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MORPHOTYPIC DIFFERENTIATION IN THE FEMALE POPULATION OF GIANT FRESH WATER PRAWN, *MACROBRACHIUM ROSENBERGII* (DE MAN)

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ABSTRACT

The differentiation of various morphotypes in female population of *Macrobrachium rosenbergii* (de Man) identical with their male counterparts from the Vembanad lake has been established on the basis of colour pattern and pattern of spination of second cheliped, structure of dactylus, relative growth and allometric characterization. A sequential pattern of transformation observed in female morphotypes of the Vembanad lake would also support the existence of various morphotypes in the population. Orange (OF) and Blue clawed (BF) females are easily distinguished by the presence of orange and blue colours respectively on merus, carpus and propodus while pretransforming stages of the former such as weak orange clawed (WOF), strong orange clawed (SOF) and pre transforming orange clawed (T-SOF) female morphotypes are clearly diagnosed by noticing their distinct colour variations. Two types of blue clawed females BF1 and BF2, despite having similar colour pattern, can be differentiated by observing the hairs on the dactylus. Information on pattern of spination, relative growth within the population and allometric relationships of various morphometric characters are also given.

INTRODUCTION

SEXUALLY matured adult population of male *Macrobrachium rosenbergii* (de Man), belonging to the same age group, reared in ponds were differentiated into three morphologically distinguishable forms such as Small Males (SM), Orange Clawed males (OC) and Blue Clawed Males (BC) based on differential growth pattern, relative body size, second cheliped characteristics and social hierarchical dominance (Cohen *et al*, 1981; Ra'anan and Sagi, 1985; Teleckey, 1984; Ra'anan and Cohen 1985). These animals were reported to be undergoing morphotypical transformations from SM to BC during their developmental pathway (Ra'anan, 1982; Kuris *et al*, 1987) and therefore, two transitional stages of OC males viz, WOC and TSOC were also recognized; former being transitional between SM and SOC, the fully differentiated OC male (Kuris *et al*, 1987) and latter being transitional between OC male and BC male (Sagi and Ra'anan, 1988). The characterization of these morphotypes were made on the basis of variations noticed in the claw colour and spination of second cheliped, relative growth within the population and allometric studies. A similar differentiation of females inhabiting natural waters into various morphotypes has not been attempted hitherto while the females of grow out are reported to be rather homogeneous in nature with regard to the relative body size and weight (Cohen *et al*, 1981; Ra'anan and Sagi, 1985). Three morphotypes viz Virgin Females (VG), Berried Females (BE) and Open Females (Previously berried, OP) were distinguished among females based on their maturity stages (Ra'anan, 1982). However, indepth study on the female population of *M. rosenbergii* collected from its home ground in Kuttanad (Kerala) revealed the female also exhibits distinguishable morphotypic characters analogous to their male counterparts. In the present study an attempt is made to differentiate female morphotypes based on a set of characteristics associated with second cheliped and also the differences brought out in allometric relationships.

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MATERIALS AND METHODS

814 female specimens belonging to size group 130 to 280 mm in total length were collected mainly from upstream regions of the Vembanad lake (Kuttanad) during the monthly fishery survey cruises conducted from March 1993 to February 1994. Total length was measured with a ruler (to 1 mm) from tip of the rostrum to the tip of the telson while the carapace length was measured with a vernier caliper to the nearest millimeter as the distance from the posterior margin of the right orbit to the posterior margin of the carapace at the mid line. Total cheliped length was measured along the extended cheliped length with a ruler (to 1 mm) from the proximal basis of the ischium to the distal tip of propodus along the ventro-lateral surface. Measurements of each podomere is similar to that of Kuris *et al.*, (1987). Telson was measured from its distal tip to the proximal margin. Pleural length was measured at the widest part of the pleural flap on the second abdominal segment. Wet weight was taken with a top pan electric balance to the nearest gram. Observations on colouration and spination were made on fresh specimens. Allometric growth technique used to differentiate male morphotypes (Kuris *et al.*, 1987) was employed by making use of the equation $Y=a+bx$ where a and b being regression parameters to be estimated. However, while studying length-weight relationships, this model was used for logarithmically transformed values of length and weight. Rate of growth of dependent variable relative to the reference character was considered negatively allometric if $b < 1$ positively allometric if $b > 1$ and isometric if $b = 1$ following Kuris *et al* (1987). Regression coefficients were estimated for various morphometric measurements on total length as well as on carapace length, and these estimates were compared using Analysis of Covariance technique (ANACOVA) (Snedecor and Cochran, 1967). However, in all cases, regressions of various morphometric characters on carapace length were found to be significant and, therefore, taken for subsequent analyses.

