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Studies on the Length-Weight Relationship (LWR) of thirteen (13) dominant estuarine finfish, shrimp and crab species found in Indus delta creeks system

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ABSTRACT

This study was carried out in the Pakistani province of Sindh to ascertain the length-weight connection of thirteen major fish species from the Indus delta creek system. Using a trawl net with a mesh size of 50µ, fish samples were collected. *Arius tenuispinis* showed negative allometric growth all year long, with b = 2.68, b = 2.21, and b = 2.66 during the pre-, during monsoon, and post-monsoon periods, respectively. During the monsoon, *Sillago sihama* exhibits positive allometry growth (b = 3.76), but during the pre- and post-monsoon, it displays negative allometry growth (b = 2.64 and 2.66). *Acanthopagrus arabicus* exhibit different allometry growth patterns: negative growth (b = 2.32) and positive growth (b = 3.48) during the pre- and post-monsoon, respectively. *Lepturacanthus savala* exhibits negative allometric growth (b = 2.47) and (b = 2.50) during the pre- and post-monsoon and isometric growth (b = 3.08) during the monsoon. In the pre-monsoon, *Hyporhamphus limabtus* exhibits negative allometry (b = 2.45) during pre-monsoon, isometric (b = 3.03) during the monsoon, and positive allometry (b = 3.24) during the post-monsoon. For *Pennahia annea,* the monsoon brings about positive allometry growth (b = 3.40) while the post-monsoon brings about negative allometry growth (b = 2.55). The growth indices for the prawn species *Penaeus indicus* were 2.14, 2.33 and 1.84, during pre-, during monsoon and post-monsoon periods respectively, showing negative allometry growth. *Metapenaeus affinis* also exhibited negative allometry growth with b=2.26 and b=1.83 during pre-monsoon and post-monsoon, respectively. *Penaeus penicillatus* also exhibits negative allometry growth with b=1.40 during pre-, b=1.38 during monsoon and b= 1.53 during post-monsoon seasons. Negative allometry growth was demonstrated by *Exopalaemon styliferus,* with b=1.50, b=0.96, and b=1.59 for pre-monsoon, during monsoon, and post-monsoon seasons, respectively. *Charybdis* sp., a species of crab, exhibits negative allometry growth during both the pre- and post-monsoon periods with (b=2.14 and b=0.33). *Charybdis feriata* showed negative allometry growth in the pre-, during-, and post-monsoon periods, with b=1.81, b=2.91 and 2.97, respectively. Moreover, *Portunus pelagicus* showed isometry growth with b=3.15 and b=3.12 during pre- and post-monsoon, respectively, but negative allometry with b=2.91 during monsoon. The values of K and relative condition factor obtained in this study are within the range of expected weight.

Key word: Length-weight relationship, b value, finfish, shrimp, crab species, Indus delta.

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INTRODUCTION

Fish weight-length relationships (WLR) or length-weight (LWR) are an important study tool in fish biology and have drawn a lot of attention. Nonetheless, a variety of variables impact development of fish, and varies appropriately (Bolognini *et al*., 2013; Li *et al*., 2023)). Fishery assessment relies heavily on length and weight relationships, or LWR (Haimovici and Velasco, 2000). Fish length-to-weight ratios can be used to assess fish weight and translate length measurements into a biomass measurement (Froese, 1998). Due to the time-consuming nature of direct weight measurements in the field, length-weight regressions have been utilised extensively for weight-by-length estimation (Sinovcic *et al*., 2004). Fish research requires an understanding of the length-to-weight ratio and the dynamics of fish populations (Lizama and Ambrosio, 2001; Ahmed *et al*., 2003). For the most part, size matters more than age since a number of physiological and ecological parameters depend more on size than on age (Santos *et al*., 2002). In fact, weight is difficult to record in sample programmes; it is typically easier to simply measure length.

According to Pervin and Mortuza (2008), measuring how a species is used and managed in a specific location is helpful. According to Orhan *et al*. (2009), it also forecasted the species' future growth, age, health, and rate of reproduction. Within the study region, three distinct growth patterns were found. The value of b determines how big the fish will become. There are three types of allometry: negative ($b < 3$), when body weight declines relative to body size, positive ($b > 3$), when body weight rises faster than body size and isometric growth ($b = 3$), when body weight grows properly with body size. Many variables, including seasonal fluctuation, species health, age, sex, habitat, and environmental circumstances specific to a certain species, influence the growth types (b = slope) (Ritcher *et al*., 2000; Moutopoulus and Stergio, 2002 and Jaiswar *et al.*, 2004).

In this study, length-weight relationship, and the relationship between the three seasons, i.e. Pre- Monsoon (Jan-May), Monsoon (Jun-Aug), and Post-Monsoon (Sep-Dec) have been determined for most frequently occurring fish species at the study area. As a result, particular species were examined independently; the data of following species were eligible for a LWR relationship plot: a) fish species *Arius tenuispinis, Sillago sihama, Hyporhamphus limbatus, Lepturacanthus savala, Pennahia anea,* and *Acanthopagrus arabicus*; b) shrimp species, *Penaeus indicus, Metapenaeus affinis, Penaeus penicillatus* and *Exopalaemon styliferus;* and c) crab species, *Charybdis* sp*., Charybdis feriata,* and *P. pelagicus.*

2. MATERIAL AND METHODS

The fish samples were collected in the creek survey under FRAP project during March 2013 to May 2014 from Indus Delta creeks system. Survey methodology and fish sample collection is described in Rizvi and Fanning (2012). One of the most crucial methods for managing, producing, and assessing fishery stocks is to keep an eye on their growth trends. The following equation was used to measure the chosen fish species:

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$$W = aLb$$

In this case, W stands for total weight, L for total length, "a" for the intercept and "b" for slope. "A" and "B" have constant and exponent values, respectively. The following formula determined the logarithm transformation of the values:

$$LogW = aLogLb$$

We ignored the "1" value from the length and weight datasets before to the logarithmic adjustment. The value 'a' is obtained from the antilog of intercept value. Since juvenile collections made up the majority of the data, the "1" value took up a lot of space and was transformed to zero. The degree of association and correlation between the length and weight of a chosen species of fish, as measured by the determination co-efficient "r^2" and the correlation co-efficient "r," respectively, is another significant analysis that was performed using LWRs.

A fish's condition factor (K) is a reflection of its physical and biological environment, which is subject to variation based on interactions between its eating habits, parasite illnesses, and physiological variables (Le Cren 1951). This also shows variations in food supplies, which is a sign of the overall health of the fish. The relative condition factor (Kn) for each individual was calculated according to Le Cren (1951) equation $Kn = W/a \times Lb$. Studies on the fish biology have utilised condition factor as a health indicator in relation to feeding intensity and growth (Froese, 2006).

