Age and Growth of the Cockles *Cerastoderma glaucum* and *Papyridea papyracea* in Lake Timsah, Suez Canal

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ABSTRACT

The cockles *Cerastoderma glaucum* and *Papyridea papyracea* are found among the most abundant molluscs in Lake Timsah, Suez Canal. Age determination based on shell-ring count was conducted to establish growth curves for their life-span. For this purpose, monthly collections of the specimens were carried out in the period between June 1996 and June 1998. Age composition proved the dominance of two and three years old individuals for both species. In *C. glaucum*, the shell length varied between 9.9 and 35 mm for males, and between 13.3 and 35 mm for females with a mean asymptotic length of 42.37 and 35.02 mm, respectively. On the other hand, *P. papyracea* revealed a wide range of shell length that varied between 7 and 60 mm, and had an asymptotic length of 69.51 mm. Some environmental factors that expected to affect growth are also discussed.
Key Words: Bivalves, Cockles, *Cerastoderma glaucum, Papyridea papyracea*, age determination, growth curves, Lake Timsah.

INTRODUCTION

Determination of age and growth in molluscs is largely concerned with species of economic importance. The present study focused on two cockle species, *Cerastoderma glaucum* and *Papyridea papyracea* that commonly inhabit Lake Timsah Suez Canal (Gabr, 1991). *C. glaucum* is an important edible cockle. This species is dioecious, usually intertidally (Boyden, 1971), suspension and deposit feeder and inhabiting a wide range of salinity (Barnes, 1980). It is widely distributed and has largely commercial value in Europe (Gabr, 1991). On the other hand the cockle *P. papyracea* is monoecious. It is also suspension feeder (Gabr, 1991) and is burrowing shallowly in sandy areas. A careful search of the literature failed to reveal any published records about its growth. This species is recorded in Golfo of Dulce, Costa Rica (Nicols-Driscoll, 1976), in the protected area of Cayos Cochinos, Honduras (Caicedo, 1989), in the eastern Pacific (Voskuil and Onverwagt, 1991), in Tunisia (Passamonti, 1996), and in Egypt (Barash and Danin, 1973; Gabr, 1991).

Individual age of bivalves is usually estimated from physical or chemical growth marks formed in their $CaCO_3$ shells by regularly occurring external events, e.g. day-night cycle, tides, annual cycle (Lomovasky *et al*., 2002). Cockles of the present study have clear growth rings. The day and night rings are broad when the growth conditions are good, and narrow near the winter rings when the conditions are poor (Brock, 1980). In addition, growth in animals has been described by various mathematical formulas. In fisheries, the most commonly used formula is that of Von Bertalanffy (1938). Growth is either termed 'Absolute' growth when it represents the cumulative increase in size or mass with respect to time, or 'Relative' growth when the rate of growth in one parameter is related to that of another parameter or to the whole body (Seed, 1968).

The present work aimed at studying age and growth of the two cockles, *C. glaucum* and *P. papyracea*. This may provide information about population parameters and characteristics of these species in the area.

MATERIALS AND METHODS

Lake Timsah, the present study area, lies between $30^{o}33'$ and 30^{o} 35' N, and 32^{o} 16' and 32^{o} 19' E. It has a surface area of about 15 Km^2 and a depth ranging from 6 to 13 m. Two sites were chosen in the southern part of Lake Timsah around El-Taawen area, Ismailia (Fig. 1). Site I extends approximately 375 m parallel to the shore, named Elwat-Othman, and Site II is located around the south island parallel to Sinai Peninsula.

The selection of these sites was based upon the variability and abundance of the studied species, which is essential for regular sampling. A total of 7700 specimens of *C. glaucum* (3900 from site I and 3800 from site II) and 3038 individuals of *P. papyracea* (from the two sites due to its scarcity) were collected monthly over a period of two years (June 1996 - August 1998). The salinity during the study period fluctuated between 30% and 44%. Monthly mean water temperature ranged between 16 ºC in winter and 29 ºC in summer. The pH values ranged between 7.4 and 8.9.

For all individuals, shell length L (the antero-posterior axis) and height H (the dorso-ventral axis) were measured to the nearest 0.05 mm by using a Varnier caliper. The total weight of every specimen was weighed to the nearest 0.0001 gm.

