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Some Morphometric Traits of S. rivulatus (Forsskål, 1775) and S. luridus (Ruppel, 1828) in Derna coast, eastern Libya, Mediterranean Sea

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بعض الصفات المورفومترية لسمكة *S. rivulatus* وسمكة *S. luridus* المجمعة من ساحل درنة، شرق ليبيا،البحر المتوسط

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Abstract:
Sixty *Siganus luridus* fish and sixty *Siganus rivulatus* were collected from the artisanal catch of Derna coast, eastern Libya during March/April 2021 for use in the present study to established morphometric traits and descriptive characters for both fish. The morphometric trait corelated to each other and related to fish length as an indicator of fish growth and age by linear and power regression. *Siganus luridus* of the present study was larger than *S. rivulatus*. For example, the mean Total Weight (TW) of *S. luridus* was 105.65±5.40 g while that of *S. rivulatus* was 59.95±2.06 g. The mean of Total Length (TL) of *S. luridus* was 18.72±0.39 cm while that of *S. rivulatus* was 17.19±0.21 cm. The linear and power weight-length relationship for *S. luridus* were Y=10.22X-85.63, R^2=0.54, $Y=0.31X^{1.98}$, R^2=0.63 while that of *S. rivulatus* were Y=6.895X-58.57, R^2=0.51, $Y=0.478X^{1.69}$, R^2=0.46 for linear and power regression respectively. Both fish indicated negative allometric growth.

Keywords: morphometric, *Siganus luridus*, *Siganus rivulatus*

الملخص
تم جمع 60 سمكة من *Siganus luridus* و60 سمكة من *Siganus rivulatus* عن طريق الصيد الحرفي في ساحل درنة شرق ليبيا خلال الفترة من مارس الي ابريل 2021 لاستخدامها في الدراسة الحالية لتحديد الصفات المورفومترية والوصفية لكلا السمكتين. وتم قياس الارتباط للصفات المورفومترية ببضعها ونسبها الي طول السمكة كإشارة لنمو السمكة وعمرها بمعادلات الانحدار الخطية ومعادلات القوة سمكة *S. luridus* للدراسة الحالية كانت بشكل عام أكبر حجما من *S. rivulatus* . كمثال لذلك، كان متوسط وزن *S. luridus* 105.65±5.40جم بينما كان وزن سمكة *S. rivulatus* 59.95±2.06جم. كان متوسط طول سمكة *S. luridus* 18.72±0.39سم بينما متوسط طول سمكة *S. rivulatus*كان 17.19±0.21 سم. كانت علاقة الطول بالوزن باستخدام معادلات الانحدار الخطية والقوة لسمكة *S. luridus* Y=10.22X-85.63, R^2=0.54, $Y=0.31X^{1.98}$, R^2=0.63 بينما كانت بالنسبة لسمكة *S. rivulatus* كالاتي Y=6.895X-58.57, R^2=0.51, $Y=0.478X^{1.69}$, R^2=0.46 لمعادلات الانحدار الخطية والقوة على التوالي. أظهرت كلا السمكتين نمو سلبي التماثل.

الكلمات المفتاحية: *Siganus luridus*، *Siganus rivulatus*، المورفومترية

Introduction

The variations in shape and size of the organisms are referred to as morphometry [1]. The most two important experimental variables in population‟s estimation and in stock assessment investigations are fish total length and body weight [2]. Rabbitfish (Family Siganidae) are widely distributed, especially in the Indo-Pacific region [3], and are the most popular fish consumed as food in many parts of the world [4] .The opening of the Suez Canal in 1869 led to the migration of several species from the Red Sea to Mediterranean Sea, known as Receptis migrants [5]; *S. rivulatus* (Forsskål, 1775) and *S. luridus* (Ruppel, 1828) are two of the most successful migratory fish species through the Suez Canal and have formed large populations in the Mediterranean Sea [6,7,8,9,10,11].

The objectives of this study are to identified Siganidae species inhabiting in Derna coast based on morphological traits, and to establish descriptive statistics of the morphometric parameters for both fish. Additionally, the study aims to relate these parameters to fish length by percentage ratio to minimize the effect of fish size, and to analyze the obtained measures with total length and head length using allometric equations to determine how they change with fish growth. Finally, the study will establish the Pearson's binary correlations for the morphometric parameters of both fish.

Material and methods

The Study Site: The city of Derna is a port city located between latitude (N' 16° 32) and longitude (E' 39° 22), which is 164 km west of Tobruk and 91 km east of Bayda. It has a modern port with water barriers and piers extending into the sea divided between commercial, naval fleet and hobby fishing. Water depth more than 35m offshore, and it has an important fish landing site [12].

Collection of fish samples: Sixty *Siganus luridus* fish and sixty *Siganus rivulatus* were collected from the artisanal catch of Derna coast, eastern Libya during March/April 2021 the total length and weight were record for individual collecting fish as well other morphometric parameters.

length-weight relationship: linear and power regressions of the length-weight relationship (L-W) were calculated according to Le Cren, (1951) [13] and Ricker (1975) [14]:

Power: $W = aL^b$, Linear: $W = a + bL$,

The Fulton condition factor (KF) of both fish was determined according to Fulton, (1902) [15] as follows:

$$KF = 100 * W / L^3$$

Where W: total fish Weight in grams, L: total fish Length in centimeters.

Results and discussion

Morphometric traits of *Siganus luridus* and *Siganus rivulatus*: The mean values for *Siganus luridus* in the present study were larger than those for *S. rivulatus*. The magnitudes of all individual morphometric traits of *S. luridus* (Table 1) were significantly greater than those of *S. rivulatus* except for MG (highlighted in yellow) where the differences were statistically insignificant. For instance, the mean Total Weight (TW) of *S. luridus* was 105.65±5.40 g while that of *S. rivulatus* was 59.95±2.06 g. Total Length (TL) of *S. luridus* was 18.72±0.39 cm whereas that of *S. rivulatus* was 17.19±0.21 cm.

The percent morphometric traits (the percentage of the trait as ratio from the fish Total Length) is shown in (Table 1 and Figure 1-19). Statistically significant differences between the percentage traits of *S. luridus* and *S. rivulatus* were observed in SL, HL, ED, PoL, PaL and MG (highlighted in green in Table 1). The standard-Length percentage of *S. rivulatus* (80.98% of total length) was slightly greater than that of *S. luridus* (80.11%). However, differences between the percentage traits of *S. luridus* and *S. rivulatus* were not statistically significant.

Table 1 Means of morphometric traits (± standard error) and their percentage from total length of *S. luridus* (SL) and *S. rivulatus* (SR).

