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Age, Growth and Shell Morphometrics of the Gastropod *Monodonta dama* (Neritidae:Prosobranchia) from the Gulf of Aqaba, Red Sea

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Abstract: A total of 360 of the midlittoral gastropod *Monodonta dama* (Phillipi, 1848) from the rocky shores in the Gulf of Aqaba, Red Sea, were studied for age, growth and shell morphometrics. The results show that *M. dama* may survive for five years. The mean observed length at each of the five age cohorts was 0.605, 0.977, 1.328, 1.568 and 1.934 cm. Theoretically, using Von Bertalaffy's and Richard's growth formulae, the maximum length of this snail may reach 2.772 and 2.210 cm, respectively. The annual observed increase in length ranges from 0.240 to 0.372 cm. Theoretically, the increase ranges from 0.180 cm in old snails to 0.472 cm in young ones using the VBGF and from 0.134 to 0.260 cm using RGF. The relationships of the shell length to shell width, aperture length and aperture width are linear. The ratios of the shell length to shell width, aperture length and aperture width increase with age. This may indicate that this snail become more elongate with age.Moreover, the ratio of the shell width to aperture width increases with length. Shell and dry body weights averaged 705 and 475 mg, respectively. The relationships of the shell length to shell and dry body weights are curvilinear. However, the relationships of the shell length to shell width, aperture length and aperture width are linear. The relative coefficient of condition (Kn) which measures the progression of body weight and length was 0.334.

Key words: *Monodonta*, Jordan, Gulf of Aqaba, Red Sea, shell morphometrics

INTRODUCTION

Gastropods represent a major biotic component of rocky beaches. This has attracted the attention of biologists to study them and a wealth of information has appeared in the literature. The Jordanian coast along the Gulf of Aqaba extends for about 27 km on the eastern side. It consists of sandy, gravel and pebbles and rocky beaches. Hulings (1987a) reported the results of several years study of rocky intertidal gastropods including zonation, substrata distribution, exposure and submersion behavior, tolerance to exposure and desiccation and reproductive strategies and other aspects. Moreover, Hulings (1987b) determined the tolerance to exposure and desiccation of seven intertidal gastropods including *Monodonta dama*. No other studies on these gastropods from the intertidal rocky beach have been conducted. The present study was initiated to shed more light on the population structure of the gastropod *M. dama*. This includes the determination of age cohorts and possible life span of this snail. Moreover, shell morphometrics of *M. dama* is examined and analyzed.

MATERIALS AND METHODS

Study area: The Jordanian coast on the Gulf of Aqaba extends for about 27 km at the eastern northern tip of the Gulf (30°lat. 29°20' E to long 29°35' N). It lies within the very warm of sahara bioclimate zone. It is characterized by low rainfall (25 mm/year, Jordan Meteorological Department) and high evaporation rate (up to 4 m/year) (Anati, 1976). Average surface sea water temperature ranges from 21°C in February-March to 27°C in July-August and surface salinity is constant at 40.4 to 40.8 ppt (Paldor and Anti, 1979). A major period of phytoplankton productivity occurs from December-January and a minor period during May-June (Hulings and Abu-Hilal,1983).

The mean monthly air temperature ranges from 16°C in January to 32°C in August with relative humidity ranging from 40-57% (Jordan Meteorological Department). The tides of the Gulf of Aqaba are mixed (Hulings, 1979). The spring tide range averages 1.0 m and the neap tide range 0.5 m. There is an annual fluctuation of sea level of about 1.0 m. In spite of the small tidal/sea level ranges the duration and level of submergence on

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the generally low profile rocky beaches is considerable (Hulings, 1987a). The substrata of the rocky intertidal include boulders and multicolored pebbles underlain by sand platform or slab (Friedman, 1968). The latter is extremely variable and includes sand stones, conglomerate and beach rock.