Age determination

Bivalves were allotted to year classes (born in the same year) by reading the number of year marks on their shells (Beukema *et al*., 2001). Age determination

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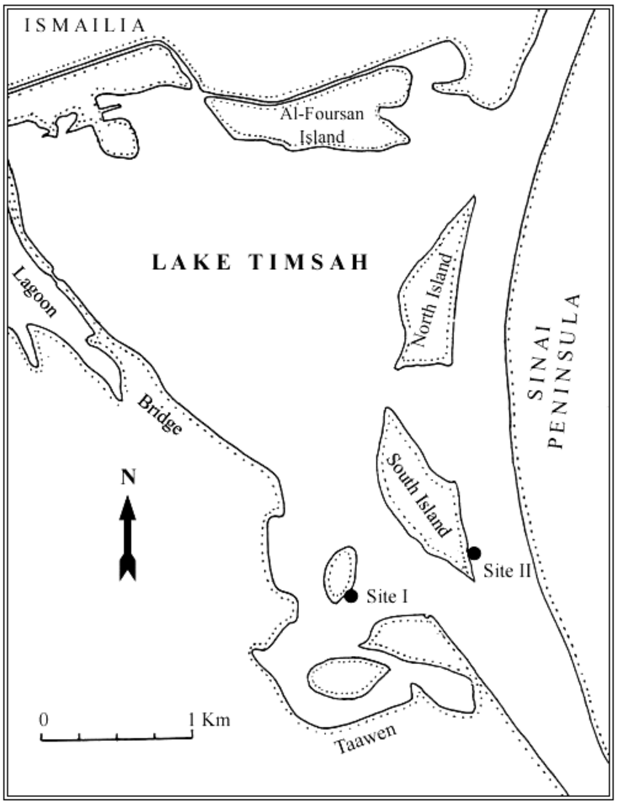

Figure (1): Map showing the investigated sites in Lake Timsah.

has been determined by counting annuli (growth rings) on the shell. Both species have very distinct rings. For each growth ring, the height was measured to the nearest 0.05 mm from the umbo to the margin of this ring. This height was converted to the corresponding length by the straight-line equation between shell height and shell length as follows:

$$L = a + b\,H$$

Where **L** is the shell length, **H** is the shell height, **a** is the intercept and **b** is the slope.

For *C. glaucum***,** it was

$$L = 2.415 + 0.768\,H \text{ (site I)}$$

$$L = 2.899 + 0.746\,H \text{ (site II)}$$

For *P. papyracea***,** it was

$$L = -0.462 + 0.977\,H.$$

Estimation of growth parameters

Growth data of the two species have been expressed by mean of Von Bertalanffy Growth Formula (VBGF) (Bertalanffy, 1938). VBGF has the following form:

$$L_t = L_{inf}\,(1-e^{-k\,(t-t_o)})$$

Where L_t is the length at age t, L_{inf} is the asymptotic length that the species would reach if they would live indefinitely. K is a growth coefficient, and t_o is the age at zero length.

Growth parameters (L_{inf} and K) were calculated according to Ford-Walford Plot (Ford, 1933; Walford, 1946) as follow:

$$L_{t+1} = a + b\,L_t$$

Where $L_{inf} = a / 1 - b$, $K = -\ln(b)$, and where L_t and L_{t+1} pertain to lengths separated by a constant time interval (one-year).

RESULTS

Cerastoderma glaucum

1. Age composition

The percentage of age composition of *Cerastoderma glaucum* (Fig. 2) indicated that male's number exceeded that of female except at the first and second age (Site I) and at the first and fifth age (Site II). Generally the second and third age groups were dominant in the population. The oldest year classes had a distinct scarcity in numbers.

2. Absolute growth

Absolute growth curves for mean shell length at the corresponding age are shown in figure (3). The length increases as the age increase. In most age groups, male cockles were slightly longer than females except for the oldest age group in site II. The absolute growth in weight increased also with age. Female cockles were slightly heavier than males at 0-group. After that the reverse was true especially in the oldest (fifth) age [9.58 and 8.81 gm (Site I) and 10.05 and 7.28 gm (Site II) for males and females, respectively].

