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Length-Weight Relationships and Monthly Variations in Body Weights and Condition Indices of Two Clam's Species; *Venerupis aurea* and *Tapes decussata* in Lake Timsah, Egypt

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ABSTRACT

Both *Venerupis aurea* and *Tapes decussata* are commercially exploited bivalves, and their populations have been severely declining in Lake Timash (Suez Canal, Egypt). Weight-length relationships and monthly changes in body weights and condition in relation to water temperature and gonadal cycle were studied for the two bivalves in this lake. All regressions between body weight and shell length showed higher determination coefficients (R^2). Total weight and shell weight of the two clams increased isometrically with length in most months. Both flesh weight and dry flesh weight indicated negative allometric and isometric relationships to length in most monthly samples of *V. aurea* and *T. decussata,* respectively. Body condition was evaluated through three condition indices (CI). Results showed that digestive gland weight of the two species is a good index for body condition. Variations in body weights and the condition indices showed no clear seasonal pattern. Changes in gonad weight and condition indices did not appear to be related to temperature fluctuation. However, temperature correlated negatively with flesh weight of *V. aurea* (R=-0.617, P<0.05) and *T. decussata* (R=-0.826 P<0.0005). Although a non-significant correlation was observed between gonad weight and body condition, a clear decline of CI_1 and CI_2 was found during spawning periods of the two clams. The highest CI_3 value of 3.63 in August 2004 for *V. aurea* and of 3.45 in November 2004 for *T. decussata* occurred as a prelude to major spawning.

Keywords: Allometric growth, body weight, condition index, Lake Timsah, monthly variation, Temperature, Veneridae , *Tapes decussata*, *Venerupis aurea.*

INTRODUCTION

Venerupis aurea (Gmelin, 1971) and *Tapes* (= *Ruditapes*) *decussata* (Linnaeus, 1758) are the most common venerids in Lake Timsah, Suez Canal (Fouda and Abou-Zied, 1990; Ghobashy *et al*., 1992). The two species are indigenous to the Mediterranean Sea and have migrated through the Canal and successfully colonized Lake Timsah (Fouda and Abou-Zied, 1990). In this lake, the two species showed no reproductive senility, exhibited remarkable reproductive effort and spawned several times per year (Kandeel, 2006).

Because of their considerable economic importance and the high market demand, over exploitation of *V. aurea* and *T. decussata* has largely depleted the natural stocks. In order to assess the sustainable exploitation rate for these clams, as well as to estimate their potential capacity for a sustainable aquaculture, it is essential to gain information on their biology which is limited (Abou-Zied, 1991; Kandeel, 1992, 2006). Clam aquaculture is a significant industry in many countries and accounted for 26% by weight of world molluscan aquaculture production in 1995 (FAO/FIDI, 1997). In Egypt, however, commercial interest in clams has been largely restricted to a relatively small fishery. It is hoped that there will be aquaculture production of these clams in our inshore waters.

The allometric principles of animal morphology have long been recognized, since the concept of allometry was first postulated by Huxley and Tessier (1936). Allometry is the study of the relationship between two measurable variables, or in most general sense, allometry is the study of size and its consequences (Reiss, 1989). The relationship between body weight and length has several uses, namely the estimation of weight from length for individuals and for length classes (Anderson and Gutreuter, 1983), the conversion of growth-in-length equations to growth-in-weight, and prediction of weight-at-age and subsequent use in stock assessment models (Pauly, 1993). Additionally, weight-length relationships allow life history and morphological comparisons between species or between populations of a species from different habitats and/or regions (Gaspar *et al*., 2001).

The concept of "condition", simply defined as a measure of the meat content of the shellfish, has been used by many workers in studies of bivalve biology (Hickman and Illingworth, 1980). Condition indices based upon allometric relationships have often been used as indicators in the reproduction of bivalves (Villalejo-Fuerte *et al*., 1995; Gaspar and Monteiro, 1999), and considered as indicators of meat quality and yield in cultured bivalves (Okumus and Stirling, 1998; Nakamura *et al*., 2002; Orban *et al*., 2002) and have been suggested for rapid assessment of the ecophysiological status of bivalves in aquaculture (Lucas and Beninger, 1985) and water quality monitoring programs (Pampanin *et al*., 2005; Rebelo *et al*., 2005).

The first objective of this study is to investigate temporal trends in weight-length relationships for *V. aurea* and *T. decussata* in Lake Timsah. These relationships can be used to convert length-frequency distributions into weights for biomass estimates (Johannessen, 1973; Nalepa *et al*., 1995). The second

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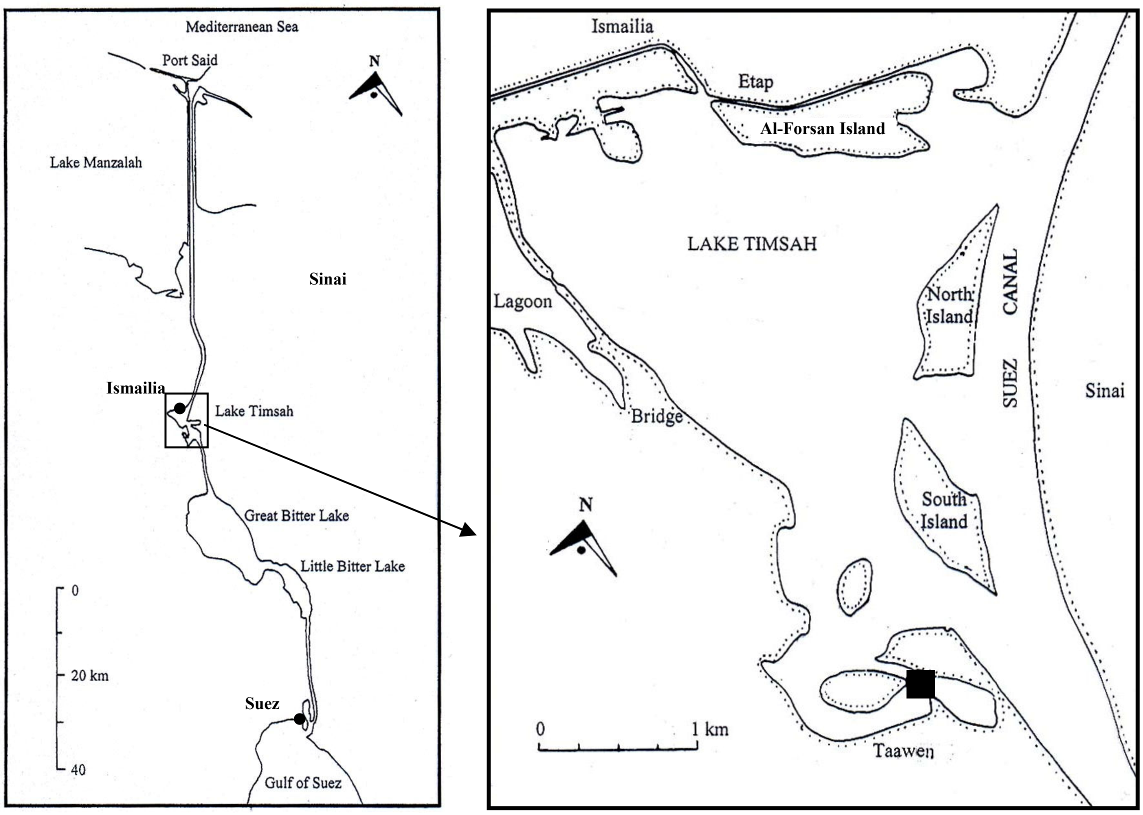

Figure (1): Map of the Suez Canal showing sampling site (■) in Lake Timsah

objective is to examine monthly variations in body weight and in condition indices and the probable influence of water temperature and gonadal cycle on these variations.

