J. Egypt. Acad. Soc. Environ. Develop., 14 (1): 1-13 (2013) (D-Environmental Studies)
E.mail: easedjournal_egypt@yahoo.com ISSN 1110-8770
www.eased.byethost13.com eISSN 2314-5471 (online)

Morphlogical and morphometric study on the keyhole limpet *Diodora rupellii* (Sowerby, 1834) from the Egyptian rocky shores of the Mediterranean and Red seas

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ABSTRACT

The differentiations in morphology and morphometery in two populations of the keyhole limpet *Diodora rueppellii* from the rocky shores of Abu Qir on the Mediterranean Sea (P1) and Suez Gulf on the Red Sea (P2) were studied. The results indicated that the shell of P1 and P2 was similar morphologically, while they are different in the rate of growth of their anterior and posterior slopping walls and in height. The computed regression constants of the different relationships between shell length and shell measurements, shell indices and body weight were computed. Their computed values indicated the possibility for differentiation between individuals of these two populations. This variations can be attributed to the difference in environmental conditions at Abu Qir and Suez Gulf.

Key words: Morphology, morphometry, intraspecific variations, interspecific variations, keyhole limpet, *Diodora rupellii* , Mediterranean shore, Red sea shore, rocky shore.

INTRODUCTION

A wealth of information on the biology of Archaeogastropods, ranging from their influence on community structure to the expression of genes during larval development was available (Branch, 1981). However, some taxonomical problems still present due to the morphological variations related to the impacts of the physical factors on them in their habitats.

Patellidae includes the true limpets, while Fissurellidae includes the false limpets. Patillidae lost their right gill and atrium but have two nepheridia, while Fissurellidae still has 2 gills, 2 atria and 2 nepheridia. The identification of the different species of fissurellids depends on the external feature of their shells (Oliver, 1984) which may cause some interpretations and misidentification. Little work has been done on the morphometry of fissurellids from different parts of the world.

The keyhole limpets are the most primitive living gastropods that belongs to the family Fissurellidae and live attached to rocks in the eulittoral zone in different rocky shores of the world (Bosch and Bosch, 1982). *Diodora* is a genus of fissurellidae that has symmetrical, cap shaped shells resembling the Patellidae or Acameidae, but have an anal opening in the form of a round, ovate or keyhole shaped opening at the apex of the shell for excretory purposes (Brosh and Danian, 1973). It is an Indio-Pacific species and is common in the Suez Canal (Tillier and Bavay, 1905). However, it was also recorded in the Mediterranean Sea (Has, 1948). Engl (1955) mentioned that the mode of introduction of *D. rueppellii* to the Mediterranean was via Suez canal. Sharabati (1984) reported the presence of 3 species of the genus *Diodora* from the Suez Canal. These were *D. rueppellii* , 1834), *D.* cf. *proxima* (Sowerby, 1862) and *D.* sp. However he didn't give any description to them. In the present study, specimens of *D. ruepellii* were only found on the shore of Suez Gulf

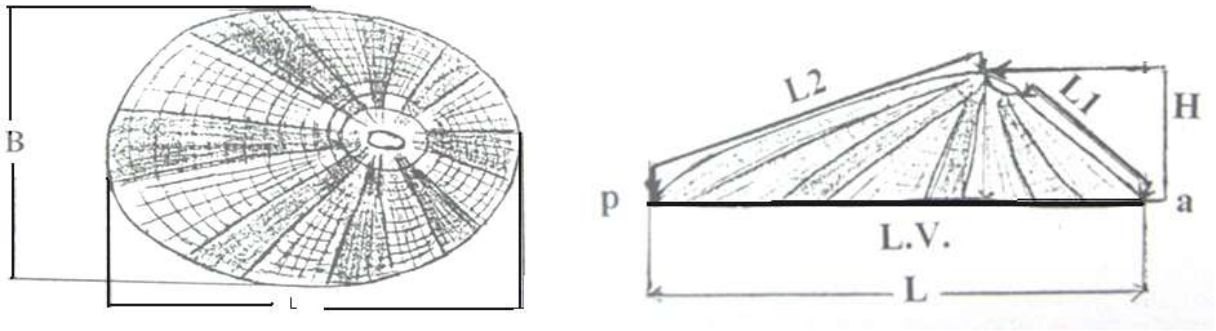
and it was described morphologically for the first time. No previous work has been yet carried out on this keyhole limpet in the Egyptian rocky shores.

The present work aims to study the variations among two populations of *D. rueppellii* collected from Abu Qir on the Mediterranean Sea and from Suez Gulf on the Red Sea. Their morphology, morphometery were investigated. The results were compared with those of other genera and species. This work will help to study the taxonomy of these keyhole limpets on the Egyptian shores of the Mediterranean and Red Sea. Also , this work represents the first record for the presence of *D. rueppellii* on the Egyptian coast of the Mediterranean Sea.

MATERIALS AND METHODS

1) Morphology and morphometry :

Specimens of the keyhole limpet, *Diodora rueppellii* were collected by hand picking from the rocky shores of Abu Qir on the Mediterranean Sea (P1) and Suez Gulf on the Red Sea (P2). The shell morphology was described using dissecting binocular microscope. The shell measurements were taken using Vernier calipers accurate to 0.1 mm (Fig. 1A & B).