RESULTS

Colour pattern of the segments of second chelipeds:

The colour pattern of cheliped segments of females distinctly helped to differentiate orange and blue morphotypes, besides, the transitional stages of these morphotypes could also be distinguished based on colour characteristics. However, presence of a female morphotype identical to the small male (SM) was not encountered in the present study. Distinguishing features of the segments of peraeopods of female morphotypes are described below:

1. Orange Clawed female

1a. Weak Orange clawed Females. (WOF)

Ischium	:	Inner and medial face white, outer distal portion white suffused with blue pigments, outer proximal parea yellow to orange.
Merus and Carpus	:	Inner and medial face orange yellow, outer face slightly bluish.
Propodus	:	Orange at the sides and dorsally, the tip of the fixed finger slightly bluish.
Dactylus	:	pale orange coloured and the tip ending in bluish spine.

1b. Strong Orange Clawed female (SOF)

Ischium	:	Inner and medial face white, outer proximal area orange suffused with bluihs pigments.
Merus and carpus	:	Inner and medial face orange to yellow, outer face slightly blue in colour.
Propodus	:	Orange at the sides and dorsally, inner and ventral sides white suffused with orange. Prominent spines present.
Dactylus	:	Orange coloured.

1c. Transforming Orange clawed female (TOF)

Ischium	:	Inner and medial face white, outer proximal area bluish.
Merus and carpus	:	Inner and medial face with slight blue, outer face bluish.

Propodus : Blue at the sides and dorsally, inner and ventral sides white suffused with orange pigments.

Dactylus : Bluish black coloured.

2. Blue clawed Females:

2a. Blue clawed female I (BF 1)

Ischium : Dorsal blue black and inner side and ventral portion whitish.

Merus and Carpus : Deep blue black dorsally and at the sides.

Propodus : Proximally bluish black on all sides, a faint orange ring at the articulation of the movable finger with propodus which pales to the median and outer sides of propodus, the middle portion of propodus deep blue and propodus ends in a reddish claw spine.

Dactylus : naked, deep blue coloured

2b. Blue clawed female II (BF 2):

Ischium : dorsal blue black and sides white.

Merus and carpus : deep blue black and small spines.

Propodus : The orange ring at the junction of the movable finger and propodus reduced to a small patch, prominent but small spines, deep bluish black colour.

Dactylus : covered fully with thick grey hairs the terminal portion being naked forming the claw spine.

Allometric characterization

Animals sampled were primarily classified into five morphotypes viz. Weak Orange clawed Females (WOF), Strong Orange clawed Females (SOF), Transforming Orange clawed Females (TOF), Blue clawed female I (BF 1) and Blue clawed Female II (BF 2), based on morphological characteristics as described above Morphometric measurements of various body parts and wet weights were subjected to detailed regression analysis in order to bring out morphotypic differentiation among females. Regression of various measurements on carapace length of these five morphotypes were tested statistically using ANACOVA and the results so obtained revealed significant differences at 1% level in cheliped length, pleural length, rostral length, ischium, merus, carpus, propodus, dactylus and telson (Table 1). The results of pair-wise analyses using t-test are given in Table 2a.

The regressions of weight, ischium and carpus on carapace length between the pooled data of orange clawed females (WOF, SOF

TABLE 1. *Results of the analysis of covariance comparing the regression coefficients among all morphotypes and betwen Orange clawed and Blue clawed females*

	Among all morphotype			Between OF and BF		
	F VALUE		df	F VALUE		df
Total Length × Weight	6.97**	4	804	19.66**	1	463
Total Length × Cheliped Length	1.47	4	457	2.76	1	463
Total Length × Pleural Length	1.76	4	457	0.29	1	463
Carapace Length × Weight	2.95**	4	457	21.59**	1	463
Carapace Length × Cheliped Length	6.12**	4	457	5.50*	1	463
Carapace Length × Pleural Length	7.15**	4	457	0.16	1	463
Carapace Length × Rostral Length	4.57**	4	'48			
Carapace Length × Ischium	11.63**	4	48	10.03**	1	54
Carapace Length × Merus	4.36**	4	48	3.83	1	54
Carapace Length × Carpus	9.05**	4	48	17.23**	1	54
Carapace Length × Propodus	5.29**	4	48	3.64	1	54
Carapace Length × Dactylus	6.14**	4	48	4.66*	1	54
Carapace Length × Telson	4.01**	4	48	1.31	1	54

* = Significant at 5%. ** = Significant at 1%.

