Seasonal and Spatial Growth Patterns of Shrimps Collected from Some Selected Creeks of Sindh, Pakistan

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Abstract: Shrimps are very important part of the export economy of Pakistan. They share about 60 % the total exports of the sea food. For the studies of shrimp health, the length-weight studies are critical for the evaluation of the shrimp stocks. In this paper an attempt has been made to explore the Length-weight relationships of the shrimps at the creeks zone of Sindh coast (the study area). Furthermore, the impacts of seasonal change on the growth of shrimps (length and weight treated as parameter) have been evaluated. The main objective of this study is to analyze the seasonal and spatial pattern of growth and condition of the selected shrimp species. For this purpose, three most abundant shrimp species *Penaeus indicus, Metapenaeus affinis* and *Exopalaemon styliferus* have been selected out of 30 found at the coastal creeks areas of Sindh, Pakistan from April 2013 to January 2014. Pre and Post-Monsoon seasonal changes were analyzed through Geographic Information Science (GIS) and universally accepted equation for LWRs $\log W = a\log L^b$ were applied on three species selected. It has been found that post-monsoon is the ideal period for shrimp catch for three species. LWRs (growth pattern) found stable in *Penaeus indicus* and *Metapenaeus affinis* while predicting an alarming deteriorated situation for *Exopalaemon styliferus* at creeks zone.

Keywords: GIS, Length-Weight Relationships, Stock Assessment, Prawn Trawl, Creek environment, coefficient of correlation and coefficient of determination.

INTRODUCTION

The warm waters of Arabian Sea near Pakistan have great potential for marine fish resources. The coast line of Western Indian Ocean where Pakistan lies is 1,100 Km long and having a large number of marine fish resources like fishes, prawns and crabs [1]. The coast of Sindh is 370 km long with the great system of inter-connected creeks [2] and also Pakistan's 71% of marine resources owned by this province [3-5]. The overall contribution of Marine Fisheries to the GDP of Pakistan is 1% of which 60% of export is constituted by Shrimps alone [5]. Sindh's Coast belt is having more than 15 different species of shrimps [5]. In recent years lots of efforts have been made to understand the growth pattern of shrimps worldwide [6]. In Pakistan very small amount of recognized works are available on length-weight relationship of shrimp species despite the fact that these species are commercially important and having a great future potential in terms of aquaculture farming.

This study aims to analyze the seasonal and spatial pattern of growth and condition of the shrimp species. These observations help us to measure stock composition, health condition, growth and production of species at study area [7].

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MATERIALS & METHODS

Study Area

For this study creeks zone of Sindh coast considered as study area (Figure **1**). Major creeks of Sindh mainly lies in two districts Karachi and Thatta. There is a large system of creeks at Sindh coast but only 13 creeks Issaro, WaddiKhuddi, Patiani, Mal, Dabbo, Richhal, Chan, Hajamaro, Chani, Jhang, Khar, Wari and Khajar Creeks have been selected as the area of interest from more than 50 creeks after the consultation of Food and Agriculture Organization (FAO). These mangroves covered creeks are rich in many marine fish resources in which juvenile of marine fishes, shrimps, and small pelagic fishes are noticeable.

Collection of Shrimps Data

Samples were collected from 13 different creeks on monthly basis from April 2013 to January 2014 using pelagic trawls, by the Food and Agriculture Organization (FAO) and Marine Fisheries Department (MFD), joint partners on a Project with University of Karachi. Gill nets were the method used to catch the samples. Measurements were taken for Fork Length (FL), Total Length (TL) and Carapace Length (CL) in centimeters (cm). The weights were measured in grams (gm). The results of data sets have been provided to the Department of Geography, University of Karachi for the Spatio-Temporal analysis of marine

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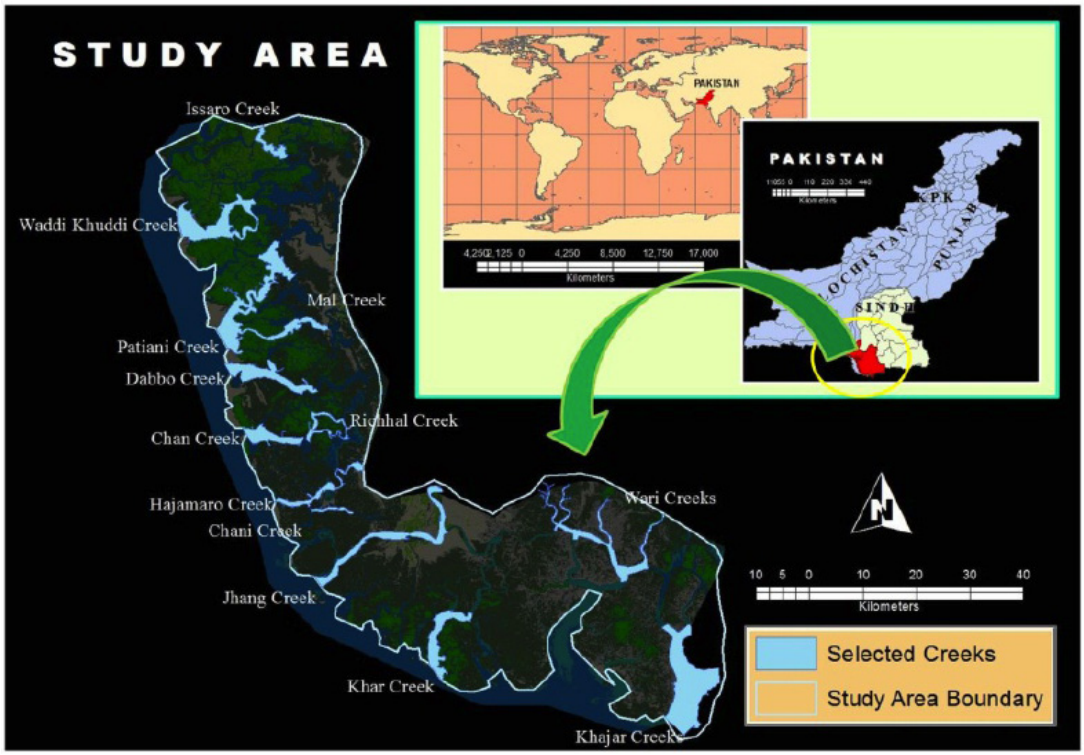