(A) (B)

Fig. 1. Drawing of shell of *Diodora rueppellii,* (A) Dorsal view , (B) Lateral view to show the different shell measurements.
ApL : length of the apical shell aperture
B : maximum shell breadth
L : Shell length
l_1 : shell lengths of sloping from aperture to the shell base at the anterior extremity
l_2 : shell lengths of sloping from aperture to the shell base at the posterior extremity
H : shell height

The taxonomy and shell shape was given after Abbott (1962). The different relationships of the shell length with various shell measurements and indices were studied using the least square regression analysis and the regression constants for these relationships were computed. The indices used in this study were those described by Emam (1994) and Saad (1997) for the true limpets.

2) Length weight relationship :

The total body weight (TBWt), shell weight (SHWt) and soft weight (SWt) were taken using an electric digital balance accurate to 0.001 g. The length-weight relationship was described according to the power regression equation:

$W = a L^b$, where

W is the weight (g);

L is the length (mm);

a (intercept)

b (slope)

The values of the constants (a b) of the curvilinear line of this relationship were computed using the program of WTLN of Abramson (1970).

3) The relative coefficient of condition (Kn) :

The values of Kn for the two populations of *Diodora rueppellii* from Abu Qir and Suez Gulf were calculated using the equation of Le Cren (1951);

Kn = observed total weight / calculated total weight.

RESULTS AND DISCUSSION

Taxonomy :

Phylum : Mollusca
Class : Gastropoda Cuvier, 1797
Subclass : Prosobranchia
Order : Archaegastropoda Thiele, 1925
Family : Fissurellidae Fleming, 1822
Genus : *Diodora* Gray, 1821
***Diodora rueppellii* (Sowerby, 1834)**

Relevant Synonyms : None

Distribution :
Indo-Pacific : Red Sea; Suez canal and Gulf of Aden; Gulf of Oman; Arabian Gulf; Somalia; Madagascar; Natal; Seychelles, Mauritius;

Pacific: Hawaii.

Mediterranean: recorded first in Palestine (Haas, 1948); later on the southeast coast of Turkey, from Gulf of Iskenderun to Alanya (Engl, 1995).

a) Shell shape :

The shell of the two populations of *Diodora rueppellii* from the Mediterranean (P1) and Gulf of Suez (P2) are nearly similar in shape (Figs. 2 & 3, respectively). The shell is elongate-ovate, steeply conical in shape and convex at the posterior, almost concave at the anterior. It has a long dumb bell shaped apical hole (about 2 mm long, about 1/10 shell

length), slightly in front of the centrally located apex (at approximately 1/3 of the way from anterior end). There are 20-25 major radiating ribs on the outer surface, alternating with some smaller ones radiating from the apex and crossed by very fine concentric ridges, giving a cancellated appearance. Margin of the aperture with conspicuous crenulations where the ribs somewhat continued towards the inside of the shell. Exterior is whitish, usually rayed with eight dark brown bands. Interior is white and the callus around the keyhole is truncated.