TABLE 2a. *Results of the pair wise analysis by t test on the means of various morphometric measurements*

Characteristics		WOF SOF	WOF TOF	WOF BF1	WOF BF2	SOF TOF	SOF BF1	SOF BF2	TOF BF1	TOF BF2	BF1 BF2
Total Len	df	74	227	327	235	265	365	273	518	426	526
	t	3.30*	3.53*	5.47*	7.58*	0.41	2.08*	6.40*	4.04*	10.75*	8.44*
Carapace	df	53	162	149	142	185	172	165	283	276	263
	t	1.98	1.74	3.43*	6.86*	0.36	2.22*	6.22*	3.96*	9.37*	4.87*
Cheliped	df	51	162	149	142	185	172	165	283	276	263
	t	1.69	1.52	2.78*	5.89*	0.29	1.75	6.69*	3.10*	10.79*	7.50*
Pleural L.	df	51	162	149	142	185	172	165	283	276	263
	t	2.64*	1.62	4.48*	5.14*	0.46	3.30*	6.12*	2.57*	8.15*	7.31*
Weight	df	74	227	327	235	265	365	273	518	426	526
	t	2.63*	2.73*	4.60*	7.45*	0.04	2.69*	8.30*	4.17*	13.23*	11.34*
Rostral L.	df	9	23	15	18	24	16	19	30	33	25
	t	1.49	1.14	1.82	4.03*	0.74	0.15	1.63	0.80	3.50*	2.44*
Telson	df	9	23	15	18	24	16	19	30	33	25
	t	1.33	0.90	1.75	5.86*	0.13	0.54	4.14*	0.74	3.78*	3.39*
Ischium	df	9	23	15	18	24	16	19	30	33	25
	t	1.42	1.24	3.00*	4.71*	0.48	2.13*	4.22*	1.67	4.84*	3.04*
Merus	df	9	23	15	18	24	16	19	30	33	25
	t	2.72*	1.38	2.91*	5.68*	0.42	1.47	4.24*	0.75	3.22*	2.87*
Carpus	df	9	23	15	18	24	16	19	30	33	25
	t	2.98*	1.77	2.63*	6.17*	0.32	0.82	4.20*	1.42	5.65*	3.42*
Propodus	df	9	23	15	18	24	16	19	30	33	25
	t	1.30	0.23	2.03	4.39*	1.26	1.14	3.82*	2.76*	6.02*	3.06*
Dactylus	df	9	23	15	18	24	16	19	30	33	25
	t	0.66	0.09	1.48	3.87*	0.33	1.11	3.82*	1.56	5.01*	3.35*

and TOF) and blue clawed females (BF1 and BF2), showed significant difference at 1% level while regressions of cheliped length and dactylus on carapace length varied significantly at 5% level. The cheliped length in orange clawed females showed allometrical growth in relation to total length (b=0.86, r=0.8188) while in blue clawed females showed nearly isometric growth (b=0.97, r=0.8264). However, the regressions of each segment of the second cheliped on carapace length revealed allometrical growth except in the case of propodus length (Table 3) (Fig. 1).