Morphometric characters	Species	Mean ± SE	%
TW	**SL**	**105.65±5.40**	**-**
	SR	**59.95±2.06**	**-**
TL	**SL**	**18.72±0.39**	**-**
	SR	**17.19±0.21**	**-**
FL	**SL**	**18.08±0.41**	**96.54**
	SR	**16.11±0.16**	**94.13**

SL	**SL**	**14.85±0.31**	**80.11**
	SR	**13.87±0.15**	**80.98**
BD	**SL**	**6.28±0.17**	**33.96**
	SR	**5.17±0.07**	**30.27**
HL	**SL**	**3.31±0.06**	**17.84**
	SR	**3.25±0.05**	**18.99**
ED	**SL**	**0.99±0.04**	**5.29**
	SR	**0.96±0.02**	**5.64**
PoL	**SL**	**1.30±0.03**	**6.98**
	SR	**1.28±0.03**	**7.49**
PosL	**SL**	**1.16±0.04**	**6.20**
	SR	**1.02±0.03**	**5.97**
PeFL	**SL**	**3.24±0.24**	**17.47**
	SR	**2.46±0.05**	**14.46**
DFL	**SL**	**10.86±0.18**	**58.45**
	SR	**9.57±0.16**	**56.04**
PFL	**SL**	**3.33±0.13**	**17.99**
	SR	**2.89±0.15**	**16.97**
AFL	**SL**	**6.31±0.15**	**34.17**
	SR	**5.67±0.14**	**33.19**
CpL	**SL**	**1.43±0.06**	**7.66**
	SR	**1.16±0.04**	**6.75**
CpW	**SL**	**0.97±0.05**	**5.26**
	SR	**0.80±0.06**	**4.62**
CFG	**SL**	**4.73±0.14**	**25.60**
	SR	**4.16±0.14**	**24.16**
PdL	**SL**	**4.15±0.09**	**22.34**
	SR	**3.69±0.07**	**21.62**
PaL	**SL**	**7.91±0.19**	**42.51**
	SR	**7.33±0.16**	**42.65**
MG	**SL**	**2.24±0.18**	**12.18**
	SR	**2.60±0.07**	**15.25**
MW	**SL**	**0.67±0.03**	**3.62**
	SR	**0.60±0.02**	**3.53**
CL	**SL**	**0.89±0.06**	**4.70**
	SR	**0.64±0.02**	**3.75**

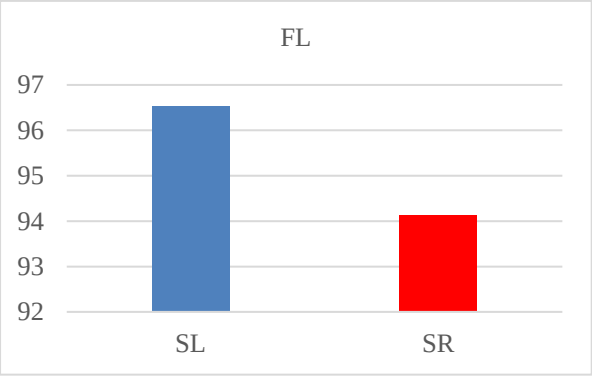


Figure1 %mean Forked Length (FL) of (SL, SR)

Figure 2 %mean Standard Length (SL) of (SL, SR)

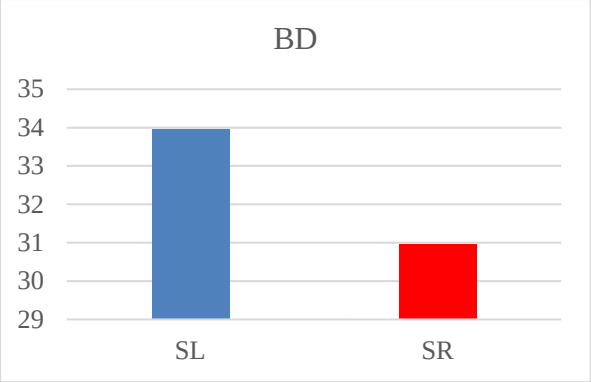


Figure 3 %mean Body Depth (BD) of (SL, SR)

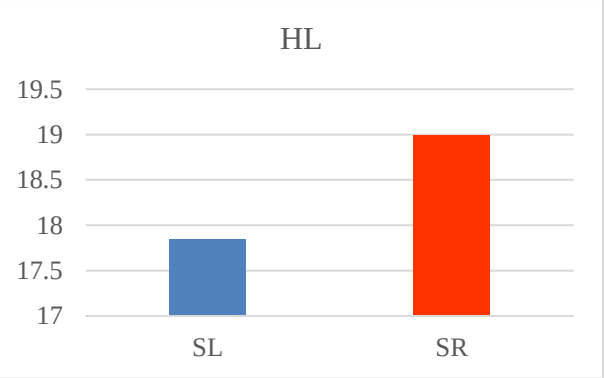


Figure 4 %mean Head Length (HL) of (SL, SR)

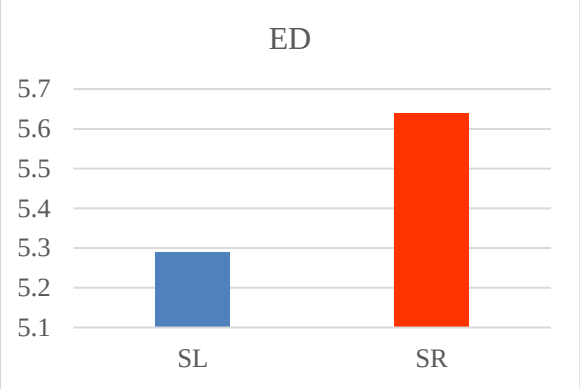


Figure 5 %mean Eye diameter (ED) of (SL, SR)

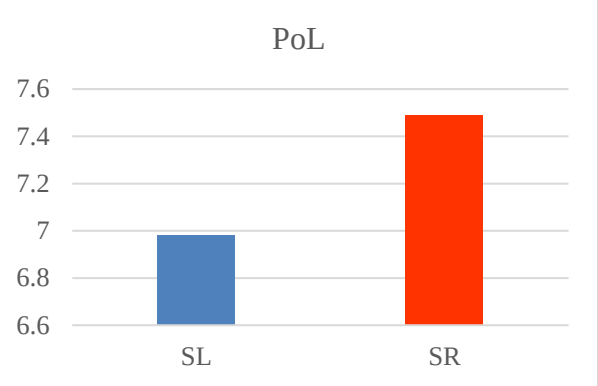


Figure 6 %mean Pre-orbital length (PoL) of (SL, SR)

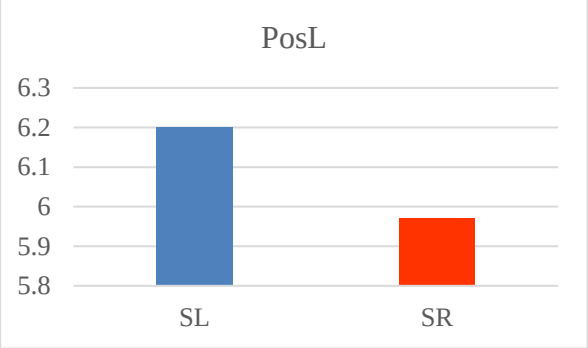


Figure 7 %mean Post orbital length (PosL) of (SR, SL)

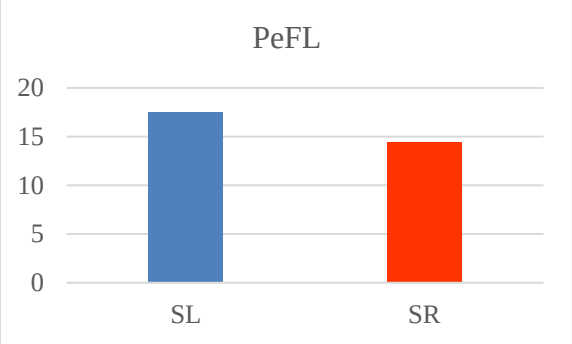


Figure 8 %mean Pectoral Fin Length (PeFL) (SR, SL)

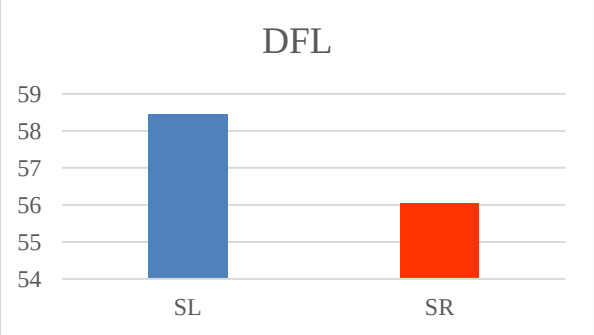


Figure 9 %mean Dorsal Fin Length (DFL) of(SR, SL)

