INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY

RESEARCH ARTICLE

Biometric Characteristics of the Siboga Squid Uroteuthis (photololigo) Sibogae (Adam, 1954) from the South East Coast of India

R John Peter[1]*, A John Chembian[2]

1 Research scholar, Chennai base of Fishery Survey of India, Fishing Harbour Complex, Royapuram, Chennai-13, India
2 Jr. Fisheries scientist, Chennai base of Fishery Survey of India, Fishing Harbour Complex, Royapuram, Chennai-13, India

OPEN ACCESS

Received: 27-06-2022

Accepted: 01-09-2022

Published: 21-09-2022

Citation: Peter RJ, Chembian AJ (2022) Biometric Characteristics of the Siboga Squid Uroteuthis (photololigo) Sibogae (Adam, 1954) from the South East Coast of India. Indian Journal of Science and Technology 15(36): 1779-1785. https://doi.org/10.17485/IJST/v15i36.1349

* **Corresponding author**.

rjohnpeter004@gmail.com

Funding: None

Competing Interests: None

Published By Indian Society for Education and Environment (iSee)

ISSN
Print: 0974-6846
Electronic: 0974-5645

Abstract

Objectives: To study the various linear and non-linear relationships among the variables of siboga squid Uroteuthis (photololigo) sibogae (Adam, 1954) from the South East Coast of India from August to November 2021. **Methods:** Samples of the siboga squid were measured to the nearest value of 1.0mm and the weight was measured to 1gm. **Findings:** Females had a mean DML of 120 mm, whereas males were 129 mm. The mean total weight of pooled sexes was 38.9 gm with the female being 35.9 gm and the male 41.8 gm. Regarding mean mantle weight, the female was 20.5gm and the male was 24.7 gm with pooled sex of 22.6 gm. The nonlinear relationship between length and the total weight of females was calculated as $0.0014x^{2.1119}$, while the male was calculated as $0.0009x^{2.1998}$ and the pooled sex as $0.0009x^{2.2075}$. Whereas, the length-Mantle weight relationship of females and males was calculated as $0.0015x^{1.9857}$, $0.0004x^{2.2663}$ respectively, with pooled one as $0.0006x^{2.1721}$. The length - total weight and length - mantle weight relationship of female, male, and pooled sex shows negative allometric (b<3) indicating less cuboidal growth. Similarly, the linear morphometric relationship of female, male, and pooled sex also showed negative allometric growth (b<1). The P-value of b shows high significance (P<0.05), which rejects the null hypothesis. **Novelty:** The study on length-weight and the morphometric relationship of the species to understand the difference in growth patterns between males and females.

Keywords: Uroteuthis (photololigo) sibogae; lengthweight relationship; morphometric study; allometry growth; sexual dimorphism

1 Introduction

Cephalopods are the second major seafood export item from India with consistent demand in export trade and their landings have increased in relative terms by 416%, since 1961. In 2019-20, 0.22 lakhs tons of cephalopod were landed and squid export quantity was 87631 tons in India [1,2]. The importance and demand of the cephalopod fisheries are ever-growing globally. However, research efforts to describe the extent and scope of the global cephalopod trade are limited [3]. Cephalopods fisheries contribute to world landings in capture fisheries and its proportion is increasing steadily over recent decades [4]. Also, the demand for the squid fisheries was increasing rapidly in the form of export food from all over the world.

According to Siddique et al [5], to understand the well-being of fish populations or cephalopods, the study of linear and non-linear parameters can be helpful. In this context, understanding the health of the squid stock acquires paramount importance because the export demand may lead to the exploitation of the species. Mishra et al [6], Tehseen et al [7], and Chhandaprajnadarsini et al [8] have done some studies on the length-weight relationships of Uroteuthis duvaucelli in Indian waters. In other waters, Munasinghe & Thushari [9], Soomro et al [10], Islam, et al [11], and Siddique et al [5] have done length-weight relationships studies on Uroteuthis duvaucelli. Similarly, Neethiselvan & Venkataramani [12], have studied the length-weight relationship of Uroteuthis (photololigo) sibogae on the east coast of Tuticorin. However, later no studies were undertaken on Uroteuthis (photololigo) sibogae. Because of that, the present study was undertaken on the species U. sibogae along the southeast coast of India to determine the linear and nonlinear relationships of various variables among both sexes.

