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Nutritional Profile of the Freshwater Edible Bivalve *Lamellidens corrianus* (Lea 1834) and its Relation to Water Quality in the Bhatsa River, India

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Abstract

Freshwater bivalve aquaculture is promoted by many fisheries management agencies as an alternative livelihood option for rural fishing communities in tropical developing countries. This study examined the nutritional profile of an edible bivalve *Lamellidens corrianus* (Lea 1834) and the water quality of its habitat in the Bhatsa River at sampling sites in Vasind and Koshimbi villages. Total length-wet weight and total length-dry weight data of animals collected from Koshimbi showed strong positive allometric relationships. The average moisture content of *L. corrianus* from Vasind and Koshimbi was estimated as 75.6±7.6 % and 77.7±4.7 %, meat yield 26.5±3.1 % and 24.9±0.5 % and condition index 8±3.5 and 5.7±2.2, respectively. Condition index of *L. corrianus* revealed significant positive correlation with dissolved oxygen and pH and negative correlation with conductivity, nitrate content, turbidity and total dissolved solids. Nutritional analysis of dry tissues (foot, gill and adductor muscle) of two different size groups (3.0–6.0 cm and 6.1–9.0 cm) showed they contain a high percentage of proteins followed by carbohydrates and lipids. Caloric content was found to be high in gills (2.31–4.43 Kcal.g^{-1}). Thus, aquaculture of *L. corrianus* can be promoted in Bhatsa River as a good alternate food source to fulfill the nutritional needs of local communities.

Keywords: Bivalve, nutritional contents, length weight relationship, condition index, caloric content

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Introduction

Increasing human population in developing countries has resulted in scarcity of food resources and malnutrition (Blossner et al. 2005). Bivalves have been identified as a cheap source of protein and other essential nutrients and have been used as food since prehistoric times (Parmalee and Klippel 1974; Dong 2001). The freshwater bivalve *Lamellidens corrianus* (Lea, 1834) is common in rivers throughout India, Nepal and Bangladesh (Nesemann et al. 2007). It is one of the 25 freshwater bivalve species reported from rivers flowing through the Western Ghats of India (Molur et al. 2011). Singh (2012) reported availability of *L. corrianus* from Vashishti, Savitri, Kundalika, Amba, Patalganga, Vaitarana, Ulhas and Bhatsa Rivers in the Western Ghats of Maharashtra. It is a proven food for many aquatic animals and has also been part of the human diet and a source of pearls in India (Subba Rao 1989). Past studies on *L. corrianus* have focused on the effects of toxic pollutants (Mane and Muley 1984; Rajalekshmi and Mohandas 1993, Rajalakshmi and Mohandas 2005) and its biology (Nagabhushanam and Lohgaonker 1978; Desai and Borkar 1989). However, no study exists in the literature on the nutritional value of *L. corrianus* in relation to local water quality parameters which will directly affect their economic value.

Health condition of the freshwater bivalves has largely been associated with water quality (Dillon 2000). Results of size-weight ratio and nutritional content in relation to local water quality may be useful in understanding species-specific habitat requirements for sustainable utilisation of bivalves. In western Maharashtra, people belonging to the Katkari community (a scheduled, socioeconomically backward class) harvest *L. corrianus* from Bhatsa River for their sustenance. Another study has shown that nearly 60 % of children in age group 0-6 years from the Katkari community are undernourished (Khandare et al. 2008). With this background knowledge, we conducted this study to evaluate the aquaculture potential of *L. corrianus* and to highlight its importance as a nutritive food source for the Katkari community.

Material and Methods

Study Area

This study was conducted along Bhatsa River which originates from Igatpuri hills of the Sahyadri range of the Western Ghats of Maharashtra and meets Ulhas River near Kalyan. An earth fill and gravity dam with volume 18,250 km^3 was constructed in 1983 on Bhatsa River near Shahapur. Owing to the dam, Bhatsa River flows all year round and provides water for agriculture, industrial and domestic uses to Thane district in Maharashtra. The substrate of the river consists of rocks, mud and gravel. After a preliminary survey on the availability of *L. corrianus*, two locations, Vasind (latitude 19˚ 24.046’ N and longitude 73˚16.571’ E) and Koshimbi (latitude 19˚22.730’ N and longitude 73˚ 13.696’ E) were selected in Thane district (Fig 1) for the study.