Figure 1: Study area; showing 13 selected creeks as study sites.

resources. For this study three most common shrimp species has been selected because of their economic and ecological importance. These species are *Exopalaemon styliferus* (Roshna Prawn), *Metapenaeus affinis* (Jhinga Prawn) and *Penaeus indicus* (Indian White Prawn).

Length-Weight Relationship Equation

The given data were in *Sql* files with separated tables for length and weight. The *Sql* files then analyze with the help of pgAdminIII software. For the acquisition of single table for selected species; the relevant queries were applied in query builder from *Sql* template. Then, the given tables were transferred to excel sheets to run the LWRs equations in SPSS-18. The relationship between length and weight of shrimp species measured with the help of the following equation [8,9]:

$$W = aL^b$$

Where, W is the total weight, L is the total length, "a" is the intercept and "b" is the slope. The "a" and "b" values are constant and exponents respectively that were obtained by linear regression of the length and weight of shrimp species respectively [8, 9]. These values were a logarithm transformation according to the following formula [10]:

$$LogW = aLogL^b$$

Before the logarithm transformation we neglected "1" value from length and weight datasets. Most of the data were consisting of juvenile collection, hence, the "1" value occupied a large space that turned it to zero after transformation. Total number of shrimp species is 1244 which is having 30 different species of shrimps caught at creeks from April 2013 to January 2014. The total catches of *Penaeus indicus, Metapenaeus affinis* and *Exopalaemon styliferus* were 414, 467 and 323 respectively and after neglecting 1 value it was 359, 397 and 264. The other important analysis that was done with LWRs is the degree of association and correlation between the length and weight of shrimp species that was computed by determination co-efficient "r^2" and correlation co-efficient "r" respectively [10]. To show the relationship between the lengths and weight the scatter plots were developed by using Minitab 17.

Seasonal Catches

For the spatio-temporal analysis seasonal and ecological variations were considered to observe the waxing and waning of the species at the selected creeks locations. For this purpose, change detection techniques were implemented to evaluate the resource potential of each species. Monthly based data of

selected study sites have provided significant information about the spatial variations of marine species behavior. To analyze the seasonal changes in the catches at creeks the data were arranged according to the Pre-Monsoon and Post-Monsoon seasons for selected shrimp species. The obtained results were then analyzed in to ArcGIS environment to examine the spatial changes in both seasons. Bar graphs from charts in symbology were used and at the end cartographic techniques were applied to display the maps.

RESULTS AND DISCUSSION

Seasonal Analysis

This analysis is focus on the application of GIS (Geographic Information Science) to show the seasonal change in catch patterns of shrimps at study area. The GIS of the environment is of great importance due to its spatial behavior. The seasonal changes of the shrimp catch can be easily observed through spatial techniques [11] Figures **2A**, **B** and **C**. It is obvious from the Figure **2A** that the catches of *Penaeus indicus* are available in both seasons, *i.e*., pre and post- monsoon; but the amount of the catch differed noticeably (Table **1**). It shows the highest catch 147 species in post-monsoon at Issaro creek of *Penaeus indicus.* While the highest catch during pre-monsoon is 33 species at Issaro creek of the same species. On the other hand Figure **2A** reveals that how these catches distributed spatially throughout the area of interest. The case is slightly different for other two species Figures **2B** and **C**. The two species *Metapenaeus affinis and Exopalaemon styliferus* show the highest catch in Post-Monsoon only. Only two species *Metapenaeus affinis* caught from Richhal creek during Pre-Monsoon (Table **2**) while not a single

