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Population Structure and Shell Morphometrics of the Gastropod *Theodoxus macri* (Neritidae: Prosobranchia) from Azraq Oasis, Jordan

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Abstract: A total of 371 specimens of the freshwater gastropod *Theodoxus macri* (Sowerby, 1849) (Neritidae: Prosobranchia) from Azraq Oasis, Jordan, were studied for age, growth and shell morphometrics. The results show the life span to be four years. The mean observed lengths of the four age cohorts range from 3.295 to 7.707 mm. Theoretically, using Von Bertalanffy's and Richard's growth formulae, the maximum length of this snail may reach 17.187 and 12.930 mm, respectively. Shell and dry body weights averaged 44.4 and 36.05 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 (Kn) was 1.008 and 0.999 for young (age groups 1-2) and old (age groups 3-4) snails, respectively.

Key words: *Theodoxus*, Jordan, Azraq Oasis, shell morphometrics, population structure

INTRODUCTION

Theodoxus is a neritid snail succeeded in invading freshwater habitats. These snails are usually subglobose or hemispherical, have few whorls, very reduced spires and very large body whorl. Two freshwater species were reported from Jordan, *T. jordani* and *T. macri* (Burch, 1985). Dagan (1971) contended that both species of *Theodoxus* are the same, a conclusion based on details of the opercular apophyses and the central teeth of the radula. However, *T. macri* is uniformly black or dark purple in color, while, *T. Jordani* is zebred having red or brown to deep purple or dark black zig-zag stripes on a white or yellow background (Burch, 1985). Both species are common in all freshwater habitats of Jordan. In Azraq Oasis, *T. macri* is mostly found in spring pools, ponds and swamps. The present research aims at providing more information on the population structure and shell morphometrics of *T. macri* from Azraq Oasis.

MATERIALS AND METHODS

Study area: Azraq Oasis is a semi-desert area in the East Jordanian Desert 85 km east of Amman, the capital of Jordan. It is the only permanent water in this region. It's water is supplied by two springs, one in North Azraq and the other is in South Azraq. Azraq pools are infested with several snail species. Most predominant are *Melanopsis praemorsa*, *Melanoides tuberculata* and *Theodoxus macri*.

Sampling and analysis: A total of 371 *Theodoxus macri* (Sowerby, 1849) (Neritidae: Prosobranchia) snails were collected by hand picking from Azraq Oasis pools. In the laboratory, shell length, shell width, aperture length and aperture width were measured using vernier calipers, to the nearest 0.1 mm. The shells of about 310 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 *T. macri* snails.

The growth in length of *T. macri* 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 , $A = 1 - (\text{minimum length}/\text{maximum length})$, k is the growth coefficient and t_0 is the length at which the age is theoretically nil. The constants L_∞ , 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 (Le Cren, 1951). K_n was calculated as: $K_n = X/aL^n$ 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 aperture width to shell length, ratio of aperture length to shell length and ratio of shell width to shell length 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 four age cohorts for *T. macri* (Fig. 1). The mean observed length at each of these age cohorts was 3.295, 4.984, 7.707 and 10.281 mm (Table 1). Calculated shell lengths using VBGF and the linear method were highly correlated with the observed values ($R^2 > 0.96$) (Table 1). However, this correlation was 78.3% using RGF. Thus, it is expected that this snail may survive to four years. The annual observed increase in length ranges from 1.689 to 2.723 mm. Theoretically, the increase ranges from 1.835 mm in old snails to 2.861 mm in young ones using the VBGF and from 1.058 to 1.650 mm using RGF. The theoretical growth parameters of *T. macri* were similar using VBGF and RGF (Table 2). The theoretical maximum growth was 17.187 and 12.930 mm and the growth coefficients (k) were 0.218 and 0.222. The length at t_0 was calculated to be 0.194.