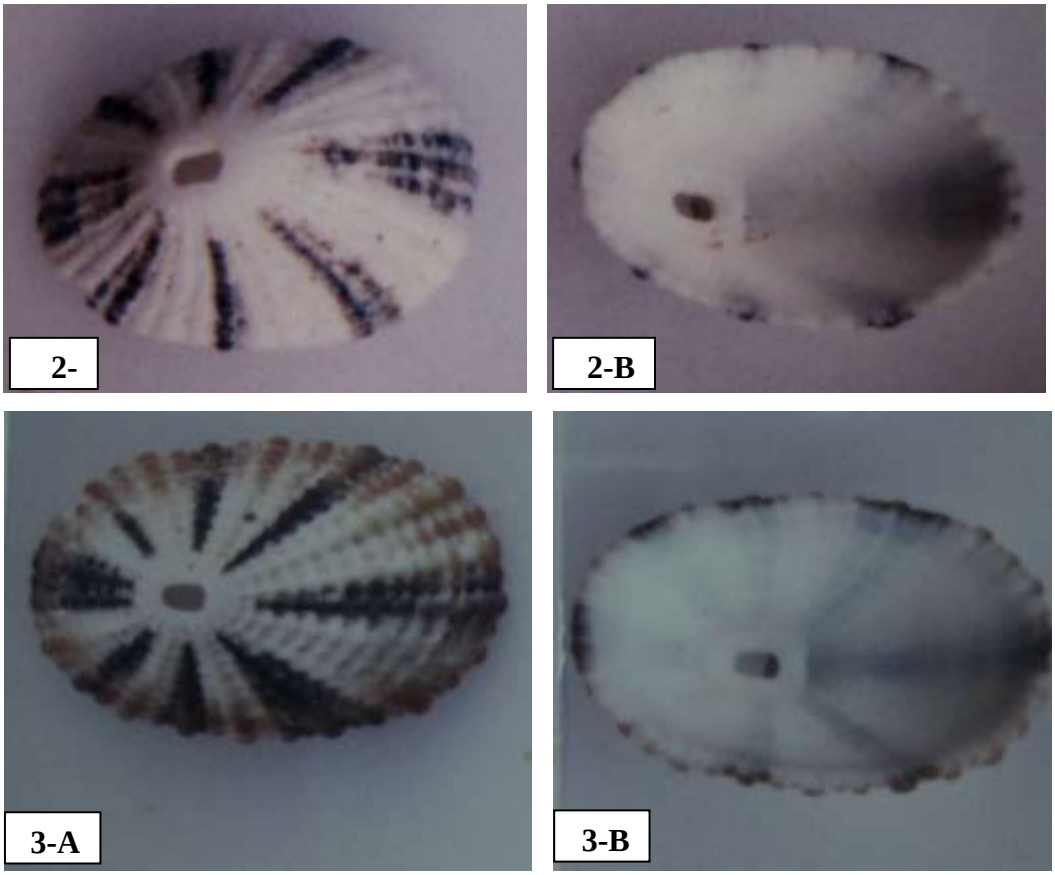


Fig. 2 : Photomicrograph of the shell of *Diodora rueppellii* from Abu Qir. X 2 (A-Dorsal view, B- Ventral view)
Fig. 3 : Photomicrograph of the shell of *Diodora rueppellii* from the Gulf of Suez. X 2 (A-Dorsal view, B- Ventral view) X 2

The shell of the keyhole limpet *Diodora rueppellii* from the Suez Gulf and from Abu Qir was found to be morphologically similar to *Diodora graeca* from the Mediterranean but has a steeper profile, coarser sculpture, and different appearance of the shell edge which has distinct continuous notches that extend towards inside. On the other hand, the shell of *D. gracea* up to 25 mm long and 18 mm wide (Oliver, 1984). It has sculpture consists of 20 principal radial ribs, usually alternating with thinner secondary ones and a dozen rather raised concentric lamellar bands; the crossing of these two series of elements produces a regular grid. The apical hole is edged internally by an ovoid swelling, usually one end is truncated. The margin of the shell is finely toothed (Mondadori, 1980).

Some morphs of *D. graeca* were found in deeper water of the Western Mediterranean with usually more continuous dark sectors on the shells (Barash and Danin, 1973).

The shell of *D. ruppellii* is also similar to that of *D. funiculata* from the Gulf of Oman, but the latter is not so regular in shape or sculpture and the shell length up to 35 mm, with about three fine ribs between each coarse radial rib (Bosch and Bosch, 1982).
Traditional scenarios of gastropod evolution suggest that the apical openings and marginal slits of keyhole limpets and other fissurellids play a key role in maintaining mantle cavity sanitation by facilitating separation of clean incurrent and waste-laden excurrent flow. The occurrence of animals that never develop excurrent openings or in which the opening is blocked by fouling organisms, however, indicates that this may not be the case (Janice and Rachel,1995). The authors examined the mantle cavity morphology and characterized the respiratory flow of individuals of *Diodora aspera* in which the apical opening was naturally or experimentally blocked. They found no evidence of damage to the mantle cavity or associated organs. Water entered ventro-poteriorly to the gill tips, which were extended beyond the mantle margin, and exited over the head. They concluded that the apical opening is not necessary for the effective removal of wastes and the opening is necessary, however, to induce passive flow through the mantle cavity. They also suggested that this function of the apical opening may have been as significant as its role in sanitation for the evolution of fissurellid gastropods. In the present study some individuals of *D. rueppellii* collected from the Suez Gulf have apical opening closed by fouling organisms (e.g. *Cathamalus*) and still active and alive. This may support the opinion of Janice and Rachel, (1995).

2) Shell morphometry :

For P1 from Abu Qir, the shell length up to 22 mm in length, 14 mm in breadth and 9 mm in height. The length of the anterior slope of the shell of P1 reaches 10 mm, while that of the posterior slope is 16 mm. On the other hand, the maximum shell length, breadth, anterior and posterior slope for P2 were 29, 20, 12, 14, and 22.2 mm, respectively. The range and the average values of different shell measurements for P1 and P2 are shown in Table (1).

Table (1). The range and average values of different shell measurements and indices for the two populations of *Diodora rueppellii* from Abu Qir on the Mediterranean Sea (P1) and Suez Gulf on the Red Sea (P2).

Measurements	P1		P2	
	Range (mm)	Average (±SD) (mm)	Range (mm)	Average (±SD) (mm)
L	5.5 – 21	13.8 (± 4.1)	12 -29	20.2 (± 4.2)
B	3.2-15.2`	9.4 (± 2.4)	7.2-20.5	13.5 (± 2.8)
H	0.6 – 10.3	5.4 (± 2.5)	5-14	8.9 (± 1.7)
L1	2 – 12	6.8 (± 2.8)	5.8-16	10.3 (± 1.8)
L2	4-17	10.5 (±2.6)	8.5 – 23.5	15.8 (± 3.7)
B/L	0.58-0.72	0.68 (±0.04)	0.60-0.71	0.67 (10.02)
H/L	0.12-0.49	0.39 (±0.08)	0.41-0.48	0.44 (±0.02)
L1/L	0.47-0.52	0.46 (±0.06)	0.48-0.55	0.51 (±0.03)
L2/L	0.72-0.83	0.79 (±0.05)	0.70-0.81	0.78 (±0.01)
L2/L1	1.54-1.59	1.54 (±0.38)	1.47-1.68	1.53 (±0.10)

P1 and P2 have the same trend with respect to growth of their shell breadth, height, anterior and posterior shell shape with shell length ; i.e. these measurements increase with the increase in shell length or growth of the animal (Figs. 4 & 5). However, the rate of growth in anterior shell slope is the highest, while that of shell height is the lowest.

