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Morphomeristic Characteristics, Length-Weight Relationship, and Condition Factors of One Stripe Spiny Eel, *Macrognathus aral* (BLOCH and J. G. SCHNEIDER, 1801)

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Abstract

The present study revealed complete information on length-weight relationships (LWRs), length-length relationships (LLRs), and meristic counts (covering different fin rays and ocellies) of a total number of 150 *Macrognathus aral* species collected from lotic water bodies and fish markets. The total length of the male and female species results from a range of 18.3cm to 32.5cm and 15.7cm to 29.0cm while body weight varies from 21.35gm to 156.6gm and 29.9gm to 138.9gm, respectively. The parabolic equation between total length and the total weight of *M. aral* is as $W = 0.177000982\ L^{2.4837}$ for male species and $W= 0.105737\ L^{2.9929}$ for female species. A strong relationship between length and weight shows a 93% ($P<0.05$) correlation in females and 82% ($P<0.05$) correlation in males. The values of 'b' showed negative allometric growth ($b<3.0$) in both sexes. The mean values of Fulton's condition factors (K_3) shown in male and female species were 0.378 and 0.558 respectively, while on the other side the values of Modified condition factors (K_b) shown in male and female species were 1.875 and 0.571, respectively, which indicates good health condition of the species in their natural habitats.

***Key words*:** *Macrognathus aral*, Length-weight relationship, Ocelli, Morpho-meristic characteristic, Condition factors

Macrognathus aral is a one-striped spiny eel. It lives in fresh and brackish water and is ornamental and edible. This species lives in canals, streams, marshes, ponds, and flooded paddy fields [1-2]. A total number of 24 species of the genus *Macrognathus* are distributed in the Asian subcontinent including Thailand, Malaysia, and Southern China [3-4]. The species has been widely distributed in India, Bangladesh, Myanmar, Pakistan, Nepal, and Sri Lanka [3]. In India, *M. aral* is called 'aral,' 'bam,' 'bami,' 'gainchi,' and 'tourah. It's called 'tara baim' in Bangladesh and 'bami'/'gainchi' in Nepal [3], [5]. East and West Midnaporeans call *Macrognathus aral* "Pankal". This "table fish" is popular in rural areas [6]. In East India, especially East Midnapore and West Midnapore, the demand for this fish is growing. In East and West Midnapore, *Macrognathus aral* species are sold for between $7.51 and $11.27 when purchased live. In 1992, the Wildlife Heritage Trust (WHT) published a 'WANTED' sign at Sri Lanka's ornamental fish export agencies and inland fishing centers. Wildlife Heritage Trust (WHT) awarded $180 for a single *Macrognathus aral* specimen [7]. IUCN considers *Macrognathus aral* "Least Concern" [8]. In 2006, [9] reported that this species distributed in India's Eastern Ghat region have found a place in the WCURT- World Conservation Union Red List.

Morphometric and meristic features can help classify and identify species [10-13]. One of the most potent tools in fish morphometry for describing intraspecific diversity [14]. The length and weight of the fish species are significant morphometric characters that are used for the taxonomy and the stock assessment of the fish [15]. [16] said measuring the length between weight and length is easy, and using the length-weight relationship, weight can be estimated. Variation in the expected weight or length of an individual or a group of fish is considered an indication of general fish health in addition to gonadal development [17], thus proving the facts of breeding biology. Biology uses the length-weight relationship for many purposes such as inferring weight from length measurements for yield assessment, calculating standing the crop biomass, estimating the age of fish weight, assessing fish population well-being indices, evaluating fish population age structure and function, growth, stock differentiation, ecological modeling, and acoustic surveys are studied [18-22]. The length-weight relationship character is used to obtain information on fish conditions to estimate whether somatic growth is either allometric or isometric [23-24]. The condition factor is based on the hypothesis that substantial fish of a given length is in better condition [25] and is also used as a growth index and feeding

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intensity [26]. [27] studied six native fish species from Deepor Beel, Assam, *M. aral* was one. [28-30] studied the length-weight relationship and relative condition factors of the species *M. aral*. [7, 2, 6] carried out their studies on the food and feeding of *M. aral*. [1], [6], [31], contributed to some attributes of the breeding biology of *M. aral*.