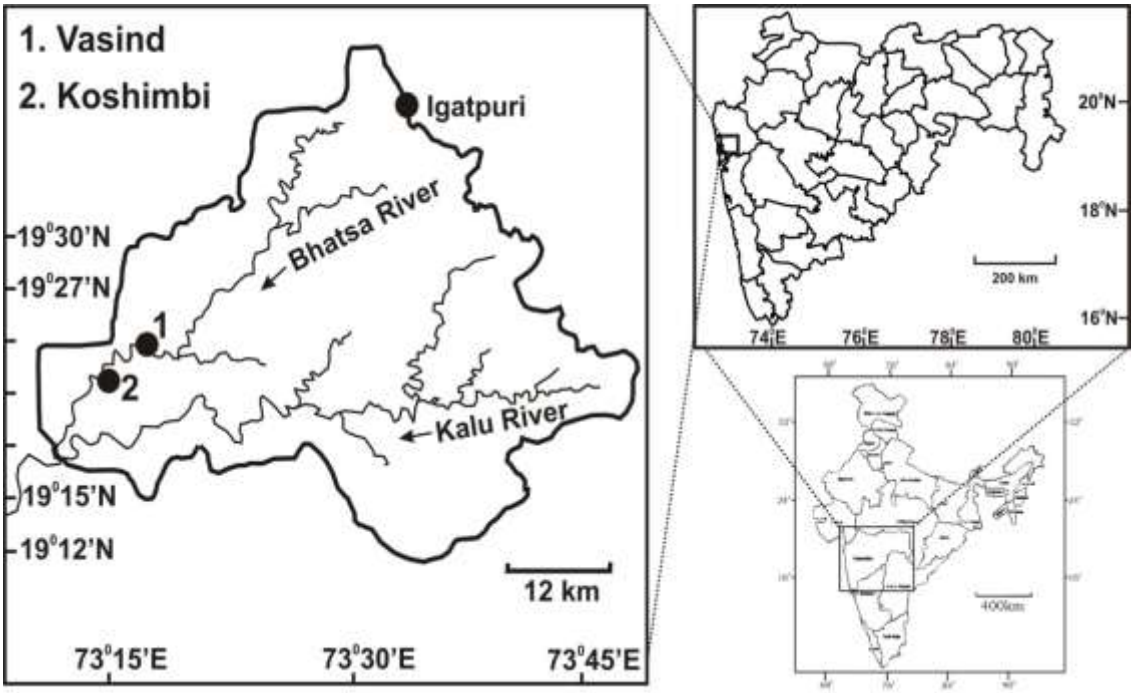

Fig. 1. Map showing locations of study sites

Sample collection and treatment

Surface water samples (2.5 l) were collected once a month from January 2015 - March 2015 from both selected sampling sites and brought to the laboratory. With the sampling of water, samples of commercial sized *L. corrianus* (visible or buried) were collected manually by excavating the top 5 cm of the muddy substrate from the shallow bank of both sites. *Lamellidens corrianus* were identified using identification keys by Nesemann et al. (2007) and Dey (2007). In every sampling 100 - 120 live specimens of *L. corrianus* were collected and transported within 2 h to the laboratory in a rectangular polyethylene carboy of 10 litres capacity containing water of the same site of collection. In the laboratory, the animals were washed with running tap water to remove sediment and associated fauna. All the animals were weighed and frozen immediately in a deep freezer at -20 ºC. Frozen animals were further processed for physiological and biochemical analysis. All analyses were run in triplicate.

Physicochemical properties of water

Parameters including pH, temperature, salinity, conductivity and total dissolved solids (TDS) were determined *in situ* using a portable field meter PCS Testr 35. Dissolved oxygen was determined *in situ* with a dissolved oxygen meter (Lutron DO-5510). Parameters including, turbidity, biological oxygen demand (BOD), nitrate content and phosphate content were analysed in the laboratory according to standard methods (APHA 2005).

Length-weight relationship

Length of each individual of *L. corrianus* was measured using vernier calipers with an accuracy of ±0.1 mm. Bivalves less than 3 cm long were not collected. Soft body tissues of all animals were carefully removed by scalpel. Excess water was drained off and blotted using filter paper. Wet tissue weight of each individual animal was recorded using a digital electronic balance with an accuracy of 0.1 g. Later wet tissues and empty shells were dried on aluminum foil in a vacuum oven at 60 ºC for 48 h. Dry weight of each individual animal's tissue and empty shell was determined. Length-weight relationship was determined in the following four types of models to obtain precise information on the dimensional relationships.

a) Total Length (TL)-Total Weight (TW),
b) Total Length (TL)-Wet Weight (WW),
c) Total length (TL)-Dry Weight (DW) and
d) Total Length (TL)-Shell Weight (SW)

Length weight relationships were determined using the equation described by Willing and Pender (1993).

$$W = a.L^b$$

where, W = weight (g), L = length (cm), a = Y intercept and b = slope constant (Cherif et al. 2008). Parameters "a" and "b" were estimated by the least-square method by transforming into natural logarithms ln(W) = b ln(L) + a (Willing and Pender 1993). The degree of association between variables L and W was calculated by the coefficient of determination (r^2). These regressions were expressed by scattered plot. Monthly data of b and r^2 were submitted to an analysis of variance (ANOVA).

Percentage moisture content

Percentage of moisture content in soft tissue of each individual *L. corrianus* was determined from the estimated fresh weight and dry weight according to the method described by AOAC (1995).

Percentage meat yield (% ME) and Condition Index (CI):

Percentage ME and CI were estimated using the following formulae (Yildiz et al., 2006)

% ME = [Wet tissue weight (g) / Total weight (g)] X100

CI = [Dry tissue weight (g) / Dry shell Weight (g)] X100

Nutritional content

Nutritional parameters (such as carbohydrate, protein and lipids) were estimated from dried tissue, viz. gills, foot and adductor muscle, of two length groups (3.0–6.0 cm and 6.1–9.0 cm) of *L. corrianus.* Protein content was calculated following Lowry et al. (1951), after alkaline hydrolysis with 0.5N NaOH at 30 °C for 24 h. Glycogen was quantified according to the phenol-sulphuric acid method (Strickland and Parsons 1972) after precipitation with 100 % ethanol. Lipids were extracted following the method of Bligh and Dyer (1959) modified by Fernandez-Reiriz et al. (1989).

