricultural Science*, **2008**, 4 (2), 137-139.
[17] Pauly D and David N, *Meeresforschug*, **1981**, 28 (4): 205-211.
[18] Pauly D and Munro, J.L, *Fish byte*, **1984**, 2 (2): 21.
[19] Pauly D, *De. Uni. Kiel*. **1979**, 63: XV + 156p.
[20] Rajeswari T, *PhD Thesis*, Scholl of Industrial Fisheries, **1996**, Cochin Uni. Sci. Tech.
[21] Reddy H.R.V and Shanbhogue S.L, *Mahasagar*, **1994**, Vol. 27, No.1 (June): pp.67-72.
[22] Rocket M.D, Standard G.W and Chittenden M.E, *Fish Bull*, **1984**, 82, 418-426.
[23] Snedecor G.W and Cochran W.G, Statistical methods, Sixth Edition, Oxford and IBH Publishing Co, New Delhi, **1967**, 593pp.
[24] Spiegel M.R, Theories at applications de la statistique, McGraw-Hill, Paris, **1991**, 358p.
[25] Yedukondala Rao P, Prasad D.R and Sirisha I.R, *Int. J. Cu. Res*, **2013**, 5(12), 4108-4112.
[26] Yusli W and Ali M, *Indo. J. Mar. Sci*, **2011**, Vol. 16 (2), 111-118.