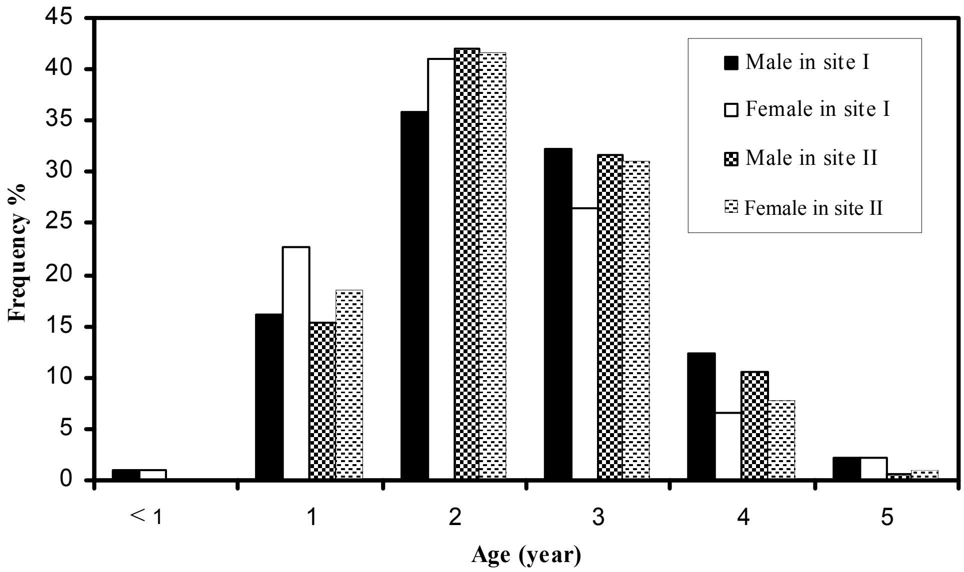

Figure (2): Age distribution of both sexes of *Cerastoderma glaucum* at both sites.

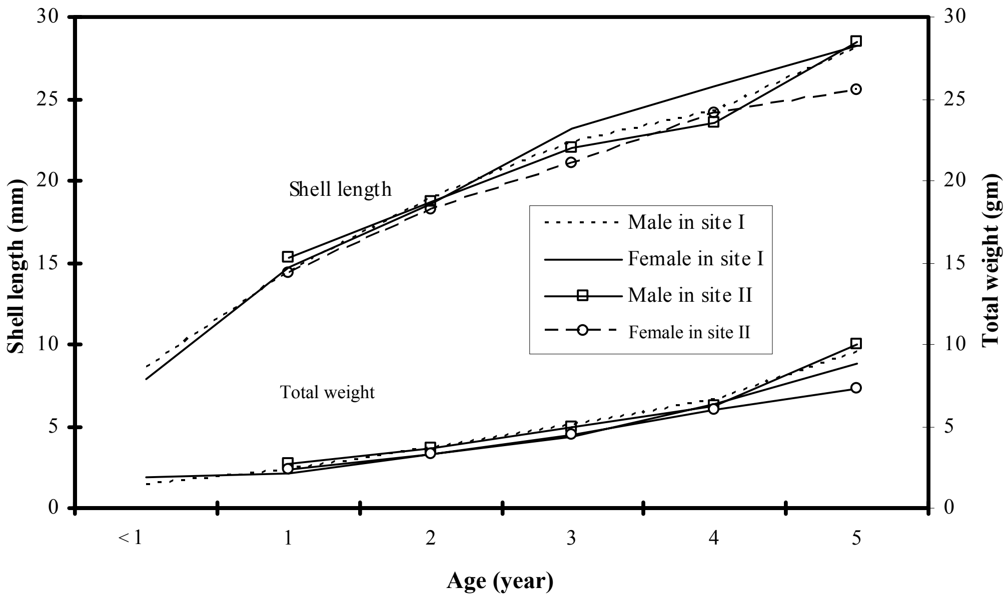

Figure (3): Absolute growth curves of mean shell length and total weight with age for both sexes of *Cerastoderma glaucum* at the two sites.