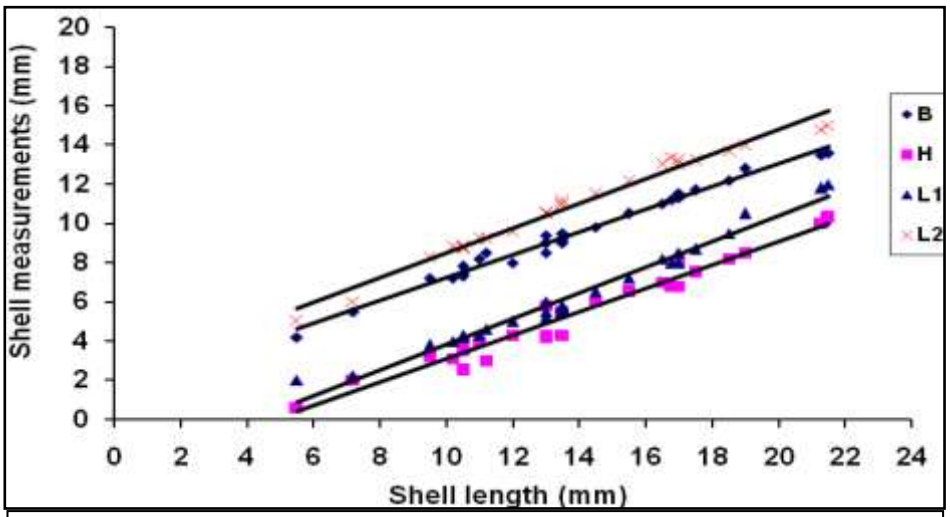


Fig. (4). Shell length-shell measurements relationship of *D. rueppelli*i from Abu Qir.

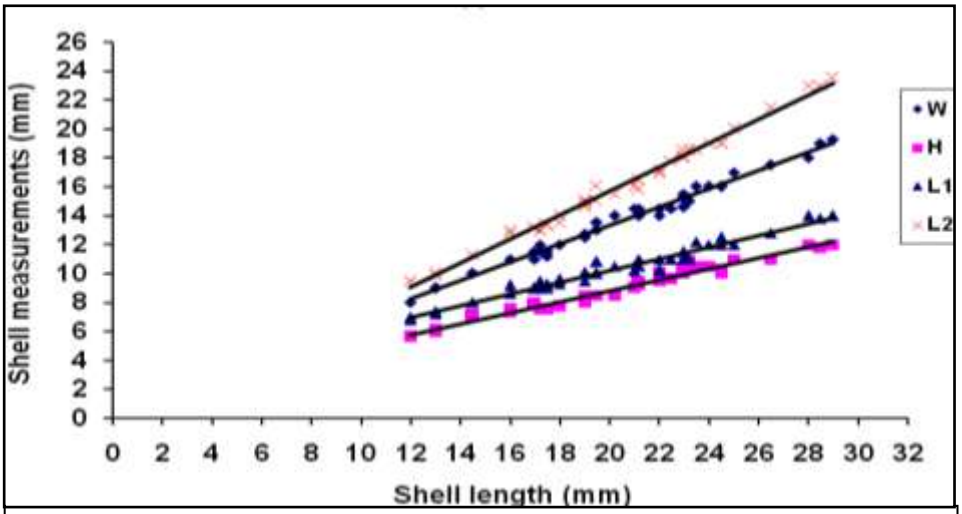


Fig. (5). Shell length-shell measurements relationship of *D. rueppelli*i from Suez Gulf.

On the other hand, the relationship between the growth in the anterior (L1) and posterior (L2) sloping of shell wall for P1 and P2 of *D. rueppellii* indicated that L2 grows more rapidly than L1 (Figs. 6 & 7).

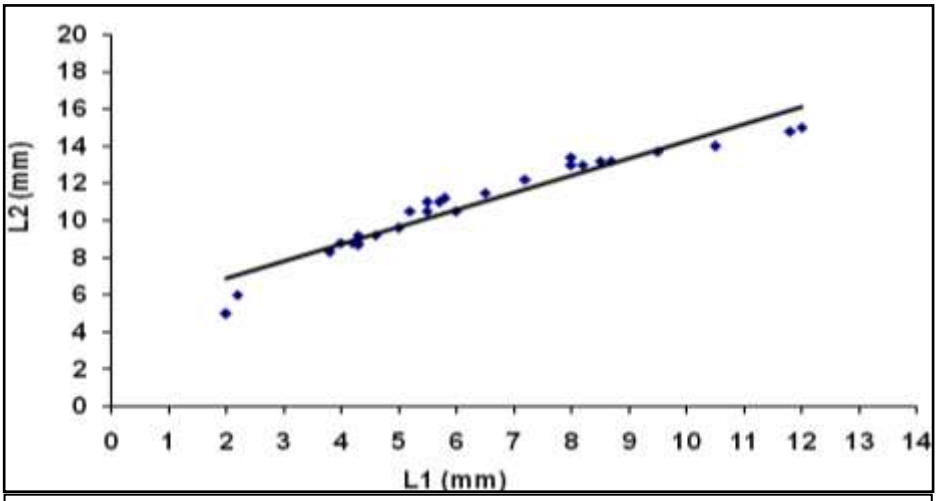


Fig. (6). Anterior-posterior sloping relationship of *D. rueppellii* from Abu Qir

