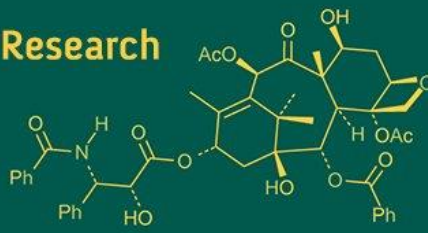


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Size Characteristics and Length-Weight Relationship of Cleftbelly Trevally (*Atropus atropos*) from the Veraval Coast, Gujarat, India

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Abstract

This study investigates the size characteristics and length-weight relationship of the cleftbelly trevally *Atropus atropos* along the Veraval coast of Gujarat, India. A total of 300 specimens (186 males and 114 females) were collected between August 2024 and May 2025. Total length ranged from 12 to 25 cm and weight from 33.75 to 260.1 g. The highest mean length and weight were recorded in September, while the lowest were observed in March and December, respectively. The dominant length group was 16.5-18.0 cm and the most frequent weight group was 59-85 g. The length-weight relationship exhibited negative allometric growth for males ($W = 0.0355 \times L^{2.7338}$, $R^2 = 0.9291$), females ($W = 0.0307 \times L^{2.7841}$, $R^2 = 0.9567$), and pooled data ($W = 0.0336 \times L^{2.7531}$, $R^2 = 0.9396$), indicating that weight increased at a slower rate than length.

Keywords: *Atropus atropos*, cleftbelly trevally, length-weight relationship, negative allometric growth, size distribution, morphometric analysis, population structure, coastal fisheries, Veraval coast, Gujarat, Arabian Sea, fish biology

Introduction

Gujarat, located on the western coast of India, possesses extensive marine and inland water resources, including a 2,340.62 km coastline, a continental shelf of about 164,000 km², and an Exclusive Economic Zone (EEZ) of 214,000 km². The state contributes nearly 32% of India's continental shelf and 10% of its EEZ. Over the past four decades, advancements in fishing technologies and allied activities have led to substantial growth in Gujarat's fisheries sector, significantly improving economic returns, employment, and nutritional security (SoI, 2024). At the national level, India's fisheries sector has expanded rapidly, with total fish production increasing from 24.42 lakh tonnes in 1980-81 to 175.45 lakh tonnes in 2022-23, reflecting an average annual growth rate of 7.98%. During 2022-23, fish exports reached 17.35 lakh tonnes valued at ₹63,969.14 crore (DoF, 2023) [5]. Marine fish production alone accounted for 3.53 million tonnes in 2023, positioning India as the world's third-largest fish producer and contributing about 8% to global production.

The family Carangidae represents one of the most commercially important groups of marine fishes, comprising jacks, trevallies, scads, pompanos, queenfishes, runners, and amberjacks. Globally, the family includes four subfamilies, 32 genera, and about 140 species, distributed across tropical and subtropical waters of the Atlantic, Pacific, and Indian Oceans. In India, approximately 62 carangid species belonging to 20 genera have been recorded, commonly inhabiting shallow coastal waters up to 60 m depth along both the east and west coasts (Nair, 2000; Joshi *et al.*, 2011) [8]. Carangids form an important component of marine fish landings, particularly during the monsoon season, and are harvested using trawls, purse seines, gillnets, boat seines, and hooks and lines. The total carangid production in India is estimated at about 1.8 lakh tonnes, contributing nearly 4.83% of total marine fish landings (Anon, 2001) [2].