2 Methodology

Specimens of Uroteuthis (photololigo) sibogae (Adam, 1954) were collected from August to November 2021 from the area between Lat 10° to 16°N and Long 80° to 86° E off the Tamil Nadu Coast at a depth range of 30 – 150 m Figure 1 onboard M.F.V Samudrika, (28.8 m OAL, 189 GRT, and 650 BHP), a Fishery Resources Survey vessel of the Chennai Base of Fishery Survey of India. The samples were collected by using a fish trawl of 27.5 m Head rope length and with 40 mm cod-end mesh size. Around 220 specimens were collected during the sampling period and preserved at -20 °C on board & thawed at room temperature for further studies at the shore laboratory. Morphometric measurements were taken following Cohen [13]. The sex-wise measurements for Dorsal mantle length (DML), Fin length (FL), Fin width (FW), Arm-1 length (AL1), Arm-2 length (AL2), Arm-3 length (AL3), Arm-4 length (AL4), Tentacle length (TL), Tentacular club length (TCL) Mantle circumference - anterior (MCA) and Mantle circumference–fin insertion (MCF) were measured to the nearest 1.0 mm using Vernier caliper's. The total body weight (TWt) and mantle weight (MWt) were measured to the nearest 1 gram. The details are furnished in [Table 1].

Table 1. Morphometric parameters of males and femalesUroteuthis (photololigo) sibogae

Parameters	Males				Females				Total			
	n	Range	Mean	SD	n	Range	Mean	SD	n	Range	Mean	SD
Dorsal mantle length (mm)	113	59-196	129.9	26.11	107	66-149	120.21	16.14	220	59-196	125.22	22.3
Total weight (gm)	113	6-89	41.8	17.8	107	10-60	35.99	10.40	220	6-89	38.99	14.97
Mantle weight (gm)	113	3-52	24.7	10.9	107	6-36	20.51	5.8	220	3-52	22.96	9.1
Tentacle Length (mm)	113	59-177	124.7	19.5	107	68-167	123	18.6	220	59-177	123.8	19.08
Tentacle Club Length (mm)	113	15-51	33.04	6.1	107	18-41	31.80	4.8	220	15-51	32.44	5.5
Fin width (mm)	113	17-62	44.49	9.4	107	20-59	43.07	7.36	220	17-62	43.80	8.5
Fin length (mm)	113	22-102	60.5	14.7	107	27-73	54.9	9.1	220	22-102	57.8	12.6
Arm length-I (mm)	113	13-52	33.2	6.5	107	18-43	31.75	5.8	220	13-52	32.53	6.2
Arm length-II (mm)	113	17-65	44.4	8.9	107	24-59	42.7	8.2	220	17-65	43.6	8.6
Arm length-III (mm)	113	23-71	50.6	9.4	107	27-68	49.37	9.08	220	23-71	50	9.2
Arm length-IV (mm)	113	18-62	44.1	8.2	107	20-59	41.8	7.7	220	18-62	43	8.0
M C A (mm)	113	46-87	63.4	8.2	107	50-77	65.1	5.7	220	46-84	65.97	6.9
M C F (mm)	113	42-87	63.4	8.2	107	46-76	62.5	6.5	220	42-87	62.9	7.4

Length-weight relationship of DML to Twt, and DML to MWt, for both males and females, were studied and compared by the equation $W= aL^b$, where 'W' is the weight in 'g', 'L' the DML in mm, 'a' intercept and 'b' slope [14,15]. The relationship between other linear variables were studied by applying a simple linear regression equation, Y= a + bX as recommended by Ricker [16]. The confidence interval was calculated at 95% level for coefficient b. Statistical significance tested for both zero slope parameter and slope parameter equal to 3 and 1 respectively using the p-value approach [15].

