

## Research Article

# Biometric analysis of rainbow sardine, *Dussumieria acuta* Valenciennes, 1847 from Andaman Waters

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The present study aimed to generate baseline biometric data of rainbow sardine *Dussumieria acuta* from the Andaman Islands. A total of 127 specimens were analysed to examine meristic and morphometric characters, while 939 specimens were used to assess sex ratio, length-weight relationship, and relative condition factor. Eight meristic and twenty-eight morphometric characters were recorded for the current study. Based on the current study of meristic characters, the fin formula for *D. acuta* can be represented as follows:  $B_{14-15}D_{18-19}P_{14}V_8A_{14-15}C_{19}G_{(10-11)+(21-22)}$ . The coefficient of correlation ( $r$ ) ranged from 0.536 to 0.983 for total length against different morphometric characters and from 0.724 to 0.785 for head length against different morphometric characters. After applying a log transformation, the pairwise linear regression between total length and various morphometric variables indicated that most characters' 'b' value was close to unity. The male-to-female ratio in the above species showed no significance difference from the theoretical 1:1 ratio. The length-weight relationship for *D. acuta* was expressed as  $W = 0.0053L^{3.1822}$  for pooled samples,  $W = 0.0049L^{3.2109}$  for males, and  $W = 0.0063L^{3.116}$  for females. The relative condition factor ( $K_r$ ) was close to an ideal threshold value in both males and females and across all seasons.

**[Keywords:** Andaman, Condition factor, *Dussumieria acuta*, Length-weight relationship, Morphometry, Meristics]

## Introduction

Clupeoid consist of an economically significant group of fishes such as sardines, herrings, shads, anchovies, and others<sup>1</sup>. Notably, Clupeiformes alone represent 10 % of the aquatic animals harvested from aquaculture and capture fisheries<sup>2</sup>. In 2022, landings of clupeoid fishes from the mainland coast of India were estimated at 0.69 million tonnes, accounting for 19.81 % of the total marine fish catch<sup>3</sup>.

*Dussumieria acuta* Valenciennes, 1847, is also known as the rainbow sardine due to the presence of an iridescent blue colour on its back with a shiny golden line below it. The species belongs to the family Dussumieriidae (Sub-family: Dussumierinae). The body is more or less compressed and elongated with a smooth belly due to the absence of scutes except for the W-shaped pelvic scute<sup>4</sup>. They are found in the Indo-Pacific region from the Persian Gulf to the South China Sea<sup>5</sup>.

Fish morphometric analysis is critical in systematic classification, growth variation, population parameter determination, and environmental relationship assessment. This analysis is instrumental in

ecomorphology, aiding in evaluating environmental influences on species' diets, feeding behaviour, ecological strategies, niche partitioning, habitat utilisation, and trophic structures. Furthermore, it contributes significantly to population ecology and metapopulation studies by examining variations in body shape among geographically separated populations<sup>6</sup>. Examining variations in morphometric and meristic characteristics among fish populations is significant in phylogenetics, as it furnishes data for future studies to enhance these populations' genetic makeup<sup>7</sup>. Similarly, the Length-Weight Relationship (LWR) is pivotal in fishery assessment, stock management, and ecological population dynamics<sup>8,9</sup>. In LWR, a fish is said to have isometric growth if its length increases with weight in equal proportion. Regression coefficient equal to 3 shows isometric growth; otherwise, allometric growth<sup>10</sup>. The Condition Factor (CF) helps to assess the fish's relative well-being<sup>11</sup>. It also indicates the interaction between abiotic and biotic factors in the fish's physiological condition, which varies with location<sup>12</sup>. Variations in the LWR and CF of fishes can be affected

by factors such as water conditions, spawning seasons, gender, maturity, and food availability<sup>13</sup>.

The Andaman and Nicobar Islands fisheries sector relies on traditional and moderately sized motorised vessels<sup>14</sup>, with fishing limited primarily to coastal waters due to rough seas for most of the year. Clupeoid species, which school in shallow areas<sup>15</sup>, offer a consistent year-round catch despite these constraints<sup>16</sup>. Studies on length-weight relationship and relative condition factor of *D. acuta* in Indian waters were previously carried out by Nair<sup>17</sup>, Abdurahiman *et al.*<sup>18</sup> and Kalita *et al.*<sup>16</sup>. However, data on biometric analysis from the Andaman Islands remains limited. Hence, this study was designed to gather data on the biometric analysis of *D. acuta* from the waters of Andaman.

## Materials and Methods

### Study area and sample collection

The study was carried out in the tropical island ecosystem of the Andaman and Nicobar archipelago (6°45'12" – 13°45'12" N and 92°10'12" – 94°15'12" E). The Exclusive Economic Zone of Andaman and Nicobar Islands spans about 0.6 million square kilometres, 30 % of India's total EEZ<sup>19,20</sup>. Based on the pattern of annual precipitation, the study period was divided into three seasons: the South-West Monsoon (SWM; wet summer characterized by heavy rainfall and strong winds from May to October), the North-East Monsoon (NEM; wet winter with occasional rainfall and moderate winds during November–December), and the Dry Season (DS; dry summer with minimal rainfall from January to April)<sup>19</sup>.

