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Length–weight analysis of ten species (Actinopterygii) supporting subsistence fishery in Lakshadweep waters, southern Arabian Sea

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Abstract

The length–weight relations of ten fish species representing eight genera and four families and that formed the backbone of the subsistence fishery in the Lakshadweep islands were estimated. These fishes which included four species of tuna [*Katsuwonus pelamis* (Linnaeus, 1758); *Thunnus albacares* (Bonnaterre, 1788); *Auxis thazard* (Lacepède, 1800); *Euthynnus affinis* (Cantor, 1849)], three species of needlefishes[*Ablennes hians* (Valenciennes, 1846); *Tylosurus crocodilus* (Péron et Leseur, 1821); *Tylosurus acus melanotus* (Bleeker, 1850)], two species of bait fishes [*Spratelloides delicatulus* (Bennett, 1832); *Spratelloides gracilis* (Temminck et Schlegel, 1846)], and one species of halfbeak (*Hemiramphus archipelagicus* Collette et Parin, 1978) contributed to 96% of the total fish landings. The samples were collected from fish landing centers of ten inhabited islands of Lakshadweep from 2015 to 2017. *Katsuwonus pelamis* showed isometric growth, *S. delicatulus* and *S. gracilis* exhibited positive allometry, while negative allometric growth was seen in other species. The coefficient *a* of the LWR ranged from 0.001 (*A. hians*) to 0.035 (*T. albacares*), while *b* ranged from 2.7 (*T. acus melanotus*) to 3.4 (*S. delicatulus*). The results of the presently reported study provide useful biological information on the stock of ten commercially important pelagic fish species supporting the traditional fisheries in Lakshadweep waters.

Keywords

length–weight relation, pelagic stock, traditional fishery, Lakshadweep, India

Introduction

The relation between body weight and length is important for fishery biology, especially in understanding the state of fish stock and assessing the population structure based on the age- and length-structured models (Pope 1972; Sparre et al. 1989). Length–weight relations (**LWRs**) are also important tools for the morphological comparisons of different species within the same taxon and populations from different geographical area (Panda et al. 2016; Karna et al. 2020). This is significantly important in developing any policy frameworks for fisheries management and conservation pertaining to a particular species or locality (Gonçalves et al. 1997; Froese et al. 2011). LWRs are usually calculated through linear regression on the log-transformed length and weight data, however, in recent years, the use of nonlinear procedures for the estimation of LWR, as well as other population parameters, has been increasing among researchers (De Giosa and Czerniejewski 2016).

The Lakshadweep archipelago, which includes a group of 36 islands lies in the southern Arabian Sea and is the only coral reef complex of India. The fishery in the Lakshadweep islands has traditionally been sustainable and for subsistence. In all the ten of its inhabited islands, fishing is the major source of livelihood. Tuna and needlefishes contribute to about 95% of the total commercial fishery in the Lakshadweep islands and have been historically harvested using pole and line, handline, troll line, and drift gillnet. The bait fishes available in the lagoon are used for chumming of the tuna. Although there have been studies in the past to assess the stock of these species individually (Appukuttan et al. 1977; Mohan and Kunhikoya 1985; Koya et al. 2013; Shahul Hameed et al. 2018), comprehensive documentation of LWR of all the major pelagic commercially exploited fishes from all the ten inhabited has been found lacking. The presently reported study is a compilation of LWRs of eight highly landed pelagic fish species and two live-baits that support traditional pelagic fisheries in Lakshadweep waters.