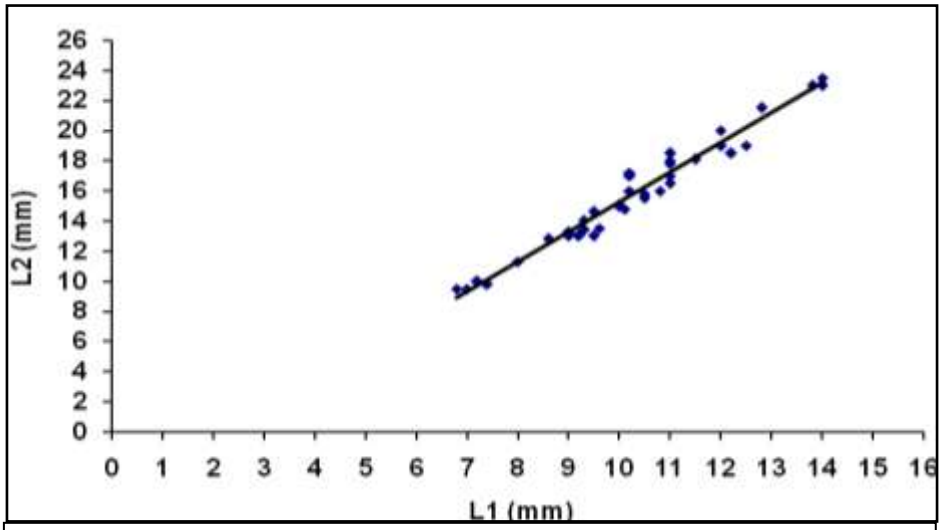


Fig. (7). Anterior-posterior sloping relationship of *D. rueppellii* from Suez Gulf

The average values of the indices L1/L and L2/L for the shell of P1 were 0.46 and 0.79, respectively. While those for P2 were 0.51 and 0.78, respectively. It was obvious that the growth in the posterior sloping shell wall was higher in P1and P2 which indicated that the shell aperture in this keyhole limpet is slightly shifted anteriorly. .

On the other hand, the average value of L2/L1 was relatively the same (1.54) (Table 1). However there was a negative correlation between the ratio L2/L1 and the growth of shell length in P1 and a positive one in P2 (Figs. 8 & 9).

The mean values of the ratio H/L was lower for the shell of individuals of P1 (0.39) than that for P2 (0.44). This may indicate that the shell of P1 is relatively flattened than that of P2.