The *D. acuta* specimens were collected from the Junglighat fish landing centre (11°39'40.0" N; 92°43'45.0" E) of South Andaman, captured from the fishing grounds of Burmanallah (11°33'41.8" N; 92°44'52.3" E), Swaraj Dweep (11°57'04.5" N; 92°57'07.4" E), Mayabunder (12°54'34.4" N; 92°59'29.0" E) and Kalipur (13°13'10.3" N; 93°03'31.3" E) between November 2022 to October 2023 (Fig. 1).

Species identification was performed based on Whitehead *et al.*<sup>21</sup> and Fisher & Bianchi<sup>22</sup>. A total of 939 (TL: 7.9 – 17.09 cm; Weight: 2.86 – 40.6 g) specimens were collected and considered for assessing the sex ratio, LWR and CF. 127 (TL: 11.04 – 17.09 cm, Mean: 14.79 cm; Weight: 11.49 – 37.84 g, Mean: 25.36 g) specimens were analysed to examine

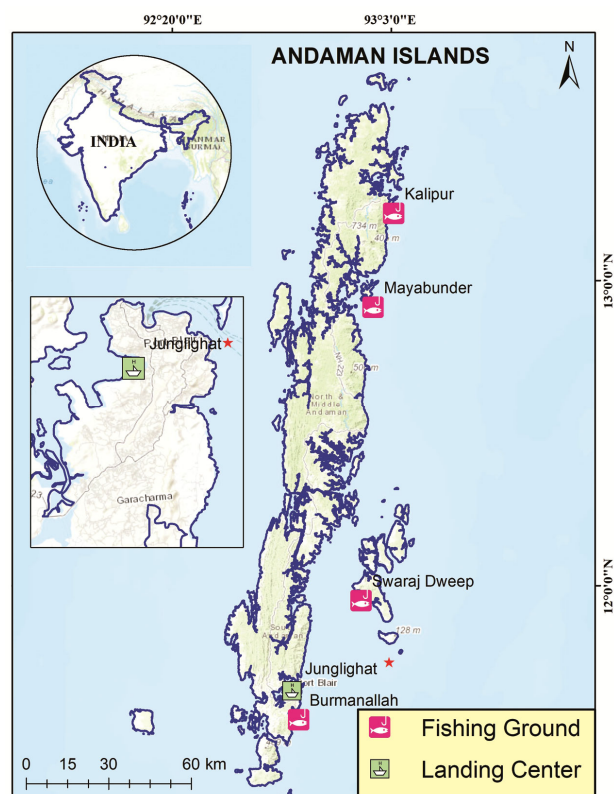


Fig. 1 — Map of the sampling sites and fishing grounds

the meristic and morphometric characters. Measurements were performed using a digital vernier calliper (Mitutoyo, Absolute AOS, Digimatic) with an accuracy of 0.01 cm and a digital weighing balance (Infra Digi IN2K) with an accuracy of 0.01 g in the laboratory.

### Data analysis

Eight meristic characters that were measured include the number of dorsal fin rays, pectoral fin rays, ventral fin rays, anal fin rays, caudal fin rays, branchiostegal rays, and upper and lower gill rakers. Twenty-eight morphometric characters that were measured include the Total Length (TL), Standard Length (SL), Pre-Dorsal Length (PDL), Pre-Pectoral Length (PPL), Pre-Ventral Length (PVL), Pre-Anal Length (PAL), Fork Length (FL), Head Length (HL), Snout Length (SnL), Eye Diameter (ED), Postorbital Length (POL), Pectoral Fin Length (PFL), Ventral Fin Length (VFL), Anal Fin Length (AFL), Caudal Fin Length (CFL), Dorsal Fin Length (DFL), Pectoral Base Length (PBL), Ventral Base Length (VBL), Anal Base Length (ABL), Dorsal Base Length (DBL), Caudal Peduncle Length (CPL), Caudal Peduncle Depth (CPD), Body Depth (BD), Inter-Orbital Length

(IOL), Head Depth (HD), Head Width (HW), Mouth Length (ML), Upper Jaw Length (UJL) and the Lower Jaw Length (LJL).

Twenty-seven morphometric measurements were expressed as percentages of the standard length, while nine were expressed as percentages of the head length. These measurements were tabulated for comparative analysis with previous literature.

Descriptive statistics for twenty morphometric characters and eight meristic characters were tabulated, including minimum, maximum, mean, median, standard deviation, and coefficient of variation (%). Spearman's rank correlation analysis was conducted using total length to assess the relationship between fish length and meristic counts.