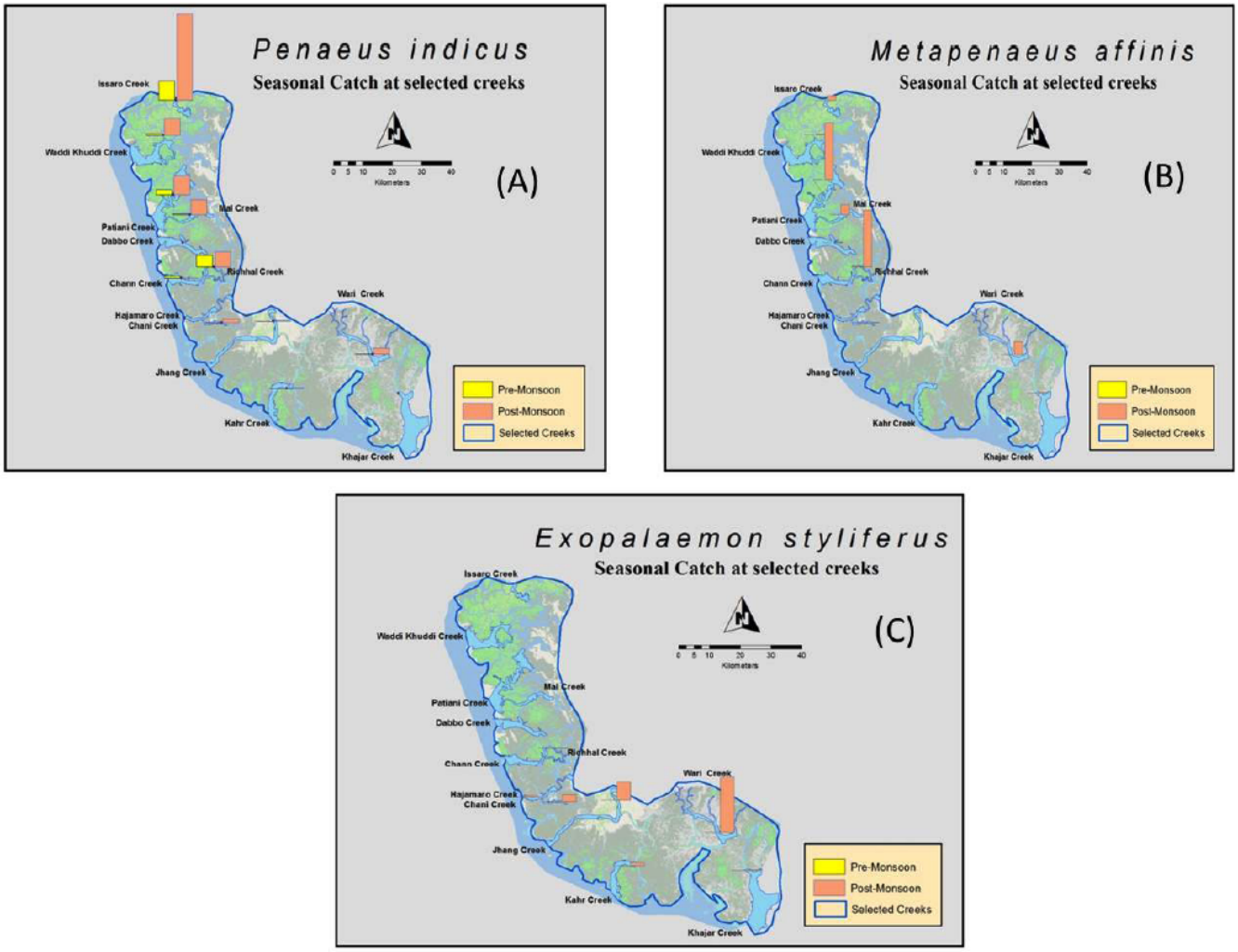

Figure 2: Seasonal change; showing the spatially distribution of seasonal catches.

(**A**) *Penaeus indicus* seasonal catch at selected creeks. (**B**) *Metapenaeus affinis* seasonal catch at selected creeks. (**C**) *Exopalaemon styliferus* seasonal catch at selected creeks.

Table 1: Length-Weight Relationship of *Penaeusindicus* at Study Area from April 2013 to January 2014

Season	Creek	N	Length range (cm) Min ± Max	*Penaeus indicus*				
				a	b	S.E	r	r^2
Pre-Monsoon	Issaro	33	2.0 ± 5.0	-0.548	2.470	0.814	0.959	0.920
	WaddiKhuddi	03	3.0 ± 6.0	-1.098	3.387	0.001	1.000	1.000
	Patiani	09	2.0 ± 30.0	0.660	-0.192	0.316	-0.268	0.72
	Mal	02	2.0 ± 3.0	0.148	0.830	-	1.000	1.000
	Dabbo	00	-	-	-	-	-	-
	Richhal	21	2.0 ± 5.0	-0.747	2.484	0.920	0.961	0.924
	Chann	04	3.0 ± 5.0	-0.305	1.951	0.971	0.990	0.981
	Chani	00	-	-	-	-	-	-
	Hajamaro	00	-	-	-	-	-	-
	Kahr	00	-	-	-	-	-	-
	Khajar	00	-	-	-	-	-	-
	Jhang	01	-	-	-	-	-	-
	Wari	00	-	-	-	-	-	-
Post-Monsoon	Issaro	147	2.0 ± 4.0	-0.343	1.834	0.225	0.580	0.336
	WaddiKhuddi	29	2.0 ± 4.0	-0.189	1.429	0.209	0.538	0.290
	Patiani	33	2.0 ± 5.0	-0.464	2.093	0.184	0.665	0.442
	Mal	27	2.0 ± 5.0	-0.150	1.656	0.109	0.892	0.796
	Dabbo	00	-	-	-	-	-	-
	Richhal	26	3.0 ± 5.0	-0.745	2.650	0.136	0.815	0.663
	Chann	00	-	-	-	-	-	-
	Chani	07	3.0 ± 4.0	-1.897	4.367	0.187	0.770	0.593
	Hajamaro	00	-	-	-	-	-	-
	Kahr	01	-	-	-	-	-	-
	Khajar	00	-	-	-	-	-	-
	Jhang	01	-	-	-	-	-	-
	Wari	11	3.0 ± 4.0	0.410	0.394	0.124	0.206	0.43

N: sample size, a: intercept, b: slope; S.E: standard error, r: correlation co-efficient, r^2: coefficient of determination.