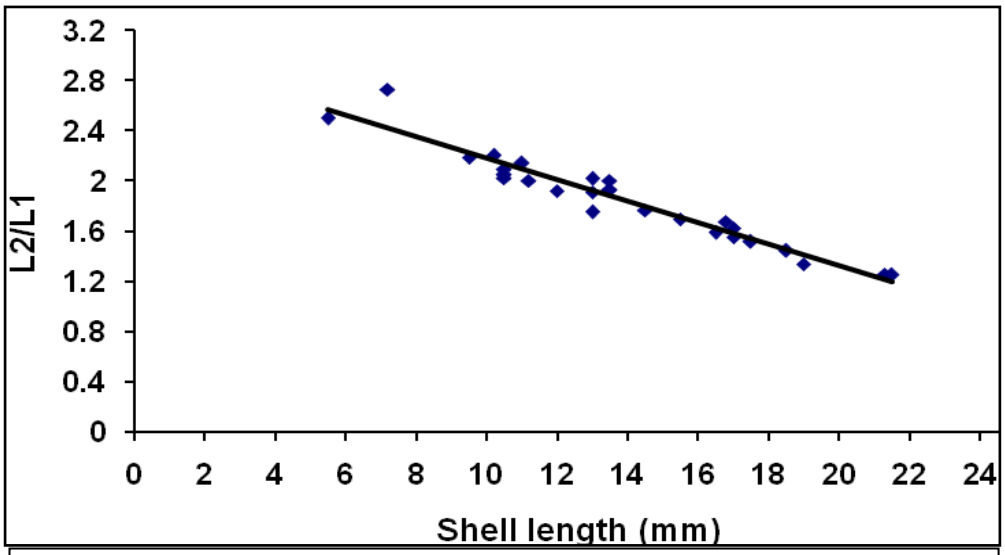


Fig. 8. Shell length-L2/L1 relationship of *D. rueppellii* from Abu Qir

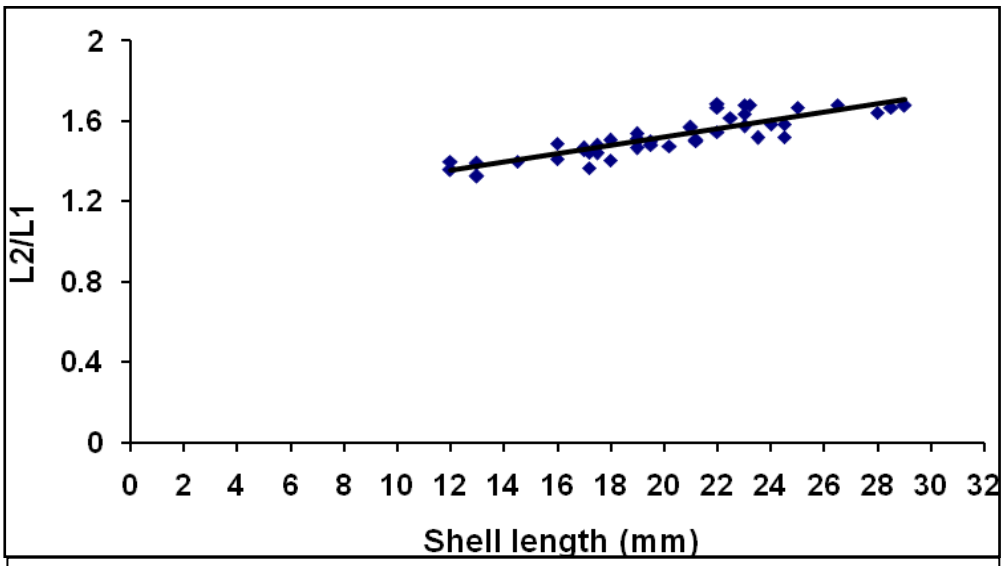


Fig. 9. Shell length-L2/L1 relationship of *D. rueppellii* from Abu Qir

The constants (A & B) for the shell length to shell measurements and indices relationships for P1 and P2 are shown in Table (2). These can be used to differentiate between the two populations of *D. rueppellii*. Also, the variation of values of indices with growth of shell length in P1 and P2 is shown in Figures (10 & 11).

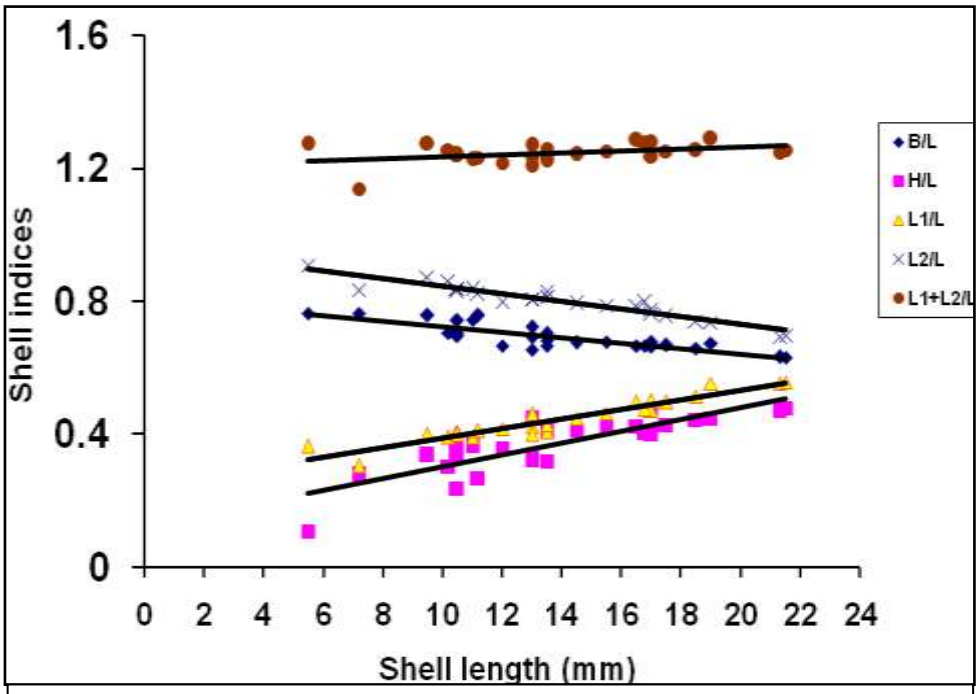


Fig. 10. Shell length-shell indices relationship of *D. rueppellii* from Abu Qir.

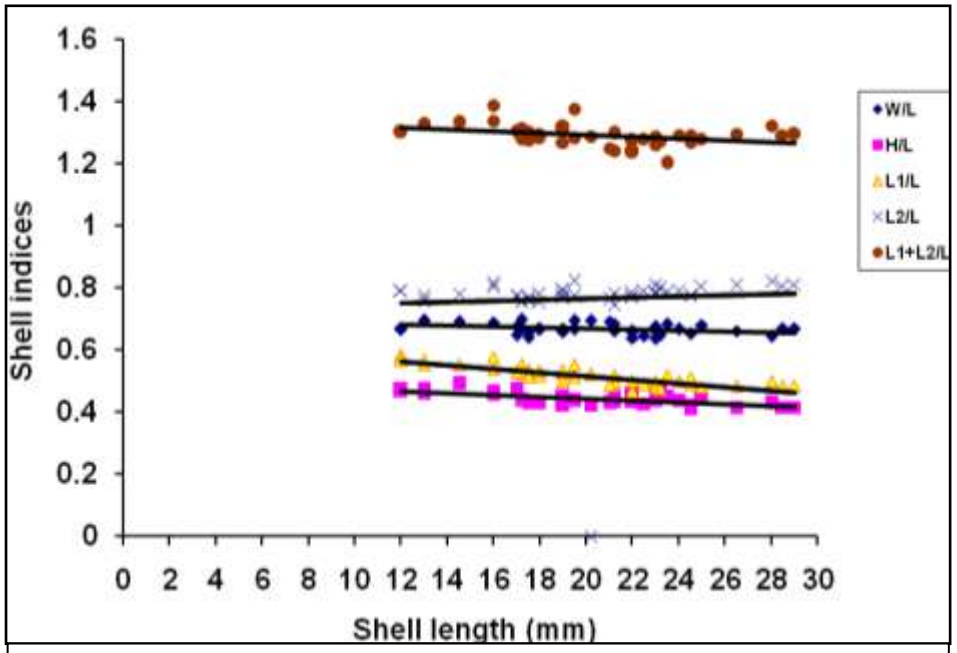


Fig. 11. Shell length-shell indices relationship of *D. rueppellii* from Suez Gulf

Table (2). Regression constants, a (intercept) and b (slope) and correlation coefficient (R^2) for the relationships between shell length and different shell measurements and shell indices for the two populations of *D. rueppellii* from Abu Qir on the Mediterranean Sea (P1) and Suez Gulf on the Red Sea (P2). (L = shell length, W = Shell width, H = shell height, L_1 = anterior sloping wall, L_2 = posterior sloping wall).