However, no noteworthy study has been carried out on bringing *M. aral* species under aquaculture or restoring natural habitats for conservation in India. The increasing demand for the species has made some entrepreneurs think deeply about exploiting the huge potential of the species in aquaculture, however, the serious lack of rudimentary scientific information on the biology of this species has hampered this initiative. A reasonable mitigation measure acceptable against the extinction of this species is to initiate rearing programs to ensure the production of quality fish seeds on a large scale. For this, it is important to gain proper knowledge of the biology of this species. Thus, to evaluate the culture process of *M. aral*, before studying the reproductive biology, behavior, and breeding season, identification of the species is of utmost importance. Therefore, the present research investigates details of the morphometric traits, length-weight relationship, and length-length relationship, as well as condition factors of *M. aral.*

MATERIALS AND METHODS

Study area

This study follows the rules in the Guide for the Use and Care of Laboratory Animals of Vidyasagar University. *M. aral* species were stocked in rectangular cemented tanks in the outdoor culture unit of the Fishery Sciences Department, Vidyasagar University (VU), West Midnapore. The fish were fed twice a day- at 9 am and 5 pm (zooplanktons and insect larvae). The complete experiment was accomplished in the departmental laboratory of the Fishery sciences, where all the characteristics of morphometric and meristic counts of the species were examined.

Sampling

A total of 150 live *M. aral* (male: 88 and female: 62), 38 individuals were randomly collected from the lotic water bodies of both the Kangsabati river in West Midnapore and the Champa canal at Baranga, Ramnagar in East Midnapore. Fishermen (those who earn their livelihood by fishing in the river Kansavati) used gill nets and cast nets and also handpicking to catch these fish and bring them alive for sale in the fish market and 112 live individuals were randomly collected from various whole-sell fish markets in West Midnapore in West Bengal, India from February 2021 to January 2022. These markets include Gate Bazar, Katuali Bazar, Raja Bazar, School Bazar, and Nayagram Bazar (Table 1, Fig 1).

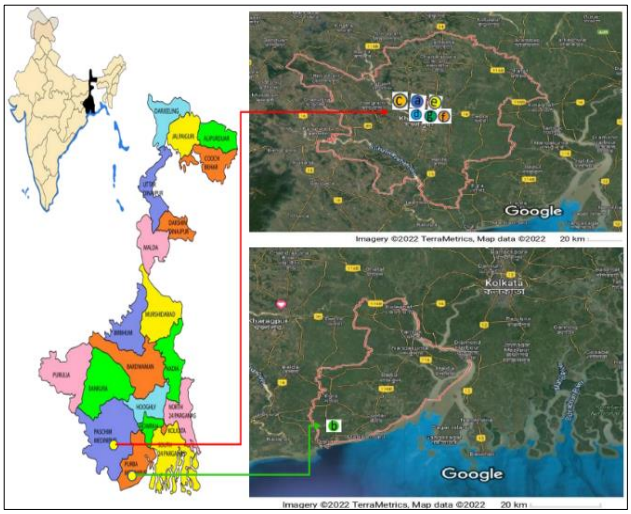

Fig 1 Map showing locations of the species sampling (Source-Google map) Spot Point: a. Kangsabati River; b. Champa Canal; c. Nayagram Bazar; d. Gate Bazar; e. Kotwali Bazar; f. Raja Bazar; g. School Bazar

Table 1 Place-wise species collection

Spot No.	Collection center	District	Geographical coordinate	Number of samples	
				Male	Female
a.	Kangsabati River	West Midnapore	22°24'33.1"N 87°17'46.6"E	14	09
b.	Champa Canal	East Midnapore	21°43'29.4"N 87°32'19.6"E	09	06
c.	Nayagram Bazar	West Midnapore	22°27'29.5"N 87°15'29.2"E	15	10
d.	Gate Bazar	West Midnapore	22°25'15.7"N 87°18'26.2"E	11	08
e.	Kotwali Bazar	West Midnapore	22°25'01.8"N 87°19'39.3"E	15	10
f.	Raja Bazar	West Midnapore	22°25'36.3"N 87°19'39.1"E	18	15
g.	School Bazar	West Midnapore	22°24'42.9"N 87°19'34.4"E	06	04

Morphometric and meristic measurements

Different measurements of morphometric characteristics such as total length (TL), standard length (SL), head length (HL), gape width (GW), pre-pectoral length (PPL), pre-dorsal length (PDL), pre-anal length (PAL), the base of pectoral length (BPL), the base of dorsal length (BDL), the base of anal length (BAL), pectoral fin length (PFL), dorsal fin length (DFL), anal fin length (AFL), caudal fin length (CFL), width (WD), body depth (BD), least width of caudal peduncle (LWCP), pre orbital length (PrOL), post orbital length (PoOL), eye diameter (ED) and meristic counts such as dorsal fin ray (DFR), dorsal fin spine (DFS), caudal fin ray (CFR), anal fin ray (AFR), pectoral fin ray (PFR), rostral teeth (RT), ocelli of the species *M. aral* was examined according to [28], [32]. The length of the species was measured with a digital vernier caliper, nearest to 0.01cm total length (TL), and also used a plastic ruler scale, nearest to 0.1cm, while the weight of the fish was measured by MH-200 (200g/0.01g) series pocket scale. The species' total number of fin rays was counted with a magnifying glass.