Caloric content

The caloric value was computed using conversion factors 5.7, 4.0 and 9.3 $Kcal.g^{-1}$ for protein, carbohydrate and lipid respectively (Beukema 1997). By adding caloric value of protein, carbohydrate and lipid, caloric content of each analysed tissue of *L. corrianus* was estimated.

Statistical analysis

All the values are expressed as mean values ± standard deviation. The differences in physiological estimations, biochemical composition and biometric measurements were analysed with a two-way analysis of variance (ANOVA). Relationships among the considered variables were tested using Pearson's correlation. All statistical analyses were performed using Microsoft Excel 2007, Prism graphpad 5 and SPSS 17.

Results

Physicochemical properties of water

The water was colourless at both the sampling stations. Average values of various physicochemical parameters from both stations are given in Table 1. Values range as follows: pH (7.48±0.04 – 7.74±0.09), temperature (19.9±1.28 – 22.04±2.23 ºC), DO (7.82±0.21 –10.21±0.44 $mg.L^{-1}$), turbidity (2.51±0.62 – 9.5±0.36 NTU), conductivity (74±3.34 –127.1±4.9 $\mu S.cm^{-1}$), BOD (0.62±0.07 – 0.92±0.05 $mg.L^{-1}$), TDS (37±1.4 – 88.7±4.29 $mg.L^{-1}$), nitrate (0.51±0.01 – 0.82±0.01 $mg.L^{-1}$) and phosphate (0.49±0.05 – 0.59±0.02 $mg.L^{-1}$). Pearson correlation analysis between the values of the physicochemical parameters is presented in Table 2.

Length-Weight Relationships

A total of 140 specimens ranging in length from 4.3 to 7.5 cm and total weight from 8 to 37.3 g were measured from the Vasind sampling site. Additionally, 160 specimens ranging in length from 3.1 to 8.1 cm and total weight from 3 to 49.8 g were measured from the Koshimbi sampling site.

Mean values for shell lengths of specimens collected from Vasind and Koshimbi were 5.9±0.74 and 5.6±1.05 cm respectively and median values 5.8 and 5.7 cm respectively. In the case of total weight, mean values for specimens collected from Vasind and Koshimbi were 20.6±7.5 and 19.1±9.9 g respectively and median values 20.6 and 18.35 g respectively.

Table 1. Average values of various physico-chemical parameters of water from Bhatsa River

Parameter	Vasind			Koshimbi		
	January 2015	February 2015	March 2015	January 2015	February 2015	March 2015
pH	7.61 ± 0.03	7.74 ± 0.09	7.71 ± 0.05	7.74 ± 0.04	7.52 ± 0.02	7.48 ± 0.04
Water temperature (ºC)	19.9 ± 1.28	22.04 ± 2.23	21.2 ± 1.53	19.9 ± 1.2	21.7 ± 2.1	20.3 ± 1.9
Dissolved oxygen ($mg.L^{-1}$)	9.18 ± 0.39	10.21 ± 0.44	9.74 ± 0.28	9.03 ± 0.31	8.67 ± 0.5	7.82 ± 0.21
Turbidity (NTU)	7.43 ± 0.89	2.51 ± 0.62	6.92 ± 0.43	8.2 ± 1.03	8.8 ± 0.91	9.5 ± 0.36
Conductivity ($\mu S.cm^{-1}$)	93.4 ± 4.52	74 ± 3.34	89.31 ±3.11	107.4 ± 4.97	113.8 ±6.19	127.1 ± 4.9
BOD ($mg.L^{-1}$)	0.77 ± 0.02	0.92 ± 0.05	0.91 ± 0.03	0.62 ± 0.07	0.88 ± 0.09	0.70 ± 0.04
TDS ($mg.L^{-1}$)	52.42 ± 6.37	37 ± 1.4	49.92 ±4.1	61.4 ± 7.23	63.1 ± 5.62	88.7 ± 4.29
Nitrate ($mg.L^{-1}$)	0.73 ± 0.03	0.51 ± 0.01	0.58 ± 0.01	0.77 ± 0.03	0.81 ± 0.01	0.82 ± 0.01
Phosphate ($mg.L^{-1}$)	0.55 ± 0.07	0.51 ± 0.04	0.52 ± 0.03	0.57 ± 0.04	0.59 ± 0.02	0.49 ± 0.05

The frequency distributions of the length and total weight of the samples (Fig 2A and 2B) indicate that specimens between 5.5 and 6.5 cm length and weighing 15 to 25 g were predominant for both sampling sites.