Exopalaemon styliferus caught from the creeks (Table **3**). Where Figures **2B** and **C** depicts the clear image of spatially distribution of catch at the creeks zone. The results from seasonal analysis indicate that the post-monsoon is the highest *Penaeus indicus, Metapenaeus affinis* and *Exopalaemon styliferus* catch season and the catch varies at every creek for three species. The highest number of species caught at Issaro, Patiani and Wari creeks that are 146, 147 and 165 respectively Figures **2A, B & C.**

Length-Weight Relationship

LWR is an important analysis to study the growth pattern of species [6]. The exponent 'b' (Tables **1, 2 & 3**) indicates the condition of fish or shrimp [7] and depends on species health, environmental parameters, age, sex, sampling seasons [12]. The 'b' values for *Penaeus indicus* during pre-monsoon ranging between 0.830 to 3.387 (Table **1**) except one outlier -0.192 and showing non-linear relationship between the variables Figure **3C**. While linear relationship found in the catch of other creeks Figures **3A, B, D, E** and **F**. The values of "r" and "r^2"in Table **1** showing the correlation coefficient and determination coefficient depicts the positive correlation [13] between the variables caught in pre-monsoon at area of interest and it is significant at 0.001 levels. On the other hand the slope 'b' value in post-monsoon for *Penaeus indicus* ranging between

Table 2: Length-Weight Relationship of *Metapenaeus affinis* at Study Area from April 2013 to January 2014

Season	Creek	N	Length range (cm) Min ± Max	*Metapenaeus affinis*				
				a	b	S.E	r	r^2
Pre-Monsoon	Issaro	00	-	-	-	-	-	-
	WaddiKhuddi	00	-	-	-	-	-	-
	Patiani	00	-	-	-	-	-	-
	Mal	00	-	-	-	-	-	-
	Dabbo	00	-	-	-	-	-	-
	Richhal	02	3.0 ± 3.0	-	-	-	-	-
	Chann	00	-	-	-	-	-	-
	Chani	00	-	-	-	-	-	-
	Hajamaro	00	-	-	-	-	-	-
	Kahr	00	-	-	-	-	-	-
	Khajar	00	-	-	-	-	-	-
	Jhang	00	-	-	-	-	-	-
	Wari	00	-	-	-	-	-	-
Post- Monsoon	Issaro	13	2.0 ± 3.0	0.089	0.296	0.088	0.169	0.029
	WaddiKhuddi	04	2.0 ± 4.0	0.105	1.071	0.087	0.911	0.830
	Patiani	148	2.0 ± 6.0	-0.391	1.819	0.147	0.850	0.723
	Mal	27	2.0 ± 5.0	0.070	1.243	0.090	0.929	0.863
	Dabbo	01	-	-	-	-	-	-
	Richhal	149	2.0 ± 6.0	-0.295	1.681	0.765	0.910	0.828
	Chann	00	-	-	-	-	-	-
	Chani	01	-	-	-	-	-	-
	Hajamaro	00	-	-	-	-	-	-
	Kahr	00	-	-	-	-	-	-
	Khajar	04	3.0 ± 4.0	0.279	0.870	0.022	0.961	0.923
	Jhang	00	-	-	-	-	-	-
	Wari	34	2.0 ± 4.0	-0.193	1.287	0.122	0.708	0.502

N: sample size, a: intercept, b: slope, S.E: standard error, r: correlation co-efficient, r^2: coefficient of determination.

0.394 - 4.367 and depicts a negative growth pattern [13] (Table **1**). The positive linear relationship has been found between the variables at each creek during post-monsoon Figures **4A, B, C, D, E, F** and **G**. The positive correlation coefficient has been observed between the variables and significance at 0.001 levels. For *Metapenaeus affinis and Exopalaemon styliferus* the results were derived only for post-monsoon as no catch data found for pre-monsoon during the survey. The slope 'b' values for *Metapenaeus affinis* are ranging between 0.296-1.819 (Table **2**) and for *Exopalaemon styliferus* ranging between 0.08 to 1.88 (Table **3**). Positive linear relationship has been found in most of the areas except at issaro creek for *Metapenaeus affinis* Figure **5A** where the correlation determination r^2 is 0.029 that is the lowest although every creek is showing positive correlation coefficient (Table **2**). Weak or low linear relation [13] has been found in two of the creeks Chani or Hajamaro Figures **6A** and **B** for *Exopalaemon styliferus* while the catch on other creeks show a positive linear relationship between the variables Figures **6C, D, E** and **F** while the values correlation coefficient 'r' and determination of coefficient' $r^{2,}$ showing the low degree of association between the variables (Table **3**) except in Wari creek that is 0.826. All the values of *Metapenaeus affinis* and *Exopalaemon styliferus* significant at 0.001 and 0.005 levels.