Relationship between length and weight

The LWR of the species was calculated using the formulae of [4], [33]; as follows: $W= aL^b$; Where W is the total body weight (BW) of the fish (g), L is the total length (TL) of the fish (cm), a= Intercept, b= Slope. This equation can be expressed as logW= loga + b logL.

Condition factor (K)

The Fulton's condition factor [34] of that fish was calculated using the following formulae: $K_3 = 100W/L^3$; where K_3 is Fulton's condition factor, W is the weight of the species (g), L is the total length of species (cm). The modified condition factor [35] was estimated using the following equation: $K_b = 100W/L^b$; where K_b is the Modified condition factor, W is the

weight of the species (g), L is the total length of species (cm), and b is regression parameters.

Data analysis

The analysis of length-weight, length-length relationship, and condition factor were estimated through statistical logarithmic and parabolic equations, regression parameters through 't'-test, multiple R, and R square test using the MS-EXCEL: D.

RESULTS AND DISCUSSION

To improve the caliber of stock documentation research, a morphomeristic study would be beneficial. Meristic and truss morphometry is a practical tool for improving fisheries management, even though many methods are routinely investigated for stock identification. Breeding, exploitation, habitat restoration, and conservation all depend on reliable data and analyses of stock structure. In the present study, a total of one hundred fifty species were observed for the morpho-meristic characteristic study. For morphometric measurements among twenty observed characters (ranges, mean, SD values), all are tabulated in (Table 2). Eight meristic characters are tabulated in (Table 3). Morphometric analysis can help identify stocks [14]. In the morphological study, it has been observed that the species possess a long snout, small teeth on the upper and lower jaws, absence of gill rakers, an eel-like body with an elongated shape, caudal fin with a round shape and is separated from the dorsal and anal fins, two to nine pairs of black ocelli at the base of the pale or orange-colored dorsal fin, pelvic fin absent, anal fin with three different sizes of spines, the second spine being the longest Small in size, the mouth does not extend past the lower posterior nostrils. It is very challenging to distinguish the male species of *M. aral* from the female by observing the phenetic characteristics, although both sexes exhibit varied body colors during the breeding season. The coloration of the male is ventrally pale yellow and dorsally brownish. Females exhibit yellow and brown colors on their ventral sides. [36] stated that the body colour is brown on top and light gray on the bottom, with two broad longitudinal bands: one is yellowish-grey above the lateral line, and the other is dark brown from the eye to the caudal peduncle. Light brown caudal fin with 4-5 white zigzag bars. The brown soft dorsal fin has a white longitudinal line and 3-7 ocelli near the base, this finding is similar to the description of [3]. Ocelli have an oval form and a black, white-coated center. The anal fin is uniformly brown and generally devoid of any white streak or ocelli, with one ocellus at this fin's base in one specimen only. Also, the fin formula of the species describes as D XVII–XXI 45–43; P i15–20; A III42–53; C 12–15.

Table 2 Morphometric measurements of *Macrognathus aral* (Bloch and J.G. Schneider, 1801)

Parameters	Male			Female		
	Range (cm)	Mean	Standard Deviation	Range (cm)	Mean	Standard Deviation
TL	18.3 - 32.5	21.96	± 2.11	15.7 - 29.0	22.40	± 3.45
SL	17.3 - 23.5	20.70	± 1.95	14.7 - 27.2	20.98	± 3.24
HL	3.3 - 4.0	3.68	± 0.22	2.5 - 4.5	3.50	± 0.53
GW	0.8 - 1.1	0.93	± 0.13	0.7 - 1.3	0.99	± 0.18
PPL	3.3 - 4.3	3.83	± 0.30	2.7 - 5.0	3.83	± 0.60
PDL	6.6 - 9.5	8.52	± 0.81	5.9 - 11.0	8.52	± 1.31
PAL	11.2 - 15.6	13.30	± 1.43	9.7 - 17.9	13.80	± 2.13
BPL	0.3 - 0.6	0.44	± 0.06	0.3 - 0.6	0.46	± 0.09
BDL	9.9 - 13.6	11.93	± 1.19	8.4 - 15.6	12.02	± 1.85
BAL	5.8 - 7.8	6.70	± 0.69	4.8 - 8.9	6.85	± 1.06
PFL	1.0 - 1.4	1.24	± 0.14	0.9 - 1.6	1.22	± 0.20
DFL	0.6 - 0.9	0.75	± 0.08	0.5 - 1.0	0.72	± 0.12
AFL	0.4 - 0.7	0.58	± 0.09	0.4 - 0.7	0.56	± 0.09
CFL	1.0 - 1.6	1.26	± 0.15	1.0 - 1.8	1.32	± 0.21
WD	5.8 - 7.8	6.92	± 0.61	5.2 - 8.9	6.86	± 1.06
BD	2.0 - 2.8	2.39	± 0.23	1.7 - 3.5	2.47	± 0.42
LWCP	0.4 - 0.6	0.50	± 0.09	0.3 - 0.6	0.46	± 0.09
Pre-OL	1.4 - 1.75	1.62	± 0.11	1.1 - 2.0	1.53	± 0.23
Post-OL	1.5 - 2.0	1.79	± 0.12	1.2 - 2.2	1.69	± 0.25
ED	0.2 - 0.3	0.28	± 0.03	0.2 - 0.3	0.26	± 0.05

