

# Length–weight relationship of six deep-sea fish species from the shelf regions of western Bay of Bengal and Andaman waters

K. V. Aneesh Kumar | R. Thomy | K. P. Deepa | M. Hashim | M. Sudhakar

Centre for Marine Living Resources and Ecology (CMLRE), Kochi, Kerala, India

## Correspondence

K. V. Aneesh Kumar, Centre for Marine Living Resources and Ecology (CMLRE), Kochi, Kerala, India.  
Email: aneeshmenan12@gmail.com

## Summary

Length–weight relationships for six deep-sea fish species inhabiting the shelf regions of the western Bay of Bengal and the waters of Andaman and Nicobar of India are presented. Samples were collected using high-speed demersal trawl and expo demersal trawl nets at depths of 231–514 m in August and September 2010. The  $b$  values in the analyses ranged from 3.05 to 3.31, showing a mean and median value of 3.21 ( $SE \pm 0.039$ ,  $SD \pm 0.097$ ) and 3.2, respectively. Comparisons of  $b$  values with earlier estimations confirm the presence of spatial and temporal variations in the length–weight relations among the species. Coefficient of determination scores ranged from 0.94 to 0.97, indicating robustness of the samples analysed. This study provides the first estimates of length–weight relationships for four of the deep-sea fishes, enriching the understanding of the growth patterns and population dynamics of these less-studied deep-sea fishery resources in Indian Ocean waters.

## 1 | INTRODUCTION

India is renowned for its vast and rich deep-sea and oceanic fish resources (Somavanshi, 1998). Information on the distribution, biology and life history patterns of the deep-sea fishes in Indian waters are rare (Sreedhar, Sudhakar, & Meenakumari, 2013; Venu & Kurup, 2002a,b, 2006). The majority of the studies on the biology of the deep-sea fishes are restricted to the southern coast of India (Deepu, Haridas, & Kurup, 2007; Jayaprakash et al., 2006; Sreedhar et al., 2013; Thomas, Venu, & Kurup, 2003). Major deep-sea fish species inhabiting the continental slope beyond 250 m depth along the west coast of India were observed as following a slightly negatively allometric growth pattern, with  $b$  values ranging from 1.97 to 3.3, mean 2.83 (Thomas et al., 2003).

The length–weight relationship (LWR) is a useful tool in fishery assessment, which helps predict weight from length required in yield assessment (Garcia et al., 1998), and in the calculation of the standing crop biomass (Martin-Smith, 1996). These relationships are highly useful in the computation of condition indexes and comparison of species growth trajectories between sexes, seasons, and regions (Froese, 2006).

Length–weight relationships of deep-sea fishes are generally less studied, especially in the western Bay of Bengal. The authors considered six species for the present study; of these, four for the first time. The objective of the present study was to contribute towards the understanding of the growth pattern of these deep-sea fish species, where information is scarce and incomplete.

## 2 | MATERIALS AND METHODS

Samples for the present study were collected during deep-sea fishery cruises on board FORV *Sagar Sampada* (cruise no: 279,280) from August to September 2010, at five sampling stations (Lat.  $10^{\circ}56.64' - 18^{\circ}30.10'$ ; Long.  $79^{\circ}59.63' - 93^{\circ}12.96'$ ) in depths between 231 and 514 m. The samples were identified at species level using standard identification keys (Alcock, 1898, 1899; FAO, 1984) and preserved in 5% formaldehyde; detailed analyses were carried out in the laboratory.

A 38 m high-speed demersal trawl II and a 45.6 m expo model demersal trawl were employed for fishing. Total lengths and weights were measured to an accuracy of 0.1 cm and 0.1 g, respectively. Necessary

**TABLE 1** Length-weight relationship of 6 deep-sea fishes from the shelf regions of western Bay of Bengal and Andaman waters

| Species                                                     | N   | Length (TL) (cm) |      | Total Weight (g) |     | Parameters of relationships |        |               |             |                |
|-------------------------------------------------------------|-----|------------------|------|------------------|-----|-----------------------------|--------|---------------|-------------|----------------|
|                                                             |     | Min              | Max  | Min              | Max | (a)                         | (b)    | 95% CL of a   | 95% CL of b | r <sup>2</sup> |
| <i>Bembrops platyrhynchus</i> (Alcock, 1894)                | 120 | 12.6             | 23.3 | 11.5             | 76  | 0.003                       | 3.247  | 0.0023–0.004  | 3.15–3.34   | .9744          |
| <i>Bembrops caudimacula</i> (Steindachner, 1876)            | 111 | 10.8             | 24.1 | 5.5              | 94  | 0.0029                      | 3.2983 | 0.0012–0.003  | 3.29–3.61   | .9388          |
| <i>Cubiceps baxteri</i> (McCulloch, 1923)                   | 214 | 7.9              | 16   | 4.5              | 47  | 0.0048                      | 3.3115 | 0.0038–0.006  | 3.22–3.40   | .9619          |
| <i>Narceses lloydi</i> (Fowler, 1934)                       | 75  | 9.4              | 23.3 | 10               | 115 | 0.0044                      | 3.2028 | 0.0027–0.0072 | 3.03–3.37   | .9514          |
| <i>Pterygotrigla hemisticta</i> (Temminck & Schlegel, 1843) | 71  | 11.6             | 18.8 | 14               | 68  | 0.0065                      | 3.1561 | 0.0039–0.011  | 2.97–3.34   | .9434          |
| <i>Satyrichthys adeni</i> (Lloyd, 1907)                     | 52  | 7.9              | 40.1 | 15               | 500 | 0.0057                      | 3.0517 | 0.0035–0.0093 | 2.90–3.20   | .9716          |