The cleftbelly trevally *Atropus atropos* (Carangidae) is a commercially important marine fish widely distributed along the Indian coast. It is locally known as "Naryala" along the Veraval coast, "Khadwo Bangada" in Gujarati, "Kat-bangada" or "Zhat Bangada" in Marathi, and "Kunni-parah" in Tamil. Morphologically, *A. atropos* exhibits a strongly compressed,

ovate body resembling larger jacks, with a steep dorsal head profile and no adipose eyelid. The jaws bear small teeth arranged in narrow bands, while the ventral profile is concave with a characteristic deep abdominal groove accommodating the large pelvic fins. The chest region between the pectoral and pelvic fins is scaleless (Carpenter and Niem, 2001^[4]; Lin and Shao, 1999)^[13]. The species possesses two dorsal fins, the first with eight spines and the second with one spine and 19-22 soft rays, while the anal fin has two detached spines followed by one spine and 17-18 soft rays. The lateral line is moderately arched anteriorly with 31-37 scutes on the straight portion. *A. atropos* attains a maximum length of about 26.5 cm, though individuals are commonly observed below 20 cm. Body coloration is bluish-green dorsally and silvery ventrally, with black pelvic fin membranes and a distinct black spot in adults. Sexual dimorphism is evident, as mature males develop elongated dorsal and anal fin rays, which are absent in females (Randall, 1995^[22]; Shameem and Dutt, 1984)^[24].

Ecologically, *A. atropos* is a carnivorous predator feeding mainly on small crustaceans and fishes, thereby playing a key role in coastal food webs (Masuda *et al.*, 1984)^[14]. The species is distributed throughout tropical and subtropical Indo-Pacific waters and occurs along the entire Indian coastline, with higher abundance reported from Gujarat, Maharashtra, Karnataka, Kerala, and Tamil Nadu. In addition to its fisheries importance, the species is nutritionally valuable due to its high omega-3 fatty acid content, enhancing its significance as a healthy food fish (Hicks *et al.*, 2019)^[6].

The length-weight relationship (LWR) is a fundamental tool in fisheries biology for understanding growth patterns, life-history traits, and population dynamics of fish species. It provides critical information on fish condition, habitat suitability, and morphological variation under different environmental conditions. LWR is widely used to estimate average body weight from length data, assess stock structure, and evaluate the productivity and resilience of exploited fish populations, thereby supporting effective fisheries management and conservation (Bradford *et al.*, 2014)^[3]. Fish size is often considered more biologically meaningful than age, as it directly reflects ecological and physiological influences such as food availability, habitat quality, and environmental stressors (Kalayci *et al.*, 2007)^[9].

Materials and method

Location for the research work

The study was carried out at the Veraval fish landing centre (20°54'912" N; 70°21'355" E) located in the Gir-Somnath district of Gujarat, India. Veraval is the largest and most active fish landing centre along the Gujarat coast, characterized by a well-developed harbour, a large fleet dominated by trawlers, and numerous fish processing and export units, making it a major hub of fisheries activities in the region. Sampling was conducted over a ten-month period from August 2024 to May 2025 at the Veraval fishing harbour. Fish specimens were collected using a random sampling approach from commercial landings to ensure representative coverage of the catch composition.

Test organisms

The taxonomic position of *Atropus atropos* is given below.
Kingdom: Animalia

Phylum: Chordata

Class: Actinopterygii

Order: Carangiformes

Family: Carangidae

Genus: *Atropus*

Species: *A. atropos* (Bloch & Schneider, 1801)



Specimen for study *A. atropos*

Methodology

Specimens of *Atropus atropos* were collected from multi-day trawlers operating along the Saurashtra coast and landing their catch at the Veraval fish landing centre. Sampling was carried out monthly, and specimens of varying sizes and weights were randomly selected from different trawlers to ensure representative coverage. Collected specimens were transported to the Fisheries Resource Management (FRM) Laboratory, College of Fisheries Science, Kamdhenu University, Veraval, for detailed analysis of Size Characteristics, length-weight relationships and associated parameters. For each specimen, total length and standard length were measured, and fresh body weight was recorded using an electronic balance with an accuracy of 0.01 g.

Size characteristics

The total length (cm) of each fish was measured using a measuring board, and body weight (g) was recorded using a digital weighing balance. The collected data were grouped into different length and weight intervals to determine frequency distribution. Monthly mean, minimum, and maximum values of length and weight were calculated to analyze variations.