Table 3: Length-weight relationship of *Exopalaemon styliferus* at study area from April 2013 to January 2014

Season	Creek	N	Length range (cm) Min ± Max	*Exopalaemon styliferus*				
				a	b	S.E	r	r^2
Pre-Monsoon	Issaro	00	-	-	-	-	-	-
	WaddiKhuddi	00	-	-	-	-	-	-
	Patiani	00	-	-	-	-	-	-
	Mal	00	-	-	-	-	-	-
	Dabbo	00	-	-	-	-	-	-
	Richhal	00	-	-	-	-	-	-
	Chann	00	-	-	-	-	-	-
	Chani	00	-	-	-	-	-	-
	Hajamaro	00	-	-	-	-	-	-
	Kahr	00	-	-	-	-	-	-
	Khajar	00	-	-	-	-	-	-
	Jhang	00	-	-	-	-	-	-
	Wari	00	-	-	-	-	-	-
Post-Monsoon	Issaro	00	-	-	-	-	-	-
	WaddiKhuddi	00	-	-	-	-	-	-
	Patiani	00	-	-	-	-	-	-
	Mal	00	-	-	-	-	-	-
	Dabbo	00	-	-	-	-	-	-
	Richhal	01	-	-	-	-	-	-
	Chann	00	-	-	-	-	-	-
	Chani	21	3.0 ± 5.0	0.368	0.378	0.131	0.226	0.051
	Hajamaro	05	4.0 ± 5.0	0.416	0.088	0.075	0.059	0.003
	Kahr	09	4.0 ± 5.0	-0.600	1.289	-	1.000	1.000
	Khajar	03	3.0 ± 4.0	0.230	0.888	0.156	0.500	0.250
	Jhang	56	2.0 ± 5.0	-0.252	1.383	0.288	0.494	0.244
	Wari	169	2.0 ± 6.0	-0.588	1.883	0.140	0.824	0.679

N: sample size, a: intercept, b: slope, S.E: standard error, r: correlation co-efficient, r^2: coefficient of determination.

If we compare these results of three species, we have discovered that *Penaeus indicus is* the most stable species at study area. The slope 'b' values in average for both pre and post-monsoon seasons are close to the standard value of slope 3 [6] for *Penaeus indicus.* The most threatening species is *Exopalaemon styliferus* whose slope'b' is not close to 3 hence the highest value that measured is 1.88. It indicates the alarming situation of that commercially important species. Overall the slope 'b' value for *Metapenaeus affinis* is also not showing the closeness to the standard value of 'b' but it shows the strong correlation between the variables that indicates the low value may be due to environmental pollution, age or other environmental factors like coastal erosion and deforestation.

In terms of growth type, the results of *Metapenaeus affinis and Exopalaemon styliferus* showed negative allometric growth (b<3) in all the creeks. However, *Penaeus indicus* showed negative allometric growth except one positive allometric growth (b>3) in both seasons. This has been observed specially in WaddiKhuddi Creek in Pre-monsoon and Chani creek in Post-monsoon seasons.

Current study provides very useful information on length-weight relationship (LWRs) despite the fact of