Methods

The Lakshadweep Archipelago includes a group of ten inhabited and 17 uninhabited islands, under the jurisdiction of the Government of India, scattered between 08°16′–13°58′N and 071°44′–074°24′E in the southern Arabian Sea. The samples were collected on a monthly basis between June 2015 to May 2017 from fish landing center of ten inhabited Lakshadweep islands: Androth (10°49.11′N, 073°41.05′E), Kavaratti (10°33.25′N, 072°38.52′E), Minicoy (08°17.41′N, 073°04.53′E), Agatti (10°15.17′N, 072°11.32′E), Kiltan (11°29.17′N, 073°04.12′E), Chetlat (11°41.21′N, 072°43.05′E), Bithra (11°66.11′N, 072°10.42′E), Amini (11°07.29′N, 072°44.45′E), Kadmath (11°13.19′N, 072°47.05′E), and Kalpeni (10°05.51′N, 073°39.02′E) (Fig. 1). Round the year sampling was done for ten species that represented eight genera and four families. The species included the flat needlefish, *Ablennes hians* (Valenciennes, 1846); the frigate tuna, *Auxis thazard* (Lacepède, 1800); the kawakawa, *Euthynnus affinis* (Cantor, 1849); the jumping halfbeak, *Hemiramphus archipelagicus* Collette et Parin, 1978; the skipjack tuna, *Katsuwonus pelamis* (Linnaeus, 1758); the delicate round herring, *Spratelloides delicatulus* (Bennett, 1832); the silver-stripe round herring, *Spratelloides gracilis* (Temminck et Schlegel, 1846); the yellowfin tuna, *Thunnus albacares* (Bonnaterre, 1788); the keel-jawed needlefish, *Tylosurus acus melanotus* (Bleeker, 1850); and the hound needlefish, *Tylosurus crocodilus* (Péron et Leseur, 1821).

Tuna were collected using a diverse type of gears viz., pole and line, hook and line, handline, and drift