3. RESULTS

a) *Arius tenuispinis*

Arius tenuispinis is a common estuary species that exhibits a modest catches during the rainy season coupled with a positive linear connection. Furthermore, allometric growth was seen to be negative throughout the year. Therefore, before, during, and after the monsoons, b = 2.68, 2.21, and 2.66, respectively. Figure 1 shows a significant connection and coefficient of determination, with the highest values occurring in the pre-monsoon and post-monsoon season ($r = 0.999$ and $r^2 = 0.999$) and ($r = 0.999$ and $r^2 = 0.999$), the lowest values occurring in the monsoon season ($r = 0.995$ and $r^2 = 0.991$), as given in Table 1.

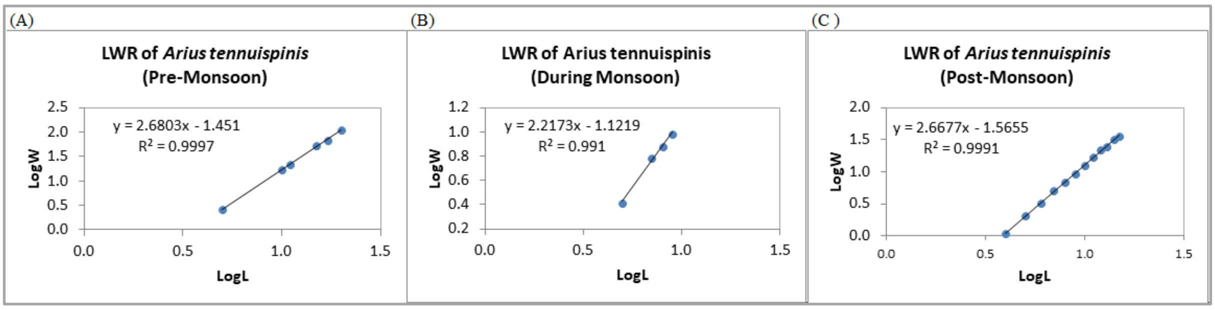

Figure 1 LWR of Thinspine sea catfish (*Arius tennuipinis*) in different seasons

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b) *Sillago sihama*

The *sillago sihama* is a demersal estuarine fish species that is extensively found in the research region. Figure 2 displays the species' LWRs. Small catches were made in the study region during the monsoon, which led to the identification of positive allometry growth (b = 3.76) with a strong correlation coefficient and coefficient of determination (1.0). On the other hand, negative allometry growth (b = 2.64 and b= 2.66, respectively) was noted during the pre- and post-monsoon. Pre-monsoon showed a very strong association (r = 0.998, coefficient of determination r^2 = 0.998), but post-monsoon showed a correlation (r = 0.994, coefficient of determination r^2 = 0.990). Scatter plots have revealed a positive linear association, whereas 0.01-level significance was found in the correlation (Table 1).

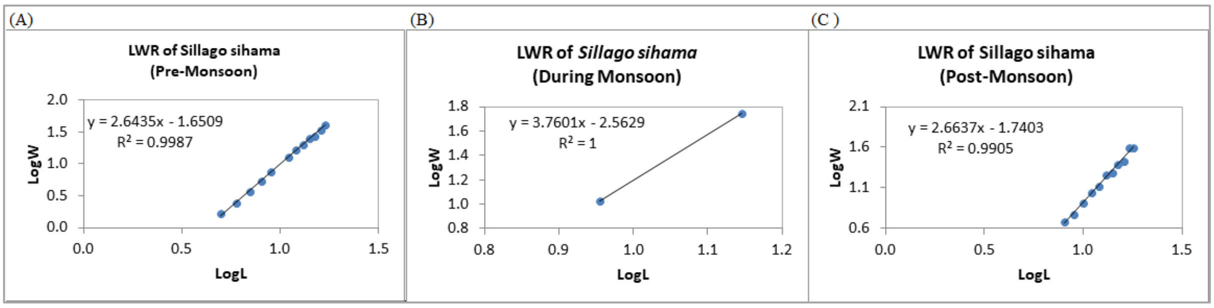

Figure 2 LWR of Silver sillago (*Sillago sihama*) in different seasons

c) *Acanthopagrus arabicus*

Acanthopagrus arabicus is a marine species that is frequently observed within the study area. Figure 3 provides an explanation of *Acanthopagrus arabicus*'s LWRs. No capture records for this species were obtained during the monsoon. However, only a few samples have been obtained for the remaining seasons, which are the pre- and post-monsoons. Conversely, a positive linear correlation has been found between the variables in both seasons, but with distinct patterns of increase. As a result, 2.32, or negative allometry growth, were recorded during the pre-monsoon, whereas 3.48, or positive allometry growth, were noted during the post-monsoon. Both pre-monsoon and post-monsoon periods showed extremely high correlation coefficients and coefficients of determination, with r = 0.996 and r^2 = 0.993 and r = 0.998 and r^2 = 0.998, respectively. At the 0.01 level, the connection was significant (Table 1).

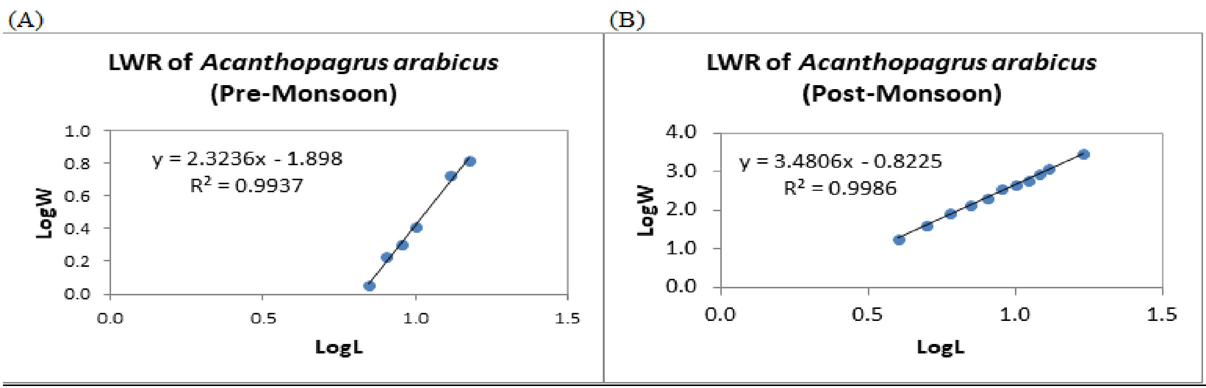

Figure 3 LWR of Arabian yellowfin seabream (*Acanthopagrus arabicus*) in different seasons

d) *Lepturacanthus savala*

Figure 4 displays the LWRs of *Lepturacanthus savala* during the various seasons in the study region. It is evident that there was a significant connection established between the two variables. An isometric growth pattern (b = 3.08) was seen during the monsoon, and both pre- and post-monsoon seasons showed negative allometric growth (b = 2.47) and (b=2.50) respectively. Strong correlation coefficients (r) of 0.996 and 0.998, together with a coefficient of determination (r^2) of over 99%, have been seen both during and after the monsoon. For that reason, three seasons have shown a positive linear association. Consequently, at the 0.01 levels, correlation is significant (Table 1). The species' steady state of health and condition might be attributed to the research area's low economic value.