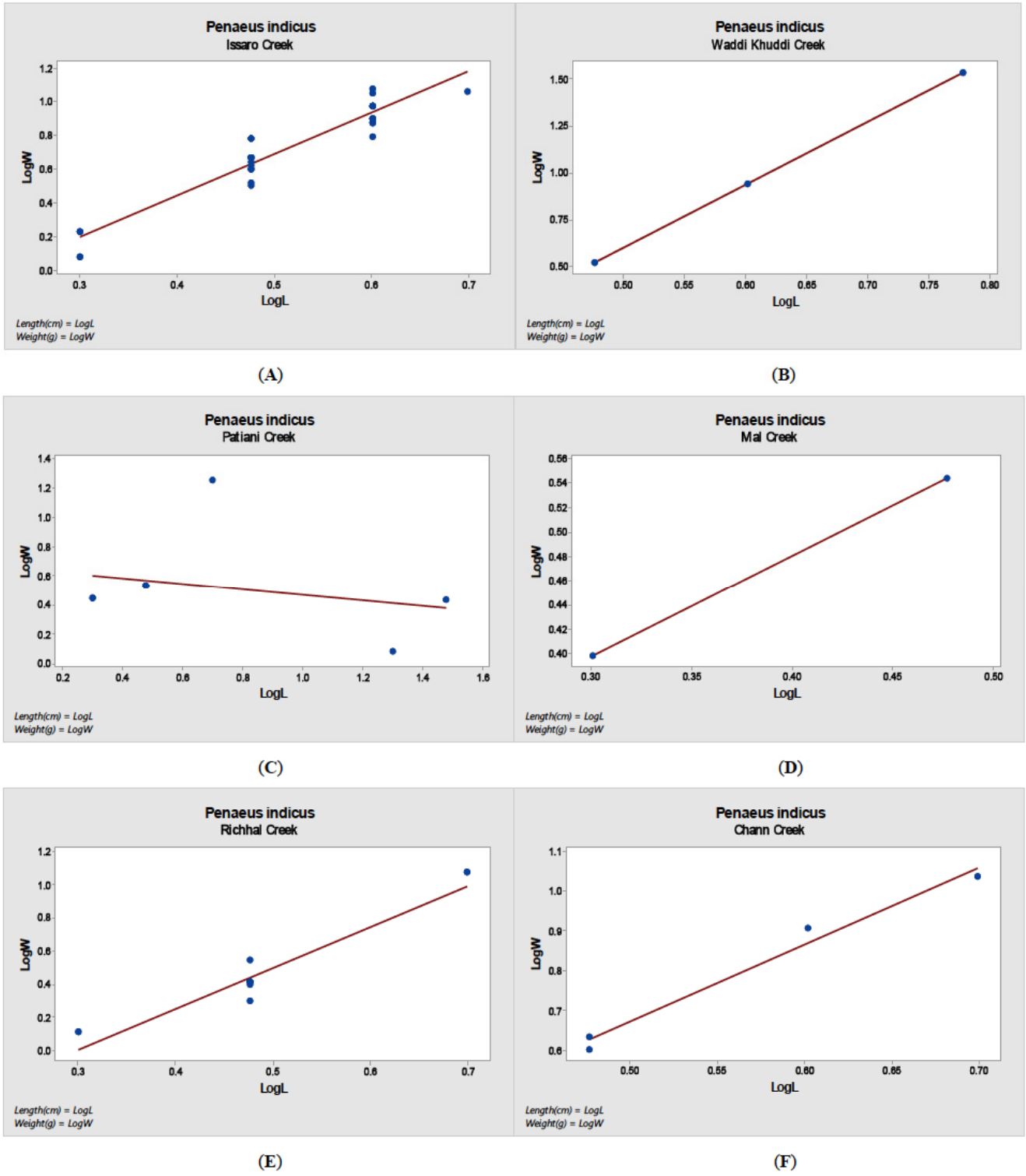

Figure 3: Scatter plots for *Penaeus indicus* during pre-monsoon season; showing the relationship between the variables (**A**) Issaro Creek; positive linear relationship (**B**) WaddiKhuddi creek; positive linear relationship (**C**) Patiani Creek; negative linear relationship (**D**) Mal Creek; positive linear relationship (**E**) Richal Creek; positive linear relationship (**F**) Chann Creek; positive linear relationship.

narrow size samples and low weight of shrimp species. Another limitation of this study is the missing data of two months, i.e., February and March, which could have been helpful to analyze the pre-monsoon data. As we discussed that shrimps constitute more than 50% of fisheries export alone [5], this study provides the better direction towards the monitoring and management of shrimp resources in Pakistan.