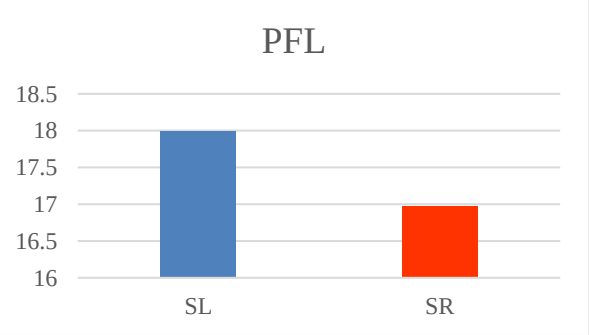


Figure 10 %mean Pelvic Fin Length (PFL) of (SR, SL)

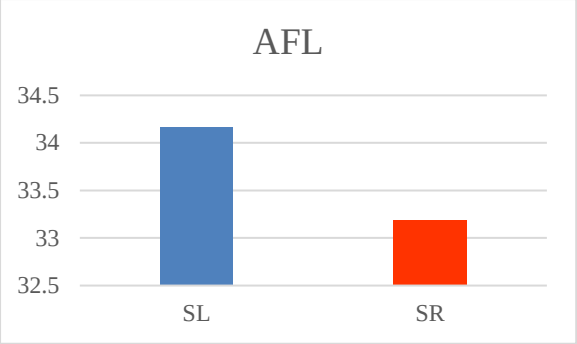


Figure 11% Anal Fin Length (AFL) of (SL, SR)

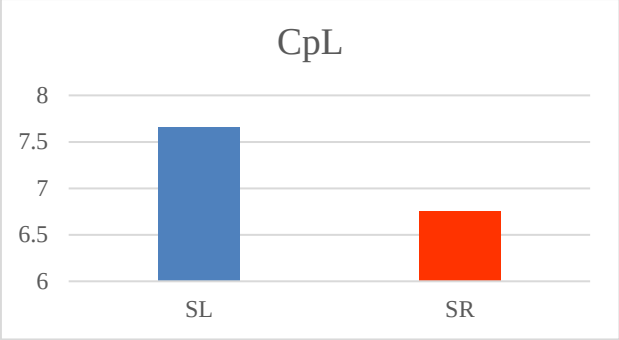


Figure 12 % Caudal Peduncle Length (CpL) of (SL, SR)

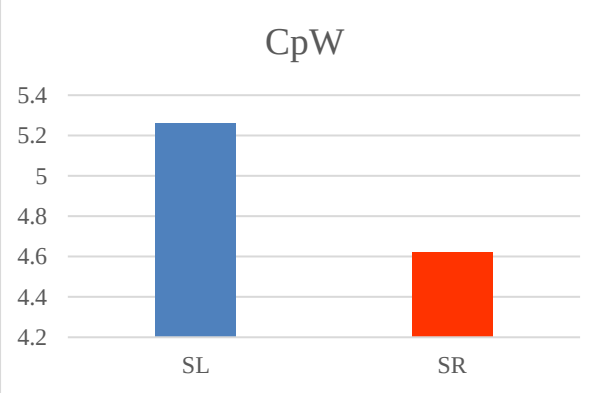


Figure13 % Caudal Peduncle Width (CpW) of (SL, SR)

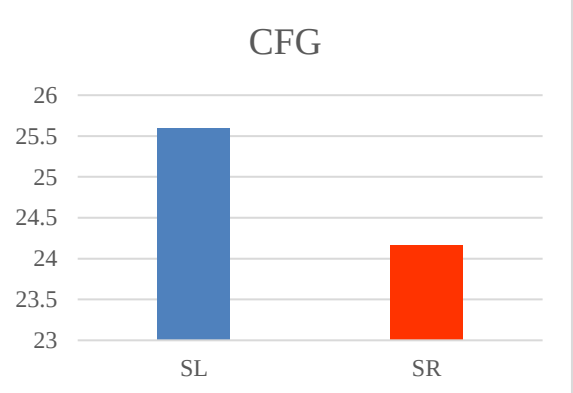


Figure14 % Caudal Fin Gap (CFG) of (SL, SR)

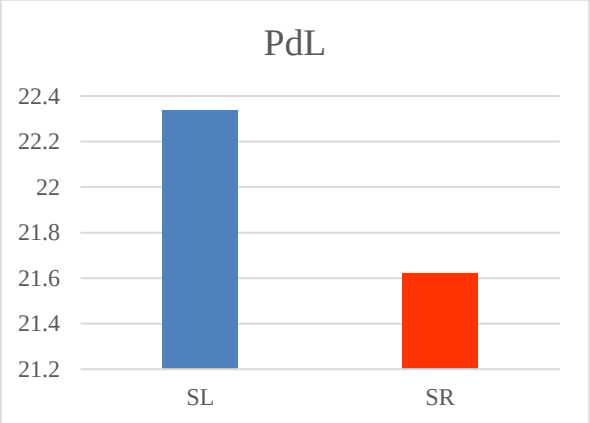


Figure 15 %mean Pre-Dorsal Length (PdL) (SR, SL)

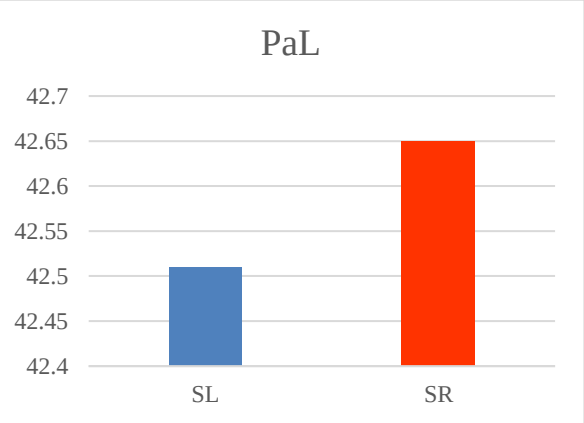


Figure 16 %mean Pre-Anal Length (PaL) (SR, SL)

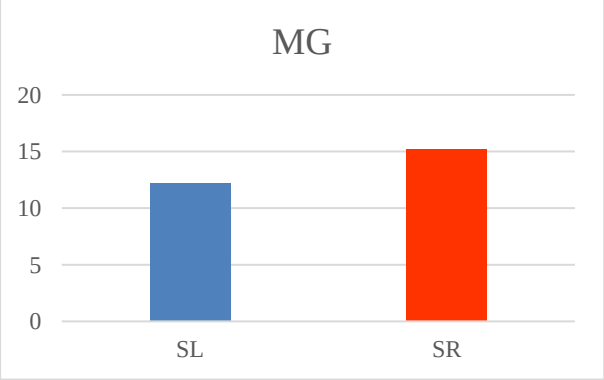


Figure 17 %mean Mouth Gap (MG) of (SL, SR).

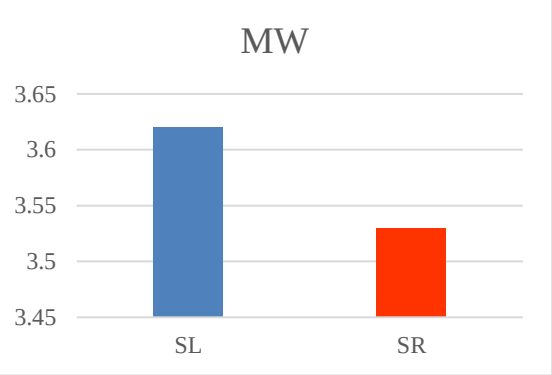


Figure 18 %mean Mouth Width (MW) of (SL, SR).