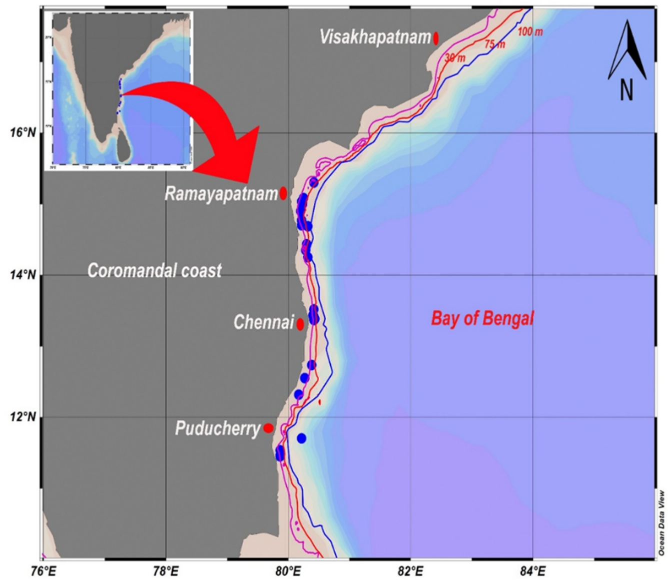

Fig 1. Map of the Southeast coast of India showing the sampling area.

3 Result and discussion

3.1 Length Weight relationship

The regression equation of dorsal mantle length (DML) with total weight (TWt) was observed: male was 0.0009x$^{2.1998}$ (R^2 0.97)' female 0.0014x$^{2.1119}$ (R^2 0.87) and pooled sex was 0.0009x$^{2.2075}$ (R^2 0.93). The relationship of dorsal mantle length with mantle weight was observed: male was 0.0004x$^{2.2663}$ (R^2 0.96)' female 0.0015x$^{1.9857}$ (R^2 0.95) and pooled sex was 0.0006x$^{2.1721}$ (R^2 0.92). From the observation, the b value of all the parameters shows lesser than the cuboidal growth i.e. negative allometric growth ($b<3$). Significance test done for male and female indicate that P-value of b is highly significant for both males and females [Table 2] [Figure 2].

Table 2. Length Weight relationship ofUroteuthis (photololigo) sibogae in the South East Coast of India.

Parameters	n	R2	a L^b	CI (b)	Growth	P (b)
DML- TWt	220	0.93	0.0009x$^{2.2075}$	(2.1, 1.2)	- Allometric	0.000
DML–FemTWt	107	0.87	0.0014x$^{2.1119}$	(1.9, 2.2)	- Allometric	0.000
DML–MaleTWt	113	0.97	0.0009x$^{2.1998}$	(2.1, 2.2)	- Allometric	0.000
DML–MWt	220	0.92	0.0006x$^{2.1721}$	(2.0, 2.2)	- Allometric	0.000
DML–Fem MWt	107	0.95	0.0015x$^{1.9857}$	(1.8, 2.1)	- Allometric	0.000
DML–Male MWt	113	0.96	0.0004x$^{2.2663}$	(2.1, 2.3)	- Allometric	0.000

Coefficientis highly significant at 0 level, R^2 : Correlation coefficient, a L^b: equation, CI

Recently the study conducted by Tehseen et al [7] on the DML and Total Weight relationship of Uroteuthis duvaucelli from Indian waters, shows that males and females had a "b" value of 2.11 and 2.42 respectively. Subsequently, the study conducted by Chhandaprajnadarsini et al [8] also showed that males and females had a "b" value of 1.92 and 2.54 respectively. In both the studies male is nearest to the results obtained in this study on U. Sibogae. However, the female of the U. sibogae exhibit less cuboidal growth when compared to the U. duvaucelli. Similarly, Neethiselvan & Venkataramani [12] in Uroteuthis sibogae observed Male b = 1.99, female b = 2.19, and pooled sex b = 2.04, which is almost equal to the b value obtained in the present study in U. Sibogae and indicate a negative allometric growth pattern. Purwiyanto et al [17] proposed that the negative allometric growth condition is indicative of the non-sustainability of the stock from high fishing pressure. In regard to the DML and mantle weight relationship, a lesser b value (1.98) of the female than the male (2.26) may perhaps, indicate that the female reproductive organs of this squid might be growing disproportionately more in weight resulting in less growth in mantle weight [Figure 2d]. Smith et al [18] in Loligo forbesii observed that the mantle weight was lighter as the gonad size increased, it appears to imply mobilization of energy from mantle tissue to produce ovary tissue. The study conducted in Illex argentinus also indicates a similar trend of mantle mass of females decreasing in relation to ML with maturity[19–21].