MATERIALS AND METHODS

1. Study area

The Suez Canal water system is approximately 162 km long and includes several shallow lakes. Of these, Lake Timsah (Fig. 1), the study area, lies between 30° 33\` and 30° 35\` N and 32° 16\` and 32° 19\` E. It has a surface area of about 15km^2 and a depth ranging from 6 to 13 m.

The southern part of the lake at El-Taawen area is considered as the main fishery ground of both *Venerupis aurea* and *Tapes decussata*. The bottom of this area is of mixed muddy sand and gravel with some shell fragments. In the present study, temperature of seawater was measured monthly during the sampling period. A cycle of water temperature was observed with values varying between 15.9°C in February and 30°C in July 2005 (Fig. 2).

2. Sampling

Samples of *Venerupis aurea* and *Tapes decussata* were collected at monthly intervals from El-Taawen area, Lake Timsah between August 2004 and September 2005. Sampling was done according to Kandeel (2006).

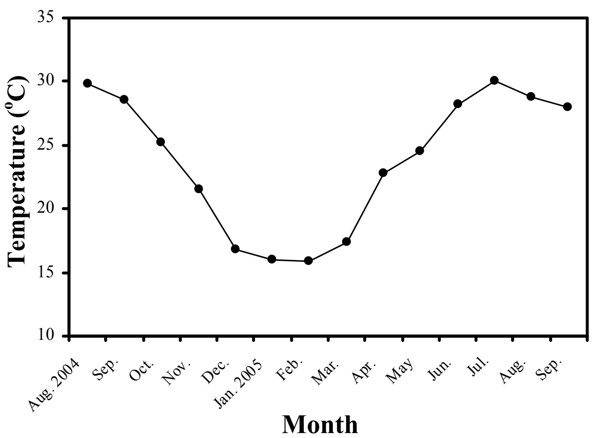

Figure (2): Monthly variations in surface water temperature at El-Taawen area, Lake Timsah.

Collected samples were kept in containers filled with 6% neutral formalin and then transported to the laboratory.

3. Biometric analysis

For each specimen, shell length (L, defined as the maximal antero-posterior axis, Gallois, 1976) was measured to the nearest 0.1mm with a vernier calliper. The flesh was then removed from the shell using a scalpel. Total weight (TW, shell + flesh), shell weight (SW), flesh weight (FW) as well as dry flesh weight

(DFW; by oven drying at 60°C for 48h) were recorded. For other samples, digestive glands were dissected out and separately weighed (DGW). All weights were determined to the nearest 0.0001g using a single-pan digital balance. Biometric analysis were restricted to adult individuals as they are likely to exhibit more variations (due to spawning activity) than juveniles or youngs.

4. Weight-length relationships

The relationship between the body weight (W; in grams) and shell length (L; in mm) was described by the following allometric equation:

$$W = a\ L^b \text{ (Ricker, 1975)}$$

Where W is a dependent variable; L is the independent variable; *a* and *b* are intercept (initial growth coefficient) and slope (relative growth rate of variables) values, respectively. Weight and length were converted to natural logs and a linear regression equation was determined:

$$\log W = \log a + b \log L$$

For each species, linear regression equations were calculated monthly for the logarithm of total weight (log TW), shell weight (log SW), flesh weight (log FW), dry flesh weight (log DFW) and digestive gland weight (log DGW) versus logarithm of shell length (log L).

5- Standard animals

The appropriate weight-length regressions were used in the recalculation of body weights corresponding to standard individuals to evaluate monthly variations independently of individual growth. Standard individuals of 22 and 26 mm shell length were selected for *Venerupis aurea* and *Tapes decussata*, respectively. These sizes are close to the mean sizes of the two studied populations over the sampling period (Table 1). Regression equations of gonad weight against shell length determined in the previous study (Kandeel, 2006) were used in the recalculation of monthly gonad weights of these standard individuals. The use of standard animals to investigate seasonal changes in body weight and gross biochemical composition was applied to some venerids (Beninger and Lucas, 1984; Tirado *et al*., 2003; Ojea *et al*., 2004).

6- Condition indices

Three different indices of condition were applied in the present study. The first condition index (CI_1), previously used by Leite *et al*. (2004) and Smaoui-Damak *et al*. (2006), was calculated as the percentage between the flesh weight and the total weight of the clams (FW/TW.100). The second index (CI_2) was the percentage between flesh weight and shell weight (FW/SW.100) as described by Davenport and Chen (1987) and Chou *et al*. (2003). The third index (CI_3) was the percentage between dry flesh weight and shell length^b, cm (DFW/L^b. 100) where *b* is the slope values from the monthly log-log DFW to shell length regressions. CI_3 corresponds to that used by Ansell *et al*. (1980), Rodriguez-Rúa *et al*. (2003) and Tirado *et al*. (2003) except they used a factor of 3 instead of the true *b* value. Condition indices were expressed as mean ± SD and calculated at each sampling date for each species.

5. Statistical analysis

Regression constant, the intercept (log *a*) and slope (*b*) values of the weight-length relationships were estimated by linear regression analysis (least squares method), and the association degree between variables was calculated by the determination coefficients (R^2). Additionally, data were submitted to an analysis of variance (ANOVA) to estimate variance ratio (*F*) and the significance level of the determination coefficient.

In order to confirm if the slope (*b*) values obtained in the linear regressions were significantly different from the isometric value (b=3), a Student's *t*-test (H_o: b=3) with a confidence level of ± 95% was applied, expressed by the following equation (Monti *et al*., 1991):

$$t_s = (b-3)/s_b$$

Where t_s = *t*-test value, *b* = slope and s_b = standard deviation of *b*.

Subsequently, the comparison between the obtained values of *t*-test and the correspondent tabled critical values, allowed for determination of the statistical significance of the *b* values, and their inclusion in the isometric range (b=3) or allometric ranges (negative allometry: $b<3$ or positive allometry: $b>3$).

The degree of association between different parameters was assessed by Pearson correlation coefficients. Statistical analysis was carried out using MINITAB software (version 13, 2000). The level of significance was set at $P < 0.05$.

RESULTS

1. Weight-length relationships

(1) Total weight-shell length regressions

Intercept (log *a*), slope (*b*), level of significance from isometry (*P*), coefficient of determination (R^2) and variance ratio (*F*) for total weight (TW)-shell length (L) regression are given monthly in Table (1) for *Venerupis aurea* and *Tapes decussata*. All regressions were highly significant ($P < 0.0005$). Coefficients of determination varied between 0.888 and 0.982 for *V. aurea* and between 0.952 and 0.990 for *T. decussata.* Slope values of the two species were not significantly deviated from 3 value ($P > 0.05$) indicating isometric growth pattern in most months.

(2) Shell weight-shell length regressions

Regressions that describe the relationship between shell weight (SW) and shell length (L) have coefficients

Table (1): Parameters of regression equations and regression statistics relating total weight (TW, g) to shell length (L, mm) according to the equation log TW = log *a* + *b* log L calculated monthly for *V. aurea* and *T. decussata.* Value of Student's *t*- test (*t*), level of significance from isometry (*P*), coefficient of determination (R^2), variance ratio (*F*), mean length of the studied population (*Lm*) and number of animals (*N*) are also given.