Length-weight relationship (LWR)

The length-weight relationship (LWR) was examined to understand growth patterns and condition of *Atropus atropos*. This relationship is particularly useful when either length or weight data are unavailable and provides insights into the health status, feeding intensity, gonadal development, and overall well-being of fish (Le Cren, 1951). The LWR was estimated separately for males and females using the allometric equation proposed by Le Cren (1951)^[12]:

$$W = a L^b \text{ or } \log(W) = \log(a) + b \log(L)$$

Where, W = Total body weight (g),

L = Total Length (cm),

a and b are the coefficients of the functional regression between W and L.

Results

Size characteristics

During this study period, a total of 300 specimens of *Atropus atropus* were collected, 186 males and 114 females. Their total lengths ranged from 12 cm to 25 cm, and their weights ranged from 33.75 g to 259.8 g. The average length was highest in September 21.68 cm, and lowest in March,

12 cm. The smallest specimen (12 cm) was found in March, and the largest (25 mm) in September. The average weight was highest in September (155.91 g) and lowest in December (84.23 g). The lightest specimen, weighing 33.75 g, was recorded in March, while the heaviest (260.1 g) was found in September.

Table 1: Monthly range and mean of total length and total weight of *A. atropus*

Month	No. of fish observed	Body Length (cm)		Body Weight (g)	
		Range (cm)	Mean (cm)	Range (gm)	Mean (gm)
Aug	30	16.5-24	20.50	72.73-210.22	143.93
Sep	30	18.5-25	21.68	88.1-260.1	155.91
Oct	30	18-24.5	21.62	103.16-220.6	148.27
Nov	30	14.5-23.5	17.07	50.14-180	86.90
Dec	30	13.5-20	16.98	41.66-147.3	84.23
Jan	30	14.5-19	16.80	53.14-156.4	86.10
Feb	30	16-20	17.58	59.53-132.54	91.87
Mar	30	12-21	17.15	33.75-159.6	85.79
Apr	30	16.5-23.5	18.03	68.94-187.5	104.75
May	30	16.5-23	19.98	72-195.3	133.94
Total	300	12-25	18.74	33.75-260.1	112.17