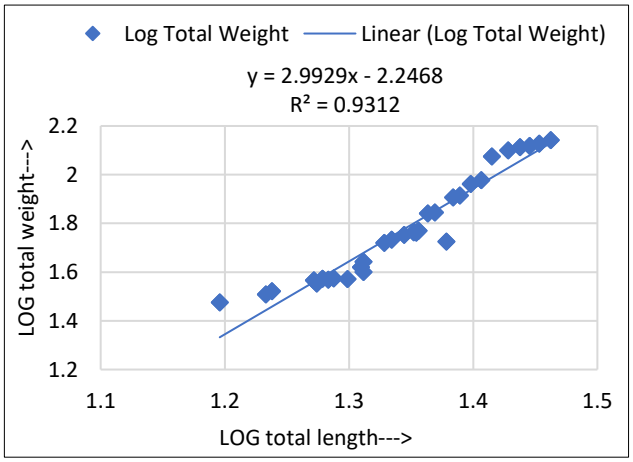

Fig 2A Length-weight relationship of female species (Log value)

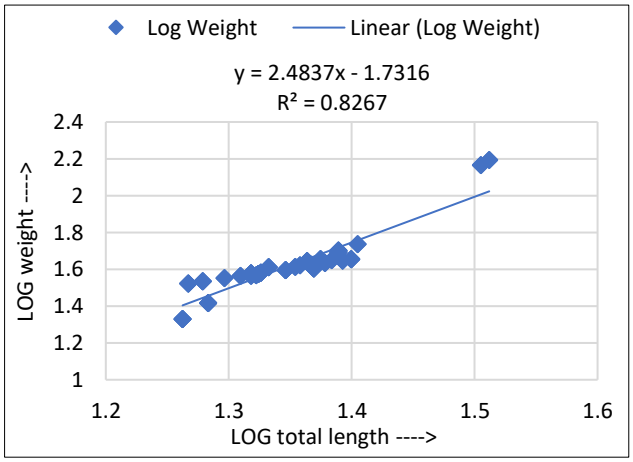

Fig 2B Length-weight relationship of male species (Log value)

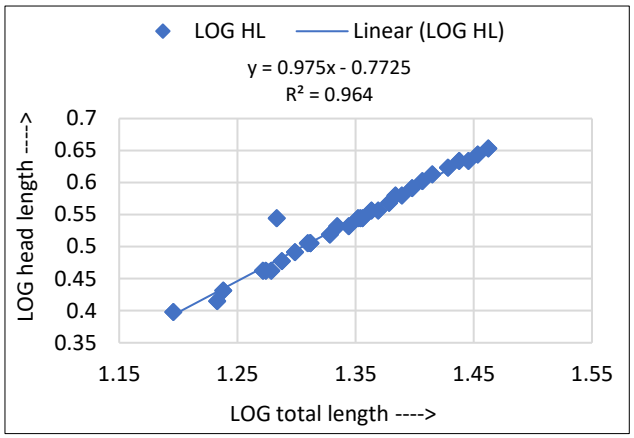

Fig 3A Total length- head length relationship of female species (Log value)