Scattergrams of fourteen different morphometric variables with total length and five different morphometric variables with head length were plotted. Then, the linear regression equation was fitted using the least square method described by Laevastu<sup>23</sup> and Snedecor & Cochran<sup>24</sup>. The relationship was represented as  $Y = a + bx$ , where 'y' is a dependent variable, 'a' is a constant, *i.e.*, the intercept, 'b' is the coefficient of regression, *i.e.*, the slope, and 'x' is an independent variable. The correlation coefficient (*r*) is calculated to find the degree of relationship between the two variables. Pairwise linear regression of log-transformed morphometric variables with log-(total length) was conducted, and regression coefficients were evaluated to assess the allometric growth of each variable relative to the total length<sup>25-27</sup>.

The length-weight equation was established by the formula given by Le Cren<sup>28</sup> ( $W = a L^b$ ). Where 'W' is the total weight of the fish in grams, 'a' is the intercept, 'b' is the coefficient of regression, and 'L' is the total length of the fish in cm. The slope parameter (*b*) and coefficient of determination ( $r^2$ ) were estimated with 95 % confidence limit<sup>29</sup>. To test any significant deviation in the 'b' value against the value of '3', a student's *t*-test ( $t = |b-3| / S_b$ ) was conducted.  $S_b$  is the standard error of *b*, and 't' has (n-2) degrees of freedom<sup>30</sup>. The relative condition factor of the individuals was found using the equation  $K_n = W / (a \times L^b)$ , Where 'W' is the body weight, 'a' and 'b' are the length-weight relationship parameters, and 'L' is the total length<sup>28,31</sup>. Differences in  $K_n$  values among fish groups were evaluated using Welch's *t*-test or one-way ANOVA, depending on data variance and the uniformity of sample sizes among groups.

The sex ratio was evaluated using the chi-square test to check the homogeneity of male and female distribution in the population.

All statistical tests were conducted with a significance level of  $p < 0.05$ . Statistical analyses were carried out using Microsoft Excel software.

## Results

### Morphometric characters

Morphometric measurements of *D. acuta* are expressed as a percentage of standard length and head length in Table 1. The analysis of the coefficient of variation is presented in Table 2, which shows that the dorsal fin length exhibited the highest coefficient of variation, followed by body depth and dorsal base length. It was found to be the lowest for eye diameter.

Table 3 shows the coefficient of correlation (*r*) of SL, PDL, PPL, PVL, PAL, FL, HL, PFL, CFL, DFL, DBL, CPL, CPD and BD against TL and that of SnL, ED, POL, IOL and ML against the HL. Total length has a maximum degree of correlation coefficient with fork length (0.983), while a minimum with dorsal fin length (0.536). Similarly, head length has a maximum correlation coefficient with mouth length (0.785), while a minimum with snout length (0.724).

Linear regression analysis between TL and fourteen morphometric variables showed a near linear fit with the highest  $r^2$  value recorded for FL (0.967) and the lowest  $r^2$  value for DFL (0.287) (Fig. 2a). Similarly, linear regression between HL and five morphometric variables shows a near linear fit with the highest  $r^2$  value recorded for SnL (0.616) and a lowest  $r^2$  value for ML (0.524) (Fig. 2b).

After log transformation, a pairwise linear regression between TL and other morphometric variables showed a 'b' value of near unity for most characters (Fig. 3a). Regression coefficient (*b*) values close to unity indicate isometric growth of the variable for total length. A considerably lower value of *b* was observed in the case of PPL (0.715), CPL (0.732), CPD (0.770) and HL (0.823), indicating negative allometric growth. In contrast, DBL and BD exhibited positive allometric growth for total length with a regression coefficient of 1.337 (Fig. 3a). In the case of the regression coefficient (*b*), values for HL following log transformation showed a 'b' value close to unity for POL and IOL. Negative allometric growth was recorded for SnL (0.827), ED (0.740) and ML (0.738) (Fig. 3b).