3. Relative growth

Figure (4) shows that the relative growth in shell length of *C. glaucum* was the greatest during the first year, in site I. Then it sharply declined in the second year, and thereafter, declined more slowly in both sites. Relative growth of males were slightly higher than females across the different age groups, but were more pronounced in the oldest age group.

The relative growth of *C. glaucum* in weight was similar to that in length, but female cockles were heavier than males till the fourth year in site II.

4. Von Bertalanffy growth model

In order to compare the growth between sexes and also between sites, the asymptotic shell length (L_{inf}) was calculated from Ford-Walford plot. There was little variation between sexes within site I (L_{inf} = 38.28 and 37.86 mm for males and females, respectively). Whereas a wide variation was observed in site II (L_{inf} = 46.45 and 32.17 mm for males and females, respectively). Also, a distinct difference between sites was observed for each sex separately (Table 1).

The lengths at their corresponding ages were fitted to Von Bertalanffy growth equation. The data for male and female cockles fitted well with the model (r^2 values were 0.993 and 0.996, respectively).

5. Growth in previous years (Back-Calculation)

Comparisons of growth in previous years using back-calculated estimates of length at age obtained

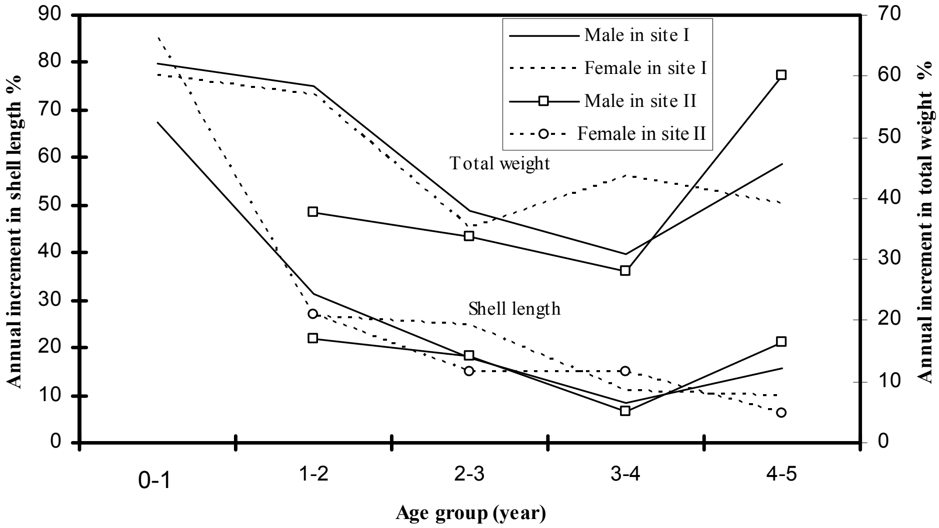

Figure (4): Percentage annual increments in shell length and total weight of both sexes of *Cerastoderma glaucum* at the two sites.

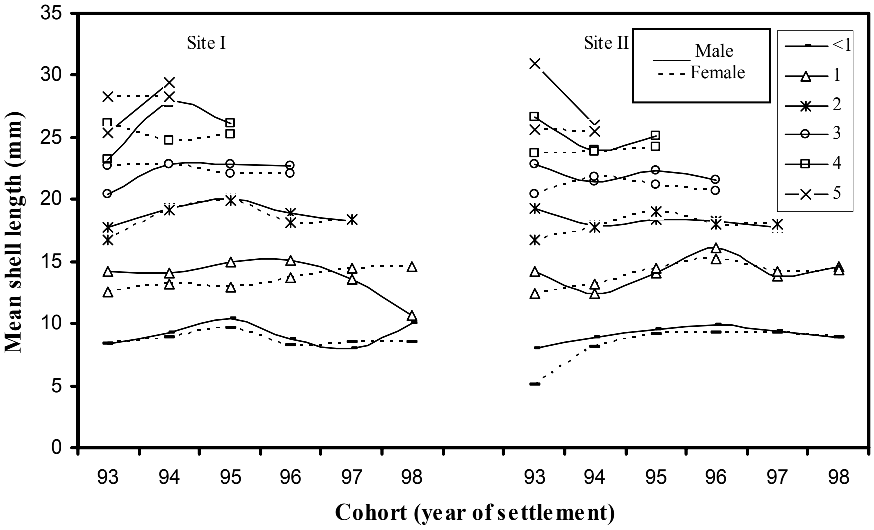

Figure (5): Back-calculated length at age for the five years of life for six cohorts (1993-1998 inclusive) in both sexes of *Cerastoderma glaucum* at the two sites.