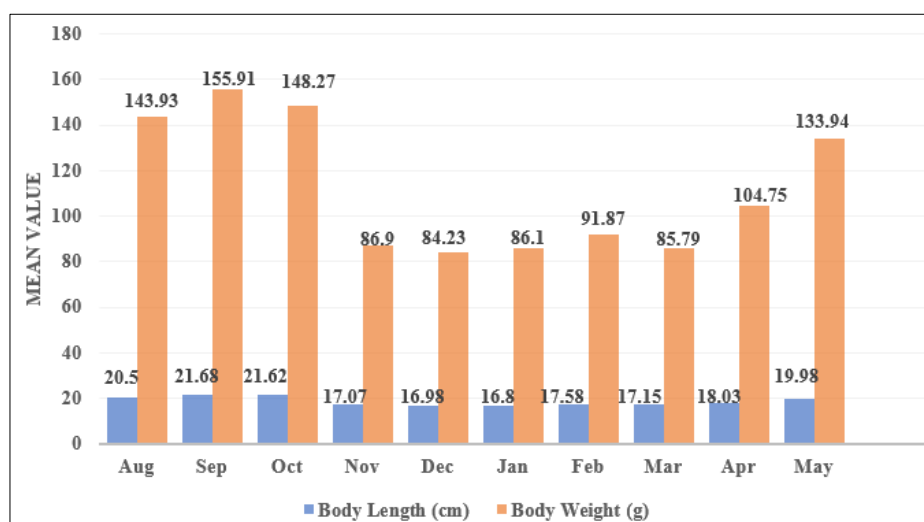


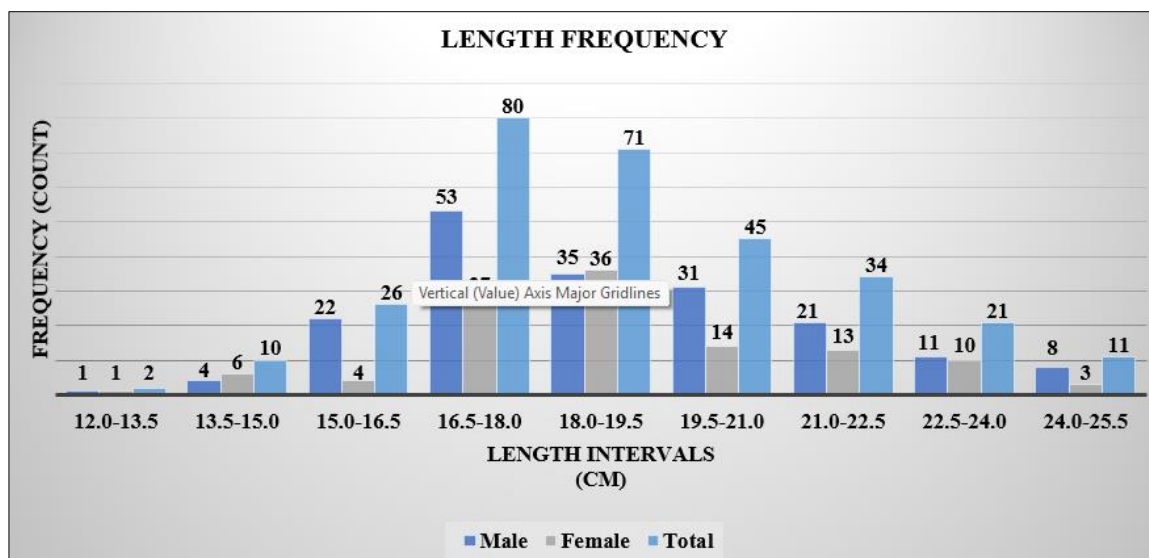
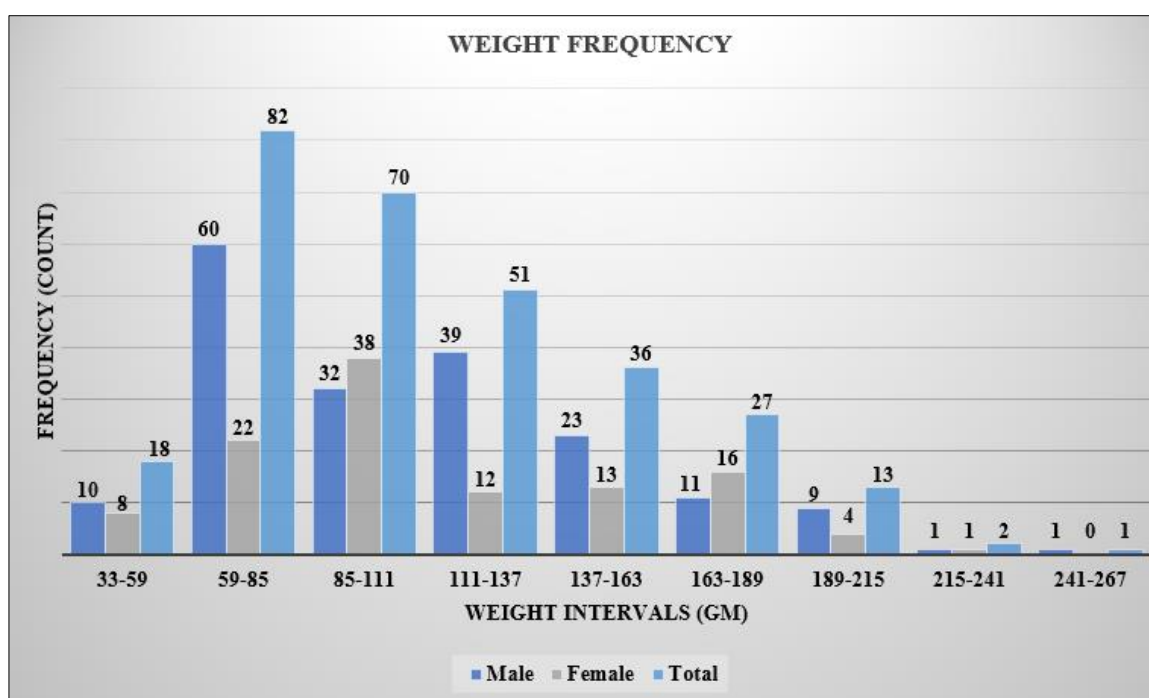
Fig 1: Monthly mean value of total length and total weight of *A. atropus*

