The Morphology, Biometry, Weight-length Relationship and Growth of the Goatfish *Parupeneus cinnabarinus* (Cuvier & Valenciennes) in the Gulf of Aqaba, Red Sea

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ABSTRACT. Selected biometric characters, weight-length relationships and growth rates of the Aqaba species *Parupeneus cinnabarinus* were studied. A total of 17 of the 20 morphometric measurements investigated grew isometrically with fish length. The eye diameter changed in a negative allometry while body depth and width showed a positive allometry. Counts of seven meristic characters were recorded. The weight of fish increased in positive allometry as the fish increased in size, with a growth factor (n) of 3.1748. The von Bertalanffy equation applied well for the growth calculations with growth factors of : $L_x = 44.4$ cm, $K = 0.208$ and $t_o = -0.998$.

Parupeneus cinnabarinus, first identified by Cuvier & Valenciennes (1829) from Ceylon (Sri Lanka) and later by Bleeker (1853) from Amboina, is a widely distributed species throughout the Indo-Pacific regions. It was first recorded in the Red Sea by Klunzinger (1870) and in the Gulf of Aqaba by Steinits and Ben-Tuvia (1955).

This fish is highly favoured in the market and well known to fishermen in Aqaba with the Arabic common name "Sabalan". However, this species has received little attention from biologists. Al-Kholy (1972) indicated that it is a sandy-bottom inhabitant of the Red Sea, usually found in deep water. Al-Absy (1977, 1987) reported on its taxonomic position and few biological parameters.

The present study is aimed at a more complete description of this species by analysis of various biometric characters, weight-length relationships as well as age and growth rates. This knowledge will contribute to the overall productivity and management of this species in the Gulf of Aqaba and other localities.

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Materials and Methods

The present work is an updated analysis of the original raw data collected by the author in the period June 1975 to May 1976 (Al-Absy 1977). A total of 170 fishes 127-369 mm TL (99-282 mm SL) and 232-631 g W, were collected from the Jordanian Sector of the Gulf of Aqaba. The site of collection stretches in length from an area in front of the Marine Science Station to about 10 km south along the sea shore, and in depth from the shoreline to about 30 m. The shore is characterized by thick fringing coral reefs, open grass beds, or sandy bottom with patchy or atoll corals.

Samples of fishes were collected twice every other week by the use of gill nets of various mesh sizes. The gill nets were laid in water overnight and recovered the next morning. Using other fishing gear, *i.e.*, hooks and lines, or gill nets during day time were not successful.

The morphological characterization of the species involved description of body form and profile, external components, and color pattern. The biometric description involved analysis of seven meristic counts and 20 morphometric measurements. Meristic counts were indicated as average and range of count when available. The analysis of morphometric measurements included the calculation of ratio indices for these measurements obtained by expressing each measurement as % of SL. The ratio index was calculated at the various total length groups of fish. All measurements were taken from fish specimens to the nearest 1 mm and weight to 0.1 g. Measurements and counts were done following Hubbs and Lagler (1958) and Krupp (1983).

The weight-length relationship was represented by the equation shown below (applied to fishes by Le Cren 1951):

$$W = c.L^n$$

or
$$\log W = \log c + n \log L$$

where W is total fish weight in grams, L is total length (TL) in centimeters, and c and n are constants. The values of the constants c and n in these equations were calculated following Backman (1948). The coefficient of condition (Q) was obtained by the equation (Hile 1936):

$$Q = \frac{W \times 100}{L^n}$$

Scales were taken from the side of the body below the lateral line just at the tip of the pectoral fin when depressed against the body. The scales were cleaned with

tissue paper, dry mounted between two slides, and read on a microprojector (micromaster, FISHER) at a magnification of 22X. Only scales with clear annuli were used in the calculations. Fishes were assigned to age groups based on the total number of annuli. Calculations of the growth rates of fish were done following Gulland (1969) by applying the von Bertalanffy equation:

$$L_t = L_\infty [1 - e^{-K(t - t_0)}]$$

where L_t = total length of fish at time t (age group); L_∞ = maximum forecasted length of fish; and K and t_0 are constants. Detailed application of the equation is demonstrated in the results section on "Growth Rates". Analysis of data was done following standard statistical procedures in Steele and Torrie (1980).

Results

Morphology and Biometry

The morphological description of the Aqaba population of *P. cinnabarinus* is as follows: The body is deep, eliptical and noticeably compressed; teeth are strong, pointed and curved laterally; the long gillrakers are lanceolate with tiny branches on the side; the suboperculum is in the form of a thin, wide angular flap, while the posterior upper margin of the operculum bears a small spine; the spines of the spinous dorsal, when depressed, never reach to base of the soft dorsal; the scales appear to have cracks or tears.

The color of the body is deep cinnabar red, brownish on the upper side and lighter (pale-red) on the belly. Each scale appears deep-cinnabar red against a deep-violet spot which appears pale yellow in water. Fins are pink or hyaline yellow, the second dorsal with few yellowish lines, while the pectoral, ventral and anal fins are pale red and the spinous dorsal and tail fins are homogeneous red.