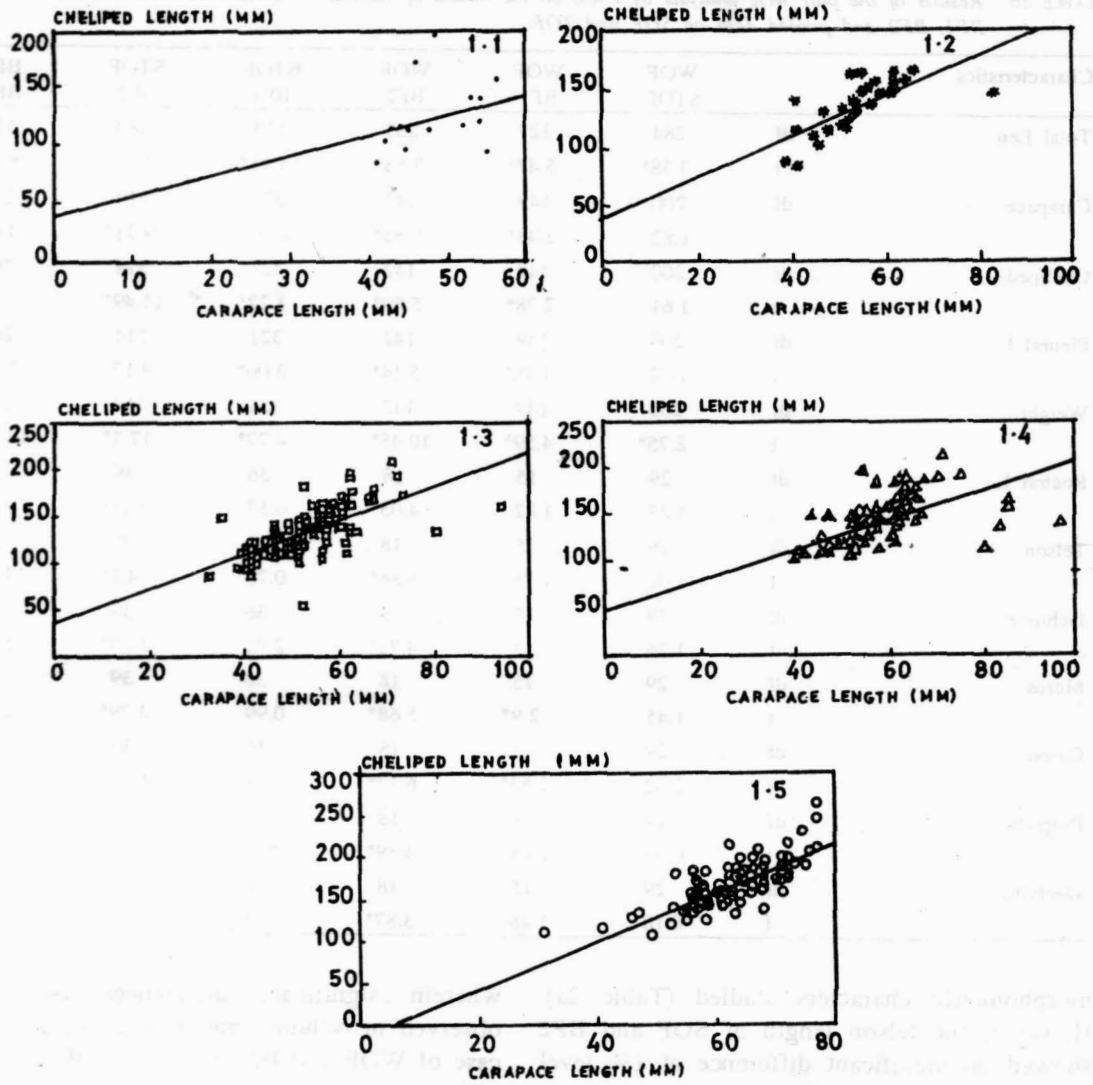

FIG. 1. The regression of cheliped length on carapace length of various female morphotypes of M. rosenbergii.
1.1 WOF 1.2 SOF 1.3 TOF 1.4 BFI 1.5 BF2

Variations noticed in respect of certain body parameters were found apparently suitable for differentiation of individual female

morphotypic changes in colouration of cheliped segments. Blue clawed female II (BF2) showed characteristically significant differences at 1% level from all other morphotypes in all morphometric characters studied (Table 2a). However, the telson length of SOF and BF2 showed no significant difference at 1% level (t=1.63). Significant difference noticed between BF1 and BF2 in all the parameters studied is also noteworthy. BF1 morphotype showed significant difference from WOF, SOF and TOF in regard to total length, carapace length, pleural length and weight. In contrast, the cheliped length of BF1 and SOF did not vary significantly. A comparison of the lengths of segments of second chelipeds of BF1 with Orange clawed females showed contrasting results, wherein significant differences could be observed in ischium, merus and carpus in the case of WOF and BF1 while in SOF and BF1 difference was only noticed in ischium. A similar difference could also be observed in propodus length between TOF and BF1.

Among three orange clawed females, WOF showed significant difference in total length

TABLE 2b. *Results of the pair wise analysis by t test on the means of various morphometric measurements of WOF, BF1, BF2 and pooled data on SOF and TOF*

Characteristics		WOF STOF	WOF BF1	WOF BF2	STOF BF1	STOF BF2	BF1 BF2
Total Len	df	284	327	235	575	483	526
	t	3.58*	5.47*	7.58*	4.11*	11.22*	8.44*
Carapace	df	200	149	142	321	314	263
	t	1.82	3.43*	6.85*	4.09*	9.71*	4.87*
Cheliped	df	200	149	142	321	314	263
	t	1.61	2.78*	5.89*	3.22*	11.49*	7.5*
Pleural L.	df	200	149	142	321	314	263
	t	1.72	4.48*	5.14*	3.00*	9.17*	7.31*
Weight	df	200	149	142	321	314	263
	t	2.75*	4.59*	10.45*	4.77*	17.7*	14.59*
Rostral L.	df	29	15	18	36	39	25
	t	1.27	1.82	4.03*	0.57	3.28*	2.44*
Telson	df	29	15	18	36	39	25
	t	1.02	1.75	5.86*	0.78	4.1*	3.39*
Ischium	df	29	15	18	36	39	25
	t	1.26	3	4.71*	2.01	5.58*	3.03*
Merus	df	29	15	18	36	39	25
	t	1.45	2.9*	5.68*	0.99	3.79*	2.87*
Carpus	df	29	15	18	36	39	25
	t	2.02	2.63*	6.17*	1.49	6.18*	3.42*
Propodus	df	29	15	18	36	39	25
	t	0.04	2.03	4.39*	2.64*	6.21*	3.06*
Dactylus	df	29	15	18	36	39	25
	t	0.18	1.48	3.87*	1.65	5.53*	3.35*

and weight with its closely related other two morphotypes. Incidentally, merus, and carpus of WOF and SOF showed significant variation, on the contrary no similar difference could be seen between WOF and TOF. Interestingly, the results of a pair-wise analysis revealed that no significant variation exists between SOF and TOF (Table 2a). Therefore, the data of these two morphotoypes were pooled and subjected to pair-wise analysis and the results conformed to that of TOF (Table 2b). It may, therefore, be inferred that SOF and TOF are not allometrically different.