Results of linear regression analysis in between log (length) and log (weight) of *L. corrianus* from the Vasind and Koshimbi sampling sites of Bhatsa River are presented in Fig 3 and Table 3. Length-weight relationship observed for the specimens of *L. corrianus* collected from Vasind was $TW = -0.84\ TL^{2.8}$, $WW = -1.47\ TL^{2.8}$, $DW = -1.89\ TL^{2.26}$ and $SW = -1.28\ TL^{2.98}$. An r^2 value was found to be higher (0.8254) for the TL-TW relationship showing 82.54% strong correlation. Length-weight relationship observed for the specimens of *L. corrianus* collected from Koshimbi was $TW = -0.86\ TL^{2.76}$, $WW = -2.06\ TL^{3.59}$, $DW = -3.54\ TL^{4.32}$ and $SW = -0.98\ TL^{2.55}$. An r^2 value in between TL-WW relationship for *L. corrianus* collected from Koshimbi, was found to be higher (0.9102) showing 91.02% strong correlation. Single factor ANOVA revealed significant length to weight relationship ($p<0.05$) for all length-weight models.

Table 2. Pearson correlation between physico-chemical parameters, percentage moisture content, percentage meat yield and Condition Index coefficients (r)

Pearson Correlation	pH	Water temperature	DO	Turbidity	Conductivity	BOD	TDS	Nitrate	Phosphate	% Moisture content	% Meat Yield	Condition Index
pH	1.0	0.117	**0.879***	-0.670	-0.769	0.127	-0.768	-0.716	0.011	-0.544	0.742	**0.839***
Water temperature		1.0	0.445	-0.580	-0.434	**0.873***	-0.470	-0.557	-0.061	-0.301	-0.044	0.444
DO			1.0	**-0.861***	**-0.964****	0.545	**-0.970****	**-0.886***	0.000	-0.693	-0638	**0.966****
Turbidity				1.0	**0.909***	-0.574	**0.838***	**0.906***	0.303	0.425	-0.202	**-0.860***
Conductivity					1.0	-0.599	**0.962****	**0.914***	0.136	0.686	-0.512	**-0.958****
BOD						1.0	-0.607	-0.660	-0.106	-0.623	0.175	0.588
TDS							1.0	**0.812***	-0.131	0.641	-0.541	**-0.903***
Nitrate								1.0	0.434	0.736	-0.487	**-0.962****
Phosphate									1.0	0.189	0.125	-0.229
% Moisture content										1.0	**-0.819***	-0.795
% Meat Yield											1.0	0.660
Condition Index												1.0

Bold values represent correlation with significance.

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

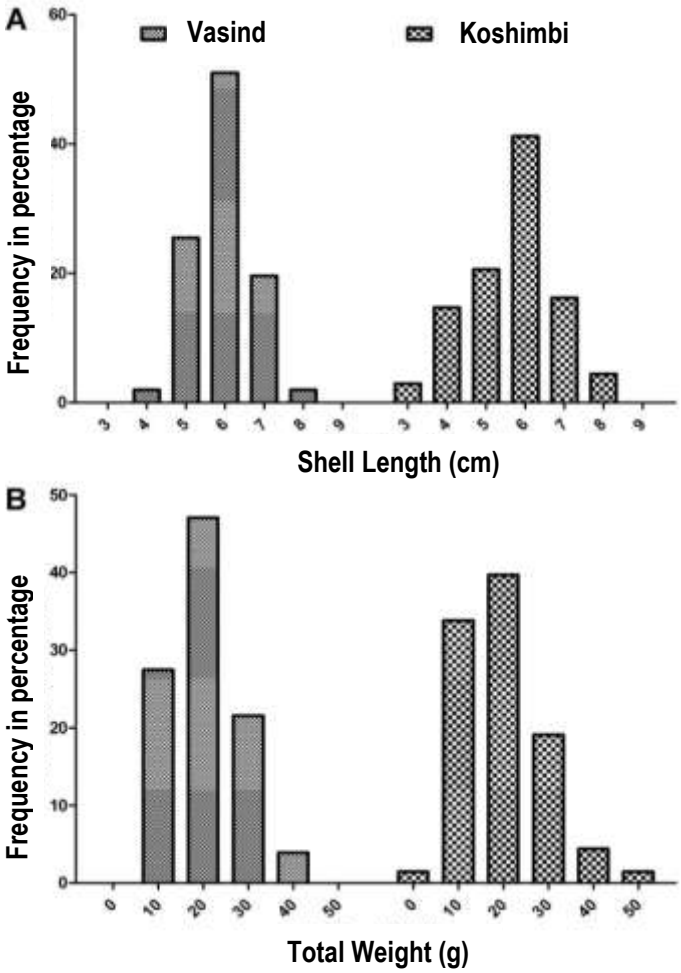

Fig. 2. Frequency distribution of (A) shell length and (B) weight of *L. corrianus* from Vasind and Koshimbi sampling sites of Bhatsa River

Percentage moisture content, meat yield and Condition Index

Results of percentage moisture content, percentage meat yield and Condition Index of *L. corrianus* collected in 3 months from Vasind and Koshimbi are presented in Fig 4A, 4B and 4C. The average moisture content of the samples collected from Vasind and Koshimbi were found to be 75.6±7.6 % and 77.7±4.7 % respectively. Average value of percentage meat yield for samples collected in three samplings from Vasind was 26.5±1.79 % and, from Koshimbi, 24.98±1.7 %. Condition index ranged between 6.82±3.95 to 8.78±3.79 and 4.93±2.20 to 6.53±2.36 for samples collected in three samplings from Vasind and Koshimbi respectively. ANOVA between percentage meat yield values as well as in between Condition Index values shows no significant difference ($p>0.05$). Pearson correlation analysis between percentage moisture content, percentage meat yield and Condition Index of *L. corrianus* and physico-chemical parameters of water is presented in Table 2.