Table 1 — Comparison of morphological traits of *Dussumieria acuta*

<b>Morphometrics</b>	<b>Present study (n = 127)</b>	<b>Hata <i>et al.</i><sup>32</sup> (n = 39)</b>	<b>Nair<sup>17</sup> (n = 25)</b>	<b>Whitehead<sup>4</sup> (n = 16)</b>
<b>% of Standard Length (SL)</b>				
Pre-dorsal length	51.13–59.78	53.3–57.5	51.06–55.93	53.0–59.0
Pre-pectoral length	18.97–29.23	27.5–32.8	26.09–28.32	-
Pre-ventral length	58.14–62.78	40.2–66.8	56.70–62.61	60.0–65.5
Pre-anal length	78.12–83.71	78.4–84.8	75.53–81.31	79.0–81.5
Fork length	100.79–110.23	-	-	-
Head length	23.61–27.30	25.0–29.6	23.71–26.67	25.7–29.4
Snout length	7.46–9.87	7.0–9.0	7.56–8.85	7.4–10.6
Eye diameter	5.93–7.14	7.0–9.2	6.96–8.16	5.3–6.3
Post orbital length	8.33–11.95	9.4–13.1	-	9.2–10.1
Pectoral fin length	11.62–15.50	16.3–18.2	-	15.8–16.2
Ventral fin length	8.34–9.86	9.2–11.2	-	8.6–8.9
Anal fin length	3.60–6.60	4.5–6.2	-	-
Caudal fin length	21.44–27.38	-	23.53–28.26	-
Dorsal fin length	8.92–13.32	12.7–14.5	-	-
Pectoral base length	3.64–4.37	-	-	-
Ventral base length	1.81–2.75	-	-	-
Anal base length	7.81–10.32	8.8–11.1	-	-
Dorsal base length	11.65–16.81	12.7–16.7	-	-
Caudal peduncle length	8.28–11.61	8.6–11.6	-	-
Caudal peduncle depth	7.39–10.26	9.0–10.7	9.73–11.54	-
Body depth	20.66–25.99	19.2–28.2	23.71–30.33	18.2–29.6
Inter orbital length	5.81–8.31	3.4–4.8	-	5.6–5.8
Head depth	15.86–16.65	-	16.36–18.27	-
Head width	10.15–11.33	-	-	-
Mouth length	6.87–8.81	-	-	-
Upper jaw length	11.92–13.43	11.8–14.7	-	12.3–12.4
Lower jaw length	11.36–12.50	8.4–10.1	8.18–9.80	8.4–9.3
<b>% of Head Length (HL)</b>				
Snout length	30.28–37.50	-	29.17–35.71	-
Eye diameter	22.28–29.58	-	27.59–32.00	-
Post orbital length	31.91–44.67	-	-	-
Inter orbital length	21.82–32.50	-	-	-
Head depth	61.00–69.35	-	62.50–73.91	-
Head width	40.48–44.51	-	-	-
Mouth length	26.01–34.54	-	-	-
Upper jaw length	47.67–53.99	-	-	-
Lower jaw length	44.73–49.88	-	32.14–39.13	-

**Meristic characters**

The estimated coefficient of variation for eight meristic traits is depicted in Table 4. It was found to be maximum for upper gill rakers, followed by branchiostegal rays and anal fin rays. Based on the data analysis, the fin formula for *D. acuta* could be written as  $B_{14-15}D_{18-19}P_{14}V_8A_{14-15}C_{19}G_{(10-11)+(21-22)}$ .

Spearman's rank correlation coefficient ( $\rho$ ) between meristic variables and total length (size variable) was

insignificant at the 1 % and 5 % significance levels. None of the variables recorded a rank correlation coefficient of  $> 0.30$  (Table 5).

**Sex ratio, Length-Weight Relationship (LWR), and relative condition factor**

939 specimens were considered for sex ratio analysis, length-weight relationship and relative condition factor. 459 males and 468 females were

Table 2 — Descriptive statistic of different morphometric characters in *Dussumieria acuta*

Morphometric characters	Min	Max	Mean	Median	Standard deviation	Coefficient of variation (%)
Total length	110.46	170.94	147.98	151.12	10.37	7.01
Standard length	89.32	133.67	116.85	119.53	8.37	7.16
Pre-dorsal length	52.31	72.86	64.80	65.95	4.74	7.32
Pre-pectoral length	23.51	35.72	30.88	31.07	2.11	6.84
Pre-ventral length	56.01	83.1	70.66	72.03	5.04	7.14
Pre-anal length	72.77	111.06	95.45	97.57	7.39	7.75
Fork length	96.61	142.72	125.93	129.05	9.04	7.18
Head length	23.79	34.18	29.81	30.29	1.92	6.43
Snout length	8.13	12.19	10.28	10.27	0.70	6.84
Eye diameter	5.3	8.29	7.54	7.59	0.46	6.06
Post orbital length	8.66	13.71	11.62	11.75	0.92	7.89
Pectoral fin length	10.57	19.37	15.92	15.97	1.49	9.39
Caudal fin length	20.07	33.27	28.37	28.40	2.49	8.80
Dorsal fin length	7.97	16.43	12.77	12.67	1.39	10.91
Dorsal base length	10.52	20.52	17.24	17.61	1.82	10.54
Caudal peduncle length	8.98	14.49	11.13	10.98	1.04	9.30
Caudal peduncle depth	7.69	11.92	10.22	10.29	0.73	7.15
Body depth	19.42	32.17	26.72	27.14	2.84	10.62
Inter orbital length	5.19	9.96	8.56	8.72	0.74	8.62
Mouth length	7.14	10.47	9.05	9.12	0.60	6.65

Table 3 — Statistical estimates of various meristic characters in *Dussumieria acuta*

Morphometric character	Correlation coefficient
TL & SL	0.980
TL & PDL	0.933
TL & PPL	0.739
TL & PVL	0.954
TL & PAL	0.979
TL & FL	0.983
TL & HL	0.908
TL & PFL	0.728
TL & CFL	0.816
TL & DFL	0.536
TL & DBL	0.823
TL & CPL	0.575
TL & CPD	0.740
TL & BD	0.880
HL & SnL	0.785
HL & ED	0.744
HL & POL	0.763
HL & IOL	0.744
HL & ML	0.724

reported throughout the study period. The Chi-square test showed no significant difference ( $p > 0.05$ ) in the male-to-female ratio 1:1.02 ( $\chi^2 = 0.087379$ ,  $df = 1$ ,  $p = 0.7675$ ).