Sampling and analysis: A total of 360 *M. dama* (Neritidae: Prosobranchia) snails were collected by hand picking from the rocky shores at the Marine Science Station 10 km south of Aqaba city during summer of 2004. In the laboratory, shell length (SHL), shell width (SHW), aperture length (APL) and aperture width (APW) were measured using vernier calipers, to the nearest 0.1 mm. The shells of snails were separated from soft tissues and dried to constant weights at 100°C. The dry weights of both the shell and soft body were weighed using an electrical digital balance accurate to 1 mg. Measured snails were divided into size groups of length intervals which were estimated using histogram plots that show normal distribution of length. Normality was tested at 95% confidence level. These histograms used to estimate the possible life span of *M. dama* snails.

The growth in length of *M. dama* was theoretically calculated using the Von Bertalanffy's Growth Formula (VBGF) ($L_t = L\infty[1-e^{-k(t-t)_0}]$) and the Richard's Growth Formula (RGF) ($L_t = L\infty[1-A*e^{-kt}]$). L_t is the length at age t, A =1-(minimum length/maximum length), k is the growth coefficient and t_0 is the age at which the length is theoretically nil. The constants $L\infty$, k and t_0 were calculated using the Quasi-Newton method (Ostle and Mensing, 1975) to the age-length data. For comparison with VBGF and RGF, the observed age length data were fitted to a linear regression equation. The relationships of the shell length to dry body weight and shell weight were described using a power regression equation (Ott, 1984)

The relative coefficient of condition (Kn) which measures the degree of fitness and suitability of the environment with regard to feeding condition was also estimated. Kn was calculated as: $Kn = X/aL^n$ where X represents the dry body weight, L is the shell length, a and n are the coefficients of the power regressing equation.

The relationships of the shell length to shell width, aperture length, aperture width, shell weight, dry body weight, total weight, ratio of shell width to aperture width, ratio of shell length to aperture length, ratio of shell length to shell width and the ratio of shell length to aperture width were studied using regression analysis.

RESULTS

Age and growth: The frequency distribution of shell length of the collected snails which fits normal distribution indicates the presence of five age cohorts for *M. dama* (Fig. 1). The mean observed length at each of these age cohorts was 0.605, 0.977, 1.328, 1.568 and 1.934 cm (Table 1). Calculated shell lengths using VBGF, RGF and the linear method were highly correlated with the observed values (R^2 >0.821) (Table 1). Thus, it is expected that this snail may survive to five years. The annual observed increase in length ranges from 0.240 to 0.372 cm. Theoretically, the increase ranges from 0.180 cm in old snails to 0.472 cm in young ones using the VBGF and from 0.134 to 0.260 cm using RGF. The theoretical growth parameters of *M. dama* were similar using VBGF and RGF (Table 2). The theoretical maximum growth was 2.772 and 2.210 cm and the growth coefficients (k) were 0.321 and 0.210. The length at t_0 was calculated to be 0.123.

Length-weight relationship: Collected *M. dama* snails range in length from 0.550 to 1.940 cm, with a mean value of 1.476 cm. Their shell and dry body weights range from 36 to 1469 mg with an average of 705 mg and from 23 to 984 mg with an average of 475 mg, respectively.

Table 1: Observed and calculated shell lengths (in cm) of various age groups of *Monodonta dama* from the Gulf of Aqaba using Von Bertalanffy's Growth Formula (VBGF) and the Richard's Growth Formula (RGF), and Linear regression equation

Age (years)	Observed	RGF	VBGF	Linear model
1	0.605	0.893	0.559	0.632
2	0.977	1.153	1.031	0.958
3	1.328	1.362	1.373	1.282
4	1.568	1.530	1.621	1.607
5	1.934	1.664	1.801	1.932
Adjusted R^2 or Variance explained (%)		82.13	99.66	0.996

Table 2: Growth parameters of *Monodonta dama* from the Gulf of Aqaba using Von Bertalanffy's Growth Formula (VBGF) and the Richard's Growth Formula (RGF)