Month	*Venerupis aurea*							
	Log *a*	***b* ± SD**	***t***	***P***	R^2	***F***	L_m	***N***
August 2004	−3.45	2.59±0.04	10.25	<0.05	0.976	3790.8	19.1	96
September	−3.42	2.57±0.04	10.57	<0.05	0.974	5201.6	19.2	143
October	−3.35	2.53±0.08	5.88	NS	0.888	1109.9	21.2	142
November	−3.31	2.50±.0.05	10.00	<0.05	0.964	2893.4	22.1	111
December	−3.71	2.78±0.05	4.40	NS	0.964	2647.6	22.8	101
January 2005	−3.64	2.76±0.05	4.80	NS	0.972	2760.2	24.7	82
February	−3.66	2.77±0.05	4.60	NS	0.975	2984.5	25.3	78
March	−3.93	2.94±0.06	1.00	NS	0.975	2725.5	23.6	73
April	−4.00	2.96±0.07	0.57	NS	0.976	1893.5	22.6	49
May	−3.68	2.74±0.06	4.33	NS	0.982	2286.6	21.6	45
June	−3.47	2.61±0.03	13.00	<0.025	0.978	6902.0	22.0	156
July	−3.34	2.49±0.03	17.00	<0.025	0.980	5997.7	20.7	127
August	−3.52	2.64±0.03	12.00	<0.05	0.975	6364.8	19.2	164
September	−3.78	2.83±0.05	3.40	NS	0.965	3669.9	19.8	134

Month	*Tapes decussata*							
	Log *a*	***b* ±SD**	***t***	***P***	R^2	***F***	L_m	***N***
August 2004	−3.32	2.62±0.05	7.60	<0.05	0.982	2763.7	22.7	52
September	−3.43	2.68±0.05	6.40	<0.05	0.972	3167.6	22.6	92
October	−3.36	2.66±0.04	8.50	<0.05	0.981	3864.0	24.6	76
November	−3.23	2.59±0.05	8.20	<0.05	0.974	2750.2	25.4	75
December	−3.47	2.76±0.04	6.00	NS	0.986	4337.3	28.3	65
January 2005	−3.43	2.73±0.05	5.40	NS	0.979	2471.1	27.7	54
February	−3.44	2.75±0.11	2.27	NS	0.952	633.2	28.2	34
March	−3.85	3.02±0.06	0.33	NS	0.988	2378.7	25.1	32
April	−3.60	2.81±0.09	2.11	NS	0.974	1078.9	25.6	31
May	−4.08	3.14±0.04	3.50	NS	0.990	4918.3	28.1	53
June	−3.77	2.91±0.05	1.80	NS	0.989	3858.5	25.7	43
July	−3.55	2.78±0.07	3.14	NS	0.981	1712.8	29.9	36
August	−3.59	2.81±0.05	3.80	NS	0.975	2651.0	25.2	71
September	−3.59	2.81±0.07	2.71	NS	0.979	1783.3	25.9	40

All regressions were highly significant ($P < 0.0005$), SD = standard deviation, NS = non significant ($P > 0.05$).

of determination (R^2) ranging from 0.792 to 0.980 for *Venerupis aurea* and from 0.830 to 0.989 for *Tapes decussata* (Table 2). Level of significance from isometry (*P*) indicated that shell weight of the two species increases isometrically with shell length throughout the study period except November 2004 and June-July 2005 for *V. aurea* and October-November 2004 for *T. decussata*. In these months, shell weight increased relatively slower than shell length indicating negative allometric growth.

(3) Flesh weight-shell length regressions

The relationships between logarithmically transformed data of flesh weight (FW) and shell length (L) of mature clams collected monthly were derived from linear regression equations in the following form:

$$\log \text{FW} = \log a + b \log \text{L}$$

Coefficients of determination (R^2) ranged from 0.914 to 0.976 and from 0.824 to 0.987 for *Venerupis aurea* and *Tapes decussata,* respectively (Table 3). Student's *t*-test showed that flesh weight of *V. aurea* increased relatively slower than shell length (negative allometric growth) in most months. In winter and early spring (January-April 2005) flesh weight increased isometrically with shell length. For *T. decussata,* isometric growth pattern was recorded throughout the study period except in August-September 2004. For samples collected during this period, flesh weight showed a negative allometry to shell length.

(4) Dry flesh weight-shell length regressions

Table (4) shows the results of regression analysis between dry flesh weight (DFW) and shell length (L) for *Venerupis aurea* and *Tapes decussata.* Coefficients of determination were also high and the variance ratios (*F*) were all significant at $P < 0.0005$. For *V. aurea,* the slope of the regression lines fluctuated from 1.14 to 2.59 and departed significantly from isometry indicating negative allometric growth in 11 months. In the other 3 months (January-March 2005) dry flesh weight increased isometrically with shell length. For *T. decussata*, slope values ranged from 1.75 to 2.97 and not significantly deviated from 3 value (i.e. isometry)

Table (2): Parameters of regression equations and regression statistics relating shell weight (SW, g) to shell length (L, mm) according to the equation log SW = log *a* + *b* log L calculated monthly for *V. aurea* and *T. decussata.* Value of Student's *t*- test (*t*), level of significance from isometry (*P*), coefficient of determination (R^2) and variance ratio (*F*) are also given. Mean length of the studied population (*Lm*) and number of animals (*N*) are as in Table (1).

Month	*Venerupis aurea*						*Tapes decussata*					
	Log *a*	***b* ± SD**	***t***	***P***	R^2	***F***	**Log *a***	***b* ±SD**	***t***	***P***	R^2	***F***
August 2004	–3.89	2.73±0.05	5.40	NS	0.968	2866.1	–3.64	2.69±0.06	5.17	NS	0.974	1846.5
September	–4.03	2.86±0.04	3.50	NS	0.792	4895.6	–3.79	2.79±0.06	3.50	NS	0.965	2484.3
October	–3.91	2.77±0.04	5.75	NS	0.973	4955.9	–3.55	2.62±0.05	7.60	<0.05	0.968	2254.1
November	–3.71	2.62±0.05	7.60	<0.05	0.954	2277.4	–3.30	2.48±0.06	8.67	<0.05	0.962	1866.0
December	–4.22	2.98±0.06	0.33	NS	0.960	2396.6	–3.66	2.74±0.05	5.20	NS	0.981	3332.9
January 2005	–4.09	2.89±0.06	1.83	NS	0.966	2282.0	–3.65	2.73±0.06	4.50	NS	0.976	2108.6
February	–3.87	2.72±0.06	4.66	NS	0.959	1777.0	–3.55	2.66±0.14	2.43	NS	0.921	373.8
March	–4.35	3.05±0.06	0.83	NS	0.977	2984.2	–4.09	3.03±0.07	0.43	NS	0.986	2169.3
April	–4.45	3.11±0.08	1.38	NS	0.972	1625.7	–3.79	2.80±0.10	2.00	NS	0.965	804.9
May	–4.21	2.93±0.07	1.00	NS	0.978	1900.9	–4.39	3.18±0.05	3.60	NS	0.989	4423.1
June	–3.82	2.67±0.03	11.00	<0.05	0.978	6865.2	–4.17	3.02±0.07	0.29	NS	0.979	1933.2
July	–3.73	2.61±0.03	13.00	<0.025	0.980	6055.7	–3.90	2.87±0.08	1.63	NS	0.972	1192.7
August	–4.02	2.84±0.03	5.33	NS	0.977	6999.2	–3.45	2.54±0.14	3.29	NS	0.830	337.1
September	–4.17	2.96±0.07	0.57	NS	0.932	1820.4	–3.83	2.84±0.07	2.29	NS	0.974	1442.3

All regressions were highly significant ($P < 0.0005$), SD = standard deviation, NS = non significant ($P > 0.05$).