Length-weight relationship: Collected *T. macri* snails range in length from 2.20 to 11.00 mm, with a mean value of 5.628 mm. Their shell and dry body weights range from

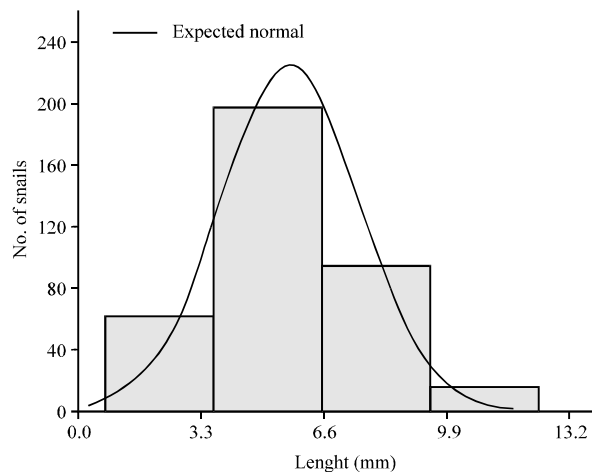


Fig. 1: Frequency distribution of estimated length groups of *Theodoxus macri* from Azraq Oasis showing expected normal distribution ($n = 371$)

2 mg to 360 mg with an average of 44.4 mg and from 1.0 mg to 150 mg with an average of 36.05 mg, respectively. Increase in shell and body weights was slower in

Table 1: Observed and calculated shell lengths (in mm) of various age groups of *Theodoxus macri* from Azraq Oasis using Von Bertalanffy's Growth Formula (VBGF) and the Richard's Growth Formula (RGF) and Linear regression equation

Age (years)	Mean observed length	VBGF	RGF	Linear Model
1	3.295	2.817	4.648	3.015
2	4.984	5.678	6.298	5.383
3	7.707	7.969	7.620	7.751
4	10.281	9.804	8.678	10.117
Adjusted R^2 or Variance explained(%)		96.44	78.30	0.991

Table 2: Growth parameters of *Theodoxus macri* from Azraq Oasis using Von Bertalanffy's Growth Formula (VBGF) and the Richard's Growth Formula (RGF)

Parameter	VBGF	RGF
L_{∞}	17.187	12.930
K	0.218	0.222
t_0	0.194	-

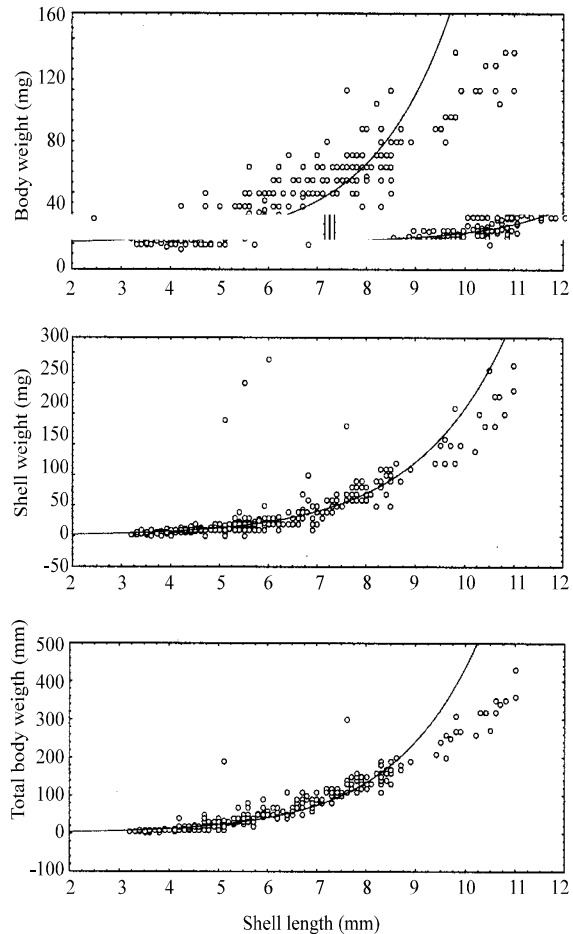


Fig. 2: The relationships of the shell length to shell, body and total weight of *Theodoxus macri* from Azraq Oasis