N, total number of samples; Min, minimum; Max, maximum; a, intercept; b, slope; r<sup>2</sup>, coefficient of determination; CL, confidence limits.

trawl parameters such as depth, duration, and time operation were noted for all operations. LWRs were calculated by least square regression (Le Cren, 1951; Zar, 1999), expressed by the regression equation  $W = aL^b$ . The meristic measurements were converted into logarithmic values to identify and exclude possible outliers in the data (Froese, Tsikliras, & Stergiou, 2011). Parameters *a* and *b* were calculated by least square regression. A *t* test was performed to determine if the slope of regression line differed significantly from the isometric value of 3 (Pauly, 1993). Curvilinear plots of length and weight values were visually inspected for any possible outlier values in the data (Froese, 2006). Fish growth is considered isometric when the *b* value is 3. When the value of *b* is other than 3, weight increase is allometric (positive if *b* > 3, negative if *b* < 3). The 95% confidence limits of *a* and *b* were calculated following Zar (1999).

### 3 | RESULTS

Major catches during fishing operations were: *Dicrolene introniger* Goode & Bean, 1883; *Psenopsis cyanea* (Alcock, 1890); *Physiculus roseus* Alcock, 1891; *Hypopleuron caninum* Smith & Radcliffe, 1913; *Priacanthus cruentatus* (Lacepède, 1801); *Bembrops caudimacula* Steindachner, 1876; *Lophius* Linnaeus, 1758; and *Myctophidae* Gill 1893. The six species considered for the study belong to five families, whereby Table 1 shows the sample size, minimum and maximum lengths and weights, LWRs, parameters *a* and *b*, 95% confidence limits of *a* and *b*, and the coefficient of determination *r*<sup>2</sup>. Sample sizes ranged from 52 for *Satyrichthys adeni* (Lloyd, 1907) to 214 for *Cubiceps baxteri* McCulloch, 1923. The *b* value ranged from 3.05 for *S. adeni* to 3.31 for *C. baxteri*. The *r*<sup>2</sup> values ranged from .94 for *Bembrops caudimacula* to 0.97 for *B. platyrhynchus*. Three species showed isometric growth patterns: *Narceses lloydi* Fowler, 1934; *Pterygotrigla hemisticta* (Temminck & Schlegel, 1843); *Satyrichthys adeni* (Lloyd, 1907). The *b* values of these species deviated slightly from the isometric value of 3 (3.20, 3.16, 3.05), but the deviance was found not to be significant statistically. Positive allometric growth patterns were observed in *B. platyrhynchus* (Alcock, 1894), *B. caudimacula*, and *C. baxteri*.

### 4 | DISCUSSION

A significant difference in the *b* values was evident in previous studies, which indicated spatial and seasonal variation in the growth patterns (Sreedhar et al., 2013; Thomas et al., 2003). The growth pattern of *B. caudimacula* ranges allometrically from negative to positive, which confirms the spatial variation in the growth pattern of this species (Aura, Munga, Kimani, Manyala, & Musa, 2011; Jayaprakash et al., 2006; Thomas et al., 2003). Estimated LWRs of six species were compared with the Bayesian LWR estimates in FishBase based on models (Froese, Thorson, & Reyes, 2014). Of the six species studied, the *b* values of four of the species are new to science; the *b* values of all six species are very close to those in FishBase. The authors confirmed the suitability and accuracy of the LWR estimates of data-poor species, especially the deep-sea fishes, using the Bayesian approach. This study is anticipated to be useful in improving and standardising the estimation of species-specific parameters of these data-poor species.

There were some divergences in the observed *b* values from earlier estimations for some of the species. Several factors affect the accuracy of LWR estimates in fishes, such as maturity, season, depth of capture, geographical locations, sex, length class, sample size, selectivity of the fishing gear, physico-chemical properties of water, and hydrographical differences (Bagenal & Tesch, 1978; Hossain et al., 2009; Mommsen, 1998; Sparre, Ursin, & Venema, 1989; Thomas et al., 2003). The use of length-weight data from the local fish stocks is highly recommended for accurate LWR estimations and to restrict their application to the specific length ranges to estimate the growth parameters (Morey et al., 2003). This paper discussed the initial estimations of LWRs of seven deep-sea fishes from the shelf waters of the Bay of Bengal. These results are intended to serve as baseline information for the population dynamics and to derive yield estimations for the less-studied rich deep-sea fishery resources in Indian waters.

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