The most common length range was 16.5-18.0 cm, while the least common was 12.0-13.5 cm. Among males, the highest number (53 individuals) was observed in the 16.5-18.0 cm group, and the lowest (1 individual) in the 12.0-13.5 cm group. For females, the highest number (36 individuals) was found in the 18.0-19.5 cm range, while the lowest (1 individual) was also in the 12.0-13.5 cm range. When looking at weight, the highest frequency was in the 59-85 g

range, while the lowest was in the 241-267 g range. Most of the males (60 individuals) were found in the 59-85 g weight group, and the minimum number (1 individual) was observed in the 215-241 g and 241-267 g ranges. Among females, the highest number (38 individuals) was observed in the 85-111 g group, while the lowest (1 individual) was observed in the 215-241 g group.

Table 2: Length-weight frequency distribution in *A. atropus*

Length Intervals (cm)	Frequency (Count)			Weight Intervals (g)	Frequency (Count)		
	Male	Female	Total		Male	Female	Total
12.0-13.5	1	1	2	3359	10	8	18
13.5-15.0	4	6	10	59-85	60	22	82
15.0-16.5	22	4	26	85-111	32	38	70
16.5-18.0	53	27	80	111-137	39	12	51
18.0-19.5	35	36	71	137-163	23	13	36
19.5-21.0	31	14	45	163-189	11	16	27
21.0-22.5	21	13	34	189-215	9	4	13
22.5-24.0	11	10	21	215-241	1	1	2
24.0-25.5	8	3	11	241-267	1	0	1

Fig 2: Length frequency distribution in *A. atropos*Fig 3: Weight frequency distribution in *A. atropos*

Length-Weight Relationship

In this study, 300 specimens were analyzed, including 186 males and 114 females, with total lengths ranging from 24.0 to 25.5 cm and weights ranging from 33.75 to 260.1 g. The length-weight relationship was examined separately for males, females, and all specimens combined.

For males, the relationship was:

Parabolic equation: $W = 0.0355 \times L^{2.7338}$ ($R^2 = 0.9291$)

Logarithmic equation: $\log W = -1.44977 + 2.7338 \log L$

For females, the relationship was:

Parabolic equation: $W = 0.0307 \times L^{2.7841}$ ($R^2 = 0.9567$)

Logarithmic equation: $\log W = -1.51286 + 2.7841 \log L$

Since there was no significant difference between the male and female relationships, the data were combined (pooled), resulting in:

Pooled data (both sexes):