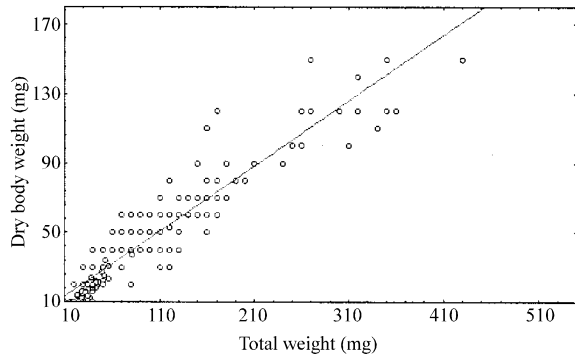


Fig. 3: The relationship between the total weight and the dry body weight of *Theodoxus macri* from Azraq Oasis

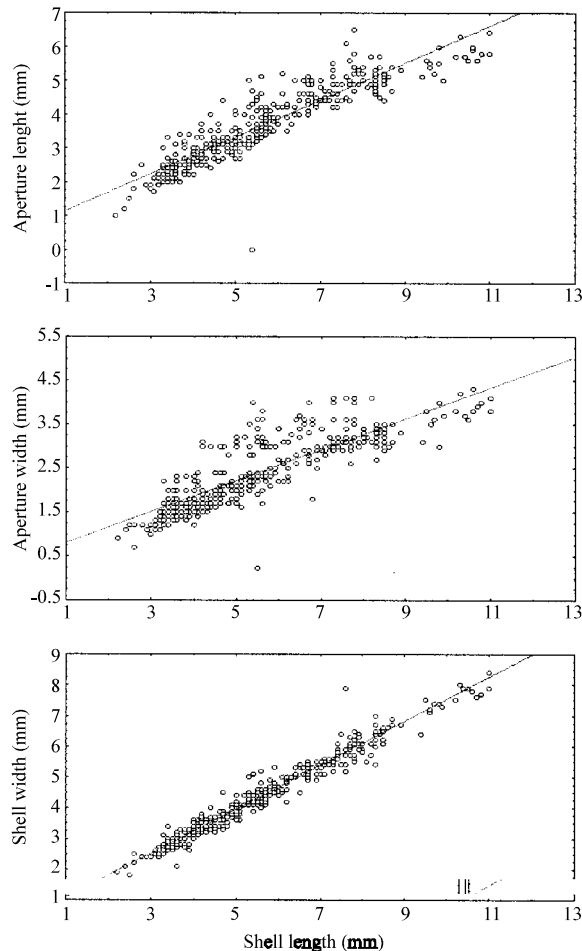


Fig. 4: The relationships of shell length to shell width, aperture length and aperture width of *Theodoxus macri* from Azraq Oasis

young snails than older ones. This produced curvilinear relationships of the shell length to both shell and dry body weights (Fig. 2). The power regression equations for these relationships are:

Table 3: Measurements (means in mm±SD) of length (SHL), shell width (SHW) aperture length (APL) and aperture width (APW) of various age groups of *Theodoxus macri* from Azraq Oasis

Age (years)	SHL	SHW	APL	APW
1	3.295±0.314	2.684±0.293	2.203±0.378	1.468±0.322
2	4.984±0.769	3.960±0.620	3.367±0.694	2.269±0.616
3	7.707±0.667	5.902±0.585	4.876±0.453	3.173±0.381
4	10.281±0.492	7.644±0.342	5.713±0.367	3.781±0.317