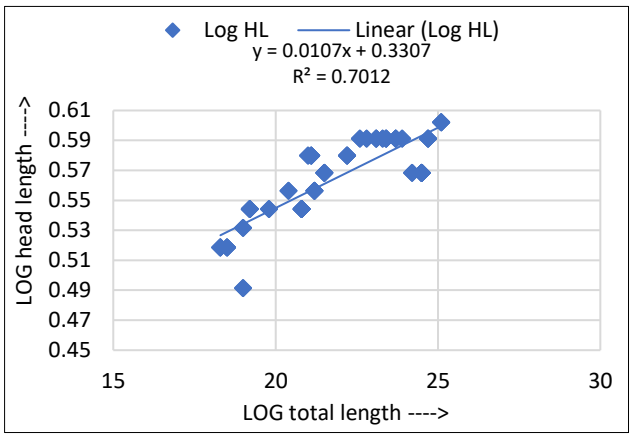

Fig 3B Total length- head length relationship of male species (Log value)

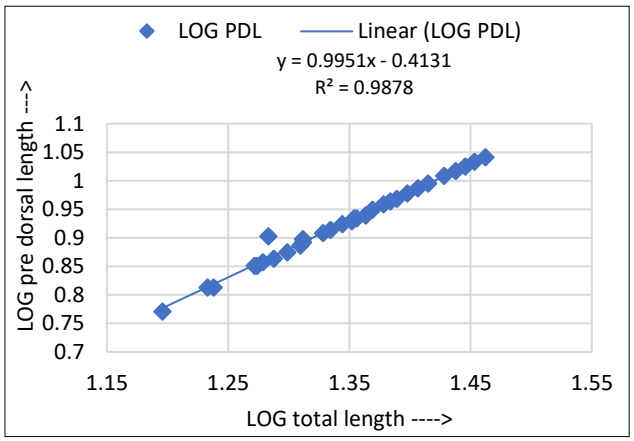

Fig 4A Total body length- PDL relationship of female species (Log value)

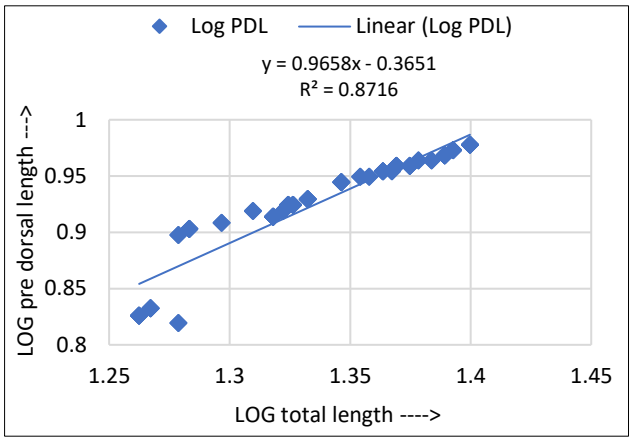

Fig 4B Total body length- PDL relationship of male species (Log value)

Table 3 Meristic counts of the species *M. aral* (Bloch and J.G. Schneider, 1801)

Characters	Numbers
Dorsal Fin Ray (DFR)	46 – 49
Dorsal Fin Spine (DFS)	15 – 20
Caudal Fin Ray (CFR)	11– 12
Anal Fin Ray (AFR)	45 – 49
Anal Fin Spine (AFS)	3
Pectoral Fin Ray (PFR)	12
Rostral Teeth (RT)	14 - 26 pairs
Ocelli	2 - 9 pairs

Fin formula: D XV-XX 46-49; Pi 12; A III45-49; C 11-12

The current study reported that the overall length of male *M. aral* ranges from 18.3 to 32.5 cm, and the body's total weight ranges from 21.3 to 156.60 gm, and in female species length ranges from 15.7 - 29.0 cm and body weight ranges from 29.9 to 138.9 gm. But in a study by [28], it was mentioned that the total length of male and female bodies ranges from 11.3 to 22.1 cm and 10.8-30.3 cm respectively and weight ranges from 2.05 to 20.27 gm and 4.95-93.6 gm, respectively, concerning the finding of the total body length and weight show much greater variation. The variation in the length and weight is due to different geographical locations and the availability of food [37]. All statistical data of the length-weight relationship and condition factors are represented in the tabulated form in (Table 4-5, 7), respectively (Fig 2A-B).