Table (3): Parameters of regression equations and regression statistics relating flesh weight (FW, g) to shell length (L, mm) according to the equation log FW = log *a* + *b* log L calculated monthly for *V. aurea* and *T. decussata.* Value of Student's *t*- test (*t*), level of significance from isometry (*P*), coefficient of determination (R^2) and variance ratio (*F*) are also given. Mean length of the studied population (*Lm*) and number of animals (*N*) are as in Table (1).

Month	*Venerupis aurea*						*Tapes decussata*					
	Log *a*	***b* ± SD**	***t***	***P***	R^2	***F***	**Log *a***	***b* ±SD**	***t***	***P***	R^2	***F***
August 2004	–3.58	2.42±0.04	14.50	<0.025	0.971	3097.9	–3.59	2.53±0.05	9.40	<0.05	0.980	2456.7
September	–3.34	2.20±0.05	16.00	<0.025	0.935	2044.6	–3.60	2.50±0.05	10.00	<0.05	0.967	2652.9
October	–3.35	2.25±0.05	15.00	<0.025	0.939	2140.7	–3.81	2.72±0.05	5.60	NS	0.979	3395.3
November	–3.47	2.35±0.06	10.83	<0.05	0.924	1323.9	–3.84	2.75±0.10	2.50	NS	0.917	807.5
December	–3.74	2.52±0.07	6.86	<0.05	0.926	1241.1	–3.93	2.80±0.05	4.00	NS	0.978	2829.2
January 2005	–3.79	2.63±0.06	6.17	NS	0.953	1618.5	–3.80	2.72±0.07	4.00	NS	0.967	1534.2
February	–4.06	2.82±0.06	3.00	NS	0.965	2095.6	–4.00	2.87±0.10	1.30	NS	0.966	911.8
March	–4.00	2.75±0.09	2.78	NS	0.929	931.5	–4.34	3.10±0.11	0.91	NS	0.963	778.9
April	–4.10	2.76±0.07	3.43	NS	0.966	1332.7	–4.04	2.84±0.10	1.60	NS	0.968	865.0
May	–3.73	2.53±0.06	7.83	<0.05	0.976	1758.4	–4.37	3.09±0.05	1.80	NS	0.987	3858.4
June	–3.69	2.52±0.04	12.00	<0.05	0.955	3297.6	–3.96	2.78±0.06	3.67	NS	0.980	2051.6
July	–3.50	2.32±0.04	17.00	<0.025	0.965	3418.7	–3.75	2.64±0.08	4.50	NS	0.970	1092.8
August	–3.56	2.38±0.05	12.40	<0.05	0.944	2710.8	–3.57	2.50±0.14	3.57	NS	0.824	323.4
September	–3.85	2.56±0.07	6.49	< 0.05	0.914	1409.0	–3.95	2.77±0.08	2.88	NS	0.970	1222.4

All regressions were highly significant ($P < 0.0005$), SD = standard deviation, NS = non significant ($P > 0.05$).

through the study period except September 2004 and August-September 2005. In these months, dry flesh weight increased relatively slower than shell length.

(5) Digestive gland weight-shell length regressions

Monthly relationship between digestive gland weight (DGW) and shell length (L) has highly significant ($P < 0.0005$) correlations. Coefficients of determination (R^2) varied between 0.514 and 0.962 for *Venerupis aurea* and between 0.614 and 0.977 for *Tapes decussata* (Table 5). The slope of the regression lines ranged from 0.56 to 1.80 and form 1.60 to 2.25 for the two species, respectively. Slope values departed significantly from isometry ($P < 0.05$) indicating negative allometric relationships throughout the study period.

2. Monthly changes in body weight

Figure (3) shows monthly variations in total weight, shell weight, flesh weight, dry flesh weight, digestive gland weight and gonad weight of standard lengths of 22 and 26 mm for *Venerupis aurea* and *Tapes decussata*, respectively.

Variations in total weight and flesh weight showed more or less similar trends in the mode of variation. The ranges of variation were 0.941 - 1.162g, 0.386 - 0.550g for *V. aurea*; 2.226 - 2.826g and 0.866 - 1.151g for *T. decussata,* respectively. Shell weights remained relatively constant throughout the entire sampling period. Their values ranged from 0.529 to 0.645g and from 1.268 to 1.648g for the two species, respectively. Changes in dry flesh weight, digestive gland weight and gonad weight showed a poorly defined seasonal pattern. Digestive gland weight fluctuated only between 0.046 and 0.073g for *V. aurea* and between 0.099 and 0.143g for *T. decussata.* Regarding the gonad weight, more pronounced monthly variations were observed.

Table (4): Parameters of regression equations and regression statistics relating dry flesh weight (DFW, g) to shell length (L, mm) according to the equation log DFW = log *a* + *b* log L calculated monthly for *V. aurea* and *T. decussata.* Value of Student's *t*- test (*t*), level of significance from isometry (*P*), coefficient of determination (R^2) and variance ratio (*F*) are also given. Mean length of the studied population (*Lm*) and number of animals (*N*) are as in Table (1).

Month	*Venerupis aurea*						*Tapes decussata*					
	Log *a*	*b* ± SD	*t*	*P*	R^2	*F*	Log *a*	*b* ±SD	*t*	*P*	R^2	*F*
August 2004	–2.80	1.35±0.19	8.68	<0.05	0.472	49.2	–3.88	2.17±0.23	3.61	NS	0.691	91.6
September	–3.52	1.84±0.09	12.89	<0.025	0.852	380.4	– 3.31	1.75±0.13	9.62	<0.05	0.714	175.1
October	–3.37	1.83±0.07	16.71	<0.025	0.909	635.8	–3.92	2.31±0.17	4.06	NS	0.787	191.7
November	–3.42	1.87±0.09	12.56	<0.05	0.854	379.4	–3.39	1.92±0.18	6.00	NS	0.673	115.1
December	–3.41	1.83±0.12	9.75	<0.05	0.795	224.3	–3.93	2.22±0.15	5.20	NS	0.780	208.6
January 2005	–4.06	2.29±0.20	3.55	NS	0.656	125.8	–4.34	2.53±0.16	2.94	NS	0.787	236.7
February	–4.48	2.59±0.09	4.56	NS	0.916	843.5	–4.96	2.96±0.14	0.29	NS	0.890	430.6
March	–4.05	2.29±0.21	3.38	NS	0.645	118.2	–4.60	2.70±0.09	3.33	NS	0.944	902.1
April	–3.91	2.11±0.06	14.83	<0.025	0.951	1228.9	–4.69	2.76±0.06	4.00	NS	0.969	2125.4
May	–3.70	1.93±0.05	21.40	<0.025	0.951	1347.1	–5.00	2.97±0.08	0.38	NS	0.956	1518.7
June	–3.78	2.07±0.10	9.30	<0.05	0.845	446.4	–4.62	2.66±0.08	4.25	NS	0.946	1146.3
July	–2.57	1.14±0.22	8.45	<0.05	0.346	25.9	– 4.41	2.54±0.09	5.11	NS	0.932	858.2
August	–3.54	1.86±0.09	12.67	<0.05	0.836	382.3	–3.86	2.18±0.11	7.45	<0.05	0.829	363.5
September	–3.62	1.90±0.11	10.00	<0.05	0.806	308.3	–4.19	2.37±0.09	7.00	<0.05	0.912	713.9

All regressions were highly significant ($P < 0.0005$), SD = standard deviation, NS = non significant ($P > 0.05$).