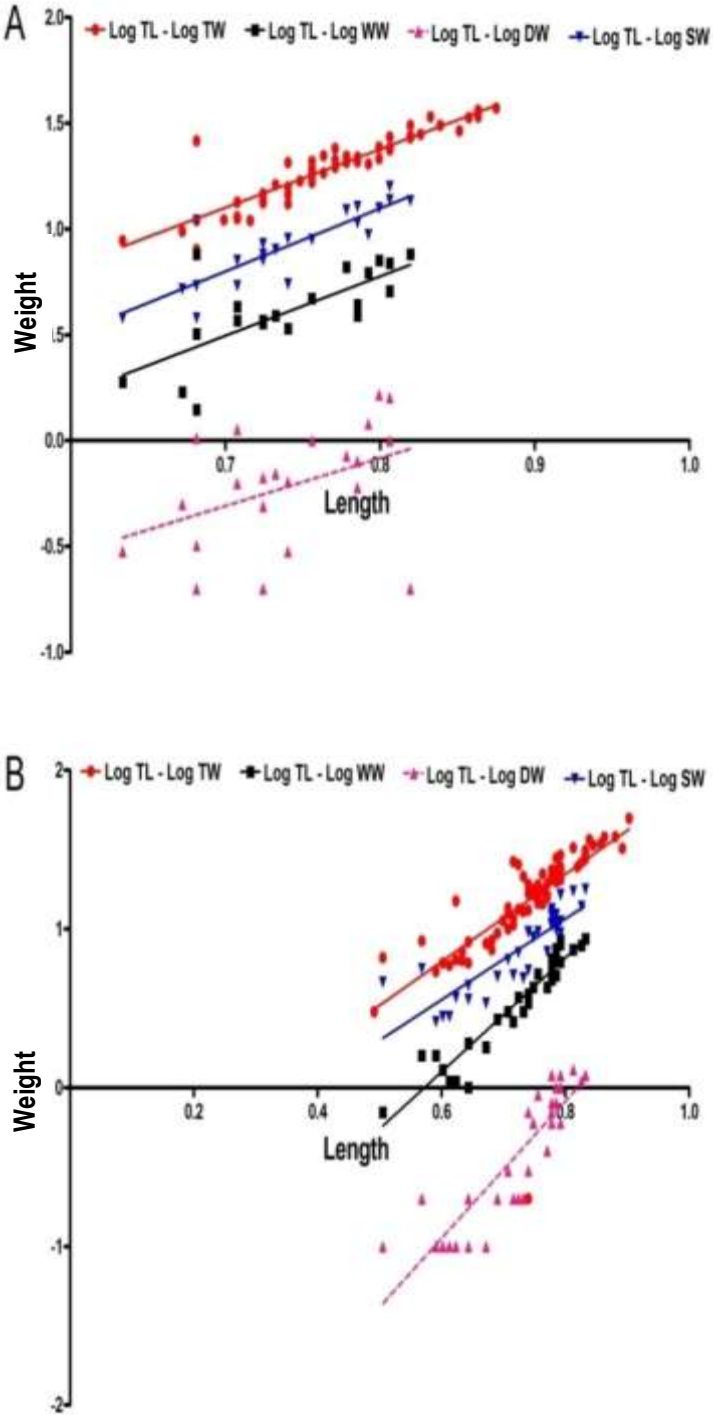

Fig. 3. Linear regression between log (length) and log (weight) of *L. corrianus* from A) Vasind and B) Koshimbi sampling sites of Bhatsa River**.**

Table 3. Values of constant 'a' and 'b' in the linear regression analysis of total length and various parameters of weight of *L. corrianus* with respective r^2 values.

Parameters	Vasind Sampling Site				Koshimbi Sampling Site			
	TW	WW	DW	SW	TW	WW	DW	SW
Slope	2.8 ± 0.18	2.8 ± 0.60	2.26 ± 1.11	2.98 ± 0.41	2.76 ± 0.36	3.59 ± 0.20	4.3 ± 0.41	2.55 ± 0.28
Y-intercept when X=0.0	-0.84 ± 0.14	-1.47 ± 0.45	-1.89 ± 0.83	-1.28 ± 0.30	-0.86 ± 0.27	-2.06 ± 0.15	-3.54 ± 0.30	-0.98 ± 0.20
R square (r^2)	0.82	0.52	0.17	0.73	0.57	0.91	0.78	0.73
F	231.6	21.74	4.095	53.12	59.69	314.1	112.2	84.41
DFn, DFd	1.000, 49.00	1.000, 20.00	1.000, 20.00	1.000, 20.00	1.000, 68.00	1.000, 31.00	1.000, 31.00	1.000, 31.00
P value	< 0.0001	0.0001	0.0566	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Deviation from zero	Significant	Significant	Not Significant	Significant	Significant	Significant	Significant	Significant