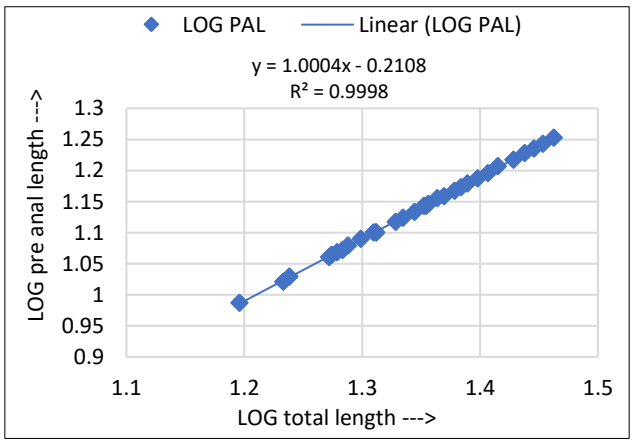

Fig 5A Total body length- PAL relationship of female species

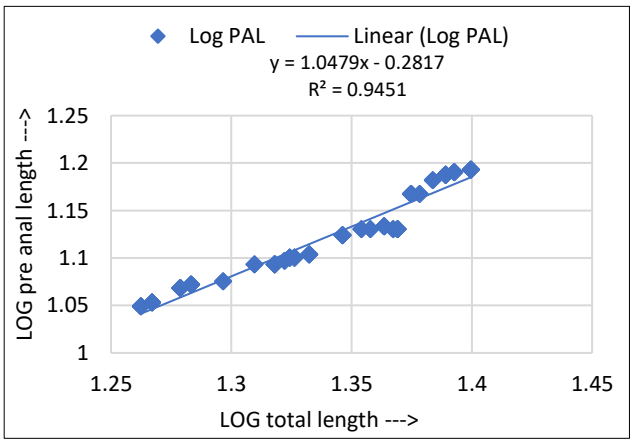

Fig 5B Total Body Length- PAL relationship of male species

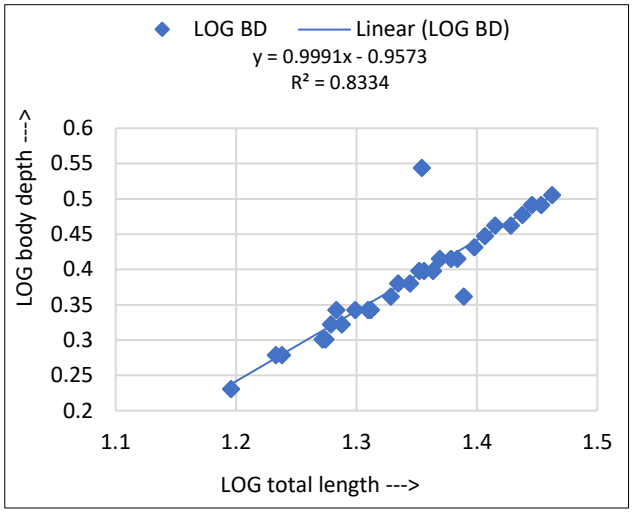

Fig 6A Total length- body depth relationship of female species (Log value)

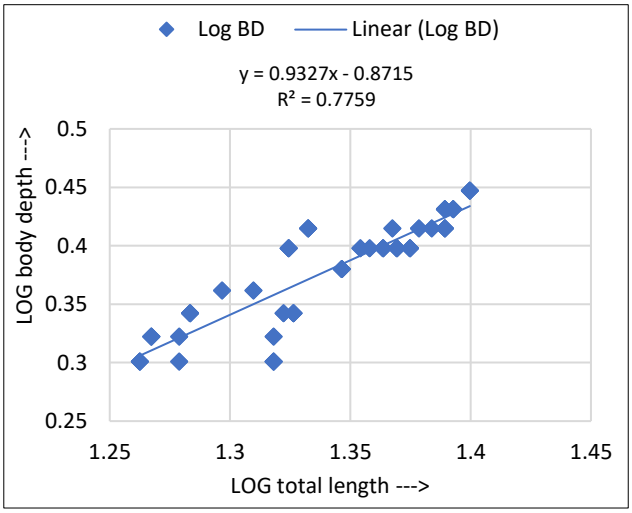

Fig 6B Total Length- Body depth relationship of male species (Log value)

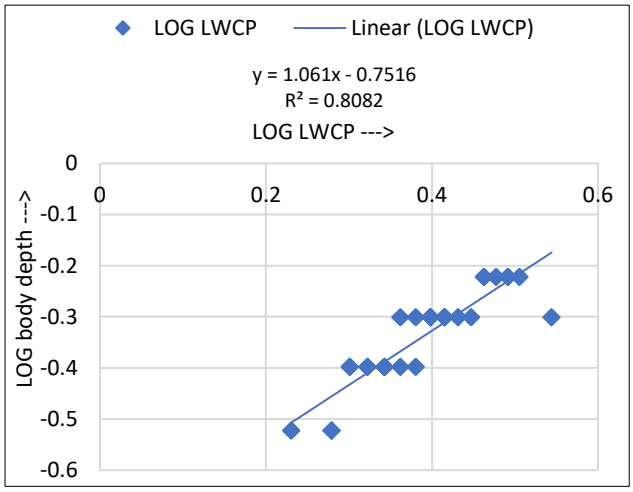

Fig 7A Body depth-LWCP relationship of female species (Log value)