Relation-ship	P1				P2			
	N	A	B	R^2	N	A	B	R^2
L-B	350	1.410	0.582	0.99	220	-2.212	0.773	0.99
L-H	350	-2.868	0.597	0.96	220	1.742	0.351	0.96
L-L_1	350	-2.696	0.6549	0.96	220	1.926	0.409	0.98
L-L_2	350	2.1806	0.631	0.98	220	-3.802	0.971	0.98
L_1-L_2	350	5.02	0.926	0.92	220	-7.872	2.321	0.96
L-(L_2/L_1)	350	3.038	-0.086	0.93	220	0.837	0.034	0.91
L-(B/l)	350	0.808	-0.008	0.70	220	0.538	0.006	0.68
L-(H/L)	350	0.0125	0.018	0.72	220	0.536	-0.005	0.68
L-(L_1/L)	350	0.244	0.015	0.89	220	0.607	-0.005	0.76
L-L1+L_2/L)	350	1.206	0.003	0.65	220	1.187	0.005	0.68
L-(L_2/L)	350	0.9622	-0.001	0.98	220	0.576	0.009	0.78

In the present study the maximum shell length of *D. rueppellii* from the Suez Gulf (29 mm) was nearly similar to that for individuals from the Arabian Gulf (30 mm; Symthe, 1982) However, that from the Gulf of Oman reached 20 mm (Bosch and Bosch,1982) and that from Abu Qir on the Mediterranean Sea reached 21 mm (in the present study). The increase in maximum shell length of populations of *D. ruepellii* from the Gulf of Suez rather than those from the Mediterranean can be attributed to the warm water in the Red Sea which enhance their growth rate.

Observations of the growth of marked individuals of the keyhole limpet *Diodora aspera* in an intertidal population and of laboratory raised juveniles suggested that *D. aspera* grow from settling to 55 mm shell length in about 9-13 years. The ages of large specimens (60 mm or greater) may be in excess of 20 years (Bruno, 1997). Comparing the results of the present study with those of *Diodora aspera* may indicates that the age of *D. rueppellii* can reach more than 3 years.

3) Length-weight relationship :

Specimens of P1 of *D. rueppellii* ranged in length from 5.5 – 21.3 mm with an average of 13.8 mm. Their total, soft and shell weights varied from 0.03-0.64, 0.02-0.43 and 0.01-0.09 g, respectively. Their respective average weights were 0.26, 0.17 and 0.09g.

The length of P2 of *D. rueppellii* varied from 12 to 29 mm, with an average of 20.2 mm. Their respective total, soft and shell weights ranged from 0.29-2.2, 0.21-1.43 and 0.64-0.69 g. Their average weights were 1.73, 1.03 and 0.7 g, respectively.

Figures (12 & 13) indicated that individuals of P1 have mainly lower total, soft and shell weights than those of P2. On the other hand, the shell weight was higher than the soft body weight for P1 and P2.