The meristic counts are: Dorsals VIII/I,8; pectoral 15-16; anal I/6; scales in the lateral line 28; scales above and below lateral line $2\frac{1}{2}/7$; gillrakes 5-7/12−22, together with 3-7 knob-like rakers on the upper arm; and vertebrae 10/14.

The analysis of ratio indices for the 20 morphometric measurements (Table 1) reveals a narrow range of measurement in most cases over the standard length range of fishes. However, most of the ratio indices exhibit only minor variations (low SD) around an average value in each case without a particular trend of change. This indicates that each morphometric measurement, except eye diameter (ED), body depth (BD) and body width (BW), grows in an isometric fashion as the fish grows in size. The ratio index of the eye diameter (ED/SL) starts relatively high (8.3%) in the smallest fish (SL, 99 mm) and decreases steadily to 5.4% in the

largest fish (SL, 282 mm). Thus eye diameter grows in a negative allometric fashion. In contrast, the body depth ratio increases, with its lowest value (27.5%) in the smallest fish and highest (33.8%) in the largest fish. Similarly, the ratio index of body width is lowest (16.2%) in the smallest fish, increases to (20.9%) in the largest fish. These figures indicate that both body depth and body width increase in a positive allometric fashion. However, the changes in the ratio indices of the three measurements were not significant ($P > 0.05$).

Table 1. Analysis of ratio indices of 20 morphometric measurements of 180 *P. cinnabarinus* from the Gulf of Aqaba

Morphometric measurement	Ratio index*		S.D.
	Average %	Range	
Total length	130.1	129.0 – 131.2	0.007
Body depth	31.4	27.5 – 33.8	1.554
Body width	18.1	16.2 – 20.9	1.064
Head length	33.0	30.8 – 34.4	0.658
Head depth	28.8	26.2 – 30.9	1.065
Head width	16.8	14.7 – 18.6	1.144
Caudal peduncle length	26.4	25.4 – 28.5	0.714
Caudal peduncle depth	10.7	10.2 – 11.4	0.272
Snout length	17.4	16.0 – 18.8	0.793
Postorbital length	12.4	11.7 – 13.0	0.330
Interobital width	9.3	8.7 – 9.6	0.292
Eye diameter	6.6	5.4 – 8.3	0.827
Barbel length	26.2	25.2 – 26.7	0.551
Pre-first dorsal	39.8	38.2 – 41.3	0.757
Pre-anal	60.3	57.5 – 61.9	1.036
First dorsal length	21.2	20.4 – 22.5	0.506
Second dorsal length	17.4	15.8 – 18.4	0.598
Pectoral length	24.4	23.3 – 26.0	0.731
Pelvic length	22.1	20.3 – 24.2	1.024
Anal length	13.3	12.5 – 14.4	0.453

* expressed as a percentage of the standard length

Weight-length Relationship

The relationship between the fish total weight (W) in grams and its total length (L) in cm is expressed by the following equation:

$$W = 7.3670 \times 10^{-3} \cdot L^{3.1748}$$

or by the logarithmic regression form:

$$\log W = -2.13 + 3.1748 \log L \quad (R^2 = 0.9310)$$

The values of the condition factor (Q) ranges between 1.11 and 1.40 with an average of 1.23. It is observed (from the raw data) that the Q value increases with the total length of fish until about 33 cm, beyond which it declines. Such changes in the Q values, however are not statistically significant ($P > 0.05$). In addition, no significant differences encountered in the Q values throughout the year (1.23 in December - February and 1.31 in June-August).

Growth Rates

The scale examination of this species revealed the presence of false annuli together with true ones. Considerable difficulty was encountered in reading the scales of fish from the Gulf of Aqaba, a subtropical habitat, and only the most readable scales were used in the growth analysis. Six age groups were encountered, the youngest age being missing from the present sample.

The data on the observed values of fish total length (L_t in Table 2) are used to estimate the growth parameters of the von Bertalanffy equation. The following equation:

$$L_{t+1} - L_t \ (Y) \ \text{vs.} \ L_t \ (X)$$

is expressed in a regression form, $(Y) = a + b \ (X)$, as:

$$(Y) = 8.398 + (-0.189)(X) \quad (R^2 = 0.780).$$

Then the growth parameters are calculated from this equation as follows:

$$L_\infty = a/\text{-}b = 44.4 \ \text{cm}$$
$$K = -[\ln(1 + b)]/t = 0.208$$
$$t_o = t + (\frac{1}{k}) \ [\ln(L_\infty - L_t/L_\infty)] = -0.998$$

The calculated values of fish TL at each age group (t) (Table 2) are derived by applying the original equation:

$$L_t = L_\infty [1 - e^{-K(t-t_o)}]$$

or
$$L_t = 44.4[1 - e^{-0.208(t+0.998)}]$$

Such values are presented in Table 2. Both the observed and calculated values of TL are used to calculate their corresponding regression equation as follows:

$$L_{cal.} = -0.033 + (0.992)(L_{obs.}) \quad (R^2 = 0.989).$$

It is obvious that the calculated values of TL represent closely the corresponding observed ones, with a coefficient of correlation = 0.989. This finding indicates that the von Bertalanffy equation expresses the present data accurately.