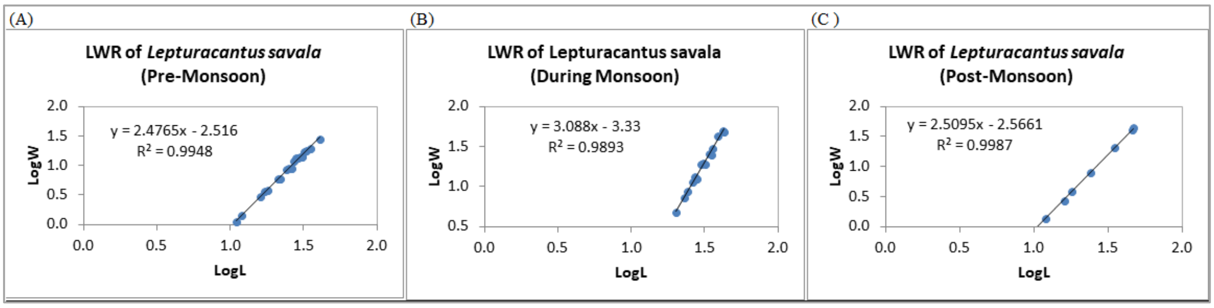

Figure 4 LWR of Savali hairtail (*Lepturacanthus savala*) in different seasons

e) *Hyporhamphus limbatus*

Figure 5 displays the LWR of *Hyporhamphus limabtus* in creeks throughout various seasons. Of the other species that were chosen, it was the first to exhibit positive allometric growth (3.24 during the post-monsoon season), isometric growth (3.07 during the monsoon), and negative allometry (2.45 during the pre-monsoon). Monsoon-related data revealed an extremely high correlation coefficient of 0.998, which was followed by a during monsoon value of 0.997. Thus, in the pre-monsoon, "r" was reported as 0.996. Over the course of three seasons, scatter plots revealed favourable linear relationships. However, a very strong coefficient of determination (0.998) was discovered during the post-monsoon, whereas strong coefficients of determination (0.996) and (0.994) were noted during and pre-monsoon. At the 0.01 level, the connection was significant (Table 1).

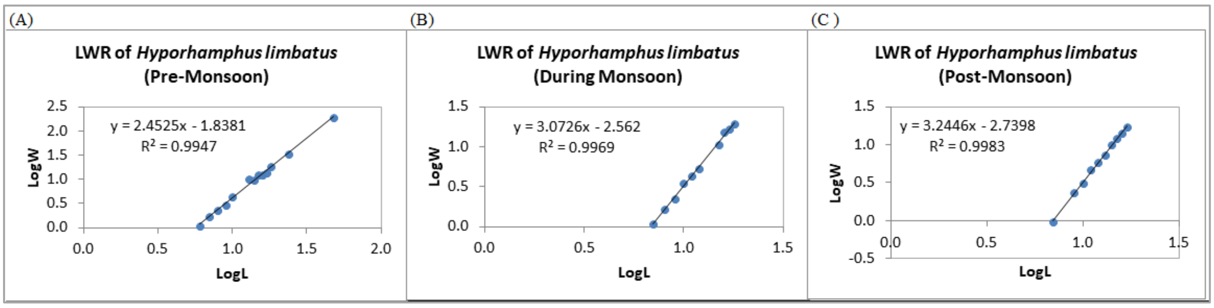

Figure 5 LWR of Congaturi halfbeak (*Hyporhamphus limbatus*) in different seasons

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f) *Pennahia anea*

The well-known croaker fish *Pennahia annea* is captured in the study area. No samples of any species were gathered prior to the monsoon (Figure 6). A few catches, however, was made during the monsoon and it displays a positive allometry growth of 3.40 along with a very significant correlation and coefficient of determination of r = 0.991 and r^2 = 0.983, respectively. A negative allometry growth of 2.55 was seen in the study region during the post-monsoon, accompanied by a significant correlation coefficient and coefficient of determination of r = 996 and r^2 = 0.994 (Table 1). Positive linear relationships between the variables were shown via scatter plots.

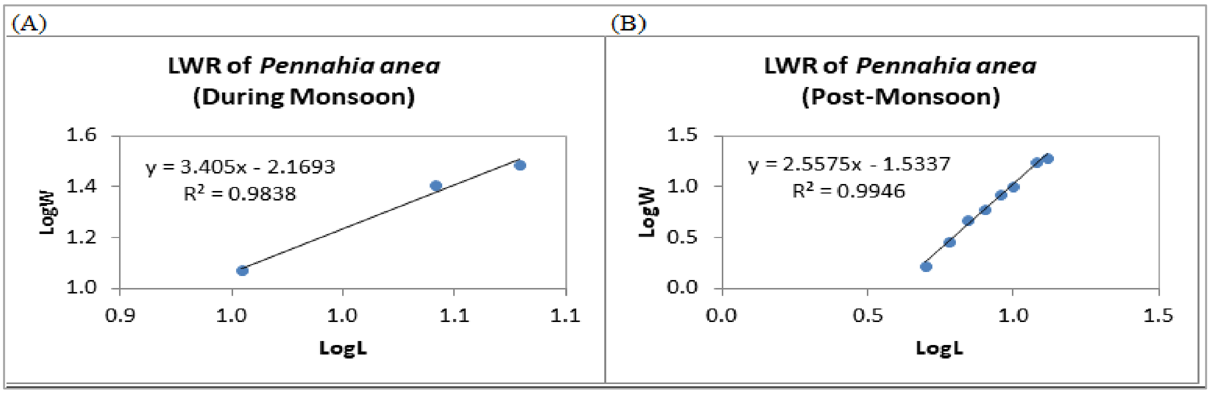

Figure 6 LWR of Donkey croaker (*Pennahia anea*) in different seasons

Shrimp species

a) *Penaeus indicus*

Among the shrimp species found in creeks, *Penaeus indicus* is most commercial species. Large numbers were captured; however the sizes were very small (Fig. 7). Since pre- and post-monsoon periods exhibited negative allometry growth, or b = 2.14 and 1.84, respectively, whereas, it was b = 2.33 during the monsoon. On the other hand, correlation coefficients and coefficient of determination were (r= 0.996) and (r^2= 0.993) during the pre-monsoon and post-monsoon, respectively. Whereas, during monsoon r= 0.997 and r^2= 996 was noted along with the usual coefficient of determination. A positive linear association between the variables was shown using scatter plots (Table 1).