The range of variation was 0.092 - 0.178g and 0.122 - 0.304g for the two species, respectively. Marked decline in gonad weight was observed during September 2004, December 2004 and April 2005 for the two species, July 2005 for *V. aurea*, June and August 2005 for *T. decussata*.

3. Monthly changes in condition indices

Monthly variations in condition indices (CI) of *Venerupis aurea* and *Tapes decussata* are illustrated in Fig. (4). The mode of variation in CI_1 and CI_2 of the two species showed more or less similar trends. There were highly significant ($P < 0.0005$) positive correlations between the two indices (Pearson correlation, $R = 0.953$ and 0.991 for the two species, respectively). The decline in the two indices of the two clams during September 2004, December 2004, April 2005 and July 2005 coincided with spawning. There was a pronounced seasonal variation in CI_3 throughout the study period. However, this variation, as in the previous indices, showed a poorly defined seasonal pattern. The highest CI_3 value of 3.63 during August 2004 for *V. aurea* and of 3.45 during November 2004 for *T. decussata* occurred as prelude to major spawnings. Low values (< 2.02 for *V. aurea* and < 1.60 for *T. decussata*) were found during winter and spring (January-June 2005).

4. Degree of association between different parameters

Matrix Pearson correlation coefficients between the different parameters are displayed in Table (6) for *Venerupis aurea* and in Table (7) for *Tapes decussata*. Variations in total weight were significantly positively correlated with variations in shell weight and flesh weight of the two species. Also, flesh weight was

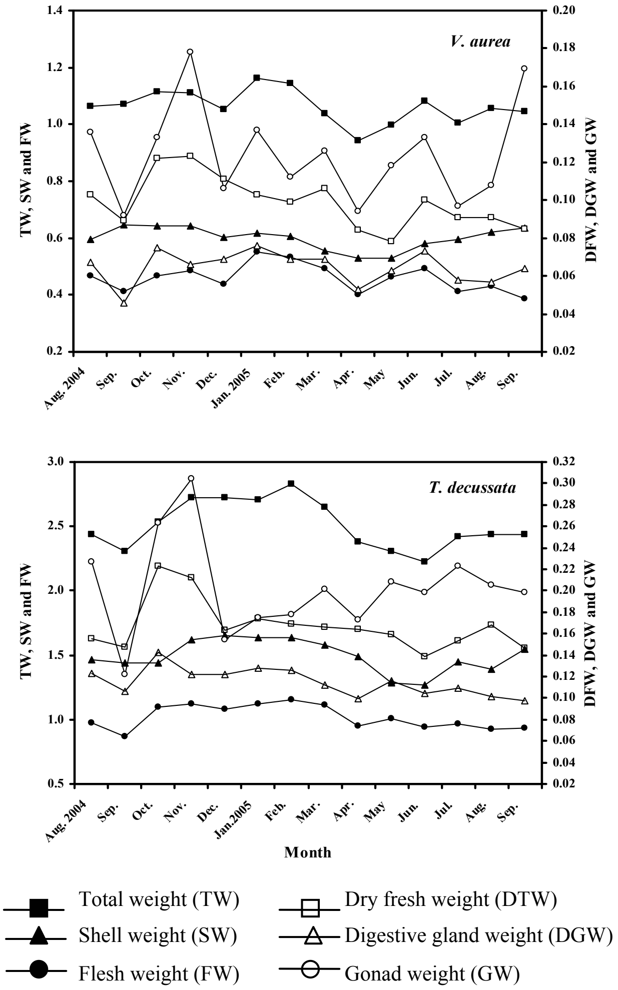

Figure (3): Monthly variations in body weight (g) of a standard individual of *V. aurea* (22 mm shell length) and *T. decussata* (26 mm shell length).

Table (5): Parameters of regression equations and regression statistics relating digestive gland weight (DGW, g) to shell length (L, mm) according to the equation log DGW = log *a* + *b* log L calculated monthly for *V. aurea* and *T. decussata.* Value of Student's *t*-test (*t*), level of significance from isometry (*P*), coefficient of determination (R^2), variance ratio (*F*) and number of animals (*N*) are also given.

Month	*Venerupis aurea*							*Tapes decussata*						
	Log *a*	*b* ± SD	*t*	*P*	R^2	*F*	*N*	Log *a*	*b* ±SD	*t*	*P*	R^2	*F*	*N*
August 2004	−2.96	1.33±0.04	41.75	<0.01	0.961	1171.1	49	−3.67	1.95±0.07	15.00	<0.025	0.953	737.9	38
September	−3.24	1.42±0.09	17.56	<0.025	0.797	220.2	58	−3.62	1.87±0.11	10.27	<0.05	0.876	302.6	45
October	−2.98	1.38±0.06	27.00	<0.025	0.894	461.6	57	−4.03	2.25±0.05	15.00	<0.025	0.977	1966.1	48
November	−3.06	1.40±0.08	20.00	<0.025	0.847	305.1	57	−4.00	2.18±0.07	11.71	<0.05	0.949	832.4	47
December	−3.12	1.46±0.06	25.67	<0.025	0.931	671.3	52	−3.87	2.09±0.11	8.27	<0.05	0.893	360.6	45
January 2005	−3.34	1.65±0.05	27.00	<0.025	0.950	1011.7	55	−3.95	2.16±0.07	12.00	<0.05	0.960	1058.4	46
February	−3.58	1.80±0.05	24.00	<0.025	0.962	1178.8	49	−3.90	2.12±0.07	12.57	<0.05	0.954	821.6	42
March	−3.28	1.58±0.06	23.67	<0.025	0.926	597.5	50	−3.78	2.00±0.06	16.67	<0.025	0.959	1043.0	47
April	−2.91	1.22±0.06	29.67	<0.025	0.886	395.4	53	−4.09	2.18±0.07	11.71	<0.05	0.964	1116.2	44
May	−1.95	0.56±0.07	34.86	<0.01	0.536	56.6	51	−3.92	2.11±0.04	22.25	<0.025	0.975	2255.3	60
June	−2.79	1.23±0.16	11.06	<0.05	0.514	60.2	59	−3.97	2.11±0.05	17.80	<0.025	0.965	1439.9	54
July	−2.71	1.10±0.06	31.67	<0.025	0.880	379.9	54	−3.37	1.70±0.04	32.50	<0.01	0.968	1597.7	54
August	−2.65	1.05±0.08	24.38	<0.025	0.778	178.4	53	−3.26	1.60±0.18	7.78	<0.05	0.614	74.9	49
September	2.48	0.96±0.04	51.00	<0.01	0.924	560.8	48	−3.87	2.02±0.09	10.89	<0.05	0.907	487.7	52

All regressions were highly significant (*P* < 0.0005), SD = standard deviation.

positively correlated with CI_1 and CI_2. For the two clams, digestive gland weight showed positive correlation with total weight ($P < 0.05$), flesh weight ($P < 0.005$) and dry flesh weight ($P < 0.05$). Significantly positive correlation was also seen between digestive gland weight and CI_1 ($R = 0.589$, $P < 0.05$) and CI_2 ($R = 0.578$, $P < 0.05$) of *T. decussata*. Unexpectedly, gonad weight of the two clams was not significantly correlated ($P > 0.05$) with temperature or condition indices. However, there was a significant positive correlation between gonad weight and dry flesh weight of *T. decussata* ($R = 0.672$, $P < 0.05$). Water temperature correlated negatively with flesh weight of *V. aurea* ($R = -0.617$, $P < 0.05$) and *T. decussata* ($R = -0.826$, $P < 0.0005$) and also with total weight ($R = -0.821$, $P < 0.0005$) and shell weight ($R = -0.721$, $P < 0.005$) of *T. decussata*.