Figure 19 %mean Caudal fin Length (CL) of (SL, SR).

Correlations Between the Morphometric Parameters

A strong correlation ($r \geq 0.7$) was observed between the following parameters:

Siganus luridus

- TW vs. TL, FL
- TL vs. FL
- SL vs. DFL, AFL

Siganus rivulatus

- TL vs. TW, FL, SL
- TW vs. FL, SL, BD
- FL vs. SL, HL
- SL vs. HL

Fulton Condition Factor (K_F) of *Siganus luridus* and *Siganus rivulatus*

K_F of *Siganus luridus*: 1.61

K_F of *Siganus rivulatus*: 1.20

Weight-Length Relationship of *Siganus luridus* and *Siganus rivulatus*

The Linear and power length-weight relationships of *S. luridus* and *S. rivulatus* are presented in Table 2 and Figure 20 and 21. Both the power and the linear equations describe well the length-weight relationship of *S. luridus* and *S. rivulatus*, with R^2 values ranged between 0.46 and 0.63. The exponent b of the power equation of the both fish was negatively allometric (less than 3), meaning that weight increase at a slower rate compared to length.

Table 2 The linear and power Weight-Length relationship of *Siganus luridus* and *Siganus rivulatus*

Species	Regression	a	b	R^2
SL	**Linear**	**-85.63**	**10.22**	**0.54**
	Power	**0.31**	**1.98**	**0.63**
SR	**Linear**	**-58.57**	**6.895**	**0.51**
	Power	**0.478**	**1.69**	**0.46**

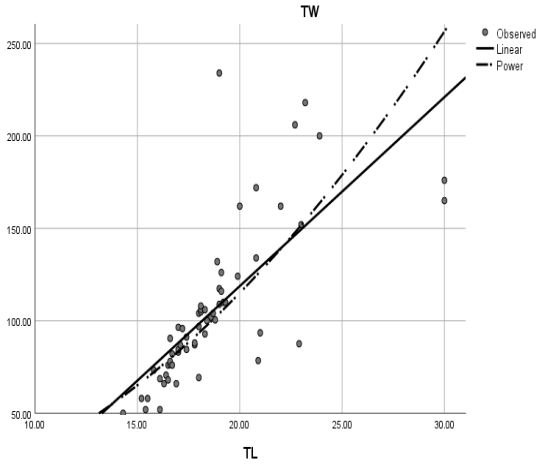


Figure 20 Linear and power regression of SL

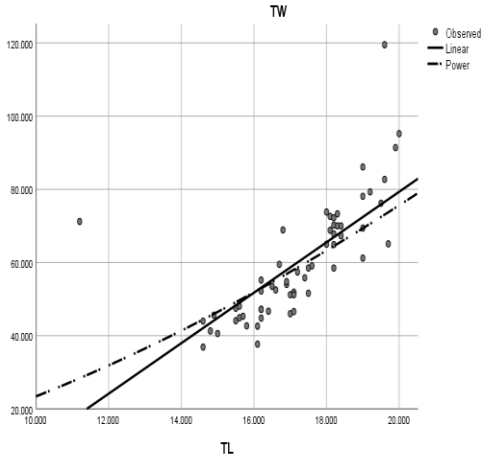


Figure 21 Linear, power regression of SR

Other Length-Traits Relationships of *Siganus luridus* and *Siganus rivulatus*

The morphometric traits in the head region, related to fish head length (HL), were analyzed in both species using linear and power equation (Table 3 and Figure 22-31). The R^2 values were low in all equation (less than 0.4). Morphometric traits outside of the head region, other than fish weight, were also related to the fish total length using linear and power equations (Table 4 and Figure 32-59). All the relationships were positive, indicating that traits increase with an increase in length. The R^2 values were moderate to high for SL, FL, and HL in both species, but were low for the other traits ($R^2 < 0.4$). The linear equation was found to be more effective in describing the length-trait Relationship than the power equation, as it exhibited higher R^2 values for all traits (Table 4 and Figure 32- 59).

Table 3 Linear (L) and power (P) regression of Morphometric traits in head region on head length of *Siganus luridus* and *Siganus rivulatus*

Morphometric traits	Regression	SL			Regression	SR		
		a	b	R^2		a	b	R^2
ED vis HL	Linear	0.09	0.27	0.22	Linear	0.405	0.172	0.111
	Power	0.24	1.11	0.13	Power	0.411	0.695	0.057
PoL	Linear	0.35	0.29	0.32	Linear	0.325	0.293	0.182
	Power	0.57	0.68	0.33	Power	0.550	0.699	0.130
PosL	Linear	-0.17	0.40	0.34	Linear	0.398	0.192	0.082
	Power	0.20	1.41	0.21	Power	0.429	0.686	0.030
MG	Linear	1.96	0.09	0.001	Linear	1.945	0.20	0.02
	Power	1.99	-0.10	0.00	Power	2.037	0.184	0.007
MW	Linear	0.66	0.01	0.00	Linear	0.206	0.122	0.059
	Power	0.71	-0.11	0.002	Power	0.18	0.98	0.092