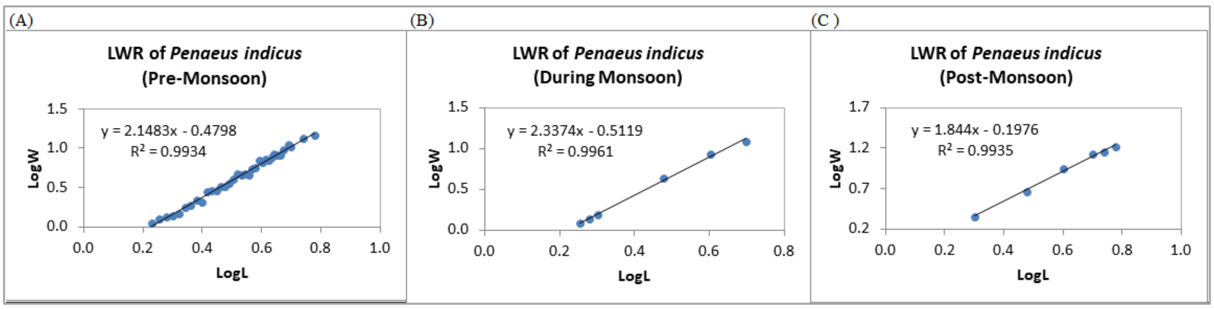

Figure 7 LWR of Indian prawn (*Penaeus indicus*) in different seasons

b) *Metapenaeus affinis*

Figure 8 displays the LWRs of the most commercially significant species in the study region, *Metapenaeus affinis*. Very little catch was reported during the monsoon, much like with *Penaeus indicus*. Scatter plots have been used to determine a positive linear connection. Both pre-monsoon 2.26 and post-monsoon 1.83 were marked by a negative allometry growth pattern, but substantial correlation was noted in the pre-monsoon (r = 0.991 & r^2 = 0.984) and post-monsoon (r = 0.998 & r^2 = 0.998). Figure 8 shows that the connection was significant at the 0.01 level (Table 1).

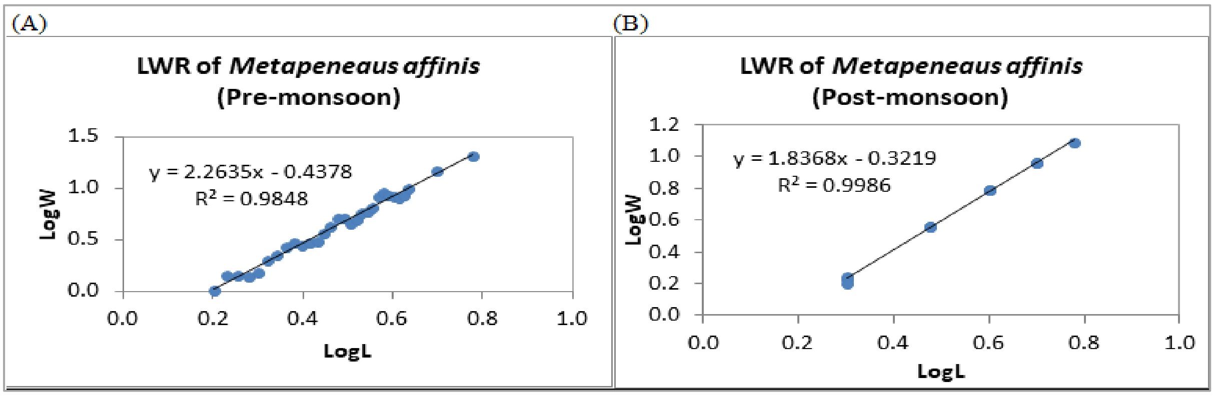

Figure 8 LWR of Jinga shrimp (*Metapenaeus affinis*) in different seasons

d) *Penaeus penicillatus*

Penaeus penicillatus catches in creeks have been few numbers. As Figure 9 makes evident, the greatest capture was reported during the monsoon, although in smaller quantities, despite the lowest catches occurring before and after the monsoon. It displayed a negative allometry growth of 1.40, and 1.38 for pre-monsoon, during-monsoon, respectively. There is strong correlation (r) and coefficient of determination (r^2), for pre-monsoon (r= 0.998) and r^2= 0.997), and (r= 0.990) and (r^2= 0.982) during monsoon respectively (Table 1). During post-monsoon also shows negative allometry growth with b= 1.53 with r^2= 1, as only two samples were recorded.

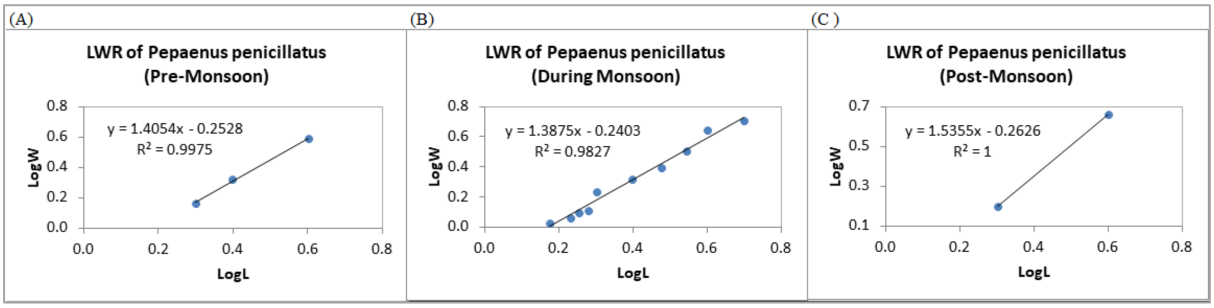

Figure 9 LWR of Redtail prawn (*Penaeus penicillatus*) during monsoon

e) *Exopalaemon styliferus*

Exopalaemon styliferus is another species of estuary prawn; LWR is shown in Figure 10. Pre-monsoon allometry growth was 1.50; during the monsoon, 0.96; and post-monsoon, 1.59. The correlation coefficient, however, was found to be modest to moderate. Pre-monsoon correlation (r =

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0.993); during-monsoon moderate correlation (r = 0.974) and post-monsoon = 0.998). Additionally, scatter plots showed a positive linear link in the pre-, post-monsoon and during monsoon seasons respectively (Table 1).

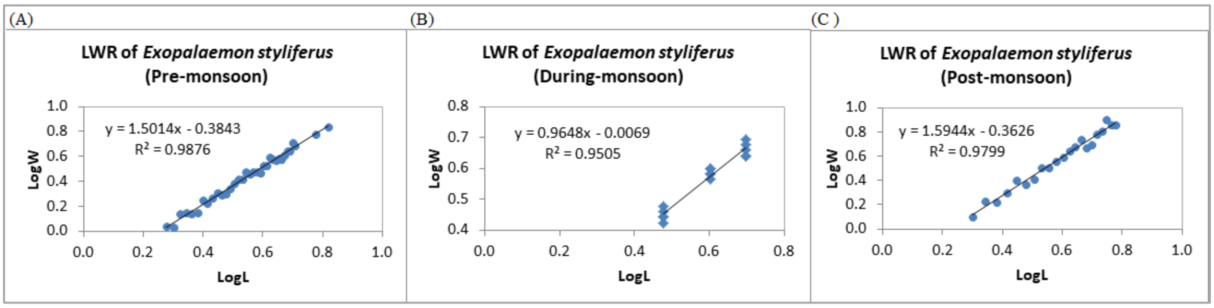

Figure 10 LWR of Roshana prawn (*Palaemon styliferus*) in different seasons

c) Crab species

i) *Charybdis* sp.