DISCUSSION

Marine resources, normally, are exploited without any management plans in the so called open-access systems (Gordon, 1953). This means that fishermen tend to increase fishing effort as long as it is profitable resulting in overexploitation and reduction of the resources until the net gain becomes zero. Basic biological data required to establish management plans are lacking. This has been the case, for instance for *Venerupis aurea* and *Tapes decussata* in Lake Timash.

Parameters of weight-length relationships of the two clams and some other venerids are shown in Table (8). All species presented higher determination coefficients *(R^2)*. Slope values *(b)* are variable among species and also between different geographical areas. Monthly changes in slope values of *V. aurea* and *T. decussata* may reflect the annual cycle of the animal's condition or reproductive cycle (Johannessen, 1973; Crisp, 1984).

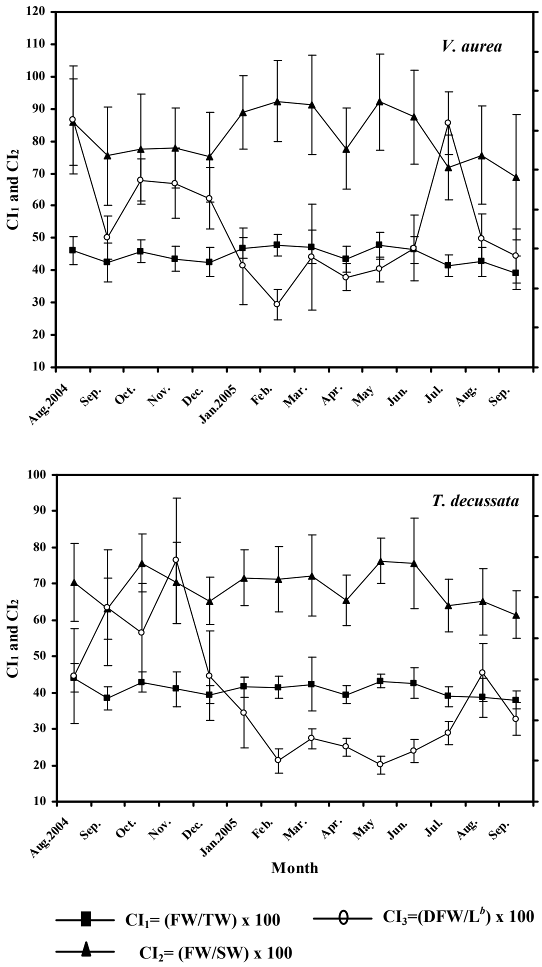

Figure (4): Monthly variations in mean values (±SD) of condition indices (CI) of *V. aurea* and *T. decussata*.

The growth in length for *V. aurea* is superior to flesh weight increase (negative allometric growth). For *T. decussata* weight increase is accompanied by growth in

Table (6): Pearson correlation coefficients between the different parameters of *V. aurea* (TW= total weight, SW= shell weight, FW= flesh weight, DFW= dry flesh weight, DGW= digestive gland weight, GW= gonad weight, CI= condition indices, °C = seawater temperature).

	TW	SW	FW	DFW	DGW	GW	CI_1	CI_2	CI_3
°C	-0.358	0.147	-0.617*	-0.368	-0.457	-0.042	-0.445	-0.467	0.469
CI_3	-0.047	0.290	-0.240	0.394	0.022	0.101	-0.270	-0.398	
CI_2	0.273	-0.497	0.806***	0.041	0.455	0.004	0.953***		
CI_1	0.337	-0.411	0.832***	0.214	0.526	-0.026			
GW	0.416	0.374	0.254	0.437	0.526				
DGW	0.568*	0.062	0.713**	0.613*					
DFW	0.611*	0.471	0.472						
FW	0.721**	-0.021							
SW	0.666*								

Significance levels: *$P < 0.05$, **$P < 0.005$, ***$P < 0.0005$

Table (7): Pearson correlation coefficients between the different parameters of *T. decussata* (the abbreviations as in Table 6).

	TW	SW	FW	DFW	DGW	GW	CI_1	CI_2	CI_3
°C	-0.821***	-0.721**	-0.826***	-0.315	-0.442	0.162	-0.319	-0.255	0.147
CI_3	0.162	0.210	0.026	0.549*	0.285	0.355	-0.209	-0.177	
CI_2	0.073	-0.283	0.604*	0.374	0.578*	0.388	0.991***		
CI_1	0.118	-0.217	0.549*	0.363	0.589*	0.359			
GW	0.151	-0.042	0.353	0.672*	0.354				
DGW	0.582*	0.328	0.746**	0.698*					
DFW	0.512	0.306	0.639*						
FW	0.880***	0.643*							
SW	0.892***								

Significance levels: *$P < 0.05$, **$P < 0.005$, ***$P < 0.0005$.

length (isometric growth). The prevalence of isometries and negative allometries over positive allometries throughout the study period is a very interesting phenomenon. Continuous spawning strategy of the two clams in Lake Timsah (Kandeel, 1992, 2006) may explain this phenomenon. However, the results of this study disagree with the prevalence of isometric and positive allometric growth over negative allometric growth for 25 bivalve species including 6 venerids from the Algarve coast in southern Portugal (Gaspar *et al*., 2001).

Venerid clams are characterized by high reproductive diversity (Morsan and Kroeck, 2005). Geographical latitude influences the gametogenic cycles. The spread of maturation and spawning decreases from low to high latitudes due to the incidence of temperature on the storage reserves (Laruelle *et al*., 1994; Gaspar and Monteiro, 1998; Drummond *et al*., 2006).

The gametogenic cycles of *V. aurea* and *T. decussata* in Lake Timsah were characterized by several emissions of gametes and a rapid gonadal restitution after spawning (no rest period). Gamete production is also continuous throughout the period when gametes are being shed (Kandeel, 1992; 2006). Continuous gamete production and repeated spawning bouts have also been documented for the mytilids *Modiolus arcuatulus* and *Brachidontes variabilis* and the cardiids *Cerastoderma glaucum* and *Papyridae papyracea* in Suez Canal lakes (Kandeel, 2002; Mohammad, 2002). The reproductive strategy of *V. aurea* and *T. decussata* differs from those observed in temperate areas (Sastry, 1979) where most marine bivalves have an annual reproductive cycle with well defined reproductive events controlled by the variation of several environmental factors. Our results showed that monthly variations in body weights of *V. aurea* and *T. decussata* in Lake Timsah showed no clear seasonal pattern. The basic pattern of spawning activity for these clams is an important contribution for the absence of clearly defined seasonal cycles. These findings have interesting implications for aquaculture, since mature individuals could in theory be induced to spawn several times throughout the year.

The digestive gland of bivalves acts as the main storage site for energy reserves utilized during high energy demand (like gametogenesis) and stress periods (Turunen and Pekkarinen, 1990; Le Pennec *et al*., 2001; Pazos *et al*., 2003; Cartier *et al*., 2004; Darriba *et al*., 2005). The importance of this gland, as a place of assimilation, storage and carbon transportation in bivalves, was also noted by Barber and Blake (1985).