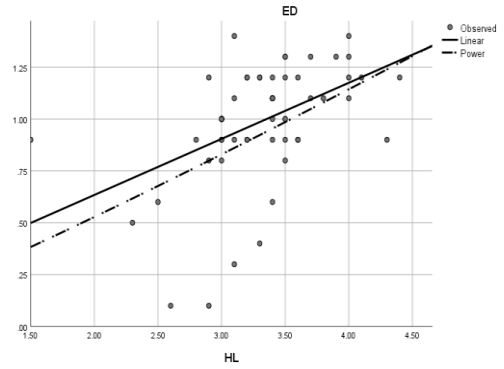


Figure 22 Linear and power regression of SL

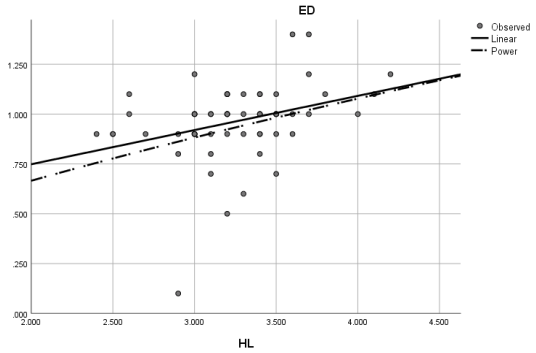


Figure 23 Linear, power regression of SR

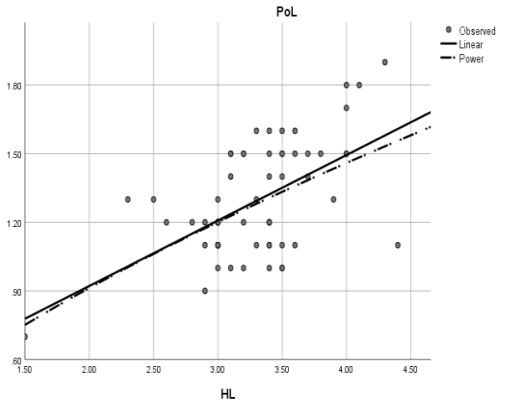


Figure 24 Linear and power regression of SL

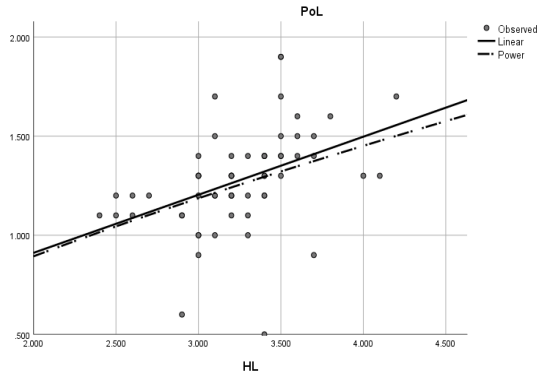


Figure 25 Linear, power regression of SR

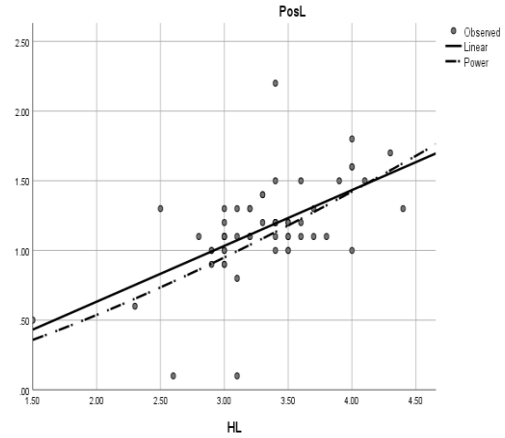


Figure 26 Linear and power regression of SL

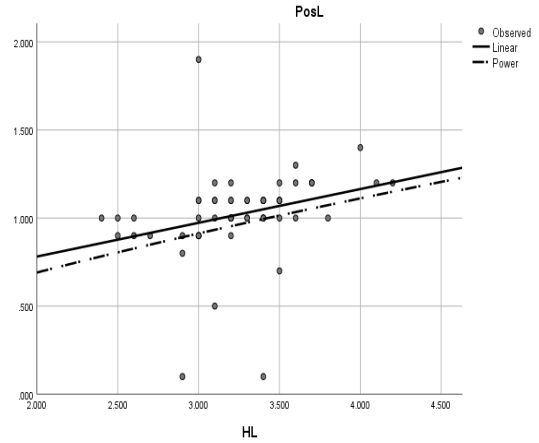


Figure 27 Linear, power regression of SR

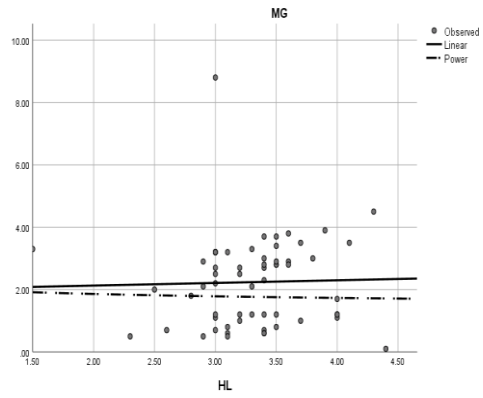


Figure 28 Linear and power regression of SL

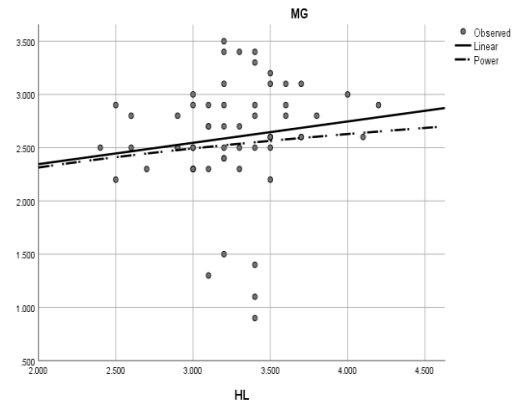


Figure 29 Linear, power regression of SR

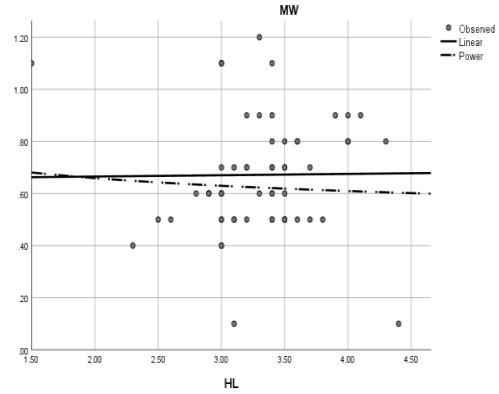


Figure 30 Linear and power regression of SL

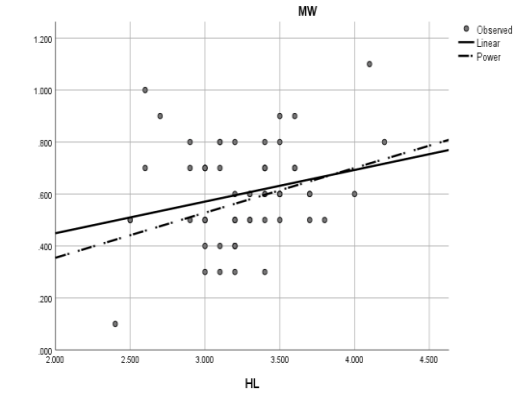


Figure 31 Linear, power regression of SR

Table 4 Linear and power regression of Morphometric traits on total length of *Siganus luridus* and *Siganus rivulatus*

Morphometric traits	Regression	SL			Regression	SR		
		a	b	R2		a	b	R2
FL vis TL	Linear	-0.40	0.988	0.86	Linear	6.28	0.571	0.545
	Power	0.82	1.06	0.78	Power	3.42	0.545	0.48
SL	Linear	7.78	0.38	0.22	Linear	4.54	0.542	0.574
	Power	3.45	0.495	0.146	Power	2.47	0.607	0.507
BD	Linear	3.94	0.125	0.078	Linear	2.57	0.15	0.233
	Power	3.79	0.16	0.005	Power	1.49	0.44	0.213
HL	Linear	1.77	0.08	0.26	Linear	0.83	0.14	0.39
	Power	0.83	0.47	0.17	Power	0.496	0.66	0.33
PeFL	Linear	1.72	0.08	0.02	Linear	2.34	0.007	0.001
	Power	0.42	0.68	0.09	Power	2.63	-0.03	0.000
DFL	Linear	5.08	0.31	0.42	Linear	5.74	0.223	0.09
	Power	1.72	0.63	0.50	Power	3.87	0.316	0.046
PFL	Linear	2.35	0.05	0.023	Linear	2.42	0.027	0.001
	Power	1.27	0.32	0.03	Power	2.11	0.089	0.001
AFL	Linear	4.77	0.08	0.043	Linear	2.54	0.18	0.077
	Power	3.15	0.23	0.02	Power	1.82	0.39	0.032
CpL	Linear	0.14	0.07	0.18	Linear	0.539	0.036	0.033
	Power	0.08	0.98	0.17	Power	0.268	0.501	0.033
CpW	Linear	1.04	-0.004	0.001	Linear	-0.71	0.088	0.105
	Power	14.58	-0.98	0.05	Power	0.025	1.19	0.119
CFG	Linear	3.71	0.05	0.02	Linear	-1.05	0.303	0.204
	Power	2.35	0.23	0.02	Power	0.11	1.26	0.147
PdL	Linear	1.68	0.13	0.30	Linear	2.21	0.086	0.06
	Power	0.62	0.65	0.28	Power	1.15	0.405	0.05
PaL	Linear	2.71	0.28	0.31	Linear	-0.35	0.447	0.36
	Power	0.78	0.78	0.16	Power	0.327	1.089	0.278
CL	Linear	-0.21	0.06	0.13	Linear	0.043	0.035	0.092
	Power	0.02	1.31	0.11	Power	0.06	0.812	0.057