The  $r^2$  value was high ( $r^2 \geq 0.92$ ) in all cases analysed (Table 6), suggesting that fish weight can be reliably predicted from the length with a high level of accuracy. The slope ( $b$ ) values for the linear

regressions in the pooled data were found to be  $3.18 \pm 0.021$  ( $p < 0.05$ ), showing a positively allometric growth pattern. Similarly, both sexes exhibited a positive allometric growth pattern (male:  $3.21 \pm 0.021$ ,  $p < 0.05$ , female:  $3.11 \pm 0.328$ ,  $p < 0.05$ ). Whereas, females of *D. acuta* (male:  $3.105 \pm 0.076$ ,  $p > 0.05$ , female:  $3.180 \pm 0.063$ ,  $p < 0.05$ ) had a higher  $b$  value and positive allometric growth. During the SWM season ( $b = 3.32 \pm 0.026$ ,  $p < 0.05$ ), *D. acuta* displayed positive allometric growth. Whereas, in the NEM season ( $b = 3.08 \pm 0.052$ ,  $p > 0.05$ ) and DS season ( $b = 3.03 \pm 0.041$ ,  $p > 0.05$ ), it exhibited an isometric growth pattern (Table 6).

The  $K_n$  values obtained in the present study were close to unity, which is the optimal value indicating good health and well-being of the fish (Table 7). The average relative condition factors for pooled, male and female populations were  $1.0032 \pm 0.0026$ ,  $1.0034 \pm 0.0039$  and  $1.0029 \pm 0.0035$ , respectively. The season-wise average relative condition factor was  $1.0025 \pm 0.0049$  during the NEM,  $1.0035 \pm 0.0041$  during the DS and  $1.0023 \pm 0.0038$  during the SWM. The  $K_n$  did not differ significantly in all six cases (One-sample  $t$ -test,  $p > 0.05$ ) from the ideal threshold value 1. The  $K_n$  values did not differ significantly between males and females according to Welch's  $t$ -test ( $p > 0.05$ ). Similarly, seasonal variation had no