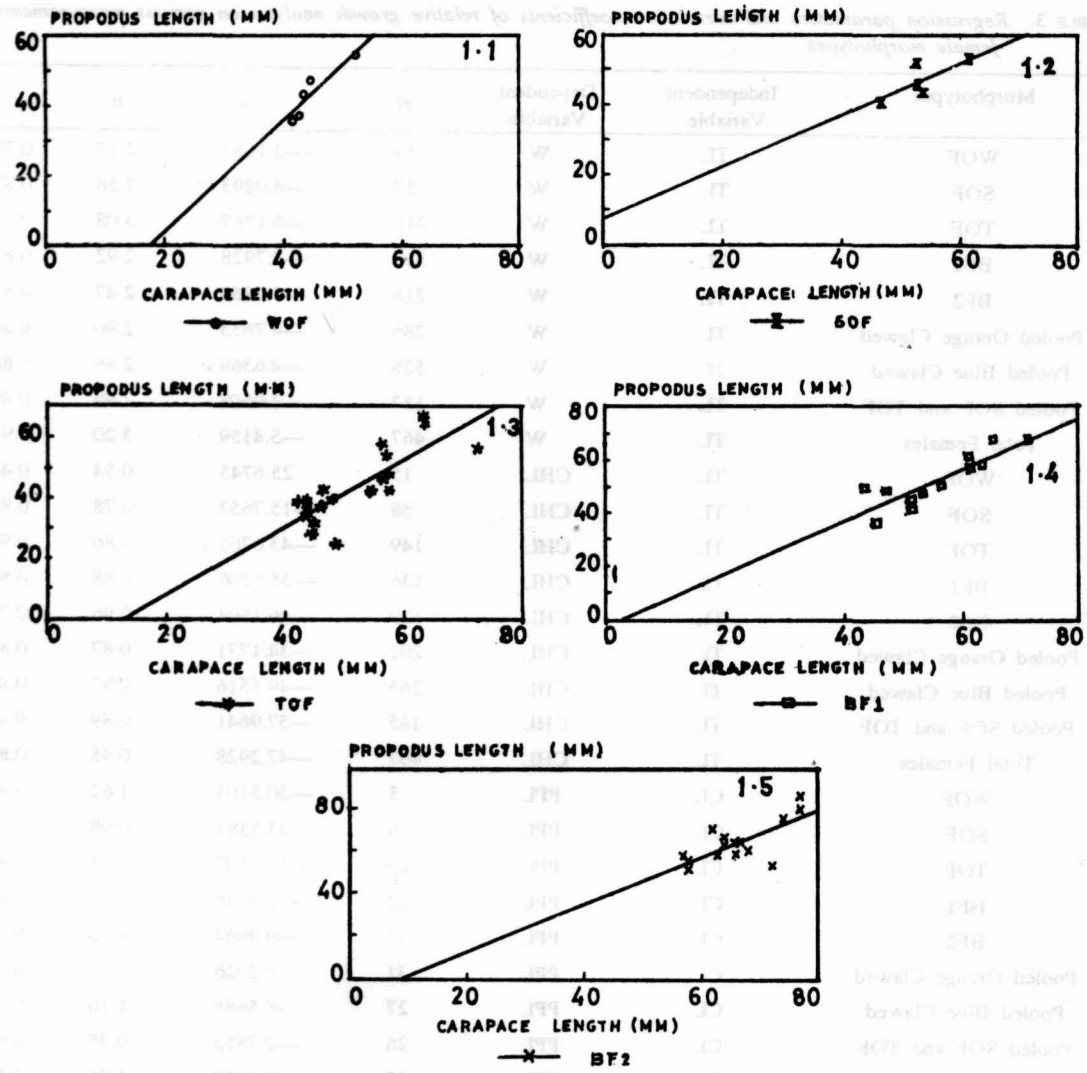

FIG. 2. The regression of propodus length on carapace length of various female morphotypes of *M. rosenbergii*.
1.1 WOF 1.2 SOF 1.3 TOF 1.4 BF1 1.5 BF2

The relative sizes of segments of second chelipeds, though not distinctly apparent as in their male counterparts, can be used as diagnostic tools for the differentiations of morphotypes. The lengths of merus and carpus

showed significant variation between WOF and SOF. In SOF, these segments showed an increase of 30% when compared to similar groups belonging to BF1 differed significantly on propodus length. The regression of propodus length of carapace length on various morphotypes are shown in Fig. 2.