Parameter	VBGF	RGF
$L\infty$	2.772	2.210
K	0.321	0.220
t_0	0.123	

Table 3: Measurements (means in cm±SD) of shell length (SHL) , shell width (SHW) aperture length (APL) and aperture width (APW) of various age groups of *Monodonta dama* from the Gulf of Aqaba

Age (years)	SHL	SHW	APL	APW
1	0.605±0.052	0.538±0.049	0.447±0.105	0.362±0.136
2	0.977±0.097	0.836±0.106	0.682±0.158	0.534±0.146
3	1.328±0.093	1.120±0.138	0.954±0.211	0.721±0.199
4	1.568±0.0106	1.334±0.133	1.041±0.224	0.791±0.211
5	1.934±0.058	1.472±0.169	1.199±0.244	0.849±0.212

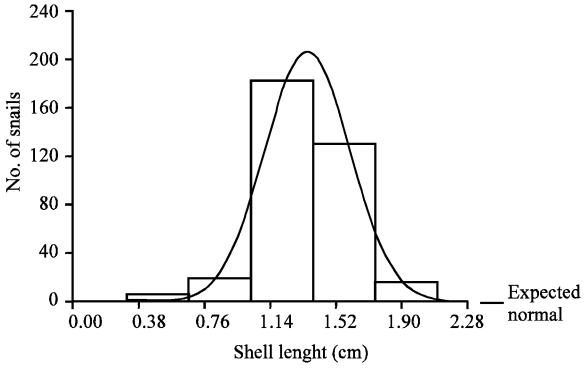

Fig. 1: Frequency distribution of estimated age groups of *Monodonta dama* from the Gulf of Aqaba showing expected normal distribution (N=360)

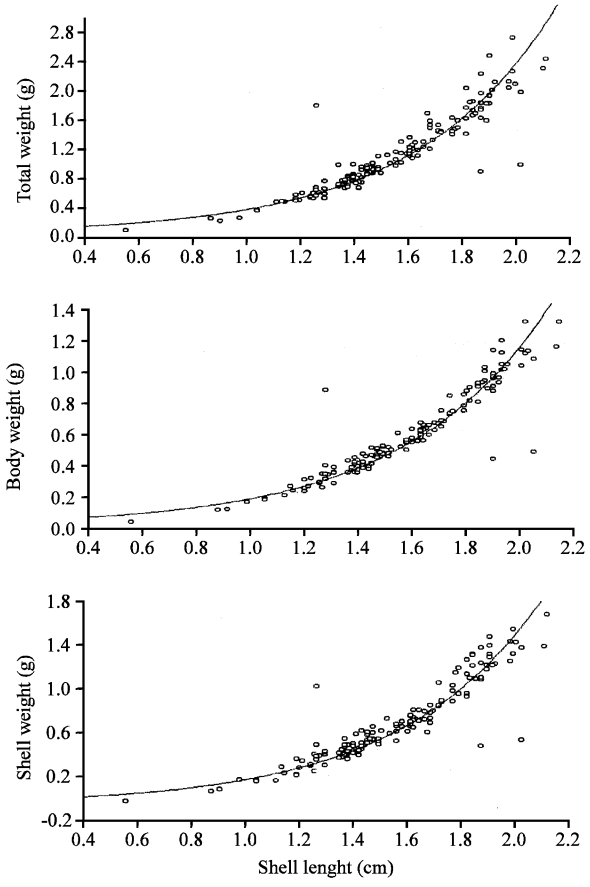

Fig. 2: The curvilinear relationships of the shell length to dry body weight, shell weight and total weight. of *Monodonta dama* from the Gulf of Aqaba.