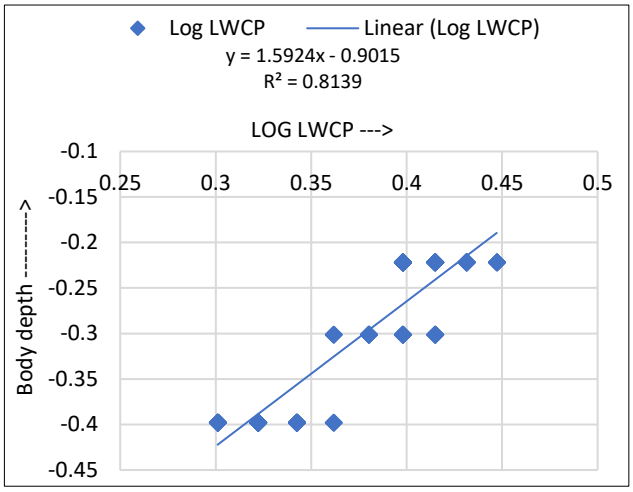

Fig 7B Body depth-LWCP relationship of male species (Log value)

Table 4 Descriptive statistics of length and weight of regression parameters of the species

Category	Regression Parameters						
	a	b	95% C.I. of b (range)	t-test value of b	Multiple R	R Square	Adjusted R Square
Male	0.177	2.483	0.24-5.21	(P<0.05)	0.909	0.826	0.824
Female	0.105	2.992	0.21-6.19	(P<0.05)	0.965	0.931	0.930

†a: intercept, b: slope, C.I.: confidence interval, R: coefficient correlation

Table 5 Descriptive logarithmic and parabolic equations of the species

Category	Logarithmic equations	Correlation coefficient	Parabolic equations	Growth type
Male	Log W = -0.75202 + 2.4837 log TL	0.82	$W = 0.1770L^{2.4837}$	Allometric (-)
Female	Log W = - 2.2468+ 2.9929 log TL	0.93	$W= 0.1057L^{2.9929}$	Allometric (-)

†TL: Total length, W: Weight, L: Length

Table 6 Comparison of previous and current studies on length-weight relationship

Study site	Researcher	b value		R Square	
		Male	Female	Male	Female
Dora Wetland, Kamrup district, Assam	Chakraborty & Goswami (2016)	3.48	3.18	0.92	0.96
Deepor Beel (Wetland) Guwahati, Assam	Deka & Barman (2020)	2.99	3.06	0.94	0.96
North 24 Parganas, West Bengal	Dutta & Banerjee (2016)	2.5615	3.2371	0.902	0.933
Current Study (East & West Midnapore, West Bengal)	Das et al.	2.4837	2.9929	0.744	0.897

The relationship between total body length- head length, total body length- PDL, total body length- PAL, total body length- body depth, body depth- least width caudal peduncle, and statistical analysis are tabulated in (Table 8, Fig 3A-B), (Table 9, Fig 4A-B), (Table 10, Fig 5A-B), (Table 11, Fig 6A-B), and (Table 12, Fig7A-B) respectively. The degree of