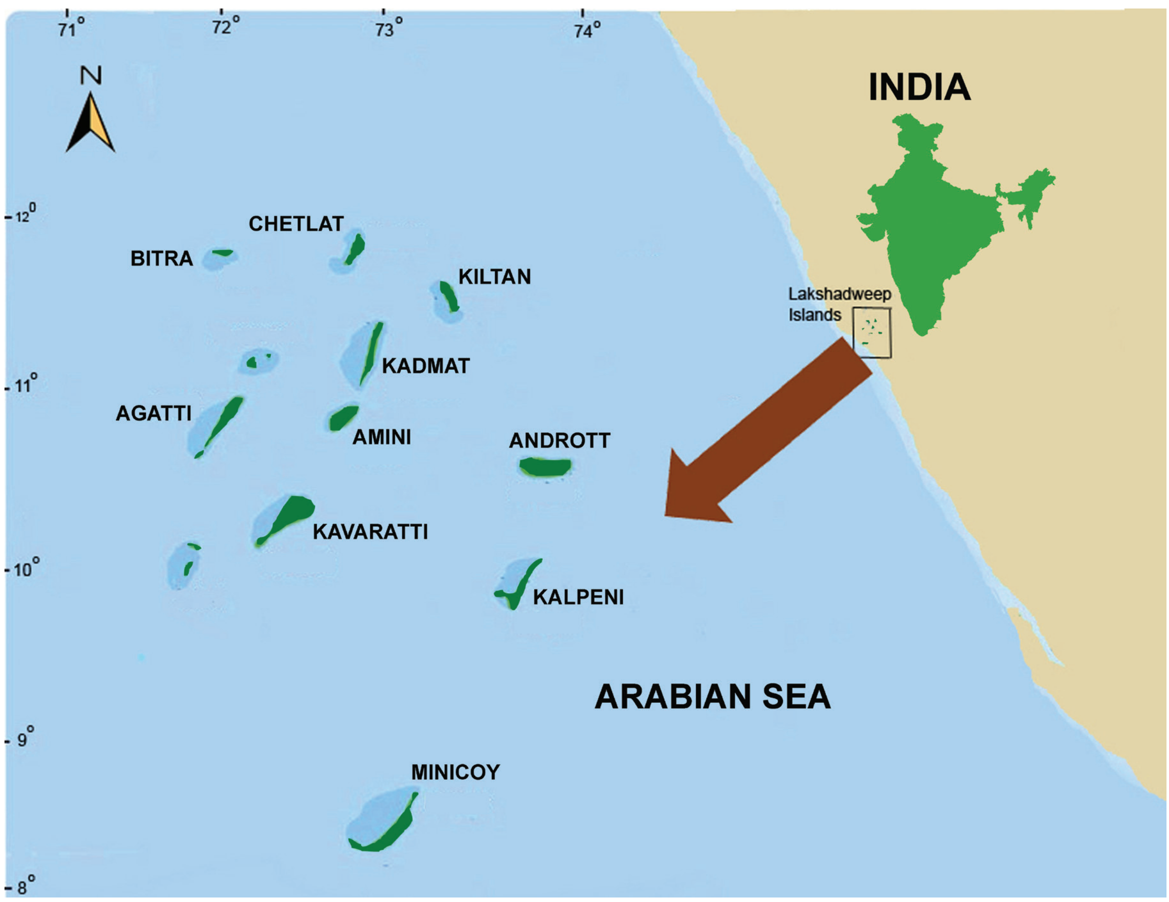

Figure 1. Map of Lakshadweep showing the ten inhabited islands from where fish landing data was collected.

gillnets (55–80 mm mesh size), while the needlefishes and halfbeaks were harvested using gillnet (22–55 mm mesh size) and bait fishes using encircling nets (4–6 mm mesh size). Specimens without physical damage were carefully transferred to the laboratory in iced condition and identified following Day (1878), Fischer and Bianchi (1984), and Collette (1984, 2003). The total length (TL) of all fishes was measured to the nearest 0.1 cm using a measuring board and scale (0.1 cm accuracy), and the individual weight (W) was recorded using an electronic balance (0.1 g accuracy). The length–weight relation described by the equation:

$$W = a\mathrm{TL}^{b}$$

where W is the total weight [g], TL is the total length [cm], a is the intercept related to body form, and b is the regression coefficient (Froese 2006) was estimated, together with the parameters a, b, and r^2 (coefficient of determination) using least-square regression analysis of the logarithm-transformed LWR expression (Garcia 2010):

$$\log W = \log a + b\log\mathrm{TL}$$

Normalization of the data was carried out using log-log plot of the length–weight pairs, and the 95% confidence limits (Cl) of a, b, and r^2 were estimated (Froese 2006; Roul et al. 2017). The null hypothesis that $b = 3$ (i.e., individuals show isometric growth pattern; Froese 2006) was tested using two-tailed t-tests. The statistical analysis was performed in PAST 3.20. All the statistical analyses were considered at a significance level of 5% ($P < 0.05$).

Results

During the presently reported study, 2474 specimens were measured. The length–weight relation parameters including the number of specimens (N), length range, weight range, length–weight parameters (both a and b values), and coefficient of determination (r^2 value) derived from regression analysis for each species are presented in Table 1. The highest number of specimens was measured for *Katsuwonus pelamis* (765), while the lowest was for *Hemiramphus archipelagicus* (70). The linear regression was highly significant ($P < 0.05$) for all species with r^2 values ranging from 0.854 (*Tylosurus acus melanotus*) to 0.979 (*Spratelloides delicatulus*). The estimated allometric coefficient a of the LWR ranged from 0.001 (*Ablennes hians*) to 0.035 (*Thunnus albacares*), while b ranged from 2.745 (*T. acus melanotus*) to 3.404 (*S. delicatulus*).