from ring measurements were made and graphed in figure (5). The best growth for all age was presumably obtained during the cohorts 1994 and 1995 for site I and II, respectively. Moreover, there was no clear variation growth between sexes except in the year 1998 (Site I) and 1993 (Site II).

Table (1): Results of the Ford-Walford method for growth patterns of the studied cockles.

Cockle	Locality	Sex	L_{inf}	K	t_o
Cerastoderma glaucum	Site I	Male	38.28	0.21	-1.27
		Female	37.86	0.22	-0.96
	Site II	Male	46.45	0.15	-2.17
		Female	32.17	0.36	-0.38
Papyridea papyracea			69.51	0.10	-2.10

In L_{inf} asymptotic length; K growth coefficient; t_o age at zero length.

Papyridea papyracea

1. Age composition

The distributions of age composition data of *P. papyracea* showed that the second (32.17%) and third (36.27%) year groups were the dominant cohorts. Thereafter, it declined as animals grow (Fig. 6).

2. Absolute growth

The absolute growth in the mean shell length was rising steadily from 13.2 up to 34.5 mm as can be seen in figure (7A). Also, the absolute growth in mean total weight showed the same trend.

3. Relative growth

The percentages of annual increment in shell length and also in total weight of *P. papyracea* were graphed in figure (7B). It is obvious that the growth rates decrease as the age increase. In addition, the highest increment occurred at the end of the first year of life.

4. Von Bertalanffy growth model

The asymptotic (L_{inf} = 69.51mm) to which length *P. papyracea* may reach was estimated from Ford-Walford plot. The value of the growth coefficient (k) was 0.10 while that of t_o was -2.1 (Table 1).

5. Growth in previous years (Back-Calculation)

The variation in the back-calculated length at age for the five years of the cockle life in the recent six cohorts is shown in figure (8). There was no great variation in the shell length among years. However, the recent years showed slight increase in the cockle length. Also, the sharp increase and decrease in the shell length of the fifth year old group may be due to the fewer cockles' number that represented in this group.

DISCUSSION

The ability to determine age of individuals is essential for demographic analysis of populations. Baird (2000) stated that the effective conservation and management of threatened species depends largely on the knowledge of age structure, growth rates, recruitment, and mortality. Growth lines are generally believed to result from changes in growth rate. The use of annual shell ring as a tool in establishing age has been early employed in a variety of bivalves: *Tivela stultorum* (Weymouth, 1923), *Cerastoderma edule* (Orton, 1926), *Venerupis pullastra* (Quayle, 1951), *Pecten maximus* (Mason, 1958), *Anodonta anatine* (Negus, 1966), *Mytilus edulis* (Seed, 1969), *Scrobicularia plana* (Hughes, 1970), *Tellina tenuis* (McIntyre, 1970), *Modiolus modiolus* (Jasim, 1986), and *C. glaucum* (Lindegarth *et al.*, 1995). In the present study, both *Cerastroderma glaucum* and *Papyridea papyracea* showed well-marked growth rings. The closely related species, *C. edule*, has been widely used as a model species to study shell growth in molluscs (Evans, 1988). Therefore, the growth ring analyses are used to sort the material into age groups, and to make up growth diagrams (Petersen, 1958).