The study area's catch of *Charybdis* sp. exhibited significant variance. This species was not observed during the monsoon (Figure 11). It has been discovered that the negative allometry growth was 2.14 and 0.33 in the pre- and post-seasons, respectively. While there is a substantial association between weeks and the variables, it shows a positive linear relationship between the two-month variables. As a result, the correlation coefficient and determination of coefficient were relatively weak in the post-monsoon, measuring 0.986 and 0.998 respectively, compared to 0.992 and 0.998 in the pre-monsoon. At the 0.01 level, the connection was significant (Table 1).

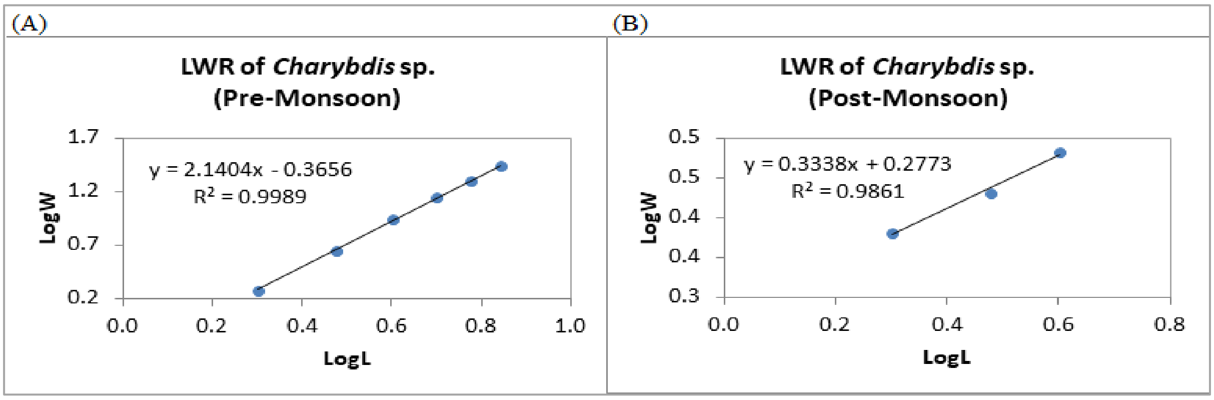

Figure 11 LWR of *Charybdis* sp. in different seasons

ii) *Charybdis feriata*

Figure 12 displays the LWRs of *Charybdis feriata* throughout three seasons in creeks. During the monsoon, only two samples of the species were taken; these samples demonstrated negative allometric growth (b= 2.91), a significant correlation coefficient of 1, and a determination of coefficient of 1. Other than this, throughout certain seasons, a positive linear association has been found between both variables. However, there has been evidence of negative allometry development, with pre-monsoon values of 1.81 and post-monsoon values of 2.97. During the pre-monsoon, a coefficient of determination of 0.997 and a strong coefficient of determination of 0.998 were noted, in addition to a high correlation coefficient of 0.999 and 0.999 during the post-monsoon (Table 1).

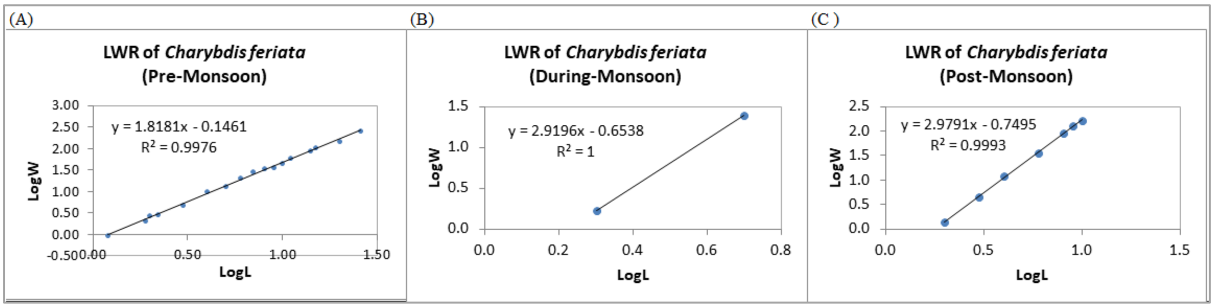

Figure 10.12 LWR of Crucifix crab (*Charybdis feriata*) in different seasons

iii) *Portunus pelagicus*

Figure 13 displays the LWRs of *Portunus pelagicus* at the research location for several seasons. Like the other two species in the Portunidae family, *P. pelagicus* was also sampled in small quantities during the monsoon season. During the monsoon season, despite the meagre catches, negative allometry 2.91 was reported; this indicated a very strong correlation coefficient and coefficient of determination, or 0.996. Pre-monsoon and post-monsoon isometric growth patterns (i.e., 3.15 and 3.12, respectively) have been seen in streams. Consequently, a very high correlation coefficient and coefficient of determination were found in the pre-monsoon period, at 0.995, and the post-monsoon period, at 0.999, both of which were significant at the 0.01 level (Table 1).

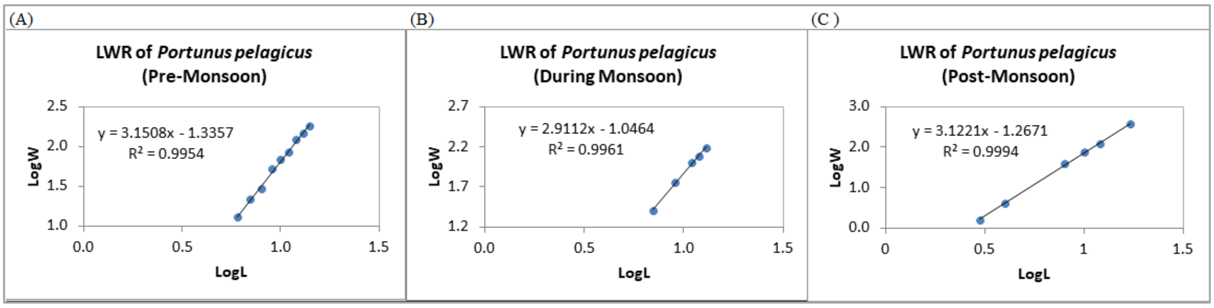

Figure 10.13 LWR of Blue crab (*Portunus pelagicus*) in different seasons

Table 1 Descriptive data and parameters of the LWR of thirteen different fish, shrimp, and crab species