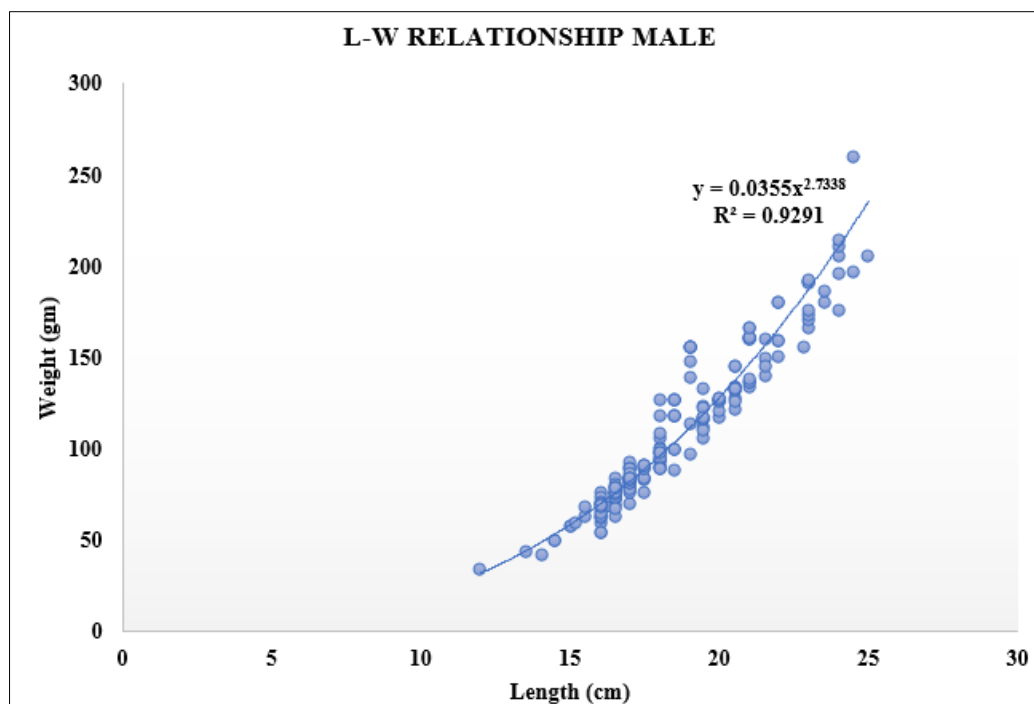
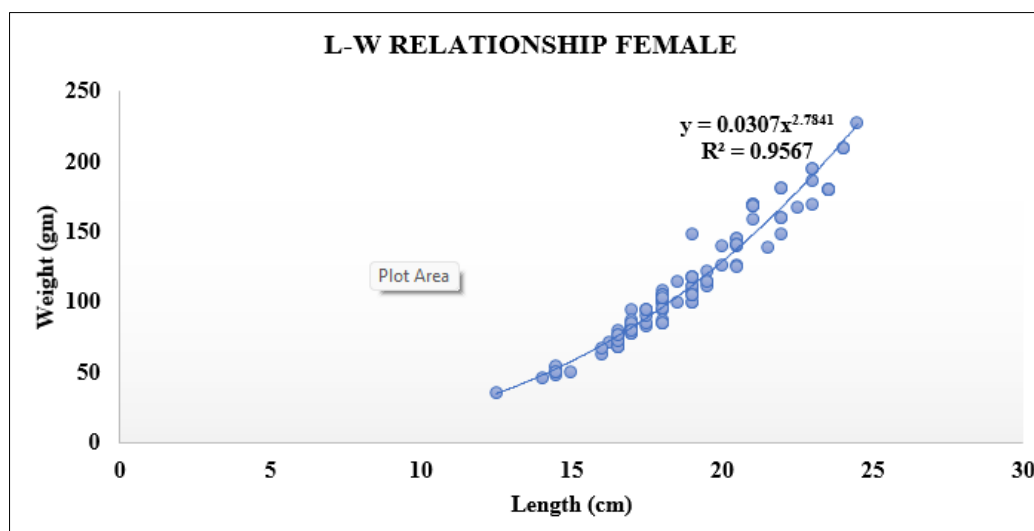
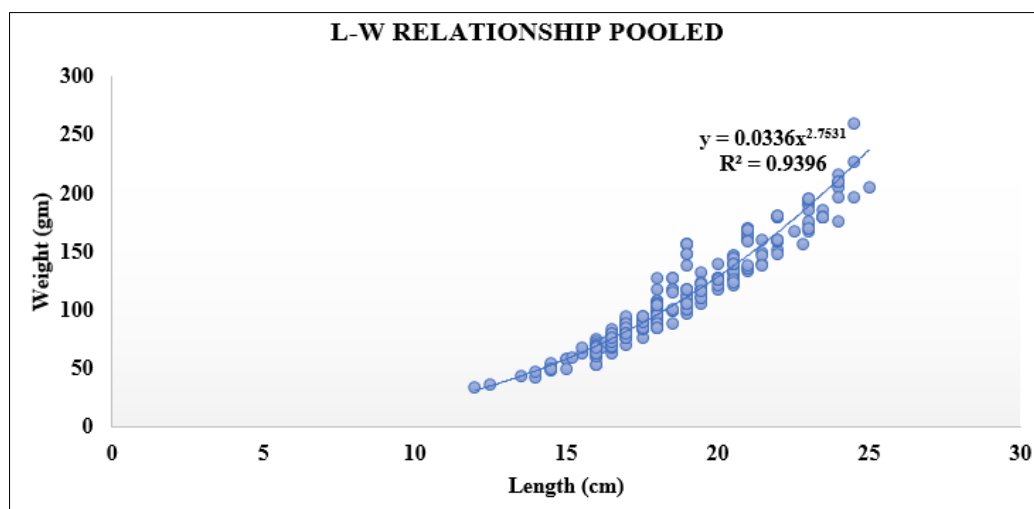
Parabolic equation: $W = 0.0336 \times L^{2.7531}$ ($R^2 = 0.9396$)