exponential variation of the length-weight relationship was represented by the "b" value [28]. In the male and female species, the value "b" was found to be 2.4837 and 2.9929 respectively, which is lesser than 3, and the result implies negative allometric growth. Similar negative allometric growth has been reported in *L. guntea* (male species) [38] and also reported in *A. mossulensis* [39], *C. carpio* with "b" values of 2.9002 [40], a system of open water like Gobindsagar with "b" value 2.42 [41], Dal Lake with "b" value 2.98 [42]. By perceiving the "b" value of males *M. aral* it was concluded that an increase in total body weight is not proportional to the increase in the total length of the body. The cause may be due to the loss of energy for the development of gonads rather than the development of somatic body weight [43]. The "b" values may be dependent on species sex [44], rate of feeding [33], developmental stages of the gonad [45-46], and state of maturity [47]. Monthly the "b" value should be varied in the different season because, during the breeding season, gonadal development occurs and reach extreme weight [45]. As the "b value" is less than 3, so it could be concluded that the species does not strictly follow the cube law. The coefficient of correlation 'r' in male and female species is the nearest to 1.0 which is 0.82 and 0.93 respectively. This shows that male and female *M. aral* has the uppermost degree of growth performance and a relationship between length and weight. This result is similar to the finding of [29] (Table 6). The relative condition factor indicates an index of well-being and rate of growth in fish [48]. In general, the 'Kn' value > 1 indicates a good condition of a fish [33]. The 'kn' value of the male species is greater than 1, which is 1.87 ± 0.28, indicating well health condition but in the case of the female species the 'kn' value is observed very less the 1 ('kn' value is 0.571 ± 0.07), so it is observed that health condition of the male was better than female in this environment as the cause may be due to developmental stages of the gonad [45-46], and the species maturity state [47]. In the length-weight relationship study, it was observed that there exists a strong relationship between total body length with head length, in males R^2 value is 0.72, ($P < 0.05$), and in females R^2 value is 0.96, ($P < 0.05$). Female species show more strong relationship between total length and head length. The relationship among total length and pre-dorsal length, the male species shows R^2 value of 0.87 ($P < 0.05$), and the female species shows R^2 value of 0.98 ($P < 0.05$). In the relationship between total length and pre-anal length, the male species shows R^2 value of 0.94 ($P < 0.05$), and the female species shows R^2 value of 0.99 ($P < 0.05$). In the relationship between total body length and body depth, the male species shows R^2 value of 0.77 ($P < 0.05$) and the female species shows R^2 value of 0.83 ($P < 0.05$). Also, it has seemed that the body depth and least width of the caudal peduncle show a greater relationship with an R^2 value of 0.81($P < 0.05$) in males and R^2 value of 0.80 ($P < 0.05$) in female species. From the above, it can be deduced that other characteristics have a substantial association with body length than length-weight. [49] similarly found a robust association between different body length factors ($P = 0.01$). In addition, an acceptable and workable method of rearing and a decorated commercial cultivation program is needed to sell this extremely beneficial species due to its nutritional worth and public readiness to consume it. This study will help determine discreteness and relationships among *Macrognathus* populations for the future breeding of *Macrognathus aral*.

Table 7 Descriptive condition factor of the species

Category	Condition Factors (K)					
	Condition Factor (Fulton, 1904)			Modified Condition Factor (Ricker, 1975)		
	Min.	Max.	Mean SD	Min.	Max.	Mean SD
Male	0.286	0.526	0.378 ± 0.06	1.511	2.752	1.875 ± 0.28
Female	0.389	0.772	0.558 ± 0.07	0.398	0.787	0.571 ± 0.07

†Min.: Minimum, Max.: Maximum, SD: Standard Deviation

Table 8 Descriptive statistics of total length and the head length of regression parameters of the species

Category	t-test value of b	Multiple R	R Square	Adjusted R Square
Male	(P<0.05)	0.849	0.721	0.718
Female	(P<0.05)	0.981	0.964	0.963

Table 9 Descriptive statistics of total length and pre-dorsal length of regression parameters of the species

Category	t-test value of b	Multiple R	R Square	Adjusted R Square
Male	(P<0.05)	0.933	0.871	0.870
Female	(P<0.05)	0.993	0.987	0.987

Table 10 Descriptive statistics of total length and pre-anal length of regression parameters of the species

Category	t-test value of b	Multiple R	R Square	Adjusted R Square
Male	(P<0.05)	0.972	0.945	0.944
Female	(P<0.05)	0.999	0.999	0.999

Table 11 Descriptive statistics of total length and body depth of regression parameters of the species

Category	t-test value of b	Multiple R	R Square	Adjusted R Square
Male	(P<0.05)	0.880	0.775	0.773
Female	(P<0.05)	0.912	0.833	0.830

Table 12 Descriptive statistics of LWCP and BD of regression parameters of the species

Category	t-test value of b	Multiple R	R Square	Adjusted R Square
Male	(P<0.05)	0.902	0.813	0.811
Female	(P<0.05)	0.898	0.808	0.804

CONCLUSION

The current study focuses on some of the most concise diagnostic characteristics of *Macrognathus aral*. It is likewise important to develop a proper feasible rearing method & then start a decorated commercial culture program for adequate marketization of that highly beneficial species due to its significant nutritional value and people's acceptance. The conclusion that may be formed from this inference would result in a redescription of the current species that were only recently described, or it could even revalidate some of the species that had been forgotten or synonymized in the past. Also, the present study and its result will help gain proper knowledge about desired aspects in determining discreteness and interactions among the *Macrognathus* sp. populations for futuristic research towards the attempt in developing successful breeding of *Macrognathus aral*.

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Conflict of interests

The authors declare that there is no conflict of interest.

Ethical statement

The research has been carried out adhering to all the overseeing rules and regulations of the Ethical committee.

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