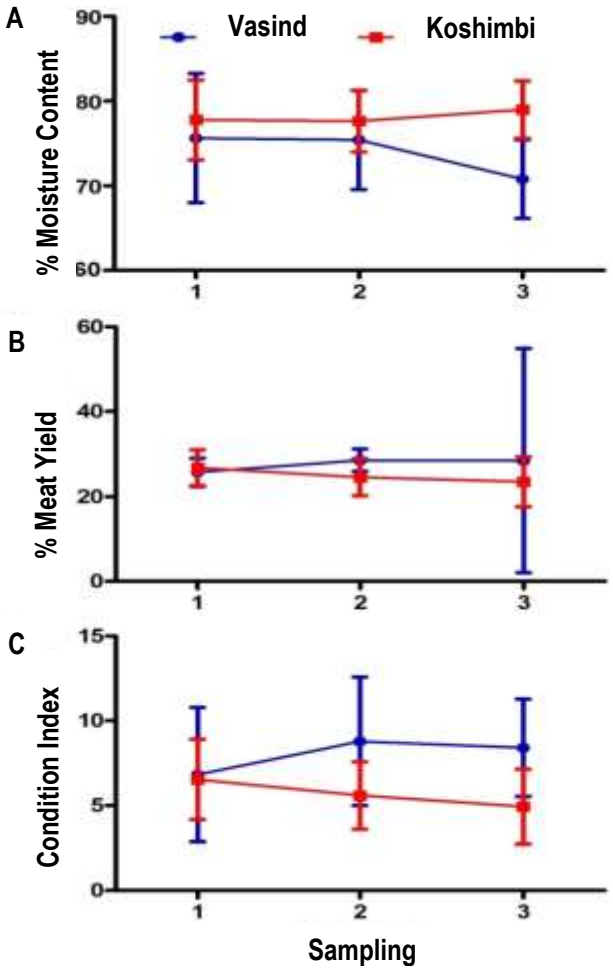

Fig. 4. Variation of A) Percentage moisture content B) Percentage meat yield and C) Condition Index of *L. corrianus* from Bhatsa and Koshimbi sampling sites

Biochemical Estimations

Percentage of protein, lipid and carbohydrate present in *L. corrianus* is presented in Table 4. In all the tissues protein is present in higher amount followed by carbohydrates and lipids. In animals of 3–6 cm size collected from Vasind and Koshimbi, percentage protein content was found to be highest in gills (between 30.2±14.14 % and 68.1±12.17 % respectively) followed by foot (between 20.8±8.64 % and 40.4±18.28 % respectively) and adductor muscle (between 20.6±3.92 % and 20.2±2.69 % respectively) whereas in the 6.1–9.0 cm size group of animals collected from Vasind and Koshimbi, percentage protein content was found to be highest in gills (61.5±4.21 % and 30.7±9.2 % respectively) followed by adductor muscle (33.9±8.11 % and 28.3±11.12 % respectively) and foot (30.6±7.14 % and 20.4±6.85 % respectively). The lipid content was found to be highest in adductor muscle followed by gills and foot for both size groups of animals collected from Vasind and Koshimbi.

The range of percentage lipid content was found to be between 3.31±0.7 % (adductor muscle of 6.1–9.0 cm size group animals collected from Vasind) to 0.97±0.13 % (foot tissue of 3.0–6.0 cm size group of animals collected from Koshimbi). Carbohydrate values were high in the foot followed by gills and adductor muscle. The range of percentage carbohydrate content was found to be between 11.72±0.84 % (foot tissue of 3.0–6.0 cm size group animals collected from Vasind) and 9.66±0.25 % (adductor muscle of 6.1–9.0 cm size group of animals collected from Koshimbi).

Single factor ANOVA between length groups of Vasind and Koshimbi shows non-significant variation for percentage protein content ($p = 0.34$), percentage lipid content ($p = 0.95$) and percentage carbohydrate content ($p = 0.98$). A significant negative correlation was obtained between the percentage carbohydrate content and the percentage lipid content ($r = -68$, $p = 0.015$) (Table 5.).

Table 4. Nutrient profile of different tissues of *L. corrianus* from Bhatsa River

Location	Length group (cm)	Tissue assessed	% Protein	% Lipid	% Carbohydrate
Vasind	3.0 – 6.0	Foot	20.8 ± 8.64	1.33 ± 0.6	11.72 ± 0.84
		Gills	30.2 ± 14.14	1.49 ± 0.03	11.32 ± 0.14
		Adductor muscle	20.6 ± 3.92	2.92 ± 0.21	10.11 ± 1.31
	6.1 – 9.0	Foot	30.6 ± 7.14	1.1 ± 0.66	11.53 ± 0.43
		Gills	61.5 ± 4.21	1.43 ± 0.55	11.22 ± 0.64
		Adductor muscle	33.9 ± 8.11	3.31 ± 0.7	9.87 ± 0.14
Koshimbi	3.0 – 6.0	Foot	40.4 ± 18.28	0.97 ± 0.13	11.46 ± 0.68
		Gills	68.1 ±12.17	1.10 ± 0.71	11.19 ± 0.28
		Adductor muscle	20.2 ± 2.69	3.05 ± 1.28	10.81 ±0.11
	6.1 – 9.0	Foot	20.4 ± 6.85	2.07±1.04	11.71 ± 0.88
		Gills	30.7 ± 9.2	2.24±1.05	11.44 ± 0.13
		Adductor muscle	28.3 ± 11.12	2.17±0.23	9.66 ± 0.25

Table 5. Pearson correlation coefficients (r) between nutritional parameters and caloric value

Correlation	% Protein	% Lipid	% Carbohydrate	Caloric Value
% Protein	1			
% Lipid	-0.482	1		
% Carbohydrate	0.111	**-0.68***	1	
Caloric Value	**0.998****	-0.434	0.0897	1

Bold values represent correlation with significance.