Increase in shell and body weights was slower in young snails than older ones. This produced curvilinear relationships of the shell length to shell, dry body and

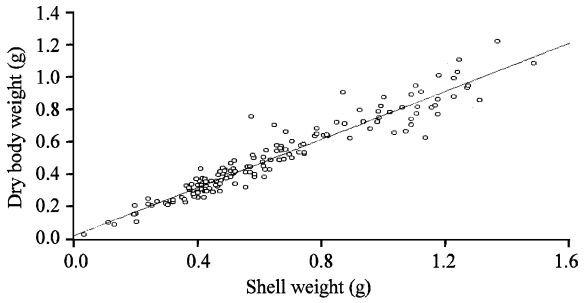

Fig. 3: The relationship of the dry body weight to the shell weight of *Mondonta dama* from the Gulf of Aqaba.

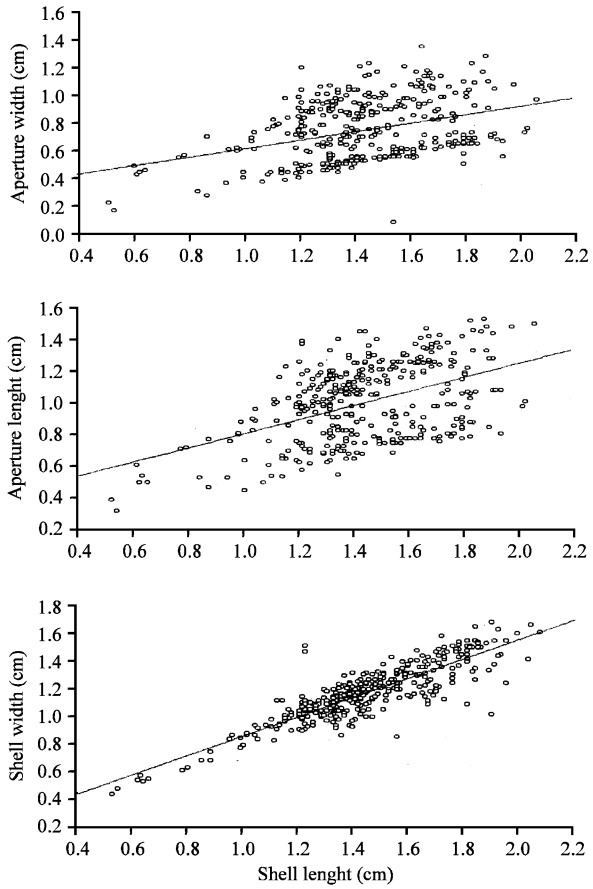

Fig. 4: The relationships of the shell length to shell width, aperture length and aperture width of *Monodonta dama* from the Gulf of Aqaba

total weights (Fig. 2). The power regression equations for these relationships are :