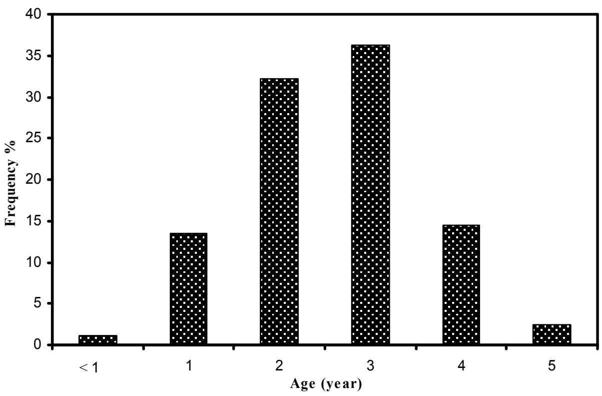

Figure (6): Age distribution of *Papyridea papyracea.*

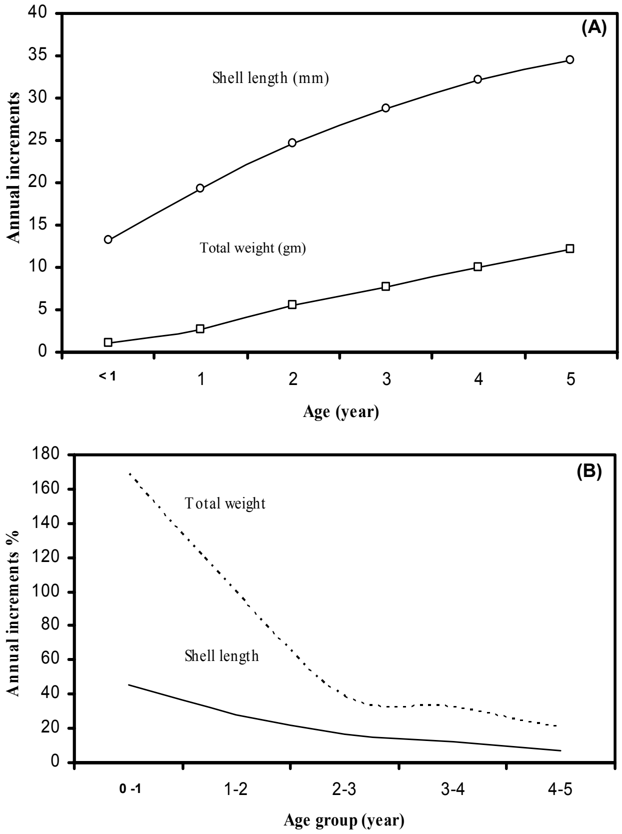

Figure (7): Absolute (A) and relative (B) growth curves of mean shell length and mean total weight with age in *Papyridea papyracea*.

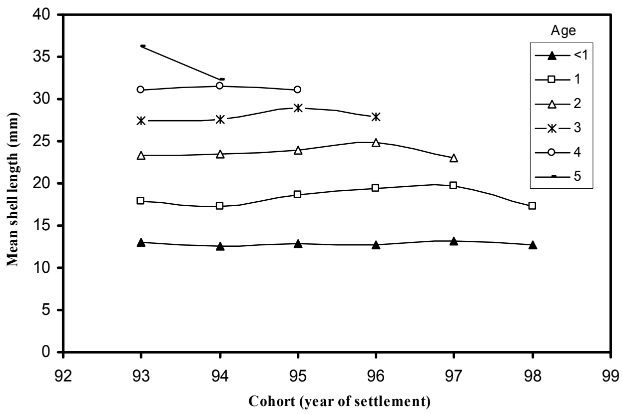

Figure (8): *Papyridea papyracea*. Back-calculated length at age for the five years of life for six cohorts (1993-1998 inclusive).

The absolute growth in shell length and total body weight of *Cerastoderma glaucum* and *Papyridea papyracea* increased with age. On the other hand, the relative growth and annual increments declined with age. A similar observation has been noted by Nair *et al.* (1978) on the *Donax incarnatus.* They found the growth of the youngest bivalve was faster than the oldest populations. Seed and Brown (1978) pointed out that the slowing of growth rate takes place at a size when the bivalve would be subjected to little predations.