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

Caloric content

Average caloric content (Kcal.g-^{1}) in foot, gill and adductor muscle tissues is given in Fig 5. Caloric content in both size group animals collected from both sampling sites, ranged from 1.78 Kcal.g-^{1} dry tissue (foot of 3.0–6.0 cm size animals from Vasind) to 4.43 Kcal.g-^{1} dry tissue (gills of 3.0–6.0 cm animals from Koshimbi). Caloric content in all analysed animals was found to be high in gills (2.31–4.43 Kcal.g-^{1}). In all animals belonging to the 6.1–9.0 cm size, caloric content was found to be highest in the gills followed by the adductor muscle and foot respectively. In animals belonging to the 3.0–6.0 cm size, caloric content following the gill was found to be nearly similar in the foot and adductor muscle from Vasind and less in the foot than in the adductor muscle in animals from Koshimbi. Pearson correlation analysis between nutritional parameters and caloric content is presented in Table 5. A highly significant correlation was established between the caloric content and percentage protein contents (r = 0.998, p = 0.001).

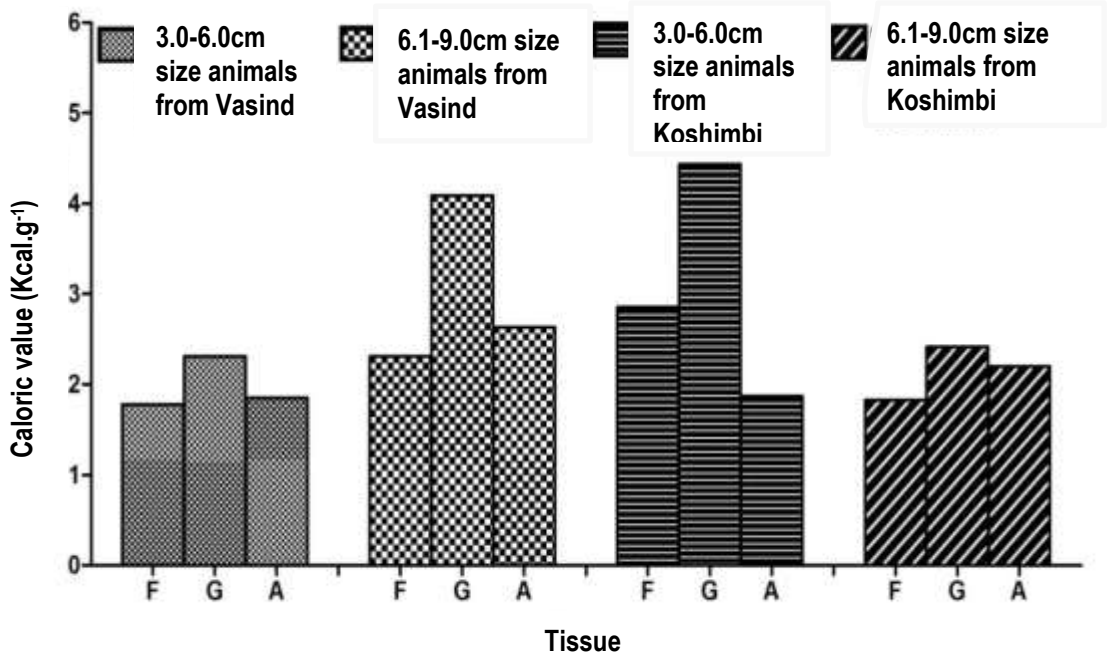

Fig. 5. Average caloric content value (Kcal.g^{-1}) in foot (F), gill (G) and adductor muscle (A) tissues of 3.0 – 6.0 cm and 6.1 – 9.0 cm sizes of *L. corrianus* from Vasind and Koshimbi sampling sites

Discussion

The results of this study indicate that the water quality parameters analysed from the Bhatsa River were all within safe limits for human consumption (BIS 2009), even though an oil factory is situated on the bank approximately 8 km upstream from the sampling site at Vasind. Presence of oil in water has been observed at Vasind sampling site.

A steel factory is situated on the bank in between Vasind and Koshimbi sampling sites. Giant housing projects are developing near the banks of the river. Illegal sand mining and the utilisation of hazardous fishery techniques, such as use of electric shock for eel fishery, were observed during the study period. Comparatively, water from Vasind sampling station contains more DO and less turbidity, conductivity, BOD, TDS and nitrate content than Koshimbi. High DO conditions may function as an indicator of more primary productivity (photosynthetic processes) in water (Odum 1956). Increase in water turbidity of river affects the availability of suspended food particles and eventually causes exponential declines in metabolic efficiencies in bivalves (Madon et al. 1998). In the present study, the condition of the bivalves was positively linked with DO and pH and negatively linked with turbidity, conductivity, TDS and nitrate content of water. The river at Koshimbi is shallow with moderate water current leading to resuspension of bottom sediment. This study demonstrates that the sampling site at Vasind in the Bhatsa River, with lower turbidity, is more suitable for rearing and utilisation of *L. corrianus*.