$$X = 0.970\ (L)^{0.429}$$
$$X1 = 0.986\ (L)^{0.694}$$
$$X2 = 0.973\ (L)^{1.057}$$

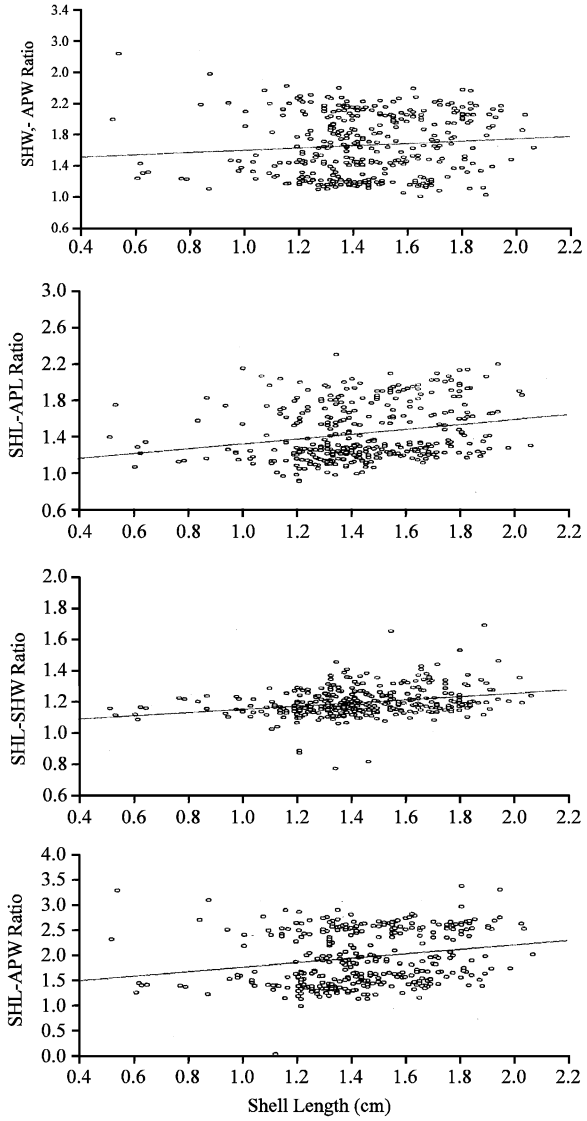

Fig. 5: The relationships of the shell length (SHL) to SHL/aperture width (APW) ratio, SHL/shell width (SHW) ratio, SHL/aperture length (APL) ratio and SHW/APW ratio of *Monodonta dama* from the Gulf of Aqaba

Where X, X1 and X2 represent the total, shell and dry body weights, respectively and L represents the shell length. The relationship of the shell weight to dry body weight was linear (Fig. 3).

The relative coefficient of condition (Kn) which measures the progression of body weight and length was 0.334.

Shell morphometrics: The mean shell length of age groups 1 to 5 of *M. dama* ranges from 0.605 to 1.934 cm. The shell width ranges from 0.538 to 1.472 cm, aperture length from 0.447 to 1.199 cm and aperture width from 0.362 to 0.849 cm (Table 3). The relationships of the shell length (L) to shell width (W), aperture length (AL) and aperture width (AW) are linear (Fig. 4). Most of these snails ranged in length from 1.000 to 1.800 cm and their width ranged from 1.000 to 1.600 cm. Their aperture length ranged from 0.600 to 1.400 cm and their aperture width ranged from 0.300 to 1.200 cm. The regression equations for these relationships are:

$$W = 0.182 + 0.694L$$
$$AL = 0.147 + 0.426L$$
$$AW = 0.105 + 0.308L$$

The ratios of the shell length to shell width, aperture length and aperture width increase with age (Fig. 5). The ratio of shell length to shell width increases from 1.2 to 1.5, while the ratio of shell length to aperture width increases from 1.5 to 2.5. The ratio of shell length to aperture length increases from 1.2 to 1.8, while the ratio of shell width to aperture width increases from 1.5 to 1.8. This may indicate that this snail become more elongate with age. Similarly the ratio of the shell width to aperture width increases with length.

DISCUSSION

Normal frequency distribution of shell length of *M. dama* indicates that this snail may survive for five years. Collected snails ranged in length from 5.55 to 19.40 mm. However, calculated maximum length using Von Bertalanffy's and Richard's growth formulae reached 27.72 and 22.10 mm, respectively. Hulings (1987a) reported that *M. dama* collected for exposure studies in the Gulf of Aqaba ranged in length from 13.2 to 21.0 mm. Although Hulings (1987a) reported a continuous spawing all year for *M. dama*, shell measurements for this snail in the present study indicate the presence of two dominant age cohorts which range in length from 11.4 and 15.2 mm and 15.2 to 19.0 mm.

The relationships of the shell length to body and shell weights are curvilinear. This was also true for *Drupella cornus* (Ismail *et al*., 2000) and *Cellana radiata* (Ismail and Elkarmi, 1999) from the Gulf of Aqaba. On the other hand the relationships of the shell length to shell width, aperture length and aperture width are linear. Similar results were reported for *D. cornus* and *C. radiata*.

The relative coefficient of condition (Kn) which measures the progression of body weight and length was relatively low (0.334). This is if compared with *D. cornus* which was 1.0 and *C. radiata* which ranged from 0.61 to 1.05.

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