Logarithmic equation: $\log W = -1.47366 + 2.7531 \log L$

Table 3: Length-Weight Relationship parameters for *Atropus atropos* from Veraval coast, Gujarat

Group	a	b	R ²	Log W = log a + b log L
Male	0.0355	2.7338	0.9291	Log W = -1.44 + 2.73 Log L
Female	0.0307	2.7841	0.9567	Log W = -1.51 + 2.78 Log L
Pooled	0.0336	2.7531	0.9396	Log W = -1.47 + 2.75 Log L

Note: W = total body weight (g); L = total length (cm); a = intercept; b = allometric coefficient

Fig 4: Length-weight relationship of male *A. atropos*Fig 5: Length-weight relationship of female *A. atropos*Fig 6: Length-weight relationship of pooled, *A. atropos*

Discussion

Size Characteristics

In the present study, the highest mean total length (21.68 cm) and mean weight (155.91 g) were recorded in September, while the lowest mean length (16.80 cm) was observed in January and the lowest mean weight (84.23 g) in December. The smallest specimen (12 cm; 33.75 g) was recorded in March, whereas the largest specimen (25 cm; 260.1 g) was observed in September.

Several studies have examined *A. atropos* across different regions. Raje (1994) [18] reported on 216 specimens from the Veraval coast of India, including 116 males with lengths of 116-264 mm and weights of 28.5-230.0 g, and 100 females with lengths of 129-283 mm and weights of 30.0-292.0 g.

Lanjewar *et al.* (2024) [11] reported on 90 specimens from the Ratnagiri coast with total lengths ranging from 15.5 to 21.9 cm. Rakhunde *et al.* (2023) [21] collected 589 specimens from the same region, including 300 males ranging from 11.2 to 25.4 cm in length and 23.9 to 222.5 g in weight, 247 females ranging from 11.4 to 25 cm in length and 26.1 to 221.6 g in weight, and 42 indeterminate individuals ranging from 10 to 12.1 cm in length and 20.9 to 35.2 g in weight.

Ilah *et al.* (2023) [7] analyzed 100 fish from the Bay of Bengal with lengths from 15 to 21 cm and weights from 46 to 136 g, while Rahman *et al.* (2021) [17] studied 109 specimens from the same region with lengths ranging from 15.0 to 21.7 cm and weights from 49.39 to 161.40 g.