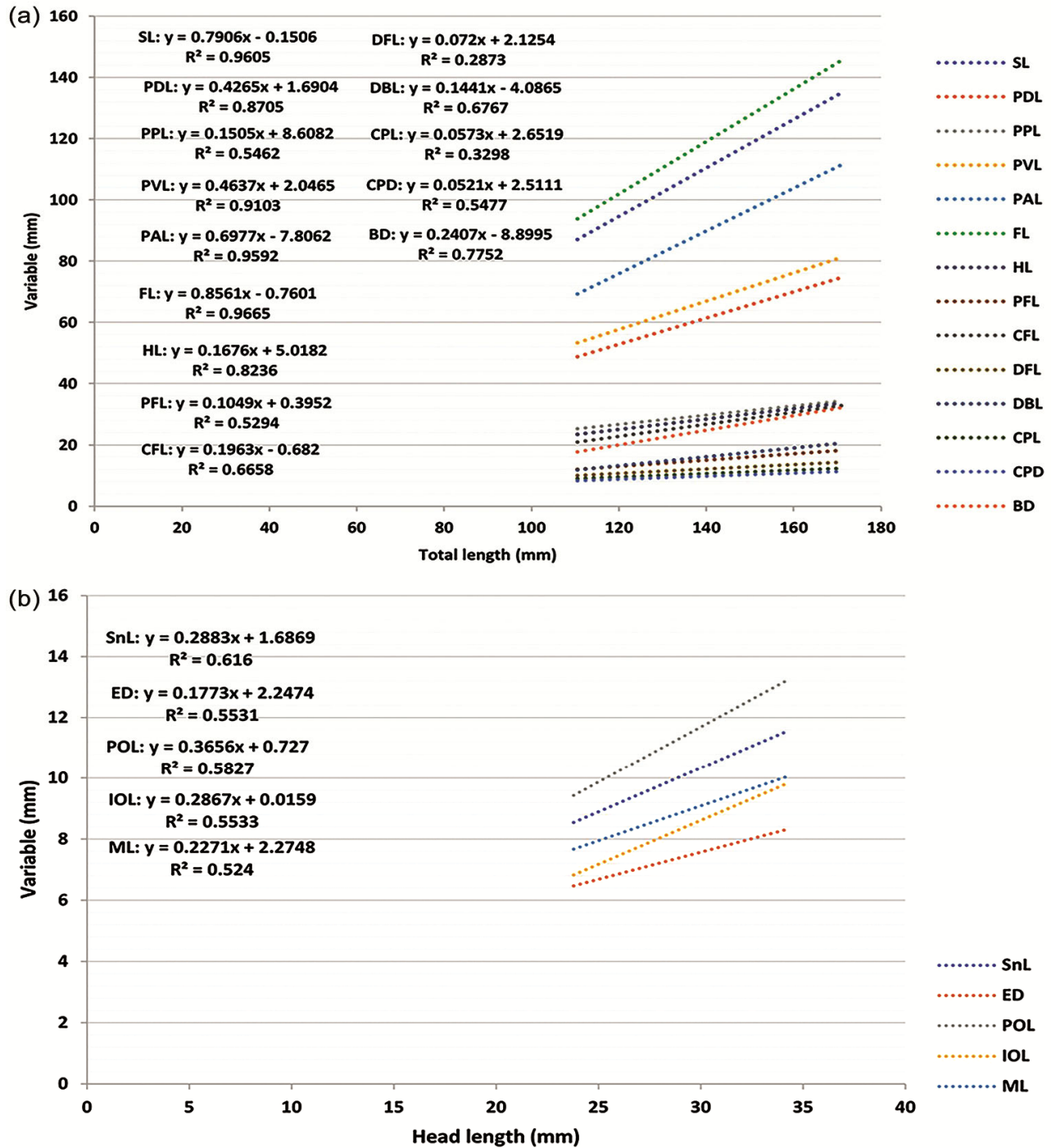


Fig. 2 — Relationship of various morphometric characters with (a) Total length, and (b) Head length, in *Dussumeria acuta*

significant effect on  $K_n$ , as indicated by the one-way ANOVA ( $p > 0.05$ ).

### Discussion

Table 8 represents a comparison of the meristic characters of *D. acuta* from the current study with findings from previous research. The mean values of

the morphometric characters, expressed as percentages of standard length and head length in the current study (Table 1), largely correlated with previous research findings. In comparison to the earlier studies, the minor variations observed in the morphometric and meristic characters in the present study may be attributed to genetic factors or