The digestive gland index of the blue mussel *(Mytilus edulis* and *M. trossulus)* seems to be sensitive to gametogenesis and to the energy storage cycle (Cartier *et al*., 2004). Variations of the index were similar to those of glycogen and lipid concentrations in the digestive gland. It has long been evident that the seasonal cycle of glycogen and lipid storage in adult marine bivalves is closely related to the annual

Table (8): Parameters of equations relating body weight (W) to shell length (L) of some venerids according to the expression log W = log a + b log L.

Species	Location	Weight type	log *a*	*b*	Relationship (*t*-test)	R^2	*P*	Reference
Gafrarium pectinatum	Suez Bay, Gulf of Suez, Red Sea, Egypt.	TW	-6.66	2.50	ns	0.940	ns	Gab-Alla *et al.* (2007)•
		SW	-6.23	2.27	ns	0.908	ns	
		FW	-8.99	2.79	ns	0.920	ns	
		DFW	-11.1	2.92	ns	0.897	ns	
Anomalocardia squamosa	Starfish Bay, Hong Kong.	SW	-3.56	2.95	ns	0.897	<0.05	Lee (1996)
		DFW	-4.15	2.00	ns	0.560	<0.05	
Tapes philippinarum	Starfish Bay, Hong Kong.	SW	-3.63	2.72	ns	0.962	<0.05	Lee (1996)
		DFW	-5.14	2.84	ns	0.905	<0.05	
Tapes japonica	Togol, Namhae, Korea.	TW	-0.82	3.31	ns	ns	ns	Yoo *et al.* (1978)*
	Shinjeon, Namhae, Korea.	TW	-0.83	3.34	ns	ns	ns	
	Mijo, Namhae, Korea.	TW	-0.59	2.63	ns	ns	ns	
	Munhang, Namhae, Korea.	TW	-0.29	2.31	ns	ns	ns	
	Jijok, Namhae, Korea.	TW	-0.71	3.11	ns	ns	ns	
Ruditapes decussatus	Urdaibai Estuary (Basque Country, North Spain).	DFW	-1.76	2.90	ns	0.903	<0.001	Urrutia *et al.* (1999)*•
Venus verrucosa	The littoral of Malaga (southern Spain).	DFW	-2.22	3.12	ns	0.738	ns	Tirado *et al.* (2003)
Venus fasciata	Algarve coast, southern Portugal.	TW	-3.00	2.63	- allometry	0.859	<0.05	Gaspar *et al.* (2001)
Venerupis rhomboides		TW	-4.70	3.61	+ allometry	0.902	<0.05	
Dosinia lupinus		TW	-3.52	2.98	isometric	0.851	<0.05	
Dosinia exoleta		TW	-4.16	3.40	+ allometry	0.963	< 0.025	
Chamelea gallinea		TW	-3.16	2.80	- allometry	0.998	< 0.025	
Callista chinoe		TW	-3.70	3.04	isometric	0.990	< 0.025	
Venerupis pullastra	Seljehölen, western Norway.	TW	-4.48	3.48	ns	ns	ns	Johannessen (1973)
		SW	-4.86	3.56	ns	ns	ns	
		FW	-4.53	3.30	ns	ns	ns	
	Etap, Lake Timsah, Suez Canal, Egypt.	TW	-3.61	2.73	ns	0.922	= 0.0001	Gabr (1991)
	Taawen, Lake Timsah, Suez Canal, Egypt.	TW	-3.95	3.00	ns	0.941	= 0.0001	
	Etap, Lake Timsah, Suez Canal, Egypt.	SW	-3.58	2.57	ns	0.902	= 0.0001	
	Taawen, Lake Timsah, Suez Canal, Egypt.	SW	-4.90	3.56	ns	0.846	= 0.0001	
	Etap, Lake Timsah, Suez Canal, Egypt.	FW	-3.61	2.73	ns	0.939	= 0.0001	
	Taawen, Lake Timsah, Suez Canal, Egypt.	FW	-4.39	2.99	ns	0.922	= 0.0001	
	Etap, Lake Timsah, Suez Canal, Egypt.	DFW	-4.02	2.19	ns	0.562	= 0.0001	
	Taawen, Lake Timsah, Suez Canal, Egypt.	DFW	-3.38	1.69	ns	0.270	= 0.0001	
Venerupis aurea	Hamble Spit, Southampton Water.	SW	-3.18	2.37	ns	0.941	ns	Hibbert (1976)
	Lake Timsah, Suez Canal, Egypt.	TW	-1.70	2.33	isometric	0.980	ns	Abou-Zied (1991)
	Lake Timsah, Suez Canal, Egypt.	TW	-3.59	2.69	isometric in most months	0.967	<0.0005	Present study•
		SW	-4.03	2.84	isometric in nearly all months	0.955	<0.0005	Present study•
		FW	-3.70	2.50	-allometry in most months	0.947	<0.0005	Present study•
		DFW	-3.59	1.92	-allometry in most months	0.774	<0.0005	Present study•
Tapes decussata	Lake Timsah, Suez Canal, Egypt.	TW	-3.55	2.79	isometric in most months	0.979	<0.0005	Present study•
		SW	-3.77	2.78	isometric in nearly all months	0.960	<0.0005	
		FW	-3.89	2.76	isometric in nearly all months	0.958	<0.0005	
		DFW	-4.22	2.43	isometric in nearly all months	0.843	<0.0005	

Key: ns, not specified; R^2, determination coefficient; *P*, significance level of R^2; TW, total weight; SW, shell weight; FW, flesh weight; DFW, dry flesh weight.
* equation format modified from original form. • the values are the mean at the sampling sites or throughout the study period.

reproductive cycle (Gabbott, 1983; Beninger and Lucas, 1984; Barber and Blake, 1985; Pazos *et al*., 1997; Ojea *et al*., 2004; Darriba *et al*., 2005).

The significant inverse relationship between digestive gland and gonad indices of the bay scallop *Argopecten irradians* noted by Sastry (1970) was not observed by Kandeel (1992) for *V. aurea and T. decussata.* In this study, digestive gland weight was not correlated with gonadal cycle. These results indicate that the typical energy storage and utilization patterns between digestive gland and gonad documented for other bivalves are not always evident and that food availability could sustain the full cost of continuous gamete production in optimal environmental conditions. Our findings confirm previous study of Racotta *et al*., (2003) on the lion-pan scallop *Nodipecten (Lyropecten) subnodosus* in Bahia Magdalena, Baja California Sur, Mexico.

Digestive gland weight of *V. aurea* and *T. decussata* increased relatively slower than shell length (Table 5) and correlated positively with total weight, flesh weight and dry flesh weight throughout the study period (Table 6 & 7). This suggest that digestive gland weight seems to be sensitive to somatic growth to be used to assess body condition of these clams. These results agree with those of Cartier *et al*. (2004) using an index based on the blue mussel (*Mytilus edulis* and *M. trossulus*) digestive gland weight to assess the nutritional quality of mussel farm sites.