Discussion

The LWR of fishes is important in fisheries biology because it allows the estimation of the mean weight of fish in a given length group (Beyer 1987) and is particularly important in parameterizing yield equations and estimations of stock size (Abdurahiman et al. 2004). The exact relation between length and weight differs among species of fish according to their inherited body shape, and within a species according to the condition (robustness) of individual fish (Froese et al. 2011). In the presently reported study, the calculated allometric coefficient b values were well within the expected range of 2.5–3.5 (Froese 2006). Similarly, the confidence intervals (95%) in this study were also found within the range and overlapped with the Bayesian confidence limits (Froese et al. 2014). Of the ten species, only one species (*Katsuwonus pelamis*) showed isometric growth, while *Spratelloides delicatulus* and *S. gracilis* exhibited significantly higher b value, while for the rest of the species the growth recorded was negatively allometric. The LWR b values calculated for all the tuna species in the presently reported study were slightly lower than those from the earlier reports (Stequert et al. 1996; Khan 2004; Ghosh et al. 2010, 2012; Koya et al. 2012; Rohit et al. 2012; Mariasingarayan et al. 2018). A similar trend was observed for all the needlefishes; wherein, the b values were significantly lower compared to earlier reports of Roul et al. (2017) and Shahul Hameed et al. (2018). For the remaining fish species, the b value was significantly higher than those already reported (Milton et al. 1991; Nasser 1999; Tabassum et al. 2015). The differences in b values for some of the species caught from the Lakshadweep islands could be attributed to the differences in the fishing gear employed, variation in sex ratio, size of the fish, stages of growth, temporal and spatial distribution, gastro-somatic index, stages of

Table 1. Descriptive statistics and estimated parameters of length–weight relation for the major pelagic species from Lakshadweep waters, southern Arabian Sea.

Family	Species	N	TL [cm]	W [g]	a	95% CI of a	b	95% CI of b	r^2
Scombridae	*Thunnus albacares*	309	28.0–136.6	350–40 600	0.03533	0.02672–0.04472	2.846	2.778–2.913	0.957
	Katsuwonus pelamis	765	23.9–70.6	200–6400	0.01779	0.01501–0.02108	3.018	2.973–3.063	0.957
	Euthynnus affinis	271	23.0–64.0	300–3300	0.03283	0.02482–0.04343	2.848	2.773–2.922	0.954
	Auxis thazard	224	26.0–61.1	380–3200	0.02936	0.01992–0.04328	2.871	2.767–2.975	0.929
Belonidae	*Tylosurus acus melanotus*	288	45.0–82.3	180–1176	0.00492	0.00284–0.00854	2.745	2.614–2.877	0.854
	Tylosurus crocodilus	103	42.0–111.0	148–2389	0.00208	0.00093–0.00465	2.963	2.778–3.149	0.908
	Ablennes hians	77	40.0–112.0	85–1310	0.00132	0.00067–0.00256	2.972	2.818–3.126	0.951
Hemiramphidae	*Hemiramphus archipelagicus*	70	16.0–34.0	22–176	0.00636	0.00455–0.00888	2.903	2.798–3.007	0.978
Clupeidae	*Spratelloides delicatulus*	106	1.6–5.3	0.013–1.102	0.00377	0.00338–0.00421	3.404	3.307–3.501	0.979
	Spratelloides gracilis	261	3.0–7.8	0.137–2.953	0.00455	0.00399–0.00517	3.130	3.055–3.205	0.963

gonad maturity, ontogeny, climatic variability, general condition or number of species examined (Froese 2006; Percin and Akyol 2009).

Conclusion

The presently reported study is a comprehensive analysis encompassing landings from all the inhabited islands of Lakshadweep. The results of the presently reported study are also the first estimates for *Hemiramphus archipelagicus* from the region. Similarly, the LWR estimates of bait fishes are being reported after two decades. The majority of the fishes studied are pelagic open ocean species with either limited geographic distribution (bait fishes and needlefishes) or are migratory (tunas) contributing substantially to the mainstay of commercial fisheries in the region. The latter is more affected by the changing oceanographic and climatic scenarios resulting in annual fluctuation of their stock. Results emerging from the presently reported study form the baseline information on the status of both straddling and migratory fish stocks of the Lakshadweep archipelago that in the future could be used as a yardstick to assess fishery stocks and also to develop sustainable fisheries management policies for the region.

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