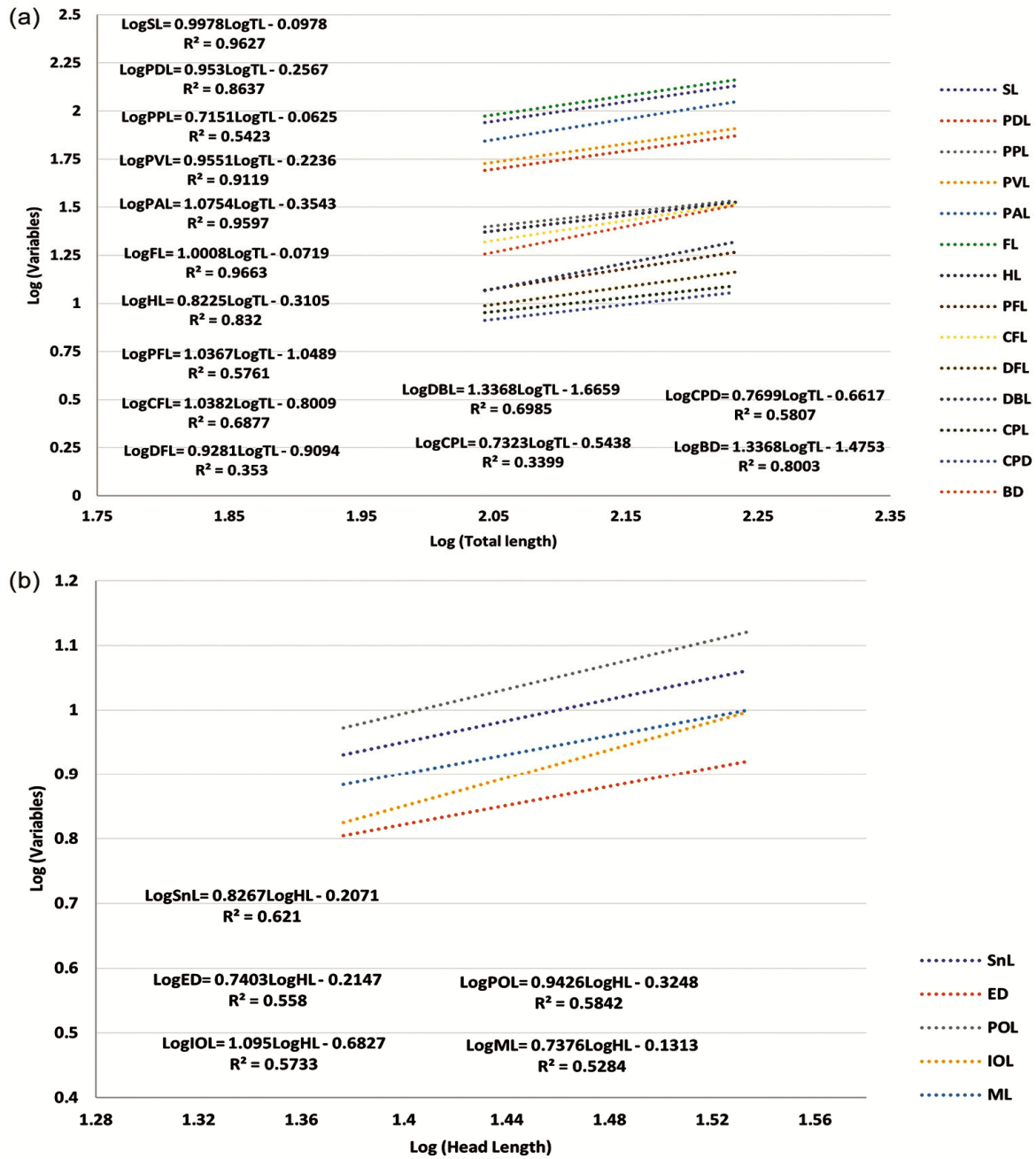


Fig. 3 — Relationship of various log-transformed morphometric characters with (a) Log total length, and (b) Log head length, in *Dussumieria acuta*

environmental parameters such as temperature, salinity, and food availability<sup>35-38</sup>. The findings also revealed minimal intraspecific variation in the morphometric (< 11 %) and meristic (< 6 %) traits of *D. acuta* among individuals sampled from the Andaman waters (Tables 2 & 4). This indicates a high degree of morphological homogeneity within the *D. acuta* population along the Andaman coast. Most of the morphometric variables exhibited a linear

relationship with total length (Fig. 2a) and head length (Fig. 2b), with a high correlation coefficient (*r*) value except TL & DFL and TL & CPL (*r* < 0.70) (Table 3).

Pairwise regression of the morphometric variables upon log transformation gave a regression coefficient different from unity for PPL, CPL, CPD, HL, DBL and BD for total length (Fig. 3a) and SnL, ED and ML for head length (Fig. 3b), portraying strong

Table 4 — Statistical estimates of various meristic characters in *Dussumieria acuta*

Meristic count	Min	Max	Mean	Median	Standard deviation	Coefficient of variation (%)
Dorsal fin rays	18	19	18.857	19	0.377	2.004
Pectoral fin rays	14	14	14	14	0	0
Ventral fin rays	8	8	8	8	0	0
Anal fin rays	14	15	14.714	15	0.487	3.316
Caudal fin rays	19	19	19	19	0	0
Branchiostegal rays	14	15	14.714	15	0.487	3.316
Upper gillraker	10	11	10.571	11	0.534	5.056
Lower gillraker	21	22	21.428	21	0.534	2.494

Table 5 — Spearman rank correlation coefficient of meristic counts with total length for *Dussumieria acuta*

Meristics	Correlation coefficient with TL	Significance (2-tailed)
Dorsal fin rays	-0.3	0.370083*
Pectoral fin rays	NA	NA
Ventral fin rays	NA	NA
Anal fin rays	0.239046	0.478997*
Caudal fin rays	NA	NA
Branchiostegal rays	-0.11952	0.726314*
Upper gillraker	-0.17321	0.610542*
Lower gillraker	0.173205	0.610542*

\*Insignificant at 1 % and 5 % of level of significance

Table 6 — Descriptive statistics and estimated parameters of length-weight relationships of *Dussumieria acuta*

<i>Dussumieria acuta</i>	N	Intercept (a)	Slope				$r^2$	Compare to 3			Growth
			(b)	SEb	95 % CL of b			t	df	p	
					Lower	Upper					
<b>Sex</b>											
Pooled	939	0.005	3.18	0.021	3.139	3.224	0.958	8.475	937	<0.01	A+
Male	459	0.004	3.21	0.034	3.143	3.278	0.950	6.151	457	<0.01	A+
Female	468	0.006	3.11	0.328	3.051	3.180	0.950	3.534	466	<0.01	A+
<b>Season</b>											
NEM	214	0.006	3.08	0.052	2.977	3.183	0.941	1.533	212	0.12	I
DS	409	0.007	3.03	0.041	2.950	3.113	0.929	0.778	407	0.43	I
SWM	316	0.003	3.32	0.026	3.269	3.373	0.980	12.11	314	<0.01	A+

(N - sample size, a - intercept, b - slope, SEb - Standard Error of b, CL - Confidence Limit,  $r^2$  - coefficient of determination, t - student's t-test, df - degree of freedom, p - statistical significance, A+: Positive allometry; A-: Negative allometry; I: Isometry)

allometric growth. In the current study, head length exhibited negative allometric growth, a phenomenon common in various fish groups<sup>39</sup>. Pre-pectoral length, caudal peduncle length and caudal peduncle depth also showed negative allometric growth. These characters' growth rate slows down with age as fish grow bigger in length. The present study also observed positive allometric growth in body depth and dorsal base length with respect to the total length.

The weak Spearman rank correlation coefficients ( $0.30 \leq |\rho|$ ) between meristic characters and total length

(Table 5) indicate an absence of a clear trend in meristic counts with increasing body size, suggesting that fish size has no significant influence on meristic traits.