TABLE 3. *Regression parameters and correlation coefficients of relative growth analysis on various measurements of female morphotypes*

Morphotypes	Independent Variable	Dependent Variable	N	a	b	r
WOF	TL	W	19	—3.1037	2.17	0.7979
SOF	TL	W	57	—4.0293	2.58	0.8702
TOF	TL	W	210	—5.1767	3.08	0.9137
BF1	TL	W	310	—4.7928	2.92	0.8956
BF2	TL	W	218	—3.6869	2.47	0.8469
Pooled Orange Clawed	TL	W	286	—4.7653	2.90	0.8999
Pooled Blue Clawed	TL	W	528	—4.6369	2.86	0.8859
Pooled SOF and TOF	TL	W	187	—4.9608	2.99	0.8987
Total Females	TL	W	467	—5.4159	3.20	0.9296
WOF	TL	CHL	15	25.6745	0.54	0.4619
SOF	TL	CHL	38	—15.7657	0.78	0.8481
TOF	TL	CHL	149	—43.6701	0.86	0.9231
BF1	TL	CHL	136	—35.5206	0.88	0.8058
BF2	TL	CHL	129	—46.1504	0.96	0.7769
Pooled Orange Clawed	TL	CHL	202	—34.1771	0.87	0.8294
Pooled Blue Clawed	TL	CHL	265	—49.5516	0.97	0.8264
Pooled SOF and TOF	TL	CHL	185	—37.9641	0.89	0.8527
Total Females	TL	CHL	467	—47.2928	0.95	0.8501
WOF	CL	PPL	5	—30.5103	1.62	0.8998
SOF	CL	PPL	6	43.5384	0.08	0.1863
TOF	CL	PPL	20	—16.7507	1.14	0.8136
BF1	CL	PPL	12	—2.8546	0.99	0.8784
BF2	CL	PPL	15	—9.9964	1.13	0.8024
Pooled Orange Clawed	CL	PPL	31	6.2026	0.71	0.6623
Pooled Blue Clawed	CL	PPL	27	—8.5686	1.10	0.8521
Pooled SOF and TOF	CL	PPL	26	—2.7853	0.75	0.6857
Total Females	CL	PPL	58	—8.4938	1.05	0.8094

TL = Total Length W = Weight PPL = Propodus Length

CL = Carapace Length CHL = Cheliped Length

WOF. However, in these two groups merus and carpus showed allometric relationship to carapace length. Similar result was also obtained between WOF and BF1 morphotypes. TOF and

The results of analysis of covariance showed that among the various morphotypes regression of weight on total length was significantly different at 1% level (Table 1).

The pair-wise analyses showed that total length and weight relationship differed significantly between all the morphotypes except between SOF and TOF. The regression coefficients so derived were tested against the isometric value b=3 by 't' test (Baily, 1959) and the results showed significant difference at 5% level in WOF (b=2.1669), SOF (b=2.5825) and BF2 (b=2.4650). However, the growth of TOF was found to be nearly isometric (b=3.0843) and similar result was also obtained in respect of pooled data of females (b=2.9695) (t=0.61, df=812). The length-weight relationship of various female morphotypes are shown in Fig. 3.