No.	Species	Season	N	Length (cm)	intercept	a	b	S.E.	R	R2
1	*Arius tennuispinis*	Pre-monsoon	11	5 ±20	-1.693	0.0203	2.894	0.044	0.998	0.996
		During monsoon	7	5±9	-1.204	0.0625	2.324	0.024	0.997	0.994
		Post monsoon	201	4 ±15	-1.58	0.0263	2.687	0.017	0.999	0.999
2	*Sillago sihama*	Pre-monsoon	54	5 ±17	-1.606	0.0248	2.63	0.027	0.998	0.997
		During monsoon	2	9±14	-2.543	0.0029	3.775	0	1.000	1.0
		Post monsoon	44	8 ±18	-1.643	0.0228	2.582	0.035	0.993	0.987
3	*Acanthopagrus arabicus*	Pre-monsoon	7	7±15	-1.822	0.0151	2.253	0.026	0.996	0.993
		During monsoon			No catch data					
		Post monsoon	22	4 ±17	-0.835	0.1462	3.502	0.031	0.999	0.998
4	*Lepturacantus savala*	Pre-monsoon	38	17 ±41	-2.559	0.0028	2.51	0.03	0.997	0.994
		During monsoon	28	20±43	-3.254	0.0006	3.044	0.037	0.992	0.985
		Post monsoon	13	10 ±47	-2.631	0.0023	2.595	0.028	0.999	0.998
5	*Hyporhomphus limbatus*	Pre-monsoon	96	4 ±48	-1.859	0.0138	2.475	0.044	0.997	0.995
		During monsoon	22	9 ±18	-2.582	0.0026	3.09	0.03	0.996	0.993
		Post monsoon	37	10 ±17	-2.689	0.0020	3.208	0.023	0.998	0.997
6	*Pennahia anea*	Pre-monsoon			No catch data					
		During monsoon	5	9±12	-2.169	0.0068	3.405	0.039	0.991	0.983
		Post monsoon	102	5 ±13	-1.534	0.0292	2.557	0.029	0.997	0.994
7	*Penaeus indicus*	Pre-monsoon	393	1.6±6	-0.486	0.3266	2.175	0.033	0.995	0.99
		During monsoon	97	1±5	-0.492	0.3221	2.305	0.042	0.996	0.993
		Post monsoon	226	1 ±6	-0.135	0.7328	1.739	0.039	0.994	0.988
8	*Metapenaeus affinis*	Pre-monsoon	828	1.4±6	-0.367	0.4295	2.125	0.05	0.989	0.979
		During monsoon	2	3±3	Data not sufficient					
		Post monsoon	355	1.4 ±6	-0.288	0.5152	1.813	0.03	0.995	0.99
9	*Penaeus penicillatus*	Pre-monsoon	4	2±3	-0.4	0.3981	1.809	0.049	0.977	0.954
		During monsoon	108	1.5±5	-0.24	0.5754	1.387	0.034	0.991	0.983
		Post monsoon	2	2±4	-0.262	0.5470	1.535	0	1.000	1
10	*Palaemon styliferus*	Pre-monsoon	506	2±6	-0.184	0.6546	0.167	0.05	0.976	0.953
		During monsoon	48	3±5	-0.085	0.8222	0.975	0.153	0.983	0.967
		Post monsoon	275	2 ±6	-0.362	0.4345	1.594	0.033	0.990	0.980
11	*Charybdis sp.*	Pre-monsoon	130	2 ±7	-0.955	0.1109	2.162	0.04	0.996	0.993
		During monsoon			No catch data					
		Post monsoon	8	2 ±4	0.179	1.5101	0.557	0.017	0.995	0.990
12	*Charybdis feriata*	Pre-monsoon	152	1.2±26	-1.138	0.0728	1.82	0.037	0.998	0.997
		During monsoon	2	2±5	-0.637	0.2307	2.921	0	1.000	1
		Post monsoon	16	2 ±10	-0.706	0.1968	2.93	0.02	0.999	0.999
13	*Portunnus pelagicus*	Pre-monsoon	29	6 ±14	-1.239	0.0577	3.059	0.03	0.997	0.994
		During monsoon	5	7±13	-1.046	0.0899	2.911	0.022	0.998	0.996
		Post monsoon	7	3±17	-1.228	0.0592	3.085	0.023	0.999	0.999

A fish's condition factor (K) is a reflection of its physical and biological environment, which is subject to variation based on interactions between its eating habits, parasite illnesses, and physiological variables. The value of relative condition factors of above species are given in Table 2.

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Table 2 Calculation of condition factor (relative k-value) of fish species used for LWR.

										relative k-value	
No.	Species	Season	N	Length (cm)	Weight (gm)	a	b	aL^b (min)	aL^b (max)	min	max
1	*Arius tennuispinis*	Pre-monsoon	11	5-20	2.62-107.97	0.0354	2.6803	2.65	108.68	0.991	0.993
		During monsoon	7	5-9	2.6-9.53	0.0755	2.2173	2.68	9.86	0.969	0.967
		Post monsoon	201	4-15	1.07-36.05	0.0272	2.6677	1.10	37.31	0.975	0.966
2	*Sillago sihama*	Pre-monsoon	54	5-17	1.67-40-84	0.0248	2.6300	1.71	42.67	0.979	0.957
		During monsoon	2	9-14	10.6-55.8	0.0029	3.7750	11.46	60.76	0.924	0.918
		Post monsoon	44	8-18	4.86-39.04	0.0228	2.5820	4.88	39.64	0.995	0.985
3	*Acanthopagrus arabicus*	Pre-monsoon	7	7-15	1.14-6.52	0.0127	2.3236	1.16	6.84	0.978	0.953
		During monsoon		No catch data							
		Post monsoon	22	4-17	18.04-2867.1	0.1505	3.4806	18.75	2885.22	0.962	0.994
4	*Lepturacantus savala*	Pre-monsoon	38	11-41	1.12-28.03	0.0030	2.4765	1.16	30.06	0.970	0.932
		During monsoon	28	20-43	4.73-48.37	0.0005	3.0880	4.79	50.92	0.989	0.950
		Post monsoon	13	12-47	1.35-43.54	0.0021	2.5815	1.29	43.73	1.046	0.996
5	*Hyporhomphus limbatus*	Pre-monsoon	96	8-48	2.29-185.83	0.0145	2.4525	2.38	192.81	0.960	0.964
		During monsoon	22	7-18	1.09-19.14	0.0027	3.0973	1.14	21.17	0.963	0.904
		Post monsoon	37	7-17	0.98-17.29	0.0018	3.2446	1.00	17.88	0.971	0.967
6	*Pennahia anea*	Pre-monsoon		No catch data							
		During monsoon	5	9-12	11.76-30.43	0.0068	3.405	12.03	32.03	0.978	0.950
		Post monsoon	102	5-13	1.65-19.38	0.0292	2.557	1.79	20.62	0.923	0.940
7	*Penaeus indicus*	Pre-monsoon	393	1.7-6	0.95-14.67	0.3312	2.1483	1.04	15.55	0.920	0.943
		During monsoon	97	1,8-5	1.2-12.09	0.3077	2.3374	1.22	13.24	0.991	0.913
		Post monsoon	226	2-6	2.27-16.36	0.6344	1.844	2.28	17.27	0.997	0.948
8	*Metapenaeus affinis*	Pre-monsoon	828	1.6-6	1.02-20.59	0.3649	2.2635	1.06	21.06	0.966	0.977
		During monsoon	2	3-3	Data not sufficient						
		Post monsoon	355	2-6	1.68-12.23	0.4765	1.8368	1.70	12.80	0.985	0.955
9	*Penaeus penicillatus*	Pre-monsoon	4	2-4	1.45-3.88	0.5587	1.4054	1.48	3.92	0.981	0.991
		During monsoon	108	1.5-5	0.96-5.09	0.5750	1.3875	1.01	5.36	0.956	0.949
		Post monsoon	2	2-4	1.58-4.59	0.5470	1.535	1.59	4.59	0.999	0.999
10	*Palaemon styliferus*	Pre-monsoon	506	1.8-6.6	0.96-6.87	0.4127	1.5014	1.00	7.02	0.958	0.980
		During monsoon	48	3-5	2.76-4.35	0.9842	0.9648	2.84	4.65	0.973	0.936
		Post monsoon	275	2-6	1.27-7.19	0.4345	1.594	1.31	7.56	0.966	0.952
11	*Charybdis sp.*	Pre-monsoon	130	2-7	1.88-22.03	0.4309	2.1404	1.90	27.75	0.992	0.974
		During monsoon			No catch data						
		Post monsoon	8	1-4	1.5-3.04	1.8936	0.3338	1.89	3.01	0.792	1.009
12	*Charybdis feriata*	Pre-monsoon	152	1.2-26	0.96-252.88	0.7143	1.8181	1.00	266.96	0.968	0.947
		During monsoon	2	2-5	1.68-24.37	0.2219	2.9196	1.68	24.37	1.000	1.000
		Post monsoon	16	2-10	1.4-162.62	0.1780	2.9791	1.40	169.64	0.995	0.959
13	*Portunnus pelagicus*	Pre-monsoon	29	6-14	;12.8-178.05	0.0461	3.1508	13.05	188.33	0.981	0.945
		During monsoon	5	7-13	24.95-152.58	0.0899	2.911	25.95	157.29	0.962	0.970
		Post monsoon	7	3-17	1.61-364.57	0.0540	3.1221	1.67	374.95	0.967	0.972