Understanding sex ratio is important because it influences the stability of fish populations in natural ecosystems. Fish populations often display biased sex ratios, which may result from differences in growth rates, mortality, or reproductive behaviour between males and females<sup>40,41</sup>. However, in the present study, the sex ratio of *D. acuta* did not differ significantly from the expected 1:1 male-to-female ratio, indicating a balanced population structure.

Table 7 — Variation of relative condition factor of *Dussumieria acuta* by sex and season

	$K_n$	SEM	CL Lower	CL Upper	$t$	$p$
			<i>Sex</i>			
Pooled	1.0032	0.0026	0.998	1.0083	1.2199	0.2228
Male	1.0034	0.0039	0.9957	1.0111	0.8864	0.3758
Female	1.0029	0.0035	0.9959	1.0099	0.8216	0.4116
			<i>Season</i>			
NEM	1.0025	0.0049	0.9927	1.0124	0.5203	0.6033
DS	1.0035	0.0041	0.9953	1.0116	0.8512	0.3951
SWM	1.0023	0.0038	0.9947	1.0099	0.6046	0.5458

(SE - Standard Error, CL - Confidence Limit)

Table 8 — Meristic count of *Dussumieria acuta* compared to other literature

Meristic count	Present work		Lectotype (MHHN 3697)	Whitehead <sup>21</sup>	Hata <i>et al.</i> <sup>32</sup>	Froese & Pauly <sup>34</sup>
	Min	Max				
Dorsal fin rays	18	19	20	-	18–23	-
Pectoral fin rays	14	14	13	-	12–15	-
Ventral fin rays	8	8	8	-	8	-
Anal fin rays	14	15	16	12–15	14–17	12–15
Caudal fin rays	19	19	19	-	19	14–18
Branchiostegal rays	14	15	11	-	11–15	-
Upper gillraker	10	11	11	-	10–15	-
Lower gillraker	21	22	23	19–26	20–25	-

In the present investigation, *D. acuta* ( $b = 3.18 \pm 0.021$ ,  $p < 0.01$ ) displayed positive allometric growth (Table 6). The  $b$  value of the current study aligns with previous findings reporting positive allometric growth ( $b > 3$ ) for this species, as noted by Cinco<sup>42</sup> from the Philippines, Nair<sup>17</sup> from India, Pauly *et al.*<sup>43</sup> from Indonesia, and Taskavak & Bileenoglu<sup>44</sup> from Turkey. Conversely, several studies have documented negative allometric growth ( $b < 3$ ) for *D. acuta* in other regions, including the Persian Gulf and Oman Sea<sup>45</sup>, Pakistan<sup>46</sup> and Iran<sup>47</sup>. Abdurahiman *et al.*<sup>18</sup> in 2004 reported a  $b$  value of less than 3 for males (2.938) and females (2.894) for this species from the Southern coast of Karnataka, India.

*Dussumieria acuta* from Kenyan waters exhibited an isometric growth pattern, as reported by Mbaru *et al.*<sup>48</sup> in 2010. The variation in the exponent  $b$  observed across different studies may be associated with geographical and ecological factors, such as variations in water quality and food availability, which can significantly influence fish growth<sup>49</sup>.

The SWM season demonstrated positive allometric growth in the present study, whereas the DS and NEM seasons showed isometric growth patterns. Seasonal variations of the ' $b$ ' value are closely linked to changes in body weight, which can be influenced

by ecological factors such as temperature, food availability, and spawning activity, as well as biological and anthropogenic factors including sex, age, fishing period, geographic location, and fishing gear<sup>50</sup>.

$K_n$  is used as an index to compare the observed weight of an individual fish with the expected mean weight corresponding to its length. It is widely employed for evaluating the health and well-being of fish both within and across populations and species<sup>51</sup>. The  $K_n$  of *D. acuta* in the present study was  $\sim 1$  (Table 7), suggesting balanced predator-prey dynamics, adequate food availability, and favourable physicochemical conditions<sup>52</sup>. In conclusion, the sampled *D. acuta* individuals appeared healthy and well adapted to the environmental conditions of the Andaman waters. Neither seasonal variation nor sex had a significant effect on the  $K_n$  in this study.

## Conclusion

This study offers crucial insights into the population structure of *D. acuta* in the Andaman waters, aiding in fisheries management and conservation efforts. It highlights the importance of adopting population-specific management strategies to promote sustainable resource use and management. Future research could improve current

estimates through a sex-segregated morphometric analysis and a larger sample size with a broader size range. Additionally, a comprehensive biological assessment of feeding and reproductive behaviours is needed to understand the reasons behind the observed patterns.

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### Conflict of Interest

The authors state that they do not have any known financial interests or personal relationships that could have been perceived as influencing the findings reported in this paper.

### Author Contributions

AM: Investigation, writing - original draft, and conceptualisation; SK: Writing - review & editing and conceptualisation; PAHR & AU: Resources; and SV: Supervision.

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