Size frequency distribution shows that the middle sizes (5.5–6.5 cm length, i.e. individuals of reproductive age) were greater in number in the population of *L. corrianus* at Bhatsa River (Fig 2). Predation by birds at a culture area can have a significant effect on mortality rates of bivalves (Hamilton et al. 1994). Large numbers of empty shells of *L. corrianus* ranging in size from 7.0 –9.0 cm displaying signs of having been cracked open by birds were observed at the study area. An appropriate control strategy for bird predators would be required to reduce selective hunting of large bivalves (Littauer et al. 1997). The use of length-weight relationships of animals to determine their growth rates is a widespread practice in fisheries research. Allometry obtained from length-weight relationships gives valuable information on condition and growth patterns of the bivalves. *Lamellidens corrianus* collected from Koshimbi TL-WW (b = 3.59) and TL-DW (b = 4.3) showed a strong positive allometric relationship. The b value of TL-WW and TL-DW relationship of *L. corrianus* specimens collected from Koshimbi in the present study is higher than that of *L. corrianus* from the Khandepar River in Goa state (Desai and Borkar 1989) and *Parreysia corrugata* (Muller 1774) from Kempuhole River in Karnataka state (Ramesha and Thippeswamy 2009) of India. It reveals that growth of flesh in *L. corrianus* from Koshimbi is faster than its length and also suggests a high food yield for human consumption. The b value of TL-SW relationship model in *L. corrianus* collected from Vasind is higher than that of other estimated length-weight models. This reveals that in specimens collected from Vasind more energy goes towards shell growth than tissue growth.

The percentage moisture content of *L. corrianus* from Bhatsa River is lower than that of *Lamellidens marginalis* (Lamarck 1819) (80.03±0.09%) collected from fresh water ponds in West Bengal (Haldar et al. 2014). This low percentage of moisture content is attributed to a higher percentage of organic content in the soft body tissue of *L. corrianus* compared to *L. marginalis*. In the same way, higher moisture content of *L. corrianus* at Koshimbi is attributed to a decline in metabolic efficiency and less deposition of nutrient in the soft body tissue compared to *L. corrianus* collected from Vasind.

The average meat yield and condition index of specimens collected from Vasind are higher than those from Koshimbi. Williams and McMahon (1989) reported high meat yield and condition index in bivalves with a high spawning rate. Spawning of *L. corrianus* occurs throughout the year with definite peaks (Nagabhushanam, and Lohgaonker 1978). The high meat yield and condition index corresponds with good gonad condition of *L. corrianus* in Vasind. Further work on seasonal condition index and reproductive physiology is needed to decide harvesting strategy for *L. corrianus* from Bhatsa River. In the collected specimens of *L. corrianus*, percentage protein content was found to be highest in the gill followed by the adductor muscle and foot tissue. Percentage lipid content was found to be highest in the adductor muscle followed by the gills and foot. Carbohydrate values were highest in the foot followed by gills and adductor muscle. These distinct variations in storage of nutrients might be related to the distinct physiological functions and degree of metabolism of each organ.

Protein content was found to be maximum in dry tissue weight of *L. corrianus* followed by glycogen and lipid. A similar pattern has been reported in dry tissue weight of freshwater bivalves *Parreysia favidens* (Benson 1862) from Tungabhadra River, Karnataka (Shetty et al. 2013). Caloric content for freshwater bivalve tissue appears to be slightly lower than in most species of marine bivalves, but considering its availability, easy access and scope of culture, the freshwater bivalve has potential to be developed as a good alternative food resource in the future. Caloric content was found to be high in flesh of large specimens collected from Vasind whereas, for specimens collected from Koshimbi, caloric content was found to be higher in the flesh of small or young animals. Harvesting of large (especially post reproductive period) individuals of bivalves is preferable for their sustainable utilisation. The caloric value in the flesh of freshwater bivalves may vary according to environmental factors such as water quality, food availability and reproductive cycles (Nalepa et al. 1993). Variation of caloric content in animals collected from different sampling sites may suggest a spatial variation in water quality, food availability and period of reproductive cycles for *L. corrianus*.

Conclusion

This study has demonstrated that water and flesh quality of the bivalve *L. corrianus* collected from Vasind and Koshimbi reflects excellent conditions for bivalve culture at Bhatsa River. *Lamellidens corrianus* from the sampling site of Koshimbi has more growth in terms of flesh content. However, meat yield and Condition Index of *L. corrianus* is superior at the Vasind sampling site. Also, the high occurrence of middle-age individuals with high caloric value at the Vasind sampling site makes this site more suitable for aquaculture. More detailed studies on the seasonal biochemistry and physiology of reproduction in *L. corrianus* are necessary to decide strategies for aquaculture and sustainable utilisation of *L. corrianus* from Bhatsa River.

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