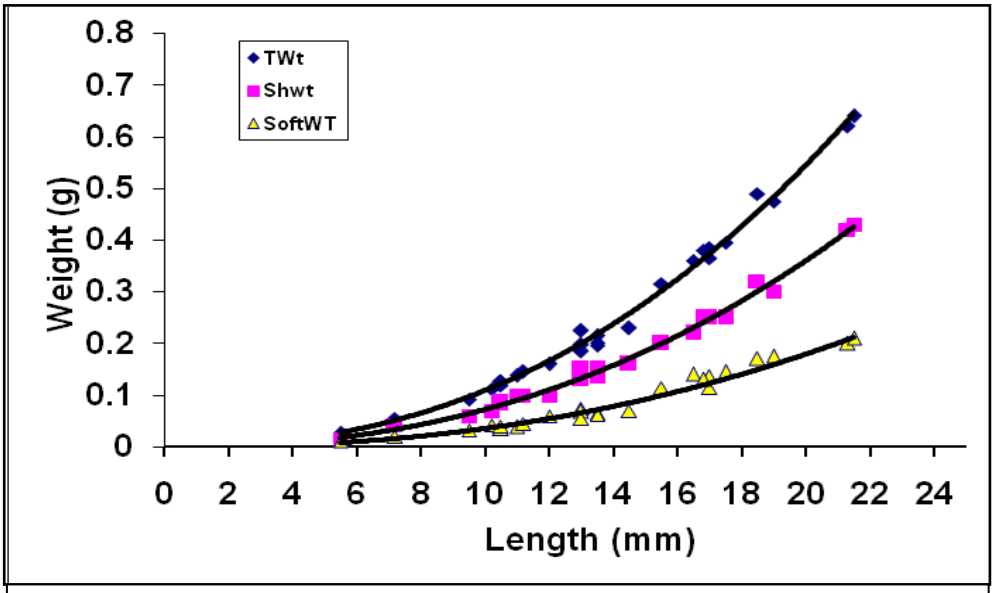


Fig. (12). Length-weight relationship of *D. rueppellii* from Abu Qir

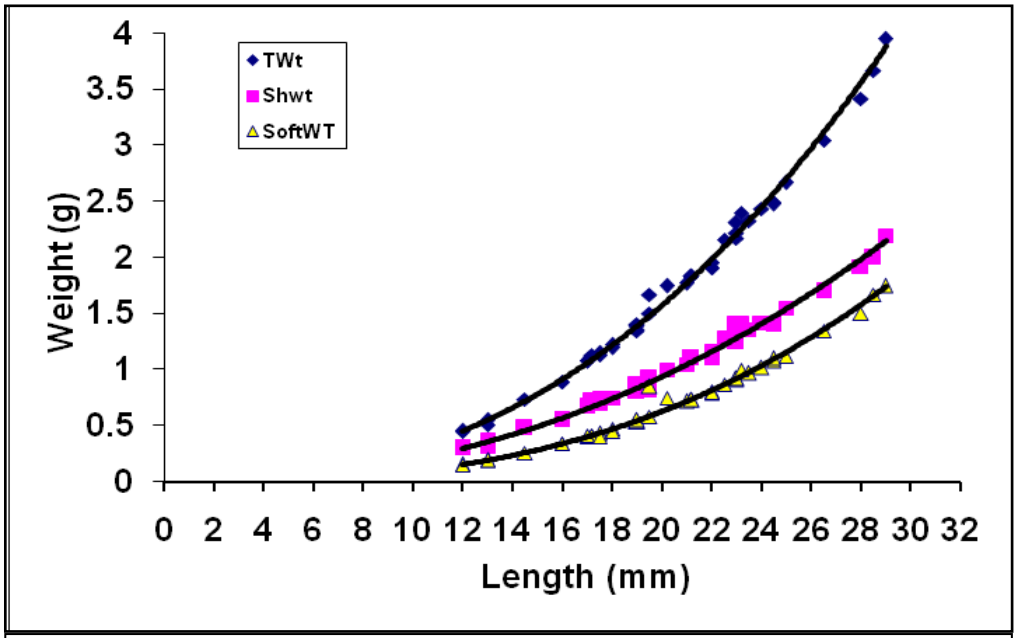


Fig. (13). Length-weight relationship of *D. rueppellii* from Gulf of Suez

The regression constants (a and b) computed for the shell length to total, soft and shell weights were different for P1 and P2 (Table 3).

Table (3). Regression constants, a (intercept) and b (slope) and the correlation coefficient (R^2) for the relationships between shell length and total body weight (TBWt), shell weight (SHWt) and soft weight (SWt) for the two the two populations of *D. rueppellii* from Abu Qir on the Mediterranean Sea (P1) and Suez Gulf on the Red Sea.

Relationship	P1				P2			
	N	a	b	R^2	N	a	b	R^2
L-TBWt	100	0.0005	2.3308	0.99	100	0.0013	2.362	0.99
L-SHWt	100	0.0004	2.314	0.98	100	0.008	2.359	0.99
L-SWt	100	0.0002	2.298	.0.99	100	0.0005	2.357	0.97

4) The relative coefficient of condition (Kn):

The mean values of Kn for P1 (1.08) and P2 (1.1) of *D. rueppellii* were relatively similar and indicates the suitability of the food and environmental conditions for their growth. However, the warm water in the Red Sea enhance the growth in individuals of P2, so they are larger in size than those of P1.

The relative coefficient of condition (Kn) was relatively high for specimens of *D. rueppellii* from Abu Qir and Suez Gulf (about 1. 1) which indicates that the environmental conditions are suitable for their growth in weight. This probably due to the abundance of bare rocks in areas from which keyhole limpets were collected which reflected the case with which moving and grazing can be achieved. Similar results were reported by Saad (1997) for *Cellana eucosmia* from the Red Sea.

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دراسة مورفولوجية ومورفوميترية للبطلينوس ذات ثقب المفتاح ديودورا *ريبيليى* من الشواطىء الصخرية المصرية للبحر المتوسط والبحر الاحمر

وحيد محمود امام ، وئام وحيد محمود امام ، طارق على غريب
قسم علم الحيوان – كلية العلوم – جامعة عين شمس

تم فى هذه الدراسة التعرف على الشكل المورفولوجى والقياسات المورفوميترية لصدفة الحيوان البطنقدمى البطلينوس ذات الصدفة المفتوحة بشكل يشبه المفتاح والمعروف باسم ديودورا *ريبيليى* والتى تم جمعها من الشواطىء الصخرية المصرية للبحر المتوسط من ابى قير ومنطقة خليج السويس على البحر الاحمر. وقد أوضحت الفحوصات المورفولوجية للصدفة وجود تشابه كبير جارجى وداخلى بين النوعين من هذا الحيوان على الرغم من وجود اختلافات بينهما فيما يتعلق بمعدل نمو الابعاد الرئيسية للصدفة مع نمو الحيوان فى الطول. كما أمكن حساب ثوابت العلاقات المختلفة للعلاقات التى تم دراستها وأتضح وجود أختلافات فى القيم الخاصة بها والتى يمكن الاستفادة منها فى التفريق بين الافراد من النوعين. وقد أرجعت النتائج هذه الاختلافات الى وجود اختلاف بين بيئة البحر المتوسط والبحر الاحمر.