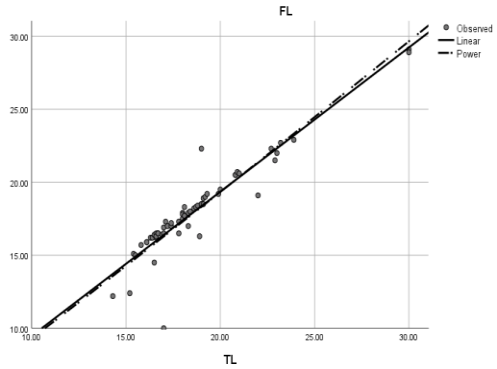


Figure 32 Linear and power regression of SL

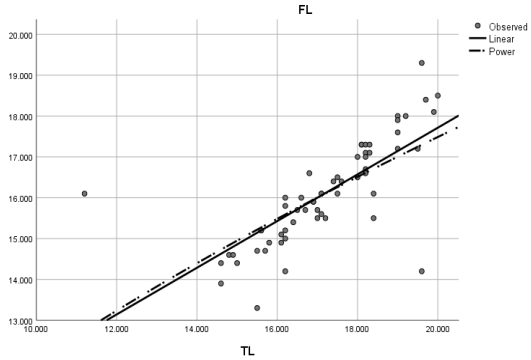


Figure 33 Linear, power regression of SR

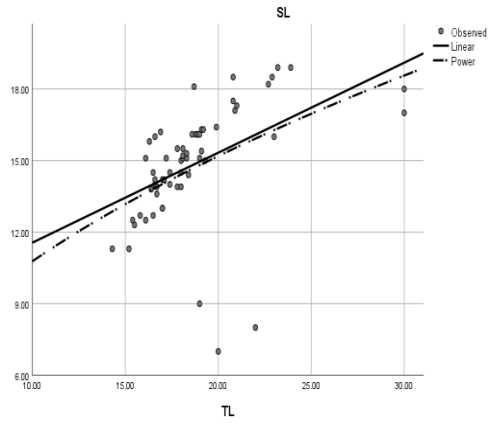


Figure 34 Linear and power regression of SL

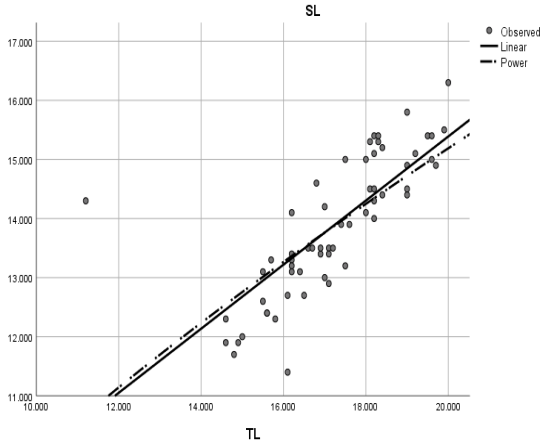


Figure 35 Linear, power regression of SR

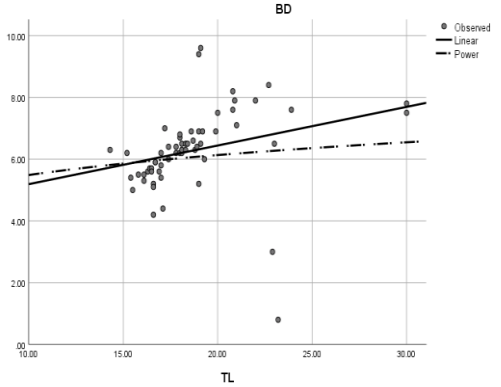


Figure 36 Linear and power regression of SL

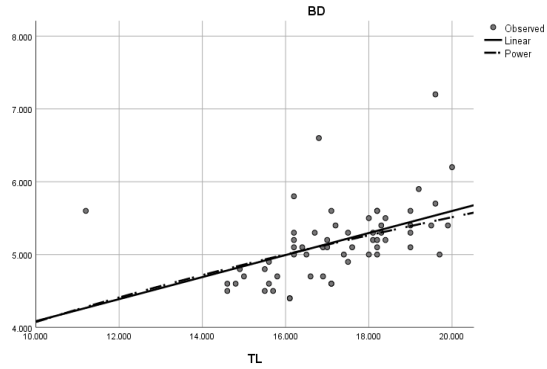


Figure 37 Linear, power regression of SR

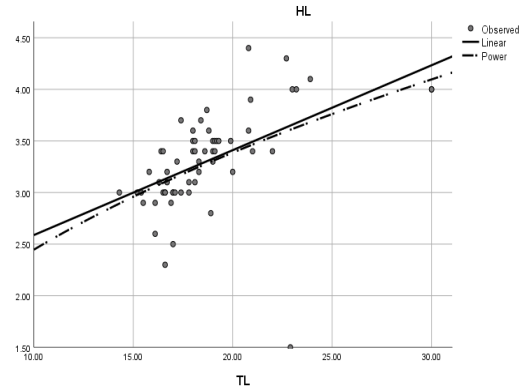


Figure 38 Linear and power regression of SL

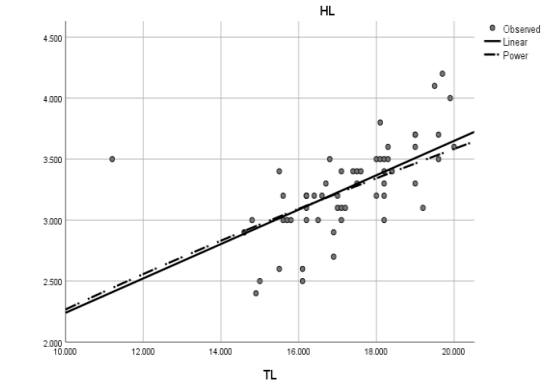


Figure 39 Linear, power regression of SR

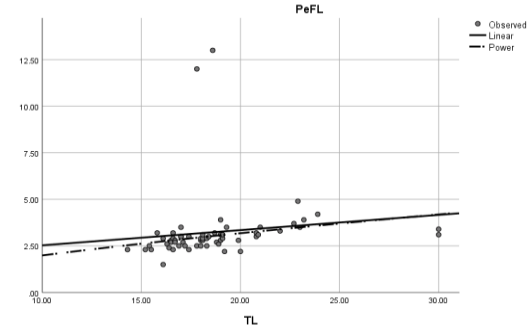


Figure 40 Linear and power regression of SL

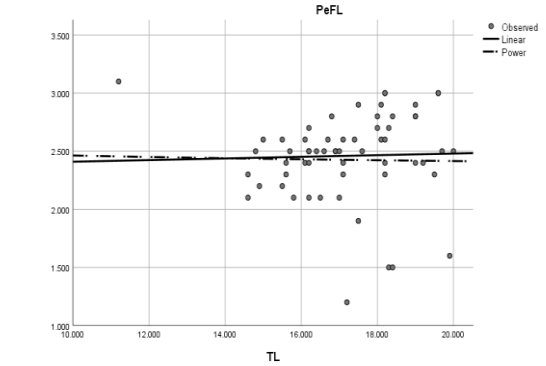


Figure 41 Linear, power regression of SR

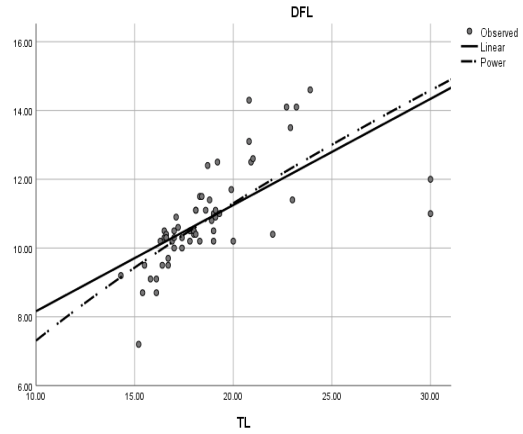


Figure 42 Linear and power regression of SL

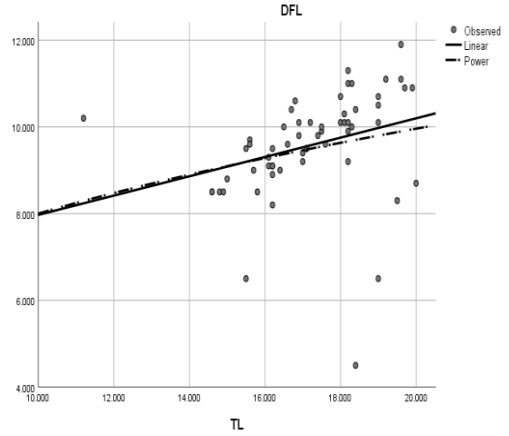


Figure 43 Linear, power regression of SR

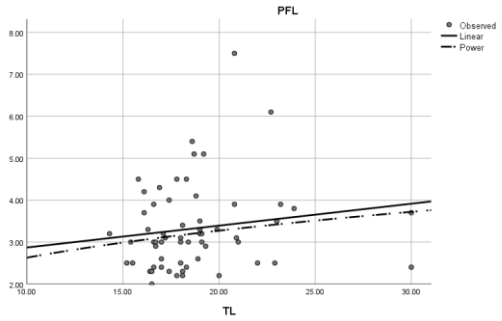


Figure 44 Linear and power regression of SL

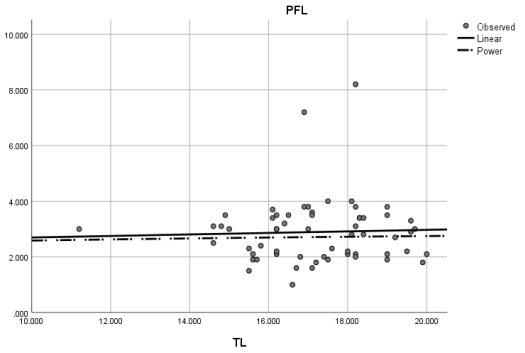


Figure 45 Linear, power regression of SR

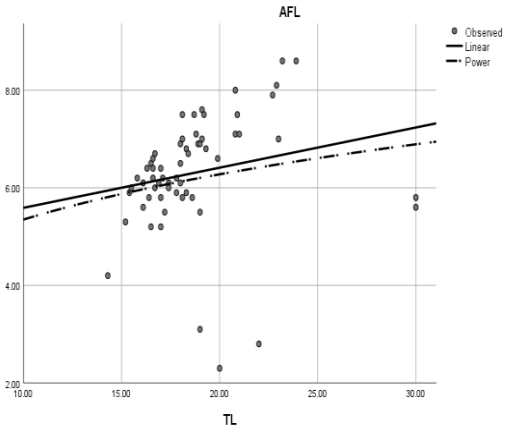


Figure 46 Linear and power regression of SL

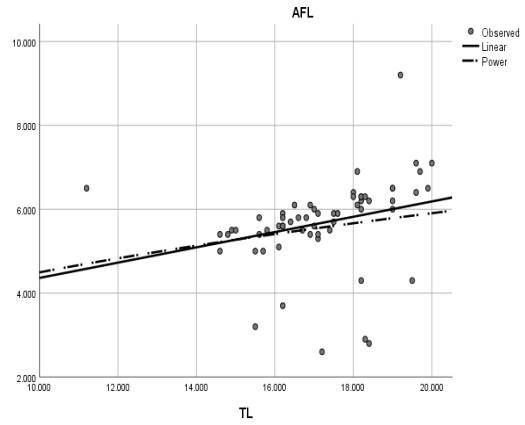


Figure 47 Linear, power regression of SR

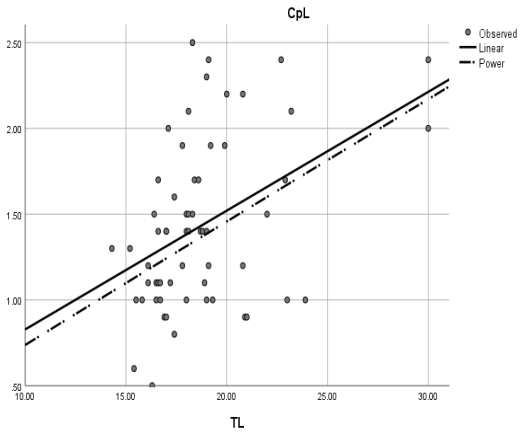