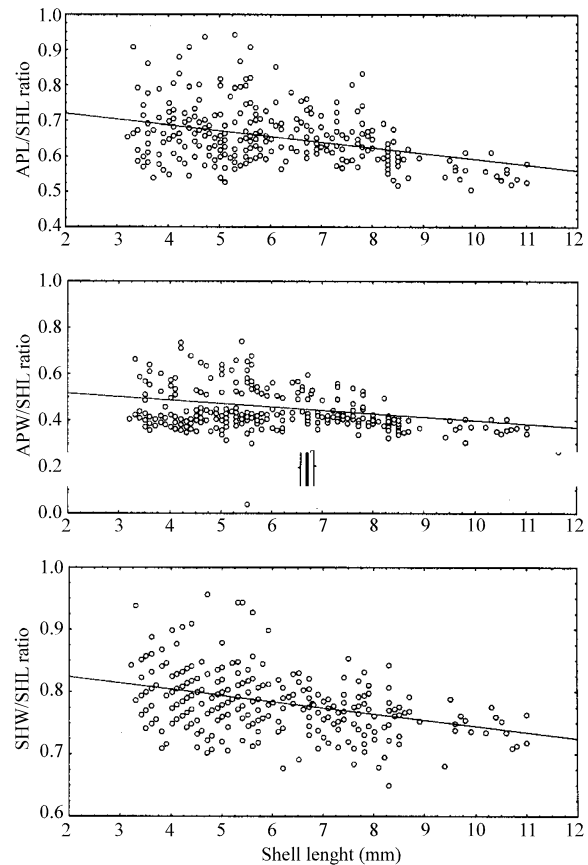


Fig. 5: The relationships of the shell length to ratios of shell length (SHL) to each of shell width (SHW), aperture length (APL) and aperture width (APW) of *Theodoxus macri* from Azraq Oasis

$$\begin{aligned}
 X &= 0.281 (L)^{3.199} \\
 X1 &= 0.189 (L)^{3.680} \\
 X2 &= 0.114 (L)^{2.712}
 \end{aligned}$$

Where X, X1 and X2 represent the total, shell and dry body weights, respectively and L represents the shell length. The relationship of the total 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 measured for young and old snails (age groups 1 and 2 and 3 and 4, respectively). It was 1.008 and 0.999 for both groups, respectively.

Shell morphometrics: The mean shell length of age groups 1 to 4 of *T. macri* ranges from 3.295 to 10.281 mm. The shell width ranges from 2.684 to 7.644 mm, aperture length from 2.203 to 5.713 mm and aperture width from 1.468 to 3.781 mm (Table 3). The relationships of the shell length (L) to shell width (W), aperture length (AL) and aperture width (AW) are linear (Fig. 4). The regression equations for these relationships are:

$$W = 0.039 + 0.713L$$

$$AL = 0.076 + 0.524L$$

$$AW = 0.073 + 0.328L$$

The ratios of the shell width, the aperture width and the aperture length to shell length decrease with age (Fig. 5). This may indicate that this snail become more elongate with age.

DISCUSSION

The frequency distribution of the shell length of collected *Theodoxus macri* snails from Azraq Oasis indicated the presence of four age cohorts. These snails range in length from 3.3 to 10.3 mm. *Theodoxus jordani* snails collected from Yarmouk River ranged in size from 1 to 20 mm and 74-84% of them measured 6-13 mm (Abel-Hafez and Ismail, 1987). Two peaks of young snails (4 mm long) appeared during September and March. These snails grew at a rate of about 6 mm per year (Abel-Hafez and Ismail, 1987). In the present study this snail increased in length at a rate of 1.689 to 2.723 mm annually. *Melanopsis praemorsa* from Yarmouk River increased by 3-4 mm between January and December and ranged in size from 3-27 mm (Ismail and Abel-Hafez, 1987). Higher rates of increase were reported from *Drupella cornus* snails from the Gulf of Aqaba (Ismail *et al.*, 2000). These snails grew at a rate of 3.7-6.8 mm annually. The limpet, *Cellana radiata*, from the Gulf of Aqaba grew at a rate of 4.0-9.0 mm annually (Ismail and Elkarmi, 1999).

Increase in shell and dry body weights of *T. macri* was slower in young snails than older ones of in the present study. This produced curvilinear relationships of the shell length to both shell and dry body weights. This was also true for *D. cornus* (Ismail *et al.*, 2000) and *C. radiata* (Ismail and Elkarmi, 1999). However, power

regression equations for these relationships for different snails were different. Moreover, the relationship of the dry body weight to shell weight was linear for both *T. macri* in the present study and *D. cornus* from the Gulf of Aqaba.

The relationships of the shell length to shell width, aperture length and aperture width were linear for both *T. macri* from Azraq and *D. cornus* (Ismail *et al.*, 2000). However, linear regression equations were different for both snails. Similarly, the shell length to shell width relationship of *C. radiata* was also linear (Ismail and Elkarmi, 1999).

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