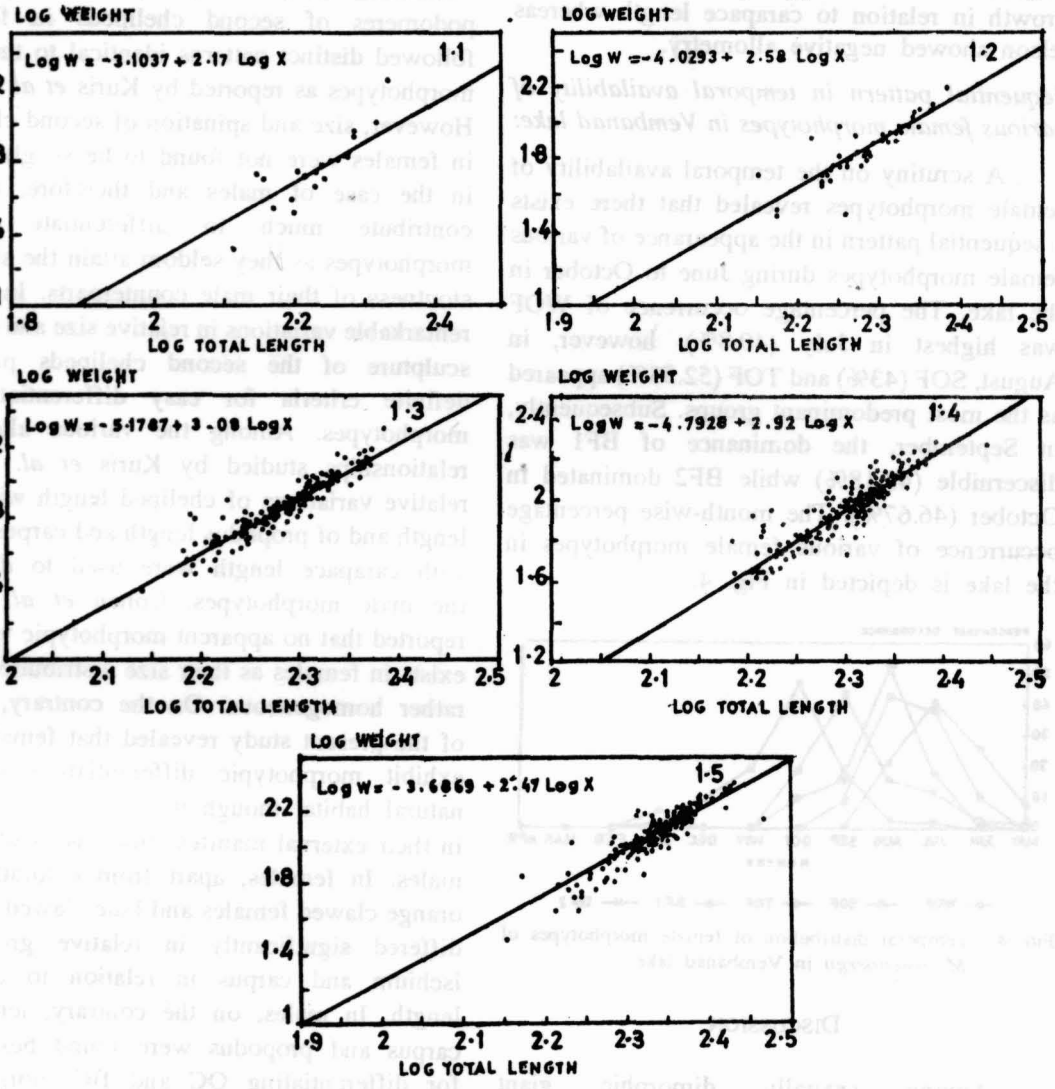

FIG. 3. The length - weight relationships of various female morphotypes of *M. rosenbergii*.
1.1 WOF 1.2 SOF 1.3 TOF 1.4 BF1 1.5 BF2

The regressions of rostral length and telson on carapace length varied significantly at 1%

between the female morphotypes. But in pair-wise analysis, these characters were found to be significant only in the combinations of BF2 with other morphotyes. Among the total females irrespective of morphotypic differentiation, the rostrum followed an isometric growth in relation to carapace length whereas telson showed negative allometry.

Sequential pattern in temporal availability of various female morphotypes in Vembanad lake:

A scrutiny on the temporal availability of female morphotypes revealed that there exists a sequential pattern in the appearance of various female morphotypes during June to October in the lake. The percentage occurrence of WOF was highest in July (40.8%), however, in August, SOF (43%) and TOF (52.58%) appeared as the most predominant groups. Subsequently, in September, the dominance of BF1 was discernible (43.18%) while BF2 dominated in October (46.67%). The month-wise percentage occurrence of various female morphotypes in the lake is depicted in Fig. 4.

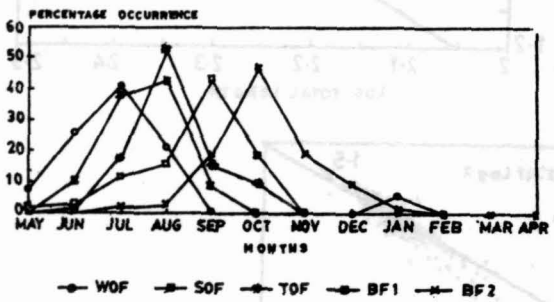

FIG. 4. Temporal distribution of female morphotypes of *M. rosenbergii* in Vembanad lake.