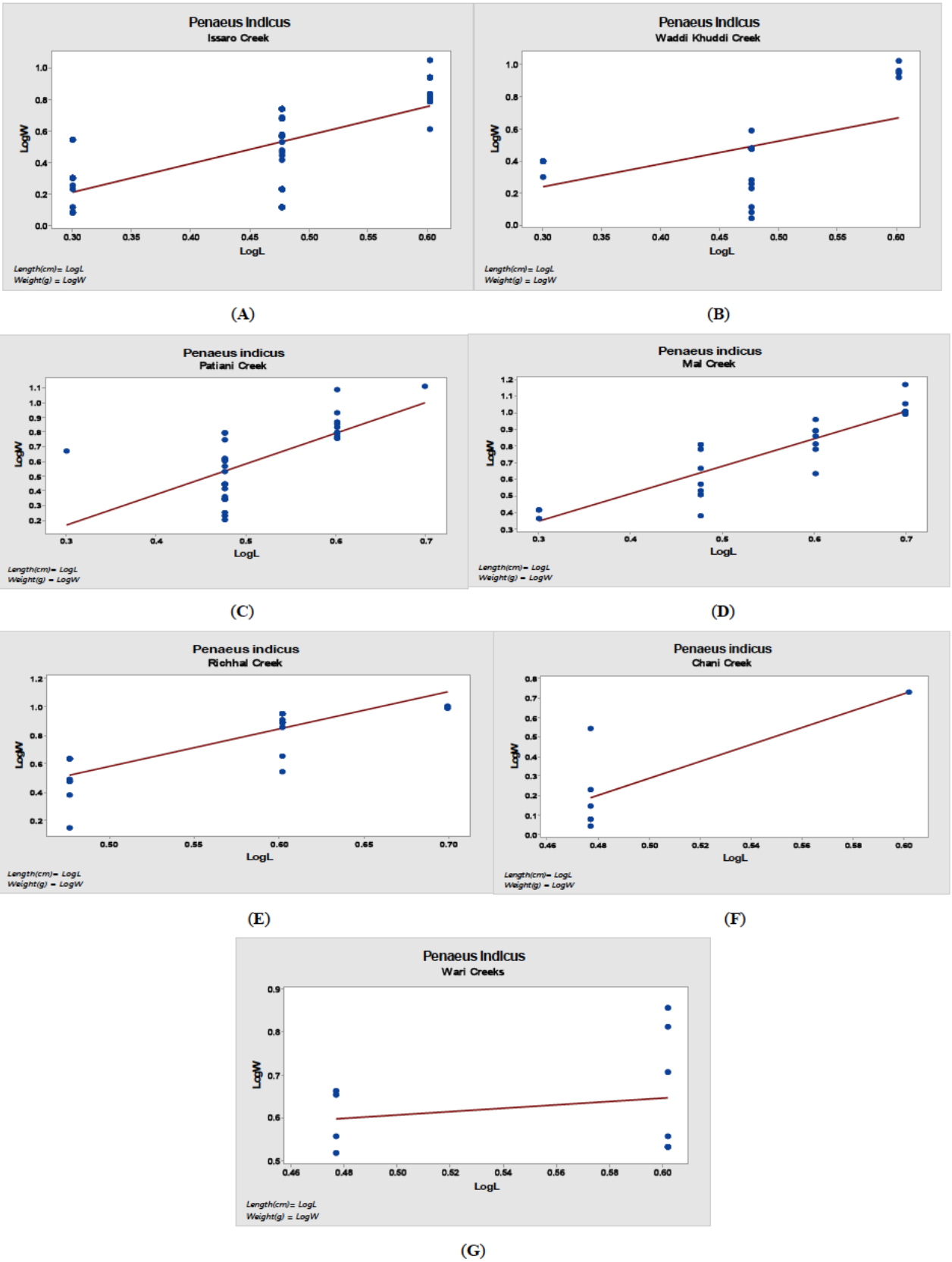

Figure 4: Scatter plots for *Penaeus indicus* during post-monsoon season; showing the relationship between the variables (**A**) Issaro Creek; positive linear relationship (**B**) Waddikhuddi creek; positive linear relationship (**C**) Patiani Creek; negative linear relationship (**D**) Mal Creek; positive linear relationship (**E**) Richhhal Creek; positive linear relationship (**F**) Chani Creek; positive linear relationship (**G**) Wari Creek; Weak linear relationship.