Table 2. The average observed and calculated total lengths (TL) at various age groups of *P. cinnabarinus* from the Gulf of Aqaba

Age Group	Number examined	Observed mean T L (cm)	Calculated T L (cm)	Increment
I			8.3	8.3
II	12	15.1	15.1	6.8
III	35	20.5	20.6	5.5
IV	30	25.5	23.7	3.1
V	20	27.9	28.7	5.0
VI	8	31.8	31.6	2.9

Total examined = 105

The trends of increments in length and weight in each age group of fish indicate the maximum increment in length occurs in the first two years (56%), while that of weight occurs in the ages 4-6 years (70%). This means that the fish adds more weight than length as it grows older, since its body increases in width and depth together with length.

Discussion

In the few sporadic records of *P. cinnabarinus* throughout the Indopacific regions, few biometric characters have been reported for diagnostic purposes of the species. These include Herre and Montalban (1928) from the Phillippines, Fowler (1941) from China, and Thomas (1969) from the Indian Ocean. With regard to diagnostic morphology, the present results are similar to those reported by other authors with only minor differences in some details of the body morphology and coloration in live fishes.

The data on ratio indices (Table 1) indicate that the examined morphometric measurements (except eye diameter, body width and body depth) grow isometrically with that of fish length. The minor variations in the ratio indices between the

different fish lengths justifies the use of ranges in describing the various diagnostic features characteristic of the species.

It is well known that the cubic parabola $W = c.L^n$ is applied in those cases when fish grow in weight isometrically with length, as the fish expands in the three dimensions; length, depth and width. The present value of the exponent n being larger than 3 (n = 3.1748), reveals that the weight of this fish exhibits allomeric growth. This finding, together with the aforementioned positive allometric growth of both body depth and width, indicate that this fish adds more to its weight than length as it grows older, and in this way, the body becomes wider and deeper (more robust). This finding is also supported by the progressive increase in the (Q) value with the growth of fish. In general, *P. cinnabarinus* has overall higher Q value than two other mullid species, *P. barberinus (= forsskali)* (Q = 1.048) and *Mulloides auriflamma (= flavolineatus)* (Q = 0.975) (Al-Absy 1977). The minor variations in the Q values of the fish caught in the different months of the year could be attributed to corresponding minor variations in the availability of food and feeding activities of this fish. Therefore, the nonsignificant changes of Q throughout the year reveal the general picture of a relatively stable environment in the Gulf of Aqaba. This finding is supported by the fact that the temperature of sea water in the Gulf does not drop below 20°C even in winter (Klinker *et al.* 1978).

The von Bertalanffy equation (and the derived regression equation) applied well to the present growth data. There is, however, about 8 cm difference between the forecasted maximum total length (L_∞, 44.4 cm) and the largest fish caught (36.0 cm). This difference could be explained by the lack of first age class in the samples and probably to selectivity of the fishing gear. Al-Kholy (1972) reported a length of 35.6 cm of the same fish from the Red Sea and Randall (1983) a length of 39.0 cm.

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الصفات المورفولوجيـه والبيومـترية وعـلاقة الـوزن بالـطول والنمــو لنـوع سمكــة السلطان إبـراهيم بـاروبينيـوس سينابارينس (كوفير وفالينسيس)

Parupenius cinnabarinus (Cuvier & Valenciennes)

في خليج العقبة من البحر الأحمر

١أحمد حسن العبسي و٢ عدنان اجياد

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٢محطة العلوم البحرية ـ ص . ب : ١٥٩ ـ العقبة ـ الأردن

لقد تمت دراسة مجمـوعة معينـة من الخصـائص البيـومترية وعلاقـة الوزن بـالطول ومعدلات النمو لأحـد أنواع أسمـاك عائلة السلطان إبـراهيم في خليج العقبـة وهو باروبينيوس سينابارينا(Cuvier & Valenciennes) *Parupenius cinnabarinus* وقد تم فحص العلاقة بين طبيعة نمو ٢٠ قياس حيوي مع طول السمكة فوجد أن ١٧ قياساً تنمـو بشكـل متجانس مـع الطول بينمـا كان نمـو قطر العين سلبيا ونمـو عرض السمكـة إيجابياً . كما تم تسجيل القياس العددي لسبعة خصائص عددية . كما وجد أن وزن السمكة يزداد بشكـل إيجابي مـطرد مع نمـو السمكة في الـطول بمعامـل نمو مقداره ٣,١٧٤٨ وطبقت معادلة فون بيرتلنفي لحساب معدلات النمو بحيث كانت قيمـة لـ∞ = ٤٤,٤ سم، وك = ٠,٢٠٨ وت٥ = ٠,٩٩٨ .