Generally, growth in shell length in all bivalves slows down with increasing age, due to a decline in activity of the shell secreting cells in the mantle margins (Brousseau, 1978). The decrease in growth rate with age was also recorded in *Tapes philippinarum* and *Tapes decussatus* (Beningeŕ and Lucas, 1984) as well as in other marine bivalves (Seed, 1976). Meanwhile, Iglesias and Navarro (1991) noticed weight loss of *C. edule* increased with increasing age. On the other hand, Sato (1994) found growth rate of shell weight in *Phacosoma japonicum* increased to seventh year and then decreased with age. In addition, growth rates were highest in young zebra mussels (Doyle *et al*., 1999). As the size classes increased, the growth rates of zebra mussels declined, with increasing size producing an inverse relationship between size class and growth rate.

Age composition of the present study revealed abundance of the second and third year old individuals. This indicated the successful settlement of 1995 and 1996 spat, which may be resulted from good environmental conditions during these years. This opinion was confirmed from back-calculation studies that reflected a better growth during these years.
Thus extensive settlement of the cockles during 1995 and 1996 was followed by dominating the population for the next few years (1998). Smidt (1944) previously suggested that there was an inverse relationship between the numbers of established cockles and numbers of settling individuals.

Comparing the present results concerning *Cerastoderma glaucum* with those of Boyden (1972) revealed discrepancy in growth rate and population structure. Cockles of the same age are smaller in the present study. In addition, the fourth and fifth age groups were the most common in the Boyden's study. It was clear that *C. glaucum* had more acclimation in cold region (where it exhibited better growth and survival) than in the semitropical region (present study). This ensured the role of latitudinal variation on growth. *Mercenaria mercenaria* showed more rapid growth in the southern bays of Texas than in the northern ones (Bright and Craig, 1985). On the other hand, Sato (1994) was found specimens of *Phacosma japonicum* from southern populations around the Japanese coast had smaller shell size than those from northern populations at a given age. These results suggest that difference in the cockle's growth is likely attributed to the variation in its latitudinal environmental condition.

Particular conditions of the sea environment, such as salinity, are known to influence growth in many species (Bayne and Newell, 1983). Both *Cerastoderma edule* and *C. glaucum* collected from low salinity environments were smaller and younger than individuals living in more marine habitats (Eisma, 1965). In contrast, the maximum age of the cockle *C. glaucum* is reduced within the hypersaline environments as stated by Boyden (1972). The maximum age (5+) recorded in Lake Timsah was in agreement with Boyden's result in Crouch estuary, England. Also, the substrate texture could be an important factor affecting growth of *C. glaucum* and the dominance of some age groups. Lindegarth *et al*. (1995) found that the variability in age structure of the cockle *Cerastoderma lamarcki* between bays has mainly attributed to the variability in the sediment structure of these bays. Moreover, clay content of the sediment appeared to affect the growth of many bivalves as it is considered as an additional source for feeding. Wanink and Zwarts (1993) found a positive correlation between growth and clay content of the sediment in the deposit feeders. The above findings could explain the high growth of *C. glaucum* in clay-rich area (site I) of the present study.

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العمر والنمو لذوات المصراعين سراستودرما جلوكوم و بيبيريديا بيبيريسيا فى بحيرة التمساح، قناة السويس

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الملخص العربـــى

تعتبر ذوات المصراعين - على هيئة قلب- سراستودرما جلوكوم و بيبيريديا بيبيريسيا من بين الرخويات السائدة في بحيرة التمساح بقناة السويس. وقد تم تحديد العمر الذي يعتمد على عد حلقات النمو لإظهار منحنيات النمو خلال دورة حياتهما. ولهذا الغرض فقد تم تجميع العينات شهريا خلال الفترة مابين يونيو 1996 وحتى يونيو 1998.

وقد أظهرت الدراسة سيادة المجموعة العمرية الثانية والثالثة لكلا النوعين. وتراوحت طول الصدفة للسراستودرما جلوكوم مابين 9.9، 35 مم للذكور والإناث على التوالي وكذلك متوسط الطول الافتراضى لهما كان 2، 35، 37، 42 مم على الترتيب. أما بيبيريديا بيبيريسيا فقد أظهرت مدى واسع بالنسبة لطول الصدفة والذي تراوح مابين 7، 60 مم أما طولها الافتراضى فقد وصل الى 51، 69 مم . وقد تمت مناقشة بعض العوامل البيئية ذات التأثير على نمو هذه الحيوانات.