4. DISCUSSION

Management objectives need an understanding of the biology and population structure of the fishery (Abdallah *et al*., 2022). Morphometric analysis is a helpful tool that complements genetic and environmental stock identification methods in population study. It converts growth-in-length formulas for stock assessment models into growth-in-weight equations. Understanding the relationships between population length and breadth and individual body weight is crucial for both exploitation and population size estimation (Josileen, 2011). Despite the low weight of the prawn species and the small size samples, the current study offers highly valuable information on length-weight relationships (LWRs). This study is further limited by the absence of data for two months (February and March) that may have been useful in analysing pre-monsoon data. This research offers a better path for the management and observation of shrimp resources in Pakistan, as we previously highlighted, as shrimp account for almost 50% of fisheries exports alone.

According to Fischer *et al*. (1990), *Arius tenuispinis* may be found in coastal waters up to a depth of around 50 m. It can also be found in brackish environments (Talwar and Jhingran, 1991). It shows a positive linear correlation and moderate catches from the study region during the wet season.

Moreover, allometric growth was seen to be negative all year long. Consequently, b = 2.68, b = 2.21, and b=2.66, respectively, before, during, and after the monsoon season. Das *et al*. (1997) also reported on allometric growth from the Bay of Bengal. Sawant *et al*. (2013) noted a similar allometric development pattern in the fish taken from the seas around Mumbai.

Within the Study area, the *Sillago sihama* is a common species of demersal estuary fish (WWF, 2015). Additionally, trawl nets (Fanning *et al*., 2016, Muchlis *et al*., 2021) and native nets such as "Tuhkri nets," which are a type of gillnet, are used to catch it (Khan, 1986). The current study's positive allometry growth (b = 3.76) with a strong correlation coefficient and coefficient of determination (1.0) was the result of samples collected during the monsoon. Conversely, negative allometry growth was seen in the pre- and pot monsoon (b = 2.64 and b = 2.66, respectively). Similar allometry growth rates were discovered in samples taken from the Mandapam area of Tamil Nadu by Jayasankar (1991) and from the Bombana district of South East Sulawesi, Indonesia by Muchlis *et al*., (2021). Khan *et al*., (2015) found no discernible variation in LWR between males and females.

According to Iwatsuki (2013), the Arabian yellowfin bream, or *Acanthopagrus arabicus*, is a marine fish that lives in pelagic-neritic environments at depths of up to fifty metres below the sea's surface (Randall, 1995). Though it was not documented during the monsoon, it was sampled often throughout the research region. Only a small number of samples, taken before and after the monsoon, show the negative allometric growth rate during pre-monsoon (b= 2.32), and positive allometric growth (b= 3.48). On the other hand, while with different patterns of rise, a positive linear connection has been discovered between the variables in both seasons. In samples taken from Pakistan's Karachi shore, Riaz *et al*. (2017) discovered a similar kind of negative allometric of LWR in both combined and separate sexes.

The ribbon fish is a benthopelagic marine and brackish water species that may be found at depths up to fifty metres (Froese and Pauly, 2023). Among the marine finfish of Pakistan Waters, it constitutes a significant and plentiful fisheries resource (Abildgaard *et al*, 1986a, Abilgaard and Khan, 1986). In the research region, the LWRs of *Lepturacanthus savala* were examined throughout the several seasons. It is clear that the two variables were found to be significantly correlated. During the monsoon, an isometric growth pattern (b = 3.08) was observed, while the pre-monsoon (b=2.47) and post-monsoon seasons (b=2.50) both displayed negative allometric growth. Both during and after the monsoon, strong correlation coefficients of 0.97 and 0.96 have been observed, together with a coefficient of determination of above 99%. Three seasons have so demonstrated a positive linear connection. Correlation is therefore significant at the 0.01 levels. The stable health and condition of the species may be ascribed to the low economic worth of the research region. Fish samples taken from the shore of Ratnagiri, Maharashtra, India, were likewise found to have the isometric growth pattern by Pakhmode *et al*. (2013). They also failed to discover any appreciable differences between the sexes. Al Sakaff and Esseen (1999) observed that samples taken in Yemeni seas showed negative growth LWR values of b = 2.77 for males and 2.84 for females.

The coastal species *Hyporhamphus limabtus* is widely dispersed in the Indo-West Pacific (Froese and Pauly, 2023) and may be found at the surface of brackish estuaries and tidal freshwaters (Rainboth, 1996). It was discovered in creeks across the study region in a variety of seasons. It was the first selected species to display negative allometry (2.45 during the pre-monsoon season), isometric growth (3.07 during the monsoon), and positive allometric growth (3.24 during the post-monsoon season). Fish taken from Chilika Lake in India showed a negative allometry growth of 2.945, according to Karna *et al*. (2017).