Figure 48 Linear and power regression of SL

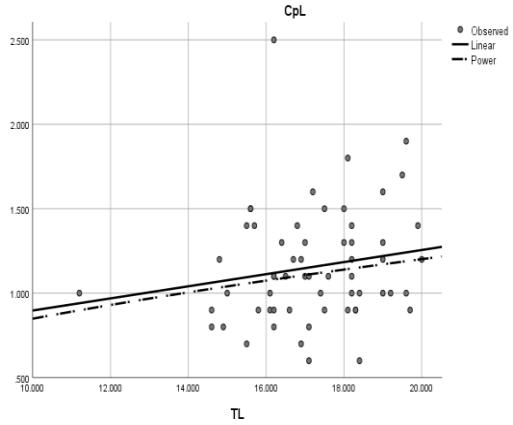


Figure 49 Linear, power regression of SR

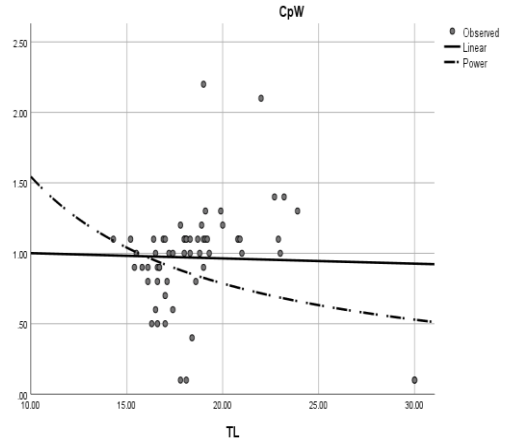


Figure 50 Linear and power regression of SL

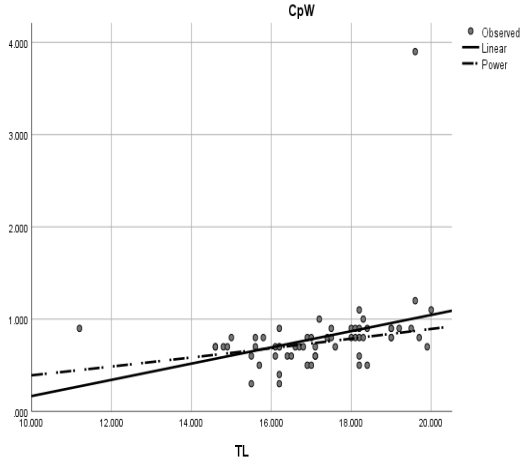


Figure 51 Linear, power regression of SR

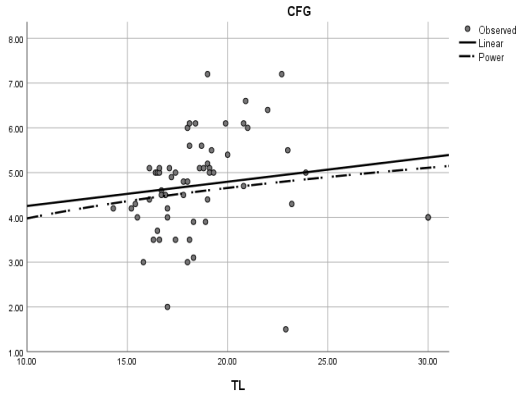
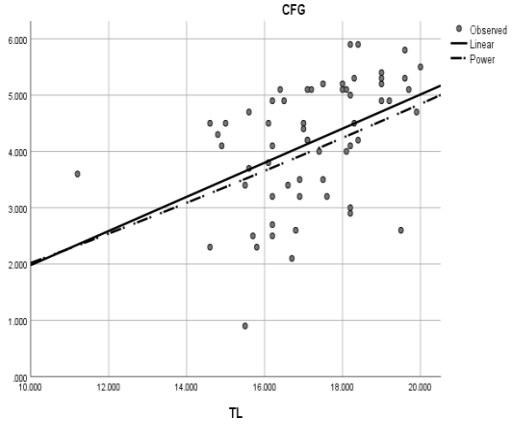


Figure 52 Linear and power regression of SL



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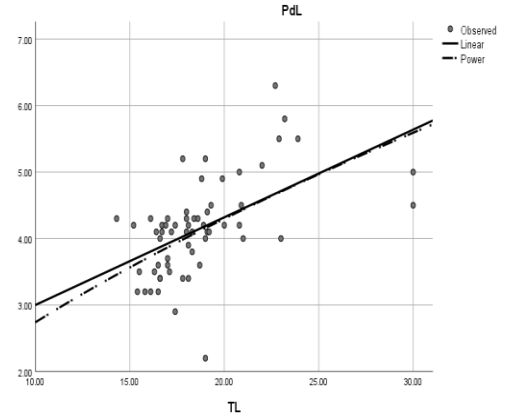

Figure 54 Linear and power regression of SL

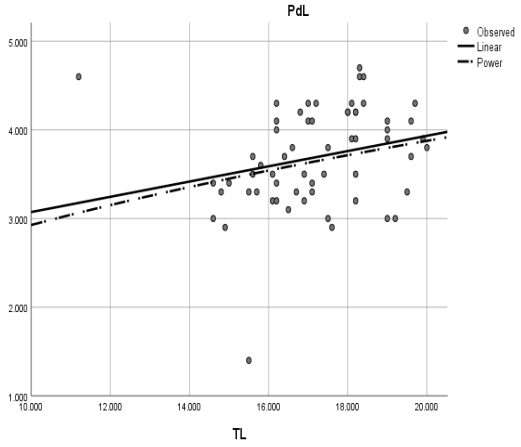

Figure 55 Linear, power regression of SR

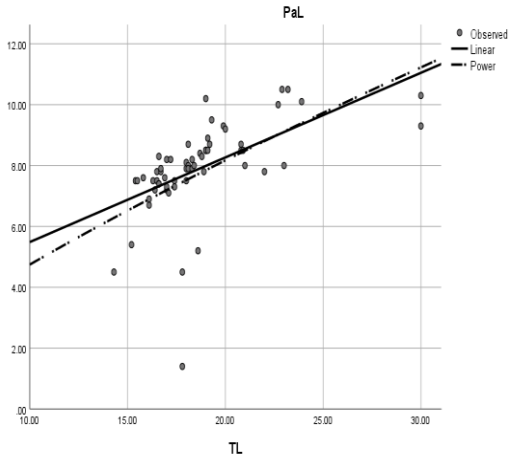

Figure 56 Linear and power regression of SL

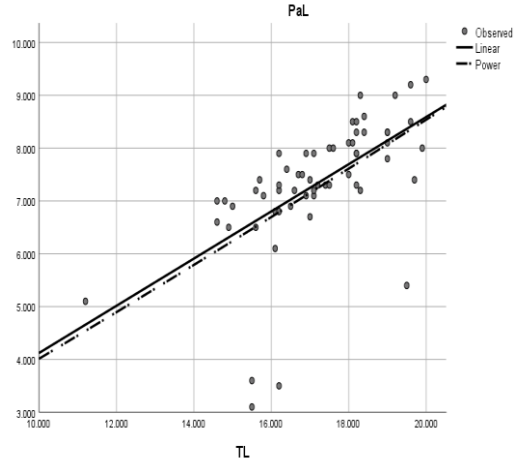

Figure 57 Linear, power regression of SR

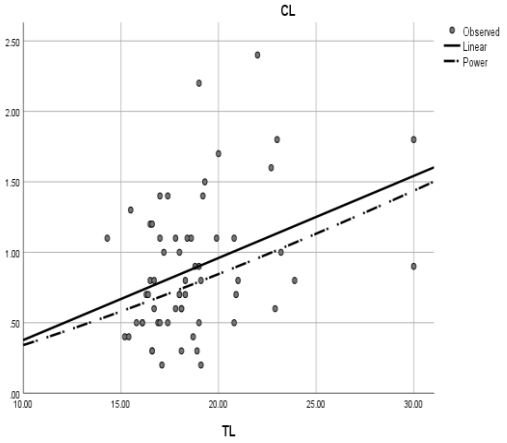

Figure 58 Linear and power regression of SL

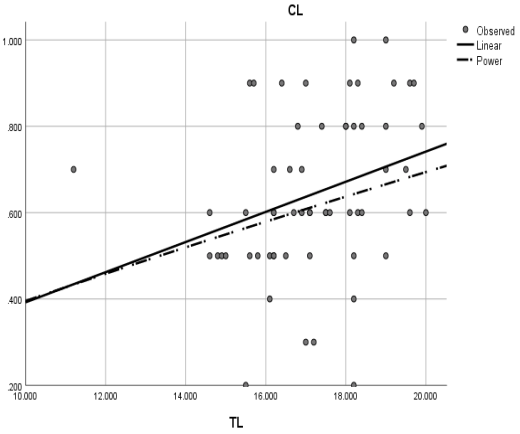

Figure 59 Linear, power regression of SR

Erguden *et al.* (2009) studied the weight–length relationships for 20 Lessepsian fish species caught by bottom trawl on the coast of Iskenderun Bay (NE Mediterranean Sea, Turkey). The mean length of *Siganus luridus* and *S. rivulatus* 14.90 cm and 15.61cm, respectively, while the mean weight was 15.45gm for *S. luridus* and 41.48gm for *S. rivulatus*. The b value was 2.92 for *S. luridus* and 2.823 for *S. rivulatus* [16]. In another study on Seasonal variation in the length-weight relationship and condition factor of thirty fish species from the Shimoni artisanal fishery, Kenya, by Ontomwa *et al.* (2018) found the b value for *S. luridus* was 1.8 (R^2 = 0.57) with a condition factor of 1.51 during northeast monsoon. The b value for the same fish was 3.0 (R^2 = 0.88) indicating isometric growth, with a condition factor of 1.47 during southeast monsoon [17].

It is well known that "b" values change over spatially and temporally due to environmental differences in fish habitats and internal physiological conditions. The "b" values obtained in this study are consistent with previous studies, supporting the idea that the length-weight ratio is affected by several factors, including: season, habitat, maturity of the offspring, sex, diet, stomach fullness, health status, and length range differences affected by fishing gear [18].

Conclusion

The morphometric traits, length-weight relationship, and condition factor were established for both fish species. All morphometric traits inside the head related to head length, while other traits outside the head were related to total length using both linear and power regression. *S. luridus* appears to be a better fish for aquaculture as it reaches a larger size compared to *S. rivulatus*.

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