Condition index reveals changes in the physiological condition of organisms. It is based on characteristics such as sensitivity, accordance with the biological events (Smaoui-Damak *et al*. 2006). Comparing the three condition indices used in this study, CI_1 (the ratio of flesh weight: total weight) strongly correlated with CI_2 (the ratio of flesh weight: shell weight) of *V. aurea* (R = 0.953, P < 0.0005) and *T. decussata* (R = 0.991, P<0.0005). These two indices are recommended by us for use in clam aquaculture because they are easy to evaluate. The index calculated by referring dry flesh weight to shell length^b (CI_3) appears to be more meaningful and to discriminate seasonal variations better. Although this index is difficult to evaluate, it is the most appropriate as a research tool. The highest CI_3 values observed in August 2004 (3.63) for *V. aurea* and in November 2004 (3.45) for *T. decussata* appear to be the result of peak ripeness following an accumulation of resources in preparation for spawning. Low values (< 2.02 for *V. aurea* and <1.60 for *T. decussata)* observed in winter and spring are most probably associated with a negative energy balance brought about by low food availability during these seasons and the subsequent mobilization of energy reserves (Beninger and Lucas, 1984; Kim *et al*., 2005).

Condition index is regarded as the most sensitive to changes in bivalve reproductive activity and usually correlates well with the gonad index (Ojea *et al*., 2004; Peharda *et al*., 2006). In this study, variations of the condition indices were not significantly correlated (P > 0.05) with the gonadal weight (i.e. gonadal activity). Mladineo *et al*. (2007) explained the missing correlation between condition and gonad index by the presence of different gonadal stages in any given monthly samples, a phenomenon was recorded in the two studied clams (Kandeel, 1992). However, the decrease of CI_1 and CI_2 observed in September 2004, December 2004, April 2005 and July 2005 coincided with the major periods of emission of gametes (spawning) of the two clams (Kandeel, 1992, 2006). Spawning in bivalves is an energy-demanding process and can significantly decrease CI due to the loss of a considerable percentage of the edible part (Gaspar and Monteiro, 1999; Smaoui-Damak *et al*., 2006). Condition indices are important because of the possibility of using them to make general inferences about the major spawning periods, but they can be modified by other factors like nutritional state (Crosby and Gale, 1990) and cycle of energy storage (Okumus and Stirling, 1998), neither of which was considered in this study.

Temperature considered the main environmental factor which regulates bivalve reproduction (Sastry, 1979). In venerid clams like, *Venerupis japonica* (Holland and Chew, 1974), *Mercenaria mercenaria* (Manzi *et al*., 1985) and *Tapes philippinarum* (Meneghetti *et al*., 2004) and other clams like, *Spisula solida* (Gaspar and Monteiro, 1999) and *Glycymeris gigantea* (Villalejo-Fuerte *et al*., 1995), a clear relation between temperature and gonadic activity has been established. Ojea *et al*. (2004) observed a positive relationship between temperature and gonad condition index (GCI) in *Ruditapes decussatus*. Laruelle *et al*. (1994) reviewed data on reproductive patterns in *R. ducussatus* throughout its geographical range and concluded that temperature has a positive effect on gametogenesis that may directly affect the metabolic rate of the animal, or indirectly affect the availability of the food.

In this study, changes in gonad [consists essentially of gametes (Kandeel, 2006)] weight and water temperature were not closely related (Table 6 & 7). These results indicate that changes in water temperature did not regulate gametogenesis and spawning processes of *V. aurea* and *T. decussata* in Lake Timsah. This agrees with the results of Garcia-Daminguez *et al*. (1994) in the venerid red clam *Megapitaria aurantiaca* at Isla Espiritu Santo, Baja California Sur, Mexico. Similarly, another bivalve species in Mali Ston Bay, Adriatic Sea, the Noah's Ark (*Arca noae* L.), showed no statistical correlation between temperature and gonad index (Peharda *et al*., 2006).

Pearson's correlation matrices showed that monthly variations in flesh weight of *V. aurea* and *T. decussata* in Lake Timsah were negatively correlated with water temperature (R = -0.617, P < 0.05 and R = -0.826, P <

0.0005, respectively). The decline in flesh weight with increasing temperature may indicate that elevated temperature is a stressing factor and facilitate the utilization of energy reserves (Lubet, 1991). Mackie and Ansell (1993), studying the behaviour of transplanted populations of *Pecten maximus,* concluded that energy storage cycles are more influenced by environmental factors than by genetic factors. However, Urrutia *et al*. (1999) reported reduced growth rate of *Ruditapes decussatus* from Urdaibai Estuary (Basque Country, North Spain) at the highest seasonal temperature, suggesting that temperature could exert a negative effect on growth.

Conclusion

From an aquaculture point of view, this study indicates that El-Taawen area is an adequate site for clam growth and reproduction. The digestive gland weight seems to be sensitive to somatic growth to be used as an index for body condition. Fluctuations in the digestive gland weight have important implications for cultivation and harvesting strategy. For optimum exploitation, the harvesting season should be timed according to the peak period for body condition. The study also indicates that natural food availability could sustain the full cost of continuous gamete production in these clams in optimal environmental conditions without or with minimal energy transfer from storage tissues. Continuous production of gametes has interesting implications for clam aquaculture, since mature individuals could in theory be induced to spawn several times throughout the year.

Research work is still required to study the biochemical composition of separate organs. This allows the identification of nutrient storage sites and determination of nutrient use during high metabolic and stress period. This study is important to asses energetic paths that could have direct impact on the potential rearing of the two clams.

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علاقات الطول بالوزن والتغيرات الشهرية في وزن الجسم ومعامل الحالة لنوعين من المحار وهما الجندوفلي الناعم والجندوفلي الخشن في بحيرة التمساح، مصر

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الملخص العربـــى

يُستثمر كل من الجندوفلي الناعم والجندوفلي الخشن تجارياً، ويتناقص مجتمع هذان النوعان بشدة في بحيرة التمساح (قناة السويس، مصر). تم دراسة العلاقات بين الطول والوزن والتغيرات في وزن الجسم ومعامل حالته وعلاقتهما بالتغير في درجة حرارة الماء ودورة المناسل لهذين النوعين فى هذه البحيرة.

أظهرت كل العلاقات بين وزن الجسم وطول الصدفة معاملات تحديد (R^2) ذات قيمة عالية. ويزداد الوزن الكلي ووزن الصدفة لكلا النوعين بصورة متساوية القياس مع زيادة الطول في أغلبية الشهور. ويظهر الوزن اللحمي علاقات ألومترية سلبية وعلاقات متساوية القياس مع طول الصدفة في معظم العينات الشهرية لكل من الجندوفلي الناعم والجندوفلي الخشن على التوالي.

تم تقييم حالة الجسم من خلال دراسة ثلاث معاملات للحالة. ويعد وزن الغدة الهضمية لكلا النوعين مؤشراً جيداً لحالة الجسم. ولم تُظهر التغيرات في وزن الجسم ومعامل حالته أي نمط موسمي واضح. التغير في وزن المنسل ومعاملات الحالة للجسم ليس لهما علاقة بالتغير في درجة حرارة الماء. وعلاوة على ذلك فإن درجة الحرارة إرتبطت سلبياً مع الوزن اللحمي لكلا النوعين. وعلى الرغم من وجود إرتباط غير معنوي بين وزن المنسل وحالة الجسم فقد وجد إنخفاض واضح لمعامل الحالة الأول والثاني أثناء فترات التكاثر للنوعين. ولقد ظهرت أعلى قيمة لمعامل الحالة الثالث وهى 3.63 في أغسطس 2004 للجندوفلي الناعم و3.45 في نوفمبر 2004 للجندوفلي الخشن كإستهلال لأوقات التفريغ الرئيسية.