DISCUSSION

Among sexually dimorphic giant freshwater prawns, the adult females seldom attain a relative body size as that of males. The sexes also differed significantly with regard to second cheliped characteristics which being less dominant in females. Kuris *et al* (1987) differentiated mature males of *M. rosenbergii* into three distinct morphotypes primarily based on colouration of claw legs, spination and allometric characteristization. A close examination of commercial catches of *M. rosenbergii* from Vembanad lake revealed that the colour of podomeres of second chelipeds in females followed distinct patterns identical to the male morphotypes as reported by Kuris *et al* (1987). However, size and spination of second cheliped in females were not found to be so glaring as in the case of males and therefore, do not contribute much to differentiate female morphotypes as they seldom attain the size and stoutness of their male counterparts. In males, remarkable variations in relative size and surface sculpture of the second chelipeds provided definite criteria for easy differentiation of morphotypes. Among the various allometric relationships studied by Kuris *et al.* (1987), relative variations of cheliped length with total length and of propodus length and carpus length with carapace length were used to diagnose the male morphotypes. Cohen *et al.* (1981) reported that no apparent morphotypic variation exists in females as their size distribution being rather homogeneous. On the contrary, results of the present study revealed that females also exhibit morphotypic differentiation in their natural habitat though it is not as perceptible in their external manifestations as exhibited by males. In females, apart from coloration, the orange clawed females and blue clawed females differed significantly in relative growth of ischium and carpus in relation to carapace length. In males, on the contrary, lengths of carpus and propodus were found best suited for differentiating OC and BC morphotypes (Kuris *et al.*, 1987). Similarly in BC males carpus showed isometric growth while propodus followed a positively allometric growth (Kuris *et al.* 1987). On the contrary, in the present study, the carpus showed an allometric growth

in both orange and blue clawed females whereas the regression of propodus was isometric. The regression of rostral length and telson to carapace length were significantly different between males and females of *M. lamarrei* (Koshy, 1969), *M. dayanum* and *M. idella* (Jayachandran and Joseph, 1988). The regressions of rostral length and telson length were significantly different among female morphotypes of *M. rosenbergii*. Among blue clawed females, apart from allometric differentiation, BF1 and BF2 could readily be differentiated by the relatively strong second cheliped and also by the presence of thick hairs on the dactylus in the latter. Among orange clawed females, SOF and TOF differed only in colour pattern and no allometric characterization could be possible. Sagi and Ra'anan (1988) reported that pretransforming SOC (t-SOC) represented a transition stage between SOC and BC and these prawns combined the SOC morphology with the first appearance of BC colouration and spination in males.

The relative growth on weight in pooled females was found to be isometrical (b=3.20), r=0.93). This is in agreement with the findings of Suresh Kumar and Kurup (1996). However, it was also reported that irrespective of sexes, *M. rosenbergii* in Vembanad lake followed an allometric form of growth (Kurup *et al.* 1992). From the present findings it is inferred that females follow allometrical growth pattern only in certain morphotypic forms such as WOF, SOF and BF2. In the developmental pathway of male morphotypes the orange clawed males represent a stage of faster somatic growth (Ra'anan, 1982; Ra'anan and Sagi, 1985). But the corresponding female morphotype (SOF) does not follow similar trend. However, when pooled weights of SOF and TOF were regressed on carapace length an isometric growth (b=2.99, r=0.8987) pattern could be seen.

The results of temporal availability of various female morphotypes in the lake also suggest that there exists a cyclic pattern in the occurrence in consonance with developmental pathway as reported in male morphotypes (Kuris *et al.* 1987; Sagi and Ra'anan, 1988). The dominance of various female morphotypes in successive months was in the order of WOF, SOF, TOF, BF1 and BF2 and therefore it may be inferred that female also shows similar differentiation and transformations as reported in males (Kuris *et al.* 1987). In males, the three morphotypes probably represented three developmental stages of maturation process of males and are developed by transformation of one morphotype to another, following an irreversible order from SM to OC to BC (Cohen *et al.* 1981). It would thus appear that the various morphotypes of female so differentiated in the present study and their sequential availability in natural habitat would suggest the possibility of representing different maturation stages and their intermediary transformation stages from one morphotype to another, as reported in their male counterparts (Cohen *et al.* 1981). However, the presence of Small Female (SF) analogous to Small Males (SM) could not be encountered from lake and it may be due to its non-availability in the exploited stock of *M. rosenbergii*. Kurup *et al.* (1995) also reported similar findings in the case of small males (SM) in Vembanad lake. In males, the undifferentiated or SM morphotype either remains as SM or undergoes transformations to orange clawed and to Blue clawed morphotypes, in the absence of the dominant BC morphotype (Cohen *et al.* 1981). Any similar behavioural pattern affecting morphotypic transformation in female, if at all present, is not relevant in a natural system where the individuals are free to be dispersed over a wide range of habitat. The male morpho types were known to exhibit a complex social

organisational hierarchy (Cohen *et al.*, 1981), however, similar behavioural peculiarities among female morphotypes if any, are worth exploring. Similarly the differential growth and mating strategies, if any, exist among the female morphotypes remain to be elucidated which would be useful for controlled mating and genetic improvement. The factors affecting morphotypic differentiation in *M. rosenbergii* are assumed to be the result of environmental consequences, social organisational or genetically determined, the actual mechanism determining such differentiation are yet to be studied.

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