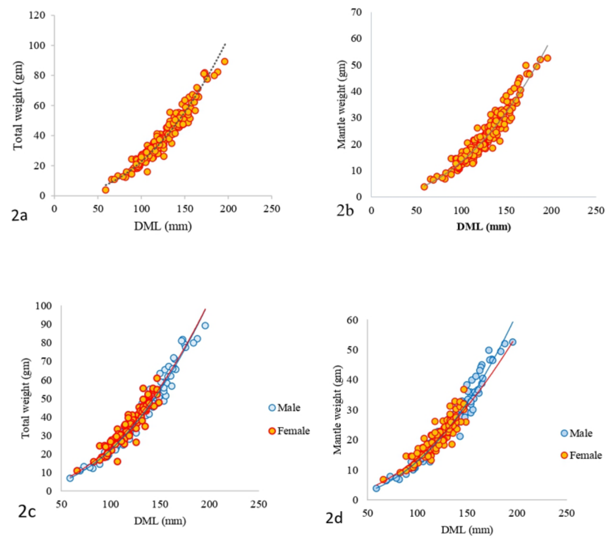

Fig 2. Dorsal mantle length-total weight relationship of Uroteuthis (photololigo) sibogae (a)Dorsal mantle length–total weight relationship of pooled sex, (b) Dorsal mantlelength– mantle weight relationship of pooled sex, (c) Dorsal mantle length–totalweight relationship between male and female, (d) Dorsal mantle length–mantleweight relationship between male and female.

3.2 Morphometric and sexual dimorphic relationship

The regression of linear morphometric variables (pooled sex) against DML was studied. The slope value was less than 1 for all the pairs (b<1) indicating a negative allometric growth pattern [Table 3]. The same trend continued for both males and females indicating a negative allometric growth pattern in the sexes also b<1[Table 4] [Figure 2].

Table 3. Morphometric relationship ofUroteuthis (photololigo) sibogae (Pooled sexes) in the South East Coast of India.

Parameters	n	R2	a+ b x	CI (b)	Growth	P (b)
DML-FL	220	0.95	-11.562+ 0.5541x	(0.53, 0.56)	-Allometric	0.000
DML- FW	220	0.81	5.383 +0.2168x	(0.32, 0.36)	-Allometric	0.000
DML- AL1	220	0.60	5.383 +0.2168x	(0.19, 0.24)	-Allometric	0.000
DML- AL2	220	0.62	5.4112+0.3051x	(0.27, 0.33)	-Allometric	0.000
DML- AL3	220	0.62	8.8936+0.3283x	(0.29, 0.36)	-Allometric	0.000
DML- AL4	220	0.71	4.8889+0.3046x	(0.27, 0.33)	-Allometric	0.000
DML-TL	220	0.58	41.951+0.6543x	(0.58, 0.72)	-Allometric	0.000
DML-TCL	220	0.69	6.3665+0.2082x	(0.18, 0.22)	-Allometric	0.000
DML-MCA	220	0.66	34.072+0.2548x	(0.23, 0.27)	-Allometric	0.000
DML-MCF	220	0.58	30.939+ 0.2559x	(0.22, 0.28)	-Allometric	0.000
FL- FW	220	0.77	9.5377+0.5926x	(0.55, 0.63)	-Allometric	0.000
TL- TCL	220	0.67	2.7054+0.24x	(0.21, 0.26)	-Allometric	0.000
TWt-MWt	220	0.96	- 0.6959+0.5996x	(0.58, 0.61)	-Allometric	0.000

b coefficient is highly significant at 0 level, R^2 : Correlation coefficient, a+bx : equation, CI (b) : Confidence interval of the co efficient b (95%), p (b) : Hypothesis testing for slope parameter equal to 1 using the p-value approach.