Rajesh *et al.* (2020) [20] further examined 1,601 specimens from the Mangalore coast in Karnataka between August 2015 and May 2017, with sizes ranging from 100 to 260 mm and comprising 704 males and 897 females. Rajesh *et al.* (2018) [19] analyzed samples from the same region during two periods. In 2015-2016, among 704 fish, males dominated the 18-20 cm group with 71 percent comprising 105 males and 43 females, while females dominated the 16-18 cm group with 73 percent comprising 87 females and 33 males. In 2016-2017, 897 specimens were recorded, with males comprising 62 percent in the 16-18 cm group including 110 males and 67 females, and females comprising 70 percent in the 20-22 cm group including 120 females and 51 males, total 405 males or 45 percent and 492 females or 55 percent.

Kochar (1988) [10] studied 360 specimens from the Mumbai coast, comprising 192 males ranging from 150-244 mm in length and 45-196 g in weight, and 168 females ranging from 137-254 mm in length and 47-212 g in weight.

Qamar and Panhwar (2018) [16] recorded 25 specimens from the northern Arabian Sea coast of Pakistan, with lengths ranging from 12 to 31.6 cm and weights between 24 and 351 g.

Length-weight relationship analysis

In the present study, the length-weight relationship (LWR) of *Atropus atropos* exhibited negative allometric growth, as indicated by regression coefficients (*b*) less than 3. For males, *b* = 2.7338 with a coefficient of determination $R^2 = 0.9124$; for females, *b* = 2.7841 and $R^2 = 0.9567$; and for the pooled data, *b* = 2.7531 and $R^2 = 0.9396$. All regressions were statistically significant ($p < 0.05$). The high R^2 values indicate a strong positive correlation between length and weight for both sexes and the combined dataset.

These findings are consistent with previous studies on *A. atropos*. Rakhunde *et al.* (2023) [21] reported negative allometric growth for specimens from the Ratnagiri coast,

with equations: males $W = 0.0361 \times L^{2.7186}$ ($R^2 = 0.9816$), females $W = 0.0309 \times L^{2.7770}$ ($R^2 = 0.9862$), and pooled $W = 0.0358 \times L^{2.7234}$ ($R^2 = 0.9848$).

Kochar (1988) [10] found strong correlations along the Mumbai coast: males $W = 0.02355 \times L^{2.8413}$ ($R^2 = 0.9774$), females $W = 0.0503 \times L^{2.5881}$ ($R^2 = 0.8933$), and pooled $W = 0.034369 \times L^{2.7207}$ ($R^2 = 0.9705$).

Raje (1994) [18] reported logarithmic relationships for Veraval coast samples: males $\log W = -4.08479 + 2.6699 \log L$, females $\log W = -3.8017 + 2.5471 \log L$, and pooled $\log W = -3.9535 + 2.6133 \log L$.

Reuben *et al.* (1992) [23] provided a pooled equation for Indian seas: $W = 0.00003165 \times L^{2.85703}$, illustrating general growth trends.

In contrast, some populations of *A. atropos* exhibit positive allometric growth. Rahman *et al.* (2021) [17] observed pooled growth in the Bay of Bengal as $W = 0.0116 \times L^{3.098}$ ($R^2 = 0.957$), and Qamar and Panhwar (2018) [16] reported $W = 0.024 \times L^{2.869}$ ($R^2 = 0.980$) in the northern Arabian Sea, reflecting regional variation in growth patterns. These comparisons indicate that while *A. atropos* generally exhibits negative allometry along the Gujarat coast, growth patterns may vary across different geographic populations.

Conclusion

The study on *Atropus atropos* from the Veraval coast indicates that the species exhibits negative allometric growth, showing a greater increase in length compared to weight. The population was dominated by males, with noticeable variation in size distribution across months. Larger individuals were mainly observed in September, while smaller ones were more common during March and December. The majority of specimens belonged to the medium size group (16.5-18.0 cm; 59-85 g), indicating their dominance in the population structure. Overall, the growth pattern and size distribution of *A. atropos* appear to be influenced by seasonal variations in the environment.

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