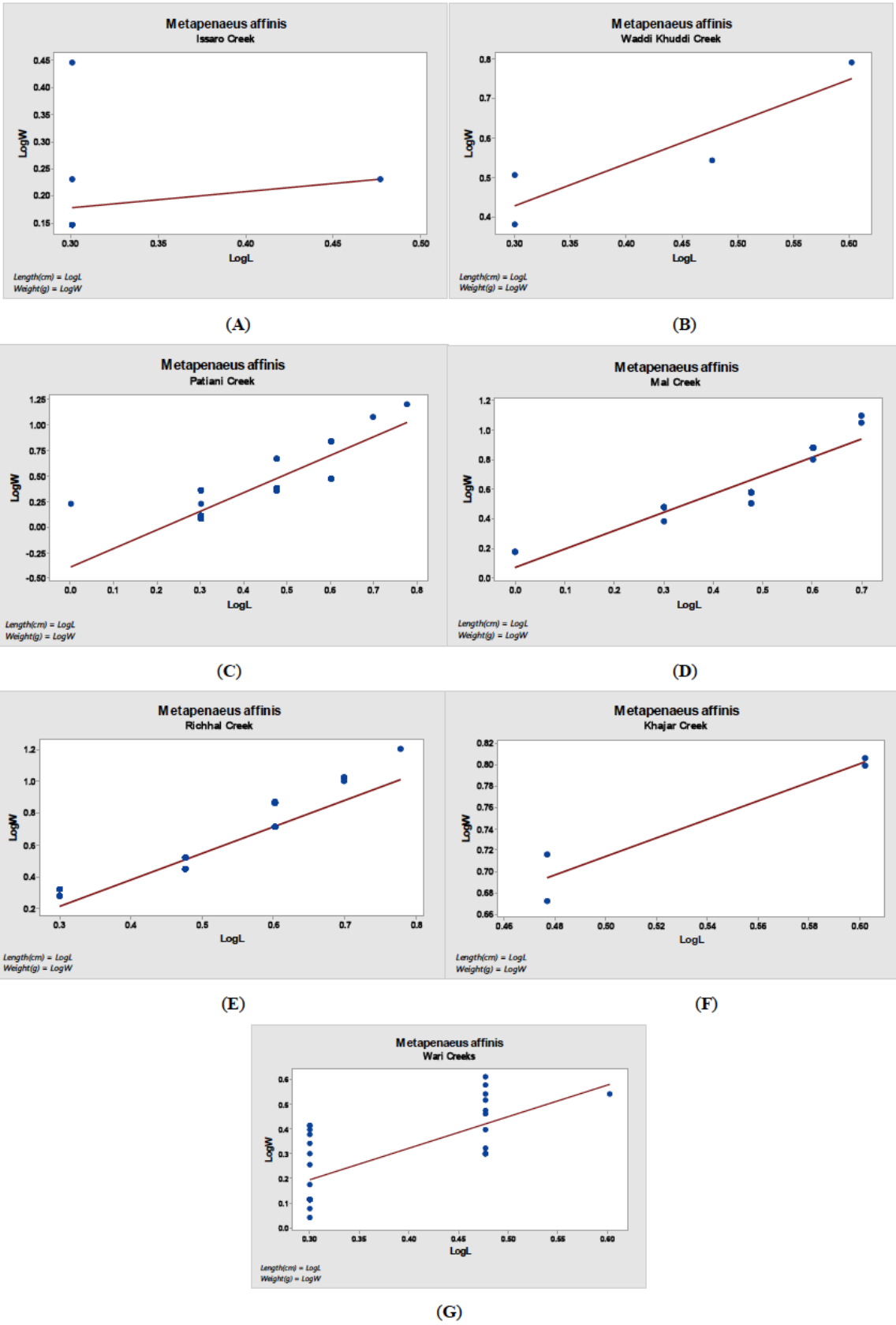

Figure 5: Scatter plots for *Metapenaeus affinis* during post-monsoon season; showing the relationship between the variables (**A**) Issaro Creek; Weak relationship (**B**) Waddikhuddi creek; positive linear relationship (**C**) Patiani Creek; negative linear relationship (**D**) Mal Creek; positive linear relationship (**E**) Richhhal Creek; positive linear relationship (**F**) Khajar Creek; positive linear relationship (**G**) Wari Creek; positive linear relationship.

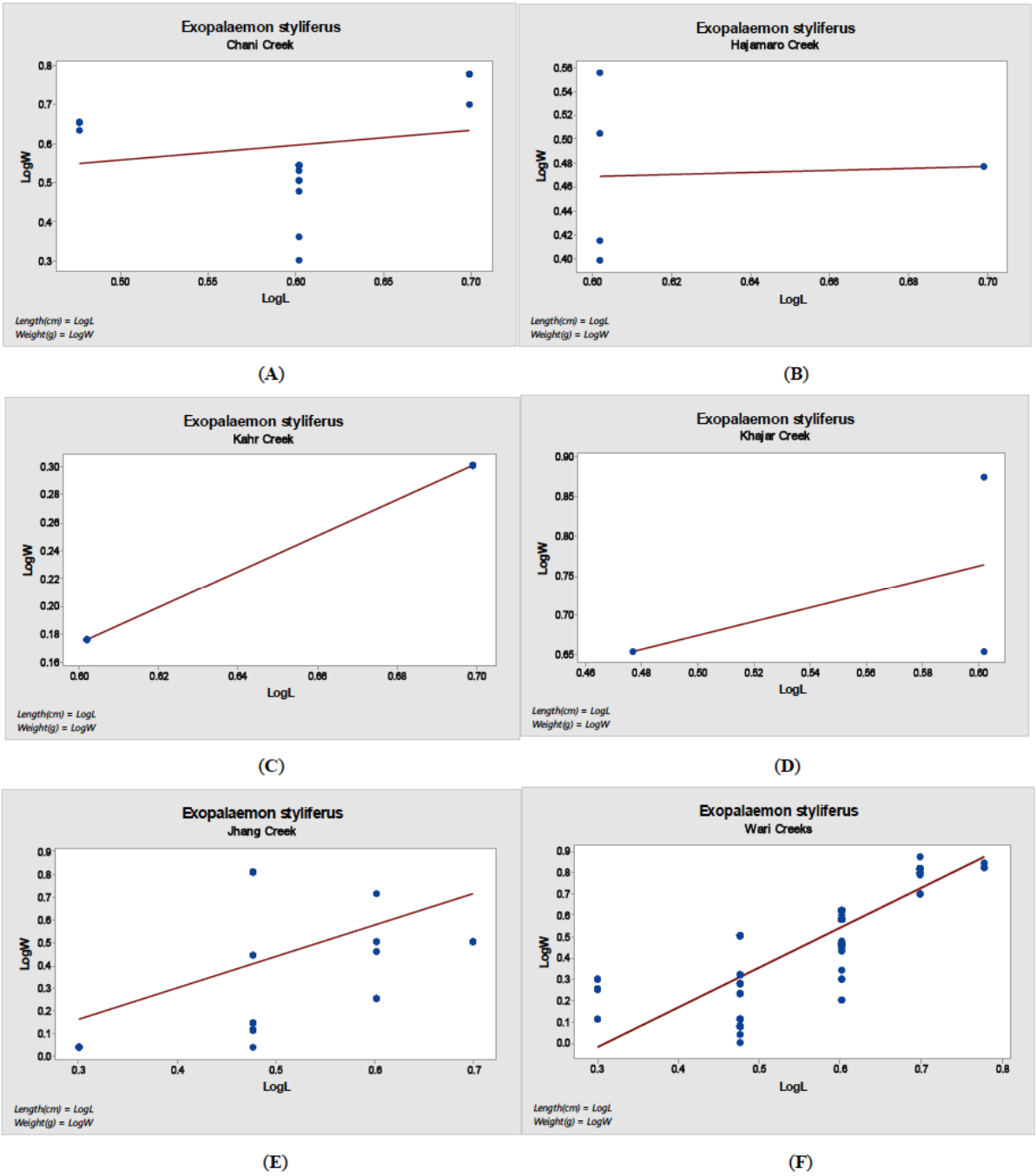

Figure 6: Scatter plots for *Exopalaemon styliferus* during post-monsoon season; showing the relationship between the variables (**A**) Chani Creek; weak relationship (**B**) Hajamaro creek; weak relationship (**C**) Kahr Creek; positive linear relationship (**D**) Khajar Creek; positive linear relationship (**E**) Jhang Creek; positive linear relationship (**F**) Wari Creek; positive linear relationship.

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