Among the linear relationship studied for the DML vs TL, TCL, AL-I, AL-II, AL-III, and AL-IV, the female growth trend indicates a lower growth for the variables studied when compared to the male of the same size in the juvenile stage. However, when it grows this pattern seems to have been reversed and female variables attain larger in length than the male of the same size. A similar trend is observed in TL vs TCL and DML vs FW [Fig. 3]. Chembian & Mathew[(15)] observed that the linear morphometric relationship is studied to understand the divergence in body growth among the sexes. This differential growth of the variables might have been influenced by various internal and external factors like seasonal change, availability of food, habitat, growth phase, size range, sex, gonad maturity, stomach fullness, health condition, preservation techniques, etc...[(5,22–24)].

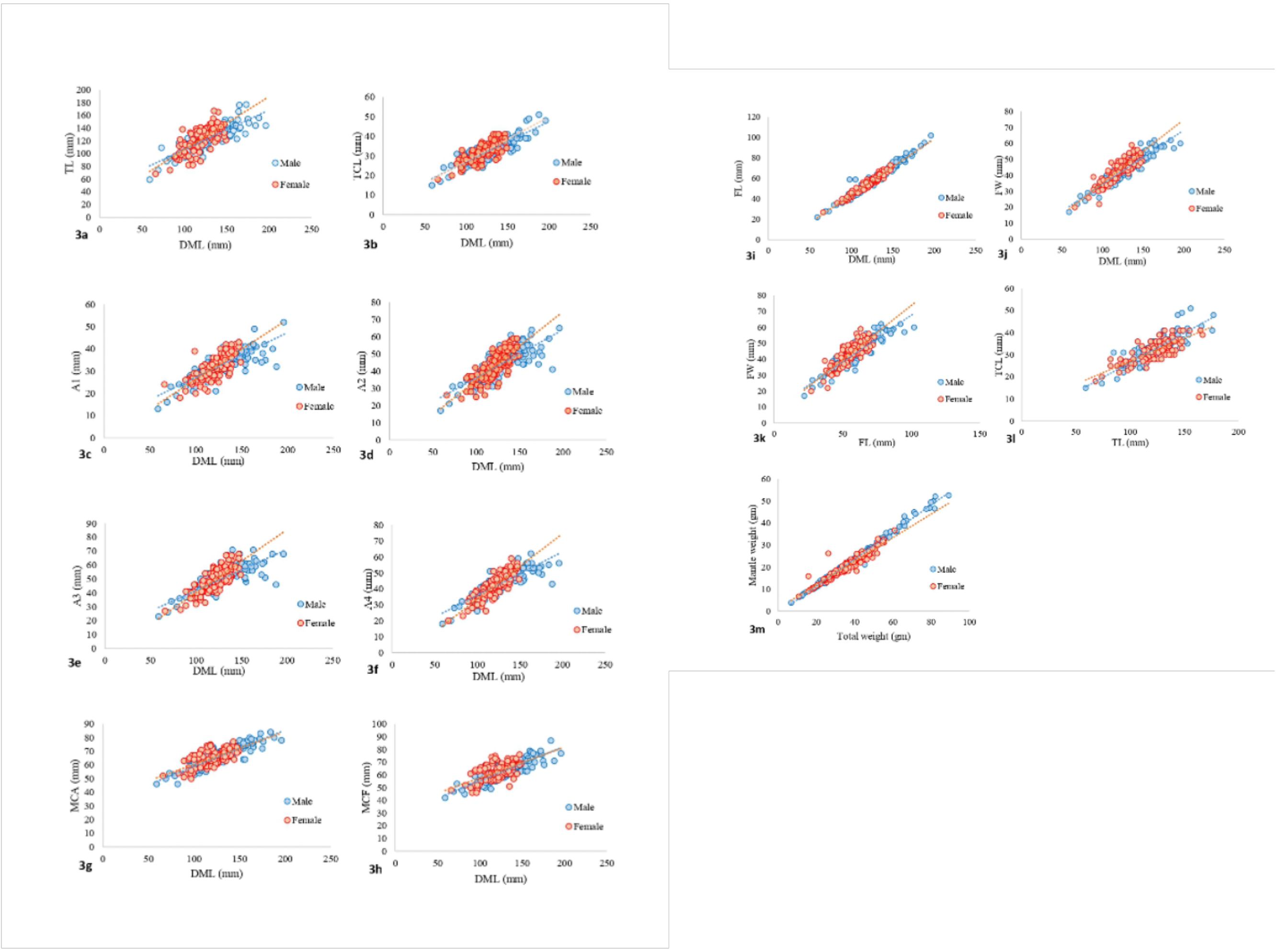

Fig 3. Linear morphometric relationship of Uroteuthis (photololigo) sibogae between male and female (a) DML vs TL, (b) DML vs, TCL (c) DML vs A1, (d) DML vs A2 ,(e) DML vs A3 , (f) DML vs A4 , (g) DML vs MCA , (h) DML vs MCF, (i) DML vs FL, (j) DML vs FW , (k) FL vs FW, (l) TL vs TCL and (m) TWt vs MWt

Table 4. Sexual dimorphic relationship ofUroteuthis (photololigo) sibogae in the South East Coast of India

Parameters	Sex	n	R^2	a+ b x	CI (b)	P (b)
DML-AL1	F	107	0.56	0.6519+0.2696x	(0.22, 0.31)	0.000
	M	113	0.65	7.03+0.2019x	(0.17, 0.22)	0.000
DML-AL2	F	107	0.61	- 5.2438+0.399x	(0.33, 0.46)	0.000
	M	113	0.66	8.1239+0.2797x	(0.24, 0.31)	0.000
DML-AL3	F	107	0.65	- 5.1559+0.4536x	(0.38, 0.51)	0.000
	M	113	0.67	12.03+0.2968x	(0.25, 0.33)	0.000
DML-AL4	F	107	0.72	- 7.3144+0.4091x	(0.36, 0.45)	0.000
	M	113	0.73	8.8087+0.2717x	(0.24, 0.30)	0.000
DML-MCA	F	107	0.44	36.409+ 0.239x	(0.18, 0.29)	0.000

Continued on next page

Table 4 continued