Pennahia annea is found in the Indo-West Pacific, extending from Taiwan to the Persian Gulf, then southward via Borneo, the Philippines, and roughly to the southernmost point of Java (Froese and Pauly, 2023). It is an exclusively marine species that inhabits inshore seas (WoRMS, 2024). It eats tiny fish, benthic worms, and crustaceans (Sasaki, 2001). The study region is home to the well-known croaker fish, *Pennahia annea*. Before the monsoon, no samples of this species were gathered. The majority of the captures, however, were made during the monsoon and show a positive allometry growth of 3.40, r = 0.99 for the coefficient of determination, and r^2 = 0.98 for the very significant correlation. During the post-monsoon, a negative allometry growth of 2.55 was observed in the study region. Muktha *et al*., (2015) showed a similar negative allometetry growth in fish samples taken from the northeast Indian state of Andhra Pradesh.

Penaeus indicus inhabits bottom mud or sand at depths of 2 to 90 metres and is widespread across the Indo-West Pacific region, ranging from East and South East Africa to South China, Papua New Guinea, and North Australia (FAO, 1980). It is most prevalent on mud or sand in shallow seas with a depth of less than 30 metres (FAO, 1984a). According to FAO (1980), the juveniles and post larvae are estuarine; adults live in the sea and reproduce offshore. According to Khan *et al*., (2001) and Macia (2004), they are euryhaline and inhabit brackish, estuarine, and marine habitats with salinities ranging from 5 to 50 ppt and temperature ranges between 18 to 34.5°C. For young *P. indicus*, a salinity of 10 to 15 ppt is ideal. The most common commercial species of prawn discovered in the examined creeks is *P. indicus*. Although a large number were caught, the sizes were quite tiny. During the monsoon, few samples were found which show negative allometry growth with b= 2.33. The pre- and post-monsoon periods also showed negative allometry growth, or b = 2.14 and 1.84, respectively. Hasan *et al*. (2020) observed a similar negative allometry growth (2.15) from Southwestern Bangladesh.

According to Froese and Pauly (2023), *Metapenaeus affinis* is extensively dispersed in the Indo-Pacific region, spanning from the South China Sea and Hawaii to the Persian Gulf and Arabian Sea. It is brackish water, benthic species that may be found at depths ranging from 5 to 92 metres (Holthuis, 1980). The study area's samples demonstrate that a negative allometry growth pattern was present in both the pre-monsoon 2.26 and post-monsoon 1.83 periods. Comparably, Subrahmanyam (1963) discovered negative allometry growth from the Malabar Coast, whereas Razek *et al*. (2022) documented isometric growth from the shores of Egypt's southeast Mediterranean.

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The red tail prawn, *Penaeus penicillatus*, is found in the Indo-West Pacific region, ranging from Taiwan and Indonesia to Pakistan (Froese and Pauly, 2023). This animal is benthic and may be found up to two hundred metres in brackish waters (SAUP, 2006). It has negative allometry growth during all three seasons i.e. b= 1.38 during monsoon, b= 1.40 during pre-monsoon and b= 1.53 during post-monsoon; in the study area. In Zhujiang Estuary, China, a similar negative allometry growth (2.42) was recorded (Chue *et al*., 1995). The negative allometry growth evaluated at 2.93 was reported by Wang *et al*. (2021) from China's Xiamen Bay. These specimens were taken from the replenished stocks.

In the Indo-Pacific region, *Exopalaemon styliferus* is extensively spread. It may be found from the north coast of Borneo and Indonesia, westward via Thailand and India to Pakistan, as well as in the seas off Iraq and Kuwait (Froese and Pauly, 2023). It has also been recorded from Abadan, Iran, downstream of the Bahmanshir River (Zare *et al*., 2010). It is a benthic species found in tropical freshwater and brackish environments (Froese and Pauly, 2023). According to LWR, allometry growth is 1.59 during the post-monsoon period, 0.96 during the monsoon, and 1.50 in pre-monsoon samples. In contrast, isometric growth of 3.18 was discovered by Zafar *et al*. (two thousand) from the Kutubdia channel on the coast of Bangladesh.

In the study area, *Charybdis feriata*'s length-weight relationship revealed allometry growth in each of the three seasons: 2.97 during the post-monsoon, 2.91 during the monsoon, and 1.81 during the pre-monsoon. It is one of the most important fishing resources in China. It was shown that morphological characteristics are essential markers for artificial breeding and seedling propagation. Body weight is always regarded as significant as it is a direct indicator of production performance and is one of the main target qualities for selection in aquaculture. Nevertheless, assessing body weight need a specific workspace in addition to a professional weighing apparatus. However, accurately quantifying physical traits is less complicated (Zou *et al*., 2016).

The study looks at the relationships between the length and breadth of the chelar propodus, the width and length of the abdominal cavity, and the width and length of the carapace in both men and females. These results might be applied to the comparison of global stock levels of the same species (Josileen, 2011). Male, female, and total crab (*P. pelagicus*) individuals in Java, Indonesia, demonstrated positive allometric growth ($b > 3$). (Rohmayani *et al*., 2018). The Portunidae family of crabs, which includes the tropical blue swimming crab *P. pelagicus*, has a significant population in the Indo-West Pacific Ocean (Svane and Hooper, 2004; FAO, 2020b). These crabs are offered frozen or fresh as crab-meet for the canning industry and are less costly than *Scylla* sp. (mud crab) (FAO, 2020a). Positive allometry growth with b= 3.15 duirng pre-monsoon, b= 2.91 during monsoon and b= 3.12 during post-monsoon were recorded. An increased condition factor was seen in the 8 cm wide carapace (Abdallah *et al*., 2022). In contrast, the sample taken from Pakistani waters by (Afzaal *et al*., 2018) revealed isometric growth with combined and separate sexes.

A fish's condition factor (K) is a reflection of its physical and biological environment, which is subject to variation based on interactions between its eating habits, parasite illnesses, and physiological variables (Le Cren 1951). This also shows variations in food supplies, which is a sign of the overall health of the fish. The relative condition factor (Kn) for each individual was calculated according to Le Cren (1951) equation $Kn = W/a \times L^{b.}$ Studies on the fish biology have utilised condition factor as a health indicator in relation to feeding intensity and growth (Froese, 2006). As fish length increases, condition factor decreases (Bakare, 1970). When comparing populations of fish living under different feeding, climatic, and other situations, the condition factor may be utilised to offer information on the variance in fish physiological state (Le Cren, 1951). The values obtained in this study are within range of expected weight.

5. CONCLUSION

This study provides valuable information on length-weight relationships for prawn species, despite low weight and small size samples. Understanding fisheries biology and population structure is crucial for management objectives, and morphometric analysis helps translate growth in length into weight increase. The study helps monitor and manage Pakistan's prawn resources, which make up half of the country's fisheries exports. Relative condition factor (k-value) are within the range.

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