	M	113	0.77	32.134+0.2665x	(0.23, 0.29)	0.000
DML-MCF	F	107	0.35	33.498+0.2415x	(0.17, 0.30)	0.000
	M	113	0.73	27.998+0.2725x	(0.24, 0.30)	0.000
DML-TL	F	107	0.52	22.752+0.834x	(0.67, 0.98)	0.000
	M	113	0.69	43.861+0.6221x	(0.54, 0.69)	0.000
DML-TCL	F	107	0.57	4.4788+0.2273x	(0.18, 0.26)	0.000
	M	113	0.77	6.16+0.2069x	(0.18, 0.22)	0.000
DML-FL	F	107	0.94	- 10.96+0.5481x	(0.52, 0.57)	0.000
	M	113	0.95	- 11.501+0.5546x	(0.53, 0.57)	0.000
DML- FW	F	107	0.76	- 4.7097+0.3975x	(0.35, 0.44)	0.000
	M	113	0.87	0.4496+0.3389x	(0.31, 0.36)	0.000
FL-FW	F	107	0.70	0.6798x + 5.7371	(0.59, 0.76)	0.000
	M	113	0.83	9.016+0.5857x	(0.53, 0.63)	0.000
TL-TCL	F	107	0.63	6.4+0.2065x	(0.17, 0.23)	0.000
	M	113	0.71	- 0.2852+0.2673x	(0.23, 0.29)	0.000
TWt-MWt	F	107	0.90	1.2663+0.5349x	(0.50, 0.56)	0.000
	M	113	0.99	- 0.9517+0.614x	(0.60, 0.62)	0.000

b coefficient is highly significant at 0 level, R^2 : Correlation coefficient, a+bx : equation, CI (b) :Confidence interval of the co efficient b (95%), p (b) : Hypothesis testing forslope parameter equal to 1 using the p-value approach

4 Conclusions

In the present study, sex wise biometric characteristics of the squid Uroteuthis_ (photololigo) sibogae were studied. Length weight relationship and the linear morphometric relationship shows negative allometric growth patterns in both. But the growth of males seems to be marginally higher than that of females, in the context of the length-mantle weight relationship. Further studies on the length-weight relationship and morphometric growth difference between both sexes give clear information about the stock or population structure to understand its exploitation.

5 Acknowledgement

Authors acknowledge the support and necessary facilities provided by the Director General, Fishery Survey of India and the Zonal Director, Chennai base of Fishery Survey of India.

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